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FEASIBILITY OF DEVELOPING A PORTABLE DRIVER PERFORMANCE DATA ACQUISITION SYSTEM FOR HUMAN FACTORS RESEARCH: APPENDICES

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
for the
DEPARTMENT OF ENERGY
under contract number DE-AC05-96OR22464

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ORNL/TM-13540, Volume 2

FEASIBILITY OF DEVELOPING A PORTABLE DRIVER PERFORMANCE DATA ACQUISITION SYSTEM FOR HUMAN FACTORS RESEARCH: APPENDICES

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Manuscript Completed: March 1997
Date Published: January 1998

Research sponsored by the
U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Crash Avoidance Research
Heavy Vehicle and Driver Performance Research Division
COTR: Michael J. Goodman
under funding document DTNH22-92-X-07453

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ABSTRACT

A two-phase, multi-year research program entitled "development of a portable driver performance data acquisition system for human factors research" was recently completed. The primary objective of the project was to develop a portable data acquisition system for crash avoidance research (DASCAR) that will allow driver performance data to be collected using a large variety of vehicle types and that would be capable of being installed on a given vehicle type within a relatively short-time frame. During phase I a feasibility study for designing and fabricating DASCAR was conducted. In phase II of the research DASCAR was actually developed and validated. This technical memorandum documents the results from the feasibility study. It is subdivided into three volumes. Volume one addresses the last five items in the phase I research and the first issue in the second phase of the project. Volume two (this report) presents the related appendices. Volume three displays the design specifications developed for DASCAR. The appendices provide literature and material associated with four tasks: identifying parameters and measures; identifying measurement techniques and state-of-the art hardware and software; developing design requirements and specifications; and determining the cost of one or more copies of the proposed data acquisition system. This report also covers the background to the program. The data acquisition system is a portable, state-of-the art system which can be installed within virtually any passenger vehicle. It is both unobtrusive to the driver and inconspicuous to the outside world. DASCAR is currently capable of collecting and analyzing more than 60 driver-related, vehicular, and environment parameters and measures. DASCAR consists of six-major elements: a data acquisition platform, a data storage and transmission system, a power system, an equipment status bus, a sensor suite, and a video data system. A central data collection/analysis facility was also assembled to manage, support, and analyze data collected by the DASCAR prototype. DASCAR will be employed to collect normative driver performance data, support system performance guideline development, evaluate both conventional and intelligent transportation systems technologies, support simulator validation, and fine tune simulators.

1. INTRODUCTION

1.1 Phases of the Research

Oak Ridge National Laboratory recently completed a two phase, multi-year research and development program entitled "development of a portable driver performance data acquisition system for human factors research" for the United States Department of Transportation, National Highway Traffic Safety Administration (NHTSA), Office of Crash Avoidance Research. The primary objective of the project was to develop a portable data acquisition system for crash avoidance research (DASCAR) that will allow driver performance data to be collected using a large variety of vehicle models and types and that would be capable of being installed on a given vehicle type within a relatively short-time frame.

During phase I a feasibility study for designing and fabricating DASCAR was conducted. Human factors research needs were evaluated, and existing methods, measures, techniques, hardware, and software for evaluating the driver/vehicle/environment were identified. The tasks consisted of the following:

- Becoming familiar with NHTSA human factors research that would benefit from use of a portable data acquisition system.
- Identifying parameters and measures that could be collected.
- Identifying analysis tools and methods that could be used to assemble, analyze, and evaluate the gathered data in relation to safety issues.
- Identifying measurement techniques and state-of-the-art hardware and software to support development of an in-vehicle data acquisition system.
- Developing design requirements and specifications for a portable driver performance data acquisition system.
- Determining the cost of one or more copies of the proposed data acquisition system.

At the conclusion of phase I, it was determined by NHTSA that the construction of DASCAR was feasible at an acceptable cost. As a result, the second phase of the program was conducted. In phase II of the research, DASCAR was actually developed and validated. The phase consisted of the following steps:

- Designing a development plan and constructing the prototype driver performance data acquisition system.
- Preparing an evaluation plan.
- Conducting the evaluation, updating the system, and performing pilot research.
- Demonstrating and delivering the system, and training NHTSA staff.

1.2 Purpose of this Report

The primary purpose of this technical memorandum is to document the results from the feasibility

study. It is subdivided into three volumes. Volume one addresses the last five items in the phase I research and the first issue in the second phase of the project. It describes and details the results from these six tasks. Volume two (this report) presents the related appendices. Volume three displays the design specifications developed for DASCAR.

2. BACKGROUND

Given the diverse nature of circumstances leading to motor-vehicle crashes and the associated problem areas and issues, the development of effective collision-avoidance countermeasures can best be realized through a comprehensive knowledge and understanding of both the antecedent events which lead to crashes and the relative contributions of behavioral, vehicular, roadway, and environmental factors. In particular, the development of collision-avoidance countermeasures involving the application of new and innovative technologies represents a promising avenue for using knowledge and understanding to significantly reduce the incidence of crashes.

The evolution of effective advanced-technological countermeasures, however, goes hand-in-hand with the availability of a research tool to investigate the causes of crashes and the influence of vehicle-design characteristics on the relationships among the driver, the vehicle, the roadway, and the environment. This is particularly important where advanced-technology applications may themselves increase the potential for crashes or their severity under a given set of conditions.

The availability of this research tool is vital to fully understand and document the safety benefits and potential liabilities associated with a wide range of countermeasures and technological advancements, and to define the requirements associated with their design and implementation. Such a capability must allow for a flexible, comprehensive, and valid appraisal of countermeasures and advanced-technology applications.

In this regard, recent technological innovations and developments in computers, computer graphics, computational speed and power, miniaturization, communications, and data acquisition and analysis have provided the opportunity to develop DASCAR, a system for addressing the wide range of issues associated with existing problem areas as well as those involving the development and implementation of new advanced-technological systems within the motor vehicle-highway environment. These advances have also greatly enhanced the ability to develop the sophisticated tool needed to carry out a systematic and controlled evaluation of new technologies under operational or high-fidelity conditions.

NHTSA envisions many future situations in which the effectiveness and consequences of new intelligent-transportation systems technologies will need to be studied in actual production vehicles. Such studies will enable evaluations in vehicles which are familiar to drivers. These studies would be further enhanced by the availability of a DASCAR that can be easily installed in these vehicles to enable specific vehicle configurations of interest (e.g., pedal placement, head-up displays) to be evaluated, thereby increasing the variety of vehicle options (incorporating

advanced technology) that are available for study. Ideally, an approach is needed that would allow data collection from a variety of vehicle models and types, and would address the issue of driver familiarity.

Such an approach is embodied in the concept of a DASCAR that can be installed in a wide range of vehicles within a relatively short period of time. As a universally adaptable system, it provides researchers with the ability to record information on driver, vehicle, roadway, and environmental parameters. Furthermore, it enables the measurement of driver performance in the driver's own vehicle, thereby ensuring vehicle familiarity. It is also possible to measure driver performance in relation to any vehicle design characteristic at relatively little expense and effort, and makes it easy to update existing models of driver/vehicle behavior to reflect performance characteristics in vehicles of current manufacture. The availability of such information can lead to improved problem identification in crash-avoidance research, as well as provide NHTSA with the capability to readily answer questions related to vehicle-design characteristics not otherwise available. In addition, such a system has the potential to measure driver performance as it relates to the location of surrounding vehicles. This will allow the study of how drivers interact with other vehicles in their immediate vicinity.

3. DESCRIPTION OF THE APPENDICES

Appendix A lists the documentation which was reviewed during the identification of appropriate parameters and measures that could be incorporated into DASCAR. Definitions of a number of the identified parameters and measures are provided in Appendix B.

Appendix C presents technical data from the two switching power-supply vendors which were analyzed during the "identify measurement techniques and state-of-the-art hardware and software to support development of an in-vehicle data acquisition system" task. Literature from the five data acquisition platform vendors who emerged as major contenders from a study of available acquisition systems is displayed in Appendix D. Appendices E and F exhibit material from radio telemetry and satellite transmission equipment vendors respectively. This instrumentation was assessed during the data storage and communications link investigation. Appendices G (gyro-sensor and gyroscope) and H (electronic compass/tilt sensor) show information which was looked at during the evaluation of general vehicle orientation instrumentation. Documentation from headway/tailway device and lateral position lane tracking system vendors is furnished in Appendices I and J respectively. Appendix K supplies technical literature on collecting time data via a separate time-stamped board inserted into the laptop computer's backplane. Material from suspension device vendors is provided in Appendix L. Appendices M and N present information from physiological and environment parameters measurement system vendors which was reviewed during the analysis of driver and environment recording instrumentation. Documentation on Scientific Atlanta's video digitization system is displayed in Appendix O.

Technical data from five personal and laptop computer vendors which was identified during the "develop design requirements and specifications for a portable driver performance data acquisition system" task are exhibited in Appendix P. Appendices Q and R show literature from gel-cell storage battery and sensor suite device vendors respectively. Information from video data system vendors is furnished in Appendix S.

Appendix T supplies documentation on Scientific Atlanta's compressed video digital storage and retrieval system encoder and Mapstar software which emerged during the "determine the cost of one or more copies of the proposed data acquisition system" task. Technical data on Exabyte's cartridge tape system and Robot Research's digital picture transmission system are provided in Appendix U. Appendix V presents a cost estimate for the development of a lateral position lane tracking system by Williamson Associates. Literature on Calspan Corporation's Test Planning, Analysis, and Evaluation System is displayed in Appendix W. Appendix X exhibits system engineering and software development requirements for DASCAR. Documentation on Cellular One's cellular telephone service agreements is shown in Appendix Y. Appendix Z furnishes price quotations from most of the DASCAR equipment vendors for 15 additional vehicle units. Technical data on three (unobtrusive physiological monitoring, unobtrusive visual scanning, and Doppler range sensor) currently unfunded efforts are supplied in Appendix AA. Appendix BB provides literature on Entran Devices' load cells and Matsushita Electric Works' dual-function antenna. Material on Edmund Scientific's black-and-white board cameras is presented in Appendix CC.

4. ACRONYMS AND ABBREVIATIONS

DASCAR	data acquisition system for crash avoidance research
NHTSA	National Highway Traffic Safety Administration

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* NHTSA project

APPENDIX B: DEFINITIONS OF A NUMBER OF THE PARAMETERS AND MEASURES

Acceleration - The smooth and effective modulation of speed through control of the accelerator pedal. The acceleration of the vehicle.

Accelerator pedal position/displacement/travel - The amount of accelerator pedal displacement expressed in inches or as a percentage of full displacement.

Ambient illumination - A measure of the areal density of light reaching the vehicle.

Barometric pressure - The pressure of the atmosphere as indicated by a barometer.

Blood pressure - The pressure of the blood against the inner walls of the blood vessels.

Brake pedal position/displacement/travel - The amount of brake pedal displacement expressed in inches or as a percentage of full displacement.

Brake system line pressure - The amount of the line pressures of the two independent hydraulic braking systems of the automobile exerted on the brake pedal.

Braking - The application of appropriate levels of braking at appropriate moments using the brake pedal.

Contrast - A measure of luminance difference.

Coarse steering/lane change - Steering reversals which exceed twelve degrees of steering wheel angular rotation.

Crown - The highest point of the road.

Density - The number of cars/trucks within 100 feet of the vehicle.

Diastolic blood pressure - An indication of the arterial pressure during the interval between heart beats.

Distance traveled - The total distance traveled by the vehicle since the start of the run or trial and/or the distance from a specified reference point.

Elapsed time - The elapsed time since the start of the run and/or the time between control activations.

Electrocardiogram - A gross measure of the electrical activity of the heart.

Electroencephalogram - A measure of the pattern of electrical activity within the brain.

Electromyogram - A measure of the agonist/antagonist muscle pairs.

Electromyogram average tension levels - An indication of how tightly a human operator is closing the manual control loop he is operating.

Electrooculogram - A record of the changes in electrical potential that occur between the front and back of the eyeball as the eyes move between two fixed points.

Fine steering - Steering reversals which exceed two but less than twelve degrees of steering wheel angular rotation.

Galvanic skin response - Represents the changing or dynamic part of skin response.

Gust - A sudden, strong blast of wind.

Haze - An aggregation in the atmosphere of very fine, widely dispersed, solid or liquid particles, or both, giving the air an opalescent appearance that subdues colors.

Head movement turning reversal frequency - The number of head turn directional changes per unit time.

Heading/headway - The distance between the front of the vehicle and the rear of the leading vehicle in the same lane.

Heart rate - Repetition rate of the electrocardiogram-wave spike.

Humidity - The amount or degree of moisture in the air.

Lane keeping - Distance between the vehicle and a reference line on the road. The lateral position of the longitudinal axis of the vehicle with respect to a specified lane reference.

Lane keeping exceedance ratio - The proportion of time that any of the tires is outside the driving lane.

Lane keeping position variability - The deviation of the center line of the vehicle from the center of the lane.

Lateral acceleration - The lateral acceleration of the vehicle. The second derivative of lane position.

Lateral lane keeping - Position of the vehicle relative to the desired path.

Lateral path deviation - The distance in inches that the vehicle moves off its intended course.

Lateral velocity - The first derivative of lane position.

Longitudinal acceleration - The longitudinal acceleration of the vehicle. The first derivative of vehicle speed.

Longitudinal lane keeping - Position of the vehicle relative to other vehicles ahead and behind on the roadway.

Path - The route, course, or track along which the vehicle moves.

Pitch - The degree of upward or downward inclination or slope of the vehicle.

Precipitation - The amount of rain, snow, hail, etc., that has fallen at a given place within a given period of time.

Reflectance - The relationship between illumination reaching a surface and the resulting luminance.

Relative velocity - The rate of change of headway.

Respiration - Inhalation and exhalation of air.

Road friction coefficient - The surface friction of the road directly below the vehicle.

Road inclination angle - The vertical grade of the road.

Road radius of curvature - The lateral curvature of the road.

Roll - The degree of left or right inclination or slope of the vehicle. The rolling motion of the vehicle.

Roll angle rate - The rate of change of the angular position of the vehicle's horizontal axis with respect to the horizontal.

Sideslip - To slip sideways in a downward direction.

Speed - The ground speed of the vehicle. The rate of change of vehicle longitudinal position.

Speed of other traffic/relative velocity - The average speed of other vehicles.

Steering - The application of the steering movements to maintain proper lane position, to track accurately, and to effect smooth lane changes.

Steering wheel position/displacement - The angular displacement of the steering wheel from the center neutral position.

Steering wheel rate/velocity - The angular velocity of the steering wheel.

Steering wheel torque - The measured ability of the steering wheel to overcome turning resistance.

Suspension - The arrangement of springs, shock absorbers, and hangers in a vehicle which connect the wheel-suspension units or axles to the chassis frame.

Systolic blood pressure - An indication of the maximum arterial pressure occurring during contraction of the left ventricle of the heart.

Tailway - The distance between the rear of the vehicle and the front of the following vehicle.

Time-to-line crossing - The time needed by the vehicle to reach either edge of the lane.

Traffic condition - The characterization of the traffic density and speed.

Visual scanning - The characterization of driver's visual performance.

Visual scanning dwell time - The duration of visual fixations within a specified visual field.

Visual scanning look frequency - The reciprocal of the interval between fixations.

Wind - The direction and speed of the wind relative to the vehicle.

Wind speed - The speed of the wind measured at the top of the vehicle.

Yaw - The motion of the vehicle about its vertical axis.

Yaw angle position/displacement - The angular position of the longitudinal axis of the vehicle with respect to the center line of the lane.

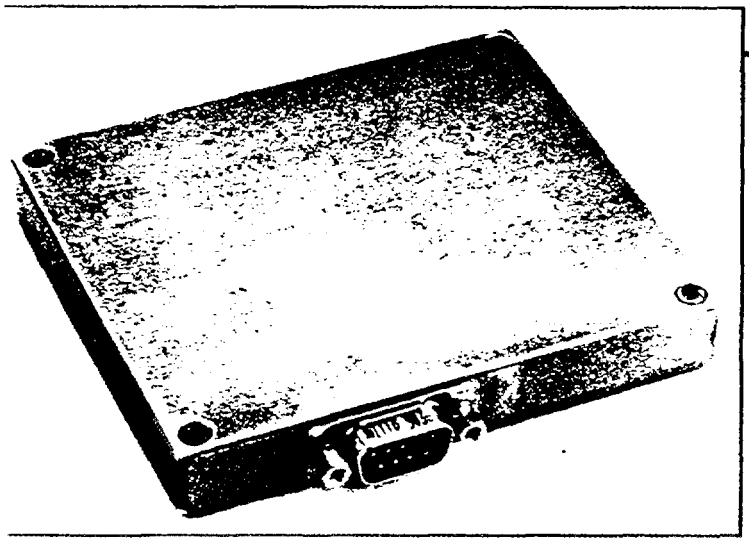
Yaw rate/velocity - The rate of change of the angular position of the vehicle's longitudinal axis with respect to the center line of the lane.

APPENDIX C: TECHNICAL DATA FROM SWITCHING POWER SUPPLY VENDORS

Powercube
Vicor

25 Watt High Reliability Industrial Modules

DCR SERIES



FEATURES:

- Low Profile
- Input/Output Isolation
- Short Circuit Protection
- Overvoltage Protection
- Low Output Ripple
- Single or Triple Outputs
- MIL-STD-461B, CE03
- D-type Connector
- Shutdown Pin
- Efficiency to 78%
- Weight: 10 oz.
- Standard 3.50" x 4.00" x 0.625" Package
- Operating Temperature (baseplate): -21°C to +71°C
- Custom Output Voltages Attainable

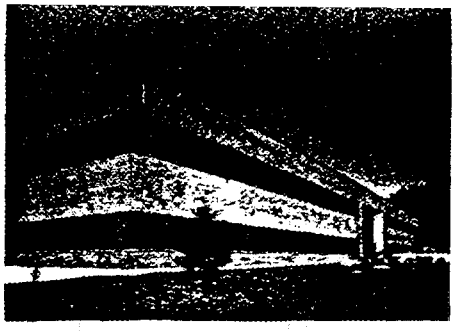
Powercube's DCR Series are a new line of high-grade industrial, single or triple output, DC-DC switching regulator modules. It includes EMI filter, offering full compliance to CE03 of MIL-STD-461B, as well as an input/output connector for ease of installment. With its high efficiency, reliability and small size, this 25 Watt module can provide a cost effective solution to your high-reliability power converter needs.

DCR Series Modules

Part Number	Input Voltage	Output Voltages	Max. Output Current	Efficiency
14DCR5-25	10.25-18VDC	5VDC	5A	78%
14DCR12-25		12VDC	2.08A	78%
14DCR15-25		15VDC	1.67A	78%
14DCR512-25		+5, +12, -12VDC	4A, 0.25A, 0.25A	75%
14DCR515-25		+5, +12, -15VDC	4A, 0.25A, 0.25A	75%
26DCR5-25	18-36VDC	5VDC	5A	78%
26DCR12-25		12VDC	2.08A	78%
26DCR15-25		15VDC	1.67A	78%
26DCR512-25		+5, +12, -12VDC	4A, 0.25A, 0.25A	75%
26DCR515-25		+5, +12, -15VDC	4A, 0.25A, 0.25A	75%
54DCR5-25	36-72VDC	5VDC	5A	78%
54DCR12-25		12VDC	2.08A	78%
54DCR15-25		15VDC	1.67A	78%
54DCR512-25		+5, +12, -12VDC	4A, 0.25A, 0.25A	75%
54DCR515-25		+5, +12, -15VDC	4A, 0.25A, 0.25A	75%

POWERCUBE The Source for Industrial and Military Power Supplies
Powercube Corporation Eight Suburban Park Drive, Billerica, Massachusetts 01821 • Phone: (508) 667-9500 • Fax: (508) 667-6280

Vicor Corporation



The Power System Architect

Vicor markets families of compact, economical, high performance power components that offer the power system architect many of the same advantages that integrated circuits brought to other areas of system design.

Compactness

By using Vicor's products, you can configure power systems that are smaller and lighter than most competitive offerings. This enables you to reduce the size and weight of your products — a competitive advantage in an electronics marketplace that values small size and high product functional density.

Simplicity and Flexibility

You can economically configure virtually any power system architecture, at virtually any power rating, by simply selecting and interconnecting appropriate power components.

Improved Time to Market

Use of power components shortens the power system development cycle, reduces skill levels required to successfully develop power systems, and decreases the risks associated with the design of complex "custom" power circuits.

Benefits of Standardization

Product performance and product design cycles become more predictable; unanticipated changes in system power requirements can be easily accommodated; unusual manufacturing and test processes can be eliminated; and economies of scale can be achieved with a minimum of product and vendor proliferation.

Three classes of power components are offered:

Modular Power Converters

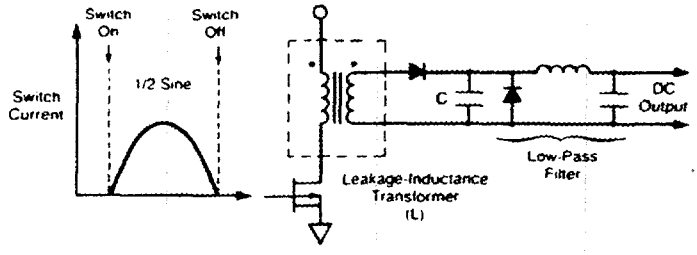
The heart of Vicor's product lines, these families of rugged, single output, fully integrated DC to DC power converters offer features that are of high value to the power system architect: very small size, high efficiency, low cost, high reliability, and modular expandability.

Configurable Products

These product families are complete power systems, offering high performance, ready-to-run, multiple output solutions in a variety of power ratings. Using modular converters as core elements, they are configured to customer's needs, typically for overnight delivery.

Peripheral Power System Components

These products integrate other important elements of the power system. For example, off-line component front-ends, incorporating unity power factor and universal inputs, provide users with a simple means to operate modular converters off worldwide AC mains.



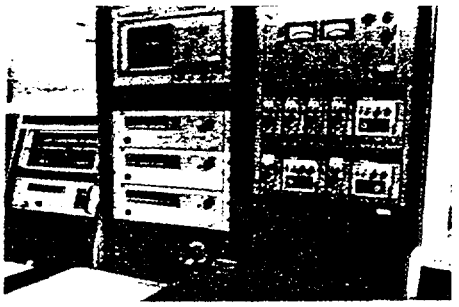
Zero-current-switching Technology

Efficient high frequency operation has long been recognized as the key to achieving high-power density and improved performance in switchmode converters. High frequency operation translates into smaller magnetics and capacitors, faster response times, lower noise levels and smaller filters. High efficiency implies low power dissipation and a minimization of volume utilized for cooling.

Conventional switchmode converters are power density limited because they inherently trade off efficiency against operating frequency. The problem is "switching losses": heat generated in the switching element each time it discontinuously makes and breaks inductive current flow during its brief turn-on and turn-off transitions. Power dissipation due to switching losses increases directly with operating frequency until it becomes a dominant loss factor: efficiency declines rapidly, and the thermal and electrical stresses on the switch element become unmanageable. Losses attributable to non-zero-current-switching result in a "frequency barrier" which limits achievable power density in conventional converters.

Vicor's patented converter topology overcomes the frequency barrier by implementing a "forward converter switching at zero-current". Each switch cycle delivers a quantized "packet" of energy to the converter output, with switch turn-on and turn-off occurring at zero-current. Zero-current-switching results in an essentially lossless switch, allowing Vicor converters to operate at frequencies in excess of 1 MHz, with efficiencies greater than 80%, and with power densities ten or more times greater than conventional converters.

Zero-current-switching, energy quantization and forward power flow are simultaneously achieved with the circuit topology shown in the figure. An LC "tank" circuit, composed of inherent transformer leakage inductance and a capacitive element in the secondary, forms an energy transfer medium between input and output. Turning on the switch initiates transfer of a discrete packet of energy from the input source to the tank circuit capacitor, during which time an approximately half-sinusoidal current flows through the switch. Resonance (bidirectional energy flow) cannot occur because the rectifiers will permit only unidirectional energy transfer. Switch turn-on occurs at zero-current, and the switch is turned off when current returns to zero. A simple, low-pass filter following the capacitor produces a very low ripple DC output. By eliminating the fast current discontinuities characteristic of conventional topologies, zero-current-switching results in a virtually



lossless transfer of energy from input to output with dramatically reduced levels of conducted and radiated noise.

Proven Power Components

The combined benefits of Vicor's zero-current-switching technology: high power density, high efficiency, high performance, high reliability, low conducted and radiated noise, and easy thermal management via a single isolated baseplate, make true component-level power conversion a reality; as affirmed by over 1400 active customers worldwide and an installed base of over 1,000,000 units.

Engineering Capabilities

Chartered with developing products and offering services that provide a full range of power system solutions, Vicor's engineering staff is fully supported by a broad array of contemporary CAD/CAE equipment. With tools at their disposal to perform analog integrated circuit simulation and design, high frequency magnetic design and analysis, through-hole and SMD PCB layout and mechanical CAD, our technical staff productively tackles problems that range from the ongoing development of an integrated line of "plug and play" power system building blocks, to design of custom power products for specific applications.

It was not just a revolutionary new idea that made Vicor a market leader, it was knowing how to turn that idea into a quality, manufacturable product. Vicor considers its depth of technical expertise to be one of its key strengths. Vicor also knows that translating innovative ideas into quality products requires attention to detail and adherence to a disciplined development process—a process which culminates in the release of a complete set of documentation representative of a product which has been thoroughly qualification tested against its full range of functional specifications. Attracting the best people, challenging them to turn a vision of the future into reality, and leveraging their productivity and creativity with the best available tools is one of the ways by which Vicor intends to stay a market leader.

Manufacturing through Automation

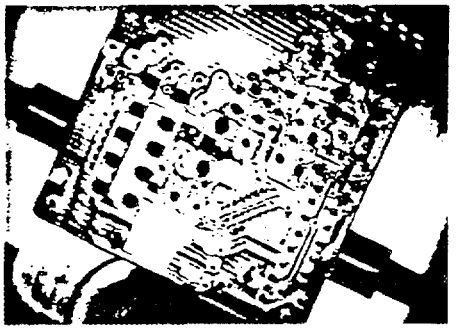
With plants in Andover, MA., Los Gatos, CA. and Western Europe, Vicor is aggressively executing a plan to make "lights out" manufacturing a reality. Combining robot based flexible assembly cells with customized, fixed automation and in-line automatic test equipment, Vicor's automation strategy addresses the manufacture of today's families of modular converter products while retaining the flexibility to handle tomorrow's. As an investment aimed at delivering competitively priced products of the highest possible quality in the shortest possible time, domestic automation represents Vicor's tangible long-term commitment of maintaining market leadership through customer satisfaction. It is also a commitment to employees that Vicor will continue to offer expanded opportunity through growth.

Quality Assurance

Vicor's formula for ensuring product quality is simple: prove that new products perform by rigorously testing them before manufacturing release, then continuously audit production through SPC to identify trends before they turn into problems.

Documenting and communicating expectations and measuring and feeding back results, are the keys to proactive quality assurance. Vanguarding the process, Vicor's trained staff of quality, reliability, test, metrology, materials and inspection personnel continuously audits incoming material and work in process, measuring compliance against predefined quality goals. A combination of in-circuit and functional test equipment is used to gather in-process data before, during and after environmental processing in computer controlled chambers. Rapid feedback to both vendors and employees is aimed at preventing small discrepancies from becoming quality problems. Dissemination of vendor ratings to engineering and purchasing closes the quality loop by ensuring that the best vendors are the preferred sources for both mainstream production and new designs.

A field reliability history ten times better than the industry norm proves that this proactive approach works. A two-year warranty on commercial, industrial and military product grades and continuing investment in automation are Vicor's commitments to continue to make it work.



Licensing Strategic Partnerships

To best serve the needs of the power market and to provide Vicor's worldwide customers with alternate sources of supply, Vicor has entered into several merchant and captive license agreements.

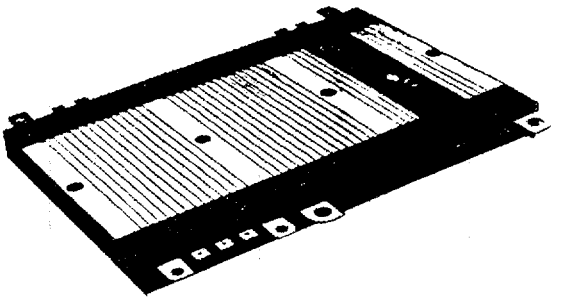
Merchant license agreements grant rights to manufacture and sell power systems utilizing Vicor's patented technology within specific market segments or geographic areas as alternative sources for Vicor products.

Captive license agreements provide large users of power systems the means to manufacture and use Vicor technology as embedded elements within their commercial products.

VICOR

Master Module Series

High Power DC-DC Converters, Dual and Triple Output



Family Features:

- Up to 27 Watts/cubic inch
- Up to 600 Watts
- 80-90% Efficiency
- Chassis Mount
- Remote Sense
- Thermal Shutdown
- Current Limit and OVP

Master Modules:

P-Series Dual 100W-400W
4.9" x 4.9" x 0.62"

Q-Series Dual 150W-600W
7.3" x 4.9" x 0.62"

R-Series Triple 150W-600W
7.3" x 4.9" x 0.62"

Product Highlights:

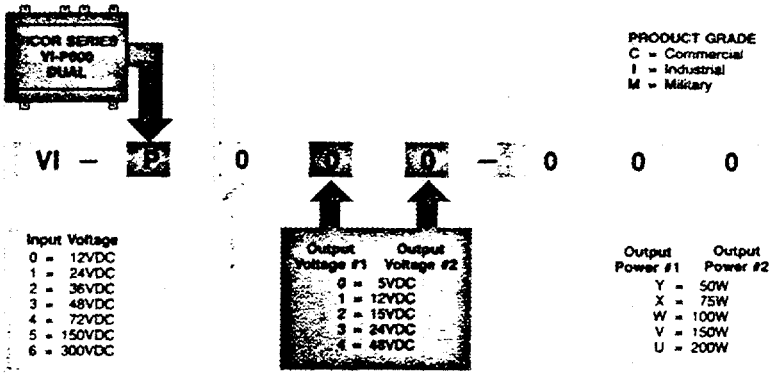
Vicor's Master Module Series of multiple output DC-DC converters provides power system designers with a cost effective, high performance, off-the-shelf solution for applications that might otherwise require a custom supply. Incorporating standard VI-200 Series converters in a rugged, chassis mount package, Master Modules can be ordered with dual or triple outputs having a combined output power of up to 600 watts. Totally isolated outputs eliminate efficiency penalties and output interaction problems. Each output may be independently sensed, adjusted, and sequenced. Designed to meet safety agency requirements, Master Modules also feature wide input voltage ranges, current limiting, independent output OVP, logic disable and thermal shutdown on each output.

Model Selection Procedure:

The following Master Module Configuration Procedure provides a simple step-bystep method for arriving at a Master Module Part Number based upon number of outputs, output voltage and power ratings, and input voltage.

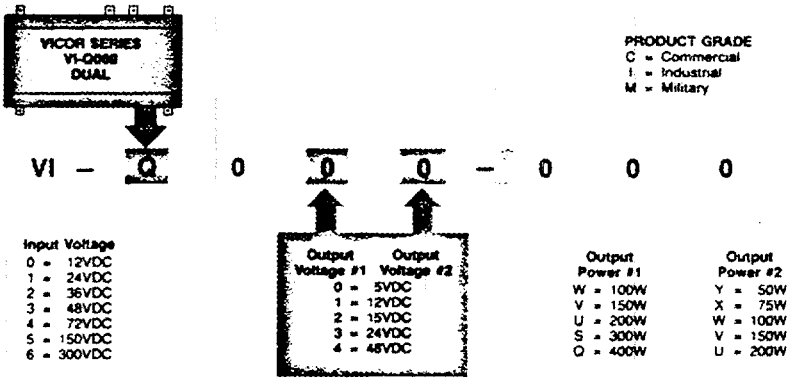
Since the input and all outputs are isolated from each other, the input source may have either a positive or negative ground reference, and outputs may be connected as either positive or negative with respect to a common return, or may be referenced to independent, isolated, circuit returns.

VI-P000 Series Configuration Chart 100W - 400W



Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-P000 and VI-200 Series converters use the same input, output and power encoding.

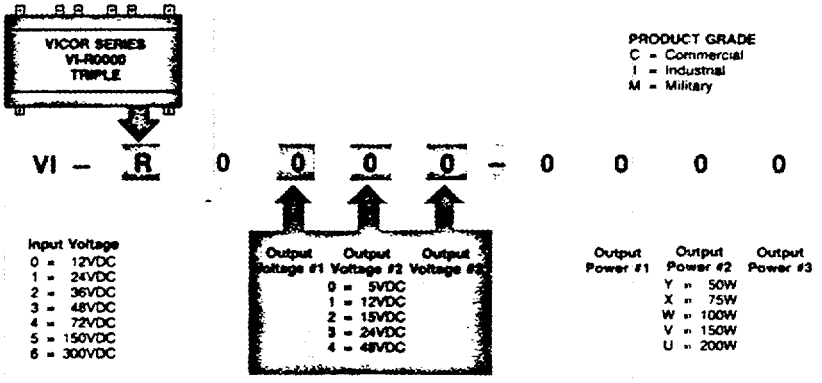
VI-Q000 Series Configuration Chart 150W - 600W



Output power (#1) is the sum of the driver plus booster output power.

Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-Q000 and VI-200 Series converters use the same input, output and power encoding.

VI-R0000 Series Configuration Chart 150W - 600W



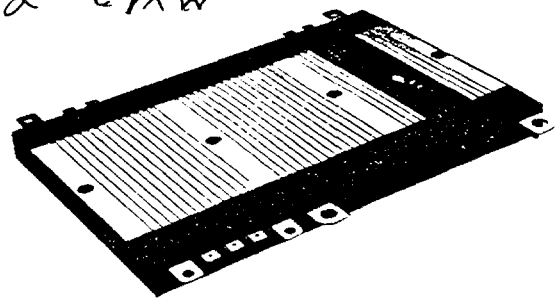
Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-R0000 and VI-200 Series converters use the same input, output and power encoding.

VICOR

VI-R00/2-CYXW

Master Module Series

High Power DC-DC Converters, Dual and Triple Output



Family Features:

- Up to 27 Watts/cubic inch
- Up to 600 Watts
- 80-90% Efficiency
- Chassis Mount
- Remote Sense
- Thermal Shutdown
- Current Limit and OVP

Master Modules:

P-Series Dual	100W-400W	4.9" x 4.9" x 0.62"
Q-Series Dual	150W-600W	7.3" x 4.9" x 0.62"
R-Series Triple	150W-600W	7.3" x 4.9" x 0.62"

Product Highlights:

Vicor's Master Module Series of multiple output DC-DC converters provides power system designers with a cost effective, high performance, off-the-shelf solution for applications that might otherwise require a custom supply. Incorporating standard VI-200 Series converters in a rugged, chassis mount package, Master Modules can be ordered with dual or triple outputs having a combined output power of up to 600 watts. Totally isolated outputs eliminate efficiency penalties and output interaction problems. Each output may be independently sensed, adjusted, and sequenced. Designed to meet safety agency requirements, Master Modules also feature wide input voltage ranges, current limiting, independent output OVP, logic disable and thermal shutdown on each output.

Model Selection Procedure:

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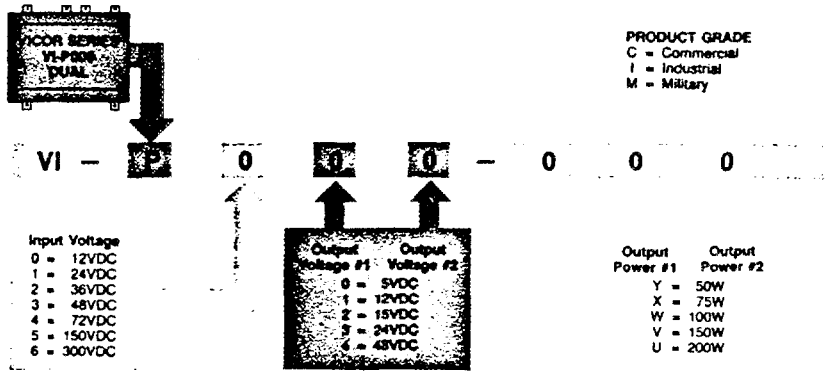
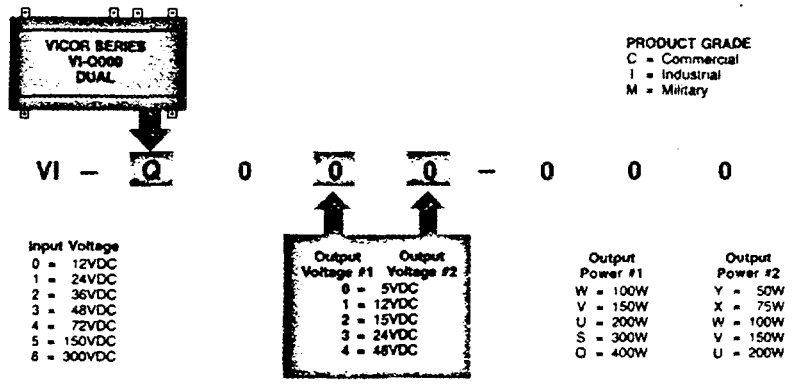


Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-P000 and VI-200 Series converters use the same input, output and power encoding.

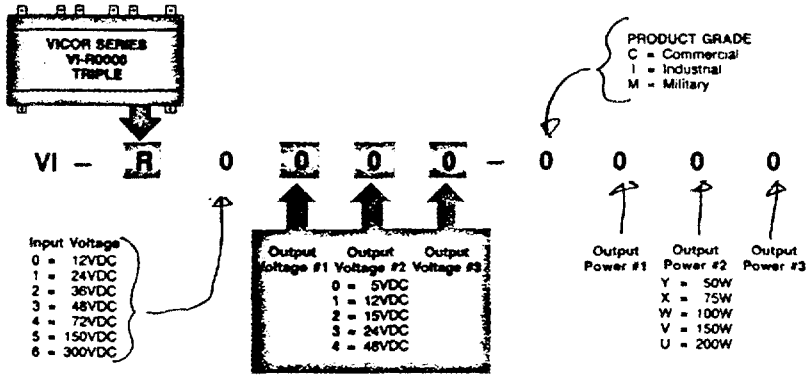
VI-Q000 Series Configuration Chart 150W - 600W



Output power (#1) is the sum of the driver plus booster output power.

Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-Q000 and VI-200 Series converters use the same input, output and power encoding.

VI-R0000 Series Configuration Chart 150W - 600W



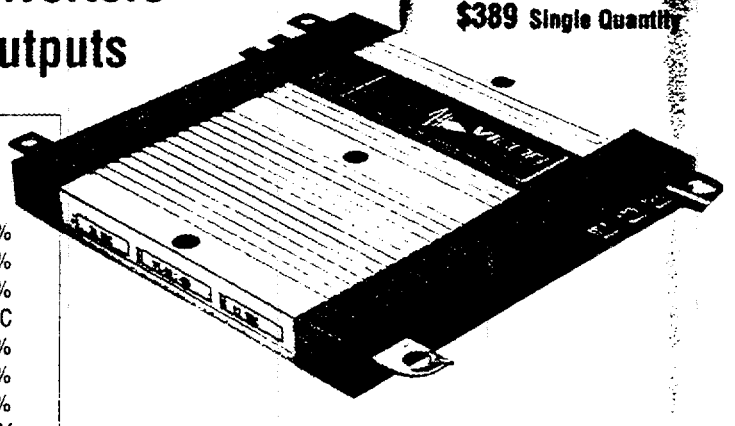
Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart details available types. VI-R0000 and VI-200 Series converters use the same input, output and power encoding.

lega/Master Module Family

l to 600 Watt DC-DC Converters

ngle, Dual and Triple Outputs

Typical Model: *VI-P601-CVX*
Input: 300 VDC
Output 1: 5 VDC at 150 W
Output 2: 12 VDC at 75 W
$389 Single Quantity



VI-RØØ12-CYXW

Summary Electrical Characteristics (typical)

Set Point Accuracy	0.5%
Load Regulation	0.05%
Line Regulation	0.05%
Output Temperature Drift	0.01%/°C
Peak to Peak Output Ripple	1%
High Trim/Program	110%
Low Trim/Program	5%
Total Remote Sense Compensation	0.5V
OVP Set Point	125%
Current Limit	115%

nputs: 10 to 400 VDC
Any Output: 2 to 95 VDC
Chassis Mount
JL, CSA, TÜV
80-90% Efficiency
Up to 27 Watts/cubic inch
50 - 200 Watts
1.9"L x 2.5"W x 0.62"H
100 - 400 Watts
1.9"L x 4.9"W x 0.62"H
150 - 600 Watts
1.9"L x 7.3"W x 0.62"H
ZCS Power Architecture
Low Noise FM Control

duct Highlights

r's Mega/Master Family of single, and triple output DC-DC converters vides power system designers with st effective, high performance, he-shelf solution for applications might otherwise require a om supply. Incorporating standard 00 Series converters in a rugged, sis mount package, Mega/Master lules can be ordered with single, or triple outputs having a combined ut of up to 600 watts. Totally isolated uts eliminate efficiency penalties output interaction problems.

Mega/Master Configuration Chart

Mega Modules:				
Single Outputs	VI-L ■■ - ■□	50-200W	4.9"L x 2.5"W x 0.62"H
	VI-M ■■ - ■□	100-400W	4.9"L x 4.9"W x 0.62"H
	VI-N ■■ - ■■	300-600W	4.9"L x 7.3"W x 0.62"H
Master Modules			
Dual Outputs	VI-P ■■■ - ■□□	100-400W	4.9"L x 4.9"W x 0.62"H
	VI-Q ■■■ - ■□□	150-600W	4.9"L x 7.3"W x 0.62"H
Triple Outputs	VI-R ■■■■ - ■□□□	150-600W	4.9"L x 7.3"W x 0.62"H

Input Voltage, Nominal

0	=	12V(1)
1	=	24V(2)
W	=	24V(3)
2	=	36V(4)
3	=	48V(5)
N	=	48V(2)
4	=	72V(5)
5	=	150V(5)
6	=	300V(5)
7	=	150/300V(6)

See VI-200 for Range

Output Voltage

0	=	5V
1	=	12V
2	=	15V
3	=	24V
4	=	28V
5	=	48V

(2 to 95V, Consult Factory)

Product Grade

C	=	-20°C to +85°C
I	=	-40°C to +85°C
M	=	-55°C to +85°C

Output Power

Y	=	50W
X	=	75W
W	=	100W
V	=	150W
U	=	200W

Output Power

W	=	100W
V	=	150W
U	=	200W
S	=	300W
Q	=	400W

Output Power

S	=	300W
P	=	450W
M	=	600W

Notes (maximum output power per module)
1. 75W max.
2. 150W max.
3. 150W max. (5 volt outputs, 100W max.)
4. 100W max.
5. 200W max. (5 volt outputs, 150W max.)
6. 100W max. (5 volt outputs, 75W max.)

AM PATIBLE

MILITARY VERSION
SEE PAGE 23

APPENDIX D: TECHNICAL DATA FROM DATA ACQUISITION PLATFORM VENDORS

Dianachart
OPTIM Electronics
Schlumberger Technologies
Scientific Atlanta
Smiths Industries

DIANACHART INC
101 ROUND HILL DRIVE • ROCKAWAY, N.J. 07866 • TELEPHONE (201) 625-2299 • FAX (201) 625-2449

March 24, 1993

Oak Ridge National Labs
PO Box 2008
Oak Ridge, TN 37831-6364

MAIL STOP: 6364
ATTN: Phil Spelt

Dear Mr. Spelt:

Thank you for taking the time to define your signal measuring needs to us.

Enclosed is a quotation which covers an Acquisitor family product as well as the options we feel are important to your application.

There is a great deal of flexibility available in our product line. Our software is very "user friendly" and when needed, we can provide custom software too! We offer many additional options and other measurement instruments, so if you decide you need something slightly different from the system quoted, please call.

If I can be of further assistance, please let me know.

Regards,

Bill McWilliams

Encl: Quote

Phone call from Bill McWilliams 5/13/93
Major software advances
- replay - real time or strip chart printout
- about to release mouse-operated version
  admin shown @ time of sale
  operates same as other
  Beta user
- Reporter: create own format of data → written reports; shown
  being called [illegible] screen like format

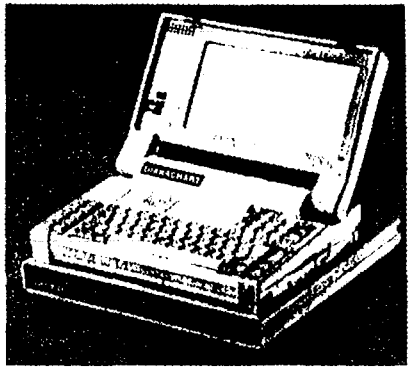
Dianachart , Inc. Travellogger plus accessories

QTY	DESCRIPTION	ORDER CODE	UNIT PRICE
	THE FOLLOWING PRODUCTS ARE RECOMMENDED TO SATISFY YOUR REQUIREMENTS:		
1	TRAVELOGGER AC or battery powered data acquisition unit attaches to a laptop computer. 6 channels, expandable to 96.	TL	$2260
1	48 CHANNEL ANALOG INPUTS	TL AI-48	$1245
	Custom option: Unit housed in light weight aluminum travel case. Provision made for expansion to AI96. Velcro included to provide more secure positioning of unit.		$ 795
1	12 V CIGARETTE LIGHTER ADAPTER CABLES-- for automotive operation	CL	$ 70
1	SIGNAL CONDITIONING**-- provides temperature referencing and linearizing for thermocouple types J,K,E,B,R,S,T,N and Tungsten. Also scales other sensors to engineering units and supplies compensated voltage for strain gauges and RTD's. Deals with up to 96 sensors per PC Acquisitor.	SC	$ 415
1	MENU-DRIVEN SOFTWARE-- for users who do not wish to write their own programs. To set up, simply follow on-screen directions. (STRONGLY RECOMMENDED).	MS	$ 340
1	**TI4000-120 486DX NOTE BOOK COMPUTER** 25 MHZ, Texas Instruments. TM3000 with 180 Meg Hard Drive, 4 Meg RAM, 1.44 Meg Floppy Disk, VGA LCD & External Display.		$3299
	Fully configured and tested for use with your Data Acquisition equipment.		
1	HIGH SPEED DATA STORAGE-- at up to 500 channels/second (AT) (Needs -MS)	HS	$ 340
1	CARRY CASE FOR TI4000-120		$ 85

$9124 + shipping

MADE IN USA!

TRAVELOGGER Portable Acquisition



The **TRAVELOGGER** is a portable **ACQUISITOR.** It is designed to fit under a Notebook or lap-top portable PC. The **TRAVELOGGER** is ideal for situations where on-site datalogging and analysis is required, or for operation in an automobile, boat or airplane. The **TRAVELOGGER** has rechargeable batteries for remote operation. It is available with 14, 48 or 96 channel inputs.

With the **TRAVELOGGER** you can set up and monitor an installation in a few minutes, displaying data from 96 thermocouples, pressure sensors, flowmeters etc.

The computer reduces and analyzes this data into either a tabular or graphical format. You can pick out, for example, peak and mean temperatures, rates of change etc.

The optional inkjet printer delivers a hard copy of your records to leave with the customer.

TRAVELOGGER goes easily with you by car or plane, and will collect and process data unattended for hours, days, even weeks. Long-term measurements are easy with the **TRAVELOGGER,** as it is rated for continuous use, and requires no maintenance.

TRAVELOGGER gives you the choice - to collect data for later analysis at your office, or do the whole job right now on site.

All the **TRAVELOGGERS** are identical, apart from the number of input channels. In addition to the measuring inputs, each has 11 Binary (ON/OFF) inputs, a pulse-counting input (which uses the same 11 inputs as an 11-bit counter), and 10 Binary (ON/OFF) TTL outputs which can be used for alarm or control purposes. Relay outputs are available for contact closure or high-power loads.

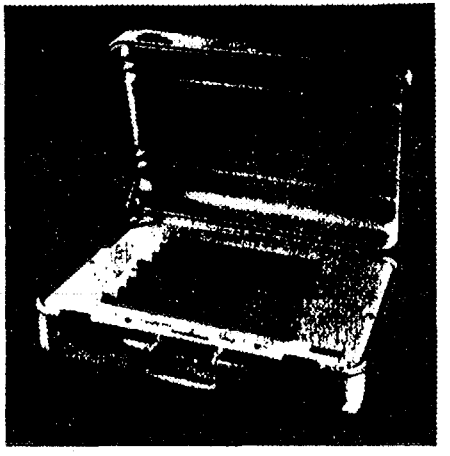
The high resolution (0.3μV on the most sensitive range) together with the autoranging feature mean you can measure signals from transducers such as thermocouples, pressure gages, strain gages and RTDs without needing external signal conditioning modules. Each input to the **TRAVELOGGER** can be used for any type of sensor, and can be redefined at any time from a software menu.

The **TRAVELOGGER** is electrically the same as a **LAB-ACQ**, with the addition of rechargeable batteries. It can be operated from its internal batteries, from the charger unit, or from a 12-Volt automobile, boat or aircraft battery. A cigarette lighter adapter is available for portable use.

The enclosure is thinner than the **LAB-ACQ**, and somewhat deeper, to better match the profile of a laptop Personal Computer, and to fit under an airline seat. The input connections are on plug-in terminal strips so that the **TRAVELOGGER** can readily be moved from place to place.

1245 - 48 channel option x2 - 96 Channel.

TRAVELOGGERs are ideally suited to situations where a portable means of measurement is needed, such as equipment installation and check-out, field service, environmental studies, energy management, automotive equipment testing, and many other fields. With the combination of a Laptop Personal Computer and a **TRAVELOGGER** you can go anywhere to measure and analyze data, and with the optional battery-operated inkjet printer even print reports without needing AC power.



The **TRAVELOGGER** can be supplied as a complete system with a laptop PC from most manufacturers. **TRAVELOGGER** can also be supplied alone, if you already have a notebook or laptop PC.

SC option
AI - 48 option
Lt wt Case

OPTIONS

All options listed in the Acquisitor options section are available with the **TRAVELOGGER.** The most popular options are **Menu-driven Software -MS, Signal Conditioning -SC Printer Driver -PD, Real-Time Graphics -RTG, Stripchart -STP** and the battery operated **Inkjet printer -IJP.**

The **-PO Programmable Output, -BO additional Binary Output** and **-RO Relay Output** require the light aluminum travel case, as does the **-AI96 96-channel input** option. The **-IT** 4-20mA terminators and the **-AP30** or **-AP200** Attenuators also require the Travel Case when used with a 48-channel unit.

The **-IJP** battery operated Inkjet printer, and the **-CL** Cigarette lighter adapter are unique to the **TRAVELOGGER.**

We can supply a complete system - the **SYSTEM-1-TL** - with your choice of **TRAVELOGGER** and options, together with any model of laptop computer you select. Ask the factory for recommendations, as laptop models change frequently.

SPECIFICATIONS

NUMBER OF CHANNELS:	Standard: 6 14 with AI-14 Expansion Option 48 with AI-48 Expansion Option → 96 with AI-96 Expansion Option
MEASURING INPUTS:	Voltage 0.3μV TO 10 V Current 4-20mA, 0-50mA Thermocouples JKEBRST RTD's, Strain Gages, etc. } with -SC
RESOLUTION:	16-Bits (1/65535) (0.3μV L.S.B.)
ACCURACY:	±0.02% of range
LINEARITY:	± 0.015%
INPUT IMPEDANCE:	10,000 Megohms/0.1μF
BINARY INPUTS:	11 ON-OFF TTL or contact and a pulse counter
CONTROL OUTPUTS:	10 TTL outputs. Expandable to 640 (3A relay outputs with -RO)
DIMENSIONS:	TL-14, TL-48: 14"W x 2"H x 15"D Weight: 6.5 lbs. TL-96: 24"W x 6"H x 16"D Aluminum Travel case Weight: 9 lbs.
INTERFACE:	Parallel printer port
POWER:	Internal 5V rechargeable Nickel-Cadmium battery with 115VAC 50/60Hz charger. Optional 12V automobile adapter (-CL option)

Bill McWilliam

Dianachart , Inc. Process-acq plus accessories

QTY	DESCRIPTION	ORDER CODE	UNIT PRICE
	THE FOLLOWING PRODUCTS ARE RECOMMENDED TO SATISFY YOUR REQUIREMENTS:		
1	PROCESS-ACQ industrial data acquisition system for monitoring, manufacturing and processes. Sealed NEMA 4/12 enclosure, parallel port communications standard. 6 channels, expandable to 192.	PA	$2305
1	48 CHANNEL ANALOG INPUTS	AI-48	$1245
	Custom option: Provision made for expansion to AI-192. Nicad Batteries and recharger electronics built in to allow in vehicle use. Velcro included to provide more secure positioning of unit.		$ 495
1	SIGNAL CONDITIONING**-- provides temperature referencing and linearizing for thermocouple types J,K,E,B,R,S,T,N and Tungsten. Also scales other sensors to engineering units and supplies compensated voltage for strain gauges and RTD's. Deals with up to 96 sensors per PC Acquisitor.	SC	$ 415
1	MENU-DRIVEN SOFTWARE-- for users who do not wish to write their own programs. To set up, simply follow on-screen directions. (STRONGLY RECOMMENDED).	MS	$ 340
1	**TI4000-120 486DX NOTE BOOK COMPUTER** 25 MHZ, Texas Instruments. TM3000 with 180 Meg Hard Drive, 4 Meg RAM, 1.44 Meg Floppy Disk, VGA LCD & External Display.		$3299
	Fully configured and tested for use with your Data Acquisition equipment.		
1	HIGH SPEED DATA STORAGE-- at up to 500 channels/second (AT) (Needs -MS)	HS	$ 340
1	CARRY CASE FOR TI4000-120		$ 85

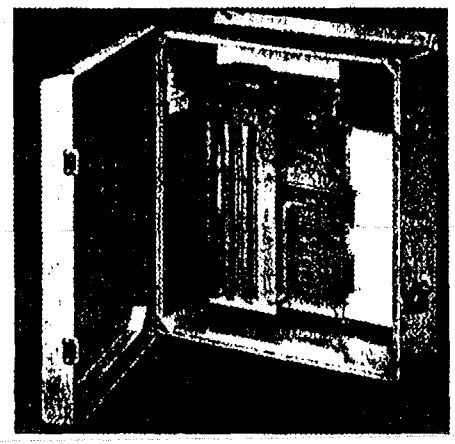
$8524 + shipping

MADE IN USA!

PROCESS-ACQ Industrial Data Acquisition

PROCESS-ACQ is a data acquisition module with 6 to 192 measurement channels mounted in an environmentally sealed enclosure. This rugged enclosure is waterproof, oil and dust resistant to NEMA4/NEMA12 specifications. The **PROCESS-ACQ** is designed for industrial monitoring in manufacturing and process industries, or any dusty or damp environment. It offers fast setup, clear displays, and NO programming.

The **PROCESS-ACQ** is connected by RS232, RS422 or **-RPI** Remote Parallel Interface to a personal computer, usually located in a less hostile environment, or a **TOUGH-ACQ**.



By placing the data acquisition module close to the signal sources, much less wiring is required than if it were next to the computer, and the high sensitivity of the **ACQUISITOR** series means that low-level inputs such as strain gages, pressure transducers and thermocouples can be measured without needing individual transmitters for each signal. This approach can result in a much more economical system.

Expandable to 192.

The **PROCESS-ACQ** also has 11 Binary inputs, and 10 Binary outputs. These can be expanded to 640 Binary outputs, in groups of 64. Alarm relays and 4-20 mA analog outputs are available, together with a comprehensive alarm software package. The expansion Binary Outputs and Programmable Outputs are mounted together with the data acquisition module in a larger NEMA enclosure. Relay outputs are mounted in a separate enclosure to prevent possible interference between the relay output circuits (often AC line voltage) and the measurement inputs.

PID control analog outputs (4-20 mA , 10 Volt or time proportioning) are available with unlimited number of loops, and "Ramp and Soak" capability.

Connections are brought into the enclosure through standard conduit, or oil-tight sealing glands available from local electrical supply houses. The input terminal strips on the **PROCESS-ACQ** are mounted directly on the circuit boards for greatest reliability, and will accept wires from 12 AWG through 30 AWG, either solid or stranded.

The **PROCESS-ACQ** can supply excitation to transducers such as RTDs and strain gages, in many cases eliminating the need for individual transmitters, or power supplies, at a further saving in cost. The input circuitry is fully differential, and so is ideal for bridge measurements.

The basic **PROCESS-ACQ** has 6 measurement inputs. Expansion options increase the number of measurement inputs to 14, 48, 96, or 192.

PROCESS-ACQs can be expanded beyond 192 channels through the **-MU MULTI-UNIT** option, which makes several physical data acquisition units appear to the software to be one large unit. This is particularly well suited to **PROCESS-ACQs** when you place the

data acquisition modules near to your signal sources, and eliminate transmitters and field wiring.

Each unit is connected to a separate communications port on the computer, either directly, or in groups of up to 4 with the **-QRS QUAD-RS232/RS422** adapter, which connects 4 **PROCESS-ACQs** to each computer port, for up to 16 units on a PC. More than 16 units can be connected using the **MULTI-ACQ**, which also supports "daisy-chain" sequential connections from a single port, rather than a "star" connection used by the **PROCESS-ACQ**.

SOFTWARE

You can operate a **PROCESS-ACQ** from your own program for special applications, using the assembly language drivers supplied, or you can use the convenient and simple **MENU-DRIVEN SOFTWARE -MS** to display your data and log it to disk. The **SIGNAL CONDITIONING -SC** option gives you Thermocouple RTD and strain gage measurement, together with individual linear (span and zero) scaling on each channel.

The advanced **INSTATREND REAL-TIME GRAPHICS -RTG** option shows you your data in many different formats, including on-screen stripchart and spreadsheet for time history, together with Bargraph, Numeric and Process Picture Diagrams, where the numeric data is overlaid on a picture of your plant or process. Options to **-RTG** are also available for **ALARMS (-ALM)**, a comprehensive alarm package, **INSTANT REPLAY (-REP)** to examine past data even while taking new data, printed **STRIPCHART (-STP)** to print a continuous multi-channel stripchart on your printer, and **INSTA-CALC (-CALC)** for user-specified calculations on any channel.

OPTIONS

All options listed in the Acquisitor options section are available with the **PROCESS-ACQ**.

RS232, RS422, or the **-RPI Remote Parallel** interface are usually specified, since the **PROCESS-ACQ** is normally operated further from the computer than the 25 feet over which the parallel printer cable can be used.

A complete system with one or more **PROCESS-ACQs** and a host computer can be supplied as a fully tested system. All software is loaded and ready to use.

SPECIFICATIONS

NUMBER OF CHANNELS:	Standard: 6 14 with AI-14 Expansion Option 48 with AI-48 Expansion Option 96 with AI-96 Expansion Option 192 with AI-192 Option
MEASURING INPUTS:	Voltage 0.3µV TO 10 V Current 4-20mA, 0-50mA Thermocouples JKEBRST RTD's, Strain Gages, etc } with -SC
RESOLUTION:	16-Bits (1/65535) (0.3µV L.S.B.)
ACCURACY:	±0.02% of range
LINEARITY:	± 0.015%
INPUT IMPEDANCE:	10,000 Megohms/0.1 µF
BINARY INPUTS:	11 ON-OFF TTL or contact and a pulse counter
CONTROL OUTPUTS:	10 TTL outputs. Expandable to 640 (3A relay outputs with -RO)
DIMENSIONS:	16"W x 18"H X 10"D typical Supplied with hinged, gasketted, locking door
MOUNTING:	Wall mounting brackets are supplied
POWER:	115VAC, 10W
INTERFACE:	Parallel standard; RS232, RS422 optional

OPTIM
ELECTRONICS CORP

MEGADAC
B&F

MIDDLEBROOK TECH PARK
12401 MIDDLEBROOK ROAD
GERMANTOWN, MARYLAND 20874
TELEPHONE (301) 428-7200

Data Acquisition Systems
Analog/Digital Sub-systems
Signal Conditioning Modules

May 20, 1993
Ref: 93-366

Mr. Phillip Spelt
Oak Ridge National Laboratory
PO Box 2008, Mail Stop 6364
Oak Ridge, TN 37381

Dear Mr. Spelt:

Thank you for your time and the opportunity to discuss Optim's MEGADAC Data Acquisition Systems with you. Optim manufactures a number of data acquisition systems for a variety of test environments and applications. MEGADAC's feature selectable sample rates, up to 250,000 samples per second, a 16-bit Dynamic Range with one microvolt sensitivity, intelligent triggering, over-range detection indicators and automated data marking facilities for data reduction. Besides the MEGADAC's integral RAMDISK memory for data storage, we also provide mass storage on removable 1 gigabyte laser disks resolving issues concerning large data sets.

Most importantly, Optim provides the total turnkey solution with our own Test Control Software (TCS), which is included with every MEGADAC. TCS is a fully integrated, menu-driven, window-oriented software package supporting all features and functionality of the MEGADAC. TCS runs on a DOS platform and streamlines your test setups, equipment verification and data analysis. TCS also allows you to export your results to many of the popular analysis packages you may already be familiar.

Please review the enclosed catalog and feel free to give me a call if I can be of any further assistance to you.

Thank you for your time and consideration.

Regards,
Optim Electronics Corporation

John Waldman

John Waldman
Sales Engineer

Enc.

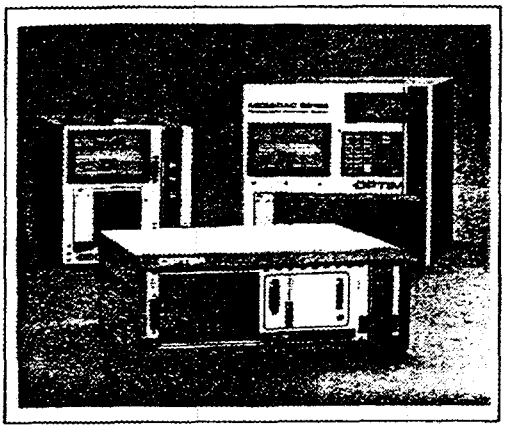
MEGADAC DATA ACQUISITION & CONTROL SYSTEMS

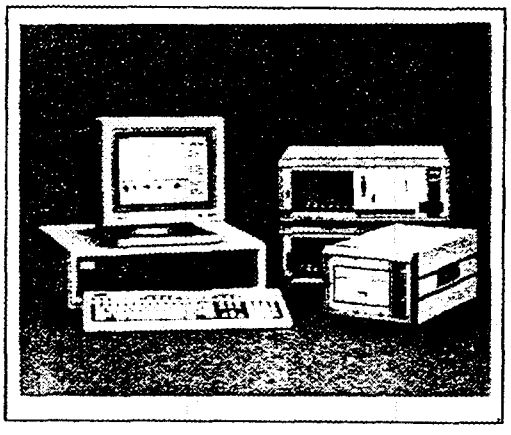
OPTIM'S field proven MEGADAC Data Acquisition Systems provide the engineering solutions to your measurement needs.

The AC powered MEGADAC is designed for laboratory based installations. OPTIM's DC powered MEGADAC can resolve your portable and remote requirements. There are also MEGADACs designed exclusively to withstand severe vibration environments.

By designing all hardware and software components concurrently, OPTIM provides the total turnkey solution with their own Test Control Software (TCS).

TCS communicates to the MEGADAC using IEEE-488, RS-422, RS-232 & RS-485 interfaces. TCS is included with every MEGADAC and is specifically designed to operate on PCs and Notebook computers, since they have evolved into cost-effective, yet powerful computing platforms.





MEGADACs feature selectable sample rates, from 1 measurement a day to 250,000 samples per second, a Full 16-bit Dynamic Range with one microvolt sensitivity, intelligent triggering, over-range detection indicators and automated data marking facilities for data reduction.

All analog input modules feature input protection withstanding voltages up to 1000 volts without damage. Selectable gains are available on a channel-by-channel basis with a full scale input of ±10 volts.

OPTIM's programmable input modules support a wide range of active and passive transducers and sensors, featuring programmable gains and filter selections, internal voltage and shunt calibration facilities, signal conditioning and sensor excitation.

Additionally, the A/D converter features an automatic offset nulling subsystem, capable of removing pre-load and residual values prior to your measurements.

Internal Storage is provided within the MEGADAC's Memory, which can be divided into Acquisition and RAMDISK storage partitions. Non-Volatile Mass Storage is provided using Internal/External 1 Gigabyte ruggedized re-writable Laser Disks, or 1 Gigabyte Fixed Disks.

TCS is a fully integrated, menu-driven, window-oriented software package supporting all features and functionality of the MEGADAC. TCS includes function specific help screens and step-by-step examples of how to define and acquire test data, plus an on-line users manual.

TCS allows you to enter your definitions in engineering units and time. Editing capabilities automatically support multiple test setups and menu presentations, providing selections and prompts tailored specifically to your applications. All data is automatically available in engineering unit terminology both during and after your measurement process.

In addition to TCS's ability to export results to most popular analysis packages, OPTIM's disk formats are transferrable to MTS's RPC® Systems & LMS's CADA-X Fourier Monitor ADC Throughput session formats, for further test development through OPTIM's External Mass Storage Readers.

OPTIM's Reader Control Software (RCS) can further enhance analysis, since the data on the disks is already digitized. RCS was specifically designed for direct access to data files using OPTIM's External Mass Storage Readers connected to a PC through a SCSI interface.

rcd 5/24/93

DATA ACQUISITION SYSTEMS DESIGNED EXCLUSIVELY FOR

- ❑ STRUCTURAL MONITORING
- ❑ PAVEMENT RESEARCH
- ❑ IN-VEHICLE TESTING
- ❑ DURABILITY TESTING
- ❑ LOCOMOTIVE TESTING
- ❑ R&D ENVIRONMENTS
- ❑ STRUCTURAL TESTING
- ❑ COMPOSITE RESEARCH
- ❑ AEROSPACE TESTING
- ❑ MILITARY TESTING
- ❑ EARTHQUAKE MONITORING
- ❑ MATERIAL TESTING
- ❑ BRIDGE TESTING
- ❑ NUCLEAR POWER STATIONS
- ❑ CLEAN ROOM MONITORING

MEGADAC
DATA ACQUISITION & CONTROL SYSTEMS

OPTIM ELECTRONICS

MEGADAC B&F

DATA ACQUISITION AND CONTROL SYSTEMS

John W. Waldman
Sales Engineer

Middlebrook Tech Park
12401 Middlebrook Road
Germantown, Maryland 20874

1-800-234-5430
(301) 428-7200
Fax (301) 353-0129

OPTIM ELECTRONICS CORPORATION
(301) 428-7200

Item Description	Part Nbr
MEGADAC 3108DC	**ML1065**

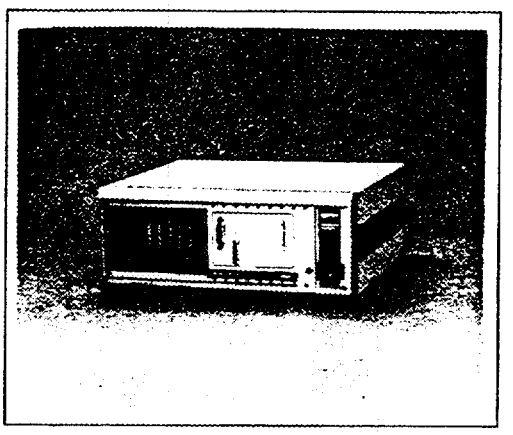
HARDWARE
- Portable Data Acquisition System
  With 12 Volt Operation For Environments
  Operating up to ± 3 g's
- 25,000 Samples per Second Throughput
- 16-Bit Analog-to-Digital Converter
- 512 KiloBytes of Acquisition & Storage Memory
- 8 Module Slots available to house:
  MEGADAC Input & Output Modules
  MEGADAC Expansion Chassis Module
- Addresses up to 256 Input Channels
- Addresses up to 128 Output Channels

REMOTE INTERFACES
- IEEE/488, RS-232, RS-422 or RS-485

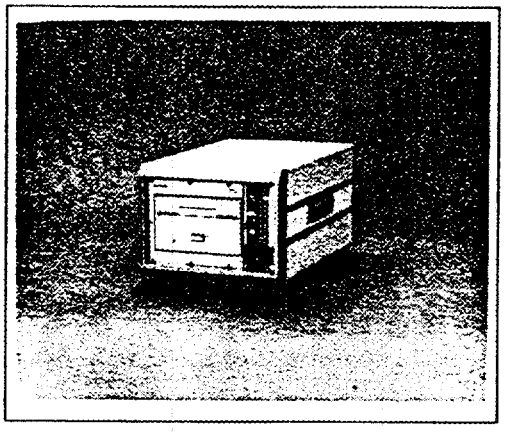
SOFTWARE
- Includes OPTIM's TCS software
- TCS Runs on DOS Based IBM compatible PC's
- TCS Supports all MEGADAC Features/Functions

DOCUMENTATION
- MEGADAC Hardware Operating manual
- TCS Software Operating manual

OPTIONS
- Up to 64 MegaBytes of Internal Memory
- DC Expansion Chassis For Input/Output Modules
- SCSI Interface & External Mass Storage
- SCSI Reader Kit & RCS Software for PC
- Power Supply 110 VAC / 12 VDC



MEGADAC 3108DC



EXTERNAL MASS STORAGE

Item Description	Part Nbr
MEGADAC 5108DC	**ML1067**

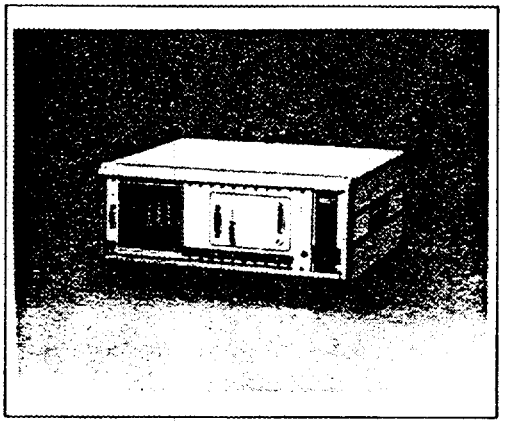
HARDWARE
- Portable Data Acquisition System
  With 12 Volt Operation For Environments
  Operating up to ± 3 g's
- 250,000 Samples per Second Throughput
- 16-Bit Analog-to-Digital Converter
- 4 MegaBytes of Acquisition & Storage Memory
- 7 Module Slots available to house:
  MEGADAC Input & Output Modules
  MEGADAC Expansion Chassis Module
- Addresses up to 256 Input Channels
- Addresses up to 128 Output Channels

REMOTE INTERFACES
- IEEE/488, RS-232, RS-422 or RS-485

SOFTWARE
- Includes OPTIM's TCS software
- TCS Runs on DOS Based IBM compatible PC's
- TCS Supports all MEGADAC Features/Functions

DOCUMENTATION
- MEGADAC Hardware Operating manual
- TCS Software Operating manual

OPTIONS
- Up to 64 MegaBytes of Internal Memory
- DC Expansion Chassis For Input/Output Modules
- SCSI Interface & External Mass Storage
- SCSI Reader Kit & RCS Software for PC
- Power Supply 110 VAC / 12 VDC



MEGADAC 5108DC

Schlumberger Technologies
Test and Transactions Division

829 Middlesex Turnpike
P.O. Box 7004
Billerica, MA 01821-7004
Tel: (508) 671-9700
Fax: (508) 671-9704
1-800-225-5765

January 25, 1993

Dr. Philip Spelt

Oak Ridge National Lab
PO Box 2008
Oak Ridge, TN 37831 6364

Dear Dr. Spelt:

Thank your for your interest in our Schlumberger Technologies' products and accessories. Schlumberger Technologies is composed of four worldwide divisions with one consuming objective - leadership in providing innovative, cost effective productivity improvement tools. Our products provide cost effective solutions in the area of mechanical design, telecommunications, radio frequency, electronics service, and test. Our committment to continuous new product development and research makes Schlumberger Technologies quick to respond to world-wide market changes that benefit our customers.

Enclosed you will find the information and/or product brochures that you have requested. If you need any further assistance or would just like to speak with a Schlumberger Technologies sales person, please feel free to call your local sales representative listed below.

Regards,

David Zimmerman
Regional Sales Engineer
3100 New Castle Lane
, 21140

Enclosure: 3535 disk

Visit Us At:
SENSORS EXPO WEST 93
The Conference and Exposition of Sensors and Systems
March 2-4, 1993
San Jose Convention Center
San Jose • California

OAK RIDGE NATIONAL LABORATORY
MANAGED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE U.S. DEPARTMENT OF ENERGY

POST OFFICE BOX 2008
OAK RIDGE, TENNESSEE 37831

May 14, 1993

Mr. David Zimmerman,Regional Sales Engineer
Test & Transactions Division
Schlumberger Technologies
3100 New Castle Lane
Riva, MD 21140

Dear Dave:

CRADA MATERIALS FROM MARTIN MARIETTA ENERGY SYSTEMS

Enclosed is the packet of material on CRADAs which I promised to send you. I did not include the video tape, since it only shows George Bush witnessing the CRADA signing between ORNL and Coors Ceramics. If you or your company have any questions, please call me.

Sincerely yours,

Philip F. Spelt
Cognitive Systems & Human Factors Group

PFS/wp

Schlumberger Technologies

Test & Transactions Division

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P.O. Box 7004
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1-800-225-5765

Rcd 2 Jun 93
PJ

May 28, 1993

Dr. Philip Spelt
Oakridge National Laboratories
MS 6364
Oakridge, TN 37831-6364

Dear Dr. Spelt:

I wanted to take this opportunity to thank you for discussing your data acquisition requirements with me at your facility. I was indeed fascinated with the scope of your project. Unfortunately, I have to bow out of the competition at this time.

I have discussed your application with my manager, Jeff Gruber. He knows of several manufacturers that would better fit your needs. Perhaps you could give him a call at 404-993-8801 and exchange ideas.

Again, thanks for your time and consideration concerning this matter.

Regards,

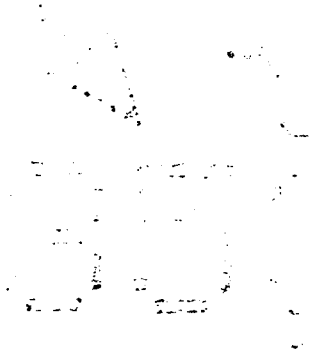
David Zimmerman

David Zimmerman
Regional Sales Engineer

DZ/kp

cc: Jeff Gruber

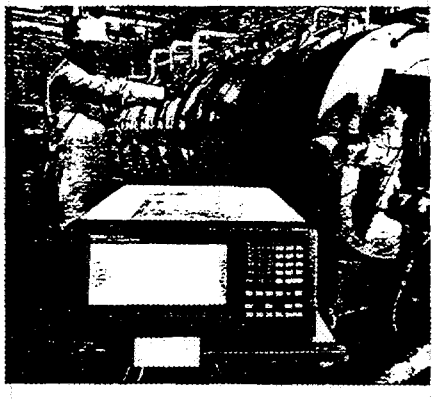
Scorpio 3535D ...
The complete standalone datalogger that's so easy to set up and use



> **MEASURE**	any mix of analog or digital inputs	
> **WATCH**	the graphical presentation of live high-precision results on a clear front panel display	
> **STORE**	logged data in MS-DOS format on 3.5" floppy disk	
> **SEND**	reports automatically to a high-resolution printer	... ALL WITHOUT ADDING A SINGLE EXTERNAL DEVICE

So easy to set up
Easy-to-follow menu prompts convert test requirements into data logging set-ups at the touch of a few buttons – even users who don't use the Scorpio regularly can program a test easily. There is battery back-up for the logger set-up, and multiple test configurations can be stored on floppy disk.

Turnkey operation
Once set up, running a test using Scorpio is straightforward. The operator simply inserts a disk carrying the required program and switches on – logging will start automatically. Operators can easily switch between displays and look at extra channels without affecting the critical logging activity.



Reliable accuracy ... in every situation
Only one annual adjustment is required to guarantee microvolt accuracy without the need for separate signal conditioning, special amplifiers or hardware adjustments.

As well as a main power line operation for laboratory use, the logger also offers 10-32V dc operation for use at field locations or in a vehicle. Disks can be removed and sent for analysis back at the lab, or data transferred to a PC via Scorpio's integral RS232 interface.

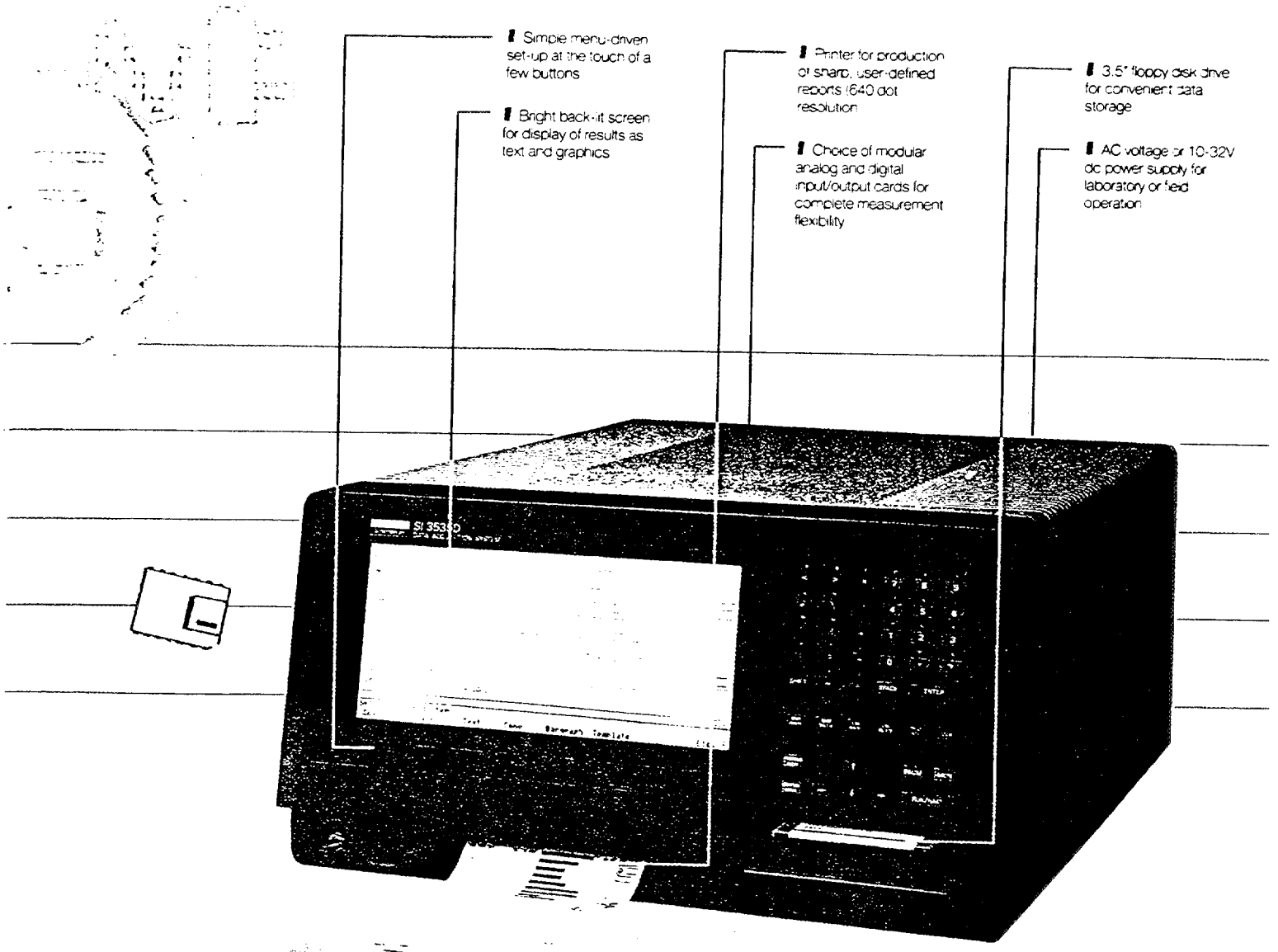
The cost-effective solution
Why pay for more capacity than you need? The basic Scorpio unit can start with only 20 input channels, but this is easily extended up to several hundred channels as your application expands.

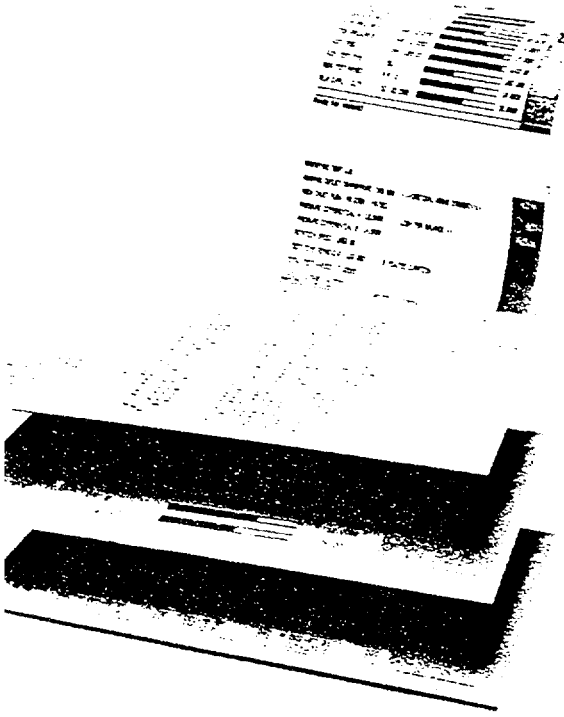
Picture your own results with the Scorpio data logger
The heart of the Scorpio 3535D data logger is its large integral display screen, offering high resolution (640 x 200 pixels) and back-light for extra clarity.

Not only does the Scorpio display provide an easy-to-use interface for menu-driven set-up options, it also presents results, as they are logged, in a variety of formats. Different display options are accessed at the touch of a few buttons.

Nine different customized screens can be specified, each displaying up to 20 lines of direct readings and processed results, with text labelling to keep everything in context.

Charts can be used with customized screens to give you a clear picture of results as they are logged. No computer is needed to create graphic images.





Status icons

The Scorpio display features a panel of easily-recognised icons which clearly indicate exactly what the logger is doing: which tasks are active, where the data is being sent, when the logger was last triggered etc. This means you can be sure the logger is doing exactly what you want during important tests.

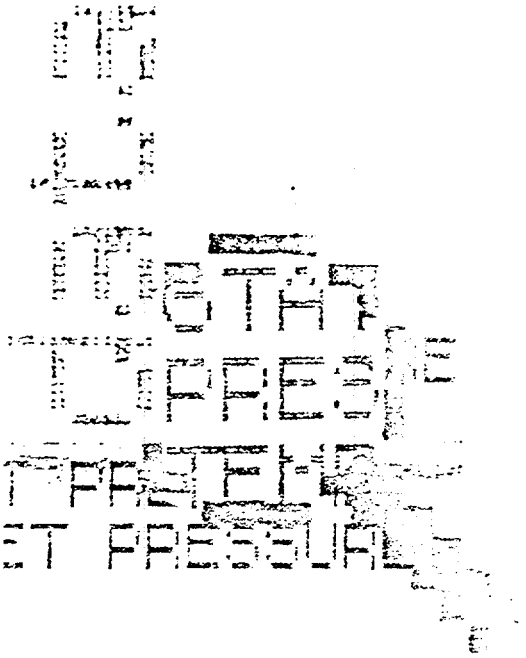
User-defined reports

There is no need to wait until the end of the logging to obtain a printed report. The high resolution Scorpio printer (640 dots wide) will produce 40 or 80 columns of crisp text output, and you can also generate hard copies of charts from the display at the push of a button. Selected results can be sent to the printer on a time schedule (every 10 minutes, for example), or whenever the logger detects a pre-defined change. Data stored on disk can also be downloaded to the printer.

Convenient data transfer

Scorpio stores data on 3.5" floppy disk in MS-DOS or HP-LIF format. Disks may be transferred directly to a PC for spreadsheet analysis. A range of free PC starter software is available with the Scorpio logger to facilitate the transfer of data into Lotus 1-2-3 (TM) and other spreadsheets. Acquisition and analysis software based on Microsoft Windows (TM) is also available.

Data can also be sent live or transferred to a computer or other mass storage device via Scorpio's integral RS232 interface. GPIB and RS422 interfaces are also available as options.



Measurement

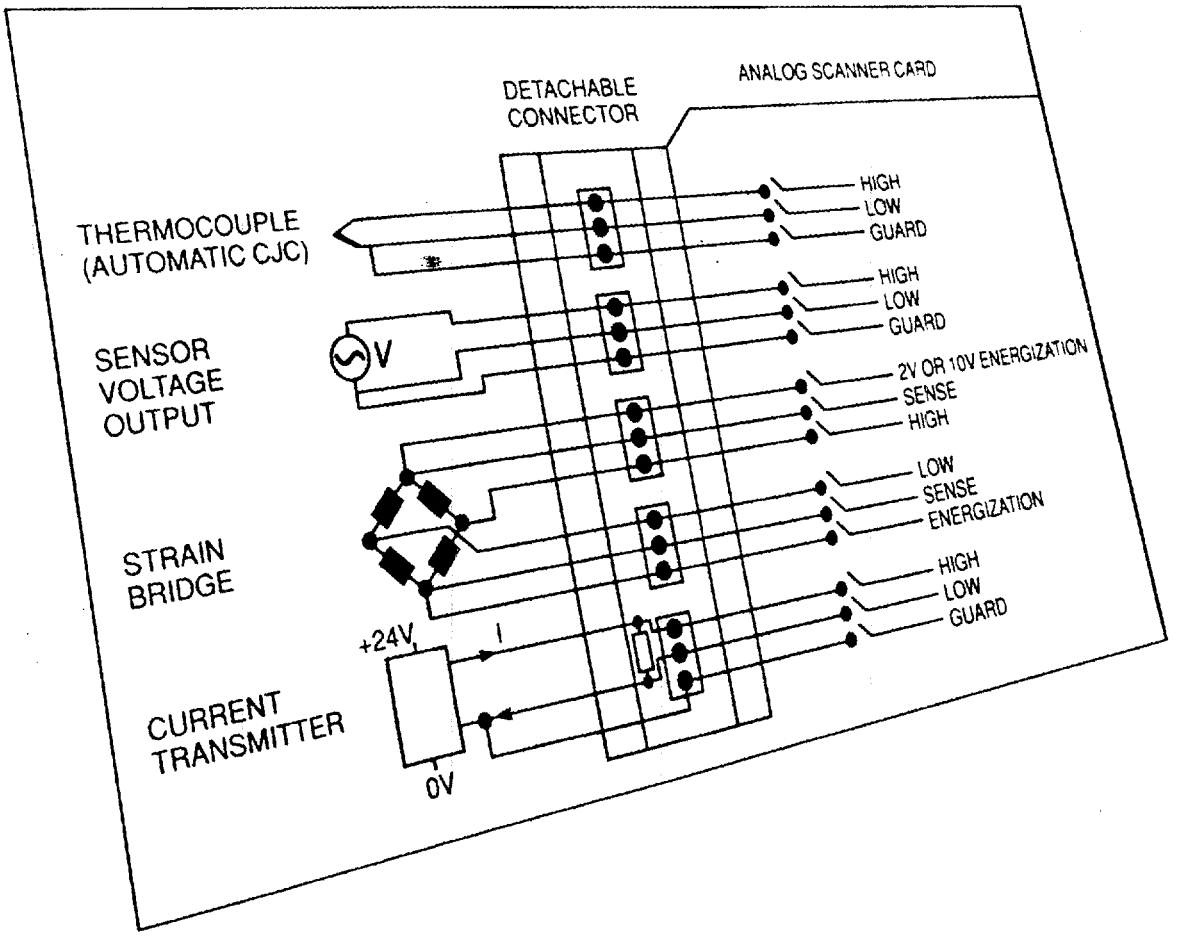
Measurement
Scorpio combines attractive data presentation with high precision measurement capability.

A complete range of analog and digital input and output modules is available for the logger, ready to handle inputs such as thermocouples, RTD's, strain gages, 4-20mA inputs, frequency signals or digital events.

Temperature measurements of the highest quality
Scorpio's state-of-the-art Isothermal Connector Block uses high quality RTD's for precision cold junction compensation on thermocouples. It can also be used for all types of analog inputs. Automatic high-precision linearization of thermocouples achieves superb accuracy over the full temperature range.

RTD's can also be measured using the same card and connector used for other analog signals. Non-standard RTDs can be measured in Ohms and linearized by means of user-defined conversions.

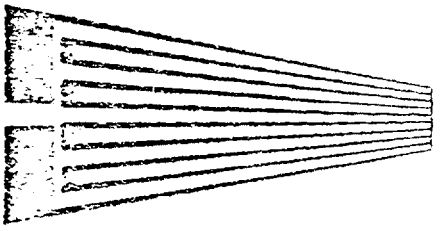
Scorpio's analog scanner cards each include a universal analog input connector which accepts any mix of sensor types using either a 3 or 6 pole switching method. Energization at 2 or 10V, or selectable constant current is switched automatically to the transducers.

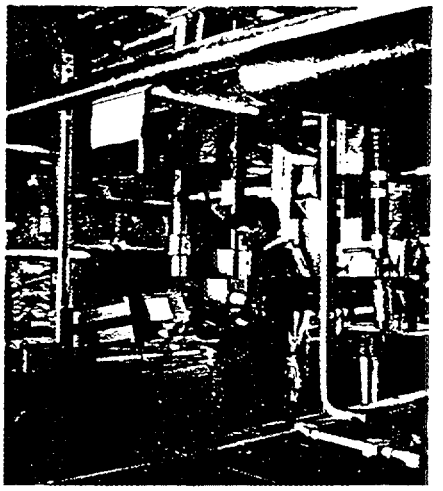


Structural testing

Acknowledged expertise in strain gage measurement has made Schlumberger a market leader for structural testing equipment in research, power plant design, and the aerospace and automotive industries worldwide.

The Scorpio data logger offers 2V or 10V voltage energization for full bridges. The dual-current method is also offered for quarter bridge, half bridge and 3-wire configurations, providing outstanding linearity, repeatability and accuracy of measurement. To prevent the introduction of thermal errors through a build-up of heat on the gages, energization is automatically applied only during measurement. In addition, the quarter bridge configuration can utilize one of three user-supplied dummy gages on the transducer energization card, avoiding the need for a dummy on every channel.

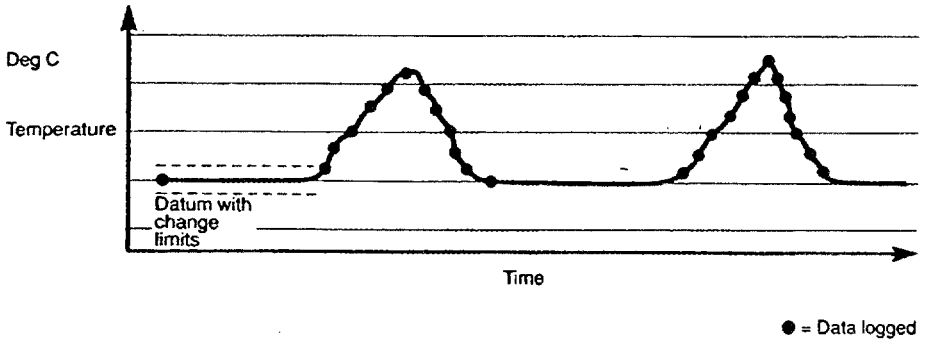




4-20mA current transmitter facilities for added convenience

Scorpio's transducer energization card also offers a 24Vdc/1A supply for powering 4-20mA current transducers, eliminating the need for an external power supply. A special conversion enables results to be changed directly into engineering units.

Scorpio's "change" alarm allows data to be logged only when it changes by more than a defined amount. This is particularly useful in applications such as the continuous load monitoring of power plant or long-term endurance testing of engines where long stable periods would normally lead to the production of a large quantity of non-changing data.



High performance analog modules

Scorpio's unique high voltage solid state scanner uses a new type of FET switching technology. This combines the benefits of long life, high reliability and fast switching speed to meet the demands of any application. In addition, the ability to withstand high common mode voltages and measure high input voltages ensure reliable operation in harsh industrial environments. Each of these unique new scanners can switch any type of analog input at a rate of up to 250 channels per second with 200V isolation.

High throughput speeds

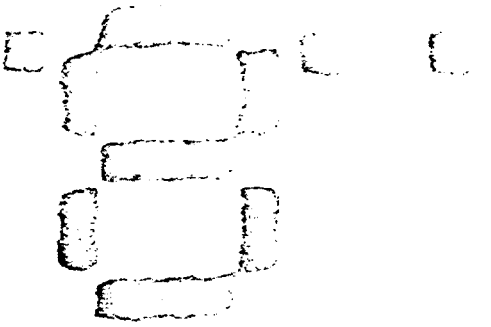
For faster applications, a high speed solid state scanner card offer a switching rate of 500 channels per second. Fully linearized thermocouple results can be sent continuously at this rate to the internal memory (5000 readings), the GPIB interface or the internal disk.

Range of digital measurements

Scorpio's digital modules include:

- Frequency measurement (useful for certain transducers or for measuring engine or turbine rotation speeds
- Time interval and totalizing inputs (for logging the sequence of processes)
- Digital events with ±2ms timestamping
- Digital inputs for status indication
- Digital outputs for alarms or control

Advanced Features



Conversion and labelling for every channel

Scorpio logs temperatures directly in Centigrade or Fahrenheit. Strain gages are logged in micro-strain. To convert transducer inputs into the engineering units you require, one of the following five standard conversions is provided for each and every channel:

Scale and offset	$y = mx+c$
Polynomial	$y = ax^2+bx^2cx+d$
Reciprocal	$y = a/x$
Square root	$y = \sqrt{(ax+b)}*c+d$
4-20mA current transmitters	

The square root conversion is useful for converting differential pressure measurements to flow results.

The 4-20mA current transmitter conversion enables engineering values for the ends of the transducer range to be entered straight from the manufacturer's data sheet. The logger does the linearization automatically.

In addition to these standard conversions, almost any formula can be defined by the user in a simple algebraic format.

A text label up to 18 characters in length (e.g. RIG C FLOW INPUT) can be attached to the input from each channel, helping the user to readily identify results.

Data reduction and alarm capability

Alarm levels may be defined for every input channel.

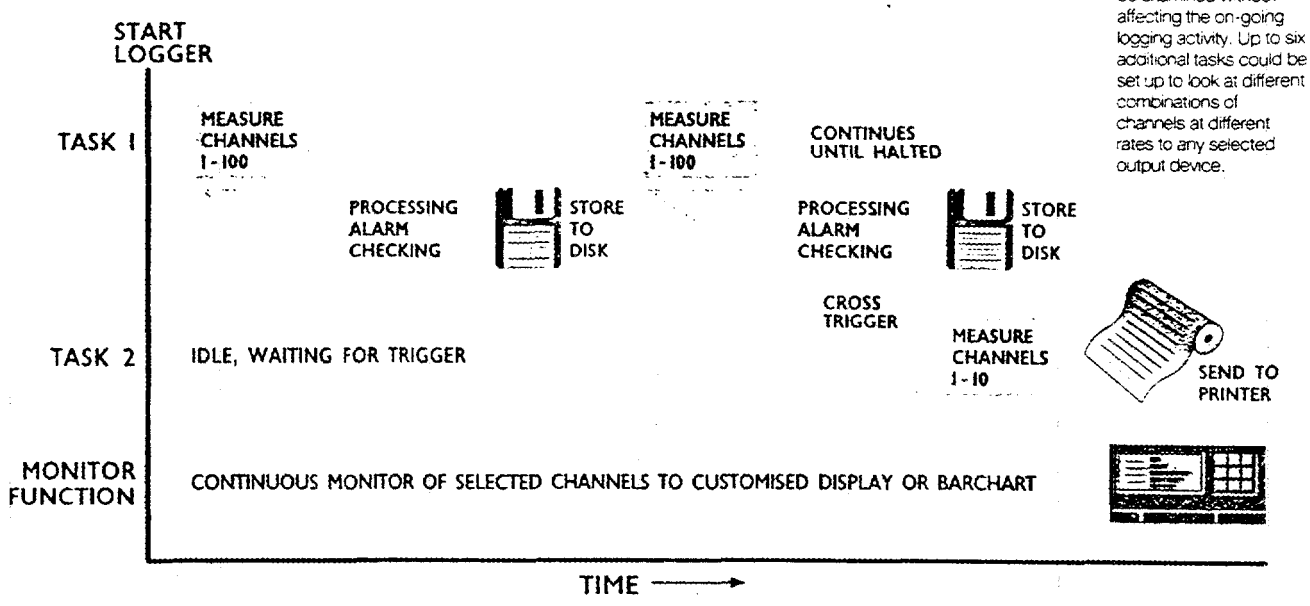
Results that deviate from pre-defined criteria can be categorized as alarms. By storing only results with alarm tags the data is compressed to include only important results.

Logger alarms can also be used to switch digital outputs, activating bells, lights or other equipment as required.

Perform up to eight tasks at once

Up to eight prioritized measurement tasks can be defined, each logging from different sets of channels at different rates. These tasks can be independent of each other for simultaneous monitoring of more than one test or experiment, but may also be linked together in order to respond to measured results in a more complex test. For example, you can set up a task to be triggered only when an alarm is detected.

In this example, TASK 1 monitors the test at fixed time intervals, storing the data to disk. TASK 2 is started by TASK 1 under certain conditions. In addition, the MONITOR function allows data to be examined without affecting the on-going logging activity. Up to six additional tasks could be set up to look at different combinations of channels at different rates to any selected output device.



Calculations and decisions ... as easy as writing a formula

Scorpio can be set up to perform inter-channel calculations, to change logging routines on certain conditions, and even to control other equipment. Instructions are entered in the form of simple algebraic equations, just like keying a formula into a programmable scientific calculator.

A full range of scientific and logical functions is available. Some typical applications of these would be to:

- Average inputs over time or in groups
- Speed up the logging rate when temperatures change by more than a specified amount
- Output only a few processed results (such as efficiency calculations) instead of thousands of raw readings
- Send messages about test details to the display or printer e.g. user warnings, or pass/fail remarks on test parameters
- Calculate angle of principal stress from individual strain gages
- Switch power supplies or control external equipment (e.g. motor speeds) using analog and digital outputs

Scorpio has at it's heart a "reduced instruction set" processor as found in the newest generation workstations. This magnitude of computing power is unprecedented in a data logger. You'll have power to spare whatever calculations and decision making your application demands.

Modem operation for remote monitoring

Scorpio data loggers may be situated remotely (in unattended plant or test houses, for example), with data being transferred to a computer over telephone lines using auto-answer Hayes compatible modems. This makes them ideal for use in power-plant, field locations or energy analysis in experimental buildings.

Scorpio speaks your language

The Scorpio menu is switch-selectable to English, French or German so that its user-friendly options are presented in whichever language you prefer.

Orion compatibility

Scorpio's command structure is compatible with that of Schlumberger's 3530 and 3531 Orion loggers, which means that a computer program written for Orion will also work with the Scorpio 3535D.

In addition, all Orion's analog and digital I/O modules, connector blocks and communication modules can be plugged into Scorpio (with the sole exception of the 35301D Transducer Energisation module).

This makes changeover to Scorpio a cost-effective proposition for existing Orion users.

3535D Data Logger Ordering Details

3535D Data Logger Mainframe
Includes high accuracy 19 bit ADC, 10 slots for I/O modules, RS232 interface for computer communication, front panel keyboard, high resolution 640 by 200 pixel backlit display, high resolution printer (640 point wide), 3.5" floppy disk drive, up to 600 conversions and text labels, post-processing using simple algebraic equations and 8 independent measurement tasks.

3535E Slave Expansion Unit (10 module slots)
Up to two can be connected to each mainframe via a 35351D TEM for connecting additional analog scanner cards.

Analog Modules

35351H High Voltage Solid State Scanner*
With 35353C isothermal universal analog connector for high performance cold junction compensation

35351G High Voltage Solid State Scanner
With 35303A universal analog connector for standard cold junction compensation

35301J High Speed Solid State Scanner
With 35303A universal analog connector for standard cold junction compensation

35301K Reed Relay Scanner*
With 35353C isothermal universal analog connector for high performance cold junction compensation

35301L Reed Relay Scanner
With 35303A universal analog connector for standard cold junction compensation

*connector requires 35351D TEM in mainframe unit for CJC.

35351D Transducer Energisation Module
Switches voltage or current energisation to transducers connected to analog input scanners

35301E Analog Output Module

Digital Modules

35302D Event-Status
35302B Digital Input/Output
35302C Counter-Timer

Optional Computer Interfaces

35304A GPIB interface
35304B Dual port RS232/RS422 interface

All 3535D mainframes include an RS232 interface free of charge. One spare interface slot is provided in each mainframe for one of the above extra interfaces.

Spare Analog Connectors

35353C Isothermal Universal Analog Connector Block
35303A Standard Universal Analog Connector Block
35303B Current Connector Block

Accessories

35355E Paper rolls (120)
346028A 3.5" inch disks (10)

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Victoria Road, Farnborough, Hampshire GU14 7PW
England. Telephone: (0252) 376666
Fax: (0252) 543854. Telex: 858245 SCHLMF G

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12 Lorong Bakar Batu #07-07/11, Singapore 1334
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Schlumberger pursues a policy of continuous development and product improvement. The specifications in this document may therefore be changed without notice.

S/PM015/Issue 02/9 92/5K/FD2683/B

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Scientific Atlanta

March 18, 1993
SPSEA-947

Oakridge National Lab
P.O. Box 2008
Oakridge, TN 37831-6364

Attention: Dr. Philip F. Spelt

Dear Dr. Spelt:

I received information from one of our Application Engineers that you have interest in instrumenting a vehicle and transmitting collected information to a distant site. We have instruments that can be used in this type of application, including a multi-channel signal collection and processing device intended specifically for on-vehicle use. We have inexpensive satellite communication devices (intended for use on mobile platforms) that interface with these instruments, as well as terrestrial RF communication devices for use at shorter distances.

Scientific-Atlanta, Signal Processing Systems in San Diego, specializes in tailoring our products to custom applications. We welcome the opportunity to tell you about our products and capabilities, and to determine how we can satisfy your needs. Please call either myself at (619)679-6355 or Don Brady, my lead engineer in this area, at (619)679-6291 to initiate a dialog.

Jim Baker

James P. Baker
Vice President, Engineering

JPB/ch

Scientific–Atlanta, Inc.
Instrumentation Group
Signal Processing Systems

13112 Evening Creek Dr. So.
San Diego, CA 92128–4199

Telephone: 619 679-6000
Fax: 619 679-6100

TRUCK MONITORING SYSTEM BRIEFING

FOR

DR. PHIL SPELT

OAK RIDGE NATIONAL LABORATORY

from spectral analysis → complete diagnostics. → Diagnostic Processing Unit
PC-based Diagnostic Analysis Station

DIAGNOSTIC PROCESSING UNIT

INTRODUCTION

THE DIAGNOSTIC PROCESSING UNIT (DPU) REPRESENTS AN EXTREMELY FLEXIBLE AND AFFORDABLE DIAGNOSTIC SYSTEM FOR MULTIPLE APPLICATIONS. THE LATEST ACQUISITION, PROCESSING AND PACKAGING TECHNOLOGY IS EMPLOYED TO ACHIEVE HIGH FUNCTIONALITY AND SMALL SIZE. KEY FEATURES INCLUDE:

REPROGRAMABILITY

4 MBYTES OF FLASH MEMORY ARE USED WHICH ALLOW THE NON-VOLATILE STORAGE OF PROGRAMS AND COLLECTED DATA. FLASH MEMORY CAN BE LOADED WITH NEW PROGRAMS WITHOUT MODIFYING HARDWARE. A COMMON HARDWARE PLATFORM CAN BE UTILIZED

FLEXIBILITY

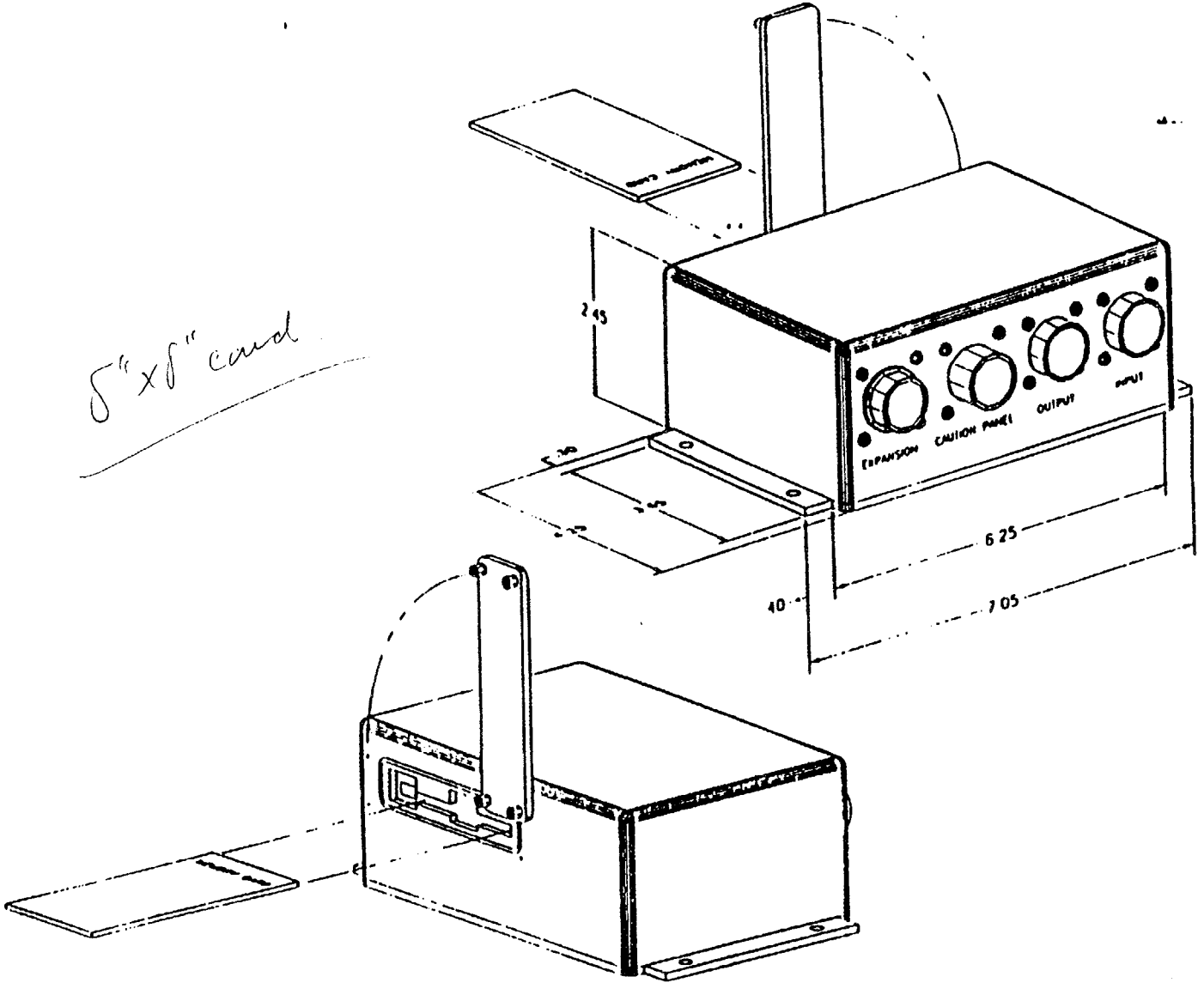
A GENERIC ACQUISITION FRONT END ALLOWS THE COLLECTION OF BOTH VIBRATION AND ANALOG SENSOR DATA SUCH AS TEMPERATURE, PRESSURE AND TORQUE. ALL DATA IS DIGITIZED AND PROCESSED WITH A HIGH SPEED DIGITAL SIGNAL PROCESSOR ALLOWING SOFTWARE BASED DIAGNOSTICS TO BE EASILY UPGRADED AND CUSTOMIZED.

ECONOMICAL

THE DPU IS MADE AFFORDABLE BY USING THE LATEST ELECTRONIC AND SOFTWARE TECHNOLOGY.

- DIGITAL SIGNAL PROCESSOR ALLOWING FAST FLEXIBLE DIAGNOSTICS
- HIGH DENSITY MEMORY ALLOWS SOFTWARE UPGRADE
- SIGMA DELTA CONVERTERS ALLOW THE ELIMINATION OF MOST ANALOG CIRCUITRY

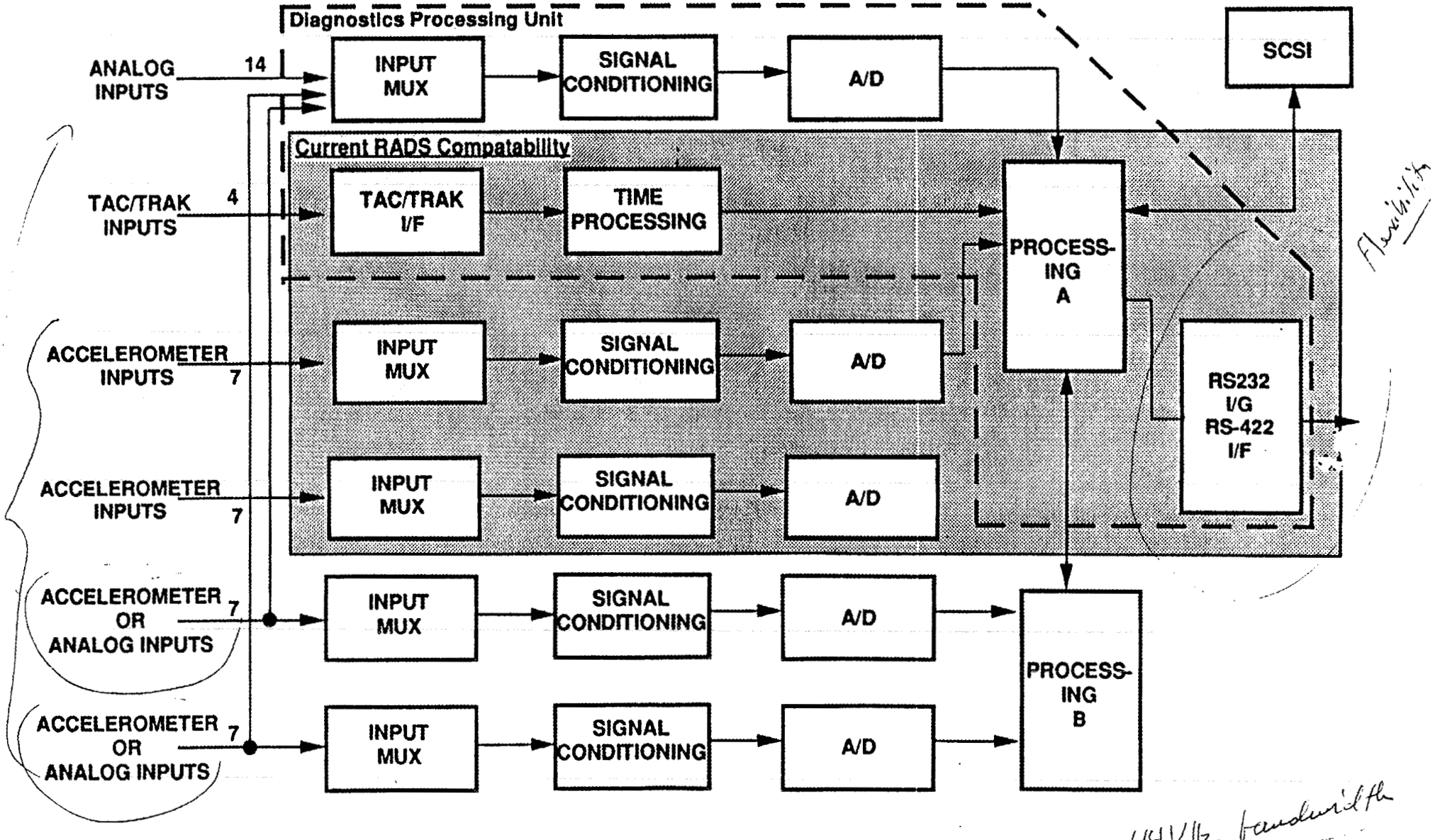
DIAGNOSTIC PROCESSING UNIT OUTLINE DRAWING



SCIENTIFIC ATLANTA, INC.	DIAGNOSTIC PROCESSING UNIT BRIEFING	SIGNAL PROCESSING SYSTEMS

Hi Flexibility Cards Can be distributed around vehicle

BLOCK DIAGRAM



Flexibility

44 KHz bandwidth

THE FOLLOWING ARE PROPOSED DIAGNOSTIC METHODS FOR GEAR BOX VIBRATION MONITORING. MANY TECHNIQUES RELY OF SIGNAL AVERAGING TO EXTRACT THE VIBRATION FROM A PARTICULAR GEAR. THE DPU USES A SOPHISTICATED INTERPOLATION METHOD TO RESAMPLE TIME DOMAIN VIBRATION DATA TO CREATE THE SIGNAL AVERAGES.

METHOD	PATTERN	PURPOSE
FMO	Deviation from a sinusoid	General purpose detector
FM1A	Overall modulation	Misalignment, Eccentricity, Swash Failure of shaft or supporting structure
FM1B	Differences in plantpass modulation levels	Planet load sharing problems
FM2	Correlated impacts	Tooth fracture, chipping
FM3	Sub-harmonic meshing	Parametric excitation, Heavy wear
FM4A	Single impacts of moderate intensity	Spalling, Tooth Fracture
FM4B	Rise in shaft-order activity	Evenly distributed wear

METHOD	PATTERN	PURPOSE
FM5	Single impacts of low intensity	Early spalling and fatigue cracking
Narrow Band Enhancement	Phase modulation of mesh. freq	Fatigue cracking
Crest Factor	Impulsive vibration sources	General
Sideband Level Factor	Ratio of first order sideband to standard deviation of signal average	Gear shaft damage or single tooth damage
Non-harmonic to harmonic	Standard deviation of difference Signal to standard deviation of regular component.	Heavy Wear

DIAGNOSTIC ANALYSIS STATION (DAS) KEY FEATURES

HARDWARE

DAS RUNS ON A STANDARD 386 OR 486 PC OR LAPTOP WITH AN 80MBYTE HARD DRIVE AND 4 MBYTES OF RAM. AN OPTIONAL CREDIT CARD READER IS AVAILABLE TO SIMPLIFY COMMUNICATIONS.

SOFTWARE

THE SOFTWARE IS BASED ON THE MICROSOFT INTERFACE WHICH MAKES IT EASY TO LEARN AND USE. ALL DATA IS STORED IN A STANDARD WINDOWS DATABASE CALL SUPERBASE 4. SIMPLE FORM TOOLS ARE AVAILABLE VIA SUPERBASE MAKING IT EASY TO MAKE UP CUSTOM REPORTS AND DATA ENTRY FORMS. EXTENSION ARE IN PROGRESS TO ADD AN INTEGRATED FAULT TREE CAPABILITY BASED ON COMMERCIALLY AVAILABLE FAULT TREE TOOLS.

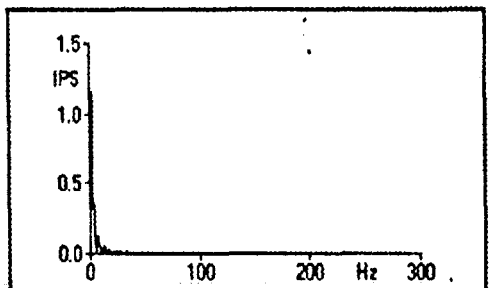
COMMUNICATION

COMMUNICATION IS SIMPLE WITH THE CREDIT CARD MEMORY, THE DAS AUTOMATICALLY STORES THE DATA FROM THE CREDIT CARD IN ITS INTERNAL DATABASE.

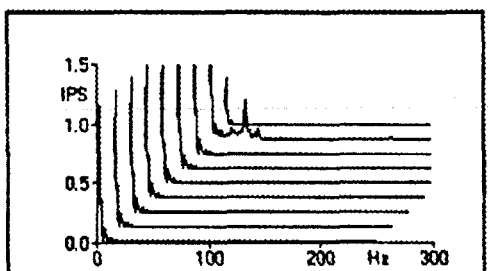
COMMUNICATION CAN ALSO BE PERFORMED VIA THE RS-232 SERIAL PORT.

THE USER CAN NOW BEGIN TO TRACK MECHANICAL COMPONENT ANOMALIES AND COMPARE ONE SYSTEM WITH ANOTHER.

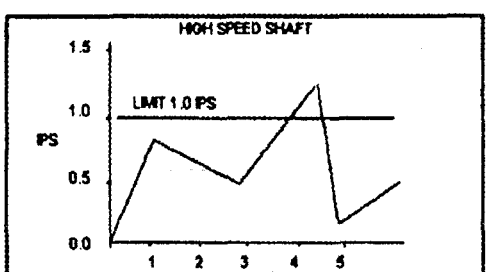
DAS VIBRATION ANALYSIS



SPECTRUM PLOT



SPECTRUM TREND



COMPONENT TREND

- ALL SPECTRUM DATA CAN BE ARCHIVED AND DISPLAYED ALLOWING THE DEVELOPMENT OF FLEET WIDE TRENDS AND LIMITS WHERE APPLICABLE.
- KNOWN VIBRATION SOURCES ARE ANNOTATED ON THE DISPLAY.
- COMPONENTS WITH LIMITS EXCEEDANCES ARE HIGHLIGHTED.
- TREND DATA ALLOWS A COMPARISON OF SPECTRUM FROM TIME TO TIME OR COMPARE SYSTEM TO SYSTEM OF A SIMILAR TYPE.
- SIMPLE OPERATION USING A MOUSE AND WINDOWS.
- INDIVIDUAL COMPONENTS ARE TRENDED OVER TIME ON A COMPONENT BY COMPONENT BASIS. LIMITS ARE INDICATED VIA COLOR CODE.
- ALL DISPLAYS CAN BE PLACED IN WINDOWS WORD PROCESSORS FOR EASY REPORT GENERATION.
- ALL DATA AVAILABLE AS TABLES OF NUMBERS FOR USE IN OTHER REPORTS OR APPLICATIONS.
- SUPERBASE 4 HAS A VERY SIMPLE FORM AND REPORT GENERATOR FOR CUSTOM REPORTS.

DIAGNOSTIC PROCESSING UNIT (DPU)

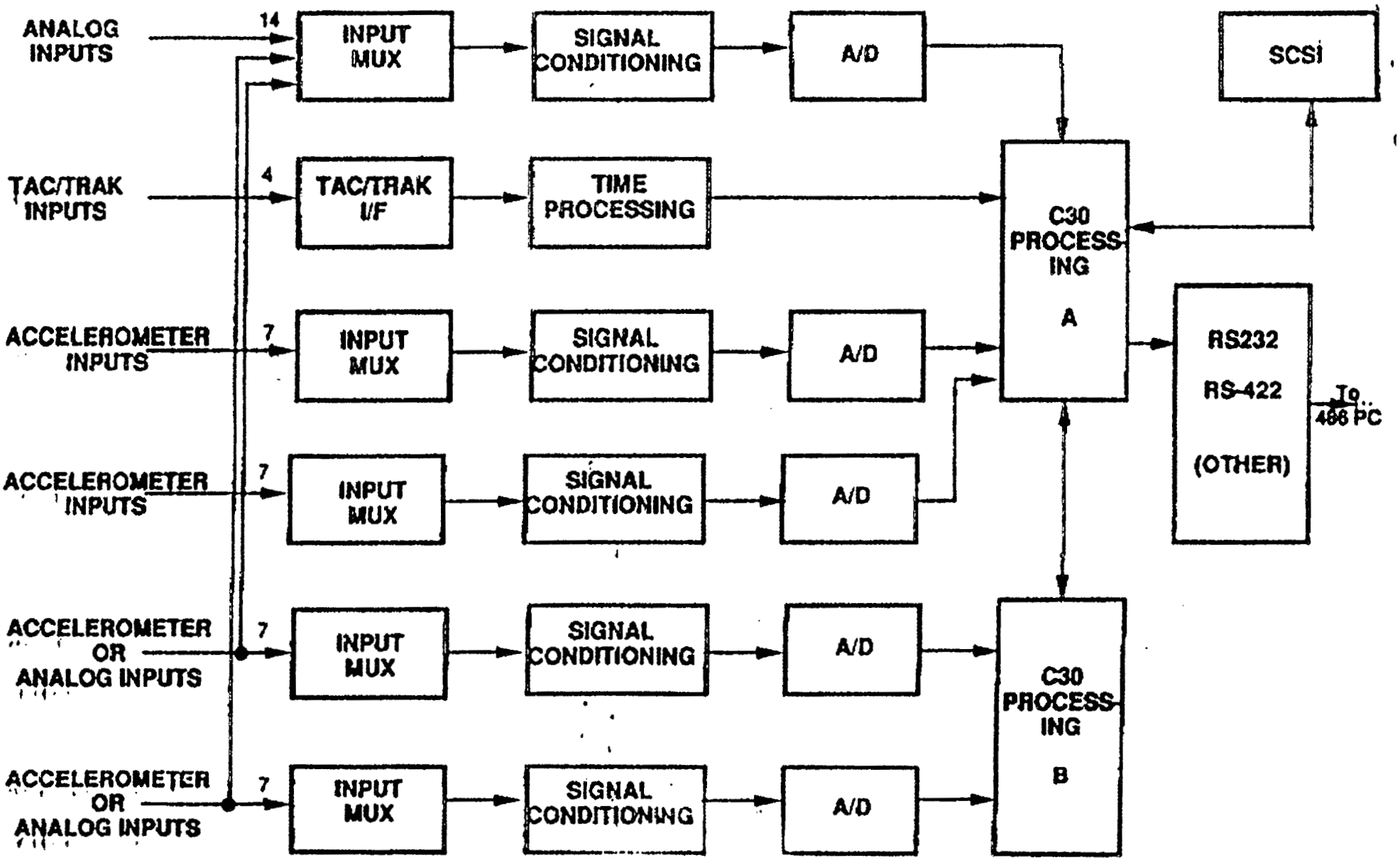


Figure 1: Diagnostic Processing Unit Functional Block Diagram

3044-1 jk

SA's Part of

DASCAR HIGH LEVEL SYSTEM OVERVIEW

SA's portion of

The DASCAR system is composed of three basic elements, the Data Processing Units (DPU), the System Control and Storage Module (SCSM) and the Data Analysis Station (DAS). As indicated in the attached figure the DPU's can be networked on the DASCAR vehicle to permit decentralized data collection and local preprocessing of analog data close to the sensor. Digital data will also be collected at the DPU and passed through to the SCSM for further relay to the DAS.

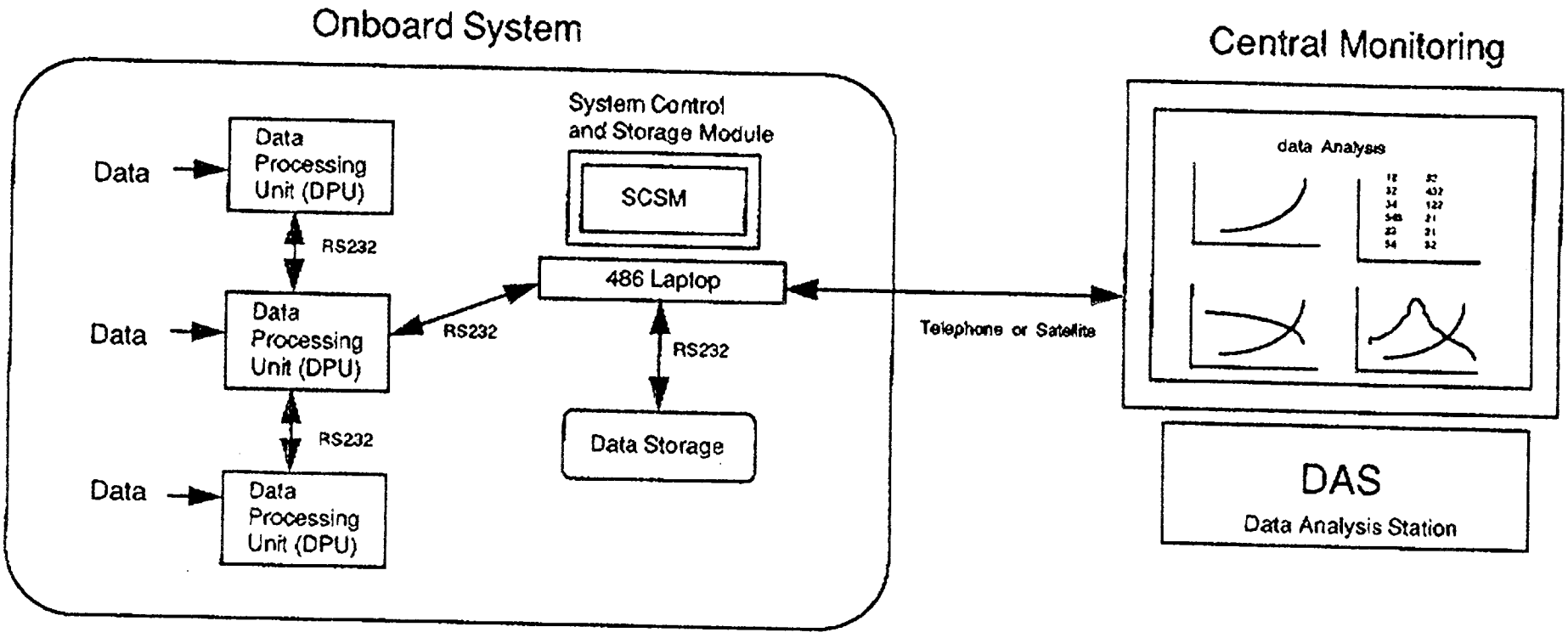
The System Collection and Storage Module (SCSM) is the system controller and also will maintain local storage of data on the vehicle. The SCSM will be a Unix based multi tasking system with an X-windows graphical user interface. The operator will be able to set up automatic collection, discreet event and storage parameters at the SCSM to configure the system to specific or emergent DASCAR requirements. A key component of the SCSM is a high volume digital data storage unit which will use either a tape or optical means of storage of the high volume of raw and preprocessed data which the DASCAR vehicle will generate.

Ultimately system will not have on-board VI

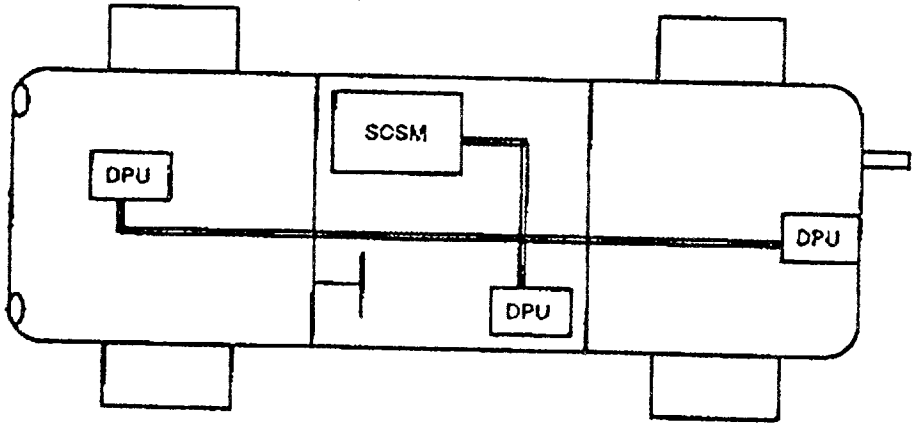
The Unix and X-windows based Data Analysis Station (DAS) will support long range trending and analysis of the data collected at the vehicle. Data can be relayed from the vehicle to the DAS by several means depending on the operational requirements. Routine transmission of data is envisioned via telephone land lines and modem, however a portable satellite terminal which will support the GPS tracking function of DASCAR can also be used to transmit real time on board data if required. This feature might be used to alert the DAS monitoring site of a significant event detected on board the vehicle. The DAS will provide the operator with multi function analysis capability in terms of equipment diagnostics and use of a relational data base to conduct analysis of the large volumes of data collected from dissimilar sensors on the DASCAR vehicle.

ORNL determines → Schwanger's area

Dascar Monitoring System



Example Dascar Vehicle



DASCAR DATA ANALYSIS STATION

I. Specifications

The Data Analysis Station (DAS) will be a UNIX based system with a user friendly X-windows based interface. The multi-sensor data input will be provided from the Data Processing Unit (DPU) via credit card memory, modem, or satellite Terrastar C. The DAS will perform detailed data analysis and store the results into a data base for trending and in-depth analysis. At the heart of the DAS will be an expert system that will analyze the operational condition of the DASCAR and all of its components including the driver. This system will also diagnose mechanical problems and make recommendations for future action. A functional breakdown of each of the DAS components can be outlined as follows:

MULTISOURCE INPUT
- Preprocessed Data
- Raw Data

MAIN FUNCTIONS
- Detailed Data Analysis
- Trending and Data Base Operations
- Diagnostics and Operational Condition Assessment
- Archiving

<u>Preprocessed Data File Input</u>

Data will be processed continuously on board the Data Processing Unit (DPU). This processing will be primarily frequency domain algorithms used for on-line condition monitoring. The algorithms will enhance and identify the critical components of the data that require constant monitoring. These components will be stored to a data file on a regular basis or will be triggered by events which have been pre designated, or activated by sensor out-of-bounds thresholds.

<u>Raw Data File Input</u>

A sampled time history file will be created and stored on DAT tape or optical disk (on board DASCAR). This file will be a high resolution "snapshot" of all the input parameters. Snapshots can be triggered by the SCSM on the basis of a predetermined schedule, or by any abnormalities or events detected by the SCSM or onboard sensors.

Detailed Data Analysis

The detailed data analysis will be performed on the raw data input. State-of-the-art signal processing algorithms will extract subtle diagnostic information from a complex waveform. These algorithms will include both time domain and frequency domain processing. Some of the methods may include:

- Signal Demodulation (gearbox and bearings)
- Cepstrum Techniques (wave form analysis)
- Spatial Filtering (array processing)
- Holometrics (linear regression of fourier coefficients.)
- Shock Pulse Analysis (gearbox and bearings)
- Specialized Gearbox Analysis (FMO,FM1A,FM1B,FM2,etc.)
- Hilbert Transform (phase modulation)
- High Resolution Spectral Analysis
- Other algorithms which support human factors assessment or DASCAR operational conditions

Trending

The key parameters pre-processed on the DPU along with the post-processed detailed data analysis on the DAS will be tracked with the use of a relational data base. The data base and trending features will be accessed automatically by the Expert system for operational assessment and diagnostics. The data base can also be accessed by the user for specialized analysis and report generation.

Diagnostics and Operational Assessment

The machinery diagnostics and operational assessment will be performed by a knowledge based Expert system. This system will function in much the same way as a safety or machinery diagnostic specialist. It uses a knowledge base drawn from the combined experiences of leading experts, coupled with specific information of the DASCAR characteristics and data analysis information, to analyze symptoms and generate event analysis and diagnoses. The user can input and edit modeling information (machine and human characteristics) and operational thresholds. This information is used by both the SCSM (to determine data processing parameters), and the Expert system. The data base will be principally used by the Expert system for comparisons to detect a change in the machinery state or DASCAR operational conditions. Once a change of state or reportable event is identified, a diagnosis is performed utilizing the knowledge base and

modeling information. The probability that the diagnosis is correct, and an indication of the problem severity will be provided for each diagnosis. The system will then recommend an appropriate action to be taken. An explanation of the reasoning behind the diagnosis can be accessed by the user if requested.

Archiving

All raw data, processed data, and Expert system diagnoses will be archived and stored for future use.

II. User Interface

The user interface will be an X-windows based system. This user friendly system will allow both customized analysis of the raw data, and customized analysis of the relational data base information. The user will have access and control of the expert diagnostic parameters and knowledge base information. Unique trends and correlations can be identified through interactive processing of the relational database. Report quality plots and tables with sources and limits annotated can be easily customized.

SMITHS INDUSTRIES
Aerospace

Defense Systems -
Grand Rapids

4141 Eastern Ave. S.E.
Grand Rapids
MI 49518-8727
Telephone: (616) 241-7000
Fax: (616) 241-7533

August 25, 1993

Mr. Richard J. Carter
Oak Ridge National Laboratory
P. O. Box 2008
Oak Ridge, TN 37831-6360

Dear Mr. Carter,

Dr. Lyle Reibling of our company requested that I send you some information on our Data Management Systems product line which may have application to your IVHS program. Smiths Industries Aerospace, formerly the Instrument Division of Lear Siegler has been developing and producing flight data recorders and data transfer systems for over a decade. We have been active in the expansion of data recording techniques and the processing of the recorded data which provides the customer with a variety of data bases to work from.

One example of this level of technology is the flight recording that we do on the F-16 fighter. We categorize the F-16 data into four categories: accident/incident data, individual aircraft tracking data, structural integrity data and engine data. Structural integrity data is normally collected from strain gauges, however the F-16 does not have strain gauges. Our recorder uses algorithms to process normally available data to compute bending moments to predict crack growth. This mathematically based model is very accurate and eliminates a lot af aircraft wiring and the unreliable strain gauges.

With all of the data available on an aircraft, there are many uses to which it can be put. One area that we have been working in is the reconstruction of any given mission by using recorded data to drive a computer simulation. This has led to the development of a capability to augment training received on the more expensive aerial combat maneuvering ranges by making mission replay available, post mission, for pilot debriefings and training. Aircraft units can then train in any airspace near their home base rather than deploying to a range for training.

The enclosed set of brochures is fairly representative of the products and capabilities which we work with every day. The are state of the art, solid state recording devices which process data in real time, compress and store for later retrieval. The reliability of our systems exceed 3,000 hours mean time between failure and all have been qualified to MIL-E-5400, Class II environment. The Standard Flight Data Recorder has the additional distinction of being qualified to aircraft gunfire environmental conditions.

We have been in production since the mid-1980s and continue to find new applications for our data management products. Currently, we are following the U.S.

Navy Common Mission Recorder program. As a result of the Gulf War, the Navy has identified a need to improve their data recorder capability to include nearly everything from "DC to Light". Since our solid state memory units have obvious memory limitations, we have a memorandum of agreement with a well known recorder 8mm tape recorder manufacturer. This allows us to offer an architectural solution with a wide variety of signal sources by integrating both solid state mass memory technology with high resolution 8mm tape recording. This technique will allow us to come very close to meeting the Navy's Common Mission Requirement with off-the-shelf, NDI hardware and software.

If you have any questions regarding our data management products or would like to discuss your particular requirements, please call me at (616) 361-8089.

Sincerely,

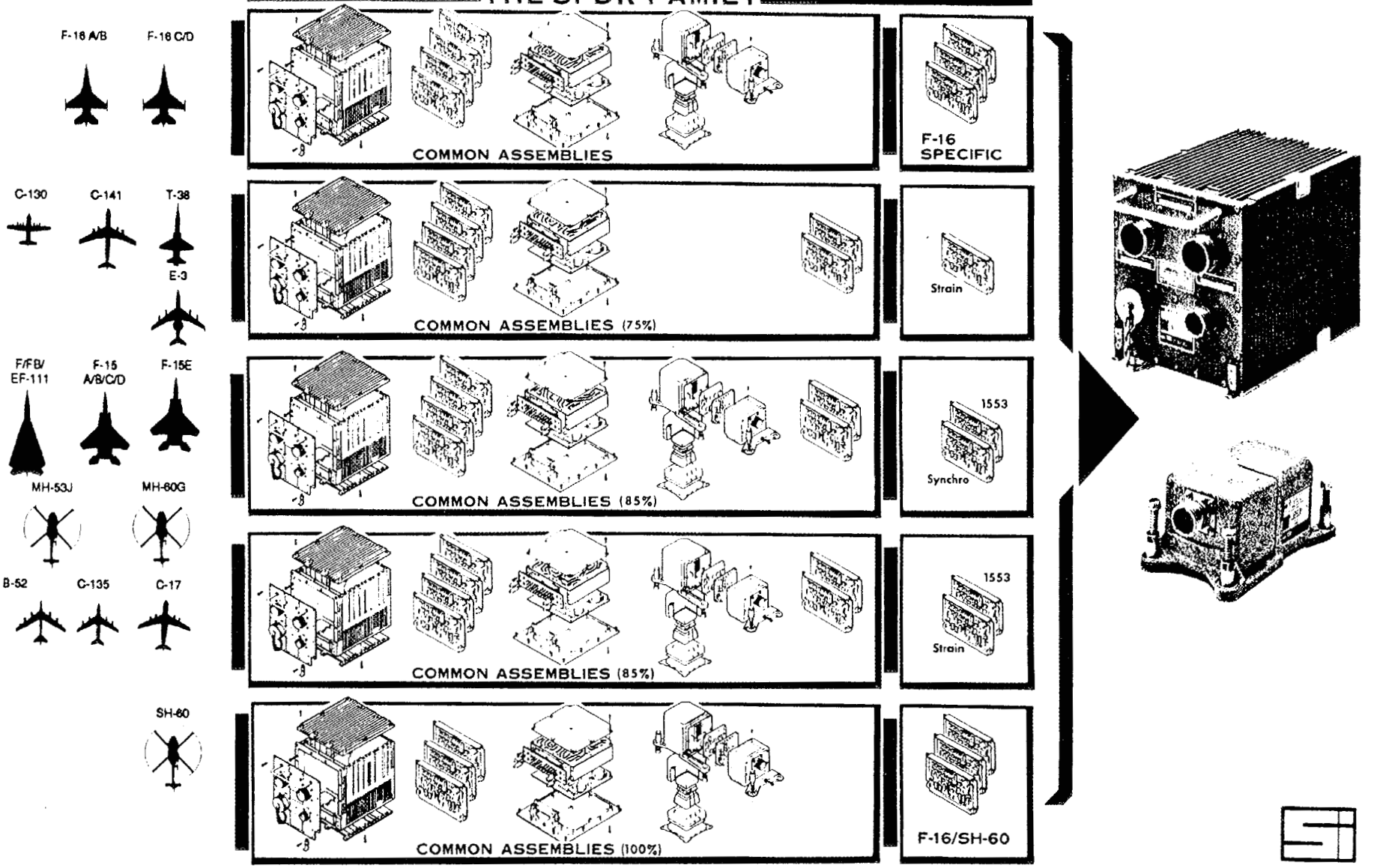
Stephen C. Gresley

Stephen C. Gresley
Manager, Standard Programs

TRI-SERVICE
FLIGHT
DATA
RECORDER

Standard Flight Data Recorder (SFDR)

THE SFDR FAMILY

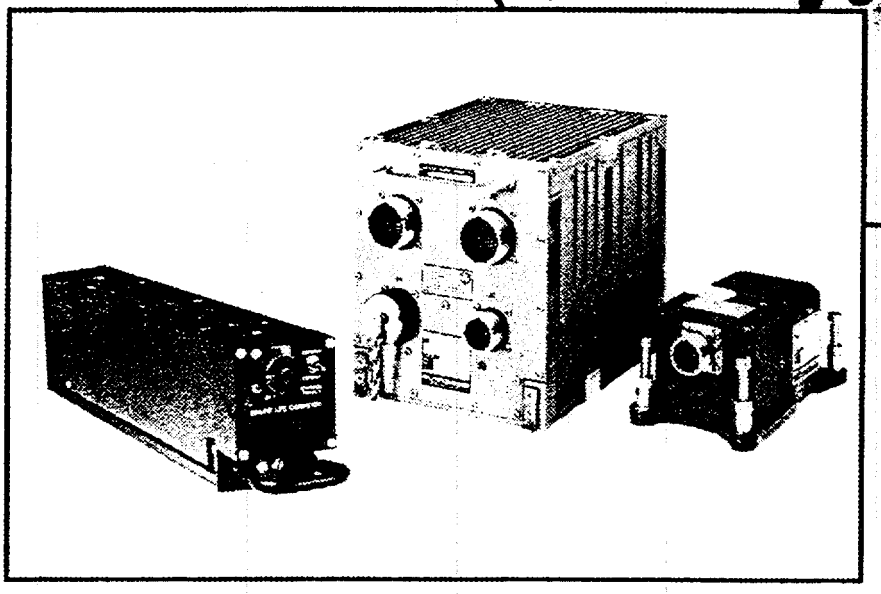


On-Board Maintenance System (OMS)

One step ahead in on-board maintenance systems

Smiths Industries worldwide resources have merged to create the diagnostic recording system. The technologies and experience of more than three decades with flight data recorders and engine health usage monitoring systems combine to put Smiths Industries one step ahead in on-board maintenance systems.

The diagnostic recording system marks the beginning of a logical evolution of mature products toward an analytical aircraft maintenance system.



Smiths Industries existing engine life computer and standard flight data recorder have been brought together into a single LRU system. The engine life computer functions not only record running hours and engine starts, but also provide real-time calculations of low cycle fatigue and 'snapshots' of data to highlight deviations, as well as recording excursion above defined limits. The standard flight data recorder functions to record structural, engine, tracking, maintance, mishap, and training/mission replay data.

Lower Cost of Ownership Through:

- **Lower Maintenance Costs**
- **Reduce Parts Usage**
- **Decrease Repair Time**
- **Reduce Maintenance Manpower**
- **Enhance Logistics Support**
- **Growth to Predictive Aircraft Maintenance System**

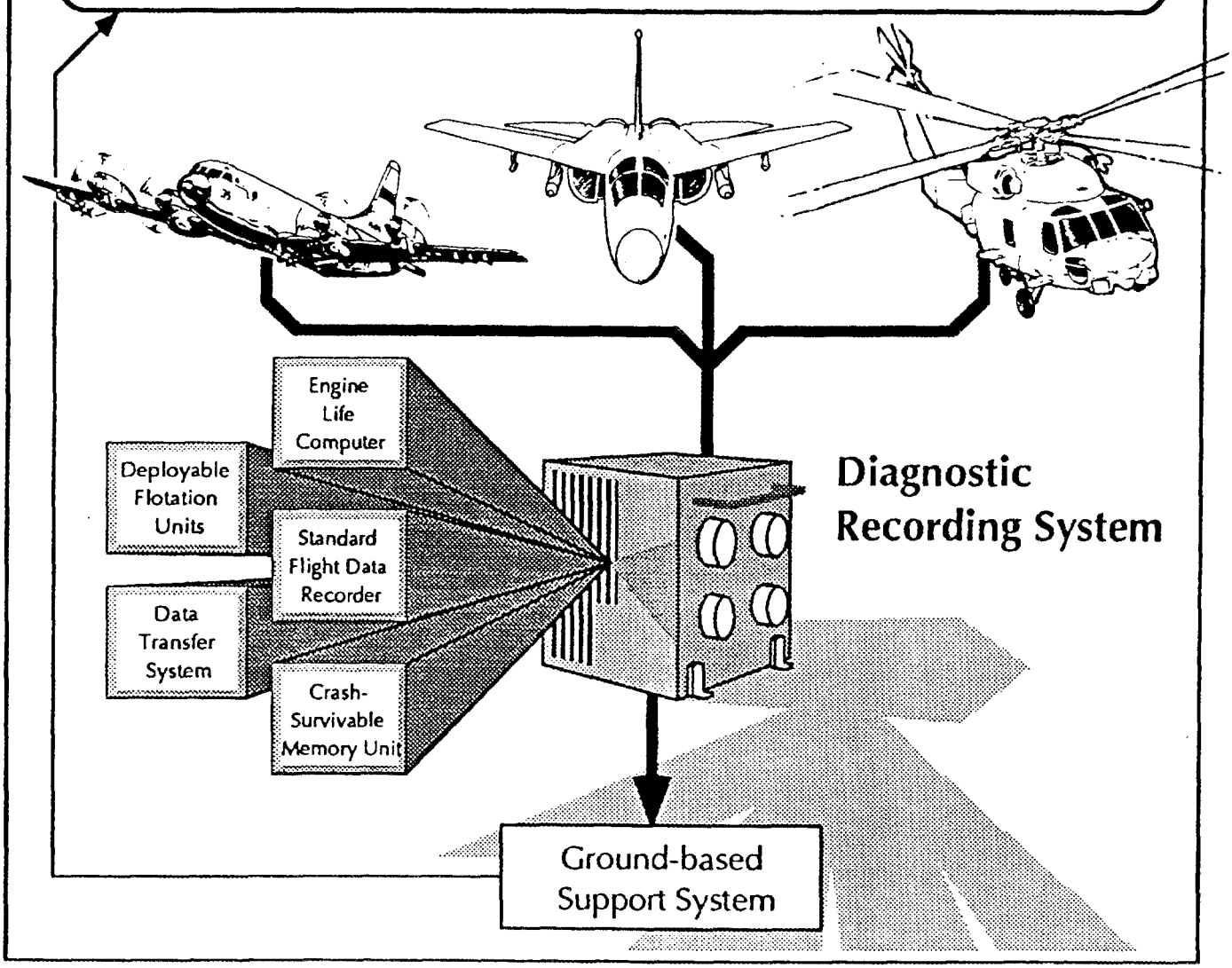
SMITHS INDUSTRIES
Aerospace Group

The Logical Choice—Worldwide

On-Board Maintenance System

On-board Diagnostic System Capability

- Data Recording
- Structural Loads & Environment
- Engine Health & Usage
- Transmission Health & Usage
- Rotor & Track Balance
- System Loading
- Automated Logbook
- Fault Diagnostics
- Training & Mission Analysis
- Corrective Action Recommendations
- Failure Prognostics
- Maintenance Scheduling
- Automated Logistics & Fleet Management System Interface
- Accident Investigation



SMITHS INDUSTRIES

GR-121D-0991

Winchester Road, Basingstoke, Hants., UK RG22 6HP
Tel: (0256) 843191 • FAX: (0256) 840355

4141 Eastern Ave., Grand Rapids, MI 49518-8727
Tel: (616) 241-7000 • FAX: (616) 241-7858

Data Transfer Interface Unit (DTIU)

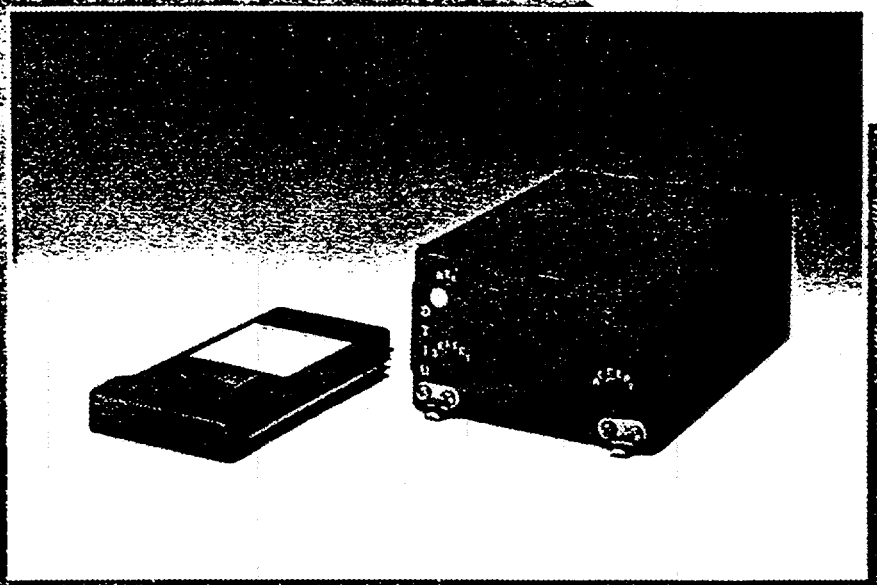
Simplifying Data Management

Smiths Industries, Aerospace Data Transfer Interface Unit (DTIU) and Programmable Cartridge (PC) provide an efficiency improved solution for recording, storing, and downloading data from Smiths Industries Flight Data Recorders (FDR). The DTIU and Programmable Cartridge simplify the process of handling and retrieving flight data by providing shirt pocket convenience and portability for recorded flight data.

Convenient, Cost Effective, and Easy to Use

The ruggedized Programmable Cartridge memory unit is highly reliable and about the size of a cassette tape. It eliminates the need for large, expensive, and awkward ground readout equipment and requires no more skill than needed to operate a cassette tape player.

The DTIU is an RS-422 interface receptacle. Other receptacles are available with 1553 interfaces. It is microprocessor controlled and implements a reprogrammable software program. A push button controlled sequential program is displayed on the DTIU eight character display (LED).



DTIU Functions:

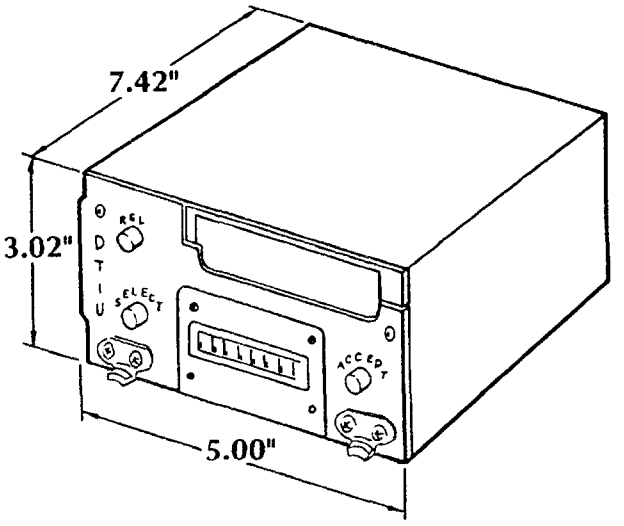
- Downloading memory
- Uploading OFPs and documentary data

Smiths Industries' Data Transfer Interface Unit (DTIU) takes information would normally be recorded into the Flight Data Recorder (FDR) and stores it in a memory unit. The unit's contents can be downloaded to a ground station for further processing and analysis.

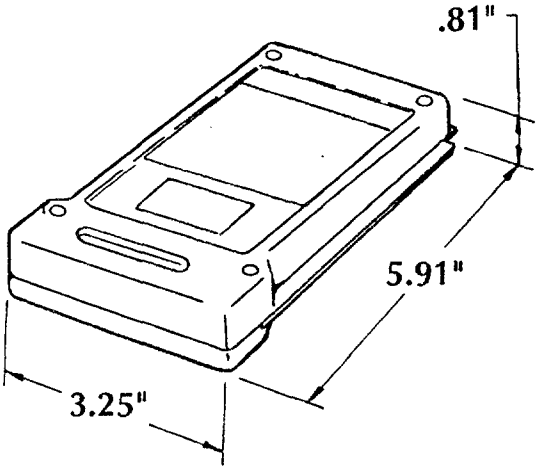
Designed from experience

Smiths Industries has extensive experience in the design, manufacture and support of Flight Data Recorders (FDR) and Data Acquisition Units (DAU) for military and civil aircraft. Our experience includes the development of the Flight Data Recorder for the Boeing 767 and the Data Acquisition Unit for the Boeing 747-400 and 767 aircraft.

SMITHS INDUSTRIES
Aerospace



Data Transfer Interface Unit (DTIU)
Model 3266E P/N 171246-01-01
Government Type No. J6005/A



Programmable Cartridge (PC)
Model 3245D P/N 171245-01-01
Government Type No. MU-1048/A

FUNCTIONALITY

Data Recording:

- Operational Flight Program (OFP) and documentary data is uploaded using the Programmable Cartridge as the memory transfer media.
- Standard Flight Data Recorder (SFDR) data is recorded into the Programmable Cartridge during flight.
- Receptacle displays the percent of the memory used and the system faults

Digital Computer Emulation:

- DTIU and Programmable Cartridge perform the following SFDR functions, eliminating the need for a digital computer:
  - Load Signal Data Recorder-Reproducer (SDRR) operational flight program
  - Load documentary data into SDRR non-volatile memory
  - Format standard flight data recorder memories
  - Clear usage accumulators and built-in-test records
  - Download Flight Data Memory Unit (FDMU) data
  - Download SDRR non-volatile memory
  - Download SDRR auxiliary memory unit (if installed)

HARDWARE

Programmable Cartridge (PC or Module):

- 512K words of battery-backed RAM (growth to 75M words)
- Hand-removable from DTIU
- Powered via DTIU
- MIL-E-5400 Class 2 environmental characteristics
- Predicted MTBF: 9,800 hours
- Size: 3.25" W x 0.81" H x 5.91" D
- Weight: 0.75 lbs.

Data Transfer Interface Unit (DTIU or Receptacle):

- RS-422 interface (SFDR YV1328 protocol)
- Motorola 68000 Processor
- Eight Character LED Display
- +28 VDC, 20 watts input power IAW MIL-STD-704
- MIL-E-5400 Class 2 environmental characteristics
- Predicted MTBF: 28,000 hours
- Size: 5.00" W x 3.02" H x 7.42" D
- Weight: 4.00 lbs.

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Aerospace
4141 Eastern Avenue, S.E. • Grand Rapids, MI 49518-8727 • Telephone: (616) 241-7000

Mass Memory Data Transfer Systems

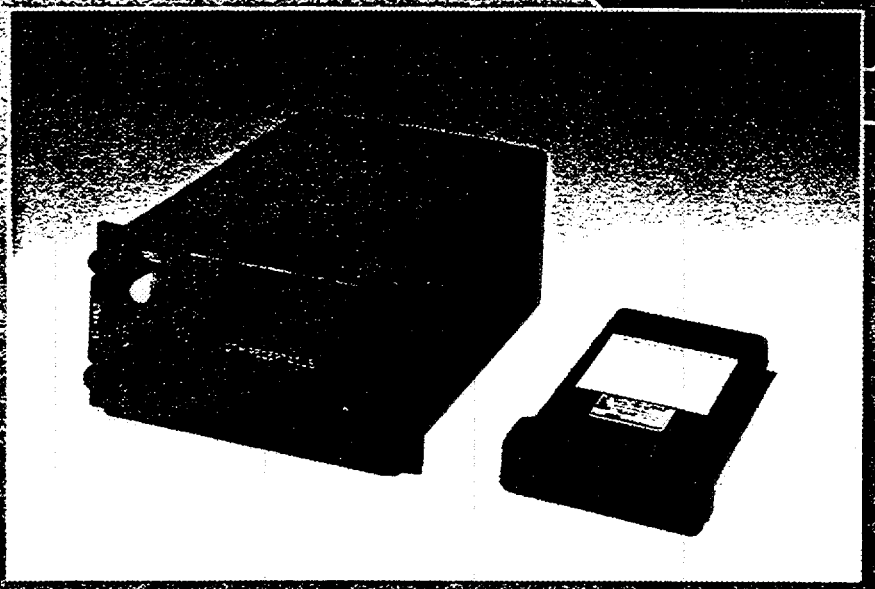
Designed for the Future Available Today

Smiths Industries, Aerospace offers its sixth generation shirt-pocket sized Data Transfer Module (DTM) for use within environmentally demanding military installations. This new family of DTM products incorporates the latest technologies in high density memories and electronic packaging.

Natural Product Evolution

The mass memory DTM retains the same physical and electrical form factor as units currently used within over 50 military applications worldwide.

The new portable DTM offers 40-150 Megabytes of transportable memory. Additional memory capacity growth to the gigabyte range is achievable.



Smiths Industries solid-state Mass Memory Data Transfer Systems (DTS) offer expanded selectability of Data Transfer Module (DTM) memory capacities. The miniaturized DTS family performs in-flight read/write functions during extreme environmental conditions.

A versatile family of processor managed DTM receptacles are available which can use both older and newer mass memory DTM's.

Designed from Experience

Extensive experience in miniaturized, high-reliability Data Transfer Systems (DTS) and Flight Data Recorders have contributed to the successful development of this state-of-the-art technology product configuration.

The Smiths Industries Mass Memory DTS is ready to satisfy present and emerging customer requirements for memory data uploading, storage and downloading.

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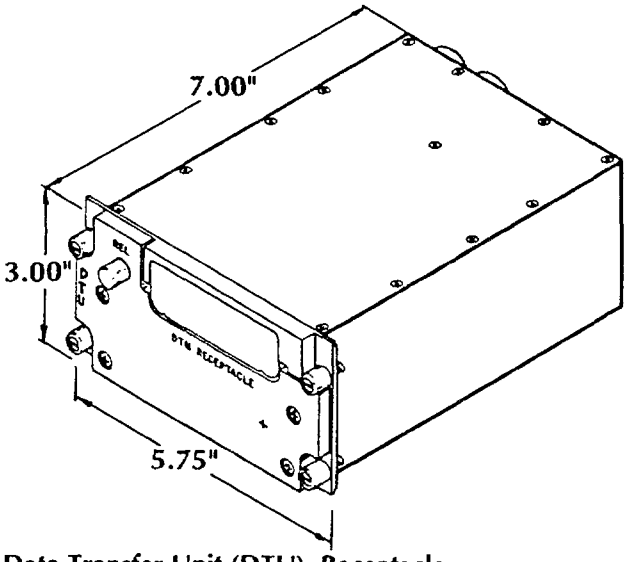
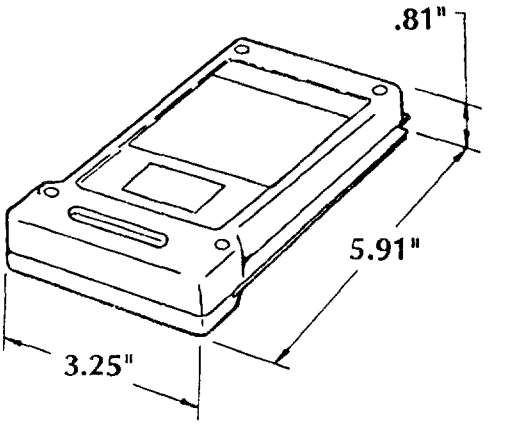
Aerospace



Data Transfer Unit (DTU), Receptacle
Model 3266H
P/N 172264-01-01



Data Transfer Module (DTM)
Model 3245E
P/N 172265-01-01

FUNCTIONALITY

Data Transfer:

- The portable DTM contains rugged high density non-volatile memory which is used to upload, record/store, and download vehicle data and operational programs.
  - Ruggedized read/write in-flight
  - Shirt-pocket convenience
- The DTM processor managed receptacle performs the following functions:
  - DTM interface to host vehicle designated interface(s)
  - Automatic DTM type/size recognition
  - Response to bus controller command(s)
  - DTM data management and fault tolerant processing
  - Memory scramble on command

COCKPIT HARDWARE

Module (DTM):

- 40-150 Megabyte non-volatile memory with growth to gigabyte range
- One hand insertion/removal from receptacle
- Powered via receptacle
- MIL-E-5400 Class I environmental characteristics
- Predicted MTBFF: 14,100 hours (Functional failures)
- Size: 3.25" W x 0.81" H x 5.91" D
- Weight: 0.75 lbs.

Processor Receptacle:

- Variable Interface (MIL-STD-1553B, SCSI, MIL-STD-1553B/SCSI)
- 68340 Processor
- 28 VDC or 115 VAC/400 Hz/ One Phase input power at 15 watts IAW MIL-STD-704
- Field reprogrammable
- MIL-E-5400 Class II environmental characteristics
- Predicted MTBF: 74,500 hours (MIL-HDBK-217F, 55°C ambient, airborne rotary wing environment)
- Size: 5.75" W x 3.00" H x 7.00" D
- Weight: 4.50 lbs.

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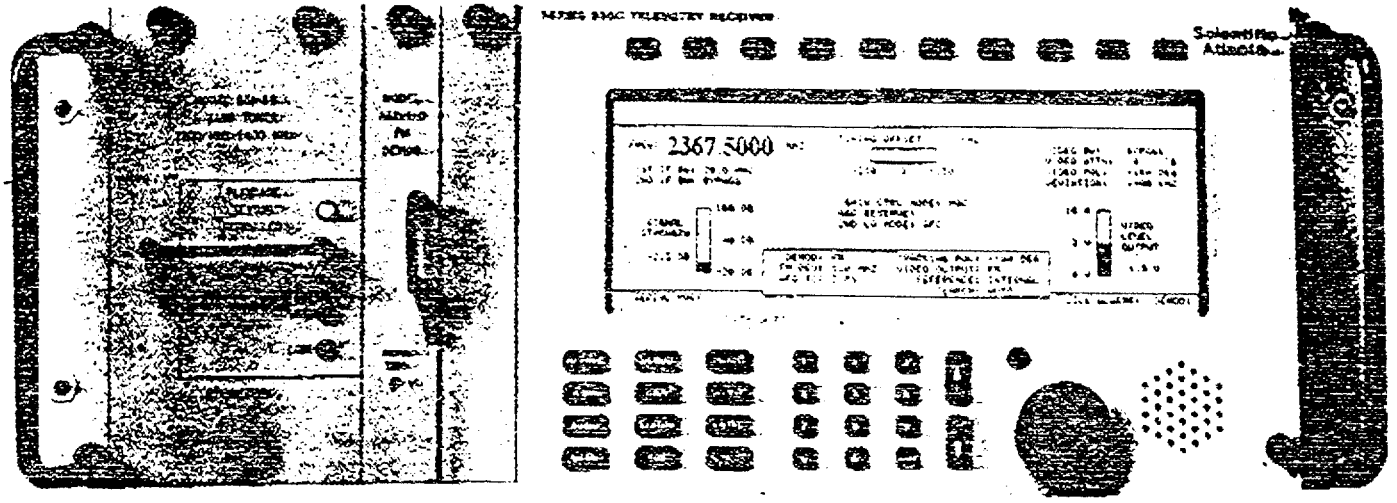
Aerospace
4141 Eastern Avenue, S.E. • Grand Rapids, MI 49518-8727 • Telephone: (616) 241-7000

APPENDIX E: TECHNICAL DATA FROM RADIO TELEMETRY VENDORS

Scientific Atlanta
Proxim

Scientific Atlanta
Instrumentation Group

Wideband Telemetry Receiver
Series 930C



High data rate multi-purpose telemetry receiver.

Features

- 40 MHz bandwidth (>20 Mbps data rates)
- Simple low-cost upgrade for existing 930B
- FM demodulation with up to ±20 MHz bandwidth
- Standard tuners can be used for wideband

Description

The Series 930C Wideband Telemetry Receiver is the new addition to the comprehensive Series 930 product line. The Series 930C accepts RF signals from 215 MHz to 2400 MHz by using a variety of plug-in tuners. A microprocessor unit controls the operation of the receiver, services the front panel display, and provides remote interface capability via RS232, IEEE-488 or RS-422. A front panel, high-contrast LCD display provides all status and tuning information. The receiver is configured using a menu driven "Hard Key," "Soft Key" approach which leads the operator through complete setup routines. Up to 10 complete setup configurations can be stored in non-volatile RAM memory. In addition, the 930C is capable of extreme high data rate applications (20 Mbps) in order to meet the requirements of the modern test environment.

Scientific-Atlanta, Inc.
1-800-848-7921

Real time telemetry station hardware will consist of off-the-shelf hardware which can support all standard telemetry bands.

The Scientific Atlanta telemetry receiver supports all bands via separate tuner plug-ins or a unique wideband frequency synthesized tuner. The wideband tuner was developed for TAG in Europe for support of Formula car real time telemetry. The wideband tuner offers immediate frequency band support for a wide variety of telemetry bands which may be available at a given site.

A brochure for the Model 930B telemetry receiver and Model 934 diversity combiner is enclosed. Diversity combining can offer off-the-shelf improvements in reception and data quality under certain operating conditions. Model 930C data sheets provide a good photographic depiction of the new receiver front panel on all Series 930 chassis. The Series 930 telemetry receiver offers complete remotability of all front panel control and status functions with the exception of on-off power and remote buss address. This unit would be very easily implemented in a roll-away-telemetry system for local and or track operations.

The Series 930 receiver offers a full family of IRIG standard front panel plug-in demodulators. These will support a wide range of off-the-shelf FM, PM, or BPSK modulations.

All telemetry hardware identified in this strawman design conforms to IRIG 106-86 standards. Scientific Atlanta is qualified through demonstrated expertise in fielding telemetry, tracking, and control systems meeting the most stringent military specifications.

An off the shelf bit sync and frame sync will be integrated to provide data to the display and processing subsystems. Representative data sheets are provided. Pre-D and post-D outputs from the 930B receiver will allow recording of the analog data for non-real time processing if desired.

Wideband Telemetry Receiver
Series 930C

Specifications

Receiver type
- Dual conversion; first conversion in tuner module. Second conversion in receiver chassis

Frequency range
- 215 MHz to 2400 MHz (tuner dependent)

Tuning increments
- 12.5 kHz or 50 kHz (tuner dependent)

Tuning accuracy
- 1 ppm

First IF frequency
- 160 MHz

Second IF frequency
- 70 MHz

Receiver bandwidth
- 10 MHz to 40 MHz

Dynamic range
- Noise level to -10 dBm

Spurious rejection
- 60 dB min

Spurious signals
- Internal spurious referred to receiver input less than -95 dBm

Noise figure
- 13 dB max

Image rejection
- 60/80 dB min (tuner dependent)

IF rejection
- 80 dB min

RF input impedance
- 50 Ω, unbalanced

Input VSWR
- 2.0 to 1.0 max; 1.5 to 1.0 typical

Demodulator options
- AM standard with FM, PM or BPSK optional

First IF, Model 930C Telemetry Receiver

Frequency
- 160 MHz center frequency

Selectable bandwidths
- 10, 20 and 40 MHz

First IF filter types
- 10 MHz
  - SAW filter
- 20 MHz
  - SAW filter
- 40 MHz
  - SAW filter

Amplitude variation
- ±0.5 dB over 80% of 3 dB BW

Phase response
- ±6° over 80% of 3 dB BW

Roll-off rate
- 1.3 to 1

Filter symmetry
- ±10%

AGC range
- 95 dB, min

First IF to second IF gain amplitude variation
- 50 dB ±3 dB

Delayed AGC applied
- 54 dB

Second LO Modes

Xtal
- Coherent (phase-locked) with receiver reference

VFO
- Digitally tuned by microprocessor. Stability ±10 ppm/°C

AFC
- Controlled by FM demod

AFC
- Controlled by PM or BPSK demodulators

EXT LO
- Externally supplied 2nd LO signal

Search and manual tuning range
- ±250 kHz min

Automatic Frequency Control (AFC)

Acquisition range
- ±250 kHz min

Tracking range
- ±300 kHz min

AFC time constants
- Selectable: 3, 15, 60, 300 msec

Automatic Gain Control (AGC)

Dynamic range
- 95 dB min

Time constants
- 0.1 msec, 1.0 msec, 10 msec, 100 msec, 1.0 sec; all ±10%

Linearity (ENV AGC) (Internal AGC bus, SIG STR outputs J16 and J17 and COMB AGC J20)
- ±1 dB from best fit straight line C/N IF of +5 dB to +30 dB ±2 dB from best fit straight line C/N IF of +30 dB to +110 dB

AM Demodulation

Bandwidth (1 dB)
- 5 Hz to 3 MHz

Distortion
- Less than 3% at 70% AM, measured at 10 kHz

Video Amplifier

Coupling
- AC or DC

Outputs
- Three buffered isolated outputs

Max output level
- 5V p-p

Output impedance
- 50 Ω or 75 Ω, optional

Rated output level
- 4 V p-p at 50% AM, or 40% of full-scale FM deviation

Attenuation range
- 0 to 63 dB in discrete 1 dB steps

Harmonic distortion
- 0.5% at rated output (at 10 kHz) 1.0% at max output (at 10 kHz)

Reference Frequencies

Internal
- Frequency
  - 100 MHz, temperature compensated crystal oscillator (TCXO)
- Stability
  - ±3 x 10^{-7}, 0°C to 70°C ±2 x 10^{-6} per year

External
- Frequency
  - 5 MHz or 10 MHz
- Level
  - 0 dBm to +17 dBm
- Input impedance
  - 50 Ω

Reference outputs
- Internal
  - 5 MHz, 70 MHz
- Rear panel
  - 5 MHz, 0 to +3 dBm, 50 Ω source impedance, VSWR 1.25 to 1.0

Physical

Physical dimensions
- 7 in. H x 19 in. W x 23 in. D

Color
- Semi-gloss grey, per federal-std-595A paint chip 26440

Weight
- 75 lbs max

Connectors
- Front-panel
  - 1 SMA female
- Rear-panel
  - 1 N-female
  - 23 BNC female
  - 1 15-pin D
  - 1 24-pin rectangular
  - 2 25-pin D
  - 1 IEC 3-pin

Power requirements
- Voltage
  - 115 V ac or 230 V ac, +10%, -15%
- Frequency
  - 47 Hz to 440 Hz
- Power
  - Less than 130 Watts

Environmental

Operating temperature
- 0°C to 50°C +32°F to +122°F

Storage temperature
- -40°C to +65°C -40°F to +150°F

Operating Humidity
- 0 to 90% relative humidity

Atmospheric pressure
- Storage
  - Sea level to 50,000 ft
- Operating
  - Sea level to 15,000 ft

EMI/RFI
- Designed to MIL-STD-461B

Unless otherwise noted, specifications are typical. Specifications and product availability are subject to change without notice.

Scientific Atlanta

Our customers are the winners.

United States: 3845 Pleasantdale Road, Atlanta, GA 30340-4268, Tel: 404-903-2308, Fax: 404-903-2395; Garden Grove, CA, Tel: 714-898-3658; Menlo Park, CA, Tel: 415-326-4018
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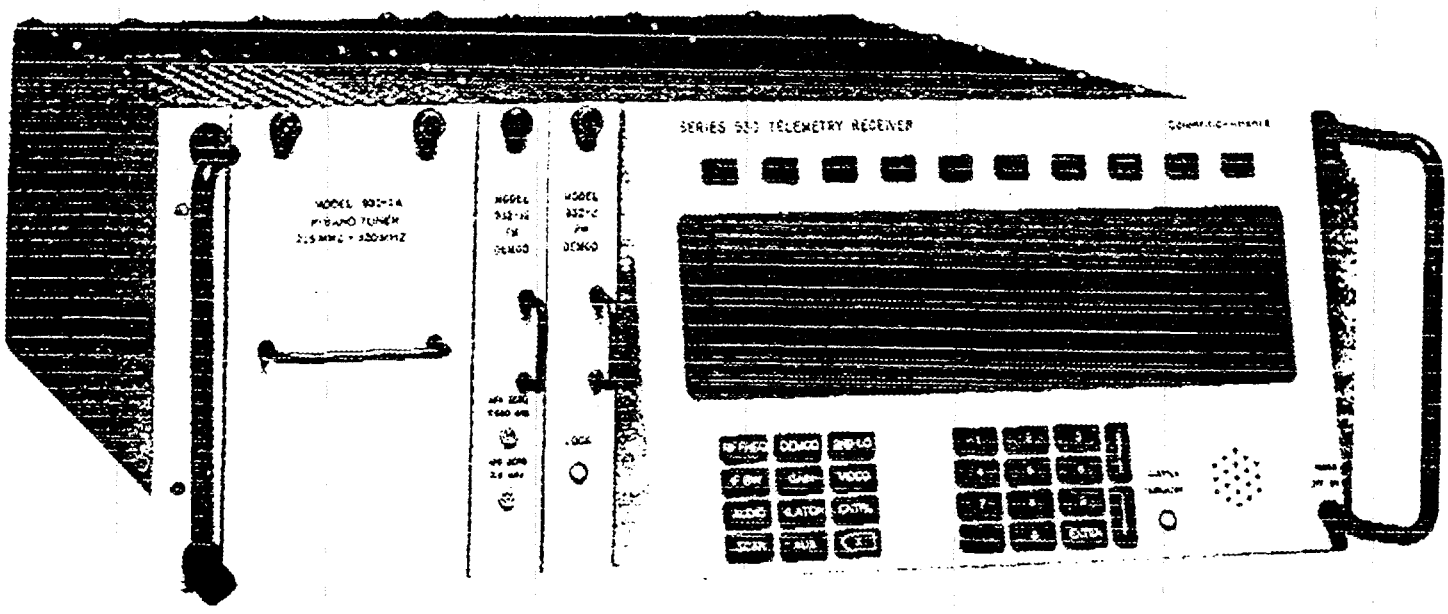
Series 930 Telemetry Receiver



Features and Advantages

- Dedicated multi-microprocessors provide control of all receiver functions, status, and controls.
- Non-volatile memory stores on-line and up to 10 programs, with instant activation and verification.
- Dedicated microprocessor powers the user-friendly, menu-driven front-panel status, controls, and displays. Fast pushbutton data entry selection and selection of program options.
- Adjustable, easy-to-read LCD menu screen, with appropriate digital and/or analog display, provides continuous display of critical functions and modes.
- Data entry lockout control.
- All status and control information presented in a common focal area.
- Local or remote control via both IEEE-488 and RS-232C/or RS-422 interface ports, with both ports simultaneously available, both with identical format and protocol.
- Total master-slave operation via serial interface.
- Raises the term 'User-Friendly' to higher levels of achievement.
- Superior stability and coherence with digitally tuned, ultra-high stability low-phase noise synthesizers and phase-lock oscillators.
- Advanced design symmetrical filters.
- Microprocessor controls all AFC/APC functions, including selection, time constants, autosearch, search range, search offset, search delay, and carrier threshold level.
- Complete control and reporting of AGC facilitates the easy automation of solar G/T and other system testing and calibration.
- All standard telemetry bands, meets or exceeds all IRIG standards and formats.
- Advanced modular design and construction.
- Automatic frequency scan.
- Double or triple conversion receiver.
- 70 MHz or 160 MHz first IF, with 20 MHz second IF.
- Full range of front-panel plug-in RF tuners.
- Two front-panel plug-in slots for FM, PM, BPSK demodulators.
- Internal AM demodulation.
- Three internal First IF filters.
- Up to seven internal module Second IF filters.
- Eleven, plus one bypass, internal video filters.
- Internal SDU with full signal display reflected on receiver viewing screen, full remote control via either remote port.
- Fully remotable, Pre-D multifrequency playback converter is housed as a PC board in the companion RF tuner, or as a stand alone plug-in.
- Fully remotable, Pre-D multifrequency record converter plugs into the right hand front-panel demodulator slot.
- Pre-D record and playback converters cover all standard frequencies plus the fully programmable synthesized LO selects any frequency from 100 kHz to 4.0 MHz in 12.5 kHz steps.
- Space saver - with simultaneous installation in the receiver of an SDU, Pre-D record and playback units, tuner, and demodulator.
- Two demodulators or one demodulator and one record converter may be simultaneously housed in the receiver.

- The receiver and the companion Model 934-2 Diversity Combiner provide a superior, advanced design, true signal combining system. Provides simultaneous optimum combining of the pre and post signals with true AM/AGC weighting. Eliminates the master-slave signal dependency. The design also solves signal fade and dropout without ambiguities in phase or data.
- Programmed 15 year operational life, rugged, reliable, maintainable.
- MIL-STD-461B qualified.
- Self-test function checks.
- Operates without a cooling fan.
- Single, discreet and removable robust power supply with primary and secondary fusing.
- Front panel speaker and volume control.
- User-friendly operating and training.
- The best performing, versatile, most cost-effective single telemetry receiver available. A superior selection for simple to complex, small-to-large operations in any environment.

Applications

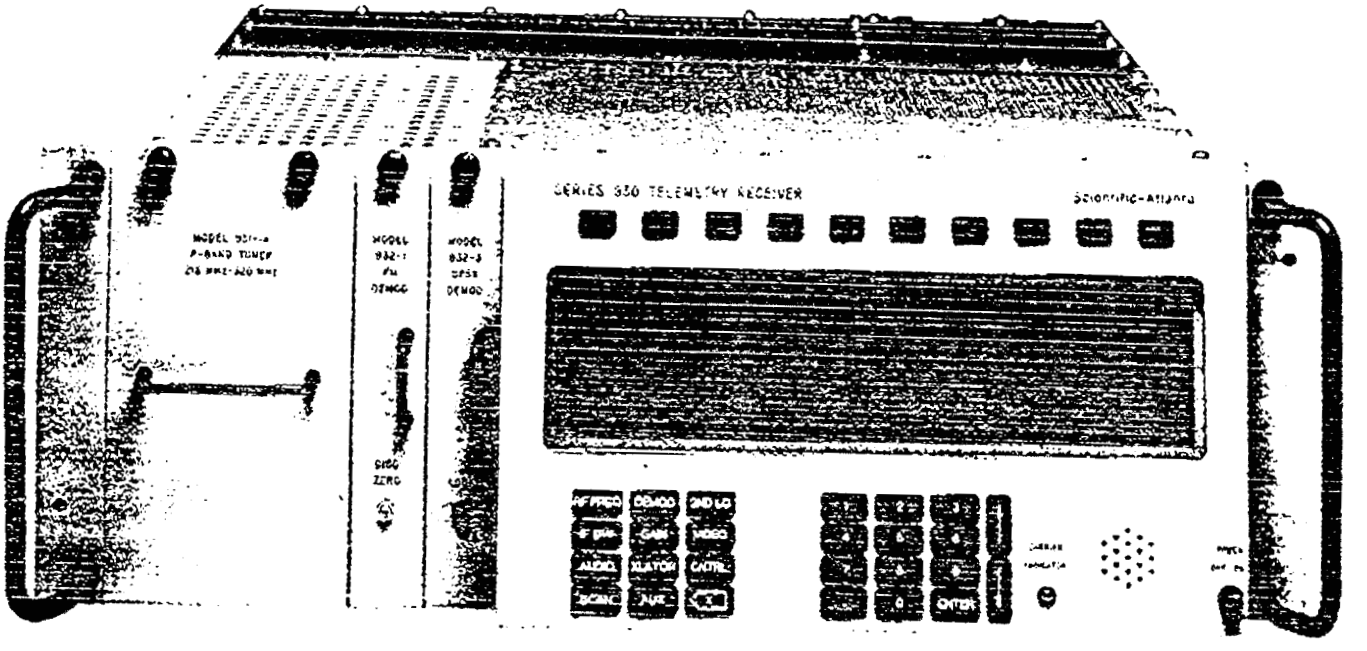
For over 20 years, Scientific-Atlanta, Inc., a Fortune 500 Company, has designed and built superior multi-purpose telemetry receivers and components which have established new industry standards. The Series 930 Telemetry Receiver system continues that standard of performance.

At a competitive price, the Series 930 Telemetry receiver is the most technologically advanced, best performing, true multi-purpose single receiver available. The receiver meets or exceeds all current receiving requirements and is inherently designed to accommodate future requirements. Standard performance and operating features are included which are normally provided as expensive options, modifications, or add-ons.

The full modular construction and carefully designed mainframe provides for a full range of external and internal plug-in components, options, and accessories. The receiver and its components provide exceptional performance through ultra-high stability, low-phase noise synthesizers, and advanced design arithmetically symmetrical filters. Digitally tuned synthesizers and phase-locked oscillators produce superior stability and coherence. A dedicated microprocessor provides the front panel data entry, program and program option selections, and the innovative menu-driven status display viewing screen. The 'user-friendly' front panel provides complete status and control of all functions and configurations, and automatically configures interrelated parameters for optimum performance. The Series 930 Telemetry Receiver is the cost-effective solution for simple-to-complex telemetry reception for any requirement in any operating environment.

Some typical applications include:

- Processing standard or unique telemetry data
- Reception of C^2 telemetry
- Reception of satellite remote sensing and meteorological data
- General antenna tracking systems
- Reception of video from airborne platforms
- Reception of weather balloon and radiosonde data
- Modulation monitoring for uplink systems
- Predetection record and playback signals
- Two-channel polarization, frequency, and space diversity systems, with two receivers and one Model 934 Diversity Combiner
- Automated test systems, local or remote
- Total master-slave operations, RS-422
- Automated operations, total remote control via RS-232C and IEEE-488
- Ultra-stable RF tuner for doppler measurements
- Small-to-large volume operations demanding precise, multiple programming



Description

General

The Series 930 Telemetry Receiver is a dual or triple conversion, full-line, solid state, general purpose, advanced performance receiver. It meets or exceeds all appropriate IRIG standards and formats, and is designed to meet tough environmental standards. The receiver is fully modular in design and construction with all internal and external modules fitting into a carefully planned mainframe. The Series 930 Receiver optimizes the union of proven design and technology with advancing technology and design. The result is exceptional stability and coherence from the use of digitally tuned synthesizers and phase-locked oscillators, and superior linearity and accuracy.

Dedicated microprocessors control receiver functions, the Second LO Search functions, and the front-panel control and status functions. A quasi-static BUS structure connects the sensitive areas of the receiver to the control and monitor microprocessor. This BUS uses controlled rise and fall times, is interrupt driven, and remains in a static state during all normal receiver operations. BUS activity only occurs during a change of receiver configuration, which minimizes internal spurious emissions and excess noise. The use of CMOS logic for digital circuitry and efficient power dissipation throughout allows the receiver to operate without a cooling fan, which further reduces noise level and improves reliability.

The receiver and its companion diversity combiner are fully tested to MIL-STD 461B requirements. The fully solid-state receiver uses double-shielding techniques for high dynamic range operation and excellent EMI/RFI characteristics. Multi-layer motherboard power and control distribution along with terminated coaxial cable distribution of all RF and baseband signals provides high reliability, high performance, and ease of maintenance. The robust power supply exists as a single descrete removable unit and features primary and secondary fusing. Rugged modular packaging, the extensive use of integrated circuitry, and low-power LCDs contribute to reliability and performance over an extended operational life.

The Series 930 has been carefully designed for easy operation. It minimizes the operator attention so often required in highly automated and sophisticated operational environments. The dedicated microprocessor provides complete control of operational functions and interfaces for remote and host computer operations. The front-panel menu and keyboard controls provide complete control and monitor of all control functions and configurations.

The receiver is the foundation for a comprehensive product line of components required in the reception and processing of telemetry signals. Its configuration versatility is ideally suited for the various frequency bands, modulation formats, and signal bandwidths required in telemetry reception. The 930 Receiver is operationally configured through the selection of front-panel plug-in and internal receiver components.

Standard Models

The Series 930 Receiver is available in two basic models: The Model 930A with a 70 MHz First IF and 20 MHz Second IF, and the Model 930B with a 160 MHz First IF and 20 MHz Second IF. The design ensures out-of-band LOs and very clean response with efficient gain distribution. All LOs are coherent to a common reference. Both contain three internal First IF Filters with the internal capability to house up to seven Second IF Filters. Both contain internal AM demodulation, and 11 plus one bypass internal Video Filters. Common-use and specific-use operating modules, components, options, and accessories are available for both models.

Data Demodulators

Three front-panel plug-in data demodulators, FM, PM, and BPSK, are available for the standard configuration. Two demodulators can be installed simultaneously and either can be selected for use via local or remote control. When configured with two demodulators, with a parameter setup for the reception of both, only one is selected to drive the post-demodulation filter/amplifier and the AFC/APC Loop. As a means to record while continuing to demodulate in real time, a multi-frequency predetection record converter can be installed in the right hand demodulator slot.

RF Tuners

Front-panel plug-in RF tuners cover the frequency range 215 MHz to 4.2 GHz. For both stability and low-phase noise, the synthesizer is phase-locked to a 5 MHz reference from either the internal or an external source. The First LO synthesizer output is microprocessor controlled with the output displayed on the front-panel display screen. Noise figures of 12 dB or less are common to all tuners.

2nd IF Filters

Up to seven second IF filters can be housed inside the receiver. Three basic filter families are available. LC Linear Phase, Crystal (Linear Phase), and Constant Amplitude Equalized: The LC Linear Phase are true linear-phase (Bessel) filters in bandwidths from 150 kHz and 12 MHz; Crystal filters covering the narrower bandwidths from 10 to 100 kHz; and, the Constant Amplitude Equalized contain group-delay equalization, in bandwidths from 300 kHz to 12 MHz.

Remote Control

Parallel IEEE-488 and Serial RS-232C remote ports for remote control operations are located on the rear panel, along with a master/slave RS-422 port. The remote interfaces are available simultaneously and use identical formats and protocol for easy system integration. The RS-422 interface totally slaves interconnected units to the master unit. Non-volatile memory program storage allows both local or remote control of up to ten programs plus the current configuration. The IEEE-488 and either the RS-232C, or RS-422 ports are standard features.

Non-volatile Memory Program Storage

Non-volatile memory storage protects up to ten programs, plus the current configuration. Microprocessor controls provide quick and easy review and alteration of all stored programs. The non-volatile memory protects current and stored programming from the loss of power or when the unit is turned off.

Saves Auxiliary/Accessory Space

The Series 930 Receiver design provides for the simultaneous installation in the receiver of an SDU, Predetection Record and Playback units, a Tuner, and a Demodulator. The SDU is an internal module with the signal display reflected on the receiver viewing screen. The Predetection Playback Converter can be housed as a PC board in the tuner. The Predetection Record Converter plugs into the receiver's right hand plug-in slot, leaving two plug-in slots for the Tuner and the Demodulator.

Front Panel Controls

A dedicated microprocessor serves all front-panel controls and continuously displays all pertinent program and operating functions on the LCD viewing screen. The receiver control front-panel provides a numeric entry keypad, 12 control function keys, and a row of 10 action/option keys across the top of the LCD screen. The selection of a control function key presents a menu of selection options below the option keys. The receiver will automatically reconfigure in response to the option/action selected and display the changed configuration on the viewing screen. Receiver configuration and status is located in a common focal area with all parameters displayed in both digital and/or analog format, as appropriate. This system has been carefully designed for rapid, user-friendly operation, with menu-driven sequencing for setups and programs.

Options

Available options include:

- Center Frequency Monitor
- First LO Monitor Output on RF Tuner
- BPSK Demodulator/BSSC 6.25 MB/s.

Accessories

Available accessories include:

- Pre- and Postdetection Record and Playback Translators
- 10 MHz Translators – Up and Down Converters
- 10 MHz/Record Translator
- Internal Module Spectrum Display Unit
- Accessory Kit.

Series 930 Telemetry Receiver Model Numbers

Model 930A (70 MHz/ 20 MHz)	Model 930B (160 MHz/ 20 MHz)
931–1A P-Band Tuner 215–320 MHz	931–1B P-Band Tuner 215–320 MHz
931–6A C-Band Tuner 3600–4200 MHz	931–2B L-Band Tuner 1435–1540 MHz
	931–3B L-Band Tuner 1650–1750 MHz
	931–4B L-Band Tuner 1700–1850 MHz
	931–5B S-Band Tuner 2200–2300 MHz
	931–7B S-Band Tuner 2300–2400 MHz
	931–8B S-Band Tuner 2200–2400 MHz (–80 dB Image Reject)
	931–9B 375 MHz Fixed Frequency Tuner
	931–10B S-Band Tuner 2200–2400 Mhz (–60 dB Image Reject)

Common Modules

Series 932 Demodulators
Series 932–1 FM
Series 932–2 PM
Series 932–3 BPSK
Series 932–4 BPSK/6.25 Mb/s BSSC
Series 933 Second IF Filters
Series 933–1 Linear Phase
Series 933–2 CAEQ
Series 933–3 XTAL
Series 934–3 Pre-D 20 MHz Record Translator
Series 934–6 10 MHz Translator
Series 934–7 Pre-D Record/10 MHz Translator

Other Options

First LO Monitor Output Port on RF Tuner
Center Frequency Monitor

Other Accessories

Series 934–1B Spectrum Display Unit
Series 934–4B 20 MHz Playback Translator
Series 934-8B 10 MHz Upconverter

proxim

Date: July 20, 1993

Name: Don Brady
Company: Scientific Atlantic

Fax # 619-679-6200

From: Matt Aver

Dear Don:

Thank you for your interest in the **ProxLink™** family of wireless asynchronous RS-232 products. Enclosed please find the information you requested.

ProxLink is designed for users who need to extend asynchronous connectivity to locations that are difficult or expensive to wire or have wireless connectivity requirements extending to 800 feet or more. In essence, a pair of ProxLinks acts as a wireless replacement for an RS-232 cable. The standard product supports a range of up to 500 feet, and our XR "extra range" model can operate up to 800 feet or more, depending on the operating environment.

From the factory floor to office settings to outdoor environments, no RF communication is more reliable than ProxLink's spread spectrum. Installation is easy and no FCC site license is required.

ProxLink is designed for applications such as:

- Factory floor data collection and NC downloading
- Connecting dumb terminals to a host
- Point-of-sale applications
- Building to building line-of-sight communications
- Process monitoring
- Any difficult or extended distance RS-232 connection

Enclosed please find the information you requested. If you need further information or would like the name of the Proxim Representative nearest you, please call us at (415) 960-1630.

Thank you for your interest in Proxim's **ProxLink**.

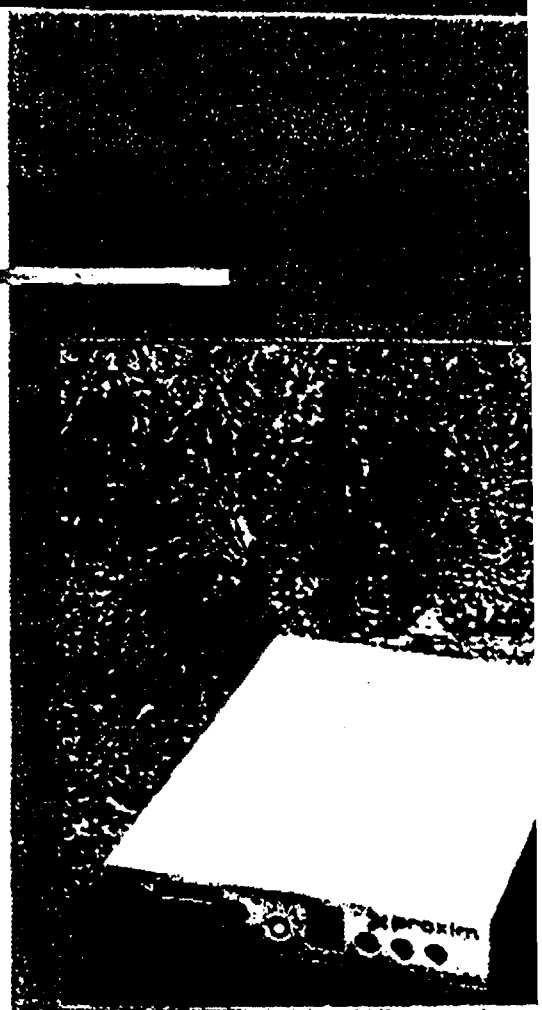
Sincerely,

Matt Aver
Account Manager

Proxim, Inc.
295 North Bernardo Avenue
Mountain View, CA 94043
(415) 960-1630 Fax: (415) 964-5181

ProxLink™ Radio Module

Wireless RS-232 Connectivity



Overview

ProxLink provides a simple and reliable wireless replacement for any RS-232 link. Utilizing Proxim's unique spread spectrum RF technology in the FCC approved 902-928 MHz band, ProxLink units communicate through walls and other obstructions.

The standard ProxLink offers excellent intermediate range of about 500 feet, while the ProxLink/XR provides extended range capabilities of 800 feet or more, depending on the specifics of the operational environment. (These distances can be achieved, "out of the box" anywhere in the United States, without the need for an FCC site license.) ProxLinks are shipped with an antenna, RS-232 cable, power supply, and a full one year warranty.

ProxLink's multiple channel options and robust built-in network protocols support numerous modules operating simultaneously without interfering with each other. Units can be paired in a simple "pass through" point-to-point mode or operated in various other topologies, utilizing the programmable packetized mode capability.

Benefits

- *Plug-and-Play Installation* - wireless RS-232 in minutes
- *No FCC Site Licensing* - ProxLink gives the user control of their own airwaves —without government licensing.
- *Guaranteed Error-Free Communication* - Spread spectrum radio and 100% error detection ensure reliable communication every time.
- *Exceptional System Performance* - RS-232 data rates up to 19.2 Kbaud (full duplex) handle demanding serial applications.
- *Flexible Configuration Stored in EEPROM* - A wide range of baud rates and flow control options can be selected and saved in ProxLink's non-volatile memory.

Applications

- Data Collection
- Measuring Systems
- Process Monitoring
- Desktop/Laptop Computers
- Remote Printers
- Environmental Monitoring
- Security Systems

Devices

- Serial Terminals
- Card Readers
- Personal Computers
- Scanners
- Printers
- Programmable Logic Controllers
- Handheld Data Recorders

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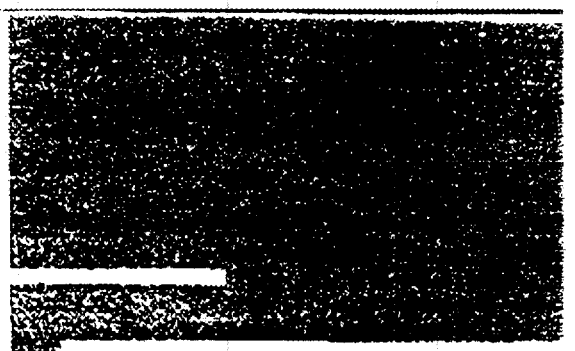
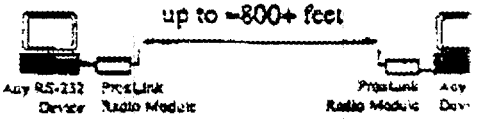
ProxLink™ Radio Module

Wireless RS-232 Connectivity





Specifications — *ProxLink Models*

	ProxLink	ProxLink XR
Serial Interface		
Data rates	1200, 2400, 4800, 9600, 19,200 baud	
Data format	8 data bits, no parity, 1 stop bit	
Connector	9-pin female D connector	
Flow Control	CTS, DSR, XON/XOFF	
Radio*		
Power output	100mW(nominal)	500mW(nominal)
Data rate	242 Kbps	121Kbps
Independent channels	3	4
Range	up to 500+ feet	up to 800+ feet
Frequency band	902-928 MHz	
Power Requirements		
Power connector	2.5mm male DC power jack	2.5mm female DC power jack
Voltage	6-9V	9V (9.5V max.)
Maximum current	250 mA	350mA
Typical current	150mA	
Packaging		
Antenna	3.625"	
Module size (w/o antenna)	4.0" x 6.50" x 0.75"	
Weight (with antenna)	12 ounces	
Status LEDs	Power, Carrier Detect, Receive Data	
Environment		
Temp. (operating/storage)	-20° to +60° C/ -50° to +85° C	
Relative humidity	20% to 90% (non-condensing)	

* Proxim's ProxLink radio modules are certified under the FCC's (Part 15) spread spectrum regulations allowing for their non-licensed use in the United States.

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Mountain View, CA 94043
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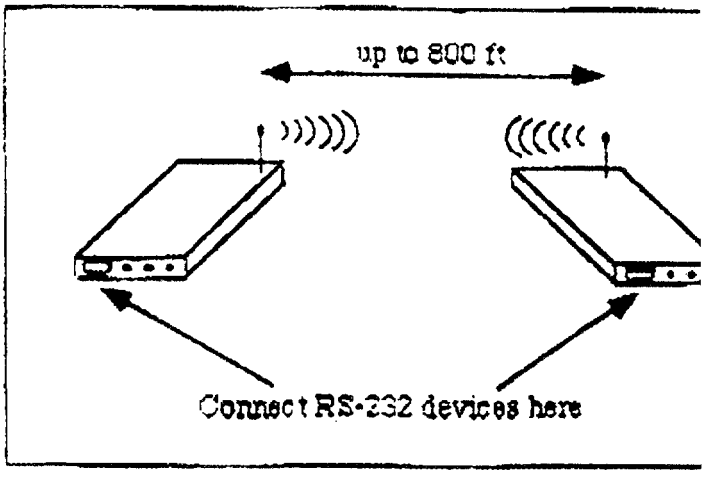
PxLk 12/92

ProxLink/XR™ Q&A

Questions and Answers about ProxLink/XR Radio Modules from Proxim, Inc.



What is ProxLink?

ProxLink is a spread spectrum radio module which permits almost any RS-232 connection to be replaced with a transparent wireless connection. You simply plug your RS-232 devices into a pair ProxLinks and obtain a wireless RS-232 link with a range of up to 800 feet with the XR version.

How does it work?

ProxLink uses spread spectrum radio signals in the 902-928 MHz range to pass the RS-232 data st through the air. Spread spectrum technology offers excellent interference rejection and requires nc user FCC license. The signal will penetrate most walls, glass, wood, plaster, and other commonly obstructions. Unlike other wireless systems, ProxLink does not require line of sight positioning.

How would I install ProxLink?

You will need a pair of ProxLinks in order to wirelessly connect two RS-232 devices together -- o ProxLink at each end. The ProxLink units draw power from a wall outlet using the AC adapter inc with each ProxLink module. Once the units are plugged in, your RS-232 devices can be connectec the serial port on each unit. Installation typically takes less than an hour.

What is the maximum and typical ranges achieved with ProxLink?

Typical ranges for ProxLink are summarized in the table below:

Environment	Range
Indoors, unobstructed environment such as a warehouse	~800 feet
Indoors, through typical indoor obstructions	~200-500 feet*
Outdoors, with line of sight	~1 mile or more

* Depends on environment

What RS-232 data rates are supported?

ProxLink supports 1200, 2400, 4800, 9600, and 19.2K baud data rates.
Data format: 8 data bits, 1 stop bit, no parity

What if I want to operate multiple pairs of ProxLink units in the same facility? Won't they confuse each other?

No! Each ProxLink unit contains a high speed radio transceiver and a network controller which transmits the RS-232 data stream using rapid radio bursts that are only received by the unit that the ProxLink is paired with in the point-to-point pass through mode. If multiple pairs of ProxLink units are operating in the same area, each pair interleaves its radio bursts with the others, cooperatively sharing the radio "backbone". Four separate channels effectively quadruple the available bandwidth.

At what data rate does the ProxLink radio system actually transmit data?

Although the ProxLink unit accepts RS-232 data at a maximum rate of 19,200 baud, the radio network system upon which ProxLink is based operates at 121,000 baud. The high speed of the radio is what permits multiple pairs of ProxLink units to "share the airwaves" without slowing down or confusing each other.

What flow control options does ProxLink's serial interface support?

ProxLink supports "in-band" flow control (CTL-S, CTL-Q which is also known as XON/XOFF). ProxLink can be configured to generate XON/XOFF, recognize XON/XOFF or both generate and recognize XON/XOFF.

ProxLink can also be configured to generate the CTS signal and respond to an RTS signal.

How are these ProxLink options selected?

Each Proxlink unit contains firmware which allows the user to set the parameters which control the behavior of the ProxLink unit. To activate the configuration firmware, the user connects an ASCII terminal to the ProxLink's serial connector and presses the small configuration button on the ProxLink device. When this is done, the ProxLink unit displays a menu on the terminal (note that a PC running terminal emulation software may also serve as a terminal).

Once the ProxLink is in terminal mode, it is very easy to set the parameters which control the RS-232 configuration (flow control, baud rate, etc). As each parameter is selected and changed, the settings are recorded in the ProxLink's nonvolatile EEPROM storage. Once a configuration has been selected, the ProxLink will remember the settings, even while it is turned off.

After parameter settings have been selected, the user can start the ProxLink unit from the menu by selecting "Launch Operating Mode". The unit will start up ready to accept data in the new configuration.

What kind of warranty and support does Proxim offer?

Each ProxLink unit comes with a full one (1) year warranty.
Technical support is available from Proxim at (415) 960-1630.

How can I obtain more information about ProxLink?

For information about ProxLink and the name of your local Proxim representative, contact Proxim at (415) 960-1630.
We may also be reached by FAX at (415) 964-5181.

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APPENDIX F: TECHNICAL DATA FROM SATELLITE TRANSMISSION VENDORS

Scientific Atlanta
QualComm

Scientific Atlanta

Network Systems Group

Application Note

MapStar™ Automatic Vehicle Location Software

Scientific-Atlanta's MapStar™ Automatic Vehicle Location (AVL) software package provides the dispatcher interface for fleet communications and tracking. Utilizing the global satellite system, Inmarsat, a consortium of 65 countries, MapStar™ is connected with Scientific-Atlanta's MariStar™ or TerraStar™ products to provide real or near real time two-way communications between the dispatch office and mobile vehicles anywhere in the world.

Scientific-Atlanta's TerraStar™ -C/MariStar™ -C Terminal is one example of an Inmarsat Earth Station that can be used to communicate with the mobile vehicle/vessel using MapStar™.

Features

MapStar™ has a number of flexible features including:

- Vehicle/Vessel Tracking for Entire Fleet
- Cartographic Flexibility
- Variable Communications Interface
- Two-way Communications
- Stand-alone Configuration
- Front-end Communications for Midrange and Mainframe
- Compatibility with TerraStar-Hub™ Network Router

Description

MapStar™ is a graphic display, communications, and database management system for vehicle tracking applications. Users will be able to track vehicles, send and receive messages, establish data communications, and obtain vehicle status reports.

Vehicle locations are displayed on maps, which may be customized to the user's specific requirements, providing an interface for the user to the map display and two-way communications. Using MapStar™, the dispatcher can monitor in real time the location, speed and ETA for all vehicles in the fleet, and send and receive messages.

INMARSAT
System Provider

Scientific-Atlanta, Inc.
Fax - 404-903-5346

Full Features of MapStar™

Vehicle/Vessel Tracking

- Receives position data and plots vehicle's exact location on map or chart
- Position options available:
  - Latest position
  - Last known/communicated position
  - 1 to 24 hour period
  - Archive Files
- Supports the following services:
  - GPS Lat/Long, course & velocity
  - Time and date sent
  - Time and date received
  - Sensor status reports
  - Forms filing
  - Fuel management data
  - Trip record data

Cartographic Flexibility

- Display of numerous vector based maps
- Zoom up to 7X for detail
- Allow any digital or hard copy map to be used as background map
- Maps are in multiple overlays
- User editable overlay
- Receives electronic file update

Variable Communications Interface

Basic map engine receives packets from many types of communications networks

Two-Way Communications

- No additional programs are necessary to exchange messages with mobiles through the network
- All handshake and protocol conversion is automated
- Operates in batch or real time

Map is Human Interface to Communications

- Communications are originated by pointing at vehicle or selecting vehicle from list
- Exact destination transmitter ID is always input when vehicle is selected
- All log keeping is automated

Stand Alone Configuration

The program is complete within itself and optimized to run in a stand-alone configuration

Front-End Communications Processor for Midrange and Mainframe

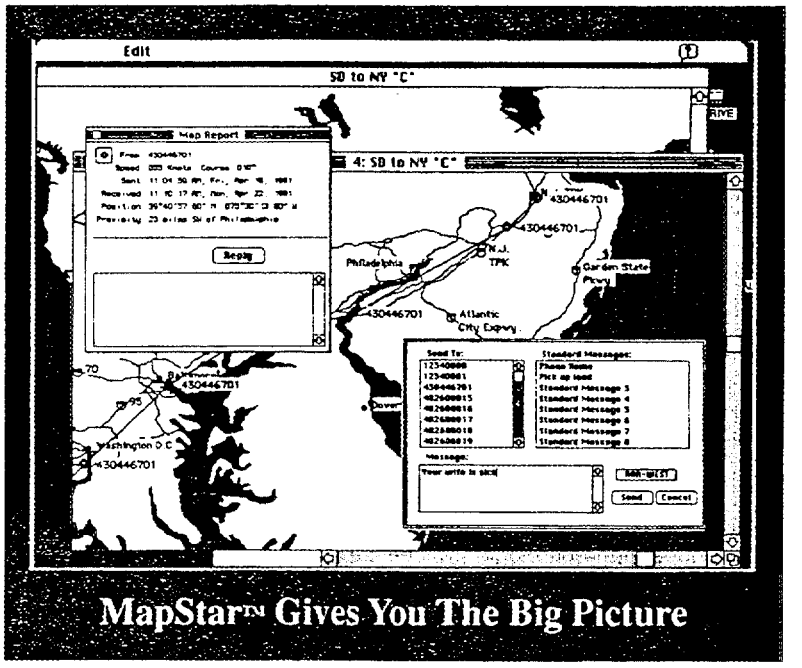
For those applications where the newly received message and position information is useful in another computer which is running an operations package. The program is designed to prepare the data for transfer to these other systems and to serve as a front-end communications processor for them. This can be accomplished in a direct connection to the other computer or via a network

Back-End Cartographic Terminal for Midrange and Mainframe

For those applications where the new dynamic data is received by the operations package in an existing computer, the program can very nicely receive the position information from the computer and display the positions on the electronic maps. This prevents the need for putting cartography on the host computer.

Low Cost

Perhaps the most cost-effective solution to vehicle tracking in the world. Plus built-in two-way communications and many other extras.



MapStar™ Gives You The Big Picture

Friendly Operation

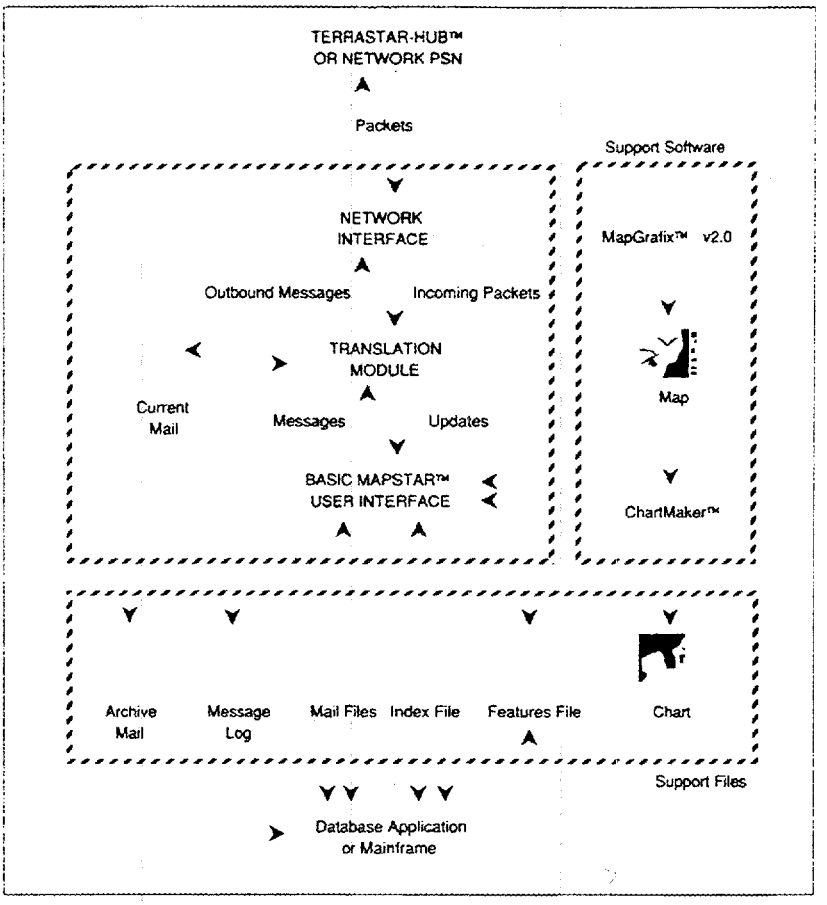
GUI-Geographical User Interface: the startlingly easy way to operate a complex and powerful computer. The ease of use and training saves even millions of dollars over time depending upon number of workstations and use.

Network Management

The optional TerraStar-Hub™ routing, store-and-forward switch gives carriers full network parameters and flexibility without compromising performance or cost effectiveness.

Benefits of MapStar™

The financial benefits of equipping a fleet with a Scientific-Atlanta MariStar™ or TerraStar™ terminal are varied depending upon the application. In a typical trucking application, benefits accrue to all interested parties.



The Trucking Company/Operator

- Cost savings lead to a payback of less than one year
  - More revenue mile per truck
  - Decreased and predictable telecommunications cost
  - Decreased out of route and deadhead miles
- MapStar™ is a marketing tool
  - Offers a competitive edge
  - A proactive rather than reactive customer service plan
- Improves management reporting capabilities
- Reduces accidents and lowers fuel consumption
- Reduces insurance premiums by 7-15%

The Driver

- Near real-time communication between the driver and the dispatcher is accomplished easily from any location
- Quicker transit times
- With the optional Mobile MapStar™ interface the driver can see his location at all times. The software gives a numeric latitude/longitude indication of current position. Vectorized maps are also available for the vehicle with a suitable display device
- Increases number of loads and revenue miles
- Emergency assistance is always available
- Eliminates filling out complex driver logs

MariStar and TerraStar are registered trademarks of Scientific-Atlanta.
MapStar is a registered trademark of ComGraphix, Incorporated.

The Shipper

- Greater degree of Quality Control
- Increases control of high-value consignments
- Precise status and shipment information
- Accurate delivery time with position reporting. Tighter ETAs can result in Just-In-Time service to customers
- Rapid response to customer request and/or order. In-transit redirects and expedited deliveries are easy to effect
- Coordinate operations with shipping personnel to maximize efficiencies and productivity

System Hardware Requirements

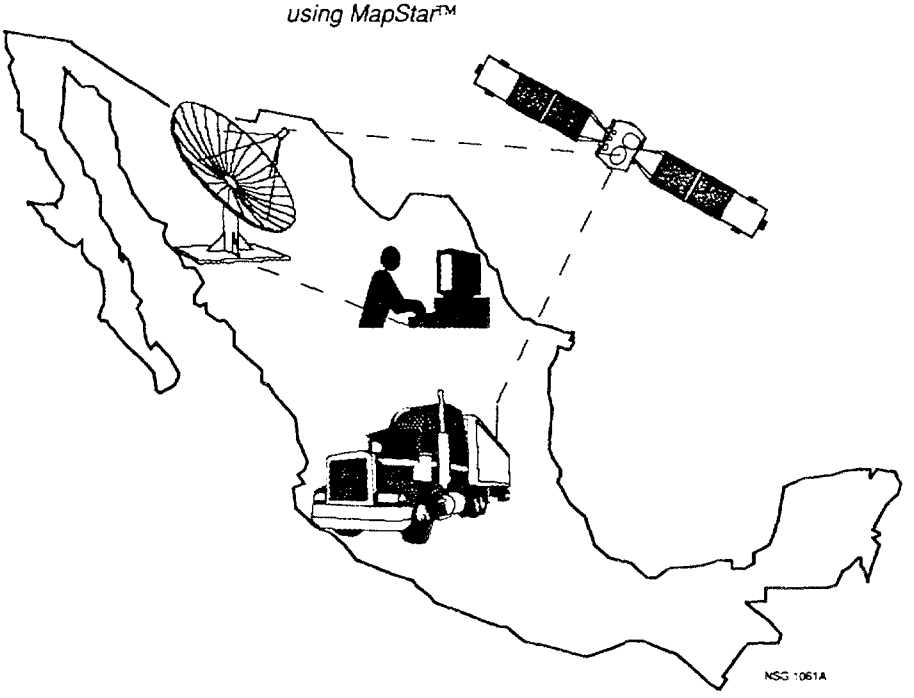
MapStar™ is designed to operate with the following system hardware:

- Scientific-Atlanta MariStar™ or TerraStar™ Inmarsat Standard-C and/or -M Terminals
- Apple Computer, Inc. Macintosh™ systems, including Macintosh II, IIx, IIcx, IIci, IIfx, and Quadra 700 and 950 computers, using System 6.0.5 or greater
- Any telecommunications network equipment that is able to connect to the specified Inmarsat Land or Coastal Earth Station
- Optional TerraStar-Hub™ for use in multiple dispatcher networks.

Macintosh is a tradmark licensed to Apple Computer, Inc.

Throughout the world, shippers can rely on Scientific-Atlanta's AVL and Inmarsat systems expertise. After providing the first Inmarsat coastal earth stations, and more than 3,000 Inmarsat terminals, the transport industry has come to rely on Scientific-Atlanta since 1976 to provide mobile communications solutions worldwide.

Illustration showing typical transportation application using MapStar™



Scientific-Atlanta, Inc.

Our customers are the winners.

United States: 4291 Communications Drive, Norcross, GA 30093; Telephone: (404) 903-6001; Telex 4611804
Canada: 120 Middlefield Road, Scarborough, Ontario M1S 4M6, Canada; Telephone: (416) 299-6888; Telex 06525344
United Kingdom: Home Park Estate, Kings Langley, Herts, WD4 8LZ, England; Telephone: Kings Langley 44-923-266133; Telex 912044
Australia: Unit 2, 2 Aquatic Drive, Frenchs Forest, N.S.W. 2086, Australia; Telephone: (612) 452-3388; Fax: (612) 451-4432; Telex 790 177418
France: 4 Avenue Gabriel Peri, 78360 Montesson France; Telephone: 33-13-976-9191; Telex 696385
Italy: Via Benedetto Croce, 19, 00142, Rome, Italy; Telephone: 39-6-5409994; Telex 621441
Germany: Albert-Schweitzer-Strasse 66, 8000 Muenchen 83, Postfach 830935 Germany; Telephone: 49-89-6780010; Telex 5212264

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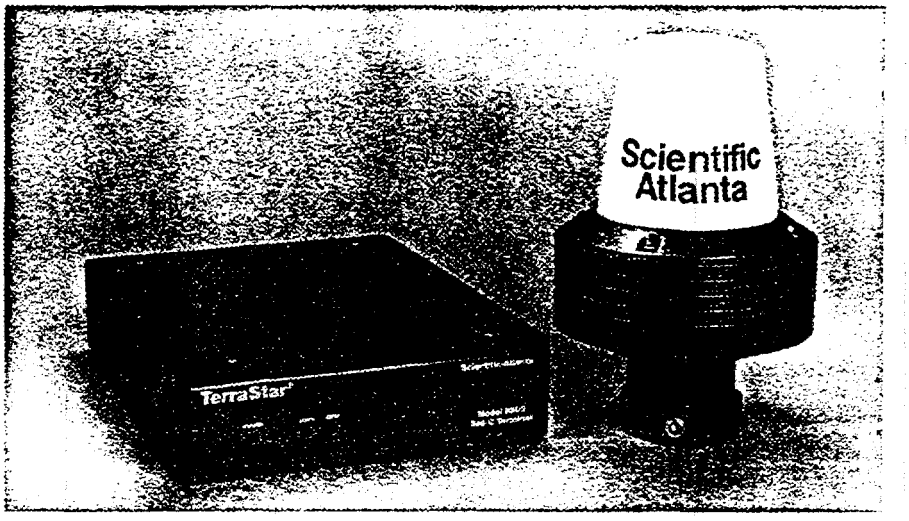
Scientific Atlanta

Network Systems Group

TerraStar-C Satellite Terminal
Model 9805



The Model 9805 TerraStar-C Satellite Terminal offers global data or telex communication through the Inmarsat Standard 'C' System. The system is easy to operate and connects with either an ASCII terminal or personal computer. With the optional GPS Receiver, precise position determination is available through the same antenna.

Features

- Smallest, lightest weight Inmarsat-C terminal available
- 2-way message and data communication to any destination
- Automatic data and position reporting
- Standard interface to NMEA 0183 navigators
- GPS interface 50-ohm SMA connector

Description

The Model 9805 offers Land Mobile users fast and reliable connections to any domestic or international telex or data network. Fast and reliable 2-way transfer of any type of written message or data is supported along with data reporting transmission and automatic polling of terminal position.

Operation and control of the Model 9805 is performed via a standard RS-232 communications port. The unit can be operated from either a standard ASCII terminal or an MS-DOS based desk-top, portable, or lap-top personal computer.

INMARSAT

Scientific-Atlanta, Inc.
404-903-6001

Model *9805* TerraStar-C Satellite Terminal

System Specifications

Meets or exceeds all current and proposed Inmarsat specifications for Inmarsat-C system.

Transmit Frequency
1626.5 to 1646.5 MHz
Receive Frequency
1530.0 to 1545.0 MHz
Channel Spacing
5 kHz

Indoor Unit Specifications

Modulation
1200 symbols/second BPSK
Ambiguity Resolution
Unique word
Coding
Rate 1/2, k=7 convolutional code with interleaved code symbols
Data Rate
600 b/s
Receive Frame Length
8.6 seconds
Transmit Signalling Access Mode
Slotted ALOHA
Transmit Message Channel
TDMA & FDMA, interleaved code symbol
Terminal Interface
CCITT rec. V. 24/28, 9-pin female D-connector, 110-9600 baud, ITA-5 code, max. 100 meter cable
Printer Interface
Standard parallel Centronics, 25-pin female D-connector, max. 4 meter cable
Navigator & Alarm Interface
CCITT Rec. V.10 Special with NMEA 0183 interface and multidrop addressing, BNC-female connector, max. 100 meter cable
Antenna Interface
Standard 50 ohm female N-connector, max. 100-meter cable
Memory
256 kbyte RAM
System Programming
EEPROM programming of installation parameters from operator's terminal

DC Power Source	10.5 to 32V dc, 9.5/80W
Ambient Temperature	-25°C to 55°C operating, -40°C to 80°C storage
Relative Humidity	95% non-condensing
Vibration	
Operational	Random 5 to 20 Hz, 0.02g²/Hz, 20 to 150 Hz -3 dB/Oct. (1.0 g rms)
Survival	Random 5 to 20 Hz, 0.05g²/Hz, 20 to 150 Hz -3 dB/Oct. (1.7 g rms)
Shock	Half sine, 20g/11 ms

Mounting
Free standing cabinet with mounting brackets or optional 19 inch mounting kit
Dimensions
2.4 in (62mm) H x 8.5 in (214mm) W x 11 in (279mm) D
Weight
7.04 lbs (3.2 kg)

Antenna Specifications

Meets or exceeds all Inmarsat specifications for antenna pattern and EIRP.

Weight	4.2 lbs (2.0 kg)
Height	6.9 inches (176 mm)
Max. Diameter	5.9 inches (150 mm), Conical
Ambient Temperature	-35°C to 55°C operational, -40°C to70°C storage
Spray	Solid droplets (AU)
Ice	Up to 2.5 cm (AU)
Precipitation	Up to 10 cm/h (AU)
Wind	Up to 100 knots (AU)
Vibration	2 to 10 Hz, 1.0 g peak
Mounting	1-1/2 inches tube mounting

Specifications and product availability are subject to change without notice.

Scientific-Atlanta, Inc.

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United States: 4291 Communications Drive, Norcross, GA 30093, Tel: 404-903-6001, ITT Telex: 4611804
Australia: Unit 2, 2 Aquatic Drive, Frenchs Forest, N.S.W. 2086, Australia, Tel: (02)-452-3388, Telex: 177418
France: 4 Avenue Gabriel Peri, 78360 Montesson, France, Tel: 13-976-9191, Telex: 696385
Germany: Albert-Schweitzer-Strasse 66, 8000 Munich 83, Postfach 830935, Germany, Tel: 48-6780010, Telex: 5212264
Italy: Via Benedetto Croce, 19, 00142, Rome, Italy, Tel: 6-5420244, Telex: 621441
United Kingdom: Home Park Estate, Kings Langley, Herts WD4 8LZ, England, Tel: 092-326-6133, Telex: 912044

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OVERVIEW OF SATELLITE COMMUNICATION ORGANIZATIONS

- COMSAT
  - Private US Company Established By Communication Satellite Act Of 1962
  - Scientific Atlanta Is A Manufacturer Of Equipment Compatible With Comsat Services
- INTELSAT
  - International Consortium Of 110 Countries That Own & Operate Telecommunication Satellites
  - COMSAT Is A Signatory
  - Provides Point To Point Capabilities
- INMARSAT
  - International Consortium Of 65 Member Countries That Own & Operate A Network Of 10 MARISAT Satellites
  - COMSAT Is A Signatory
  - Provides Telecommunication Network Tailored To Mobile Users; Standards Permit Competitive Development Of Equipment
  - Provides Off Shore Service ("only")!

VALUE-ADDED AND SPECIAL SERVICES

In addition to every Inmarsat basic communication service, we offer a number of value-added services. Examples are credit and debit card telephone services, customized billing arrangements for independent service providers, and a variety of voice, fax, data and telex store-and-forward and delivery options.

Special services have been developed to satisfy requirements for both voice and data broadcasting. One such service enhances the accuracy of GPS (the U.S. Global Positioning System) and is used to position vessels operating far at sea. Another COMSAT special service permits continuous, real-time collection of data from multiple sites using a single satellite channel.

SERVICES AVAILABLE

TERMINAL TYPE	VOICE	FAX	DATA	HIGH SPEED DATA OPTION	TELEX	AVAILABLE CONFIGURATIONS: TRANS-PORTABLE	PERSONAL PORTABLE	MOBILE (VEHICLE MOUNTED)
STANDARD-A	3kHz FM	4.8 - 9.6kb	2.4 - 9.6kb	56/64kb	YES	YES	NO	NO
STANDARD-B	9.6kb digital	9.6kb	16kb	56/64kb	YES	YES	NO	NO
STANDARD-M	4.8kb digital	4.8kb	2.4 - 4.8kb	NONE	YES	YES	YES	YES
STANDARD-C	NONE	**	600bps*	NONE	YES	YES	YES	YES

*store-and-forward

**COMSAT supports mobile-to-base text messaging delivered to FAX machines

TECHNOLOGY

- Synchronous Satellites
  - Station Keeping To Within ± 0.1 Degree
  - 7 to 10 Year Life
  - Can Be As Close As 2 Degrees
  - Footprints Can Be Tailored
- Capacity (Comstar - Leased To AT&T)
  - 24 "Bent Pipe" Transponders (C Band Or Ku Band)
  - Polarized Channels -- 12 Vertical & 12 Horizontal On 40 Mhz Centers
  - Can Handle:

    One Analog Video Channel Per Transponder (24 Total)

    Or

    18,000 Voice Channels Total
  - Transponders Cost Approximately $2M

Scientific Atlanta
Network Systems Group

TerraStar-C Satellite Terminal
Model 9805

Scientific Atlanta	SCIENTIFIC ATLANTA TERRASTAR C	SPS INSTRUMENTATION GROUP

Model *9805* TerraStar-C Satellite Terminal

International Agreement/Standard

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Receive Frequency
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Channel Spacing
5 kHz

Indoor Unit Specifications

Modulation
1200 symbols/second BPSK

Ambiguity Resolution
Unique word

Coding
Rate 1/2, k=7 convolutional code with interleaved code symbols

Data Rate
600 b/s

Receive Frame Length
8.6 seconds

Transmit Signalling Access Mode
Slotted ALOHA

Transmit Message Channel
TDMA & FDMA, interleaved code symbol

Terminal Interface
CCITT rec. V. 24/28, 9-pin female D-connector, 110-9600 baud, ITA-5 code, max. 100 meter cable

Printer Interface
Standard parallel Centronics, 25-pin female D-connector, max. 4 meter cable

Navigator & Alarm Interface
CCITT Rec. V.10 Special with NMEA 0183 interface and multidrop addressing, BNC-female connector, max. 100 meter cable

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Standard 50 ohm female N-connector, max. 100-meter cable

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256 kbyte RAM

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EEPROM programming of installation parameters from operator's terminal

DC Power Source	10.5 to 32V dc, 9.5/80W
Ambient Temperature	-25°C to 55°C operating, -40°C to 80°C storage
Relative Humidity	95% non-condensing
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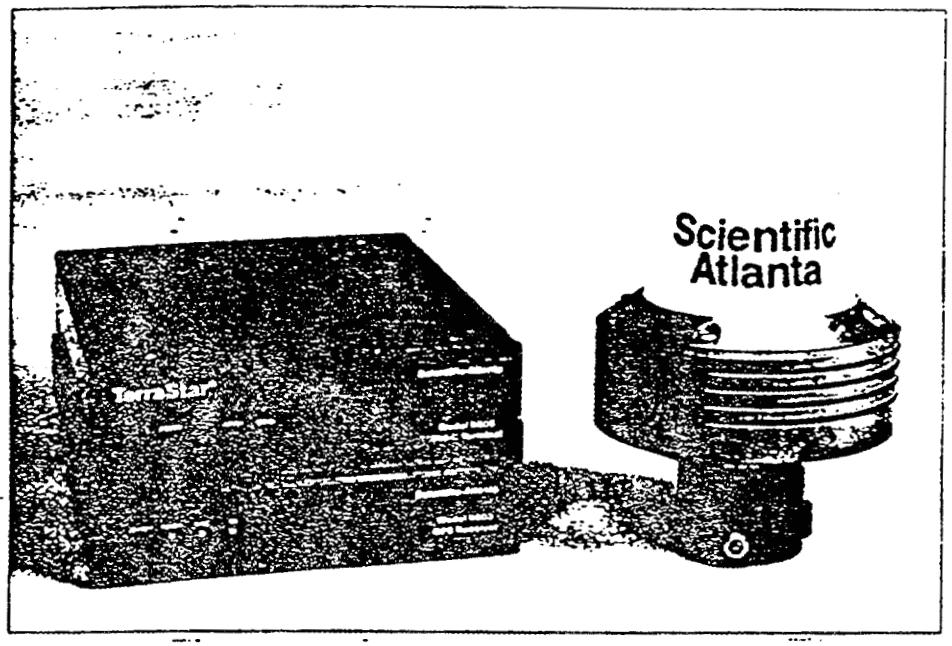
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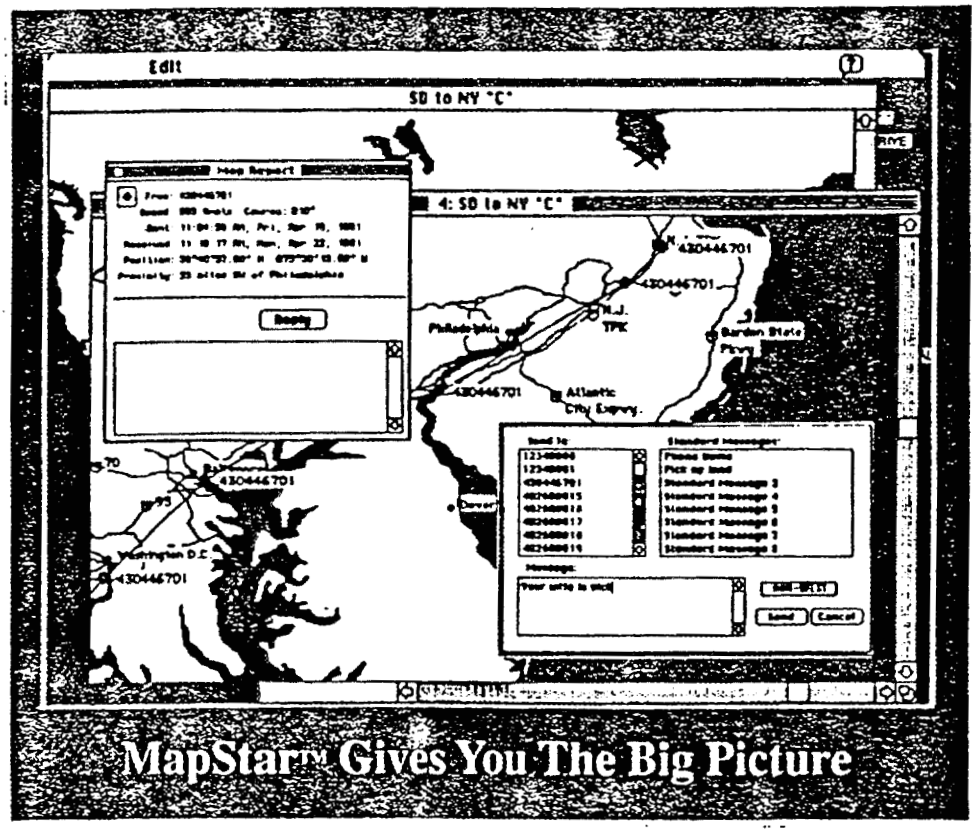
TerraStar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SD to NY "C"
4: SD to NY "C"
Map Report
Reply
Philadelphia
N.J. TPK
Garden State Pkwy
Atlantic City Expwy.
Washington D.C.
Cancel
Send
Cancel
MapStar™ Gives You The Big Picture

OmniTRACS: A BETTER BOTTOM LINE.

OmniTRACS® satellite communications systems not only provide you with the ability to offer superior customer service, but also improve your bottom line profit figures. Saving valuable operating dollars begins the first day you install OmniTRACS on your vehicles.

A study of OmniTRACS customers revealed significant cost savings and revenue enhancements provided by QUALCOMM's satellite communications system. These include:

- Reduced telecommunications costs – as much as 90 percent in some cases.
- Reduced out-of-route miles.
- Increased dispatcher productivity – more time spent on dispatching and planning – less time on the telephone. Additionally, handling customer service becomes proactive rather than reactive.
- Increased potential number of trips. The ability to locate every vehicle and communicate with every driver instantaneously increases route efficiency.
- Reduced empty miles – with the ability to assign unexpected load(s) with a key stroke.
- Reduced driver turnover – driver satisfaction is of foremost importance to most trucking companies. OmniTRACS enables drivers to get the rest they need and increases their opportunities to make money.
- Reduced fuel and maintenance costs due to consistent vehicle operation and the elimination of excessive engine idling associated with check-call procedures.
- Since it minimizes the number of stops, OmniTRACS also reduces the probability of vehicle collisions. Not only does this lower repair costs, but fewer collisions ultimately reduce insurance premiums.
- **The bottom line – a significant increase in asset/vehicle utilization and profitability.**

For these reasons, QUALCOMM has prepared a detailed Cost Justification Model to evaluate data collected from your operation. Your QUALCOMM Account Manager will work with you to customize the Cost Justification Model to your company's specific operating needs.

The answers may surprise you. The bottom line of the cost justification analysis may indicate that you cannot afford to wait another day to install OmniTRACS.

To receive your own customized Cost Justification, call 800-541-7490 (in CA, 619-597-5025), or write: QUALCOMM, Inc., 10555 Sorrento Valley Road, San Diego, CA 92121.

OmniTRACS

QUALCOMM, Inc.
10555 Sorrento Valley Road
San Diego, CA 92121
(619) 587-1121

OmniTRACS: ANSWERING THE DEMANDS FOR IMPROVED CUSTOMER SERVICE.

Shippers in the United States are demanding better customer service. They want to be assured their loads will consistently arrive on schedule. They want to know their loads are safe. They are demanding better, more proactive service. OmniTRACS answers these demands – and more.

SCHEDULING

Imagine a customer calling your dispatcher asking about the status of their load. You have not spoken with the driver for hours. Before installing OmniTRACS you could have given the customer only a rough approximation of the vehicle's status. With OmniTRACS, you can tell your customer the truck is currently 40 miles south of his facility with no traffic congestion or weather problems anticipated. The load will arrive within the next hour, on schedule. This type of customer service is no longer a dream; OmniTRACS makes it a reality.

Scheduling becomes even more important for shippers of just-in-time and sensitive shipments. These shipments are subject to inventory management systems that can instantly re-direct or change dock appointments. The OmniTRACS system gives you the ability to react to such circumstances. With the simple touch of a button you are in instant contact with your drivers. No longer are both you and the shipper at the mercy of the check call to communicate changes in requirements. OmniTRACS allows you to guarantee your customers a whole new level of responsiveness.

SAFETY

Shippers, carriers, government and the general public alike are extremely concerned with both the performance and safety of vehicles and drivers.

The demands placed on drivers today create an environment which can lead to unsafe practices. Heightened competition in the trucking industry dictates total efficiency at all times. Unfortunately for drivers, this means numerous check calls, pulling in and out of antiquated truck stops and pushing that rig in need of service just a few more miles.

OmniTRACS addresses these safety concerns directly. Drivers no longer need to pull off the road to check in. In fact, they state they now have more time to rest, to react to all dispatch assignments and tend to vehicle maintenance requirements. These quality-of-life improvements have a direct impact on driver fatigue and safety. OmniTRACS allows you to put safety first. More rested drivers, driving better maintained vehicles means safer loads, fewer losses, and thus improved service for your customers.

PROACTIVE SERVICE

You want to provide your shippers with safe shipments and on-time service that approaches 100 percent. Nationwide vehicle positioning and real-time communications is the only way you can assure such service in a dynamic environment. With OmniTRACS, you will not only cut costs and raise revenue, but you will also be proactive to your customers' service requirements. OmniTRACS provides you with the ability to anticipate your customers' requirements and react accordingly.

If you have any questions regarding OmniTRACS, just stop one of the thousands of drivers using OmniTRACS or one of the many shippers who insist our equipment is essential to the success of their business. Ask them what they think. OmniTRACS users are our best salespeople.

OmniTRACS: THE COMPLETE SATELLITE SYSTEM

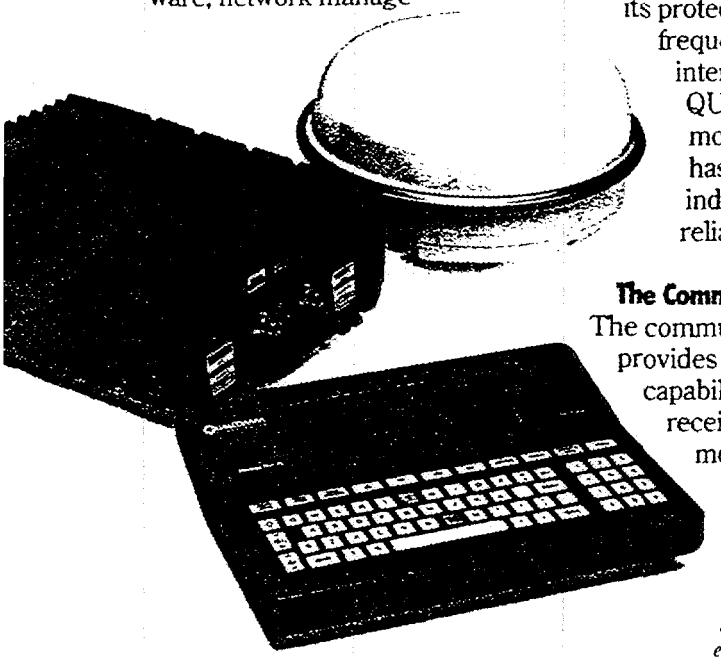
OmniTRACS is an interactive communications network linking every vehicle in your fleet to a dispatch center. Messages and positioning information are beamed, via satellite, through our Network Management Center (NMC) in San Diego to dispatch centers throughout the United States.

The OmniTRACS system is comprised of three major components or sub-systems: mobile communications hardware; network management service, including satellites; and dispatch software.

MOBILE EQUIPMENT

The OmniTRACS system includes a ruggedized portable keyboard and display terminal, a communication unit housing the electronics, and a continuously tracking antenna in a sealed unit. Each component is designed, manufactured and tested to survive temperature extremes of -30° to 70°C and extreme shock/vibration. With its protection from radio frequency and electrical interferences, QUALCOMM's mobile equipment has proven to be the industry's most reliable.

The Communications Unit – The communications unit provides the computing capability to send and receive digital (text) messages to and from the vehicle. At the heart of the system is the Viterbi decoder and Intel's C186 processor – together providing the most reliable signal processing capability in the world.



OmniTRACS system hardware consists of a sealed, aerodynamic dome housing the antenna; the communications unit which is ruggedized for the rough on-road environment; and the "user-friendly" display unit.

The QUALCOMM Automatic Satellite Position Reporting system is now featured in all communication units. As a result, Loran C has become obsolete as a position determinate. Accurate to 1/4 of a mile, QASPR uses existing electronics and an antenna, along with satellite triangulation, to eliminate Loran's "black holes."

In addition, the communications unit in conjunction with TrailerTRACS, has the capability of transmitting real-time information such as refrigeration monitoring from trailers to dispatch via the existing tractor-to-trailer seven-way cable. TrailerTRACS provides serialized trailer inventory and tracking and location information with each connect or disconnect of a trailer. Now high-value and critical shipments are not only tracked, but monitored for both shipper assurances and overall fleet utilization.

The Outdoor Antenna – QUALCOMM's rapid development of OmniTRACS was made possible by an innovative, proprietary Ku-band antenna design. This technology breakthrough has made it possible to manufacture an affordable and highly-reliable unit.

Compact and ruggedized, QUALCOMM's antenna is encased in an aerodynamic dome. Electronics drive a small motor directing the antenna toward the satellite at all times. The use of a directional antenna permits the highest data rates, the most error-free transmissions and greatest degree of reliability – a proprietary advantage superior to any satellite system.

Operator Keyboard and Display Unit – OmniTRACS units come equipped with a full keyboard and numeric pad, to send and receive text messages of up to 1900 total characters. While the size is small in comparison to a computer keyboard, it is no less functional. Coupled to the communications unit, the keyboard is easy-to-use, install and maintain. A user-friendly device prompts the operator with simple, straightforward language and commands.

NETWORK MANAGEMENT

The Network Management Center (NMC) is the communication hub of the OmniTRACS system. Here proprietary electronics and software are designed, integrated and maintained on-site. Within

QUALCOMM's Network Management Center in San Diego.

the NMC are two large DEC VAX 6410 computer cluster systems. One cluster constantly operates the system and the second remains in "warm-standby." All communications are transmitted via satellite through a 7.6 meter dish located on premises of the headquarters complex.

Satellite service is provided by GTE aboard an existing satellite under a "protected lease" which guarantees transponders will always be available to QUALCOMM through one of 3 GTE satellites. Connections to the QUALCOMM NMC are supported through any number of existing lease-line and dial-up services, and to time share networks. V-sat service will be offered shortly.

Through numerous communications protocols supported at our NMC, QUALCOMM now operates the largest transportation communication center in the world today.

SPECIFICATIONS

OUTDOOR UNIT (ANTENNA)

Sealed lexan radome with automatically tracking horn antenna

Diameter: 11.5"

Height: 6.75"

Weight: 11 lbs.

Radiated Frequency: Ku Band

COMMUNICATIONS UNIT

Dimensions: 12.75" x 9.25 " x 4.5"

Weight: 16 lbs.

Maximum Message Size: 1900 message characters

Memory: previous 99 messages or 256 lines

Temperature Range: -30° C to 70° C

Operating Voltage: +12 vdc or +24 vdc (AC operation is optional)

Return Message Buffer: up to 3

Construction: ruggedized aluminum with heat transfer fins

Communications interfaces: two RS 232, One SAE J 1708

DISPLAY UNIT

Dimensions: 11.5" x 7.5" x 2.75"

Weight: 2.5 lb.

Display: backlit LCD; 4 lines, 40 characters/line

Keyboard: 69 key standard typewriter function keys

Key Pad: elastomeric-type, splash resistant against contaminants

Audible alert and visual indicator for message waiting

Call-up auxiliary displays for in-field trouble shooting

OmniTRACS

QUALCOMM Incorporated
10555 Sorrento Valley Road
San Diego, CA 92121
(619) 587-1121

With OmniTRACS, you can track your vehicles as well as send and receive messages. Messages of up to 1,900 characters can be sent to any vehicle in your fleet, regardless of how desolate its location may be.

Three Simple Components

You might think that such space-age technology is hard to use. But the truth is, the elegant design of OmniTRACS results in delivery of simple, easy-to-use hardware and software to assist you in your business. Three simple yet sophisticated components comprise the OmniTRACS System. They include an environmentally ruggedized control unit, a dome unit that houses the small driver antenna, and an interface keyboard.

"OmniTRACS gives operators real-time control over their fleets – no matter how remote their location. The result is reduced costs, higher revenues and more responsive customer service."

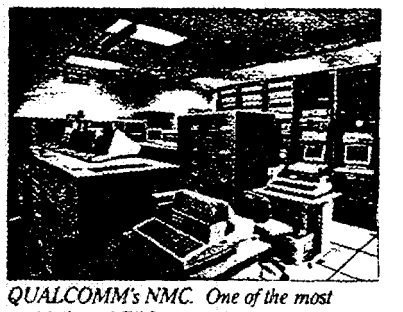
Network Management Center

The NMC is the most sophisticated customer communications facility in the trucking industry. This state-of-the-art center controls all traffic on the network, carefully tracking all your messages – both sent or received – and the delivery time of every message.

First In Delivery and Quality

We are the market leader in satellite tracking and communications. We achieved this distinction by offering top quality products to the transportation industry long before anyone else. But it takes more than first to market to maintain the number one position – it takes first quality products, first quality service and first response to customers' needs.

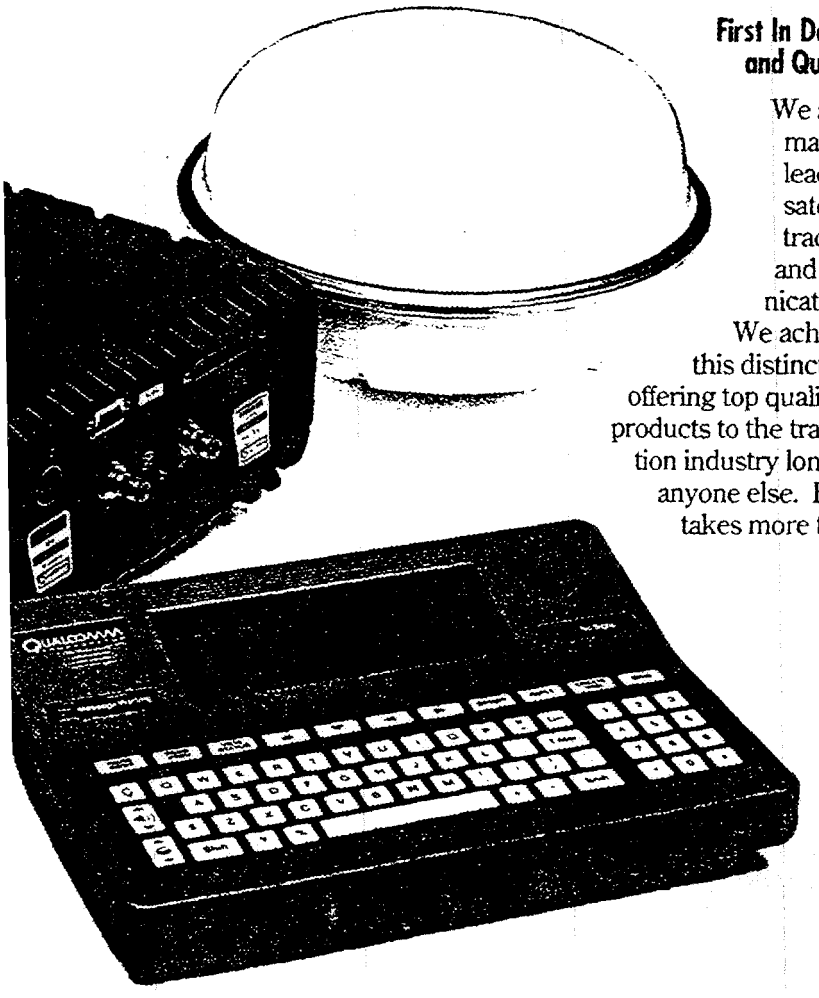
For example, recognizing the difficulty specialized carriers experience due to the inaccuracies of Loran C, we did more than offer promises – we delivered the solution. QUALCOMM's Automatic Satellite Position Reporting (QASPR) system replaces Loran C to pinpoint location within less than 1000 feet.



QUALCOMM's NMC. One of the most sophisticated EDI systems in the trucking industry.

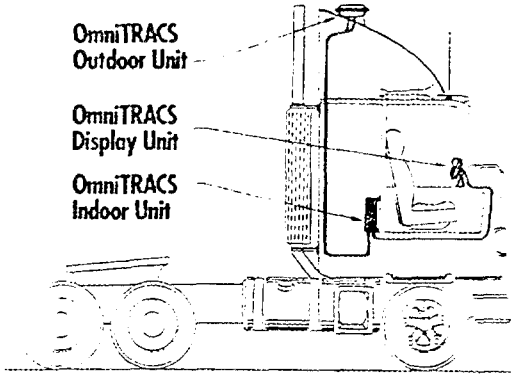
QASPR offers consistently more accurate positioning of all your rigs – continent-wide. Another first, and an example of our desire to hear our customers requests and do more than promise solutions. Others may promise, we deliver.

We think our philosophy of first and best should also apply to our business partners. For this reason, we pick our partners carefully.



OmniTRACS environmental unit, ruggedized power supply, and driver-friendly on-board keyboard.

"At first, it seemed like Big Brother was watching, but now I call it Daddy's Little Helper. It lets me stay on the road. And the more miles I go, the more money I make."



Ask a dispatcher why a driver hasn't called in, and he'll likely just roll his eyes and shake his head. The fact is, there are a thousand-and-one reasons why. And he's heard them all.

Because of traffic congestion, a driver may not be able to get to a truckstop he usually frequents. Or he may have broken down, way out on a lonesome stretch of highway, and can't get to a phone at all. Or he may have gotten to a phone, only to find himself standing in a long line of other truckers waiting to put in check-calls.

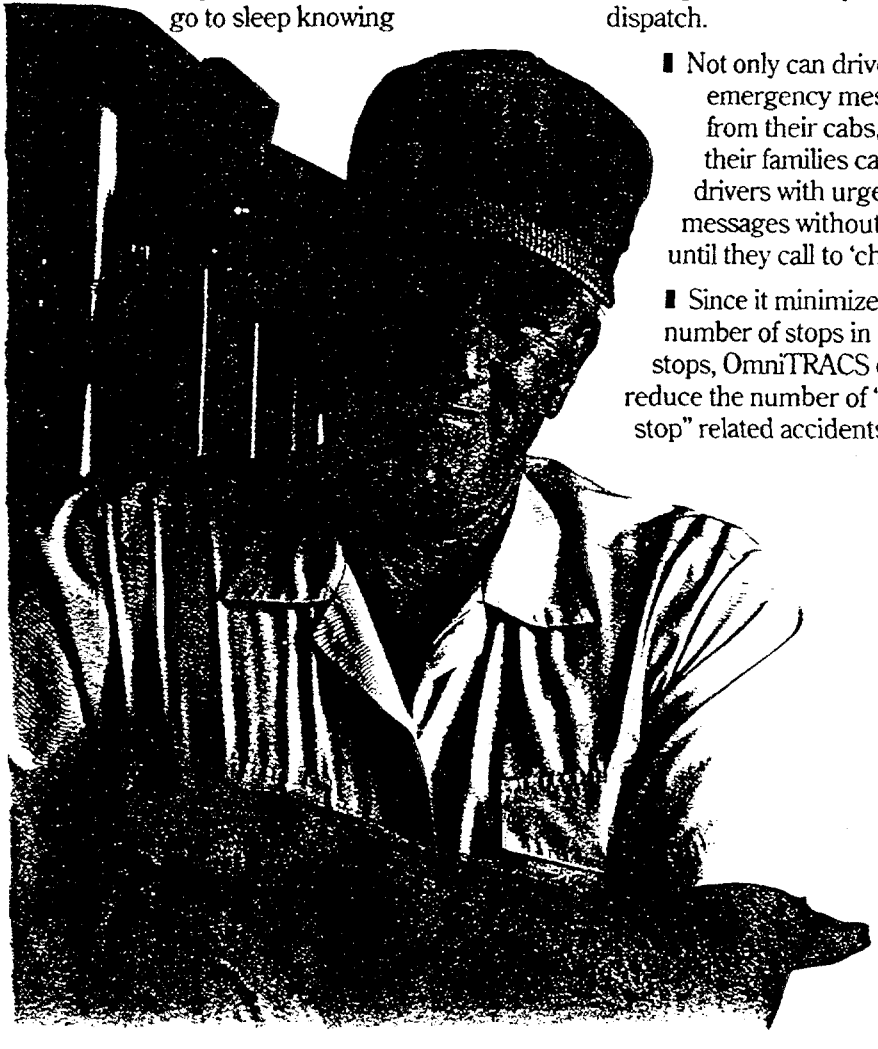
Driver Benefits

- Truckers awaiting new consignments often have to wake up every hour to make check-calls. With OmniTRACS' paging capability, a driver can go to sleep knowing that the pager will rouse him when a new shipment is ready to go. And a more rested driver is a safer driver.
- Drivers also have greater personal safety than they've ever had before. Whether it's a sudden-onset health problem, a potential hijacking, or other crisis threatening life or property, the driver can send a message that instantly notifies dispatch.
- Not only can drivers send emergency messages from their cabs, but their families can reach drivers with urgent messages without waiting until they call to 'check-in.'
- Since it minimizes the number of stops in truck stops, OmniTRACS can also reduce the number of "truck stop" related accidents.
- OmniTRACS also enables dispatch to track a driver's course of travel, which aids in addressing out-of-route miles.
- Most importantly, driver after driver has reported an increase in earnings. Less deadhead miles and time wasted waiting for phones has enriched driver earnings along with their lifestyle.

The Bottom Line

With OmniTRACS, everybody wins. Operators make more tonnage and reduce operating costs. Drivers avoid check-calls, and since their wages are mileage-driven, make more money as well.

Better-rested and higher-paid, OmniTRACS-equipped drivers will stay with you longer. And with turnover approaching 100% per year, keeping drivers is a big competitive advantage.



OmniTRACS provides so many benefits to driver, many fleet operators use it as an integral part of their recruiting programs.

APPENDIX G: TECHNICAL DATA FROM GYRO-SENSOR AND GYROSCOPE VENDORS

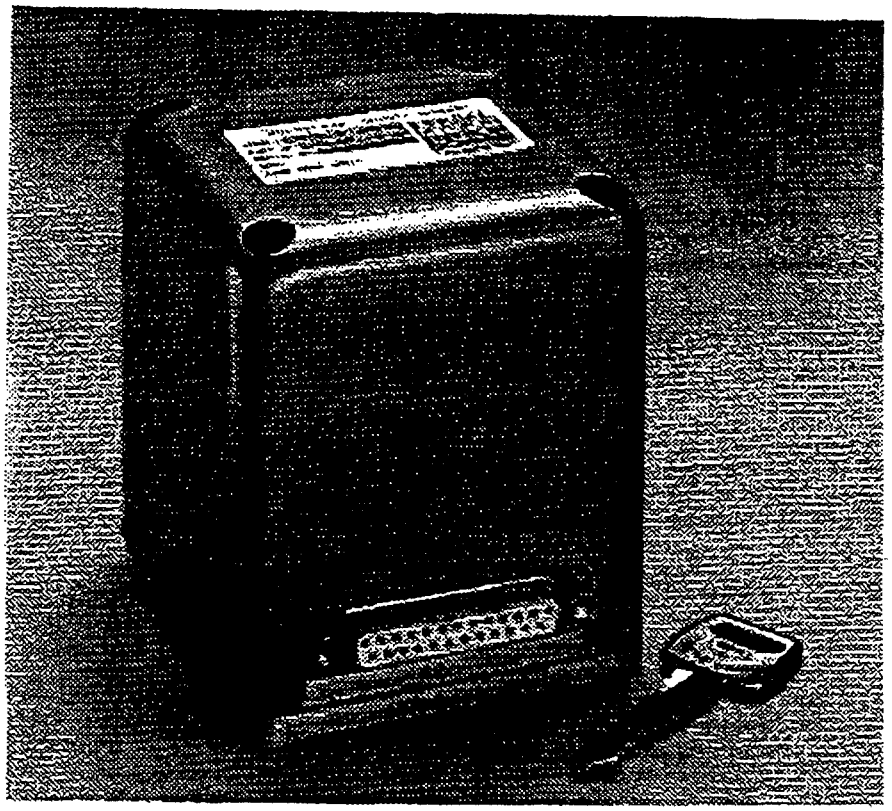
Systron Donner
GRA-MAR

MotionPak™

Applications

- Vehicle Instrumentation
- Robotics
- Automotive Testing
- Attitude Reference Systems
- Antenna Stabilization
- Control Systems
- Dead Reckoning with GPS

"Solid-State" 6 DOF Sensor Cluster



Description

The MotionPak™ is a six degree of freedom sensor cluster used for measuring linear and rotational motions. It is designed to be a more reliable, lower cost alternative to conventional sensor clusters. It uses three "solid-state" gyros and servo accelerometers mounted in a compact, rugged package, with internal regulation and signal conditioning electronics.

Features

- Self-Contained, DC In/DC Out Rate & Acceleration Channels
- Compact, Rugged Package
- Quick Start-up
- Wide Bandwidth Frequency Response
- Long Operating Life
- High-Performance Inertial Sensors
- Low Cost

Operation

Angular rates are sensed using subminiature vibrating quartz gyros. Linear accelerations are sensed using servo accelerometers. The MotionPak™ is directly powered by a DC voltage input and provides three high-level analog DC rate signal outputs and three high-level analog DC acceleration signal outputs, with a wide bandwidth frequency response. The package contains internal power regulators and a temperature sensor. Combinations of rate only, acceleration only, or a mix can be accommodated.

SYSTRON DONNER INERTIAL DIVISION
A BEI Electronics Co.

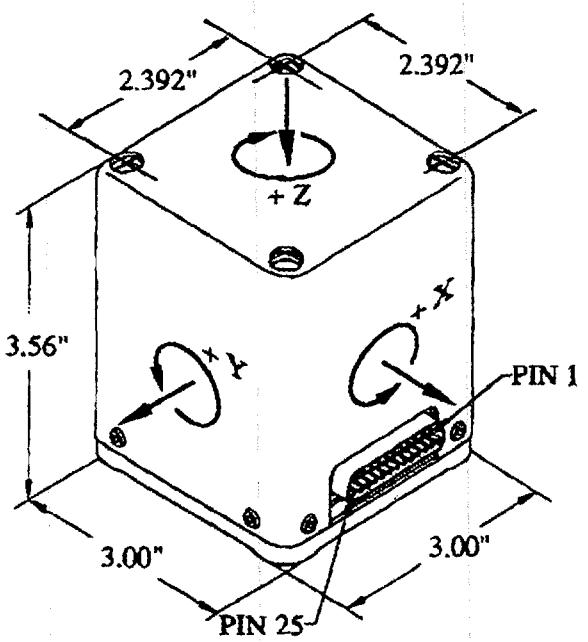
2700 Systron Drive · Concord, California 94518 · Toll-Free Number: (800) 227-1625 (Outside California)
Sales: (510) 671-6601 · Customer Service (510) 671-6499 · FAX: (510) 674-4847
European Business Office (Dover, England): 44 304 216281 · FAX: 44 0304 214638

SYSTRON DONNER INERTIAL DIVISION
A BEI Electronics Co.

MotionPak™

PARAMETER	SUMMARY SPECIFICATION	
POWER REQUIREMENTS		
Input Supply Voltage	±15 VDC (nominal)	
Input Power	7 watts nominal	
PERFORMANCE	RATE CHANNELS	ACCELERATION CHANNELS
Standard Ranges*	50, 100, 200, 500°/sec	1, 2, 5, 10 g's
Full Scale Outputs	±2.5 VDC	±7.5 VDC
Scale Factor Calibration	<1%	<1%
Scale Factor Temp. Sensitivity	<0.03%/°C	<0.03%/°C
Bandwidth	0 to >60 Hz	0 to >100 Hz
Linearity	<0.05% of FS	<50 μg/g²
Bias (Factory Set)	<0.5°/sec	<12.5 mg
Temp Sensitivity	<0.03°/sec/°C	<100 μg/°C
Long Term Stability (1 year)	<0.2°/sec	<500 μg
G Sensitivity	<0.02°/sec/g	–
Alignment to Base	<1°	<1°
Threshold/Resolution	<0.002°/sec	<10 μg
ENVIRONMENTS		
Operating Temperature	-40°C to +85°C	
Storage Temperature	-55°C to +100°C	
Vibration Survival	10 g rms, 20 to 2KHz random	
Shock	200 g	
WEIGHT	<800 grams	

*Inquire about other ranges.



NOTES:
1. MATING CONNECTOR IS SUPPLIED WITH THE UNIT (ADB-25).
2. MotionPak™ CASE IS FOR DUST AND MOISTURE PROTECTION ONLY.

Connector Pin	Assignment
1	+15 VDC
2	-15 VDC
3	Power Ground
4	Case Ground
5	Rate-X
6	Rate-X Return
7	Rate-Y
8	Rate-Y Return
9	Rate-Z
10	Rate-Z Return
11	Accel-X
12	Accel-X Return
14	Accel-Y
15	Accel-Y Return
16	Accel-Z
17	Accel-Z Return
23	Temp Sensor Out
All other pins not used.	

If it moves, MotionPak™ it.

Systron Donner also manufactures accelerometer products. Call for more information today!

1 January 1994

STANDARD TERMS AND CONDITIONS OF SALE

1. **DEFINITIONS**

As used herein, "Seller" means Systron Donner, Inertial Division, 2700 Systron Drive, Concord, California 94518; "Buyer" means the party to which this quotation is addressed.

"Product" means all articles, materials, work or service to be furnished by the Seller under this quotation.

"Seller's Authorized Representative" means the person or persons authorized to alter, modify, or change the provisions of the order or proposal. "Order" means any contract or purchase order resulting from this quotation.

2. **ACCEPTANCE**

The quotation and any resulting order shall be the exclusive agreement between the parties for the product, subject to the terms and conditions herein. Any of the following constitute Buyer's unqualified acceptance of the terms and conditions:

(a) Issuance or assignment of an order for the product,

(b) Acceptance of any products under the order, or

(c) Payment for any or all of the products under the order.

Additional or different terms or conditions proposed by the Buyer shall be void and of no effect unless accepted in writing by the Seller's Authorized Representative. No change in, modification of, or revision to these terms and conditions shall be valid unless in writing and signed by the Seller.

3. **TERMS**

Seller's terms are net thirty (30) days from date of invoice, F.O.B. Seller's plant in Concord, California.

4. **PROPOSAL VALIDITY**

Unless modified by written agreement, the quotation will be valid for thirty (30) days from submission date.

5. **WARRANTY**

Should any item furnished by Seller be defective or fail to meet specifications because of faulty material or workmanship, it will be repaired or replaced by Seller at no charge to Buyer provided request to return such material is made within a reasonable period but in no event longer than one (1) year from date of delivery to Buyer F.O.B. Concord, California, and provided further that an examination by Seller discloses to Seller's reasonable satisfaction that the defect is covered by this warranty. The warranty shall be null and void for any products which have been repaired or altered by anyone other than the Seller.

Seller's responsibility in this order is limited to repair, replacement (F.O.B. Seller's plant, Concord, California), or refund of the purchase price at Seller's option, and these remedies are expressly agreed to be exclusive of any others.

The warranty period for items repaired or replaced under this warranty provision shall be limited to the components repaired or replaced and shall run for one hundred and eighty (180) days or the balance of the original one (1) year excluding the time the product was out of service and in the Seller's plant, whichever is longer.

In no event shall Seller be liable for consequential or punitive damages (including but not limited to loss of profits, loss of customers, loss of goodwill, or delay).

THERE ARE NO WARRANTIES EXPRESSED OR IMPLIED OF FITNESS OR MERCHANTABILITY WHICH EXTEND BEYOND THIS DESCRIPTION.

6. **DELIVERIES**

The delivery of items proposed in terms of time after receipt of order (ARO) shall be based on receipt of order at Seller's facility. Unless otherwise specifically agreed upon in writing, shipments will be made F.O.B. Seller's plant, Concord, California, freight either collect or prepaid and bill.

7. **DELAYS**

Seller shall not be liable for delay in delivery, for failure to manufacture, due to force majeure or causes beyond its reasonable control. By way of illustration but not limitation, such causes include acts of God, acts of any government, acts of civil or military authority, acts of Buyer, application of priorities, fires, strikes, floods, war, riot or civil commotion, delays in transportation, difficulty in obtaining necessary labor or materials. In the event of any such delay, date of delivery shall be extended for a period of time equal to that lost by reason of the delay.

8. **TAXES**

Buyer agrees to pay, in addition to the sale price, all taxes, imposts, duties, fees, or other charges by any governmental or other body resulting from this transaction or the manufacture, sale, ownership, possession, or use of the goods described herein. As appropriate, Buyer shall provide the Seller with a tax exemption certificate acceptable to the taxing authorities.

9. **SHIPMENT**

Title to all purchased material and risk of loss therefor is passed from Seller to Buyer at the time of shipment from Seller's facility. Unless otherwise agreed upon in writing, all purchased material will be shipped uninsured. Seller may request partial shipment and invoice therefor.

10. **FOREIGN ORDERS TERMS OF PAYMENT**

Export orders (outside of the USA), unless otherwise specifically agreed upon in writing, are payable within sixty (60) days from the date of invoice, payable in United States funds at par. Such payment shall be transferred direct to the following bank or payable by check drawn on a U. S. bank.

Wells Fargo Bank
San Francisco, California USA
ABA # 121000248
BEI Systron Donner Company
Inertial Division
Account # 4518 052451

11. **RIGHTS AND DATA**

The seller does not extend or offer for sale any rights in technical data. Data to be delivered under the contemplated contract is limited to product outline drawing and final test data.

12. **INSPECTION**

Items that are subject to customer source inspection shall be limited to the review of final test data on a non-interference basis.

13. **TERMINATION**

In the event a binding agreement is entered into pursuant to these terms and conditions, and such agreement subsequently is cancelled for the convenience of Buyer, Buyer shall be liable for the payment of reasonable cancellation charges.

14. **PATENT INDEMNITY**

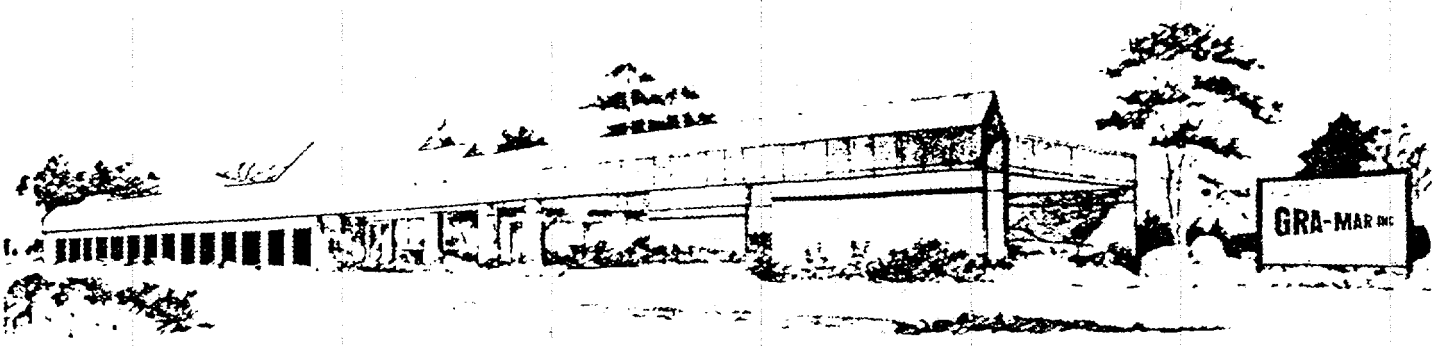
The Seller agrees to hold the Buyer harmless against any damage awarded by court of final jurisdiction in any suit or suits for the infringement of any United States Letter of Patent by reason of the sale or use of such product furnished by the Buyer under this quotation and subsequent acquisition.

15. **CORRECTIONS**

Stenographical and clerical errors are subject to correction.

BEI SYSTRON DONNER INERTIAL DIVISION

2700 Systron Dr. • Concord, CA. 94518-1399
(800) 227-1625 • FAX (510) 671-6567



GRA-MAR INC. CORPORATE OFFICES
5135 Curry Ford Road, Suite 100, Orlando, Florida 32812
Phone (407) 658-1971 FAX (407) 658-4101

January 19, 1993

Dr. Philip Spelt
Oak Ridge National Lab
P.O. Box 2008
Oak Ridge, TN 37831

Dear Dr. Spelt:

I appreciate the thoroughness of your request. I don't think I've ever been given so much on which to base my information presentation.

I am Enclosing literature from:

HUMPHREY - on motion sensors and accelerometers

DCS - on telemetry products

POWERVOLT - on linear power supplies

These are, necessarily, representative brochures and summary catalogs. If your exact requirement does not appear, just fax me your specs and I will get a price and delivery quote.

It was not on your requirement, but I have enclosed a flier on SCOTT ELECTROKRAFTS. They are a contract manufacturing facility specializing in board stuffing and wiring harness manufacturing. SCOTT is already an approved supplier at Martin Marietta.

I will contact you shortly to ensure this packet arrived in proper order.

Sincerely,

GRA-MAR INCORPORATED

Roy Mac Donald
District Sales Representative

Enclosures

GRA-MAR INC.
5135 Curry Ford Road, Suite 100 • Orlando, FL 32812
Phone (407) 658-1971 • FAX (407) 658-4101

Roy A. MacDonald

Communications Consultants and Manufacturers Representatives

GYROSCOPES • VERTICAL INDICATORS • NORTH SEEKERS • RATE SENSORS • DYNAMIC TEST STABILIZATION SYSTEMS
POSITION TRANSDUCERS • ACCELEROMETERS • PENDULUMS • POWER SUPPLIES • MAGNETOMETERS • DIRECTIONAL SURVEYOR SYSTEMS

: a tradition of excellence in guidance and control instrumentation and components.

umphrey Inc., has made significant state-of-the-art advances in yroscopes, rate sensors, accelerometers, and switches used in uidance and control systems for high performance aircraft, helicopters, issiles, drones, remotely piloted vehicles, target boats, and undersea emotely operated vehicles, and in sub-surface directional surveying ystems for the petroleum and mining industries.

he company is recognized by more than 400 commercial and defense riented firms worldwide as a highly reliable supplier of custom designed strumentation to meet specialized needs in command/control and data cquisition systems.

umphrey is recognized by military and overnment agencies both in the U.S. and broad as a leading supplier of compoents for aerospace and weapon system pplications including guidance and conol for RPV's, target and reconnaissance rones and autopilots. The company is fully ualified in accordance with MIL specificaons and NASA requirements.

Humphrey is an established supplier of products ranging from miniature precision components to sophisticated, highly accurate measuring and control instruments used on a wide variety of commercial products and robotic systems. Humphrey's dynamic testing systems provide data for evaluating automotive, seagoing and ground vehicles under actual operating conditions.

umphrey manufactures an extensive line f special purpose instruments used in undreds of oceanographic applications etween the surface and the sea-bed. The ompany has developed a reputation for st response on special systems and comonents including such new developments s underwater attitude sensors, shipboard onar stabilizing equipment, and towed unerwater sonar vehicle autopilots.

Humphery vertical and horizontal directional surveying systems provide continuous or selected downhole readings to 20,000' and more. Data includes slant angle, slant angle bearing, azimuth, time, and cable depth. All information is displayed on the surface readout and a permanent record is provided by computer Humphrey directional surveying systems reduce field surveying time and improve accuracy

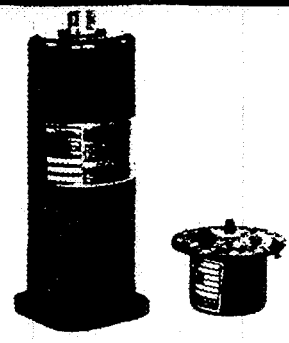
MODEL VARIATIONS

The standard models described herein are typical only. Numerous variations are available or modifications can be readily made. Custom designs and engineering offered.

Call or write:
Humphrey, Inc., 9212 Balboa Ave.
San Diego, CA 92123 U.S.A.,
Telephone: (619) 565-6631.
FAX: 619-565-6873

Contents

	Page
Directional gyros	1 and 2
Free gyros	3 and 4
Rate gyros	5 and 6
Vertical gyros	7, 8 and 9
Vertical indicators	9 and 10
North seekers	11
Magnetic flux detectors	12
Position transducers	13
Vertical stabilized accelerometers	14
Pendulums	15 and 16
Linear accelerometers	17 and 18
Rate sensors	18, 19 and 20
Power supplies	20
Dynamic test, stabilization systems	21
Magnetometers	22
Special purpose instruments	22
Drilled hole surveying equipment, reference measuring unit, magnetometers	

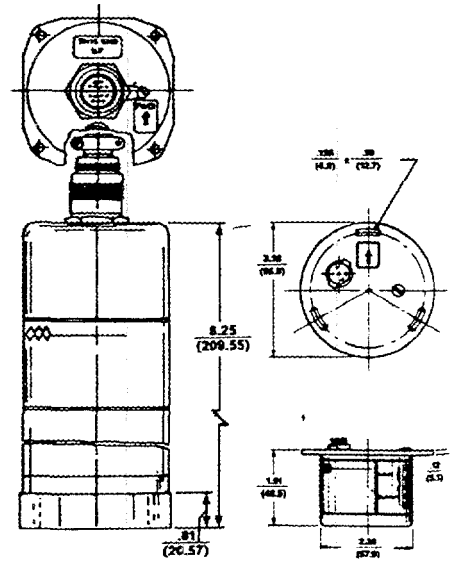


DG11-0105-1

Directional gyro with synchro output on outer gimbal and flux gate north seeking system. AC motor. Power 115V-400 Hz and 26V-400 Hz. Weight approx. 2.5 lbs. Size approx. 8.25" high x 3.77" dia. May be used with standard 3-inch GRO6 repeater or 5-inch GRO3 repeater.

SPECIFICATIONS

MECHANICAL FREEDOM	
Inner gimbal	± 85° minimum
Outer gimbal	360° continuous
Accuracy (with flux detector)	± 1.5°
Input motor	115V ± 400 Hz @ 65 MA
Erection system	26V ± 400 Hz @ 50 MA
AMPLIFIER (supplied from 26V input)	
Voltage	28VDC
Power	4 watts approximately
OUTPUT SYNCHRO OUTER GIMBAL	
Input voltage	400 Hz, 26 volts
Output voltage	11.8 volts
Accuracy	± 0.5°
Slaving rate	0.5°/minimum
Insulation resistance	50 megohms min. with 50 VDC applied
Service life	500 hours minimum
ENVIRONMENTAL CONDITIONS	
Altitude	−1000 feet to 40,000 feet
Temperature	−55°C to +70°C
Vibration	0.036 DA or 5G, whichever is limiting, 5 to 500 Hz
Shock	15G. 11 MS
Humidity	0 to 95% relative humidity
Weight	2.5 pounds



directional gyros

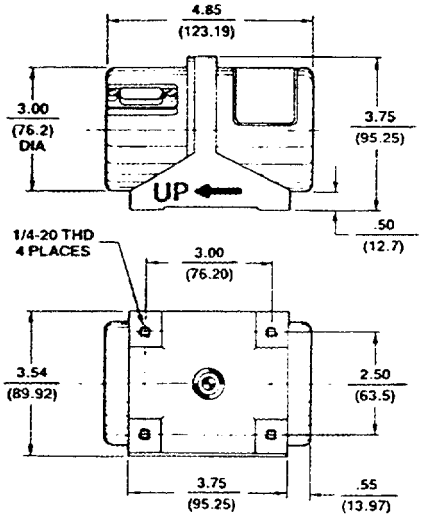
DG57-0201-2

Cageable directional gyro with potentiometer pickoffs on inner and outer gimbal. 115 VAC 400 Hz motor power, 28 VDC cage and uncage. Fully qualified for major missile program.

SPECIFICATIONS

Output potentiometers ..... Non-wirewound conductive type with output proportional to angular displacement about pitch & yaw.
Electrical travel ..... Yaw ±80° minimum
Pitch ±60° minimum
Resistance .... 5,000 ohms ±5% (each axis)
Input voltage ..... 28 ±4 VDC cage
28 ±4 VDC uncage
Current..... 5.0 amps maximum cage
4.0 amps maximum uncage
Caged freedom ..... ±0.5 degree maximum (yaw)
+1° ±1° maximum (pitch)
Pitch vertical accuracy ..... ±0.5° after 5.0 min. warm-up

SPIN MOTOR
Input voltage... 115 ±2.3V, 400 ±8 Hz, 1Φ
6% maximum harmonic distortion
Input power... 16 watts maximum running
25 watts maximum starting
Scorsby Drift (outer gimbal) yaw .... 0.5°/min. max. average (5.0 min. run).Random vibration: 0.5°/min. max. average with 2° max, during any 1.0 min (0.025 G^2/Hz, 50 – 2000 Hz) 5 minutes/axis.
Environmental MIL-STD-810B
Weight..... 5.0 lbs. reference



DG04-0115-1

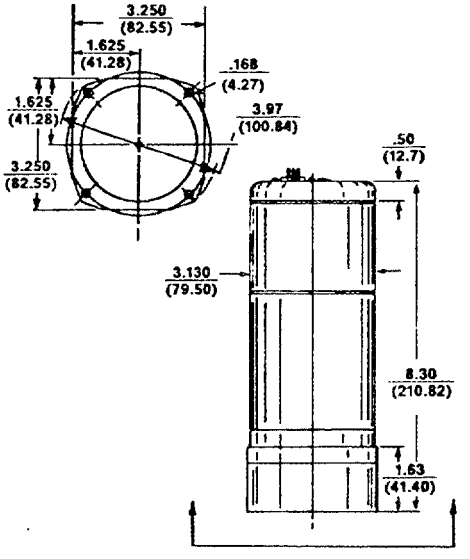
Self-contained magnetically slaved gyroscope. Eliminates need for separate flux gate installation where gyro can be mounted directly in non-magnetic areas. Operates off 115V-400 Hz AC. Size 3.250" dia. 8.30" high.

SPECIFICATIONS

Inner gimbal freedom.....±86° minimum
Outer gimbal freedom .....360° continuous
Pickoff Yaw .....Synchro transmitter
Input voltage.....26 VAC ± 400 Hz
Input current.....280 MA maximum
Input power .....0.95 watts nominal
Output voltage .....11.8V ± 5%
Transformation ratio.....0.454 ± 4%
Sensitivity (MV/degree) 206

SPIN MOTOR
Voltage.....115 VAC ±10%, 400 Hz ±5%
Current .....200 MA maximum starting
125 MA maximum running
Time to speed .....2 minutes nominal
Accuracy (slaved) .....±2°

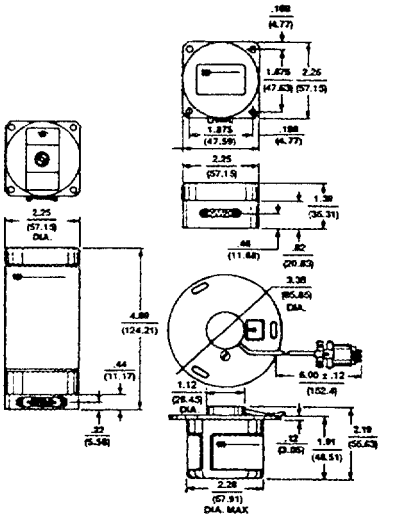
ENVIRONMENTAL SPECIFICATIONS
Temperature.....−67°F to +165°F
Altitude .....−1000 feet to 70,000 feet
Vibration .....5 to 500 Hz, 0.036 inch D.A. or 5G whichever is the limiting value
Humidity....0-95% relative humidity at 90°F
Sealing....."0" ring, sealed
Weight.....4 lbs.



DG60-0101-1

SPECIFICATIONS

MECHANICAL FREEDOM
Inner gimbal .....±80° minimu
Outer gimbal .....360° continuo
Accuracy (with flux detector) .....±3
INPUT POWER
Voltage.....28 ±3 VD
Starting current.....0.8 amp maximu
Running current.....0.7 amp maximu
OUTPUT POTENTIOMETER—
OUTER GIMBAL
Resistance .....5000 ohms ±5.0
Resolution .....0.25° maximu
Electrical travel .....357° ±
Power dissipation .....0.5 watts maximu
Linearity.....+0.5% of full sca
Equivalent contact
Resistance.....100 ohms maximum p
N.A.S. 7
Slaving rate..... 5°/min. minimu
Service life ..... 200 hours minimu
ENVIRONMENTAL CONDITIONS
Temperature.....−45°F to +150
Vibration.....2 g, 5 to 500 H
Shock .....10 g, 11 M
Weight .....2.0 pounds maximu
(with flux detector FD01-0501-

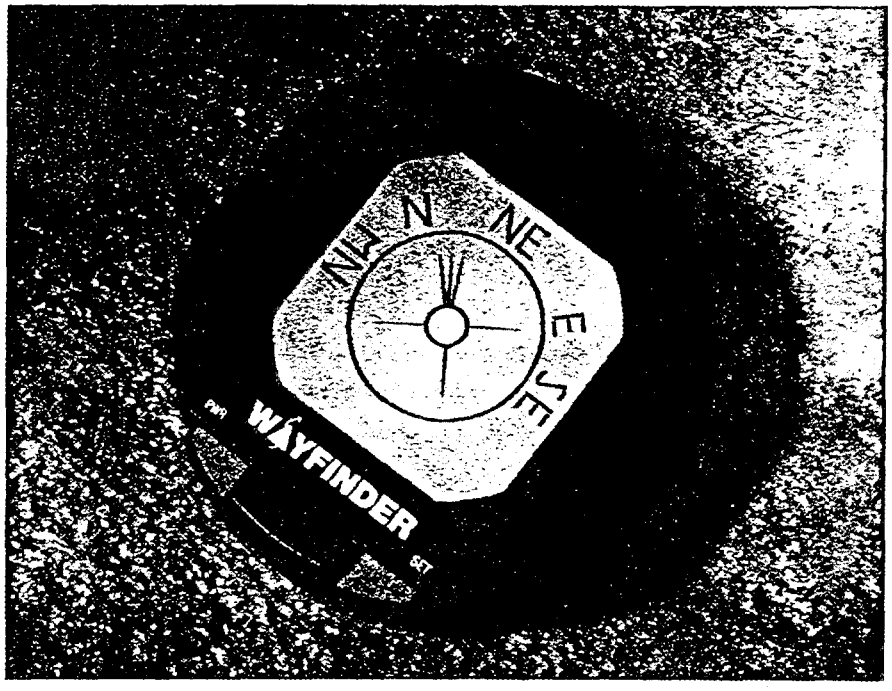


APPENDIX H: TECHNICAL DATA FROM ELECTRONIC COMPASS/TILT SENSOR VENDORS

Precision Navigation
Lucas Schaevitz

Always
Head in the
Right Direction

WAYFINDER™



DIGITAL ELECTRONIC AUTOMOBILE COMPASS

A new, state-of-the-art electronic compass has found its way into your hands – the Wayfinder.™ Based on patented microprocessor-controlled technology, the Wayfinder is the only *truly* useful and portable automobile directional device ever created. Use the Wayfinder on city streets, backroads, business trips, family outings – everywhere. It's the perfect, compact, portable accessory for drivers who want to head the right way.

- Large, easy-to-read liquid crystal display shows car heading.
- Precise, instantaneous response to car's movement.
- Battery-powered for complete portability. Use it in the mounting bracket. In your hand. On the trail.
- Reference Pointer Direction Memory helps you "find your way"
- Backlight automatically illuminates display at night.
- Simple and effective one-time automobile calibration.
- Microprocessor-controlled magnetometer invented in the Silicon Valley. Derived from the same compass developed for the U.S. Military.
- Adjustable windshield mount included.

PRECISION NAVIGATION
1350A Pear Ave. • Mountain View • CA • 94043 • Phone (415) 962-8777 • FAX (415) 962-8776

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WAYFINDER

▲ ▲ ▲

The city is *mostly* a grid. Except, of course, where diagonal streets and rosettes break it up. The buildings are tall. And after a few turns here and there, and countless "No Left Turn" signs, you have no idea which way you're going – and no idea how to get to your destination. . . . .

The impatient rental car representative said take the highway East. Then, stay South at the intersection. It's a rainy night. You've never been in this area. Which way is East? . .

The RV is 23' long. You're hauling the motor boat on a trailer behind you. When you exit off this winding lakeside road, you better know which way is West. Because turning this monster around is a nightmare. . .

. . . the solution:
WAYFINDER™

Using patented, microprocessor-controlled magnetometer technology, the WayFinder is a unique digital electronic compass. It's technological advances and features make it portable, versatile, accurate, and friendly to use.

The WayFinder is ideal for:

- Weekend Vacationers
- Driving Enthusiasts
- Field Salespeople
- Recreational Vehicle and 4WD Owners
- Business Travelers
- Professional Drivers and Couriers
- People who don't want to get lost.

"Find Your Way" – Digital Direction Memory. This helpful navigation function is exclusive to the WayFinder. Before exiting the highway, push a button to set the Digital Direction Memory. The WayFinder will remember which way you were going, so when you travel off the highway you can "Find Your Way" back. Or simply use this function to orient yourself to a familiar direction or road instead of North, South, East and West.

Portable, Versatile, Useful – The Technology Makes it Possible. The WayFinder's microprocessor-controlled magnetometer is a unique low power system, which makes battery-operation and portability possible. Designed to operate either in or out of your car using two distinct modes, the WayFinder incorporates the most advanced compass technology available.

DIGITAL ELECTRONIC MAGNETOMETER TECHNOLOGY

Traditional liquid-filled compasses use magnets that respond to magnetic fields. In cars, which are essentially large metal objects, they are slow to respond, and often "swim" or simply do not move at all.

Other, less sophisticated electronic compasses overcome some of these problems, but use external power sources or sensors that require cumbersome wires and installation.

The WayFinder solves all those problems. It compensates for the car's magnetic field, and is very easy to set – making it the most advanced and reliable compass for automobiles.

INVENTED IN THE SILICON VALLEY

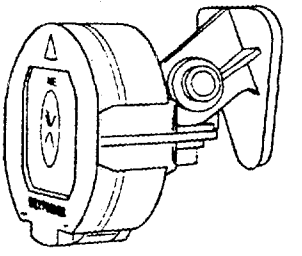
Precision Navigation develops state-of-the-art navigational devices, including proprietary electronic compass technology for the U.S. Military. The WayFinder benefits from the same technology, design and quality materials. It is fully-assembled and tested in the USA.

TECHNICAL SPECIFICATIONS

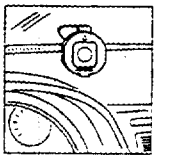
Compass size: 2.83" x 2.64" x 1.05".
Weight: compass alone, 2.6 ounces (72.5 grams).
compass and bracket, 3.7 ounces (104 grams).
LCD window size: 1.55" x 1.55".
Photo-electric light sensor for backlight control.
Lithium battery life: up to 1 year, depending on use.
Operating temperature range: 14° – 140°F (-10° – 60°C).
3 magnetometer sensors.
Accuracy: ± 4.5°.
Resolution: 9°.
Sampling rate: 5 Hz (five times a second).
Gold-plated printed circuit boards.
Surface-mount technology components.
Ultrasonically welded case.
One year limited warranty.

Fully-Adjustable Windshield Mount and Compass.

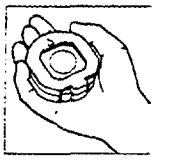
LCD compass rose
Power button
Set/Memory button
Photo-electric backlight control
Tripod suction cup windshield mount
(compass is removable)
Adjustable swivel and tilt joints



Place and adjust the WayFinder anywhere on your windshield so that it's easy to see, but out of your direct field of vision.



The WayFinder fits easily in your hand, and can be taken anywhere.



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TCM1 ELECTRONIC COMPASS SENSOR MODULE
— PRELIMINARY DATA SHEET —

Description

The TCM1 is a high-performance, low-power electronic compass sensor that outputs magnetic azimuth readings via digital or analog interface to a parent system. It is based upon a proprietary triaxial magnetometer system and a biaxial electrolytic inclinometer. While consuming less than 12 mA of current, it will output compass readings of ±1° accuracy up to 10 times per second. Its magnetometer and inclinometer readings may also be output across the digital interfaces. It is user-configurable and programmable, provides advanced calibration and distortion detection algorithms, and tolerates rugged environments.

The TCM1 is implemented on a compact, single-sided printed circuit board with tooling holes for mounting to a motherboard or chassis. Each unit is rigorously tested and calibrated before shipment.

Heading Information

Accuracy	±1°
Repeatability	±0.1°
Resolution	±0.1°
Tilt Range	±30°

Tilt Information

Accuracy	±0.1°
Repeatability	±0.1°
Resolution	±0.1°
Tilt Range	±30°

Electrical Power

Supply Voltage	+5V to 15V DC
Current	5-12 mA (depending on sampling rate)

Physical Measurements

Dimensions	2.5" x 2" x 1"
Weight	3 ounces

Environmental Characteristics

Operating Temperature	-20° to 70° C
Storage Temperature	-30° to 90° C

Interfaces

Digital	RS232C NMEA 0183 N+1
Analog	0.1 to 4VDC linear variation

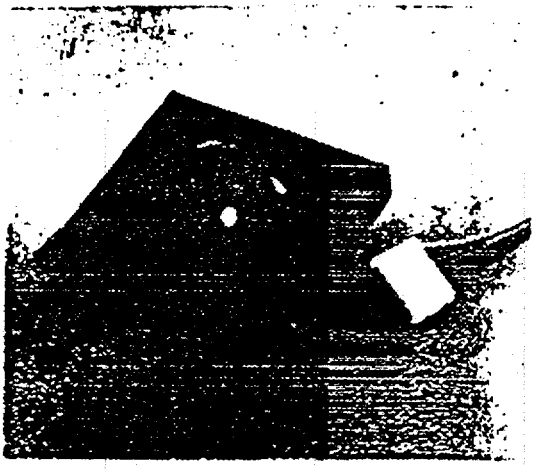
Features

- Distortion Detection: raises a warning flag when magnetic disturbances such as nearby ferrous metals and electrical currents are compromising accuracy.
- Variable sampling rate (up to 10 Hz)
- Optional damping (0.1 to 10 second period)
- Automatic calibration algorithms
- Programmable magnetic declination correction

[redacted]

AccuStar® II
Dual Axis Clinometer

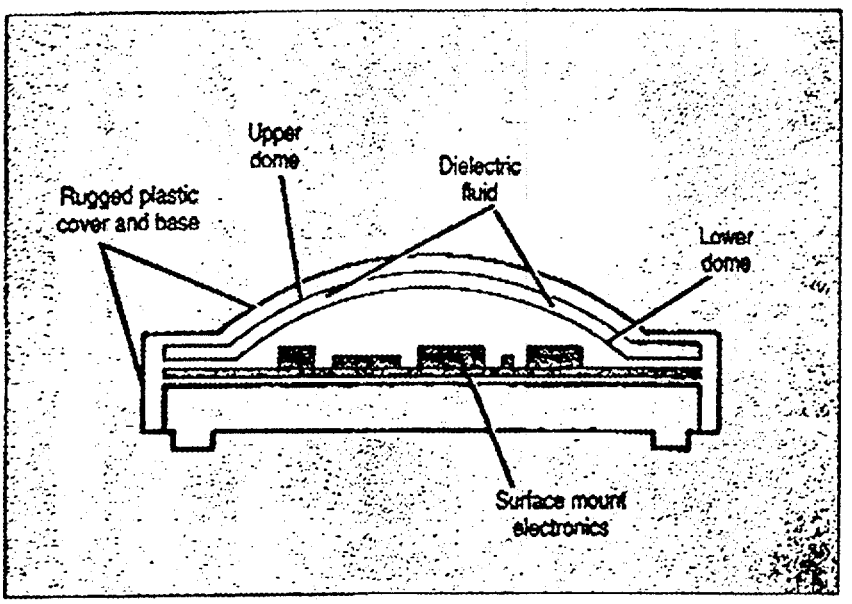
Scott Kohler



AccuStar® II combines the function of two clinometers in one package. The unique, dome shaped design features a capacitance based sensor which produces output signals directly proportional to the relative tilt in two axes.

Designed for high volume applications, AccuStar® II is priced to compete with much less capable mercury switches and other low cost level sensors.

Performance	
Resolution	0.01°
Range	± 20°



Cutaway view of the AccuStar® II illustrates the simple design concept (patent pending).

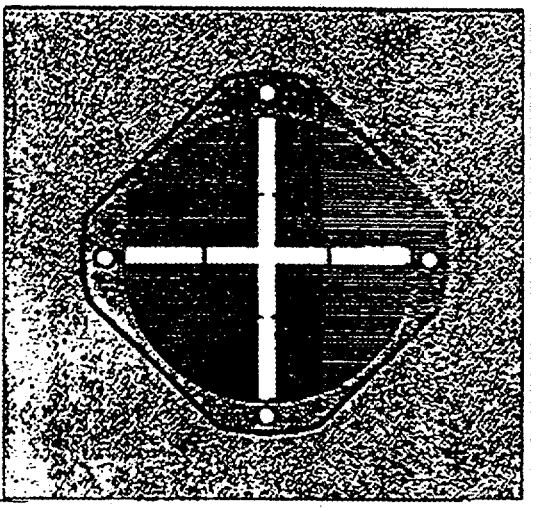
Design concept

Physically the sensor is composed of two hermetically sealed domes spaced about 1/8" apart. The lower, polyester plastic dome has 4 capacitance plates while the aluminum, upper dome acts as a ground. A fluid with a high dielectric constant is sealed within the dome sandwich, leaving an air bubble about the size of a quarter. The bubble is centered at level position and will, of course, move from one side to the other as the device is tilted.

The secret is under the dome

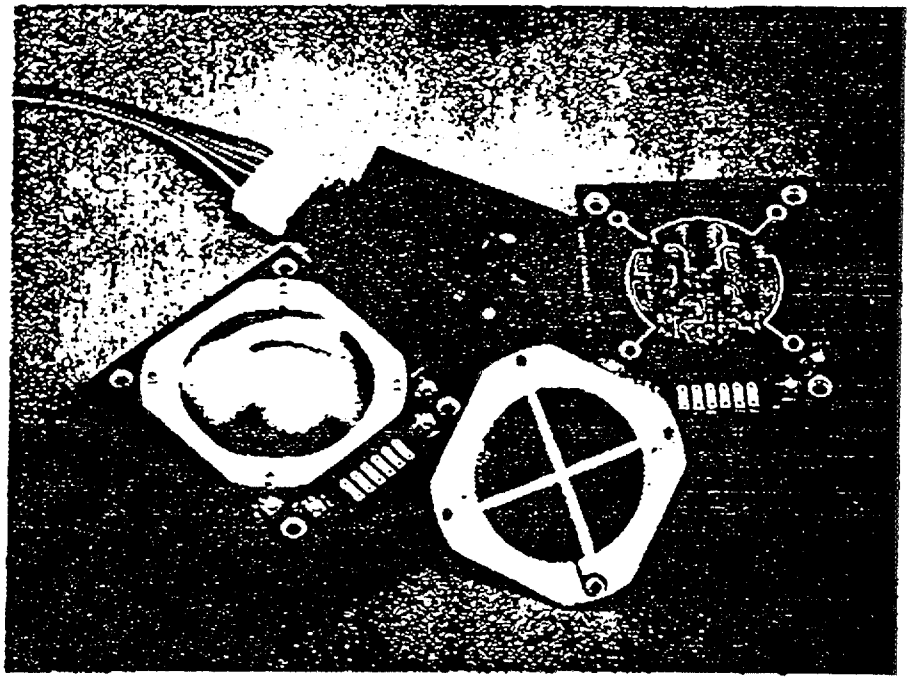
The underside of the lower dome is divided into four conductive quadrants. A pair of quadrants, opposed to each other are used to sense position in one axis while the opposite pair is used for the other axis.

When you tilt the sensor, the bubble, moving under the force of gravity changes the capacitance. The resulting differential generates an output signal which accurately reflects the relative tilt of the device in either x or y axis. The pin selectable output signal provides both pulse width modulation or a DC analog voltage output.



View looking down at the top of the dome depicts the moving bubble and the four conductive quadrants.

AccuStar® II
Dual Axis Clinometer



Adaptable design

The simplicity of the design concept makes it possible to adapt the basic sensor to almost any configuration. The unit can be provided with or without a cover. The circuit board is available with or without aluminum mounting legs. The molded cover assembly is sealed with a silicone rubber compound to protect the sensor and electronics.

The majority of the surface mount circuitry is contained underneath the dome. The only electronics located outside the dome area are four potentiometers which provide scale factor and null adjustments. There are six input and output connections located on the card edge connector providing a choice of ratiometric analog or pulse width (PW) digital output. A mating connector (sold separately) provides the user with an easy plug-in connection.

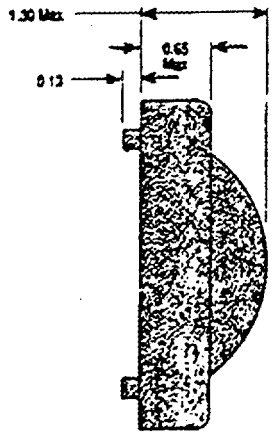
Specifications

Performance	
Range	±20°
Threshold/resolution	0.01°
Linearity	
Null to 10°	±0.2°
10° to 15°	2% of reading
15° to 20°	Monotonic
Null repeatability	±0.1°
Time constant	0.3 second
Frequency response (-3dB)	0.5 Hz
Environmental	
Temperature range	
Operating	-40° to +85°C
Storage	-55° to +85°C
Temperature coefficient of null	0.01° per ° C
Temperature coefficient of scale factor	0.10 % per ° C
Electrical	
Voltage supply nominal	+9 VDC
Voltage supply range	+5.0 VDC to + 15.0 VDC regulation required
Current	3.5 milliamps
Analog Output	
Scale factor @ +9 VDC	100 millivolts per degree
Load resitance	10K ohms minimum
Pulse Width Output	
Null	50%
Scale factor	0.7% per degree to (14 µs per degree nominal)
Duty cycle	$t_1/(t_1 + t_2)$
	t_1 and t_2 varies from 0.2 to 0.7 msec
Frequency	≈ 1 kHz nominal

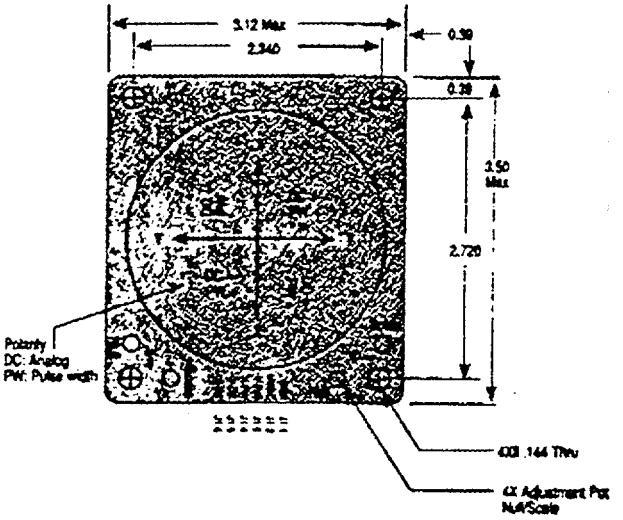
AccuStar® II
Dual Axis Clinometer

Dimensions

Side View



Top View

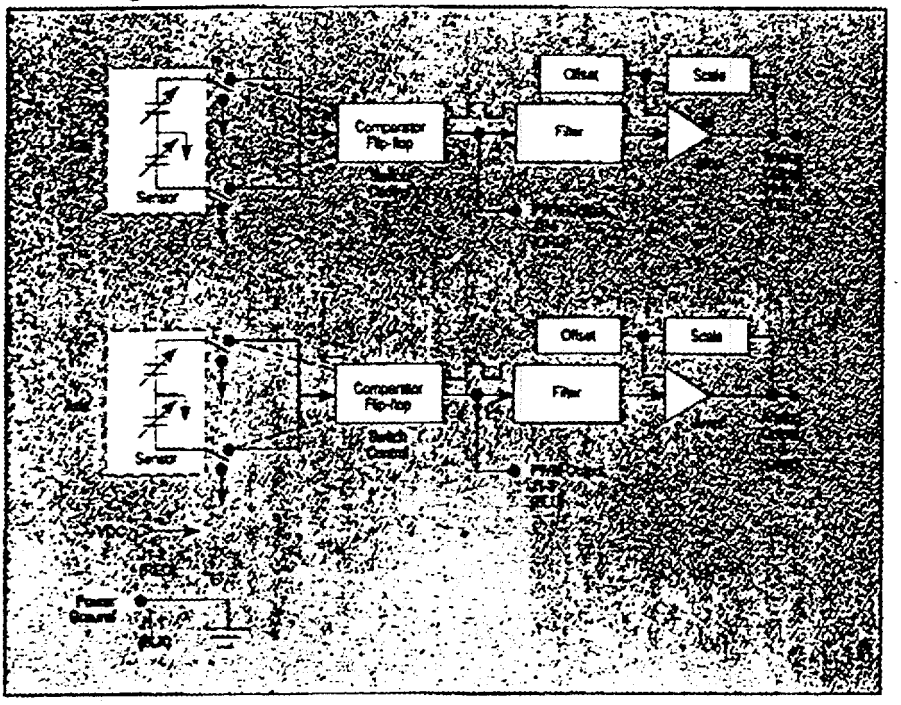


Horizontal Mounting - Standard

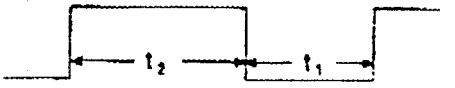
Electrical Connections

Pin	Wire	
1	Black	Ground
2	Red	+9 VDC
3	Blue	PWM output (Y)
4	Orange	PWM output (X)
5	Green	Analog output (Y)
6	Yellow	Analog output (X)

Block Diagrams



Dual axis digital output



The pulse widths t_1 and t_2 are proportional to the sensor capacitance. As the sensor is rotated, t_1 increases or decreases and t_2 decreases or increases.

Pulse width ratio: $R = \frac{t_2}{(t_1 + t_2)}$

At null when ($t_2 = t_1$) R = 50%

At +1° rotation R ≅ 50.70%

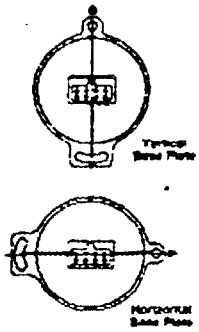
At +20° rotation R ≅ 64.0%

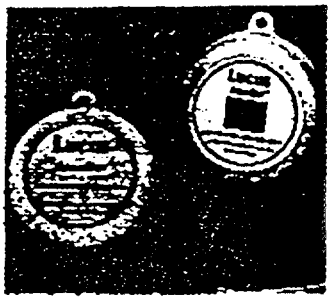
At −1° rotation R ≅ 49.30%

At −20° rotation R ≅ 36.2%

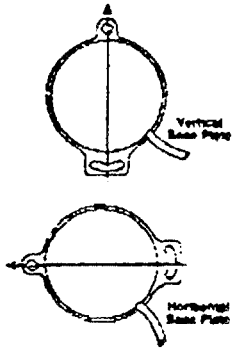
AccuStar I®

Electronic Clinometer





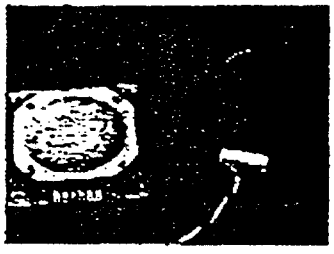
	Part Number	1-9	10-24	25-49	50-99	100+
Connector Models						
Analog I/O (Vertical)	02383-01	$120	$114	$109	$101	Consult
Analog I/O (Horizontal)	02481-01	120	114	109	101	Factory
Ratiometric (Vertical)	02383-09	120	114	109	101	
Ratiometric (Horizontal)	02481-04	120	114	109	101	
Digital I/O (Vertical)	02383-02	120	114	109	101	
Digital I/O (Horizontal)	02481-02	120	114	109	101	
Mating Connectors						
Molex (Connector only)	22-56-8087A	$2				
Analog I/O with 18" pigtail	02507-02	7				
Ratiometric with 18" pigtail	02450-04	7				
Digital I/O with 18" pigtail	02527-02	7				
Adaptor						
Single Point Mounting Adaptor	02448-01	$12				



	Part Number	1-9	10-24	25-49	50-99	100+
Pigtail Models						
Analog I/O Vertical	02338-03	$133	$127	$122	$114	Consult
Analog I/O (Horizontal)	02706-01	133	127	122	114	Factory
Ratiometric (Vertical)	02364-01	133	127	122	114	
Ratiometric (Horizontal)	02706-03	133	127	122	114	
Digital I/O (Vertical)	02382-03	133	127	122	114	
Digital I/O (Horizontal)	02706-02	133	127	122	114	
Adaptor						
Single Point Mounting Adaptor	02448-01	$12				

AccuStar II®

Dual Axis Clinometer



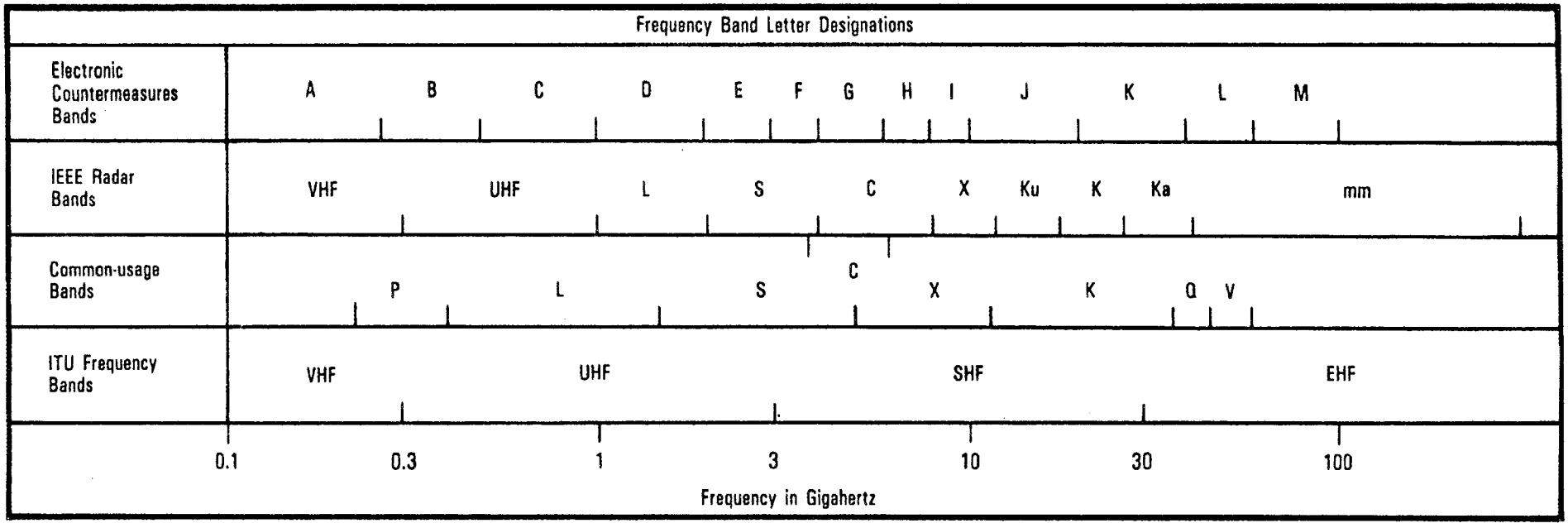
	Part Number	1-9	10-24	25-49	50-99	100+
Clinometer with plastic case	02753-01	$80	$76	$71	$68	Consult
Clinometer without plastic case	02755-01	75	71	67	64	Factory
Mating Connector						
Molex	09-01-1061A	$2				

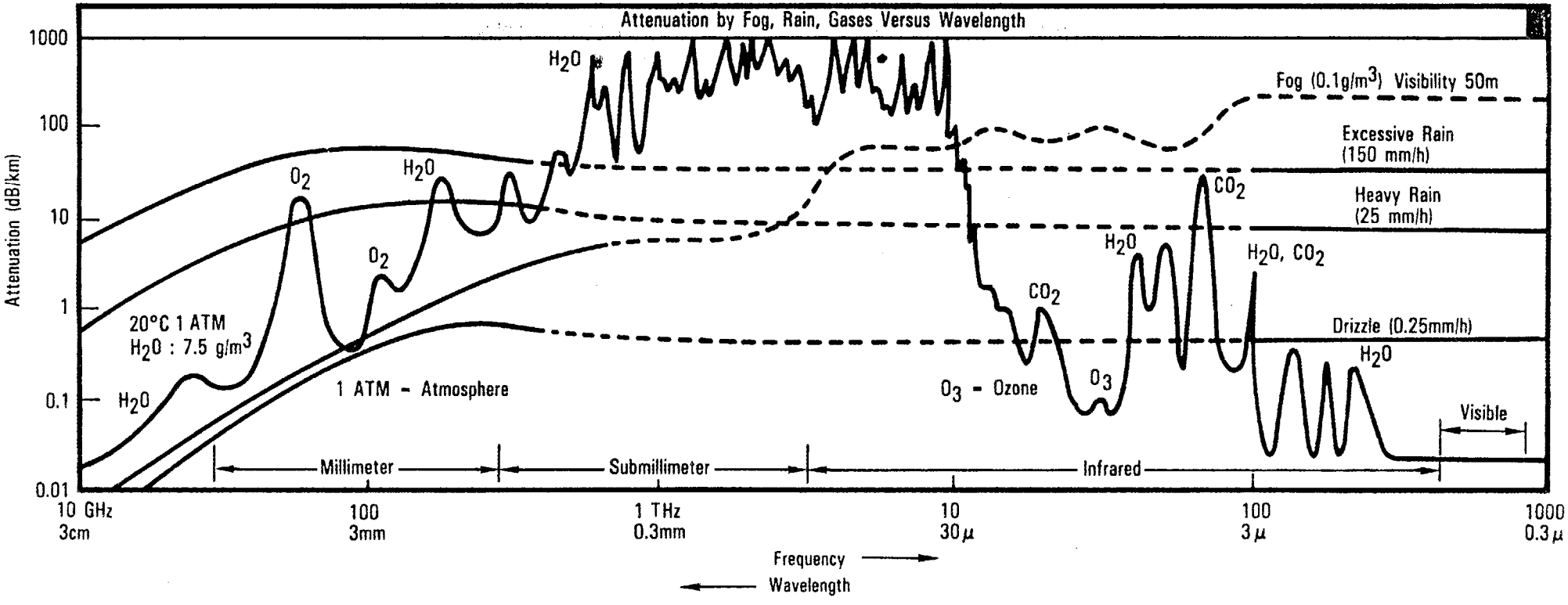
NOTE: Connector is necessary for 02753-01 because of limited access to edge connector.

800/745-8008 (609/662-8000 in NJ)
FAX: 609/662-6281

APPENDIX I: TECHNICAL DATA FROM HEADWAY/TAILWAY DEVICE VENDORS

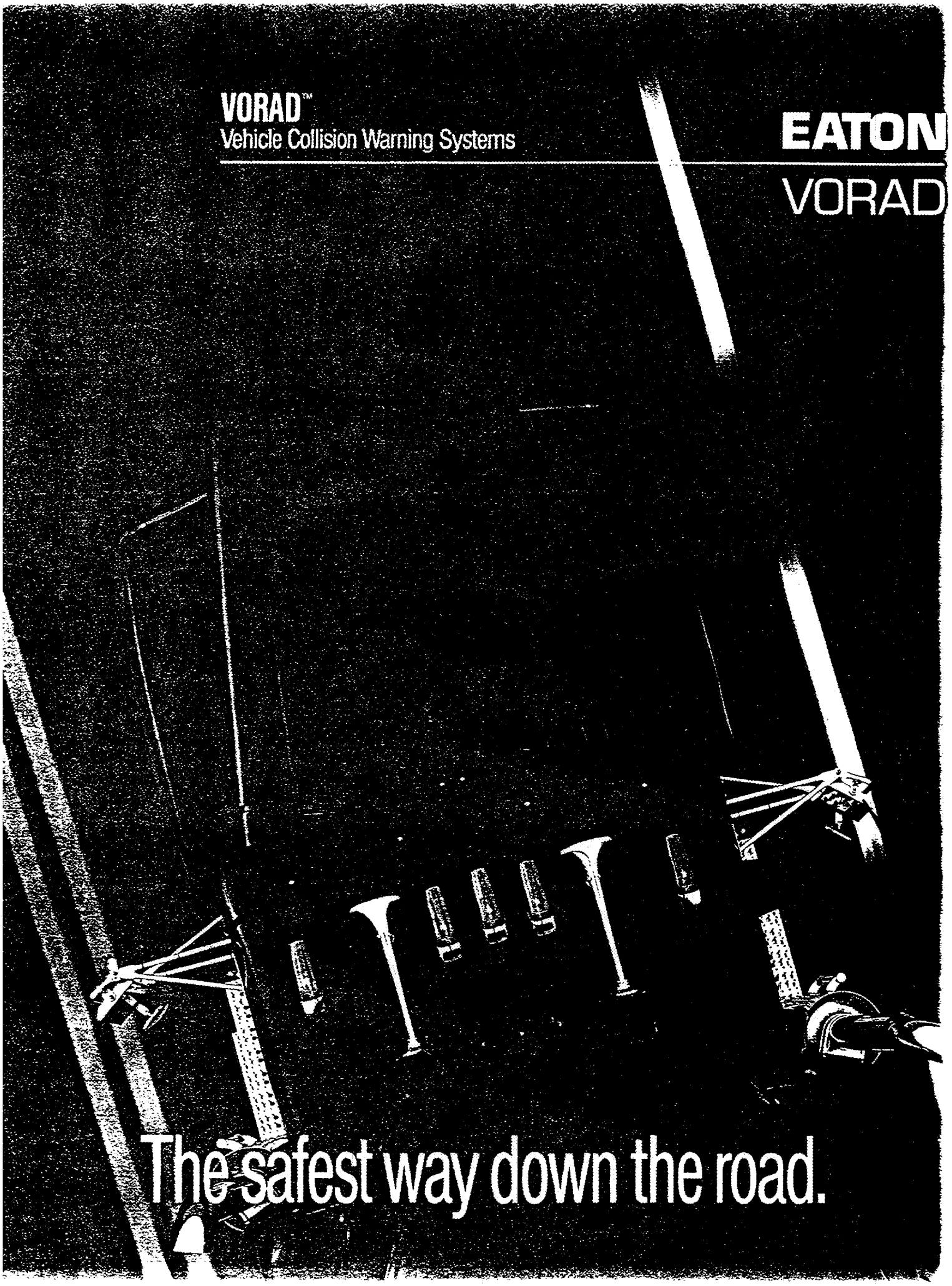
TRW Electronic Systems
VORAD Safety Systems


Frequency Band Letter Designations
Electronic Countermeasures Bands
A B C D E F G H I J K L M
IEEE Radar Bands
VHF UHF L S C X Ku K Ka mm
Common-usage Bands
P L S C X K Q V
ITU Frequency Bands
VHF UHF SHF EHF
0.1 0.3 1 3 10 30 100
Frequency in Gigahertz


Attenuation by Fog, Rain, Gases Versus Wavelength
Attenuation (dB/km)
1000
100
10
1
0.1
0.01
Fog (0.1g/m3) Visibility 50m
Excessive Rain (150 mm/h)
Heavy Rain (25 mm/h)
Drizzle (0.25mm/h)
H2O
O2
CO2
H2O, CO2
O3
20°C 1 ATM
H2O : 7.5 g/m3
1 ATM - Atmosphere
O3 - Ozone
Visible
Millimeter
Submillimeter
Infrared
10 GHz 3cm
100 3mm
1 THz 0.3mm
10 30μ
100 3μ
1000 0.3μ
Frequency
Wavelength

VORAD™
Vehicle Collision Warning Systems

EATON
VORAD



The safest way down the road.

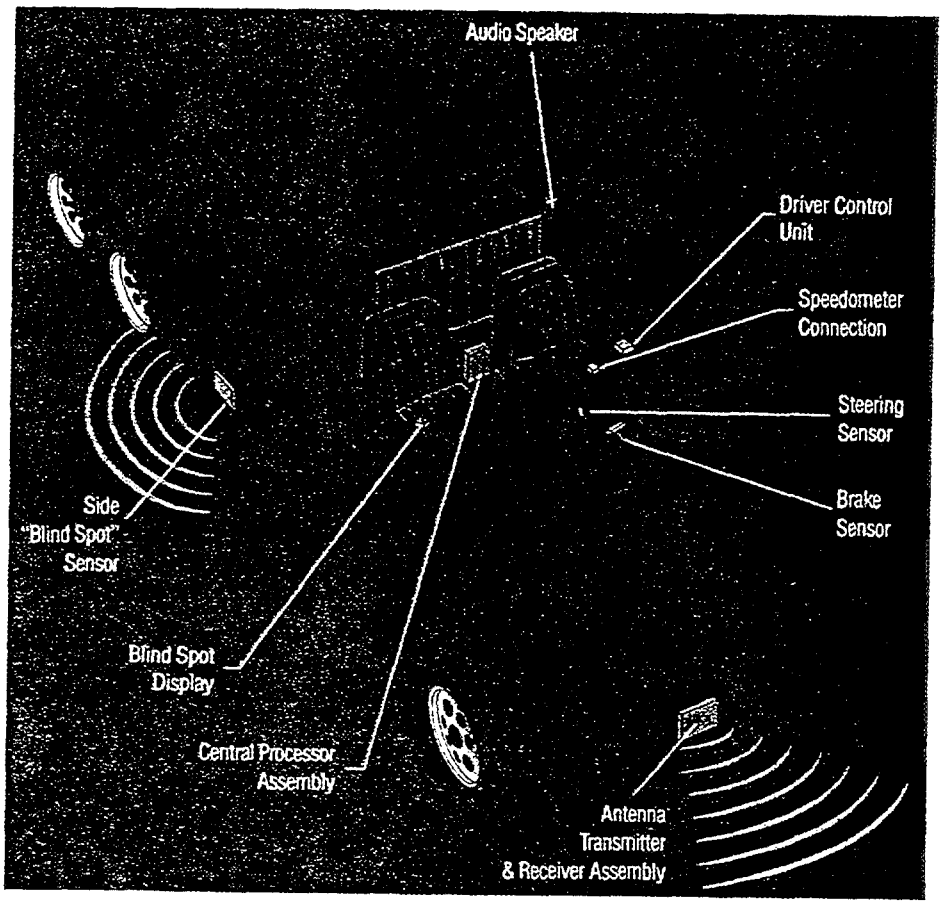
In a world full of hazards, VORAD™ gives you peace of mind.

VORAD™ (Vehicular On-board Radar) is like an electronic eye that constantly monitors other vehicles on the road. The VORAD Vehicle Collision Warning System gives your drivers additional reaction time to respond to potential dangers.

But just how valuable is a split second of extra reaction time? In reality, it could mean the difference between life and death. Studies show that if drivers are given just a half-second more time to react, they can avoid 60% of all rear-end collisions, 50% of intersection accidents, and 30% of all head-ons.*

That means money saved by reduced accident litigation, liability judgments, and lower insurance costs. But more important than that could be the savings in injuries, and even lives.

*Daimler-Benz

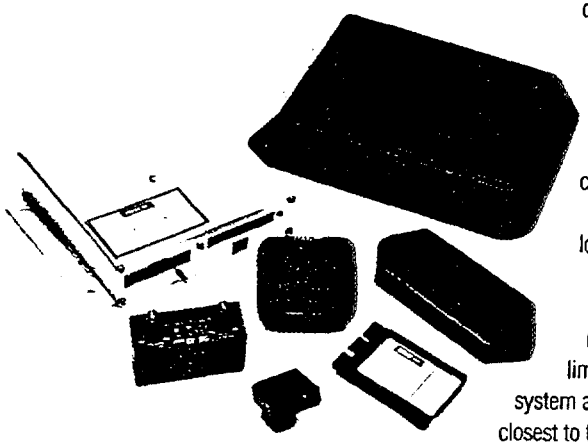


What is VORAD?

VORAD is a high frequency radar system comprised of an antenna, transmitter/receiver assembly, a central processor, a speaker assembly, and a driver control unit which includes warning display lights: green, yellow, and red.

These components function together to determine the speed and relative distance of objects ahead. Upon sensing a potential hazard, such as a vehicle suddenly decelerating, VORAD emits a combination of lights and audible warning tones to give your drivers additional time to apply the brakes or take other evasive action.

The radar's reach can be adjusted to the driving environment, in order to make it less sensitive in city driving and more sensitive on the freeway, where it can be set to reach up to 350 feet. VORAD has a computational rate of over 10 times per second, providing your drivers with more reaction time in conditions where they need it the most, such as darkness, dense fog, dust, or smoke.



How VORAD works.

VORAD is based on proprietary aerospace technology that combines microwave signals with patented circuits and algorithms.

By transmitting and receiving very low-power microwave energy and using Doppler phase shift principles, the VORAD System can track up to 20 moving or stationary objects. Within the limitations of its range and antenna, the system actually analyzes the three vehicles closest to the host vehicle. The signals are relayed to the central processor, analyzed, and passed on to the driver control unit.

The driver control unit uses a combination of lights and tones to communicate this information to the driver. Adjustable controls allow your drivers to set the volume of the alert tone and the amount of advance warning time desired.

The VORAD System also offers an optional side "blind spot" detector, which uses a red light to indicate when a vehicle has entered the blind spot and a yellow light to indicate when the vehicle has cleared the area. If a turn signal is activated while the red light is on, a warning tone will sound to further alert your drivers to hazardous situations.

Is it effective? Here's what Hub Cummings, an independent trucker from Charleston, WV, has to say: "On a foggy night run through western Pennsylvania, VORAD kept me from rear-ending a truck whose rear light had failed."

Reducing insurance costs.

VORAD™ can save lives. But it can also save you a lot of money.

Today's insurance costs account for as much as 20% of truck operating costs.

Insurance costs many fleets more than 50% of their fuel expense, and 45% of total parts and maintenance. But insurance costs can become much lower with VORAD because it can reduce the number of costly accidents.

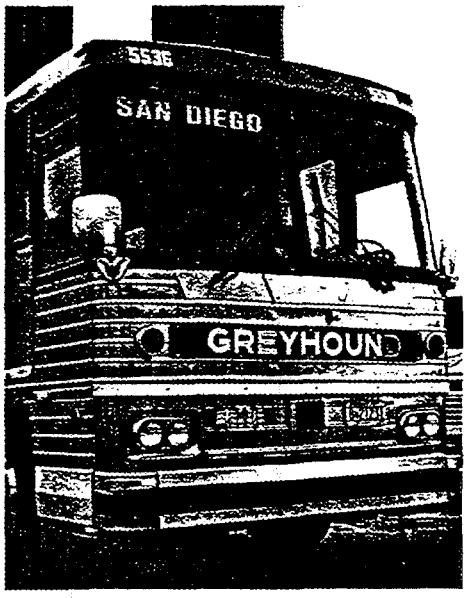
One look at a recent study by a major carrier reveals that the average cost per year of preventable accidents was over $1,400 per truck. With VORAD, savings from reduced accidents is money right back in your pocket if your fleet is self-insured. And if your fleet is covered by an insurance company, it means long-term savings on your premiums. Allstate President, Jerry Choate says, "Ultimately, we believe this technology will keep the cost of insurance down by reducing accidents and saving lives."

With accident settlements ranging upwards of $1 million, you cannot afford to be without VORAD.

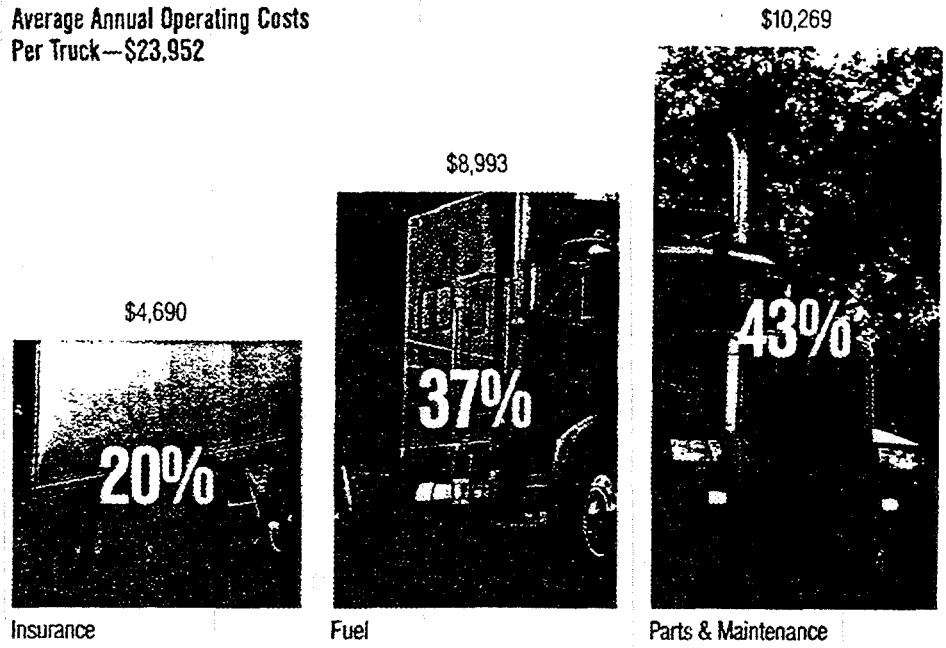
Tracking the cause of accidents.

If an accident does occur, VORAD's optional accident reconstruction feature can act as a "black box" to assist in reconstructing events leading up to the accident. This feature can help insurance adjusters and law enforcement officials determine responsibility with greater accuracy than ever before. The Accident Recorder is particularly useful in situations where vehicles with antilock brakes are involved and there are no skid marks at the accident site.

"We're the first ground transportation company in the world to employ this technology... it will be installed on all 2,400 of our buses."—Frank Schmieder, President, Greyhound Lines, Inc., Dallas, TX. ▼



Average Annual Operating Costs Per Truck—$23,952



▲ *Nearly $1 of every $5 in truck operating costs goes to insurance. It represents more than half the cost of fuel and over two-fifths of maintenance.*

Optional trip recorder capabilities.

VORAD's integral trip recorder displays idle time, speed (average and maximum), average following distance, number of hazard warnings given the driver, and distance traveled. This data is organized into 50 segments that can cover more than 30 days of operation. The data can then be downloaded at the fleet maintenance facility directly to a PC or onto a high density data memory card capable of storing information for up to 80 vehicles before it must be downloaded.

VORAD can be configured to allow information interchange between fleet operations and the host vehicle using cellular telephone or satellite communication through standard SAE data links.

Other options include three additional blind spot sensors, an ignition security interface and driver fitness-for-duty evaluations.

Reliability is built right in.

VORAD can give you years of trouble-free operation. The complete system has been subjected to stringent vibration and burn-in tests that simulate the road environment.

VORAD has a Built-In Test (BIT) that checks the system every ten seconds. If it detects a fault, the driver control unit gives a blink code that identifies the problem. Eaton VORAD also offers a diagnostic kit that provides even greater capability in trouble-shooting.

Installs easily on existing vehicles.

Using two qualified technicians, the optional VORAD tool kit, and the field test unit, installation of the VORAD System takes two to three hours. A step-by-step check out procedure with the field test unit checks all circuits and functions to assure the VORAD System has been properly installed.

Twelve-month warranty.

VORAD is sold with a twelve-month warranty. Exhaustive testing, including over two million highway miles by fleets and owner-operators, has proven VORAD in actual use. Stringent quality control in the manufacturing process ensures that the system will be extremely reliable. VORAD has been approved by the FCC for use on U.S. highways.

▲ *"Having used it for over 300,000 miles, I can tell you it really works. It has already prevented more than three accidents. If VORAD prevents one accident it has paid for itself. It is well worth the investment."—Jim Kennington, Independent Trucker, Charlotte, NC.*

Eaton and VORAD joining forces.

Eaton and VORAD Safety Systems have combined to serve the growing safety management needs of trucks and truckers. From our new offering of collision warning systems and blind spot detectors will evolve future applications, such as Eaton® VORAD™ SmartCruise™ Control.

SmartCruise combines normal vehicle speed control systems with VORAD,™ allowing the vehicle to maintain a fixed distance from the traffic ahead. If your vehicle is travelling at a set speed and approaches slower traffic, the adaptive cruise control automatically slows the engine down to maintain a safe distance from the traffic ahead.

SmartCruise is just one of the many safety management products to expect from Eaton VORAD in the future.

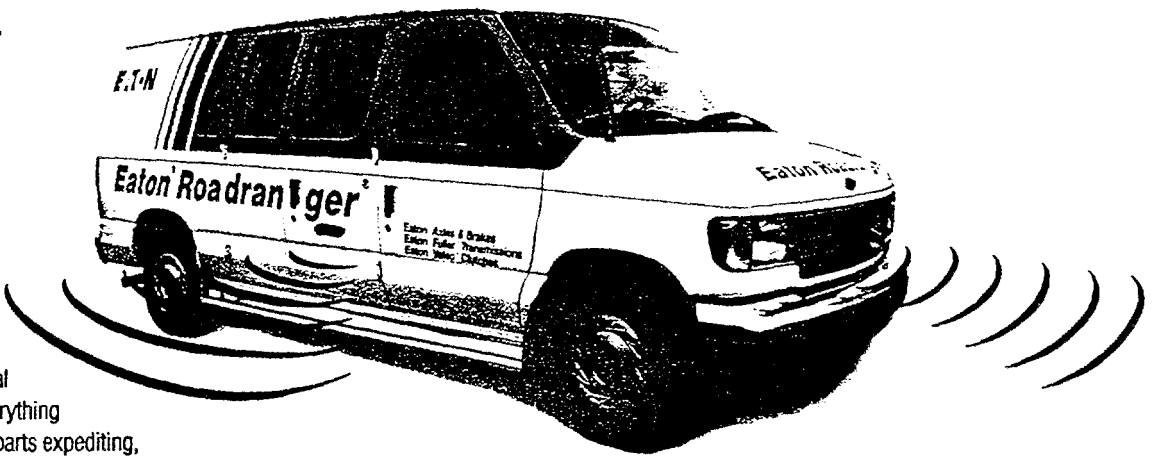
Eaton® Roadranger® Support.

When you order a VORAD System from Eaton VORAD, you automatically receive help from the largest, most experienced, most accessible field service support network in the industry—the VORAD-equipped Eaton® Roadranger® network.

You can call on our technical experts 24 hours a day for everything from spec'ing assistance and parts expediting, to on-the-spot troubleshooting. And you'll get this kind of service whether you own one truck or an entire fleet. For more information about VORAD, call 1-800-782-7825.

Specifications:

Vehicle Closing Rate	0.25-100 MPH 0.4-160 km/h	
Operating Range	1-350 feet typical 0.3-110 m typical	
Host Vehicle Speed	0.5-120 MPH 0.8-190 km/h	
Power Requirements	12 to 24 VDC 20 watts nominal	
Operating Frequency	Forward Radar Blind Spot Radar	24.125 GHz 10.525 GHz
Total System Weight	6.75 lbs. (approximate) 3.1 kilograms (approximate)	



Eaton VORAD Technologies
10802 Willow Court
San Diego, CA 92127
(800) 782-7825

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VORAD

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THE WALL STREET JOURNAL.

MARKETPLACE

TECHNOLOGY

Crash-Avoiding Radar Is Ready To Hit the Road

By ROBERT TOMSHO
Staff Reporter of THE WALL STREET JOURNAL

Collision-avoidance radar, which may become a pivotal part of the nation's ground transportation system, is scheduled for a major road test.

Greyhound Lines Inc. later this year will begin equipping its 2,400-bus fleet with "vehicle on-board radar," or Vorad, systems manufactured by Vorad Safety Systems Inc., a unit of San Diego-based **IVHS Technologies** Inc.

Greyhound and Vorad plan to announce the $5 million project at a joint news conference with U.S. Secretary of Transportation Andrew H. Card Jr. this morning in Washington, D.C.

With land for urban highway expansions scarce and government funding for such construction projects even harder to find, more transportation planners and engineers are looking to so-called "intelligent vehicle highway systems," or IVHS, to make overburdened highways more efficient and safer. And with the potential market for such products and services estimated at as much as $200 billion over the next two decades, a host of auto makers and parts manufacturers are working on a wide range of "smart car" products.

In addition to reducing accidents by giving drivers more time to react to dangerous situations, transportation analysts say the sort of radar being employed by Greyhound could lead to an electronic de-

Please Turn to Page B6, Column 6

Other devices employing such technology could ultimately include cars that read highway sensors to steer and brake themselves, cellular communications systems that feed information about traffic jams and construction delays onto dashboard display screens and advanced vehicle identification systems that let truckers drive long distances without having to stop for document checks and weigh-ins.

Such Japanese auto makers as **Nissan Motor** Co. Ltd. and **Toyota Motor** Corp. are already offering high-tech navigation systems that direct drivers to their destinations with the help of computerized maps displayed on a video screen. A group of 14 European car makers have conducted joint research on similar systems since 1986.

In this nation, the federal government has set aside $660 million for IVHS research and development over the next six years. Meanwhile, **General Motors** Corp. is developing a "smart" cruise control that reacts to surrounding traffic, trucking companies have begun using satellite communications to track and dispatch their vehicles more efficiently, and various public-private research projects are experimenting with IVHS techniques to untangle transportation trouble spots in California, Michigan and other states.

But the Greyhound project marks "the first large-scale deployment of any of these devices," says Steven Shladover of the Institute of Transportation Studies at the University of California at Berkeley.

Until recently, radar systems were too bulky and couldn't reliably differentiate moving vehicles from guardrails and highway signs. But recent advances in computer technology, including smaller data-storage devices, have made the $2,000 system more appealing, at least for big fleet operators like Dallas-based Greyhound. Still, Vorad says it may be several years before it develops a more affordable, $500-to-$700 unit for passenger cars.

Nonetheless, transportation engineers say the current project will give them their best chance yet to test the acceptance of such devices, since it involves hundreds of professional drivers who travel millions of miles under a variety of driving conditions. Moreover, if the radar results in fewer accidents, it could help popularize such devices with the general public. "It has the potential to provide some immediate payoff," says Gary Euler, chief of program management and systems engineering for the Federal Highway Administration.

Greyhound eventually hopes to modify its system to provide computer-collected information on highway accidents, drivers' reactions to near-collisions and perhaps even vehicle maintenance needs.

But in the short run, the company is banking on the new radar to help it improve upon a safety record that has come under fire since the company replaced striking Amalgamated Transit Union drivers with new hires in March 1990.

Earlier this year, the National Transportation Safety Board said inadequate driver training was the probable cause of two 1991 bus crashes that killed one Greyhound passenger and injured 47 others. Greyhound also paid a $150,000 fine to settle Federal Highway Administration claims related to alleged violations of federal motor carrier regulations and hiring procedures. The company had 5.5 accidents per million miles during the first quarter vs. 6.6 accidents per million miles during the year-earlier quarter.

"Accident reduction is the major thing," says Frank Schmieder, Greyhound president and chief executive officer, who projects that the radar will cut Greyhound's accident rate 25%.

The Vorad system being purchased by Greyhound involves a cigar-box sized sensor that can detect moving objects up to 400 feet in front of a bus and, by transmitting the information through a computer processor in the vehicle's cab, warn the driver with a system of dashboard lights and sirens as to what sort of threat, if any, they present. A second radar system attached to the side of the buses will warn the drivers if there are vehicles in their so-called "blind spot."

In addition to aiding drivers on foggy days or at night, Greyhound says the system will alert drivers to suddenly decelerating vehicles in all weather. "This is an extra pair of eyes and ears for our drivers," says Ted Meyer, Greyhound's director of safety and security.

But the Vorad system won't include automatic emergency braking, as its developers originally envisioned. "It's not in the Greyhound system and we don't see it in the commercial or automotive world for a number of years," says Paul Bouchard, president and chief executive officer of Vorad Safety Systems. "Anytime you have an electronic device that in any way takes control of the vehicle, you have some liability concerns . . . to think about."

Despite its promise, the system being installed by Greyhound could have problems. The sensor's electronic eye doesn't readily pick up dangers in other traffic lanes and it senses metallic objects such as cars more readily than humans. Truckers who tested it say it tends to set off police radar detectors in other vehicles.

Nevertheless, at least one consumer advocacy group says it is eager for the Greyhound radar to hit the road. "I think it may very well be a good step forward," says Clarence Ditlow, executive director of the Center for Auto Safety, a Washington-based group associated with consumer watchdog Ralph Nader. "We're not interested in perfection. You will never have a system—brakes, air bags or seatbelts—that is going to work 100% of the time."

Radar Technology For Avoiding Crashes Is Set to Hit the Road

Continued From Page B1

vice that relieves traffic congestion by allowing platoons of vehicles to travel together at high speeds while maintaining a safe distance between themselves.

Popular Science

THE WHAT'S NEW MAGAZ

SEPTEMBER 1992
Founded in 1872/Vol. 241, No. 3

Anti-collision radar

The day is coming when mesmerized commuters tailgating their way to work will be able to add black boxes to their cars that issue a sharp warning of an impending collision.

Called VORAD (for vehicular on-board radar), the system developed by IVHS Technologies of San Diego uses a radar antenna mounted in a vehicle's front grille to sense obstacles ahead. Sophisticated software in a signal-processing module discriminates relatively benign objects, such as a bird in flight, from those that pose a likely threat. When a hazard is identified, the system immediately warns the driver to slow down, stop, or possibly swerve to avoid a collision.

Whether such an alert system makes an impact on road safety should be demonstrated within a few years by Greyhound Lines. The bus company is equipping its 2,400-vehicle fleet with VORAD systems that use a narrow "pencil-beam" radar to monitor objects as far as 450 feet down the road. The version Greyhound is using has a second wide-beam radar antenna that warns the driver of objects in the blind spot on the right side of the bus.

The $5 million worth of equipment Greyhound is purchasing includes a short-term event recorder—much like an airplane flight recorder—that stores data on the most recent 15 minutes of driving. Information on vehicle speed, closing rate with target objects, time of brake application, and steering movements is collected. It can later be retrieved to teach and monitor driver skills or to reconstruct events leading up to an accident, according to Paul Bouchard, president of VORAD Safety Systems.

Microwave signals emitted from a vehicle's front-grille antenna (above) provide warnings of impending collisions on a dashboard display

Scaling down VORAD in size for widespread use in cars depends on the microwave frequency band assigned by the Federal Communications Commission for such use. The bus system uses a flat six-by-eight-inch phased-array antenna to operate on the 24.125-gigahertz band, which is also shared by radar detectors. VORAD triggers some false alarms on the detectors, although initial tests show that it doesn't excite the VG-2 "radar-detector detectors" used by police in Canada and in states that ban use of radar-sensing devices, Bouchard says.

Antenna size could be reduced (and radar detector interference eliminated) if the higher-frequency 60- or 77-gigahertz bands proposed for anti-collision radar in Japan and Europe are adopted here too. Then the antenna would only need to be one-third as large, Bouchard says, although the cost of the electronic circuitry would be higher. He estimates that volume-manufactured systems for cars would cost $500 to $750.

Traffic and obstacle information sensed by VORAD can be used to do much more than trigger bells and whistles. IVHS provided a test drive in a Lincoln car equipped with "adaptive" cruise control, which slows the vehicle to maintain a safe distance from slower-moving traffic ahead. The car also has a system that automatically applies the brakes when VORAD determines that a collision is imminent. This feature could someday be part of a system that would enable automated vehicle "platooning," or convoy-style group driving in close proximity on highways.—*Stuart F. Brown*

APPENDIX J: TECHNICAL DATA FROM LATERAL POSITION LANE TRACKING SYSTEM VENDORS

Williamson Associates
TNO Institute for Human Factors
Netrologic
Aerometrics

2 July

WILLIAMSON ASSOCIATES

Consultants APOT

Specializing in design and development of prototype systems

June 30, 1993

6613 Lynndale Drive
Raleigh, NC 27612
1-919-848-3618

Mr. Dick Carter, Manager
Cognitive Systems & Human Factors Group
Engineering Physics and Mathematics Division
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6360

RE: Lane Tracker Proposal (Lateral Position Tracking System).

Dear Dick,

I enjoyed our conversation last Thursday. After realizing that you are in the Human Factors Group, I "replayed" some of my comments about "human factors types", and I do apologize...I think. Actually, I am recommending to the curriculum committee that Electrical Engineering students be required to have Human Factors courses. Too often EEs make Human Factors decisions, and very often they are wrong! It is interesting: I can think of few of my last projects that didn't have Human Factors implications that needed to be addressed. Anyway, have I extracted my self...just a little?

I have enclosed the proposal for the lane tracker.

I have also enclosed my resume, as well as the following paragraphs, which will bring you up to date.

Williamson Associates

Williamson Associates is a sole proprietorship, electronics engineering consulting firm. It has been in business for over nine years and has serviced such customers as IBM, AT&T/Bell Labs, Sun Microsystems--to name a few. Williamson Associates's speciality is the design of prototype systems: our clients will have a need without a specific design in mind and we are commissioned to research the various approaches available and to suggest the best approach. At the option of the client: this is followed by the design, prototype construction, testing, final evaluation and documentation of the selected approach.

Being a consulting firm, Williamson Associates has the advantage of using the services of various professionals whose skills fit the particular project at the time. This coalition allows us to maximize our productivity with a minimum of people and overhead. Our forti is the "real world" approach oriented toward practical results, not academic esoterrica.

Glen A. Williamson

NCSU

Presently I am involved in several projects: the most fun of which is teaching the senior design class at The Design Center of the ECE Department, NCSU at Raleigh. I am in the process of receiving a permanent appointed as "Technical Specialist in Residence." There I am developing several proposals of mine dealing with remote DWI detection and IVHS.

HiRes Camera

Also, I am developing an inexpensive, very high resolution color television camera of my design. What is unique about my camera is that it is an off-the-shelf ($1,500) cameras modified in such a fashion that I am able to get better than HDTV resolution (3000H x 1800V pixels). I am developing this camera as an integral part of what I call: The Next Generation Automated Workstation Imaging System.

Over...

Elderly Home Care
I am also developing a system that would allow the elderly or infirm to remain living in their own home, beyond the time they would go into a nursing or retirement home. Unlike the "popular approaches," this system is based on covertly monitoring the person's day to day activity. Monitoring such things as opening and closing kitchen cabinets; light switches; watching TV; using the toilet, etc. This activity is compared to previous activity in an attempt to detect any untoward events or marked change in behavior, and respond appropriately.

Other Fun
For about the last nine years I have run my own consulting firm--Williamson Associates--and have consulted for various companies and institutions. Among the more notable clients have been IBM, on two separate occasions, for a total of four and one half years; and for AT&T/Bell Labs for over a year on their "Pixel Machine" supercomputer. At IBM a large amount of my time was devoted to applied research and development of a comprehensive--PC based--communications system utilizing voice and imaging for teleconferencing: similar to what recently has become known as "Multi Media."

Project Engineering
As a consulting project engineer, I was responsible for the project from its initial design, prototyping, testing of the pre-production boards/system--including EMC testing--through to, and including, its production. Sometimes I worked alone on certain parts of a project, but often I worked as part of a team. In either case, working and communicating with disparate groups within that organization--as well as outside vendors--was part of my function.

OJT
I am self educated: At 25, I completed and filed for, and was granted, a patent on an invention of my design: a Speech Bandwidth Compression system (8:1). I was invited to join the staff of the Electrical Engineering Dept. at North Carolina State University, in Raleigh. There I designed and developed communication and imaging research projects mainly for DoD, and I participated in seminars and occasionally lectured in the graduate school for the next 10 years.

Dick, if you've read this far, *sorry about that!* My resume has been known to give hernias.

Anyway, I have had some good results with the "Heart Rate/Breathing Rate" device. I have used it in a vehicle, and had much better results than in the Lab. As far as motion artifacts are concerned, it turns out, with the transducer mounted in the driver's bucket seat, that most driver movement is orthogonal to the incidence of the transducer. Only Z axis movement (too and from the steering wheel/seat) is of consequence--not a common movement. The power level can be, and needs to be reduced: as I was driving around listening to my heart and breathing, the device was "spilling" out of the vehicle and I was getting vehicle speed Doppler returns--that was a *trip*!

Also, the other day I had left the system operating on the lab bench, and was seated at my workstation about 20 feet away, and I could hear my heart beating. I do believe the power level can be reduced!

I hope to send you a video tape of it in operation and a written proposal in the next few days.

Thanks Dick, for the opportunity to make these proposals, and if I can answer any questions, please don't hesitate to call.

Sincerely,

Glen A. Williamson

Glen A. Williamson, Owner

Enclosures:

Lateral Position Tracking System
Using a Line Scan CCD Array Camera With an IR Diode LASER

Abstract

We propose the design of a Lateral Position Tracking System, LPTS, that will utilize a small linear CCD array camera and a, low power, IR diode Laser. This camera would be strategically placed on the vehicle, e.g., inside the side mirrors (or directly under) for detecting and tracking the vehicle's lane position relative to the white/yellow lines and/or roadway edge.

The main feature of this system is that, unlike most cameras that are hardwired and fixed function devices, this system is under stored program control. More precisely, it is under the control of the vehicle's host computer. This is a most powerful concept: improvements to this unique imaging task would be a matter of software changes or up grades.

This system, while designed to be under computer control in normal operation, has the capability to operate autonomously if desired (e.g., useful in troubleshooting the hardware/software interface, etc.).

Lateral Position Tracking System

Camera System

The camera consists of one 256 element, linear CCD array mounted behind a "C" mount taking-lens. The lens has a rudimentary auto-aperture system that is under CPU control, and mounted on the front of the lens is an optical band pass filter (3 stage interference type, FWHM = 10nm) centered at 830 nm. The CCD array is clocked, read out and reset by a simple state machine controller, under CPU control

The camera system is in essence a shell, with the major operation and control functions performed by the host computer, under software control. This is accomplished via the computer's parallel port or SCSI interface. On the camera side: It consists of 3, 8 bit control registers; 1, 8 bit status register (optional); and 2, byte-wide data registers.

The only processing or data reduction that occurs in the camera is the determination of line distance from the vehicle. This is done by a presettable up/down counter that is clocked by the scanner clock. As the scanner starts its scan from the vehicle-edge (reference point), the counter counts up. When the white line is encountered, the comparator stops the counter's counting. As the scanner leaves the white line, the counter resumes its counting--but now counts down. In this way the width of the white line in nullified, i.e., the answer is the same whether the white line's width were 12 inches, 4 inches, or was only the roadway/shoulder boundary (road's edge).

How the System Works

Referring to the system block diagram in figure 2: the video output from the CCD array is applied directly to the "white line detection" comparator, while simultaneously tracked by the peak detector. The peak detector output is digitized to 8 bits, using an inexpensive ADC running at about the "frame" rate of the CCD array. (see Fig. 6) This "peak video" data is used by the CPU to determine the proper comparator threshold setting for proper white line/road edge detection. This threshold data is sent to the system after the CPU determines the correct value, and writes control register #1, thus causing the reference voltage DAC to output the proper comparator reference voltage.

Williamson Associates © 1993

The "white line detection" comparator's function is to control the counting and direction of count, of the "distance" counter. As the scan starts and the counter counts up from some preset value: when the white line is detected, the count stops, and then as the line is cleared by the scanner, resumes count in the opposite direction (down). The final count in the counter is the absolute distance of the center of the white line: this 8bit data is written into data register #2, and therefore available for the Host CPU to read.

The final transaction is the control register's control of the CCD array controller and the lens' auto aperture settings. The CCD controller controls the scan rate, the effective exposure interval of the CCD array: a kind of electronic auto aperture.

Exposure Control
The new CCD technology allows electronic exposure control, such that auto aperture with its lag time and over shoot is virtually eliminated. Additionally, if and when extra sensitivity is need, the system's controllable scan rate allows for longer integration time.

Camera Location
The cameras could be mounted inside of, or under, both side-mirrors. As an option, four cameras could be implemented--two facing forward and two facing rearward--yielding greater reliability in determining the actual position of the auto in a traffic lane.

Where's the Line?
Because of the loss of the white-line at intersections, dashed center-lines and the confusion caused by cross-walks, etc.: looking at all four quadrants simultaneously will improve tracking.

Look Forward
Cameras that look forward pick up fine steering variations or quick erratic adjustments; good for erratic driver detection or warning of sudden lane change. Forward looking cameras' lens tend to get dirty and would require some type of wiper/washer system.

Look Backward
Cameras that look backwards are good for averaging steering performance as in a logging of driving history; it effectively filters out fine steering adjustments or quick erratic steering changes. Also, backward looking camera's lens tend to stay cleaner, and might not need a wiper/washer.

Bugs on My Teeth
The cameras would be located behind glass windows or port-holes in a waterproof housing, positioned for minimum road film and bugs; and, if necessary, would have built-in wiper/washers.

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Lateral Position Tracking System
Using a Line Scan CCD Array Camera With an IR Diode LASER

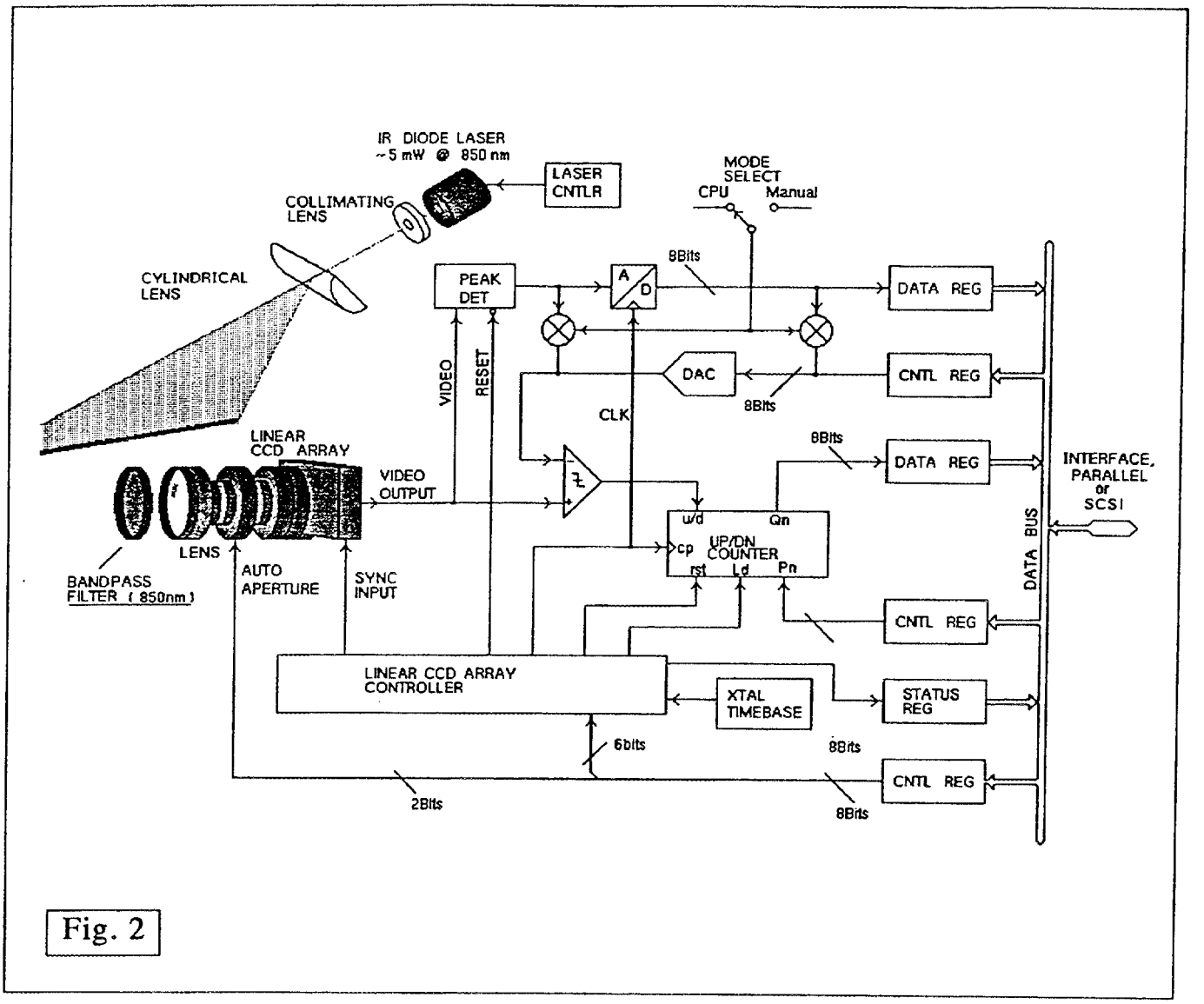

Fig. 2

System Block Diagram

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Lateral Position Tracking System
Using a Line Scan CCD Array Camera With an IR Diode LASER

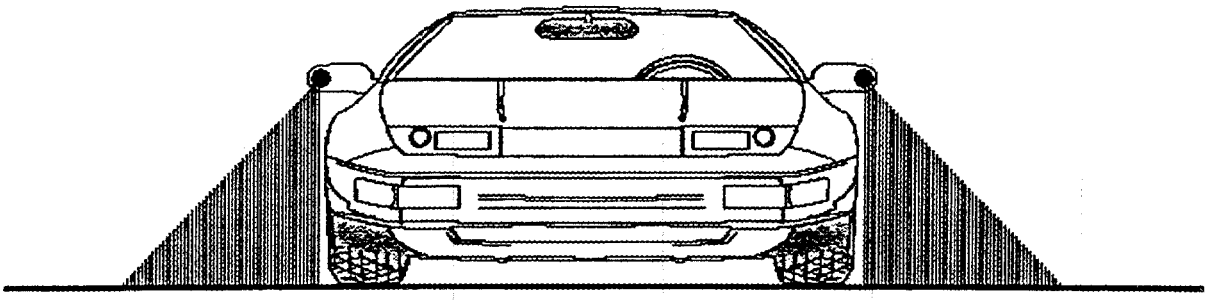

Fig. 3

Sensor & Laser Positioning
Using Mirror Mounts

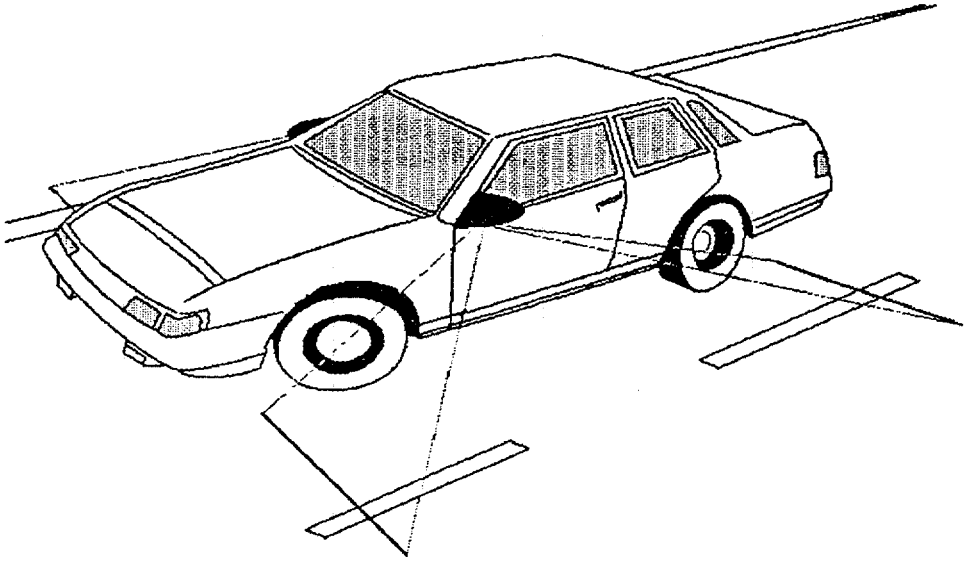

Fig. 4

Sensor Viewpoints
With Optional Quad View

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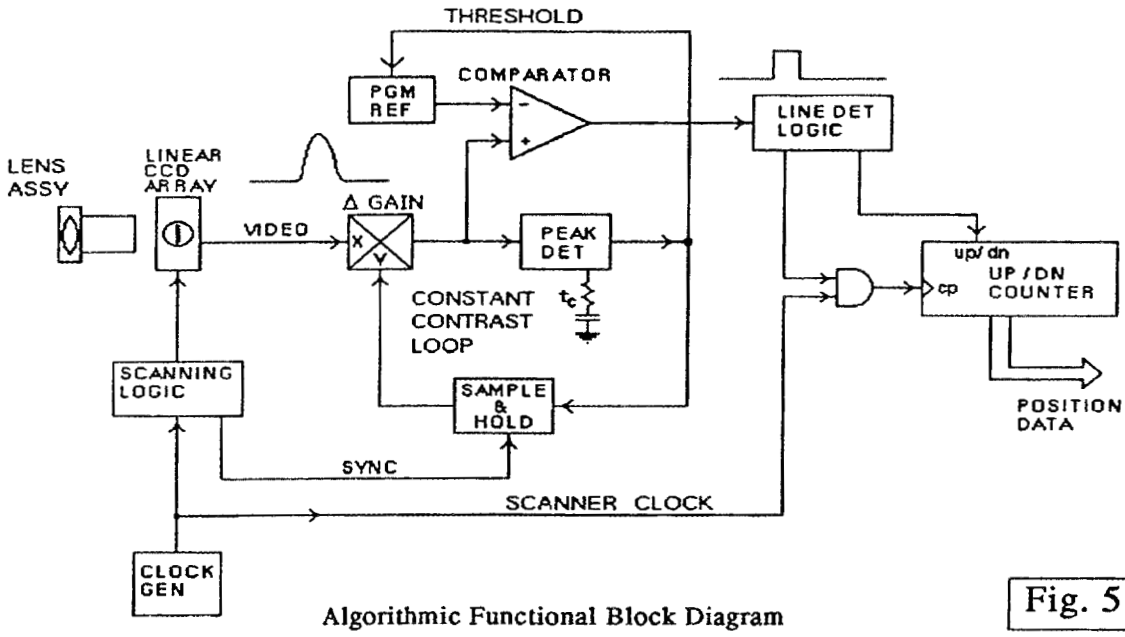
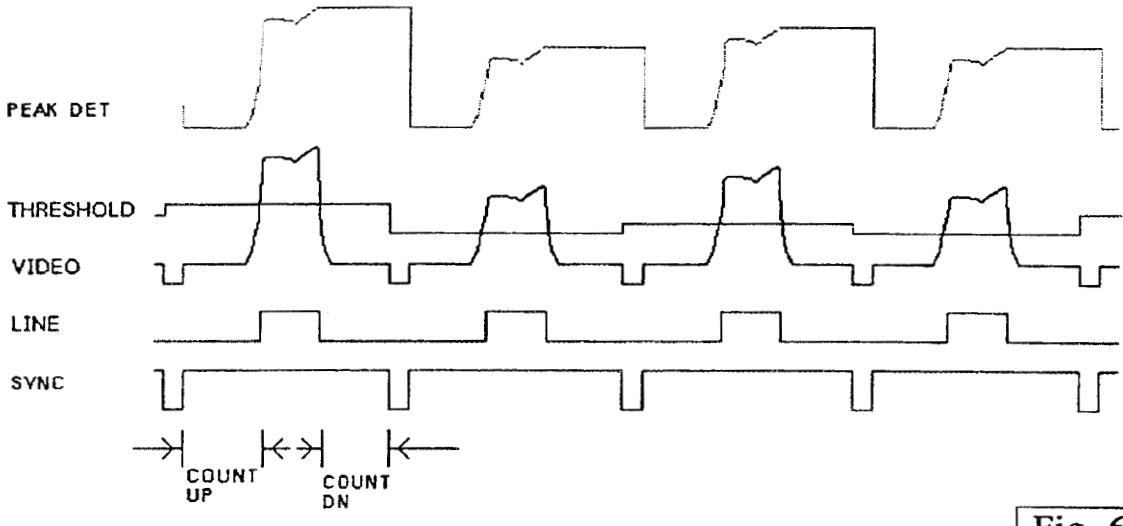
Lateral Position Tracking System
Using a Line Scan CCD Array Camera With an IR Diode LASER



Algorithmic Functional Block Diagram

Fig. 5



Algorithmic Functional Timing Diagram

Fig. 6

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Lateral Position Tracking System
Using a Line Scan CCD Array Camera With an IR Diode LASER

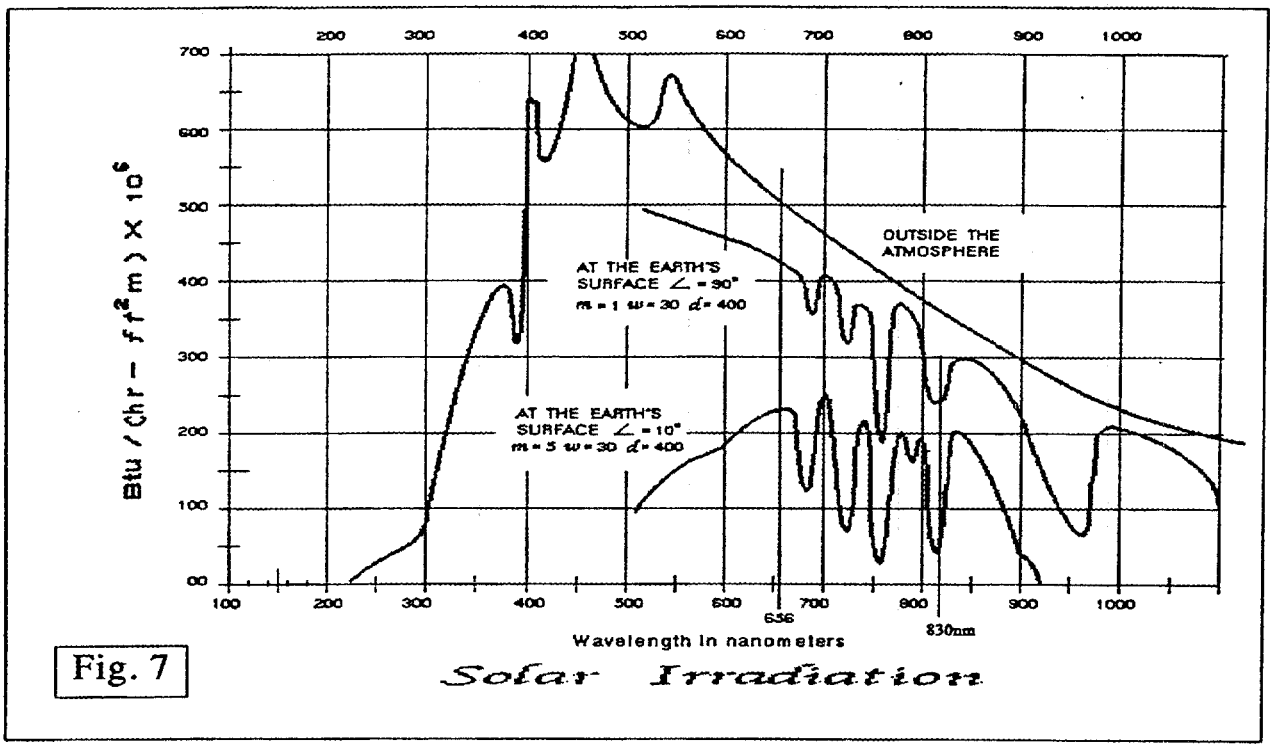


Fig. 7

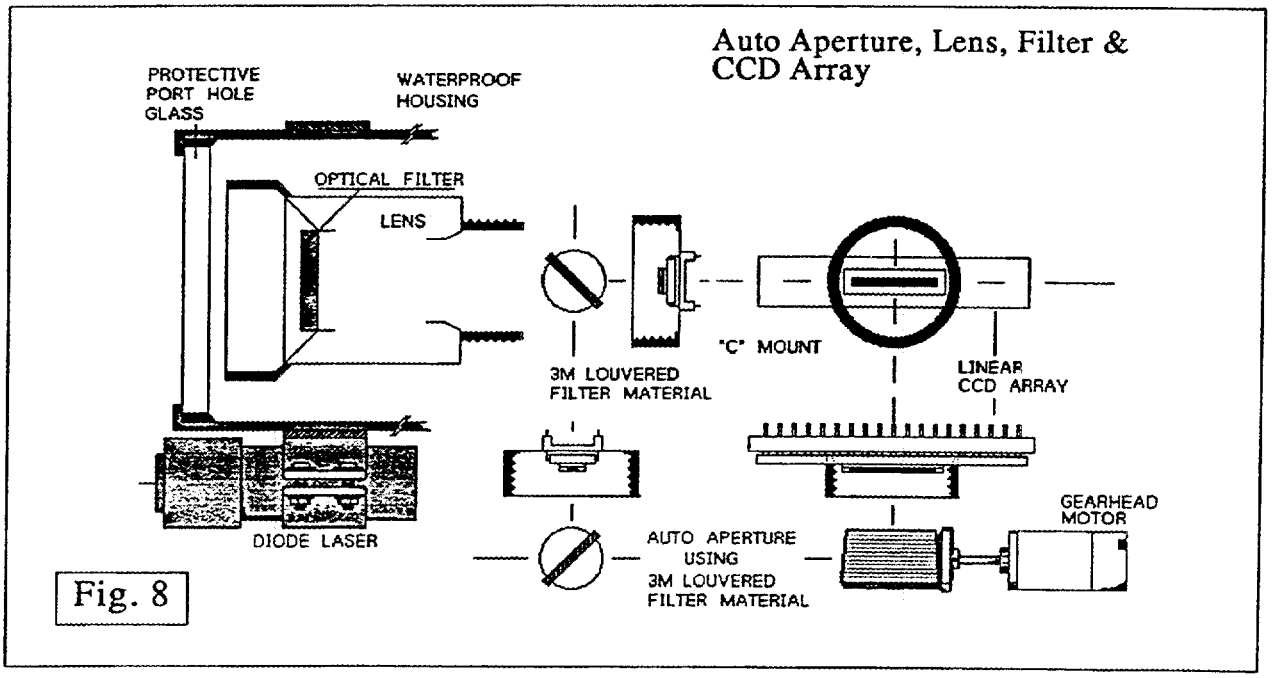


Fig. 8

Camera/Laser Arrangement

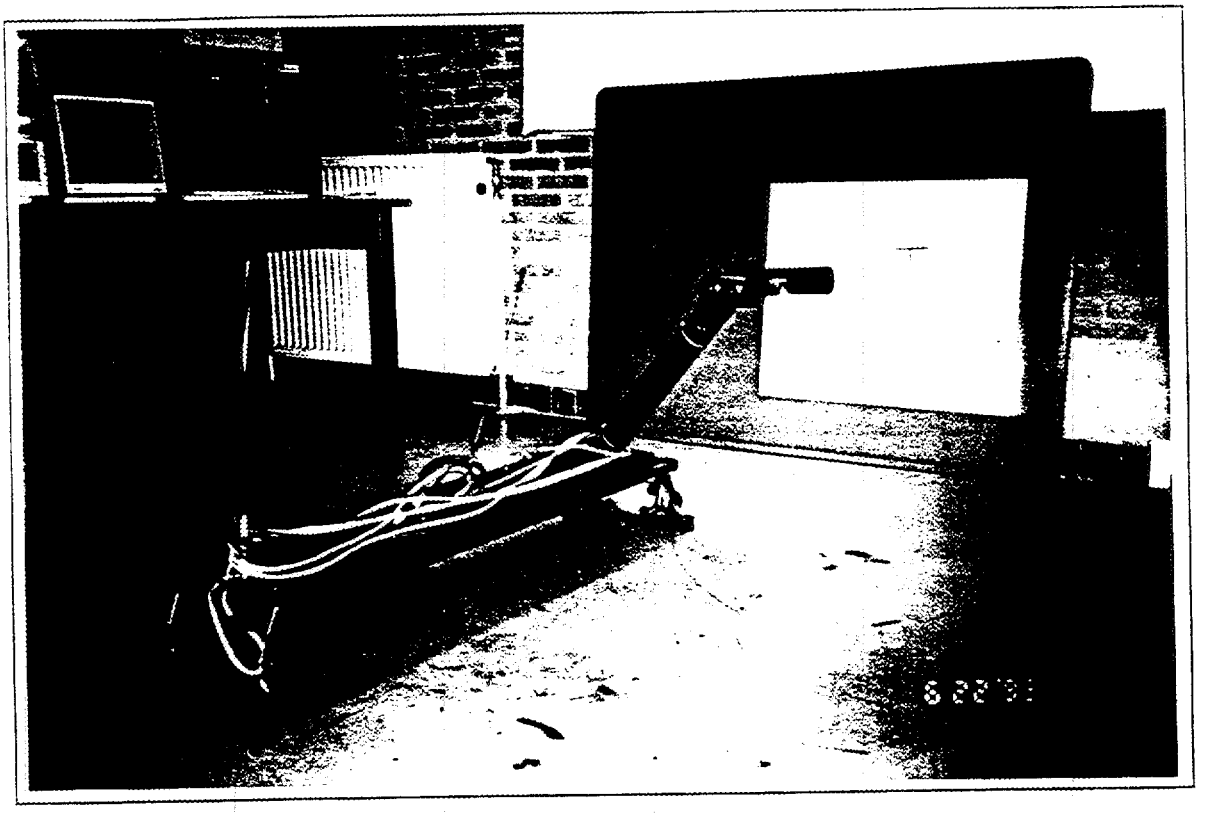
Williamson Associates © 1993

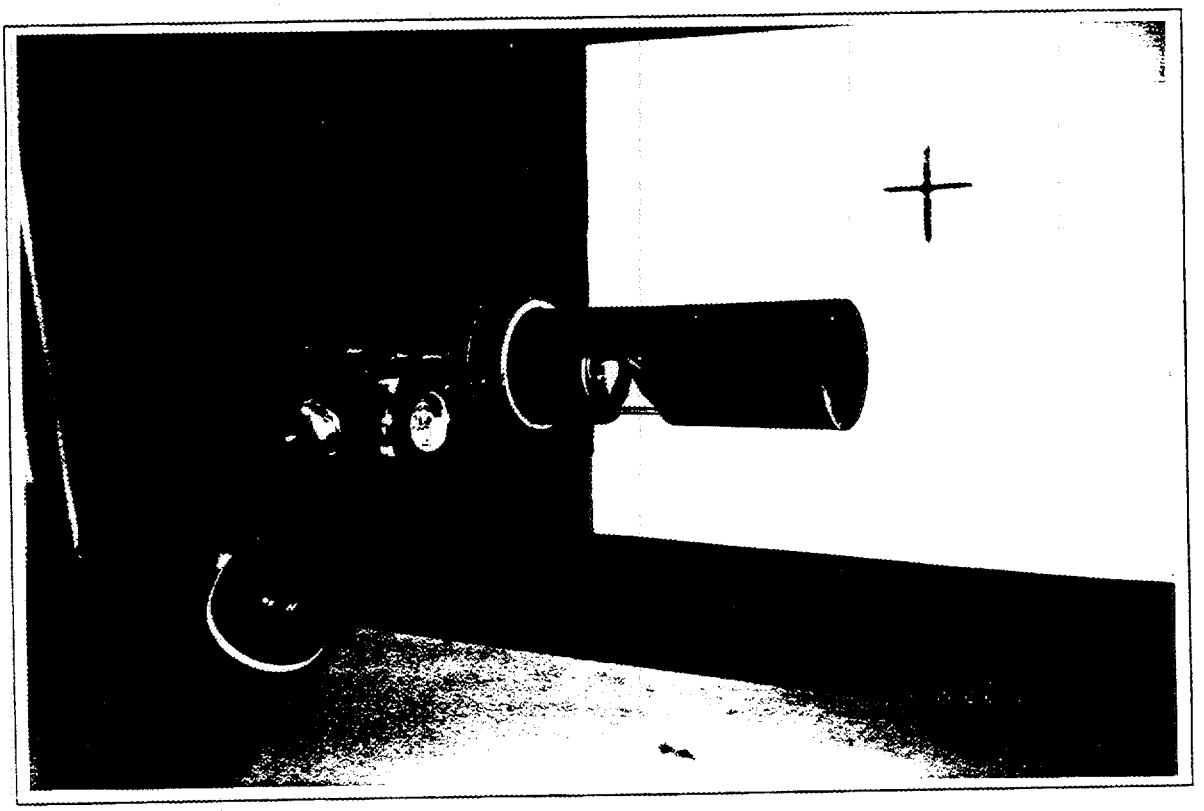
Lane Tracker

The Institute has developed and built a lane tracking device for measuring vehicle lane position. This device is normally mounted on the roof of the test vehicle and consists of an optical system which comprises a fast rotating prism and a photo amplifier which scans the reflected light in a lateral plane across the road. The prism angle at the peak luminance intensity (produced by the lane delineation) is used in calculating the lateral position of the vehicle relative to the lane. While the lane tracker works well under a wide range of ambient illumination, special lights are required for night driving to illuminate the road.

Figure 1 shows two photographs of the TNO lane tracker. The possibility of IZF building a lane tracker for ORNL or, alternatively, providing the technical drawings was explored. Because of the unavailability of certain key people in the production section, it was not possible to determine their willingness to undertake this effort. Moreover, existing documentation of the lane tracker is not adequate for outside clients. However, I was advised that they will pursue this matter internally and provide a response about mid-August.

FIGURE 1 - IZF LANE TRACKER





Dr. Ian Noy.
Transport Canada
Fax: 613 998 4831

Soesterberg, 23-8-1993.

Dear Ian,

I discussed the possibilities of building a lane tracker with our Instrumentation Department. They advice some slight modifications given the fact that some of the components are no longer available. This will require some extra effort in the building and testing phase. A global estimate of the total costs of rebuilding is:

* Reproduce/redesign of electronic circuit and building prototype		
	520hrs engineer	Fl. 76440,-
* Building mechanical system		
	160hrs mechanical dep.	18400,-
* Testing in the laboratory		
	40hrs engineer	5880,-
* Testing on the road		
	40hrs engineer	5880,-
	40hrs mechanical dep.	4600,-
	40hrs instrumented car	4000,-
* Components		5000,-
	Total :	Fl. 120200,-

Prices are in Dutch guilders, excluding taxes and f.o.b. Amsterdam Airport. Due to the fact that we are a research laboratory, which is building this kind of facilities for its own use, we offer you a product which is a replica of our own system. Under this condition we will not be able to provide you with 'after sales' service. At the moment of delivery the system should be accepted by the responsible technician.
Our Instrumentation Department would be able to build the system in the period 1-oct 1993 - 1 april 1994. Later on we might have a problem due to personnel changes and other work in 1994. If you would like us to build a system we will be pleased to make a more official offer. Mr. Leo Spiekman, head of the Instrumentation Department, would be in charge as the TNO-project leader.

een groet van

Hans Godthelp

Phase I Final Report

Neural Network Lane Change Detector

2 June 1992

Dept of Transportation SBIR 91-NH2

Contract Nr. DTRS-57-91-C-00112

NETROLOGIC

INCORPORATED

5200 Springifield Pike, #312
Dayton, OH
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Submitted to:

Ron Knipling

National Highway Traffic Safety Administration

Submitted from:

Dr. Dapeng Li

James R. Johnson, Netrologic

Abstract

In this project Netrologic designed a highway lane monitoring safety alarm for drowsy drivers. The system used a computer vision system to detect lane marks, deduce the position of a vehicle in a lane, and activate an alarm for unsignaled lane changes. In a significant image processing advance the highway lane detection system (HLDS) designed by Netrologic, Inc. uses a neural network to automatically control brightness and contrast of the input images at a uniform level for much easier subsequent processing. HLDS uses a linear regression method to generate candidate lane boundary marks and then uses an expert system to reason about the geometry of the road edge candidate lines relative to the vehicle to select the appropriate road edge lines from the possibilities generated by the regression equation. A driving history module provides continuity in cases of missing and ambiguous data to supply information regarding lane edge trends necessary to monitor the vehicle safety. In the experiments with HLDS the algorithm showed 100% accuracy for lane changing cases under both day and night viewing conditions for all cases tested including the worst cases in our database. The HLDS design completed in Phase I provides a basis for a Phase II project in which a low cost, high speed hardware implementation is constructed to allow a practical drowsy driver alarm system to be installed on vehicles. HLDS is a viable alternative to alarm drivers to unsafe situations and to reduce the number of accidents on the highway.

Final Report

1. Introduction
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3. Image Acquisition
4. Image Enhancement
5. Feature Extraction
6. Alarm Activation and History Analysis
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Appendix A. Discussion of FFT for Lane Detection

1. Introduction

1.1 Problem review

Our nation's highways are the scene annually of more deaths than we suffered during the ten years of the Vietnam war. Most of these accidents are due to driver irresponsibility such as drunken driving or driver mistakes such as not seeing another car. Public awareness is curtailing some of the effects of the drunken driver. More effort is needed to reduce the frequency of driver errors.

While no system short of complete automation will eliminate driver stupidity, there are steps which can be taken to help the responsible driver reduce errors. The advances made in cockpit-pilot interfaces point to aids which can be made available to assist drivers. Plummeting costs of electronic hardware and advances in numeric techniques such as neural networks make possible the introduction of low-cost, high performance aids which function unobtrusively with undiminishing alertness whenever the vehicle is in operation. While systems such as proximity alarms or automatic other-vehicle avoidance systems, if developed, would assist drivers in avoiding collisions, a simpler system could aid drivers by maintaining vehicle position relative to the road.

The United States is at the beginning of a move to bring much more automation to the nation's highways, but in some respects we are behind Japan and Europe in our automation efforts. Due to the enormous scope of the effort involved in changing a highway system such as exists in the US, the effort necessarily will be one of heroic proportions. In spite of the level of effort that will be required to completely automate our nation's highways, work is already underway at the major car companies and suppliers like Ford, GM, EDS, TRW and Delco to develop major components of an automated highway system. At General Motors, for example, they have been working on the Intelligent Vehicle Highway System for 15 years or more under various names, but more recently they have begun to form a significant group at GM which will substantially advance the state of highway automation.

The scope of a highway automation system involves automating both the vehicle and the road. Some tasks like automatic toll collection require having a transmitter or transponder on the car and an interrogator at a stationary toll station or service vendor. Other tasks such as a car navigation system require installation of microprocessors and sensors on cars and perhaps navigation aids in or along the road or in the sky. Security systems which recognize vehicle license plates can be built which would be completely independent of systems on the car. Conversely, a lane recognizer such as we have developed would be completely contained within the vehicle and would use currently existing highway structures and markings to monitor highway lane position.

Some pilot programs to evaluate vehicle automation concepts are already under evaluation in Orlando and Los Angeles, and toll roads in the Northeast have introduced automated toll stations for congestion reduction and commuter convenience. These pilot programs are providing the engineering data necessary to introduce automation projects on a much wider scale and are validating the economic viability of such systems by showing increased profit to toll collectors. Other types of automation are achievable using only equipment on the vehicle which does not depend on special highway equipment or assume a fleet of comparably equipped vehicles occupies the road. These

levels of automation that are completely implemented using the instrumented vehicle and existing highway structure are the most easily constructed and it is to one of these, automated lane monitoring, that the DOT has directed this request for proposal, and we have directed our development efforts.

1.2 Summary of results

Netrologic tried three different approaches for lane detection:

1) Regression lane detecting using a neural network controller to control image brightness and contrast in the image enhancement stage;
2) Neural network lane detection;
3) FFT feature extraction;

Netrologic collected highway data using a car and a camcorder on interstate highways around Cincinnati, Ohio. From the raw video we extracted information using a VCR freeze frame and a frame grabbing digitizer. From the imagery collected we selected 584 images for training and testing our neural networks. Among these, 133 were taken during clear night conditions which we call dark images. The others were taken during the day with good weather and visibility which we call normal images. The dark images were taken on I-74 west from Cincinnati. The normal images were taken on the northern part of I-275 west of I-75.

In our development of a lane detection system we tried several approaches to determine which one would yield the most satisfactory results. One approach used neural nets operating on the video data in the time domain. The second approach used the frequency transformed images and the third approach used regression analysis with neural nets for image brightness and contrast control. In our discussion below we recount the various problems and successes we experienced with each approach with the most successful approach being discussed first.

The regression analysis technique shows very high accuracy, 100% correct lane detection and alarm activation for all testing cases when we incorporate a history analysis stage to account for noisy frames and frames with missing data. Netrologic will adopt this method to develop a real time system in Phase II. The second approach which uses neural network lane detection only reached 65% accuracy. It shows no potential based on the required level of safety required for systems involved with human life and health. The last approach, FFT feature extraction as was originally proposed, failed due to the coherent property of the Fourier Transform. A detailed analysis of the reasons for failure of this approach is given in the appendix in this report.

2. System Design

2.1 Proposed system design

For a highway lane detection system (HLDS), there are two main components, one is the signal acquisition subsystem, another is the signal analysis subsystem. The original design of HLDS is shown in Figure 2.1. Functionally, the signal acquisition subsystem will take a highway scene and preprocess the highway images. The output of the acquisition subsystem supplies enhanced, segmented, 2-dimensional digital images to the analysis subsystem. The signal analysis subsystem extracts features of enhanced highway images to give information relating the vehicle position to the lane marks. This information is stored in a history table as trace records of previous vehicle lane positions. From the history records the system determines a trend and predicts whether the vehicle will cross the lane or not. If the prediction indicates that vehicle is going to cross the lane and driver has not given a turn signal, the system infers that this is not a safe lane change and activates the driver-alert alarm.

2.2 New system algorithm design

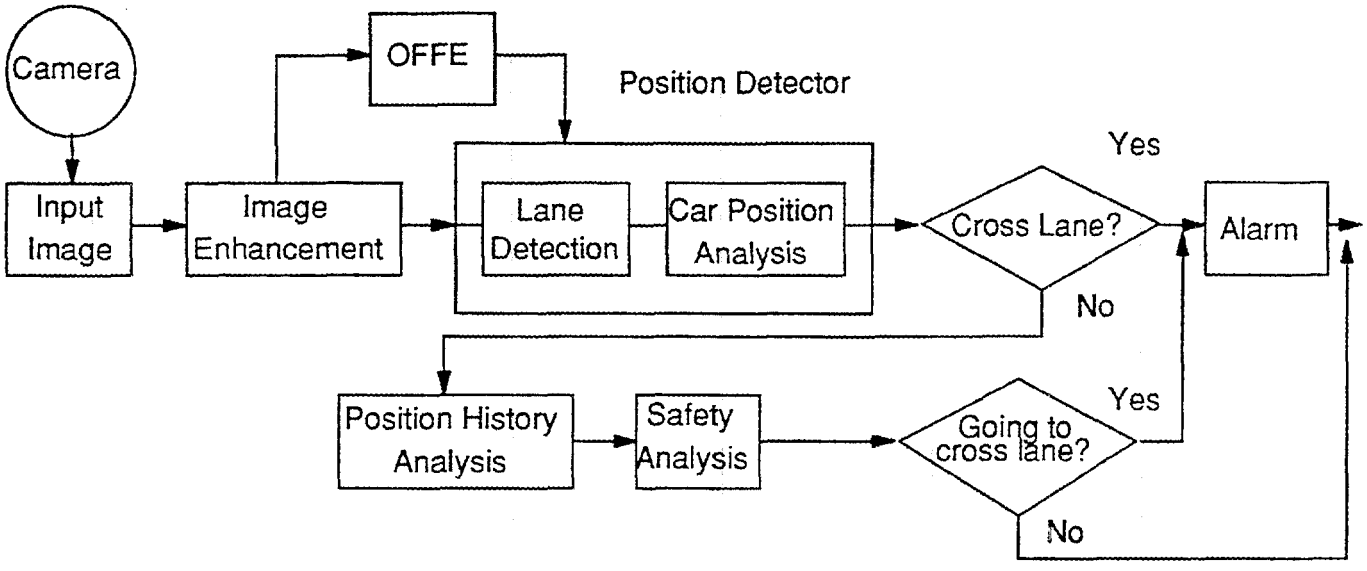

Figure 2.1 Proposed HLDS Design

The system proposed originally proved to be inaccurate when asked to detect lane position from the images. We tried many variations of the approach to train a network to detect lane changes but the nature of the data was such that it was not well suited to a neural network approach because it was too fuzzy. Because the edge of the road was fuzzy, the neural network of the estimation of the center was also fuzzy, so much so that it was too inaccurate for activating an alarm. The fuzziness of the road edges was amplified when the car was moving left or right of centerline which made the problem even worse. Because of the problem with neural network acting on the raw data, we designed an algorithm to construct a single line through the data points associated with the edge of the road. There were many spurious lines created by this process, but we were able to use knowledge of the road/car geometry to constrain the possible lines and eliminate spurious road edge lines.

The new system includes an image acquisition and enhancement subsystem using the same preprocessing stages as the neural network approach. As soon as the segmented binary highway images are transformed into threshold images, a regression algorithm is used to determine the location and orientation of the edge of the road. These candidate lane marks will be regressed to generate parameters of linear equations which are candidate representations of solid lane marks. Only lines having an orientation possible from the road-edge and car geometry is permitted. This eliminates lines with improper slopes which sometimes result from noise in the data. The regression algorithm is very successful in eliminating all specious lines and preserving only those lines which represent the edge of the road. This is significant since many times the line at the edge of the road is composed of broken segments. The regression equation relates all of the broken segments into a simple linear equation. Since lane information is translated into linear equations by the new algorithm, the lane center can be calculated through linear algebra. The accuracy of the new algorithm is also based on the accuracy of linear equation regression which is a least mean square fit to the data which is about as good as can be done.

An additional advantage of the algorithm is that it is readily amenable to parallelization. Many algorithms rely on relations from adjacent pixels so that if the image is divided into subimages for parallel processing this correlation information is lost. Our algorithm relies on histograms formed from the raw image and does not require cross correlation data. This means that we can use as many parallel processes as required to obtain the requisite speed to do the operation in real time. The conclusion is that the preprocessing algorithms and the regression algorithm can be parallelized and pipelined so that we are highly confident that the algorithm will be both robust and real-time. Additionally, our algorithm relies on contrast at the road edge to obtain the road edge information. It does not require a painted line at the road edge to find the edge. It does rely on the painted lane marker to find the other side of the lane, but this is even necessary for a human driver. We do not mean to imply that if you have

imagery of a newly paved road with no lane markers taken at night and it is raining that the system will necessarily be able to accurately find the road edge. We do not have data for this and cannot say. We do know that with our automatic brightness and contrast enhancement algorithms (this is an original result from this project) that the system can adjust the image to enhance contrast. Our current images taken at night look like day-time images after the enhancement process. It may be that the enhancement feature would allow contrast to be enhanced to a point that the machine could find the road edge even when an alert driver could not easily do so. The flow chart of the algorithm shown in Figure 2.2 illustrates the process of preprocessing, image enhancement, and edge detection with regression analysis.

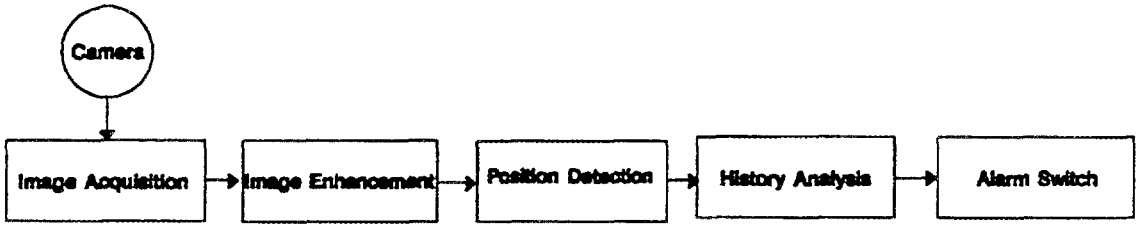

Figure 2.2 Simple Flow Chart of New HLDS Design

2.3 Reason for design change

The original proposed design of lane detector was going to use a Fast Fourier Transform (FFT) and neural network (NN) technique in the system. Functionally, the FFT should extract features of lane marks and NN should predict the lane position based on the result of FFT. The result of our experiments shows that the FFT could not generate satisfactory features due to Fourier Transform's property of position invariance. Since position sensitivity was the very important thing we were trying to capture, this generally desirable feature of the FFT worked against us. Because of this we were forced to remove the FFT component from the system in the new design. Then we tried to use neural network to detect the lane position directly from threshold images. The accuracy of the detection is very poor due to the nature of the data as we have already mentioned. Therefore, Netrologic changed the original design of the system to the current linear regression Highway Line Detection System, or HLDS.

In the new design, an innovative component, an image enhancement controller, is added. This controller is implemented by a back propagation neural network. After training the neural network to remember the histograms of some special image cases, the back propagation network can tell the system how good the brightness and contrast of an input picture is. The HLDS will choose a correction enhancement algorithm from our library corresponding to quality of the picture it has observed. Using this technique it is possible to automatically adjust the picture histograms by the using a neural network to judge the quality of the image and select the appropriate correction method. Otherwise, an universal enhancement algorithm determined by a human to be generally appropriate to all of the data will be applied to each image. By our new design, HLDS can use a user selected fixed threshold to simply put the input original grey-scale images having 256 gray levels into binary images having clear lane boundaries by virtue of its being able to automatically adjust the brightness and contrast. In Figure 2.2, a brief flow chart of the system is given while a detailed system diagram is shown in Figure 2.3.

3. Image Acquisition

3.1 Operation under real world conditions

The Highway Lane Detecting System (HLDS) will be required to operate in the real world under the full spectrum of highway conditions. The full spectrum of conditions means that system should work 24 hours a day under any weather conditions, and this task is made more difficult by the fact that the visibility of highway scenes varies greatly from day to night. This strongly affects the quality of input images taken for the HLDS. Pictures

An Advanced Laser-Based Tracking Device For Motor Vehicle Lane Position Monitoring and Steering Assistance

Final Technical Report

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Prepared for the U.S. Department of Transportation
Small Business Innovative Research Contract No. DTRS-57-91-C-00111

Aerometrics, Inc.
550 Del Rey Avenue
Sunnyvale, CA 94086

March 19, 1992

ATTACHMENT NUMBER 1

APPENDIX A

FINAL PROJECT SUMMARY REPORT

PROJECT IDENTIFICATION INFORMATION

1. BUSINESS FIRM AND ADDRESS	2. DOT PROGRAM	3. DOT CONTRACT NUMBER
AEROMETRICS, INC. 550 Del Rey Avenue, Unit A Sunnyvale, CA 94086 (408) 738 6688	SBIR - 1991 Phase 1	DTRS-57-91-C-00111
	4. PERIOD OF PERFORMANCE From Sept 13, 1991	To March 20, 1992

5. PROJECT TITLE An Advanced Laser-Based Tracking Device for Motor Vehicle Lane Position Monitoring and Steering Assistance.

SUMMARY OF COMPLETED PROJECT

The data in this final report shall not be released outside the government without permission of the contractor for a period of two years from the completion date (3/20/92) of this project from which the data were generated.

In this research program, an innovative laser diode based device has been developed that provides a warning signal when the vehicle deviates from the center of the lane. This device is one of the key components required in a system that automatically controls vehicle steering during highway operation. The device scans the roadway on either side of the vehicle and determines the lateral position relative to the lines marking the lane. A warning is used to alert the driver of excessive weaving or unanticipated departure from the lane center, and an alarm system can be easily added. Low power consumption and the possibility of making it compact in size so that installation is not a problem make its commercialization very attractive. Furthermore, the laser beams are at invisible wavelengths so the operation of the device will not pose a distraction to other motorists. Installation on long haul trucks and other existing vehicles should be straightforward. A very important feature of the sensor head developed in this research program is that it uses the *existing roadway lane markers* to maintain the automatic guidance. When appropriate pavement delineators are not available, the steering control system would detect this condition, warn the driver, and revert to a manual control mode. The sensor head developed here is expected to function well irrespective of the ambient light levels, fog, and rain. This is a significant factor in the acceptance of the device and the success of its commercialization. Laboratory and field tests show that the device is reliable and functions well irrespective of ambient light levels, and rain.

This new sensor has enormous commercial potential. In the early stages it could be marketed as an instrument to warn drivers that they are weaving. Truck drivers operating their vehicles for long hours and distances would find the device useful in preserving their safety and that of others around them. The device could also be a requirement for those convicted of prior "driving under the influence" violations such that any erratic behavior detected by the device would disable the vehicle or cause warning lights to flash to alert nearby drivers or call attention to the subject vehicle.

APPROVAL SIGNATURES

1. PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR *(Typed)*	2. PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR *(Signature)*	3. DATE
William D. Bachalo, Ph.D.	W D Bachalo	3/20/92

1. INTRODUCTION.

Because of the innumerable advantages that automobiles and trucks provide for transportation and the movement of cargo, the number of these vehicles will continue to increase. This, in turn, will lead to the inevitable increase in congestion and accidents. Increasing the capacity of highways by increasing the number of lanes or number of highways is not always practical or even possible. Turning to mass transit systems is an alternative, but has not been widely accepted in the United States. Another alternative is to develop means to increase the traffic flow rate by increasing the speed and density of the traffic while maintaining the much desired individual mobility and safety. This will place greater demands on the motorists and especially, upon truck drivers. A means to automatically steer the vehicle in a wide range of traffic conditions would allow the driver to better focus on maintaining longitudinal separation with other vehicles and attention to traffic flow. Furthermore, it may eventually make it possible to decrease the lateral separation between vehicles to allow the opening of additional lanes on existing highways while maintaining a safe operating environment.

In this research program, an innovative laser diode based device has been developed that provides a warning signal when the vehicle deviates from the center of the lane. This device is one of the key components required in a system that automatically controls vehicle steering during highway operation. This system would act as a subordinate to the manual steering to keep the vehicle following the lane even in curves and under lateral forces due to wind gusts, passing vehicles, and uneven roadways. Such a system would improve the driver's control and greatly relieve the driver of strain and fatigue on long distance trips. One may consider this as analogous to flying an aircraft with the auto-pilot function: the system ensures that the vehicle is kept within the lane unless the driver applies a force to the steering wheel to execute a deliberate lane change or exit from the highway. If the driver becomes incapacitated, the system microprocessor would detect this dangerous condition and take appropriate measures such as enabling an alarm, turning on warning lights for surrounding vehicles, or slowing the vehicle. Nonetheless, the tracking device would keep the vehicle from veering left or right unexpectedly and thus preventing serious accidents.

A very important feature of the sensor head developed in this research program is that it uses the *existing roadway lane markers* to maintain the automatic guidance. When appropriate pavement delineators are not available, the steering control system would detect this condition, warn the driver, and revert to a manual control mode. The sensor head developed here is expected to function well irrespective of the ambient light levels, fog, and rain. This is a significant factor in the acceptance of the device and the success of its commercialization.

Several methods have been investigated for achieving lateral control of vehicles and for automatic steering (see, for example, Shladover et al., 1991, Bender, 1991, Johnston, 1979, Fenton, 1970) . These and other approaches are discussed in a following section. In the present research program, we start from the less ambitious point of providing a

warning when the vehicle begins to weave due to driver fatigue, drowsiness, intoxication, or inability to properly control the vehicle for other reasons. This helped to place less of a burden on the early phases of the development and has led to a device that has merit even if the development of the full system is not carried through until the next phase.

As will be seen in the literature review section, many approaches for lateral position monitoring and control have been proposed that rely on the placement of special, embedded pavement markers and transponders and sophisticated sensing equipment on the vehicle. This approach has enormous associated installation and maintenance costs. What we demonstrate here is that an *inexpensive* (between $500 and $1000) and *reliable* sensor can be manufactured that relies only on *existing* roadway lines and markers. This approach will permit a much easier initial implementation and commercialization of the system.

1.1. Overview of the Sensor and Warning System Developed in this Research Program.

The laser-diode based device scans the roadway on either side of the vehicle and determines the lateral position relative to the lines marking the lane. A warning is used to alert the driver of excessive weaving or unanticipated departure from the lane center, and an alarm system can be easily added. Low power consumption and the possibility of making it compact in size so that installation is not a problem make its commercialization very attractive. Furthermore, the laser beams are at invisible wavelengths so the operation of the device will not pose a distraction to other motorists. Installation on long haul trucks and other existing vehicles should be straightforward.

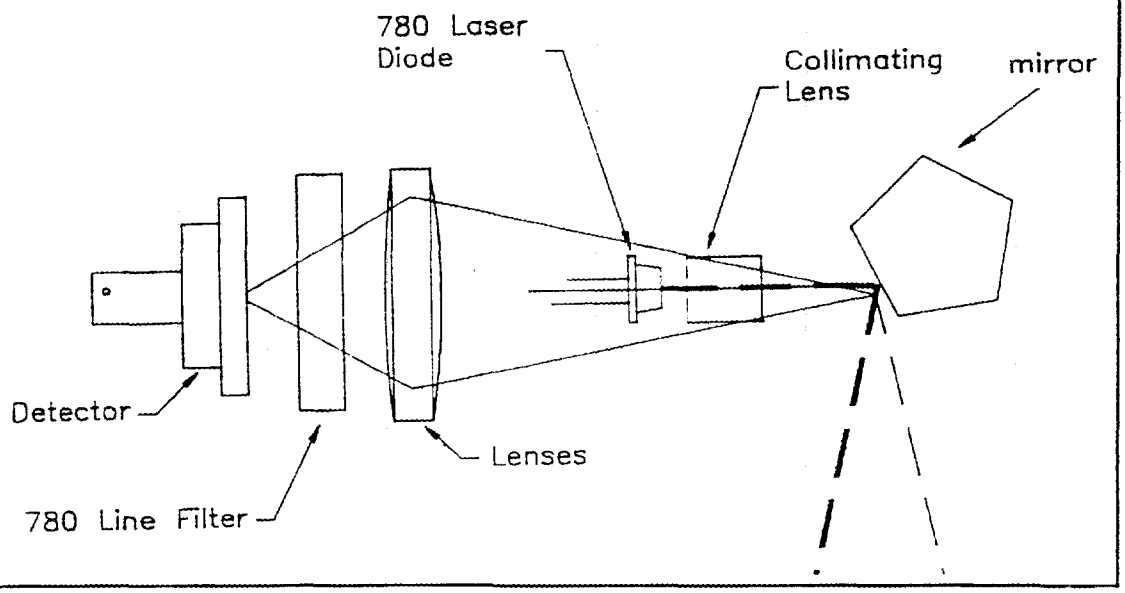
Referring to Figure 1 a diode laser is used to generate a collimated laser beam. The beam is swept onto the roadway surface employing a multifaceted rotating mirror. The same mirror is employed to receive the reflection of the laser beam back from the roadway surface and direct it back to a photo-detector. Since highway roadway lines and other markers are much more retroreflective than the background surface, a very strong signal is obtained from the photo-detector every time the scanning beam crosses the roadway line.

A master clock is coupled to the mirror, and a count start is generated every time a scanning sweep begins. The signal coming from the photo-detector is employed to stop the clock count. A processor is coupled to the counter, and uses the timing information to calculate the distance between the vehicle and the roadway line or marker, and if this distance is not within given limits, a warning is issued.

1.2. Potential Applications of the Device.

This new sensor for monitoring the lateral position of a vehicle in a lane has enormous commercial potential. In the early stages it could be marketed as an instrument to warn drivers that they are weaving. Truck drivers operating their vehicles for long hours and distances would find the device useful in preserving their safety and that of others around them. The device could also be a requirement for those convicted of prior "driving under

Figure 1: Simplified schematic of the monitoring system.



the influence" violations such that any erratic behavior detected by the device would disable the vehicle or cause warning lights to flash to alert nearby drivers or call attention to the subject vehicle.

As the development of the device continues and it is proven reliable under a broad range of conditions, it could be incorporated into the steering control of the vehicle. The device would then be sold as an option on new vehicles and as an add-on to existing vehicles. This commercial market is very large. Under appropriate licensing agreements, it would be a major step in improving the competitiveness of the U.S. automotive industry. The device could result in a major improvement in vehicle handling and safety. A significant number of studies have identified the advantages of steering assisted vehicles at a time when the technology discussed in this report was not yet available (see, for example, Fenton, 1968 and 1970, and Gardels, 1960).

The government should find the device useful in the continuing research on automatically-controlled vehicles. Other applications could include the automatic recording of driver performance in lateral control studies while drowsy, fatigued, or under the influence of alcohol or drugs. The U.S. Department of Transportation's March 1990 "Report to Congress on Intelligent Vehicle/Highway Systems (IVHS)" recommends that there be "a national cooperative effort to foster the development, demonstration, and use of IVHS technologies. We further propose that this effort be formulated and coordinated jointly by industry and government." Statements like these stress the importance of the development of innovative technologies like the one presented here.

1.3. Specific Objectives of the Phase I Research.

The specific goals of the Phase I research and development program were to:

1. Identify and review the available methods of sensing lateral vehicle position.

2. Develop a preliminary design of the laser diode-based tracking system.

3. Review the available laser diodes, detectors, and laser scanning devices and select the appropriate devices to be tested for the present application.

4. Build a breadboard optical system for testing the concept on the detection of simulated and then actual roadway lines having various degrees of deterioration.

5. Develop the microprocessor-based signal processing electronics to be used with the breadboard system.

6. Analyze the vehicle dynamics and control requirements under conditions of periodic loss of tracking, breaks in the lines, curves, and under lateral gust forces due to adjacent vehicles and wind.

7. Evaluate the system in the laboratory under ideal conditions and under various simulated road conditions such as rain, bright sun, and darkness. Continue the evaluation on actual roadways by recording the output of the device under a realistic range of conditions.

8. Define methods to protect the device from damage and contamination in normal operation on the vehicle.

1.4. Summary of Activities Performed During this Phase I Program.

The following tasks were performed under this program:

1. Technology Review

2. Preliminary Design

3. Performance Evaluation

4. Engineering Review

5. Documentation and Reporting

During the first bimonthly period, a thorough review of the methods evaluated to date to sense lateral vehicle position in a lane, and an analysis of their relative merits was performed. The results of this review will be presented in the next section. In addition, a survey of the literature available on the subject of intelligent vehicle/highway systems was performed. The results of this survey are presented in Appendix 4. Also in this period, the appropriate solid state laser diodes and detectors were selected to ensure that the most suitable devices were available in the feasibility studies. The laser-diodes were selected using criteria such as power output, beam divergence, wavelength of the emitted

beam, cost, and reliability. The detector was selected to match the laser wavelength and to provide good immunity to ambient light. Once these tasks were completed, our efforts were focused toward setting up the environment where equipment and design ideas were tested. In particular, the specification and purchase of a scanning mirror assembly to be used in the initial prototype, the gathering of information regarding highway line characteristics and other demarcation standards, and a preliminary assessment of the light reflection characteristics from the paint and the glass beads employed in highway/roadway lines were among the most important activities performed.

In the second reporting period of this project, our efforts were focused toward testing and evaluating various design concepts, both in the laboratory and on the demarcation lines that were deployed in the parking lot adjacent to our laboratories. In particular, the scanning beam / single detector and the laser sheet / CCD array methods were compared in terms of performance, reliability and cost.

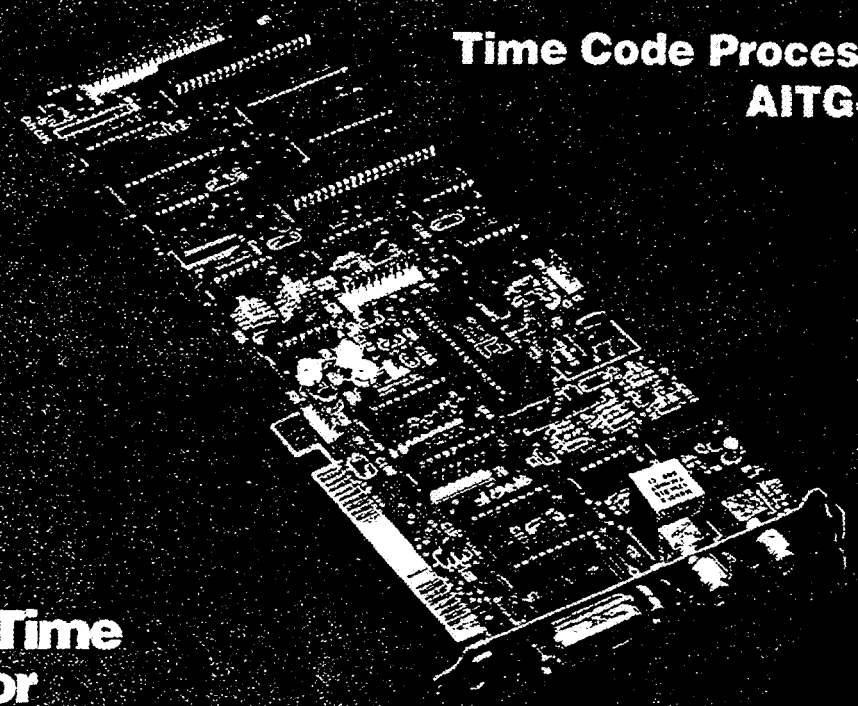
The third period of this Phase I grant was employed to develop a prototype of the sensor head, mount it on a small truck and test it on real roadways. The output of the sensor head was fed to custom electronic circuits that determined the vehicle's position relative to the lane and issued a visual warning when the weave of the vehicle exceeded predetermined limits. In addition, the signal from the sensor head was acquired and digitized using a digital scope connected to a computer, and several sensor sweeps were permanently stored on the computer's disk. These signals were used to test various digital signal processing algorithms. Finally, the last two weeks of this contract were spent on testing and the preparation of the present report.

The remainder of this report will be devoted to document in detail these research activities and the results obtained. Finally, an assessment of the technical feasibility of the device will be presented.

APPENDIX K: TECHNICAL DATA FOR TIME MEASURES

Precision Time Division

Time Code Processor AITG-PC



IBM PC Bus Synchronized Time Code Processor

Applications

- Radar Data Collection
- Data Time Annotation
- Time Correlated Distributed Data Collection
- "Bit-creep" Elimination

One PC bus peripheral board— several useful functions

- Time code reader with AGC
- Reads IRIG A, B, NASA 36, XR3 time codes
- Synchronizable time generation and modulated IRIG-B output
- Propagation delay correction
- On-board event time measurement, days through µseconds
- IBM PC-AT bus compatible
- Low-overhead interrupt-driven operation with FIFO
- Interrupt level configured by user
- Jumper-selectable I/O address
- Status register

The AITG-PC incorporates the functions of a propagation delay-corrected, synchronizable time base generator, an event time freeze register, a PC-bus interface, all on a single IBM-PC peripheral board.

Synchronizable Generator — The synchronizable generator accepts IRIG-A, IRIG-B, NASA 36, XR3 modulated input, corrects it for propagation delay, and generates local "on time" frequencies and rates from 1 MHz to 1 PPS. The synchronizable generator can be used stand-alone (without input time code), self starting at 0 days ... 0 µseconds.

Time Code Input Auto-Polarity and AGC — Balanced high impedance input allows isolation from ground loops. The analog processing section includes an automatic gain control (AGC) amplifier for accommodating a wide range of input amplitudes. The on-board microprocessor automatically detects and corrects for inverted time code polarity.

Time Base Correction — An on-board microprocessor constantly measures the time base error between local time and the input time code and adjusts the local on-board oscillator frequency for minimum error. The local time is checked through days for agreement with the input time code. If the input time code is lost or obliterated by noise pulses, the local time base continues unperturbed, using an open loop frequency adjustment based on the most recent several minutes of error correction. When the input time code returns, the correction loop can again be smoothly closed, without jitter or jumps in local time generation.

Event Time Measurement — The time when an event occurs is measured with µsecond accuracy by an on-board microprocessor controlling several counters. The event may be an external TTL pulse input or may be generated by the users host processor. The microprocessor copies the freeze register into a FIFO after an event occurs so that the user program can access all the event data with 8 input operations.

Rate/Frequency Outputs — Rates (pulses) and frequencies (50% duty cycle) are produced "on-time" propagation delay corrected by dividing the corrected 6 MHz basic time base. Synchronous modem transmit clocks and 6 decades of rates are produced—all with leading edges on-time.

Bus Interface — The AITG-PC generates a base address match by decoding all ten I/O address lines provided on the PC bus. The AITG-PC provides the user with I/O ports for reading data, setting propagation delay, setting time, generating internal events and reading status. An interrupt may be generated to the host processor via one of the PC bus interrupt lines (IRQ2-IRQ7) or AT bus interrupt lines (IRQ10-IRQ12, IRQ14, IRQ15) when an event has been captured in the output FIFO of the AITG-PC. Interrupt line selection is made with a hard wire jumper connection. Alternatively, the user may poll the output ready bit of the status register to test if an event has been captured by the on-board FIFO and can be read by the user program.

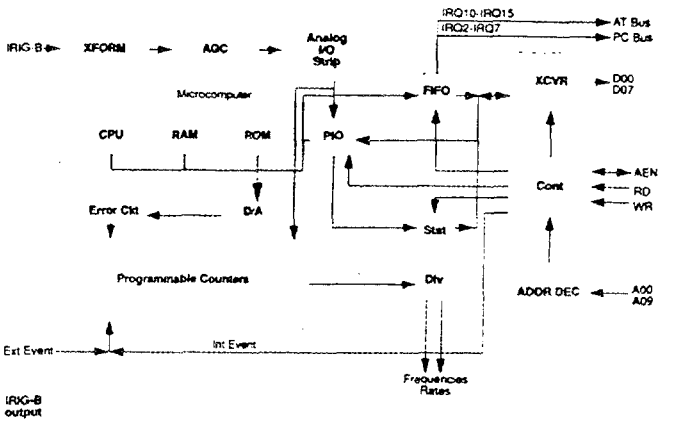
Options

- Modulated IRIG-B output
- External master time base

JSI Jim Springer Inc.
Technical Representativ
Office: (205) 883-4163
Home: (205) 883-1756
2611 Lancelot • Huntsville, Al 3580

SPECIFICATIONS

AITG-PC



GENERAL

TTL Input Levels	Low < .8V, high >2.0V
TTL Input Load	1 Low-power Schottky TTL load
TTL Output Levels	Low <.4V, high >2.4V
TTL Output Drive	10 TTL loads

TIME CODE INPUT (J1, J2)

Connector	15 pin type D (J1), Type F Coaxial (J2)
Input Impedance	> 10 K ohms
Input Isolation	Instrumentation Amplifier
Format	IRIG A, IRIG B, NASA 36, XR3 (modulated)
Level	.5V to 10V peak to peak
Indicator	On-board LED lights when input level is < .5V peak to peak
Polarity	Autopolarity standard
Noise Immunity	Bayesian error correction, 5 second consistency check

EVENT INPUT (J1)

Event Rate	2000 events/second maximum
Event Latency	< 200 µseconds from event until data ready
Source	Internal or external
Internal Event	Triggerable by host control

MULTIPLE TTL OUTPUTS (J1)

Connector	15-pin D-Type (J1)
Rates/Frequencies	100 PPS, 1 MHz (standard)
Rates/Frequencies	5 jumper-selectable from 24 KHz, 2.4 KHz, 100K, 50K, 10K, 1K (Option D)
Pulse Widths	1.0 ± 10% µseconds
Pulse Polarity	Positive, rising edge on-time
Duty Cycle	50% for frequency outputs

IBM PC BUS INTERFACE

Bus address	Base I/O address - jumper-selectable (0—3FF)
	Offset 0 - FIFO data read
	Offset 1 - Status register
	Offset 2 - Command Stobe
	Offset 3 - Internal event register
Status Byte	0 - FIFO output ready
	1 - Loss of signal error
	2 - Incorrect sync error
	3 - 7 unused
FIFO Data Format	2 BCD digits per byte
	Byte 0 - 0, 10^2 days
	Byte 1 - 10^1, 1 day
	Byte 2 - 10^1, 1 hours
	Byte 3 - 10^1, 1 minutes
	Byte 4 - 10^1, 1 seconds
	Byte 5 - 10^5, 10^4 µseconds
	Byte 6 - 10^3, 10^2 µseconds
	Byte 7 - 10^1, 1 µseconds

PROPAGATION DELAY SELECTION

Range	0 to 9975 µseconds
Resolution	1.0 µseconds
Format	Programmable from IBM PC Bus

MECHANICAL, ENVIRONMENTAL, AND POWER

Mechanical	IBM-PC Bus compatible
Operating Temp	0 degrees C to 55 degrees C
Relative Humidity	< 90% (non-condensing)
Power	+ 5V at 1.2 A
	+12V at 0.1 A
	-12V at 0.1 A

ORDERING INFORMATION

Order Number	AITG-PC - *(Option letters)*
Option Letter "D"	Daughter Board-supplies extra rates/Frequencies
Option Letter "P"	External 1 MHz or 6 MHz master time base (for extended open loop operation)
Option Letter "O"	Crystal oven for extended temperature range operation

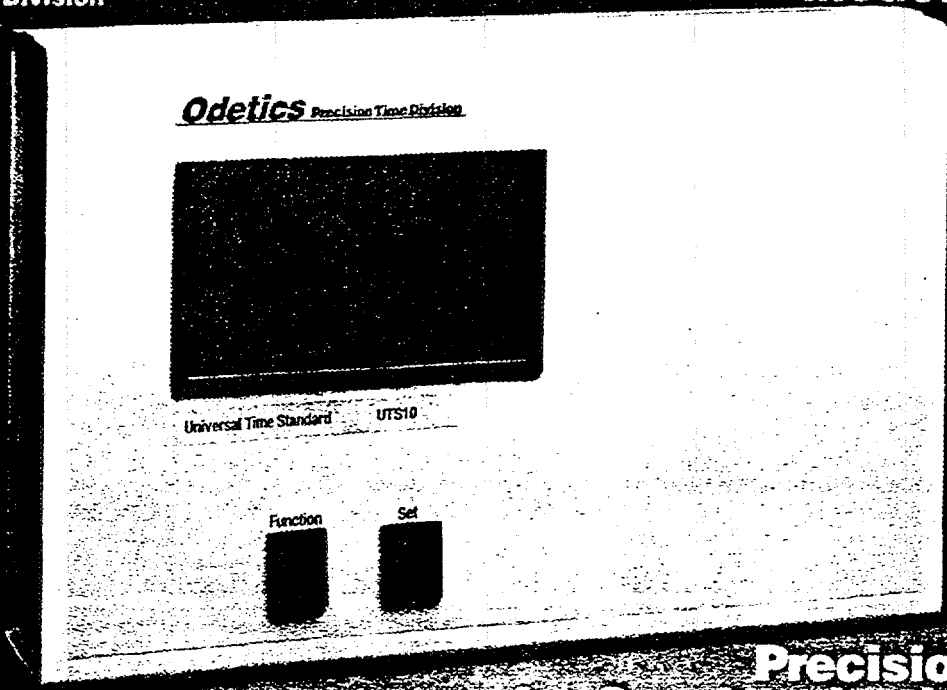
IBM PC is a trade mark of International Business Machines

Odetics **Precision Time Division**
1515 South Manchester Avenue, Anaheim, California 92802-2907
Phone (714) 758-0400 Fax (714) 776-6363

Specifications subject to change without notification

Precision Time Division

Universal Time Standard Model UTS-10



Precision Clock for Synchronization, Data Acquisition and Process Control

The UTS10 is an inexpensive, stand-alone source of precision time, synchronized to Coordinated Universal Time (UTC), an international time standard. It can be used anywhere a precision clock is required to provide absolute time, measure elapsed time, make sense of time invariant data, or synchronize data acquisition and control processes such as traffic signal light synchronization.

The UTS10 is based on Odetics' popular board-level CTS-10 Computer Time Standard which synchronizes IBM PCs and compatibles to UTC. Using proprietary microprocessor technology and a sensitive radio receiver, the UTS10 decodes UTC timing signals transmitted by WWV and WWVH, public broadcast services of the U.S. National Institute of Standards and Technology, formerly National Bureau of Standards.

Depending on received signal strength, the UTS10 can acquire lock in four to seven minutes, synchronizing to within ± 20 ms of UTC. A microprocessor-based clock provides continuous precision time during adverse signal conditions. In the event of power loss, the UTS10 contains a CMOS clock that can keep track of time for up to 24 hours via a charged capacitor ("super-cap") power backup circuit. An optional lithium battery is available that powers the CMOS clock for up to one year.

A built-in LCD display and simple keypad allow the UTS10 to be setup and monitored locally. For remote control applications, the UTS10 incorporates an RS-232 serial interface. In addition, a programmable TTL pulse output can be used to periodically synchronize or reset external devices.

Sensitive Receiver

Optimized to receive WWV on 10 MHz, the UTS10 employs a low noise, wide dynamic range receiver that assures consistent and reliable reception.

Common Mode Rejection

The UTS10's RF input circuitry features an exclusive Common Mode Rejection feature that minimizes noise and cross-talk.

Microprocessor Decoding

The heart of the UTS10 is a microprocessor that executes proprietary digital signal processing (DSP) algorithms, enabling the system to attain high levels of performance with minimal hardware.

Automatic Daylight Savings Time (DST) and Leap Second Detection

The UTS10 automatically detects DST and leap second announcements embedded in the WWV and WWVH signals.

Informative LCD Display

An informative display aids the setup, operation and maintenance of the UTS10. UTC, local or daylight savings time can be displayed in a 12 or 24 hour format. The date is shown in both calendar or Julian formats. Other indicators show whether UTC or the local time zone is selected, if DST is enabled, signal strength, sync state, last update and sync loss interval for at-a-glance system checks.

Low Power, Cool Operation, Conservatively Rated

Powered by an external 12VDC converter or any other 12VDC source, the UTS10 is a power miser. Specifically

designed for harsh environments such as traffic signal control boxes and remote data acquisition sites, the UTS-10 runs cool.

Active Antennas Available

Two active antennas are available for use with the UTS10. The ADA-10 is an inexpensive low-noise, high-gain active dipole antenna, for use in both marginal and nominal signal areas. The AFA-10 is a small and inexpensive active ferrite antenna for use in nominal signal areas where space is limited, or where other requirements preclude the use of dipoles or whips. Other 12VDC active or passive antennas may also be used, depending on their reception characteristics.

RS-232 Interface, Standard Command Set and Advanced Features

An RS-232 serial interface command set makes host programming easy. Query and Set commands monitor and control every feature. In addition, the UTS10's Time Log can be polled to evaluate the reception characteristics of a remote site for the previous week.

Flexibility

The UTS10 delivers precision time in a variety of settings; in the laboratory or office, at a remote data acquisition site or in a traffic control cabinet.

Designed to survive brown-outs and black-outs, the flexibility to choose between "supercap" or battery backup meets the preferences of any user. Once power is restored, estimated time is immediately available — there is no need to wait for full synchronization.

Ease of Use

The LCD built into the UTS10 offers a convenient summary of the system's setup state and performance. Each display field is clearly identified, logically placed and easily accessed via a simple keyboard.

Remote site checks on the UTS10 can be performed quickly and easily by both first time or infrequent users. Operation is intuitive and friendly. Standard and advanced RS-232 commands make host programming equally simple.

More For Less

The UTS10 provides accuracy, reliability and versatility at a price that can't be matched. Its rugged design makes it perfect for harsh environments such as traffic signal control boxes. Call today for an onsite demonstration and evaluation.

SPECIFICATIONS

UTS10

Locked Performance

Accuracy	Within ±20 ms of Coordinated Universal Time (UTC), via WWV or WWVH, National Institute of Standards and Technology
Time To Lock	7 Minutes max. under nominal signal conditions. 4 Minutes min, with strong signal present

Receiver

Type	AM (Crystal Controlled), Single Conversion, Superheterodyne
Frequency	10 MHHz
Antenna Input	50 ohm, BNC Connection
I.F. Frequency	455 KHz
Sensitivity	Audible at less than 0.5 µv input

Display

Type	Custom Liquid Crystal Display (LCD)
Dimensions	1.5" X 3.5"
Display Fields	Month, Day, Year – MM DD YY
Julian Date	NNN
Day of Week	SUN, MON, TUE, WED, THU, FRI, SAT
Time	HH:MM:SS
Last Update	HH:MM
Indicators	Loss Interval Daylight Savings AM, PM Pulse Signal Strength Time Zone Reset

Outputs

TTL Pulse	1 second pulse, once per day, programmable
Audio Monitor	Miniature 8mm Mono jack, headphone or 8Ω speaker

Unlocked/Loss of Power Performance

Max Drift, -20 °C to +70 °C

Micro-processor clock	30 PPM
CMOS clock	50 PPM
Power Loss Backup	Up to 24 hours with "supercap" power backup Up to one year with lithium battery power backup

RS-232 Interface Communication

Parameters	300 - 9600 Baud, Selectable Parity, Word Length and Stop Bits

Physical

Dimensions	2.5" D X 7" W X 5" H
Power	12VDC, 150 ma
Weight	1.5 Lbs

JSI Jim Springer Inc.
Technical Representative
Office: (205) 883-4163
Home: (205) 883-1756
2611 Lancelot • Huntsville, Al 35803

Odetics Precision Time Division
1515 South Manchester Avenue, Anaheim, California 92802-2907
Phone (714) 758-0400 Fax (714) 758-TIME

APPENDIX L: TECHNICAL DATA FROM SUSPENSION DEVICE VENDORS

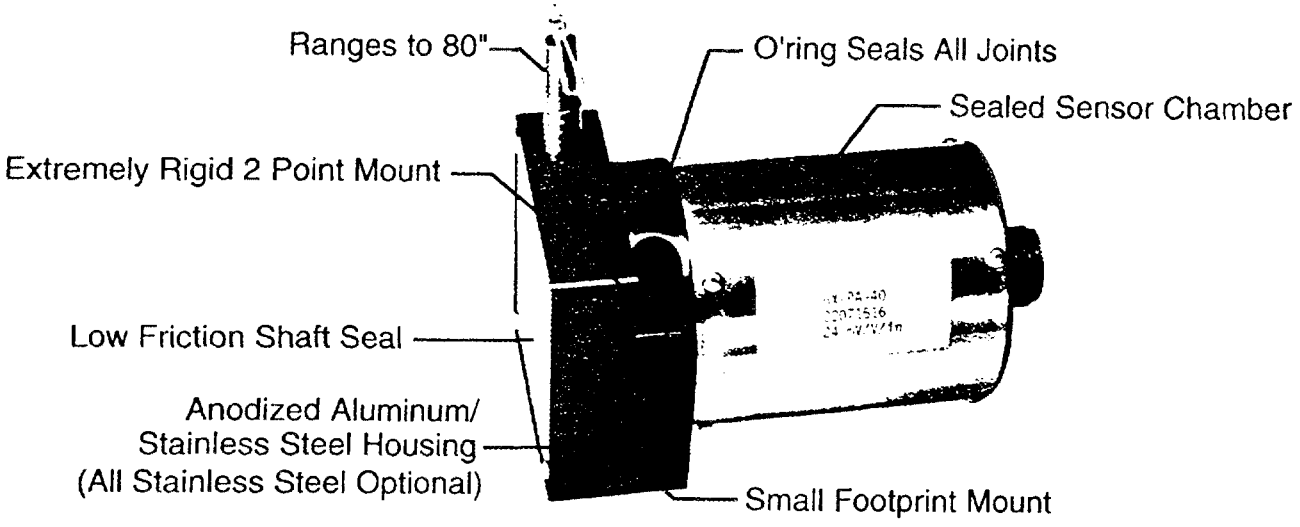
UniMeasure
Systron Donner
Lucas NovaSensor

UniMeasure
Corvallis, Oregon, U.S.A.
Tel: 503-757-3158 Fax: 503-757-0858

Simply the best!

ENVIRONMENTALLY SEALED

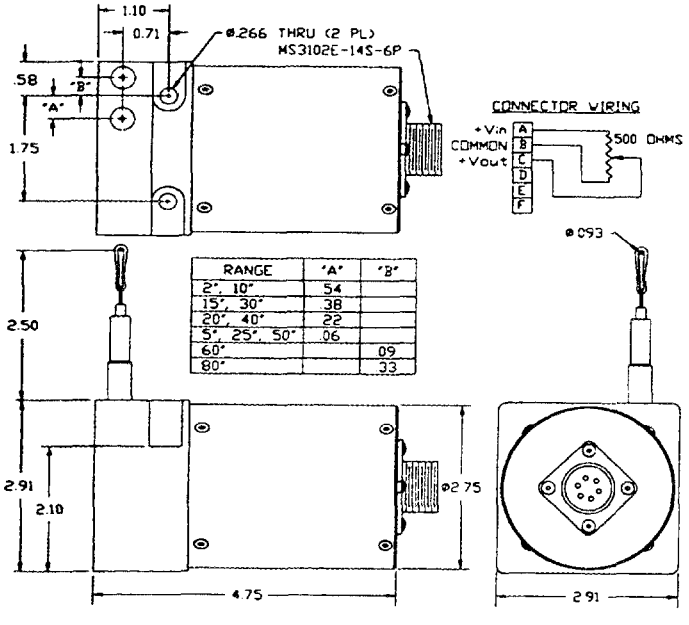
HX SERIES *LINEAR POSITION TRANSDUCER*



DESCRIPTION

The UniMeasure HX series consists of a family of environmentally sealed cable extension linear motion transducers for measuring position, velocity and velocity/position. Available in a rugged anodized aluminum/stainless steel housing (all stainless steel optional), the HX models are appropriate for hostile environments where exposure to rain, wash down, or submersion in various liquids are concerns. The position units are available with analog or digital position output. This bulletin gives specifications on the HX-PA position model with voltage divider circuit.

With standard features such as o'ring seals in all joints, cable dust and debris filter, and rigid two point mounting system, the HX series is the preferred solution when measurement in an adverse environment is necessary.



RANGE	"A"	"B"
2", 10"	54	
15", 30"	38	
20", 40"	22	
5", 25", 50"	06	
60"		09
80"		33

SPECIFICATIONS...ANALOG LINEAR POSITION MODEL HX-PA

General

Linearity
- 2", 5" Ranges ..... ±0.25% Full Scale
- 10", 15", 20" & 25" ..... ±0.15% Full Scale
- All other ranges ..... ±0.10% Full Scale
- Repeatability ..... ±0.015 Full Scale

Resolution
- Ranges 10" and above ..... Essentially Infinite

Construction ..... Anodized Aluminum & Stainless Steel
Sensing Device ..... Precision Potentiometer
Connector MS3102E-14S-6P
Mating Connector (Included) MS3106E-14S-6S

Electrical

Input Impedance ..... 500 ohms ±10%
Output Impedance ..... 0 to 500 ohms
Excitation Voltage ..... 25 Volts Max. AC or DC

Environmental

Thermal Coefficient of
- Sensing Element ..... ±100 PPM/°C Max.

Operating Temperature ..... -15°C to 95°C
Shock ..... 50 G @ 0.1 ms Max.
Vibration ..... 10 Hz to 2000 Hz, 15 G peak
Ingress Protection of Internal Mechanism exclusive of Cable area ..... NEMA 4
Optional Ingress Protection ..... NEMA 6

MODEL	RANGE (inch)	RANGE (mm)	NOMINAL OUTPUT (mV/V/in)	NOMINAL OUTPUT (mV/V/mm)
HX-PA-2	2	50	475	18.7
HX-PA-5	5	125	196	7.7
HX-PA-10	10	250	95	3.7
HX-PA-15	15	390	65	2.5
HX-PA-20	20	500	49	1.9
HX-PA-25	25	640	39	1.5
HX-PA-30	30	750	32	1.3
HX-PA-40	40	1000	24	1.0
HX-PA-50	50	1250	20	0.8
HX-PA-60	50	1500	16	0.7
HX-PA-80	80	2000	13	0.5

#400038A

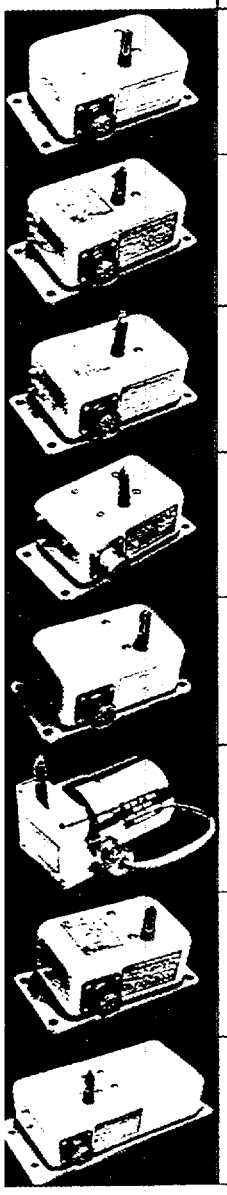
UniMeasure

LINEAR POSITION AND VELOCITY TRANSDUCERS

CABLE EXTENSION TRANSDUCERS FOR THE MEASUREMENT OF LINEAR POSITION AND LINEAR VELOCITY

Description

With relatively non-critical alignment requirements, compact size, and ease of installation, cable extension transducers have proven to be an attractive approach for many different types of linear position and/or velocity measurement applications. The transducer contains a small diameter stainless steel cable which is wrapped onto a drum. Operationally, the transducer is mounted at a fixed position and a clip on the end of the stainless steel cable is attached to a moveable element. As movement occurs, the cable extends from the transducer while rotating a sensing element connected to the internal drum. An electrical output signal is produced which is directly proportional to the cable extension and/or cable velocity. An internal spring maintains near constant tension on the cable and serves as the retraction mechanism.



SERIES	DESCRIPTION	RANGES	LINEARITY
P Analog Absolute Position	Precision potentiometric sensing device gives absolute position voltage output through a voltage divider circuit.	0-2" or 50 mm to 0-500" or 12500 mm	±0.10% Full Scale most ranges
P420 Analog Absolute Position	Two wire connection 4-20 mA output with adjustable zero and span. Requires 14 VDC to 35 VDC input.	0-2" or 50 mm to 0-500" or 12500 mm	±0.15% Full Scale most ranges
P510 Analog Absolute Position	0-10 VDC output with adjustable zero and span. Span can be adjusted to give 0-5 VDC output. Requires 12 VDC to 35 VDC input.	0-2" or 50 mm to 0-500" or 12500 mm	±0.15% Full Scale most ranges
P1010 Analog Absolute Position	±10 VDC output with adjustable zero and span controls. Requires ±15 VDC input with optional +5, +12, +15 or +24 VDC inputs available.	0-2" or 50 mm to 0-500" or 12500 mm	±0.15% Full Scale most ranges
EP Digital Position	Two channel, TTL compatible square wave output. at 5 VDC. Optional differential line driver and voltages to 28 VDC available.	0-2" or 50 mm to 0-500" or 10000 mm	±0.05% Full Scale
HX Environmentally Sealed Position or Velocity	Environmentally sealed transducer available with both position or velocity outputs. Voltage divider circuit, 4-20 mA, 0-10 VDC, ±10 VDC and 2 channel square wave digital outputs available.	0-2" (50 mm) to 0-80" (2000 mm)	Analog output ±0.10% Full Scale most ranges Digital output ±0.05% Full Scale
V Velocity	Velocity transducer with self generating voltage output directly proportional to cable speed.	0-2" or 50 mm to 0-500" or 12500 mm	3% RMS ripple linearity to 0.1%
VP Velocity and Position	Velocity/position transducer with self generating voltage output directly proportional to cable speed and with absolute analog position voltage output.	0-2" or 50 mm to 0-500" or 12500 mm	Velocity: 3% RMS ripple, linearity to 0.1% Position: ±0.1% Full Scale most ranges

UniMeasure Corvallis, Oregon, U.S.A. **Tel: (503) 757-3158 Fax: (503) 757-0858**

UniMeasure

LXMC SERIES
LINEAR POSITION TRANSDUCER

Description

The LXMC linear position cable extension transducer is a compact device for moderate duty applications. The light weight transducer features a machined body, low tension return spring, and long life nylon jacketed extension cable. Since many optional features are possible, the device can be configured for specific applications.

General

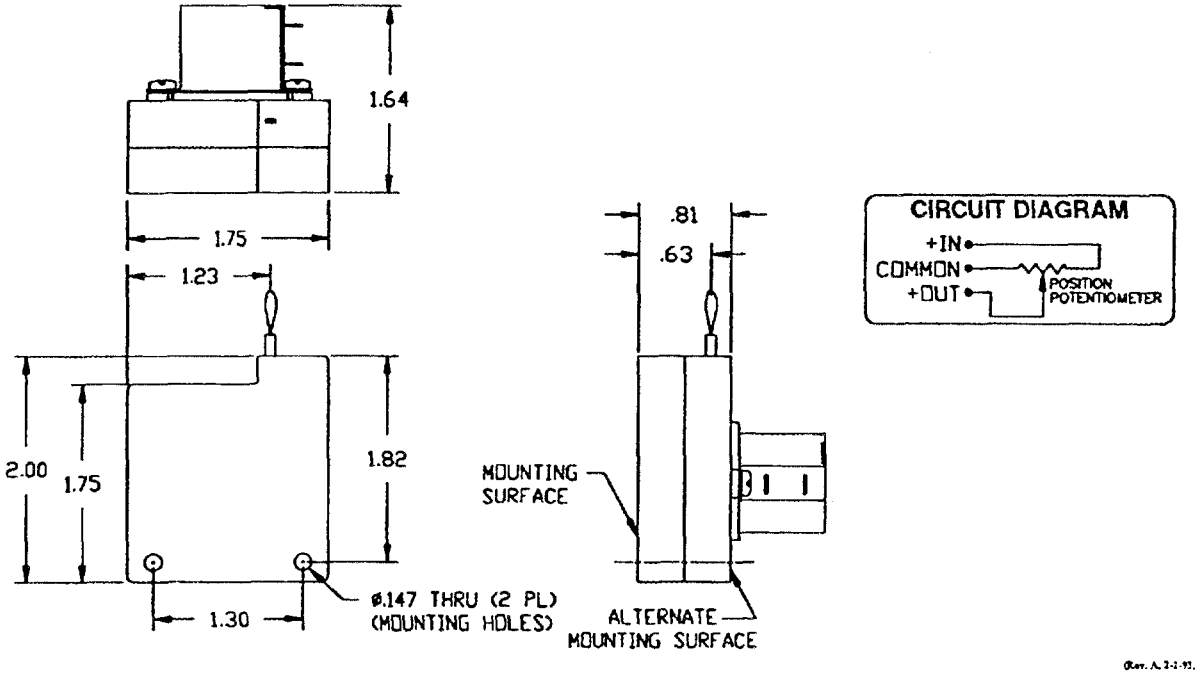
Ranges	0-2" to 0-50"
Sensing Device	Potentiometer--Wire Wound, Conductive Plastic or Hybrid
Linearity	±1% Full Scale Typical
Repeatability	±0.05% Full Scale Typical
Cable	Multistrand Stainless Steel, Nylon Jacketed
Construction	Thermoplastic Body standard
Weight	3 oz.
Connections	Solder Terminals
Expected Life	500,000 Cycles

Electrical

Input Impedance "A" Circuit	500±10% Ohms Standard
Output impedance "A" Circuit	0-500 Ohms
Excitation Voltage	25 Volts Max. AC or DC

Environmental

Operating Temperature	0-60°C
Operating Humidity	95% R.H. max. Non-Condensing
Storage Temperature	-25°C to 80°C



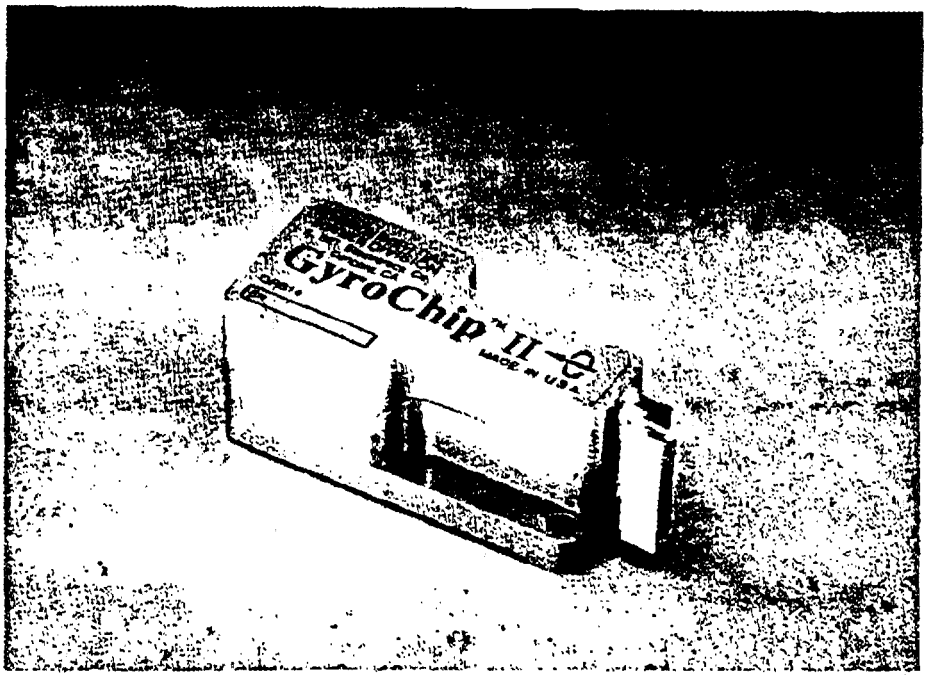
(Rev. A, 2-1-93, P/N: LXMC.PM4)

GyroChip™ II

"SOLID-STATE" RATE SENSOR

Applications

- ❑ Servo Control
- ❑ Short Term Navigation
- ❑ GPS Augmentation
- ❑ Camera Stabilization
- ❑ Virtual Reality
- ❑ Instrumentation
- ❑ Robotics



Description

The GyroChip II is a compact, rugged, "solid-state" sensor used to measure angular rotation rates. It features a monolithic quartz sensing element, internal regulation and DC-in, DC-out operation. Two versions are available: the standard version is suitable for operations from a single-sided (+12 V) supply, while the low noise version operates from a double-sided (±15 V) supply.

Features

- ❑ Rugged Design
- ❑ Lightweight
- ❑ DC-in, DC-out Operation
- ❑ Wide Temperature Range
- ❑ Internal Regulator

Model specific...

- ❑ Low Noise
- ❑ POWER SAVE Mode

Operation

The sensing element of the GyroChip II is a microminiature double-ended quartz tuning fork. By using the Coriolis effect, a rotational motion about the sensor's longitudinal axis produces a DC voltage proportional to the rate of rotation. Use of piezoelectric quartz material simplifies the active element, resulting in exceptional stability over temperature and product life.

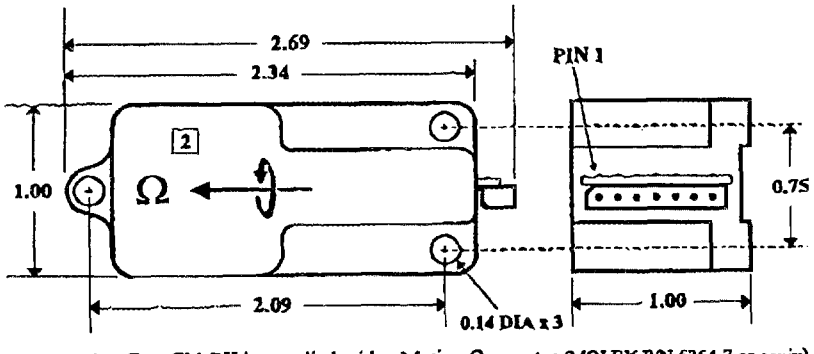
SYSTRON DONNER INERTIAL DIVISION
A BEI Electronics Co.

2700 Systron Drive • Concord, California 94518
Toll-Free Number: (800) 227-1625 Outside California • Sales: (510) 671-6601
Customer Service: (510) 671-6480 • FAX (510) 674-4847
European Business Office (Dover, England): 44 304-216281 • FAX: 44 304-214638

SYSTRON DONNER INERTIAL DIVISION
A BEI Electronics Co.

GyroChip II

POWER REQUIREMENTS	QRS14-00100-102 STANDARD	QRS14-00100-103 LOW NOISE
Input Supply Voltage	+12 to +18 VDC	±9 to ±18VDC
Input Supply Current (Max)	35 mA	35 mA (each supply)
PERFORMANCE		
Range	±100°/sec	±100°/sec
Scale Factor (±2%)	15 mV/°/sec	50 mV/°/sec
S.F. Over Operating Temperature	<4% from Ambient	<4% from Ambient
Bias (Initial Offset)	+2.5 ±0.045 VDC	0.0 ±0.075 VDC
Bias Stability		
–Short Term (100 sec constant temp)	<0.05°/sec	<0.05°/sec
–Long Term (1 year)	<1.0°/sec	<1.0°/sec
–g Sensitivity (all axes)	<0.06°/sec/g	<0.06°/sec/g
–Over Operating Environments	<±3.0°/sec	<±3.0°/sec
Linearity	<0.05 % of F.R.	<0.05 % of F.R.
Output Noise (to 100 Hz)	<0.05°/sec/√Hz	<0.02°/sec/√Hz
Bandwidth (90°)	DC to 50 Hz	DC to 50 Hz
Resolution and Threshold	<0.004°/sec	<0.004°/sec
Start Up Time	<1.0 second	<1.0 second
Operating Life	>5 years	>5 years
ENVIRONMENTS		
Temperature		
–Operating	-40° C to +85° C	-40° C to +85° C
–Storage	-55° C to +100° C	-55° C to +100° C
Vibration (20 to 2,000 Hz, Random)		
–Operating	4 g RMS	4 g RMS
–Survival	10 g RMS	10 g RMS
Shock – Survival	200 g's	200 g's



1. GyroChip™ II is supplied with a Mating Connector (MOLEX P/N 5264-7 or equiv).
2. Angular Rate applied as shown will produce a Positive Output.
3. Unit of measure in INCHES.
4. WEIGHT is less than 50 Grams.

PIN	QRS14-00100-102	QRS14-00100-103
1	Power and Signal Ground	-VDC
2	+VDC	+VDC
3	POWER SAVE[1]	Power Ground
4	Factory Test	Signal Ground
5	Rate Output	Rate Output
6	Factory Test	Factory Test
7	Built-in-Test[2]	Built-in Test[2]

[1]POWER SAVE turns off power to internal circuits and is activated by 5 VDC ±1 V.

[2]Built-in-Test activated by grounding pin 7. Activation causes a nominal increase in Rate Output (pin 5) of 25°/sec.

If it moves, GyroChip it.

Systron Donner also manufactures accelerometer products.

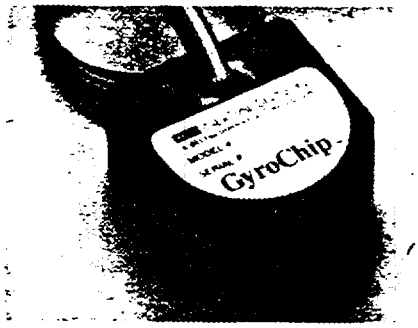
Printed 2/94

R&D

Research and Developments

Stephanie vL Henkel

D Gyro-on-a-Chip Acts As Coriolis Sensor



A new inertial sensor, the GyroChip, is made of single-crystal piezoelectric quartz in the shape of a double-ended tuning fork. The tines of one fork, driven by an oscillator at a precise amplitude, move toward and away from each other at a high frequency. This fork drives the other, which produces the output signal. The forks, support flexures, and frame are all fabricated from a single wafer.

Each tine has a Coriolis force acting on it of:

$$F = 2\, m\omega_i V_r$$

where:

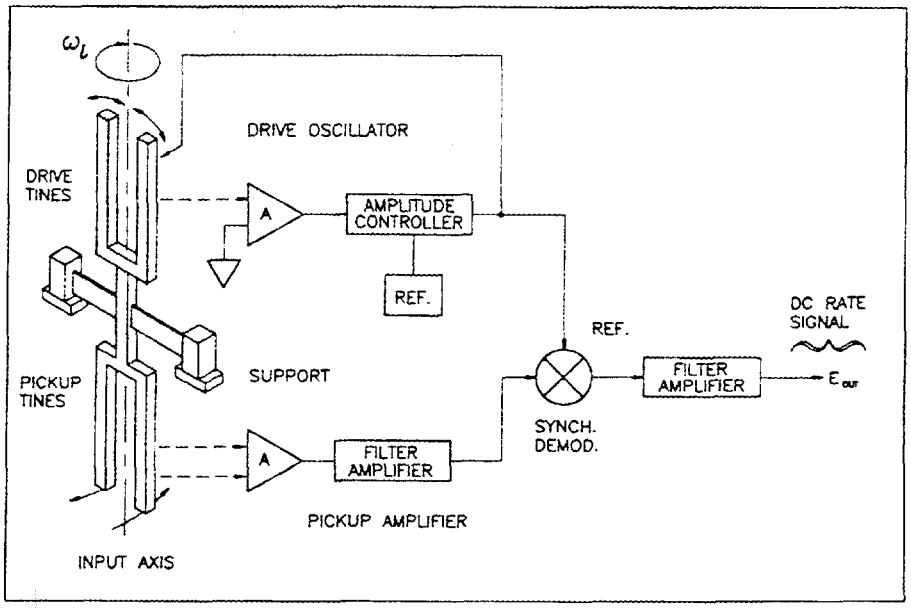
m = tine mass
ω_i = input rate
V_r = instantaneous linear radial velocity

The force is perpendicular to both the input rate and the radial velocity. Because each tine moves in a direction opposite to the other, the forces are normal to the plane of the fork assembly at each of the tines and in opposite directions. The configuration yields a torque proportional to the input angular velocity. Since the radial linear velocity is sinusoidal, the torque produced is also sinusoidal at the frequency of the drive tines, and in phase with the radial velocity of the tine.

The pickup tines respond to the oscillating torque by moving into and out of plane, causing the pickup amp to produce output signals. The synchronous demodulator, which responds only to the output rate signals, demodulates them into a DC signal proportional to angular rate.

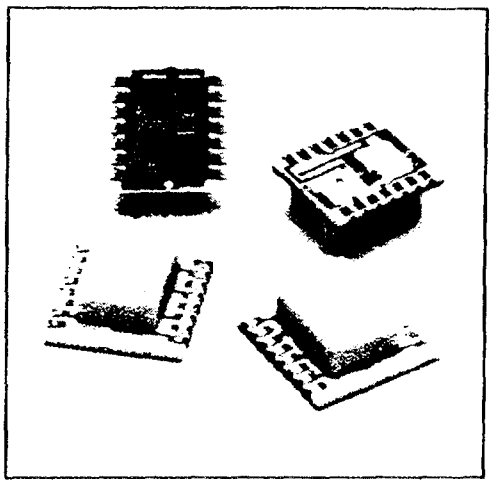
The input rate sensitivity is only about the axis of symmetry of the fork assembly since that is the only motion which, by Coriolis sensing, will produce an oscillating torque at the frequency of the drive tines. The output signals are demodulated with respect to the drive tine oscillator signal since the rate signal is directly in phase with the oscillator signal. Because the oscillating torque produced by Coriolis reverses phase when the input rate reverses, the output signal is a DC signal directly proportional to input rate, reversing sign with the reversal of the input rate.

Contact Gary W. Felsing, Systron Donner Inertial Div., A BEI Electronics Co., 2700 Systron Dr., Concord, CA 94518-1399; 800-227-1625 (outside CA); 510-671-6582, fax 510-674-4847.



NAC Series
Silicon Accelerometers
Ceramic Packages

PRELIMINARY



APPLICATIONS

- Automotive: smart suspension, crash sensing, air bag systems, & anti-lock braking
- Consumer appliances
- Earthquake monitoring
- Biomedical instruments
- Computer peripherals
- Military arming and fusing

FEATURES

- Low cost, miniature size
- Available ranges: ± 2g & ± 50g (consult factory for additional ranges)
- Similar electrical performance to NAH Series accelerometers;
  — Nonlinearity < 0.25% FSO typical
  — Cross-axis sensitivity < 3% FSO maximum
- Self-test feature included on ±50g devices; 5g at 5 VDC and 50g at 12 VDC (consult factory for other ranges available with self-test feature)
- Output signal of up to 60mV FSO with 2.0mA excitation
- Integral offset and temperature compensated from –30 to +85°C
- Maximum acceleration limit of 2000g in all three axes.

DESCRIPTION

Cost-effective ceramic package and thick-film circuit technology enables the Lucas NovaSensor NAC Series piezoresistive accelerometers to be particularly suitable for high volume OEM applications including automotive crash sensing, anti-lock braking systems (ABS), and automotive suspension control. Chip-on-ceramic technology utilizes automated batch fabrication and assembly as well as computer-aided thick-film laser-trim to reduce costs. As with all Lucas NovaSensor silicon sensors, the NAC Series accelerometer uses SenStable® processing technology for excellent signal stability over time. The NAC Series provides the same performance benefits offered by the NAH Series accelerometers such as built-in damping, Silicon Fusion Bonding, and 2000g over range protection.

OPERATING CHARACTERISTICS

PARAMETER		VALUE	UNITS	NOTES
GENERAL				
Acceleration Range	NAC-101, -103	±2	g	0 ± 2g
	NAC-201, -206	±50	g	0 ± 50g
Acceleration Limits		2000	g	any direction
ELECTRICAL @ 2mA, 25°C (77°F) unless otherwise stated				
Input Excitation		2.0	mA	3.0mA max.
Input Impedance	NAC-101, -201	2000	Ω	±25%
	NAC-103, -206	1300	Ω	±25%
Output Impedance		2000	Ω	±25%
Bridge Impedance		2000	Ω	±25%
ENVIRONMENTAL				
Temperature Range				
Operating[9]		-40 to +100	°C	-40° to +212°F
Compensated		-30 to +85	°C	-22° to +185°F

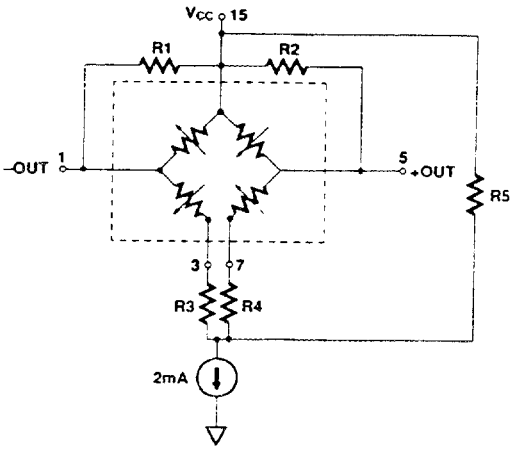
Performance[1]		±2g			±50g			
Parameter	**Units**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Notes**
Zero Acceleration Output								
NAC-101, -201	mV	-40	0	40	-40	0	40	
NAC-103, -206	mV	-2	±1	2	-2	±1	2	
Full Scale Output								
NAC-101, -201	mV	12	20	28	50	75	100	
NAC-103, -206	mV	8	12	16	30	45	60	
Nonlinearity	%FSO	-0.5	±0.25	0.5	-0.5	±0.25	0.5	
Frequency Response	Hz	200			500			
Mounted Resonant Frequency	Hz	400	600		1000	1500		
Damping Ratio		0.4	0.7	1.0	0.4	0.7	1.0	
Vibration Rectification	mg/g²		±1.5			±0.15		2
Cross-axis Sensitivity	%FSO	-3	±1	3	-3	±1	3	3
Thermal Accuracy of Offset								
NAC-101, -201	%FSO		±3			±3		4
NAC-103, -206	%FSO	-4		4	-4		4	5
Thermal Accuracy of FSO								
NAC-101, -201	%FSO		±1			±1		4
NAC-103, -206	%FSO	-2		2	-2		2	5
Thermal Hysteresis	%FSO		±0.5			±0.5		6
Self-Test Output	g	—	—	—	4	5	6	7
Short-Term Stability of Offset								
NAC-101, -201	µV		±20			±20		8
NAC-103, -206	µV		±15			±15		8

Notes:
1. All values measured in reference to 25°C and 2mA constant current, unless otherwise noted.
2. Offset shift under constant AC vibration.
3. When mounted at specified angle of 9.7° (edge of pins 1 through 7 raised with respect to opposite edge).
4. Dependent upon compensation method. When compensated using supplied resistor values and constant current excitation, thermal accuracy will be similar to the corresponding NAC-103 and NAC-206 Series accelerometers.
5. Between -30 and +85°C reference to 25°C.
6. -30° to 85°C.
7. With 5 VDC actuation voltage.
8. Normalized offset/bridge voltage — 100 hrs.
9. Reduced performance outside compensation range.

PRELIMINARY

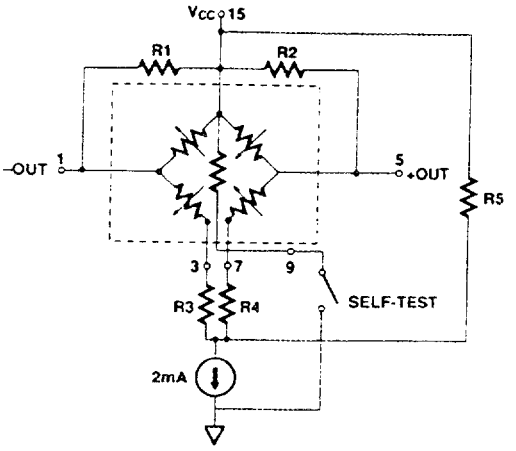
SCHEMATIC DIAGRAMS

NAC-101



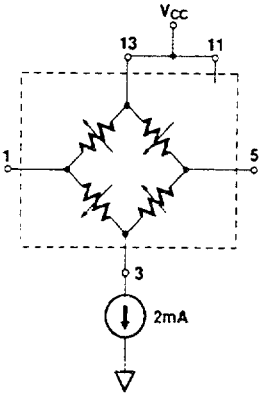
Note: A. Pin #15 connected to chip substrate.
B. R1 – R5 values supplied with sensor.

NAC-201 with Self-test Circuit



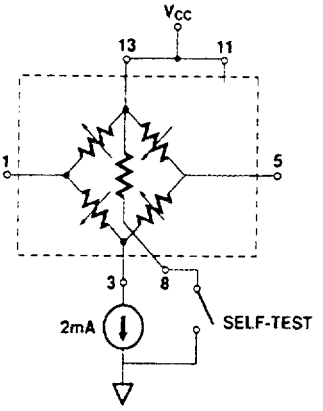
Note: A. Pin #15 connected to chip substrate.
B. R1 – R5 values supplied with sensor.
C. Self-test switch should be closed for 50msec. then output read.

NAC-103



Note: A. Pin #13 connected to chip substrate.
B. Pins #11 and #13 must be shorted together by customer.

NAC-206 with Self-test Circuit

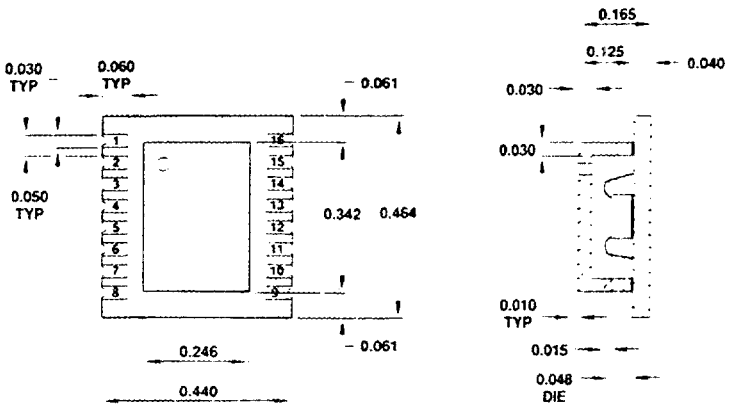


Note: A. Pin #13 connected to chip substrate.
B. Pins #11 and #13 must be shorted together by customer.
C. Self-test switch should be closed for 50msec. then output read.

PACKAGE

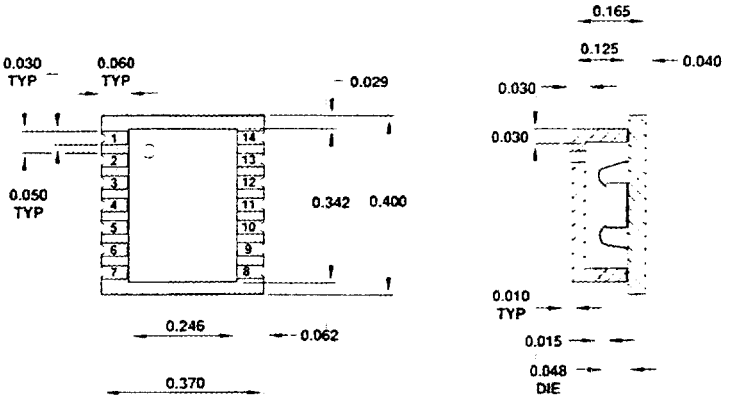
NAC-101, -201

PIN	FUNCTION
1	– OUTPUT
2	NC
3	– EXCITATION B
4	NC
5	+ OUTPUT
6	NC
7	– EXCITATION A
8	NC
9	SELF-TEST(B)
10	NC
11	NC
12	NC
13	NC
14	NC
15	+ EXCITATION
16	NC



NAC-103, -206

PIN	FUNCTION
1	– OUTPUT
2	NC
3	– EXCITATION
4	NC
5	+ OUTPUT
6	NC
7	NC
8	SELF-TEST(C)
9	NC
10	NC
11	+ EXCITATION
12	NC
13	+ EXCITATION
14	NC



Notes:
A. All dimensions shown in inches.
B. Pin #9 is not to be connected on the NAC-101.
C. Pin #8 is not to be connected on the NAC-103.

ORDERING

N A C – 101

- NovaSensor
- Acceleration
- Type = Ceramic
- Acceleration Range
  - 101 = ±2g without compensation
  - 103 = ±2g with compensation
  - 201 = ±50g without compensation
  - 206 = ±50g with compensation

Sales Terms: Lucas NovaSensor standard sales terms apply. Prices and specifications are subject to change without notice.

Warranty: Lucas NovaSensor warrants its products against defects in material and workmanship for 12 months from date of shipment. Products not subjected to misuse will be repaired or replaced. THE FOREGOING IS IN LIEU OF ANY OTHER EXPRESSED OR IMPLIED WARRANTIES. Lucas NovaSensor reserves the right to make changes to any product herein and assumes no liability arising out of the application or use of any product or circuit described or referenced herein.

Lucas NovaSensor
1055 Mission Court
Fremont, CA 94539

Telephone: 510-490-9100
Fax: 510-770-0645
Telex: 990010

VIBRATION RECTIFICATION IN SILICON MICROMACHINED ACCELEROMETERS

Lee A. Christel, Michael Bernstein,
Russell Craddock and Kurt Petersen
Lucas NovaSensor
1055 Mission Ct.
Fremont, CA 94539

Abstract

The phenomenon of vibration rectification in silicon accelerometers is described. Examples of the effect are looked at for the case of piezoresistive silicon micromachined accelerometers. Quad-beam (doubly clamped) devices are compared to dual-beam (simple cantilever) devices. It is shown that for dual-beam accelerometers, the majority of vibration rectification can be attributed to simple quadratic nonlinearity of the accelerometer response and that other rectification effects are at least an order of magnitude lower.

Introduction

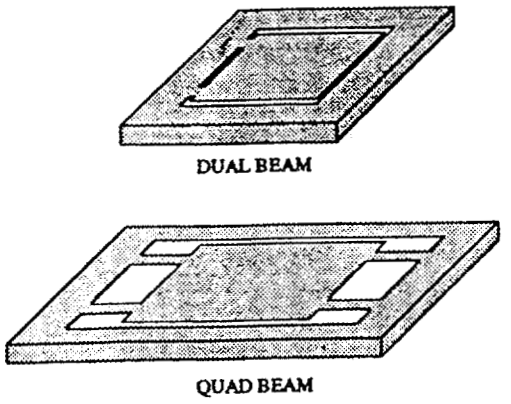
Silicon micromachined piezoresistive accelerometers have evolved from their first realization [1] to highly accurate and complex devices [2,3] suitable for real-world applications in automotive, medical and industrial markets. The accuracy and stability levels obtained recently are comparable to traditional aerospace-grade mechanical accelerometers. Offset stability, for example, has now been improved to the point where effects previously neglected as second order are becoming important.

One of these effects is known as vibration rectification. Vibration rectification is a phenomenon that is well known to manufacturers of inertial-grade accelerometers, but has received little attention in discussions of micromachined silicon accelerometers. The basic effect is that the DC (filtered) output of the accelerometer changes as a function of vibration level, even though the net time-averaged acceleration input level is zero. This means that when vibration is present, an anomolous DC offset can occur. This DC effect must be taken into account if the overall accuracy of the system is to be maintained.

All real world applications of accelerometers involve an environment in which the sensing accelerometer is exposed to some amount of vibration. There are several mechanisms by which vibration rectification might occur. One mechanism is asymmetric damping. If the motion of the accelerometer is more strongly damped in e.g. the +g direction than it is in the -g direction, the magnitude of the vibration response in the positive direction will be less than that in the negative direction. If the signal is then time-averaged by circuitry to get a DC output, the net DC output will be shifted to the negative g direction as compared to the output with no vibration present.

Another mechanism that leads to vibration rectification is simple DC scaling nonlinearity of the accelerometer response. The basic concept is the same, i.e. the time-averaged response in the +g direction is not equal to that in the -g direction. When the total signal is time-averaged, the resulting DC output is again shifted from the value it would have with no vibration present.

In this paper we will give results of measurements showing that the effect is significant and must be considered for its impact on overall system performance. The results show that existing simply supported dual-beam devices outperform doubly supported quad-beam devices in this respect (see Fig. 1). We also have found that in the best devices, the vibration rectification observed can almost entirely be attributed to the simple DC scaling nonlinearity of the accelerometer. Other contributions such as asymmetric damping are at least an order of magnitude below those due to DC nonlinearity.



|. 1: Comparison of Dual-Beam and Quad-Beam Silicon Accelerometers

Theoretical Considerations

Consider an accelerometer that is ›osed to a simple oscillatory input:

$$G(t) = G_1 \cos(\omega t) \qquad (1)$$

: time average of this input is 'o. If the accelerometer has an :al, linear output as a function of ›ut, then the time-averaged .ltered DC) output will also be 'o.

Suppose, however, that the :elerometer output can be racterized by a nonlinear function input and frequency such as

$$V_o = aG + bG^2 \qquad (2)$$

.response of piezoresistive devices typically of this form. stituting the input function (1), accelerometer response becomes

$$V_o = aG_1\cos(\omega t) + bG_1^2\cos^2(\omega t) \qquad (3)$$

time average of this output is al to the sum of the time averages each term. The time average of the ear term is sinusoidal and hence als zero. However, since

$$\int_t \cos^2(\omega t)\, dt = \frac{1}{2} \qquad (4)$$

the time average of the response (3) becomes

$$\overline{V_o} = \frac{bG_1^2}{2} \qquad (5)$$

This value of output is in essence the vibration rectification. Note that the magnitude of the vibration rectification varies as the square of the input acceleration. This is usually a very good approximation to the actual response. The measure of this effect is called the coefficient of vibration rectification and is defined as

$$\gamma = \frac{\overline{V_o}}{G_{max}^2} \qquad (6)$$

Note that the coefficient of vibration rectification resulting from the simple nonlinear response (2) is related to the coefficient of second order non-linearity by

$$\gamma = \frac{b}{2} \qquad (7)$$

This is the minimum vibration rectification that can be achieved by a sensor with this level of nonlinearity. Of course the actual vibration rectification can be made worse by other factors such as asymmetric damping or mechanical effects.

Experimental

Measurements of vibration rectification were made by using a Ling Dynamic Systems V411 shaker system driven by a Ling PO300 power amplifier controlled with an Hewlett Packard 35660A dynamic signal analyzer. The accelerometer output was fed into an amplifier with a low pass filter at the output. The amplifier stage was carefully designed using a high performance operational amplifier and was checked for linearity by DC measurements.

Measurements of linearity and other performance parameters of accelerometers at accelerations above 1g necessitated the construction of a custom precision inertial grade centrifuge. A machine was constructed using a D.C. servomotor with digital controller and feedback from a 1024 line encoder (4096 quadrature counts per revolution). This produced a rotational accuracy of ±0.002%, verified using an independent frequency counter. The radius of rotation was 15 cm, which is sufficient to make errors due to coriolis forces negligible for our device. An on-board linear amplifer was used to produce a high level output signal from the raw sensor. This signal was passed through slip rings to be read by external circuitry.

Measurements were performed on devices fabricated at NovaSensor, as well as on other commercially available quad-beam devices. The results for a typical dual-beam 2g device subjected to 200 Hz vibration at various g levels are shown in Fig. 2. As is evident from the figure, the rectification error varies nearly as the square of the peak acceleration level, as expected from theory. From the results, the coefficient of vibration rectification for this device is about 0.65 mg/g².

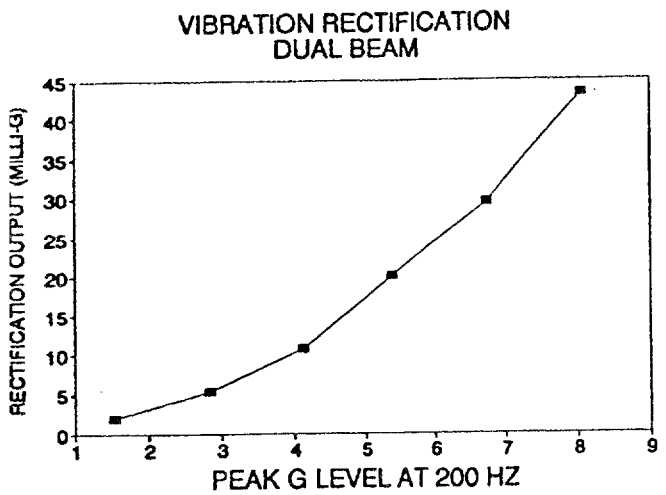


Fig. 2: Vibration Rectification of Dual-Beam 2g Accelerometers

In Fig. 3 we show centrifuge data for the same device. The nonlinearity of the device follows a quadratic function with a second order coefficient of about 1.4 mg/g². Eqn. (7) would predict that the minimum vibration rectification we would expect for such a device would be 0.7 mg/g². Thus within our experimental error, the level of vibration rectification observed is primarily due to scaling nonlinearity. Additional testing on a number of devices showed this to be the case in general.

As an example, the error introduced for a 2g device that operates in vibration levels of ±6g peak at 200 Hz would be 23 milli-g or roughly 1.2% of full scale output. This level of error is to be compared with the scaling nonlinearity error of approximately 3.9 milli-g at 2g, which is about a factor of six lower. This illustrates that care must be taken regarding the vibration environment to which the sensor is exposed if one intends to make accurate DC measurements of acceleration. Levels of nonlinearity which are acceptable from the standpoint of the total static error budget for an accelerometer can produce unacceptable levels of vibration rectification in the wrong environment.

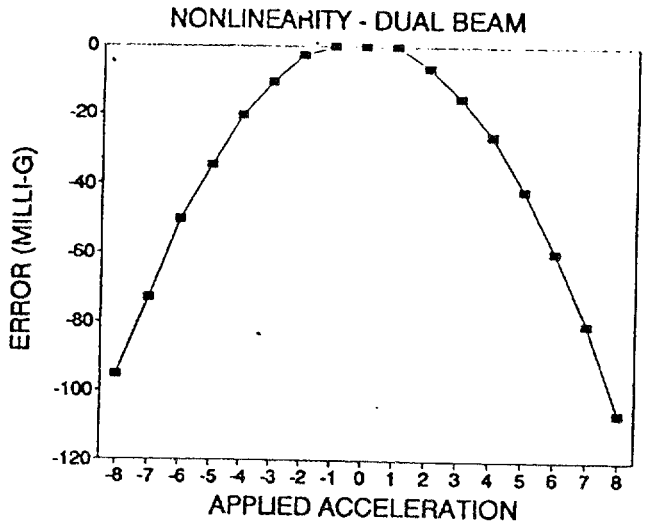


Fig. 3: Nonlinearity of 2g Dual-Beam Accelerometers

Several 2g quad-beam piezoresistive silicon devices currently on the market were also tested. Centrifuge data for these is shown in Fig 4. In this case, the nonlinearity shows odd quadratic behavior in contrast to the even quadratic behavior of the dual-beam devices, with extremely large nonlinearities occurring at higher g levels. At first glance it would appear that the rectification errors for such a device might cancel. However, if the zero point of the device differs from the point of symmetry of the nonlinearity (either due to inherent device characteristics or due to applied acceleration), or if the nonlinearity is in fact not symmetric, substantial vibration rectification will occur.

The vibration rectification data from a quad beam device is compared to the results from a dual-beam device with similar sensitivity in Fig. 5. It can be seen that the dual-beam devices perform substantial better than the quad beam accelerometers. Evidently the mechanical nonlinearities introduced due to stretching of the beams in a quad-beam device degrades the performance as compared with the dual-beam device in which only simple bending of the beams is present.

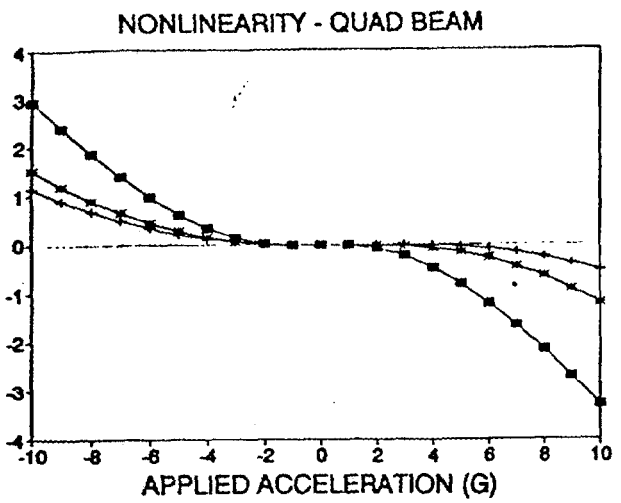


Fig. 4: Nonlinearity of 2g Quad-Beam Accelerometers

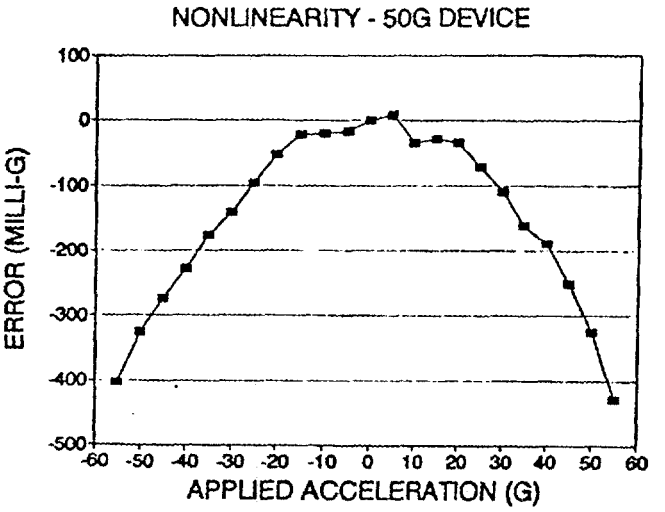
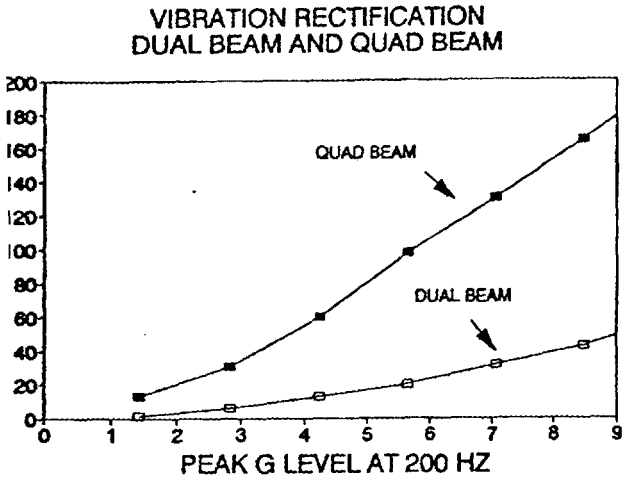


Fig. 6: Nonlinearity of 50g Single-Beam Accelerometer



ig. 5: Vibration Rectification of Dual-Beam and Quad-Beam Accelerometers

50g devices were also centrifuge ested and show a coefficient of econd order nonlinearity of 140μg per . The data is shown in Fig 6. For ese higher range devices, nlinearity is more important as a re scaling error than as a source of ctification errors. This is because aling calibration of accelerometers normally carried out at 1g and such vices are not normally exposed to bration levels much higher than eir full scale outputs.

Summary

We have described the phenomenon of vibration rectification and have presented data showing that the majority of vibration rectification for piezoresistive accelerometers results from scaling nonlinearities of the device. 2g dual-beam devices perform substantially better than quad-beam devices. This effect should be kept in mind when applying these devices to DC measurements, especially when high levels of vibration may be present. Higher g devices suffer relatively less from this phenomenon, with errors dominated by scaling nonlinearities.

References

[1] L. M. Roylance and J. B. Angell, "A Batch-Fabricated Silicon Accelerometer", IEEE Trans. Elec. Dev. ED-26, 1979 pp. 1911-1917.

[2] S. C. Terry, "A Miniature Accelerometer with Built-In Damping", Trans. IEEE Solid-State Sensors and Actuator Workshop, Hilton Head Island, SC, USA, June 6-9, 1988, pp. 114-116.

[3] P. W. Barth, F. Pourahmadi, R. Mayer, J. Poydock and K. Petersen, "A Monolithic Silicon Accelerometer with Integral Air Damping and Overrange Protection", Trans. IEEE Solid-State Sensors and Actuator Workshop, Hilton Head Island, SC, USA, June 6-9, 1988, pp. 35-38.

APPENDIX M: TECHNICAL DATA FROM PHYSIOLOGICAL MEASUREMENT SYSTEM VENDORS

Marquette Electronics
UFI
Williamson Associates

marquette electronics

Marquette Electronics, Inc.
8200 West Tower Avenue, Milwaukee, Wisconsin 53223 U.S.A.
Tel. (414) 355-5000, TLX: 297991 MEI UR, FAX: 355-3790

August 9, 1993

Richard J. Carter
Intelligent Systems Section
Engineering Physics & Mathematics Division
Oakridge National Laboratory
P.O. Box 2008
Oakridge, TN 37831

Dear Dick:

Thank you for your consideration of Marquette in developing your non-obtrusive physiological measurement recording system. I have reviewed the information that you sent to me in detail, and we have decided that due to our present development priorities we can not participate in this project at this time. Again, we appreciate your consideration, and maybe in the future Marquette can apply its physiological monitoring technology to a project of this type.

Sincerely yours,

MARQUETTE ELECTRONICS, INC.

Phillip T. Weinfurt, Ph.D.
Manager, New Product Development

PTW/cc

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UFI

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SYSTEMS

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• WHY A FETRODE®?

Historically there have been only two solutions to the problems of noise in bio-electrical recordings:
1. Use the very best silver/silver chloride electrodes with a liquid junction interface.
2. Reduce the skin/electrode contact impedance by abrading the skin.

With the increasing possibility of exposure to the HIV and /or Hepatitus viruses, it is no longer advisable to break the skin barrier. Fetrodes® eliminate the requirement to abrade the skin.

• WHAT IS A FETRODE®?

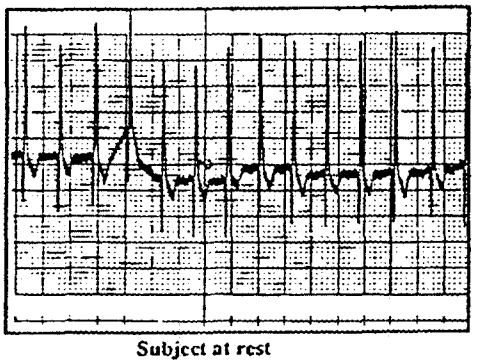
The FETRODE® is a unique, temperature compensated amplifier possessing an extremely high input impedance and a very low output impedance. The circuitry is built with state of the art, surface mount, technology into a miniature enclosure which can be snapped on to any high quality electrode.

• WHAT DOES A FETRODE® DO FOR YOU?

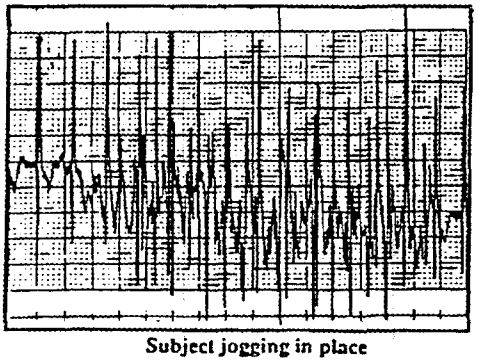
FETRODES® virtually eliminate artifacts due to electrostatic potentials and cable noise.

WITHOUT SKIN PREP OF ANY KIND !!!

ECG WITH PLAIN ELECTRODES

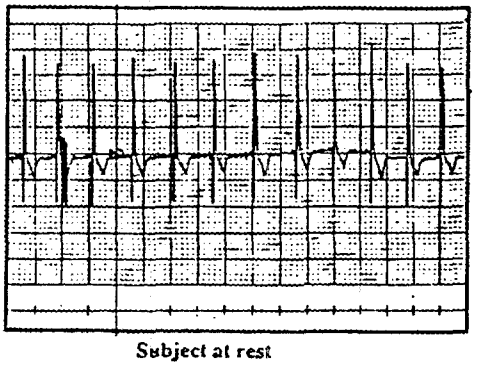


Subject at rest

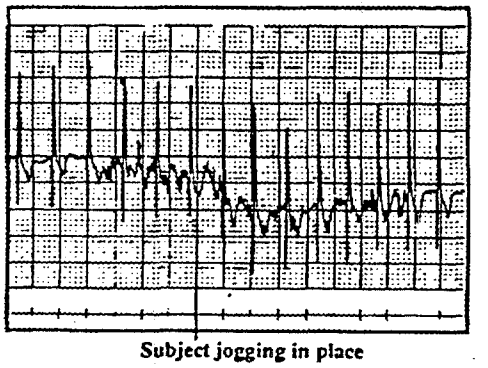


Subject jogging in place

ECG WITH SAME ELECTRODES PLUS FETRODES®



Subject at rest



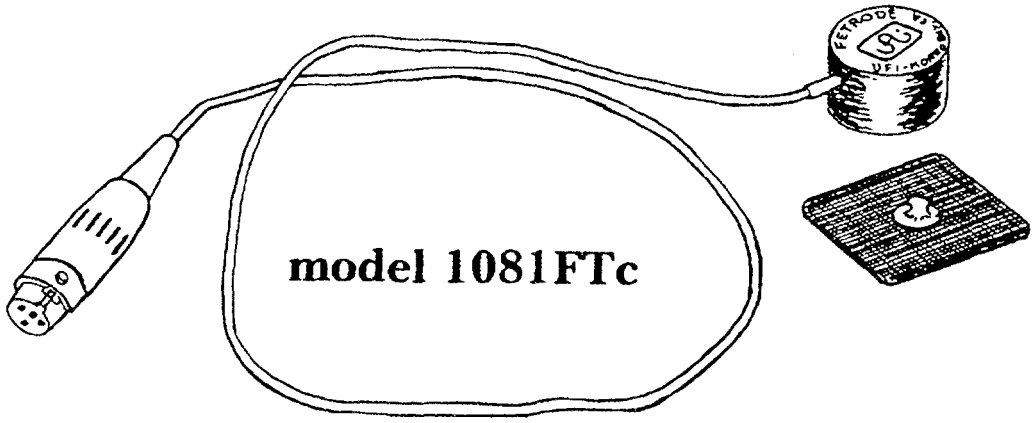
Subject jogging in place

TEST CONDITIONS:

Silver/silver chloride electrodes attached without skin prep of any kind.

Electrode contact Z = 65 KΩ, Amplification = 1,000, Electrode placement=Xyphoid to V5/V6
Paper speed = 10 mm./sec. Low frequency response = 0.01 Hz.

The baseline shift seen above is NOT an artifact. It is a physiological signal often seen when the recording system has such an extended low frequency response.



fetrode® model numbers & prices

model #	description	price
1081 FT	Single FETRODE® less connector	$110.00
1081 FTc	Single FETRODE® with connector	$125.00

fetrode® *system* model numbers & prices

note that signal conditioners sold with FETRODES® are less expensive

model #	description	uses					prices	
		ECG	EEG	EGG	EMG	EOG	COMPLETE SYSTEM	SIG. COND. ONLY
2280 FT	1 mV. interface w/2 FETRODES®	X			X		$345.00	$195.00
2281 FT	Amplified Interface (1V/mV) w/2 FETRODES®	X			X		$445.00	$245.00
2283 FT	Universal FETRODE® Amplifier w/2 FETRODES®	X	X	X	X	X	$545.00	$395.00
2283 FTi	Universal FETRODE® Amplifier w/isolation & 2 FETRODES®	X	X	X	X	X	$745.00	$595.00

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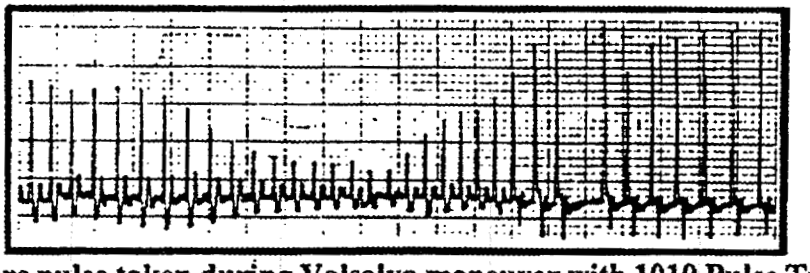
model 1010
pulse transducer

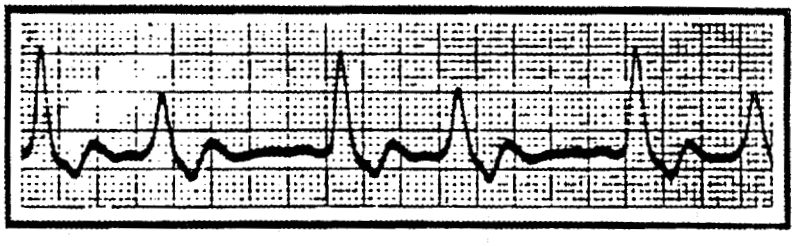
DESCRIPTION:

A rugged piezo-electric transducer which has been designed to reliably monitor and record peripheral pressure pulses, Korotkoff sounds, carotid pulses, small animal respiratory activity, swallowing and other dynamic biological functions. Its small size and high signal output make it ideal for both teaching and research applications.

The Model 1010 is easily attached to the subject at any desired location with the integral Velcro™ strap.This durable transducer is simply and easily connected to existing direct writing oscillographs, polygraphs, or computer based data acquisition systems.



Finger pressure pulse taken during Valsalva maneuver with 1010 Pulse Transducer. Notice the skipped beat and increased compensatory pressure pulse immediately following.



Finger pressure pulse taken on a subject exhibiting chronic bigeminal heart beats.

SPECIFICATIONS:

Frequency Response: .....2.5 Hz to 5kHz
Signal Output: .....20 - 40 mV into 1 Megohm
Weight: .....0.5 ounces
Size: .....0.9" Diameter X 0.5" Thick

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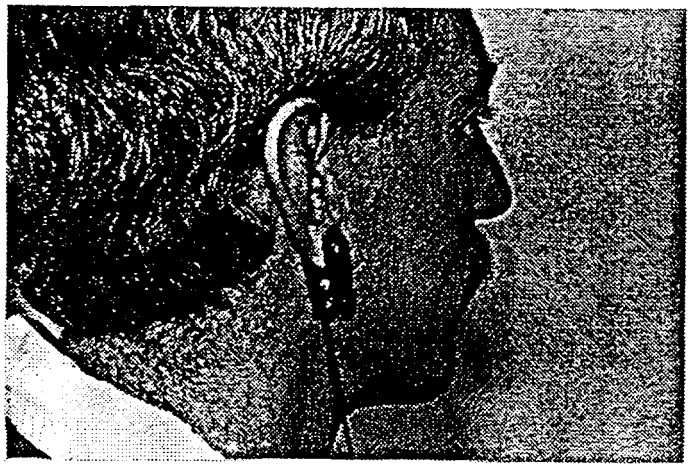
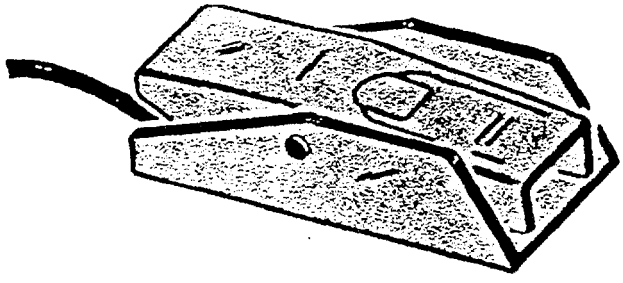
model 1020 EC
EARCLIP
photoelectric
pulse transducer



This is the earclip version of the 1020 PPG. It operates by transmitting infra-red light through the tissue—rather than reflecting from the surface.
Operating voltage—6-12 VDC. Current consumption—20 mA. Nominal signal output —— 5-15 mV.

model 1020 FC
FINGER CLIP
photoelectric
pulse transducer



The 1020 FC is the finger clip version of the 1020. Its specifications are essentially the same as the model 1020.

NOTE: PIN DIODE VERSIONS OF ALL PPG TRANSDUCERS ARE AVAILABLE FOR THOSE USERS WHO REQUIRE ENHANCED TEMPERATURE STABILITY

ALL UFI TRANSDUCERS ARE COVERED BY OUR EXCLUSIVE LIFELINE WARRANTY

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Consultants AFOT
Specializing in design and development of prototype systems

August 25, 1993

6613 Lynndale Drive
Raleigh, NC 27612
1-919-848-3618

Mr. Dick Carter, Manager
Cognitive Systems & Human Factors Group
Engineering Physics and Mathematics Division
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6360

RE: Noninvasive, Biomedical Monitoring System, R & D Proposal.

Dear Dick,

Enclosed, please find the cost breakdown for developing the "Heart Rate / Breathing Rate System."

These costs reflect a strategy that I feel should yield a system that will be the most flexible. It should be capable of quantifying the desired information while preserving or archiving the "raw" data for later analysis.

To that end, one would perform continuous FFT (Fast Fourier Transform) on a finite bandwidth signal, while simultaneously recording (and compressing) the time domain representation of that signal.

Originally I had planned to use adaptive filtering to extract the numerical values for heart rate and breathing rate without retaining any other data. Because this approach would prevent any post analysis of the data (for other attributes), and because of the research nature of this device: it is appropriate that the above architecture be used.

As a rational for this approach, consider the following: it could be used for the detection of cardiac arrhythmia, signalling the possible onset of a heart attack; as a indicator for fatigue or sleepiness, the very artifact that has been seen as interference, i.e., driver movement or "squirming," restlessness (trying to get comfortable) might just be such an indicator. Also, breathing depth or shallow breathing (another possible indicator) might better be analyzed in the time domain.

I propose that the microwave Doppler transducer consist of one very low power GUNN microwave emitter, with two or more diode detectors--spaced at <1/4 wavelength (~1/8, for standing waves). The output from these detectors go to a DSP board for two different processes. The first is to take a continuous FFT of the real-time signal and pass the resulting data (frequency and amplitude) to the Host computer. The second, is to compress and store the digitized--time domain--data from the transducer for post processing and/or near real time processing by the host computer.

Again Dick, thanks for the opportunity to propose these fun projects.

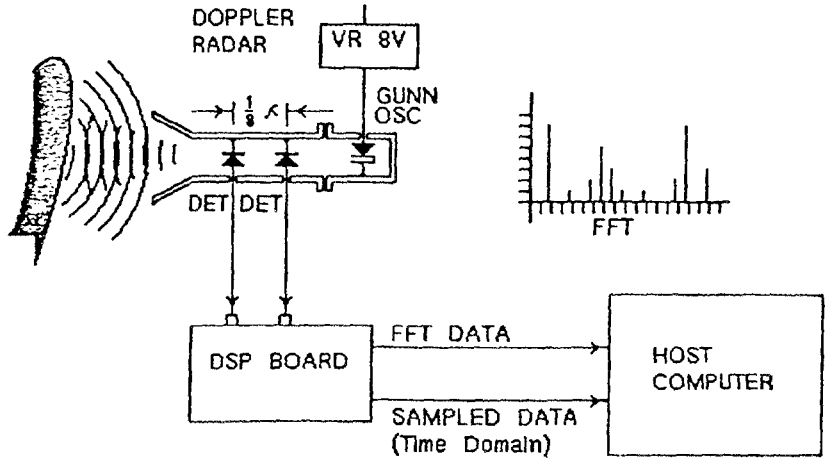
Sincerely,

Glen

Glen A. Williamson, owner

Enclosures:

Noninvasive, Biomedical Monitoring System, R & D Proposal



System Block Diagram

FFT is a method of extracting frequency and amplitude information without altering the signal. If adaptive filtering were used, it is possible signal attributes not yet appreciated might be filtered out, or lost.

Also, due to the nature of adaptive filtering's need to capture the wave of interest, and to track the signal's varying frequency, When track or "lock" is broken, until re-capture, the signal is essentially lost.

In the case of FFT, all signal characteristics are preserved during analysis, and can be stored for near real-time selection or post evaluation.

Williamson Associates © 1993
Proprietary

APPENDIX N: TECHNICAL DATA FROM ENVIRONMENT PARAMETERS MEASUREMENT DEVICE VENDORS

Armtec Industries
Vaisala
LC Technologies
ISCAN

General Sensors - Thermal, etc
Air Flow - back Page

MEGGITT AEROSPACE

ARMTEC INDUSTRIES INC

VOLUME 1 NUMBER 1

Technology Report

Armtec Is A Sensor Technology Company.

Armtec is a manufacturer of specialty instrumentation products based on a foundation of proprietary sensor technology. Our sensors are used to detect ultraviolet and infrared radiation, respond to fire and overheat conditions and measure air or mass flow.

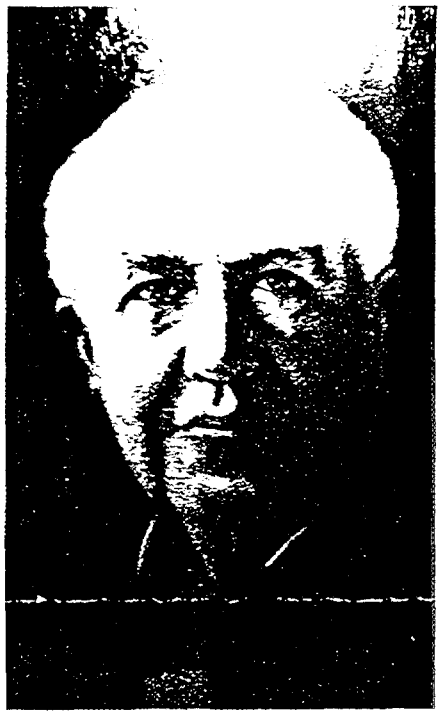
Each of these technologies is based on proprietary Armtec development programs which have resulted in sensor products that are used worldwide in industry, aerospace, and defense.

Armtec is a descendant of the original Thomas A. Edison Company and continues the tradition of innovation and technological leadership that was begun by our founder.

This first issue of the Armtec Technology Report summarizes the sensor technologies available from Armtec. Future issues will provide technical details for each of our technologies. These technologies have nearly limitless application in automotive, aerospace, laboratory equipment, marine, and oil/gas pipeline industries.

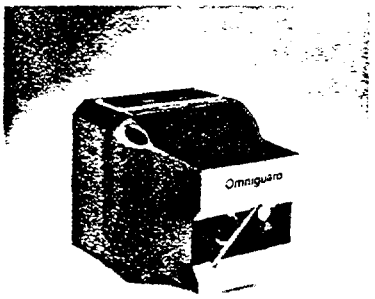
We invite you to call Armtec to discuss your application and to obtain future issues of our Technology Report. An order form on the back page of this issue may be used if desired.

Armtec also manufactures products which use our technology. If your company is developing new products and seeks a design, manufacturing, or distribution partner, we would like to talk with you. If you would like to discuss your application with us further, please return the form on the back page or call Mr. Dick Oliver at 603-669-0940 ext. 260.



THOMAS EDISON

Armtec is the successor to several successful ventures which trace their roots to the Thomas A. Edison Company. Our heritage is developing practical solutions for the instrumentation and safety needs of the markets we serve. Armtec is committed to continue this heritage, offering new products and friendly service through our qualified staff and modern facilities.



Combination Ultraviolet/Infrared (UV-IR) Flame Detector

Thermal Resistive film (TRF) Wind/Air Flow Sensor

irflow Measure-
ıent Technology
eveloped for the
lilitary Has
ommercial Uses

ıtec's mass airflow technology is
cally used in applications that require
ırate measurement of wind speed and
ction under harsh environmental con-
ɔns. The thermal resistive film sensor
no moving parts, provides high speed
esponse to transient flow conditions
withstands extreme vibration and
:k loads.

Technical Description

Armtec's mass airflow sensors are based on a proprietary, thermal resistive film (TRF) technology. Elements are electrically isolated but mechanically joined together in pairs. Elements are heated to a controlled temperature above ambient.

Air flowing over the element pair cools the upwind element faster than the partially blocked downwind element. Wind speed is determined by the amount of electrical current required to maintain the controlled temperature in each element. With two pairs of elements, mounted perpendicularly to each other, wind direction can be calculated.

Because the elements are heated, contamination problems from dust, ice, snow and moisture are minimized.

Applications

Armtec's airflow sensors are used in combat vehicles to provide cross-wind vector information to the on-board main gun fire control system. Omni-directional wind information is provided on vehicles that provide meteorological and NBC contamination detection missions.

Commercial applications include wind measurement at airports, on ships and at weather stations. The fast-time response of the sensor makes it well suited for wind shear or micro-burst detection systems. Variations of the basic wind sensor product are available which provide integrated measurement of barometric pressure, ambient temperature and relative humidity.

Armtec continues to make further refinements in sensor fabrication and signal conditioning electronics to broaden the application base for its air and mass flow sensors.

SUBSCRIPTION ORDER FORM

_____ Please add me to your mailing list for Armtec Technology Reports.

_____ I need immediate information on the following:

- _____ Ultraviolet sensors
- _____ Infrared sensors
- _____ Heat sensing cables
- _____ Airflow measurement sensors

My application is _____

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

TELEPHONE _____ FAX _____

MAIL OR FAX TO: Armtec Industries, Inc.
Technology Report Editor
10 Ammon Drive
Manchester, NH 03103-7406
603-669-0940 FAX 603-669-0931

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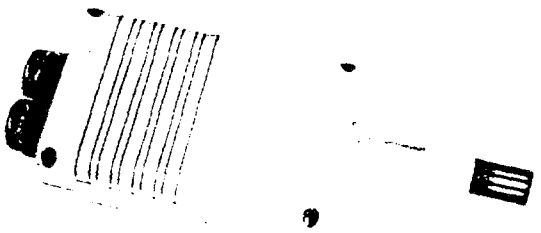
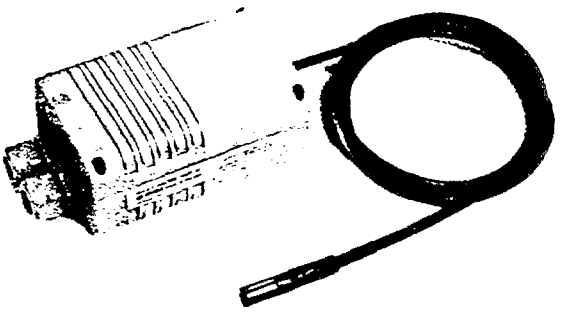
VAISALA
SENSOR SYSTEMS

NEW RUGGED INDUSTRIAL HUMIDITY AND TEMPERATURE TRANSMITTERS

5 m probe/cable assembly optional



HMP 131Y For storage and warehousing applications



HMP 133Y For use in tight spaces

RECOMMENDED FOR CHANGING ENVIRONMENTS

Vaisala's newest humidity transmitters are ideal for applications where both humidity and temperatures tend to fluctuate. The HMP 131Y and HMP 133Y are fully temperature compensated and provide unsurpassed accuracy and repeatability under varying conditions.

DEPENDABLE H-SERIES SENSOR

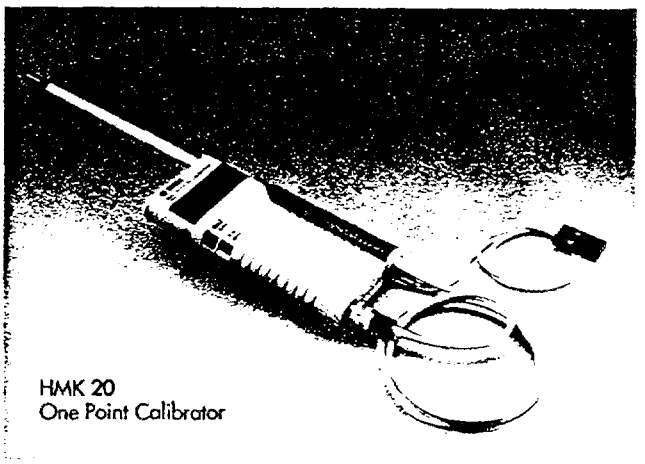
THE HMP 131Y and HMP 133Y transmitters utilize Vaisala's H-Series HUMICAP® capacitive humidity sensor. This new sensor covers the entire range of relative humidity, from 0 to 100% RH, has excellent stability and delivers accuracies as high as ±1%. The sensor operates over a broad temperature range and is not affected by most chemicals or dust particulates.

VERSATILE FEATURES

The HMP 131Y and HMP 133Y transmitters provide the user with many convenient features. The products operate off 11 to 30 VDC power supply and can provide several common output signals, which may be switched without recalibration. In addition, both transmitters can be connected to main power supply using Vaisala's HPP 130 series Power Supply Unit.

ON-SITE CALIBRATION

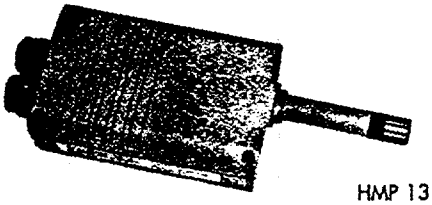
These transmitters are also compatible with Vaisala's HMK 20 One Point Calibrator. This hand-held instrument allows fast, on-site calibration of the transmitters to be accomplished in minutes, without disturbing their operation. This saves hours of maintenance time and assures high measured accuracy.



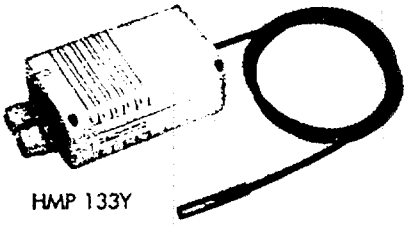
HMK 20
One Point Calibrator

TECHNICAL DATA

RELATIVE HUMIDITY AND TEMPERATURE TRANSMITTERS



HMP 131Y



HMP 133Y

HPP 130A, B, C

General

Input voltage:	11 to 30 VDC (15 to 30 VDC for 0/1 to 5 V outputs, and for current outputs depending on external load)
Input current:	20 to 60 mA
Electronics Operating temperature range:	-5 to +60 °C (+23 to +140 °F)
Storage temperature:	-40 to +75 °C (-40 to +168 °F)
Electronics housing:	ABS plastic, class IP 65 (NEMA 4)
Electrical connections:	Screw terminals for wires 0.5 to 1.5 mm (AWG 20 to 16)

Relative humidity

Measuring range:	0 to 100% RH
Accuracy:	±1% RH (0 to 90% RH), ±2% RH (90 to 100% RH) maximum achievable accuracy when calibrated against high quality, certified standards
	±2% RH (0 to 90% RH), ±3% RH (90 to 100% RH) for factory calibration and when calibrated against salt solutions (DIN 50 008)
Temperature dependence of electronics inside the housing:	±0.03% RH/°C, none at 20°C
Selectable output signals:	• 4 to 20 mA, 0 to 20 mA, 0.25 to 1.25 V, 0 to 1 V, 1 to 5 V, 0 to 5 V
Response time (90%) at 20 °C in still air:	15 sec with sintered filter 15 sec with optional sintered filter 5 sec with optional plastic grid
Sensor:	HUMICAP® H-sensor
Sensor protection	
HMP 131Y:	ø 18.5 mm membrane filter
HMP 133Y:	ø 12.0 mm membrane filter

Temperature

Measuring range:	
HMP 131Y:	-20 to +60 °C (-4 to +140 °F)*
HMP 133Y:	-20 to 80 °C (-4 to 176 °F)
Accuracy at + 20 °C :	±0.2 °C
Typical temperature dependence of electronics:	±0.005 °C/°C
Linearity of electronics:	better than 0.08 °C
Sensor:	Pt 100 RTD, 1/3 DIN 43760B

Power Supply Units HPP 130A, B, C (optional)

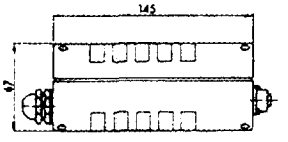
HPP 130A	
Input voltage	24 Vac ± 10% 50/60 Hz
HPP 130B	
Input voltage	110 Vac ± 15% 50/60 Hz
HPP 130C	
Input voltage	230 Vac ± 15% 50/60 Hz

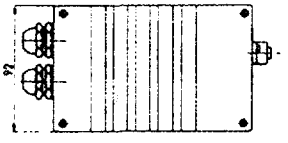
Output voltage compatible with HMP 130Y-series transmitters.

• Factory setting 4 to 20 mA. Other outputs jumper-selectable. Recalibration unnecessary.

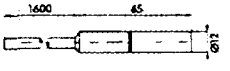
Specifications subject to change without notice.

Dimensions in mm

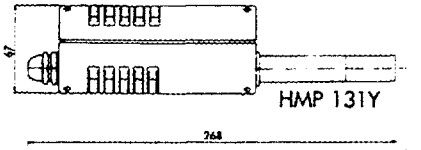




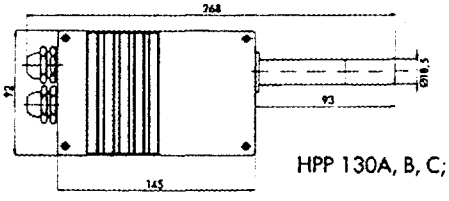
HMP 133Y



HMP 133Y



HMP 131Y

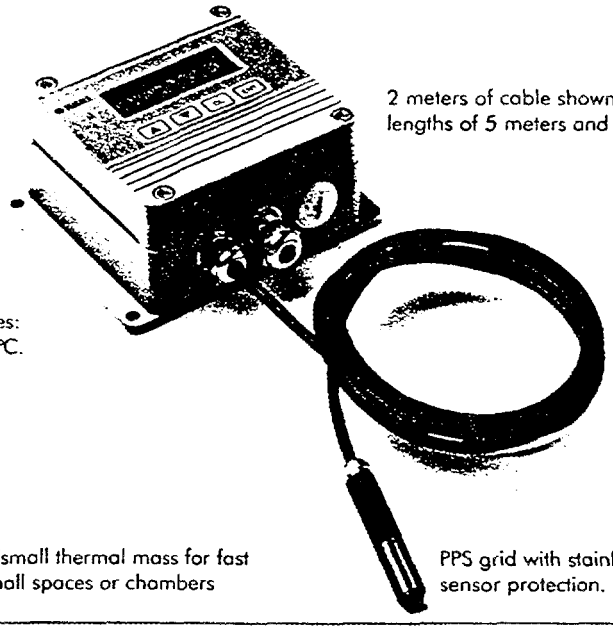


HPP 130A, B, C; dimensions are identical with the cover.

VAISALA
SENSOR SYSTEMS

VAISALA
SENSOR SYSTEMS

NEW "SMART" HUMIDITY/DEWPOINT TRANSMITTER FOR MEASUREMENT IN DUCTS AND SMALL SPACES



2 meters of cable shown. Also available in lengths of 5 meters and 10 meters.

Available operating temperature ranges: Either -40° to +80°C or -40° to +120°C. (120°C version is electromagnetically compatible.)

Small sensor head/small thermal mass for fast measurement in small spaces or chambers

PPS grid with stainless steel netting is standard sensor protection. Other filters also available.

CUSTOMIZE YOUR INSTRUMENT

(Also see easy-to-use order form)

Vaisala's unique microprocessor design and modularity allow you to customize the HMP 233 at time of purchase:

- Selection of output parameters:
  - relative humidity
  - absolute humidity
  - dewpoint
  - mixing ratio
  - temperature
  - wet bulb temperature
- Selection of temperature range
- Selection of:
  - cable length (2, 5, or 10 meters)
  - local display and keypad
  - serial bus type (RS 232 or 485/RS 422, current loop)
  - type of sensor protection (variety of filter types available)
  - operating voltage 24 VDC, 115 AC, 230AC, 50/60 Hz

After purchase, you can directly program either via computer or local display and keypad:

- units (metric or non-metric)
- the two output parameters corresponding to analog channels 1 and 2 (note: all output parameters selected by users are also available via serial output and display)
- selection of the following output signals:
  - 4 to 20 mA
  - 0 to 20 mA
  - 0 to 1V
  - 0 to 5V
  - 0 to 10V
- scaling of measurement parameters and output signals (e.g. -10°C to +80°C corresponds to 0 to 5V)

FOR DUCTS & SMALL AREAS

The HMP 233 has been engineered for use particularly in small, tight spaces including chambers and incubators, as well as typical low temperature duct applications. Its small sensor head with its small thermal mass is an advantage especially in situations where the sensor head must respond quickly to surrounding temperature changes. An optional kit consisting of aluminum flange, lead-through piece, and steel support bar enables installation of the HMP 233 in ducts, channels, and through walls.

RELIABLE MEASUREMENT

This instrument incorporates the H-sensor which measures humidity more accurately (up to ± 1%) and reliably than other sensors. Its tolerance to high temperature, ability to operate in condensing environments, resistance to harsh chemicals and contaminants, and excellent long-term stability are of great value in accurately monitoring and controlling chambers, processes, etc. The HMP 233 transmitter is fully temperature compensated and provides unsurpassed accuracy over the entire humidity range (0 to 100% RH).

ON-SITE, ONE-POINT CALIBRATION

By utilizing a reference RH or temperature probe for comparison, routine maintenance and calibration of the HMP 233 can be performed on site within a matter of minutes without disturbing transmitter operation. This unique one-point calibration feature will save down time, reduce service costs, and ensure high accuracy operation.

TECHNICAL DATA

HMP 233 HUMIDITY/DEWPOINT TRANSMITTER

Measured Variables

Relative Humidity

Measurement range	0...100%
Accuracy (including non-linearity and repeatability) Maximum achievable when calibrated against high quality, certified humidity standards:	± 1%RH (0...90% RH) ± 2%RH (90...100% RH)
When calibrated against salt solutions (ASTM E104-85)	± 2%RH (0...90% RH) ± 3%RH (90...100% RH)
Response time (90%) at +20°C in still air (with sintered filter)	15 s
Sensor	HUMICAP® H-sensor

Temperature

Measurement range	-40°...+80°C (-40...+176F) OR -40°...+120°C (-40...+248°F)
Accuracy	± 0.1°C
Sensor	PT 100 RTD 1/3 DIN 43760B

Calculated Variables

Typical ranges:

dewpoint temperature	-40...+100°C
mixing ratio	0...600 g/kg d.a.
absolute humidity	0...600 g/m³
wet bulb temperature	0...100°C

Outputs

Two analog outputs selectable and scaleable	0...20 mA 4...20 mA	0...1V 0...5V 0...10V
Serial output available	RS 232C, RS 485/RS 422 current loop	

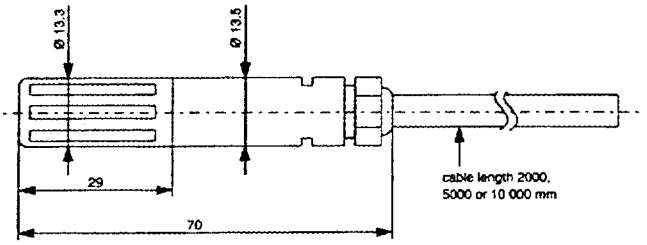
General

Connections	screw terminals for 0.5 mm² wires (AWG 20)
Operating voltage	24 VDC/VAC (20...28V) 115 VAC/230 VAC option
Power consumption	100 mA maximum
Recommended external load for current outputs	< 500 ohm
Recommended external load for 0...1V ouput	> 2 kohm
Recommended external load for 0...5 and 0...10 V outputs	> 10 kohm
Operating temperature range for electronics	-40...+60°C (-40...+140°F)
Storage temperature range	-40...+70°C (40...+158°F)
Housing material	G-AlSi12 (DIN 1725)
Housing classification	NEMA 4 (IP 65)
Bushing	for 7...10 mm diameter cables (8 x 0.5 mm² shielded cable
Sensor protection (ø 13.3 mm)	PPS grid with stainless steel netting recommended. Others, including sintered filter, are also available.

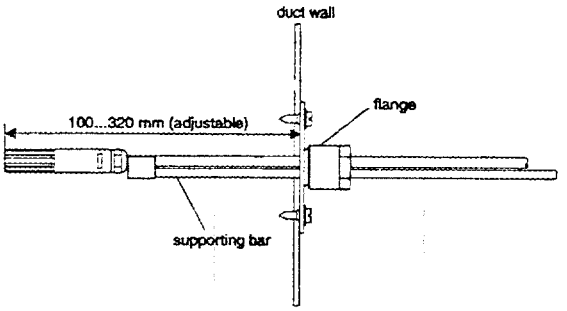
Specifications subject to change without further notice.
HUMICAP® is a registered trademark of Vaisala

HMP 233

Dimensions in mm



Installation kit for duct mounting. Dimensions in mm.



VAISALA
SENSOR SYSTEMS

Technology for Demanding Applications

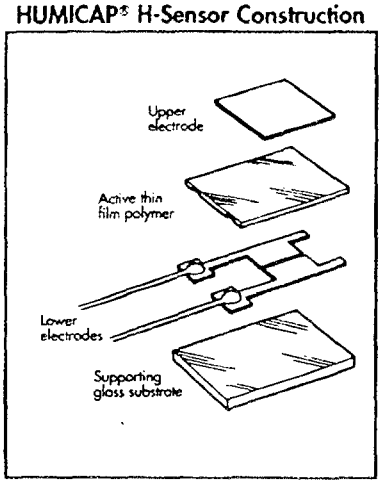
HUMICAP® H-Sensor: Proven High-Accuracy Performance

Introduced in 1973 as the world's first thin-film capacitive solid-state RH sensor, the HUMICAP® is well known for its high accuracy and long term stability over a broad environmental range. All Vaisala RH products, except for our calibration-free instruments which are discussed next, incorporate the HUMICAP® H-sensor. Features include:

- Complete measurement range of 0 to 100% RH
- Broad temperature range: -40°C to +160°C (-40°F to +320°F)
- Unmatched accuracy (including non-repeatability, hysteresis and calibration uncertainty): ±1% (0 to 90% RH) ±2 % (90 to 100% RH)
- Excellent long term stability: better than 0.5% RH/year in normal air conditions
- Negligible hysteresis: less than 0.5% RH (over an excursion of 20 to 90 to 20%)
- Exceptional chemical resistance

The HUMICAP® is manufactured using state-of-the-art processing and advanced thin-film techniques to assure excellent quality and performance.

HUMICAP® H-Sensor Construction

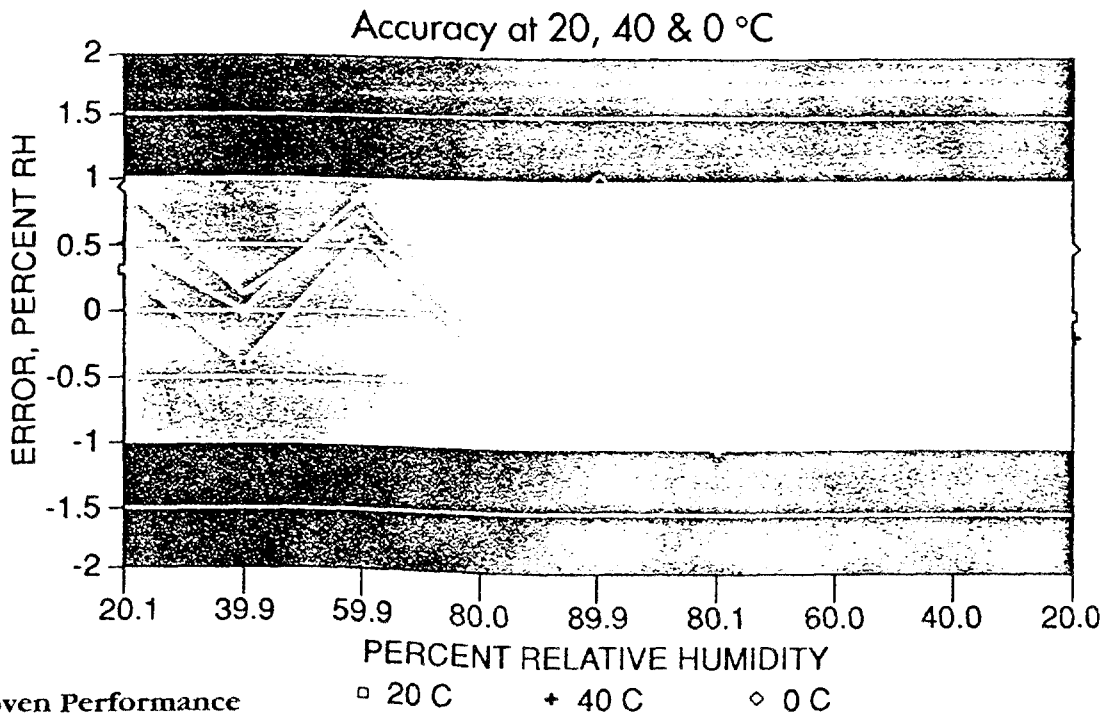


INTERCAP® Calibration-Free, Totally Interchangeable RH Sensor

Vaisala's most recent technological advancement in RH measurement is the revolutionary INTERCAP® sensor. Precise laser-trimming technology ensures that each INTERCAP® sensor is totally interchangeable with another. This means that sensors can be replaced, in the field, and you can be back in operation without calibrating the instrument. The INTERCAP® sensor is featured in Vaisala's calibration-free RH transmitters for HVAC/EMCS applications, and in the HUMITTER® a popular RH module used in a variety of custom applications.

Humidity Instruments For All Applications

Vaisala manufactures a full line of instruments to meet all of your measurement needs. From low-cost individual sensors to hand held monitors, to high-accuracy transmitters, Vaisala products are relied on for their superior design, quality and performance in all Industrial Process, HVAC/EMCS, R&D and Custom applications. The next four pages will provide you with an overview of our instruments and their applications, followed by individual data sheets for more specific information. To learn more about our products and how they will best meet your requirements, please call (617) 933-4500.



Proven Performance

Recently Vaisala undertook the testing of its standard products at the National Institute of Standards & Technology (formerly N.B.S.). The above graph illustrates measurements accuracy of ±1% RH (including calibration uncertainty, non-repeatability, hysteresis and temperature dependence) at three temperatures, 20 °C, 40 °C and 0 °C. The results of this testing document the exceptional measurement accuracy attainable with Vaisala's products.

THE EYEGAZE™ DEVELOPMENT SYSTEM

A TOOL FOR HUMAN FACTORS APPLICATIONS

LC Technologies, Inc.

4415 Glenn Rose Street
Fairfax, Virginia 22032

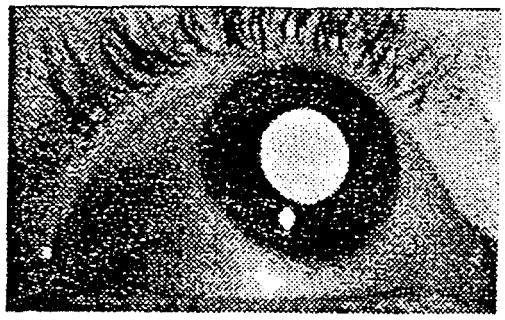
(800) 733-5284
(703) 425-7509
FAX: (703) 323-4782

EYEGAZE SYSTEM DESCRIPTION

There are many situations when it is desirable to know where a person is looking. The Eyegaze System is a tool for measuring, recording, playing back, and analyzing what a person is doing with his eyes. A video camera located below the computer screen, or below the work space if the computer monitor is not used, continually observes the subject's eye, and specialized image-processing software determines the eye orientation and projects the subject's gaze point.

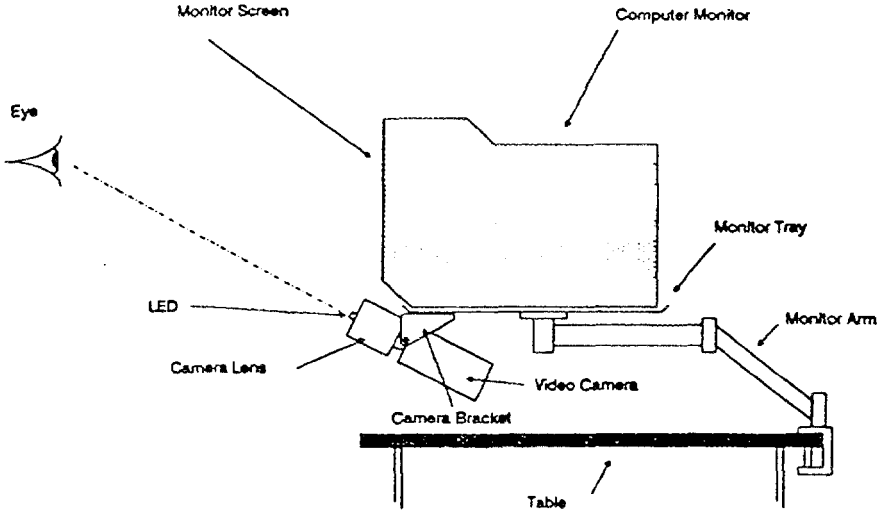
The Eyegaze System uses the Pupil-Center/Corneal-Reflection method to determine the eye's gaze direction. A small, low power, infrared light emitting diode (LED) located at the center of the camera lens illuminates the eye. The LED generates the corneal reflection and causes the bright pupil effect which enhances the camera's image of the pupil. Trigonometric calculations project the person's gaze point based on the positions of the pupil center and the corneal reflection within the video image.

No attachments to the head are required.



Bright Pupil Effect & Corneal Reflection

DEVELOPMENT SYSTEM HARDWARE



Camera Configuration (without HeadTracker)

The Eyegaze Development System is intended for use as a general tool for human factors applications. The hardware includes a) an infrared video camera, b) an infrared light source, c) an adjustable monitor support arm and tray with an adjustable camera bracket attached to the bottom of the tray, d) a frame-grabber board to digitize the camera image, and e) an Intel 80386 based DOS compatible personal computer with an 80387 math co-processor that performs the image processing and gazepoint projection. The computer system includes a 40 megabyte hard disk and a VGA color monitor.

DEVELOPMENT SYSTEM SOFTWARE

The Eyegaze software package is organized such that a developer can easily create custom analysis programs for human factors applications. These "applications" programs may run either on the Eyegaze System computer itself or on a host computer which treats the Eyegaze Computer as a peripheral device. LC Technologies supplies a set of user-linkable libraries that execute the fundamental "eyetracking" functions and perform a variety of data storage and analysis functions for use in the "applications" programs.

Calibration Procedure

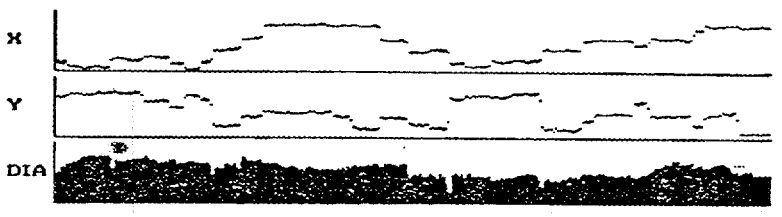
Prior to operating the eyetracking and applications functions, the Eyegaze System must learn several physiological properties of a person's eye in order to be able to project his gaze point accurately. It must know the radius of curvature of the eye's cornea and the angular offset between the eye's optic and focal axes. The system learns these parameters by performing a calibration procedure where the subject sequentially looks at a series of calibration dots displayed at different locations on the screen. The procedure takes about 15 seconds and need not be repeated for a given person on different work sessions. The calibration results are passed to the eyetracking functions for purposes of future gazepoint projection and are also placed in disk files for access by the applications programs if desired. After completion of the calibration procedure, the Calibration Program is released from the computer memory to free up space for the applications programs.

Eyetracking Software

The eyetracking functions constitute the fundamental software that computes the raw eyegaze data each 30th or 60th of a second in synchronization with either the frame or field rate of the video camera. The 30 or 60 Hz sampling rate is selected by the applications program. To allow the eyetracking software to run concurrently with an applications program, the eyetracking software runs on an interrupt basis, receiving its interrupt from the camera's frame-grabber board and executing as a stay-resident interrupt service routine. At each iteration, the eyetracking software places the measured eyegaze data into memory locations where they are readily available to the application program. The eyetracking software requires between 200K and 240K of memory and takes between 30% and 50% of the available computer time. The remainder of the CPU time is available for the user's application program.

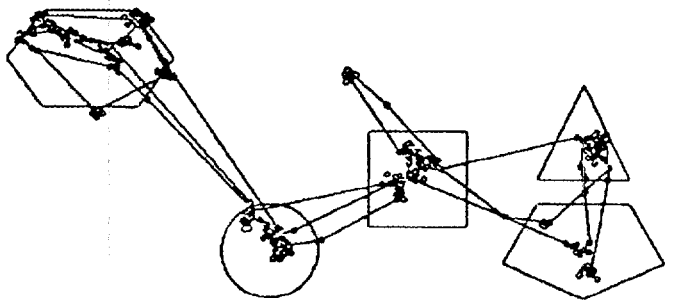
Applications Software

Eyegaze applications programs access the raw eyetracking data generated by the eyetracking functions and perform the recording, analysis, and display functions desired by the developer. The Eyegaze Development System includes the source code for several complete applications programs that may be used as is, modified to meet custom needs, or used as references for preparing other Eyegaze applications programs. The applications programs are written in the C programming language. The following are brief descriptions of some of the applications programs.



The simplest application program is the Gaze Demonstration program. It simply places a cursor on an otherwise blank computer screen at the person's projected gaze point.

The Trace program displays a user-prepared image on the computer monitor and passively collects the eyegaze activity as a subject observes the screen. The eyegaze history is stored in a disk file. After the data collection phase, the eyegaze history is played back as a trace superimposed on the original screen image. The trace may be paused, reversed and replayed at different speeds. Different eyegaze variables, such as the pupil diameter or the x and y coordinates of the gazepoint, may be plotted out as a function of time.



Eyegaze History Recorded by Trace Program

ISCAN®

HEADHUNTER™

HEAD & EYE SLAVED POINTING SYSTEM

REAL-TIME HEAD & EYE POSITION MEASUREMENT & COMPUTATION OF LINE OF SIGHT

The ISCAN HEADHUNTER™ Head and Eye Slaved Pointing System consists of helmet mounted sensors and processing electronics that track human eye and head position and compute the operator's line of sight vector over a 360 degree azimuth and 180 degree elevation range. The HEADHUNTER™ may be used to rapidly, accurately and naturally designate targets or areas of interest within the field of view just by looking at them. Real-time head and eye position data provide for quantitative assessment of a subject's visual scan path while performing specific tasks in real world or simulated environments. Eye and head position analysis software computes the intersection of the line of sight with fixed targets in real time. A cursor may be displayed on surrounding video screens at the subject's look point for automatic console interaction.

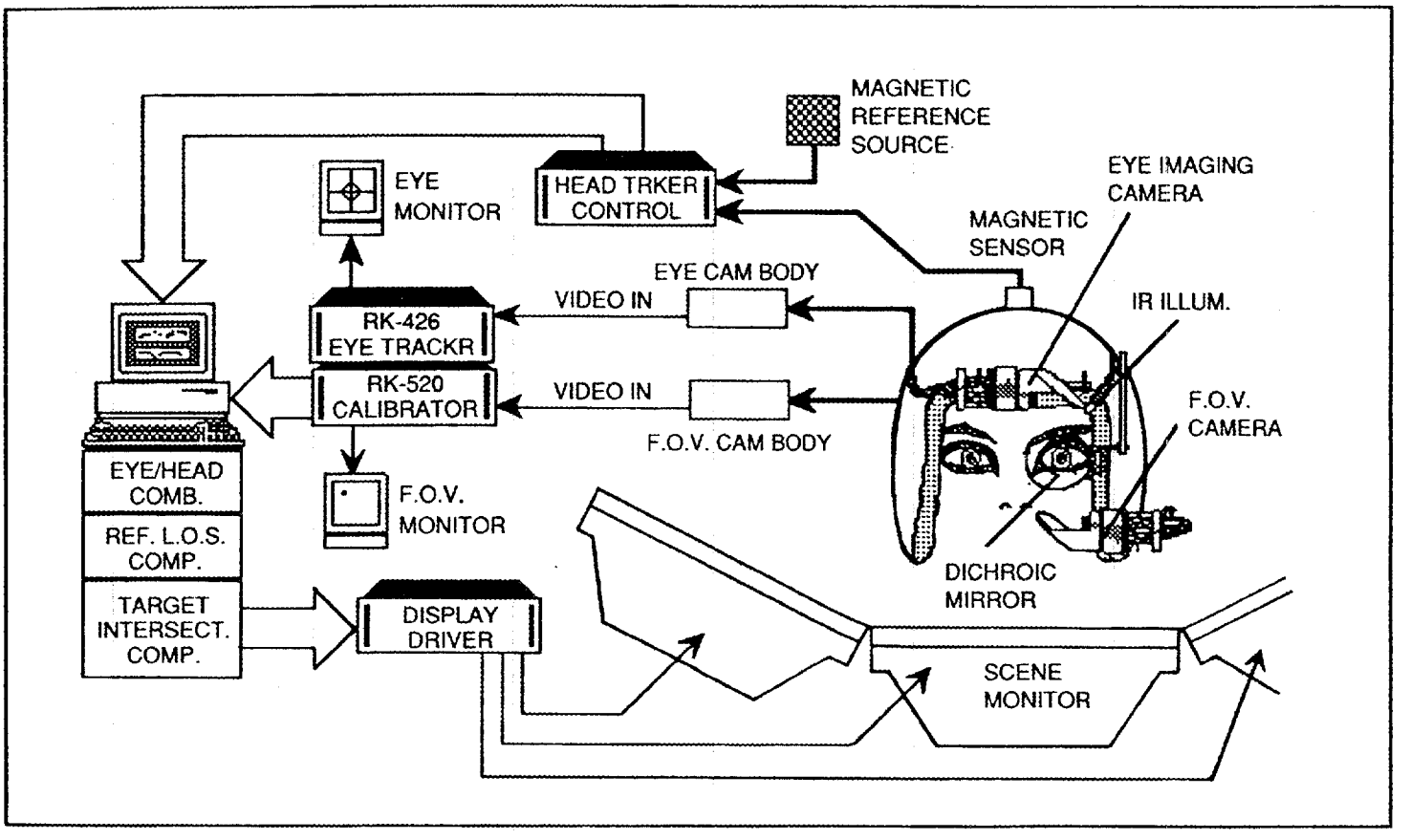
The HEADHUNTER™ is the first integrated head and eye movement based control and analysis system which is low cost and works reliably with virtually any subject in any ambient light environment. Applications for the HEADHUNTER™ include:

- **Weapon Pointing**
- **Simulator Area of Interest Control**
- **Human Factors Evaluation**
- **Teleoperation**

ADVANCED MAN/MACHINE INTERFACE APPLICATIONS

The human eye is an ideal input device for advanced man/machine interface applications due to the inherent ability of the human oculomotor system to rapidly and precisely shift the vector of attention in response to visual stimuli.

The HEADHUNTER™ employs ISCAN's unique EVIL EYE™ helmet mounted eye tracking technology to non-invasively monitor



the position of the subject's eye with respect to a miniature imaging sensor mounted on the helmet. Eye position is computed at a 60 Hz rate and the eye's point of regard is determined to an accuracy of better than one degree of visual angle over a ±25 degree range. Also mounted on the helmet is a magnetic sensor which allows for the computation of x,y,z,az,el & roll of the subject's helmet with respect to a fixed reference frame. Helmet position data is also output at a 60 Hz rate and combined with the eye position data via real-time software. The software calculates, in reference frame coordinates, a combined head/eye line of sight. This data may be mapped to up to any of twenty-five user defined planar surfaces or visual displays within the subject's field of view. The subject's line of sight information may be stored in reference frame cartesian coordinates or in spherical coordinates based on a user-defined origin for simulator dome applications.

The standard HEADHUNTER™ system includes:

- ISCAN EVIL EYE™ Helmet Mounted Eye Tracking and Calibration System
- Helmet Mounted Magnetic Head Tracking System
- Helmet Mounted Subject Field of View Imaging System
- Real-time Line of Sight Computation Software
- Real-time Target Intersection Computation Software

Optional components include:

- PC Compatible 386 Computer System
- Video Displays & Multiple Video Display Control Unit for Real-time Subject Cursor Control
- Raw Eye Movement Analysis Software
- Fixation Analysis Software

HEADHUNTER™
HEAD & EYE SLAVED POINTING SYSTEM

TECHNICAL SPECIFICATIONS

EVIL EYE™ HELMET MOUNTED EYE TRACKING SYSTEM

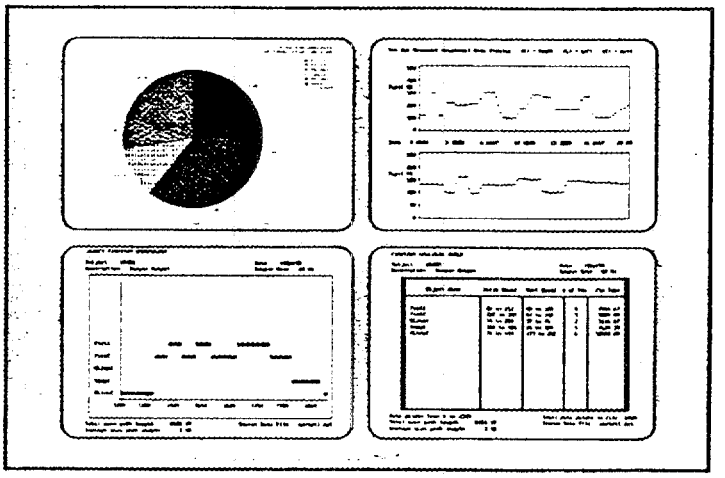
Monocular Eye Imaging Assembly:
- Sensor Head: 17.5mm D x 52.9mm L
  - Resolution: 744H x 256/308V pix, 60/50 Hz
- Dichroic Mirror: 2" Diam. Circle
  - Transmission: 70%, 400-700nm
  - Reflection: 750-1200nm
- Illuminator: Solid State IR LED, 880nm
  - Irradiance at Eye: 1.2mW/sq.cm., typical

RK-426 Pupil/Corneal Refl. Tracker:
- General: 19" x 16" x 5.25", 12 lbs.
- Power: 115/230 VAC, 60/50 Hz, 10W
- Eye Video I/O: NTSC/PAL
- Data Outputs (Digital TTL) (60/50 Hz):
  - Pupil Horiz. & Vert. Position
  - Corneal Refl. Horiz. & Vert. Position

RK-520 Autocalibration System:
- General: 19" x 16" x 5.25", 12 lbs.
- Power: 115/230 VAC, 60/50 Hz, 15W
- Scene Video I/O: NTSC/PAL
- Data Outputs (Digital TTL) (60/50 Hz):
  - Point of Regard Horiz. Pos. (9 Bits)
  - Point of Regard Vert. Pos. (8/9 Bits)
- Resolution: <1.0 deg. of visual angle, typical

HEAD TRACKING COMPONENT

Magnetic Source, Sensor & Electronics:
- Electronics: 11.6" x 12.5" x 5.0", 7.5 lbs.
- Power: 115 VAC, 60 Hz, 60W
- Resolution: 0.023", 0.1 deg., 60 Hz, typical
- Coverage: Sensor within 30" of source



SYSTEM SOFTWARE

Line of Sight Computation Software:
- Eye Data Inputs (Parallel) (60 Hz):
  - Horiz. & Vert. P.O.R. from RK-520
- Head Data Inputs (Parallel) (60 Hz):
  - X,Y,Z,AZ,EL & Roll from head tracker
- Outputs: X,Y,Z,AZ & EL of L.O.S. Vector

Target Intersection Software:
- Inputs: Coordinates of L.O.S. Vector & Plane Boundaries (up to 25 surfaces)
- Outputs: Plane # & X,Y position of intersection in plane coordinates

Fixation Analysis Software:
- Inputs: Coordinates of L.O.S. Vector & Object Boundaries (up to 250 objects)
- Outputs (for each defined object):
  - # of Fixations; Average Fix. Duration; Total Fixation Time; % of Total Time; Fixation Chronology; Tabular, Bar and Pie Chart Graphics

For further information about ISCAN Eye Movement Monitoring Systems, or other ISCAN products, please contact:

ISCAN®
125 Cambridgepark Drive
P.O. Box 2076
Cambridge, MA 02238 USA
Tel: 617-868-5353 Fax: 617-868-9231

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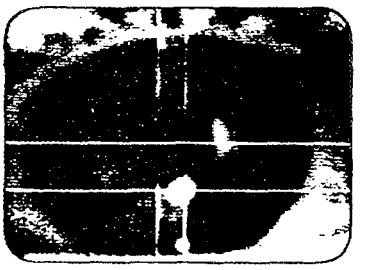
ISCAN® EVIL EYE™

EYE SLAVED TARGET ACQUISITION SYSTEM

The ISCAN EVIL EYE™ Eye Slaved Target Acquisition System is an advanced man/machine interface that allows an operator to rapidly, accurately and naturally designate areas of interest or targets within the field of view. Just by looking at the target of interest, the operator may designate or control various machine functions. The EVIL EYE™ is the first eye movement based control system which works reliably in "real world" environments and with virtually any human operator. Applications of the EVIL EYE™ include:

- Rapid Weapons Pointing
- Surveillance Camera Guidance
- Aircraft Cockpit Control
- Automatic Tracking Initialization
- Human Factors Evaluation



Output of RK-426 Pupil/Corneal Reflection Tracking System.

Air-to-Ground Target Acquired using RK-520 Autocalibrator.

General Information

The human eye is an ideal input device for advanced man/machine interface applications due to the inherent ability of the human occulomotor system to rapidly and precisely shift the vector of attention in response to visual stimuli.

The ISCAN EVIL EYE™ system employs a non-invasive, video based eye tracking technique to monitor the position of the subject's eye with respect to an imaging sensor. The lightweight eye imaging sensor and associated optics may be completely mounted beneath a flight helmet visor or embedded into a fixed sighting system. The system operates at a sample rate of 60 Hz and the subject's visual point of regard may be determined with an accuracy of better than 1 degree over a ±15 to ±20 degree visual angle range.

Data corresponding to the subject's point of regard may be used to control various system functions or designate targets of interest on a helmet-mounted or external display. The EVIL EYE™ automatically compensates for slippage between the subject's head and the eye imaging assembly, allowing for normal head movements while in operation. Eyeglasses or contact lenses do not affect system performance.

SYSTEM COMPONENTS

The components of the EVIL EYE™ are the Eye Imaging System, the RK-426 Pupil/Corneal Reflection Tracking System and an Autocalibration System.

ISCAN Eye Imaging System

The Eye Imaging System consists of the lightweight imaging and illumination components required to obtain high quality eye images. These components may be helmet mounted or embedded into a fixed sighting station. The system includes a miniature two dimensional image sensor with optics, a solid state infrared illuminator, a dichroic mirror and mechanical assembly. The dichroic mirror is transparent to the operator. ISCAN can custom mount an eye imaging assembly to a variety of flight, communication and combat helmets.

ISCAN RK-426 Pupil/Corneal Reflection Tracking System

The RK-426 is a real time, digital image processor that simultaneously tracks the center of a subject's pupil and a reflection off of the subject's cornea from the infrared illuminator. By tracking both the pupil and corneal reflection, data corresponding to eye movements can be separated from data generated by movements of the subject's head within the camera's field of view. The RK-426 is a dark pupil tracking system that operates in high illumination environments with virtually any subject using simple optical components. The RK-426 offers ISCAN's unsurpassed eye tracking performance and minimal operator adjustments because it is able to automatically discriminate the pupil and corneal reflection from shadows or highlights which are invariably present in eye images. Computation of the pupil and corneal reflection center positions is not affected by changes in pupil size or if the corneal reflection moves to the edges of the pupil area.

ISCAN Autocalibration System

The standard RK-520 Autocalibration System is a computational unit that accurately calculates the subject's point of gaze with respect to a scene being viewed using the raw eye position data generated by the RK-426. Point of gaze data may be output as a cursor on the operator's display as well as in parallel digital format for computer interface. The RK-520 features a flexible five point calibration procedure which is simple to operate and can be completed in a few seconds. After the calibration procedure, the RK-520 automatically translates the raw eye data from the RK-426 to point of regard coordinates.

The system also includes a manual joystick and on-screen numerical data display for delimiting fixed scene elements within the field of view, such as control panel buttons or switches, which can then be selected by sight. ISCAN can custom design appropriate calibration hardware and software for particular system requirements.

EVIL EYE™

TECHNICAL SPECIFICATIONS

EYE IMAGING SYSTEM

Monocular Imaging Assembly:

Weight:	4 ounces
Construction:	1/16th Anodized Aluminum

Imaging Sensor Head:

Size:	17.5mm D×52.9mm L
Spatial Resolution:	511H×256V pixels
Temporal Resolution:	60 Hz

Dichroic Mirror:

Size:	2"×2" Square w/rounded edge
Transmission:	70%, 400-700nm
Reflection:	750-1200nm

Illuminator:

Solid State Infrared LED
(No cooling required)

Size:	1.25"×0.5" D Cylinder
Wavelength:	880nm
Irradiance at Eye:	1.2mW/sq.cm., typical

EYE TRACKING ELECTRONICS

RK-426 Pupil/Corneal Reflection Tracker:

Power:	115/230 VAC, 60/50 Hz, 20W
Eye Video Input:	EIA Standard RS-170 or PAL
Eye Video Output:	Same as above.

Data Outputs (Digital TTL):
- Pupil Horizontal Position (9 Bits)
- Pupil Vertical Position (8 Bits)
- Corneal Refl. Horizontal Position (9 Bits)
- Corneal Refl. Vertical Position (8 Bits)

RK-520 Autocalibration System:

Power:	115/230 VAC, 60/50 Hz, 15W
Scene Video Input:	EIA Standard RS-170 or PAL
Scene Video Output:	Same as above.

Data Outputs (Digital TTL):
- Point of Regard Horizontal Position (9 Bits)
- Point of Regard Vertical Position (8 Bits)
- Data Strobe

For further information about ISCAN Eye Movement Monitoring Systems, ISCAN Automatic Video Tracking Systems or the ISCAN Optimouse™ Remote Cursor Control System, please contact:

ISCAN®

125 Cambridgepark Drive
P.O. Box 2076
Cambridge, MA 02238
USA

Telephone: 617-868-5353 Fax: 617-868-9231

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APPENDIX O: TECHNICAL DATA FROM THE VIDEO DIGITIZATION SYSTEM VENDOR

Scientific Atlanta

MPEG Compressed Video Digital Storage and Retrieval

Scientific Atlanta

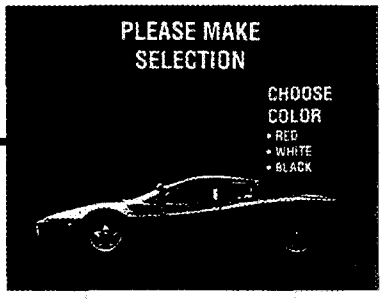
Ad Insertion Digital storage and retrieval provides a high quality, efficient means for automating the ad insertion process for broadcasters and cable system operators. Once an ad is compressed, it can be stored in a library of current spots at a headend. The ad insertion controller retrieves the appropriate ad and routes a digital copy of it to a decoder associated with a video router. The ad is decoded and inserted into the appropriate channel in time slots prompted by cue tones from the programmer. Digital ad insertion can accommodate late deadlines and last minute changes, be customized to demographic characteristics, and provide accurate tracking of avails and verifications of ads that have run.

Movie On Demand With DSR, hundreds or even thousands of movies can be compressed and stored in a digital movie library. This single DSR system will support growth in the number of access channels as channels dedicated to movies are expanded. Various staging techniques allow several or even hundreds of movies to be played from the digital movie library simultaneously. You can even have the same movie play on several channels at once, at different start times or "on demand" by a pay-per-view customer. In two-way cable systems, a version of "Stop," "Pause," "Reverse" and "Forward" VCR-type features can be supported.

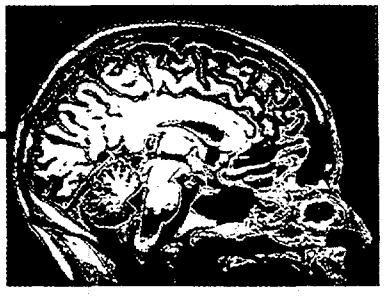
Video Training Training built around active video improves the learning process by providing the audience with a visual experience to supplement words and charts. Digitally stored material fully supports interactive training sessions where participants proceed at their own speed through the material. The high resolution graphics of the DSR encoder and decoders makes possible the use of complex images, fast motion and enlarged subjects, providing a new dimension to video training. Digital storage also enables quick capture of new material and interactive capabilities.

Video Previews and Distribution Programmers, production studios, home shopping networks and program guide suppliers desire automated systems to feature and promote their products. Cross-channel promotions and PPV ads can employ DSR systems to store, retrieve and display video clips.

Scientific-Atlanta technology can also be used to distribute videos digitally, display previews to customers, then produce first generation copies of video material, on demand,at remote locations. To whet the appetite of a potential viewer, a high quality, visually appealing image must be displayed, making Scientific-Atlanta's DSR equipment the perfect solution.



Information Kiosks Trade shows, retail stores and auto dealerships sometimes use interactive information displays called "kiosks." Customers interact with the kiosk using a touch screen or some other method to select video data files for playback to receive a variety of product or educational information. In some cases, items may be directly ordered from a two-way kiosk, adding significantly to customer convenience and order efficiency. Scientific-Atlanta digital storage and retrieval products provide the fast interactions and high resolution video desired by retailers to provide the "feel" of the product as if it were being seen live.



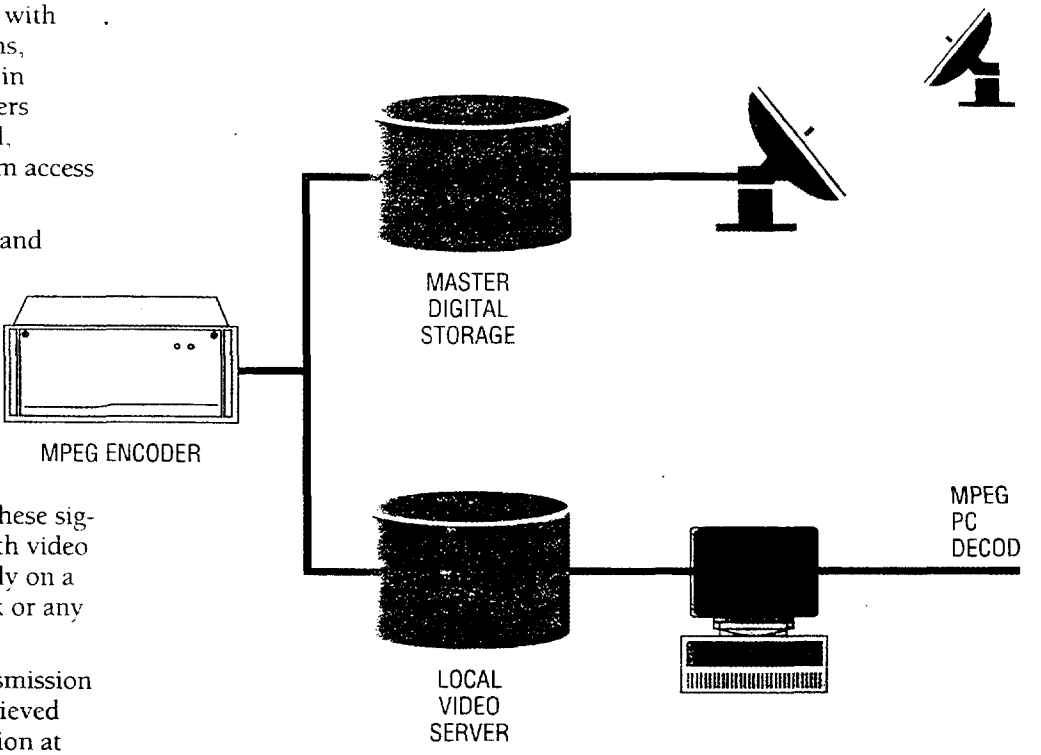
Multimedia Multimedia over broadband cable is a vision being pursued vigorously by members of the computer, entertainment and communications industries. Scientific-Atlanta's DSR products will play a key role in making this vision a reality by providing fast access, interactive video, along with CD-quality audio, that meets the highest resolution standards.

The Digital Advantage

Digital — due to the powerful benefits it offers, digital has found its way into virtually every aspect of our lives and businesses. Now, with digital video technological breakthroughs, storing and retrieving program material in digital form can be performed easily. Users can now realize the advantages of digital, including source-like quality, fast random access retrieval and data transport efficiencies.

With Scientific-Atlanta's Digital Storage and Retrieval System, analog program material is digitized and compressed in real time by an MPEG encoder. MPEG (Moving Pictures Experts Group) is now the de facto U.S. and internationally recognized standard for digital video compression. But, thanks to Scientific-Atlanta's DSR technology, you don't have to transmit these signals as soon as they are compressed. Both video and audio can be stored together digitally on a hard disk drive, digital tape, optical disk or any other digital storage device.

Using standard computer and data transmission technologies, the digital files can be retrieved and directed to the appropriate destination at the exact time desired. The original video and audio is reproduced with digital precision. This can happen minutes, days, or even months from the time the files are received and stored. It is possible to establish large distributed libraries of digitally compressed material such as ads, movies or training material. And, the digitally stored material can be replayed as often as required — hundreds or thousands of times, without reduction in quality.

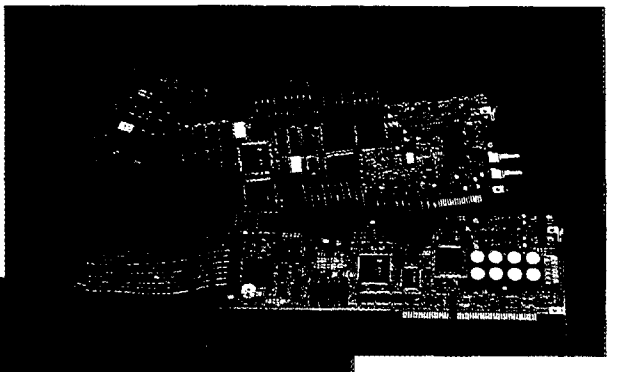


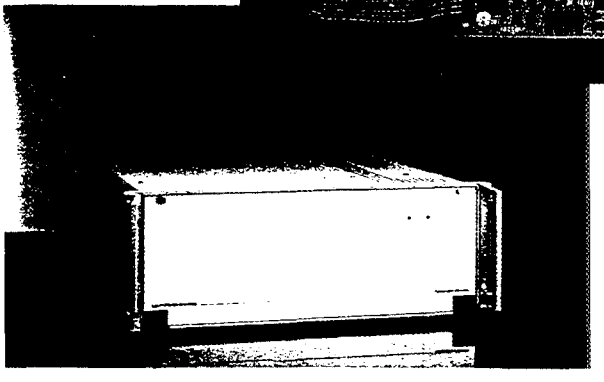
Components of the Video Storage and Retrieval System

The digital storage and retrieval (DSR) system is designed to be modular and flexible, allowing it to be used in a wide variety of applications. There are five basic components: the MPEG encoder and four PC boards.

The DSR Encoder digitally compresses the analog video and audio source material, using the MPEG standard, in real time. This process includes converting the signals and storing them as a computer data file. Source video and audio input is received generally from a VTR and output in digital form to a PC, which controls both the encoder and the VTR.

PC Decoder Boards with SCSI-2 Interface to Hard Disk





Real-time MPEG Encoder

The PC Record Board is located within the PC that is interfaced to the encoder. This board formats the MPEG compressed video and audio from the encoder into a single bit stream suitable for direct storage on standard digital devices. The record board interfaces with a digital storage device via high-speed SCSI-2 technology to provide real-time digital capture of the compressed material. The data file is passed to either a local video server or a PC Uplink Board for distribution over satellite.

The PC Uplink and PC Transport Boards interface with the Scientific-Atlanta digital satellite transmission system to move the compressed video data files and other control information between encoders, libraries and decoders. Compressed data files can be transported via dial-up modems, T1 links, fiber or microwave circuits as well.

One or more PC Decoders, using an ISA bus, are installed in a PC where they receive the compressed video data files in either real time or from a digital storage device. The decoders convert the digital data stream back into NTSC video and stereo audio components for transmission through the analog cable plant or for display on a TV or monitor.

Specifications

Encoder (Model D5200)

Video encoding: single channel MPEG-1; I, B and P frames

Resolution: meets CCIR-601

Horizontal resolution: 704, 544, 480 and 352 pixels (user controlled)

Vertical resolution: 480 lines

Inputs accepted: NTSC or component video (CCIR-656)

Audio encoding: two-channel MPEG Layer II

Dimensions: 7.0 in. H x 13.2 in. D x 19 in. W (EIA rack compatible)

Digital storage interface: PC Record Board Model D5310 (SCSI-2 compatible)

Decoder (Model D5100)

Digital input: via onboard SCSI-2 controller

Video decoding: MPEG-1; all formats, rates and resolutions supported by Model D5200 Encoder

Video output: NTSC

Video connector: BNC

Audio output/audio connector: two channels (one stereo pair) via quick-connect barrier strip

Frequency response: ±25 dB at 20 Hz to 20 kHz

Total harmonic distortion: <.25% at 20 Hz to 20 kHz

Size: set of two full-length PC/AT (ISA interface)

Capacity: one to eight decoder card sets per PC (depending on chassis size and storage configuration)

Minimum PC requirements: 25 MHz 386DX with industrial cooling

Digital Storage

Minimum hard disk: SCSI-2 with sustained data transfer rate >2 MB per second and full stroke seek time <40 ms

Expandable to meet customer storage requirements using various media:

- hard disk
- digital tape
- optical read/write

Software: wide range of software drivers provided to permit customization of applications. The high level software interface allows boards to run autonomously, leaving the PC free to run other tasks.

A Reputation for Excellence and Innovation

Scientific-Atlanta, Inc., is a world leader in cable television and satellite-based analog and digital products and systems. The company is also a key supplier of high technology instrumentation for industrial, telecommunications and government applications.

Founded in 1951, Scientific-Atlanta began as a small manufacturer of electronic test equipment for antennas used in the space and defense industries. Today, the company is a global technology leader with a reputation for excellence and innovation.

Headquartered in Atlanta, Georgia, Scientific-Atlanta has offices throughout the United States with seven international subsidiaries and representatives located in 75 countries. Throughout its history the company has invested in core technologies, including:

- Digital and analog processing and transmission of video and audio
- Digital video compression
- Secure transmission with scrambling and encryption
- Network management and control
- Fiber optics
- Satellite communications
- Broadband cable communications
- Antenna design and measurements
- Telemetry and tracking of air and space vehicles
- Signal processing and analysis

Our strong commitment to technological innovation has resulted in the development of new businesses, products and systems. At Scientific-Atlanta, we are dedicated to adapting technology to meet the special needs of our customers.

For more information contact:

Scientific-Atlanta, Inc.
One Technology Parkway, South
Norcross, GA 30092
Tel: 800-722-2009 (U.S. only)
404-903-5300
Fax: 404-903-5080

Scientific Atlanta

APPENDIX P: TECHNICAL DATA FROM PERSONAL AND LAPTOP COMPUTER VENDORS

International Business Machines
Northgate
System-DFI
Austin Computer
Ultra

486 DX2 66
17" Austi → 8-2687.00
2mb VRAM 8 → 16-3077.00

Note Book
→ 2549.00

THETA SYSTEMS
SMARTLOG SYSTEM SELECTION

: 01/19/94 Time: 14:28:14

PART NUMBER	DESCRIPTION	PRICE
PS-6387-W91	486DX2/66 VESALB M-TOWERIBM VALUEPT; 8MB	3128.00
INSTALL SOFT	INSTALLATION WINDOWS 3.1, TCP/IP & VINES	27.50
MTR-800	MONITOR, SONY 17" COLOR MULTISCAN	1051.00
NCC-005	3COM TP ETHERLINK NETWORK CARD	230.00
	8mb RAM → (up to 64MB [3 slots])	
	1.44 Floppy Drv.	
	527 MB IDE 9NS HARD DISK	
	1 MB VRAM	
	SLOTS: 8 16 Bit & 1 VL-Bus; Avail. Bays 2-5.25" & 2-3.5" w/ & w/o Media Access	
	PORTS: SVGA, 2 Serial, Parallel, Kybd & Mouse	
	PART UPGRADEABLE	
	200WATT; 101 KEYBD; OS/2, Mouse	
	TOTAL SYSTEM COST:	4436.50

USING THIS SYSTEM DOES NOT PLACE AN AVID ORDER

This system is designed to assist in placing an order for a computer system through AVID.

Please see an authorized AVID requestor for assistance with placing an AVID order.

Questions regarding this system or the PCS catalog may be refered to Theta Systems at 482-2626.

THETA SYSTEMS
SMARTLOG SYSTEM SELECTION

)ate: 01/19/94 Time: 14:24:46

COLOR $4381.00

LN	PART NUMBER	DESCRIPTION	PRICE
1	PS-9552-308	IBM THINKPAD 720 486SLC2/50MHZ MONO NOTE	3102.00
2	APA-05	CARRYING CASE FOR ALL NOTEBOOKS	56.00
3	PTA-02	BATTERY PACK FOR THINK PADS 720 & 700	167.00
4	PTA-10	CAR ADAPTER FOR IBM THINK PAD 720 & 700.	156.00
5	PTRAM-021	RAM UPGRADE 8MB FOR IBM THINK PAD 720	506.00
		4mb RAM ~~[illegible]~~ 160MB Removable HD 1.44 MB Floppy Disk 64 Key - Kybd w/ integrated trackpoint 9.5" STN LCD 16 Bit VGA Display 64 Gray Scale Ports: VGA, SERIAL, PARALLEL, KYBD/MOUSE, MC BUS Expan. 2 PCMCIA TYPE II or 1 TYPE III SLOTS DOS 5.02; Batt; AC Adapt 6.5lbs	
		TOTAL SYSTEM COST:	3987.00

USING THIS SYSTEM DOES NOT PLACE AN AVID ORDER

This system is designed to assist in placing an order for a computer system through AVID.

Please see an authorized AVID requestor for assistance with placing an AVID order.

Questions regarding this system or the PCS catalog may be refered to Theta Systems at 482-2626.

THETA SYSTEMS
SMARTLOG SYSTEM SELECTION

: 01/19/94 Time: 14:31:04

PART NUMBER	DESCRIPTION	PRICE
NV462-ZXP	VESA 486DX2/66 TOWER NORTHGATE. 4MB RAM	1993.00
NSD-06	245MB SCSI HARD DISK, SEAGATE 12MS 3.5"	333.00
MTR-700	NEC 3FGE 15" NON-INTERLACED; FLAT SCREEN	741.00
NCC-005	3COM TP ETHERLINK NETWORK CARD	230.00
RAM-080	RAM UPGRADE TO 16MB	863.00
	4mb on NV462-ZXP; 3.5"/5.25" Floppy Drils HARD DRIVE OPTIONAL Local Bus Video (Requires Local Bus Vid Card) 101WI KYBD; DOS, WIN, Mouse RAM EXP to 32mB 64K Cache 1-Parallel, 2-Serial	
	TOTAL SYSTEM COST:	4160.00

USING THIS SYSTEM DOES NOT PLACE AN AVID ORDER

This system is designed to assist in placing an order for a computer system through AVID.

Please see an authorized AVID requestor for assistance with placing an AVID order.

Questions regarding this system or the PCS catalog may be refered to Theta Systems at 482-2626.

THETA SYSTEMS
SMARTLOG SYSTEM SELECTION

Date: 01/19/94 Time: 14:21:45

LN	PART NUMBER	DESCRIPTION Color @$3789.00	PRICE
1	NZP-M01	486DX-25MHZ MONOCHROME NORTHGATE PORT	2295.00
2	NZPA-02	BATTERY NIMH FOR NORTHGATE ZXP PORTABLES	117.00
3	NZPA-03	CAR ADAPTER FOR NORTHGATE ZXP PORTABLES.	75.00
		8mb RAM (expand to 16Mb)	
		1.44Mb Floppy	
		120Mb Hard Drive	
		Parallel, Serial 9 pin	
		PS/2 Mouse,	
		Monitor & Docking Station Connector Ports	
		86 Key - Kybd ; DOS ; Windows ; TRACK BALL	
		AC ADAPTER/CHARGER	
		NiMH BATTERY ; Carry Case	
		8.5"D 11"W 1.8"H 6.8 lb.	
		TOTAL SYSTEM COST:	2487.00

USING THIS SYSTEM DOES NOT PLACE AN AVID ORDER

This system is designed to assist in placing an order for a computer system through AVID.

Please see an authorized AVID requestor for assistance with placing an AVID order.

Questions regarding this system or the PCS catalog may be refered to Theta Systems at 482-2626.

HAL 458

O-A-K R-I-D-G-E C-O-M-P-U-T-E-R S-Y-S-T-E-M-S

QUOTE FOR: FRANK BAIRD

FILE: DFI486FB
DATE: 1/21/94

S-Y-S-T-E-M -- DFI 486DX2/66Mhz UPGRADEABLE SYSTEM

* STANDARD FEATURES -

- o 80486DX2/66 Intel microprocessor
- o Zero wait state
- o 8MB RAM, upgradable to 32MB
- o 128k static RAM cache
- o 1.44 MB 3.5" Toshiba floppy drive
- o Six 16-bit expansion slots
- o Two 8-bit expansion slots
- o Small foot Desktop case
- o MS-DOS 6.2
- o One-year Manufacturers parts and labor warranty
- o 101 key enhanced keyboard
- o 200 watt power supply
- o Two serial 550 UART, one parallel and one game ports

SYSTEM_INCLUDES:

* 245MB Maxtor 7245A, 15ms. hard drive
* Diamond Speedstar Pro w/1MB
* Samsung Syncmaster 3n 1024x768NI .28dot

486/66 SYSTEM PRICE ----------> Price $ 2142.00

OPTION:

- Local Bus system available starting at only an additional $200

Thanks you,

Tom Kiser

--- Quote good for 30 days ---

QUOTE

Austin Computer Corporation
10300 Metric Blvd.
Austin, Texas 78758

Terms:

DELIVERY 2 WEEKS
NET 30 (1%, 20 DAYS)
SMALL BUSINESS
F.O.B. DESTINATION
FED ID # 74-2475679

Pages: 2 (No cover page)

Date: 1/20/94

To: Mr. Frank Barickman US DOE OAK RIDGE TN
Phone :
Fax : 615 574 7860

From: Mark Moyer Federal Account Representative
Phone : 800-833-4472 Ext 5229
Fax : 512-339-3558

	Part No.	Descriptions	Unit	Total
1	4D5000	486 DX2-66, 8 MB RAM, 3 IN 1 COMBO NIC	$2,687	$2,687
		17" Color NI .28 SVGA Monitor, 340 mb IDE		
		Included: Intel Processor		
		2 year warranty (Year 1 is On-Site)		
		MS DOS 6.2, Windows 3.1		
		2 button MS Compatible mouse		
		256 k Cache		
		Dual 1.44/1.2 mb Floppy drives		
		2 serial and 1 parallel ports		
		101 Enhanced Keyboard		
		1 mb VESA local bus video		
		*Add $390 to upgrade to 16 mb RAM		390

** We use only INTEL Processors **

Thank you

	Options:			
1	NB0020	EXTERNAL BATTERY CHARGER	$45	$45
1	NB0016	AC ADAPTOR	$57	$57
1	NB0039	NYLON CARRY CASE	$29	$29
1	NB0018	NIMH SPARE BATTERY	$135	$135
1	NB0013	14.4 INTERNAL FAX/MODEM	$249	$249
1	NB0046	DOCKING STATION	$279	$279
1	NB0046	16 MB MEMORY UPGRADE	$520	$520
1	NB0051	PCMCIA SOUND CARD	$299	$299
1	KT0062	KIT: 15"NI SVGA MONITOR, DOCKING STA, MOUSE,	$599	$599
		101 KEYBOARD		
1	KT00043	545 MB HARD DRIVE UPGRADE	$100	$100

** We use only INTEL processors **

Thank you

Austin 486 Premier Systems

Available 11/15/93

High Performance Systems

Austin Performance Features

- Intel 486 Processors
- Integrated I/O
- Upgradeable to Pentium™ Processor Technology

Memory

- 8 MB Memory Standard
- Memory Expandable to 64 MB
- 128 KB Level 2 Cache

Hard Disk Drive Choices

- 250, 340, 425 and 525 MB IDE
- 340, 525 and 1050 MB SCSI-2

Optional CD-ROM Drive

- Sony 31A Double-Spin CD-ROM
- Toshiba 3401 Double-Spin, 200ms, SCSI CD-ROM

Floppy Drive

- 3.5" 1.44 MB Floppy Disk Drive
- Opt. 5.25" 1.2 MB Floppy Drive
- Opt. Dual 3.5" / 5.25" Floppy Dr.

Optional Tape Backup

- 250 MB QIC-80 Tape Backup
- 1.5 GB QIC-121 Tape Backup
- 2 GB DAT Tape Backup
- 4 GB DAT Tape Backup

Video Display Adapter

- 1 MB VL-Bus Accelerator
- Optional 2 MB Video Memory
- Resolutions up to 1280 x 1024
- Refresh Rates of Over 70 Hz

Standard Video Display

- 15" Super VGA Color Monitor
- 640 x 480, 800 x 600 and 1024 x 768 Non-Interlaced
- 0.28 mm Dot Pitch
- Optional 15" and 17" Non-Interlaced Monitors

Additional System Features

- Integrated Super I/O Chip
  - Two 16552 Serial Ports
  - EPP / ECP Parallel Port
  - IDE Hard Drive Interface
- Dual Floppy Controller
- EMS LIM 4.0 Support
- 101-key Keyboard with Separate Numeric and Cursor Keypads

Memory Architecture

- 32-bit Memory Architecture
- 36-bit, 72-pin SIMMs with Parity
- Uses 4, 8, 16 and 32 MB SIMMs
- 2 SIMM Sockets

BIOS

- AMI System and Keyboard BIOS
- Supports Multi-Sector Reads to Enhance Hard Drive Performance
- System and Video BIOS Shadowing
- Built-In Setup Program

Expansion Bus

- Seven 16-bit ISA Slots
- Two Slots with VL-Bus Extension
- One Slot Used for Video Card — All Other Slots Open

Desktop Chassis

- Small Footprint Desktop Chassis
  - 16" W x 16.5" D x 6.5" H
  - Three 5.25" HH Drive Bays
  - Two Internal 3.5" Drive Bays
  - Plated Steel
- 200 Watt Power Supply
- Approximately 25 lbs.

Environmental

- 50° F to 95° F (10° C to 35° C)
- 8 to 80% Non-Condensing Humidity

Regulatory

- FCC Class A
- Approved for Business Use Only
- FCC Class B Pending

EPA Energy Star

- Energy Saving Mode Reduces Power Consumption to Less Than 24 Watts
- Unique Power Control Circuitry Makes Any Monitor Energy Star Compliant
- Timed or Instant Access to Power Conservation Mode

Service and Support

- Two Years Parts Warranty
- First Year On-Site Service
- Second Year Depot Service
- Optional Warranty Extension
- Lifetime Toll Free Technical Support
- 30-Day Money-Back Guarantee

Call Toll Free: 1-800-752-1577

CANADA: 1-800-338-1565 • INTERNATIONAL: 512-339-3500 • FAX: 512-454-1357

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AN IPC COMPANY

10300 Metric Blvd. • Austin, Texas 78758

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CWM102093

AUSTIN 486 NOTEBOOK COMPUTERS

WINDOW SOURCES

SPECIFICATIONS

PROCESSOR OPTIONS	SX/25, DX/33, DX2/50, DX2/66
COLOR DISPLAY OPTION	TFT Color, 9.5" Diagonal, 640 x 480, 256 Colors
MONO DISPLAY OPTION	STN Mono, 9.5" Diagonal 640 x 480, 64 Shades of Gray
HDD OPTIONS	130/213/340MB
FDD	1.44MB, 3.5"
MEMORY OPTIONS	4MB, 8MB, 16MB, 20MB, 32MB
VIDEO CONTROLLER	32-bit Local Bus, Windows Accelerator, 512KB DRAM
PORTS	2 Serial, 1 Parallel External Color Monitor: 640 x 480 (256 Colors) 800 x 600 (256 Colors) 1024 x 768 (16Colors) Mouse/External Keyboard
PCMCIA SLOTS	2 Type II or 1 Type III
SOFTWARE	MS-Dos 6.0 Windows 3.1
POINTING DEVICE	Built in micro trackball (16mm diameter)
INTERNAL MODEM	2400k bps Modem with 9600 bps send/receive fax, 14.4k bps Modem with 9600 bps send/receive fax
DOCKING STATION	• 2 Full Size, 16-bit ISA Bus Slots • 2 Serial Ports, 1 Parallel Port • External VGA • 40 Watts Power Supply
OTHER OPTIONS	Docking station, external Battery charger, car adapter
WEIGHT	6.38 lbs (2.9kg) with battery
SIZE	11.1" x 8.58" x 2.00" (color) (282 x 218 x 51mm) 11.1" x 8.58" x 1.77" (mono) (282 x 282 x 45mm)
BATTERY TYPE	NiCad / NIMH
BATTERY LIFE	2 - 3 hours
POWER REQUIREMENTS	Voltage: 115 - 230Vac Frequency: 50 - 60Hz
ENVIRONMENTAL RANGE OPERATING	Temp: 50° to 95° F (10° to 35° C) Shock: 5G Vibration: 1.0G peak, 3-200 Hz
NON-OPERATING	Temp: -4° to 140° F (-20° to 60° C) Shock: 60G Vibration: 1.5G peak, 3-200 Hz

The Austin 486 notebook is architecturally the most advanced on the market. Designed to fully utilize the entire family of powerful Intel 486 processors, Austin's notebooks pack all the speed and power of the best desktop workstation into a compact, light weight case. A unique 32-bit local bus video, with a windows accelerator, creates the best notebook graphics performance available. Technologically advanced, high-performance, glass media, hard drives, in sizes up to 340MB, set the industry standard for storage. The color models feature an active-matrix display providing crisp, clear color while running a CRT and the LCD simultaneously for impressive portable presentations. The large 16mm trackball, located front and center, affords optimal comfort and control. Two PCMCIA slots support two type II devices or one type III device at any given time. This 6.38 lbs. powerhouse gets you up and running while you are up and running.

AC/ 6" x 3" x 1.5"
1.1 LBS.
* 1 YR WARRANTY P&L
* 30 MONEY BACK

CALL TOLL FREE: 1-800-752-1577

CANADA: 1-800-338-1565 • INTERNATIONAL: 512-339-3500 • FAX: 512-454-1357

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10300 Metric Boulevard • Austin, Texas 78758

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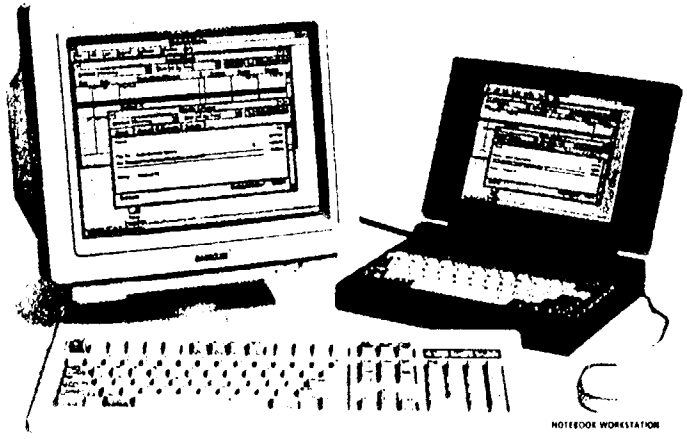
The Austin Notebook. Next to you, it's the most pov

(And right now, it's on SALE!*)

*SALE ENDS DEC. 31, 1993



It's no longer a question of whether or not to buy a notebook to go with your desktop workstation.

It's simply buying an Austin Notebook *instead* of a workstation.

You don't have to sacrifice work space to gain computing power. At just 11.1" x 8.58" x 2.0", an Austin Notebook Workstation takes up less space than a file folder and delivers outstanding performance.

Now when you leave your desk, you can take your workstation with you. No more transferring files to your portable. With an Austin Notebook, your portable *is* your workstation.

Ultimate Notebook Workstation

This is it. The fastest, most powerful notebook ever made, equipped with the largest notebook hard drive available. The Ultimate Notebook comes ready for desktop or portable performance with docking station, 15" high-resolution SVGA monitor, keyboard, and mouse. No portable can match it, no desktop model can beat it. And now, through the end of the year, you can get it at our special bundled sale price.

Ultimate Notebook Workstation Special Sale Package **$3,899**†
340 MB hard drive • Dual-Scan display • 15" Digital SVGA monitor
Docking Station • Keyboard • Mouse

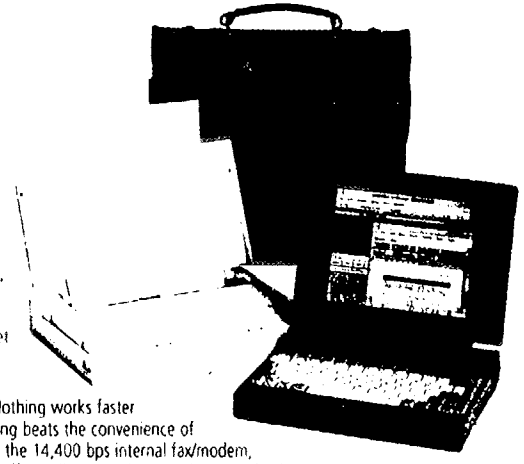
Notebook Workstation

This is what your accountant calls a performing asset. The Notebook Workstation's 486 33 MHz processor rivals many desktop models in speed and power. And with a generous 213 MB hard drive, you have plenty of space to load it up and take it on the road. This system comes complete with an impressive and affordable desktop setup—14" SVGA monitor, keyboard, and mouse—so you get the most out of your investment wherever you use it.

Notebook Workstation Special Sale Package **$2,999**†
Includes 486DX-33 MHz processor • 8 MB memory
213 MB hard drive • Dual-Scan display • 14" SVGA Monitor
Keyboard • Mouse

The Traveler. Take your business around the world or down the hall.

The Traveler is a productivity tool the mobile worker can't afford to be without. And with our sale prices, it's even easier to afford. Two models are equipped with the power, memory, and communication tools you need while traveling, whether you're crossing the globe or crossing the street.

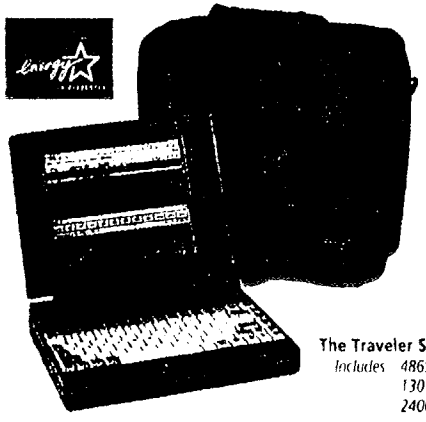


Pro Traveler

The Pro Traveler takes you first class. Nothing works faster than the 486 66 MHz processor. Nothing beats the convenience of your Canon portable printer. And with the 14,400 bps internal fax/modem, nothing comes between you and your office. All wrapped up in a luxurious leather carrying case, it's an attractive package at a very attractive price.

Pro Traveler Special Sale Package **$3,799**†
Includes: 486DX2-66 MHz processor • 8 MB memory
213 MB hard drive • Dual-Scan display • 14,400 bps fax/modem
Portable printer • Leather carrying case

MICROSOFT WINDOWS READY TO RUN



The Traveler

Don't leave your desk without packing this affordable portable. You'll enjoy the view on your Dual-Scan color display. And with a 130 MB hard drive, you have enough memory to record everything about your travels. All you need is a phone line to send and receive data through your 2400 bps internal fax/modem. Enjoy the freedom of the road and the convenience of constant communication.

The Traveler Special Sale Package **$2,299**†
Includes 486SX-25 MHz processor • 4 MB memory
130 MB hard drive • Dual-Scan display
2400 bps fax/modem • Nylon carrying case

A dazzling presenter and a smart study buddy.

Pro Business Presenter

You'll deliver an impressive performance every time with this full-featured presentatio
The 66 MHz processor runs even the most co
multimedia applications with ease. A state-of
dual scan display shows detailed graphics in
and the sharpest resolution. And with stereo
your presentation sounds as good as it looks
the Pro Business Presenter is your best vehic

Pro Business Presenter Special Sale
Includes: 486DX2-66 MHz processor • S
340 MB hard drive • Dual Scan
Stereo Speakers • Leather carry

Student Workstation

Give your educational career an extra advant
Take it to class, to the library, and back hom
each battery lasts up to five hours. Upgrade
increase. You can even use it to impress your
Student Workstation comes with an internal
and an Epson desktop printer.

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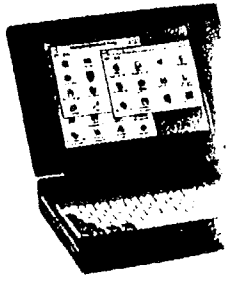
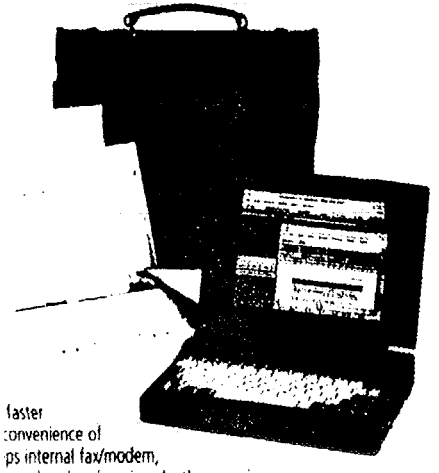


Student Workstation Special Sale P
Includes 486SX-25 MHz processor • 4
130 MB hard drive • Monochr
Desktop printer

t to you, it's the most powerful player in your office.

nd right now, it's on SALE!*)

*SALE ENDS DEC. 31, 1993



faster
convenience of
ps internal fax/modem,
pped up in a luxurious leather carrying
ice.

$3,799†

mory
• 14,400 bps fax/modem

MICROSOFT WINDOWS READY TO RUN

The Traveler

Don't leave your desk without packing this affordable portable. You'll enjoy the view on your Dual-Scan color display. And with a 130 MB hard drive, you have enough memory to record everything about your travels. All you need is a phone line to send and receive data through your 2400 bps internal fax/modem. Enjoy the freedom of the road and the convenience of constant communication.

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-25 MHz processor • 4 MB memory
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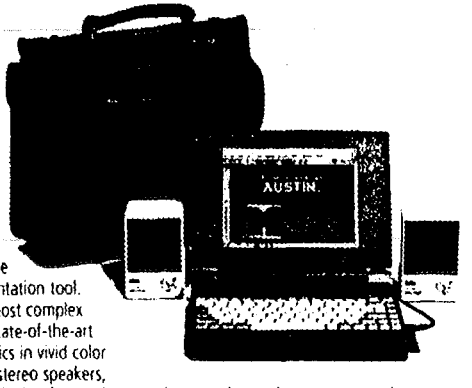
A dazzling presenter and a smart study buddy.



Pro Business Presenter

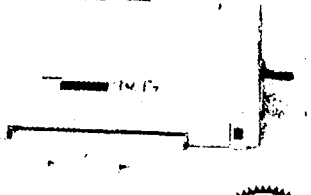
You'll deliver an impressive performance every time with this full-featured presentation tool. The 66 MHz processor runs even the most complex multimedia applications with ease. A state-of-the-art dual scan display shows detailed graphics in vivid color and the sharpest resolution. And with stereo speakers, your presentation sounds as good as it looks. If you take your show on the road, the Pro Business Presenter is your best vehicle.

Pro Business Presenter Special Sale Package **$3,599**†
Includes: 486DX2-66 MHz processor • 8 MB memory
340 MB hard drive • Dual Scan color display • PCMCIA multimedia card
Stereo Speakers • Leather carrying case • Complete cabling

Student Workstation

Give your educational career an extra advantage with a full-function, low-cost Notebook. Take it to class, to the library, and back home. With Austin's power management system, each battery lasts up to five hours. Upgrade your Notebook as your needs increase. You can even use it to impress your first boss! The hard-working Student Workstation comes with an internal 2400 bps fax/modem and an Epson desktop printer.

intel inside



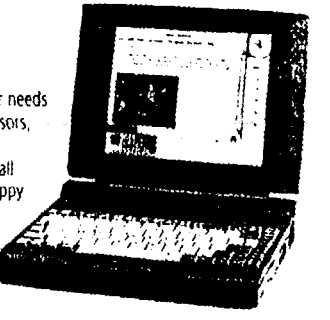
Student Workstation Special Sale Package **$1,949**†
Includes: 486SX-25 MHz processor • 4 MB memory
130 MB hard drive • Monochrome display • 2400 bps fax/modem
Desktop printer

SERVICE & RELIABILITY PC MAGAZINE READERS' CHOICE

† Promotional pricing
* Sale ends December 31, 1993

Don't see exactly what you want?

We have a wide variety of other configurations to suit your needs and your budget. Select from 25 MHz to 66 MHz 486 processors, 130 to 340 MB hard drives, monochrome, dual-scan color or active matrix color displays. They're all available, and they're all priced right. Call us toll-free. Our sales consultants will be happy to help you select the system that's right for you.



Accessories

Travel Cases
Organize, store, and protect your Notebook and all its essentials.

Nylon Travel Case	$ 39
Leather Travel Case	129

Docking Station
Turn your Notebook into an expandable desktop system with two drive bays, keyboard, and mouse ports.

Docking Station	$ 399

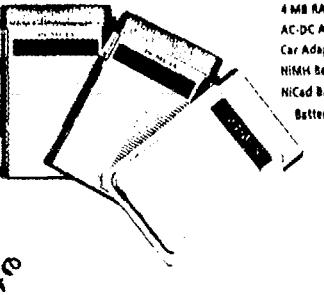
The docking station adds desktop extension capabilities to your Austin Notebook.

FaxModems
Send and receive faxes on the road, and connect quickly to on-line services.

Fax/Modem 9,600/2,400	$ 199
Fax/Modem 14,400/14,400	299

Network Adapters
These PCMCIA adapters connect your Austin Notebook to your organization's network.

Ethernet Adapter	$ 399
Token Ring Adapter	650



Other Accessories

PCMCIA 16-Bit Stereo Sound Card	$299
4 MB RAM Upgrade	279
AC-DC Adapter	79
Car Adapter	59
NiMH Battery Pack	149
NiCad Battery Pack	99
Battery Charger	49

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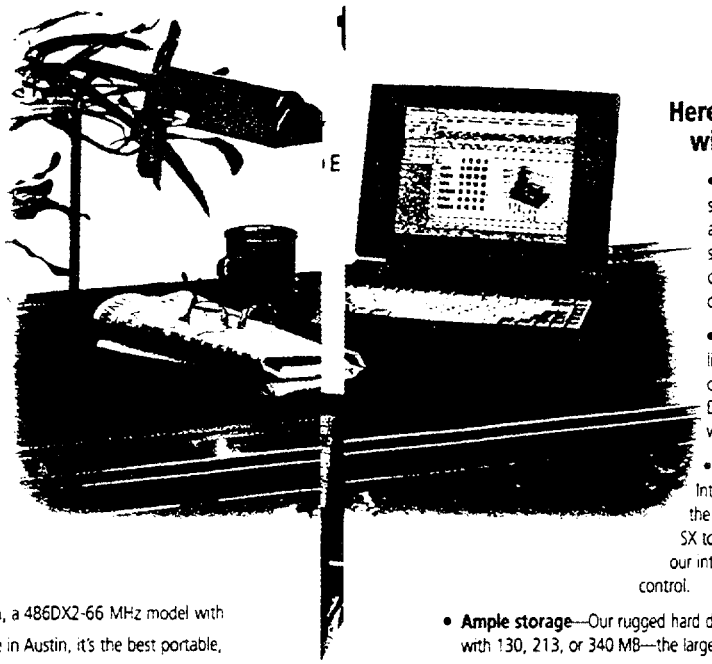
Clear your desk before it's too late.



Does your computer have more room to work than you do?

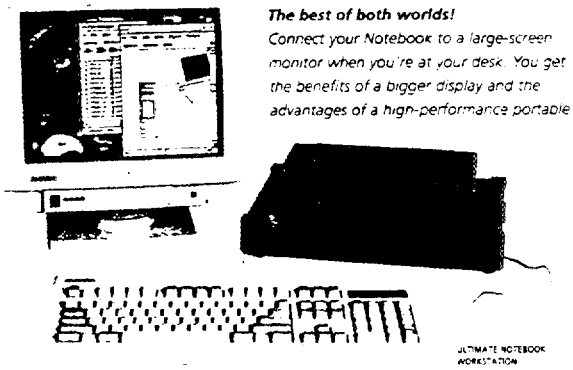
Now you can gain more desktop space without sacrificing power, performance, or memory. Whether you need a tower of power or a back-to-school basic, we have an Austin Notebook for you. And through December 31 you can save on special Notebook bundles designed to deliver the greatest value at the lowest price.

Let's make a deal.

Austin's super selection of Notebooks starts with our top-of-the-line Ultimate Notebook Workstation, a 486DX2-66 MHz model with a 340 MB hard drive. It's not only the best portable in Austin, it's the best portable, period! No other notebook matches the processing speed and memory capacity. And no desktop model can beat it.

Are you spending more time away from your desk? Are your presentations falling flat? Would a portable put you at the head of the class? We have models for you, too.

And if we haven't made your dream machine, we'll let you make your own. Just mix and match the features you want and phone in your order. See inside for "build-your-own" details.



The best of both worlds!
Connect your Notebook to a large-screen monitor when you're at your desk. You get the benefits of a bigger display and the advantages of a high-performance portable

ULTIMATE NOTEBOOK WORKSTATION

Here's what you get with an Austin Notebook!

- **Lightning-fast video**—Your presentations score on the power of our 32-bit local-bus video accelerator with 1 MB Video RAM. And with simultaneous output to an external monitor, you can show off your show in the office, in the classroom, or on the road.
- **Your choice of displays**—Choose a top-of-the-line Active Matrix display for the most demanding color applications. Get cost-effective color with a Dual-Scan display. Or opt for razor-sharp resolution with our affordable monochrome display.
- **Peak performance**—Austin Notebooks run on Intel's powerhouse 486 processor. You can choose the level of performance and speed you want—from SX to DX2 and from 25 to 66 MHz. Even at top speeds, our integrated cooling system keeps temperatures under control.
- **Ample storage**—Our rugged hard drives feature glass-media construction. Load up with 130, 213, or 340 MB—the largest drives on the market!
- **Future expandability**—Add-on devices (two Type II or one Type III) plug instantly into two PCMCIA slots. You also have the capacity for additional RAM and ROM.
- **Auto stop**—One touch puts your system into Standby Mode and back into Active Mode. You can return to work exactly where you left off, without waiting for the system to boot.
- **Sophisticated power management**—What good is a portable if you're tied to a power source? Austin Notebooks use less energy, our batteries last longer, and you have more time to work (or play) unplugged.
- **Energy efficient operation**—Austin Notebooks meet EPA Energy Star™ guidelines, providing the full power of a desktop system at only a fraction of the electricity. It's good for the environment, and it's good for your bottom line.
- **Strong service and support**—Austin provides free expert consultation, lifetime toll-free technical support, and a full one-year warranty on all our award-winning systems. We are a five-time winner of the *PC Magazine* Editors' Choice Award and a recent recipient of the *PC Magazine* Readers' Choice award for excellent service and reliability. *PC World* rated Austin #1 in service and support. No wonder 70% of our orders are from repeat customers.

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AUSTIN COMPUTER SYSTEMS • AN IPC COMPANY • 10330 METRIC BLVD • AUSTIN, TX 78758
FAX 512-454-1357 • OVERSEAS 512-339-3500 • CANADA 1-800-338-1565

Here's what you get with an Austin Notebook!

- **Lightning-fast video**—Your presentations score on the power of our 32-bit local-bus video accelerator with 1 MB Video RAM. And with simultaneous output to an external monitor, you can show off your show in the office, in the classroom, or on the road.
- **Your choice of displays**—Choose a top-of-the-line Active Matrix display for the most demanding color applications. Get cost-effective color with a Dual-Scan display. Or opt for razor-sharp resolution with our affordable monochrome display.
- **Peak performance**—Austin Notebooks run on Intel's powerhouse 486 processor. You can choose the level of performance and speed you want—from SX to DX2 and from 25 to 66 MHz. Even at top speeds, our integrated cooling system keeps temperatures under control.

le storage—Our rugged hard drives feature glass-media construction. Load up 130, 213, or 340 MB—the largest drives on the market!

e expandability—Add-on devices (two Type II or one Type III) plug instantly into CMCIA slots. You also have the capacity for additional RAM and ROM.

stop—One touch puts your system into Standby Mode and back into Active . You can return to work exactly where you left off, without waiting for the n to boot.

isticated power management—What good is a portable if you're tied to a r source? Austin Notebooks use less energy, our batteries last longer, and you more time to work (or play) unplugged.

gy efficient operation—Austin Notebooks meet EPA Energy Star™ guidelines, ding the full power of a desktop system at only a fraction of the electricity. ood for the environment, and it's good for your bottom line.

ng service and support—Austin provides free expert consultation, lifetime toll-echnical support, and a full one-year warranty on all our award-winning systems. re a five-time winner of the *PC Magazine* Editors' Choice Award and a recent ent of the *PC Magazine* Readers' Choice award for excellent service and reliability. Vorld rated Austin #1 in service and support. No wonder 70% of our orders are repeat customers.

intel inside

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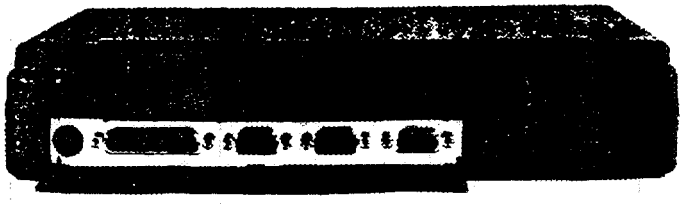

Specifications

Processor	32-bit Intel 486-SX, DX, or DX2 25, 33, or 66 MHz
Hard Drive	130 MB 14ms IDE 213 MB 13ms IDE 340 MB 12ms IDE
Memory	4 MB standard, upgradable to 32 MB
Display Interface	32-bit local-bus Windows accelerator, 1 MB RAM
Active Matrix Color LCD	9.5" TFT Active-Matrix display, 256 color with simultaneous VGA monitor output
Dual-Scan Color LCD	Dual-Scan Passive-Matrix display, 256 color
Mono LCD	Edge-lit supertwist with 16-level gray scale
Keyboard	Full-sized 85-key, with cursor keys in inverted T
Trackball	Integral 16mm, front-center mounted
PCMCIA	Two PCMCIA Type II or one PCMCIA Type III
I/O Ports	One parallel, two serial, SVGA
Diskette Drive	3.5", 1.44 MB
Power Usage	<10 watts in Standby Mode, conforms to EPA Energy Star guidelines
Battery Life	2 to 5 hours
Preinstalled Software	MS-DOS 6.0 Microsoft Windows 3.1
Dimensions	11.1" x 8.58" x 2.0"
Weight	6.3 lbs.
Regulatory	UL and CSA Approved FCC Class B
Warranty	One year

intel inside

MICROSOFT WINDOWS READY TO RUN

Novell Gold Authorized Reseller

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Oak Ridge Computer Systems, Inc.

Service, Sales & Consulting

1974 Oak Ridge Turnpike Oak Ridge, Tennessee 37830

Seagate Microsoft EVEREX COMPUTER SYSTEMS DIVISION Maxtor SAMSUNG Semiconductor & Telecommunications

Please ask us about the wide variety of products and brands that we carry for your convenience!

To. FRANK BAIRD	
For Information Call: (615) 482-7280	At: OAK RIDGE COMPUTER SYSTEMS, INC.
My FAX Number : (615) 481-3929	Pages: 2

SUBJECT:

Mr. Baird,

I am sorry for the delay in getting you this quote. Between the bad weather and our scanner being down, we have been a little behind. I will be calling you about the details of the notebook computer I am about to quote:

- **Ultra 486sx/25 notebook** $ 1,874
  - * **4MB**
  - * **200MB hard drive**

options:

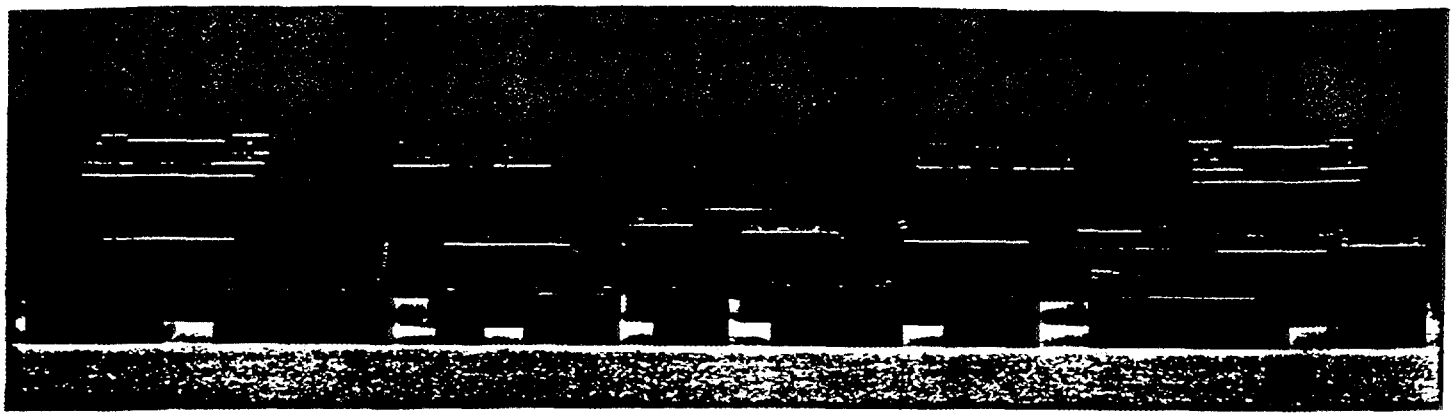
- * **8MB memory** +$ 235
- * **486DX/33 system** +$ 263

4mb ext -> 64 level
200 mbg 6 hours
Ac Adapt
6.2
Carry Case
ext Keyboard 5/2K
1 PCMIA Trackball
Tyoe 3.5" 1.44mB
Parallel/Serial

APPENDIX Q: TECHNICAL DATA FROM GEL-CELL STORAGE BATTERY VENDORS

PowerSonic
Gates Energy Products

POWER-SONIC Sealed Lead-Acid Batteries



FEATURES

Sealed/Maintenance-Free — The sealed construction of the Power-Sonic battery allows trouble-free, safe operation in any position. There is no need to add electrolyte, as gases generated during overcharge are recombined in a unique "Oxygen Cycle."

Easy Handling — No special handling precautions or shipping containers — surface or air — are required due to the leak-proof construction.

Economical — The high watt-hour per dollar value is made possible by the materials used in a sealed lead-acid battery; they are readily available and low in cost.

Long Service Life — Under normal operating conditions, four or five years of dependable service life can be expected in standby applications or between 200 and 1000 charge/discharge cycles depending upon depth of discharge.

Design Flexibility — Batteries may be used in series and/or parallel to give you choice of voltage and capacity. Due to recent design breakthroughs, the same battery may be used in either cyclic or standby applications without sacrificing life or performance. Furthermore, Power-Sonic offers over 30 basic model sizes.

Rugged Construction — The high-impact resistant battery case is made of non-conductive ABS plastic with superior resistance to shock, vibration, chemicals and heat.

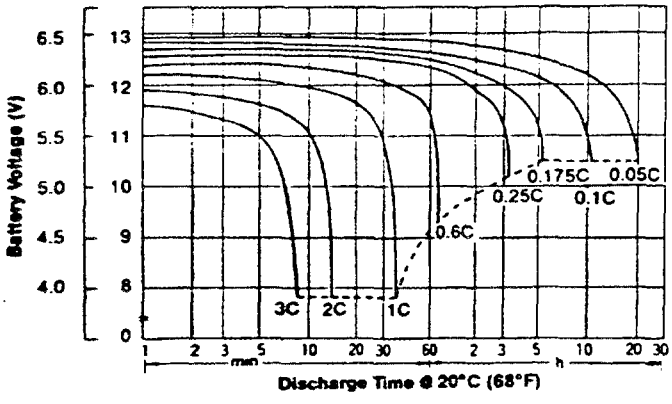
Compact — Power-Sonic batteries utilize state of the art design, highest grade materials, and a carefully controlled plate-making process to provide excellent output per cell. This high energy density results in superior power/volume and power/weight ratios.

High Discharge Rate — Low internal resistance allows discharge currents of over ten times the rated capacity of the battery. Therefore, a relatively smaller battery may be specified in applications requiring high peak currents.

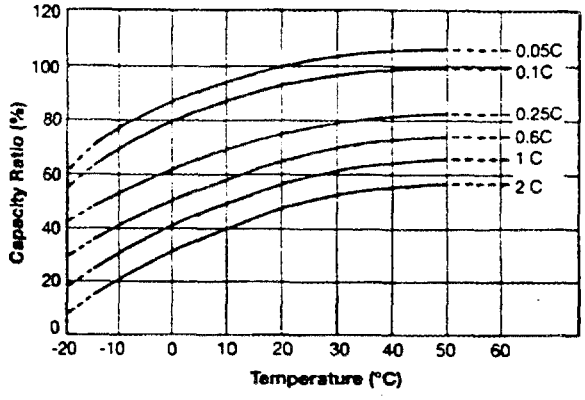
Long Shelf Life — A low self-discharge rate permits storage of fully charged batteries for up to a year at room temperature before charging is required. Lower storage temperatures enhance shelf life characteristics even further.

Wide Operating Temperature Range — Power-Sonic batteries may be used over a temperature range of -76°F to +140°F (-60°C to +60°C).

Deep Discharge Recovery — Special separators, advanced plate composition, and a carefully balanced electrolyte system have greatly improved the capability of recovering from deep discharge.



Characteristic Discharge Curves



Effect of Temperature on Capacity

CHARGING

Cycle Applications: Limit initial current to 0.20C (C is the nominal A.H. capacity of the battery). Charge until battery voltage (under charge) reaches 2.45 volts per cell at 68°F (20°C). Hold at 2.45 volts per cell until current drops to approximately 0.01C ampere. Battery is fully charged under these conditions, and charger should either be disconnected or switched to "float" voltage.

"Float" or "Stand-By" Service: Hold battery across constant voltage source of 2.25 to 2.30 volts per cell continuously. When held at this voltage, the battery will seek its own current level and maintain itself in a fully charged condition.

TERMINALS

Standard Terminals: Quick disconnect "FASTON" tabs 0.187" × 0.032"; mate with AMP. INC. FASTON "187" series receptacles. Models: PS-445, 610, 612, 620, 630, 632, 640, 670, 682F, 6100, 1212, 1220, 1226, 1230, 1232, 1242, 1252, 1270, 1282.

"250" FASTON: Quick disconnect tabs 0.250" × 0.032", mate with AMP. INC. "250" series receptacle. Models: PS-490, 6100, 12100, 12120, 12170F, 12260F.

Polarized FASTON: Quick disconnect tabs; positive 0.250" × 0.032", negative 0.187" × 0.032". Models: PS-665, 695, 6120, 1295, 12120L.

Spring Type: PS-650L (lantern battery)

Wire Leads: C.U. insulated, stranded wire leads

a) terminated with AMP. INC. Mate-N-Lock connector housing P/N 1-480318-0 and female pin P/N 60619-1. Mates with connector housing P/N 1-480319 and male pin P/N 61116-1. Models: PS-640WL, PS-1207.
b) terminated with "250" female FASTON receptacles. Model: PS-682WL. c) terminated with MOLEX housing P/N 5264-02 and plug P/N 5263-PBT: Model PS-605.

Nut and Bolt: Post with nut and bolt terminals; 5mm Ø for Models: PS-6200, 12170NB, 12260, 12280. 6mm Ø for Model PS-12400.

Heavy Duty Flag Terminals: Models: PS-12330, 12500, 12600, 12800.

SPECIFICATIONS

Model	Nominal Voltage V	Nominal Capacity @ 20 hr. rate A.H.	Discharge Capacity @ 20 hr. rate mA	DIMENSIONS								Weight	
				Length		Width		Height		Ht. Over Terminal			
				in.	mm	in.	mm	in.	mm	in.	mm.	lbs.	kg.
PS-445	4	4.5	225	1.93	49	2.09	53	3.70	94	3.86	98	1.5	0.7
PS-490	4	9.0	450	4.02	102	1.73	44	3.70	94	3.86	98	2.4	1.1
PS-605	6	0.5	25	2.24	57	0.55	14	1.97	50	1.97	50	.20	.09
PS-610	6	1.0	50	2.00	51	1.65	42	2.00	51	2.20	56	0.6	0.3
PS-612	6	1.2	60	3.82	97	0.94	24	2.00	51	2.13	54	0.6	0.3
PS-620	6	2.0	100	2.95	75	2.00	51	2.09	53	2.28	58	1.1	0.5
PS-630	6	3.0	150	5.28	134	1.34	34	2.35	60	2.56	65	1.5	0.7
PS-632	6	3.2	160	2.60	66	1.30	33	4.84	123	5.00	127	1.5	0.7
PS-640	6	4.0	200	2.76	70	1.89	48	4.02	102	4.25	108	1.8	0.8
PS-650L	6	5.0	250	2.63	67	2.63	67	3.78	96	4.28	109	2.0	0.9
PS-665	6	6.5	325	3.86	98	2.20	56	4.05	103	4.05	103	3.0	1.4
PS-670	6	7.0	350	5.95	151	1.34	34	3.70	94	3.86	98	3.0	1.4
PS-682	6	8.0	400	3.86	98	2.20	56	4.65	118	4.65	118	3.3	1.5
PS-695	6	9.5	475	4.26	108	2.75	70	5.54	141	5.54	141	4.9	2.2
PS-6100	6	10.0	500	5.95	151	2.00	51	3.70	94	3.86	98	4.6	2.1
PS-6120	6	12.0	600	4.26	108	2.75	70	5.54	141	5.54	141	5.5	2.5
PS-6200	6	20.0	1000	6.18	157	3.27	83	4.92	125	4.92	125	8.2	3.7
PS-1207	12	0.7	35	3.78	96	0.98	25	2.42	62	2.42	62	0.8	0.35
PS-1212	12	1.2	60	3.82	97	1.65	42	2.00	51	2.13	54	1.3	0.6
PS-1220	12	2.0	100	7.01	178	1.34	34	2.36	60	2.56	65	1.9	0.9
PS-1226	12	2.6	130	7.01	178	1.34	34	2.36	60	2.56	65	2.2	1.0
PS-1230	12	3.0	150	5.23	134	2.64	67	2.36	60	2.60	66	2.6	1.2
PS-1232	12	3.2	160	7.68	195	1.85	47	2.76	70	2.95	75	3.1	1.4
PS-1242	12	4.0	200	3.54	90	2.76	70	3.98	101	4.13	105	3.8	1.7
PS-1252	12	5.0	250	3.54	90	2.76	70	4.02	102	4.25	108	4.2	1.9
PS-1270	12	7.0	350	5.95	151	2.56	65	3.70	94	3.86	98	5.7	2.6
PS-1282	12	8.0	400	3.86	98	4.40	112	4.65	118	4.65	118	6.7	3.0
PS-1295	12	9.5	475	8.38	213	2.75	70	5.50	140	5.50	140	10.0	4.6
PS-12100	12	10.0	500	5.95	151	4.00	102	3.70	94	3.86	98	9.2	4.2
PS-12120	12	12.0	600	5.94	151	3.86	98	3.70	94	3.94	100	9.0	4.1
PS-12120L	12	12.0	600	8.38	213	2.75	70	5.50	140	5.50	140	11.0	5.0
PS-12170	12	17.0	850	7.13	181	2.99	76	6.57	167	6.57	167	12.8	5.8
PS-12260	12	26.0	1300	6.89	175	6.54	166	4.92	125	4.92	125	18.7	8.5
PS-12280	12	28.0	1400	6.54	166	4.92	125	6.89	175	6.89	175	19.4	8.8
PS-12330	12	33.0	1650	7.68	197	5.19	132	6.38	162	7.15	182	26.5	12.0
PS-12400	12	40.0	2000	7.75	197	6.50	165	6.69	170	6.69	170	30.9	14.0
PS-12500	12	50.0	2500	9.40	239	5.50	140	8.20	208	9.05	230	36.0	16.4
PS-12600	12	60.0	3000	10.25	260	6.60	168	8.20	208	9.45	240	46.0	20.9
PS-12800	12	80.0	4000	12.00	305	6.60	168	8.20	208	9.45	240	55.0	25.0

$2.00

Gates®

Energy Products

BATTERY ASSEMBLY AND DISTRIBUTION
ENGINEERED ASSEMBLIES CORPORATION
KENNEDY SPACE CENTER, BLDG. #3
3035 BARROW DRIVE
RALEIGH, NORTH CAROLINA 27604
(919) 790-9700 FAX #(919) 790-0223

CYCLON

Battery Application Manual

GATES SEALED RECHARGEABLE BATTERIES

standard cells and batteries

Cells

Product Number	Voltage	Capacity (Ampere-Hours) 20 Hr. Rate	Capacity (Ampere-Hours) 10 Hr. Rate	Discharge Current at 10 Hr. Rate	Height (Incl. Terminals) in/mm	Diameter in/mm	Weight (Approx.) lb/kg	Package
0810-0004	2	2.7	2.5	250mA	2.65/67	1.34/34	.40/.18	D Cell
0800-0004	2	5.2	5.0	500mA	3.17/81	1.74/44	.81/.37	X Cell
0840-0004*	2	13.0	12.5	1250mA	5.34/136	2.04/52	1.85/.84	J Cell
0820-0004	2	26.0	25.0	2500mA	6.78/172	2.55/65	3.49/1.58	BC Cell

*J Cell information is preliminary. Contact Gates Energy Products, Inc., for up-to-date information.

Batteries

Product Number	Voltage	Capacity (Ampere-Hours) 20 Hr. Rate	Capacity (Ampere-Hours) 10 Hr. Rate	Discharge Current at 10 Hr. Rate	Length in/mm	Width in/mm	Height** in/mm	Weight (Approx.) lb/kg	Package
0810-0011	6	2.7	2.5	250mA	4.20/107	1.53/39	2.69/68	1.32/.60	1x3D-Case
0810-0102	6	2.7	2.5	250mA	4.00/102	1.48/38	2.63/67	1.23/.56	1x3D-Shrink
0810-0017	6	2.7	2.5	250mA	2.63/67	2.63/67	3.84/98	1.53/.69	Cluster D-Lantern
0800-0011	6	5.2	5.0	500mA	5.42/138	1.94/49	3.10/79	2.58/1.17	1x3X-Case
0800-0102	6	5.2	5.0	500mA	5.22/133	1.86/47	3.08/78	2.43/1.11	1x3X-Shrink
0802-0008	6	10.4	10.0	1000mA	5.38/137	3.64/92	3.14/80	5.23/2.37	2x3X-Case
0802-0016	6	10.4	10.0	1000mA	5.20/132	3.60/91	3.08/78	4.86/2.20	2x3X-Shrink
0820-0014	6	26.0	25.0	2500mA	8.05/204	2.85/72	7.16/182	11.08/5.02	1x3BC-Case
0822-0008	6	52.0	50.0	5000mA	8.05/204	5.45/138	7.16/182	22.30/10.12	2x3BC-Case
0800-0027	8	5.2	5.0	500mA	7.16/182	1.94/49	3.10/79	3.43/1.56	1x4X-Case
0800-0104	8	5.2	5.0	500mA	6.96/177	1.86/47	3.08/78	3.33/1.51	1x4X-Shrink
0810-0008	12	2.7	2.5	250mA	4.20/107	2.87/73	2.69/68	2.61/1.18	2x3D-Case
0810-0016	12	2.7	2.5	250mA	8.22/209	1.53/39	2.69/68	2.61/1.18	1x6D-Case
0810-0108	12	2.7	2.5	250mA	8.01/203	1.48/38	2.63/67	2.48/1.13	1x6D-Shrink
0810-0114	12	2.7	2.5	250mA	4.00/102	2.82/72	2.63/67	2.44/1.11	2x3D-Shrink
0800-0008	12	5.2	5.0	500mA	5.42/138	3.68/93	3.10/79	5.18/2.35	2x3X-Case
0800-0016	12	5.2	5.0	500mA	10.63/270	1.94/49	3.10/79	5.26/2.39	1x6X-Case
0800-0108	12	5.2	5.0	500mA	10.41/264	1.83/46	3.08/78	4.93/2.24	1x6X-Shrink
0800-0114	12	5.2	5.0	500mA	5.22/133	3.60/91	3.08/78	4.85/2.20	2x3X-Shrink
0820-0020	12	26.0	25.0	2500mA	8.05/204	5.45/138	7.16/182	22.30/10.12	2x3BC-Case

**Height given excludes battery tabs. For height including tabs, please add the following:

	D in/mm	X in/mm
Case	.02/1	.12/3
Shrink	.08/2	.14/4

Note: Standard lead wires for the above available at extra cost are:

0810: 18 AWG Plain Ends, Red Positive, Black Negative, Extended 9.0 + ½ in. outside cell pack.

0800: 16 AWG Plain Ends, Red Positive, Black Negative, Extended 9.0 + ½ in. outside cell pack.

Special lead assemblies and/or battery configurations are available upon request.

APPENDIX R: TECHNICAL DATA FROM SENSOR SUITE DEVICE VENDORS

UniMeasure
Sensors Development
GSE
UFI
American Electronics Components
KVH Industries
Riegl
Silicon Heights
Bruel and Kjaer Instruments
International Light
Larson Davis
Quest Electronics
Armtec Industries

UniMeasure, Inc.
7055 NW Grandview Dr., Corvallis, Oregon, 97330, U.S.A.
Tel: (503) 757-3158
Fax: (503) 757-0858

DATE	12 January, 1994
NO. OF PAGES (including this page)	7

TO	Frank Barickman	FAX NO.	615 574 7860
COMPANY	Oakridge National Laboratory		
FROM	Tom Peterson	Doc. No.	OAKRIDG1.DOC

Frank:

Attached are various data sheets and a price list on UniMeasure linear position transducers.

The HX series is environmentally sealed. All of the outputs available in our standard series are available in the HX series including velocity/position.

In addition to the standard potentiometric output, the VP series is available with 0 to 10 VDC, 4 to 20 mA, and ±10 VDC outputs.

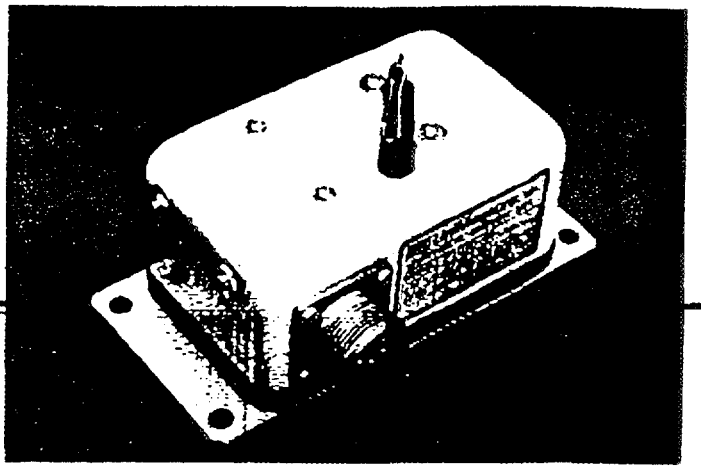
We will send you our complete literature package today. If you have any questions on the faxed material, please call me.

Best regards,

Tom Peterson

P1010 SERIES

±10 VDC ANALOG OUTPUT LINEAR POSITION TRANSDUCER

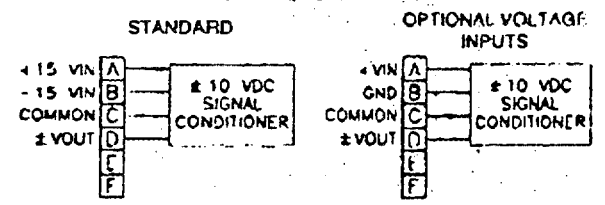


- ±10 VDC OUTPUT
- LINEARITIES TO 0.15%
- INFINITE RESOLUTION
- RANGES TO 500 INCHES
- REPLACEABLE CABLE
- RUGGED CONSTRUCTION
- ADJUSTABLE ZERO AND SPAN CONTROLS

+10 VDC output

The P1010 series couples internal electronics with the basic P series transducer to provide a ±10 VDC output. The zero position may be set within 10% to 90% of the total range of the transducer. The output voltage will be positive when the cable is extending from the zero position and negative when retracting from the zero position. The span may be adjusted to the maximum output voltage within 50% to 100% of the longest possible travel, whether positive or negative, from the zero position. A ±15 VDC input is required but optional single inputs of +5, +12, +15, or +24 VDC are available. With optional inputs, the power supply ground is isolated from the output common.

CONNECTOR WIRING



SPECIFICATIONS

General

Linearity	
2", 3", 4" & 5" Ranges	±0.30% Full Scale
10", 15", 20" & 25" Ranges	±0.20% Full Scale
All other ranges	±0.15% Full Scale
Repeatability	±0.015% Full Scale
Resolution	
Ranges 10" and above	Essentially Infinite
Construction	Aluminum Cover & Baseplate Stainless Steel Cable
Sensing Device	Precision Potentiometer
Connector	MS3102A-14S GP

Electrical

Output	±10 VDC
Excitation Voltage	±15 VDC ±10% ← NOTE
Input Current	25 mA max.
Output Impedance	1.0Ω max.
Output Load	5KΩ min.
Capacitive Load	1000 pF
Adjustment Range	NOTE.
Zero	10% to 90% of Total Range
Span	50% to 100% of Longest Possible Travel from Zero Position
Protection	Reversed Polarity
Temperature Stability	0.02%/°C of Span

Environmental

Operating temperature	0°C to +70°C
Storage Temperature	-40°C to +85°C
Operating humidity	90% R.H. max. non-condensing
Vibration	15 G's 0.1 ms max.
Shock	50 G's 0.1 ms max.

MODEL	RANGE (inch)	RANGE (mm)	NOMINAL OUTPUT SENSITIVITY WITH ZERO AT MIDPOINT OF RANGE (mV/inch)	(mV/mm)	CABLE TENSION (NOMINAL) (oz)	(kg)	CABLE ACCEL (G's)	DIMENSIONAL INFORMATION
P1010-2	2	50	±10000.0	±400.0	34	.96	>50	
P1010-3	3	75	±6667.7	±266.7	24	.68	>50	
P1010-4	4	100	±5000.0	±200.0	24	.68	>50	
P1010-5	5	125	±4000.0	±160.0	34	.96	>50	
P1010-10	10	250	±2000.0	±80.0	34	.96	>50	Figure 1
P1010-15	15	390	±1333.3	±51.3	24	.68	>50	
P1010-20	20	500	±1000.0	±40.0	24	.68	>50	
P1010-25	25	640	±800.0	±31.3	34	.96	>50	
P1010-30	30	750	±667.7	±26.7	24	.68	>50	
P1010-40	40	1000	±500.0	±20.0	24	.68	>50	
P1010-50	50	1250	±400.0	±16.0	34	.96	>50	
P1010-60	60	1500	±333.3	±13.3	24	.68	27	
P1010-75	75	1750	±266.7	±11.4	21	.59	18	Figure 2
P1010-80	80	2000	±250.0	±10.0	19	.54	16	
P1010-100	100	2500	±200.0	±8.0	24	.68	18	
P1010-150	150	3800	±133.3	±5.3	24	.68	18	
P1010-200	200	5000	±100.0	±4.0	24	.68	18	
P1010-250	250	6300	±80.0	±3.2	24	.68	18	Figure 5
P1010-300	300	7500	±66.7	±2.7	24	.68	10	
P1010-350	350	8800	±57.1	±2.3	24	.68	10	
P1010-400	400	10000	±50.0	±2.0	24	.68	10	
P1010-500	500	12500	±40.0	±1.6	24	.68	10	

NOTES

1. Mating connector included.

OPTIONS

- +5, +12, +15, or +24 VDC single input voltage.

Voltage Option	Input Current (mA max.)
+5	150
+12	65
+15	50
+24	32

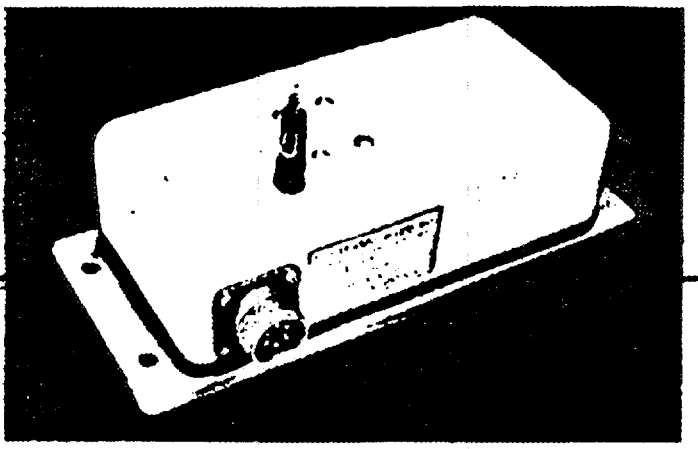
- See price list for other applicable options.

ORDERING INFORMATION

Order by model number corresponding to range required.

VP SERIES

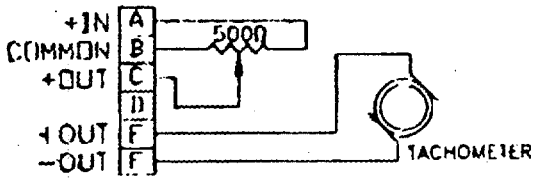
LINEAR VELOCITY AND POSITION TRANSDUCER



- SELF-GENERATING
- POSITIONAL LINEARITY TO 0.1%
- VELOCITY LINEARITY 0.1%
- INFINITE RESOLUTION
- RANGES TO 500 INCHES
- REPLACEABLE CABLE
- RUGGED CONSTRUCTION

Simultaneous velocity and position measurement
The VP series combines a self-generating tachometer and a precision potentiometer to give an output of both velocity and analog position. Standard position output is the "A" circuit. Outputs optionally available are the "B" circuit, 4-20 mA, 0-10 VDC, and ±10 VDC. See P series, P420 series, P510 and P1010 series data sheets for specifications.

CONNECTOR WIRING



POSITIVE OUTPUT OCCURS WITH CABLE EXTENDING

SPECIFICATIONS

General
- Positional Linearity
  - 2", 3", 4" & 5" Ranges ..... ±0.25% Full Scale
  - 10", 15", 20" & 25" Ranges ..... ±0.15% Full Scale
  - All other ranges ..... ±0.10% Full Scale
- Repeatability[1] ..... ±0.015 Full Scale
- Positional Resolution
  - Ranges 10" and above ..... Essentially Infinite
- Construction ..... Aluminum Cover & Baseplate, Stainless Steel Cable
- Connector MS3102A-14S-6P

Electrical (Position)
- Input Impedance
  - "A" Circuit ..... 500±10% ohms standard
- Output Impedance
  - "A" Circuit 0-500Ω
- Excitation Voltage ..... 25 Volts Max. AC or DC
- Insulation resistance ..... 100 megohms min. at 100 VDC

Electrical (Velocity)
- Output ..... See Table
- Linearity ..... ±0.10% F.S. within 25 Volt

Output
- Ripple ..... 3% Max.
- Output Impedance 350Ω

Environmental
- Thermal Coefficient of potentiometer ..... ±100 PPM/°C max.
- Operating temperature ..... -15°C to 95°C
- Operating humidity ..... 95% R.H. max. non-condensing
- Vibration ..... 15 G's 0.1 ms max.
- Shock ..... 50 G's 0.1 ms max.

MODEL	RANGE (in)	RANGE (mm)	"A" CIRCUIT NOMINAL OUTPUT (mv/V/in)	"A" CIRCUIT NOMINAL OUTPUT (mv/V/mm)	VELOCITY OUTPUT (mV per 100 in/min)	VELOCITY OUTPUT (mV per m/min)	CABLE TENSION (NOMINAL) (oz)	CABLE TENSION (NOMINAL) (kg)	CABLE ACCEL[2] (G's)	DIMENSIONAL INFORMATION
VP-2	2	50	475	18.7	333	131	34	.96	33	Figure 4
VP-3	3	75	325	12.8	227	89	24	.68	30	
VP-4	4	100	244	9.6	171	67	24	.68	36	
VP-5	5	125	196	7.7	137	54	34	.96	33	
VP-10	10	250	95	3.7	333	131	34	.96	33	
VP-15	15	390	65	2.5	227	89	24	.68	30	
VP-20	20	500	49	1.9	171	67	24	.68	36	
VP-25	25	640	39	1.5	137	54	34	.96	33	
VP-30	30	750	32	1.3	227	89	24	.68	30	
VP-40	40	1000	24	1.0	171	67	24	.68	36	
VP-50	50	1250	20	0.8	137	54	34	.96	33	
VP-60	60	1500	16	0.7	115	45	24	.68	27	
VP-75	75	1750	13	0.52	93	37	21	.59	18	
VP-80	80	2000	12	0.49	87	34	19	.54	16	
VP-100	100	2500	9.9	0.39	340	134	24	.68	9	Figure 5
VP-150	150	3800	6.6	0.26	340	134	24	.68	9	
VP-200	200	5000	5.0	0.20	340	134	24	.68	3	
VP-250	250	6300	4.0	0.16	340	134	24	.68	3	
VP-300	300	7500	3.3	0.13	340	134	24	.68	3	
VP-350	350	8800	2.8	0.11	340	134	24	.68	3	
VP-400	400	10000	2.5	0.10	340	134	24	.68	3	
VP-500	500	12500	2.0	0.08	340	134	24	.68	3	

NOTES
1. "A" circuit is standard.
2. Mating connector included.

OPTIONS
- "B" Circuit
- 4-20 mA Output
- 0-10 VDC Output
- ±10 VDC Output
- See price list for other applicable options.

ORDERING INFORMATION

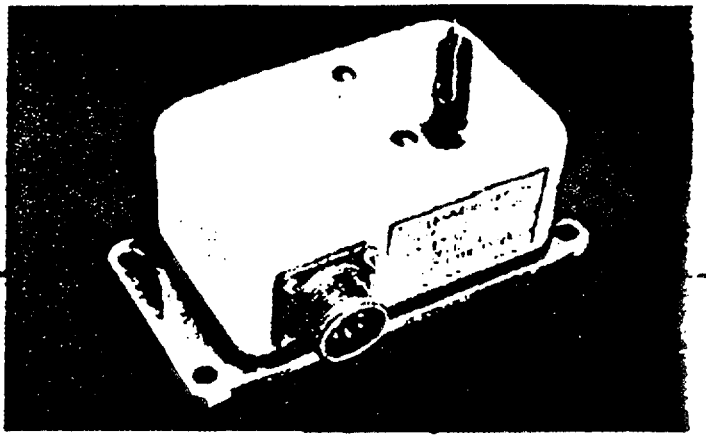
VP-100A

MODEL OUTPUT

FOOTNOTES
1. Moving to the same position from the same direction.
2. Maximum cable retraction acceleration.

EP SERIES

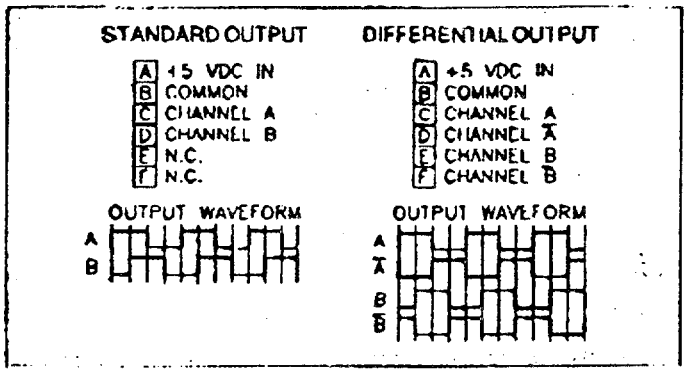
DIGITAL LINEAR POSITION TRANSDUCER



- TTL COMPATIBLE DIGITAL OUTPUT
- 0.05% LINEARITY
- INCH AND METRIC VERSIONS
- RESOLUTIONS TO 0.002" OR 0.05 MM
- DIFFERENTIAL OUTPUT OPTION

Two channel digital output

The UniMeasure EP series position transducer provides a digital output signal for applications where a digital signal is desirable. The standard output is a two channel single-ended TTL compatible square wave which allows external electronics to determine cable movement direction. Options include a differential line driver output and an input voltage capability of 8 to 28 VDC. With the 8 to 28 VDC input option, the output voltage level is approximately the same as the input. Both current sourcing and current sinking outputs are available with the 8 to 28 VDC input option.



SPECIFICATIONS

General

Linearity[1]	±0.05% F.S. ±1 count
Count Accuracy[2]	
EP-10, EPM-250	±0.25% F.S. ±1 count
EP 50, EPM 1250	±0.15% F.S. ±1 count
All other models	±0.10% F.S. ±1 count
Repeatability[3]	±0.015% F.S. ±1 count
Resolution	See Table
Construction	Aluminum Cover & Baseplate Stainless Steel Cable
Connector	MS3102A-14S-6P

Electrical

Input Voltage	+5 VDC ±5%
Input Current	125 mA maximum
Output	Two channel single-ended TTL compatible square wave from LM339 open collector output stage 2 KΩ pullup resistors provided.
Phase Quadrature	90°±20°

Environmental

Operating temperature	0°C to 70°C
Storage temperature	-25°C to 90°C
Shock	50 G's for 11 ms duration
Vibration	20 Hz to 2000 Hz @ 5G's
Humidity	98% R.H. maximum (non-condensing)

MODEL	RANGE	NOMINAL RESOLUTION[4] (in/pulse)	(pulse/in)	CABLE TENSION (NOMINAL)	CABLE ACCEL[5] (G's)	DIMENSIONAL INFORMATION
EP-10	10"	0.002	500	34 oz	43	Figure 3
EP-50	50"	0.004	250	34 oz	37	
EP-100	100"	0.010	100	24 oz	14	Figure 5
EP-250	250"	0.010	100	24 oz	4	
EP-500	500"	0.010	100	24 oz	3	
		(mm/pulse)	(pulse/mm)			
EPM-250	250 mm	0.05	20	.96 Kg	43	Figure 3
EPM-1250	1250 mm	0.10	10	.96 Kg	37	
EPM-2500	2500 mm	0.20	5	.68 Kg	14	Figure 5
EPM-6300	6300 mm	0.20	5	.68 Kg	4	
EPM-10000	10000 mm	0.20	5	.68 Kg	3	

NOTES

1. Mating connector included.

OPTIONS

- Differential line driver output
- 8 to 28 VDC input voltage
- See price list for other applicable options.

ORDERING INFORMATION

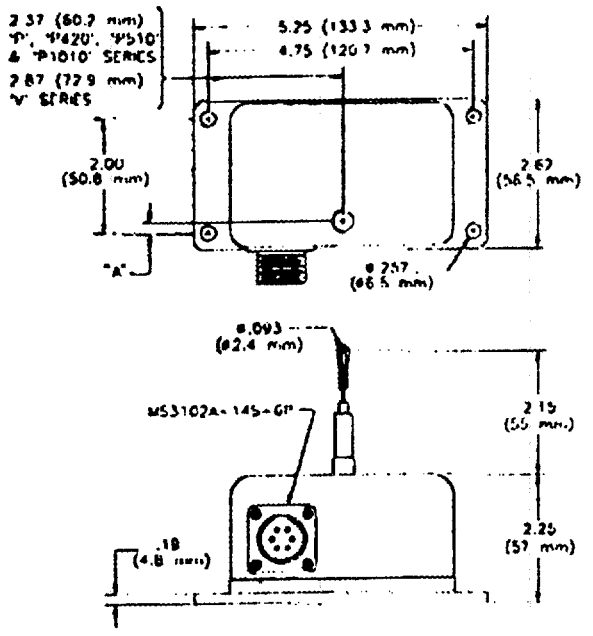
Order by model number corresponding to range required.

FOOTNOTES

1. End point linearity based upon actual output.
2. Maximum difference between actual output and theoretically perfect output calculated from nominal resolution and range
3. Moving to the same position from the same direction.
4. Resolution can be increased by a factor of 2 or 4 with external logic.
5. Maximum cable retraction acceleration.

Product appearance, design and specifications are subject to change without notice.

DIMENSIONAL INFORMATION



RANGE	"A" (in)	"A" (mm)
2", 10"	0.66	16.8
3", 15", 30"	0.51	12.9
4", 20", 40"	0.35	8.8
5", 25", 50"	0.19	4.8

Figure 1

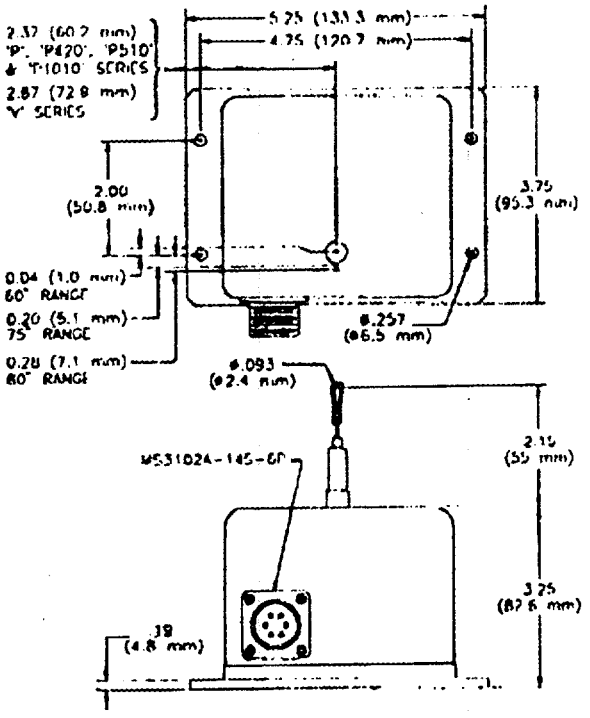


Figure 2

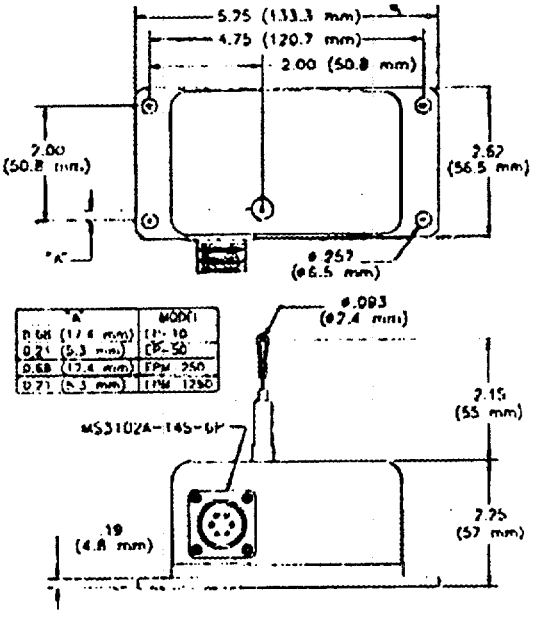


Figure 3

UniMeasure, Inc.

Corvallis, OR 97330
Tel: (503) 757-3158 Fax: (503) 757-0858

PRICE LIST

SEPTEMBER 1992 A

PRICES IN U.S. DOLLARS

RANGE (in)	RANGE (mm)	P POSITION VOLTAGE DIVIDER OUTPUT	P420 POSITION 4-20 mA OUTPUT	P510 POSITION 0 TO 5 OR 10 VDC OUTPUT	P1010 POSITION ±10 VDC OUTPUT	HX-PA ENVIRONMENTALLY SEALED VOLTAGE DIVIDER OUTPUT	EP & EPM DIGITAL POSITION SQUARE WAVE OUTPUT	V VELOCITY OUTPUT	VP VELOCITY & POSITION OUTPUT
2	50	$225	$335	$335	$375	$375	—	$375	$405
3	75	225	335	335	375	375	—	375	405
4	100	225	335	335	375	375	—	375	405
5	125	225	335	335	375	375	—	375	405
10	250	225	335	335	375	375	$495	375	405
15	380	225	335	335	375	375	—	375	405
20	500	225	335	335	375	375	—	375	405
25	640	225	335	335	375	375	—	375	405
30	750	225	335	335	375	375	—	375	405
40	1000	225	335	335	375	375	—	375	405
50	1250	225	335	335	375	375	495	375	405
60	1500	310	420	420	460	395	—	435	460
75	1750	310	420	420	460	—	—	435	460
80	2000	310	420	420	460	435	—	435	460
100	2500	450	575	575	600	—	630	580	620
150	3800	510	635	635	660	—	—	610	645
200	5000	510	635	635	660	—	—	610	645
250	6300	510	635	635	660	—	655	610	645
300	7500	530	650	650	680	—	—	610	645
350	8800	530	650	650	680	—	—	610	645
400	10000	530	650	650	680	—	725	610	645
500	12500	530	650	650	680	—	725	610	645

DISCOUNT SCHEDULE

QUANTITY	DISCOUNT
1-4	NONE
5-9	5%
10-24	7%
25-49	10%
50 and greater	Consult Factory

NOTE: HX SERIES IS ALSO AVAILABLE WITH THE FOLLOWING:
- DIGITAL OUTPUT
- VELOCITY OUTPUT
- VELOCITY/POSITION OUTPUT
- ALL STAINLESS STEEL CONSTRUCTION

CONSULT FACTORY FOR PRICING

TERMS

1. Net 30 days
2. F.O.B. Corvallis, Oregon, U.S.A.

SEE OPPOSITE SIDE FOR APPLICABLE OPTIONS AND ACCESSORIES

WARRANTY

UniMeasure products are warranted for 6 months from date of shipment against defects in materials and workmanship. During the warranty period, UniMeasure, at its option, will promptly repair or replace defective units at no charge to the purchaser if the product is returned to the factory freight prepaid. The warranty is void if the product is misused, damaged by accident, disassembled or intentionally abused.

UniMeasure makes no other warranties either expressed or implied other than that above. UniMeasure assumes no liability for consequential damages under any circumstances. Prices, specifications and product appearance are subject to change without notice.

Prices, specifications and product appearance are subject to change without notice.

Sensor Developments Inc.
INNOVATIONS IN FORCE MEASUREMENT
Phone: (313) 391-3000
FAX: (313) 391-0107

January 20, 1994

Mr. Frank Barickman
Oakridge National Laboratories
Bethel Valley Rd.
Building 6025
M.S. 6360
Oakridge, TN 37831-6380

Dear Frank,

Thank you for the phone inquiry today concerning Sensor Developments Inc. (SDI) products and services, specifically our Model 10118 Pedal Effort Sensor.

The Model 10118 is available in several force capacity ranges, (see drawing 12182CO-F). SDI also provides two mounting assemblies for attaching the unit to the pedal. I would recommend the Cable Tie Adapter Assembly for your specific application. This arrangement provides a low profile when attached to the vehicle's brake pedal.

PRICE & DELIVERY

Model 10118 Pedal Effort Sensor ..... $ 1800.00 ea.
Delivery ..... stk - 8 wks ARO

Quantity pricing is also available.

Please contact me with any questions you might have concerning this quote.

Best Regards,

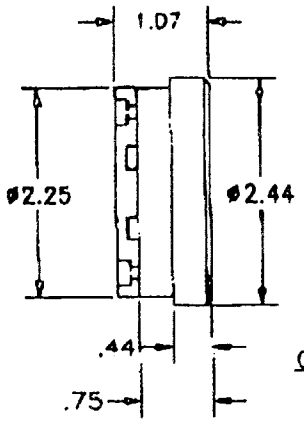
SENSOR DEVELOPMENTS INC.

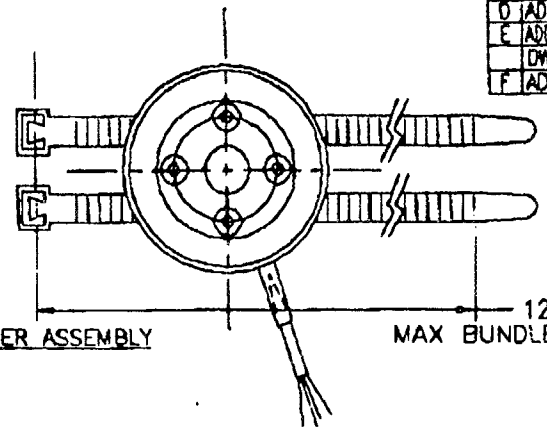
Michael G. Maher
Sr. Sales Application Engineer

Mail:
P.O.Box 290
Lake Orion, MI 48361-0290

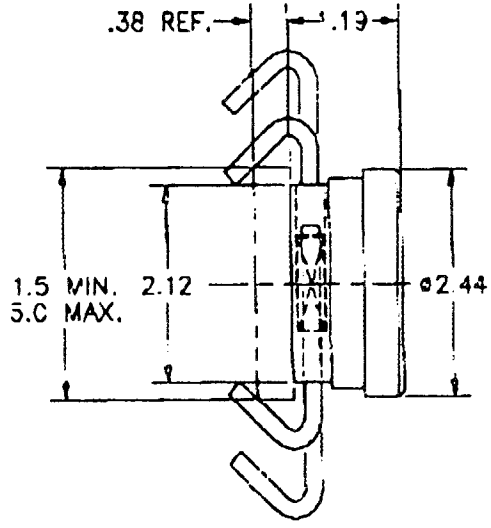
Shipping:
1050 W. Silver Bell Rd.
Orion, MI 48359

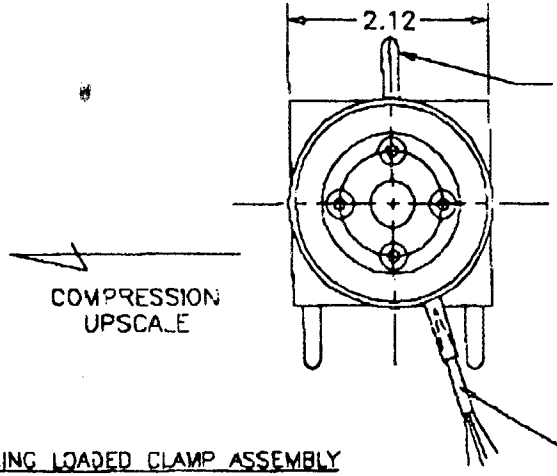
REV	DESCRIPTION	BY	DATE	C-IN	DWG	REL DATE
A	DRAWN & REVISED	ALC	8-30-91	–	–	-----
B	ADDED 250 LB CAP	KKB	11-18-91	–	–	-----
C	ADDED 400 LB CAP	ALC	2-3-92	–	–	-----
D	ADD 50 & 100 LB CAP	MJC	2-6-92	–	–	-----
E	ADDED CABLE TIE ASSY	KKB	9-21-92	GP	GP	10-1-92
	DWG WAS B-SIZE					
F	ADDED CHART	GLK	12-9-92	GP	GP	12-11-92





CABLE TIE ADAPTER ASSEMBLY





SPRING LOADED CLAMP ASSEMBLY

WIRING CODE	
COLOR	FUNCTION
RED	+ EXC.
GREEN	+ SIG.
WHITE	– SIG.
BLACK	– EXC.

SPECIFICATIONS: MODEL:10118

CAPACITY — 25, 50, 100, 200, 250, 400 LBS.
OVERLOAD CAPACITY — SEE CHART (F)
OUTPUT (NOM.) — +2mV/V
NON-LINEARITY — <.10% F.S.
HYSTERESIS — <.10% F.S.
REPEATABILTY — <.10% F.S.
COMPENSATED TEMP. RANGE — +70° TO +170° F
BRIDGE RESISTANCE — 700 OHM

MODEL NO.	OVERLOAD CAPACITY (LBS) (F)
11018-250	150
11018-051	150
11018-012	300
11018-022	300
11018-251	375
11018-042	600

INSTALLATION MODEL: 10118		CHECKED BY AC
		PROJ. ENG. GP
FINISH	SCALE FULL	DRAWN BY ALC
MATRL		DATE 08-30-91

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
X.X ±.03 X.XX ±.01 X.XXX ±.005 ANG. ±.5°

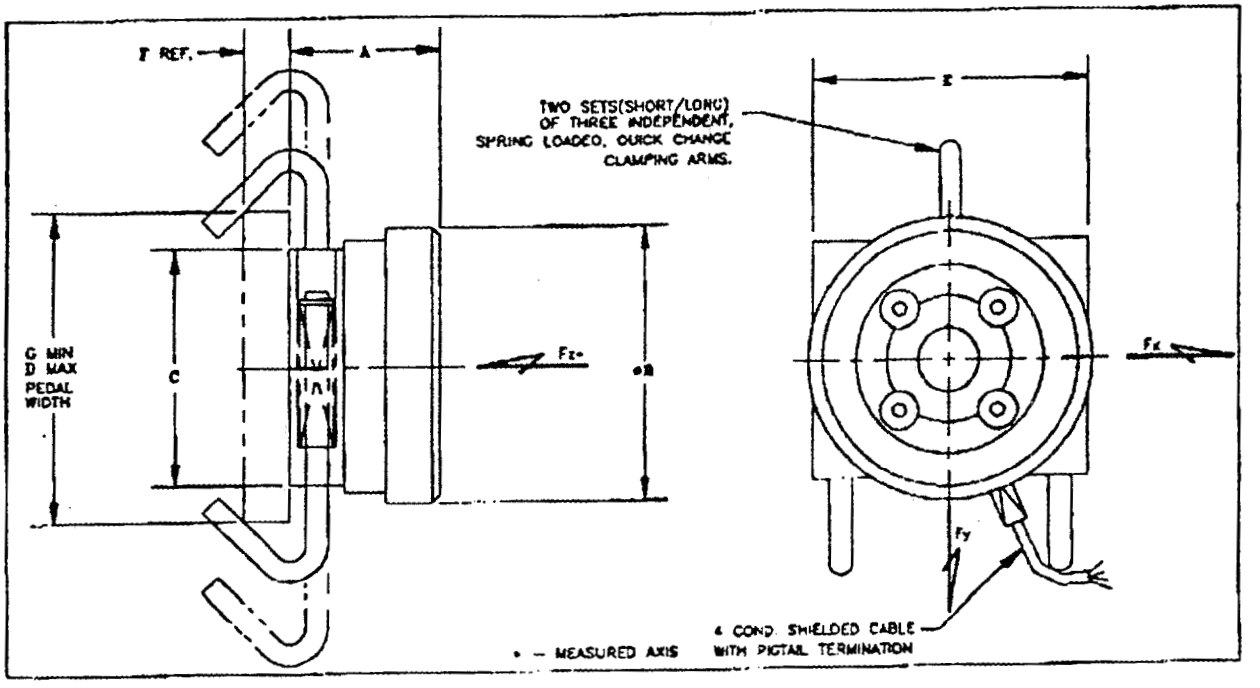
Sensor Developments Inc. 1050 W SILVER BELL RD OXFORD, MI 48359 — DRAWING NUMBER 12182C0-F

01/28/94 17:26 ☎ 313 391 8187 SENSOR DEV. INC. 02

MODEL 10118
BRAKE PEDAL TRANSDUCER

Sensor Developments' Model 10118 is designed to measure pedal force requirements. The transducer adapts to brake pedals in automobiles, trucks, buses or material handling equipment.

For easy installation, the transducer mounts directly to the pedal with spring-loaded, quick-change clamping arms. Capacities range from 50 to 200 lbs.



10118	A	B	C	D	E	F	G	H
in	1.19	2.44	2.12	5.0 max	2.12	.36	1.5 min	6 ft
cm	3.022	6.197	5.384	12.7	5.384	.915	3.81	182.88

Available Models: 10118-051 50 lbs
10118-012 100 lbs
10118-022 200 lbs

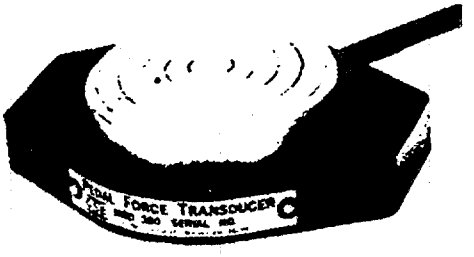
INSTRUCTION MANUAL
FOR
MODEL 3100
PEDAL FORCE
TRANSDUCER INDICATOR

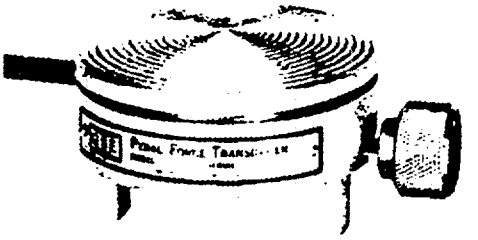
GSE INC.

23640 RESEARCH DR.
FARMINGTON HILLS, MI 48024 U.S.A.

(313) 476-7875, FAX: (313) 476-7249
TELEX: 23-0738

MODEL 300 and 300-CB PEDAL FORCE TRANSDUCERS



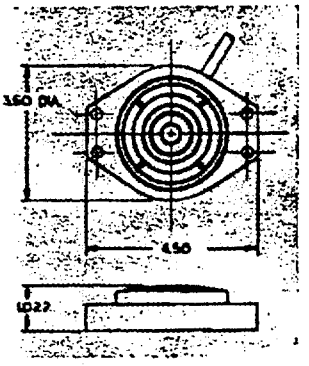


The Model 300 and 300-CB Pedal Force Transducers are specifically designed for use in automotive and truck brake testing applications. The compact, rugged, and light weight units accurately measure brake application forces regardless of the angle or position of the foot.

A unique suspension flexure completely isolates the measuring section from the mounting base. Installation forces and variations in geometry of the pedal on which the transducer is mounted have no effect on transducer accuracy.

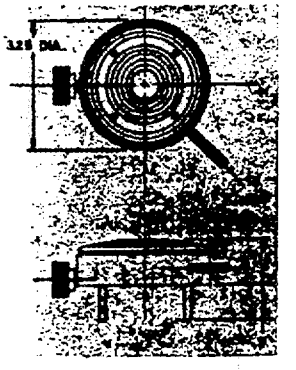
A built-in positive overload stop prevents damage to the transducer when loads beyond 150% of rated capacity are applied.

The basic difference between the Model 300 and 300-CB is in the design of the mounting configuration utilized for installation. The Model 300 is bolted to the pedal with four mounting bolts, whereas the Model 300-CB incorporates a vice-grip configuration for easy transfer from installation to installation.



SPECIFICATIONS

CAPACITY:	300 lbs., standard
BRIDGE RESISTANCE:	350 ohms
LINEARITY:	0.2% FS
ACCURACY:	Within 2% for all possible locations of force applications
BRIDGE EXCITATION:	15 VDC max.
OUTPUT:	1.5 mv/v-FS, nominal
WEIGHT:	15 ounces, nominal
CABLE:	8 ft. heavy neoprene insulated (includes connector)
PRICE:	Model 300 @ $575.00 Model 300-CB @ $675.00

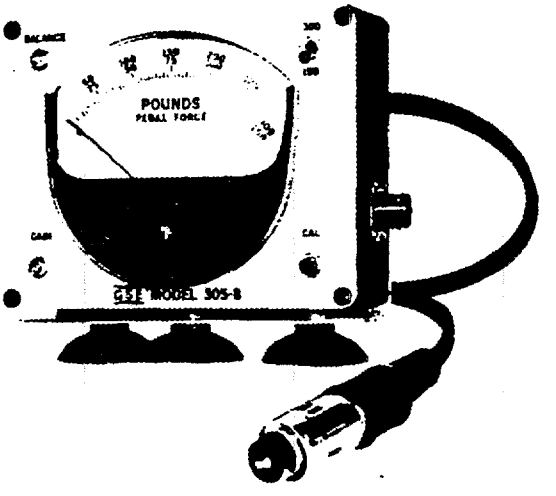


MODEL 305-B PEDAL FORCE INDICATOR

The Model 305-B Pedal Force Indicator is the companion instrument for the Model 300 and 300-B Pedal Force Transducers. The meter movement and associated electronics are specifically designed to provide extremely fast response time and low overshoot for brake testing. The instrument operated from the vehicle cigarette lighter outlet or external battery. An analog out-put jack is provided to drive additional instrumentation.

SPECIFICATIONS

ACCURACY:	±2% FS
INPUT:	350 ohm Strain Gage Transducer
POWER:	11 to 18 VDC at 60 ma
METER:	Dual Range, 150/300 3" Scale
AUX. OUTPUT:	1 volt full scale, nominal
SIZE:	5 x 4 x 2 inches
WEIGHT:	1.5 lbs.
MOUNTING:	(3) - 1.5 in. dia. suction cups with mounting bracket
PRICE:	$325.00
OPTIONS:	Special meter faces to fit specific customer requirements (consult factory for prices)



SPECIFICATIONS

Signal Input:	240 OHM to 700 OHM Four (4) arm strain gage bridge transducer with .75 mv/v to 3.1 mv/v sensitivity.
Bridge Excitation:	+9.5 volts DC
Meter Output:	Three (3) selectable scales 0-50 lbs. 0-100 lbs., 0-200 lbs. Peak or track
Meter Physical Specs:	4½", mirror scaled, analog meter (4" scale)
Tracking Accuracy:	+0.5% F.S.
Response Time:	0.7 Seconds Typical
Analog Signal Output:	0-2 volts (Floating) DC to 0-200 lbs. 1.0 mA maximum load
Step Response(1%-99% F.S.):	0.004 Seconds
Peak Acquisition Time:	0.020 Seconds
Peak Decay Time:	0.05%/minute typical
Zero Range:	± 75 lbs. (± .75 V)
Zero Thermal Stability:	Less than .1% / C^{o}
Span Thermal Stability:	Less than .14% / C^{o}
Controls:	"Zero" adjustment "Span" adjustment "Peak" adjustment "Reset"button "Cal" button "Range" switch with three (3) positions
Calibration Setting:	Simulation of 100 lbs. (.4 mv/v) with 350 Ω Bridge (GSE Transducer)
Power Input:	10-14 volts DC cigarette lighter plug with center pin positive.
Protection:	½ amp slo-blo fuse plus over voltage protection at +15 volts DC
Size:	8-1/64" long (12" with mounting plate) 4-9/32" high (4½" with mounting plate) 3" Deep
Weight:	2 Lbs.

OPERATION:

1. Connect the transducer to the instrument.
2. Plug the unit into any cigarette lighter that has the specified voltage
3. Adjust the "Zero" setting to read -0- on the meter. No load should be on the transducer for this adjustment.
4. Calibrate the instrument by pressing "Cal" and adjusting the "Span" setting to read full scale on the meter. The scale for the GSE transducer/instrument combination will be 0-100 lbs.

GSE INC.
23640 Research Drive
Farmington Hills, Michigan / 48335-2621 U.S.A.
Telephone (313) 476-7875
FAX. (313) 476-7249
Manufacturer of Transducers, DC Electric Tools and Automation Systems

QUOTATION

TO: Oak Ridge National Labratory
P.O. Box 2008
Bethel Valley Road
Bldg. 6025, MS 6360
Oak Ridge, TN 37831-6380

Attn: Frank Barickman
FAX 615-574-9619

COPY TO: Dale Sturm
G & A

DATE 01/31/94

QUOTATION QMC16,035

YOUR REFERENCE

F. O. B./EX-WORKS

TERMS: Net 30 days
Subject to Credit Approval

DELIVERY 12 Weeks,A.R.O.

The following quotation is being submitted in response to your recent request.

Item 1
Fifteen (15) P/N 114351-04301 **Price: $1,705.50** each
Model 4350 Pedal Force Transducer with vise grip mounting
- Rated Capacity - 300 lbs.
- Output @ Rated Capacity - 1.25 mV/V nominal
- Non-linearity - ± 0.5% FS
- Bridge Resistance - 350 ohms
- Excitation - 10 VDC Maximum
- Cable - Eight (8) foot long captive cable
- Cable terminates with Bendix PT06A-8-4P (SR) 4 pin connector

Item 2
Twenty-Five (25) P/N 114351-04301 **Price: $1,516.00** each
Model 4350 Pedal Force Transducer with vise grip mounting
- Rated Capacity - 300 lbs.
- Output @ Rated Capacity - 1.25 mV/V nominal
- Non-linearity - ± 0.5% FS
- Bridge Resistance - 350 ohms
- Excitation - 10 VDC Maximum
- Cable - Eight (8) foot long captive cable
- Cable terminates with Bendix PT06A-8-4P (SR) 4 pin connector

*** Frank, The only feasible way to reduce the height on the pedal sensor would be to eliminate the clamp base and have your pedal attatch directly to the unit. This could work if you can somehow have your pedal mount directly to the bolt circle from the base of the sensor.

If you have any questions, feel free to contact me.

Sincerely,

Michael J. Helwig
Product Specialist

SUBSIDIARY OF CORE Industries Inc

GSE Inc. Standard Conditions of Sale, listed on the back of this page, apply to ALL ITEMS quoted and sold by GSE Inc.

PFS → RJC

UFI MEMOFAX Dec. 17, 1993

TO: Dr. P.F. Spelt, **OAKRIDGE NATIONAL LABORATORIES**
FAX#: 615-574-7860
FROM: Pamela Baumann, Customer Service
PAGES: 3

Dear Dr. Spelt:

Attached are the data sheets regarding our model 3992 Biolog® ambulatory data recording system. The list price per unit is $3500 for a single channel and $4250 for two channels.

If you have any technical questions, please call and ask for either Harve M. Hanish or Marty Loughry.

If you would like to place an order, just ask for me.

A complete 1993 Compendium is being sent to you via U.S. mail today.

Thank you fore your interest in **UFI** and our products.

Very truly yours,

Pamela Baumann

Pamela Baumann
Customer Service

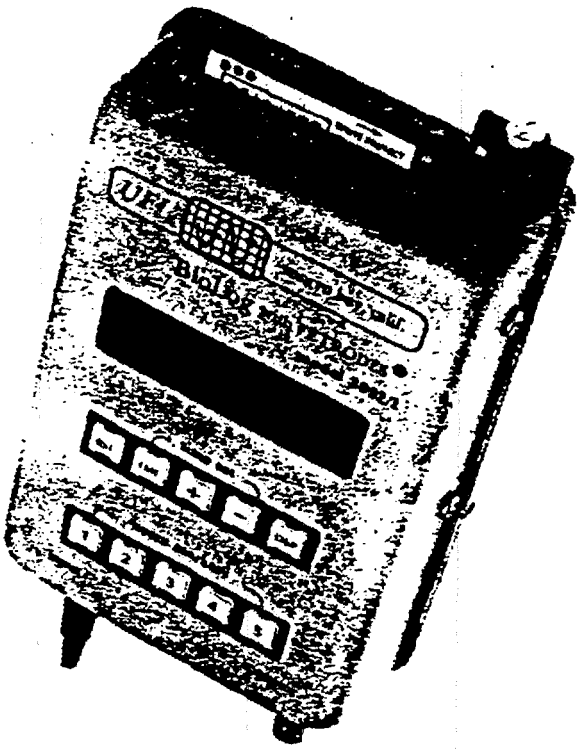
Fax 805-772-5056

UFI — serving science with experience

545 main street • morro bay, ca. 93442 • 805-772-1203

model 3992 BIOLOG® ambulatory data recording system *with FETRODES®*

We call our new BioLog® "ARNOLD" because it has a real attitude problem—



- ***AGGRESSIVE*** —
  Hunts down the data you want — even in the presence of noise.

- ***TENACIOUS*** —
  Holds on to the recorded data for up to 1 year.

- ***STEADFAST*** —
  Designed and constructed by UFI to yield years of faithful service.

- ***ADAPTABLE*** —
  Considerate design allows us to modify software and hardware to meet your changing research requirements.

— *designed by UFI at NASA's request* —

Reliably collects up to 6 channels of biological data from any ambulatory subject, in most environments, over an extended period of time.
The BioLog® assures confidence by giving you continuous feedback of both analog and digital system operation.

Inclusion of UFI's proprietary FETRODE® technology for bio-electric signals makes the BIOLOG® virtually unaffected by subject movement!

Can be configured to record:

- EGG (Electro-Gastrogram)
- IBI (Inter-beat Interval)
- Integrated EMG
- Pulse transit time
- Vocalization
- ECG
- GSR
- ENG
- Temp
- Activity
- Respiration
- Snoring
- Swallowing
- ***And many more***

Complete systems include <u>everything</u> required to record and download data into your computer. Subsequent detailed analysis, using your own spreadsheet software, is easily accomplished.

UFI *serving science with experience*
545 main street • morro bay, california • 93442 • 805-772-1203

3992 BIOLOG®
ambulatory data
recording system

specifications

physical——

size	4" x 6" x 1.5"
weight	22 oz.
case	deep drawn aluminum-- powder coated

power supply——

battery	standard 9 V. Alkaline
battery life	> 50 hours with 1 MB ram card

data storage——

medium	PCMCIA (68pin) 1 MB Ram Card (standard)
backup	internal lithium battery backup (> 1 year)
protection	internal write protect switch
download	<1 minute

misc———

sample rate	software configured--- supports variable rates for different channels
time	real time clock encodes time stamp in data field
event marks	5 available---encoded in data field with time stamp
display	16 x 1 characters--front panel display programmed to display continuous system status as well as incoming signal status, time, and key board activity

analog channels——

resolution 8 bits

All other analog characteristics are tailored to your requirements

All bio-electric channels use UFI's *FETRODES*® for artifact reduction!

Complete systems include all required FETRODES®, transducers, 1 MB RAMcard, card reader, and downloading software.

distributed by:

PRICES

3992/1	**(single channel)**	**$3,500**
3992/2	**(two channel)**	**$4,250**

+750/channel extra per Hans Hausch VP of engineering

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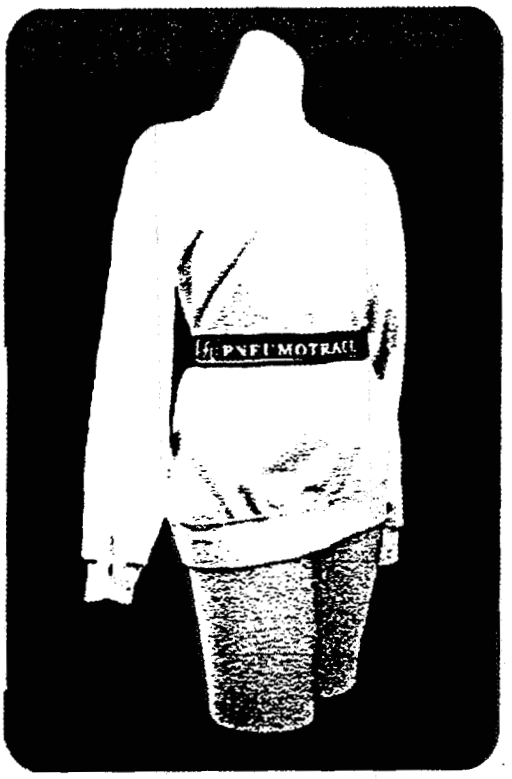
model 1130
PNEUMOTRACE®
respiration transducer



"an innovative solution to the often difficult problem of recording respiration over long time periods"

patent applied for

This radically new, solid state, strain gauge transducer responds linearly to changes in abdominal or thoracic circumference.

- RUGGED --- virtually indestructable!
- COMFORTABLE --- so supple and resilient it is perfect for use with the sleeping subject
- RELIABLE --- measures TOTAL circumference --- not just one small segment of the chest
- ADAPTABLE --- **easily connected** to ANY polygraph, impedance pneumograph or strip chart recorder
- ECONOMICAL --- replaces the bulky bellows/pressure transducer combination, while saving hundreds of dollars

SPECIFICATIONS

- SIZE--------2" wide x 0.125" thick x adjustable length (Regular size will accomodate circumferences of 12" to over 100". special sizes also available)
- RESISTANCE---200 ohms (units may vary +/- 50 ohms)
- WIRE LENGTH--6' nominal--can be 50 feet or more without degradation of performance
- CONNECTORS--as required
- WASHABLE

COVERED BY UFI'S EXCLUSIVE LIFELINE WARRANTY

UFI *serving science with experience*
545 main street • morro bay, california • 93442 • 805-772-1203

UFI MEMOFAX Feb. 8, 1994

TO: Frank Barickman, Oakridge National Laboratories
FAX#: 1-615-514-9619
FROM: Harve M. Hanish, VP Engineering
PAGES: 3

Dear Dr. Barickman:

Thank you for your recent telephone inquiry requesting information about our Model 3992 Digital BioLog® systems.

The attached quote is in response to your request. We are proposing to supply you with 8 channel BioLogs ® with the folliowing specifications:

Memory size ---- 2 Mb. PCMCIA Ram Card.

Channels---

ECG --- uses FETRODE® technology, 8 bit AD, non-clinical waveform (rate monitoring)
EOG --- uses FETRODE® technology, 8 bit AD, vertical or horizontal
EMG --- uses FETRODE® technology, 8 bit AD, supplies rectified envelope of signals
EEG --- uses FETRODE® technology, 8 bit AD, miniature Ag/Ag Cl Biodes®
RESP-- 8 bit AD, uses PneumoTrace® transducer, records analog waveforms
PPG -- 8 bit AD --- uses UFI's 1020 PPG transducer to derive pulse transit time or pulse wave velocity
TEMP -- CORE & SKIN --- 12 bit AD -- multiplexed on one channel 0-40°C-- 0.1° resolution
SCL -- BASAL --- recorded with 12 bit AD --- Sufficient resolution to derive ΔSCL from this channel with better than 0.05 μmho resolution.

Please note that these units are supplied complete with all necessary accessories such as software, transducers and re-usable electrodes. Also, while we have specified this as an 8 channel system, there are actually 10 channels of data being recorded.

more

We have some additional questions for you:

1. What are you expecting to derive from the EEG?
2. What locations will you use for the EEG?
3. Do you want vertical or horizontal EOG?
4. What muscle group will you use for the EMG?
5. Where do you expext to place the Core temperature transducer?
6. Where do you want to measure SKIN temperature?
7. Where do you want to measure PPG---ear, finger (thumbnail), forehead?
8. Where do you plan to mount the BioLog® ?
9. The software we supply with your system will download the contents of the ramcards as ASCII files into your computer. Is this satisfactory for your data analysis people?

Thank you for your interest in UFI and our products.

Please let me know if you need any further assistance.

Very truly yours,

Harve M. Hamsh
VP ENGINEERING

Fax 805-772-5056

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QUOTATION #9406

TO: Frank Barickman
Oakridge National Laboratories

VOICE: 615-574-6198
FAX: 615-574-9619

date: February 8, 1994
inquiry: February 2, 1994
terms: Net 10 Days
fob: Factory
delivery: 45-60 days ARO

item	quant	description	unit price	extension
1	1	Model 3992/8 BioLog® Complete 8 ch. system with card reader, software, with all transducers, and Fetrodes®		$ 10,000
2	2	1 complete system + 1 BioLog®		$ 18,750
3	3	1 complete system + 2 BioLogs®		$ 27,500
4	4	1 complete system + 3 BioLogs®		$ 36,250
5	5	1 complete system + 4 BioLogs®		$ 44,500
6	6	1 complete system + 5 BioLogs®		$ 52,750
7	7	1 complete system + 6 BioLogs®		$ 61,000
8	8	1 complete system + 7 BioLogs®		$ 68,750
9	9	1 complete system + 8 BioLogs®		$ 76,500
10	10	1 complete system + 9 BioLogs®		$ 84,250
11	11	1 complete system + 10 BioLogs®		$ 91,500
12	12	1 complete system + 11 BioLogs®		$ 98,750
13	13	1 complete system + 12 BioLogs®		$106,000
14	14	1 complete system + 13 BioLogs®		$112,750
15	15	1 complete system + 14 BioLogs®		$119,500

prices quoted are subject to 30 day acceptance

submitted by:

Harve M. Hanish

HARVE M. HANISH, VICE PRESIDENT

BIOLOG® SYSTEM DESCRIPTION

A basic BioLog® system consists of:

1. Patient carried data logger containing-
   timer, control, and power supply, the signal conditioner and memory circuitry.
2. Quick-Log® readout/ interface
3. SlickLog® computer interface with software

The timer, control, and power supply accurately determines the data logging interval, insures that the data goes to the correct location (address) in the memory, and furnishes regulated ± 5V to all of the Biolog circuitry. The signal conditioner and memory circuitry puts the measured variable in the proper format, converts this analog data into a meaningful digital number, and stores it in proper sequence in a solid-state memory chip.

The QUICKLOG® (Model 3902 QL) has been designed to easily recover the data stored in your BIOLOG® Memory. This battery-powered instrument allows immediate, non-destructive readout of this data. Readout may be performed under manual control (step-by-step) or automatic control. Sample rates for automatic readout are selectable between 1,2,5, and 10 per second.The QuickLog® converts the digital information contained in the BioLog® memory into an analog signal. This reading is displayed on a front panel LCD meter and is also available for plotting on any strip chart recorder, as shown below.

QuickLog® Specifications:

Size:	6" X 6" X 2.5"
Weight	1.25 lbs.
Power:	9V Alkaline Battery (MN 1604 Duracell).
	Battery life— 30 hours (continous)
	3-6 months avg. use
Readout:	3 1 2 digit -- liquid crystal display
	0-2.55V @ output for strip chart recorder.
Channels	1 or 2
Sample rates:	Manual, Auto-- 1,2,5, 10 per second.

QuickLog® Software Specifications

Computer supported	IBM PC or compatible with 286, 386, or 486 processor.
Operating system	DOS 3.1 or newer and WINDOWS® 3.0 or 3.1
Functions	Download and store BioLog® data as ASCII disk files
	Create and review short annotation messages
	Print PLOT sections
	Recall previous files for analysis.

The BioLog® has been designed to transfer its data directly to most PC-type computers using the QuickLog® together with the SLICLog® computer interface and appropriate software(supplied). The data are stored in an ASCII file which may easily be imported to any of the popular spread sheet programs (such as Lotus 1-2-3®) for more intensive analysis.

SLICLog® Specifications

Size	6.35" x 9.5" x 1.4"
Weight	1 lb. 4 oz.
Channels	1 or 2
Input Connector	BNC
Output Connector	DB 25 (Serial Port)
Baud Rate Clock	Crystal Controlled
Baud Rates	9600, 4800, 2400, 300
Power	Wall transformer type DC supply

BIOLOG® TECHNICAL SPECIFICATIONS

SIZE AND PACKAGING:	All of the 3902 systems are housed in rugged, extruded aluminum enclosures measuring 1.00" X 3.0" X 4.0".
Number of Channels	1 or 2
Power:	9V Alkaline battery (MN 1604 Duracell) Battery Life ≈ 80 hours
Memory:	(2K X 8) per channel - non-volatile (on chip lithium battery- stores data for 10 years).
Logging Rate :	Nominal—1/minute— other rates available
Heart Rate:	**USES UFI FETRODES® FOR NOISE IMMUNITY** Input signal–ECG (.5mV to 2.5mV) R wave –variable threshold—aural monitor to adjust triggering Input connector–Switchcraft TB4
Temperature:	Range–as specified by customer –96 - 106 (core temp.), etc.
EMG:	**USES UFI FETRODES® FOR NOISE IMMUNITY** Input signal– 20μV to 3mV. Input connector–Switchcraft TB4
Activity:	Uses UFI's unique " Jitterbug" Actigraph transducer. Equally sensitive to the first derivative of acceleration in all three axes.
Respiration:	Uses PNEUMOTRACE®– UFI's proprietary new system which records reliable respiratory data, even in the presence of exercise and arm motion.
Sensitivity Adjustment:	Each Biolog channel has an external jack which allows you to aurally monitor total system operation.. A beep is heard each time a counter is incremented. Using this exclusive system monitor, a screwdriver control facilitates accurate and fast adjustment of each channel's sensitivity to accomodate your experimental requirements.
Warranty	1 year parts and labor

HEART RATE & RESPIRATION

Heart rate is measured using UFI's proprietary **FETRODE®** technology. The FETRODES® reject and filter out unwanted signals and noise. The remaining raw ECG is amplified and shaped so that the "R" wave becomes a reliable pulse to be counted. The resulting pulses are totalized for the selected period (usually one minute). The total is then converted to an eight-bit digital (binary) number and stored in the memory. When the address/counter has stepped through all of its memory locations(2048 in the standard BioLog®), it automatically stops logging, preventing erasure of the previously stored data. Data will be stored for up to 10 years or until erased.

Respiration is handled in a similar fashion, using a Model 1130 PNEUMOTRACE® Respiration Transducer to generate the proper signals.

EMG & ACTIVITY.

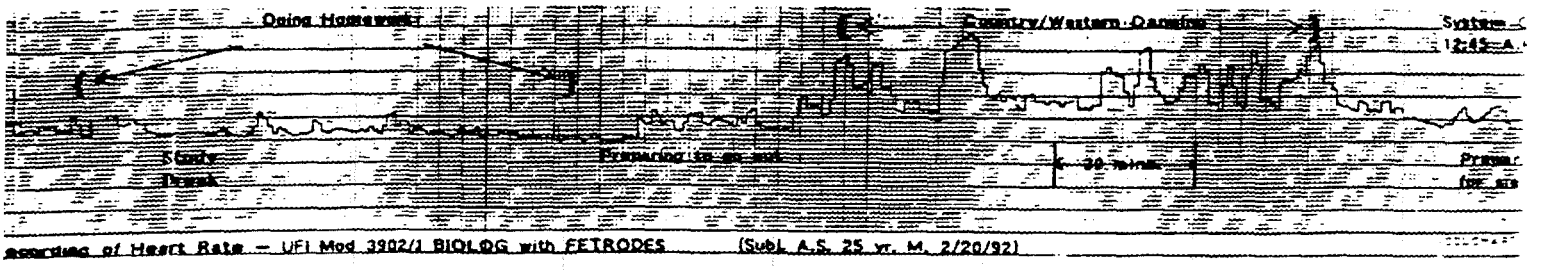
High frequency signals (such as EMG and activity) are amplified, rectified, and integrated. Again, **FETRODES®** are used to acquire noise-free EMG signals—**IN ANY ENVIRONMENT!**

Activity is measured with UFI's JITTERBUG activity transducer which is equally sensitive to motion in all axes.

The integrator is essentially an electronic "bucket". Each time it fills up, it is automatically dumped. A digital counter totals the number of times the integrator is dumped (or reset) each minute. This number is stored in the BioLog® memory. Thus, **total activity** is measured with zero drift, very low current consumption, and very high accuracy..

TEMPERATURE

Temperature is sensed using very accurate, linear, interchangeable probes. The signal from the probe is directly converted into a digital number. At the designated sample time, this number is stored in the memory. Depending on the required range, temperature resolution can be better than 0.1° F



UFInformer

a chronicle of progress in the instrumentation arts

NUMBER ONE | morro bay, california | FALL 1989

A SLIC SOLUTION

SLIC—— Serially Linked Interface Component—
Cuts the cost of computer based data acquisition. Imagine! EIGHT channels of data input to your computer for a mere $62.50 per channel! NOW, most of your old (and new) lab instruments can be easily connected to your computer via UFI's latest addition to the art of instrumentation —SLIC. No longer will you require an expensive A-D board and even more expensive interface board. SLIC contains an 8 channel multiplexer, A/D converter and all of the other electronics required to convert your analog data into a digital stream compatible with your computer's serial (RS-232) port.

SLIC SPECIFICATIONS

Input Range:
0-+2.5 volts
Sample Rate:
Baud rate/10/ # of channels
Baud Rates:
300, 1200, 2400, 4800, 9600
Power Supply :
Battery or AC adapter
Resolution:
0.004 (8 Bits)
Inputs:
8-Single ended

Software to assist in data display, storage, and analysis is also available from UFI. Of course, SLIC data files are compatible with most other popular software programs.

SLIC 8000 —PRICE $500

UFI BEGINS TWELFTH YEAR

serving science with experience

For the past 11 years we have been dedicated to the concepts that instrumentation can be excellent without being exorbitantly expensive; that the instrument-crafter can be —yes, should be—part of your research team; that we can find a rewarding life—serving science with our experience.

These past 11 years have been rewarding. They have also been tough...because your instrumentation problems, at least the ones you brought to us, have been tough. We are known for usually delivering on those problems—— usually late —but delivering!

It is rewarding for us to look back at some of the unique instruments and systems we delivered with sweat, blood and often, some tears, over the past years.

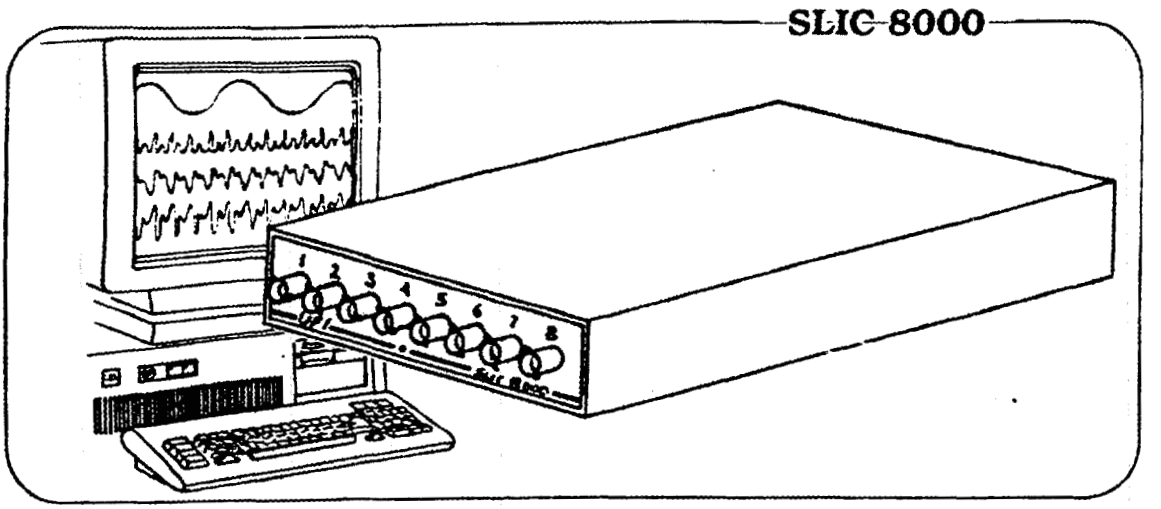
Now, as we look forward to the next decade, this is a time for reflection and analysis. Those things we have done right — such as our unique LIFELINE WARRANTY — we will continue to do. Those things we have done not so well or so swell — (yes, there are skeletons in every closet) we will strive mightily to correct.

This, then, is UFI's promise to the scientific research and teaching community—to continue to serve— with care and experience!

HIGHLIGHTS - A LOOK BACK AT 11 YEARS OF PROGRESS

- Electrode impedance meter for US and European space shuttle
- Electro-capacitance plethysmograph for accurate non-invasive measurement of blood flow
- JITTERBUG®— activity transducer
- BIOLOG® ambulatory data recording system
- PNEUMOTRACE® respiration transducer
- TETRAPOLAR HIGH RESOLUTION IMPEDANCE METERS (THRIM)® for space shuttle, for bladder filling studies in paraplegics, for fluid shift studies on humans during exposure to high G's.
- SEALINK — Underwater, long-range, physiological telemetry and data acquisition system for freely swimming divers

UFI • 545 main street • suite C2 • morro bay • california • 93442 • (805) 772-1203



SLIC---Serially Linked Interface Component---Cuts the cost of computer based data acquisition. EIGHT channels of data input to your computer for a mere $62.50 per channel! Virtually any laboratory instrument can be easily connected to your computer via UFI's latest addition to the art of instrumentation. No longer will you require an expensive A-D board and an even more expensive interface board. SLIC contains an 8 channel multiplexer,, A-D converter, and all of the other electronics required to convert your analog data into a digital stream compatible with your computer's serial (RS-232) port.

SLIC data files are compatible with most popular software programs used for data analysis. Software to assist in data display, storage, and analysis is also available from UFI.

SPECIFICATIONS

Input Range	0- +2.5 Volts
Sample Rate	Baud Rate ÷ 10 ÷ # of Channels
Baud Rates	300, 1200, 2400, 4800, 9600
Power Supply	AC Adapter or 9 Volt battery
Resolution	0.004 (8 Bits)
Inputs	8 - single ended, BNC connecor
Size	6.35" x 9.5" x 1.4"
Weight	1 lb. ,4 oz.

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isoSLIC 8000
ISOLATED
COMPUTER INTERFACE

SPECIFICATIONS

ANALOG INPUTS	
# of Channels	8
Input Connectors	Miniature (3.5 mm) 2 ckt. phone jack
Input Voltage Range	0.0 to +2.5 V.
Isolation	>2,500 V.
A-D CONVERSION	
Conversion Protocol	Single Byte Channel select/Initiation Automatic Conversion /Re-Transmission
Resolution	0.004 (8 bits)
Sample rate	200 Hz. divided by # of channels being polled (@ 9600 Baud)
SERIAL INTERFACE	
Serial Protocol	RS 232-C
Baud Rate Clock	On board, Xtal controlled, switch selectable
Baud Rates	9600, 2400, 1200, 300 (others available)
MISCELLANEOUS	
Power supply	110 VAC "Wall mount" type, 9-12 VDC
Size	6.35" x 9.5" x 1.4"
Weight	1 Lb. 8 oz.

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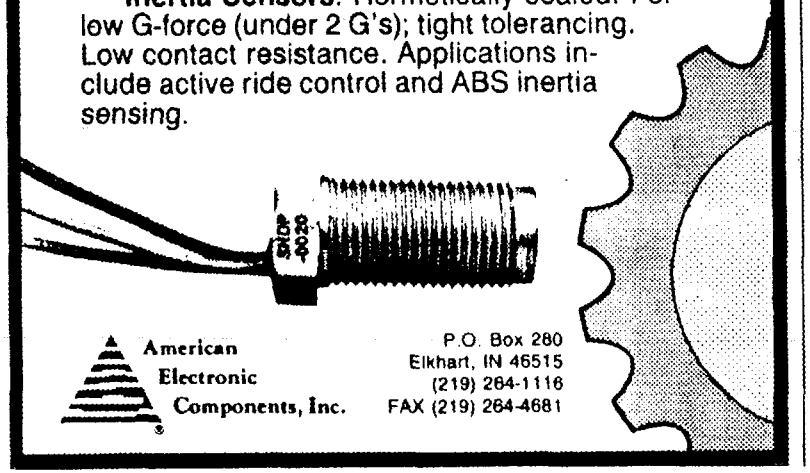
Sensors.

Hall Effect Magnetel® Sensors. For speed and position sensing. Wide operating temperatures (-40°c to +150°c); wide air gap. Drop in, Bolt 'n Go. True zero speed. Power-up recognition. High data resolution. Applications include cam and crankshaft speed and position, transmission input/output shaft speed, ABS wheelspeed sensing, and throttle position sensing. Also, general industrial controls and equipment.

Variable Reluctance Sensors. Typically used in applications where supply voltage is not available. Wide air gap; high signal output; wide temperature range (-40°c to +150°c). (See "Magnetel®" applications above).

Inertia Sensors. Hermetically sealed. For low G-force (under 2 G's); tight tolerancing. Low contact resistance. Applications include active ride control and ABS inertia sensing.

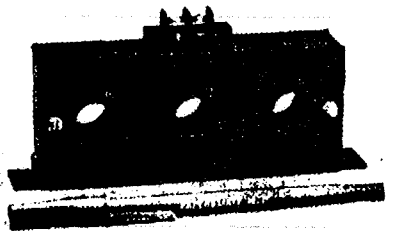


American Electronic Components, Inc.

P.O. Box 280
Elkhart, IN 46515
(219) 264-1116
FAX (219) 264-4681

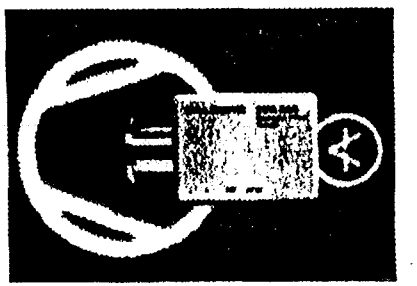
Circle 30 on *Sensors* RS Card

AC Current Sensor



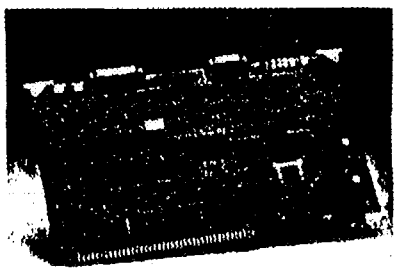
Riley Corporation Sales, Inc., Houston, TX, introduces the Model 3P, which measures all 3 phases of DCS systems and outputs the average of the readings via a 4-20 mA signal. This allows the user to immediately see a change in the reading of any of the legs in the system. **SEN Circle 114**

Compact Vacuum Gauges



Balzers, Hudson, NH, introduces the TPR 250 Compact Pirani gauge. Features: measures medium-to-high vacuum from atmosphere to 3.75×10^{-4} torr; needs no charts or conversion tables; doesn't require a separate controller. **SEN Circle 115**

Motion Control Board



Delta Computer Systems, Inc., Vancouver, WA, introduces the MC 186/40, which offers 4-axis position control of hydraulic and electric servo systems. Features: direct connection to magnetostrictive transducers; onboard processor with complete feed forward PID loop. **SEN Circle 116**

American Electronic Components, Inc.

Hall Effect Sensors

What are they?

A Hall effect sensor is essentially a solid state transducer with integrated control circuits and an electronic switch. A transducer changes physical characteristics (magnetic field strength, in this case) into an electrical signal (voltage).

A Hall effect transducer is a small sheet of semiconductor material activated by a magnetic field. A constant voltage source causes a constant bias current to flow in the semiconductor sheet.

When the Hall transducer is placed in a magnetic field with flux lines at right angles to the current, a voltage is produced at the opposite edges with an output directly proportional to the strength of the magnetic field. The other circuits of the IC amplify this transducer voltage into a strong output, thus converting the magnetic flux into output voltage. Hall effect sensors are, therefore, magnetically operated transducers.

The sensor assembly is a finished component with a plastic or stainless steel housing, with mounting capability and lead-wire terminations or an integrated molded connector, containing a Hall sensor IC and magnetic circuits. Other desired or necessary electronics, such as electrical protection from over-voltage, can also be included. The sensors generally have three leads—input, sensing, and ground—but two lead designs are also possible.

Why are they used?

Many switching and sensing requirements make non-contact Hall effect sensors an attractive alternative, such as:

- with a virtually unlimited life, they are a more reliable means of switching than mechanical contacts
- they can provide a signal directly to a computer logic circuit
- an existing steel gear or sprocket can serve as the sensed rotating member for RPM sensing
- a permanent magnet fixed to a machine part can serve as the sensed member
- they are a lower cost method of sensing the proximity of a steel machine member vs. other electronic proximity sensors

Hall effect sensors can be used for proximity, position, RPM, speed, and gear tooth sensing; on/off and limit switching; ignition timing; and other applications.

What do we have to offer?

American Electronic Components, Inc. has three versions of custom OEM Hall effect sensors: a) Hall effect magnetic sensors, b) zero speed Hall effect rpm sensors, and c) a combination Hall effect proximity and zero speed rpm sensor.

All provide a digital output and are easily applied to 5 to 12 VDC Logic circuits. And, because of an internal voltage regulator, they will properly function with a varying supply voltage from 5 to 24 VDC. They will function at temperatures from −40°C to +170°C and at air gaps up to .100 inches, with an appropriate target.

a) Hall effect magnetic sensor

This Hall effect sensor detects the presence or absence of a permanent magnet, activated when the magnet either "slides-by" in front of the sensor or approaches the sensor head-on. The sensor is placed in a permanent position where the magnet will pass sufficiently close to the sensing face to assure operation of the output. Several mounting bracket configurations are available.

b) Zero speed Hall effect sensor

A biased magnet is permanently mounted behind the Hall effect IC to sense the presence or absence of rotating steel teeth. As the ferrous toothed or notched wheel passes in front of the Hall sensor, the magnetic flux is concentrated through the sensor.

This change in magnetic field strength is used to actuate the sensor output for every notch or gear tooth which passes. It provides an output pulse for each time that it senses the transition of an approaching tooth edge, regardless of the wheel's speed of rotation. The number of teeth of the target wheel determines the number of output pulses per revolution, one pulse per tooth.

This sensor is available in a standard design, part #SHDG-0008 and also in custom OEM designs.

c) Hall effect proximity and zero speed RPM sensor (patent #4,970,463)

The presence or absence of steel objects or steel teeth as they approach or rotate by is sensed with this combination Hall effect sensor. No external magnet is necessary, as the proximity of a steel object is sensed immediately on circuit "power-up," even in the static condition before movement or rotation begins.

It will sense the presence or absence of a notch or tooth on a simple ferrous wheel and monitor the speed, position, and timing of that rotating wheel, providing an output pulse for each approaching tooth edge, regardless of the wheel's speed of rotation. The "power-up" feature can simplify control system software and avoid false indications which could cause control errors.

DPI 17219

1990 AEC 0791
Rev 4/93

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Components, Inc.

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PRODUCT RELEASE

Patent received for activation method of sensor

American Electronic Components, Inc. has received a patent (#4,970,463) for its Hall effect sensor which combines zero speed gear tooth rpm sensing and proximity sensing, even on circuit "power-up."

This new electronic sensor is based upon a Hall effect integrated circuit and self-contained magnets. It is capable of sensing the presence or absence of a tooth or notch of a rotating ferrous object and is able to monitor the speed and position of the rotation.

The patented Hall effect sensor does not rely on the conventional method of activation of directing the magnetic field from one of the pole faces of the permanent magnet through a sensing plane. Instead, it relies upon magnetism which emanates from a lateral surface of the permanent magnet, intermediate the opposing pole faces. In addition, it functions as a proximity sensor giving the proper output immediately on power up, without motion of the target object.

As a result of the patented activation method, the sensor is also capable of operating at changing temperatures and at temperatures ranging from −40°C to +170°C. The wide range of temperatures the sensor is capable of operating in makes it useful for crank or cam shaft sensing in automobiles, as well as ignition timing and other rpm sensing systems.

- more -

The sensor is positioned at the periphery of the toothed or notched wheel so that the end of the sensing face clears the rotating teeth such that an air gap exists between the sensing face and the adjacent tooth. The sensor will provide an output pulse for each time that it senses a passing tooth or notch, regardless of the wheel's speed of rotation. The number of teeth or notches of the target wheel determines the number of output pulses per revolution, providing one pulse per tooth or notch.

Hall effect sensors can provide a computer compatible output signal, with a high signal to noise ratio on a low impedance load, independent of wheel speed and air gap distances. These sensors eliminate the need for shielded cable, minimize control circuit interface considerations, and provide broad frequency response.

The sensor housing may be made of plastic, metal, or ceramic, and may include a potting compound and insert molding. Non-oriented and/or fixed mounting are both feasible since only a single threaded mounting hole may be needed and an extremely wide range of air gaps are possible. The sensor output is easily applied to 5 to 12 Vdc logic circuits without the need for amplification or signal conditioning circuits.

Although this sensor will eventually be offered as a standard packaged sensor, currently it is only available in custom designed OEM quantities.

American Electronic Components, Inc. is also a manufacturer of mercury switches, sensors, and relays, plastic injected parts, wire assemblies, and sump pump floats.

###

Contact:

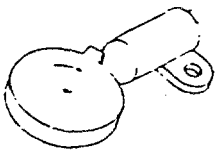
219-264-1116
July 1991
Rev 4/93

DP: 17221

American Electronic Components, Inc.

HALL EFFECT SENSORS

General Information:
Series: Proximity Hall Sensor (Dual edge sensing gear tooth and/or proximity sensors)



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Fax (219) 264-4681
Telex 25-8482

Advantages

- Power up recognition
- Functions both as a gear tooth and proximity sensor
- Senses wheels with large tooth pitch
- Senses both the first and second tooth edge
- High temperature automotive compatibility
- Wide frequency response from "zero" speed to over 10,000 Hz
- Direct TTL compatible, digital output pulse, one pulse per tooth
- Low impedance output signal resists interference without shielding
- Precise control of air gap dimension is unnecessary
- Large air gap is permissible
- Long experience in design of Hall Effect sensors and their production processes for high temperature automotive use

Applications

— *Crankshaft ignition/injection timing*
— *Camshaft position*
— *Proximity sensor/switch*
— *Transmission sensor*
— *Differential sensor*
— *Non-automotive*

Technical Data (preliminary)

Type: Active sensor for detecting both edges of a passing tooth, or sensing the proximity of a steel object, providing a digital output pulse, even down to "zero" speed.

Principle: Magnetic field shift (patent # 4,970,463 11/13/90).

Construction: Silicon-based IC, together with (or without) additional discrete protective components, on an epoxy PC board in SMD technology, all hermetically-sealed with epoxy encapsulant in a plastic or metal housing with either a special integrated electrical connector, or with a cable and discrete connector.

Housing dimensions: Custom made per customer's requirements. Typical minimum dimensions for sensors which do not utilize internal discrete components for circuit protection:

A) Air gaps of 0.0 mm to 2.0 mm (from the sensitive face to the tooth): 18 mm diameter (min.) x 25 mm length (min.).
B) Smaller diameter limits to 10 mm are possible.

Housing material: High temperature plastics or metal, per customer requirement.

Supply voltage: 4.5 VDC to 24 VDC.

Quiescent current: 5 to 8 mA (typical).

Temperature range: -40° to +150° C continuous (+170° C temporary).

Output signal type: Digital; NPN transistor, (open collector, current sinking).
(Note: a current-limiting series resistor must be provided either within the sensor, or on the system controller board; the output connection is made between the series resistor and the sensor's output transistor.)

Output signal voltage, "high" logic state: Equals supply voltage, minus the voltage drop across the series resistor (and also minus the voltage drop across the reverse-polarity protective diode, if used).

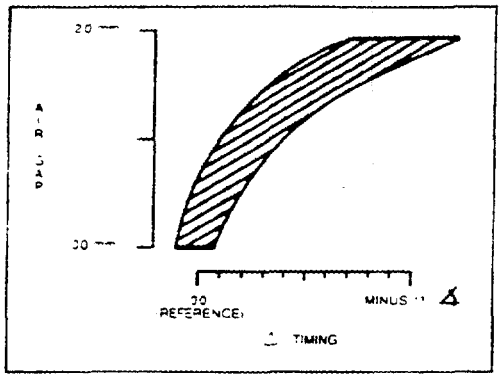
Output signal voltage, "low" logic state: 100 to 200 mV (typical).

Output signal current: 20 mA (maximum).

Rise time of the pulse: 800 nSec (typical) @ +25° C; 1.2 microSec (typical) @ +150° C.

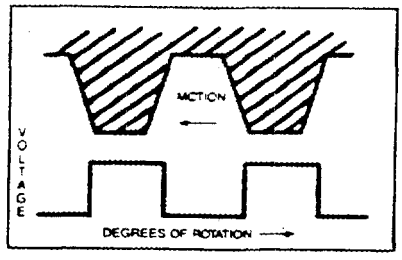
Fall time of the pulse: 250 nSec (typical) @ +25° C; 400 nSec (typical) @ +150° C.

Timing variation: At a 0.0 mm air gap, the moment when the pulse falls will vary ±0.1° ∡ (typical*) within the full temperature range. At a 2.0 mm air gap, the moment when the pulse falls will vary ±0.25° ∡ (typical*) within the full temperature range. At a constant temperature, the moment when the pulse falls will shift -1.0° ∡ (typical*) at 2.0 mm air gap, referenced to 0.0 mm air gap.



*All values apply only to a toothed wheel of 300 mm diameter; variation increases as wheel diameter decreases.

Relationship of pulse timing versus tooth position: The pulse rise occurs as the first edge of the tooth arrives near the center of the sensor housing, and the pulse fall occurs after the second edge passes beyond the center of the sensor.



Toothed wheel dimensions:

A) For a 0.0 to 2.0 mm air gap: tooth thickness of 5 mm (min.); gap between adjacent teeth 10 mm (min.), thus a tooth pitch of 15 mm (min.); tooth width 7 mm (min.); tooth height (consult factory).
B) For small air gap ranges: consult factory for minimum dimensions.

C100 COMPASS ENGINE
TECHNICAL MANUAL

KVH Part No. 54-0044
Revision G
May 24, 1993

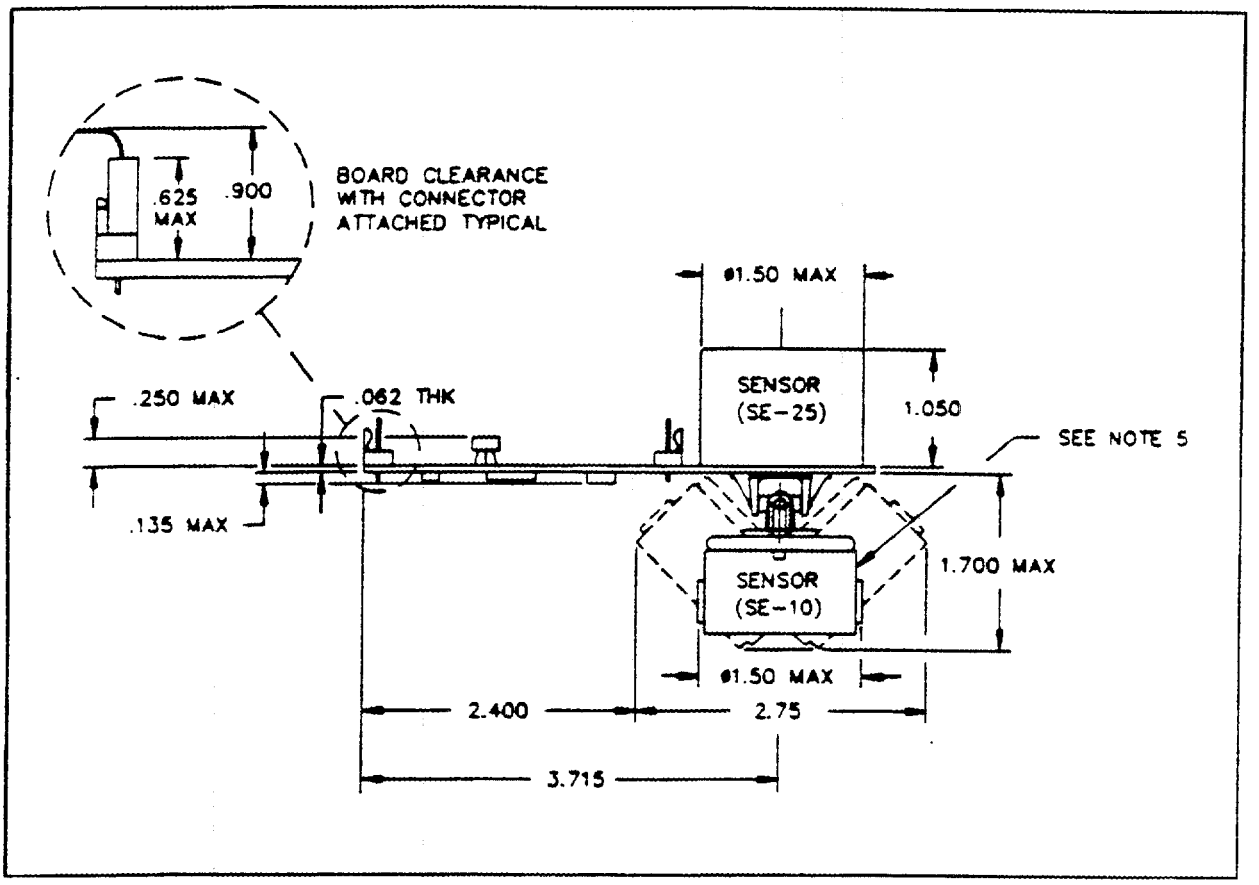
KVH Industries, Inc.
110 Enterprise Center
Middletown, RI 02840
(401) 847-3327

1.1 Sensor Type

Two fluxgate sensors are available.

The SE-25 is the standard sensor provided with the C100. The C100 should be mounted in a level attitude in the host system. This sensor will operate through tilt (pitch and roll) ranges of ±16°.

The SE-10 is a gimballed sensor which will operate through ±45° of tilt (pitch and roll). Its circuit board should also be mounted in a level attitude for optimum tilt performance. If the installation requires the gimballed sensor, it should be specified when the C100 order is placed.



Following are step-by-step instructions for correct installation. Make sure that whomever is going to install your C100 is familiar with these installation instructions and understands the principles of installation that ensure your sensor has the precision, convenience and usefulness for which it is designed.

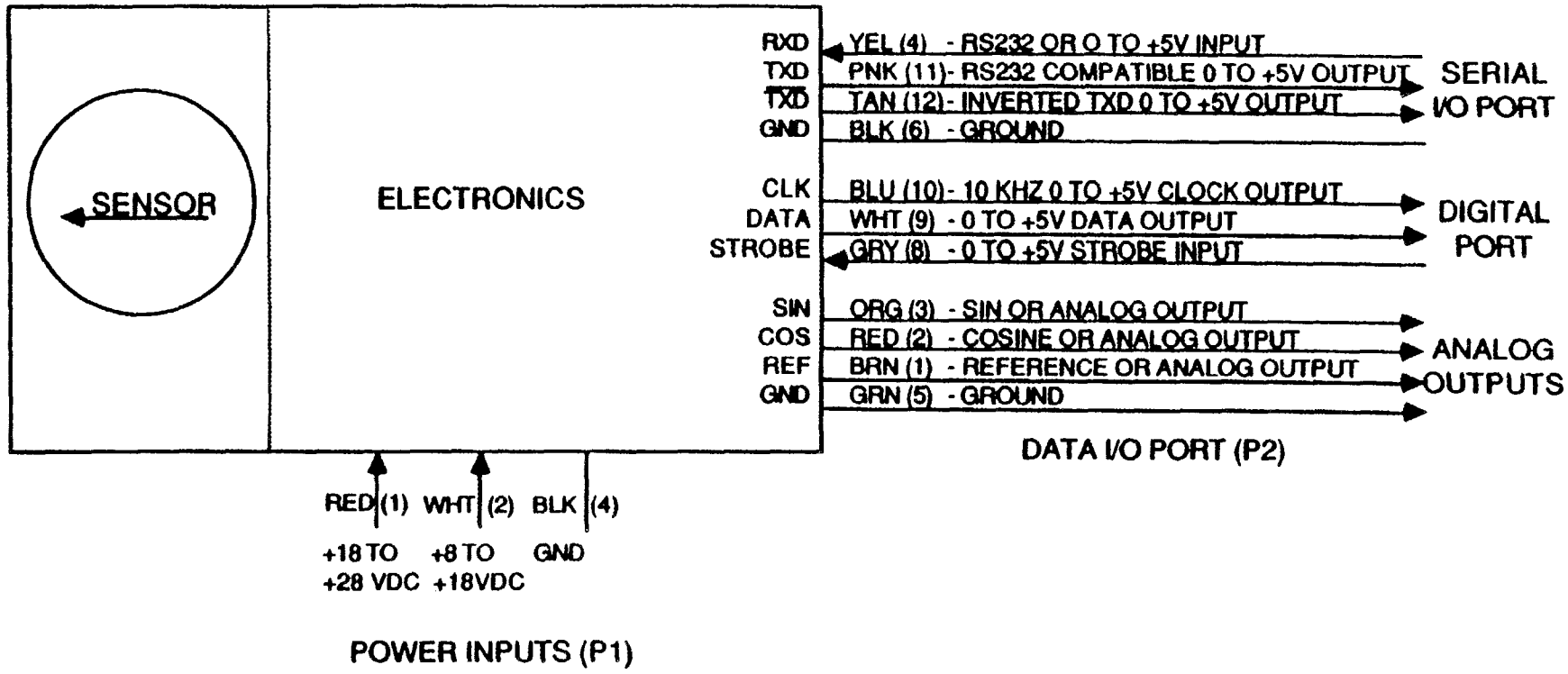


Figure 4-1.
C100 Interface Features

II FEATURES AND SPECIFICATIONS

1 Default Values

When you receive your C100 it will be factory configured as follows:

Heading Type:	Variation Off
Variation:	0.0
"A" Offset:	0.0
Powerup Mode:	Sending
Baud Rate:	4800
Message Rate:	1 Hz Continuous
Message Type:	NMEA
Message Units:	Degrees
Digital Output Type:	Continuous
Digital Output Format:	4 Digital BCD
Analog Output Format:	Linear
Damping Type:	Double Infinite Impulse Response Filter (Double IIR) (Similar to a 2 section RC LPF)
Damping Rate:	3 Seconds (to Final Value)

2 Features

The serial port allows the user to communicate and configure the C100 to their own individual requirements. The following selectable parameters and features are included in the C100 compass:

Variation:	0 to ±359.9° or 0 to ±6399 mils
"A" Offset:	0 to ±359.9° or 0 to ±6399 mils
Baud Rate:	300 to 9600
Message Rate:	up to 10/sec or on command
Message Type:	NMEA, KVH, X&Y corrected and uncorrected
Message Units:	degrees or mils
Digital Output Type:	continuous at selected message rate or strobed
Digital Output Format:	BCD, Binary, Gray
Analog Output Format:	sin/cos/ref, linear, linear with hysteresis
Damping Type:	undamped, single IIR, sum & dump, double IIR
Damping Rate:	3 seconds to 24 seconds (to final value)
Autocal:	user enabled

III APPENDIX

A Technical Specifications

Performance

Accuracy*	±0.5° or ±10 mils RMS (SE-25 Coil Assembly and digital/serial outputs)
Repeatability	±0.2° or ±5 mils (SE-25 Coil Assembly and digital/serial outputs)
Resolution	0.1° or 1 mil
Dip Angle	±80° Maintains stated accuracy, after autocal, over ±80° Magnetic Dip Angles
Tilt Angle*	±16° (SE-25 Coil) Dev.=±0.3° RMS ±45° (SE-10 Coil - Gimballed) Dev.=±0.5° RMS
Electrical Power	Input Voltage: +8 to +18 VDC or +18 to +28 VDC - user selectable Current Drain: 40 mA DC; maximum
Variation/ Declination	±180.0° adjustment range (offset) - user selectable
Index Error Offset	±180.0° adjustment range (offset) - user selectable
Damping	0.1 to 24 seconds (to final value) - user selectable

*Accuracy measurements apply to a level compass module after compensation. After installation and autocompensation, typical accuracies of 0.5° are achievable on most platforms.

Characteristics

Size	Electronics Board: 1.80" x 2.80" x 0.40" (4.6 cm x 7.1 cm x 1.0 cm) Sensor Board: 1.80" x 1.58" x 1.10" (4.6 cm x 4.2 cm x 2.8 cm) (SE-25 Coil). Gimballed coil (SE-10) hangs 1.70" below the PC board. Combined Board: 1.80" x 4.50" x 1.10" (4.6 cm x 11.4 cm x 2.8 cm) (SE-25 Coil)
Weight	2.25 ounces (64 grams) with SE-25 Coil Assembly
Operating Temp.	-22°F to +122°F (-30°C to +50°C)
Storage Temp.	-71°F to +160°F (-57°C to +71°C)
Shock/Vibration	Designed to meet MIL-STD-810 shock and vibration requirements
Altitude	Designed to meet 40,000 ft. MSL (operating and non-operating)
Reliability	MTBF calculated to exceed 30,000 hours

Input/Outputs

Digital Interfaces*

Serial Port	RS232 Compatible	Bidirectional Serial Data, UART Format with ASCII Characters, (1 start, 8 data, 1 stop, no parity), 300 to 9600 baud - user selectable
	Serial Input	Accepts RS232 levels or 0 to +5V Logic Levels
	Serial Output	Same as RS232 except for 0 to +5V Logic Levels, (Logic "0" = +5V) 10K Ohm - minimum load
	Inv. Serial Output	Same as above serial output excepts Logic "1" = +5V
	NMEA 0183	NMEA 0183 compatible bidirectional data/levels/ formats
Digital Port	Synchronous	Strobe Input: Ground momentarily (1µS minimum) to obtain data output Clock Output: 0 to +5V squarewave @ 10kHz rate. Data Output: 0 to +5V levels Data Format: 4 digit BCD, 16 Bit binary or 16 Bit Serial Gray Code, C100 Display*, NCSC* - user selectable through serial port 10K Ohm minimum load on output signals

*Digital (synchronous) outputs can be user configured to provide strobed or free running data at up to a 10Hz message rate.

Analog Outputs	Sine/Cosine/Ref	Output voltage +1.5V ±1.0V, Reference Voltage +1.5 VDC, 20K Ohm minimum load capability
	Linear Voltage	+0.1 to +1.9 VDC into 20K Ohm minimum load (5mv/° slope)
	Linear Voltage with Hysteresis	+0.105 to +1.925 VDC into 20K Ohm minimum load (5mv/° slope)

Note: Accuracies using the ratiometric sine/cosine outputs are within the specified ±0.5° RMS. Linear output accuracies are within ±1.0° RMS.

* Contact KVH for details.

Looking for a Laser Measurement System?

For nearly 20 years, RIEGL has dedicated itself to the development and production of time-of-flight laser measurement systems. Our designs and production techniques incorporate the latest in reliable state of the art technology. This commitment to advanced technology combined with two decades of knowledge and experience have yielded a product line which sets the industry standard for performance, quality and reliability.

RIEGL offers a diverse and innovate product line:

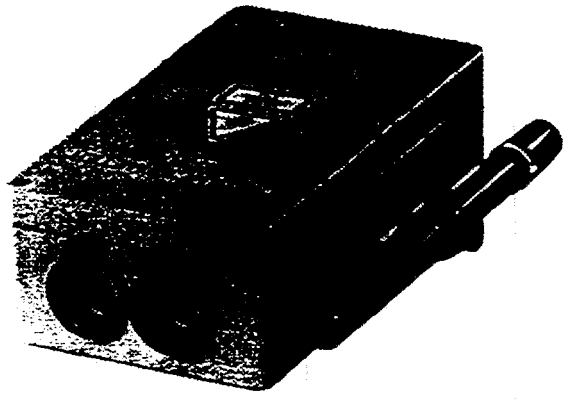
- "Laser Binoculars" **Lasertape**
- "Laser Speed Gun" LR90-235/P
- Surveying System *LASER SCOUT*
- Rangefinders & Speed Meters LR90-2
- Distance & Level Meters LD90-2
- Distance-, Level- and Speed Sensors LD90-3
- Instruments with Glass-Fiber Coupled Optical Head
- Profile Measuring Systems PMS90-2, CMS390
- Laser Radar System TWS390

For more information, ask for our detailed data sheets.

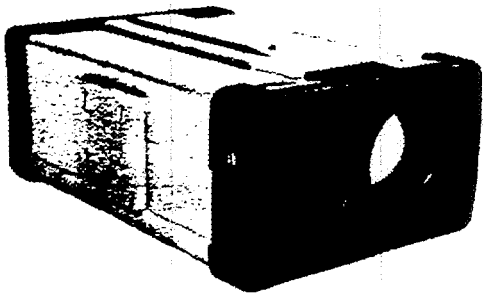
RIEGL
LASER MEASUREMENT SYSTEMS

Distance & Level Meters series LD90-2

The Laser Distance and level meter **LD90-2** provides a high degree of accuracy, interference immunity, and reliability. ***The instrument is protected by a very robust, dust and splash water proof aluminium case and is therefore ideally suited for highly demanding industrial applications.*** Besides the operating and display elements and the RS232 computer interface, the LD90 can additionally be equipped with various digital and/or analog data outputs commonly used in industry.



Distance-, Level-, and Speed Sensors series LD90-3

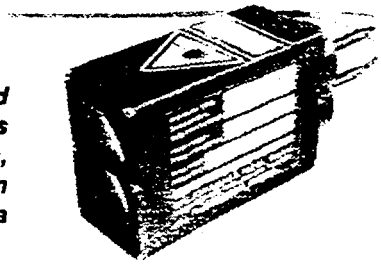


The sensors of the new **LD90-3** series can be operated with any target surfaces up to several hundred meters, and with reflecting foil or retro-reflectors up to considerably more than 1000 m. ***They provide an accurate and dynamic measurement of distance and speed,*** continous self-monitoring, and various data interfaces, all that in a small, light-weight and stable metal housing with rubber coatings.

Instruments with Glass Fiber Coupled Optical Head

This measuring concept consists of a lightweight and small optical head and the separate electronics box, connected via a duplex glass-fiber cable with connectors on both sides. The main features and advantages of this flexible and powerful configuration are:

The optical head can be operated in explosion-endangered areas as well as in high-temperature areas, whereas the electronics box can be remotely installed in a protected area.



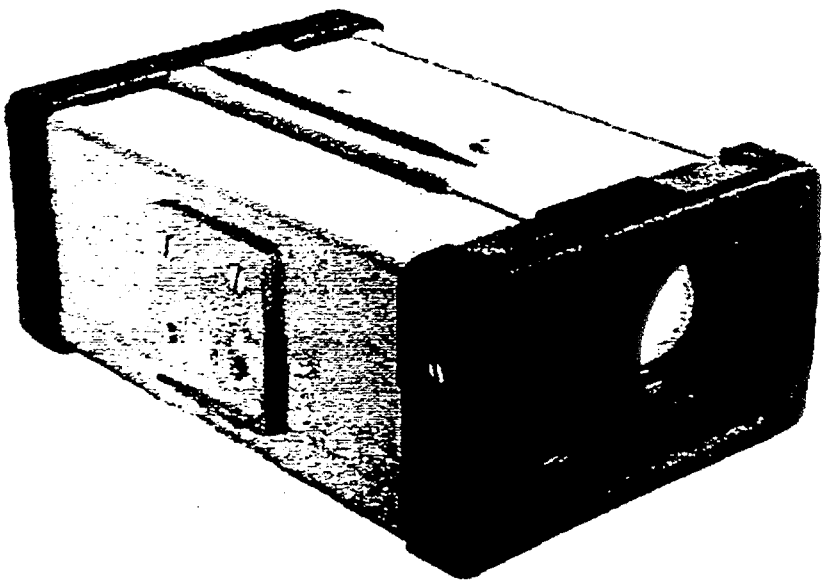
The glass-fiber cable provides galvanic insolation between optical head and electronics box.

The optical head contains no electronics and is therefore extremely small, leightweight, inexpensive, high-temperature resistant, and insensitive against electromagnetic interference as well as against ionizising radiation.

LASER DISTANCE, LEVEL and SPEED SENSOR

LD90-3

- **Distance and speed sensor for automatic positioning**
- **Collision avoidance for cranes and vehicles**
- **Level measurement in silos, bunkers, etc.**



The sensors of the new series LD90-3 use the well-proved principle of time-of-flight measurement of short laser pulses, like all RIEGL products.
They can be operated with any target surfaces ("reflectorless") up to several hundred meters, and with reflecting foil or retroreflectors up to considerably more than 1000 m.

Experience for more than ten years in development and production of optical distance meters, the use of large-scale integrated microelectronics and most modern production technology provide a profound basis for the excellent performance, the high reliability, and the outstanding cost- performance ratio of the LD90-3 industrial sensors.

Main features

- ***Accurate & dynamic measurement of distance and speed***
- ***Small, lightweight and stable metal housing with rubber coatings***
- ***Continuous self-monitoring when operating with reflecting foil***
- ***Various data interfaces available***

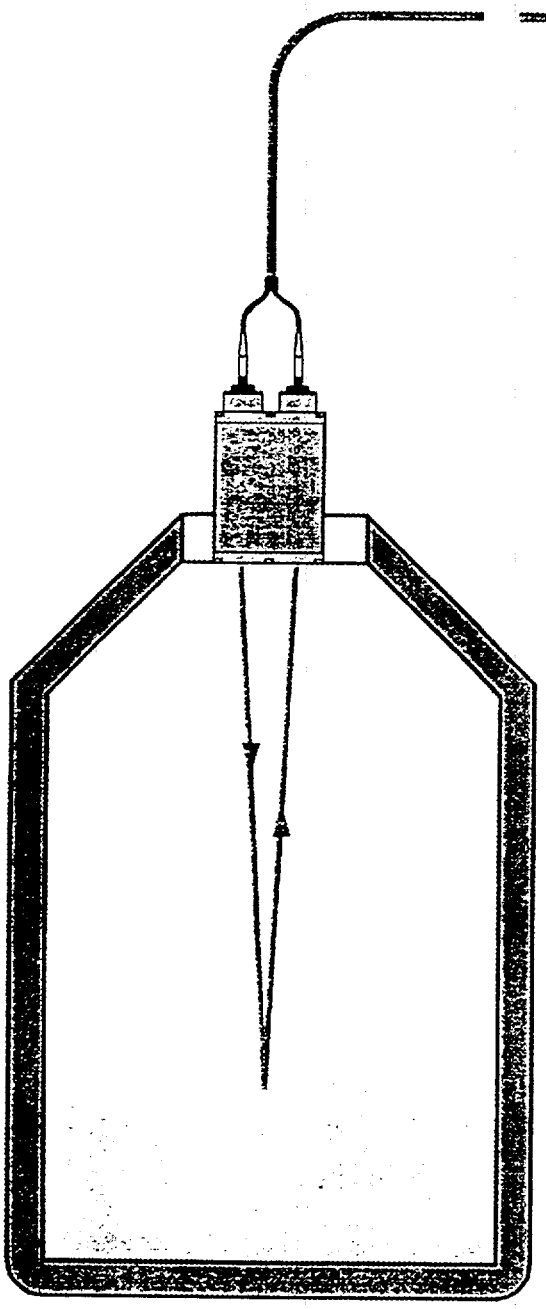
RIEGL
LASER MEASUREMENT SYSTEMS
Orlando, FL 32808

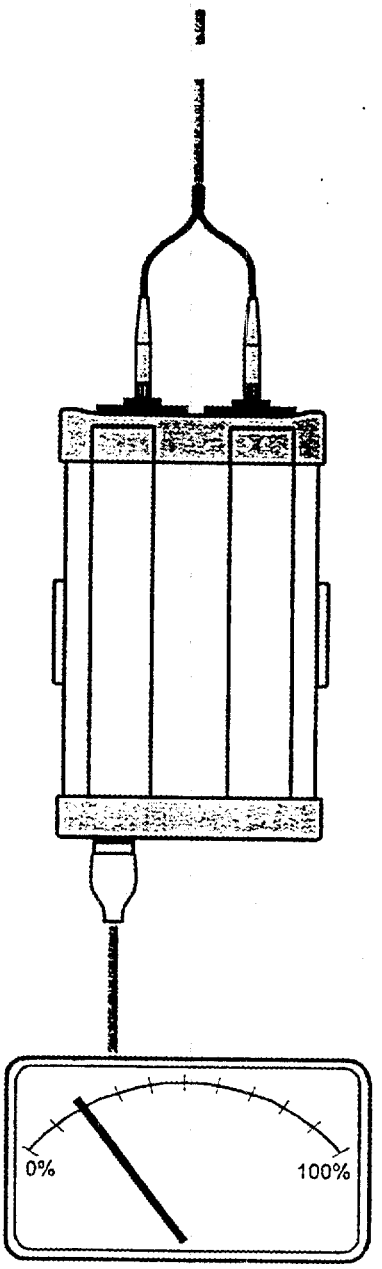
vox (407) 294-2799
fax (407) 294-3215

LASER DISTANCE and LEVEL SENSOR

LD90-3-GF

WITH GLASS-FIBER COUPLED OPTICAL HEAD





- *Distance and level measurements in explosion-endangered areas*
- *Ship-docking systems*
- *High-temperature applications*
- *Scanning systems demanding a very small measuring head*

RIEGL
LASER MEASUREMENT SYSTEMS

General

The distance and level meter LD90-3-GF with glass-fiber coupled optical head makes use of the time-of-flight method to determine the distance of a remote target by measuring the transit-time between transmission and reception of a short laser pulse. Distance measurements can be performed to both non-cooperative and cooperative targets with high accuracy, interference immunity, and excellent reliability. The RS232 interface allows communication and operation of the instrument. Furthermore, the LD90-3-GF can be equipped with the various digital and analog data outputs frequently used in industry.

The measuring system consists of a lightweight and small optical head and a separate electronics box, connected via a duplex glass-fiber cable with connectors on both sides. The main features and advantages of this flexible and powerful configuration are:

- The optical head contains no electronics and is therefore extremely small, lightweight, inexpensive, high-temperature resistant, and insensitive against electromagnetic or ionizing radiation.
- The optical head can be operated in explosion-endangered areas as well as in high-temperature areas, whereas the electronics box can be remotely installed in a protected area.
- The glass-fiber cable provides galvanic insulation between optical head and electronics box.
- Installation as well as replacement of parts of the system in case of servicing requirements is easy and cost-effective.

The following specifications are typical for use of the standard optical heads MK36 and MK42. Several other optical heads are available for specific high-demanding requirements:

- MK42-Z80: Cylindrically shaped, diameter 80 mm, water-proof, for measurements through thin bore-holes
- MK56-Z150: Cylindrically shaped, diameter 150 mm, water-proof, for explosion-proof long-range ship docking systems
- MK56-V: Equipped with heat-protecting filters and with protection tube, for various high-temperature application in steel plants
- Miniaturised high-speed scanning heads for robotics and anticollision systems

Detailed data sheets of the special optical heads are available on request.

Detailed specifications LD90-3100-GF

Position and speed sensing, crane distance measurement, level measurement in large silos, robotic applications, etc.

Measuring range with optical head MK36: depending on the reflection coefficient ρ of the target	
good, diffusely reflecting targets, ρ ≥80%	up to 100 m[1]
bad, diffusely reflecting targets, ρ ≥10%	up to 35 m[1]
Reflecting foil[2] or plastic cat's-eye reflectors	> 1000 m
Minimum distance, typically	2 m

Distance measurement:

Accuracy[3]	typically ±3 cm, in the worst case ±5 cm							
Measuring time (ms or s)[4]	10ms	20ms	50ms	0.1	0.2	0.5	1	2
Statistical deviation (cm)[5]	±10	±7	±5	±3	±2	±1.5	±1	±0.7
Resolution (cm)[5][6]	10	10	5	5	2	2	1	1

Speed measurement:

Measuring range	0 to ±30 m/s
Accuracy	±0.3 m/s
Measuring time, typically[4]	0.5 s
Divergence of the infrared measuring beam[7]	2.5 mrad
Eye safety class according to CENELEC EN 60825 (1991)	Laser Class 1

Detailed specifications LD90-3300-GF

Measurement of distances to badly reflecting targets, e.g. level measurement in coal silos, height-of-flight measurement, ship docking systems, etc.

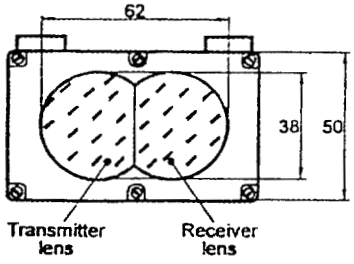
Measuring range with optical head MK42: depending on the reflection coefficient ρ of the target	
good, diffusely reflecting targets, ρ ≥80%	up to 300 m[1]
bad, diffusely reflecting targets, ρ ≥10%	up to 100 m[1]
Reflecting foil[2] or plastic cat's-eye reflectors	> 1000 m
Minimum distance, typically	5 m

Accuracy[3]	typically ±5 cm, in the worst case ±10 cm					
Measuring time (s)[4]	0.05	0.1	0.2	0.5	1	2
Statistical deviation (cm)[5]	±15	±10	±7	±5	±3	±2
Resolution (cm)[5][6]	10	10	5	5	2	2

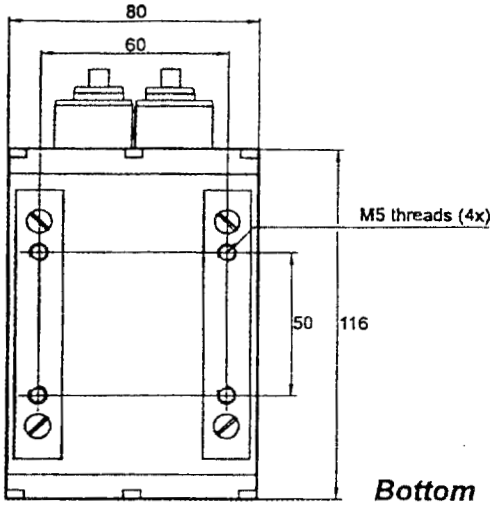
Divergence of the infrared measuring beam[7]	3.5 mrad
Eye safety class according to CENELEC EN 60825 (1991)	Laser Class 1

1) typical values for average conditions. In bright sunlight, the operational range is considerably shorter than under an overcast sky. At dawn or at night the range is even higher.
2) reflecting foil 3M 2000X or equivalent, minimum dimensions 0.45 x 0.45 m^2
3) standard deviation, plus distance depending error ≤20 ppm
4) adjustable via RS232 (RS232 data output useful only for measuring times of 50 ms or more)
5) depending on measuring time
6) chosen automatically by the internal microprocessor
7) 1 mrad corresponds to 10 cm beamwidth per 100 m of distance

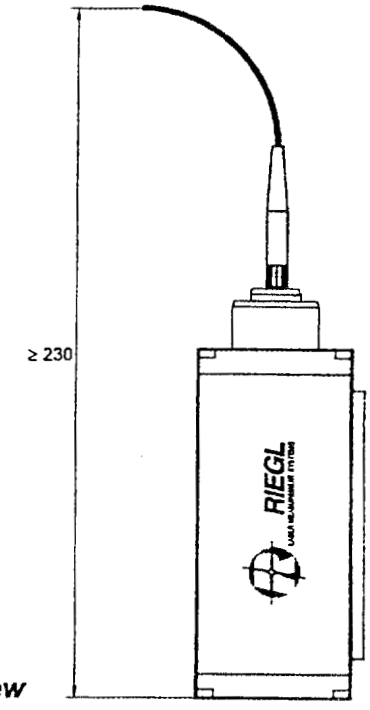
Dimensional drawings of optical head MK36



Front View

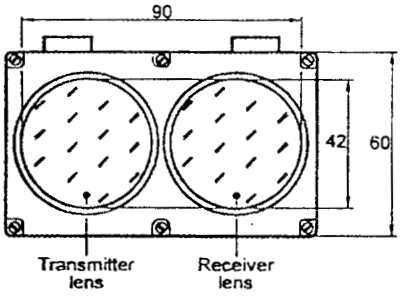


Bottom View

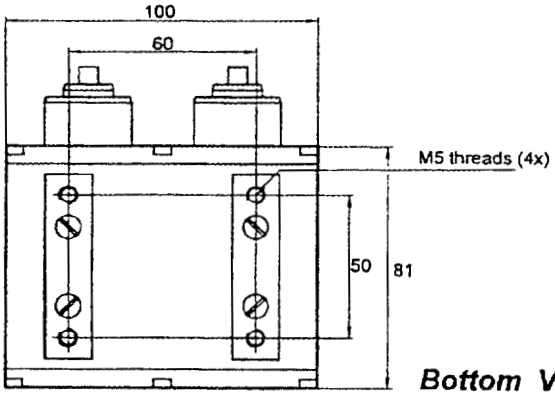


Side View

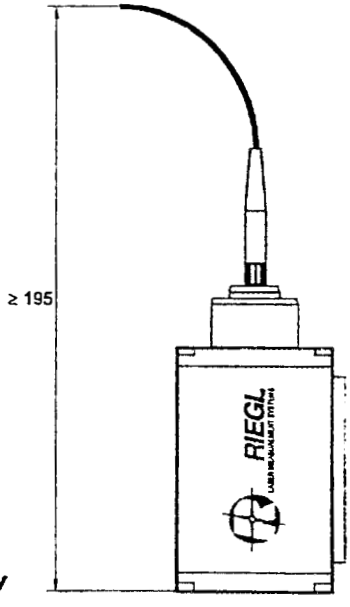
Dimensional drawings of optical head MK42



Front View



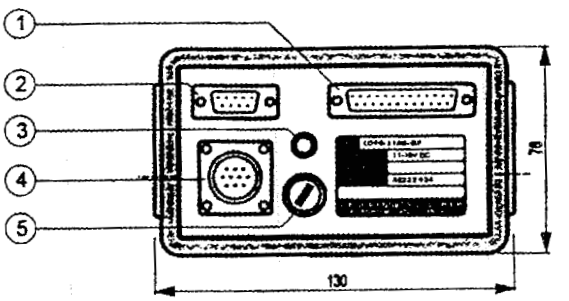
Bottom View

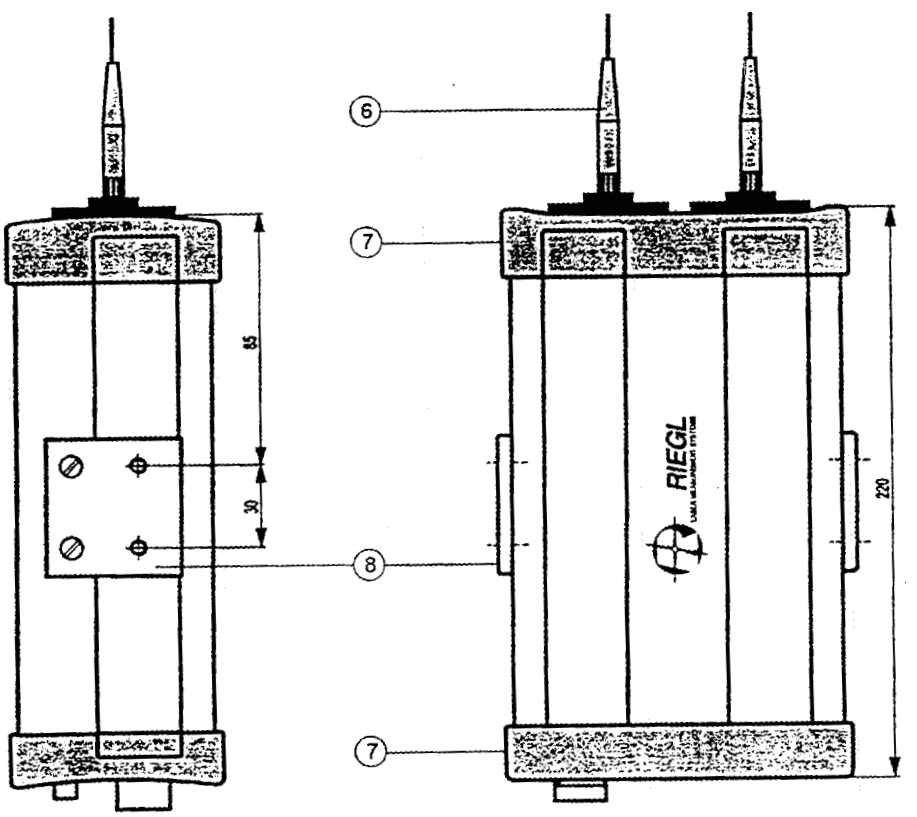


Side View

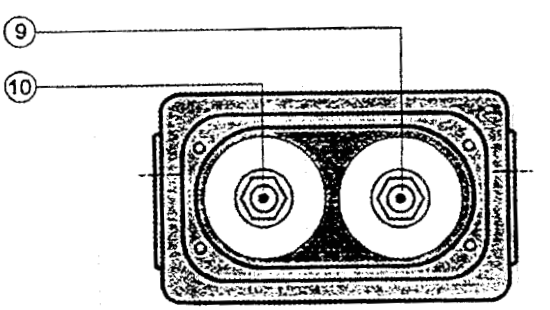
Dimensional drawings of electronics box

(1) 25pole plug for binary data output (optional)
(2) 9pole plug for RS232 / RS422 data interface
(3) LED "POWER ON"
(4) 10pole plug for power supply and current output 4 - 20 mA
(5) Fuse holder





(6) SMA glass-fiber connectors
(7) Rubber-armoured front and rear panel
(8) Mounting plates with 2xM6 threads
(9) SMA glass-fiber plug for receiver
(10) SMA glass-fiber plug for transmitter



General technical data LD90-3-GF

Serial data interface

RS 232	V24, bidirectional, baud rate adjustable between 150 and 19200
RS 422	optional, for long transmission paths

Additional data outputs available (optional)

Digital	binary data output, TTL level, 20 bit (distance data and amplitude data)
Analog	current output 4-20 mA

Power supply

Standard	11-18 Volt DC, approx. 10 Watt built-in protecting circuitry for over-voltage and reverse polarity
Option 220 V AC	External power supply VNG 90, input voltage 220 Volt AC / 50 Hz Dimensions 120 x 120 x 80 mm
Option 24 V DC	Pre-stabilisation and protecting unit STAB 90, input voltage 20 - 28 V DC, Dimensions 125 x 80 x 55 mm

Temperature range

	Electron. box	MK36	MK42
Operation	-10 to +50 °C	-20 to +80 °C	-20 to +80 °C
Storage	-20 to +60 °C	--	--

Additional data

Dimensions (LxWxH)	220x130x76 mm	142x80x50 mm	107x100x60 mm
Weight	approx. 1.5 kg	approx. 0.5 kg	approx. 0.5 kg
Protection class	IP64	IP54	IP54

Aiming device (optional)

Telescope to be screwed on with a mounting plate on the optical head

Information contained herein is believed to be accurate and reliable. However, no responsibility is assumed by *RIEGL* for its use. Technical data are subject to change without notice.

Preliminary data sheet 1/94

RIEGL
LASER MEASUREMENT SYSTEMS

DR. JOHANNES RIEGL
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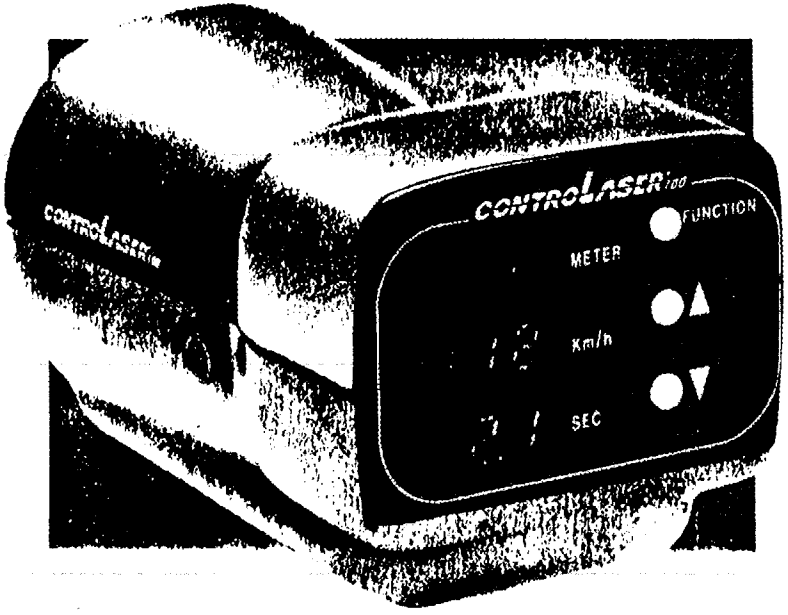
CONTROLASER

CONTROLASER



User's Manual

SILICON HEIGHTS Ltd.
280 A. Dizengoff St., 63117 Tel Aviv Israel,
Tel (972)3 5465113, 5466201, Fax: (972)3-5441966

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Features

Interior Mounting
- Prevents the laser lens from getting fouled with dirt, insects, and other debris.

Night Vision
- Laser performance *improves* at night when the human eye has more difficulty estimating distances. Nighttime sensitivity is better because there are less squrious reflections caused by sunlight.

Compact Size
- Facilitates convenient mounting in all types of vehicles.

Long Range
- Monitors vehicles up to 120 meters away in order to provide sufficient warning if they stop suddenly.

Quick Release Base
- Allows for easy removal of ControlLaser 100 in theft prone areas.

Stay More Alert

Your Safety Margin

- The ControlLaser 100 helps ensure that you will have enough Reaction Time in order to make a safe, emergency stop if the car ahead stops suddenly.

Alert Drivers Stop More Quickly

- When Concentration Lapses . . .
- L-o-n-g m-o-n-o-t-o-n-o-u-s d-r-i-v-e-s
- Distractions:
  - ★ Kids in the car
  - ★ Pretty scenery
  - ★ Wrecks along the side of the road

. . . the ControlLaser 100 alerts you to pay close attention when you get too close to the car in front.

Drive Within the Law

- **Tailgating** - Many jurisdictions are redefining their laws regarding tailgating. These new laws typically require the driver to maintain a distance that gives a separation time of 1 or 2 seconds to the vehicle ahead. The ControlLaser 100 will sound a warning if your following distance is less than law requires.

What It Does:

1. If you approach too close to the car in front, the ControlLaser 100 will warn you of potential danger.
2. It is up to YOU to decide how to react. (For example, slow down as required until the warning stops.)
3. The ControlLaser 100 sounds a warning alarm and flashes "SLO" (for Slow Down) when 2 conditions
   a. You are traveling at least 30 Km/H. This feature prevents frequent alarms in parking lots and at sto lights.
   b. Your following distance to the car ahead is less than the Safety Margin that you have set (e.g. 1.5 seconds).
4. If you are traveling less than 30 Km/H when you approach too closely to the car ahead, no alarm will sound but the middle display will still flash the "SLO" warning.
5. The middle display shows "SAF" (for SAFE) when your distance to the car ahead is greater than the Safety Margin.

How it Works:

- The ControlLaser 100 uses a laser range finder to measure the distance to the vehicle in front of you. In order to prevent bystanders from staring into its laser range finder, the laser beam will activate only w you are traveling faster than 10 Km/H.
- The ControlLaser 100 uses an electro-optical Speed Sensor next to the drive shaft to measure how fast wheels are turning.
- The ControlLaser 100 activates automatically every time you start your car. It is switched on by the ca ignition.
- The ControlLaser 100 permanently stores all settings (Safety Margin, speed calibration data, etc.) in memory. This information will continue to be retained in nonvoltile memory even when the ControlLaser 100 is turned off or disconnected from the vehicle's battery.

No Power

- **Fuses** - Check the appropriate fuse or circuit breaker in the in the car's fuse box. Also check the ControlLaser's in-line fuse (1 amp) which is located in the power cable
- **Heat** - The High Temperature LED will light above 70° C (158° F) to indicate that the unit has ceased to function. The unit will automatically reactivate when the temperature returns to the operating range.
- **Loose Connection** - Check that the plug at the end of the Power/Sensor cable has not become disconnected.

Continuous Alarm

- **Range Finder Blocked by Dirt or Snow** - If the windshield in front of the ControlLaser 100 is completely coated with dirt or snow the laser range finder will not be able to function. In this case, the unit will sound a continous alarm to warn you. Clean the windshield to restore normal operation.

Failure to Register Vehicles at Long Range

- **Dirty Windshield** - If you notice that the ControlLaser 100 is no longer picking up cars at a long distance (70 meters or more) try using the windshield washer. A dirty windshield can reduce the effective range of the laser range finder. (However, the measurments that are dispalyed will continue to be accurate).
- **Fragile Laser Lens** - A dirty lens can reduce the effectiveness of the laser range finder. Note, do NOT attempt to clean the laser lens on the front of the unit. Take the unit to your installer if you think the lens needs cleaning. The front of the unit is very sensitive and easily damaged.
- **Unit Partially Out of Alignment** - If the ControlLaser 100 or its base receives a hard knock, it could upset the precise alignment set during installation. In this case, the unit might fail to register vehicle until they are relatively close. If the ControlLaser 100 does not register vehicle up to 100 meters ahead on the straight away, return to an autorized service center for realignment.

Real World Conditions

Special Situations

- **Especially Dangerous Situations** - A more strident alarm will sound if you are rapidly approaching a slow moving vehicle ahead.
  - If you are traveling less than 100 Km/H, this special alarm will sound if there is a slow moving vehicle ahead that is traveling less than 1/3 of your speed.
  - If you are traveling 100 Km/H or more, this special alert will occur for vehicles ahead that are traveling less than 1/2 your speed.
- **Stationary Objects** - The ControlLaser 100 identifies stationary object directly ahead such as stalled cars, barricades, etc. and will sound an alarm accordingly. It is designed to "overlook" objects it detects on the side of the road when rounding acurve.
- **Bumpy Roads** - The ControlLaser 100 functions normally on bumpy roads.

"NoAlarm" Conditions

No alarm will sound if you encounter:

- **Oncoming Traffic** - the ControlLaser 100 will not sound an alarm if a car traveling in the opposite direction has temporarily crossed over into your lane in order to pass another car. Nor will it sound if you switch lanes on a 2-way highway.
- **Sharp Curves** - The ControlLaser 100 may momentarily stop measuring the car ahead when going around a sharp curve if the car goes out of its line of sight. It will resume monitoring this car as soon as it comes back "into view".

- **Nighttime & Cloudy Weather** - The performance of the ControlLaser 100 actually improves at night and under cloudy conditions when the human eye has more difficulty estimating distances. Nighttime and cloudy sensitivity is better because there are no spurious reflections cuased by sunlight.

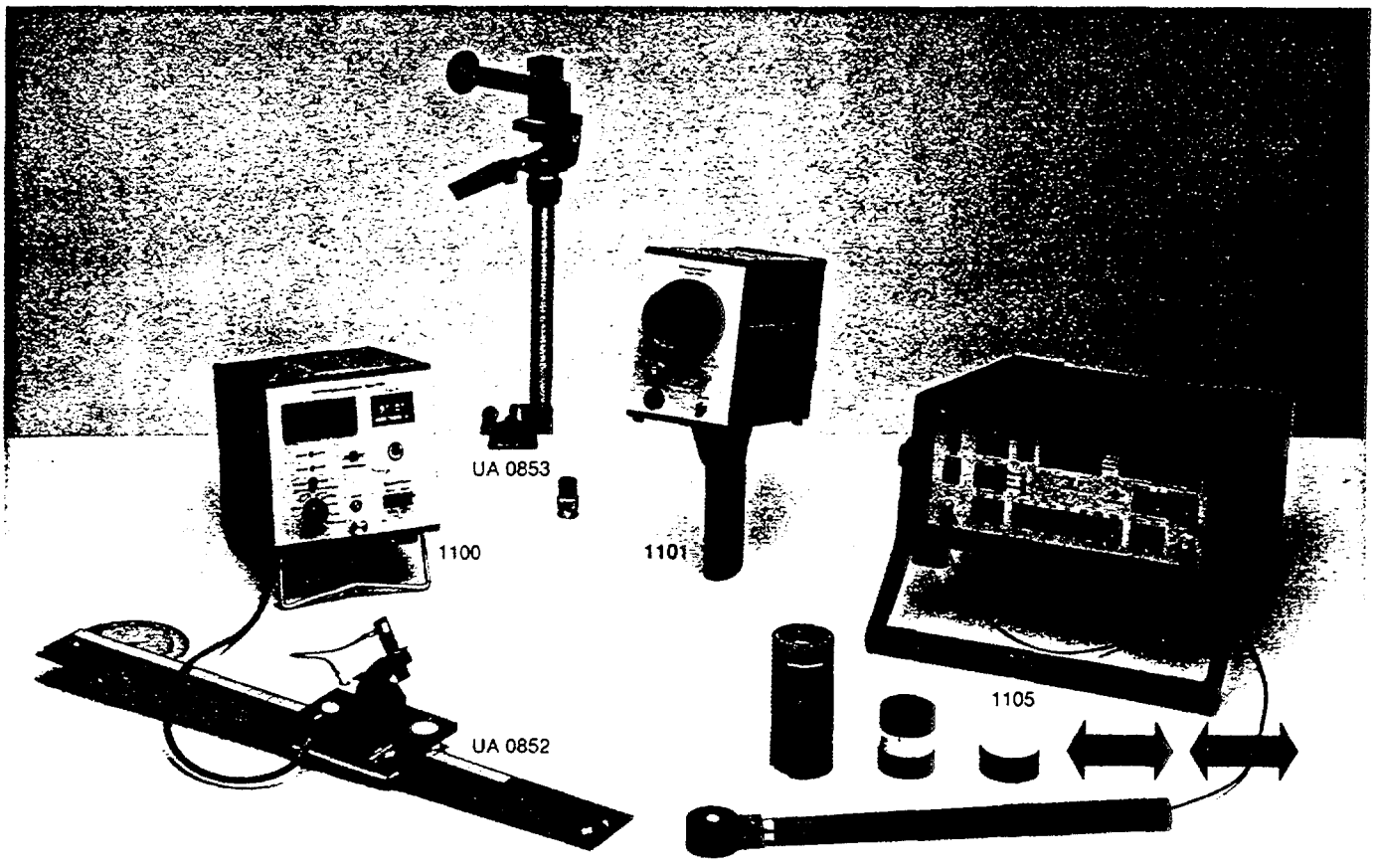
- **Dirt or Snow on the Windshield** - Dirt or snow accumulation that blocks the laser range finder will reduce the range of the ControlLaser 100. If the windshield is not cleaned, eventually the ControlLaser 100 will sound a continous alarm to alert you that it can no longer measure cars ahead. Clean the windshield to restore normal operation.

- **Rain is NOT a problem** - Rain and snowfall do not interfere with the operation of the ControlLaser 100 (not even heavy downpours). The ControlLaser 100 will continue to function normally even when windshield wipers are moving rapidly. However, the accumulating of snow on the windshield can cause problems as discussed in the paragraph above.

- **Fog Conditions** - In light or medium fog the ControlLaser 100 will detect vehicles ahead as well or better than the human eye.
  In heavy fog the unit will sound an alarm for 2 seconds if it is unable to effectively detect vehicles ahead. a "FOG" warning will flash on the middle row of the display until conditions improve.

● **Dimensions**	75mm (W) x 130 mm (L) x 70 mm (H) (Not including the mounting base)
● **OperatingTemperature**	-20°C to 70°C (-4°F to 158°) High Temperature LED lights above 70°C (158°) to indicate that the unit has ceased to function. The unit automatically reactivate when the temperature returns to the operating range.
● **Weight**	Detector: ~ 250 grams
● **Effective Range**	Can measure distance to vehicle up to 100 meters ahead (less in foggy weather)
● **Power Requirements**	5 watts @ 12 volts NOTE, all calibration and customer preference setting are stored in nonvolatile memory. These settings are permanently retained even when the unit is disconnected from the vehicle's battery.

Illumination Measuring Equipment



Type 1100 Luminance Contrast Meter. A portable, battery-powered instrument for evaluation of lighting quality and the effects of veiling reflections in offices or classrooms. The 1100 includes Luminance Transducer UA 0601 and Battery Pack with 6 × IEC LR20/D-size batteries (Ni-Cd Batteries QB 0008 and Charger/Power Supply ZG 0199 available).

- Automatic and manual luminance-range selection. Measuring range: 0.1 cd/m² to 200 kcd/m²
- **Measures Luminance Contrast, C;** Contrast Rendering Factor, CRF (CIE Publication no. 29) and Luminance

Type 1100 can be ordered with either of the two following sets:

UA 0853 Visual Display Unit Accessory Set for measurements of character contrast and luminance distribution on computer screens.

- Included: Table Stand, Aiming Adaptor (2,2°), Wide Angle Adaptor (24°) for measurement of average luminance, 100 mapping charts **QP 4592** and carrying case

UA 0852 Desk Top Accessory Set for measurements of luminance contrast from printed paper material as rendered by lighting systems. Uses **Type 1104 Luminance Contrast Standard**, which is a standard visual task with contrast characteristics designed to match those of commonly encountered office documents (to be ordered separately).

- Included: Radius Arm, Carriage, 2 contrast standard blanks, 100 mapping charts **QP 4590** and carrying case

Type 1101 Luminance Meter. Portable, battery-powered precision luminance meter having a bright viewfinder with an internal 3½-digit LED display. Wide measuring range (0.01 cd/m² to 2000 kcd/m²).

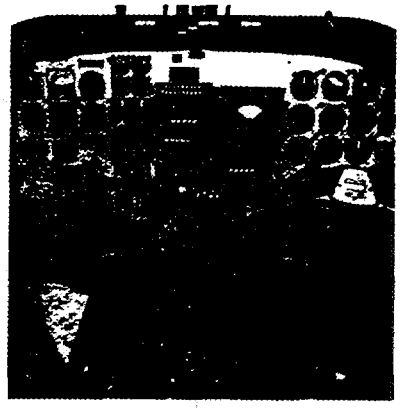
- Bright, magnified field of view (11°) with clearly marked ⅓° and 1° center rings. Split image focusing
- Measurement field angles: ⅓° and 1°
- Automatic and manual range selection
- Automatic zero calibration
- Focusing distance 0.5 m to infinity (0.25 m to 0,5 m with close-up lens)
- Minimum measurement field diameter 1,4 mm with ⅓° angle and close-up lens
- Adjustable eyepiece (+2 to −3 dpt.)
- Extra LCD on the top of the instrument
- V(λ)-match, $f_1' < 3\%$ (CIE Publ. no. 53, CIE Publ. no. 69 (1987), DIN 5032 parts 6 and 7)
- Accuracy ± 3%, ± 1 digit
- Selectable fast and slow averaging
- Average, Max, Average and Peak readings
- Aperture adaptor for measuring illuminance from source inside the measurement field
- DC output for recording (fast and slow averaging)
- Alkaline Batteries (8 × IEC LR6/AA size) included. Ni-Cd batteries QB 0032 and Charger ZG 0113 available
- Included: Close-up lens, illuminance adaptor, handgrip, wrist strap and shoulder carrying case
- Weight: 2,3 kg (5 lb)
- H × W × D: 133 × 83 × 198 mm

Type 1105 Precision Photometer. Portable, battery-powered instrument for measurement of Illuminance using **Type 8600 Illuminance Transducer** included. Typical applications in workplace and interior lighting, sports lighting, road lighting. Measurement of Hemispherical Illuminance with Adaptor UA 0881, Semicylindrical Illuminance with Adaptor UA 0883 and wide angle (10°) luminance with Adaptor UA 0882 included.

- Measurement range 0,001 lux to 200 klux, autoranging and autozeroing
- 3½-digit LCD, can be calibrated in any desired unit (lux, footcandle, cd/m², etc.) by keying in the transducer sensitivity and the relevant conversion factor
- V (λ)-match $f_1' < 2\%$, cosine response $f_2 < 1{,}5\%$, transducer supplied with individual calibration chart
- Accuracy ± 0,2%, ± 1 digit
- Linear averaging, selectable 0,1, 1, and 10 s av. time, plus peak detection
- Storage of mean, max. and min. values of averages taken
- Parameters like uniformity, reflectance and directionality requiring the quotient of two values can be displayed
- DC output for recording (lin. average and instantaneous value)
- IEEE/IEC interface and B&K serial interface
- Plug-in Battery Pack (6 × IEC LR20/D size) included. Ni-Cd batteries QB 0008 and Charger/Power Supply ZG 0199 available
- H × W × D: 284 × 138 × 300 mm
- Weight: 4.2 kg (9.2 lb)

Vibration-monitoring systems protect valuable plant machinery and provide cost-effective maintenance

The compact size of sector transducers makes intraoperative sonography possible and allows surgeons to obtain vital diagnostic information

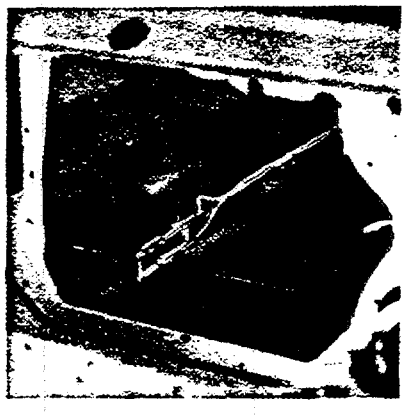


Luminance measurements, for example in a cockpit, can be used to check the visibility of vital instruments and indicators

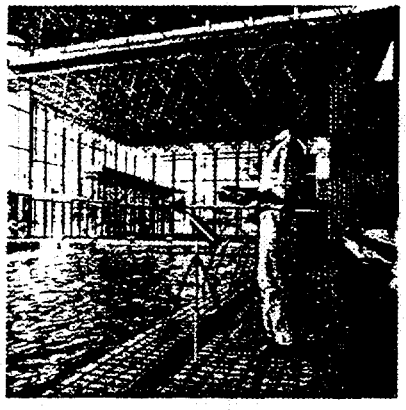
Smooth on- and off-axis frequency responses in Brüel & Kjær studio microphones give faithful reproduction and superb stereo imaging

Brüel & Kjær's unique Delta Shear accelerometers offer state-of-the-art design and performance in all vibration measurements

Brüel & Kjær sine and random generators cover the majority of signal requirements for R & D and testing



Brüel & Kjær's sound intensity probes open up new fields in acoustics research, leading to better noise control.



Reverberation time measurements are just one of the possibilities with Brüel & Kjær's Modular Precision Sound Level Meter Type 2231

For testing and evaluating audio systems, Type 4128 gives a correct representation of acoustic effects around the human head and torso.

Brüel & Kjær

Bruel & Kjaer Instruments, Inc.

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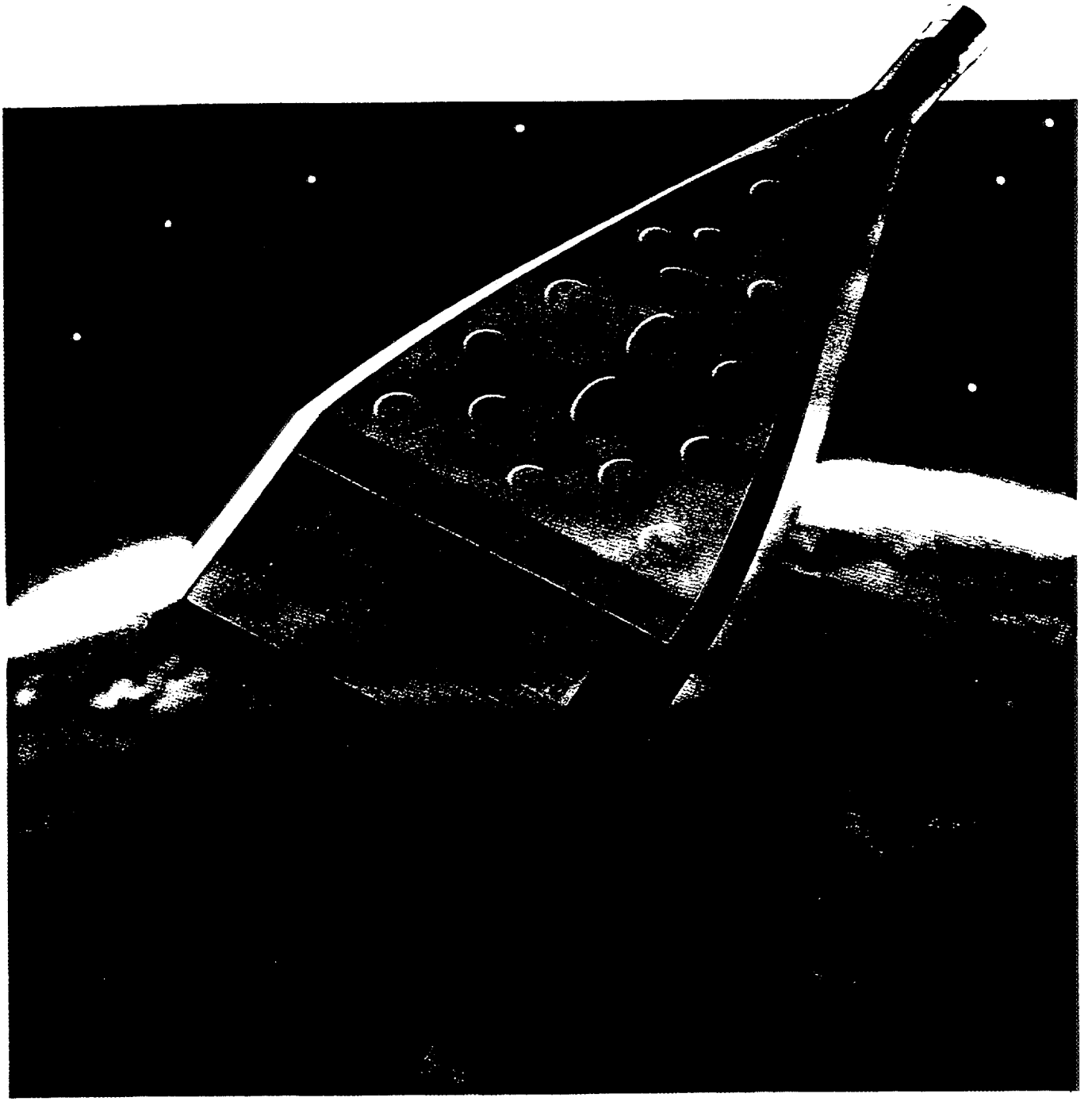
MI (313) 522-8600 · IL (312) 358-7582 · TX (713) 645-0167 · CA (714) 978-8066 · (415) 574-8100 · WA (206) 324-8268

Dawn of a new era

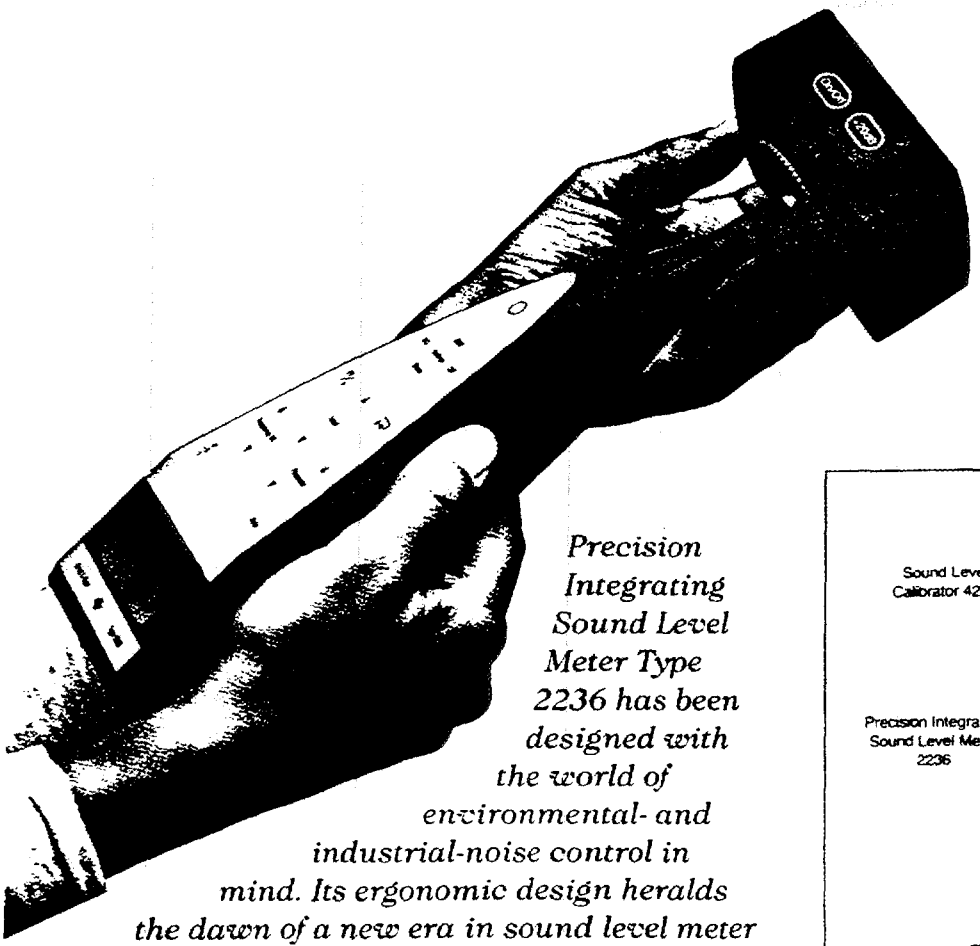
Precision Integrating Sound Level Meter Type 2236

United States version

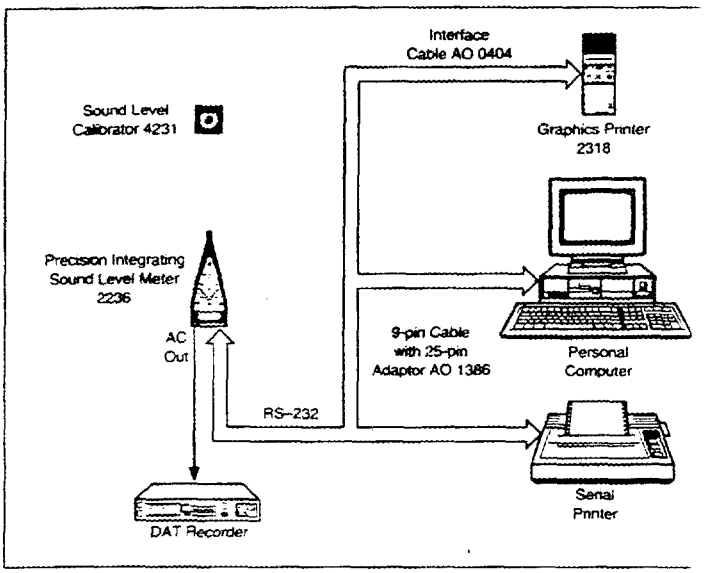


Brüel & Kjær

A sound l



Precision Integrating Sound Level Meter Type 2236 has been designed with the world of environmental- and industrial-noise control in mind. Its ergonomic design heralds the dawn of a new era in sound level meter design. Just see for yourself.



System set-up for printing, recording and transferring results from the sou meter

Easy to use

Making measurements with the 2236 is simplicity itself. The pushkeys are self-explanatory and well laid out and give you direct access to all major functions. The display is clear and concise, and an interactive dialogue guides you every step of the way, ensuring fast and efficient usage. We've even taken the guesswork out of calibration: nothing could be easier, or more convenient, than using the pocket-sized Sound Level Calibrator Type 4231.

Measuring the L_{eq} and SEL from railway lines

Direct print and storage

You can print your results as soon as you've finished measuring, either on the lightweight Graphics Printer Type 2318, or on a standard serial printer. You can store results in the sound level meter's non-volatile memory, or transfer the results via the built-in serial interface to your personal computer in a spreadsheet compatible format, for additional analysis or graphical presentation using standard office software.

A front-end unit

The sound level meter also acts as a cost-effective front-end for a data acquisition system. While the sound level meter is measuring and displaying A-weighted parameters, the linearly-weighted output signal can be recorded, via the AC output, on a DAT recorder, providing a calibrated recording for further spectrum analysis and noise source identification.

:vel meter made just for you

Measuring the LEP.d for a particular worker. The filter versions can also be used to investigate the type of hearing protection required

Versatile

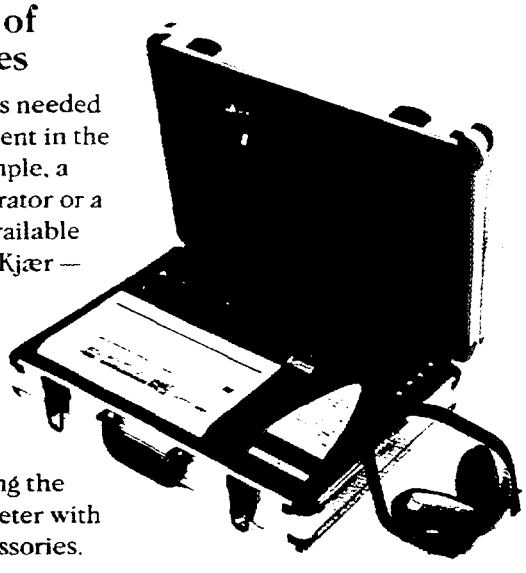
The sound level meter is available with an optional built-in 1/1-octave filter which enables you to perform frequency analyses according to American and international standards. Additionally, the sound level meter can be upgraded to include extra memory so that you can log results, for example, every second over an entire 24-hour period.

A complete measurement solution

Precision Integrating Sound Level Meter Type 2236 provides all the relevant parameters, defined by OSHA and ANSI standards, you need for your chosen measurement task — whether measuring environmental noise, industrial noise exposure or both. For example, it allows you to measure both L_{eq} and Peak in parallel. For environmental measurements, it can show any L_{xs} of your choice. Hand-held or tripod-mounted, it is a self-contained, precision instrument. To expand, just add a printer, a lap-top computer or DAT recorder, and a Sound Level Calibrator Type 4231 for a complete measurement solution.

A wealth of accessories

All accessories needed for measurement in the field (for example, a tripod, a calibrator or a printer) are available from Brüel & Kjær — your single-source supplier. We also supply a handy carrying case for transporting the sound level meter with essential accessories.



Carrying Case KE 0325 has space for the sound level meter, the calibrator, Tripod UA 1251 and Serial Printer WQ 1138

The Brüel & Kjær hallmark

Precision Integrating Sound Level Meter Type 2236 is just one of a long line of quality instruments from the company whose name is synonymous with sound level meters — Brüel & Kjær. As such, it comes with the Brüel & Kjær guarantee of quality which ensures that you will get years of reliable, accurate performance from a type-approved* sound level meter. And for regular calibrations and instrument checks, Brüel & Kjær provides a world-wide service back-up that is second-to-none.
In order to help you make better measurements, Brüel & Kjær also provides an extensive seminar and workshop programme run by local application specialists.

* Type approval is independent ratification of conformance to international standards

Product Data

Uses

- Investigation of hearing protection (filter set versions)
- Measuring industrial-noise according to American and international directives and legislation
- Measuring environmental-noise according to American and international directives and legislation

Features

- Type 1 sound level meter
- Exchange Rates of 3, 4 and 5 dB
- Cumulative and level distribution
- Calculates and displays three user-defined L_N values
- Simultaneous L_{eq} and Peak measurement with independent frequency weightings
- Automatically logs L_{eq} and two L_N values
- 40 Records of manually stored results

Specifications 2236

Standards: Conforms with ANSI S1.4-1983 and Draft S 1.43 6th September, 1992 Type 1S, and IEC 651 (1979) and 804 (1985) Type 1
Optional 1/1-octave Filter: 31.5 Hz to 8 kHz conforming with ANSI S 1.11 – 1986 order 3 Type 1D and IEC 225 (1966)
Measuring Range: 20 – 140 dB RMS (143 dB Peak) in five 80 dB ranges*
Noise Floor: Typically 18 dB(A) RMS
Time Weighting: S, F, I according to ANSI S1.4 Type 1
Frequency Weighting: A (RMS only) and C according to ANSI S1.4 Type 1, L (20 Hz to 20 kHz)
Exchange Rate: 3, 4 or 5 dB
Detectors: RMS and Peak with independent frequency weightings
Display: LCD with back-light and battery low indicator
Parameters: MaxL, MinL, MaxP, Peak, SPL, L_{eq}, L_{10}, L_{W4}, L_{W5}, SEL, IEL, L_{EQd}, L_N (3 values with L_{10}, L_{50} and L_{90} as default) and Overload in % of measurement time
Memory: 40 Records of Overall Results stored manually
Automatic Logging: L_{eq}, L_{10} and L_{90}
  Logged Every: 0.1+, 1, 10 s, 1, 10, 30 min. or 1 hour
  Log Capacity: 21 600 (or 86 400) sets of results (for example, 6 or 24hrs of 1s logging) dependent on version
Outputs:
  Serial Interface: Compatible with EIA-574 and EIA-232-E
    Result Output Formats: Overall and Logged Results, Level and Cumulative Distribution
    Distribution Resolution: 1 or 5 dB
  DC Output: SPL
  AC Output: Preamp. output (L-weighted)
Clock: Real-time (calendar) and elapsed time
Electromagnetic Compatibility: FCC class B part 15J
Batteries: Four 1.5V LR6/AA size alkaline cells (lifetime > 8 hrs)
External Power Supply: 7 – 15 V DC
Size: 252 × 97 × 41 mm
Weight: ~ 460 g (incl. batteries)

* *plus 10 – 90 dB RMS range with filter versions*
\+ L_{eq} only

Ordering Information

Type 2236 A Precision Integrating Sound Level Meter
Type 2236 B Precision Integrating Sound Level Meter (extended memory)
Type 2236 C Precision Integrating Sound Level Meter with 1/1-octave filter set
Type 2236 D Precision Integrating Sound Level Meter with 1/1-octave filter set (extended memory)

Accessories included:
4 × QB 0013 Four 1.5V LR6/AA size alkaline cells
Type 4188 Prepolarized Condenser Microphone Cartridge
KE 0323 Shoulder Bag
UA 1236 Protective Cover

Accessories available:
Type 4231 Sound Level Calibrator
UA 1251 Tripod
UA 0237 and UA 0459 Windscreens
AO 0408 and AO 0409 Microphone Extension Cables (3 m and 10 m)
KE 0325 Carrying Case with Insert for Type 2236, Type 4231, WQ 1138, UA 1251
ZT 0326 Octave Filter Set Ugrade

For output to PC, serial printer:
AO 1386 9-pole Cable with 25-pole Adaptor
WQ 1138 Serial Printer

For output to recorders:
AO 0403 LEMO to BNC Cable

For output to graphics printer:
AO 0404 9-pole to LEMO Cable
Type 2318 Graphics Printer

Services available with delivery of 2236:
EK 0102 Accredited calibration re. IEC 651 and IEC 804

Brüel & Kjær reserves the right to change specifications and accessories without notice.

Contact your local Brüel & Kjær representative for more information about Precision Integrating Sound Level Meter Type 2236 – the dawn of a new era.

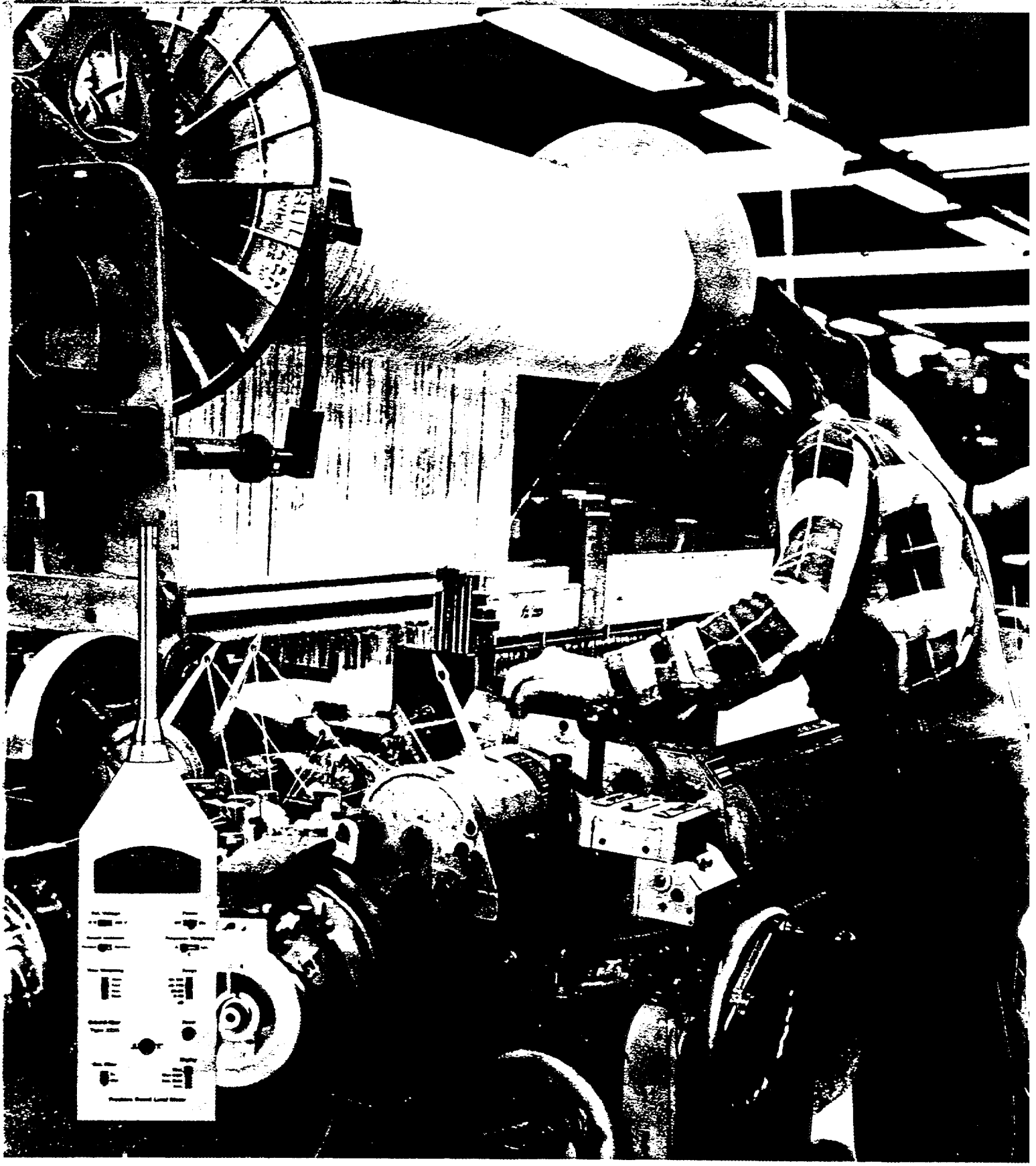
Brüel & Kjær

Bruel & Kjaer Instruments, Inc.

NORTHEAST 185 Forest Street · Marlborough, MA 01752-3093 · Tel.: (508) 481-7737 · Fax: (508) 624-0503
SOUTH 2364 Park Central Blvd. · Decatur, GA 30035 · Tel.: (404) 981-6225 · Fax: (404) 981-8370
CENTRAL 15873 Middlebelt Road · Livonia, MI 48154-3809 · Tel.: (313) 522-8600 · Fax: (313) 522-4369
MIDWEST 555 West Central Road · Hoffman Estates, IL 60195 · Tel.: (708) 358-7582 · Fax: (708) 358-7886
WEST 721 North Eckhoff Street · Orange, CA 92668 · Tel.: (800) 442-1030 · Fax: (714) 978-3176
NORTHWEST 3980 150th Ave. N.E., T/C · Redmond, WA 98052 · Tel.: (206) 883-2203 · Fax: (206) 882-1877

Versatile and accurate

Precision Sound Level Meter Type 2225



el Meter Type 2235

FEATURES:

- Fulfills IEC 651 Type 1! & ANSI S1.4
- "S", "F", "I" time weightings and Peak
- AC and DC Output for paper or tape recordings
- Selectable microphone polarization voltage

Processing

The signal from the microphone is amplified, filtered, rectified and digitized. The digital signal can then be processed to obtain the maximum SPL (IEC standard) or the instantaneous SPL (Japanese standard), both with automatic (once a second) or manual reset. The manual reset, i.e. the "Hold" functions, gives the maximum SPL since last reset, and the instantaneous SPL when the instrument was last reset. "Max. Hold" is useful for example when looking for the maximum SPL produced by a machine during a cycle, and it can even be measured with the "I" weighting or the Peak mode. "Inst. Hold" can be used to allow time for writing down a reading or to compare the SPL measured at different points in time.

Display

The measured SPL is displayed with a resolution of 0,1 dB and updated every second. Measurements affected by an overload, or underload, cannot be read. The display also indicates when the batteries need replacing.

Frequency analysis

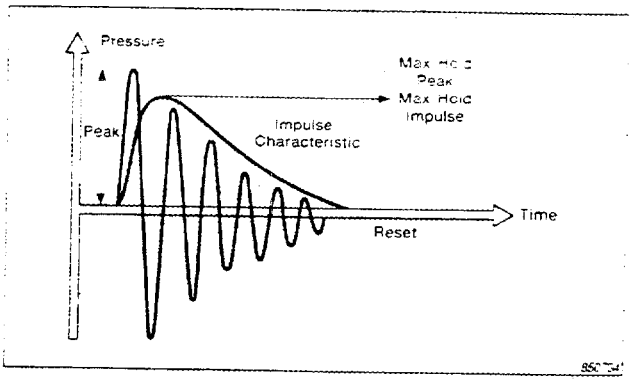
The Sound Level Meter is designed for easy connection to the Filter Sets Type 1624 or 1625. Type 1624 offers octave analysis recorded semi-automatically on the Level Recorder Type 2317, while Type 1625 offers 1/3 octave or octave analysis recorded fully automatically. The Filter Set plugs into the bottom of the Sound Level Meter to form an easy-to-use integral instrument. To make the best use of the frequency range of the Type 1625 (up to 20 kHz), a microphone other than the 4176 can be selected from the wide B & K range of prepolarized and 200 V external polarization microphones. A set-up for calibration of audiometers can be made with the Sound Level Meter, a Pressure Microphone, an Artificial Ear and a Filter Set.

Recordings

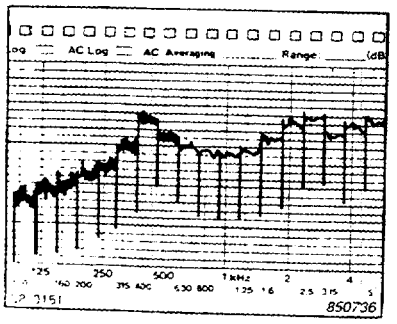
The Type 2235 [illegible] DC and AC Outputs to enable all kind of recordings to be made for direct use or further processing in the laboratory.

The AC Output is particularly well suited for recordings with the Tape Recorder Type 7005 or 7006, or with the Level Recorder Type 2317. With these instruments recordings can quickly be made using precalibrated settings. Graphic recordings using the AC Output also permit determination of reverberation time. In addition, the AC Output allows audio monitoring of the measured noise, a feature especially useful when measuring in locations where heavy electromagnetic fields may induce electrical noise.

The DC Output allows recordings to be made of the signal processed by the detector. Recordings of this signal are recommended when the level recorder does not incorporate a very accurate rectifier or well defined time weightings. Overloads are also clearly indicated on the DC recording by an hysteresis circuit which ensures that the pen will deflect unambiguously.



Max. Hold Peak and Max Hold Impulse



Precision Sound L

USES:

- Industrial and community noise measurements
- Building acoustic measurements
- Detailed noise analysis (with Filter Set)
- Audiometers calibration

[illegible] for general purpose sound level measurement. Its precision (IEC 651 Type 1!) and versatility enable accurate and reliable results to be obtained in most measurement situations whether the noise is continuous, rapidly re[illegible]. Addition of a filter set allows accurate [illegible] frequency analysis in octave or third-octave bands. Chart [illegible] recordings can be obtained from the AC or DC signal output [illegible] documentation of the measurement or further noise analysis. More specialized applications can also be met, such as the calibration of audiometers by use of a Pressure Microphone, Filter Set and Artificial Ear.

Microphone

The Type 2235 is delivered with a half inch Prepolarized Microphone Type 4176 complying with IEC 651 Type 1. The microphone is robust and well-suited to field use. It is supplied with a windscreen which protects it from dust, condensation and light precipitation.

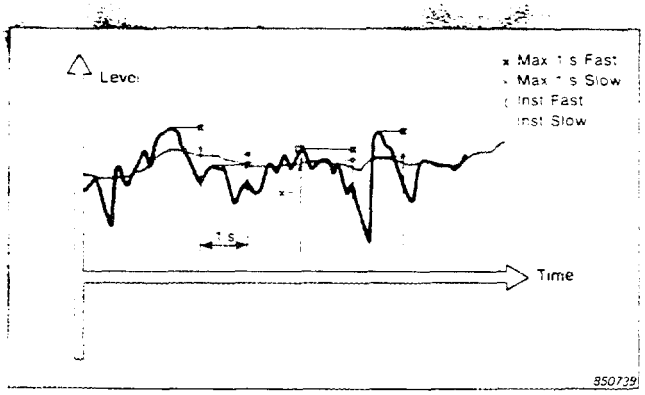
The Type 4176 covers most applications, a linear free field or linear random incidence response being selected by a switch. For applications such as audiometer calibration or high frequency signal measurements, another microphone from the B & K range, prepolarized or with 200 V external polarization, can be substituted. Extension cables can be inserted between the microphone preamplifier and the Sound Level Meter to allow measurements to be performed without disturbing the sound field. When measuring electrical signals the microphone can be replaced by an input adaptor.

Frequency weighting

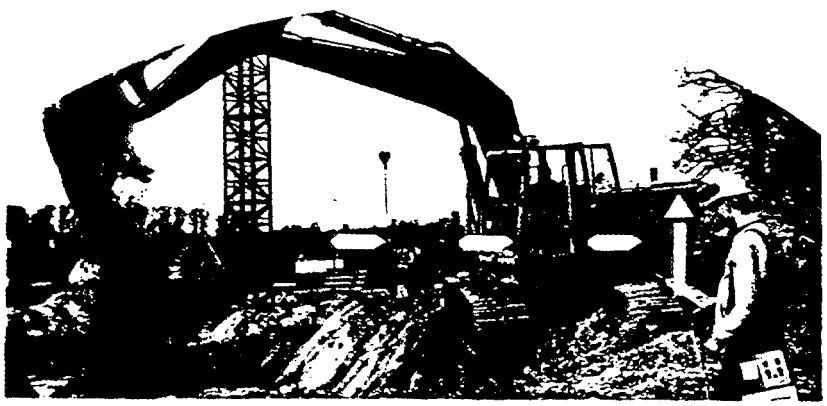
The signal picked up by the microphone is frequency weighted with an "A", "C" or "Lin." frequency weighting in accordance with IEC 651. "A" weighting is the most widely used frequency weighting for improved correlation with the subjective effect of noise. By comparing measurements made with "A" and "C" weightings an estimate can be made as to the frequency content of the signal. For greater versatility it is also possible to carry out a frequency band analysis of the "A", "C" or "Lin." frequency weighted signal.

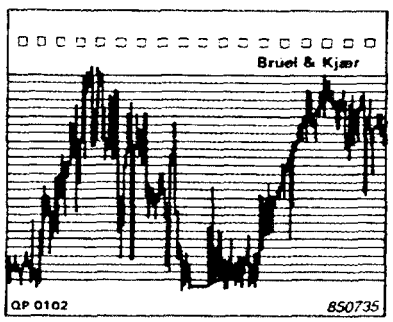
Detector and Time weighting

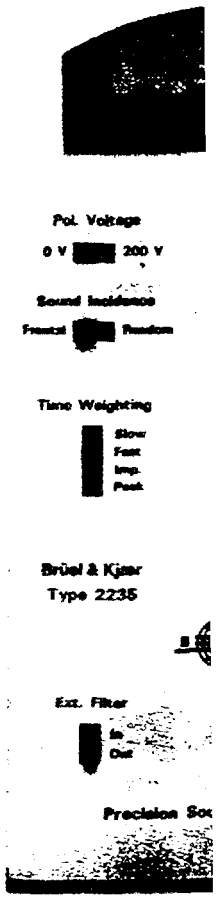
True RMS detector for measuring sound pressure levels between 24 dB and 130 dB (or 150 dB with a 20 dB attenuator inserted) in four 70 dB ranges, and with four normalized time weightings: "F", "S", "I" and Peak. The "F" time weighting closely follows the variations of the SPL and is used in most measurements. If the fluctuations between successive readings are too large, a more accurate and meaningful reading is obtained using the "S" time weighting. When the noise measured is impulsive (high levels of short duration), it is better characterized by a measurement with Impulse time weighting or a measurement of the Peak value.

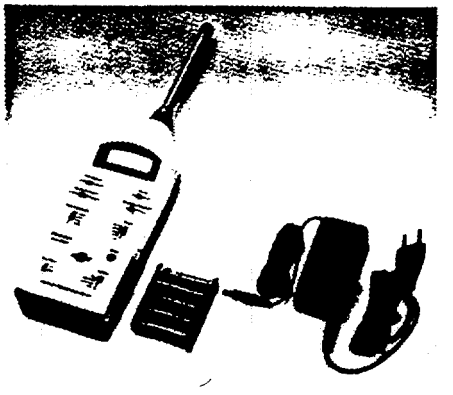


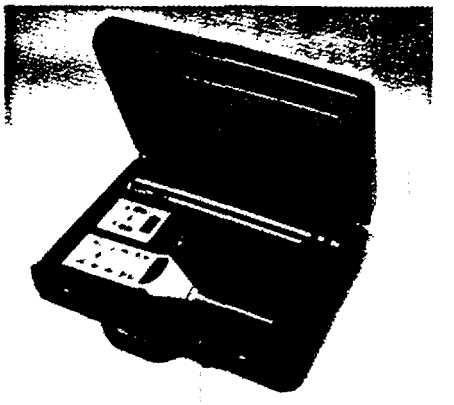
Max. and Inst. SPL readings with "F" and "S" time weightings











Calibration

The 2235 can easily be calibrated with the Sound Level Calibrator Type 4230 which fits directly over the microphone and checks that the complete measuring chain is working properly.

Power supply

The 2235 is powered from 4 "pen-light" alkaline cells giving a life time of approximately 16 hours. A battery drawer with four rechargeable cells can also be fitted (option ZG 0254, charger included).

Measurement set

As an option, the Sound Level Meter can be delivered with an attaché-case offering room for the Sound Level Meter, a Filter Set, a Sound Level Calibrator, a Windscreen, a Tripod and personal documents.

SPECIFICATIONS

MEASURING RANGE:

Range	Measuring Range		
	Lower limit for S/N ratio -5 dB (A-weighting)	Max. peak level	Upper limit for signals of crest factor ±10 (20 dB)
0–70	24	73	53
20–90	24	93	73
40–110	40	113	93
60–130	60	133	113
80–150*	80	153	133

700580GB0

* Only with attenuator ZF 0020 employed

FREQUENCY RESPONSE: according to IEC 651 Type 1

FREQUENCY WEIGHTING: (to IEC 651 Type 1) A-weighting, C-weighting and Lin 5 Hz-20 kHz

DETECTOR:
Characteristics: true logarithmic RMS and Peak
Linearity range: 70 dB
Pulse range: 73 dB

TIME WEIGHTING CHARACTERISTICS:
"F": to IEC 651 Type 1
"S": to IEC 651 Type 1
"I": to IEC 651 Type 1
"Peak": rise time <100 μs with a resetting time of 400 ms

DISPLAY:
3½ digits 7 segments, liquid crystal, 8 mm high. Resolution: 0.1 dB
Updated once a second for Max or inst. modes. Updated when reset if in Max Hold or Inst. Hold modes. Also updated if a higher value occurs in Max Hold mode

Hold decay rate: 0 dB/s (digital)
Warnings: Overload (---⁺); Under range (---); Battery low (**BAT**)

AC OUTPUT:
1 V RMS for full scale. <100 Ω output impedance. Short circuit protected. Mini-jack socket

DC OUTPUT:
0 to 3.5 V. 50 mV per dB. <100 Ω output impedance. An hysteresis circuit insures unambiguous Level Recorder deflections if an overload occurs. Short circuit protected. Mini-jack socket

RESET FUNCTION: automatic for max. or instantaneous SPL; manual for Hold modes

STANDARD MICROPHONE:
Type: ½ inch B & K Prepolarized Condenser Microphone Type 4176
Sensitivity: 50 mV/Pa
Capacitance: 13 pF
Windscreen effect: <0.9 dB up to 10 kHz

CALIBRATION:
Screwdriver operated potentiometer adjustment using Sound Level Calibrator Type 4230

REFERENCE CONDITIONS FOR ACOUSTICAL CALIBRATION WITH TYPE 4230:
Type of Sound Field: Free
Reference Incidence Direction: Perpendicular to microphone diaphragm
Reference SPL: 94 dB (re 20 μPa)
Reference Frequency: 1 kHz
Reference Temperature: 20°C
Reference Measuring Range: 40–110 dB

WARM-UP TIME: <5 s

EFFECT OF HUMIDITY (AT 40°C AND 1000 Hz):
<0.5 dB for 30% < RH < 90%

EFFECT OF TEMPERATURE:
Microphone: −0.004 dB/°C typically
Complete instrument:
±0.5 dB −10 to +50°C
Operating range: -10 to +50°C (+14 to 122°F)
Storage without batteries: -20 to +70°C (-4 to 158°F)

EFFECT OF MAGNETIC FIELD:
negligeable for 80 A/m (1 Ørsted) at 50 Hz

VIBRATION SENSITIVITY: 70 dB max. at 95 Hz and 1 ms⁻²

BATTERIES:
Type: Four 1.5 V Alkaline cells IEC type LR6 "AA" size). **Life:** approx. 16 hours of continuous operation

OVERALL DIMENSIONS AND WEIGHT:
370 × 85 × 47 mm (14.7 × 3.3 × 1.8
770 g (1.7 lb) with batteries

ACCESSORIES INCLUDED:

Half inch Prepolarized Condenser Microphone	Type 4176
2.5 mm mini-jack plug	JP 0213
Windscreen	UA 0237
Cells (×4)	QB 0013

ACCESSORIES AVAILABLE:

20 dB Attenuator	ZF 0020
Carrying case	KE 0226
Tripod	UA 0801
Sound Level Calibrator	Type 4230
Level Recorder Cable	AO 0173
Pressure Microphone	4144
Free field Microphone	4155
3 m Microphone Extension cable	AO 0027
Mains Power Supply and Charger	ZG 0254

Bruel & Kjaer Instruments, Inc.

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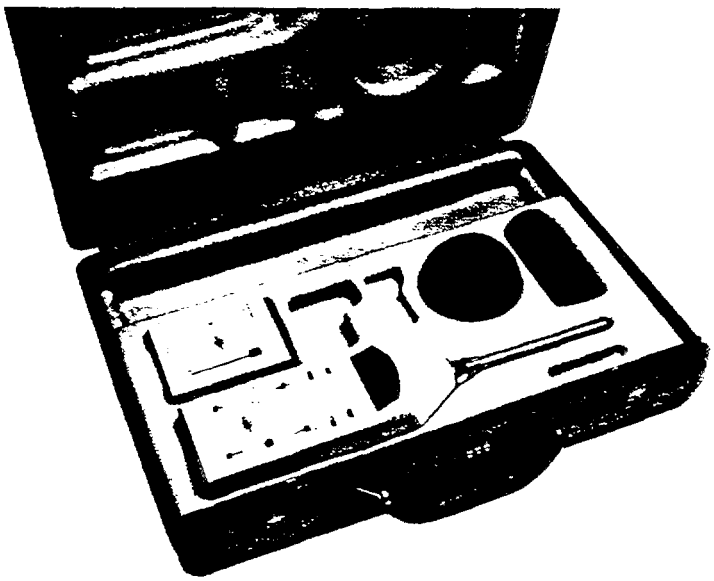
Regional Offices: MA (617) 481-7000 ext. 139; NJ (201) 227-6100; MD (301) 948-0494; GA (404) 951-0115; MI (313) 522-8600; IL (312) 358-7582; TX (713) 645-0167; CA (714) 978-8066, (415) 574-8155; WA (206) 625-1112

World Headquarters: Nærum, Denmark. Sales and service in principal US cities and 55 countries around the world

Sound Measurement Kits

Sound Level Meter System Type 2235S



- 2235 Precision Sound Level Meter
- 1624 Octave Filter Set
- 4230 Acoustic Calibrator
- KE 0226 Carrying Case

APPLICATIONS:

- Industrial Noise Exposure Evaluation
- Community Noise Measurements
- Audiometer Calibration
- Building Noise Measurements (NC)
- Frequency Analysis of Noise Sources

FEATURES:

- Type 1 Sound Level Meter
- Slow, Fast, Impulse Time Constants plus Peak
- A- and C-weighting and Linear
- AC and DC Output
- Selectable Microphone Polarization Voltage
- Octave Band Filter Set
- Calibrator for System Checkout

CONDENSED SPECIFICATIONS 2235S

2235 Precision Sound Level Meter

FREQUENCY RESPONSE:
According to IEC 651 Type 1

FREQUENCY WEIGHTING:
(To IEC 651 Type 1) A-weighting, C-weighting and Lin 5 Hz - 20 kHz

DETECTOR:
Characteristics: true logarithmic RMS and Peak
Linearity range: 70 dB
Pulse Range: 73 dB

TIME WEIGHTING CHARACTERISTICS:
"F": to IEC 651 Type 1
"S": to IEC 651 Type 1
"I": to IEC 651 TYpe 1
"Peak": rise time < 100 µs with a resetting time of 400 ms

DISPLAY:
3-1/2 digits 7 segments, liquid crystal, 8 mm high.
Resolution: 0.1 dB
Updated once a second for Max or inst. modes. Updated when reset if in Max Hold or Inst. Hold modes. Also updated if a higher value occurs in Max Hold mode.

Hold decay rate: 0 dB/s (digital)
Warnings: Overload (---T);Under range (---); Battery low (BAT)

AC OUTPUT:
1 V RMS for full scale. <100Ω output impedance. Short circuit protected. Mini-jack socket.

DC OUTPUT:
0 to 3.5V. 5 mV per dB. <100Ω output impedance. A hysteresis circuit ensures unambiguous Level Recorder deflections if an overload occurs. Short circuit protected. Mini-jack socket.

RESET FUNCTION: automatic for max. or instantaneous SPL; manual for Hold modes.

STANDARD MICROPHONE:
Type: 1/2 inch B&K Prepolarized Condenser Microphone Type 4176
Sensitivity: 50 mV/Pa
Capacitance: 13 pF
Windscreen effect: <0.9 dB up to 10 kHz

CALIBRATION:
Screwdriver operated potentiometer adjustment using Sound Level Calibrator Type 4230.

REFERENCE CONDITION FOR ACOUSTICAL CALIBRATION WITH TYPE 4230:
Type of Sound Field: Free
Reference Incidence Direction: perpendicular to microphone diaphragm
Reference SPL: 94 dB (re 20 µPa)
Reference Frequency: 1 kHz
Reference Temperature: 20°C
Reference Measuring Range: 40-110 dB

WARM -UP TIME:
<5 s

EFFECT OF HUMIDITY (at 40°C and 1000 Hz):
<0.5 dB for 30% <RH < 90%

MEASURING RANGE:

Range	Measuring Range: Lower limit for S/N ratio -5 dB (A-weighting)	Max. peak level	Upper limit for signals of crest factor = 10 (20 dB)
0 - 70	24	73	53
20 - 90	24	93	73
40 - 110	40	113	93
60 - 130	60	133	113
80 - 150*	80	153	133

* Only with Attenuator ZF 0020 employed

1624 Octave Filter Set

FREQUENCY RANGE:
Selective: 22 Hz to 22 kHz
Linear: Typical 5 Hz to 75 kHz (-1 dB)

BAND PASS FILTERS:
10 active 6-pole Butterworth octave filters

In accordance with standard
IEC R-225-1966, DIN 45 651 and ANSI S1.11-1966, Class II

Center Frequencies
31.5 Hz to 16 kHz

Attenuation at Center Frequency
0 dB ± 0.5 dB

Peak-to-valley Ripple
<0.5 dB

Attenuation outside Pass Band
> 60 dB at 8 f_o and 1/8 f_o

Filter Shift
Slider switch
Green lamp indicates time for filter switching when used with Level Recorder

INPUT IMPEDANCE:
10 kΩ in series with 5 µF

INPUT TERMINATING IMPEDANCE:
≤ 100Ω

INPUT VOLTAGE:
Max. 2 V sinus (2.8 V peak)

OUTPUT IMPEDANCE:
<5 Ω in series with 15 µF

OUTPUT TERMINATING IMPEDANCE:
≥ 10 kΩ // 1 nF

INHERENT NOISE:

f_o Hz	max. µV
31.5 Hz	200 (typ. 140)
63 Hz - 16 kHz	150 (typ. 70)
Lin	250 (typ. 120)

4230 Sound Level Calibrator

SOUND PRESSURE LEVEL:
94 dB re 2 x 10^{-5} Pa (or 1 Pa)

ACCURACY OF SPL:
at 1013 mbar when loaded with 1.333 cm^3 (corresponding to B&K microphones with protecting grid, and their respective adaptors)
± 0.3 dB at 23°C ±3°C (68 to 79°F)
± 0.4 dB between 10 and 40°C (50 to 104°F)
± 0.5 dB between 0 and 50°C (32 to 122°F)

FREQUENCY:
1000 Hz ± 1.5%

DISTORTION:
<1%

INFLUENCE OF STATIC PRESSURE:
± 0.05 dB/100 mbar from 500 mbar to 1100 mbar

LONG TERM STABILITY:
Better than ± 0.1 dB/year (expected for normal field use)

MICROPHONE TYPES:
1" directly
1/2" with supplied adaptor

POWER SUPPLY:
Internal supply from 1 x 9 V transistor (IEC 6 LF 22, NEDA 1604) battery

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Printed in U.S.A 110190-2235S

IL1400A SMART RADIOMETER/PHOTOMETER

*AUTOMATIC RANGING,INCL INTEGRATION MODES
*LIGHT INTEGRATION, SECONDS TO 24 HOURS
*TTL SERIAL PRINTER/COMPUTER INTERFACE
*SMART DETECTOR DETERMINED PROCESSING
*USER FRIENDLY ALPHA-NUMERIC DISPLAY
*DIRECT READING IN ANY OPTICAL UNITS
*ANALOG RECORDER OUTPUT (0-1 VOLT)
*DARK ROOM HOLD READING FEATURE
*HAND HELD-COMPLETELY PORTABLE
*AUTOMATIC UNITS DISPLAYED
*SIMPLE OPERATING BUTTONS
*7 DECADE DYNAMIC RANGE
*AUTOMATIC SHUT-OFF
*AUTOMATIC ZEROING
*BATTERY OPERATED

The IL1400A is a significant advancement in hand held radiometer technology in its ability to provide superior performance without sacrificing simplicity. The IL1400A provides the proper units of measurement, the detector conveys its own specific calibration information and range limitations to the IL1400A microprocessor. The display reads out alphanumerically in standard optical units. All essential functions are under microprocessor control. The IL1400A provides automatic ranging over a full seven decades, and reads out linearly, in real time in any optical units. The recorder output, can be used as an input to a data logger or computer analog interface. We also offer a TTL serial port.

Detectors are available to cover the full line of applications in the ultraviolet, visible and infrared Spectra. We also offer customized detectors. Our standard detector design offers improved cosine spatial response, necessary for full immersion applications. Low profile probes are available in several different styles. Detectors with extension cables or fiber optic input heads are also available for those cases where the probe must go to a remote light source or harsh environment. STANDARD UNITS IN SIGNAL MODE: W/cm², W, lm/ft², lux, fL, E/cm², cd/cm², cd/m², Amp, W/cm²/sr, W/cm²/nm, dBu, & dBm. IN INTEGRATE MODE: J/cm², J, lm*s/ft², lux*s, fL*s, E*s/cm², cd*s/cm², cd*s/m², Coulomb, J/cm²/sr, J/cm²/nm, dBu*s, & dBm*s.

<u>FRONT PANEL CONTROLS:</u> The ZERO button nulls the displayed signal to zero. The SIGNAL button selects direct measurement mode, including automatically selected range and units. The INTEGRATE button alternately selects between two overlapping integration modes, HI and LO, also with auto-ranging and auto units. The HOLD button freezes the display to terminate/pause integration or to hold darkroom readings. The ON/OFF button is complemented by an automatic shut-off feature for longer battery life, which can be optionally defeated for special long duration measurements. The 32 character alpha-numeric LCD continuously displays detector data with full units as well as the present mode of operation. Easy to understand messages such as LOW BATTERY and OVER RANGE also appear to indicate error situations.

<u>ELECTRICAL/MECHANICAL:</u> Input Power: 4 'AA' alkaline batteries, 26 mA. Singal Current: Over 7 decades of overlapping current measurement from 10 picoAmperes to 350 microAmperes. Input Impedance: Virtual ground (summing node of operational amplifier). Linearity +/-0.2% +/-1 digit. Recorder Output: 408 ohm impedance, 1 volt scale, current limited, 1/2 second update. Size: 185mm height x 100mm width x 43mm depth (7.3 x 3.9 x 1.7"). Weight:

(2)

IL1400A, less detector **$679**

SMART RADIOMETER/PHOTOMETER
Computer controlled, battery powered, digital and alpha numeric display, seven decade range of either signal or integrated dose measurements, direct reading in any units appropriate for the detector, auto range, auto zero, auto units, CC500 Carrying Case, recorder output.

WHOLE PHOTO. DETS

SED(SEL)033/Y/L30 ..... **$650**

HIGH SENSITIVITY ILLUMINANCE PROBE
33 mm² silicon detector, Y Photopic Filter, L30 High Gain Lens, YIS(IYIS) Calibration for direct reading in foot-candles. Spectral range: 400-700nm (C.I.E.).

SED(SEL)033/Y/R. **$651**

LUMINANCE PROBE
33 mm² silicon detector, Y Photopic Filter, R Barrel, YLS(IYLS) Calibration for direct reading in footlamberts. This combination is designed for average measurement of luminance over a target area greater than 30mm diameter plus 1.5 degree half angle divergence. Spectral range: 400-700nm (C.I.E.).

SED(SEL)033/Y/W **$571**

ILLUMINANCE PROBE
33 mm² silicon detector, Y Photopic Filter, W Diffuser, YIS(IYIS) Calibration for reading in foot-candles and(or) lux. Spectral range: 400-700nm (C.I.E.).

W **$102**

QUARTZ "WIDE EYE" DIFFUSER
For use with SED(SEL)(SL) detectors for cosine response.

R **$182**

RADIANCE/LUMINANCE BARREL
Optical input assembly for SED(SEL)(SHD) detectors. Produces a narrow field of view to measure the radiance/luminance of extended sources. Also fits PM271 Detectors.

A509 ..... **$205**

TTL SIGNAL PROCESSOR/EXTENSION CABLE (FOR IL1400A)
Converts the IL1400A data for a computer/printer and provides 7 foot extension cables for both SEL(SL) detectors and digital device. Required for A514 operation.

A514 ..... **$249**

DIGITAL PRINTER(FOR TTL OUTPUT FROM IL1400A)
A509 cable required for operation. (Not included)

(3)

6mm diameter, 6 feet long glass cable.

H $102

HOOD FOR SED(SEL)(SHD) DETECTORS
64mm L x 42mm D barrel with 1 1/4"-24 female threads running through barrel.

RESTRICTS STRAY LIGHT.

L30 ..... $181

HIGH GAIN LENS ASSEMBLY
Sensitivity booster of 13 times the bare detector at a sacrifice in acceptance angle. It is used with silicon detectors for visible and near IR applications, especially for effective intensity from flash lamps.

~14° FOV

YIN $102

STANDARD LAMP INTENSITY
Mean spherical candle power output of lamp used with INS250 Integrating Sphere.

YINS $102

PHOTOPIC INTENSITY SENSITIVITY
Photopic intensity response, amp/candela, of an I.L. sensor assembly.

YIS $102

PHOTOMETRIC (Y) ILLUMINANCE SENSITIVITY
Illuminance sensitivity, (amps)(ft^2)(lm^{-1}), of an I.L. sensor assembly.

YLS $102

PHOTOMETRIC (Y) LUMINANCE SENSITIVITY
Luminance sensitivity, amps/fL, of an I.L. sensor assembly.

international light, inc.
17 Graf Rd. Newburyport, MA, 01950-4092

TEL: 508/465-5923 TLX: 947135 intllight
FAX: 508/462-0759 DDD: 508/462-7456

TO: OAK RIDGE NATL LAB - ENGIN PHYSICS & MATCH DIVISION

ATTN: DR PHIL SPELT-INT SYS SEC FROM : BOB ANGELO

YOUR REF: FAX INQUIRY FAX #: 615/574-7860

DATE: 01FEB94 PAGE 1 OF 4

DEAR DR SPELT:
THANK YOU FOR YOUR FAX AND CALL REGARDING PHOTOMETRIC MEASUREMENTS INSIDE VEHICLE.

PAGE 2 & 3 CONTAINS PHOTOCOPIED SECTIONS FROM OUR $LIST SHOWING INSTRUMENTS WHICH MAY BE OF INTEREST TO YOU.

A FULL DESCRIPTION OF THE IL1400A METER IS SHOWN ON PAGE 4
AS YOU CAN SEE, IT PROVIDES ANALOG AND TTL OUTPUTS. THE A509 TTL CABLE IS REQUIRED FOR ACCESS TO TTL OUTPUT THRU CONNECTOR AT TOP OF UNIT.

THE SEL033/Y/W IS A THREE PART DETECTOR ASSEMBLY WHICH INCLUDES THE DETECTOR SEL033, Y PHOTOPIC FILTER AND W DIFFUSER. IT IS CALIBRATED TO READ DIRECTLY IN FOOT-CANDLES OR LUX WITH IL1400A. THE Y AND W CAN BE REMOVED FROM DETECTOR AND OTHER FILTERS INPUT OPTICS CAN BE ADDED FOR DIFFERENT APPLICATIONS. FOR INSTANCE, THE R LUMINANCE BARREL CAN BE ADDED TO SEL033/Y TO FORM THE SEL033/Y/R LUMINANCE DETECTOR. A NEW CALIB FACTOR WOULD BE SUPPLIED FOR THE NEW COMBINATION. THIS FACTOR WOULD HAVE TO BE SELF-PROGRAMMED INTO IL1400A METER SO THAT IT WOULD READ DIRECTLY IN LUMINANCE UNITS.
SO THE SEL033/Y CAN PROVIDE THE BASE FOR ALL PHOTOMETRIC MEAS.
OTHERWISE, MULTIPLE DETECTORS COULD BE USED FOR THE VARIOUS APPLICATIONS SAVING TIME BUT NOT EXPENSE. TIME WOULD BE SAVED SINCE THE CAL FACTORS WOULD NOT HAVE TO BE SELF-PROGRAMMED INTO IL1400A EVERY TIME. THEY WOULD READ DIRECT WHEN CONNECTED TO IT.

I FAILED TO GET YOUR FULL MAILING ADDRESS, SO PLS FAX SO I CAN PROVIDE FULL LINECATALOG AND PRICELIST.

PLS CONTACT ME WITH ANY FURTHER QUESTIONS.

BEST RGDS-BOB ANGELO

2

international light, inc.
17 Graf Rd. Newburyport, MA, 01950-4092

international light, inc.
17 Graf Rd. Newburyport, MA, 01950-4092

TEL: 508/465-5923 TLX: 947135 intllight
FAX: 508/462-0759 DDD: 508/462-7456

TO: OAK RIDGE NATL LAB-ENGIN PHYS & MATH DIV

ATTN: FRANK BARICKMAN FROM : BOB ANGELO

YOUR REF: TELCON TODAY: PHOTOM FAX #: 615/574-7860

DATE: 02FEB94 PAGE 1 OF 9

DEAR MR BARICKMAN:
IN REPONSE TO YOUR CALL TODAY I HAVE INCLUDED SOME INFORMATION ON THE NEXT PAGES YOU REQUESTED.

PAGES 2-7 CONTAIN INFORMATION ON THE IL1400A DIGITAL AND ANALOG OUTPUTS.
I WILL MAIL IL1400A MANUAL TO YOUR ATTENTION TODAY.

PAGE 8 CONTAINS THE SPECTRAL PLOT OF THE SEL033/Y/W DETECTOR AS COMPARED TO THE CIE RESPONSE. THE DETECTOR IS 42MM DIAMETER X 35MM LONG. PAGE 9 CONTAINS MECH DWG OF DETECTOR BASE HOUSING SHOWING MOUNTING HOLES, ETC.
CABLE LENGTH IS SEVEN FEET. MEAS RANGE OF IL1400A/SEL033/Y/W: 0.005 TO 17,500 FOOT-CANDLES. THE RANGE CHANGES SLIGHTLY WHEN W DIFFUSER IS REMOVED AND ANOTHER INPUT OPTIC IS ADDED SUCH AS THE H HOOD OR L30 LENS.
SEL033/Y/L30 RANGE: 0.0001 TO 233 FC. SEL033/Y/H: 0.0007 TO 2333 FC.
WITH THE L30 LENS, THE DETECTOR FIELD OF VIEW IS REDUCED TO 14 DEGREES. H BARREL REDUCES FIELD TO 23 DEGREES. W DIFFUSER PRODUCES NEAR COSINE SPATIAL RESPONSE.
TYPICAL SENSITIVITY OF SEL033/Y/W: 2.5E-8 (AMPS)(CM2) / (WATT)

PLS LET ME KNOW IF ANY OTHER INFORMATION IS NEEDED.

BEST RGDS-BOB ANGELO

```
|-------------------------------|  |-------------------------------|
| + 1 2 3 . 4   m W / c m 2     |  |  + 2 2 . 7    J / c m 2       |
|                               |  |                               |
| S I G N A L     N O   O F F   |  | H I   I N T E G    N O   O F F |
|-------------------------------|  |-------------------------------|
```

'NO OFF': This message will blink in the 'status' register (lower right corner of the LCD) when the automatic 10 minute shutoff feature has been disabled. This indicates that a previous user selected 'AUTO SHUT OFF' 'DISABLED' using the programming mode capabilities. Refer to section 3.1.2 for more information on enabling or disabling the auto shut off. Refer to section 6.4 for more information on using the program mode.

5.2 ANALOG DATA RECORDER OUTPUT

An analog output voltage is available via the Recorder Output Jack located in the lower right corner of the front panel. This accepts a standard RCA type coaxial phono jack. We offer a phono jack which terminates in clip leads for simple connection to a data logger. The graph below shows a typical recorder plot using the IL1400A.

5.2.1 Voltage Range

The voltage is designed to be compatible with most strip chart and X-Y recorders, and yet provide a large enough signal to avoid excessive noise pickup. For these reasons, we have selected a range from 0 to 1.0 Volt (1000 mV), rescaling every decade to provide sufficient resolution. To accomplish this, the IL1400A first converts the digits on the display into scientific notation form, with a mantissa and exponent component. The mantissa portion of the reading, ranges between 1.000 and 9.99 before the exponent portion is scaled either up or down by a decade. The analog voltage created is equal to 100 times the mantissa, in milliVolts. Consequently, a mantissa of 1.000 creates a voltage of 100 mV, and a mantissa of 9.99 creates a voltage of 999 mV. If the voltage goes either above or below one of these thresholds, the recorder output ranges by a decade to accomodate the reading. The above graph is given as an example of a typical strip chart recording using the IL1400A.

5.2.2 Auto Ranging Considerations

The IL1400A auto ranging software is designed to limit the least significant digit to 0.5 % of the full scale reading, and the resolution on the low end to 10 picoAmperes. The instrument decides whether to display either three or four digits of resolution. When the magnitude of the reading on the display is greater than 2000 (disregarding the decimal point), the smallest digit represents less than 0.5 % of the total, so the instrument displays only the three most reliable digits. The units auto range every three decades, using standard SI prefixes from femto to Mega.

The resolution of the 1000 mV Analog Recorder Output is 1 mV, inherently limiting the minimum resolution. In order to display the full seven decades of dynamic range while providing significant resolution, the Analog Recorder Output auto ranges EVERY DECADE. The

output spans from 100 mV to 1000 mV, automatically ranging upon reaching either threshold. When the output is increasing and passes 999 mV, the voltage instantly drops to 100 mV and continues increasing. Similarly, when the output is decreasing and drops below 100 mV, the voltage instantly jumps to 999 mV. These range changes are easy to spot on a typical chart recorder plot. Thus, by noting the decade at any point on the plot, the other decade changes can be easily deduced.

5.2.3 Negative Readings

Since there is no such thing as negative light, we elected to use a Unipolar Digital to Analog (D/A) Converter. Negative readings should not occur if the 'ZERO' was properly set and if your ambient conditions do not change throughout the experiment. From our own experiences, however, we understand that mistakes occasionally get made which make the reading go negative. The data will not get lost since the absolute value of the negative reading will be sent out to the recorder. From the plot it is fairly easy to determine that the reading is negative, since the curve comes back up after it hits zero. If in doubt, it would be wise to rerun the experiment.

5.3 TTL SERIAL OUTPUT

A509 Pinout:

PIN 1: "BUSYNOT" - Busy (Not) from Printer (RED wire)
PIN 2: "GND" - Ground (SHIELD wire)
PIN 3: "DATA" - TTL Serial Data to Printer (WHITE wire)
PIN 4: "RQSNDNOT" - Request to Send (Not) (BLACK wire)
PIN 5: No Connection

Detector Edge Connector Pinout:

LINE 1: "DODM" - EEPROM Output and "BUSY NOT"
LINE 2: "DIDM" - EEPROM Input and "DATA"
LINE 3: "SKDM" - Clock for EEPROM
LINE 4: "CSDM" - Chip Select for EEPROM or Printer (Not)
LINE 5: "GARD" - Signal Return
LINE 6: "INPUT" - Current Signal Input
LINE 7: "GND" - Ground
LINE 8: "RQSNDNOT" - Request to Send (Not)
LINE 9: "-5V" - Negative 5 Volts
LINE 10: "+5V" - Positive 5 Volts

The TTL Serial Port is primarily intended for use with our A514 Digital Dot Matrix Printer and A509 adapter cable accessory for an immediate hard copy of time variation or optical profiling measurements. The A514 prints one line of data every second as long as Request to Send ("RQSNDNOT") and Chip Select ("CSDM") are held low. The IL1400A holds Request to Send low momentarily when the 'HOLD' button is pressed, thus printing one line of data with each keypress. The Request to Send line (PIN 4) can be wired externally to Ground (PIN 2) through a switch. When the switch is closed, connecting PIN 2 to PIN 4, the A514 Printer will print a continuous stream of data at a rate of one line (one reading) per second. The output is expressed in digital exponential notation. The IL1400A transmits data once every 0.5 seconds. Since the A514 printer takes longer than 0.5 seconds to print a line and has a buffer capacity of one printed line, it is capable of printing data only once every 1.0 seconds. When the printer is busy, the "BUSYNOT" line is held low and the IL1400A will not send data until the next 0.5 second cycle.

For experienced users who wish to connect to a computer or other data collecting device, we provide detailed information on the data format. One of the big advantages of the TTL output is the ability to interface directly with most computer user ports without buying an expensive hardware adapter. A small machine language (or even BASIC) program can often make a direct connection possible.

The IL1400A TTL Serial Output Port transmits a 12 byte, fixed field scientific notation reading (4 numerical mantissa digits with a +/- sign and decimal point, the letter e, 2 exponent digits with a +/- sign, a carriage return, and line feed).

5.3.1 Baud Rate

The IL1400A is factory set to an asynchronous baud rate of 1200. Baud rate is the number of bits per second transmitted in each word. In this case, there are 10 bits transmitted per character, which translates to a maximum of 120 characters per second. In actual

practice, however, the IL1400A computer sends character data only half the time, resulting in one transmitted character every 1/60 of a second. This is typical for asynchronous data transmissions.

5.3.2 Character Format

The 20 bits that make up each character word are comprised of 1 start bit, 8 data bits, and 11 stop bits. The extra 10 stop bits provide a necessary delay to allow the microprocessor to perform its other duties. Thanks to crystal control, the length of a single character (before the stop bit) is exactly 7.5 milliseconds, followed by a stop bit delay of exactly 9.17 milliseconds. The following diagram shows the voltage waveform for the serial character format of the number "5". The binary number is transmitted in reverse order, from least to most significant digit. The most significant digit is always a binary zero (+ 5 Volts), which ensures a negative leading edge to the first stop bit.

ONE CHARACTER: "5" (ASCII 53, Binary 00110101)

```
        0  0.833 mS                          7.5 mS          16.67 mS
        ↑   ↑                                  ↑                ↑
5.0V.... ---     ---     ---    :    -------    :              ---
        |   |   |   |   |   |   :   |   :   |   :              |   |
2.4V....|   |   |   |   |   |   :   |   :   |   :              |   |
        |   |   |   |   |   |   :   |   :   |   :              |   |
0.7V....|   |   |   |   |   |   :   |   :   |   :              |
0.0V----     ---     ---     -------    :    -------//-------
        start 1   0   1   0   1   1   0   0 stop              start
             LSB                         MSB
            ************ASCII DATA***********
        *************SERIAL CHARACTER************
```

True ASCII	IL1400A Value	Decimal Number	Hex Number	Binary Number
LF	Line Feed	10	0a	0 0 0 0 1 0 1 0
CR	Carriage Return	13	0d	0 0 0 0 1 1 0 1
+	Positive Sign	43	2b	0 0 1 0 1 0 1 1
-	Negative Sign	45	2d	0 0 1 0 1 1 0 1
.	Decimal Point	46	2e	0 0 1 0 1 1 1 0
0	Zero	48	30	0 0 1 1 0 0 0 0
1	One	49	31	0 0 1 1 0 0 0 1
2	Two	50	32	0 0 1 1 0 0 1 0
3	Three	51	33	0 0 1 1 0 0 1 1
4	Four	52	34	0 0 1 1 0 1 0 0
5	Five	53	35	0 0 1 1 0 1 0 1
6	Six	54	36	0 0 1 1 0 1 1 0
7	Seven	55	37	0 0 1 1 0 1 1 1
8	Eight	56	38	0 0 1 1 1 0 0 0
9	Nine	57	39	0 0 1 1 1 0 0 1
e	Exponent Base 10	101	65	0 1 1 0 0 1 0 1

5.3.3 Voltage Levels & Current Drive

The output voltage level on PIN 3 ("DATA") of the DIN connector is capable of driving one TTL load. The voltage swing will be a full five (5) Volts instead of the typical TTL voltage of four (4) Volts. The serial word will be in negative logic for the printer

(positive logic for the EEPROM). In negative logic, a logic 'ONE' will be between 0.0 and 0.8 Volts and a logic 'ZERO' will be between 2.4 and 5.0 Volts. The output line is capable of 'sinking' 1.3 milliAmps, and of 'sourcing' much more than 100 microAmps, which conforms to the one TTL load requirement. The inverted Request to Send line ("RQSNDNOT") on PIN 1 of the DIN connector will initiate transmission of the data string when pulled to a voltage below +0.8 Volts, provided that the Chip Select line "CSDM" is also low.

5.3.4 Word String Format

The IL1400A sends out a string of serial words (characters) to transfer the displayed data to other equipment, such as a printer or computer. The interface sends out exactly twelve (12) characters to portray the line of data. The first character is a '+' or '-' sign for the mantissa. The second character is the first digit of the mantissa. The third character is a decimal point. The fourth, fifth, and sixth characters are the remainder of the 4 digit mantissa. The seventh character is the lower case letter 'e' to separate the mantissa from the exponent. The eighth character is a '+' or '-' sign for the exponent. The ninth and tenth characters are the 2 digit exponent. The eleventh character is a carriage return. The twelvth character is a line feed.

ONE STRING: "+ 1 . 2 3 4 e - 0 5"

```
        0 mS                    183 mS                                  500 mS
        ↑                       ↑                                       ↑
5V..... X X X X X X X X X X X X X                                       X X X
        X X X X X X X X X X X X X                                       X X X
0V------X-X-X-X-X-X-X-X-X-X-X-X-X-----------------//---------------X-X-X
        + 1 . 2 3 4 e - 0 5 CRLF                                        + 1 .
        MANTISSA    EXPONENT
        *******STRING********                                           etc...
```

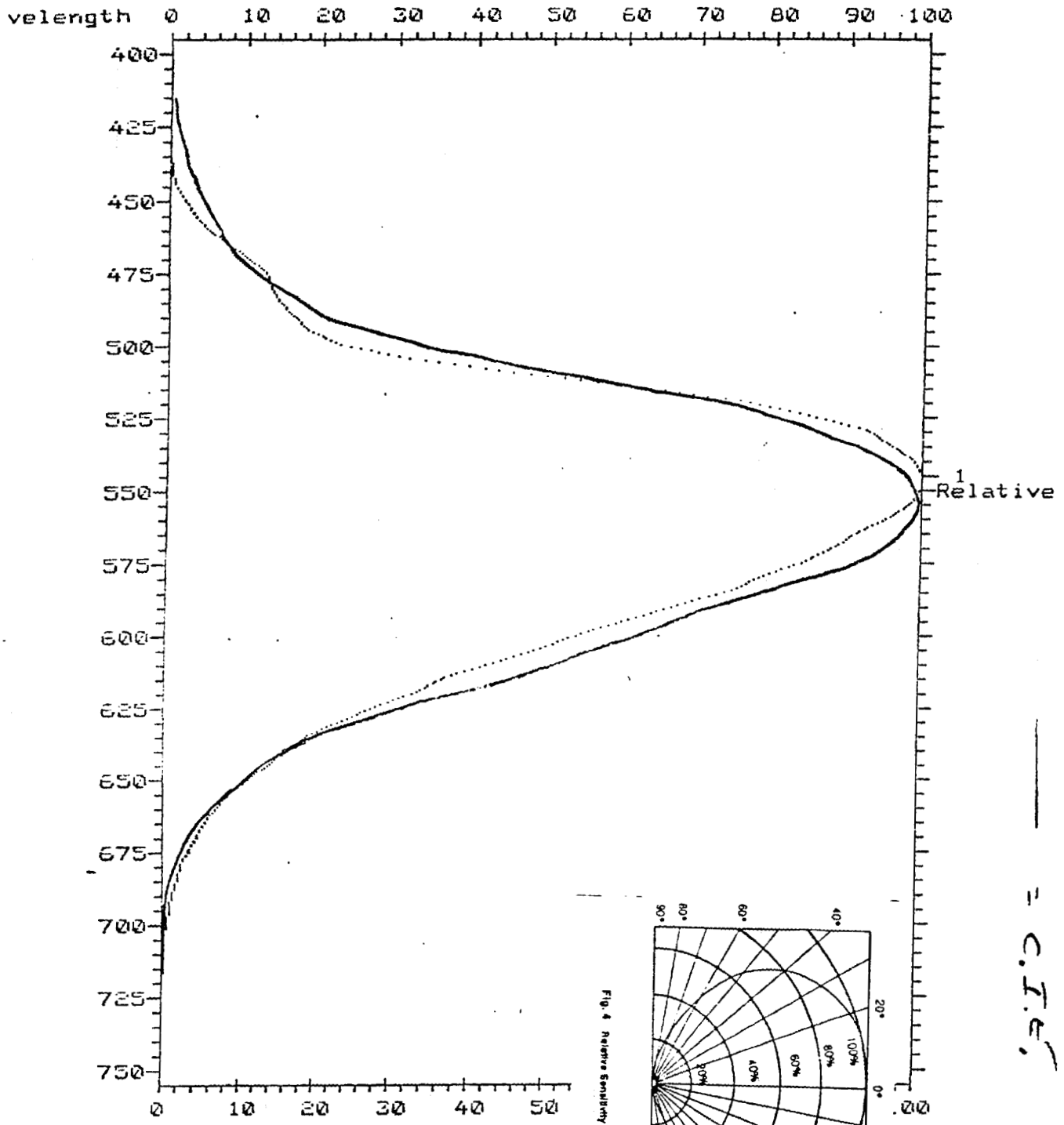
5.3.5 Plug and Cable Requirements

We offer a special detector connector adapter accessory (A509) for use with the A514 Digital Dot Matrix Printer or a computer. The connector housing contains the necessary electronics for adaptation to the A514 printer. A 7 foot detector extension cable and 3 foot printer cable are included. The 5 pin DIN printer connector pinout is listed at the beginning of section 5.3.

DISPLAY (S.F.: 1.000 e-2)	TTL STRING FORMAT	
+ + + + + + mW/cm2	+ + + + + + e + 0 0	(C.R. L.F.)
+ 3 5 . 0 mW/cm2	+ 3 . 5 0 0 e - 0 2	"
+ 2 0 . 0 0 mW/cm2	+ 2 . 0 0 0 e - 0 2	"
+ 1 0 . 0 0 mW/cm2	+ 1 . 0 0 0 e - 0 2	"
+ 9 . 9 9 mW/cm2	+ 9 . 9 9 0 e - 0 3	"
+ 5 . 0 0 mW/cm2	+ 5 . 0 0 0 e - 0 3	"
+ 2 . 0 0 0 mW/cm2	+ 2 . 0 0 0 e - 0 3	"
+ 1 . 0 0 0 mW/cm2	+ 1 . 0 0 0 e - 0 3	"
+ 9 9 9 uW/cm2	+ 9 . 9 9 0 e - 0 4	"
+ 5 0 0 uW/cm2	+ 5 . 0 0 0 e - 0 4	"
+ 2 0 0 . 0 uW/cm2	+ 2 . 0 0 0 e - 0 4	"
+ 1 0 0 . 0 uW/cm2	+ 1 . 0 0 0 e - 0 4	"
+ 9 9 . 9 uW/cm2	+ 9 . 9 9 0 e - 0 5	"
+ 5 0 . 0 uW/cm2	+ 5 . 0 0 0 e - 0 5	"
+ 2 0 . 0 0 uW/cm2	+ 2 . 0 0 0 e - 0 5	"
+ 1 0 . 0 0 uW/cm2	+ 1 . 0 0 0 e - 0 5	"
+ 9 . 9 9 uW/cm2	+ 9 . 9 9 0 e - 0 6	"
+ 5 . 0 0 uW/cm2	+ 5 . 0 0 0 e - 0 6	"
+ 2 . 0 0 0 uW/cm2	+ 2 . 0 0 0 e - 0 6	"
+ 1 . 0 0 0 uW/cm2	+ 1 . 0 0 0 e - 0 6	"
+ 9 9 9 nW/cm2	+ 9 . 9 9 0 e - 0 7	"
+ 5 0 0 nW/cm2	+ 5 . 0 0 0 e - 0 7	"
+ 0 . 2 0 0 uW/cm2	+ 2 . 0 0 0 e - 0 7	"
+ 0 . 1 0 0 uW/cm2	+ 1 . 0 0 0 e - 0 7	"
+ 0 . 0 5 0 uW/cm2	+ 5 . 0 0 0 e - 0 8	"
+ 0 . 0 2 0 uW/cm2	+ 2 . 0 0 0 e - 0 8	"
+ 0 . 0 1 0 uW/cm2	+ 1 . 0 0 0 e - 0 8	"
+ 0 . 0 0 5 uW/cm2	+ 5 . 0 0 0 e - 0 9	"
+ 0 . 0 0 2 uW/cm2	+ 2 . 0 0 0 e - 0 9	"
+ 0 . 0 0 1 uW/cm2	+ 1 . 0 0 0 e - 0 9	"
+ 0 . 0 0 0 nW/cm2	+ 0 . 0 0 0 e - 0 9	"
- 0 . 0 0 1 uW/cm2	- 1 . 0 0 0 e - 0 9	"
- 0 . 0 1 0 uW/cm2	- 1 . 0 0 0 e - 0 8	"
- 0 . 1 0 0 uW/cm2	- 1 . 0 0 0 e - 0 7	"

SED033/Y/W TYPICAL RESPONSE 14AUG91

this is a spectral plot of file '033/y/w/0891' normalized to 100



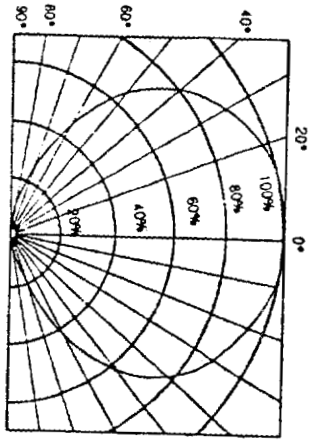
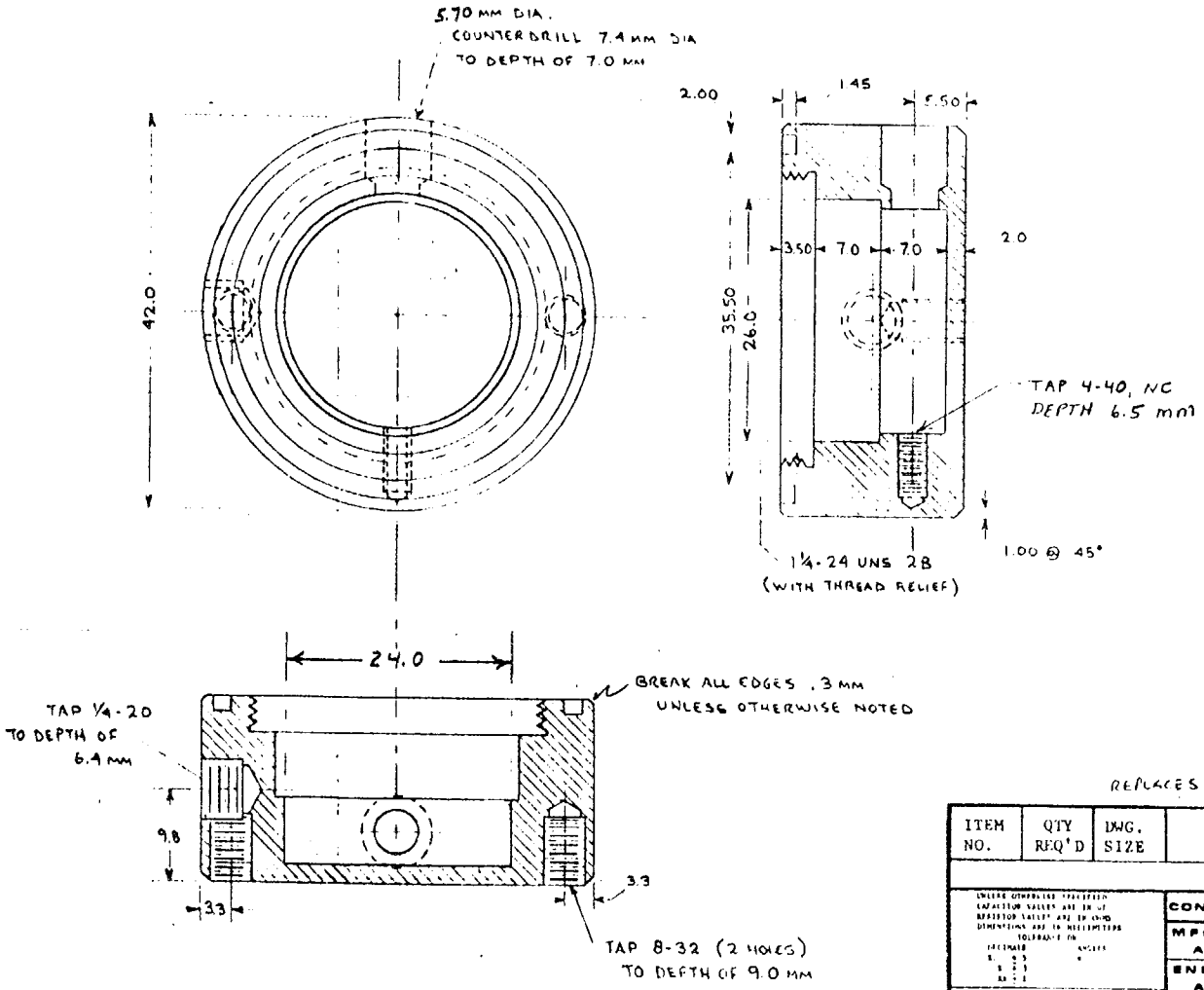
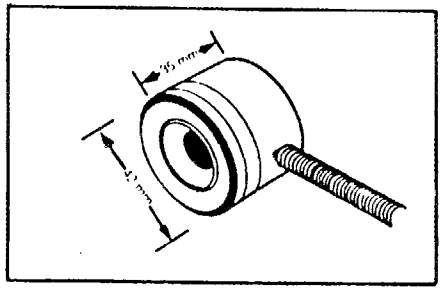


Fig. 4 Relative Sensitivity vs Angle

FIG. 4

9





	DATE	APPROVED
	16 Aug 77	[illegible]
LE	7 FEB 80	LVR
	21 MAY 80	DVR
m	9 APR 82	DVR

(MM) METRIC	(IN) ENG
42.0	1.65
35.50	1.398
26.0	1.02
9.8	0.39
9.0	0.35
7.4	0.29
7.0	0.28
6.4	0.25
5.20	0.50
5.50	0.217
3.50	0.138
3.3	0.13

(MM) METRIC	(IN) ENG
2.00	0.079
1.45	0.057
1.00	0.039
0.3	0.01
24.0	0.94

REPLACES PRINT # A 1686

METRIC DIMENSIONS

ITEM NO.	QTY REQ'D	DWG. SIZE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
LIST OF MATERIALS OR PARTS LIST				

UNLESS OTHERWISE SPECIFIED CAPACITOR VALUES ARE IN UF RESISTOR VALUES ARE IN OHMS DIMENSIONS ARE IN MILLIMETERS TOLERANCE ON DECIMALS ANGLES

CONCENTRICITY ALL SHAFT ENDS ALL BORE SURFACES

CONTRACT NO		
MFG. APPD		DATE
ENGR APPD	D Ryk	DATE 14 JAN 82
DRAWN	NJS	DATE 11/14/77

MATERIAL: ALUMINUM 6262-T9 OR 6061-T6

FINISH: BLACK ANODIZE

SCALE 2:1

International light INC.
NEWBURYPORT, MASSACHUSETTS 01950

SEE ⅞ SEA BASE HOUSING

SEL

SIZE	DRAWING NO.	REV.
B	1792	D

DO NOT SCALE THIS DRAWING — SHEET 1 OF 1

Larson•Davis

FACSIMILE TRANSMISSION

Superior Instrumentation for Acoustics and Vibration

1681 W 820 N, PROVO, UT 84601 TEL:(801)375-0177 FAX:(801)375-0182
If this fax is not received properly, please call LD at the above number.

TO: FRANK BARICKMAN / OAKRIDGE NTL. LABORATORY
FROM: JULIE VANWAGENEN, MARKETING February 4, 1994
SUBJECT: NEW SOUND LEVEL METERS

Dear Frank,

Here is the information on our new sound level meters. The complete literature and brochures will be mailed to you today. If there is anything else I can do for you, please let me know.

Best regards,

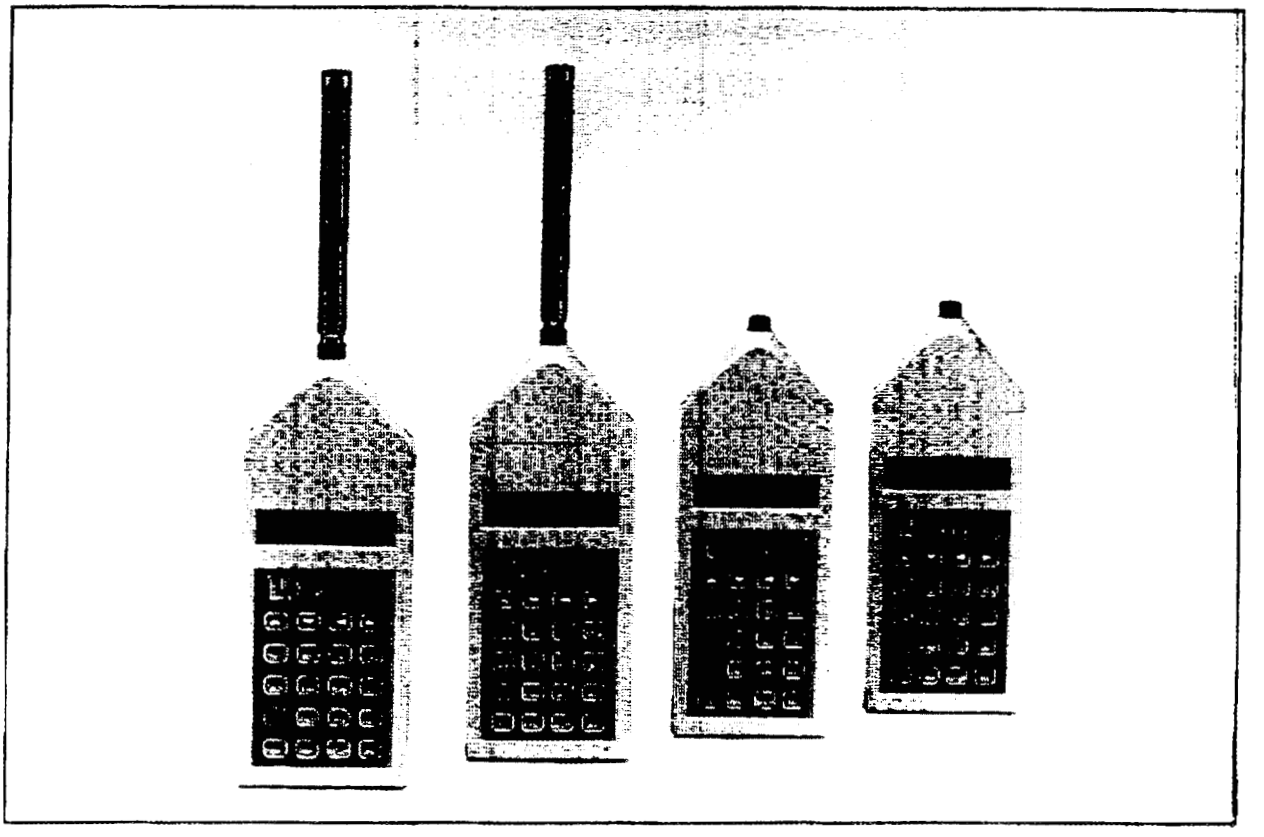
Julie VanWagenen

JULIE VANWAGENEN
Marketing

THE LARSON•DAVIS HAND-HELD

Sound Level Meters

Larson•Davis sound level meters are the leading edge in noise measurement instrumentation technology. The Model 712, 720, 812, and 820 sound level meters provide unmatched power, versatility, and precision, at prices that won't alienate the economically minded.



The greatest strength of the Larson•Davis sound level meters is their adaptability to a variety of measurement applications. The new Model 712, 720, 812, and 820 sound level meters continue this tradition.

Measurement Applications

- Sound Level Measurements
- Community Noise Assessment
- Environmental Noise Monitoring
- Statistical Analysis
- Transportation Passby Measurements
- Employee Noise Exposure/Dosimetry
- Hearing Protection Evaluation
- Sonic Boom/Artillery Fire Measurements
- Production Line Testing

Measurement Precision

For applications mandating Type 1 measurement accuracy, the Model 812 and 820 meters are the appropriate choice. These instruments meet ANSI S1.4, IEC 651 and 804 specifications for Type 1 precision. When Type 2 measurement accuracy is sufficient, the Model 712 and 720 meters are recommended. These instruments meet the ANSI S1.4, IEC 651 and 804 specifications for Type 2 precision. All four meet the requirements for ANSI S1.25 for worker noise exposure.

Versatile Sound Level Meter

Fundamental to each of these instruments is an integrating sound level meter. Each features true RMS and dual Peak detectors which operate simultaneously. Each has Slow, Fast, and Impulse detector rates. Each has A and C frequency weighting filters.

Also common to this family of meters is a serial digital interface for communication with a computer or direct connection to a printer.

Each meter also features AC and DC outputs for transferring data to a DAT or chart recorder during data acquisition. The analog output signal can be weighted (A or C) or unweighted, independent of how the data is acquired and stored within the instrument.

For compliance to the European Community Directive on noise exposure in the workplace (86/188/EEC), independent frequency weighting can be applied to the RMS and Peak detectors. This feature allows simultaneous measurement of the A-weighted RMS and C-weighted Peak levels.

Noise Dosimetry

Each meter is also equipped to measure employee noise exposure or dose based on user-definable dose parameters (exchange rate, criterion time and level, and threshold level). Two doses (with independent dose parameters) can be measured at the same time. A projected dose can be calculated when the total workshift noise exposure is less than the required criterion time. Larson•Davis sound level meters also provide Sound Exposure in units of Pa^2Hr, which fulfill the requirements of the proposed IEC Sound Exposure meter standard.

For the evaluation of hearing protection devices, the Larson•Davis sound level meters offer unique C minus A analysis capability. This feature sequentially measures a C-weighted L_{eq}, then an A-weighted L_{eq}. The A-weighted L_{eq} is subtracted from the C-weighted L_{eq} and the resultant value is computed.

Unsurpassed Dynamic Range

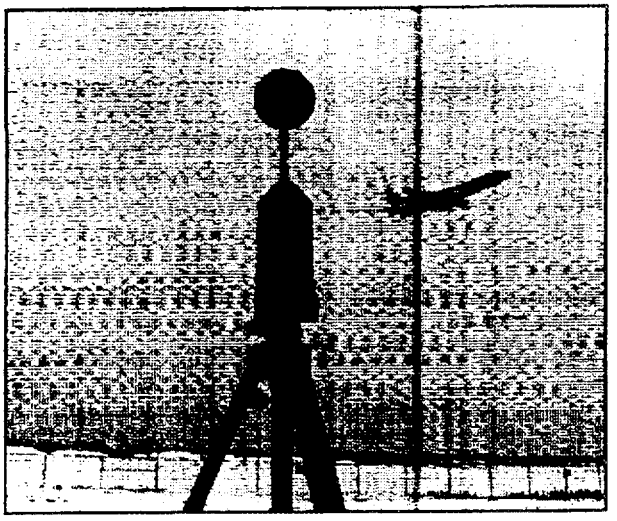
The Larson•Davis sound level meters have a unique 110 dB dynamic range. Unlike other sound level meters that require the operator to manually adjust the input range according to the level of the measured sound, Larson•Davis meters provide a full 110 dB in a single range. This is a critical feature for unattended measurements and for applications that have a wide range between high and low sound levels: no more problems of overloading, measuring near the bottom of the meter's range, or missing data while making a range adjustment.

Powerful Measurement Capability

Measurements made by the Larson•Davis sound level meters include instantaneous Sound Pressure Level, L_{min} (rms), L_{max} (rms), L_{peak} and Unweighted Peak Levels, L_N (statistics), L_{eq}, SEL, Time Weighted Average (TWA), and Taktmaximal 3 & 5. All of these parameters are measured simultaneously by the Larson•Davis sound level meters.

Measurement Intervals

For noise monitoring applications, it is common to acquire measurements in minute, hourly, or daily segments. The Interval feature of the Larson•Davis sound level meters provides this invaluable capability. Measurement intervals can be as short as 1 second, or as long as 99 hours, depending on the meter used. They can include the following data: L_{eq}, L_{max}, L_{min}, L_{peak} (weighted and unweighted), SEL, Time Weighted Average (TWA), and L_N statistical descriptors.



Time Histories

When the time history feature is activated, Larson•Davis sound level meters will gather L_{eq} and Peak (weighted and unweighted) data in rapid succession. This is a useful feature when characterizing a noise event that changes rapidly. The Model 720 and 820 meters can also be configured to gather a separate exceedance time history during an exceedance event. The result is a detailed view of the L_{eq} during the noise exceedance.

Superior Memory Capacity

All Larson•Davis sound level meters come standard with extensive "on board" non-volatile memory. Data can be acquired and stored in the field and later transferred to a PC for further analysis, or printed directly to a serial printer, in tabular and graphic formats.

Exceedance Events/Passby Measurements

The 720 and 820 meters can be configured to trigger and gather data based on a predefined event or threshold level and duration. This powerful feature allows the instrument to gather detailed information of a noise event such as the L_{eq}, Peak (weighted & unweighted), L_{max}, SEL, time/date of the exceedance, and exceedance duration. Exceedance operates independent of other functions in the instrument such as Intervals.

All Larson•Davis sound level meters feature Passby measurement capability. Passby is used to characterize aircraft flyovers or ground vehicle passbys. A passby measurement is calculated from the data taken where the level is 10 dB below the maximum level preceding the passby, and ending when the level decreases to 10 dB below the maximum level following the passby. The parameters measured and stored include L_{eq}, SEL, Peak (weighted & unweighted), Max, time/date of the passby, and the passby duration.

Built- in Report Generation

Larson•Davis sound level meters communicate directly with Hewlett Packard™ LaserJet and ink jet printers, Epson™ & Epson™ compatible printers, and Kodak™ Diconix printers. Each meter generates high quality tables and graphs as part of the report generation feature. Following is a list of the different reports that can be activated:

Data Report- The data report contains a summary of the measurements for the total measurement runtime. The L_{max}, L_{min}, L_{peak}, and L_{uwpk} are also printed (with the date and time of their occurrence). Included data are L_{eq}, SEL, TWA, and L_N's (statistical descriptors); and Dose, Projected Dose, and Sound Exposure (Pa^2Hr).

Interval - This report provides a summary of the measured data during each of the sequential measurement intervals. This includes the L_{eq}, L_{max}, L_{min}, L_{peak}, L_{uwpk}, SEL, TWA, L_N's (statistical descriptors), interval duration, and the interval start time/date.

Time History - The time history report includes the L_{eq} and L_{peak} (weighted & unweighted) values for the predetermined time history period (1/32 second to 255 hours depending on the instrument).

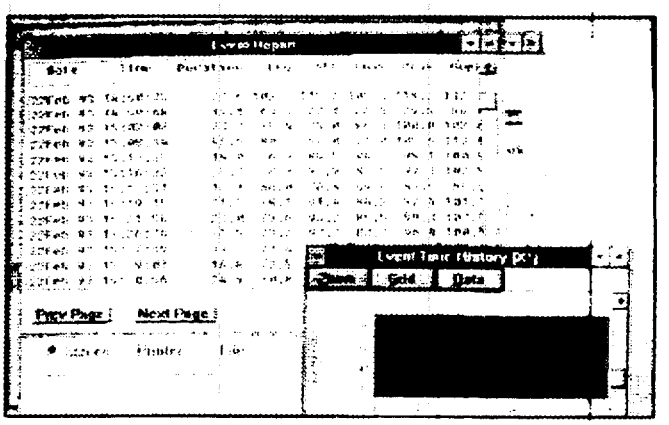
Exceedance - The exceedance report contains the information gathered during an exceedance event. This includes the L_{eq}, L_{peak} (weighted & unweighted), L_{max}, SEL, time/date of the exceedance, and exceedance duration.

Histograms - This report contains tables of percentages of the total samples occurring at each sound pressure level. Both Peak and RMS histograms can be generated.

Daily Report (820 only) - This report includes the overall L_{eq}, L_{dn}, CNEL, L_{min}, L_{peak}, L_{uwpk}, and 24 hourly L_{eq}'s. A graphic of the hourly L_{eq}'s is avaiable.

Computer Software

PC software is available for data retrieval, analysis, reporting, and archiving. Summary tables and graphs of the data can be generated and printed. The meters can also be controlled remotely via the computer software.



Additional Capabilities

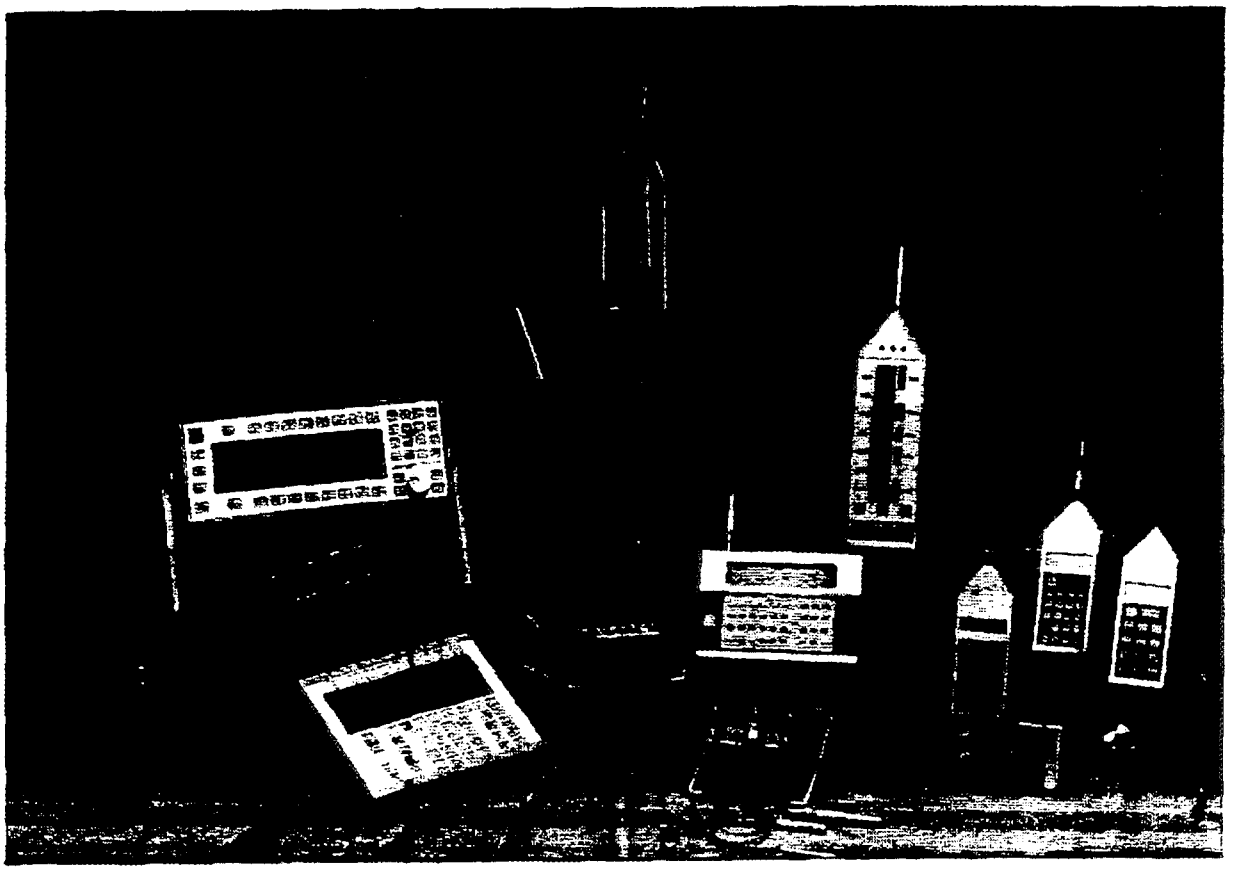
Each sound level meter has a built-in quartz clock and calendar. Thus, measurements receive a date and time stamp during data acquisition. In addition, the 720 and 820 can use the clock to establish two "pre-programmed" run/stop times. This allows the meter to be placed at a measurement location, and left unattended. At the pre-programmed time, the meter will turn on and gather data until a programmed shut off time is reached.

Each sound level meter contains an external logic output control line. This feature is used if one wishes to activate an external device (such as a light or a tape recorder) when a predefined exceedance level (in dB) is reached.

In addition a user can use the new meters to create and store measurement setups. Setups can be stored with a title and a description.

Larson•Davis also offers environmental enclosures which provide protection for the meter and the microphone in instances where measurements are made outdoors for an extended period of time. Optional external battery power and cabling to separate the microphone from the meter are available.

The LARSON • DAVIS Product Family



Larson • Davis Laboratories has been designing and manufacturing precision instruments for the measurement and analysis of sound and vibration since 1981. Their diverse product line includes condenser microphones and accessories, handheld sound level meters, portable real-time frequency analyzers, noise dosimeters and environmental noise monitorig systems. They are a major supplier of integrated systems used around airports for the measurement, analysis and real-time mapping of noise related to aircraft operations.

Larson • Davis Laboratories makes extensive use of the most modern hardware and software technologies in their design, manufacturing, quality control, and instrument service/calibration activities.

For Sound/Vibration Measurement Look to Larson • Davis

Main Office:

Larson • Davis Inc.
1681 West 820 North
Provo, UT 84601
U.S.A.

801-375-0177 • Telex 705560 • FAX 801-375-0182

Larson•Davis

U.K. Office:

Larson • Davis Ltd.
16 Scardale Crescent
Scarborough, North Yorkshire
England Y0126LA

Phone: 0723 36 44 95 • FAX: 0723 50 00 94

LARSON•DAVIS SOUND LEVEL METER FEATURES

November 4, 1993

MODEL	712	812	720	820	870
Type (Precision)	2	1	2	1	1 or 0 w/type 0 mic.
RMS Detector	Slow, Fast & Impl	Slow, Fast & Impl	Slow, Fast & Impl	Slow, Fast & Impl	Slow, Fast & Impl
Dynamic Range	110dB (35 to 145 typ)	110dB (18 to 175 avail[1])	110dB (35 to 145 typ)	110dB (18 to 175 avail[1])	115dB (18 to 180 avail[1])
Peak Detector	✓	✓	✓	✓	✓
Weighting	A & C	A & C	A & C	A & C	A, C & Flat
Filters	O	O	O	O	HP:1, 5, 20 & 100Hz LP: 1K, 16K, 25K & 35KHz
Un-weighted Peak Detector	✓	✓	✓	✓	✓
Un-weighted Peak Range	45dB (100 to 145 typ)	45dB (91 to 136 typ)	45dB (100 to 145 typ)	45dB (91 to 136 typ)	80dB (53 to 136 typ)
Microphone	3/8" Electret	1/2" Air Condenser	3/8" Electret	1/2" Air Condenser	1/2" Air Condenser
Bias Supply	O	0, 28 & 200 Volts	O	0, 28 & 200 Volts	0, 28 & 200 Volts
Memory (K=1024, M=1024[2])	64 K	64 K	64 K	256 K	512 K (1¼M, 2M available)
L_N Statistics	4 values	4 values	4 values	6 values	6 values
Histogram Table	1 dB bins[3]	1 dB bins[3]	1 dB bins[3]	1/8 to 10 dB bins[3]	1/8 to 10 dB bins
Time History	1 to 255 sec	1 to 255 sec	1 to 255 sec	1/32 sec to 255 hours	1/32 sec to 255 hours
Interval History	1 min or 1 hour	1 min or 1 hour	1 sec to 99 hr (hh:mm)	1 sec to 99 hr (hh:mm)	1 sec to 99 hr (hh:mm)
Interval L_N Statistics	4 values	4 values	4 values	6 values	6 values
Event History	O	O	✓*	✓*	✓*
Event Time History	O	O	O	✓	✓
Daily History	O	O	O	✓	✓
Hourly L_{EQ}	O	O	O	✓	✓
Hourly Event & Background L_{EQ}s	O	O	O	O	✓
Six Daily L_N Values	O	O	O	O	✓
Setup Registers (RAM EEPROM ROM)	5 (2 1 2)	5 (2 1 2)	5 (2 1 2)	16 (10 1 5)	16 (10 1 5)
Leq, SEL, TWA, Takt 3 & 5	✓	✓	✓	✓	✓
Sound Exposure Pa^2H	✓	✓	✓	✓	✓
Dose & Projected Dose	✓	✓	✓	✓	✓
L_{DN}, C_{NEL}	O	O	O	✓	✓
SPL, L_{MIN}, L_{MAX}, L_{PK}, L_{UWPK}	✓	✓	✓	✓	✓
Dual SLM Feature	O	O	O	O	✓
C minus A (Sequential)	✓	✓	O	O	O
PassBy	✓	✓	✓*	✓*	✓*
Event and Background L_{EQ}	O	O	O	✓	✓
Mathematical Noise Floor Compensation	O	O	O	✓	✓
Programmable R/S Timer	O	O	✓	✓	✓
Multi-Tasking Gather/Print/View Data	✓	✓	✓	✓	✓
Serial Digital I/O[11]	≤19.2K baud	≤19.2K baud	≤19.2K baud	≤19.2K baud + Modem[4]	Dual[5] ≤57.6K baud +Modem[4]
AC/DC Outputs	✓	✓	✓	✓	✓
External Control Lines	1 Output	1 Output	1 Output	1 Output	4 Outputs & 1 Input
Weather Measurements	O	O	O	O	✓ up to six inputs[66]
Pre-Amplifier Configuration	3/8": 789 Dosimeter	1/2": 828 SLM or 829 Dosimeter	3/8": 789 Dosimeter	1/2": 828 SLM	1/2": 900B, 1/2": 2100, 1/4": 910B SLM
Price	$1,680**	$2,600**	$1,980**	$3,900**	$8,610**

*Exceedance record (Event or PassBy) is triggered by either a fixed threshold or by a ▲10dB passby detection. [1]Actual measurement range is determined by microphone sensitivity, numerous choices are available. [4]Modem control for answering, data security, dialing (due to high level event, tamper alarm or full memory) and initialization. [3]Available through I/O & Reports, not on LCD. **Price includes microphone & preamplifier. [11]For computer and printer I/O. [5]Second Serial Port supports computers, printers (≤19.2K baud) and the LD Model 875 Real-Time Spectrum Analyzer (9600 baud). [66]Wind Speed & Direction, Temperature, Humidity, Barometric Pressure & Rainfall. Note: Prices and features subject to change without notice.

O = Feature Not Included ✓ = Feature Available

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Larson•Davis

FACSIMILE TRANSMISSION

Superior Instrumentation for Acoustics and Vibration

1681 W 820 N, PROVO, UT 84601 TEL:(801)375-0177 FAX:(801)375-0182

If this fax is not received properly, please call LD at the above number.

TO: FRANK BARICKMAN / OAKRIDGE NTL. LABORATORY
FROM: JULIE VANWAGENEN, MARKETING February 4, 1994
SUBJECT: NEW SOUND LEVEL METERS

Dear Frank,

Here is the information for the weather sensors, the engineer that I need to speak with in regards to the rain sensor is not here today but, I will get with him and let you know any information I receive from him.

Best regards,

Julie VanWagenen

JULIE VANWAGENEN
Marketing

Environmental Systems

Weather Sensors

2130 $550
- Weather sensor interface
- Interfaces the 2140, 2141, and 2142 to the Model 870
- Scaling and offset adjustment for up to 3 sensors

2131 $950
- Similar to Model 2130, for up to 5 sensors
- Adds interface for 2143 barometric sensor, rain gage or road traffic monitor (none included)

2140 $1,200
- Wind monitor
- Measures wind speed and direction

2141 $450
- Temperature sensor

2142 $1,700
- Humidity and temperature sensor, 12 plate radiation shield

2143 $600
- Barometric pressure sensor
- 0-16 psi range, 0.01 in. Hg max. resolution

Environmental Towers and Housings

The following are for permanent/semi-permanent monitoring. See Model 2105 for portable systems.

2150 $1,200
- Steel 17 ft. tilt-down tower
- Used to support the 2100
- 20 ft. microphone height
- Comes ready to mount the 2170 or 2171 housing

2151 $150
- Tower mount for sensors
- For 2140 series weather sensors
- Bolts to side of the 2150 pole

2152-10 $900
- Portable tripod tower for 2100
- Collapsible tripod base, radius 9 in. to 6 ft.
- 1 1/2 in. aluminum section mast ready for mounting 2170 or 2171
- Leg base plates can be staked
- Provides 10 ft. microphone height

2152-20 $1,000
- Same as 2152-10, provides 20 ft. microphone height. Additional collar for optional guy-wires

2153 $160
- Portable tower support arm
- Allows for mounting weather equipment such as the 2140, 2141, and 2142

2170 $900
- NEMA 4X stainless steel enclosure
- For the Model 870 and peripheral equipment
- Space for two batteries, weather sensor interface (2130), modem, phone, etc.
- Mounts to the 2150 or 2152 tower
- Requires 2175 power supply and panel

2171 $550
- NEMA 4 steel enclosure, custom painted gray
- For the Model 870 and peripheral equipment
- Space for two batteries, weather sensor interface (2130), modem, phone, etc.
- Mounts to the 2150 pole
- Requires 2175 power supply and panel

Environmental Power Supplies

2175-115V $600
- 115 V power supply and mounting panel
- 115 Vac mains with battery backup
- Provides power to the Model 870, 2100, and peripheral equipment
- Includes 12 V, 26 Ah battery and charger for 1 week of operation without AC power

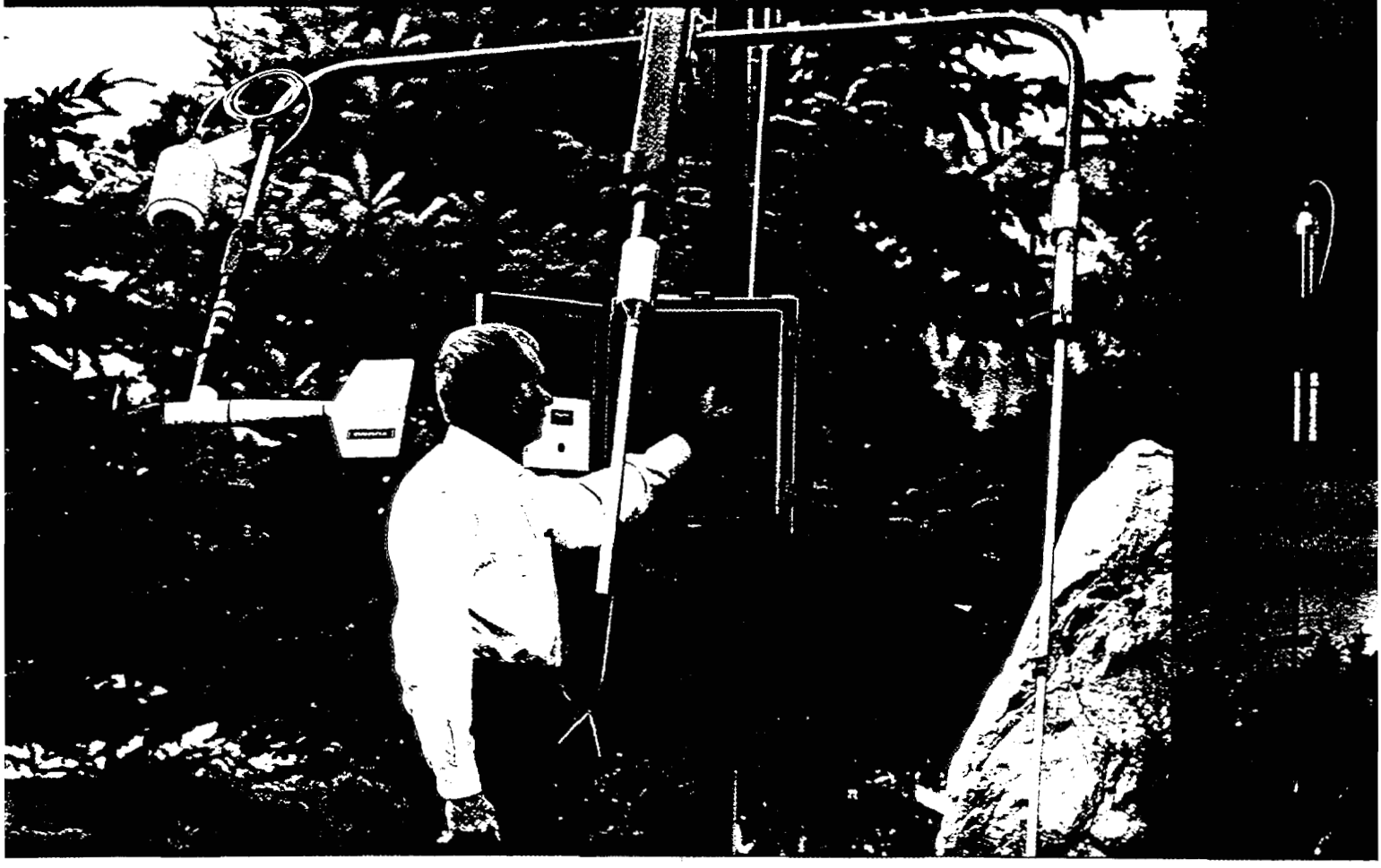
2175-220V $700
- 220 V power supply and mounting panel
- 220 Vac mains with battery backup
- Provides power to the Model 870, 2100, and peripheral equipment
- Includes 12 V, 2626 Ah Ah battery and 220 Vac charger for 1 week of operation without AC power

2176 $1,100
- Solar battery power supply and panel
- Provides power for the Model 870, 2100, and peripheral equipment
- Includes 47 W solar panel and mounting hardware. Batteries are not included. Order one or two 2176-2s or one 2176-3 as indicated by site solar survey (call Larson•Davis for details).
- Several battery and solar panel configurations can be provided

2176-1 $880
- Additional 47 W solar panel
- Includes mounting hardware
- For use with the 2176

2176-2 $150
- 26 Ah battery
- Sealed battery for use with 2176
- H 13 cm x W 18 cm x D 16 cm (5 x 7 x 6.5 in.)
- Weight 8.9 kg (19.6 lb.)

THE Larson•Davis OUTDOOR NOISE MONITORING SYSTEM



Larson•Davis offers a complete Outdoor Noise Monitoring System which includes (A) the Model 2100 Preamplifier, (B) the Model 870 Sound Level Meter, and (C) the Model 2150 Tilt-down Tower. Optional enhancements available include (D) the Model 2140 Wind Speed and Direction Monitor, (E) the Model 2142 Temperature and Humidity Sensor, and (F) a solar panel and (G) a wireless modem link which allow installation in areas not served by power/telephone utilities. All components are manufactured with materials that provide maximum resistance to shock, corrosion, and extremes in environmental conditions.

(A) Preamplifier

An aerodynamically designed profile minimizes wind resistance and acoustic reflections. Included accessories are:

- Electrostatic actuator which gives a steady tone to verify that the system is correctly calibrated
- Heater and drying agent to keep the microphone at a steady temperature and free of moisture
- Windscreen
- Birdspikes
- Rainhat

(B) Sound Level Meter

Having the capacity to measure and store up to 250,000 samples of data on noise, vibration, wind, temperature, and humidity makes the 870 the most versatile and powerful airport and environmental data monitor available.

Some of its other key features are:

- 115 dB dynamic range
- Noise floor less than 20 dBA
- A, C, and linear weightings
- 16 individual bandwidths
- 3 parallel detectors: weighted and unweighted peak and rms
- Automatic calibration check
- 9 month memory retention
- Lithium battery backup

(C) Tilt-down Tower

The tilt-down design makes accessing and maintaining all components easy. All cables are installed inside the tower core for protection against adverse weather conditions and vandalism.

(D) Wind Speed/Direction

The collection of wind data is useful for qualifying noise measurements.

The 2140's high quality components assure excellent fidelity, low threshold, and fast response in measuring:

- Average wind speed
- Speed, time, and direction of maximum gust
- Percentage and number of times above threshold
- Percentage of windy time from each of eight compass points

(E) Temperature/Humidity

The 2142 sensors permit the system to monitor the current, average, extremes, and number of exceedances above threshold for temperature and humidity.

LARSON•DAVIS LABORATORIES

1681 West 820 North
Provo, UT 84601
801-375-0177 TELEX 705560
FAX 801-375-0182

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LARSON•DAVIS

LARSON•DAVIS Weather Sensor System

Collecting meteorological data is necessary in many environmental and airport noise monitoring situations. The powerful Model 870 Environmental Noise Monitor is designed to meet that need, offering inputs for receiving measurements from the Model 2140 Wind Speed and Direction Monitor and the Model 2142 Humidity and Temperature Sensor. In combination with the Model 2130 Weather Sensor Interface, the 2140 and 2142 allow the following to be measured:

Overall

- Current wind speed and direction.
- Current, average, extremes, and number of exceedances of user threshold for temperature and humidity.

Overall and Daily

- Average wind speed.
- Speed, time, and direction of maximum gust.
- Percentage and number of times above user-set windy threshold.
- Percentage of windy time from each of eight compass points.

Interval and During Sound Level Exceedance

- Average wind speed.
- Maximum gust speed and direction.
- Extremes of temperature and humidity (average values for interval only)

Acoustic measurements can be paused while wind speed, temperature, or humidity exceed user-set levels.

Model 2130 Weather Interface

The 2130 solves the problem of connecting meteorological sensors to the 870 by (1) scaling and offsetting the linear output of the sensors to meet the 0 to 5 Vdc input range of the 870's A:D channels and (2) converting the wind monitor's sinusoidal speed output to a square wave.

Model 2140 Wind Speed and Direction Monitor

The 2140 permits wind data collection that can be used to qualify noise measurements made with the Model 870. High performance components result in excellent fidelity, low threshold, and fast response.

The wind speed sensor is a four blade propeller that induces a sinusoidal ac voltage with frequency proportional to wind speed.

To record wind direction, the vane position is translated into a voltage by a precision potentiometer, the reference voltage of which is provided by the Model 870.

Originally designed for use with ocean buoys, the 2140 has a highly corrosion resistant construction. A UV stabilized thermoplastic body and stainless steel and anodized aluminum fittings improve its resistance to environmental pollutants.

Model 2142 Temperature and Humidity Sensor

Housed in a lightweight thermoplastic radiation shield, the 2142 minimizes direct and reflected solar radiation for accurate temperature measurements. Tests with maximum radiation and an airspeed of 1 m/s showed < 1.5 °C variation from ambient temperature. The 2142 can measure temperatures ranging from - 30 to 70 °C. The actual floor and ceiling of the range depend on the scale and offset used at the 2130 interface and the A:D channel parameters. Temperature measurements are very stable, making calibration unnecessary under normal circumstances.

The 2142's fast time constant makes precise humidity readings possible. Humidity calibration may be performed with humidity standard solutions.

Mountings

The 870, 2130, and peripherals can be mounted in a compactly designed environmental enclosure (Model 2170 or 2171) with various power options available.

Both sensors can be mounted on the Model 2151 Sensor Mount, which bolts to the side of the Model 2150 Pole. With the Model 2100 Outdoor Microphone System, the pole provides a 20 ft microphone height. The pole is center hinged to allow easy access to the microphone and sensor systems.

Specifications*

Model 2130

Wind Speed

Output Voltage	0 to 5 V square wave
Input :	
Sensitivity	0.085 V_{p-p}
Impedance	10 KΩ ‖ 0.01μF differential 5 KΩ each input to ground
Frequency Range	dc to 60 kHz
Max. Voltage	6.0 V

Wind Direction

Time Constant	0.001 s
Reference	Supplied by Model 870, 5.0 V ± 5%
Input :	
Voltage Range	0 to 5.0 V

Sensors A and B

Gain Range	0 to 10
Offset Range	± 3.25 V
Frequency Response	dc to 12 Hz
Output range	0 to 10.5 V (should be limited to 0 to 5 V for input to Model 870 A:D channels)

Electrical

Power	9 to 15 V, 10 mA
Protection	
Wind speed and direction	≤ - 0.7 V and ≥ 6.4 V clamp to earth ground with 600 W peak pulse
Sensors A and B	± 19 V clamp to earth ground with 600 W peak pulse

Physical

Height	7.5 cm (4.0 in)
Width	10.5 cm (5.5 in)
Depth	3.0 cm (1.2 in)
Weight	241 g (8.5 oz)

Model 2140

Signal Output

Wind Speed	Magnetically induced ac voltage. Three pulses per revolution converted by the Model 2130 Interface and Model 870 Analyzer to Hz, mph, fps, km/hr, m/s, and knots
Wind direction	Analog dc voltage from conductive plastic potentiometer. Resistance 10 kΩ Linearity 0.25 % Life 50M rev.
Cable	The 2140 is connected to the Model 2130 Weather Interface by a 20 ft, five connector cable.

Range

Wind speed	0 to 60 m/s (134 mph)
Gust speed	80 m/s (180 mph)
Direction	360° mechanical, 355° electrical (5° open)

Threshold

Propeller	0.6 m/s (1.3 mph)
Vane	0.9 m/s (2.0 mph) at 10° displacement

Physical

Height	37 cm (14.6 in)
Length	55 cm (21.7 in)
Propeller dia.	18 cm (7.1 in)
Weight	1.3 kg (2.8 lb)
Mounting dia.	34 mm (1.34 in) (standard 1 in pipe)

Model 2142

Temperature

Range	- 30 to 70 °C, linear
Accuracy	± 0.35 °C (entire range)
Precision	0.1 °C, long term stable
Time constant	10 s
Linear output†	- 0.5 to 1.5 Vdc = - 50 to 150 °C

Humidity

Range	0 to 100 % RH, linear
Accuracy at 25 °C	± 1 % RH in reference to calibration
Precision	< 0.5 % RH, long term stable
Time constant	< 10 s at 25 °C
Error due to temp.	± 0.5% RH/Δ 70 °C
Linear output†	0 to 1 Vdc = 0 to 100 % RH

Electrical

Power	8 to 30 Vdc, 15 mA max.
Cable	The 2142 is connected to the Model 2130 Weather Interface by a 20 ft, five connector cable.

Physical

Height	27 cm (10.6 in)
Diameter	12 cm (4.7 in)
Weight	1.13 kg (2.5 lb)
Mounting	V-block with U-bolt fit a 25 to 50 mm (1 to 2 in) pipe

*All specifications are subject to change.

†Outputs can be scaled and offset by the 2130 Weather Interface to provide the chosen range and accuracy for the 870 A:D channels.

Model 2100K Specifications
(Outdoor Preamplifier Kit)

Included Components

Preamplifier (2100)

Frequency: -3 dB at 1 Hz; ±0.1 dB to 200 kHz

Gain: -0.05 dB

Input impedance 10 GΩ // 0.3 pF

Output impedance: < 50 Ω

Max rms out: 3.7 V with Model 870 sound level meter (10 V with Model 2201 amplifier)

Noise with Model 870 and 18 pF on input (2540 mic):
A-weight: 29 dB SPL
C-weight: 27 dB SPL
Flat (1 Hz to 35 kHz): 32 dB SPL

Quiescent Current: 5 mA typ.

Resistive Heater

Operating power: 8 to 14 Vdc (75 mA at 12 Vdc), 160 Ω, 0.9 W

Turn-on: 0 Vdc, 45 µA into open collector

Electrostatic Actuator

Output: 391 Vac at 500 Hz (provides 90 dB SPL at 1 kHz)

Operating power: 5 to 18 V (60 mA at 12 V), 70 µA when off

Turn-on: 4 to 15 Vdc (20 µA at 5 V)

Desiccant (dehumidifier)

17.5 g blue silica gel (7 capsules @2.5 g) with expected life of 6 –12 mo (replacement required when gel turns pink)

Rainhat (2110)

Windscreen (2120)

Windscreen Insert (2120-1)

Recommended Components

Model 870 Noise and Vibration Monitor

Dynamic range: 115 dB

Data storage: 64K

Interface: RS-232

Frequency range: 1 Hz to 35 kHz

High and low pass Filters

Microphone (Model 2540)

½ in free field condenser, 18 pF (diaphragm impervious to nitric acid, sulfuric acid, hydrochloric acid, and salt)

Cables for Model 870 Sound Level Meter

20 ft preamp cable (2100–C01)

20 ft control cable (2100–C02)

Calibration

Electrostatic actuator built into rainhat provides 90 dB at 1 kHz (±2 Hz) (initiated from remote station or by 870)

Environmental

Temperature Range

-35 to 70 °C (-31 to +158 °F)

Humidity Range

0 to 100 % relative humidity

Physical

Mounting Screw Thread

1 ½ in NPT (shock mounting built in)

Dimensions (not including windscreen)

Preamp diameters:
Top: 13.3 mm (½ in)
Middle: 26.7 mm (1 in)
Bottom: 76.2 mm (3 in)

Lengths:
Over all (top of birdspikes): 1092 mm (43.0 in)
Preamp: 918 mm (35.8 in)

Weight:
3 kg (6.6 lb)

Connectors

Signal (female, mates with Switchcraft TA5ML))

Pin	Purpose
1	Ground
2	Signal output
3	-9 V
4	Microphone bias
5	+9 V

Control (male, mates with Switchcraft TA5FL)

Pin	Purpose
1	Ground
2	+12 V
3	Electrostatic actuator control
4	Heater control
5	Not used

TO: OAKRIDGE NAT'L LABS	FROM: QUEST TECHNOLOGIES
ATTN: FRANK BARICKMAN	VICKI KUHL
FAX #: (615) 574-9619	FAX #: 414-567-4047
PAGES INCLUDING THIS PAGE: # 8	DATE: FEBRUARY 4, 1994
RE:	

Dear Frank:

Per our telephone conversation, I have enclosed three different sound level meter models that I thought would work for your application. I have also enclosed a price sheet on the different models and kits. These prices are valid for 45 days.

If you have any questions, please feel free to contact me.

If you decide to order, please contact our dealer in your area:

CLEMENT SAFETY
Memphis, TN
TEL: (901) 775-3600

Best Regards,

Vicki Kuhl

Vicki Kuhl,
Regional Sales Coordinator

QUEST
TECHNOLOGIES
510 South Worthington Street • Oconomowoc, Wisconsin 53066 USA
800-245-0779 • Fax 414-567-4047
414-567-9157 • Telex 910-260-1438 LaBelle

QUEST™ TECHNOLOGIES

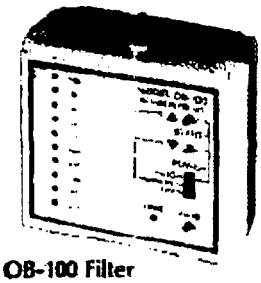
• Model 2800 Integrating Sound Level Meter
• Model OB-300 1/3 – 1/1 Octave Band Filter Set
• Model OB-100 Octave Band Filter Set

- Type 2 General Purpose Integrating Sound Level Meter
- For Industrial and Occupational Noise Studies
- Direct Readout of SPL, L_{eq}, Peak Level, Impulse Level, L_{max}, L_{min}, SEL and Run Time
- Easy-to-Read LCD Digital Display plus Additional Quasi-Analogue Display
- AC and DC Recording Outputs
- RS-232 Digital Outputs to Printers, Computers and Quest NL-15 Data Logger
- Expands to Full Octave Band or Combination 1/3 - 1/1 Octave Band Analyzer
- Printouts show Summary Data, Exceedance Levels, L_{eq}, L_{max}, L_{min}, and SEL by frequency

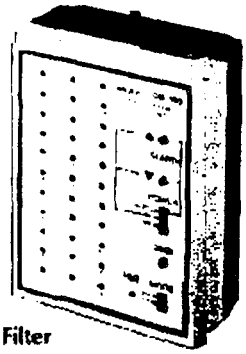
The Quest 2800 Integrating Sound Level Meter provides comprehensive data for occupational and environmental noise measurements as well as many other general purpose applications. It displays and prints out Sound Level, Integrated Sound Level, Max Level, Min Level, SEL, Peak, and Impulse readings. A clear easy to read digital readout is complemented by a quasi-analogue display.

The Quest 2800 outputs directly to serial printers to provide a detailed report including all displayed parameters plus a complete chart of all exceedance levels from L1 to L99. When used with the optional filter sets, it also prints each octave or 1/3 octave band reading from memory storage. AC and DC outputs are provided for connection to chart recorders and a digital data output allows connection to the Quest NL-15 Noise Data Logger. (The Logger is used with the meter only and not applicable with the filter sets.)

The Quest OB-300 combination 1/3 – 1/1 Octave Band Filter Set gives a choice of measuring all 33 one-third octave bands or selecting standard 1/1 octave band measurements. The filter set will automatically sequence through each octave or third octave band, display the measured level and store it in memory, or the user can manually select any individual octave band. The OB-100 has the same automatic and manual features of the OB-300 except that measurements are made in full octave bands only.



OB-100 Filter



OB-300 Filter

Specifications

Model 2800 Sound Level Meter

Range: Meter only: 35 to 140dB. With external filters: 10–140dB. Noise floor varies depending on filter frequency selection.

Standards: ANSI S1.4 Type 2 and relevant sections of IEC 651, and IEC 804.

Microphones: Removable .83-inch (21mm) prepolarized condenser (electret). Microphone preamp: removable and will drive up to 100 feet of cable.

Outputs: RS-232 outputs to computers, printers, or Quest NL-15 Data Logger. Selectable baud rates of 300, 600, 1200 or 2400. ASCII character format. AC and DC for chart recorders.

Frequency Weighting Networks: A, B, C, and Linear. When using OB-100 or OB-300 filter sets, any one of the weightings may be selected.

Frequency Range: 4 Hz (–3dB) to 50kHz (–3dB) linear scale, subject to microphone limitations.

Display: 3-1/2 Digit Liquid Crystal Display with additional Quasi-Analogue 60dB indicator in 2dB increments. Level display to 0.1dB resolution. Time display of Min:Sec or Hr:Min. Annunciators for Battery Check, Hold, Run, and Overload indications.

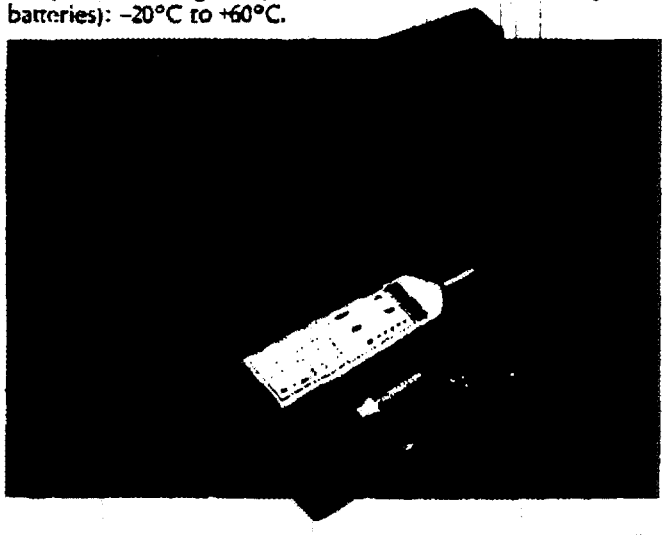
Meter Response: Slow, Fast, Peak, and Impulse.

Modes of Operation: As an integrating sound level meter, calculates sound pressure level (SPL), maximum level (MAX), minimum level (MIN), sound exposure level (SEL), and equivalent level (L_{eq}). Also measures peak and impulse levels.

Batteries: Two 9-volt alkaline batteries (NEDA 1604A) will provide approximately 20 hours of continuous operation (10 hours with optional filters).

Tripod Mount: Accepts standard 1/4-20 tripod mounting screw.

Temperature Range: Operation: –10°C to +50°C. Storage (less batteries): –20°C to +60°C.



Size: 3.3 x 8.2 x 1.8 inches (84 x 208 x 47mm) not including preamp height.

Weight: 24 ounces (680 grams) including preamp, microphone and batteries.

Model OB-300 1/3 - 1/1 Octave Filter Set

Standards: ANSI S1.11, Order 3 and IEC R225.

Center Frequencies: 33 frequencies from 12.5 Hz to 20kHz.

Frequency Selection: Full manual control or automatic sequential stepping through each frequency band.

Power Source: Sound Level Meter.

Size: 3.3 x 4.2 x 1.8 inches (84 x 107 x 47mm).

Weight: 9 ounces (255 grams).

Model OB-100 Octave Filter Set

Standards: ANSI S1.11, Order 3 and IEC R225.

Center Frequencies: 10 frequencies from 31.5 Hz to 16kHz.

Frequency Selection: Full manual control or automatic sequential stepping through each frequency band.

Power Source: Sound Level Meter.

Size: 3.3 x 2.8 x 1.8 inches (84 x 71 x 47mm).

Weight: 6 ounces (170 grams).

Accessories

NL-15 Noise Data Logger — for use with meter only. Provides dosimetry type analysis.

Model QC-10 Calibrator — a single-frequency, single-amplitude calibrator.

Model VA-508C Vibration Assembly — for the measurement of vibration velocity, displacement and acceleration.

Model WS-6 Windscreen.

Model TP-2 Tripod.

Microphone Cables — 10' and 50' foot lengths.

Model 56-163 Microphone Adapter.

Coupler, Weight and Stand — for calibrating audiometers.

Kits

The meter and filters are available in kits designated as Models 2800-100110 and 2800-100110. These kits include a QC-10 Sound Calibrator, the WS-6 Windscreen and a carrying case. The TP-2 Tripod and microphone cables are optional.

An audiometer calibration kit, Model 2800-100110AM, is available which includes, in addition to the items listed above, an earphone coupler, weight and calibration stand.

Represented by:

QUEST TECHNOLOGIES

510 Worthington St.• Oconomowoc, WI 53066 USA • Phone: (414) 567-9157 • Toll Free: (800) 245-0779 • TWX: 910 260 1438 LA BELLE • Fax: (414) 567-4047

QUEST
ELECTRONICS

Model 2700 Digital Sound Level Meter
with Optional Octave Band Filter Sets

- Type 2 General Purpose Sound Level Meter
- Easy-to-Read LCD Digital Display plus Additional Quasi-Analogue Display
- Wide Dynamic Range from 35-140dB
- Direct Readout of SPL, Peak Level, Impulse Level and Lmax
- AC and DC Recording Outputs
- Expands to Full Octave Band or Combination 1/3 – 1/1 Octave Band Analyzer
- Removable Microphone for Remote Measurement Capability

The Quest 2700 is a professional all-purpose wide range Sound Level Meter for accurately measuring sound pressure levels in virtually any application. It displays Sound Level, Max Level, Peak and Impulse readings on a clear easy-to-read digital readout complimented by a quasi-analogue display.

The 2700 is housed in a rugged, yet lightweight, injection-molded case with internal shielding and operated with easy-to-use slide switches and push buttons.

The microphone and preamp are detachable to enable measurements from a remote location and to input other devices such as the Quest Model VI-90 Vibration Integrator.

Capabilities of the Quest 2700 can be expanded by adding any of three octave band filter sets, ... the Quest Model OB-50 which provides nine bands from 31.5 Hz to 8kHz, the OB-100 that goes out to 16kHz in both a manual and unique automatic mode, or the OB-300 combination 1/3 – 1/1 Octave Filter with both manual and automatic mode.

Model 2700 Sound Level Meter with attached Model OB-50 Octave Band Filter Set

Specifications

Model 2700 Sound Level Meter

Range: Meter only: 35 to 140dBA. With external filters: 10-140dB. Noise floor varies depending on filter frequency selection.

Standards: ANSI S1.4 Type 2 and relevant sections of IEC 651.

Microphones: Removable .83-inch (21mm) prepolarized condenser (electret). Microphone preamp: removable and will drive up to 100 feet of cable.

Outputs: AC and DC for chart recorders.

Frequency Weighting Networks: A, B, C, and Linear. When using an octave filter, any one of the weightings may be selected.

Frequency Range: 4 Hz (-3dB) to 50kHz (-3dB) linear scale, subject to microphone limitations.

Display: 3-1/2 Digit Liquid Crystal Display with additional Quasi-Analogue 60dB indicator in 2dB increments. Level display to 0.1dB resolution. Annunciators for Battery Check, Hold, and Overload indications.

Meter Response: Slow, Fast, Peak, and Impulse in SPL and MAX mode.

Batteries: Two 9-volt alkaline batteries (NEDA 1604A) will provide approximately 20 hours of continuous operation (10 hours with optional filter).

Tripod Mount: Accepts standard 1/4-20 tripod mounting screw.

Temperature Range: Operation: -10°C to +50°C. Storage (less batteries): -20°C to +60°C.

Size: 3.3 x 8.2 x 1.8 inches (84 x 208 x 47mm) not including preamp height.

Weight: 24 ounces (680 grams) including preamp, microphone and batteries.

Model OB-50 Octave Filter Set

Standards: ANSI S1.11, Order 3 and IEC R225.

Center Frequencies: 9 frequencies from 31.5 Hz to 8kHz.

Power Source: Sound Level Meter.

Size: 3.3 x 2.8 x 1.8 inches (84 x 71 x 47mm).

Weight: 6 ounces (170 grams).

Model OB-100 Octave Filter Set

Standards: ANSI S1.11, Order 3 and IEC R225.

Center Frequencies: 10 frequencies from 31.5 Hz to 16kHz.

Frequency Selection: Full manual control or automatic sequential stepping through each frequency band.

Power Source: Sound Level Meter.

Size: 3.3 x 2.8 x 1.8 inches (84 x 71 x 47mm).

Weight: 6 ounces (170 grams).

Model OB-300 1/3 - 1/1 Octave Filter Set

Standards: ANSI S1.11, Order 3 and IEC R225.

Center Frequencies: 33 frequencies from 12.5 Hz to 20kHz.

Frequency Selection: Full manual control or automatic sequential stepping through each frequency band.

Power Source: Sound Level Meter.

Size: 3.3 x 4.2 x 1.8 inches (84 x 107 x 47mm).

Weight: 9 ounces (255 grams).

Accessories

Model QC-10 Calibrator – a single-frequency single-amplitude calibrator.

Model VA-508C Vibration Assembly – for the measurement of vibration velocity, displacement and acceleration.

Model WS-6 Windscreen.

Model TP-2 Tripod.

Microphone Cables – 10- and 50-foot lengths.

Model 56-163 Microphone Adapter.

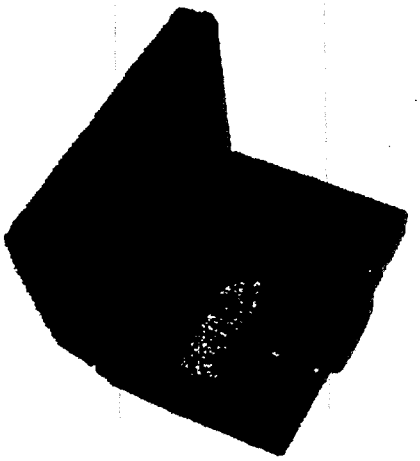
Coupler, Weight and Stand – for calibrating audiometers.

Kits

The meter and calibrator are available in a kit designated as the 2700-10.

The meter and filters are available in kits designated, for example, as Model 2700-5010 which includes a QC-10 Sound Calibrator, the OB-50 Filter Set, the WS-6 Windscreen and a carrying case. The TP-2 Tripod and microphone cables are optional.

An audiometer calibration kit, Model 2700-5010AM, is available which includes, in addition to the items listed above, an earphone coupler, weight and calibration stand.



QUEST ELECTRONICS
...the Emphasis of Quality

510 Worthington Street
Oconomowoc, WI 53066 U.S.A.
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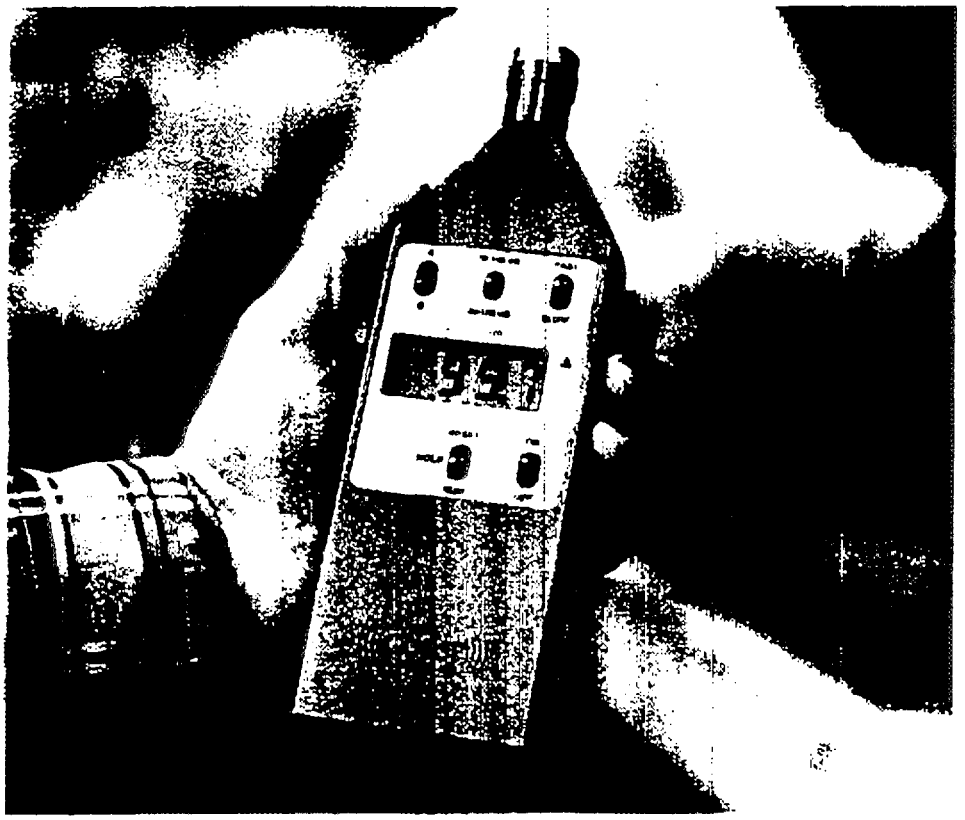
TWX 910 260 1438 LA BELLE
FAX (414) 567-4047
TOLL FREE (800) 245-0779

Represented by

QUEST ELECTRONICS

Model 2400 Sound Level Meter



The Quest 2400 Type 2 Sound Level Meter offers accurate noise measurement and analysis at a very competitive price. Its rugged, compact, yet high quality design makes it the perfect choice for industrial, military, law enforcement, and environmental applications.

Versatile

The 2400's many features accommodate a wide variety of situations.

- Wide 70 dB range is switchable between low and high settings (30-100dB or 70-140dB). "Overrange" and "Underrange" warnings indicate when a change from one range to the other is recommended for accurate readings.
- Choose between "A" and "C" frequency weightings.
- May be hand-held, mounted on a tripod, or simply placed in a convenient location.
- "Fast Response" setting permits accurate measurement of short duration noises, such as moving vehicles.
- "Max Hold" mode displays maximum weighted sound level encountered. "Run" mode continuously updates sound level readings each second.
- AC and DC output jacks permit connection to peripheral devices, such as recorders and oscilloscopes.

Easy to Use

- Lightweight, compact design is extremely portable. The 2400 weighs just 15 ounces (425 grams) including batteries.
- Features a large, easy-to-read LCD display.
- Slide switches are easy to operate, even with gloves.
- "LOBAT" symbol indicates when battery needs replacement to maintain accuracy.

Rugged

- Tough die cast metal case is impact- and crush-resistant.
- High technology surface-mount electronic design provides solid connections and resists damage due to impact.
- Slide-in battery compartment eliminates battery connector failure.

Quest 2400 Type 2 Sound Level Meter

Specifications

Standards: Meets or exceeds ANSI S1.4, Type 2 and relevant sections of IEC 651 and BS 5969, Type 2.

Display: 3½ Digit Liquid Crystal display. Level display indicates to 0.1 dB resolution. Annunciator is included for Battery Check. LED indicators are used for overrange and underrange conditions.

Modes of Operation: Measures sound pressure level (SPL) or maximum level (MAX).

Range: 30 to 140 dBA. 40 to 140 dBC.

AC Gain Calibration: External calibration adjustment available on front of meter near the microphone. Calibrate using an acoustic calibrator that is properly adapted to the microphone.

Frequency Weighting Networks: A and C.

Meter Response: Slow and Fast.

Microphone: Field replaceable prepolarized condenser (electret) microphone.

AC Output: 0.85 V RMS at 100 dB on LOW range.
8.5 mV RMS at 100 dB on HIGH range.
The output impedance is 1 Kohms.
⅛ inch phone jack.

DC Output: 0 VDC ±15 mV at 100 dB.
Each 0.167 V change equals 10 dB (1 V/60 dB).
The output impedance is 1 Kohms.
⅛ inch phone jack.

Detector: True RMS.

Crest Factor: 15 (23 dB) up to 88 dB LOW range, 128 dB HIGH range.

5 (14 dB) up to 98 dB LOW range, 138 dB HIGH range.

3 (10 dB) up to 103 dB LOW range, 143 dB HIGH range.

Crest factor is always sufficient to handle the signal if the overload indicator does not light.

Overload Indication: A red LED indicates overload.

Accuracy: Within 0.5 dB at 25°C; within 1.0 dB over the temperature range of –10°C to +50°C.

Temperature Range: Operation: –10°C to +50°C.

Storage: –20°C to +60°C. (less batteries).

Operating Humidity: 0 to 95% relative humidity, non-condensing.

Effect of Magnetic Fields: A magnetic field of 1 Oersted (80 A/m) at 60 Hz produces a maximum reading of 40 dB on C weighting.

Effect of Electrostatic Fields: Negligible.

Batteries: Two 9 volt alkaline batteries (NEDA 1604A) will provide approximately 25 hours of continuous operation.

Tripod Mount: A threaded insert on back of the meter accepts a standard ¼ 20 tripod mounting screw.

Size: 2.75 x 7.6 x 1.0 inches (70 x 193 x 25 mm) not including the height of the microphone housing. The microphone extends 1.5 inches (38 mm).

Weight: 15 oz. (425 g) including batteries.

Accessories

Model QC-10 Calibrator: A single-frequency, single-amplitude calibrator.

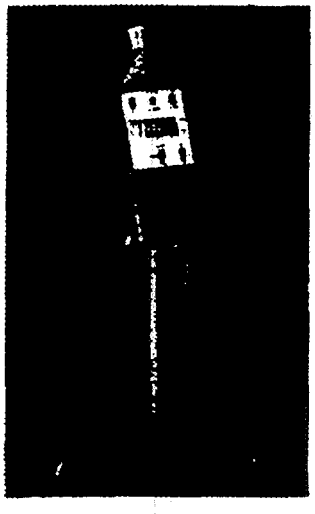
Model WS-6: Windscreen.

Model TP-2: Tripod.

Model 56-163: Calibrator adaptor.

Kits

Model 2400 Sound Level Meter, Model QC-10 Calibrator and Model WS-6 Windscreen are available, complete with carrying case, as Kit number 2400-10.



QUEST ELECTRONICS
...the Emphasis of Quality

510 Worthington Street
Oconomowoc, WI 53066 USA
Phone: (414) 567-9157
Toll Free: (800) 245-0779
TWX: 910 260 1418 LA BELLE
Fax: (414) 567-4047

Represented by:

QUEST ELECTRONICS

U.S. INSTRUMENT PRICE LIST

Effective October 1, 1992
PRICES SUBJECT TO CHANGE WITHOUT NOTICE.
THIS PRICE LIST SUPERSEDES ALL PREVIOUS PRICE LISTS.

WARRANTY:
Quest Electronics warrants its instruments to be free from defects in materials and workmanship under normal conditions of use and service. Sh unit prove to be defective within one (1) year after delivery to the original purchaser, we will replace or repair the unit at Quests option, free of cha (Exception: Model 208/208L meters and precision microphones - 90 days warranty.) Chart Recorders and Printers are warranted by their manufacta

FOR ORDERING INFORMATION CONTACT
OUR MAIN OFFICE AND FACTORY:

QUEST ELECTRONICS
510 S. Worthington . Oconomowoc, WI 53066 USA
414/567-9157 . TWX 910 280 1438 LaBelle . FAX: 414/567-4047
Toll Free: 800/245-0779 U.S., Canada and Puerto Rico

MODEL	SOUND LEVEL METERS	LIST PRIC
	All Sound Level Meters except 208/208L include calibrator adapter, windscreen, and carrying case.	
	Type 1 Precision	
1800	INTEGRATING SOUND LEVEL METER: includes 1/2 inch remotable microphone, and computer cable	2655
1700	SOUND LEVEL METER: includes 1/2 inch remotable microphone	2395
1400	SOUND LEVEL METER: includes fixed microphone	995
	Type 2 General Purpose	
2800	INTEGRATING SOUND LEVEL METER: includes remotable microphone, and computer cable	1450
2700	SOUND LEVEL METER: includes remotable microphone	825
2400	SOUND LEVEL METER: includes fixed microphone	465
208L	SOUND LEVEL METER: special purpose, 50-100dBA, includes pouch	165
208	SOUND LEVEL METER: same as above except range is 70-120dBA	165
	KITS WITH CALIBRATORS *	
	***Includes same as unit above, plus QC-10 or QC-20 calibrator as indicated.**	
1800-20	INTEGRATING SOUND LEVEL METER & CALIBRATOR KIT	3180
1700-20	SOUND LEVEL METER & CALIBRATOR KIT	2895
1400-20	SOUND LEVEL METER & CALIBRATOR KIT	1630
2800-10	INTEGRATING SOUND LEVEL METER & CALIBRATOR KIT	1795
2700-10	SOUND LEVEL METER & CALIBRATOR KIT	1170
2400-10	SOUND LEVEL METER & CALIBRATOR KIT	795
	OCTAVE BAND FILTER SETS	
OB-300	OCTAVE BAND FILTER SET: combination 1/3-1/1 filter, 12.5Hz to 20KHz	1645
OB-100	OCTAVE BAND FILTER SET: 31Hz to 16KHz	795
OB-50	OCTAVE BAND FILTER SET: 31Hz to 8KHz	695
	OCTAVE BAND ANALYZER KITS	
1800-30020	INTEGRATING OCTAVE BAND ANALYZER: includes 1800, OB-300, QC-20, windscreen, and carrying case	4895
1700-10020	OCTAVE BAND ANALYZER: includes 1700, OB-100, QC-20, windscreen, and carrying case	3790
2800-10010	INTEGRATING OCTAVE BAND ANALYZER: includes 2800, OB-100, QC-10, windscreen, and carrying case	2690
2700-5010	OCTAVE BAND ANALYZER: includes 2700, OB-50, QC-10, windscreen, and carrying case	1975

Note: Octave Band Filters and Calibrators may be substituted within the kits, add or subtract difference in co accordingly.

MEGGITT AEROSPACE

ARMTEC/ RAGEN INC

10 Ammon Drive
Manchester
New Hampshire
03103-7406
USA
telephone
(603) 669 0940
fax
(603) 669 0931

FACSIMILE

TO: **Frank Barickman**

COMPANY: **Oakridge Nat'l Lab** COUNTRY: **TN**

FROM: **Nancy Dyer**

REF #: **ND-F-0294-0315** FAX # **615-574-9619**

DATE: **February 3, 1994** COVER + PAGES

If you have any difficulty in receiving the full message, please contact us immediately on (603) 669-0940.

Subject: Meteorological Sensor, P/N 88658-02

The tolerances for the sensors in the above referenced product are:

Sensor	Range	Tolerance
Headwind/Crosswind	2-4 M/S 5-40 M/S	0.5 M/S ± 5%
Pressure	500-1080 millibars	± 2 millibars at room temp.
Temperature	-40°C to 60°C	± 2°C at min. 5 M/S wind

Budgetary pricing:

1 - 4	$7,500.00
5 - 9	$6,150.00
10 - 24	$5,140.00
25 - up	$4,550.00

Dely: 38 weeks ARO

Sincerely,

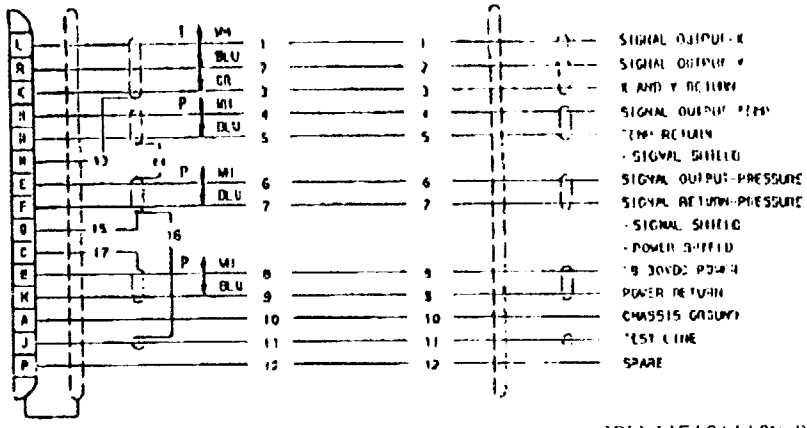
ARMTEC/RAGEN INC.

Nancy Dyer

Nancy Dyer
Contract Administrator

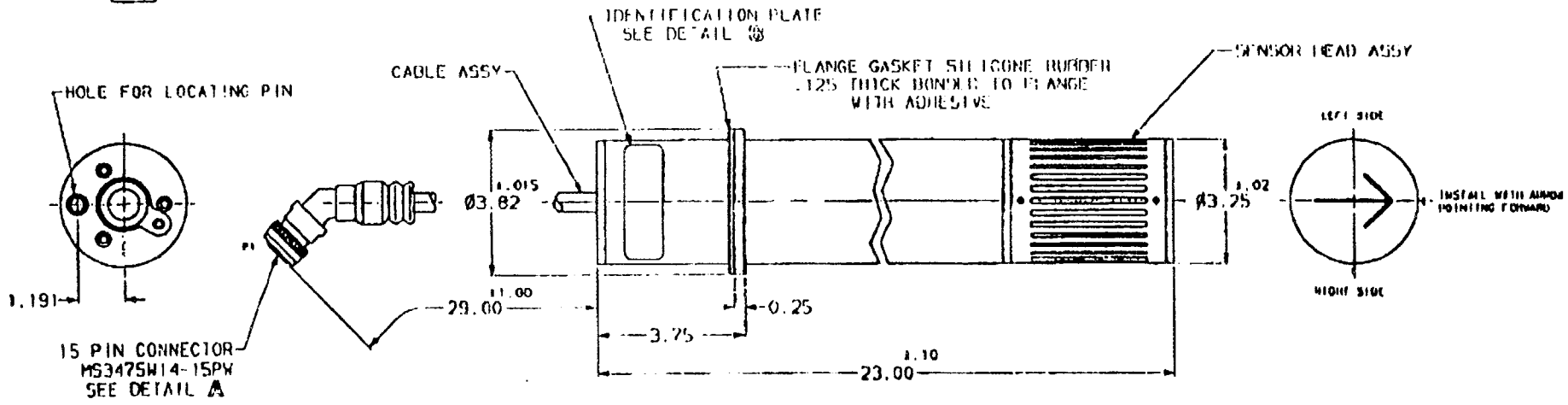
REVISIONS					
ZONE	REV	DESCRIPTION	ECO	DATE	APPROVED
	A	[illegible]		17 MAY [illegible]	
	B	[illegible]	[illegible]	[illegible]	[illegible]
	C	CABLE LENGTH WAS 16.00 ±.50	-	-	[illegible]

15 PIN CONNECTOR
MS3475W14-15PW



WIND SENSOR
MFR ARMTEC INDUSTRIES, INC. 58880
ARMTEC-PN 088658-02 REV
NSN
SERNO DATE

DETAIL B
SCALE = 2/1



DETAIL A
REAR VIEW OF P1
(14 No. 20 CONTACTS)
(1 No. 16 CONTACT)
CONNECTOR MATED WITH
MS3474W14-15SW

NOTES:
1. FINAL PROTECTIVE FINISH ON EXTERIOR SURFACES:
   A. BOTTOM PLATE AND MAST - PAINTED NO. 383 GREEN PER MIL-C-46168 (CARC).
   B. TOP PLATE AND HEAD ASSEMBLY - ANODIZED BLACK
   C. CAGE AND CAGE TOP - TEFLON COATED BLACK
2. WEIGHT SHALL NOT EXCEED 13 POUNDS.
3. OPTIONAL SHOCK MOUNT ASSY - 08470

ADVANCE COPY

QTY	PART NO.	DESCRIPTION		MFR
		LIST OF MATERIALS		

PROPRIETARY NOTICE
[illegible]

DRAWN	D.O./KWG	
CHK	C.A./TEN	
APD	PAD	
MFG	P BENTLEY	
QA	C [illegible]	
APPR	-	
USED ON	INC	

ARMTEC INDUSTRIES, INC.
MANCHESTER, N.H. 03103-7406

OUTLINE DRAWING
WIND SENSOR, DUAL AXIS
(W/PRESS TEMP & TEST)

SIZE C | CAGE CODE 58880 | DWG NO. (0)88658-02
PART NO. 088658-02.C
SCALE 1/2 | SHEET 1 OF 1

CAD DRAWING - DO NOT REVISE MANUALLY

01/24/94 15:39 603 889 0931 ARMTEC IND. USA

JTPUT MEASUREMENT VOLTAGE

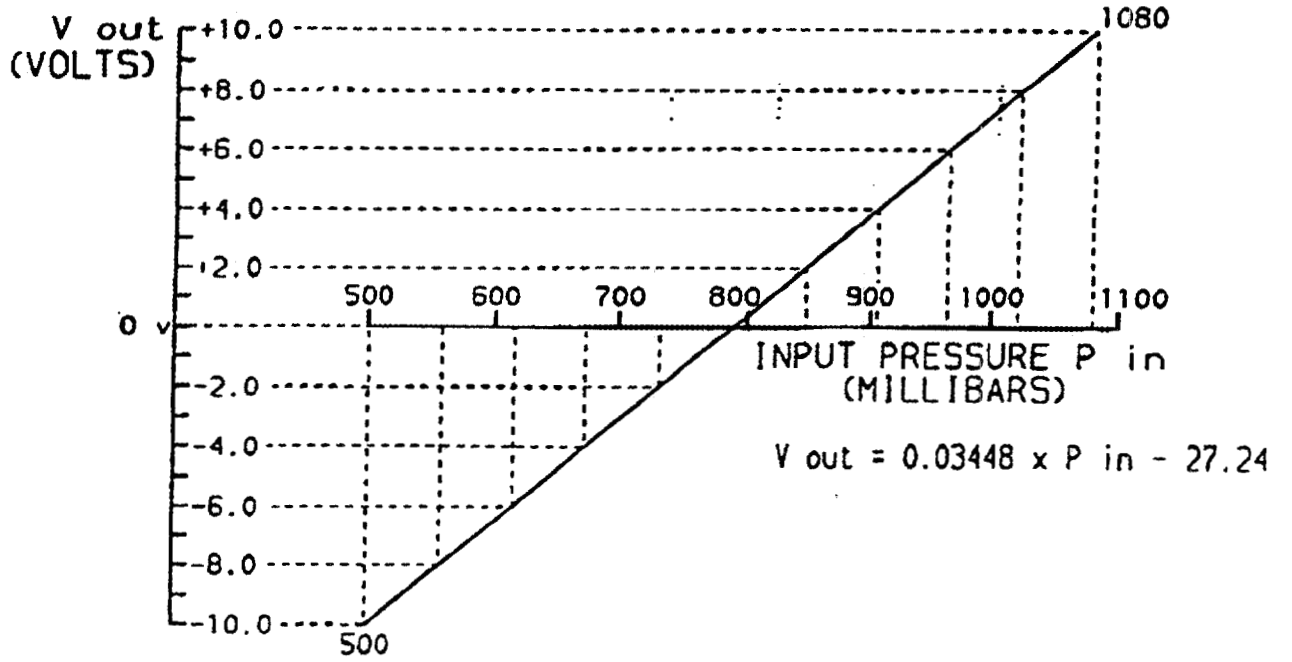


FIGURE 4: INPUT PRESSURE TO OUTPUT MEASUREMENT VOLTAGE

ALLOWABLE DEVIATION OF MEASUREMENT
VOLTAGE FROM NOMINAL VOLTAGE AT AMBIENT TEMPERATURE

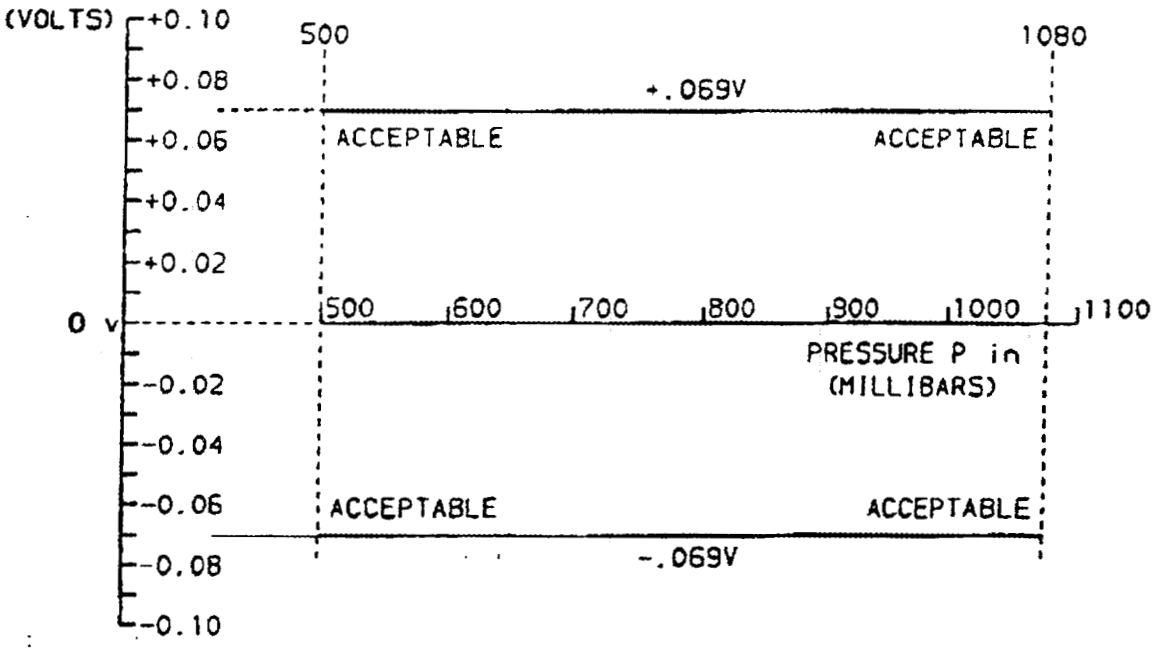


FIGURE 5: ALLOWABLE MEASUREMENT ERROR FOR THE PRESSURE SENSOR

ARMTEC INDUSTRIES, INC. MANCHESTER, N.H. 03103-7406			
SIZE A	FSCM NO. 58880	DWG NO. E.S. 1608	REV. B
SCALE NONE	ES1608510.B	SHEET 10 OF 13	

CAD DRAWING ▲ DO NOT REVISE MANUALLY

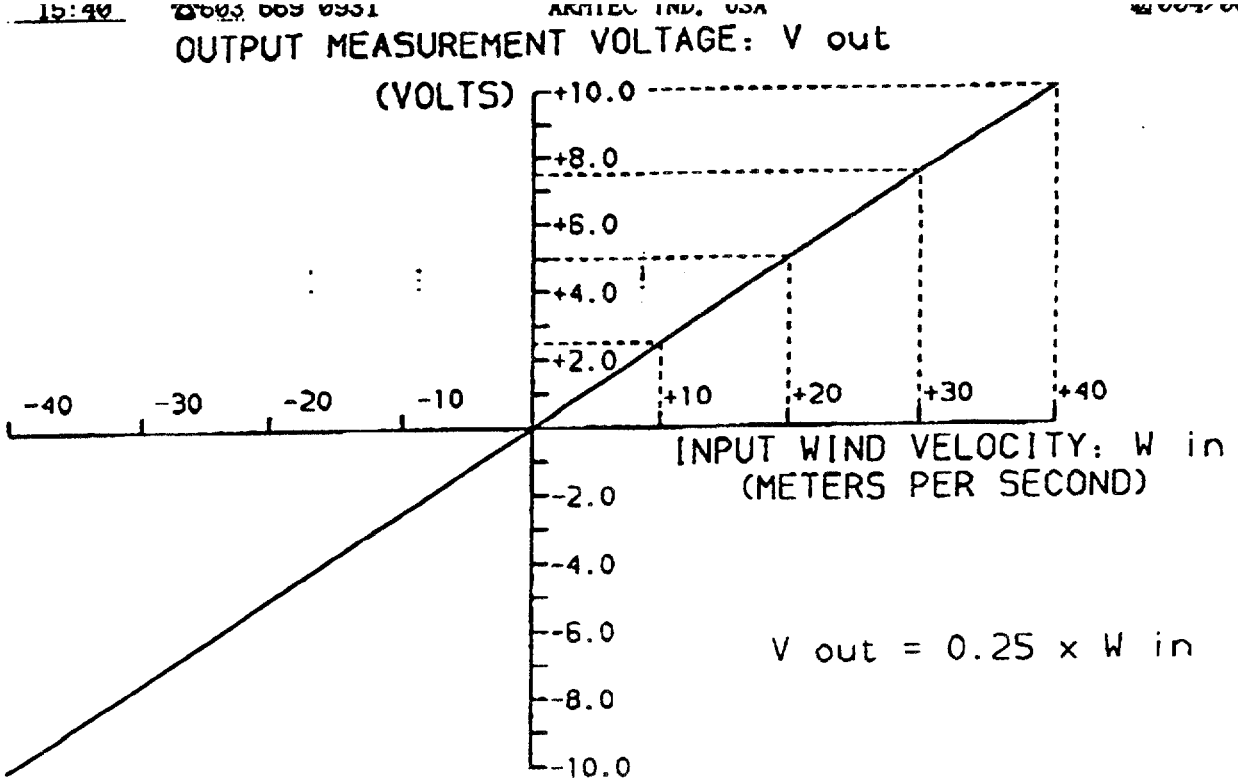


FIGURE 2: INPUT WIND VELOCITY TO OUTPUT MEASUREMENT VOLTAGE

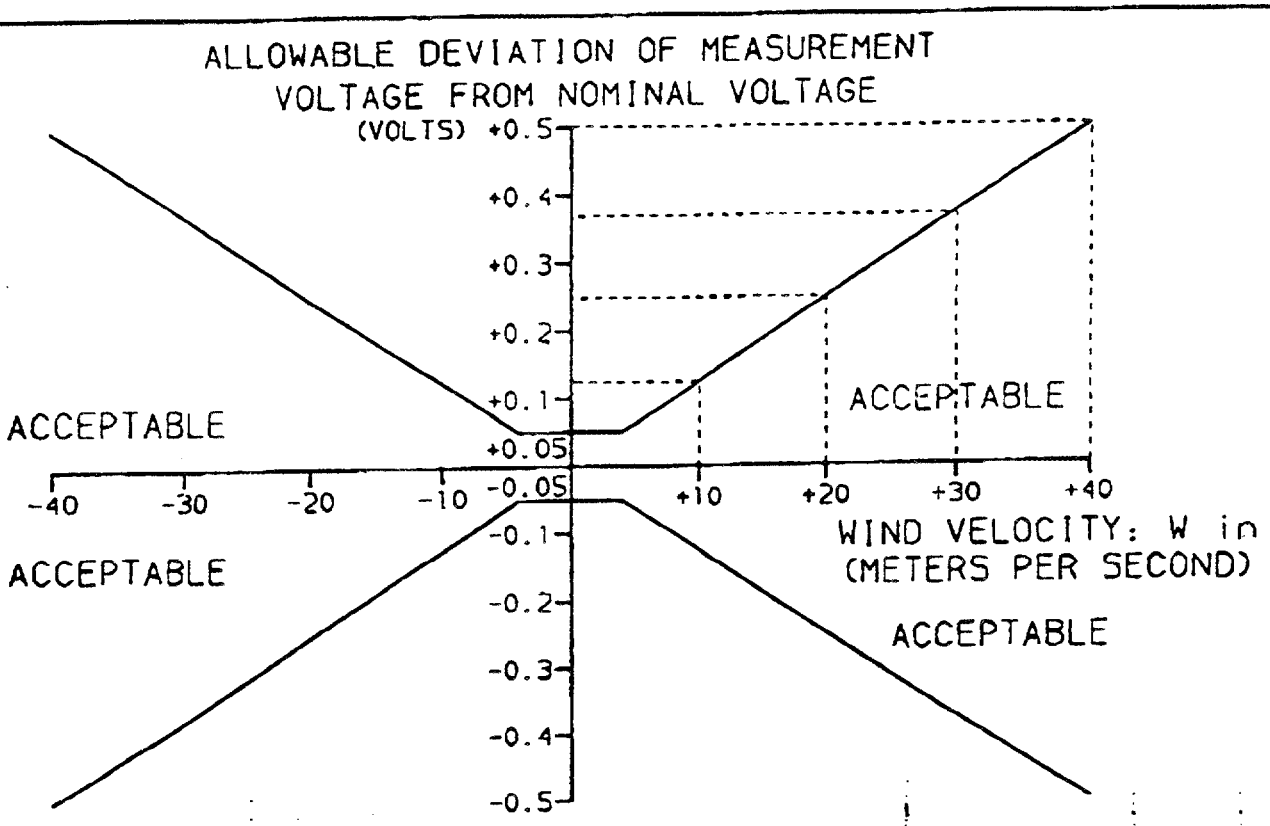


FIGURE 3:
ALLOWABLE MEASUREMENT ERROR
FOR THE WIND SENSOR

ARMTEC INDUSTRIES, INC. MANCHESTER, N.H. 03103-9990			
SIZE A	FSCM NO. 58880	DWG NO. E.S. 1608	REV. B
SCALE NONE	ES1608S9.B	SHEET 9 OF 12	

CAD DRAWING ▲ DO NOT REVISE MANUALLY

APPENDIX S: TECHNICAL DATA FROM VIDEO DATA SYSTEM VENDORS

Cohu
Panasonic Broadcast and Television Systems
Skotel
American Video Equipment
Horita
Robot Research
JVC Professional Products

Microlens Sensor

REMOTE-HEAD CCD CAMERAS

8290 & 8390 SERIES

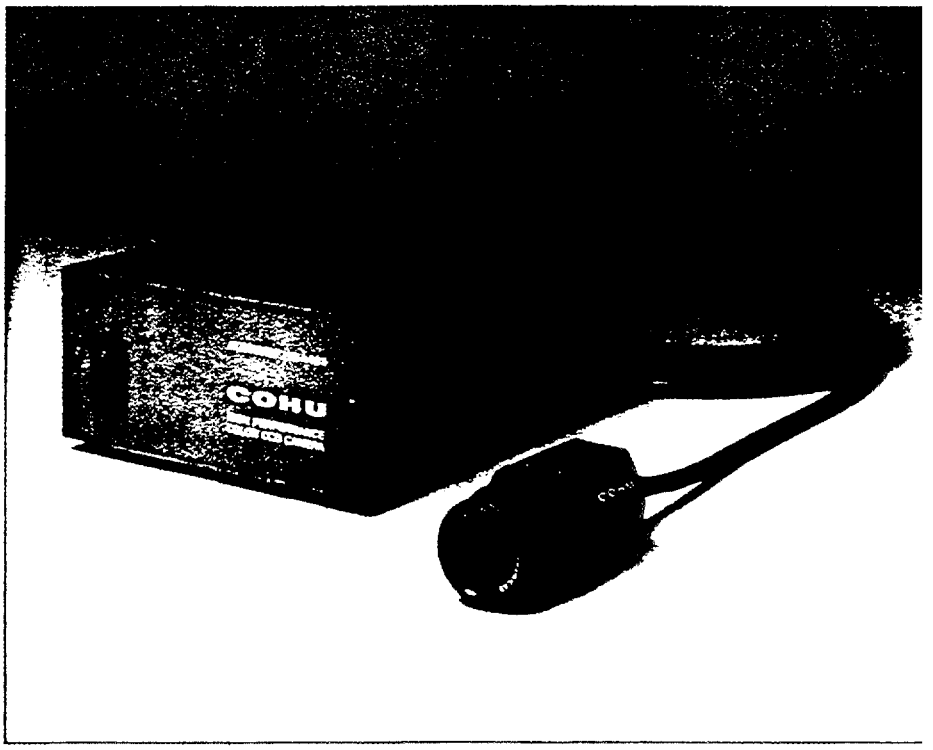
NTSC/Y-C, PAL/Y-C, or RGB On-Chip Microlens Sensor

Cohu's new 8290 and 8390 Series High Performance Color Remote-Head CCD Cameras are the perfect solution for applications requiring high performance in a compact package. The lightweight remote head is easily incorporated into microscopes and machine vision systems, and is ideal for specialized security/surveillance applications.

Available in NTSC/Y-C, PAL/Y-C, and RGB models, these high resolution cameras use on-chip microlens HAD sensor technology, which enhances dynamic range and sensitivity while reducing vertical smear.

An easily removable trim plate on the camera control unit provides convenient access to electronic shutter timing, integration, AGC, and white balance controls.

Designed and manufactured in the U.S.A., 8290 and 8390 Series High Performance Color Remote-Head CCD Cameras are backed by a two-year warranty. OEM engineering requests are welcomed.



Cohu High Performance Color Remote-Head CCD Camera

FEATURES AND BENEFITS

- **Compact, Lightweight Remote Head** — for easy installation and operation
- **On-Chip Microlens Sensor** enhances sensitivity and dynamic range, reduces vertical smear
- **High Resolution** — 460 horizontal TV lines for sharper images
- **High Sensitivity** — permits operation over a wide range of light levels
- **Convenient External Adjustments** for control of shutter speed, integration period, AGC, and other critical parameters
- **Zero Geometric Distortion** ensures precision measurement.
- **Two Year Warranty**
- **Choice of Video Formats** — including Y-C and RGB outputs for specialized applications
- **Eight-Speed Electronic Shutter** reduces blurring of fast-moving objects
- **Selectable Integration Periods with Grab Pulse** — for low light level microscopy applications.
- **1000:1 Overload Capability** permits incidental light overloads up to ten times that of other CCD cameras
- **AGC with Peak-Average Adjustment** for clear images in varying light level applications
- **Made in U.S.A.** — direct factory support, quality design and construction.

APPLICATIONS

- **Microscopy**
- **Image Processing**
  Medical and Industrial
- **Machine Vision**
  Pattern Recognition
  Non-Contact Measurement
  3-D Imaging
  Inspection
- **Robotics**
- **Computer Graphics**
- **Remote Sensing**
- **Mapping**
- **Teleradiology**
- **Quality Control**
- **Teleconferencing**
- **Security/Surveillance**

Designed and manufactured in U.S.A.

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8290 AND 8390 SERIES REMOTE-HEAD COLOR CCD CAMERAS

SPECIFICATIONS

ELECTRICAL—NTSC AND PAL MODELS

Imager
Single interline transfer CCD with matrix filter (cyan, yellow, magenta, green)

Image Area
6.4 x 4.8 mm (1/2" format)

Active Picture Elements
NTSC/Y-C: 768(H) x 493(V)
PAL/Y-C: 752(H) x 582(V)

Resolution
NTSC/Y-C: Horizontal 460 TV lines
Vertical 350 TV lines
PAL/Y-C: Horizontal 460 TV lines
Vertical 415 TV lines

Sensitivity
3200 K faceplate illumination.
6.5 lux at full video, AGC Off.
0.55 lux at 80% video, AGC On.

Electronic Shutter
Switch selectable, 1/60 second (off) to 1/10,000 second (8 steps)

Integration
Switch selectable, 2 to 16 fields (8 steps). Grab pulse available

Gamma
0.5

AGC
0-20 dB
Peak-average adjustable

Signal-to-Noise Ratio (AGC Off)
48 dB (NTSC with 4.5 MHz filter)
45 dB (PAL with 5 MHz filter)

Video Outputs
Encoded: NTSC and PAL
1 V p-p @75 ohms, unbalanced, composite

S Video:
Y: 1 V p-p @75 ohms, unbalanced, composite
C: 0.285 V p-p

Auto Lens Output
Peak-average characteristic tracks AGC adjustment to eliminate AGC/auto lens interaction

Color Lock
Burst phase adjustment
Horizontal phase adjustment

Color Balance
Through-the-lens type
Less than 10 IRE units unbalance from 2850 to >5800 K

Synchronization
NTSC or PAL crystal, color lock standard

Power Requirements
12V ac or dc (standard)
115V ac, 60 Hz for NTSC models (optional, with wall transformer)
230V ac, 50 Hz for PAL models (optional, with wall transformer)

Power Consumption
4.5W

ELECTRICAL—RGB MODELS

Imager
Single interline transfer CCD with matrix filter (cyan, yellow, magenta, green)

Image Area
6.4 x 4.8 mm (1/2-inch format)

Active Picture Elements
RGB/60: 768(H) x 493(V)
RGB/50: 752(H) x 582(V)

Resolution
RGB/60: Horizontal 460 TV lines
Vertical 350 TV lines
RGB/50: Horizontal 460 TV lines
Vertical 415 TV lines

Sensitivity
3200 K faceplate illumination.
6.5 lux at full video, AGC Off.
0.55 lux at 80% video, AGC On.

AGC
0-20 dB
Peak-average adjustable

Gamma
0.5 or 1.0

Electronic Shutter
Switch selectable, 1/60 second (off) to 1/10,000 second (8 steps)

Integration
Switch selectable, 2 to 16 fields (8 steps); grab pulse available

Power Requirements
12V ac or dc (standard)
115V ac 60 Hz (optional, with wall transformer)
230V ac 50 Hz (optional, with wall transformer)

Power Consumption
4.5W

Video Outputs
RGB, per channel: 0.714 V p-p @75 ohms, unbalanced; sync on green, jumper selectable
Sync: 0.4 V p-p @75 ohms, unbalanced

Synchronization
Genlock, H & V drive

ENVIRONMENTAL

Ambient Temperature Limits
Operating: –20 to 50 °C (–4° to 122° F)
Storage: –30 to 70 °C (–22° to 157° F)

Humidity
Up to 95% relative humidity, non-condensing

Vibration (less lens)
5 to 60 Hz with 0.082 inch total excursion (15 g's @ 60 Hz). From 60 to 1000 Hz, 5 g's rms random vibration without damage

Shock (less lens)
Up to 15 g's in any axis under nonoperating conditions, MIL-E-5400T, paragraph 3.2.24.6

Altitude
Sea level to equivalent of 3,000m/10,000 feet (508mm/20 inches of mercury)

MECHANICAL

Dimensions
Please see dimensional drawings.

Weight
Camera Control Unit (12 V model): 36 ounces (1000 grams)
Camera Head (less lens and cable): 4 ounces (113 grams)
15' Remote Cable: 17 ounces (483 grams)

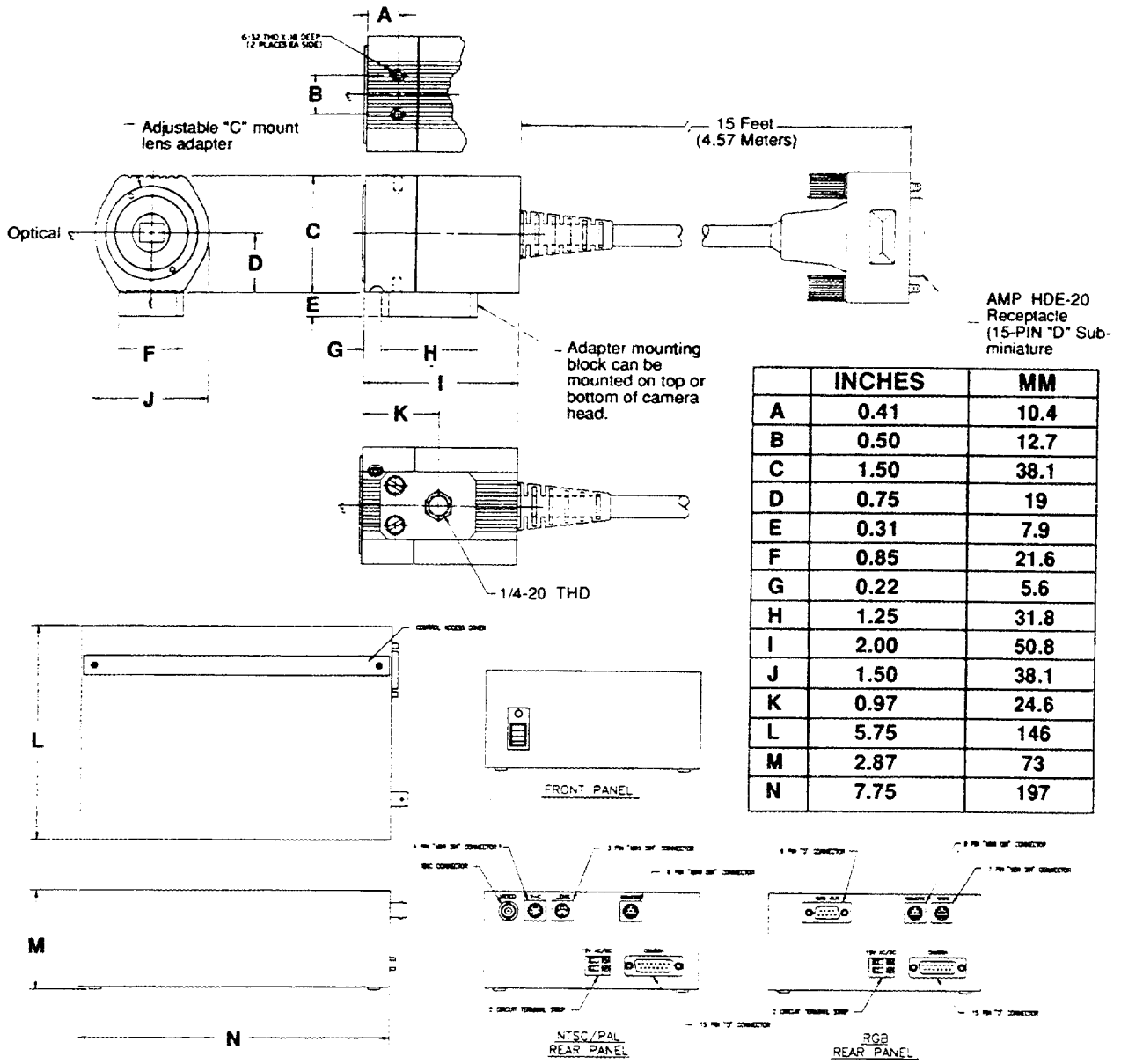
Lens Mount
Adjustable "C" mount

Connectors
Please see dimensional drawings

Top Panel Adjustments
Shutter/Off/Integrate
8-Position Shutter/Integrate Switch
AGC On/Off *
AGC Peak/Average Adjustment
Auto/Manual/Remote White Balance Switch *
White Balance Adjustment*
Horizontal Phase/Color Lock*
SC Phase Switch*
SC Phase Adjustment*
AGC/Manual/Remote**
Gain**
Vertical Phase Adjustment**
Horizontal Phase Adjustment**

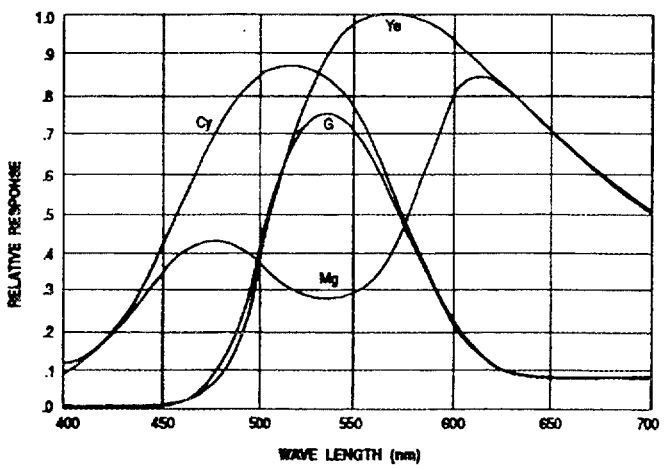
* NTSC/Y-C and PAL/Y-C Models Only
** RGB Models Only

DIMENSIONS

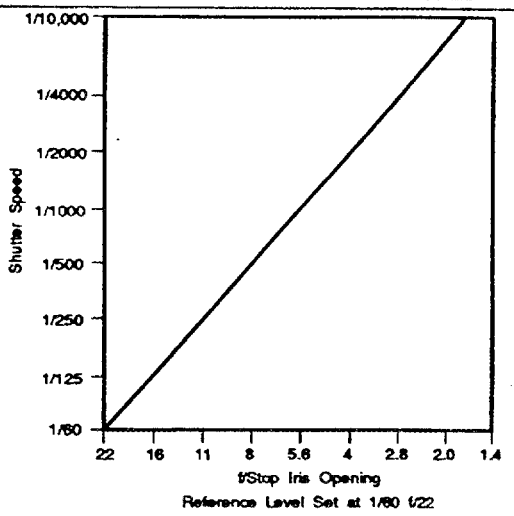


	INCHES	MM
A	0.41	10.4
B	0.50	12.7
C	1.50	38.1
D	0.75	19
E	0.31	7.9
F	0.85	21.6
G	0.22	5.6
H	1.25	31.8
I	2.00	50.8
J	1.50	38.1
K	0.97	24.6
L	5.75	146
M	2.87	73
N	7.75	197

MATRIX FILTER COLOR RESPONSES



TYPICAL f/STOP VS. SHUTTER



8290 AND 8390 SERIES REMOTE-HEAD COLOR CCD CAMERAS

ORDERING INFORMATION

8X9 X — XXXX / XXXX

Format Options

2 NTSC Format (60 Hz)

3 PAL Format (50 Hz)

Power Options

2 12V ac/dc

3 230V ac, 50 Hz, with wall transformer (8390 Series only)

5 115V ac, 60 Hz, with wall transformer (8290 Series only)

Configuration Options

1000 NTSC/Y-C or PAL/Y-C

2000 RGB/60 or RGB/50

Lens Options

0000 None

Manual Iris, C Mount
AL04 4.5mm, f/2.0, 2/3"
AL06 6.5mm, f/1.8, 2/3"
AL08 8mm, f/1.4, 2/3"
A014 12mm, f/1.2, 1/2"
AL16 16mm, f/1.4, 2/3"
AL25 25mm, f/1.4, 1"
AL50 50mm, f/1.8, 1"

Auto Iris, C Mount*
ES05 4.8mm, f/1.8, 2/3"
ES08 8mm, f/1.4, 2/3"
ES16 16mm, f/1.4, 2/3"
EH35 35mm, f/1.4, 2/3"

* Customers supplying their own auto iris lenses must order lens connector separately. Please consult factory

PLEASE NOTE: Cohu welcomes the opportunity to provide special features to better serve your particular requirement. For example, custom painting, silkscreen and logo for OEM customers and special connector pin configurations can be ordered. Please contact Cohu for details.

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NTSC & PAL CONNECTOR CONFIGURATIONS

LENS

1	Power
2	Lens Video
3	Ground

Y-C

1	Y—Ground
2	C—Ground
3	Y
4	C

REMOTE

1	Auto/Man
2	White Balance
3	Sync/Video In
4	Shutter On/Off
5	+5
6	Ground
7	Ground
8	Grab Pulse

RGB CONNECTOR CONFIGURATIONS

REMOTE 1

1	Blue Level
2	Red Level
3	Sync/Horizontal In
4	Shutter On/Off
5	+5
6	Vertical In
7	Ground
8	External Gain

SYNC

1	Grab Pulse
2	V Drive Out
3	H Drive Out
4	Clock Out
5	Ground

RGB

1	Ground
2	Ground
3	R
4	G
5	B
6	NC
7	Sync
8	NC
9	NC

NOTE: The RGB connector layout is directly compatible with Targa®, Vista®, and other image capture boards.

ADVANCED VIDEO TECHNOLOGY Made in the U.S.A.

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Printed in U.S.A. 91-08 (02/93) February 1993

TWO-YEAR WARRANTY

REMOTE-HEAD MONOCHROME FRAME-TRANSFER CCD CAMERAS

6400 & 6700 SERIES

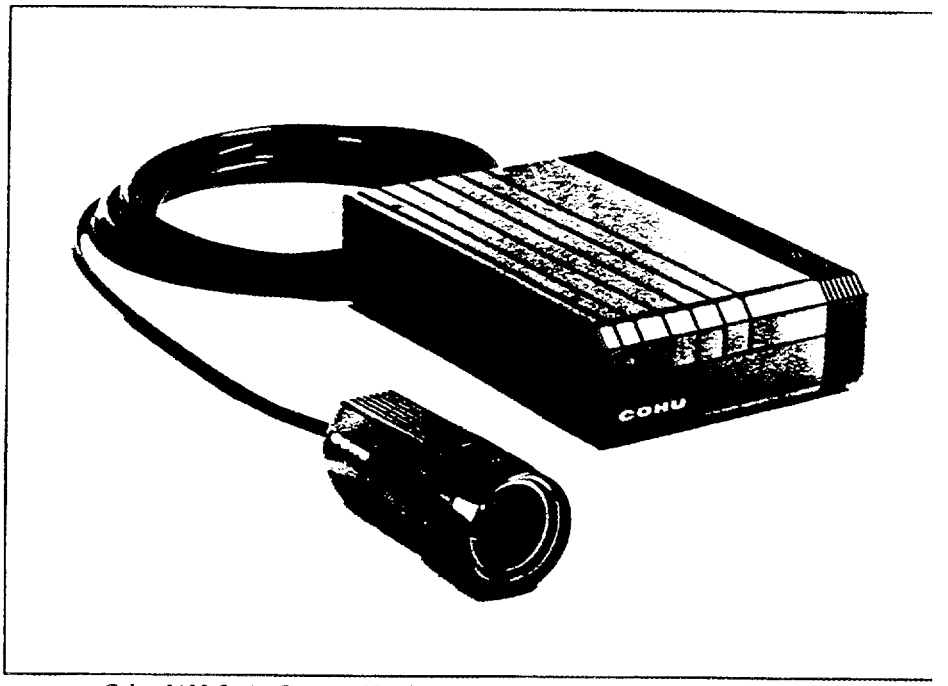
Compact, Lightweight Electronic Shutter

Cohu's Monochrome Remote-Head Frame-Transfer CCD Cameras offer all the outstanding performance characteristics of Cohu's 4800 and 4700 Series standard monochrome frame-transfer cameras, with the added benefits of a two-piece configuration, electronic shutter, and enhanced signal-to-noise characteristics. The lightweight remote camera head is ideally suited for mounting on microscopes, robots, and other equipment with size and weight limitations.

Both the 6400 Series RS-170 and the 6700 Series CCIR cameras provide high resolution and high sensitivity. The blemish-free CCD sensor provides pixel-to-pixel contrast variation of less than 5%, with zero geometric distortion and no lag or image retention.

Connected to the camera control unit by an integral 15-foot cable, the remote camera head weighs only 113 grams, and measures only 38mm in diameter and 51mm in length.

As with all Cohu CCD cameras, the 6400 and 6700 Series cameras are designed and manufactured in U.S.A., and are backed by a full two-year warranty.



Cohu 6400 Series Remote-Head Monochrome Frame Transfer CCD Camera

APPLICATIONS

- **Microscopy**
- **Machine Vision**
- **Medical Imaging**
- **Process Control**
- **Quality Control**
- **Image Analysis**
- **Security/Surveillance**

FEATURES AND BENEFITS

- **Compact, Lightweight Remote Head** — maximum flexibility for end users or OEMs
- **High Resolution** — for better definition, error-free results
- **Two-Speed Electronic Shutter** reduces blurred images of fast-moving objects.
- **High Sensitivity** permits operation over a broad range of light levels.
- **Genlock, H & V Drive, Pixel Clock Outputs** for machine vision interface
- **High Signal-to-Noise Ratio** for better dynamic range.
- **Auto Black** for contrast enhancement
- **100% Blemish-Free Frame-Transfer Image Sensor** — no dead pixels.
- **Made in U.S.A.** — direct factory support
- **No Lag or Image Retention** — provides fast, clean images
- **Zero Geometric Distortion** for consistent corner-to-corner linearity
- **Selectable AGC Ranges** for better control under varying light conditions
- **Optional IR Filter**
- **State-of-the-Art Design and Construction** for high performance, reliability and long life
- **Choice of RS-170 & CCIR Models**
- **Two-Year Warranty**
- **15' Remote Cable** facilitates system design and installation.
- **Special Configurations** for OEMs and end users

Designed and Manufactured in U.S.A.

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400 & 6700 SERIES REMOTE-HEAD FRAME-TRANSFER CCD CAMERAS

SPECIFICATIONS

ELECTRICAL

mager Type
Single CCD using frame-transfer method

mage Area
6.4 x 4.8 mm (corresponding to ½" image tube)

ctive Picture Elements
RS-170: 739H x 484V
CCIR: 699H x 576V

ell Size
RS170: 8.5(H) x 19.5 (V) microns
CCIR: 9.2(H) x 16.8(V) microns

esolution
RS170: 550 horizontal TV lines, 350 vertical TV lines
CCIR: 525 horizontal TV lines, 415 vertical TV lines

ensitivity (faceplate) @2850 K
0.4 lux at full video, AGC off
0.04 lux at 80% video, AGC on

ontrast Variation
<5% overall at gamma 1, gain 0 dB

lectronic Shutter
Switch selectable, 1/1,000 second, 1/2,000 second, and Off

ideo Output
1.0 V p-p @75 ohms, unbalanced

AGC
Switch selectable, Off/Low Gain/High Gain
Peak-average adjustable
Low Gain: 0 - 6 dB
High Gain: 0 - 20 dB

Auto Black
Maintain set-up level at 7.5 ±5 IRE units if picture contains at least 10% black

Signal-to-Noise Ratio
≥56 dB at gamma 1, gain 0 dB
38 dB at gamma 1, AGC On

Auto Lens
Separate lens video signal tracks AGC peak/average adjustment to eliminate AGC/auto lens interaction
Power: +15V, 35 mA maximum

Gamma
0.5 or 1.0 jumper selectable

Synchronization
Genlock, revert to crystal
Genlock, revert to phase adjustable line lock
External H & V Drive
Internal Clock Speeds
RS170: 14.31818 MHz
CCIR: 14.375 MHz

Power Requirements
4.2 watts dc

MECHANICAL

Dimensions (less lens)
Camera Head: 1.50" dia. x 2.00" length (38.1 x 50.8 mm)
Cable: 15 feet (4.57 meters)
CCU: 1.7"(H) x 5.0"(W) x 7.3"(D) (43.7 x 127 x 189 mm)

Weight
Camera Head (less lens and cable): 4 ounces (113 grams)
Remote Cable: 17 ounces (483 grams)
CCU: 29 ounces (822 grams)

Lens Mount
Adjustable "C" mount, 16mm format

Connectors
BNC connector — Video Out
Switchcraft TB4M — Lens Drive
Switchcraft TB3M — Power In
Hirose SR30-10R-7S — Auxiliarye

ENVIRONMENTAL

Ambient Temperature Limits
Operating: -10 to 50°C (14 to 122°F)
Storage: -30 to 70 °C (-22 to 157°F)

Humidity
Up to 95% relative humidity

Vibration
5 to 60 Hz with 0.082 inch total excusion (15 g's @ 60 Hz). From 60 to 1,000 Hz, 5 g's rms random vibration without damage.

Shock (less lens)
Remote head: Up to 30 g's.
CCU: Up to 15 g's in any axis under nonoperating conditions. MIL-E-5400T, paragraph 3.2.24.6

Altitude
Sea level to the equivalent of 3,000 meters or 10,000 feet (508mm/20 inches of mercury)

ORDERING INFORMATION

6X	1X	—	X	XXX	/	XXXX
Video Format	Power Options		Sync Options	Optical Filters		Lens Options

6X Video Format
RS-170 (EIA)
CCIR

1X Power Options
2 12V ac or dc
3 230V ac, 50 Hz, with ac wall adapter (CCIR models)
5 115V ac, 60 Hz, with ac wall adapter (RS-170 models)

X Sync Options
2 Genlock (revert to crystal)
3 Genlock (revert to phase adjustable line lock)
7 External H & V Drive (revert to crystal)

XXX Optical Filters
000 None
100 IR Filter (non-removable)

XXXX Lens Options

Manual Iris, C Mount
***AL04** 4.5mm, f/2.0, 2/3"
***AL08** 8mm, f/1.4, 2/3"
AL09 9mm, f/1.4, 2/3"
AL16 16mm, f/1.4, 2/3"
AL26 25mm, f/1.6, 2/3"
AL51 50mm, f/1.8, 2/3"
* Wide Angle

Auto Iris, C Mount
ES04 4.2mm, f/1.6, 1/2"
ES06 6mm, f/1.2, 1/2"
ES08 8mm, f/1.4, 2/3"
ES13 12mm, f/1.2, 1/2"
ES16 16mm, f/1.4, 2/3"
ES25 25mm, f/1.4, 1"
EH35 35mm, f/1.4, 2/3"*

NOTE: Auto iris lenses require auto iris cable assembly 8352-1, to be ordered separately.

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ted in U.S.A. 89-00/03/12.92) December 1992

Announcing the GP-KS152. Panasonic's New Digital Signal Processing Color CCD Micro Camera.

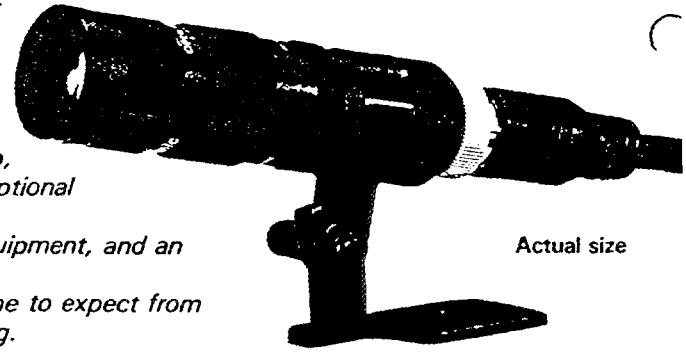
The GP-KS152's exceptionally small camera head measures only 0.66 inches in diameter and 1.5 inches in length. It is also ultra-light, weighing in at a low 0.04 lbs. It features a 336,000 pixel half inch CCD, with a horizontal resolution of 430 lines, and has outstanding resistance to vibration, shock, and magnetism.

The GP-KS152's Digital Signal Processing enables a wide variety of pre-programmed picture enhancement functions, which help deliver extremely accurate images-even in areas with low light (minimum illumination: 0.5 fc, 5 lux).

The GP-KS152 features an eight stage variable electronic shutter, with speeds ranging from 1/60th to 1/10,000th of a second for sharp, clear, images of fast moving objects. Also, there are a wide range of optional lens accessories to fit your specific needs.

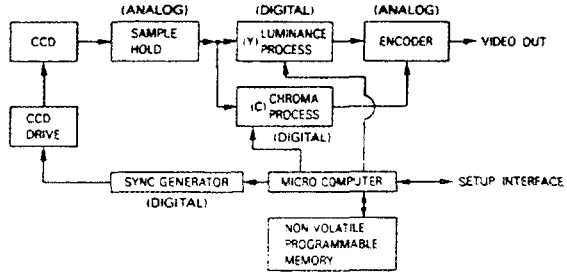
Other features include an output for direct connection to S-VHS equipment, and an interface for a charactor generator.

The GP-KS152 incorporates the outstanding technology you've come to expect from Panasonic; for use in industry, medicine, recording, and broadcasting.



Actual size

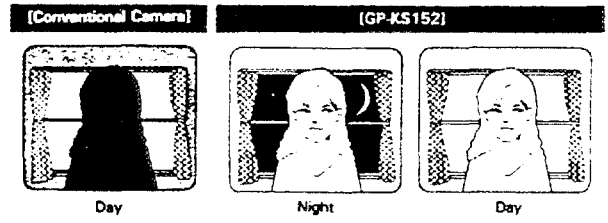
■ **Digital Signal Processing Diagram**



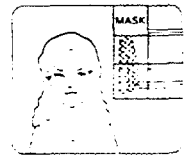
Quality Engineering Features

- 1/2-inch interline transfer CCD color image sensor with 682(H) × 492(V) pixels
- 430-line horizontal resolution
- 2H enhancer, aperture correction, knee circuitry, and minimize artificial camera noise for crisp, sharp pictures
- Minimum scene illumination of 0.5 fc (5 lux) (F 1.6 with AGC On)
- 46dB signal-to-noise ratio
- Selectable through-the-lens (TTL) auto-tracing white balance (ATW), auto white balance control (AWC) or manual white balance control
- Gen-Lock capability for multi-camera systems
  - •Color composite video signal (VBS)
  - •B/W composite video sync signal (VS)
  - •HD/VD signal
  - •VD signal
  - •Internal sync (INT)
- Eight-speed electronic shutter helps ensure clear images of rapidly moving subjects. Selectable speeds: 1/60-sec. (Off); 1/100-sec.; 1/250-sec.; 1/500-sec.; 1/1,000-sec.; 1/2,000-sec.; 1/4,000-sec. and 1/10,000-sec.
- Automatic Gain Control (AGC) On/Off and sensitivity up On/Off
- Auto backlight compensation equipped with a backlight compensation mode as part of the light control function

  Factory setup mode: Preset On; More photometric weight is given to the center of the screen than to the edges, where backlighting would most likely be located.

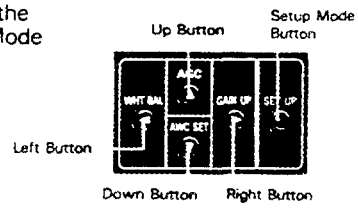


Manual field setup mode: Preset Off; With a GP-KS152 in Manual field setup mode, the picture is divided into 25 zones for mask areas. It is possible to mask out the spotlight and increase the rest of the scene's brightness.

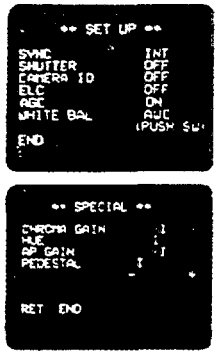


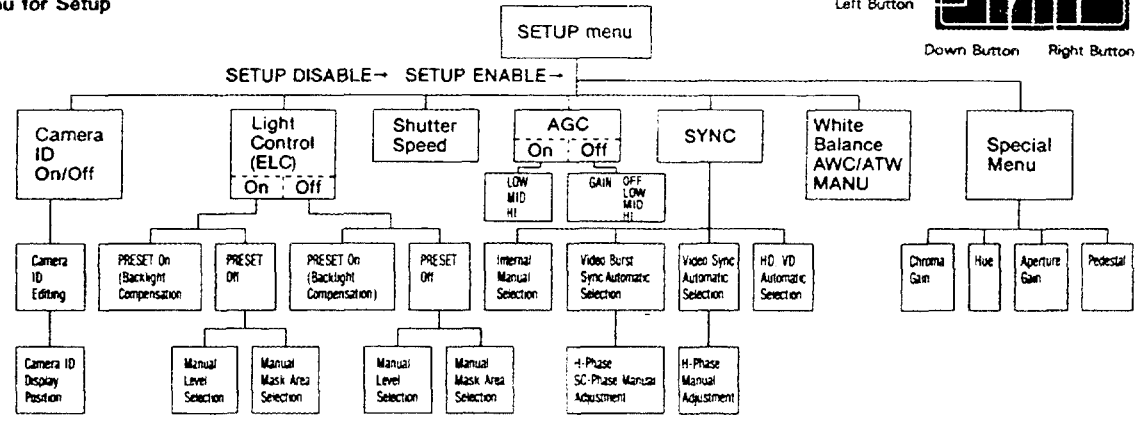
Night and Day

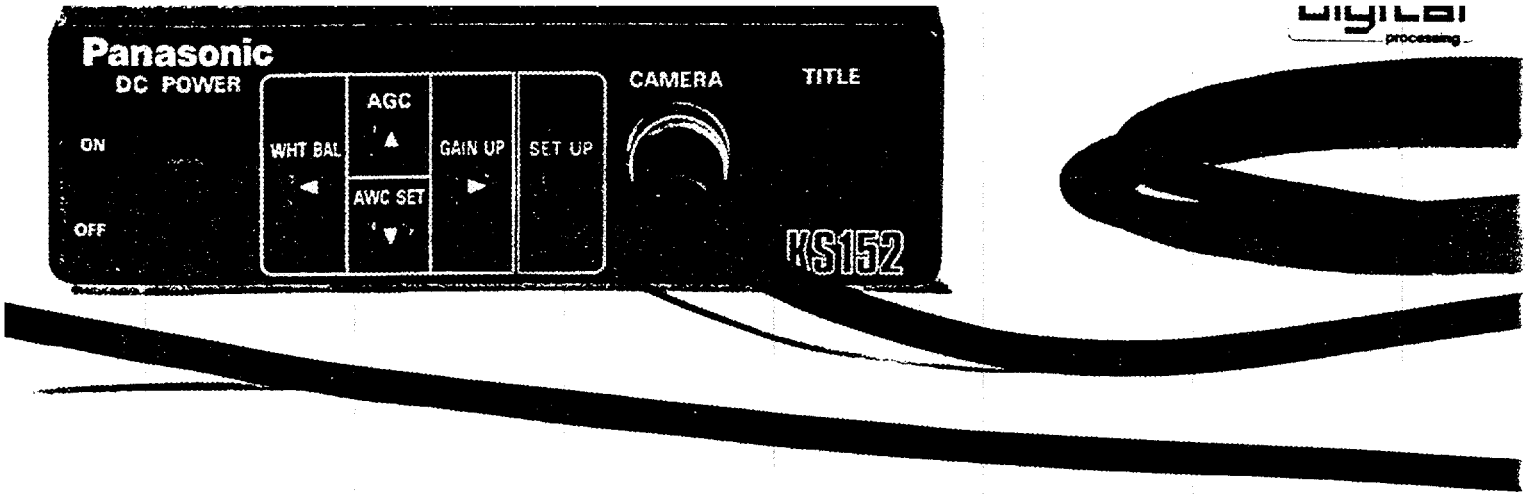
- **Advanced Electronic Light Control;** When the electronic light control (ELC) mode is engaged a variable electronic shutter automatically and continuously controls the exposure of incoming light to the CCD.
- S-VHS video output
- Accepts optional 3mm Super-Wide-Angle, 7.5mm Wide-Angle, 12mm Pinhole and 15mm/24mm Telephoto lenses
- Optional C-Mount Adaptor, GP-AD22T, is available for use with C-Mount lenses
- 12V DC operation
- Selectable function from the Direct Mode and Setup Mode



■ **On-Screen Menu for Setup**

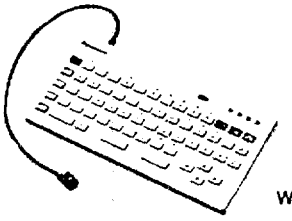






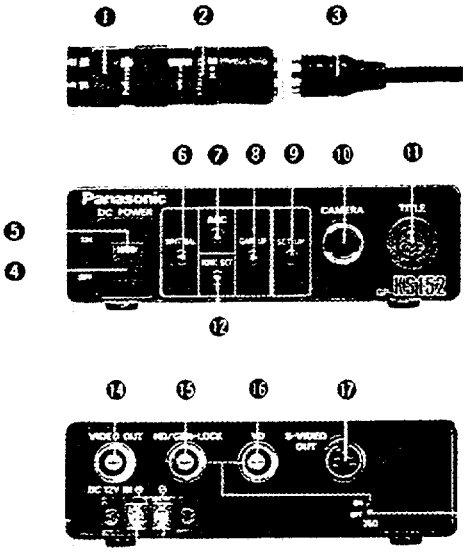
- Maximum cable length between camera head and camera control unit with optional Camera Cables:
  GP-CA56: 6.7 ft (2m), GP-CA57: 33 ft (10m)
- Video titles: Two optional keyboard-type Character Generators, the WV-KB12A and WJ-KB15 are available to enable quick, easy production of titles

WV-KB12A



WJ-KB15

Major Operating Controls



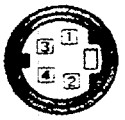
⑬

① Lens (Optional)
② Focus Lock Ring
③ Cable (Optional)
④ Power On/Off Switch
⑤ Power Indicator
⑥ White Balance Mode Selection Button
ATW: Auto Tracing White Balance Control
MANU: Manual White Balance Control
⑦ AGC Selection Button
OFF; LOW (+6dB); MID (+9dB); HI (+12dB)
⑧ Gain Selection Button
OFF; LOW (+6dB); MID (+9dB); HI (+12dB)
⑨ Setup Mode Button
⑩ Camera Cable Connector
⑪ Title Input Connector:
Optional Character Generator WV-KB12A or WJ-KB15
⑫ Auto White Balance Control Button
⑬ 12V DC Input Terminals
⑭ Video Output Connector (BNC)
⑮ Horizontal Drive/Gen-Lock Input Connector (BNC)
⑯ Vertical Drive Input Connector (BNC)
⑰ S-VHS Video Output Connector
⑱ Gen-Lock Termination Switches

⑩ **Camera Cable Connector** (female)

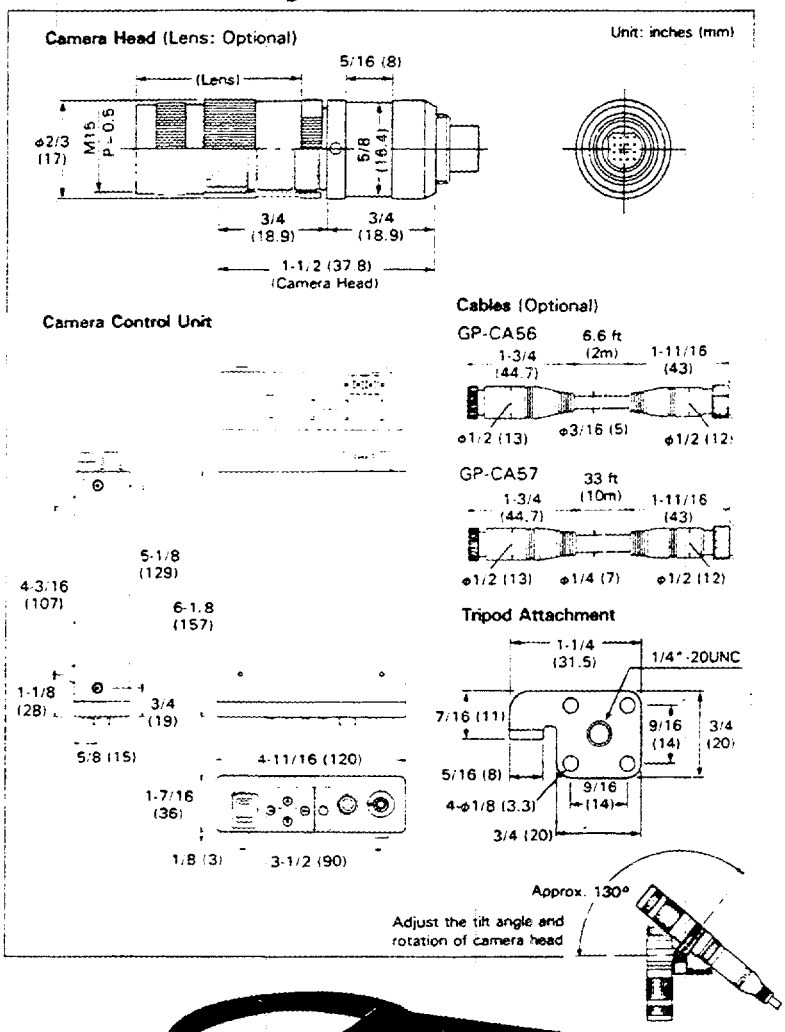
Pin No.	Function
1.	Not Used
2.	Shield (only GP-CA57)
3.	Not Used
4.	Reset
5.	CCD Out
6.	V1
7.	Signal Ground
8.	+15V
9.	−8V
10.	V2
11.	V3
12.	Ground
13.	V. Sub
14.	V4
15.	H2
16.	H1

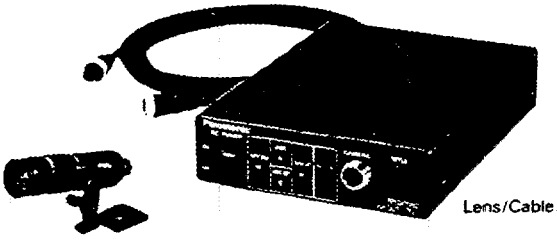
⑰ **S-Video** (female)



No.	CONTENTS
1	Y Ground
2	C Ground
3	Y Signal Output
4	C Signal Output

Dimensional Drawings





Lens/Cable: Optional

Pick-up Device	682 (H) × 492 (V) pixels, 1/2" Interline Transfer CCD
Scanning System	2:1 Interlace
Scanning **Horizontal:** **Vertical:**	525 lines/60 fields/30 frames 15.734kHz 59.94Hz
Horizontal Resolution	430 lines
Video Output	1.0Vp-p NTSC composite, 75 ohms/BNC connector
S/N Ratio	46dB (AGC Off)
Electronic Light Control	Equivalent to continuous variable shutter speed between 1/60-sec. and 1/15,700-sec.
Minimum Scene Illumination	0.5 fc (5 lux) at F1.6 (AGC On)
White Balance	AWC/ATW/MANU selectable
Backlight Compensation	Preset On (Factory setup) Preset Off (Manual setup at field) Photometry area is selectable (25 blocks) Signal level is adjustable
Sync. System	HD/VD/VBS/VS is selectable, H-PHASE adjustment in the VBS, VS, Gen-Lock, SC-PHASE adjustment in VBS, Gen-lock mode
Electronic Shutter Speed	Selectable 1/60 (Off); 1/100; 1/250; 1/500; 1/1,000; 1/2,000; 1/4,000; 1/10,000-sec.
AGC Control	OFF/LOW/MID/HI Selectable
Gain Control	LOW/MID/HI Selectable
Ambient Temperature	14°F – +104°F (–10°C – +40°C)
Power Source	12V DC, 500mA
Dimensions Camera Head (Excluding lens); Camera Control Unit (W × H × D);	2/3" × 1-1/2" (17mm × 37.8mm) 4-11/16" × 1-7/16" × 6-1/8" (120mm × 36mm × 157mm)
Weight Camera Head (Excluding lens); Camera Control Unit;	0.04 lbs (16 g) 1.6 lbs (730 g)
Standard Accessories	Tripod attachment.....1 pc. Lens cleaning paper .....1 sheet

Weight and dimensions indicated are approximate. Specifications subject to change without notice.
These products may be subject to export control regulations.

Cables

GP-CA56: 6.6 ft (2m)
GP-CA57: 33 ft (10m)

Super-Wide-Angle Lens

GP-LM3T

Wide-Angle Lens

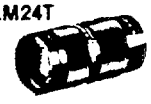
GP-LM7R5TA

Pinhole Lens

GP-LP12T

Telephoto Lenses

GP-LM15T
GP-LM24T



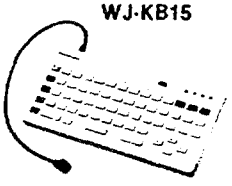
C-Mount Adaptor

GP-AD22T

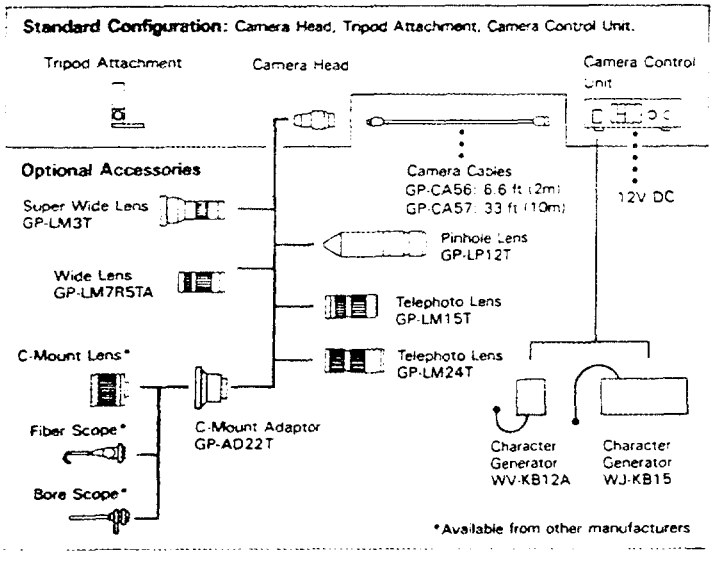
Character Generators

WV-KB12A

WJ-KB15



System Block Diagram



Applications

Industrial
- Sensor for checking completed printed circuit boards
- Internal inspection of engines and precision machinery
- Visual sensor for factory robots, etc.

Medical
- Microscopic camera observation of microorganisms and bacteria
- Use as an endoscopic camera, eyepiece etc.

Scientific
- Time-lapse observation and surveillance of experiments

Educational
- Monitor display of teaching materials, etc.

Special Applications
- Peripheral supervision of production machinery and factory robots
- Filming and observation of hazardous areas from the air via radio-controlled helicopter

Other Applications
- Sporting events and other broadcast applications
- Assistance with installation and maintenance of machinery

Panasonic

Broadcast & Television Systems Company

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VSD3025 (04132.1) (20K)

Printed in Japan
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The Panasonic
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he Industrial Camera Division (ICD)
with Original Equipment Manufacturers. ICD
ur firm has unique requirements, which are
of many other video users. We're prepared
out together a program that will meet those
s.

ong engineering support for our product line.
mechanical specs for our customers'

also have in-house engineering capabilities.

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formation not only on the current product line,
oducts and enhancements. We'll work as a
product planning and marketing group to help
neet its future needs.

an aggressive credit department that
OEM environment, and is structured to
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nt of Products:

is that your firm knows more about its market
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nents these manufacturers have targeted.

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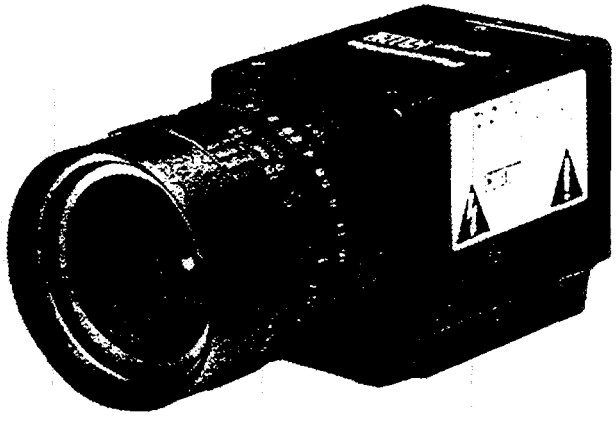
GP-MF502

Industrial CCD B/W Camera



The Panasonic GP-MF502 is a high resolution, small sized black and white camera. All functions are selectable by a mechanical switch.

Pick-up Device:	2/3" Interline transfer CCD. 768(H) x 493(V)
Scanning:	2:1 Interlace
Synchronization:	Internal or External (Automatic); Internal: Built-in sync generator; HD, VD output ON/OFF External: HD, VD 75 ohm ON/OFF Interlace or Non-interlace
Horizontal Resolution:	570 lines
Vertical Resolution:	485 line (Frame integration) 380 lines (Field integration)
Sensor Gate Control:	Sensor Gate Control Function for asynchronous strobe light application or long time exposure.
Signal-to-Noise Ratio:	59dB (typ. AGC OFF, Gain 0dB)
Gain Control:	AGC Off or On (+9dB) Gain-up Off or ON (+6dB)
Gamma Correction:	Off or On
Standard Illumination:	50fc (500 lux) at f 5.6
Minimum Illumination:	1.0 lux at f 1.4
Shutter:	1/60, 1/125, 1/250, 1/500, 1/1000, 1/2000, 1/4000, 1/10000 sec
Vibration Resistance:	8G (10Hz - 150Hz) IEC 68-2-6
Shock Resistance:	80G IEC 68-2-7
Ambient Temperature:	+14°F to +122°F (-10°C to +50°C)
Lens Mount:	C-Mount
Power:	+12V DC, 250 mA
Dimensions (WxHxD):	1-5/8" x 1-5/8" x 3-1/8"
Weight:	0.46 lbs. (210g)

Standard Accessories:

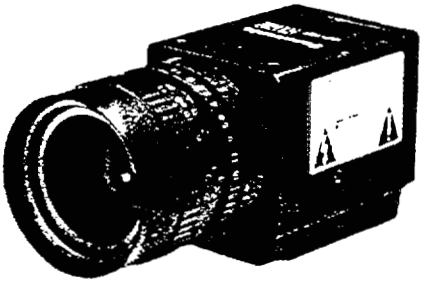
- Hexa-Wrench for flangeback adjustment ring
- Tripod Mounting Adaptor

Optional Accessories:

• GP-CA33	15' Camera cable (12pin - 12pin)
• GP-CA34	15' Camera cable (12pin - BNCx3)
• GP-CA39	30' Camera cable (12pin - 12pin)
• GP-CA59	15' Camera cable (12pin - BNCx1)
• GP-CA60	15' Camera cable (12pin - BNCx5)

GP-MF552

Industrial CCD B/W Camera



The Panasonic GP-MF552 is a high resolution, high sensitivity, small sized black and white camera. Vertical Drive Reset function and asynchronous electronic shutter are for high speed vision inspection.

All functions are selectable by a mechanical switch.

Pick-up Device:	2/3" Interline transfer CCD, 768(H) x 493(V)
Scanning:	2:1 Interlace Frame/Field Integration selectable
Synchronization:	Internal or External (Automatic); Internal: Built-in sync generator; HD, VD output ON/OFF External: HD, VD 75 ohm ON/OFF Interlace or Non-interlace
Horizontal Resolution:	570 lines
Vertical Resolution:	485 line (Frame integration) 380 lines (Field integration)
Async VD Reset:	Used with the electronic shutter or strobe light.
Sensor Gate Control:	Sensor Gate Control Function for asynchronous strobe light application or long time exposure.
Signal-to Noise Ratio:	59 dB (typ. AGC OFF, Gain 0dB)
Gain Control:	AGC Off or On (+9dB) Gain-up Off or ON (+6dB)
Gamma Correction:	Off or On
Standard Illumination:	25 fc (250 lux) at f 5.6
Minimum Illumination:	0.05 fc (0.5 lux) at f 1.4
Shutter (Normal):	1/60, 1/125, 1/250, 1/500, 1/1000, 1/2000, 1/4000, 1/10000 sec
Shutter (Trigger):	1/2000, 1/4000, 1/10000 sec.
Vibration Resistance:	8G (10Hz - 150Hz) IEC 68-2-6
Shock Resistance:	80G IEC 68-2-7
Ambient Temperature:	+14°F to +122°F (-10°C to +50°C)
Lens Mount:	C-Mount
Power:	+12V DC, 250 mA
Dimensions (WxHxD):	1-5/8" x 1-5/8" x 3-1/8"
Weight:	0.46 lbs. (210g)

Standard Accessories:

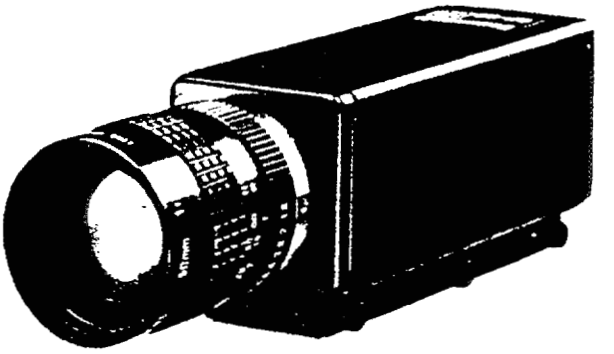
- Hexa-Wrench for flangeback adjustment ring
- Tripod Mounting Adaptor

Optional Accessories:

- GP-CA33 15' Camera cable (12pin - 12pin)
- GP-CA34 15' Camera cable (12pin - BNCx3)
- GP-CA39 30' Camera cable (12pin - 12pin)
- GP-CA59 15' Camera cable (12pin - BNCx1)
- GP-CA60 15' Camera cable (12pin - BNCx5)

GP-MF702

Industrial CCD B/W Camera



The Panasonic GP-MF702 is a black and white machine vision camera featuring an MOS chip with square pixels (pixel clock in/out). Its flexible scanning mode, VD reset and Read-out-Inhibit are for high speed vision system.

Pick-up Device:	2/3" Transversal signal-line MOS 316,000 pixels, 649(H) x 491(V)
Pixel Size:	13.5 μm x 13.5 μm
Scanning:	2:1 Interlace (Frame/Field Integration) Full-line Non-interlace Non-interlace field integration
Synchronization:	Internal or External (Automatic); Internal: Built-in sync generator; HD, VD output ON/OFF External: HD, VD 75 ohm ON/OFF Interlace or Non-interlace (up to 400 frame/sec)
Horizontal Resolution:	450 lines
Vertical Resolution:	485 lines (Interlace frame integration) 490 lines (Full-line Non-interlace) 242 lines (Non-interlace field integration)
Async VD Reset:	Used with the strobe light.
Read out Inhibit:	Asynchronous read out control
Pixel Clock:	12/14MHz Pixel Clock In or Out
Signal-to-Noise Ratio:	46dB (Gain 0dB)
Gain Control:	Manual: -6dB, 0dB, +3dB, +6dB
Gamma Correction:	Off or On
Standard Illumination:	250 fc (2500 lux) at f 8
Minimum Illumination:	5 lux at f 1.4, +6dB
Vibration Resistance:	7G (10Hz - 150Hz) IEC 68-2-6
Shock Resistance:	80G IEC 68-2-7
Ambient Temperature:	+14°F to +122°F (-10°C to +50°C)
Lens Mount:	C-Mount
Power:	+12V DC, 500mA
Dimensions (WxHxD):	1-3/4" x 1-3/4" x 4-11/16"
Weight:	0.73 lbs. (330g)

Standard Accessories:

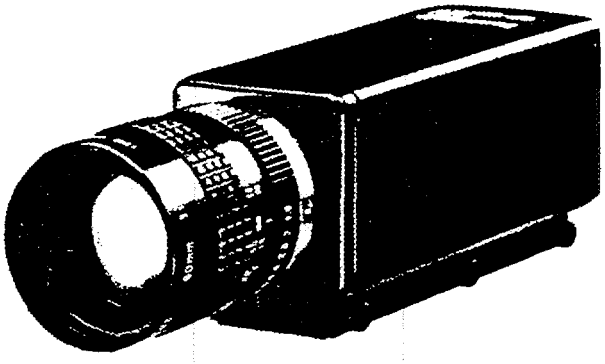
- Mounting Band and Hexa Wrench
- Hexa-Wrench for flangeback adjustment ring

Optional Accessories:

- GP-CA33 15' Camera cable (12pin - 12pin)
- GP-CA34 15' Camera cable (12pin - BNCx3)
- GP-CA39 30' Camera cable (12pin - 12pin)
- GP-CA59 15' Camera cable (12pin - BNCx1)
- GP-CA60 15' Camera cable (12pin - BNCx5)

GP-MF702D

Industrial CCD B/W Camera



The Panasonic GP-MF702D is a black and white machine vision camera featuring a MOS chip with square pixels. Its double speed scanning mode (frequency of HD is 31.5kHz), VD reset and Read Out Inhibit are for high speed vision system.

Pick-up Device:	2/3" Transversal signal-line MOS 316,000 pixels, 649(H) x 491(V)
Pixel Size:	13.5 μm x 13.5 μm
Scanning:	(Double speed mode only) 2:1 Interlace Frame Integration Full-line Non-interlace (60-frame sec)
Synchronization:	Internal or External (Automatic); Internal: Built-in sync generator; HD, VD output ON OFF External: HD, VD 75 ohm ON OFF Interlace or Non-interlace (up to 800 frame sec)
Horizontal Resolution:	420 lines
Vertical Resolution:	485 lines
Async VD Reset:	Used with the strobe light.
Read out Inhibit:	Asynchronous read out control
Gain Control:	Manual: -6dB, 0dB
Gamma Correction:	Off or On
Standard Illumination:	100fc (1000 lux) at f 8
Minimum Illumination:	10 lux at f 1.4 (0 dB)
Vibration Resistance:	7G (10Hz - 150Hz) IEC 68-2-6
Shock Resistance:	80G IEC 68-2-7
Ambient Temperature:	+14°F to +122°F (-10°C to +50°C)
Lens Mount:	C-Mount
Power:	+12V DC, 500mA
Dimensions (WxHxD):	1-3/4" x 1-3/4" x 4-11/16"
Weight:	0.73 lbs. (330g)

Standard Accessories:

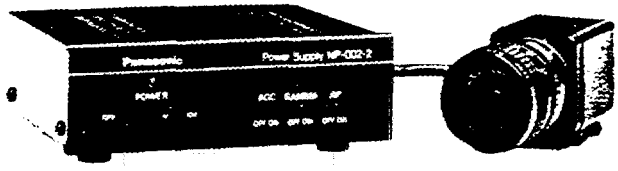
- Mounting Band and Hexa Wrench
- Hexa-Wrench for flangeback adjustment ring

Optional Accessories:

- GP-CA33 15' Camera cable (12pin - 12pin)
- GP-CA34 15' Camera cable (12pin - BNCx3)
- GP-CA39 30' Camera cable (12pin - 12pin)
- GP-CA59 15' Camera cable (12pin - BNCx1)
- GP-CA60 15' Camera cable (12pin - BNCx5)

GP-MF200

Industrial CCD B/W Camera



The Panasonic GP-MF200 is a high-resolution, remote head, black-and-white camera. The small remote head provides strong advantages in physical placement and positioning capabilities of the camera for all types of inspection and other factory automation applications.

Pick-up Device:	2/3" Interline transfer CCD, 768(H) x 493(V) pixels
Scanning:	2:1 Interlace
Synchronization:	Internal or External (Automatic): Internal: Built-in sync generator External: 4.0V p-p, 75 ohms, HD and VD
Horizontal Resolution:	570 lines
Vertical Resolution:	485 lines
Signal-to-Noise Ratio:	50dB with AGC and Gamma Off
Gain Control:	AGC Off or On (+9dB)
Standard Illumination:	100 fc (1,000 lux) at f5.6
Minimum Illumination:	2 lux at f1.4, AGC On, IR Cut Filter
Vibration Resistance:	8G (10.5Hz - 150Hz) IEC 68-2-6
Shock Resistance:	80G IEC 68-2-6
Ambient Temperature:	+14°F to +122°F (-10°C to +50C)
Power:	120V AC, 60Hz
Dimensions (WxHxD):	1-5/8" x 1-5/8" x 2-3/16"
Head Weight:	1.5 lbs. (450g; includes Mount Band)

Standard Accessories:

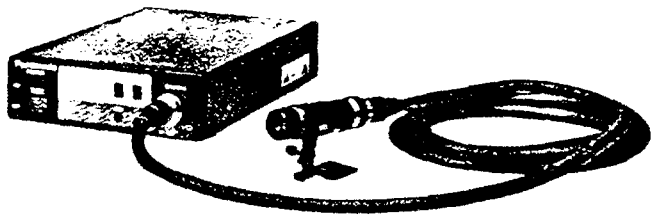
- C-Mount Adaptor
- Mounting Band and Hexa-Wrench

Optional Accessories

- GP-CA42 33' Camera Extension Cable
- WV-CS15 15' Camera Extension Cable
- WV-CS30 30' Camera Extension Cable

GP-MS112

CCD B/W Microcamera



The Panasonic GP-MS112 Remote-Head, Black-and-White Microcamera overcomes space limitations that have complicated many video applications. The GP-MS112 features a detachable head, with up to 30 meters of cable length available between the camera head and the CCU.

Pick-up Device:	1/2" Interline transfer CCD, 682(H) x 485(V) pixels
Scanning:	2:1 interlace
Synchronization:	Internal or External (VS, HD-VD, Genlock)
Horizontal Resolution:	500 lines
Signal-to-Noise Ratio:	50dB with AGC Off
Gain Control:	AGC Off or On (+9dB); Manual Gain: 0dB, +6dB
Minimum Illumination:	0.05fc (0.5 lux) at f1.4, 2,856°K
Lens Mount:	Special mount (C-Mount Adaptor available)
Connectors:	12-pin camera cable connector and composite Video Out (BNC)
Shock Resistance:	80G IEC 68-2-27
Ambient Temperature:	+14°F to +104°F (-10°C to +40°C)
Power:	+12V DC, 6W
Head Dimensions (Approx.):	2/3" Diameter x 1-7/16" Length (17 x 51.9mm)
Head Weight:	0.04 lbs. (16 g)

Optional Accessories:
Lenses: GP-LM3T, 3mm Wide-Angle; GP-LP12T, Pinhole; GP-LM7R5TA, 7.5mm Wide-Angle; GP-LM15T, 15mm Telephoto; GP-LM24T, 24mm Telephoto; plus GP-AD22T, C-Mount Adaptor

Cables: GP-CA44, 2m Cable; GP-CA45, 5m Cable; GP-CA48, 10m Cable; GP-CA49, 30m Cable

GP-KR212

Industrial CCD Color Camera

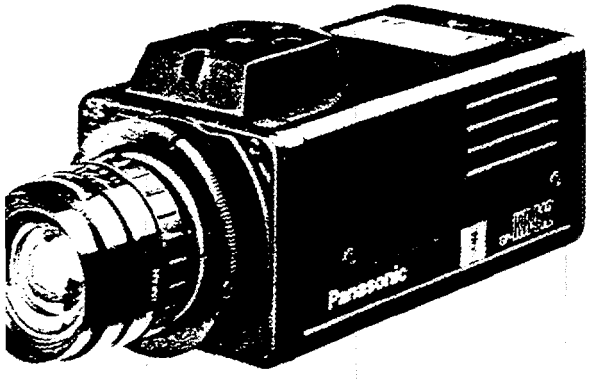
The Panasonic GP-KR212 Digital Signal Processing Circuitry enables high picture quality on advance functions. A microlens on each pixel triples the intensity of incoming light the image sensor receives. The 2H Enhancer operative correction and knee circuitry minimizes artificial camera noise for crisp sharp pictures.

Pick-up Device:	1/2" interline transfer CCD with 682 (H) by 492 (V)
Scanning:	2:1 interlace
Synchronization:	Internal
Horizontal Resolution:	430 lines
Signal-to-Noise Ratio:	46dB (AGC Off)
Gain Control:	AGC On (14dB)
Minimum Illumination:	0.3 fc (3 lux) at f1.4 (AGC On)
White Balance:	ATW/Lock
BLC: Back Light Compensation	On/Off
ELC: Electronic Light Control	Off/On (1/60 sec. ~ 1/15,000 sec shutter control)
Lens Mount:	C-Mount
Connectors:	12-pin camera cable connector and composite Video Out (BNC)
Ambient Temperature:	14 F ~ +122 F (-10 C ~ +50 C)
Power:	12V DC
Head Dimensions:	2-7/8" (W) x 2-5/16" (H) x 4-5/8" (D)
Weight:	0.82 lbs. (without lens)

Optional Accessories:
Cables: GP-CA34; GP-CA59

GP-KR412

ndustrial CCD Color Camera

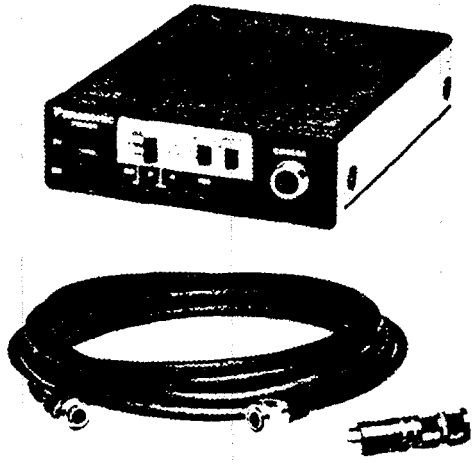


The Panasonic GP-KR412 Digital Signal Processing Circuitry DSP) enables a wide variety of pre-programmed picture enhancement functions which help deliver extremely accurate mages. Plus an Electronic Light Control (ELC), 2H Enhancer operative correction and knee circuitry minimizes artificial camera noise for crisp sharp pictures.

Pick-up Device:	½" interline transfer CCD with 682 (H) by 492 (V)
Scanning:	2:1 interlace
Synchronization:	Internal and Gen-lock w/H-Phase and SC-Phase adjust
Horizontal Resolution:	430 lines
Signal-to-Noise Ratio:	48dB (AGC Off)
Gain Control:	LOW/MID/HI selectable
Minimum Illumination:	0.3 fc (3 lux) at f1.4 (AGC On)
White Balance:	ATW/AWC/Manual
BLC: Back Light Compensation	Off/On (Preset, Manual)
ELC: Electronic Light Control	Off/On (1/60 sec. ~ 1/15,700 sec shutter control)
Lens Mount:	C-Mount or CS-Mount
Connectors:	12-pin camera cable connector Composite Video Out (BNC) Gen-Lock Input (BNC)
Ambient Temperature:	14 F ~ +122 F (-10 C ~ +50 C)
Power:	12V DC
Head Dimensions:	2¾" (W) x 2¾" (H) x 5½" (D)
Weight:	1.25 lbs. (without lens)

GP-KS102

Remote-Head CCD Color Microcamera



The Panasonic GP-KS102 Remote-Head CCD Color Microcamera simplifies many video applications with its detachable head, S-VHS (Y/C separate) output, and up to 30 meters of (optional) cable available between the camera head and the CCU.

Pick-up Device:	1/2" Integrated color filter interline transfer CCD, 682(H) x 485(V) pixels
Scanning:	2:1 Interlace
Synchronization:	Internal or External (VBS, HD-VD, Genlock)
Horizontal Resolution:	430 lines
Video Output:	Composite video or Y/C Out for S-VHS
Signal-to-Noise Ratio:	46dB with AGC Off
Gain Control:	AGC Off or On (+9dB); Manual Gain: 0dB, +6dB
Minimum Illumination:	1.5fc (15 lux) at f1.6, AGC On, 3,200°K
White Balance:	Auto-Tracing White Balance or
(TTL) Through-the-Lens	Auto White Balance Setting or Manual
Lens Mount:	Special mount (C-Mount Adaptor available)
Connectors:	Y/C video output (4-pin), 12-pin camera cable connector and composite video output (BNC)
Ambient Temperature:	+14°F to +104°F (-10°C to +40°C)
Power:	+12V DC, 6W
Head Dimensions:	2/3" Diameter x 1-7/16" Length
Head Weight:	0.04 lbs. (16 g)

Optional Accessories:

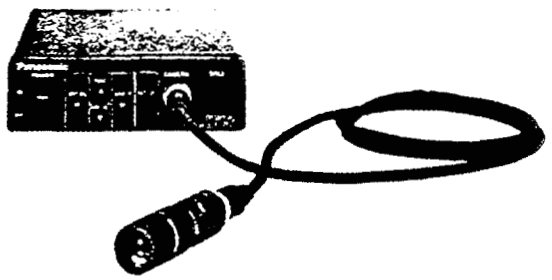
Lenses: GP-LM3T, 3mm Wide-Angle; GP-LP12T, Pinhole; GP-LM 7R5TA, 7.5mm Wide-Angle; GP-LM15T, 15mm Telephoto; GP-LM24T, 24mm Telephoto; plus GP-AD22T, C-Mount Adaptor

Cables: GP-CA44, 2m Cable; GP-CA45, 5m Cable; GP-CA48, 10m Cable; GP-CA49, 30m Cable

Note: PAL system version available with different specifications/format.

GP-KS152

Remote-Head CCD Digital Color Microcamera



The Panasonic GP-KS152 is a highly sensitive remote-head CCD color microcamera. Its digital signal processing (DSP) enables many pre-programmed functions such as electronic light control (ELC) and back light compensation (BLC), with other features that include S-VHS (Y/C separate) output, Auto-Tracing White Balance, gain control and built-in character generator.

Pick-up Device	1/2" Integrated color filter interline transfer CCD, 682(H) x 485(V) pixels
Scanning:	2:1 Interlace
Synchronization:	Internal or External (VBS, VS, HD.VD)
Horizontal Resolution:	430 lines
Video Output:	Composite video or Y C out for S-VHS
Signal-to-Noise Ratio:	46dB with AGC Off
ELC: Electronic Light Control:	Auto sensitivity control by electronic shutter (1 60sec - 1/15,700sec)
Gain Control:	AGC Off or On (+6dB,+9dB,+12dB) Manual Gain: 0dB,+6dB,+9dB,+12dB
BLC: Black Light Compensation:	Photometric measuring area set for ELC and AGC Preset: Priority at center Manual: 25 Block setting
Electronic Shutter:	1/100, 1/250, 1/500, 1 1,000, 1/2,000, 1/4,000, 1/10,000 sec
Camera ID:	MAX 16 characters
Minimum Illumination:	0.5fc (5 lux) at f1.6, AGC On, (+12dB), 3200K
White Balance: (TTL) Through-the-Lens	Auto-Tracing White Balance or Auto White Balance Setting or Manual
Special Adjustment:	Chroma gain, Hue, Aperture gain, Pedestal
Lens Mount:	Special mount (C-Mount Adaptor available)
Connectors:	Character generator input, 16-pin camera cable connector, Composite video output (BNC), Y/C output, and HD,VD input (BNC)
Ambient Temperature:	+14°F to +122°F (-10°C to +50°C)
Power:	+12V DC, 500mA
Head Dimensions:	2/3" Diameter x 1-1/2" Length
Head Weight:	0.04 lbs. (16g)

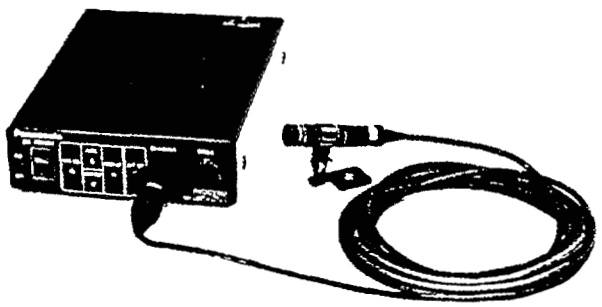
Optional Accessories: **Lens:** See GP-KS102

Cables: GP-CA56, 2m Cable; GP-CA57, 10m Cable

Character Generators: WJ-KB15, WJ-KB50

GP-KS252

1/3" CCD Color Micro Camera



Panasonic's digital signal processing 1/3" CCD Color Microcamera. (Pal System Version also available)

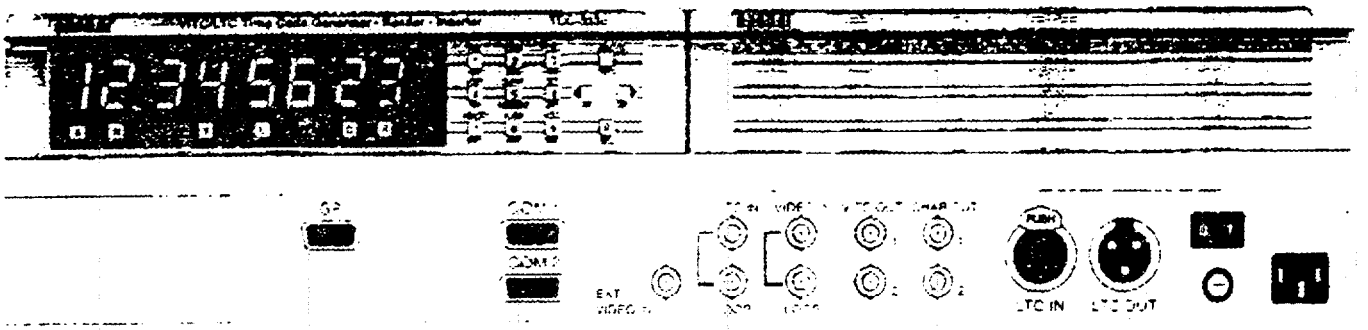
Pick-up Device:	682 (H) x 492 (V) pixels, 1/3" Interline Transfer CCD
Scanning System:	2:1 Interlace
Scanning:	525 lines/60 fields/30 frames Horizontal: 15.734kHz, Vertical: 59.94Hz
Horizontal Resolution:	430 lines
Video Output:	1.0Vp-p composite, 75-ohms BNC connector Y: 1.0Vp-p 75-ohm, C: 0.286Vp-p 75-ohm (S-Video)
S/N Ratio:	46dB (AGC Off)
Electronic Light Control:	Equivalent to continuous variable shutter speed between 1 60-sec. and 1/15,700-sec.
Minimum Scane Illumination:	1.5 fc (15 lux) at F1.6 (AGC On)
White Balance:	AWC/ATW/MANU selectable
Backlight Compensation:	Preset On (Factory setup), Preset Off (Manual setup at field), Photometry area is selectable (25 blocks), Signal level is adjustable
Sync. System:	HD/VD/VBS/VS is selectable, H-PHASE adjustment in the VBS, VS, Gen-Lock, SC-PHASE adjustment in VBS, Gen-lock mode
Electronic Shutter Speed:	Selectable 1/60 (Off); 1/100; 1/250; 1/500; 1/1,000; 1/2,000; 1/4,000; 1/10,000-sec.
AGC Control:	OFF/LOW/MID/HI Selectable
Gain Control:	LOW/MID/HI Selectable
Ambient Temperature:	14°F + 104°F (-10°C + 40°C)
Power Source:	12V DC, 500mA
Dimensions:	Camera Head (Excluding lens); 1/2" x 1-3/8" (12mm x 35mm) Camera Control Unit (WxHxD); 4-3/4" x 1-7/16" x 5-15/16" (120mm x 36mm x 151mm)
Weight:	Camera Head (Excluding lens); 0.01 lbs. (7g) Camera Control Unit; 1.6 lbs. (730g)

Optional Accessories: **Lens:** GP-LM6R3T

Character Generators: WJ-KB15, WJ-KB50

GP-KS252 (Camera cable: 2m)

GP-KS252S (Camera cable: 3m)



TCG-333c

GENERATOR FEATURES

The full featured TCG-300 series include independent Time Code Generators, Readers and Character Inserters. Time Address and User Bits may be independently jammed to the reader input. A unique feature, Cross Jam, slaves the Time Address to the User Bits and vice versa. The generator-readers can do standards conversion between differing frame rates and also translate between VITC and LTC formats. Versions are available with a RS232/RS422 computer interface that enables data to be transmitted to other equipment.

FEATURES:

- Combination Generator, Reader & Inserter
- Dual standard PAL, NTSC
- Generates 25, 30 & 30 Drop Frame codes
- Reader and Generator functions independent
- Time Code Standards Conversion
- Time Code Translation.
- Jam/Slave and Cross Jam
- Selectable Jam Offset and Error Bypass
- Color Field Identification
- Full User Bit access.
- Time Address & User Bits pass-thru
- Video, Power Line or Crystal time base reference
- VITC Insertion & Blanking lines selectable.
- Wide band LTC reading from 1/40 to 80 times play speed
- VITC Reading from Pause to ± 50 times play
- Look ahead reading compensation of active User Bits
- Simultaneous video display of both Time Address & User Bits
- Time and User windows position control.
- Character heights of 16, 32 or 64 lines
- Front panel setup of all system parameters

SPECIFICATIONS:

- LTC Time Code Input: SMPTE/EBU Standards
  - Speed Range: 1/40 to 80 times play speed
  - Level: 100 mVp-p to 10 Vp-p
  - Impedance: Hi-Z bridging 600 Ω balanced/unbalanced
- LTC Time Code Output: Generator or Reader/Inserter output
  - Impedance: Lo-Z source 600 Ω balanced/unbalanced
  - Level: 0.5 to 5 Vp-p
  - Rise time: Auto selected according to frame rate
- VITC Input: Loop-through, bridging 75 Ω BNC
  - Speed Range: Pause to ± 50 times play speed
- VITC Output: Dual, 75 Ω source, BNC
  - (VITC inserted into Reference Video)
- Video Input: Generator reference
  - Loop-through, bridging 75 Ω BNC
- Character Inserter Input: Internal VITC output
  - External Video input
- External Video Input: 75 Ω terminated, BNC
- Character Inserter Output: Dual, 75 Ω source, BNC
- COM1: RS-232/RS-422 serial I/O DB-9S
- COM2: RS-232/RS-422 serial I/O DB-9S
- GPI Interface: General Discrete I/O DB-9S
  - Open Collector output +5VDC pull-up
  - Contact closure input Common GND
- Power: 115/230 VAC, 50/60 Hz 20 VA Max
- Dimensions: TCG-311 & TCG-313
  - 1/2 RU wide X 12 (305mm) deep
  - TCG-333 & TCG-333c
  - 1 RU wide X 12 (305mm) deep
- Protected by U.S. Patent 4,970,602

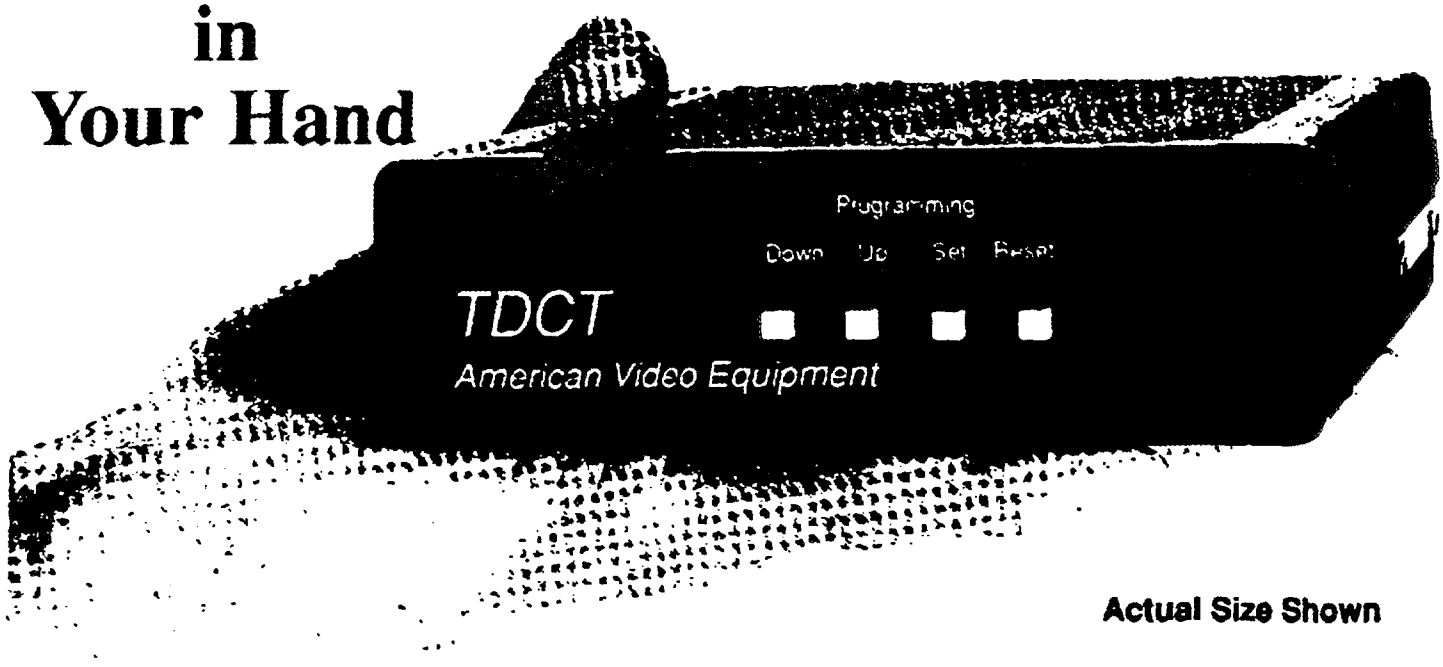
ORDERING INFORMATION:

TCG-311	LTC Generator/Reader
TCG-311c	LTC Generator/Reader with serial data I/O
TCG-313	LTC Generator/Reader/Inserter
TCG-313c	LTC Generator/Reader/Inserter with serial data I/O
TCG-333	VITC/LTC Generator/Reader/Inserter
TCG-333c	VITC/LTC Generator/Reader/Inserter with serial data I/O
RMK-TE	Rack mount kit for one 1/2 RU unit on the left
RMK-2	Rack mount kit for two 1/2 RU units
RMK-1W	Rack mount kit for one 1 RU unit

FILM TO VIDEO TRANSFER

The Film to Video Transfer series contain all of the features and versatility of the Readers and Generators. A Film to Tape transfer session is documented by a character inserter display of Time and Keykode, the full Keykode multiplexed into User Bits and data output in FLEX format for computer logging. The information obtained, consisting of a Video Time Address and film data in the User Bits is fully compatible with video editing systems. The full film Keykode number, frame offset and pull-down sequence may be multiplexed into the User Bits using a SMPTE standard format. Field rate precision is achieved by a method which is compatible with both LTC and VITC Time Code formats. Readers are available to demultiplex Keykode from the User Bits or to synchronize film footage referenced to Time Address.

Put the Power of Time in Your Hand



Actual Size Shown

When You Demand

- ❑ **Time - Day - Date**
- ❑ **40 Characters Camera Title**
- ❑ **Digital Programming**
- ❑ **Digital Color Selection**
- ❑ **12 VDC Operation**
- ❑ **Ultra Slim Case**
- ❑ **Low Power Circuitry**

Choose the

TDCT

Time & Date Camera Titler

by

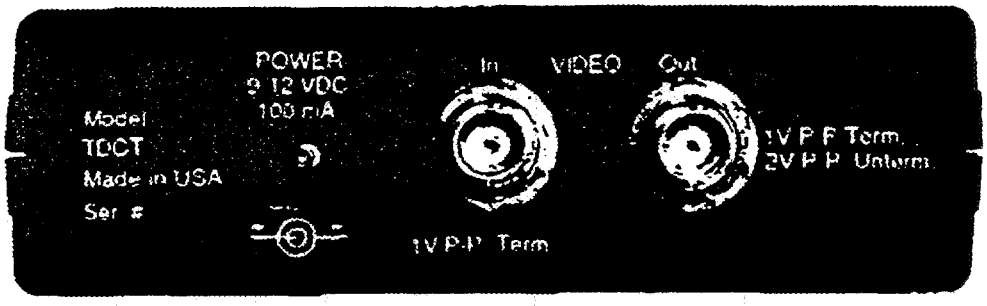
American Video Equipment

A Division of Trans American Int'l Inc.

Made in U.S.A.

The TDCT, a VLSI digital design for the highest reliability and quality offered today in a Time & Date Camera Titling generator. All selections are set through interactive on-screen programming. The low power CMOS circuitry offters a full 90 days of rechargeable battery backup. Digital programming includes character color from white to black, full screen positioning, Time & Date only or Title only or both, and a jumper selectable gray matte border. For those remote site applications, the TDCT-PCB can usually operate from the cameras' power and mount directly with a common video camera. The compact size allows a minimum amount of space for those extra tight installations. For mutiple unit installation, use the convenient rack mount kit for up to 16 Time & Date Camera Titlers in one attractive card cage.

Offered by

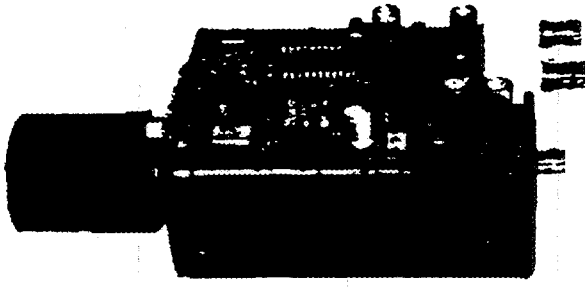


Specifications

Video Input (BNC).....1V P-P Terminated
Video Output (BNC).....1V P-P Terminated
2V P-P Unterminated
Power (DC Coax).....9-12 VDC
2.1mm x 5.5mm.....130 mA
Battery Backup (NiCad).....90 Days
with 24 hr. charge
Mechanical.....High Impact Plastic Case
(5.1"W x 5.7"L x 1.6"H)
PCB (3.3"W x 4.3"L x .6"H)
Clock Accuracy.....better than +/- 20 ppm

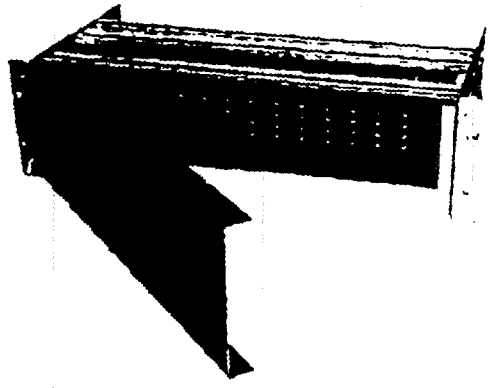
Date.....Month - Day - Year Day of Week
Time.....Hours : Minutes : Seconds AM/PM
Title.....2 lines of 20 characters max.
A-Z, 0-9,?,!,', . , (blank)
Display.....White to black (8 levels)
Gray Matte (jumper selectable)
T/D Only or Title Only or both
Transformer.....9 VDC @ 250 mA min.
UL Rated with 6' cord & plug
Warranty.....One Year Parts and Labor
Video S/N.....better than 52 dB
Video BW.....better than 7 Mhz

Models For All Applications



Options

- ❑ Camera Titler Only
- ❑ 24 VAC Power
- ❑ +/-5 ppm Clock



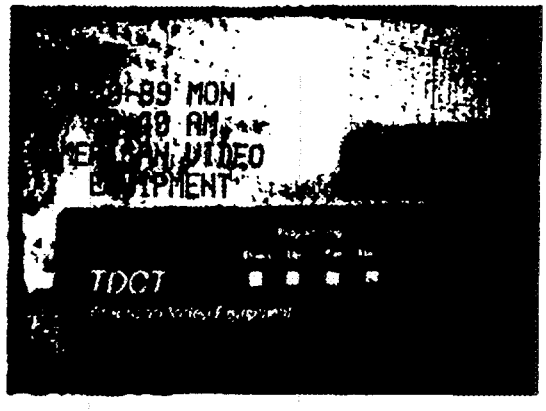
❑ Circuit Board Only

❑ 16 Card Rack Mount Kit

American Video Equipment

1906 Treble Drive
Humble, Texas 77338
Tel: 713-446-6077
Fax: 713-446-6087

Typical Display



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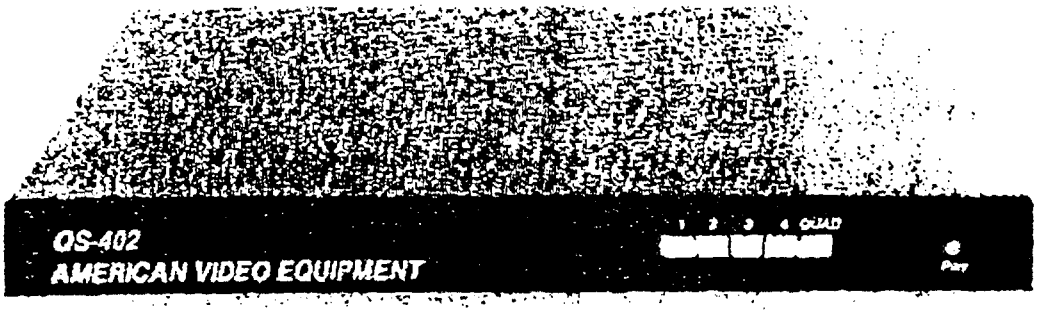
All Specifications Subject to Change

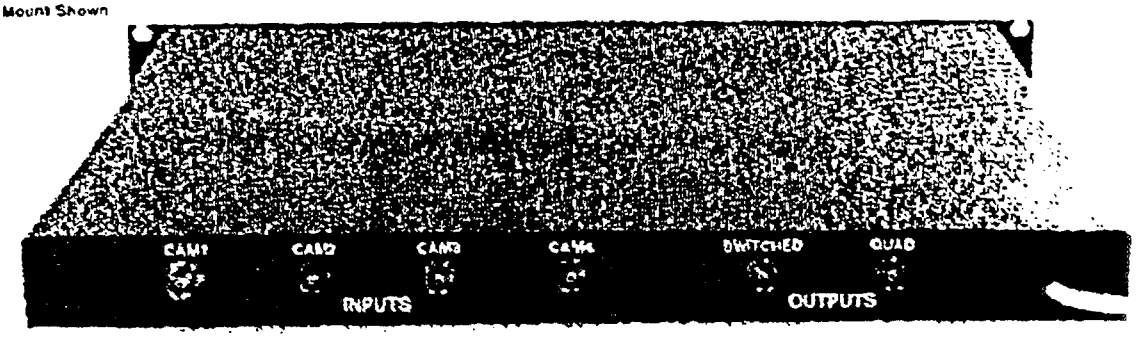
real time quad compressor

Features
- *Real Time - 60Hz In/60Hz Out*
- *256 (8 bit) Gray Scale B&W*
- *512 x 512 Pixel Resolution*
- *Full Screen Selection*
- *Two Outputs*
  - *Quad Only*
  - *Switched*
- *Simple Front Panel Controls*
- *Rugged Metal Case Mounts Under VCR*
- *Optional Rack Mount 1-3/4" Height*
- *12VDC Operation*



The new AVE QS-402 Quad Screen Compressor, offers real time performance and superior resolution at competitive pricing. The 256 levels of gray scale offers fine detail and eliminates subject contouring. The QS-402 displays a full 512 x 512 of pixels on the screen. The interlaced output of the QS-402 allows the AVE VSI to be fully legible while being digitized by the QS-402 even in our smallest display mode. This allows multiple readouts from cash registers to be simultaneously displayed without cluttering up the screen. The QS-402 has simple push-button front panel controls to home to any camera full screen or return to the quad mode. The two rear mounted video outputs allow quad only connection to the VCR while monitoring any input full screen on its separate output. The AVE rugged metal enclosure mounts underneath the VCR to eliminate security office clutter. This enclosure will also contain an optional titling board for labeling each quadrant of the screen independently. The VSI cash register interface can also be optional mounted in this same enclosure for convenience store installations. Look to the AVE QS-402 family of B&W Quads to satisfy all your multi-camera installations.

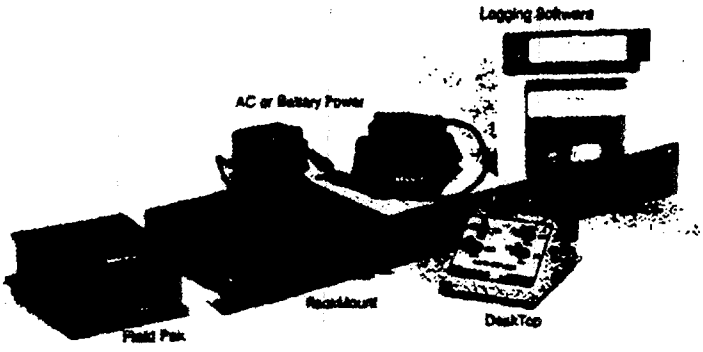
Optional Rack Mount Shown



HORITA

AFFORDABLE TIME CODE EQUIPMENT

for desk top, rack mount, or field use



SMPTE LTC TIME CODE

HORITA SMPTE Longitudinal Time Code products, designed to add functions and features with each step up the product line, are fully upgradeable at a later date.

"Time Code Analyzer" display now on all LTC models.

The time code/video phase analyzer display shows the exact timing relationship between time code and video. Continuous visual readout tells if (and at what point) time code is genlocked to video, permits precise adjustment of VCR tracking control when making window dubs, adjustment of audio deck speeds for time code playback, etc.

WG-50 Window Dub Inserter — $289

- Makes burned-in SMPTE time code window dub copies
- Compatible with all 1/2", 3/4", and 1" tape formats
- Displays time code or user bits
- Indicates drop-frame or non-drop-frame time code
- Field 1/field 2 indicator
- Pleasing, sharp characters
- Dark mask or "see-thru" mask surrounds display
- Adjustments for horizontal and vertical size and position
- Display on/off
- Always frame accurate (on time)
- Provides reshaped time code output for copying time code
- Also functions as play speed SMPTE time code reader

TG-50 Generator/Inserter — $379

- Combination time code generator and window dub inserter includes all features of WG-50

  PLUS
- Generates SMPTE time code in drop/non-drop-frame format
- Jamsync mode jams to time code input and outputs new time code
- Simple "on screen" preset of time code and user bits
- Run/stop operation using front panel momentary switch
- Selectable 30/60/90/120-second automatic generator backtime
- Make a window dub copy while recording time code on source tape

TRG-50 Generator/Search Speed Reader/Inserter — $469

- All features of TG-50

  PLUS
- Reads and displays SMPTE time code from 1/30 to over 10x play speed
- Reads forward and reverse

TRG-50PC — $589
Includes TC-TOOLKIT Tape Logging Software
PC Serial Control

- All features of the TRG-50

  PLUS
- "Two-way" communication with IBM compatible PC using RS-232 serial port. No plug-in cards required, log in field using portable PC

SMPTE LTC AND VITC TIME CODE READERS, GENERATORS, INSERTERS, TAPE LOGGING SOFTWARE

- Operate in complete video bypass mode when switched off
- Powered from AC power adapter (included) or batteries for use in field
- Small size 2" x 3" x 4"
- All models also available in RackMount, ShortRack, or FieldPak

PAL

- All models also available in PAL 625/50

SMPTE VITC TIME CODE

HORITA SMPTE Vertical Interval Time Code products permit generating and reading VITC as well as interfacing it into LTC systems.

VG-50 VITC Generator, LTC-VITC Translator With "On-Screen" Time Code Display — $289

- Generates industry standard VITC (Vertical Interval Time Code)
- Translates LTC (audio) time code into VITC time code
- "Jamsync" mode presets VITC time code to SMPTE LTC input
- Generates VITC in drop-frame or non-drop-frame format
- Simple "on screen" preset of time code or user bits
- Front panel switches to select line pairs for VITC placement
- Selectable 30/60/90/120-second automatic generator backtime
- Run/stop operation using front panel momentary switch
- Field-1/field-2 indicator
- FieldPak model with 14-Pin option inserts VITC into camera video
- Use with VLT-50 to form VITC reader/window inserter
- Regenerates VITC for edit system Record deck when used with VLT-50

no discounts

VLT-50 VITC-to-LTC Translator — $289

- Translates VITC into LTC at play speed and at search speeds from ± 10 X play speed down to still frame.
- LTC output can be read by other HORITA LTC products to display the VITC time code numbers frame-by-frame, make window dubs, log tapes, etc.
- LTC output can operate time code-based editing systems that use LTC rather than VITC, and can be used to synchronize audio or video recorders requiring LTC, or to make LTC copies, etc.
- VLT-50 auto select mode automatically routes externally applied LTC directly to the LTC output if VITC is unreadable or not present. No need to switch cabling to select between VITC and LTC when both are used in system.
- Switch selectable forward only or bi-directional forward/reverse LTC output from the VLT-50 insures greatest compatibility with a variety of LTC readers, edit controllers, and synchronizers.
- Switch selectable "search offset" provided by the VLT-50 when translating VITC at search speeds or at still frame, compensates for the "on time" updating done by many LTC readers, edit controllers, and other LTC products.
- Regenerates VITC for edit system Record deck when used with VG-50

VLT-50PC — $409
Includes TC-TOOLKIT Tape Logging Software

- All features of VLT-50

  PLUS
- One way communication with IBM compatible PC using RS-232 serial port. No plug-in cards required, log in field using portable PC

- **Time Code TOOLKIT** Software does tape logging, automatic EDL generation, import/export time code to word processor, database, spreadsheet, plus more. See reverse side for additional details.

TIME CODE TOOLKIT(TM) TAPE LOGGING SOFTWARE

The Time Code TOOLKIT tape logging/EDL software (TC TOOLKIT) comes packaged with the HORITA TRG-50PC and VLT-50PC products. The TRG-50PC reads and generates LTC and serially outputs it to a PC. The PC also controls the time code generator in the TRG-50PC. The VLT-50PC reads VITC, translates it into LTC, and also has serial output to the PC. TC-TOOLKIT has six time code programs plus a seventh menu select program.

- **PC-LOG** captures time code or user bits and calculates durations with a single keystroke. Log tapes while reading or generating time code, add comments, print, disk I/O, search for keywords or phrases using wildcard characters, print "search report".
- Ten "Macro Keys" permit single keystroke to capture time and insert any pre-typed message of up to 34 characters. Scene/take counter macro key operates with special IN/OUT macro keys to tag entries and auto increment take counter.
- **TC-CALC** "pop-up" time code calculator with separate pop-up tape timer does all drop-frame/non-drop-frame and film foot-frame math, imports and exports time code, user bits, and other calculator values directly into and out of word processor documents, database or spreadsheet fields, etc.
- **TC-TRN** converts PC-LOG file into standard CMX 340 EDL format.
- **TC-DBT** converts log file into two delimited ASCII files for import into database.
- **TC-TRK** generates commented EDL from simple playback of an off-line tape containing SMPTE time code from source tapes, determines reel #, edit type, mode, source/record IN and OUT times, and adds comments from PC-LOG files.
- **TG-SET** quickly presets generator time code, user bits from keyboard, single key to set time code to PCs real-time clock time, user bits to date, start/stop generator, turn display on/off. (operates TRG-50PC only)
- **TCTK** menu shell allows quick movement between TC TOOLKIT programs
- Includes TRG-50PC and TC TOOLKIT manuals, serial cable, DB-9/DB-25 adaptor, 3-1/2 and 5-1/4 disks

OPTIONS

14-PIN CAMERA/VCR INTERFACE OPTION $69

- For FP-50/TG, TRG, TRGPC, VG
- Automatic generator start/stop with camera trigger switch
- Powers FP-50 from VCR power
- Quick connect and disconnect of FP-50 into portable system
- Requires use of additional 14 pin cable

LTC models:

- Time code window displayed on camera viewfinder return video
- Can also be used in the studio for reading, generating and making time code window dubs
- Time code can be recorded on audio or address track

VITC model FP-50/VG:

- VITC inserted into camera video going to VCR

USER BIT SCENE-TAKE COUNTER $29

- Scene/take window display for user bits

USER BIT EVENT COUNTER $59

- Simple switch closure updates user bit counter to log external event

CUSTOM WINDOW DISPLAYS AVAILABLE

UPGRADES

All SMPTE LTC series time code products can be upgraded should additional time code capabilities and product features be desired at a later time.

Price: Product list price difference plus $35 service charge. Example: Upgrade TG-50 to TRG-50, price difference $90; service $35; TOTAL price $125

BATTERY PACK

BP-50 Battery Pack $49

- 8 AA rechargeable batteries, holder
- Heavy duty Cordura battery pack with velcro straps
- Recharger with LED
- Works with all HORITA products

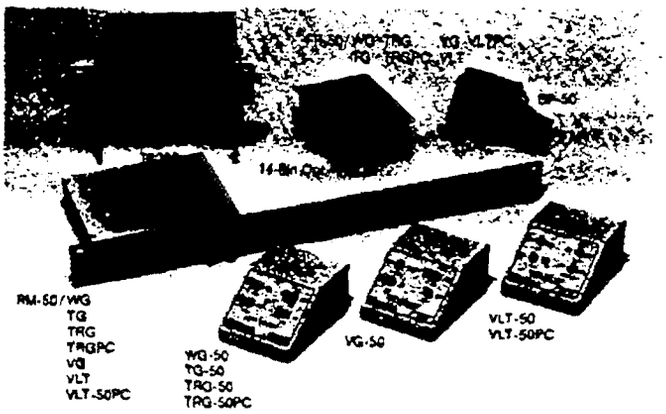
PACKAGING OPTIONS

RM-50 RackMount	Standard 19" rack, holds one two or three units	add $90
AO-50 Add-On	2nd, 3rd rack units each	add $50
SR-50 ShortRack	7 1/2" rack, holds one unit	add $90
FP-50 FieldPak	Rugged, portable pak for field use (Time code models)	add $90

Hi8 TIME CODE TRANSLATOR

RLT-50 Hi8 (EVO-9800/9850) Time Code to Longitudinal Time Code Translator $289

- Translates time code obtained from standard VCR DB-9/RS-422 9-pin remote connector, such as found on Sony EVO-9800/9850 Hi-8 VCR into standard SMPTE longitudinal time code (LTC).
- Operates in stand alone local mode or in "listen" mode when used as part of an editing system.
- Provides LTC time code at all VCR speeds, from highest search speeds down to still frame.
- Simple front panel switch control allows individual preset of all user bits or the translated time code to add reel number, date, etc.
- LTC output can be used to operate audio synchronizers, make LTC copies for interformat editing, or used with other HORITA LTC products to make window dubs, log source tapes, etc.
- Switch selectable forward only or bi-directional forward/reverse LTC output from the RLT-50 insures greatest compatibility with a variety of LTC readers, synchronizers, and other video production equipment.
- Switch selectable "search offset" provided by the RLT-50 when translating at search speeds or at still frame, compensates for the "on-time" updating done by many LTC readers, edit controllers, and other LTC products.
- Available in RackMount (RM-50/RLT) or ShortRack (SR-50/RLT) only (No additional charge)



All HORITA products come with an unconditional 30-day money back guarantee and a one year parts and labor warranty.

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HORITA
P.O. Box 3993, Mission Viejo, CA 92690 (714) 489-0240

VIDEO DISTRIBUTION AMP

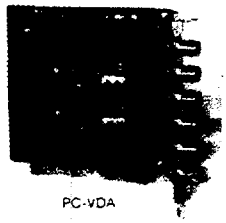
VDA-50 Wideband Multiple I/O Video Distribution Amplifier — $229

The VDA-50 consists of two or three separate high performance video distribution amplifiers with user selectable jumpers on the PCB that allow it to be configured for various multiple or single video DA applications.

- User configurable for number of inputs and outputs. Ideal for small desktop video editing systems.
- Desktop version VDA-50 configurable as dual 1 x 2, 1 x 3 DA, or as single 1 x 6 DA. Includes looping video input with switchable 75-ohm terminator.
- Rackmount version RM-50/VDA user configurable as a triple 1 x 2 DA, dual 1 x 4, 1 x 3 DA or 1 x 5, 1 x 2 DA, or single 1 x 8 DA. Includes looping video input with switchable 75-ohm terminator.
- Looping input permits multiple VDA units to be easily connected for expansion or to pass the input video signal on to other pieces of equipment.
- Single HORITA RM-50 rackmount panel can hold up to three VDA's which can be looped together to form single 1 x 24 VDA for video duplication purposes.
- Wide bandwidth of over 80 MHz, differential gain .04%, differential phase .08%.
- Separate Level and Eq. screwdriver adjustments provided for each DA section permit amplitude and frequency compensation for driving up to 500 feet of RG-59U coaxial cable.
- Can operate from battery power for use in field.

PC-VDA PC Plug-In Wideband Multiple I/O Video Distribution Amplifier — $179

The PC-VDA is actually two separate high performance video distribution amplifiers with user selectable jumpers on the PCB that allow it to be configured for multiple or single video DA applications.


PC-VDA

- User configurable for number of inputs and outputs. Ideal for small desktop video editing systems based in IBM compatible PC.
- Configurable as dual 1 x 2 or single 1 x 5 DA. One input can be made looping via PCB jumper.
- Looping input permits multiple VDA units to be easily connected for expansion or to pass the input video signal on to other pieces of equipment.
- Wide bandwidth of over 80 MHz, differential gain .04%, differential phase .08%.
- Separate Level and Eq. screwdriver adjustments provided for each DA section permit amplitude and frequency compensation for driving up to 500 feet of RG-59U coaxial cable.
- Halfcard size, uses BNC connectors for all video I/O.

PACKAGING OPTIONS

• **RM-50 RackMount**	Standard 19" rack, holds one two or three units	**add $90**
• **AO-50 Add-On**	2nd, 3rd rack units each	**add $50**
• **SR-50 ShortRack**	7 1/2" rack, holds one unit	**add $90**

BATTERY PACK

BP-50 Battery Pack — $49

- 8 AA rechargeable batteries, holder
- Heavy duty Cordura battery pack with velcro straps
- Recharger with LED
- Works with all HORITA products

TITLER, TIME CODE CAPTIONER

SCT-50 Serial Control Titler "Industrial" CG, Time-Date Stamp, Time Code Captioning — $329

An industrial character generator for adding titles or captioning to video from cameras, VCRs, computers, etc. Use for video data collection and monitoring, adding instructional information, time and date, or other information from PC. Log and document experiments, add video source ID, camera and location display for security monitoring, video information displays, and subtitiling.

- Standard DB-9 connectors for serial port with RS-232 loop thru operation allows up to 99 units to be daisy chained together and individually or group addressed by PC.
- Front panel switch control for stand alone operation or simple two letter commands from computer for character selection, location, size, background, flashing, black or white, horizontal and vertical position, text or HEX data monitor.
- "Pop-up" TSR text editor and control program for PC controls SCT-50 from within other programs. Auto centering, copy, move, delete, etc., full screen or selectable line editing. Three modes of communication with PC include a "continuous" mode for real time positioning of text within video image. Programming examples are included in both Basic and C to get you started writing your own programs, if you desire.
- Built in time code captioning software operates SCT-50 in association with the HORITA TRG-50PC and the PC-LOG software to automatically caption video images with comments from PC-LOG files according to their time code.

SAFE AREA GENERATOR

SAG-50 Safe Area, Convergence Pattern and Oscilloscope Line Trigger Generator — $289

The SAG-50 overlays safe action and safe title borders, with optional center cross, over incoming video so that graphics and other information can be correctly positioned within the picture. The SAG-50 can also overlay video image with dot and crosshatch test patterns (with image center indicators) for performing convergence and centering adjustments on single monitors or for setting up video walls.

An added feature not found in any other safe area generator is the ability of the SAG-50 to output an oscilloscope "line trigger" signal and display an intensified line with a digital readout showing its actual line and field number on the video monitor.

- Safe action and safe title overlays are fixed at the SMPTE RP-27.3 standards of 80% and 90% of the scanned image area, and include individual 25% and 30% horizontal markers.
- Safe area center cross can separately be switched on or off.
- Dot/crosshatch convergence patterns are 15 lines/dots across, by 13 lines/dots top to bottom. Both patterns have special "center screen" pattern for locating exact center of scanned image.
- Intensified line and trigger can quickly be changed from line - 10 to line 262, and the field can be selected as field-1, field-2, or both. This provides a very accurate method of identifying the exact location of and/or placing graphics in the picture, measuring text height in line numbers, etc.
- The trigger output signal changes an ordinary oscilloscope into a precise piece of video test equipment capable of observaton and identification of individual video lines of either or both fields for viewing VITS test signals, VITC time code, head switching points, etc.

All HORITA products come with an unconditional 30-day money back guarantee and a one year parts and labor warranty.

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MV85

Multivision™ Color Digital Picture Processor

1 2
3 4

Data Sheet

Features

- Full compression, digitally processed quad picture display.
- Today's highest quality digital color picture with real-time refresh rate and a palette of more than 4 million colors.

Multivision is a remarkable advancement in digital picture processing that allows you to display, tape record or transmit the pictures from four video cameras at one time. Multivision compresses the pictures to one-fourth their size, then combines them into a single picture with a four-quadrant format. In may applications, it's the cost-effective alternative that gives you the full surveillance coverage you need, but with far less equipment costs. Because time base correction is a natural function of digital picture processing, no special cameras or camera synchronization is required.

Our latest addition to the Multivision line is the Model MV85 Color Quad Picture Processor. Performance specifications include

- Super VHS VCR compatibility for high quality quad picture recording and playback. Quad to full screen picture zoom on VCR playback.
- Menu driven set-up programming.
- Alarm called full screen picture.
- 8-character camera titling, plus on-screen alarm and video loss indication.
- Four looping video inputs, quad picture output, and a separate sequential switching output.
- Security lockout.

real-time picture display, excellent resolution and a palette of more than 4 million colors. With the MV85, subtle color differences are easily seen in the most lifelike digitized pictures available. Even black and white pictures will look superb due to its wide luminance range of 256 shades of grey. And, because the MV85 is Super VHS VCR compatible, you may expect the highest quality tape playback when video tape documentation is required. These performance specifications make the MV85 the ideal choice for applications where fast, accurate identification is required.

Unmatched in performance by any other color quad picture processor, the MV85 also offers the operational features that users appreciate most. Features like menu driven set-up programming, full screen display of a selected camera picture, auto full screen sequential switching, security lockout and quadrant zoom during VCR playback. Features that make the MV85 today's most sophisticated yet easy to use color quad picture processor.

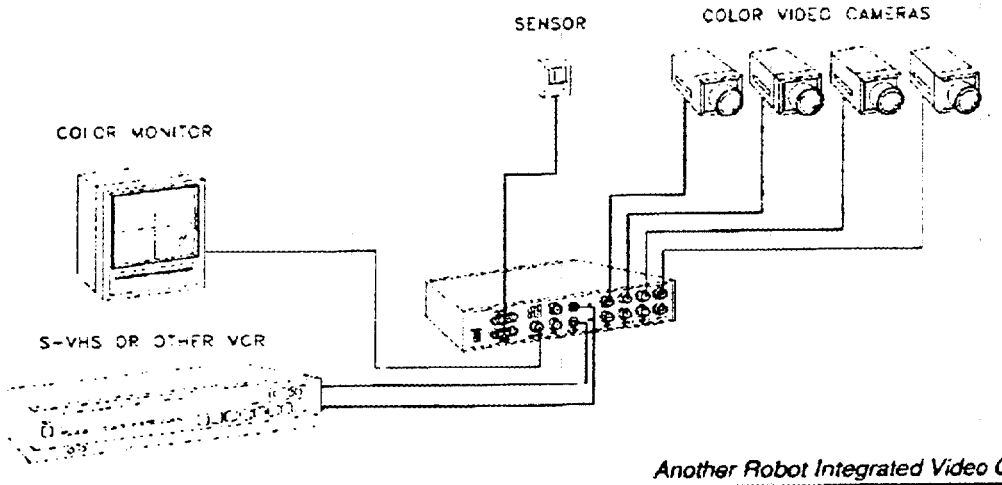
Multivision MV85... the color quad picture processor for the nineties.

MV85

Technical Specifications

Video Standard	NTSC: 525 lines, 60 fields/second PAL: 625 lines, 50 fields/second
Video Inputs	1.0 V p-p composite, 75 ohm or high Z, BNC
Monitor Output	1.0 V p-p composite video, 75 ohms, BNC
VCR Input	1.0 V p-p composite video, 75 ohm, BNC --OR-- 1.0 V p-p S-luma (y), 75 ohm, S-video 0.286 V p-p S-chroma (c), 75 ohm, S-video
VCR Output	1.0 V p-p composite video into 75 ohms, BNC --AND-- 1.0 V p-p S-luma (y), 75 ohm, S-video 0.286 V p-p S-chroma (c), 75 ohm, S-video
Digital Memory	512 X 512 pixels full screen 256 X 256 pixels per quadrant 8-bit luma, 256 shades of grey 7-bit chroma; more than 4 million colors on pallet
Display Rate	Real-time refresh rate
Alarm Inputs	(4): Dry contact closure
Alarm Outputs	(1): Normally open or closed contacts 2 A @ 30 VDC or 1 A @ 120 VAC, resistive
Alarm Duration	4 second minimum duration pulse
Alarm Hold Input	+5 to +15 VDC or TTL active high
Operating Voltage	12 VDC; less that 10 watts
Ambient Temperature	40°to 104°F (5°to 40°C)

WEIGHT	DIMENSIONS	POWER
7 lbs (3.2 kg.)	1.75"H X 8.5"W X 12.25"D (46mm X 270mm X 318mm)	10 Watts



Another Robot Integrated Video Component ROBOT

ROBOT RESEARCH INC.
1636 Ruffin Road
San Diego, California
619 279-9430
800 854-2057
FAX: 619 279-7931

MV94

Multivision Plus™ Color Record/Display Multiplexer

DTD™
DYNAMIC TIME DIVISION MULTIPLEXING

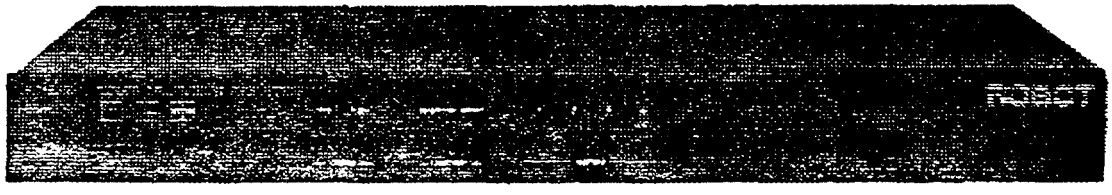
Data Sheet

The MV94 Multivision Plus is the latest advancement in digital picture processors. With the MV94, you may tape record the pictures from up to 4 EIA/NTSC or CCIR/PAL video cameras while simultaneously displaying them on a monitor. Because time base correction is a natural function of digital picture processing, camera synchronization is not required.

Business managers and security personnel rely heavily on the time lapse VCR for visual documentation of security breaches and other incidents. But the time lapse VCR has always been limited to recording the pictures from one camera at a time. Automatic sequential switchers and quad picture processors improve recording efficiency, but may not give you the full security coverage or tape playback quality you need.

Features

- Full duplex with separate multiplex Rec/Disp Live and Rec/Disp Play modes.
- Dynamic Time Division multiplexing allocates recording time for each camera input based on activity detection.



- Picture motion sensing for each camera input is user programmable on a 16H x 12V grid.
- Compatible with standard and Super VHS VCRs.
- On-screen displays include date, time, video loss indication, and 10-character camera titles.
- Live or tape playback display formats include full screen, picture-in-picture (PIP) and 2x2. 2x dynamic zoom is available full screen.
- Cameras may be user assigned to any display window within all display formats.
- On-screen set-up menus and front panel pushbuttons greatly simplify operation.
- 4 alarm inputs and RS-232 remote control capability enhance product application and flexibility.
- Power loss protection on programmable features and display window camera assignments.

MV94 overcomes these limitations. The unit digitizes the incoming pictures, then encodes them by camera number for full- field, multiplexed recording on a single VCR. Multiplexed recordings are produced in the Robot Dynamic Time Division™ format. This proprietary multiplexing system continually analyzes the motion content of all incoming pictures, then sequentially interlaces them with proportionately more recording time allocated to the higher motion pictures. Because the MV94 is also Super VHS VCR compatible, you may expect the nearest to real time, highest quality tape playback available today.

The MV94 also offers the picture display options and operational features that users appreciate most. Live, or from tape, users may select full screen picture display with dynamic zoom, picture-in-picture, or 2 x 2 display formats. All with the high definition, vivid color pictures you would expect from a pixel matrix of 512 x 512, 256 shades of grey and a palette of 16,000,000 colors. And, with all of its impressive performance, the MV94 is suprisingly easy to use. Like on-screen menu driven set-up, pushbutton display selection, and pushbutton function selection.

Multivision Plus... picture processing technology that makes multi-picture recording and display far more economical, yet so simple.

Another Robot Integrated Video Component ROBOT

MV94

Technical Specifications

Video Standard	NTSC: 525 lines, 60 fields/second PAL: 625 lines, 50 fields/second
Video Inputs	(4 looping): 1.0 V p-p composite, softset 75 ohms or High Z, BNC
Monitor Output	1.0 V p-p, composite, 75 ohms, BNC
VCR Input	1.0 V p-p, composite, 75 ohms, BNC — or — 1.0 V p-p, S-luma, 75 ohms, S-video 0.286 V p-p S-chroma, 75 ohms, S-video
VCR Output	1.0 V p-p, composite, 75 ohms, BNC — and — 1.0 V p-p S-luma, 75 ohms, S-video 0.286 V p-p S-chroma, 75 ohms, S-video
Digital Memory	512 X 512 pixels full screen 8-bit luma, 256 shades of grey 8-bit chroma, 16,000,000 colors on palette
Alarm Inputs	(4): Dry contact closure, DB25
Alarm Output	Normally open or closed contacts 2A @ 30 VDC or 1A @ 120 VAC, resistive
Alarm Duration	4 seconds
Alarm Hold Input	+5 to +15 VDC or TTL active high
Operating Voltage	12 VDC, 12 watts, 2.1mm pin jack
Ambient Temp	40° to 104° F (5° to 40° C)

WEIGHT	DIMENSIONS	POWER
7 lbs. (3.2 kg.)	1.75"H X 17"W X 12.25"D (46mm X 432mm X 318mm)	12 Watts

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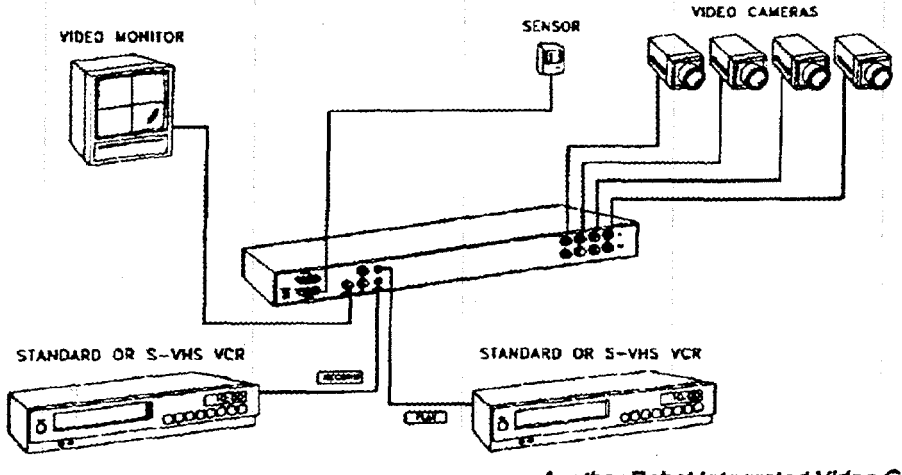

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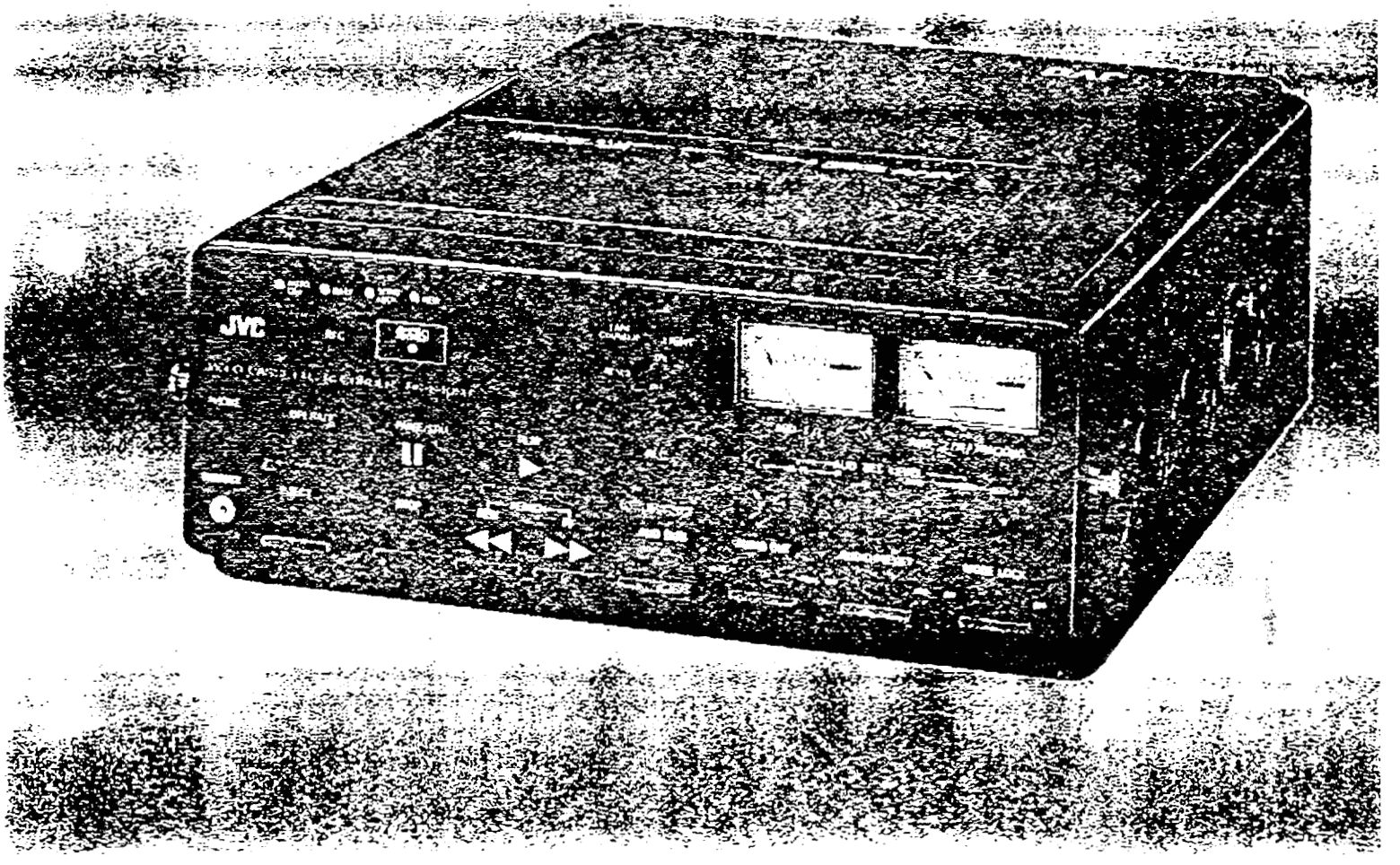
JVC
PROFESSIONAL

S-VHS

PORTABLE S-VHS
RECORDER

BR-S405U

A separate portable professional S-VHS recorder ideal for use with any existing stand-alone camera.



IF YOU DON'T NEED A CAMCORDER, WHY US

JVC's BR-S405U Portable S-VHS Recorder Is Designed Exclusively For Use In Separate System Configurations

Not everybody who needs a portable recorder, needs a camcorder. If you prefer a separate system — whether it's for long-duration on-location shooting or it's because your assignment requires you to mount the camera on a dolly and the recorder on a cart — then why compromise with a recorder that's not really designed to do the job? For maximum efficiency and professional results, you need a portable recorder designed specifically for separate use. You need JVC's BR-S405U Portable S-VHS Recorder. Free from the kind of design characteristics that can make a dual-purpose (dockable/portable) recorder less than ideal for use as a separate system, the BR-S405U features optimally positioned controls, easy connection to any existing camera, plus a handy mode lock function and an audio preset switch to ensure worry-free operation in any situation.

So when you need separate system portability, don't compromise. Choose the recorder that's designed to do the job. The BR-S405U. With its superior S-VHS picture quality and Hi-Fi VHS stereo sound, full range of professional features, and separate system flexibility, it'll make it easy for you to get the job done right.

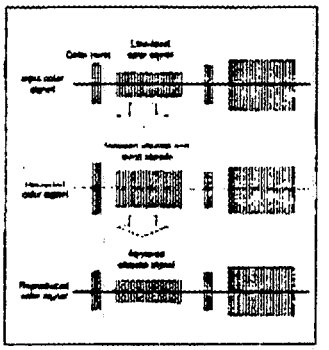
HIGH-QUALITY PICTURES

High-quality S-VHS pictures

To provide pictures with the detail and clarity demanded by field acquisition and industrial applications, the BR-S405U incorporates JVC's advanced S-VHS technology for high-quality pictures with resolution of more than 400 lines. VHS recording is also available.

Built-in chroma noise reduction

To further improve picture quality, an advanced ALU (Automatic Level Up) recording circuit is used to improve the chroma signal-to-noise ratio. This sophisticated system increases signal level and color burst in recording, then reduces the signal to its original level in playback, thus maintaining the original chroma level while reducing chroma noise.



Separate Y/C input and output

In addition to permitting connection with any existing camera, the BR-S405U's 14-pin camera connector can accept separated Y/C signals, making it possible to build a high-quality field acquisition system by combining the BR-S405U with a professional camera equipped with separate Y/C output. And, to ensure that the picture that goes out is as good as the picture that goes in, the BR-S405U is also equipped with separate Y/C output* to deliver high-quality color pictures with reduced Y/C interference.

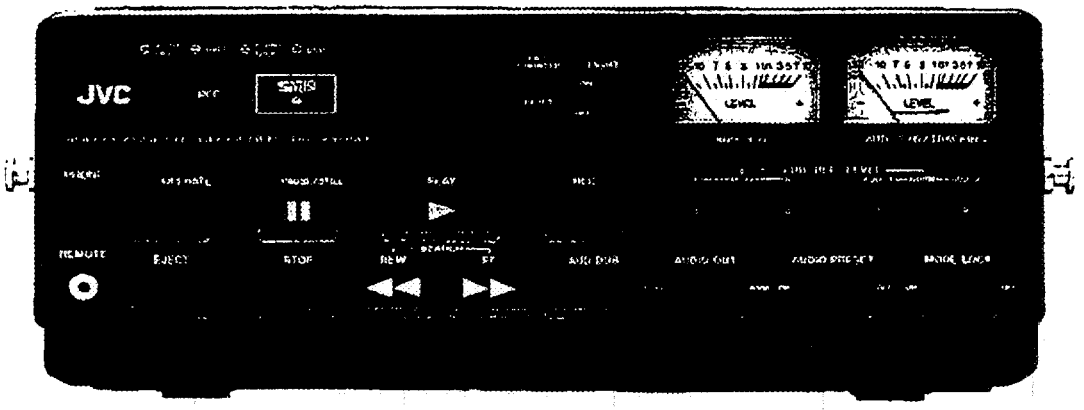
Reduced jitter

To improve picture quality still further, the BR-S405U incorporates twin impedance rollers in the tape path to stabilize tape transport. This greatly reduces jitter components to ensure a clear, stable picture.

Rotary erase heads and AEF function

A pair of rotary erase heads are mounted on the head drum to ensure clean, professional-quality recordings. During re-recording, each rotary head scans a single field on the video track, erasing the field prior to re-recording and preventing chroma beats and picture distortion at edit points. For clean assemble editing with no overlapping, automatic backspacing is provided by the AEF (Automatic Editing Function) mechanism.

* Y/C filtering technique incorporated under license from Faroudja Laboratories Inc.



E A CAMCORDER DECK?

HIGH-QUALITY SOUND

Hi-Fi Stereo sound
Using two rotary FM-audio heads to record Hi-Fi audio signals on a separate layer of tape, the Hi-Fi VHS system assures you of superb sound quality with extended frequency response of 20 Hz to 20 kHz, a dynamic range in excess of 80 dB, and minimal wow and flutter. A Hi-Fi REC switch is provided to defeat recording on the Hi-Fi track.

Balanced XLR input connectors
A set of XLR balanced audio input connectors maintain the highest level of audio reception performance. Input levels are switchable between -60 dB, -20 dB, and +4 dB to allow connection of professional microphones for interviews and other applications.

Audio Preset switch
For added convenience when you need to set up quickly, an Audio Preset switch is provided. When set to ON, this automatically sets audio input to rated levels. Manual level adjustment is also possible with independent controls provided for each track.

Audio Dubbing
The BR-S405U's stereo normal audio track features audio dubbing capability, using either Channel 2 only or both channels together.

MOBILITY

Large REC indicator
A large red REC indicator located on the BR-S405U's front panel blinks during recording, making visual confirmation of recording easy even from a distance.

LCD lap timer with 10-hour memory backup
The BR-S405U's 4-digit tape counter can be switched to a 5-digit lap timer displaying elapsed tape time in hours, minutes, and seconds. A BACKLIGHT ON/OFF switch is provided for easy viewing in lowlight situations while 10-hour memory back-up ensures continued accuracy even after power switch-off.

Rugged construction
To meet the rigorous demands made on a portable professional recorder, the BR-S405U's critical components are mounted in a rugged diecast aluminum casing capable of withstanding severe shocks and vibrations.

RELIABILITY

Mode lock function
When you want to prevent accidental or deliberate mishandling of the recorder's controls, simply set this switch to ON after setting all necessary controls. You'll be able to concentrate on camera operations without worrying about mishaps. Especially convenient in situations where you can't keep a close eye on the recorder or have to leave it unattended in a crowded area.

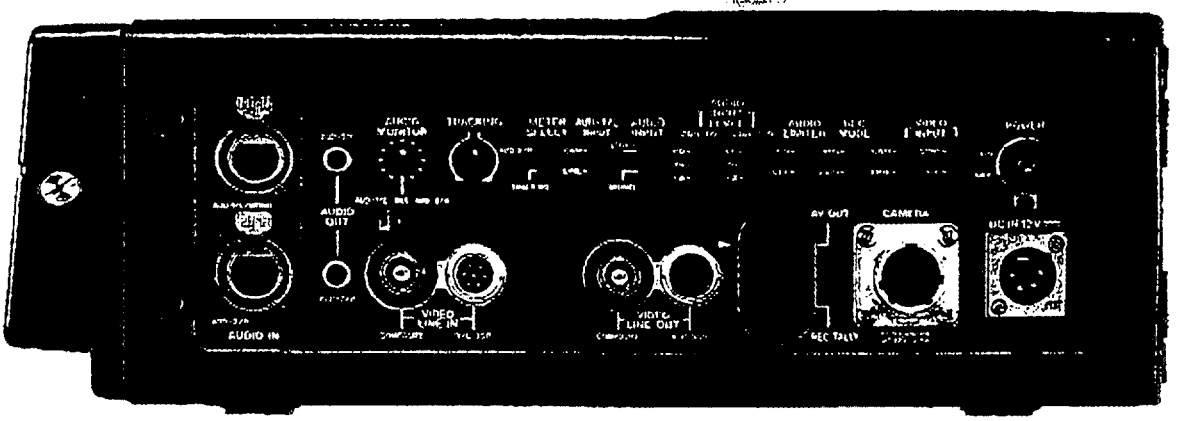
2000H hour meter
To facilitate scheduling of maintenance, a meter is provided which shows operating time up to 2000 hours.

Comprehensive warning system
To ensure trouble-free operation and minimize downtime, LED indicators warn of problems such as servo lock failure, depleted battery, condensation, and automatic shut-off due to malfunctioning tape transport. An audible warning is simultaneously output from the earphone jack.

AV output terminals
In addition to Y/C 3S8 output, the BR-S405U is equipped with composite video and 8-pin AV outputs. Independent L/R audio output terminals are also provided.

High-speed shuttle search
For more search flexibility in the field or in the studio, shuttle search at 7 times normal speed in either direction is possible.

Large backlit audio level meters
For easy monitoring of audio levels even in dark or dimly-lit conditions, two large backlit VU meters are provided.



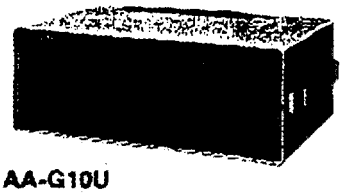
SPECIFICATIONS

Format: VHS/S-VHS standard
Recording system: Luminance: FM recording
Color: Down-converted subcarrier/
Separate Y/C signals
Signal system: NTSC
Tape speed: 33.35 mm/sec
Record/play time: 120 minutes (with T-120/ST-120 cassette)
FF/REW time: Within 4 minutes (with T-120 cassette)
Power source: 12 V DC
Power consumption: 19 W
Dimensions: 280(W) x 112.5(H) x 324(D) mm (11-1/16" x 4-7/16" x 12-13/16")
Weight: 4.3 kg (9.5 lbs.) (5.2 kg (11.5 lbs.) with NB-G1U and tape)
Operating temperature: 0°C to 40°C
Storage temperature: -20°C to 60°C

Video
Input: 0.5 to 2.0 Vp-p, 75 ohms, unbalanced
Output: 1.0 Vp-p, 75 ohms, unbalanced
Y/C input: Y: 1.0 Vp-p, 75 ohms, unbalanced
C: 0.286 Vp-p, 75 ohms, unbalanced (Burst)
Y/C output: Y: 1.0 Vp-p, 75 ohms, unbalanced
C: 0.286 Vp-p, 75 ohms, unbalanced (Burst)
Horizontal resolution: More than 240 lines (VHS color)
More than 400 lines (S-VHS color)
S/N ratio: 46 dB (S-VHS)
45 dB (VHS) (Detail SW OFF)
(Rohde and Schwarz noise meter)

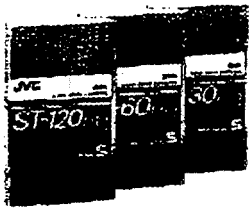
Audio
Number of channels: 2 Hi-Fi channels, 2 normal channels
Input: -60 dBs (3 k-ohms)/-20/+4 dBs (10 k-ohms), balanced (Hi-Fi and normal)
Output: -6 dBs, 1 k-ohm, unbalanced (Hi-Fi and normal)
Headphone output: -45 to -25 dBs, 8 ohms
Hi-Fi audio
Frequency response: 20 Hz — 20,000 Hz
Dynamic range: More than 80 dB
Wow & flutter: Within 0.007% WRMS
Normal audio
Frequency response: 40 Hz — 12,000 Hz
S/N ratio: More than 44 dB
Wow & flutter: Within 0.25% RMS
Accessories: Carrying handle x 1, Shoulder strap x 1, NB-G1U x 1

OPTIONAL ACCESSORIES



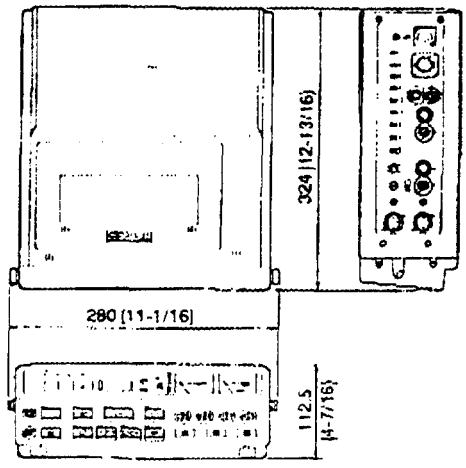
AA-G10U
Battery Charger/AC Power Adapter
Charges four NB-G1U battery packs.

NB-G1U
Rechargeable Battery Pack
One NB-G1U is provided with the BR-S405U as a standard accessory.



Professional-S Tapes
ST-120PRO (2 hours recording)
ST-60PRO (1 hour recording)
ST-30PRO (30 minutes recording)
High-performance S-VHS tape with increased durability and higher-density magnetic particles designed especially for professional use.

DIMENSIONS



Unit: mm (inches)

Design and specifications subject to change without notice.

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JVC CANADA INC.

APPENDIX T: TECHNICAL DATA ON THE COMPRESSED VIDEO DIGITAL STORAGE AND RETRIEVAL SYSTEM ENCODER AND MAPSTAR SYSTEM

Scientific Atlanta

Scientific Atlanta

Model D5200 DSR MPEG Encoder

Preliminary

SCIENTIFIC-ATLANTA, INC.
PROPRIETARY INFORMATION

Technical Specifications

Mechanical

Power	A automatic sensing Universal Input accepting 98 to 240VAC at 50 to 60 Hz
Size	177.8 mm (7.0 in.) high, 483 mm (19 in.) wide, 533 mm (21 in.) deep
Weight	approximately 9.1 kg (20.0 lbs)
Storage temperature	-20°C to 125°C
Operating temperature	0°C to 40°C
Operating humidity range	10% to 90% non-condensing

Video Encoder Board

Resolutition	704 x 480 30 Hz NTSC
Bit rates	5.3 Mbps - 8.3 Mbps
Bit stream protocol	MPEG Video Layer (CL950 Compatable)

Video Input Board

Video input	NTSC (RS 170)
Video input level	1V p-p ± 1V
Input impedence	75Ω
Input return loss	20 dB
Input connector type	BNC

SCIENTIFIC-ATLANTA INC
PROPRIETARY INFORMATION

MPEG Audio Encoder Board

Input type	Balanced, XLR inputs
Impedance	Higfh impedance (.10KΩ) driven by a 600Ω source
Input level	+18 dBu nominal
Input adjustment range	+12 dBu to +24 dBu
Frequency response	±0.25 dB from 20 Hz to 20 KHz
THD	<0.25%, full scale, 20 Hz to 20 KHz
Hum and noise	<86 dB, A-weighted
Crosstalk isolation	>75 dB, 20 Hz to 20 KHz, reference in other channel
Encode algorithm	MPEG I, Layer 2, Psycho-Acoustic Model #1, Dual Channel Mode
Sampling rate	48 KHz
Compressed data rate	256,000 bps
Emphasis	None

Simple Mux Board

Connection type	Differential terminated
Levels/Protocol	RS-485
Duplex	Synchronous
Data bits	8
Data rate	3.14×10^6 bps

Serial Data - Status/Control link

Baud rate	57,600
Parity	No Parity
Data bits	8
Stop bits	1
Duplex	Half Duplex
Levels/Protocol	RS-232C

Preliminary

SCIENTIFIC-ATLANTA, INC.
PROPRIETARY INFORMATION

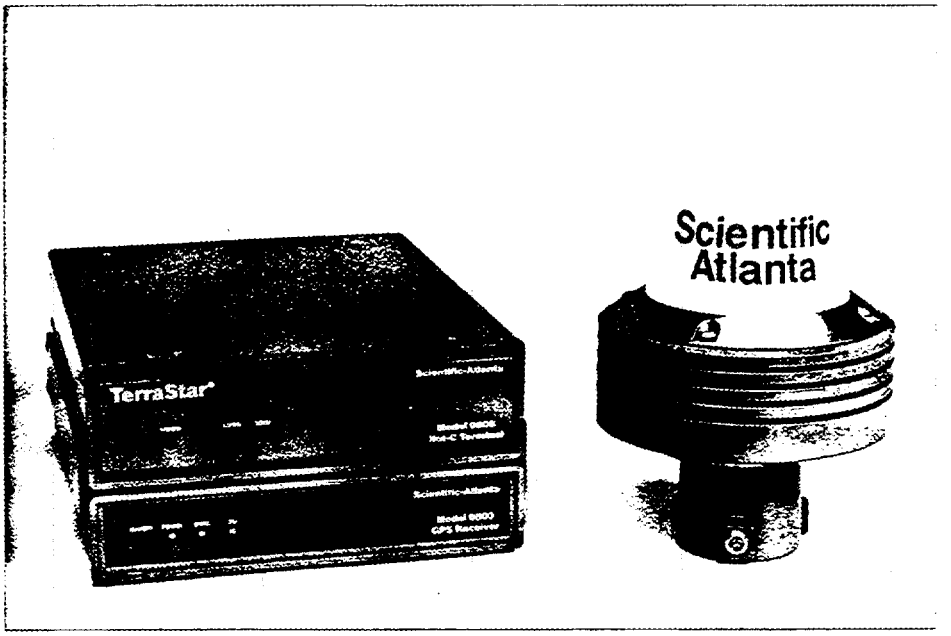
Scientific Atlanta

Network Systems Group

Application Note

MapStar™ Automatic Vehicle Location Software

Scientific-Atlanta's MapStar™ Automatic Vehicle Location (AVL) software package provides the dispatcher interface for fleet communications and tracking. Utilizing the global satellite system, Inmarsat, a consortium of 65 countries, MapStar™ is connected with Scientific-Atlanta's MariStar™ or TerraStar™ products to provide real or near real time two-way communications between the dispatch office and mobile vehicles anywhere in the world.



Scientific-Atlanta's TerraStar™-C/MariStar™-C Terminal is one example of an Inmarsat Earth Station that can be used to communicate with the mobile vehicle/vessel using MapStar™.

Features

MapStar™ has a number of flexible features including:

- Vehicle/Vessel Tracking for Entire Fleet
- Cartographic Flexibility
- Variable Communications Interface
- Two-way Communications
- Stand-alone Configuration
- Front-end Communications for Midrange and Mainframe
- Compatibility with TerraStar-Hub™ Network Router

Description

MapStar™ is a graphic display, communications, and database management system for vehicle tracking applications. Users will be able to track vehicles, send and receive messages, establish data communications, and obtain vehicle status reports.

Vehicle locations are displayed on maps, which may be customized to the user's specific requirements, providing an interface for the user to the map display and two-way communications. Using MapStar™, the dispatcher can monitor in real time the location, speed and ETA for all vehicles in the fleet, and send and receive messages.

INMARSAT
System Provider

Scientific-Atlanta, Inc.
Fax - 404-903-5346

Full Features of MapStar™

Vehicle/Vessel Tracking

- Receives position data and plots vehicle's exact location on map or chart
- Position options available:
  - Latest position
  - Last known/communicated position
  - 1 to 24 hour period
  - Archive Files
- Supports the following services:
  - GPS Lat/Long, course & velocity
  - Time and date sent
  - Time and date received
  - Sensor status reports
  - Forms filing
  - Fuel management data
  - Trip record data

Cartographic Flexibility

- Display of numerous vector based maps
- Zoom up to 7X for detail
- Allow any digital or hard copy map to be used as background map
- Maps are in multiple overlays
- User editable overlay
- Receives electronic file update

Variable Communications Interface

Basic map engine receives packets from many types of communications networks

Two-Way Communications

- No additional programs are necessary to exchange messages with mobiles through the network
- All handshake and protocol conversion is automated
- Operates in batch or real time

Map is Human Interface to Communications

- Communications are originated by pointing at vehicle or selecting vehicle from list
- Exact destination transmitter ID is always input when vehicle is selected
- All log keeping is automated

Stand Alone Configuration

The program is complete within itself and optimized to run in a stand-alone configuration

Front-End Communications Processor for Midrange and Mainframe

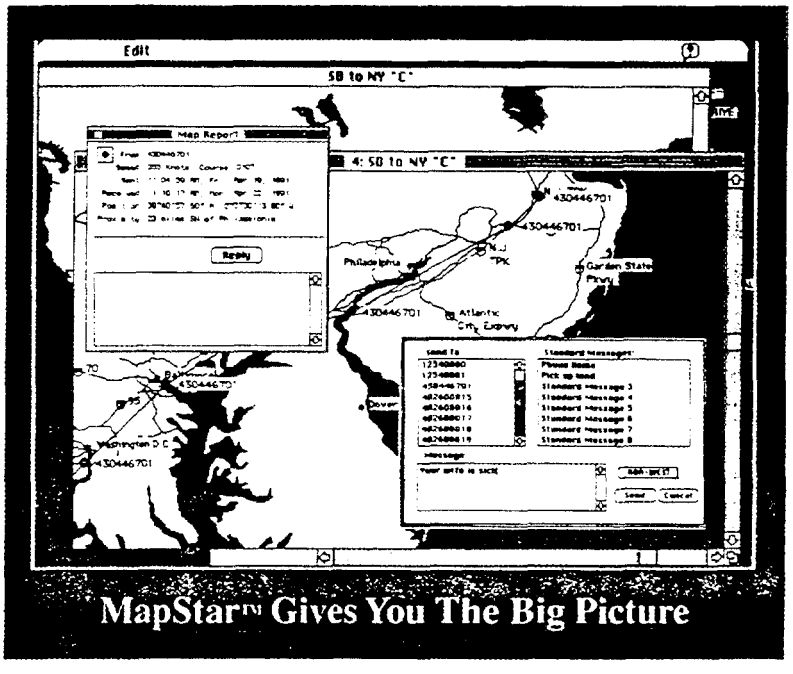
For those applications where the newly received message and position information is useful in another computer which is running an operations package. The program is designed to prepare the data for transfer to these other systems and to serve as a front-end communications processor for them. This can be accomplished in a direct connection to the other computer or via a network

Back-End Cartographic Terminal for Midrange and Mainframe

For those applications where the new dynamic data is received by the operations package in an existing computer, the program can very nicely receive the position information from the computer and display the positions on the electronic maps. This prevents the need for putting cartography on the host computer.

Low Cost

Perhaps the most cost-effective solution to vehicle tracking in the world. Plus built-in two-way communications and many other extras.



MapStar™ Gives You The Big Picture

Friendly Operation

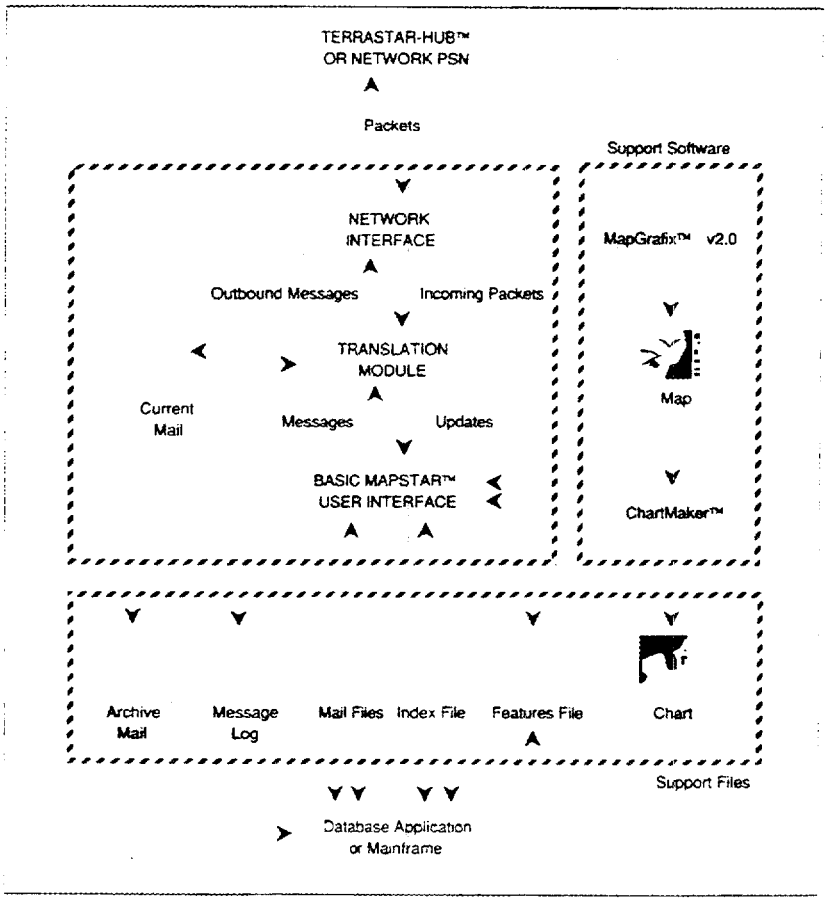
GUI-Geographical User Interface: the startlingly easy way to operate a complex and powerful computer. The ease of use and training saves even millions of dollars over time depending upon number of workstations and use.

Network Management

The optional TerraStar-Hub™ routing, store-and-forward switch gives carriers full network parameters and flexibility without compromising performance or cost effectiveness.

Benefits of MapStar™

The financial benefits of equipping a fleet with a Scientific-Atlanta MariStar™ or TerraStar™ terminal are varied depending upon the application. In a typical trucking application, benefits accrue to all interested parties.



The Trucking Company/Operator

- Cost savings lead to a payback of less than one year
  - More revenue mile per truck
  - Decreased and predictable telecommunications cost
  - Decreased out of route and deadhead miles
- MapStar™ is a marketing tool
  - Offers a competitive edge
  - A proactive rather than reactive customer service plan
- Improves management reporting capabilities
- Reduces accidents and lowers fuel consumption
- Reduces insurance premiums by 7-15%

The Driver

- Near real-time communication between the driver and the dispatcher is accomplished easily from any location
- Quicker transit times
- With the optional Mobile MapStar™ interface the driver can see his location at all times. The software gives a numeric latitude/longitude indication of current position. Vectorized maps are also available for the vehicle with a suitable display device
- Increases number of loads and revenue miles
- Emergency assistance is always available
- Eliminates filling out complex driver logs

MariStar and TerraStar are registered trademarks of Scientific-Atlanta.
MapStar is a registered trademark of ComGraphix, Incorporated.

The Shipper

- Greater degree of Quality Control
- Increases control of high-value consignments
- Precise status and shipment information
- Accurate delivery time with position reporting. Tighter ETAs can result in Just-In-Time service to customers
- Rapid response to customer request and/or order. In-transit redirects and expedited deliveries are easy to effect
- Coordinate operations with shipping personnel to maximize efficiencies and productivity

System Hardware Requirements

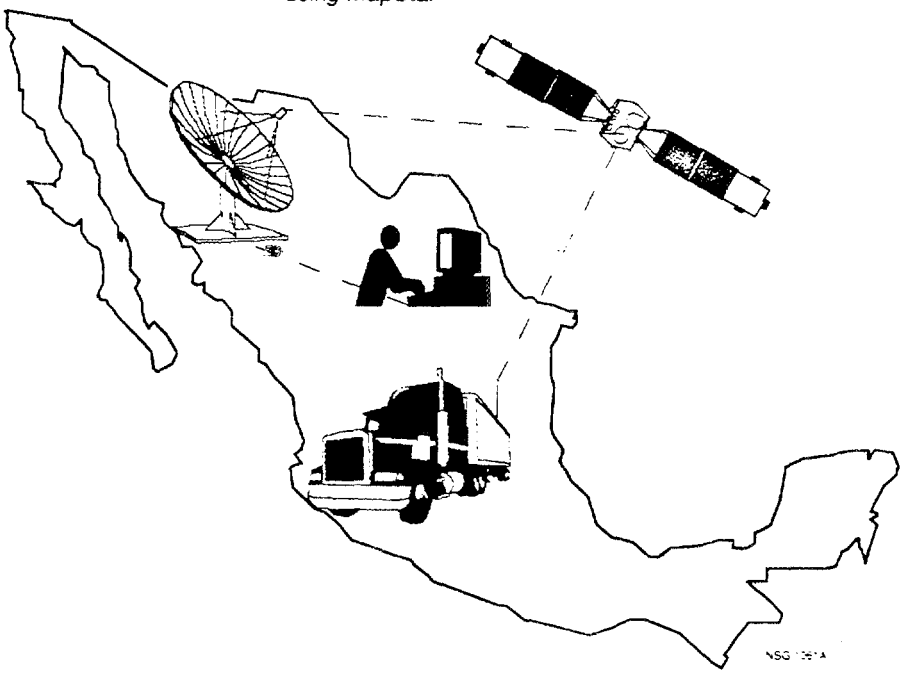
MapStar™ is designed to operate with the following system hardware:

- Scientific-Atlanta MariStar™ or TerraStar™ Inmarsat Standard-C and/or -M Terminals
- Apple Computer, Inc. Macintosh™ systems, including Macintosh II, IIx, IIcx, IIci, IIfx, and Quadra 700 and 950 computers, using System 6.0.5 or greater
- Any telecommunications network equipment that is able to connect to the specified Inmarsat Land or Coastal Earth Station
- Optional TerraStar-Hub™ for use in multiple dispatcher networks.

Macintosh is a tradmark licensed to Apple Computer, Inc.

Throughout the world, shippers can rely on Scientific-Atlanta's AVL and Inmarsat systems expertise. After providing the first Inmarsat coastal earth stations, and more than 3,000 Inmarsat terminals, the transport industry has come to rely on Scientific-Atlanta since 1976 to provide mobile communications solutions worldwide.

Illustration showing typical transportation application using MapStar™



Scientific-Atlanta, Inc.

Our customers are the winners.

United States: 4291 Communications Drive, Norcross, GA 30093; Telephone: (404) 903-6001; Telex 4611804
Canada: 120 Middlefield Road, Scarborough, Ontario M1S 4M6, Canada; Telephone: (416) 299-6888; Telex 06525344
United Kingdom: Home Park Estate, Kings Langley, Herts, WD4 8LZ, England; Telephone: Kings Langley 44-923-266133; Telex 912044
Australia: Unit 2, 2 Aquatic Drive, Frenchs Forest, N.S.W. 2086, Australia; Telephone: (612) 452-3388; Fax: (612) 451-4432; Telex 790 177418
France: 4 Avenue Gabriel Peri, 78360 Montesson France; Telephone: 33-13-976-9191; Telex 696385
Italy: Via Benedetto Croce, 19, 00142, Rome, Italy; Telephone: 39-6-5409994; Telex 621441
Germany: Albert-Schweitzer-Strasse 66, 8000 Muenchen 83, Postfach 830935 Germany; Telephone: 49-89-6780010; Telex 5212264

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APPENDIX U: TECHNICAL DATA ON THE CARTRIDGE TAPE AND DIGITAL PICTURE TRANSMISSION SYSTEMS

Exabyte
Robot Research

20 GB capacity at 3 MB/sec. transfer rate—uncompressed

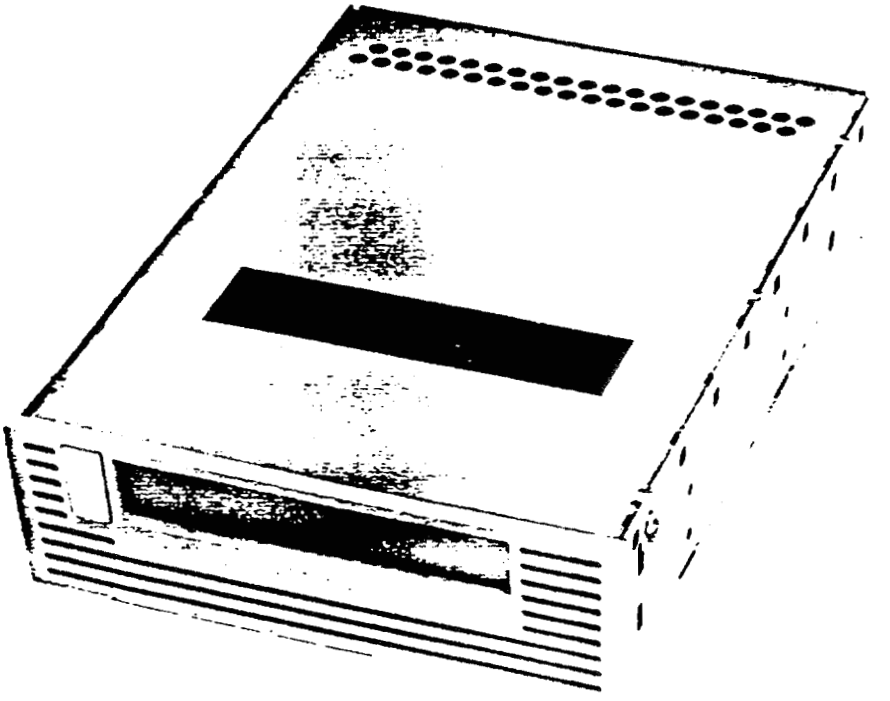
40 GB capacity at 6 MB/sec. transfer rate—compressed*

Records 10.8-21.6 GB per hour

High-speed search 188-376 MB/sec.

Less than 20 sec. load to ready

MTBF over 200,000 hours



MAMMOTH

8MM CARTRIDGE TAPE SUBSYSTEM

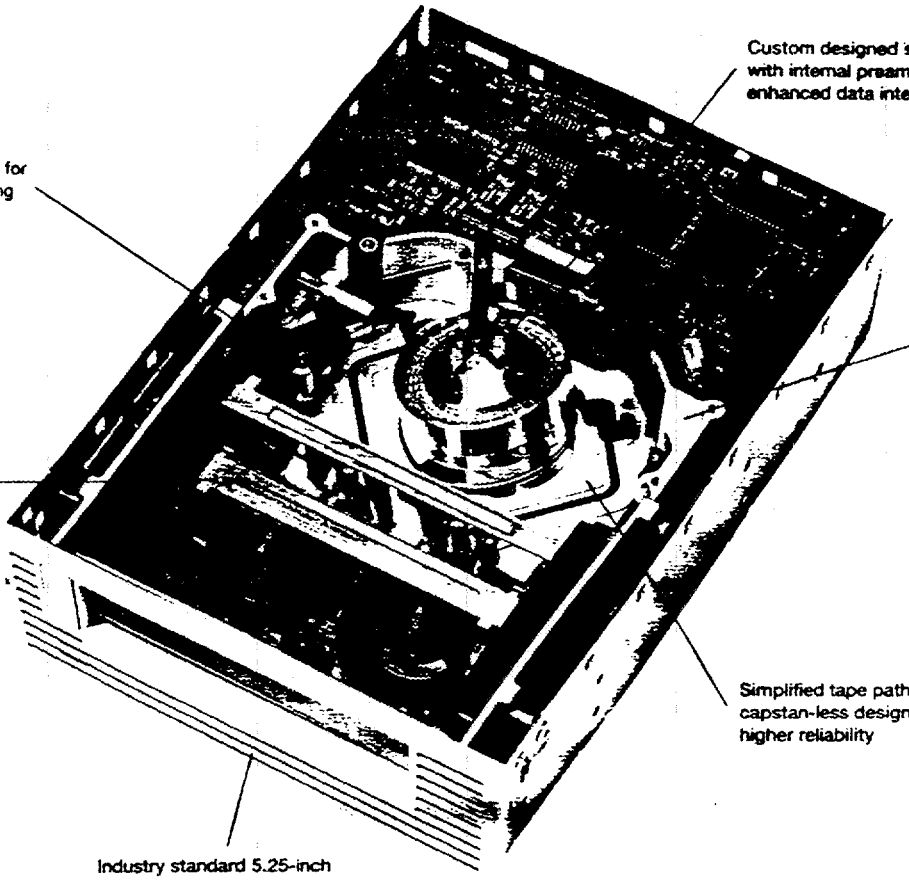
The Mammoth Cartridge Tape Subsystem takes 8mm tape performance to new levels. Its high capacity, fast transfer rate and rapid search speed provide the performance required to meet growing data storage needs. Mammoth not only provides quick backup of ever-expanding quantities of data, but also paves the way for emerging applications such as digital video and multimedia, near-online storage and hierarchical storage management.

High-performance data compression using the intelligent IDRC (Improved Data Recording Capability) algorithm typically doubles capacity and throughput. Mammoth's read compatibility with previous product generations protects the long-term investment in 8mm technology.

Mammoth features an Exabyte-designed and manufactured deck with 30 percent fewer parts. A streamlined tape loading mechanism and capstan-less tape path provide gentle tape handling. This robust deck, along with Mammoth's data reliability, will lower the cost of ownership and reduce support costs.

EXABYTE

*Assumes 2:1 compression ratio



SPECIFICATIONS

Models

Mammoth: single-ended SCSI
Mammoth: differential SCSI

Capacity

20.0 GB uncompressed
40.0 GB compressed*

Performance

Sustained transfer rate:
3 MB/sec. uncompressed
6 MB/sec. compressed*
Burst transfer rate:
7 MB/sec. asynchronous
20 MB/sec. synchronous
Search rate:
188 MB sec. uncompressed
376 MB sec. compressed*
Rewind speed: 60 ips.
(63 times nominal)
Load to ready: <20 sec.

Data Integrity

BER: <1 in $10^{\ }$ bits

Drive Reliability

MTBF: >200,000 hours
MTTR: <15 minutes

Interface

SCSI-2, designed for fast and wide
Single ended or differential

Read and Write Formats

Read and write: Mammoth
Read: 8500, 8500c, 8200

Environmental

Operating temperature:
+5°C to +40°C (+41°F to +104°F)
Nonoperating temperature:
-40°C to +60°C (–40°F to +140°F)
Relative humidity (noncondensing):
20% to 80%

Power

+5 VDC, +12 VDC
15 watts typical

Physical Dimensions

Standard 5.25-inch half-height form factor
1.63 in. (h) x 5.75 in. (w) x 8 in. (d)
(4.14 cm x 14.61 cm x 20.32 cm)
Weight: 3 lbs. (1.36 kg.)

Media

EXATAPE™ 160m advanced metal evaporated

*Compression capacity and throughput will vary dependent upon type of data

Exabyte Corporation
1685 38th Street
Boulder, Colorado 80301
Phone (800) EXABYTE
Fax (303) 447-7501

1994 Exabyte Corporation

TX42E
RX42E

HYPERSCAN Digital Picture Transmission System

Data Sheet

HyperScan is a quantum leap in long distance picture transmission technology. Unlike today's slow-scan television systems, this PC based system uses advanced digital technology and proprietary Robot algorithms to achieve very high quality B/W picture transmission over a variety of communication media. Practical media include ordinary voice grade telephone lines, cellular links and the Integrated Services Digital Network (ISDN). Picture updates may be transmitted worldwide over these media with virtually no loss in as little as a fraction of one second. With an end user cost of less than $8,500.00 (USD) for a basic system, HyperScan is the new standard for all long distance management, surveillance and visual communication applications.

The system is available as a fully integrated turnkey package consisting of a PC based RX42 Receiver and one or more TX42 Transmitter/modem pairs. The compact, lightweight transmitter accepts video inputs from up to 4 standard television cameras. A selected input is digitized into a 512 X 480 pixel array, then transmitted by means of high speed error correcting modems to the PC where it is displayed on a SuperVGA monitor. Picture transmission may be initiated by the user or an alarm at the camera site.

Proprietary software converts the PC to the system's digital picture receiver and control console. Features include high resolution, non-interlaced picture display, pull down menus, and easy "point and click" mouse control of system setup and operation. Sequential full screen, quad (2X2) and hex (4X4) picture display formats are user selectable for maximum viewing flexibility in each application. And, documentation has never been easier. The system's high quality images may be saved to hard disk for pixel perfect re-display at any time, or optionally, transfer to a VCR or video printer.

HyperScan... the new high definition picture transmission technology that takes the "slow" out of slow-scan

Features

- Transmission over ordinary telephone lines, cellular links or the Integrated Services Digital Network (ISDN).
- Turnkey packaging for total component capatibility and ease of setup.
- A high performance 486SX, 33 MHz PC platform with open ended architecture for future expansion and enhancements.
- High definition 512 X 480 pixel, full screen picture transmission typically in 1 to 6 seconds with virtually no loss. Typical quad and hex picture transmission in one second or less.
- Four camera inputs with a single TX42 Transmitter, up to 16 inputs with optional EX40 4-camera Expansion Modules.
- One alarm input for each camera input. Auto-dialup of the Receiver upon alarm.
- Save image to hard disk functions including none, all or alarm activated. Optional video output for use with a VCR or printer.
- A special display screen and pull down menus for all setup and control functions. Simple "point and click" mouse operation
- Talk back capability with optional TB40 Digital Audio Module.
- Remote Device Control capability with RC40 4-channel Relay Unit

TX42E
RX42E

Technical Specifications

TX42E 4-CAMERA TRANSMITTER/COMPANION MODEM

Video Standard	EIA: 525 lines, 60 fields/second CCIR: 625 lines, 50 fields/second
Video Inputs	(4): 1.0 V p-p, differential, softset 75 ohms/ HIZ, BNC
Video Output	1.0 V p-p, 75 ohms, BNC
Data Output	RS232 serial data, DB9S
Digital Memory	512 X 480 pixels full screen picture 256 X 240 pixels quad picture 128 X 120 pixels hex picture
Update Rate	With dynamic compression: 1 - 6 seconds full screen picture 0.5 - 2 seconds quad picture
Grey Scale	64 shades of grey
Alarm Inputs	(4): Dry contact closure or TTL active low
Alarm Output	TTL compatible active low
Operating Power	250 MA at 12 VDC
Ambient Temperature	40° to 104° F (5° to 40° C)
Construction	Anodized extruded aluminum
CCITT Modem	V.32bis (14.4 Kbaud), V.42 error control

RX42E RECEIVER - INTEGRATED, CONFIGURED, TESTED

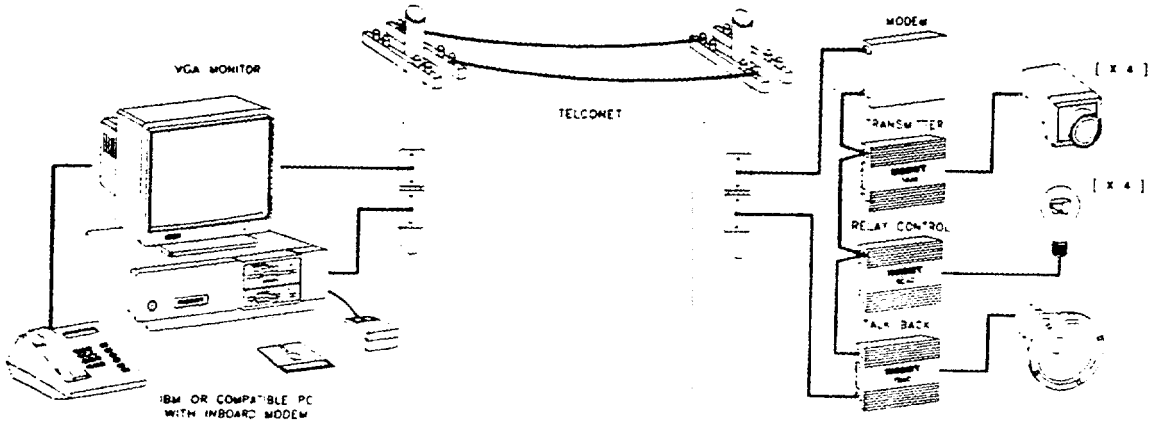
486SX, 33 Mhz platform or better
8 MB random access memory
120 MB fixed disk drive or better*
3.5" floppy disk drive
Internal modem: V.32bis (14.4 Kbaud)
Enchanced keyboard
Mouse pointer
SuperVGA monitor, 0.28 dot pitch
RX40E2.0 software with MS DOS-6

*Image Storage: Approximately 10Mb per hour upper limit while viewing high activity

TX40 Transmitter

WEIGHT	DIMENSIONS	POWER
1.25 lbs (0.6 kg)	5"H X 8"W X 1.25"D 127mm X 203mm X 32mm	3 Watts

Specifications subject to change without notice ©1993 USA



Another Robot Integrated Video Component ROBOT

ROBOT RESEARCH INC
619 279-9430
800 854-2057
5636 Ruffin Road
San Diego California
FAX 619 279-7931

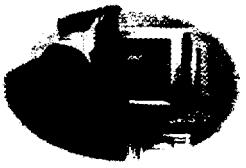
HYPERSCAN ULTRA

THE PERSISTENCE OF VISION

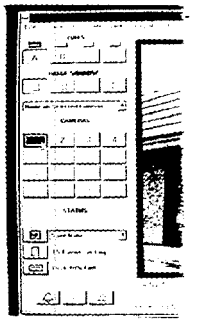
ROBOT

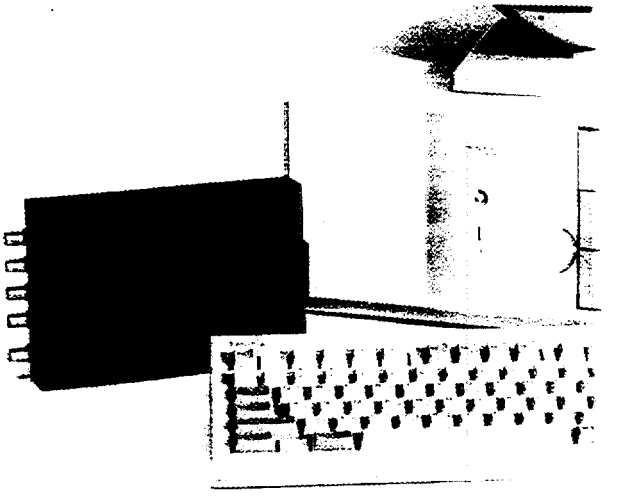
PERSISTENCE OF VISION

It's real simple. Nothing beats HyperScan Ultra for cost-effective, high-performance, long-distance Tru-color picture transmission. ☐ In just seconds, HyperScan Ultra can link you to remote sites around the world or right next door – all by using ordinary voice grade telephone lines or the new "communications super highway" ISDN lines. ☐ And HyperScan Ultra puts you in complete control. Besides visual communications, HyperScan Ultra provides audio and complete camera and device operation. So you can speak to personnel, pan, tilt and zoom



all cameras, and control locks, lights, and alarms simply and easily from one central location anywhere in the world. ☐ The system even enables you to display images from four entirely different transmitter sites at one time. ☐ Plus simple, ultra-advanced





RECEIVERS	RX475	RX470
PIXEL RESOLUTION	512 x 448/FULL HIGH-RES, 256 x 224/QUAD, OR FULL MID-RES, 128 x 112/HEX, OR FULL LOW-RES	512 x 448/FULL HIGH-RES, 256 x 224/QUAD, OR FULL MID-RES, 128 x 112/HEX, OR FULL LOW-RES
COLOR/B/W	16 MILLION COLORS DISPLAYED	16 MILLION COLORS DISPLAYED
TYPE OF REFRESH	CONDITIONAL OR FULL FRAME	CONDITIONAL OR FULL FRAME
UPDATE SPEED – PSTN	1 TO 2 SECONDS/FRAME (HIGH-RES)	1 TO 2 SECONDS/FRAME (HIGH-RES)
UPDATE SPEED – ISDN	1 TO 5 FRAMES/SECOND (HIGH-RES)	1 TO 5 FRAMES/SECOND (HIGH-RES)
DISPLAY MODES	VIEW 1, PIP 4, OR 16 IMAGES	VIEW 1, PIP 4, OR 16 IMAGES
NUMBER OF TRANSMITTER LOCATIONS ON SCREEN AT ONE TIME	1	UP TO 4
IMAGE ENHANCEMENTS	YES	YES
PTZ	YES	YES
IMAGE STORAGE OPTIONS	NONE, ALL, OR ALARM ONLY	NONE, ALL, OR ALARM ONLY
IMAGE RECORDING SPACE	10MB PER HOUR IN HIGH ACTIVITY	10MB PER HOUR IN HIGH ACTIVITY
IMAGE OUTPUT	PIXEL PERFECT	PIXEL PERFECT
REPORTING CAPABILITY	PRINTER, FAX, OR VCR (WITH VCR ADAPTER)	PRINTER, FAX, OR VCR (WITH VCR ADAPTER)
DEVICE CONTROL	YES	YES
AUDIO	WITH DI45 OR TB40 MODULES	WITH DI45 OR TB40 MODULES
ONLINE HELP	YES	YES
EX45 TRANSMITTER		
CAMERA INPUTS	4, EXPANDABLE TO 16 WITH EX45 MODULE	4, EXPANDABLE TO 16 WITH EX45 MODULE
MODEM	EXTERNAL 28.8 KBAUD	EXTERNAL 28.8 KBAUD
DATA OUTPUT	RS232 SERIAL DATA, DB9S	RS232 SERIAL DATA, DB9S
DIGITAL MEMORY	512 x 448/ FULL, 256 x 224/QUAD, 128 x 112/HEX	512 x 448/ FULL, 256 x 224/QUAD, 128 x 112/HEX
ALARM INPUTS	4, EXPANDABLE TO 16 WITH EX45 MODULE	4, EXPANDABLE TO 16 WITH EX45 MODULE

picture management and image enhancement are now just quick mouse clicks away. With its Windows™-based operation, you can organize recorded images by transmitter site, camera, time, date or alarm event. Then enlarge and enhance any picture area for more exact identification. Even add your own notes to pictures and fax them to remote security authorities. ☐ All of which makes HyperScan Ultra the perfect solution for banks, transportation departments, utilities, and convenience, retail, and franchise stores. ☐ As for savings, HyperScan Ultra now offers you Tru-color picture transmission at the price you used to pay for black-and-white. ☐ Ultra powerful PC performance. Unparalleled control. And outstanding value. All from HyperScan Ultra, the Tru-color transmission system that brings you the world.

- *Multiple full screen updates per second in 512 x 448 pixel Tru-color.*
- *Transmits over ordinary telephone lines or the Integrated Services Digital Network (ISDN).*
- *Communicates over a single link or four links at once.*
- *Video, audio, device and camera control over one line.*
- *Enlarges and enhances any picture area using off-the-shelf image processing software.*
- *Allows annotation of recorded pictures.*
- *Transmits recorded pictures and annotations to fax machines and other HyperScan Ultra receivers.*
- *High-performance, PC-based operations, with open-ended architecture for inexpensive system expansion and software upgrades.*
- *Upgrades black-and-white HyperScan systems to HyperScan Ultra via inexpensive update disk and kit.*
- *Four camera inputs with a single transmitter, up to 16 inputs with optional expansion modules.*
- *One alarm input for each camera input. Auto-dial up of receiver upon alarm.*
- *Simple pull-down menus, help screens and point-and-click mouse operations.*
- *See matrix for specific features.*

TX45-CAMERA TRANSMITTER/COMPANION MODEM

VIDEO STANDARD
EIA: 525 LINES, 60 FIELDS/SECOND
CCIR: 625 LINES, 50 FIELDS/SECOND

VIDEO INPUT
4: 1.0 V P-P, SOFTSET 75 OHMS/Hi-Z, BNC

LOCAL VIDEO OUTPUT
1.0 V P-P, 75 OHMS, BNC

DATA OUTPUT
RS232 SERIAL DATA, DB9S

DIGITAL MEMORY
512 x 448 PIXELS FULL SCREEN PICTURE
256 x 224 PIXELS QUAD PICTURE
128 x 112 PIXELS HEX PICTURE

UPDATE RATE
WITH DYNAMIC COMPRESSION:
1 – 3 SECONDS FULL SCREEN PICTURE (PSTN)
0.5 – 1 SECONDS QUAD PICTURE (PSTN)
MULTIPLE FRAMES PER SECOND (ISDN)

GREY SCALE/COLOR PALETTE
64 SHADES OF GREY
18 BIT COLOR

ALARM INPUT
4: PROGRAMMABLE-ACTIVE LOW, ACTIVE HIGH

ALARM OUTPUT
4: PROGRAMMABLE-ACTIVE LOW, ACTIVE HIGH

OPERATING POWER
250 MA AT 12 VDC

AMBIENT TEMPERATURE
40° TO 104°F (5° TO 40°C)

CONSTRUCTION
ANODIZED EXTRUDED ALUMINUM

CCITT MODEM
V.34 (28.8 KBAUD), NULL MODEM TO 115 KBAUD,
ISDN – 56 KBAUD OR 115 KBAUD

HYPERSCAN ULTRA RECEIVERS – INTEGRATED, CONFIGURED, TESTED

486SX, 33MHZ PLATFORM OR BETTER

8MB RANDOM ACCESS MEMORY

170MB FIXED DISK DRIVE OR BETTER*

3.5" FLOPPY DISK DRIVE

ENHANCED KEYBOARD

MOUSE POINTER

SUPERVGA MONITOR, 0.28 DOT PITCH

RX45 1.0 SOFTWARE WITH MS DOS V6.2

RECEIVER MODEM
1MB VIDEO RAM CHIP
RX47S 1: V.34 (28.8 KBAUD)
RX47Q 4: V.34 (28.8 KBAUD)

*Image Storage: Approximately 10MB per hour upper limit while viewing high activity.

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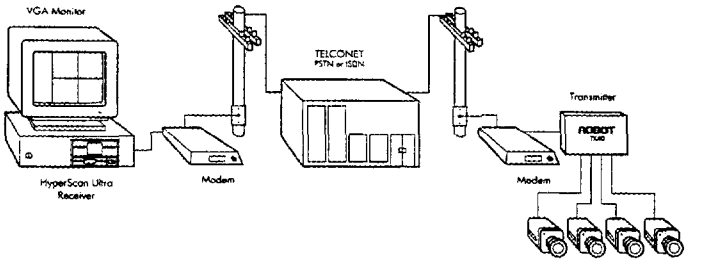
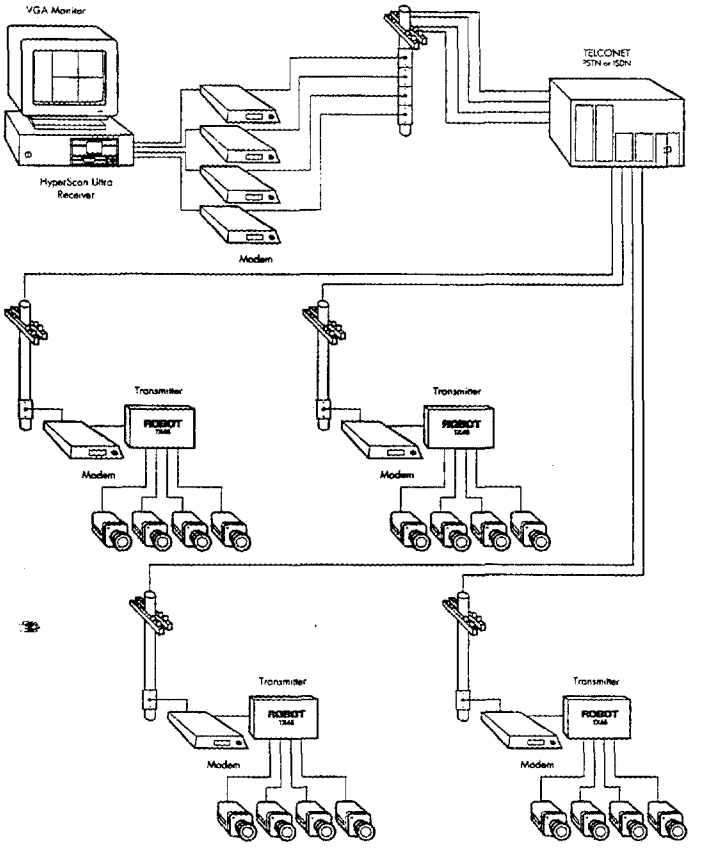


SINGLE COMMUNICATION LINK: RX47S RECEIVER



FOUR COMMUNICATION LINKS: RX47Q RECEIVER

MODEL	WEIGHT	DIMENSIONS	POWER
TX45	1.25 LBS. (0.6 KG.)	5"H X 8"W X 1.25"D (127MM X 203MM X 32MM)	3 WATTS

ROBOT
PERSISTENCE OF VISION

5636 RUFFIN ROAD, SAN DIEGO, CA 92123 • 619/279-9430 • 800/854-2057

APPENDIX V: COST ESTIMATE FOR THE DEVELOPMENT OF THE LATERAL POSITION LANE TRACKING SYSTEM

Williamson Associates

WILLIAMSON ASSOCIATES

Consultants AFOT

Specializing in design and development of prototype systems

6613 Lynndale Drive
Raleigh, NC 27612
1-919-848-3618

Mr. Dick Carter, Manager
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6360

March 4, 1994

RE: Lane Tracker

FAX: to Mr. Dick Carter, ORNL
Fax: 1-615-574-7860
Voice: 1-615-5746454

Dear Dick,

Here is the information you requested.

Pricing

- First advance payment: $ 37,500.00
- Intermediate payment: $ 10,000.00 (est.) hardware costs for eight (8) systems
- Final payment: $ 27,500.00 (est.) ($ 37,500.00 (-) $ 10,000.00)

+

- Total cost: $ 75,000.00
- Additional Costs: Extra systems: $ 1,800.00 each (est.) (1 - 9)
  $ 1,200.00 each (est.)(10 -24)

Deliverables:

1.. One (1) working prototype (bread board) for testing by ORNL. To be delivered after first advance payment and before intermediate payment.

2.. Eight (8) fully functional systems. To be delivered after intermediate payment and before final payment.

System Description:

Hardware:
A system consists of: one lens, one sensor, one controller, one LASER, two housings, and one interconnect kit (necessary cables and connectors).

Software:
The software will be writen in C or C+, and will be a core program (or programs) sufficient to operate and test the system. Also, this "core program" should be of sufficient robustness, as to be used as the core of ensuing applications (to be created by the customer),however, no guarantee is made for this.

Dick, if you need clarification on any of the above, or additional info please call.

APPENDIX W: TECHNICAL DOCUMENTATION ON THE TEST PLANNING, ANALYSIS, AND EVALUATION SYSTEM

Calspan Corporation

PERFORMANCE ASSESSMENT AND WORKLOAD EVALUATION SYSTEM

A critical aim of flight testing for piloted aircraft is to assess the operability of the crewstation and the adequacy of its design to enhance the aircrew's ability to meet mission objectives. Currently, there is no standard process to be used for that important aspect of flight test. This leads to a variety of different metrics and procedures being employed, which results in lack of commonality of procedures being used among test beds, programs and systems. Data from one set of flight tests are often not directly comparable to those of another, leading to duplication of effort and a lack of efficiency in evaluations.

The Performance Assessment and Workload Evaluation System (PAWES) effort is developing and demonstrating a proof-of-concept system for planning crewstations flight evaluations, preparing flight test materials, processing flight test data, and reporting crewstation evaluation results in a timely and responsive manner. PAWES includes a structured process, a set of structured test procedures, and a set of comparable measures. This effort is demonstrating test support tools for a variety of flight test users to facilitate an objective evaluation of the cockpit in terms of operational measures, aircrew performance, workload, situational awareness, system performance, aircrew accommodation and safety of flight.

Also under development are additional capabilities within PAWES to support cockpit evaluations during ground-based engineering flight simulation and during Operational Test and Evaluation (OT&E). These additional capabilities will broaden the PAWES customer base to include industry, SPOs, the Air Force R&D Laboratories, the Operational MAJCOMS and the Air Force Operational Test and Evaluation Center (AFOTEC). The simulation procedures will facilitate data exchange between ground-based simulation activities (that take place during the design phase) and the actual flight test. The AFOTEC specific procedures will provide structure during operational testing of crewstations and again, will help provide continuity between developmental and operational testing.

The PAWES development will provide the test community with a core capability to perform structured crewstation evaluations as normal test practice, including use of objective measures for crewstation evaluation, while establishing connectivity between flight test and ground simulation databases. PAWES represents an essentially new capability for the efficient evaluation and technical communication of flight test results to engineers, researchers, and managers.

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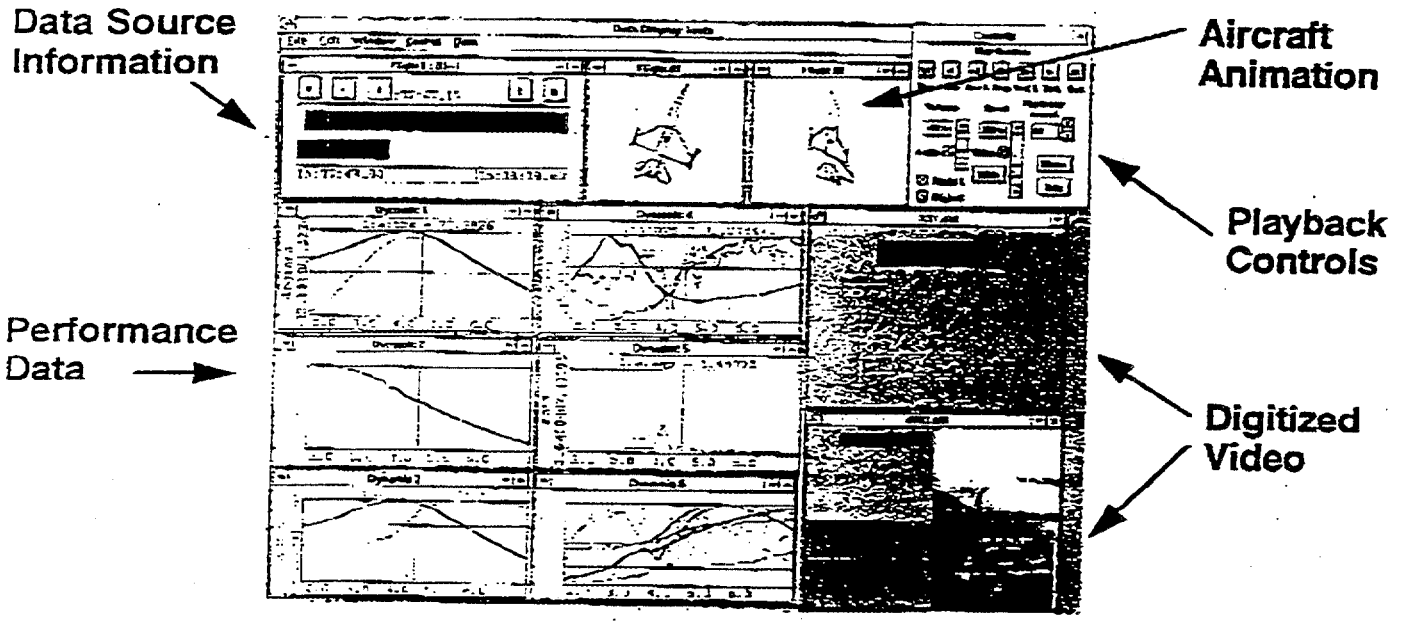
PAWES

PERFORMANCE ASSESSMENT AND WORKLOAD EVALUATION SYSTEM

System to help perform crewstation evaluations during flight test

- Structured Crewstation Evaluation Process
- Structured Test Procedures (STPs)
- Comparable Measures Database
- Computer Tools
  - Data Analysis
  - Card Catalogue
  - Lessons Learned Database
  - Statistics Package
  - Dictionary
  - Safety Database
  - Adaptive Questionnaire
  - Process Help



APPENDIX X: SYSTEM ENGINEERING AND SOFTWARE DEVELOPMENT REQUIREMENTS FOR THE DATA ACQUISITION SYSTEM

Development of a Portable Driver Performance Data Acquisition System for Human Factors Research
(Funding Document DTNH22-92-X-07453)

PHASE 1, TASK 5 - INTERIM AND FINAL LETTER REPORT
Identify System Engineering and Software Development Requirements for Phase II Development of the In-Vehicle Data Acquisition System

Prepared for :

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January 1994

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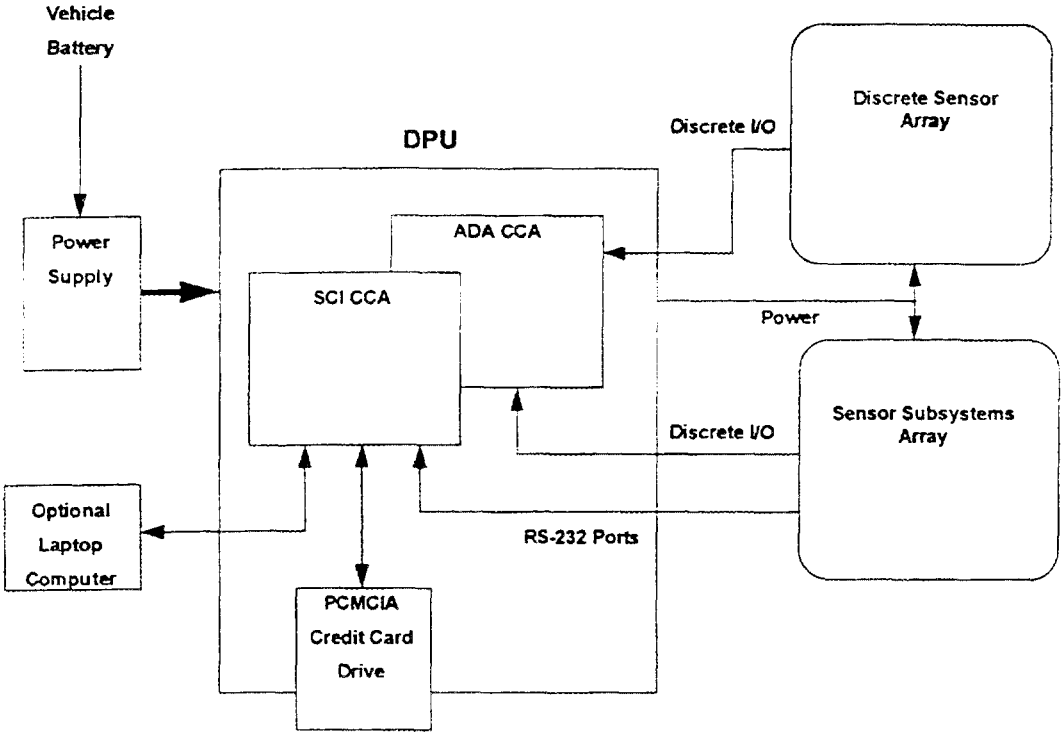
1.0 Scope

The Cognitive Systems and Human Factors Group in the Engineering Physics and Mathematics Division at Oak Ridge National Laboratory (ORNL) is conducting a research program for the National Highway Traffic Safety Administration. The purpose of the effort is to develop a portable data acquisition system that will allow driver performance data to be collected using a variety of vehicle types and that would be capable of being installed on a given vehicle type within a relatively short period of time.

This document defines the System Engineering Requirements and related Software development required to support the design and integration of the DASCAR system. The level of detail contained in this document will be sufficient for a third party to perform the System Engineering effort. Rough Order of Magnitude (ROM) costing information for the effort has been included.

2.0 System Overview

The Data Acquisition System for Crash Avoidance Research (DASCAR) will consist of four major components: 1) Sensor Suite; 2) Data Processing Unit (DPU); 3) Data Storage/Transmission Module; 4) Power Supply. This system is described in Figure 1 below.



3.0 Referenced Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

3.1 Oak Ridge National Laboratory Documents

Development of a Portable Driver Performance Data Acquisition System for Human Factors Research, Phase 1, Task 4 - Interim Letter Report September 1993

3.2 Scientific Atlanta Publications

ISO 9001 Signal Processing Systems Quality Policy Manual

Signal Processing Systems Software Standards and Practices for the Software Development Process, Document No. SSPMAIN

4.0 System Requirements Overview

This section provides an overview of the system requirements based upon the data acquisition parameters identified to date. In general, the Scientific Atlanta DPU provides broad capacity for data acquistion growth beyond that defined in the current Sensor Suite.

4.1 Sensor Suite

The following paragraphs define the Sensor Suite in terms of known system requirements. Table 4.1 documents the currently defined Sensor List.

4.1.1 Vehicle Parameters

The Vehicle Parameter set defines the current operational condition of the vehicle. In general these parameters require the highest data acquisition sampling rates, and the largest data storage requirements of all those monitored by DASCAR.

Due to the technical complexity of measuring these parameters the devices utilized tend to be in the form of a subsystem, or module. Actual data collection by the DPU is accomplished via a digital serial data stream. To allow for the expansion, or modification of the modules used to measure the vehicle parameters the Motorola MVME-162 Circuit Card Assembly (CCA) has been chosen to act as the System Communications Interface (SCI). This assembly allows for expansion via four Industry Pack standard mezzanine CCA's. One Octal Serial RS-232 Industry Pack will be installed on the SCI to interface to the currently specified modules.

To allow for flexibility in tailoring the data storage requirements of the vehicle parameters, the software/firmware of the DPU will support a Sensor Control Table (SCT). This table will contain a field for each DASCAR parameter which allow selection of a storage mode / rate which is independent of the parameters sample rate. Refer to Section 4.3.1.

DASCAR

Sensor List

Parameter	Sensor	Vendor	I/O	Sample Rate	Processing	Storage
VEHICLE						
Acceleration	Motionpack	Systron Donner	Disc	20 Hz	None	16
Distance Traveled	Derived from Vel.	N/A	N/A	Once per Min	Counter	16
Elapsed Time	DPU Clock	N/A	Dig	Once per Min.	Format	32
Heading	Compass Engine	KVH Industries	COM_1	20 Hz	Conversion	16
Headway	Isreal	Isreal	COM_2	20 Hz	Format	16
Lane Keeping	Isreal	Isreal	COM_2	20 Hz	Format	16
Pitch	Motionpack	Systron Donner	Disc	20 Hz	Conversion	16
Tailway	Isreal	Isreal	COM_2	20 Hz	Format	16
Velocity	Hall Effect	AEC	Disc	30 Hz	Calculation	8
Yaw	Motionpack	Systron Donner	Disc	20 Hz	Conversion	16
DRIVER CONTROL						
Throttle	String Pot	UniMeasure	Disc	20 Hz	Conversion	8
Brake Pedal	Strain Gauge	Data Instruments	Disc	20 Hx	Conversion	8
Steering	String Pot	UniMeasure	Disc	20 Hz	Conversion	8
Time: Accl->Brake	Derived	N/A	N/A	20 Hz	Counter	8
EQUIPMENT						
Telephone	Mic on Handset	N/A	Disc	1 Hz	Conversion	1
Cruise Control	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Hand Location	Video	N/A	N/A	N/A	N/A	N/A
Horn	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Seat Belt	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Turn Signals	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	2
IVHS Devices	Digital Comm Port	N/A	COM_3	1 Hz	Conversion	1
Headlights	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Heater/AC	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Parking Lights	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Audio Devices	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Rear Defog/Wpr	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1
Front Wpr/Wash	Sensor/V.B.	N/A	Disc	1 Hz	Conversion	1

Table 4.1,1

DASCAR

Sensor List

Parameter	Sensor	Vendor	I/O	Sample Rate	Processing	Storage
ENVIRONMENTAL						
Ambient Illum.	Video	N/A	N/A	N/A	N/A	N/A
Contrast	Video	N/A	N/A	N/A	N/A	N/A
Glare	Video	N/A	N/A	N/A	N/A	N/A
Noise	Audio	N/A	N/A	N/A	N/A	N/A
Precipitation	Unknown	Unknown	Unknown	1 Hz	Unknown	Unknown
Road Gradient	Unknown	Unknown	Unknown	1 Hz	Unknown	Unknown
Wind Conditions	Unknown	Unknown	Unknown	1 Hz	Unknown	Unknown
PHYSIOLOGICAL						
Fidget Index	Video	N/A	N/A	N/A	N/A	N/A
Head Movement	Video	N/A	N/A	N/A	N/A	N/A
Blood Pressure	BioSensor	UFI	Disc	2 Hz	Conversion	8
Body Temp.	BioSensor	UFI	Disc	2 Hz	Conversion	8
EEG	BioSensor	UFI	Disc	5 Hz	Conversion	8
EMG	BioSensor	UFI	Disc	5 Hz	Conversion	8
EOG	BioSensor	UFI	Disc	5 Hz	Conversion	8
GSR	BioSensor	UFI	Disc	5 Hz	Conversion	8
ECG	BioSensor	UFI	Disc	5 Hz	Conversion	8
Respiration	BioSensor	UFI	Disc	5 Hz	Conversion	8
Skin Temp.	BioSensor	UFI	Disc	2 Hz	Conversion	8

Table 4.1,2

4.1.2 Driver Control Parameters

The Driver Control Parameters measure and store the physical activity of the mechanical driver controls. Implementing a sensor, string pot or strain gauge, to measure these parameters will require system and mechanical engineering attention towards sensor sensitivity and installation complexity. A prime factor effecting the complexity of the installation is the necessity to insure that the physical mounting is non-obtrusive. At time of installation, test will be required to verify sensor sensitivity and physical stress conditions.

Given that the driver control parameters are accurately measured, a number of derived parameters can be calculated. To simplify, and later expand these calculations, all processing shall be performed "Post Real-Time" by the Data Compression / On-Board MMI Laptop computer.

4.1.3 Equipment Parameters

The Equipment Parameters monitor aspects of the vehicle controlled by the driver, which do not effect the motion of the vehicle. These parameters are in general ON/OFF signals. While it is possible to monitor each of the parameters with discrete sensors, it will be much more efficient to access the information via the vehicle's main system control computer. At present specifications on the this computer system are not available and it is proposed that tasking be assigned to address the development of an interface/interface specification for the vehicle main control computer/data bus.

If discrete sensors must be utilized to access equipment parameters, a separate system / mechanical engineering task is required to determine sensor points, voltages, cable routing, and any required signal conditioning for the DASCAR vehicle.

4.1.4 Environmental Parameters

The Environment Parameters will be in general monitored by video surveillance. If the addition of temperature, humidity, and wind sensors is required the DPU is fitted with more than sufficient spare input ports to accommodate them.

Storage of video data can be accomplished via a variety of methods. These include analog tape storage (an adaptation of systems utilized by state law enforcement), video MPEG encoding/compression storage to disk, and RF transmission to a base station along with analog tape storage. In all scenarios the DPU will have the capabilities to control the video storage subsystem. Due to the large data rates required for video storage the DPU will not be required to store video data via it's functional components.

4.1.5 Physiological Parameters

The Physiological Parameters monitor the physical condition of the driver. While some of these parameters may be monitored by the video system, the majority is monitored via biological sensors. Given that all of the currently identified parameters can be monitored in a non-obtrusive manner, attention must be paid to the signal conditioning requirements of each parameter. Vendor supplied condition units can support all of the parameters and it is assumed that the DPU will accept a voltage of sufficient maximum and minimum levels for sampling and storage of physiological parameters.

4.2 Data Acquisition Platform Requirements

Data acquisition requirements shall be supported by the Analog Data Acquisition (ADA) CCA and the System Communications Interface (SCI) CCA. All analog inputs will be handled by the ADA,

all digital serial inputs shall be handled by the SCI. Given the number of analog inputs supported by the ADA, and the two spare Industry Pack mezzanine boards of the SCI, a great deal of expansion capabilities is supported by the DPU.

4.2.1 Analog Data Acquisition CCA

The ADA CCA consists of nine major components: the Central Processing Interface, the Discrete Input Interface, the Discrete Output Interface, the Differential Analog Interface, the Pulse/Speed interface, the Synchro/Digital Interface, the Air Pressure Interface, and the Small Computer System Interface (SCSI). A block diagram of the ADA CCA is given in figure 3.

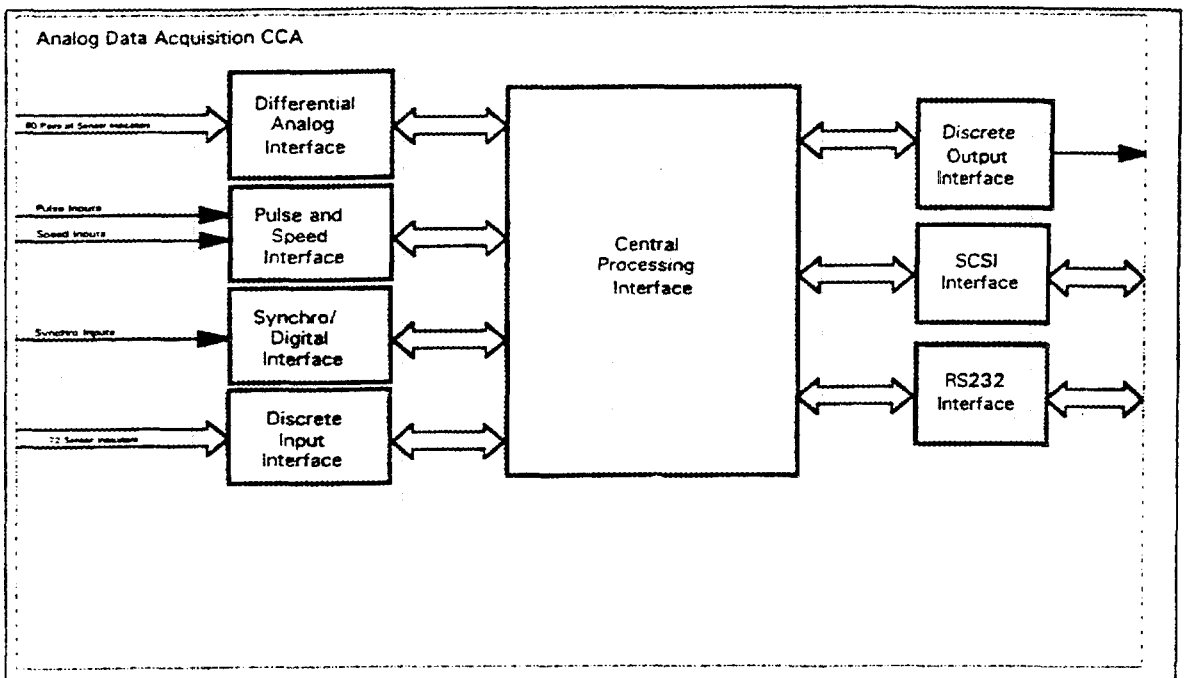


Figure 3. Analog Data Aquisition (ADA) Block Diagram

4.2.1.1 Central Processing Interface

The Central Processing Interface is the heart of the ADA CCA. The Central Processing Interface accesses the other seven major interfaces to monitor the various input signals.

The Central Processing Interface is built around a Motorola 16.78 MHz 68332 microprocessor. The 68332 is based on the 32 bit 68020 Central Processing Unit (CPU) but also includes a versatile Time Processor Unit (TPU) that can perform various time, period, and frequency measurements on up to 16 separate signals. The 68332 includes logic, such as programmable chip selects, that eliminates much of the glue logic typical of microcomputer designs. The Central Processing Interface also consists of 256 KB of fast static RAM, 256 KB of Flash memory, and an RS-232C serial port. Both the fast static RAM and the Flash memory will be expandable to 1 MB on the ADA CCA. This upgrade shall be accomplished by replacing the original device with device that have 4 times the capacity and a solderable jumper configuration if necessary. The asynchronous serial port is built into the 68332. A debug/monitor program, Motorola CPU32BUG, is also present in on-board PROM and can be used to perform low-level debugging and monitoring of the ADA CCA. The CPU32BUG is present on a 128 KB PROM, only 50 % of the PROM is used by the debugger program and 50 % is usable by the ADA

system operating system. A reset switch, a software abort switch, eight programmable LEDs, along with a RUN LED and a HALT LED, are also present to aid in debugging. An 8 position DIP switch, readable by the 68332, is also present to allow configuration options.

4.2.1.2 Discrete Input Interface

The Discrete Input Interface receives 72 single-ended discrete DC analog signals from equipment external to the DPU and performs gain control and analog-to-digital conversion on the analog signals. The data is then made available to the Central Processing Interface.

Each of the 72 single-ended signals is received by a high-impedance receiver capable of receiving 0 V to +28 V peak signals. Each receiver output feeds an input to an analog multiplexer. The outputs of the analog multiplexers feed a programmable gain amplifier (PGA). The output of the PGA feeds a 12 bit Analog to Digital Converter (ADC) whose output feeds a 4K deep FIFO. An interrupt can be generated to the Central Processing Interface after every FIFO write or when the FIFO becomes half-full. Optionally, the FIFO can be polled to check for any words present in the FIFO. The Central Processing Interface can directly read the contents of the FIFO.

The Discrete Analog Interface is completely programmable including sampling order, sampling rate, gain control, and channel enable/disable control. The Discrete Analog Interface can perform a maximum of 4000 total samples per second in any combination across the 72 single-ended analog channels. For example, all 72 single-ended analog signals can each be sampled at a maximum of a 50 Hz rate or only 1 analog signal can be sampled—with all other channels disabled—at a maximum of a 4000 Hz rate. The minimum sample rate of a single-ended analog input is 0.25 Hz. The order that channels are sampled is programmable as is the gain control—either 1, 2, 4, 8, 16, 32, 64, 128, or 256 for each channel. The parameters for each channel are stored in a control RAM. The Discrete Analog Interface includes 20 constant-current diodes that can be used for sensor biasing.

Two adjacent single-ended channels can be programmed via the control RAM to act as one 0 V peak to +28 V peak differential analog channel. Sampling order, sampling rate, and gain control of these differential analog channels are also programmable as per the single-ended channels. All 72 single-ended channels can be programmed for differential mode giving a total of 36 differential channels. These 36 differential channels are completely independent of the 80 differential channels contained in the Differential Analog Interface described in section 3.1.4.

4.2.1.3 Discrete Output Interface

The Discrete Output Interface receives parallel data from the Central Processing Interface. The parallel data received represents static DC control signals used to control equipment external to the DPU. The Discrete Output Interface consists of a read/write register and a high-current driver that are used to send static DC control signals to external equipment.

4.2.1.4 Differential Analog Interface

The Differential Analog Interface receives 80 differential analog signals from equipment/sensors external to the DPU and performs low-pass filtering, gain control, and analog-to-digital conversion on the analog signals. The data is then made available to the Central Processing Interface.

Each of the 80 differential signals are received by a high-impedance receiver. Each receiver output feeds a low-pass RC filter and is input to an analog multiplexer. The outputs of the analog multiplexers feed a differential receiver whose output feeds a programmable gain amplifier (PGA). The output of the PGA feeds a 12 bit Analog to Digital Converter (ADC) whose output feeds a 4K deep FIFO. An interrupt can be generated to the Central Processing Interface after every FIFO write or when the FIFO becomes half-full. Optionally, the FIFO can be polled to check for any words present in the FIFO. The Central Processing Interface can directly read the contents of the FIFO.

The Differential Analog Interface is completely programmable including sampling order, sampling rate, gain control, and channel enable/disable control. The Differential Analog Interface can perform a maximum of 8000 total samples per second in any combination across the 80 differential analog channels. For example, all 80 differential analog signals can each be sampled at a maximum of a 100 Hz rate or only 1 analog signal can be sampled—with all other channels disabled—at a maximum of an 8000 Hz rate. In addition, the order that channels are sampled is programmable as is the gain control—either 1, 2, 4, 8, or 16—for each channel. The parameters for each channel are stored in a control RAM.

4.2.1.5 Pulse/Speed Interface

The Pulse/Speed Interface receives up to 10 pulse/speed inputs and formats the input signals for measurement by the Central Processing Interface. The interface is capable of recognizing frequencies from 1 Hz to 16 KHz. The pulse/speed inputs are received by dedicated receiver ICs and then fed directly to the 68332 microprocessor.

4.2.1.6 Synchro/Digital Interface

The Synchro/Digital Interface receives up to 3 synchros and a reference input and then calculates the phase offset of each synchro against the reference input. Each synchro is a standard 3-wire interface consisting of S1, S2, and S3. The reference signal is a standard 2-wire interface consisting of R1 and R2. All signals are 90 VAC maximum and are reduced to 11 VAC by transformers located inside the DPU but external to the ADA CCA. This prevents high voltage from being input to the ADA CCA and creating a safety hazard. The Synchro/Digital Interface is based on a DDC hybrid module that incorporates monolithic ICs to perform the synchro to digital conversion for all 3 synchro channels. The resolution on all 3 channels is 14 bits.

4.2.1.7 Small Computer System Interface (SCSI)

The Small Computer System Interface or SCSI interface is used to send and receive data to and from other CCAs inside the DPU. The SCSI interface is implemented using the 16 bit fast and wide SCSI-2 standard. Synchronous burst transfer rates up to 20 MB/sec are supported as are asynchronous burst transfer rates up to 10 MB/sec. Active terminators are used on the SCSI-2 bus to improve SCSI-2 signal characteristics. The SCSI-2 interface has the ability to perform DMAs from and to the main ADA CCA memory. The interface is built around the NCR 53C720 SCSI I/O Processor and is software compatible with the NCR 53C710 SCSI I/O Processor used in the FTAS system. The 53C720 can interrupt the 68332 microprocessor or optionally the 68332 can poll the 53C720 for status and error conditions.

4.2.2 System Communications Interface CCA

The System Communications Interface (SCI) CCA will provide a variety of communications interface ports for both the in-vehicle digital sensor subsystems of DASCAR, and for the upload/download of application programs and data to an external computer. In the initial DASCAR prototype system a Commercial Off The Shelf (COTS) CCA, the Motorola MVME162 will be utilized.

4.2.2.1 Motorola MVME162 Overview

The MVME162 MC68040-based embedded controller is designed to provide a powerful and functional CPU which can be reconfigured in an existing application. With the compute power of the MC68040 and the flexibility of the IndustryPack mezzanine interface, the MVME162 bridges the gap between embedded controllers and single board computers by offering versions with increasing levels of functionality up to the single board computer families.

A key feature of the MVME162 is the IndustryPack interface. IndustryPack module provide a wide variety of connections to "real-world" I/O. Expansion is accomplished by means of a mezzanine board mounted to the MVME162. Up to four IndustryPack modules can be installed on the MVME162 and still occupy only one VME slot.

The following list is a summary of the MVME162's functional components :

- 25 MHz MC68LC040 Enhanced 32-Bit Microprocessor with 8KB of Cache and MMU
- Optional 25 MHz MC68040 32-Bit Microprocessor with 8KB of Cache, MMU and FPU
- A32/D64 VMEbus Master/Slave Interface with System Controller Function
- High Performance DMA Supports VMEbus D64 and Local Bus Memory Burst Cycles
- 1 or 4MB of Shared DRAM, with Programmable Parity
- 512KB to 2 MB SRAM with Battery Backup
- 1 MB FLASH Memory for On-Board Monitor/Debugger or User Installed Firmware
- 8K x 8 NVRAM and Time-of-Day Clock with Battery Backup
- Two Serial Communications Ports, console ports as EIA-323-D DTE, Second Port is User Configurable for EIA-232-D/EIA-422 (V.36) DTE/DCE
- Four IndustryPack Ports
- Six 32-bit Timers (Four Without VMEbus) and Watchdog Timer
- Optional SCSI Bus Interface with 32-bit Local Bus Burst DMA
- Optional Ethernet Transceiver Interface with 32-bit Local Bus DMA
- One 32-Pin PLCC EPROM Socket
- 4-Level Requester, 7-Level Interrupter, and 7 Level Interrupt Handler for VMEbus

- Remote RESET/ABORT/STATUS/ Control Functions
- On-board Debugger and Diagnostic Firmware

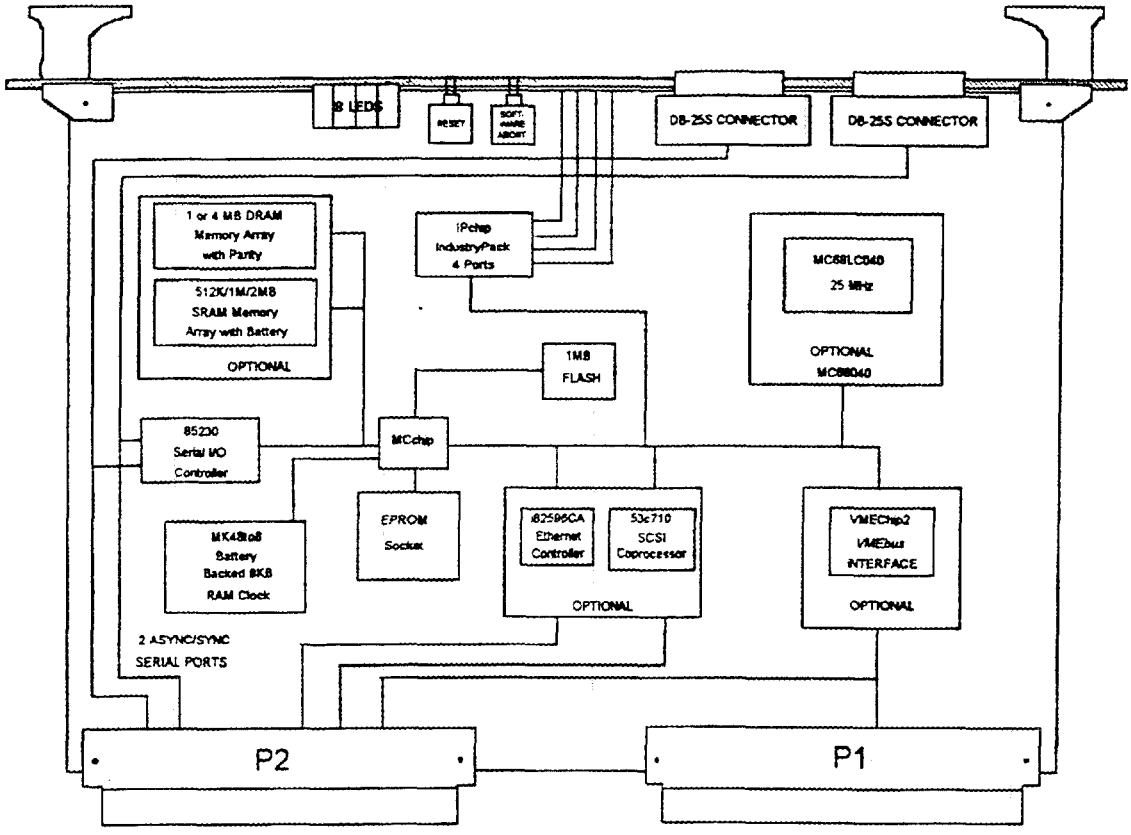


Figure 4.1 SCI CCA BLOCK DIAGRAM

4.3 Data Storage Requirements

The DASCAR system must be able to not only collect data from a wide range of sensors, but also store this data for later retrieval and analysis. Because of the fact that this data is composed of a wide range of formats, sizes, and collection rates, care must be taken to fully quantify and qualify storage requirements. As a further complication, attention must be paid to preserving a "snapshot" of all parameters for a pre defined period of time prior to an actual crash.

In order to provide a flexible, scalable, data storage system, the DPU will be required to accept Sensor Control Table (SCT) from the Data Decompression / On-Board MMI laptop computer. The SCT contains a set of fields for each parameter monitored by DASCAR, which completely specify the sampling, thresholds, data format, and storage requirements of the parameter. The following paragraph defines the required fields of the SCT as currently defined.

Parameter Name 16 character ASCII string representing the parameter name. Used for reference only.

Sample Rate 16 bit integer representing the sample rate in Hz. Sample rates less than 1 Hz are represented as a negative number, indicating the denominator of the fraction.

Gain Input gain to be applied to the signal.

Data Format 16 bit code indicating the output format of the samp
indicate 8 bit integer, 1 indicates 16 bit integer, 2 indicates 32 bit IEE
800X hexadecimal indicates a single ON/OFF bit, formatted in a 16 bit
indicates the bit position.

Maximum Value 16 bit integer representing the ON threshold level.

Minimum Value 16 bit integer representing the OFF threshold level.

Output Mode 16 bit code indicating the method of outputting sampled data. A 0 (zero) indicates output at the Sample Rate, 1 indicates output on change of sampled value, and a 2 indicates output at the Output Rate.

Output Rate 16 bit code indicating the output rate of sampled data.

To accommodate retention of pre crash "snapshot" data storage capability the DPU buffers acquired data in tiers within the CCA's. Analog data sampled by the ADA CCA is buffered in the on board 128 K of battery backed up SRAM. Digital data sampled by the SCI CCA is buffered in it's 512 K of battery backed up SRAM. And all data to be output to either the SCSI storage media, the laptop computer, or the PCMCIA Credit Card is also buffered by the SCI CCA in battery backed SRAM. In the event of a crash, even if the mechanical storage media in use is damaged, up to 20 minutes of pre crash data shall be accessible from the DPU via battery backed up SRAM.

Note that currently active Sensor Control Table (SCT) is continuously stored in non-volatile memory on the DPU. This image is reused as the default SCT on subsequent power up operation of the DPU. This autonomous configuration feature will be applied to all externally controlled settings of the DPU.

4.3.1 Data Rates

The DASCAR system must be capable of storing all monitored parameters at the input sample rate. This criteria determines the worst case storage requirements of the system. Figure 4.3.2.1 documents the storage rate per hour based upon the current Sensor Table, with the originally specified sample rates. Figure 4.3.2.2 documents the storage rate based upon sample rates rounded up to the nearest base two multiple. This second figure represents the most efficient method of implementing multiple sample rates on the ADA CCA. Once the DASCAR system is fielded, data storage rates may be optimized on a per parameter basis.

Sample Rate	Data Size	# of Param	Storage / Hour		
0.016666667	1	128	960		
1	1	16	7200		
1	8	3	10800		
2	8	3	21600		
5	8	6	108000		
20	8	3	216000		
20	16	9	1296000		
30	8	1	108000		
			1768560	for 72 Hr =	**127336320**

Figure 4.3.2.1 Data Storage per Hour in Bytes

Sample Rate	Data Size	# of Param	Storage / Hour		
0.016666667	1	128	960		
1	1	16	7200		
1	8	3	10800		
2	8	3	21600		
8	8	6	172800		
32	8	3	345600		
32	16	9	2073600		
64	8	1	230400		
			2862960	for 72 Hr =	**206133120**

Figure 4.3.2.2 Data Storage per Hour in Bytes, Base 2 Sample Rates

4.3.2 Storage Methods

The DPU shall provide the ability to store acquired data on various forms of storage media. This includes in-vehicle storage devices and external devices accessed over an RF or satellite communications link. To accommodate this requirement all output data samples will be formatted by the SCI software in standard data "packets". The output of data over the RS-232 link to a PCMCIA Credit Card Drive, an RF radio link, or the Data Decompression / On-Board MMI Laptop computer shall all be performed in an identical manner and format by the SCI software. This will also be true of the SCSI interface. The SCI software is required to support a set of software drivers which may be selected at time of configuration, as the active device driver. As is the case for the SCT, the selection of storage device driver is stored in non-volatile memory for automatic configuration on the next power on condition of the DPU.

4.4 Communications Requirements

The DPU of the DASCAR system shall support a variety of communications interfaces. This includes the Proxim telemetry system, the TerraStar-C Satellite Terminal, an RF modem and the Laptop Computer or a cellular telephone-to-landline automatic data transmission. As is the case for the output of sampled data, command and control input to the DPU shall be formatted in a standard "packet". In this way the selection of the communications interface will specify the software driver to be used, and will not affect the main body of the SCI software.

4.5 Power Supply Requirements

The DASCAR Power Supply subsystem shall be required to support the DPU chassis and all of the sensors, and sensor modules of DASCAR. In examining the existing Sensor List it becomes immediately obvious that voltages other than the standard ±12 VDC and ±5 VDC are necessary. The currently proposed approach of utilizing a set of Vicor DC to DC converters, along with a Gell Cell battery for surge protection is appropriate, as long as it is designed in a method which will allow the addition, and interchange of DC to DC converters.

The DPU shall require the supply voltages identified in Table 4.5. Note that power consumption figures are maximum levels and do not indicate typical operating consumption.

Sub-Assembly	Voltages	Power
ADA CCA	+ 5 VDC, ±15 VDC	10 Watts
SCI CCA	+ 5 VDC, ±12 VDC	20 Watts
Serial Port Mezzanine	+ 5 VDC, ±12 VDC	.2 Watts
SCSI Mezzanine	+ 5 VDC, ±12 VDC	.2 Watts

5.0 System Engineering Requirements

The following sections define the top level System Engineering tasks required to support the implementation of a prototype DASCAR system. These tasks include system design engineering efforts and the project engineering efforts.

5.1 Prime Item Development Specification

The initial System Engineering task of DASCAR shall be the creation of a Prime Item Design Specification (PIDS). This document establishes the performance, design development and test requirements for the system. Completion of this document shall signifiy finalization of all system design issues. The document shall be jointly developed between Scientific Atlanta and ORNL.

A major portion of this task shall be the generation of a final Sensor Specification List. This list shall resolve the following issues :

Vehicle Parameters

- Verify all Discrete analog input voltages.
- Determine communication port specifications on the subsystems which output serial data (RS-232, Baud Rate, etc.).
- Verify subsystem power requirements.

Driver Control

- Determine ranges required for the String Pots and Strain Gauge.
- Verify subsystem power requirements.

Equipment

- Finalize Vehicle Bus or direct connection method for each parameter.
- Determine input voltages.

Environmental

- Identify sensors required other than video surveillance.
- Determine the video storage media, and control interface required from the DPU.

Physiological

- Determine if special signal conditioning is required on any of the parameters.
- Determine input voltages.

5.2 Detailed Scheduling

A detailed prototype development schedule shall be jointly generated by ORNL and Scientific Atlanta. All tasks shall be defined with predecessor / successor dependencies so as to accurately present any program slips due to the slip of an individual task. Each task shall be assigned a resource, either Scientific Atlanta or ORNL personal, who shall be responsible for completion of the task. The master schedule shall be updated on a bi-weekly period, and shall be published on the first Monday afternoon of the period. Responsible resources will be required to supply task status on the second Thursday morning of each period. Copies of each period's schedule shall be archived by Scientific Atlanta's Configuration Management Department. The initial schedule shall contain only the top level tasks and milestones. Detailed, low level tasks shall be defined upon completion of the PIDS.

5.3 Sensor Interface Definition

In concurrent development with the PIDS, Scientific Atlanta and ORNL shall generate an Interface Control Document (ICD). This document shall specify the electrical, mechanical, and software interface requirements on a sensor by sensor basis. The accuracy and completeness of this document is essential to the success of the DASCAR program.

5.4 Design Reviews

Throughout the development of the DASCAR prototype a series of design reviews shall be conducted. Upon completion of each review a Summary Report shall be generated and distributed to all participants. All reviews will include sessions on each of the engineering disciplines applied to DASCAR; Systems, Electrical, Software, and Mechanical. The following reviews shall be conducted as part of DASCAR.

Prime Item Design Review (PIDR) The PIDR ensures that the system engineering effort establishes performance, design development and test requirements for the system. The outcome of this review shall be a finalized system architecture which defines each physical subsystem and sensor, and specifies data throughput, data storage, environmental, power, EMI/RFI, and installation goals. Additionally, prototype installation logistics shall be agreed upon during this review. This includes specification of the vehicle manufacturer and model,

Preliminary Design Review (PDR) The PDR ensures that the specified architecture will meet the functional requirements. In addition, it ensures that all documentation generated in the preliminary design phase is accurate and complete according to a predefined checklist. The outcome of this review shall be finalized documents which

include a Drawing Tree, Chassis Assembly Drawing, Cable Harness Assembly Drawing, and Power Subsystem Assembly Drawing. Installation requirements for each sensor and sensor subsystem shall be shall also be defined.

Critical Design Review (CDR) The CDR ensures that the detailed design meets all functional an performance criteria, and that the design is well-documented, testable and manufacturable. A predefined checklist will be used to ensure adequate review coverage. As part of the preparation for this review a detailed inspection of the target vehicle shall be performed so as to fully understand all aspects of the DASCAR installation process.

Test Readiness Review (TRR) / Acceptance Testing (AT) Due to the fact that the initial DASCAR effort is the development of a portable prototype, some degree of incremental testing and design refinements will occur at time of install. To speed this process the TRR and AT will be combined, and will occur during the initial vehicle installation effort.

5.5 EMI/RFI/Thermal Analysis

As part of the system engineering effort analysis shall be conducted on EMI/RFI radiation, and thermal requirements of the DPU. EMI/RFI test results shall be input into mechanical engineering to determine any specialized shielding requirements of the DPU chassis.

Thermal requirements shall be determined jointly between Scientific Atlanta and ORNL. Cooling and heating requirements shall be strongly influenced by the placement of the DPU in the vehicle, and by the anticipated environmental conditions during deployment.. Conclusions shall determine whether specialized fans or heating elements are required for the DPU chassis.

5.6 Testing Management

In support of the Test and Readiness Review a Test Plan (TP) shall be created jointly between Scientific Atlanta and ORNL. This document shall specify the test procedures, test fixtures, testing hierarchy, and acceptance criteria of the DASCAR testing effort. The document must describe an evolutionary testing plan which verifies each component as the DASCAR system is installed.

6.0 Software Engineering Requirements

This section defines the software engineering requirements for the development of a prototype DASCAR system. As is the case for all Scientific Atlanta hardware assemblies utilized in DASCAR, software components shall be "reused" as much as possible form other Scientific Atlanta data acquisition programs.

6.1 Analog Data Acquisition CSCI

The ADA CSCI shall be created by modifying the existing ADA CSCI of the HUMS program. This software performs control of the acquisition circuitry, collection of acquired data, formatting of the data, and transmission to the SCI CCA. Major components of the CSCI are as follows :

CPU32Bug Debug/Monitor program burnt into the PROM device on the ADA. This COTS software is utilized during the software development phase for debugging and monitoring the CSCI. The program will remain resident in all units as a field service aid if required. This program will be used as is for DASCAR.

Board Initialization This portion of the CSCI initializes all hardware components of the ADA, performs power on confidence test, and initiates communications with the SCI CSCI. This portion will be used as is for DASCAR.

Control Ram Module This module supports non-application specific programming of the ADA Control Ram. This requirement is based on the need to alter the sensor suite support as specified in the user interface. This module will be used as is for DASCAR.

SCSI Communications Module This module supports SCSI communications between the ADA and SCI CCA's. The interface is bi-directional, supporting both the "real-time" output of acquired data from the ADA to the SCI, and the downloading of new application code from the SCI to the ADA. This module will be used as is for DASCAR.

Data Acquisition Module This module supports the collection of all acquired data from the input FIFO. It further formats the data in "packets" for output by the SCSI Communications module. This module will have to be reviewed to verify direct application to the DASCAR system.

The majority of the Helicopter Usage Monitoring System (HUMS) ADA CSCI will be reused for DASCAR. Nonetheless, "reuse" does not imply "plug-and-play". This CSCI will require software engineering support to support specific DASCAR requirements during all phases of integration and test, along with the generation of appropriate software documentation.

6.2 System Communications Interface CSCI

The System Communications Interface (SCI) CSCI is responsible for collecting digital sensor data and for communicating all sensor data to either the chosen storage media, or the DDOM CSCI. Major components of the CSCI are as follows :

162Bug Debug/Monitor program burnt into the PROM device on the SCI. This COTS software is utilized during the software development phase for debugging and monitoring the CSCI. The program will remain resident in all units as a field service aid if required. This program will be used as is for DASCAR.

SCSI Communications Module This module supports SCSI communications between the ADA and SCI CCA's. The interface is bi-directional, supporting both the "real-time" output of acquired data from the ADA to the SCI, and the downloading of new application code from the SCI to the ADA. This module will be used as is for DASCAR.

Data Acquisition Module This module supports the collection of all acquired data from the digital serial input ports. Because DASCAR shall utilize specialized sensor modules this software module must be created for DASCAR.

Data Storage Module This module contains the software device drivers required to store acquired data on various forms of media. Currently the DPU utilized for HUMS will support a subset of drivers required for DASCAR (PCMCIA Memory Cards, RS-232 Serial Port). Once new forms of storage are specified for DASCAR, this module must be modified to supply the appropriate support.

System Control Module This module provides the mechanism to control the DPU via the laptop computer. While this module exists in the DPU of HUMS, it must be examined to determine whether it is completely applicable to the DASCAR system.

The majority of the SCI software will be reused from the HUMS program. Any modifications to the software will be predicated on specification of digital output sensor modules, and additional storage media.

6.3 Data Decompression / On-Board MMI CSCI

The Data Decompression / On-Board MMI (DDOM) CSCI is responsible for converting all raw DASCAR sensor data into a format that may be viewed and/or stored for later post processing. This software will be required to run both on a laptop computer in the vehicle, and on a fully configured desktop workstation.

The Data Decompression portion of the CSCI will convert the sampled data "packets" into a processing format suitable for input to a spreadsheet, database, or statistical analysis program. This function shall execute in two modes, post processing mode, in which a raw packet file is read, and a processing formatted file is written, and real time mode, in which data collected real time, in the vehicle is written in processing format to the laptop hard disk.

The On-Board MMI shall allow the operator to control the DPU, and view sampled sensor data in real time. Control of the DPU will primarily consist of creating and downloading the Sensor Control Table from the laptop computer to the SCI software. Note that on power up the SCI software shall autonomously begin execution with the last loaded Sensor Control Table The MMI will additionally display all sensor data in realtime. The software shall be flexible enough to allow follow on addition of statistical analysis in real time.

6.4 Documentation

As part of the software development process under Scientific Atlanta's Software Standards and Practices for the Software Development Process Procedures a number of design documents shall be generated. These documents chronicle the software effort from requirements analysis to detailed design implementation. The format of the documents is in a version of the DOD-STD-2167A standard, tailored for small and/or commercial applications. A version of each document type shall be generated for each of the three DASCAR CSCI's Note that since two of the CSCI's are to be reused from the HUMS, their associated documents shall also be reused. The documents are :

Software Requirements Specification (SRS) The purpose of an SRS is to specify the requirements for the design, implementation and qualification of the CSCI. The document is to be written and approved prior to the initiation of design to ensure common understanding of the requirements .

Interface Requirements Specification (IRS) The purpose of an IRS is to specify the interfaces between CSCI and CSCI and between CSCI and Hardware. Note that sensor interface requirements is a subset of the software interfaces, and will be documented in detail in the ICD.

Software Design Document (SDD) The purpose of an SDD is to document the high level architectural design of the CSCI. Due to the fact that DASCAR is a relatively small, commercial program this document will exist as a "living" document, and shall only be finalize on completion of prototype testing.

6.5 Design Tools

All software developed for the DASCAR program will be written in the C program language, and will be compiled and linked with industry standard tools (Microtec Research, Microsoft C, Ver

7.0). The software development platform shall be an IBM PC compatible. This platform must have the ability to exist as a laptop so as to support field changes and updates.

7.0 Mechanical Engineering Requirements

This section defines the mechanical engineering requirements for the development of a prototype DASCAR system. It must be stressed that this effort is to design and implement a *prototype* system. A output of this task shall be a great deal of knowledge and experience on methods of specifying a production DASCAR system.

7.1 Cable Harness Definition

The DPU chassis and backplane shall accept a removable cable harness which will contain all sensor inputs. The initial harness will be that used in the HUMS program. Upon installation of the prototype system analysis should be performed to determine if this connector system is adequate.

The prototype DASCAR cable harness will be developed as it is built on the vehicle. In this way detailed issues of cable lengths, routing, attachment and portability will be resolved in the most cost effective manner.

7.2 Power Supply Definition

The currently conceived approach of the DASCAR power supply system will accept input 12 VDC from the battery (via a secondary Gell Cell), contain a set of Vicor DC to DC converts, and output a set of voltages which may be reconfigured. The power supply module shall exist as a separate entity from the DPU. Space must be reserved for expansion in the event that addition circuitry is required for surge suppression and/or noise reduction.

7.3 Drawing Package

All cable mechanical assembles created by Scientific Atlanta shall be documented in a Level 1 format drawing package. While the installation and test phase of the DASCAR program is under way, drawings shall be updated to represent the as built condition of the system. Upon completion of this phase the entire drawing package shall be identified as Revision 1, and shall be stored in the Reproduction Department of Scientific Atlanta.

All software generated for the DASCAR prototype shall be maintained using Scientific Atlanta's standard configuration management practices for commercial software development. During the development phase all software shall be backed up on a daily basis, with weekly off site backup. Upon completion of the test and integration phase all source software shall be checked into Scientific Atlanta's Configuration Management Department for regulated version management.

8.0 Costing Breakdown

The following section provides a rough order of magnitude (ROM) breakdown of the cost to execute the system engineering requirements documented above.

DASCAR System Engineering Work Breakdown

Work Center	Task	Estimated Hours	Total
System Engineering / Design Support	Prime Item Development Specification	120	120
	Sensor Interface Definition	80	80
	Design Reviews	4x20	80
	EMI/RFI/Thermal Analysis	80	80
	Power Supply Definition	40	40
	Installation/Test Management	160/2	80
			480
System Software Implementation Support	Analog Data Acquisition CSCI		
	5000 SLOC Reused		
	Design / Code	120	120
	Test / Integration	45x4	180
	SRS, IRS, SDD	40 + 40 + 40	120
	System Communications Interface CSCI		
	5000 SLOC Reused, 1000 SLOC New		
	Design / Code	400	400
	Test / Integration	200	200
	SRS, IRS, SDD	20 + 20 + 40	80
	Data Compression / MMI CSCI		
	2000 SLOC New		
	Design / Code	430	430
	Test / Integration	200	200
	SRS, IRS, SDD	40- + 40 + 80	160
			1890
System Installation Support	Cable harness Definition	120	120
	Machine Shop	40	40
	Technician	120	120
	Components	20	20
	Drafting Package	80	80
			380
			2750

ENAME: DASCAR
OPOSAL NO:
STOMER:
OJECT TITLE: DASCAR

SCIENTIFIC-ATLANTA, INC.
SIGNAL PROCESSING SYSTEMS
COST PRICE BREAKDOWN

27-Jan-94
3:51 PM

Escal Rate: 0.00%
riod of Perf: 3/94 - 12/95
ect Rates: 19-Oct-93 Fwd Price
irect Rates: FY94

ITEM 1
P/N DASCAR System Integration ROM

Quantity 1

st Element	Labor Class	Current Rate	Proposed Rate	Unit Basis Base Hours	Unit Basis Amount	Total Basis Base Hours	Total Basis Amount
RECT LABOR							
ST CENTER 7203 - ENGINEERING							
Staff Engineer	3000	$39.34	$39.34	480.0	$18,883.20	480.0	$18,883.20
Sr Eng/Prg Mngr	3100	$32.50	$32.50	0.0	0.00	0.0	0.00
HW/SW Engineer	3200	$21.43	$21.43	2,010.0	43,074.30	2,010.0	43,074.30
Technician	3300	$18.85	$18.85	120.0	2,262.00	120.0	2,262.00
Drafting/Eng Dsgnr	3400	$17.84	$17.84	80.0	1,427.20	80.0	1,427.20
Mechanical Design	3500	$26.32	$26.32	0.0	0.00	0.0	0.00
Material Analyst	3600	$18.56	$18.56	20.0	371.20	20.0	371.20
Rel/QA/CM Engr	3700	$22.58	$22.58	0.0	0.00	0.0	0.00
HW/SW CM/DM	3800	$19.91	$19.91	0.0	0.00	0.0	0.00
Clerical Support	3900	$11.21	$11.21	0.0	0.00	0.0	0.00
ILS	4000	$29.11	$29.11	0.0	0.00	0.0	0.00
ILS Clerical	4010	$13.89	$13.89	0.0	0.00	0.0	0.00
Tech Pubs Writer	4020	$22.69	$22.69	0.0	0.00	0.0	0.00
TOTAL ENGINEERING LABOR				2,710.0	$66,017.90	2,710.0	$66,017.90
OST CENTER 7202 - MANUFACTURING							
PC Assembly	22000	$9.54	$9.54	0.0	0.00	0.0	0.00
Metal Assembly	23000	$12.42	$12.42	40.0	496.80	40.0	496.80
Final Assembly	24000	$9.82	$9.82	0.0	0.00	0.0	0.00
Test and Checkout	25000	$16.52	$16.52	0.0	0.00	0.0	0.00
Final Inspection	51000	$11.17	$11.17	0.0	0.00	0.0	0.00
TOTAL TOUCH LABOR				40.0	$496.80	40.0	$496.80
Mfg Support (percent Touch Labor)			48.50%		240.95		240.95
TOTAL MANUFACTURING LABOR				40.0	737.75	40.0	737.75
TOTAL DIRECT LABOR				2,750.0	$66,755.65	2,750.0	$66,755.65
ABOR OVERHEAD				Dollars		Dollars	
CC 7203 - ENGINEERING			128.70%	66,017.90	84,965.04	66,017.90	84,965.04
CC 7202 - MANUFACTURING			188.45%	737.75	1,390.29	737.75	1,390.29
TOTAL LABOR OVERHEAD					$86,355.32		$86,355.32
IATERIAL							
Direct Material					$0.00		$0.00
Mtl Usage Variance			1.50%	0.00	0.00	0.00	0.00
TOTAL MATERIAL					0.00		0.00
IATERIAL HANDLING			7.01%	0.00	0.00	0.00	0.00
OTHER DIRECT CHARGES					0.00		0.00
STEWART HUGHES LICENSING FEES			0.00%		0.00		0.00
TOTAL FACTORY COSTS					$153,110.97		$153,110.97
SELLING EXPENSE			24.37%	153,110.97	37,313.14	153,110.97	37,313.14
SUBTOTAL					190,424.12		190,424.12
G&A			31.04%	190,424.12	59,107.65	190,424.12	59,107.65
SUBTOTAL					249,531.76		249,531.76
COST OF MONEY				Dollars			
Engineering			0.03461	66,017.90	2,284.88	66,017.90	2,284.88
Manufacturing			0.08623	737.75	63.62	737.75	63.62
Material			0.00282	0.00	0.00	0.00	0.00
Selling			0.00069	153,110.97	105.65	153,110.97	105.65
G&A			0.00139	190,424.12	264.69	190,424.12	264.69
TOTAL COST OF MONEY					$2,718.83		$2,718.83
TOTAL COSTS					252,250.59		252,250.59
PROFIT			10.00%	249,531.76	24,953.18	249,531.76	24,953.18
INTERDIVISIONAL TRANSFERS AT COST					0.00		0.00
TOTAL PRICE					$277,203.77		$277,203.77

(Any variance due to rounding)

*** COMPANY PRIVATE DATA • USE OR DISCLOSURE OF DATA IS SUBJECT TO RESTRICTIONS ON TITLE PAGE ***

APPENDIX Y: INFORMATION ON CELLULAR TELEPHONE SERVICE AGREEMENTS

Cellular One

Service Plans and Rates

◆ ◆ ◆ ◆ ◆ ◆ ◆

CELLULARONE®

Clear Across America℠
Clear Across Tennessee

ANNUAL SERVICE PLANS

	Basic Price Plan Per Month	Unlimited Weekend Plan Per Month*	Minutes Included	Per Minute Rate
Diamond Plan†	$199.95	$209.95	800	25¢/801+
Gold Plan†	$139.95	$149.95	400	28¢/401+
Silver Plan†	$79.95	$89.95	200	35¢/201+/Peak 22¢/201+/Off P
Bronze Plan†	$47.95	$57.95	75	38¢/76+/Peak 22¢/76+/Off Pea
Copper Plan	$29.95	$39.95	0	39¢
Security Plan	$19.95	$29.95	0	60¢Peak 25¢ Off Peak

Peak: 7 AM - 8 PM Off Peak: 8 PM - 7 AM, Monday thru Friday

†FEATURES INCLUDED: •*Call Forwarding* •*No Answer Transfer* •*Call Waiting* •*Three Party Conferencing*

UPON REQUEST: •*Incoming Calls Only* •*Outgoing Calls Only* •*Local Calls Only*

*Plan includes Unlimited Weekend Calling which includes local calls from 7:00 PM Friday to 7:00 AM Monday. Long Distance, roaming and taxes are not included.

- ACTIVATION FEE $40.00

PACKAGE OPTIONS

- SUPER SYSTEM $10.00-$15.00/month
  Super System offers toll and roamer free calling throughout the State of Tennessee when calling from a Cellular One®* city! Ask your sales representative for more details!
  *Contel Cellular owned and operated city, d/b/a Cellular One.

- MR. RESCUE® $2.00/month
  Mr. Rescue offers emergency roadside service, exclusively to Cellular One customers, providing24 hour, 7 days a week service nationwide. With Cellular One and Mr. Rescue, life on the road doesn't have to be so lonely.

- DETAILED BILLING $2.50/month
  Call by call detail of cellular usage.

- CELLULAR ASSURANCE PLUS $2.95/month
  Insurance protection for your cellular phone and equipment provided by Insurance Company of North America, a CIGNA company.

CELLULARONE®

VOICE MAIL

Cellular Secretary

Cellular Secretary is an electronic voice mail service which answers your calls when you are not available and it helps make your cellular phone even more productive and effective as a business tool. It is easy to use, cost effective and has a secret password to insure your privacy so only you can access your messages. There's no airtime charge when you retrieve your messages from a landline phone or when people leave you messages.

OPTIONS	BASIC	BASIC PLUS	ADVANCED
Monthly Fee	$6.95	$9.95	$18.95
Greeting Length	1 Min.	2 Min.	2 Min.
Message Length	3 Min.	5 Min.	10 Min.
Number of Messages	20	40	50
New Messages Kept	3 Days	7 Days	14 Days
Save Messages Kept	3 Days	7 Days	14 Days
Local Outdialing	No	Yes	Yes
Message Distribution	No	No	Yes

AUTOMATIC CALL DELIVERY

You are "roaming" when you use your cellular phone away from your home cellular service area and are traveling in another cellular market. There is a special per-minute charge for roaming, which varies depending on which city you are in. Cellular One is pleased to offer you the most comprehensive cellular roaming network in North America. When you travel throughout the U.S. and Canada, callers can reach you instantly by simply dialing your cellular phone number, even if they don't know where you are before they call. In addition, you have the option of forwarding your calls to another number or if you prefer not to receive your calls while traveling, you simply enter a two-digit star code. Furthermore, you can place long distance calls without using calling cards, credit cards, or operator assistance.

Roaming America is also a national call forwarding system in which callers can reach you throughout the U.S. where cellular service is available. However, with Roaming America, you are required to activate the Roaming America features with the use of a star code each time you enter a new city.

Best of all, there's no monthly charge for either service. Ask your sales representative for more details.

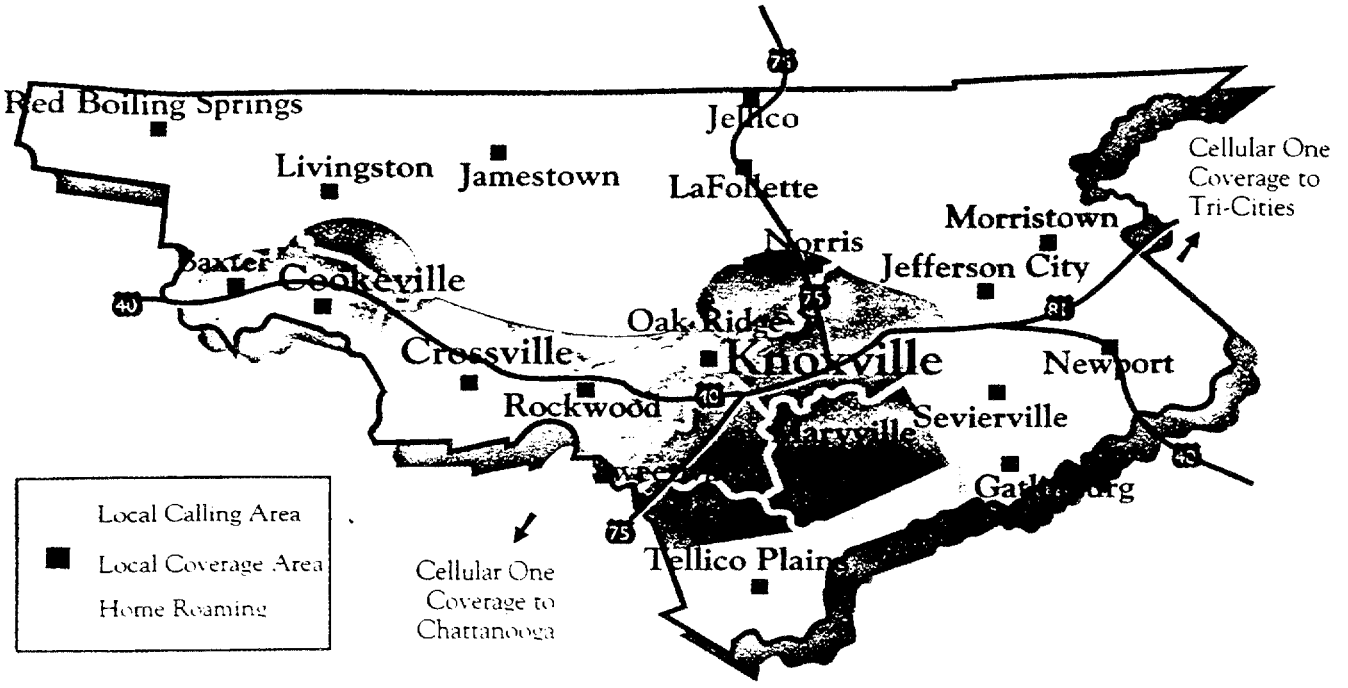
A cancellation fee is applicable if service is disconnected prior to fulfillment of annual agreement. Customer may upgrade and downgrade plans at any time without penalty. This will initiate a new annual agreement.

Cellular One is a registered service mark of Cellular One Group.

Effective January, 1994
Complete Edition

CELLULARONE

Knoxville ~ Crossville ~ Cookeville Coverage Area



Local Calling Area for Knoxville, Crossville and Cookeville

Knoxville
250, 281, 521, 522, 523, 524, 525, 531, 539, 541, 544, 545, 546, 549, 558, 564, 567, 573, 577, 579, 584, 588, 594, 595, 599, 631, 632, 637, 656, 673, 687, 688, 689, 690, 691, 693, 694, 850, 971, 974, 996

Crossville
456, 484

Cookeville
260, 280, 372, 432, 520, 526, 528, 537, 935, 979

Surrounding Areas

Ball Play	295
Baxter	858
Bean Station	993
Byrdstown	864
Celina	243
Clarkrange	863
Claxton	945
Clinton	457, 463
Coker Creek	261
Concord	640, 671, 675, 679, 680, 966
Crawford	445
Cumberland Gap	869
Dandridge	397
Deer Lodge	965
Fork Ridge	249
Gainesboro	268
Gatlinburg	430, 436
Granville	653
Greenback	856
Halls Crossroads	922
Harriman	882
Hillsdale	633
Huntsville	663
Jamestown	879
Jefferson City	471, 475
Jellico	784
Kingston	376
La Follette	562, 566
LaVergne	287
Lafayette	666
Lake City	426
Lenoir City	986, 988
Livingston	823
Loudon	458
Lyles	670
Madisonville	442
Maryville	448, 681, 972, 977, 981, 982, 983, 984, 985, 995, 932, 933
Mascot	932, 933
Maynardville	992
Monterey	839
Morristown	581, 585, 586, 587
Moss	258
New Tazewell	626
Newport	487, 623, 625
Niota	568
Norris	494
North Springs	621
Oak Ridge	220, 241, 481, 482, 483, 574, 575, 576
Oakdale	369
Oliver Spring	435
Oneida	569
Petros	324
Pleasant Hill	277
Powell	938, 947
Red Boling Springs	699
Rickman	498
Robbins	627
Rockwood	354
Rutledge	828
Sevierville	428, 429, 453
Sharps Chapel	278
Sneedville	733
Solway	927
Sweetwater	337
Sunbright	628
Tansi	788
Tate Springs	767
Tellico	253
Vonore	884
Wartburg	346
Washburn	497
White Pine	674

APPENDIX Z: PRICE QUOTES FOR 15 ADDITIONAL VEHICLE UNITS

Scientific Atlanta
Sinclair Radio Laboratories
Austin Computer
Vicor
UniMeasure
GSE
Systron Donner
UFI
DBA Systems
Pro Sports Engineering
KVH Industries
Riegl
International Light
Dawson Associates
Quest Electronics
Armtec Industries
Eastern Video Systems
Robot Research

2/18/94

Dick,

Here is the pricing data you requsted.

DPU @ $8,000.00 each quantities up to 25

Terrastar C @ $5,500.00 each

Mapstar---- The system delivered with the prototype could support the rest of the production DASCAR fleet nationwide. If another were to be purchased, cost will run at $20,000.00 each.

MPEG Video Compresion @ $35,000.00 each

RF Modem @ $1400.00 per pair.

Cheers,

Don

SINCLAIR

Sinclair Radio Laboratories Inc. • 675 ENSMINGER ROAD, TONAWANDA, N.Y. 14150 • (716) 874-3682

FAX 716-874-4007

FAX MESSAGE COVER SHEET

TO: Oakridge Nat'l Lab FROM: Meg Driggers

ATTN: Frank Barickman DEPT: APPLICATIONS

SUBJECT WIRELESS LAN DATE:

NUMBER OF PAGES INCLUDING COVER SHEET: 9. IF YOU DO NOT RECEIVE THE CORRECT NUMBER OF PAGES, PLEASE CALL 1-800-288-2763 OR 716-874-3682

MESSAGE:

MODEL#	DESCRIPTION	LIST PRICE	NET PRICE
SRL441W	DATA ANTENNA WALL MOUNT	$159.00	$119.25
SRL441P	DATA ANTENNA POLE MOUNT	$154.00	$115.50
SRL410C2	ENCLOSED DIPOLE ARRAY	$555.00	$416.25
SRL433	OMNIDIRECTIONAL ANTENNA	$461.00	$345.75
SRL401	OMNIDIRECTIONAL ANTENNA	$223.00	$167.25

DELIVERY NORMALLY 2-3 WEEKS ARO ON THE PRODUCTS LISTED ABOVE.

THANK YOU

QUOTE

Austin Computer Corporation
10300 Metric Blvd.
Austin, Texas 78758

Terms:

DELIVERY 2 WEEKS
NET 30 (1%, 20 DAYS)
SMALL BUSINESS
F.O.B. DESTINATION
FED ID # 74-2475679

Pages: 2 (No cover page)

Date: 1/20/94

To: Mr. Frank Barickman US DOE OAK RIDGE TN
Phone :
Fax : 615 574 7860

From: Mark Moyer Federal Account Representative
Phone : 800-833-4472 Ext 5229
Fax : 512-339-3558

	Part No.	Descriptions	Unit	Total
1	4D5000	486 DX2-66, 8 MB RAM, 3 IN 1 COMBO NIC	$2,687	$2,687
		17" Color NI .28 SVGA Monitor, 340 mb IDE		
		Included: Intel Processor		
		2 year warranty (Year 1 is On-Site)		
		MS DOS 6.2, Windows 3.1		
		2 button MS Compatible mouse		
		256 k Cache		
		Dual 1.44/1.2 mb Floppy drives		
		2 serial and 1 parallel ports		
		101 Enhanced Keyboard		
		1 mb VESA local bus video		
		*Add $390 to upgrade to 16 mb RAM		

** We use only INTEL Processors **

Thank you

QUOTE

Austin Computer Corporation
10300 Metric Blvd.
Austin, Texas 78758

Terms:

DELIVERY 3 WEEKS
NET 30 (1%, 20 DAYS)
SMALL BUSINESS
F.O.B. DESTINATION

Pages: 2 (No cover page)

Date: 2/21/94

To: Mr. Frank Barickman US DOE Oak Ridge
Phone:
Fax: 615 574 7860

Mark Moyer Account Representative
Phone : 800-833-4472 Ext 5229
Fax : 512-339-3558

Qty	Part No.	Descriptions	Unit	Total
15+	466340	486/DX2-66 Notebook, 340 hard drive, Mono	$2,425	$2,425
		8 mb RAM, Trackball, 1.44 FD, DOS 6.2, WIN 3.1		
		Built-in upgradabilitiy and 3 expansion slots		
		See following specs.		
	Options:			
15+	NB0017	CAR ADAPTOR	$48	$48
		Total unit price		$2,473

** We use only INTEL processors **

Thank you

	Options:			
1	NB0020	EXTERNAL BATTERY CHARGER	$45	$45
1	NB0016	AC ADAPTOR	$57	$57
1	NB0039	NYLON CARRY CASE	$29	$29
1	NB0018	NIMH SPARE BATTERY	$135	$135
1	NB0013	14.4 INTERNAL FAX/MODEM	$249	$249
1	NB0046	DOCKING STATION	$279	$279
1	NB0046	16 MB MEMORY UPGRADE	$520	$520
1	NB0051	PCMCIA SOUND CARD	$299	$299
1	KT0062	KIT: 15"NI SVGA MONITOR, DOCKING STA, MOUSE,	$599	$599
		101 KEYBOARD		
1	KT00043	545 MB HARD DRIVE UPGRADE	$100	$100

** We use only INTEL processors **

Thank you

Vicor Power Supply

Mega / Master Module Junior--- **VI-RJ002L-CZZZ**

12 V input ------

Price: 1-9 $376.00
10-49 $343.00

+5 V out @ 25 watts
-15 V out @ 25 watts
+28 V out @ 25 watts

***NOTE: -9 V out @ 0.5 watt
w/ 3 terminal regulator
off -15 V out

Mega / Master Module---- **VI-MO1-CV**
VI-LB01-CX

12V input ------

Price: 1-9 $328.00 ; $164.00
10-49 $290.00 ; $150.00

+12 V out @ 225 watts

Mega / Master Module--- **VI-M02-CW**

12V input -----

Price: 1-9 $301.00
10-49 $274.00

+15 V out @ 100 watts

Mega / Master Module--- **VI-R0011-CXXY**

12V input -----

Price: 1-9 $478.00
10-49 $435.00

+5 V out @ 75 watts
+12 V out @ 75 watts
-12 V out @ 50 watts

UniMeasure, Inc.

Corvallis, OR 97330
Tel: (503) 757-3158 Fax: (503) 757-0858

PRICE LIST

SEPTEMBER 1992 A

$125 - For Grad cp
$650 - [illegible]

PRICES IN U.S. DOLLARS									
RANGE (in)	RANGE (mm)	P POSITION VOLTAGE DIVIDER OUTPUT	P420 POSITION 4-20 mA OUTPUT	P510 POSITION 0 TO 5 OR 10 VDC OUTPUT	P1010 POSITION ±10 VDC OUTPUT	HX-PA ENVIRONMENTALLY SEALED VOLTAGE DIVIDER OUTPUT	EP & EPM DIGITAL POSITION SQUARE WAVE OUTPUT	V VELOCITY OUTPUT	VP VELOCITY & POSITION OUTPUT
2	50	$225	$335	$335	$375	$375	—	$375	$405
3	75	225	335	335	375	375	—	375	405
4	100	225	335	335	375	375	—	375	405
5	125	225	335	335	375	375	—	375	405
10	250	225	335	335	375	375	$495	375	405
15	380	225	335	335	375	375	—	375	405
20	500	225	335	335	375	375	—	375	405
25	640	225	335	335	375	375	—	375	405
30	750	225	335	335	375	375	—	375	405
40	1000	225	335	335	375	375	—	375	405
50	1250	225	335	335	375	375	495	375	405
60	1500	310	420	420	460	395	—	435	460
75	1750	310	420	420	460	—	—	435	460
80	2000	310	420	420	460	435	—	435	460
100	2500	450	575	575	600	—	630	580	620
150	3800	510	635	635	660	—	—	610	645
200	5000	510	635	635	660	—	—	610	645
250	6300	510	635	635	660	—	655	610	645
300	7500	530	650	650	680	—	—	610	645
350	8800	530	650	650	680	—	—	610	645
400	10000	530	650	650	680	—	725	610	645
500	12500	530	650	650	680	—	725	610	645

DISCOUNT SCHEDULE

QUANTITY	DISCOUNT
1-4	NONE
5-9	5%
10-24	7%
25-49	10%
50 and greater	Consult Factory

NOTE: HX SERIES IS ALSO AVAILABLE WITH THE FOLLOWING:
- DIGITAL OUTPUT
- VELOCITY OUTPUT
- VELOCITY/POSITION OUTPUT
- ALL STAINLESS STEEL CONSTRUCTION

CONSULT FACTORY FOR PRICING

TERMS

1. Net 30 days
2. F.O.B. Corvallis, Oregon, U.S.A.

SEE OPPOSITE SIDE FOR APPLICABLE OPTIONS AND ACCESSORIES

WARRANTY

UniMeasure products are warranted for 6 months from date of shipment against defects in materials and workmanship. During the warranty period, UniMeasure, at its option, will promptly repair or replace defective units at no charge to the purchaser if the product is returned to the factory freight prepaid. The warranty is void if the product is misused, damaged by accident, disassembled or intentionally abused.

UniMeasure makes no other warranties either expressed or implied other than that above. UniMeasure assumes no liability for consequential damages under any circumstances.Prices, specifications and product appearance are subject to change without notice.

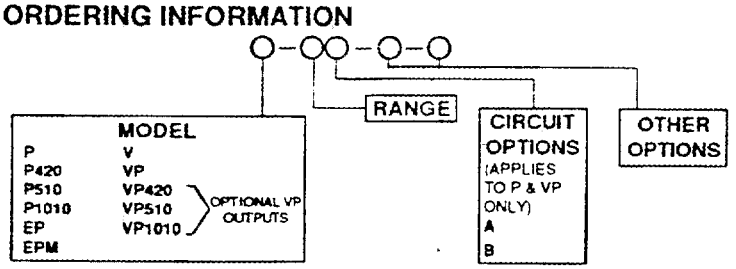
Prices, specifications and product appearance are subject to change without notice.

OPTIONS (ADD TO PRICE OF TRANSDUCER)		PRICES IN U.S. DOLLARS							
DESCRIPTION	OPTION DESIGNATOR	P	P420	P510	P1010	HX	EP	V	VP
4-20 mA OUTPUT	420	—	—	—	—	$125	—	—	$125
0-5 OR 10 VDC OUTPUT	510	—	—	—	—	125	—	—	125
±10 VDC OUTPUT	1010	—	—	—	—	150	—	—	150
'B' CIRCUIT	B	45	—	—	—	45	—	—	45
NYLON JACKETED CABLE[1]	NJC	NC	NC	NC	NC	NC	NC	NC	NC
NON-STANDARD POTENTIOMETER[2]	NSPXXX[3]	45	—	—	—	45	—	—	45
100G ACCELERATION 2"-50" UNITS	100G	125	125	125	125	—	—	125	125
SIDE OR BOTTOM CABLE EXIT	CES, CEB	25	25	25	25	25	25	25	25
TERMINAL STRIP	TS	10	10	10	10	—	10	10	10
DUST SHIELD AT STAINLESS STEEL CABLE EXIT	DS	20	20	20	20	—	20	20	20
5 VDC 2 CHANNEL OUTPUT WITH INDEX	I	—	—	—	—	—	10	—	—
5 VDC DIFFERENTIAL LINE DRIVER OUTPUT	DLD	—	—	—	—	—	45	—	—
5 VDC DIFFERENTIAL LINE DRIVER OUTPUT WITH INDEX	DLDI	—	—	—	—	—	95	—	—
8 TO 28 VDC CURRENT SOURCING OUTPUT	HVBSRC	—	—	—	—	—	95	—	—
8 TO 28 VDC CURRENT SINKING OUTPUT[4]	HVBSNK	—	—	—	—	—	75	—	—
8 TO 28 VDC DIFFERENTIAL LINE DRIVER OUTPUT[4]	HVBDLD	—	—	—	—	—	75	—	—
5, 12, 15 OR 24 VDC VOLTAGE INPUT (P1010 OR 1010 OPTION)	SIYY[5]	—	—	—	45	45	—	—	45

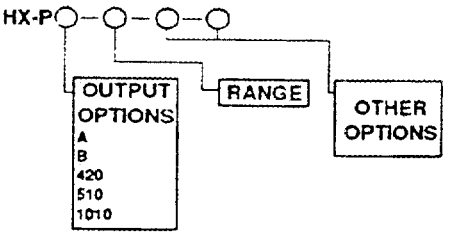
1. Nylon jacketed cable maximizes transducer life but adversely affects linearity by as much as ±0.05%.
2. Specifications of non-standard potentiometers may differ from those published in UniMeasure data sheets.
3. Replace XXX with desired potentiometer value when ordering.
4. 10K ohm internal pullup resistors provided.
5. Replace YY with desired voltage value when ordering.

ACCESSORIES		PRICE
P/N 10028	Included mating connector with 8' of shielded, twisted pair electrical cable attached. (Not applicable to HX series)	$35
P/N 10067	Stainless steel auxilliary external extension cable .016" diameter. Both ends equipped with swivels and clips. Specify length required up to 100" maximum.	$10
P/N 10107	Standard.016" diameter stainless steel replacement cable. Includes clip, swivel, bumper & cable guide. Specify transducer range when ordering.	$15
P/N 10108	Nylon jacketed stainless steel replacement cable. Includes clip, swivel, bumper & cable guide. Specify transducer range when ordering. To 100" / 150" to 500"	$15 / $30

ORDERING INFORMATION



HX SERIES ONLY



NOTES

- Cable acceleration on units with ranges between 2" and 50" is 50G minimum except HX series.
- Transducer prices include mating connector.
- Maximum travel of metric units is equivalent to the comparable inch model.
- Order accessories by part number.

GSE INC.
23640 Research Drive
Farmington Hills, Michigan / 48335-2621 U.S.A.
Telephone (313) 476-7875
FAX. (313) 476-7249
Manufacturer of Transducers, DC Electric Tools and Automation Systems

QUOTATION

TO: Oak Ridge National Labratory
P.O. Box 2008
Bethel Valley Road
Bldg. 6025, MS 6360
Oak Ridge, TN 37831-6380

Attn: Frank Barickman
FAX 615-574-9619

COPY TO: Dale Sturm
G & A

DATE 01/31/94

QUOTATION QMC16,035

YOUR REFERENCE

F. O. B./EX-WORKS

TERMS: Net 30 days
Subject to Credit Approval

DELIVERY 12 Weeks,A.R.O.

The following quotation is being submitted in response to your recent request.

Item 1
Fifteen (15) P/N 114351-04301 **Price: $1,705.50 each**
Model 4350 Pedal Force Transducer with vise grip mounting
- Rated Capacity - 300 lbs.
- Output @ Rated Capacity - 1.25 mV/V nominal
- Non-linearity - ± 0.5% FS
- Bridge Resistance - 350 ohms
- Excitation - 10 VDC Maximum
- Cable - Eight (8) foot long captive cable
- Cable terminates with Bendix PT06A-8-4P (SR) 4 pin connector

Item 2
Twenty-Five (25) P/N 114351-04301 **Price: $1,516.00 each**
Model 4350 Pedal Force Transducer with vise grip mounting
- Rated Capacity - 300 lbs.
- Output @ Rated Capacity - 1.25 mV/V nominal
- Non-linearity - ± 0.5% FS
- Bridge Resistance - 350 ohms
- Excitation - 10 VDC Maximum
- Cable - Eight (8) foot long captive cable
- Cable terminates with Bendix PT06A-8-4P (SR) 4 pin connector

*** Frank, The only feasible way to reduce the height on the pedal sensor would be to eliminate the clamp base and have your pedal attatch directly to the unit. This could work if you can somehow have your pedal mount directly to the bolt circle from the base of the sensor.

If you have any questions, feel free to contact me.

Sincerely,

Michael J. Hetwig
Product Specialist

SUBSIDIARY OF CORE INDUSTRIES INC

GSE Inc. Standard Conditions of Sale, listed on the back of this page, apply to ALL ITEMS quoted and sold by GSE Inc.

SYSTRON DONNER INERTIAL DIVISION CUSTOMER SERVICES
2700 Systron Drive * Concord, CA. 95618 Phone (510) 671-6499
FAX (510) 671-6567

Tuesday, February 22, 1994

Product Quotation

Oak Ridge National Lab
P.O. box 2008
Oak Ridge TN 37831-6360

SDID Quote #: 94 5699

Ref #: Phone RFQ

Date recvd : 2/17/94

ATTN : *Richard Carter*

Phone :

FAX : 615-574-7860

Model : QRS14-00100-102

Type : *GyroChipII* NSN : N/A

Quantity	*Ship Date ARO**	*Unit PRICE*
1-2	4 weeks	$1,195.00
3-8	4 weeks	$1,021.00
9-20	8-12 weeks	$934.00
21-50	8-12 weeks	$855.0

TERMS and CONDITIONS

Certificate of Conformity required: Yes

1. Standard Systron Donner Inertial Division Terms & Conditions apply (copy included).
2. The QRS14-00100-102 requires a +12 VDC input.

Note: ALL EXPORT order lead times will begin after the receipt of the Customer Approved export papers (DSP-83).

Thank you for the opportunity of your business!

Completed by : Tim Liguori

Quotation Valid for ~~30~~ 90 days.

SYSTRON DONNER INERTIAL DIVISION CUSTOMER SERVICES
2700 Systron Drive * Concord, CA. 95618 Phone (510) 671-6499
FAX (510) 671-6567

Tuesday, February 22, 1994

Product Quotation

Oak Ridge National Lab
P.O. box 2008
Oak Ridge TN 37831-6360

SDID Quote #: 94 5699

Ref #: Phone RFQ

Date recvd : 2/17/94

ATTN : *Richard Carter*

Phone :

FAX : 615-574-7860

Model : QRS14-00100-103

Type : *GyroChipII* NSN : N/A

Quantity	*Ship Date ARO**	*Unit PRICE*
1-2	4 weeks	$1,315.00
3-8	4 weeks	$1,123.00
9-20	8-12 weeks	$1,028.00
21-50	8-12 weeks	$941.0

TERMS and CONDITIONS

Certificate of Conformity required: Yes

1. Standard Systron Donner Inertial Division Terms & Conditions apply (copy included).
2. The QRS14-00100-103 requires both a +15 VDC and a -15 VDC input.

Note: ALL EXPORT order lead times will begin after the receipt of the Customer Approved export papers (DSP-83).

Thank you for the opportunity of your business!

Completed by : Tim Liguori

Quotation Valid for ~~30~~ 90 days.

SYSTRON DONNER INERTIAL DIVISION CUSTOMER SERVICES
2700 Systron Drive * Concord, CA. 95618 Phone (510) 671-6499
FAX (510) 671-6567

Tuesday, February 22, 1994

Product Quotation

Oak Ridge National Lab
P.O. box 2008
Oak Ridge TN 37831-6360

SDID Quote #: 94 5699

Ref #: Phone RFQ

Date recvd : 2/17/94

ATTN : *Richard Carter*

Phone :

FAX : 615-574-7860

Model : MotionPak 6-DOF

Type : *MotionPak* NSN : N/A

Quantity	*Ship Date ARO**	*Unit PRICE*
1-2	6 weeks	$11,994.00
3-8	6 weeks	$10,844.00
9-20	8-12 weeks	$9,923.00
21-50	8-12 weeks	$9,217.00

TERMS and CONDITIONS

Certificate of Conformity required: Yes

1. Standard Systron Donner Inertial Division Terms & Conditions apply (copy included).
2. The MotionPak comes in many configurations; this quote is for a standard 6 Degree of Freedom package.

Standard Rate Sensor ranges are: 50, 100, 200, 500 °/sec.

Standard accelerometer ranges are: 1g. 2g, 5g, 10g.

Note: ALL EXPORT order lead times will begin after the receipt of the Customer Approved export papers (DSP-83).

Thank you for the opportunity of your business!

Completed by : Tim Liguori

Quotation Valid for ~~30~~ 90 days.

UFI MEMOFAX Feb. 8, 1994

TO: Frank Barickman, Oakridge National Laboratories
FAX#: 1-615-514-9619
FROM: Harve M. Hanish, VP Engineering
PAGES: 3

Dear Dr. Barickman:

Thank you for your recent telephone inquiry requesting information about our Model 3992 Digital BioLog® systems.

The attached quote is in response to your request. We are proposing to supply you with 8 channel BioLogs ® with the folliowing specifications:

Memory size ---- 2 Mb. PCMCIA Ram Card.

Channels---

ECG --- uses FETRODE® technology, 8 bit AD, non-clinical waveform (rate monitoring)
EOG --- uses FETRODE® technology, 8 bit AD, vertical or horizontal
EMG --- uses FETRODE® technology, 8 bit AD, supplies rectified envelope of signals
EEG --- uses FETRODE® technology, 8 bit AD, miniature Ag/Ag Cl Biodes®
RESP-- 8 bit AD, uses PneumoTrace® transducer, records analog waveforms
PPG -- 8 bit AD --- uses UFI's 1020 PPG transducer to derive pulse transit time or pulse wave velocity
TEMP -- CORE & SKIN --- 12 bit AD -- multiplexed on one channel 0-40°C-- 0.1° resolution
SCL -- BASAL --- recorded with 12 bit AD --- Sufficient resolution to derive ΔSCL from this channel with better than 0.05 μmho resolution.

Please note that these units are supplied complete with all necessary accessories such as software, transducers and re-usable electrodes. Also, while we have specified this as an 8 channel system, there are actually 10 channels of data being recorded.

more

UFI *serving science with experience*

545 main street • morro bay, ca. 93442 • 805-772-1203

QUOTATION #9406

TO: Frank Barickman
Oakridge National Laboratories

VOICE: 615-574-6198
FAX: 615-574-9619

date: February 8, 1994
inquiry: February 2, 1994
terms: Net 10 Days
fob: Factory
delivery: 45-60 days ARO

tem	quant	description	unit price	extension
1	1	Model 3992/8 BioLog® Complete 8 ch. system with card reader, software, with all transducers, and Fetrodes®		$ 10,000
2	2	1 complete system + 1 BioLog®		$ 18,750
3	3	1 complete system + 2 BioLogs®		$ 27,500
4	4	1 complete system + 3 BioLogs®		$ 36,250
5	5	1 complete system + 4 BioLogs®		$ 44,500
6	6	1 complete system + 5 BioLogs®		$ 52,750
7	7	1 complete system + 6 BioLogs®		$ 61,000
8	8	1 complete system + 7 BioLogs®		$ 68,750
9	9	1 complete system + 8 BioLogs®		$ 76,500
10	10	1 complete system + 9 BioLogs®		$ 84,250
11	11	1 complete system + 10 BioLogs®		$ 91,500
12	12	1 complete system + 11 BioLogs®		$ 98,750
13	13	1 complete system + 12 BioLogs®		$106,000
14	14	1 complete system + 13 BioLogs®		$112,750
15	15	1 complete system + 14 BioLogs®		$119,500

prices quoted are subject to 30 day acceptance

submitted by:

HARVE M. HANISH, VICE PRESIDENT

DBA Systems, Inc.

16 March 1994
File: ES94-357

Fax: (615) 574-9619

Dr. Richard Carter
Research Psychologist
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6360

Subject: Stereo Eye Tracker, Production Systems

Dear Dr. Carter:

In response to your request for ROM pricing for 15 production units, the following assumptions were made.

1. Some NRE would be required to repackage the dual PC configuration into a common chassis. This includes both software and hardware tasks. The price for this effort is $25K dollars.

2. The system would be packaged in a ruggedized chassis for the vehicle environment. The system configuration would also include a solid state monitor and flash ram disk for increased reliability.

3. DBA would provide all the peripheral hardware items including cameras, lenses illumination sources, mounting brackets and hardware.

The estimated unit price for follow-on systems is $36K dollars based on quantity one. If ordered in quantity 15 the price would be around $30K dollars each. The final price will be dependent on system configuration, environmental constraints and quantity ordered.

If you have any questions, please feel free to contact George Downey at Extension 2743.

Sincerely,

Richard Van Pelt
Vice President
DBA Systems, Inc.
Electro-Optical Systems Division

RVP/krk

PRO SPORTS ENGINEERING

Hall Effect Sensor

-Unit Cost.....$75.00

-Cost per 15 units.....$1125.00

-Cost per 25 units.....$1875.00

Facsimile Cover Sheet

To: Frank Barickman
Company: Oak Ridge National Lab
Phone: 615-574-7860
Fax: 615-574-6198

From: Barbara Butler
Company: KVH Industries, Inc.
Phone: 401-847-3327
Fax: 401-849-0045

Date: 02/22/94
Pages including this cover page: 1

Comments:

On behalf of KVH Industries, I am pleased to provide you with the following quotation for the KVH C100 Compass Engine.

Quantity	Unit Price
1	$695
2 - 25	$595
26 - 100	$495

Delivery is 1 week ARO. Shipping is FOB Middletown, RI.

If you have any questions, please contact me.

RIEGL
LASER MEASUREMENT SYSTEMS

4419 Parkbreeze Court
Orlando, FL 32808
tel:(407)294-2799 fax:(407)294-3215

To:	Frank Barickman	Date:	February 21, 1994
Company:	Oak Ridge National Laboratory		
Fax:	615 574 7860		
From:	Ted Knaak	Pages:	1

Re: LD90-3300

Dear Frank,

Per our discussion last Friday, I have assembled a LD90-3300 price schedule. Before submitting a formal quote, I thought we could review this information further.

LD90-3300 quantity prices

Quantity	Price
1-5	$7215
6-10	$6900
11-15	$6575
16-20	$6250
21-25	$6000

As I mentioned, the LD90-3300 is an excellent rangefinder packaged for very rugged environments. It meets numerous IEC standards for shock, vibration, dust and humidity resistance, input transient suppression, etc. I can make these available to you upon request.

I hope that I have satified your requirements and look forward to your response.

Best Regards,

Ted Knaak

01012

QUOTATION

international light INC.

17 GRAF ROAD • DEXTER INDUSTRIAL GREEN
NEWBURYPORT, MA 01950-4092 • U.S.A.
TEL (508) 465-5923 • FAX (508) 462-0759

TO Mr Frank Barickman Fax: 615/574-7860
OAK RIDGE NATIONAL LABORATORY
Engin Physics & Math Div
Intelligent Systems Section

DATE 18Feb94

REFERENCE: YOUR TELECON RFQ DATED 18Feb94

In response to your request, International Light is pleased to submit the following quotation:

ITEM	QUANTITY	DESCRIPTION	UNIT PRICE	EXTENSION
1	2	IL1400A SMART RADIOMETER/PHOTOMETER: Computer controlled, battery powered, digital & alpha numeric display, Seven decade range of either signal or integrated dose measurements, direct reading in any units appropriate for the detector, auto range, auto zero, auto units, CC500 carrying case, recorder output, manual.	$679.00	1358.00
2	1	SEL033/Y/L30 ILLUMINANCE PROBE: 0.33cm² detector, Y photopic filter, L30 High Gain Lens & IYIS Illuminance calibration for direct reading in foot-candles.	650.00	650.00
3	1	SEL033/Y/R LUMINANCE PROBE: 0.33cm² detector, Y photopic filter, R Barrel and IYLS Luminance Calibration in foot-lamberts. This combination is designed for average measurement of luminance over a target area greater than 30mm diameter plus 1.5 degree half angle divergence.	651.00	651.00
4	2	A509 TTL SIGNAL PROCESSOR/EXTENSION CABLE: Converts IL1400A data for a computer/printer and provides 7 foot extension cables for both SEL(SL) detectors and digital device. Required for A514 operation.	205.00	410.00

15% DISCOUNT ALLOWED FOR QTY 15 SYSTEMS
21% DISCOUNT ALLOWED FOR QTY 25 SYSTEMS
WITH ALL SYSTEMS RELEASED AT ONE TIME

DELIVERY: 2 WEEKS ARO QTY 2 SYSTEMS
8 WEEKS ARO QTY 15 SYSTEMS
12 WEEKS ARO QTY 25 SYSTEMS

QUOTATION IS VALID FOR SIXTY DAYS FROM DATE SHOWN

ESTIMATED SHIPPING DATE: AS STATED

TERMS: NET 30 DAYS, FOB NEWBURYPORT, MA

TOTAL ▶

CUSTOMER COPY

SIGNATURE Bob Bal

PRICE QUOTATION

DAWSON ASSOCIATES, INC.

P.O. BOX 846 • LAWRENCEVILLE, GA 30246-0846 • (404) 963-0207

TO Frank Barickman/Oakridge Nat'l Labs
PO Box 2008
Bethel Valley Road-Bldg 1625-MS 6360

Oakridge TN 37831

fx 615-574-7860

DATE	Please indicate this number when ordering	004173
2-18-94		
YOUR INQUIRY DATED	TERMS	
2-18-94	TBA	
PROPOSED SHIPPING DATE	TO BE SHIPPED VIA	
TBA	UPS	
SALESPERSON	F.O.B.	PPD. / COLL.
DAF	origin	X

ERE IS OUR QUOTATION ON THE GOODS NAMED, SUBJECT TO THE CONDITIONS NOTED:

ONDITIONS: The prices and terms on this quotation are not subject to verbal changes or other agreements unless approved in writing by the Home Office of the Seller. All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials and all other causes beyond our control. Prices are based on costs and conditions existing on date of quotation and are subject to change by the Seller before final acceptance.

Typographical and stenographic errors subject to correction. Purchaser agrees to accept either overage or shortage not in excess of ten percent to be charged for pro-rata. Purchaser assumes liability for patent and copyright infringement when goods are made to Purchaser's specifications. When quotation specifies material to be furnished by the Purchaser, ample allowance must be made for reasonable spoilage and material must be of suitable quality to facilitate efficient production.

Conditions not specifically stated herein shall be governed by established trade customs. Terms inconsistent with those stated herein which may appear on Purchaser's formal order will not be binding on the Seller.

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	2700 Quest Sound Meter	785.00	
1	calibrator for 2700	328.00	
1	10' extension cable for above	110.00	
15	2700 Quest Sound Meter	742.00	
15	calibrator for 2700	310.00	
15	10' extension cable for above	110.00	
25	2700 Quest Sound Meter	702.00	
25	calibrator for 2700	294.00	
25	10' extension cable for above	110.00	

— # PQR113 © Wheeler Group Inc. 1983

QUOTE VALID FOR 30 DAYS.

BY David Fogarty

ORIGINAL

U.S. INSTRUMENT PRICE LIST

Effective October 1, 1992

PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

THIS PRICE LIST SUPERSEDES ALL PREVIOUS PRICE LISTS.

WARRANTY:

Quest Electronics warrants its instruments to be free from defects in materials and workmanship under normal conditions of use and service. Sho unit prove to be defective within one (1) year after delivery to the original purchaser, we will replace or repair the unit at Quests option, free of cha (Exception: Model 208/208L meters and precision microphones - 90 days warranty.) Chart Recorders and Printers are warranted by their manufactu

FOR ORDERING INFORMATION CONTACT
OUR MAIN OFFICE AND FACTORY:

QUEST ELECTRONICS
510 S. Worthington . Oconomowoc, WI 53066 USA
414/567-9157 . TWX 910 280 1436 LaBelle . FAX: 414/567-4047
Toll Free: 800/245-0779 U.S., Canada and Puerto Rico

MODEL	SOUND LEVEL METERS	LIST PRICI
	All Sound Level Meters except 208/208L include calibrator adapter, windscreen, and carrying case.	
	Type 1 Precision	
1800	INTEGRATING SOUND LEVEL METER: includes 1/2 inch remotable microphone, and computer cable	2655.
1700	SOUND LEVEL METER: includes 1/2 inch remotable microphone	2395.
1400	SOUND LEVEL METER: includes fixed microphone	995.
	Type 2 General Purpose	
2800	INTEGRATING SOUND LEVEL METER: includes remotable microphone, and computer cable	1450.
2700	SOUND LEVEL METER: includes remotable microphone	825.
2400	SOUND LEVEL METER: includes fixed microphone	465.
208L	SOUND LEVEL METER: special purpose, 50-100dBA, includes pouch	165.
208	SOUND LEVEL METER: same as above except range is 70-120dBA	165.
	KITS WITH CALIBRATORS *	
	*Includes same as unit above, plus QC-10 or QC-20 calibrator as indicated.	
1800-20	INTEGRATING SOUND LEVEL METER & CALIBRATOR KIT	3180.
1700-20	SOUND LEVEL METER & CALIBRATOR KIT	2895.
1400-20	SOUND LEVEL METER & CALIBRATOR KIT	1630.
2800-10	INTEGRATING SOUND LEVEL METER & CALIBRATOR KIT	1795.
2700-10	SOUND LEVEL METER & CALIBRATOR KIT	1170.
2400-10	SOUND LEVEL METER & CALIBRATOR KIT	795.
	OCTAVE BAND FILTER SETS	
OB-300	OCTAVE BAND FILTER SET: combination 1/3-1/1 filter, 12.5Hz to 20KHz	1645.
OB-100	OCTAVE BAND FILTER SET: 31Hz to 16KHz	795.
OB-50	OCTAVE BAND FILTER SET: 31Hz to 8KHz	695.
	OCTAVE BAND ANALYZER KITS	
1800-30020	INTEGRATING OCTAVE BAND ANALYZER: includes 1800, OB-300, QC-20, windscreen, and carrying case	4895.
1700-10020	OCTAVE BAND ANALYZER: includes 1700, OB-100, QC-20, windscreen, and carrying case	3790.
2800-10010	INTEGRATING OCTAVE BAND ANALYZER: includes 2800, OB-100, QC-10, windscreen, and carrying case	2690.
2700-5010	OCTAVE BAND ANALYZER: includes 2700, OB-50, QC-10, windscreen, and carrying case	1975.

Note: Octave Band Filters and Calibrators may be substituted within the kits, add or subtract difference in cost accordingly.

MEGGITT AEROSPACE

ARMTEC/ RAGEN INC

10 Ammon Drive
Manchester
New Hampshire
03103-7406
USA
telephone
(603) 669 0910
fax
(603) 669 0931

FACSIMILE

TO: **Frank Barickman**

COMPANY: **Oakridge Nat'l Lab** COUNTRY: **TN**

FROM: **Nancy Dyer**

REF #: **ND-F-0294-0315** FAX # **615-574-9619**

DATE: **February 3, 1994** COVER + PAGES

If you have any difficulty in receiving the full message, please contact us immediately on (603) 669-0940.

Subject: Meteorological Sensor, P/N 88658-02

The tolerances for the sensors in the above referenced product are:

Sensor	Range	Tolerance
Headwind/Crosswind	2-4 M/S 5-40 M/S	0.5 M/S ± 5%
Pressure	500-1080 millibars	± 2 millibars at room temp.
Temperature	-40°C to 60°C	± 2°C at min. 5 M/S wind

Budgetary pricing:

1 - 4	$7,500.00
5 - 9	$6,150.00
10 - 24	$5,140.00
25 - up	$4,550.00

Dely: 38 weeks ARO

Sincerely,

ARMTEC/RAGEN INC.

Nancy Dyer

Nancy Dyer
Contract Administrator

Page No 1 of 1 Pages

216

EASTERN VIDEO SYSTEMS, INC.
2 Sterling Road
BILLERICA, MASSACHUSETTS 01862

(508) 667-0009
FAX (508) 663-3769

PROPOSAL

TO Mr. Frank Barickman
Oak Ridge National Laboratory
P.O. Box 2008, Bethel Valley Rd
Bldg. 6025, MS 6360
Oak Ridge, TN 37831-6380

PHONE (615) 574-6198
DATE 1/27/94
JOB NAME / LOCATION
JOB NUMBER
JOB PHONE

We hereby submit specifications and estimates for:

Quantity	Model	Description	Price	Extension
	Color System			
4	Panasonic GP-KS152	Color Video Camera	$1850.00	$7400.00
4	Panasonic GP-CA56	2M Camera Cable	$240.00	$960.00
4	Panasonic GP-LM7R5TB	7.5MM Lens	$180.00	$720.00
1	JVC BR-S405U	Portable S-VHS VCR	$2450.00	$2450.00
1	Skotel TCG-333	VITC Time Code Gen.	$2700.00	$2700.00
1	Robot MV-85	Color/B&W Quad	$1300.00	$1300.00
			Total:	$15530.00
	B/W System			
	Panasonic GP-MS112	B/W Video Camera	$1450.00	$5800.00
4	KS-102P2.0S	2M Camera Cables	$180.00	$720.00
4	Panasonic GP-LM7R5TB	7.5MM lenses	$180.00	$720.00
1	JVC BR-S405U	Portable S-VHS VCR	$2450.00	$2450.00
1	Skotel TCG-333	Time Code Generator	$2700.00	$2700.00
1	Robot MV-85	Color/B&W Quad	$1300.00	$1300.00
			Total:	$13690.00

We Propose hereby to furnish material and labor — complete in accordance with the above specifications, for the sum of: dollars ($)

Payment to be made as follows:

Terms: Net 30 Days on approved credit
Freight: FOB Billerica, MA

Authorized Signature [signature]

Note: This proposal may be withdrawn by us if not accepted within 30 days.

Acceptance of Proposal — The above prices, specifications and conditions are satisfactory and are hereby accepted. You are authorized to do the work as specified. Payment will be made as outlined above.

Signature

Signature

Date of Acceptance:

217

EASTERN VIDEO SYSTEMS, INC.
2 Sterling Road
BILLERICA, MASSACHUSETTS 01862

(508) 667-0009
FAX (508) 663-3769

PROPOSAL

'OMr. Frank Barickman
Oak Ridge National Laboratory
P.O. Box 2008,Bethel Valley Rd
Bldg. 6025, MS 6360
Oak Ridge, TN 37831-6380

PHONE (615) 574-6198
DATE 1/31/94
JOB NAME / LOCATION
JOB NUMBER
JOB PHONE

/e hereby submit specifications and estimates for:

:SCRIPTION	QUANTITY		PRICE
ANASONIC GP-KS152 CAMERA	45+	15 units @ 3 cameras per unit	$1800.00
ANASONIC GP-CA56 CABLE	45+		$225.00
ANASONIC GP-LM7R5TB LENS	45+		$170.00
/C-BRS405U PORTABLE VCR	15+		$2398.00
ORITA VG-50 TIME CODE GENERATOR	15+		$275.00
OBOT MV-85 TIME CODE GENERATOR	15+		$1250.00
ORITA VG-50 TIME CODE GENERATOR	1-4		~~$330.00~~ $317.90

We Propose hereby to furnish material and labor — complete in accordance with the above specifications, for the sum of:

dollars ($).

Payment to be made as follows:

:ERMS:NET 30 DAYS ON APPROVED CREDIT
'REIGHT:FOB BILLERICA, MA

All material is guaranteed to be as specified. All work to be completed in a professional manner according to standard practices. Any alteration or deviation from above specifications involving extra costs will be executed only upon written orders, and will become an extra charge over and above the estimate. All agreements contingent upon strikes, accidents or delays beyond our control. Owner to carry fire, tornado and other necessary insurance. Our workers are fully covered by Worker's Compensation Insurance.

Authorized Signature: Jon Scott Hardy

Note: This proposal may be withdrawn by us if not accepted within 30 days.

Acceptance of Proposal — The above prices, specifications and conditions are satisfactory and are hereby accepted. You are authorized to do the work as specified. Payment will be made as outlined above.

Signature

Signature

Date of Acceptance:

Price List

EFFECTIVE OCTOBER 15, 1994

- Multivision Plus™ Record/Display Multiplexers
- Multivision® Digital Picture Processors
- Senturion™ CCTV Control Systems
- Analog Picture Transmission System
- HyperScan® Plus and Ultra™ Digital Picture Transmission Systems
- HyperComm™ Digital Audio Communication System
- Rack Mounts

ROBOT
PERSISTENCE OF VISION

TELEPHONE: (619) 279-9430 (800) 854-2057 FAX: (619) 279-7931

RX43UK	**UPGRADE KIT** Allows upgrade of RX42 or RX43SX Turnkey Receivers to RX43QX four-channel communication. Includes RX41 3.0 software, SI41 4-port Serial Interface Card and three 19.2 Kbaud modems.	**3995.**
TX42	**4-CAMERA B/W DIGITAL PICTURE TRANSMITTER WITH MODEM** Features differential video inputs, auto-answer, auto-dial upon alarm, four alarm inputs, TTL alarm output, monitor output, and VIDI expansion port. Includes external 19.2 Kbaud modem and DC power supply.	**1695.**
EX40	**VIDEO AND ALARM INPUT EXPANSION MODULE** Expands the TX42's video and alarm input capacity to 7, 10, 13 and 16 inputs. Operates on the VIDI bus and includes 18" VIDI bus cable.	**495.**
RX47S NEW	**TRU-COLOR TURNKEY RECEIVER – SINGLE COMMUNICATION CHANNEL** Fully integrated Receiver including 486/33 platform with S-VGA monitor, 19.2 Kbaud modem, 3.5" disk drive, 170 MB hard drive, and mouse. Windows 3.1 and RX45 1.0 software installed.	**5995.**
RX47Q NEW	**TRU-COLOR TURNKEY RECEIVER – FOUR COMMUNICATION CHANNELS** Fully integrated Receiver including 486/33 platform with S-VGA monitor, four 19.2 Kbaud modems, 3.5" disk drive, 170 MB hard drive, and mouse. Windows 3.1 and RX45 1.0 software installed.	**9995.**
RX47UK NEW	**UPGRADE KIT** Allows upgrade of RX42, RX43SX or RX47S Turnkey Receivers to RX47Q four-channel communication. Includes RX45 1.0 software, SI41 4-port Serial Interface card, 1 MB video RAM chip and three 19.2 Kbaud modems.	**3995.**
RX48S NEW	**TRU-COLOR ST TURNKEY RECEIVER – SINGLE COMMUNICATION CHANNEL** Fully integrated Receiver including 486DX2/66 platform with S-VGA monitor, 28.8 Kbaud modem, 3.5" disk drive, 528 MB hard drive, and mouse. Windows 3.1 and RX45 1.0 software installed.	**9995.**
RX48Q NEW	**TRU-COLOR ST TURNKEY RECEIVER – FOUR COMMUNICATION CHANNELS** Fully integrated Receiver including 486DX2/66 platform with S-VGA monitor, four 28.8 Kbaud modems, 3.5" disk drive, 528 MB hard drive, and mouse. Windows 3.1 and RX45 1.0 software installed.	**13995.**
RX48UK NEW	**UPGRADE KIT** Allows upgrade of RX48S Turnkey Receivers to RX48Q four-channel communication. Includes RX45 1.0 software, SI41 4-port Serial Interface card and three 28.8 Kbaud modems.	**3995.**
TX47/8 NEW	**4-CAMERA TRU-COLOR DIGITAL PICTURE TRANSMITTER WITH MODEM** Features four video inputs, auto-answer, auto-dial upon alarm, four alarm inputs, 3-picture alarm memory, TTL alarm output, and VIDI expansion port. Includes external 28.8 Kbaud modem and DC power supply.	**2420.**
EX45 NEW	**VIDEO, ALARM AND TRANSCOAXIAL EXPANSION MODULE** Operates on the VIDI bus to expand the TX47's video and alarm input capacity to 7, 10, 13, and 16 inputs. Also provides a trancoaxial interface to the RC60 Receiver/Driver for pan/tilt and power zoom lens control. Includes 18" VIDI bus cable.	**595.**
RC40	**RELAY CONTROL MODULE** Connects to the TX42 or TX47 VIDI bus and operates under control of the HyperScan Receiver. Four normally open or closed relay contacts are provided. Up to four RC40s may be used in the system for a total of 16 relay contacts. Includes 18" VIDI bus cable.	**395.**

APPENDIX AA: TECHNICAL INFORMATION ON ADDITIONAL HARDWARE AND SOFTWARE DEVELOPMENT

Williamson Associates
DBA Associates
Mnemonics
VORAD Safety Systems

WILLIAMSON ASSOCIATES
Consultants AFOT
Specializing in design and development of prototype systems

August 25, 1993

6613 Lynndale Drive
Raleigh, NC 27612
1-919-848-3618

Mr. Dick Carter, Manager
Cognitive Systems & Human Factors Group
Engineering Physics and Mathematics Division
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6360

RE: Noninvasive, Biomedical Monitoring System, R & D Proposal.

Dear Dick,

Enclosed, please find the cost breakdown for developing the "Heart Rate / Breathing Rate System."

These costs reflect a strategy that I feel should yield a system that will be the most flexible. It should be capable of quantifying the desired information while preserving or archiving the "raw" data for later analysis.

To that end, one would perform continuous FFT (Fast Fourier Transform) on a finite bandwidth signal, while simultaneously recording (and compressing) the time domain representation of that signal.

Originally I had planned to use adaptive filtering to extract the numerical values for heart rate and breathing rate without retaining any other data. Because this approach would prevent any post analysis of the data (for other attributes), and because of the research nature of this device: it is appropriate that the above architecture be used.

As a rational for this approach, consider the following: it could be used for the detection of cardiac arrhythmia, signalling the possible onset of a heart attack; as a indicator for fatigue or sleepiness, the very artifact that has been seen as interference, i.e., driver movement or "squirming," restlessness (trying to get comfortable) might just be such an indicator. Also, breathing depth or shallow breathing (another possible indicator) might better be analyzed in the time domain.

I propose that the microwave Doppler transducer consist of one very low power GUNN microwave emitter, with two or more diode detectors--spaced at <1/4 wavelength (~1/8, for standing waves). The output from these detectors go to a DSP board for two different processes. The first is to take a continuous FFT of the real-time signal and pass the resulting data (frequency and amplitude) to the Host computer. The second, is to compress and store the digitized--time domain--data from the transducer for post processing and/or near real time processing by the host computer.

Again Dick, thanks for the opportunity to propose these fun projects.

Sincerely,

Glen

Glen A. Williamson, owner

Enclosures:

Research & Development Costs
(Noninvasive, Biomedical Monitoring System, R & D Proposal)

A. Hardware

1.. Datel, PC-430 DSP Board 4 channel (uses TI TMS320 DSP)	$ 4,595.00	
2.. "K" Band Doppler RADARs Sub "X" Band Doppler RADARs	$ 450.00	
3.. Misc. Hardware Planar Antenna Piezo SWR Diverters Motor driven auto-positioner System hardware (misc) DRAM 8meg (for LabView, etc.)	$ 1,250.00	
Subtotal	$ 6,295.00	——> $ 6,295.00

B. Software

1.. Datel Software PC-430SRC	$ 1,195.00	
2.. Lab View for Windows	$ 1,995.00	
3.. Windows 3.1	$ 150.00	
10.. Custom Software	$ 2,000.00	
Subtotal	$ 5,340.00	——> $ 11,635.00

C.. Labor: 14 weeks x 1/2 time = 280 hours x $ 65.00 + $ 18,200.00

NOTE:
The 14 week number is worst-case; it is expected that the required time will be less.

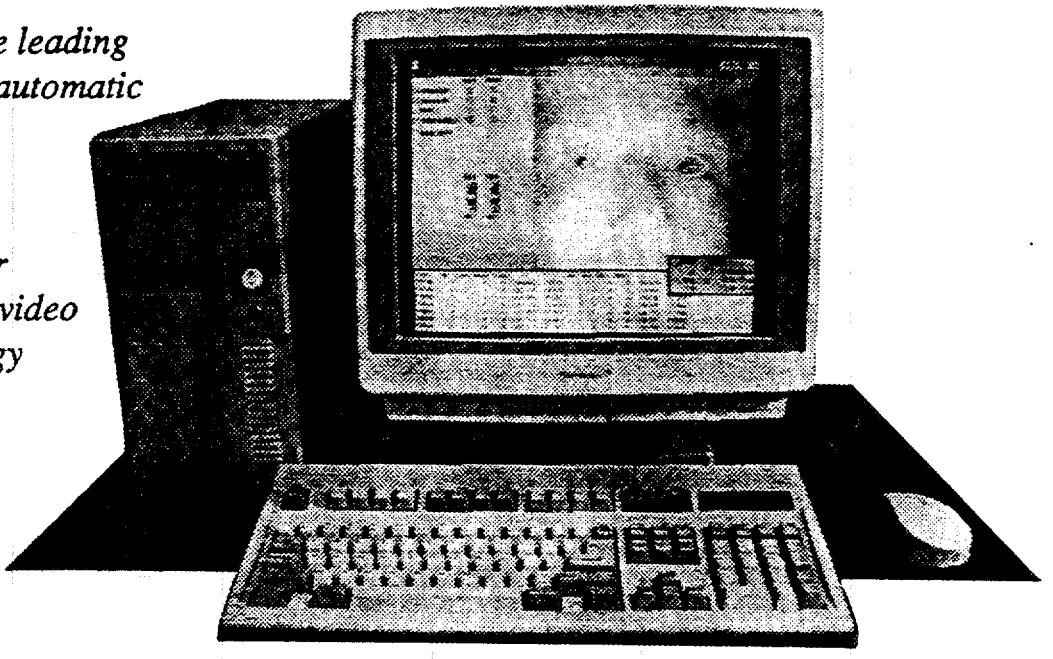
Total ..... $ 29,835.00

Needed Data ?

1.. What CPU is being used ?
2.. What DOS Is it using ?
3.. Is it Multi-tasking ?
4.. How much computer time can this task have: MIPS ?
5.. How much RAM can this task have ?
6.. How much disk space can this task have ?
7.. Is there an empty accessory slot (ISA) ?

MODEL 626 PC-Based Automatic Video Tracking System

DBA Systems, the leading manufacturer of automatic video trackers, announces the Model 626, a PC-based tracker based on proven video tracker technology



This PC-Based system was specifically designed and developed for commercial tracking and monitoring applications. The Model 626 utilizes state-of-the-art multimedia technology to window the video into the PC's control monitor and allows simple operational control, while offering the same performance of our proven military tracker product line.

System Description

The basic hardware platform is an IBM–compatible 486 processor operating at 33 MHz with 4 Megabytes of on-board RAM and a 120 Megabyte hard disc. The system operates under MS-DOS 5.0 and Windows 3.1. The video input is standard black and white RS-170 video format and is received by a Super VGA multimedia card. This card performs three basic functions for the Tracker:

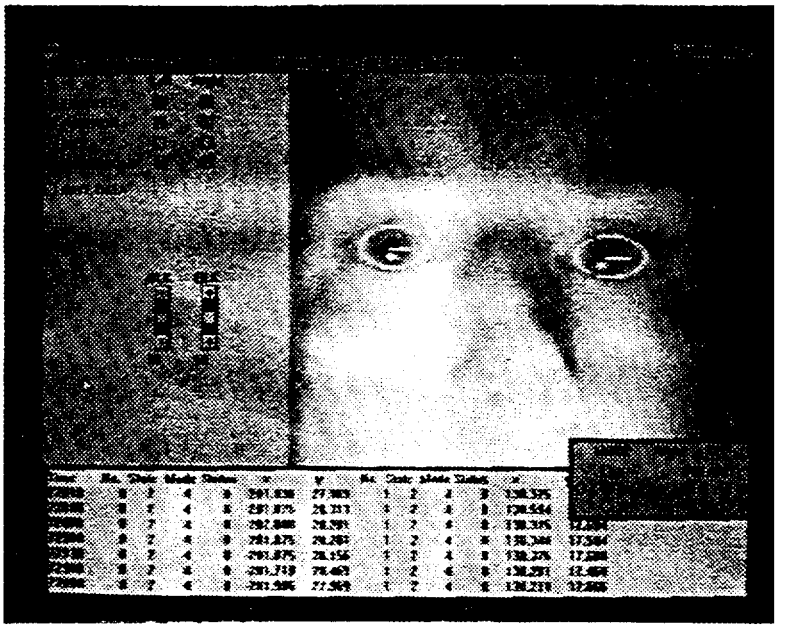
- ***Provides normal PC display functions***
- ***Provides a video window display of the target and track window annotations***
- ***Provides digitized video to the track processor boards in real time (pixel rates)***

1200 S. Woody Burke Road • P.O. Drawer 550 • Melbourne, Florida 32902-0550 • Phone (407) 727-0660 • FAX (407) 723-7019

The gate processor provides the track point locations (top, bottom, left, right and centroid) for each video field. In addition, there is sufficient video intensity data provided to automatically adjust the target threshold detection logic in real time. The target edges are used to determine the size of the track window automatically and adjust each window size independently. Similarly, the number of target pixels detected is available and provides numeric data as to the target's area.

The Model 626 can be configured to track multiple targets simultaneously. The baseline unit is a single target tracker and comes equipped with a single DBA Gate Processor Card. The Dual Gate Tracker configuration is depicted in the block diagram. Presently, the system can be configured to track three targets simultaneously.

The operator interface with the Tracker is via an application program operating under Microsoft Windows 3.1. This application follows the guidelines for Graphic User Interface recommended by Microsoft, thereby reducing operator learning curve and operating errors. The mouse is used to select the track window and position it over the target. The operator can specify target polarity (black, white, mixed or grey), track window shape and size and desired track point (top, bottom, left, right or centroid) for each track window.

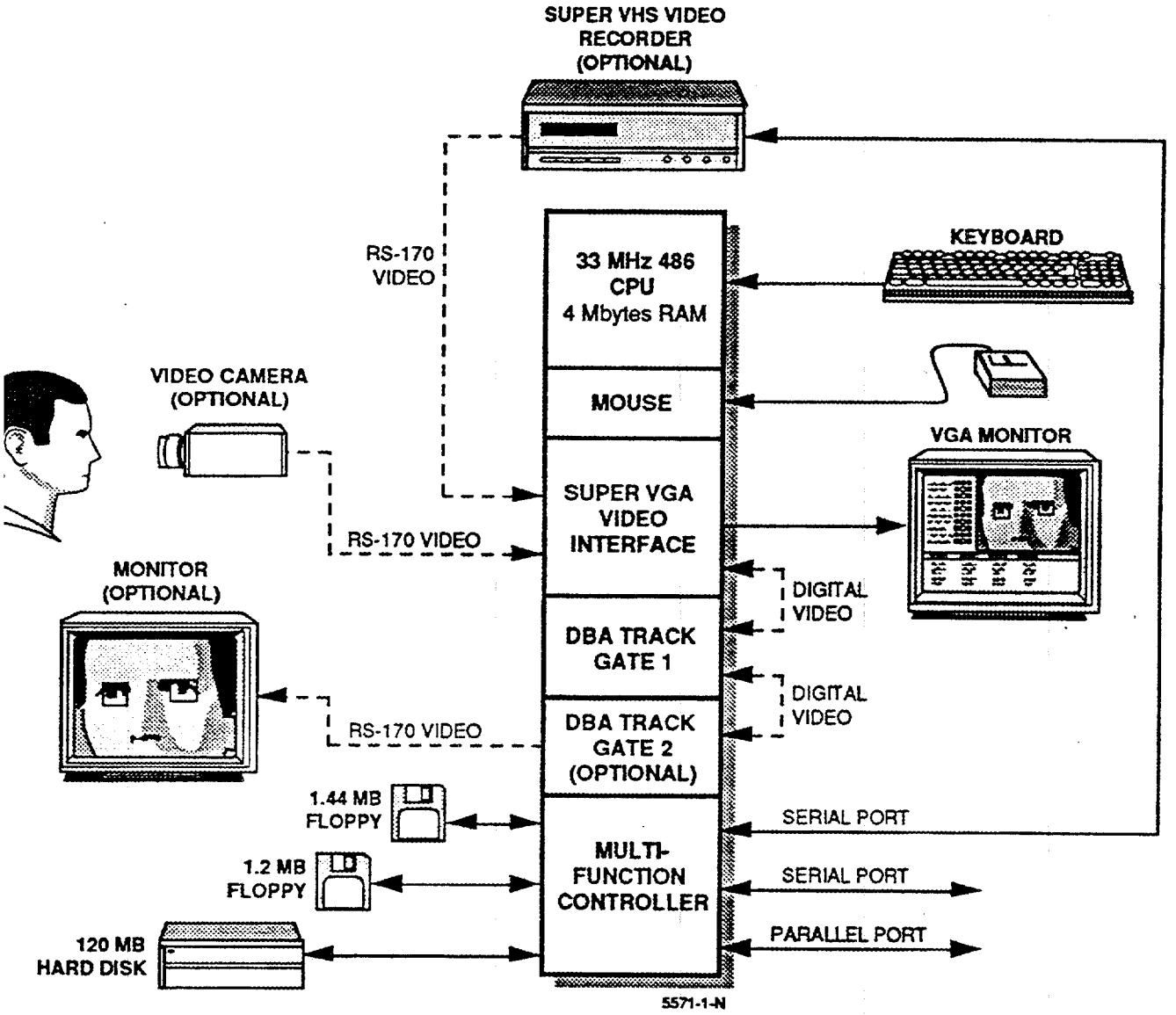


Operator Monitor/Controls Display

The system includes various means to ensure that the track window stays on target and even provides algorithms for track recovery if the target momentarily moves out of the camera field of view. A digital filter is included which reduces the effect of video noise on the tracking.

Upon operator command, the real-time data is recorded on the hard disc for post-test analysis. There are various tools available for this analysis, including tabulation by track window number or left/right criteria, as well as computing velocity and acceleration information. This analysis package includes calculation of various statistical parameters — mean, standard deviation, correlation coefficients, etc. based on the collected data. This package will also reformat the collected data into an ASCII file which can be easily ported to other utility programs for further analysis/display.

MS-DOS and Windows are registered trademarks of Microsoft Corporation.



Dual Gate Tracker Configuration

SYSTEM HARDWARE CONFIGURATIONS

- *486-33MHz PC (IBM Compatible)*
- *4 Megabytes RAM*
- *120 Megabytes hard disc*
- *5 1/4 & 3 1/2 floppy disc drives*
- *Dual serial ports*
- *110 key extended keyboard*
- *Printer port*
- *Bus mouse*
- *14-inch super VGA monitor*
- *Super VGA Video Interface*
- *DBA Gate Processor Card*

SYSTEM SOFTWARE

- *MS-DOS 5.0 (copyright Microsoft)*
- *Windows 3.1 (trademark Microsoft)*
- *WINTRKR 2.2 (trademark DBA Systems)*
- *New Media Windows display library*

SYSTEM PERFORMANCE CHARACTERISTICS

- *RS-170 black and white video input*
- *Dual or single target tracking*
- *Data collection at 60 Hz*
- *Real time data storage (10 minutes/1 Megabyte binary)*
- *Standard Graphical User Interface*

Track Mode	Resolution		Accuracy	
	Horizontal	Vertical	Horizontal	Vertical
Centroid	720 pixels	480 lines	1:2880	1:960
Edge	720 pixels	480 lines	1:720	1:480

ENVIRONMENTAL SPECIFICATIONS

- *Standard laboratory environment*
- *110 Vac 60 Hz*

OPTIONS

Video camera/lens, Computer-controlled video recorder, High-resolution monochrome video monitor

SYSTEM CAPABILITIES

CAPABILITY	CURRENT	NEAR TERM	FUTURE
NUMBER OF SENSORS	1	1 OF 4	STEREO
NUMBER OF GATES	2 (TESTED) 8 (DESIGN)		3 TO 6
GATE SHAPE	RECTANGLE ELLIPSE		PARALLAGRAM ADAPTABLE
TRACK MODES	CENTROID (CONTRAST) EDGE	CENTROID (INTENSITY) PEAK INTENSITY	GEOMETRIC CORRELATION (STATISTICAL)
COAST MODES	LAST VALID HISTORICAL	PREDICTION MULTI-GATE	AS REQUIRED
DATA RATE	60 HZ	60 HZ	120 HZ (MULTISENSOR) 240 HZ (SPECIAL RECORDER)
DATA ANALYSIS	COLLECTION	GRAPHICAL	AS REQUIRED
CALIBRATION	MANUAL	AUTOMATED	AUTOMATED
ACQUISITION	MANUAL	ASSISTED	AUTOMATED
REMOTE CONTROL	BASIC	COMPREHENSIVE	TBD

DBA Systems, Inc.

11 March 1994
File: ES94-357

Fax: (615) 574-9619

Dr. Richard Carter
Research Psychologist
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6360

Subject: Stereo Eye Tracking

Dear Dr. Carter:

DBA would like to thank you for the opportunity to participate in the DASCAR Program. As Mike Churillo told you, we are currently working on developing a stereo measurement capability which is totally non intrusive. The system is configured using two dual gate PC based trackers, and an IR illumination source capable of operating in high ambient light conditions.

The system for your prototype requirement would be based on an enhanced version of this configuration including required software modifications and calibration models. The prototype system would also include the cameras, lenses and hardware necessary to integrate the system in the test vehicle. For follow-on systems the dual processors would be combined in a single unit containing all computer an support electronics.

The estimated price to develop the prototype system is $75K dollars and includes 1 week of integration support at Oak Ridge, TN. The price is contingent on receipt of other anticipated contract work which would compliment this effort. Additional support would be based on a Time & Material type contract which can be discussed at a later date.

We look forward to working with you on this in the future. If you have any questions, please feel free to contact Tom Riding or George Downey at Extensions 2703 or 2743 respectively.

Sincerely,

Richard Van Pelt.
Vice President
DBA Systems, Inc.
Electro-Optical Systems Division

RVP/krk

MNEMONICS, INC.

INDUSTRIAL VISION SYSTEMS
VISION SYSTEMS INTEGRATION
SIGNAL & IMAGE PROCESSING
BIOMEDICAL INSTRUMENTATION
CUSTOM DESIGN & PROTOTYPING

March 22, 1994

Richard Carter
Oak Ridge National Laboratory
PO Box 2008
Oak Ridge, TN 37831-6360

Voice: 615 574 6454
Fax: 615 574 7860

Dear Richard,

I am writing to you as a follow up to our telephone conversation yesterday. MNEMONICS, INC. specializes in Machine Vision software development and systems integration. Our emphasis has been on the delivery of turnkey systems in a number of industries, including microelectronics, defense, automotive, food and medicine. MNEMONICS, INC. has used the IBM-AT computer platform in most of these applications. I have enclosed some literature on MNEMONICS, INC. which may be of interest or use to you.

In response to your requests for my input on the Driver Gaze monitoring, I can suggest two alternatives, each of which would best be implemented by phased approaches. The two approaches I have conceived are outlined below, with some detail for each. For a project to be established to bring either of these to realization, there are some common development areas that will need addressing, which I have listed as well.

METHOD 1. - MARKER TARGET TRACKING
- ENGINEERED WITH MINIMAL INTRUSION MODEL

1. Specification
2. Data Collection Design
3. Data Collection Implementation
4. Video Image Processing Design
5. Video Image Processing Implementation
6. Video Image Processing Test & Evaluation
7. Rework and Final Design, Implementation, and Test

102 GAITHER DRIVE ■ P.O. BOX 877 ■ MT. LAUREL, NJ 08054 ■ 609-234-0970 ■ FAX: 609-234-6793

METHOD 2. - OPTIC FLOW/BIOMETRIC TRACKING
- NATURAL ENVIRONMENT, NO INTRUSION.

1. Specification
2. Data Collection Design
3. Data Collection Implementation
4. Video Image Processing Design
5. Video Image Processing Implementation
6. Video Image Processing Test & Evaluation
7. Rework and Final Design, Implementation, and Test

COMMON PROBLEMS TO BOTH APPROACHES

Both of the methods described below would require the software and hardware to be interfaced to the MNEMONICS, INC. custom turnkey system. The interface components required would be at least a computer controllable video tape deck, and access to the time coded information. Both methods would use standard frame grabbers. Both would require the development of user interfaces and would need to interface to other data base information. Both methods will require the computation of Gaze information from the location of the target areas. Both methods would also need to establish the position of the head relative to some fixed reference.

The cost of this effort is dependent on the exact statement of work, but should not exceed four labor weeks. A budget of $15,000 to $20,000 for the labor effort should be allowed. The computer system hardware and software costs (excluding tape deck, interface boards, etc.) for this phase should be less than $10,000, including the PC-AT, frame grabber, and packaged software costs.

METHOD 1. - MARKER TARGET TRACKING
- ENGINEERED WITH MINIMAL INTRUSION MODEL

This method would require some type of markers to be placed on the forehead of the vehicle operator, such as an "X" or an "O" to be placed above each eyebrow. These could be affixed with adhesive tape or a non caustic adhesive such as that used for EEG (electroencephalogram) electrode placement which is easily removed with a mild organic solvent such as alcohol or acetone. The markers can be tracked by the use of one of MNEMONICS, INC. standard software packages, ALIGN. ALIGN is designed for tracking and reference mark location in environments where significant light level variations are expected.

This method would require the operator to set up initial windows for learning the targets, but should be able to reduce specific operator tracking to a negligible amount. Occasional operator input may be needed for exception handling.

The labor for this development phase should be approximately $15,000. There should be little, if any additional hardware required.

METHOD 2. - OPTIC FLOW/BIOMETRIC TRACKING
- NATURAL ENVIRONMENT, NO INTRUSION.

This method would make use of natural vehicle operator characteristics for performing the tracking. Perhaps the inner/outer canthus of the eyes, or other relatively stable prominences could be used. These features would need to be taught prior to each data analysis run. These features are more variable than the engineered targets, and more development time will be required to ensure good tracking results.

One method that may be useful is optical flow information processing. Optic flow makes use of scene to scene changes along gradient lines that yields motion direction information. This information, in conjunction with tracking of natural features may provide a more robust location of the features.

The labor required for this method would cost approximately $30,000.

BUDGETARY ESTIMATES

METHOD 1. - MARKER TARGET TRACKING
- ENGINEERED WITH MINIMAL INTRUSION MODEL

FIRST SYSTEM: APPROXIMATELY $ 45,000
REPEAT SYSTEMS: APPROXIMATELY $ 12,000

METHOD 2. - OPTIC FLOW/BIOMETRIC TRACKING
- NATURAL ENVIRONMENT, NO INTRUSION.

FIRST SYSTEM: APPROXIMATELY $ 60,000
REPEAT SYSTEMS: APPROXIMATELY $ 12,000

If you have any further questions, please do not hesitate to call.

Sincerely yours,

Michael Negin
President

enclosure

MNEMONICS, INC.

INDUSTRIAL VISION SYSTEMS
VISION SYSTEMS INTEGRATION
SIGNAL & IMAGE PROCESSING
BIOMEDICAL INSTRUMENTATION
CUSTOM DESIGN & PROTOTYPING

CORPORATE EMPHASIS

MNEMONICS, INC. is a high-technology research, design, and development company, primarily engaged in the delivery of turnkey systems in the following general areas:

- Integration of custom and standard vision systems into automated manufacturing systems,
- Computer Vision and Sensing, including real-time high-speed (video rate) image and signal processing,
- Software and Hardware Development of operational image processing systems for industrial and research applications,
- Biomedical signal processing and image processing systems, and
- Microcomputer systems design.

MNEMONICS, INC. was incorporated in late 1979, specifically for the purpose of contract engineering in high technology research, design, development and productization. Since 1983, MNEMONICS has expanded its corporate goals to include custom development and systems integration for a variety of end user industries. MNEMONICS' clients include industrial firms requiring image and signal processing assistance and resources in R&D, industrial product development, University research projects, and medical research.

EXPERIENCE

The staff of MNEMONICS has a wide range of machine vision, image and signal processing research and development experience. The staff has been instrumental in organizing and implementing numerous projects involving mathematical image modeling and interpretation, including motion analysis of cardiac cineradiographs, semiconductor defect inspection, generalized detection theory, true three-dimensional graphics, robot vision systems, consumable goods inspection, food industry process inspection, and a variety of other industrial, government, military, and medical applications.

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The staff of MNEMONICS is active in machine vision systems and software development as well as activities in general image processing. Other activities include real-time video-rate image processing system research, design, and implementation. Some of MNEMONICS' relevant activities include:

1) Extensive use of various operating systems and general purpose computers to develop software for real-time signal and image processing.

2) Special purpose microprocessor design and implementation for applications where processing speeds could not be achieved using standard hardware and software products.

3) Extensive use of commercial machine vision/image processing products.

4) Extensive experience in evaluating, selecting and utilizing appropriate vision sensors such as area array camera, line-scan array cameras, and tube cameras.

5) Extensive experience in the design, specification and construction of specialized illumination systems.

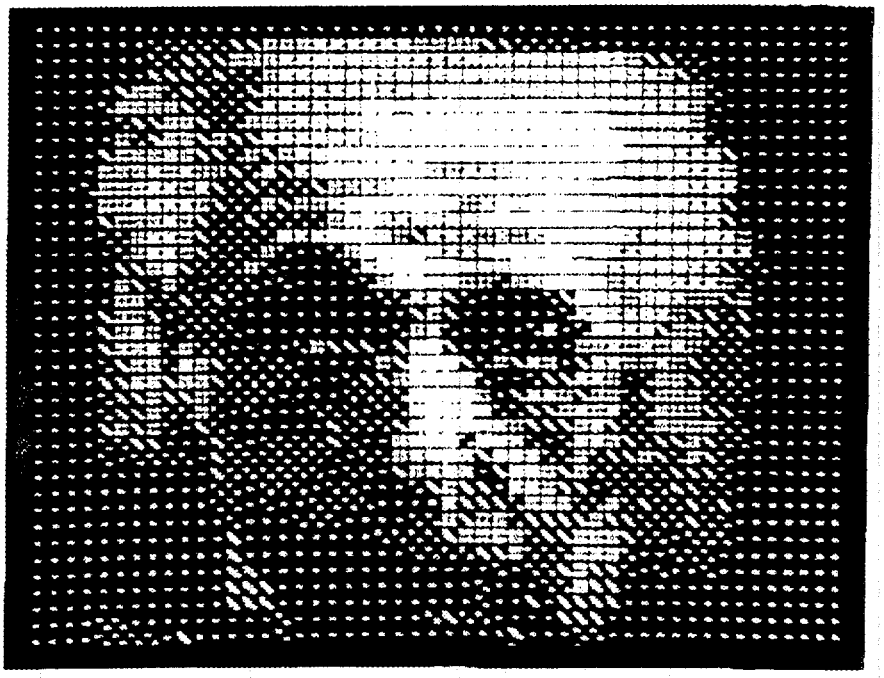
6) General purpose microprocessor system design and implementation. Includes Intel, Motorola, and Digital Equipment microprocessors and controllers.

7) Extensive mathematical modeling and analysis, statistical modeling and analysis.

8) Extensive documentation packages.

Key to MNEMONICS qualifications is a unique blend of talents and experience that result in practical solutions to machine vision and image processing problems in application environments. The MNEMONICS staff has created software packages and operational machine vision and image processing systems that are in day-to-day use in industry, academic, defense, government, and medical environments, many of which have been incorporated in clients' product lines or have been integrated into manufacturing systems. MNEMONICS designs have been productized and installed in several thousand test instruments and automated manufacturing systems in over forty different applications in ten different industrial categories.

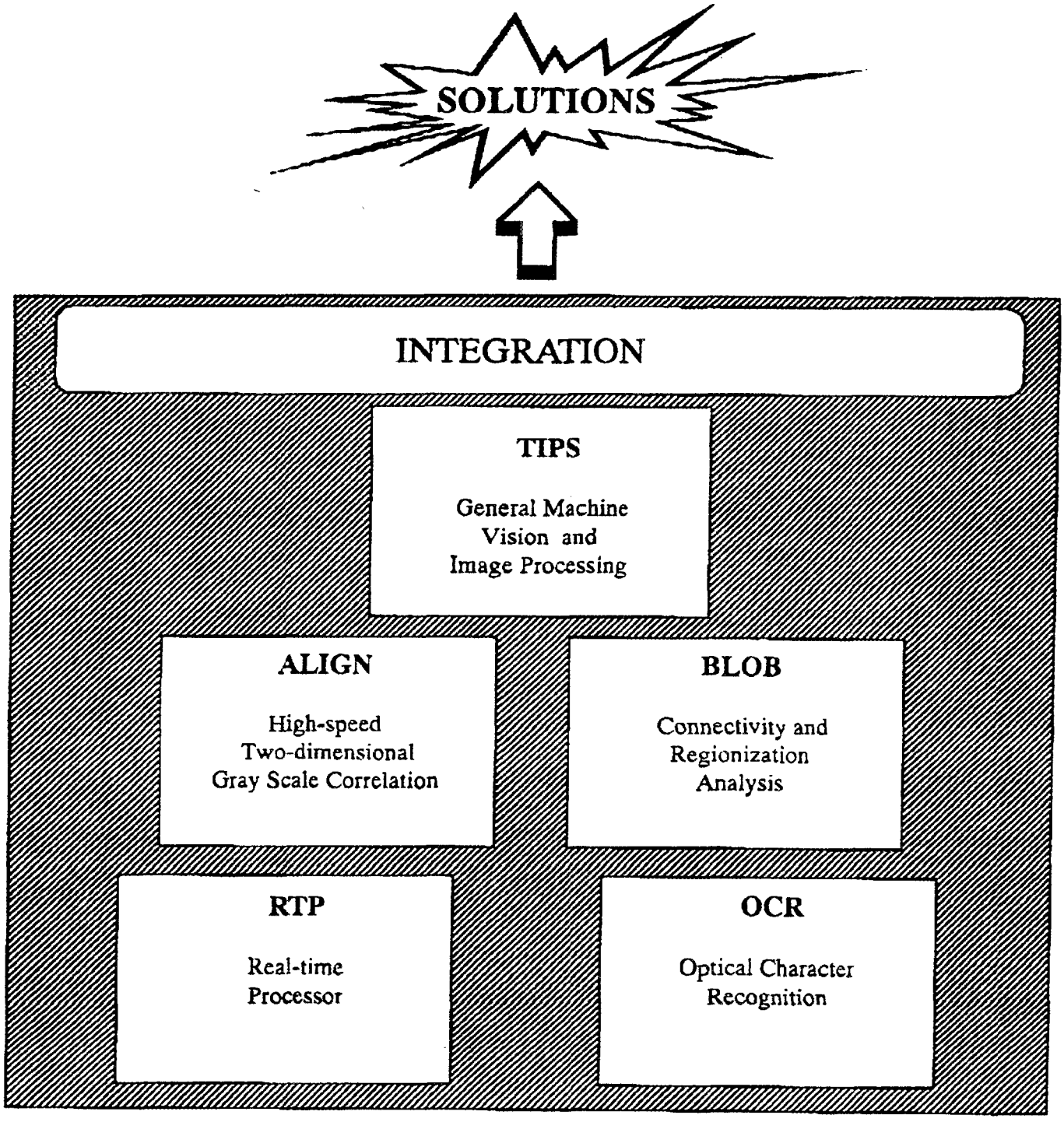
Look to
MNEMONICS



for Genius in Vision

MNEMONICS'

OFF-THE-SHELF MACHINE VISION and IMAGE PROCESSING SOFTWARE PACKAGES PROVIDE THE BUILDING BLOCKS TO SOLUTIONS



All of MNEMONICS software products have interactive image tools that are useful in exploring algorithmic approaches.
All of the packages have C libraries that smoothly integrate with each other and other libraries.

MNEMONICS, INC. has been supplying solutions to machine vision problems since 1979. In the process of developing these solutions, a number of software tools have been defined, implemented and proven in real world applications. Many of these tools have been organized and documented into a family of vision products. Each of these software "toolboxes" can simplify the process of developing in-house solutions to your machine vision problems. These packages are provided as interactive programs and libraries of Microsoft C callable routines. The interactive programs allow users to become familiar with the capabilities of the software and quickly develop and test potential solutions. The C libraries facilitate integration of machine vision solutions into finished applications.

The packages also feature:

- o Cross product compatibility.
- o Use of a variety of imaging hardware, PCPLUS, FG100, OFG, AFG, SR151, CORTEX I
- o Operation in a cost-effective, standard PC-AT host computer environment.

ALIGN

High Speed Alignment System

ALIGN is a software package for vision applications requiring gray-scale pattern recognition and object registration, alignment or tracking. Alignment is performed using an enhanced normalized gray scale correlation technique.

Features:

- o Pattern quality scores to aid in selection.
- o Gray scale and edge based patterns.
- o High immunity to noisy images and image degradation.
- o High robustness to brightness, contrast and focus changes.

Functions:

- o Teach a pattern at a user selected size and location.
- o Teach a vision system selected pattern.
- o Set a search window.
- o Locate pattern in search window.
- o Development support functions.

Performance:

400x400 search window, 127x127 pattern.
140 msec, PCVISIONplus, 80486-25MHz,
108 msec, SR151 with IPA-150.

BLOB

Blob Analysis

BLOB is a software package for vision applications requiring binary object recognition, measurement or location.

Features:

- o Mouse or keyboard driven.
- o Processes multiple binary objects.
- o Blob statistics returned:
  - Area, Enclosing rectangle,
  - Centroid, Major and minor axis,
  - Angle of major axis.
- o Provides shape & orientation information.
- o Enables object counting.
- o Mouse or keyboard driven.
- o Variable resolution coarseness.

Performance:

Using a 512x480 image, 0.8 sec. processing time using a PCPLUS or CORTEX I with an 80486 DX 33MHZ.

RTP

Real-time Processor

RTP is a software package that implements a number of the Real-time capabilities of the Imaging Technology Series 151.

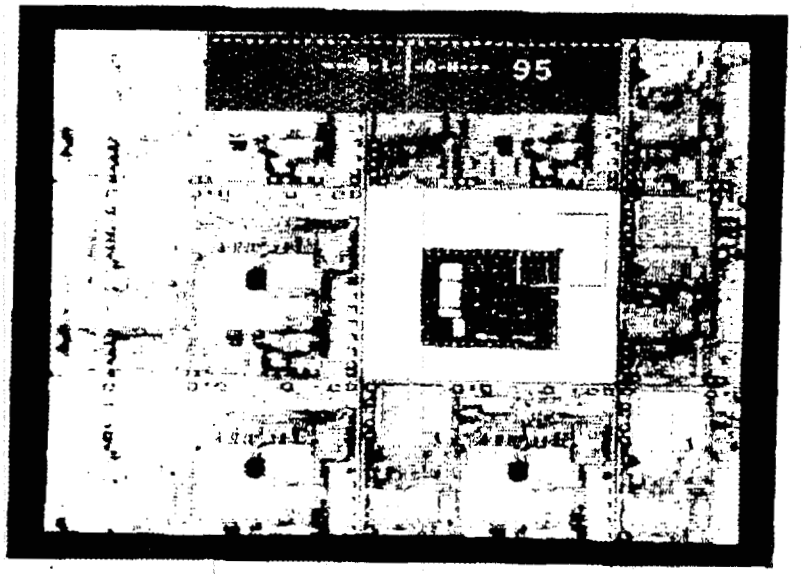
Functions:

- o Binary blob analysis.
- o Large kernel convolution.
- o 1 x 16 convolution.
- o 3 x 3 convolution.
- o 4 x 4 convolution.
- o 1 x 16 integration.
- o Minimum and maximum.
- o Feature count.
- o Feature centroid.
- o Histogram.
- o Image subtraction.

Performance:

Using a 512x480 image, 240 msec regionized blob analysis time using an SR-151 with an HF-150, and an 80286/87-10MHz.

Chip Alignment



TIPS

Turnkey Image Processing System

TIPS is a software package which implements most of the major image processing algorithms.

IMAGE ACQUISITION AND DISPLAY FUNCTIONS

- o Live/Snap
- o Clear Area of Interest (AOI)
- o Color enhance image
- o Copy AOI
- o Display a sequence
- o Horizontal and Vertical wedges
- o Input LUT manipulation and setting
- o Camera input selection
- o Label image
- o Output LUT manipulation and setting
- o Overlay on live image
- o Page selection
- o Print AOI to line printer or disk file
- o Restore AOI
- o Replicate AOI
- o Roam image
- o Set AOI
- o Save AOI
- o Replicate AOI
- o Snap a sequence
- o Squeeze AOI

SINGLE IMAGE FUNCTIONS

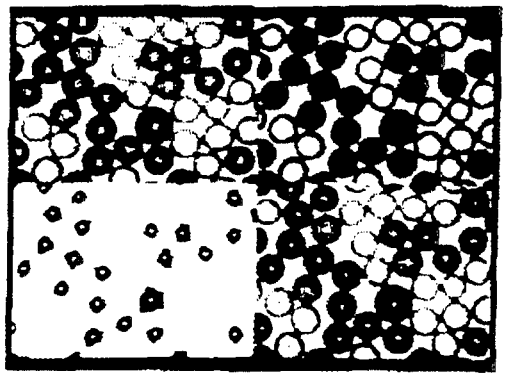
- o AND AOI with mask
- o Binarize AOI
- o Block average AOI
- o Blur AOI
- o Complement AOI
- o Contrast enhance AOI
- o Edge enhance AOI
- o Erode / Dilate AOI
- o Histogram equalize from AOI
- o Horizontal mirror
- o OR AOI with mask
- o Rotate AOI
- o Shift AOI
- o Slice AOI
- o Vertical mirror
- o Zoom-in on AOI

MULTIPLE IMAGE FUNCTIONS

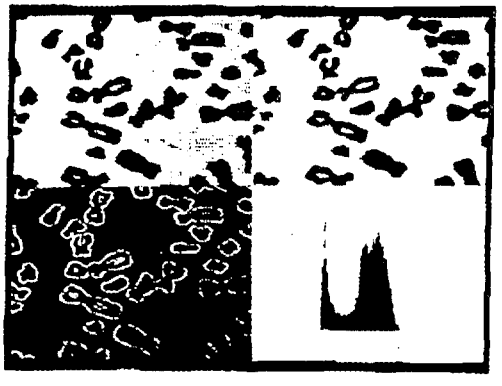
- o Add AOI's
- o AND AOI's
- o Divide AOI's
- o Multiply AOI's
- o OR AOI's
- o Subtract AOI's

MEASUREMENT FUNCTIONS

- o Cursor movement
- o Display Statistics for AOI
- o Histogram AOI
- o Line Profile



Labeled Blob and Morphology Analysis



Contrast and Edge Enhancement

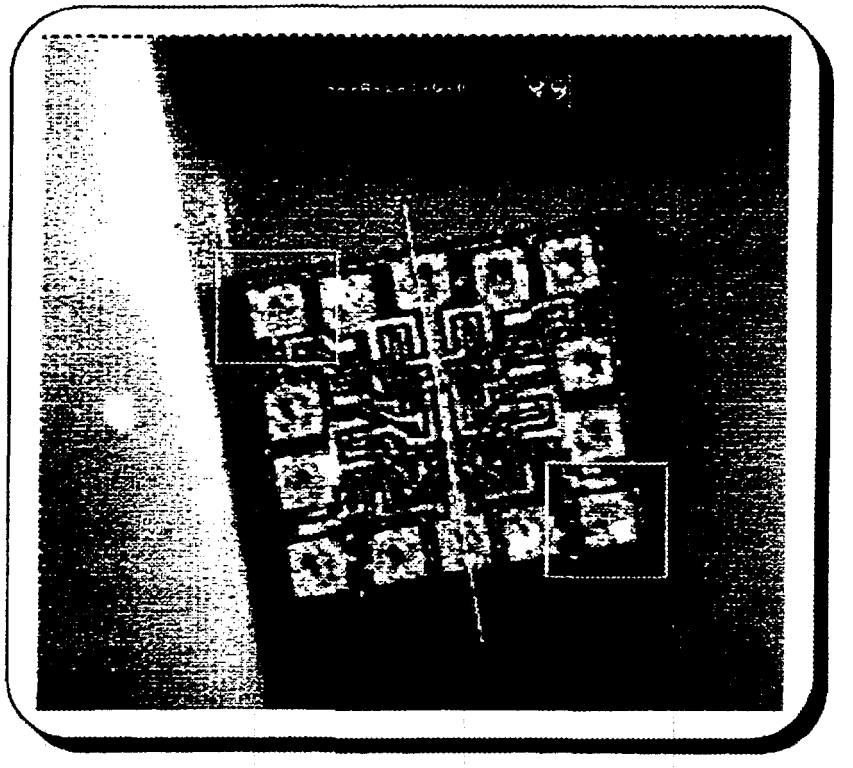
MNEMONICS, INC.

PO Box 877 ▪ 102 Gaither Drive • Mt. Laurel, NJ 08054 • 609 234-0970 • Fax: 609 234-6793

MNEMONICS ALIGN SOFTWARE

High Speed Alignment Software

ALIGN is a ***software*** package for vision applications requiring pattern recognition, object registration, alignment, or tracking. Alignment is implemented using normalized gray scale correlation. Timing benchmarks for a 127x127 pattern in a 400x400 search window range from 57 to 163 milliseconds depending on hardware configuration. These times compare favorably with proprietary ***hardware*** solutions, and offer the advantage of easy upgradability to new and faster platforms as they are introduced. Since **ALIGN** is a software product, users can easily migrate to other frame grabber platforms as they become available.



Products Supported

SHARP GPB-1
MuTech IMAGE/VGA
Imagenation CORTEX-I
Imaging Technology Products
Custom porting available

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High Speed Alignment Software

Features

- Pattern quality scores to aid in selection
- Gray scale and edge based patterns
- High immunity to noisy images and image degradation
- High robustness to brightness, contrast and focus changes
- Programmable sub-pixel resolution
- Menu driven interactive program is provided for user experimentation
- Compatible with MNEMONICS software (BLOB, TIPS, OCV, OCR)
- Compatible with CHARISIS® OCR software

Functions

- Teach a pattern at a user selected size and location
- Teach a vision system selected pattern
- Set a search window
- Locate pattern in search window
- Development support functions
- Menu utilities for rapid prototyping

Performance

Search window: 400 x 400 pixels
Pattern size: 127 x 127 pixels
80486 AT at 66 MHz

SHARP GPB-1	57 ms
ITI Visionplus-AT OFG/VIPA	58 ms
Imagenation CORTEX-I	75 ms
ITI PCVISIONplus	97 ms
MuTech IMAGE/VGA	100 ms
ITI Visionplus-AT OFG	163 ms

Hardware Requirements

- IBM PC-AT or compatible with 640 K RAM
- A math coprocessor is strongly recommended

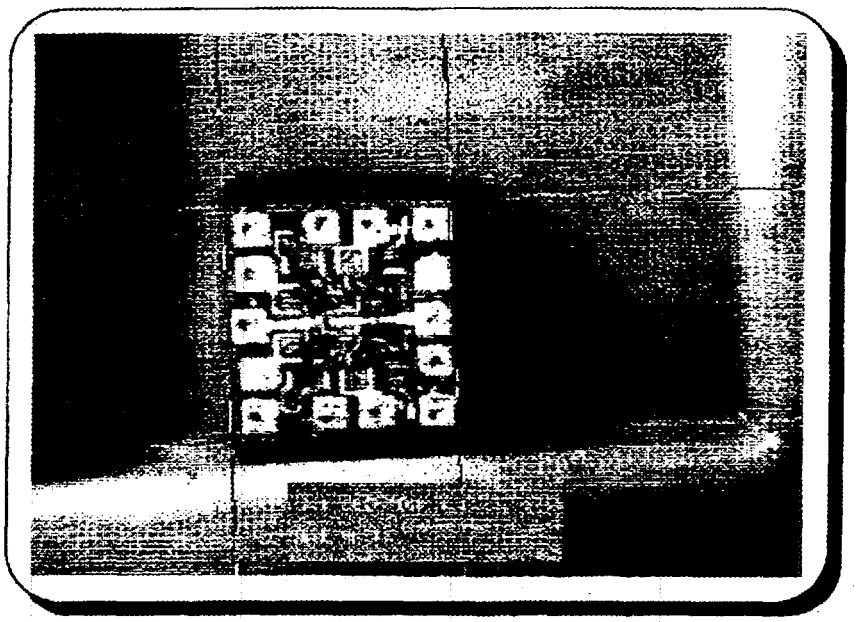
Software Requirements

- DOS 2.0 or higher, Microsoft C Version 6.0 or higher

TYPICAL APPLICATIONS FOR ALIGN

- Silicon Wafer Alignment
- Hybrid Circuit Alignment
- Mail Envelope/Mail Insert Verification
- Adaptive Biological Cell Tracking
- Printed Circuit Board Registration
- Waffle Pack Die Alignment
- Die Bonder Alignment
- Fiducial Mark Registration
- Target recognition and tracking
- Integrated Circuit Chip Alignment
- Fiducial Mark Registration
- Pick and Place Guidance
- Character String Verification (Optical Character Verification)
- Critical Dimension Measurement on Silicon Wafers
- Label Presence/Absence for Pharmaceutical packaging applications

ALIGN smoothly integrates with other MNEMONICS libraries as well as those from other vendors. When used in conjunction with these packages, **ALIGN** is a powerful tool that is useful in solving many challenging machine vision applications. **ALIGN** has been integrated into numerous sophisticated products and applications as well as more simple processes.



WAFFLE PACK DIE ALIGNMENT

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OTHER MNEMONICS OFF-THE-SHELF SOFTWARE

BLOB - Binary Object Analysis Software

BLOB is a software package for vision applications requiring connected binary object recognition, measurement or location. Features include area of interest processing, fine and coarse sampling, processing of multiple binary objects. BLOB statistics returns include enclosing rectangle, area, centroid, major and minor axis moments of inertia, and the angle of the major axis. BLOB statistics provide the ability to infer simple shape information, orientation, enables object counting, and object location.. On a 66 MHz 486AT, processing speeds of 250 milliseconds on a full resolution fame are typical. Smaller areas of interest are processed faster as are pixel coarsened images.

TIPS - Turnkey Image Processing System

TIPS is a software package which implements many of the major image processing algorithms. Most functions are area of interest (AOI) based. Functions included are Image Acquisition and Display Functions (live/snap, set AOI to a value, copy AOI, display a sequence, horizontal/vertical wedge, text label image, print image, replicate AOI, restore image, set Area of Interest, save image, snap a sequence, squeeze), Single Image Functions (AND image with mask, binarize image, block average, blur, complement, contrast enhance, edge enhance, erode/dilate, histogram equalize, horizontal/vertical mirror, OR with mask, rotate, shift image, slice, vertical mirror, zoom image), Multiple Image Functions (add images, AND images, divide image, multiply images, OR images, subtract images), Measurement Functions (cursor movement, display statistics, histogram image, line profile).

CORTEX-I XFUNCS

XFUNCS is a library of C-callable functions for the Imagenation CORTEX-I frame grabber. This library contains a comprehensive set of board drivers and imaging routines and is designed to provide hardware-independent software development across a wide variety of video imaging platforms. Pixel access functions have been coded in assembly language to provide the fast frame buffer access times. XFUNCS provides functions to allow control port manipulation, image acquisition, frame buffer access, image save and restore, graphics with smart overlays, and selected image processing capability .

VORAD Safety Systems, Inc.
10802 Willow Court
San Diego, CA 92127
619•674•1450
Fax 674•1355

February 28, 1994
Via Fax
1-615-574-9619
Total Number of Pages: 1

Richard J. Carter
Oak Ridge National Laboratory
Cognitive Systems and Human Factors Group
P.O. Box 2008
Oak Ridge, Tennessee 37831-6360

Subject:

Dear Dick:

In follow up to our recent discussions, the correspondence is to confirm the interest of VORAD Safety Systems, Inc. in participating in the DASCAR project. We understand that the effort may involve both a CRADA and a purchase order for support activity. Assuming the contracts can be reasonably negotiated, our participation would be contingent upon seeing the actual statement of work and associated schedules to ensure there was not an internal conflict of resources. As you are aware, confidentiality of the hardware design and its performance are very important to us. We understand that these concerns can be handled through appropriate provisions in the relevant contracts.

We also would like to restate our interest in participating in your consortium for the AHS activities. We would appreciate receiving additional information as it becomes available regarding requirements, expected efforts, timing, etc.

We look forward to receiving the initial DASCAR documents so that we can begin the internal planning process. If you have any questions, please feel free to contact me at any time.

Sincerely,

Don Murphy

Donald O. Murphy
Vice President
Business Development

APPENDIX BB: TECHNICAL INFORMATION ON LOAD CELLS AND A DUAL-FUNCTION ANTENNA

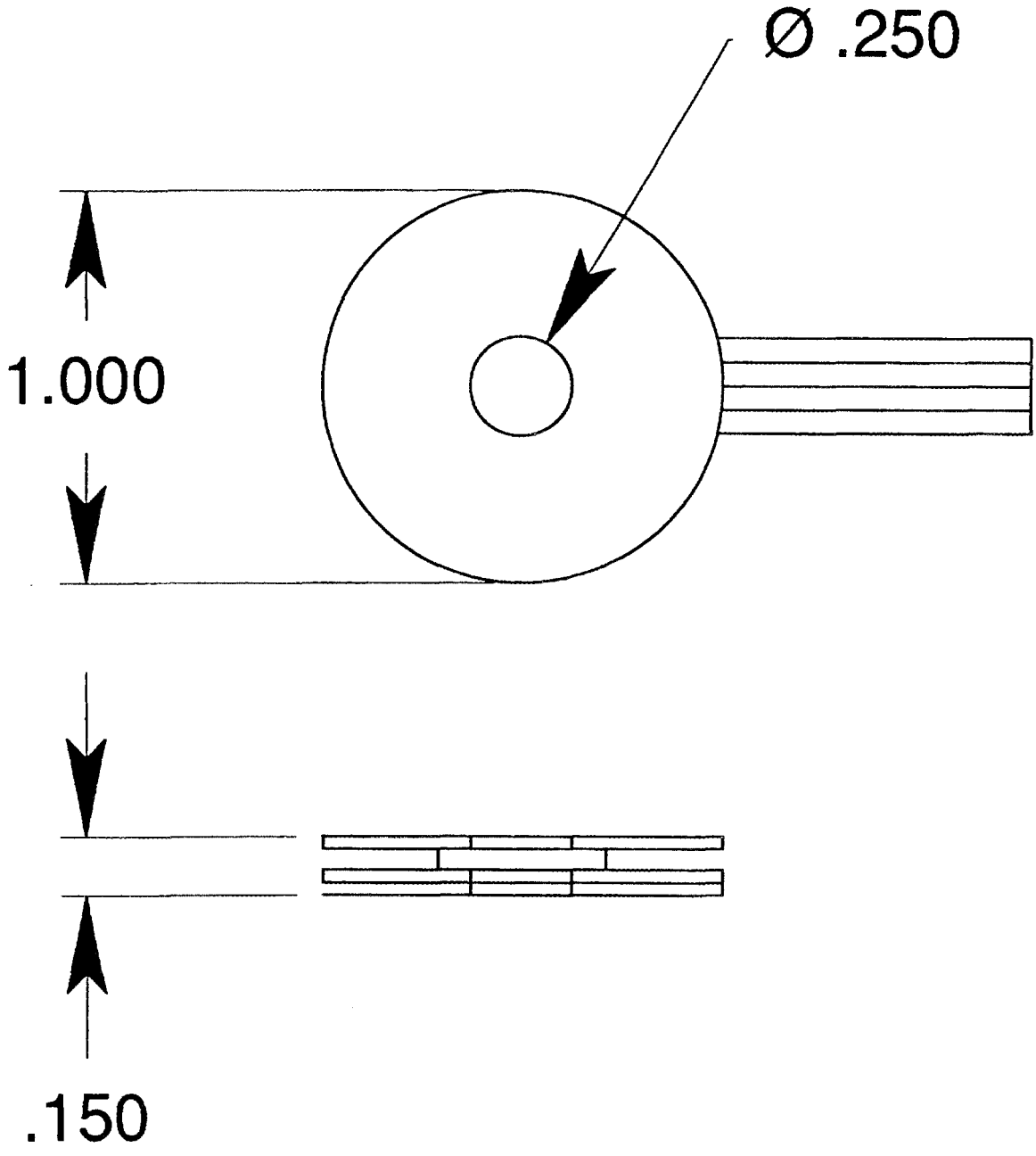
Entran Devices
Matsushita Electric Works

Load Cell Specifications

Model	ELF-1000-100-Z
Range (lbs)	100
Overrange (lbs)	200
Sensitivity (mV/lb nominal)	2.5
Compliance	Deflection: <500µin FS typ. Useful Freq.: >300 Hz typ.
Non Linearity	±1% F.S.
Hysteresis	±1% F.S.
Thermal Zero	±1% F.S. / 100°F
Mode	Compression
Input Impedance nominal	2000Ω nom. typ. (1000Ω min.)
Output Impedance nominal	1000Ω nom.
Excitation	15 VDC
Compensated Temperature	Option "Z" 32°F to 140°F
Operating Temperature	-40°F to 250°F

Model	ELF-1000-250-Z
Range (lbs)	250
Overrange (lbs)	500
Sensitivity (mV/lb nominal)	1
Compliance	Deflection: <500µin FS typ. Useful Freq.: >300 Hz typ.
Non Linearity	±1% F.S.
Hysteresis	±1% F.S.
Thermal Zero	±1% F.S. / 100°F
Mode	Compression
Input Impedance nominal	2000Ω nom. typ. (1000Ω min.)
Output Impedance nominal	1000Ω nom.
Excitation	15 VDC
Compensated Temperature	Option "Z" 32°F to 140°F
Operating Temperature	-40°F to 250°F

Load Cell Physical Size (inches)
-For both 250lb and 100lb Models

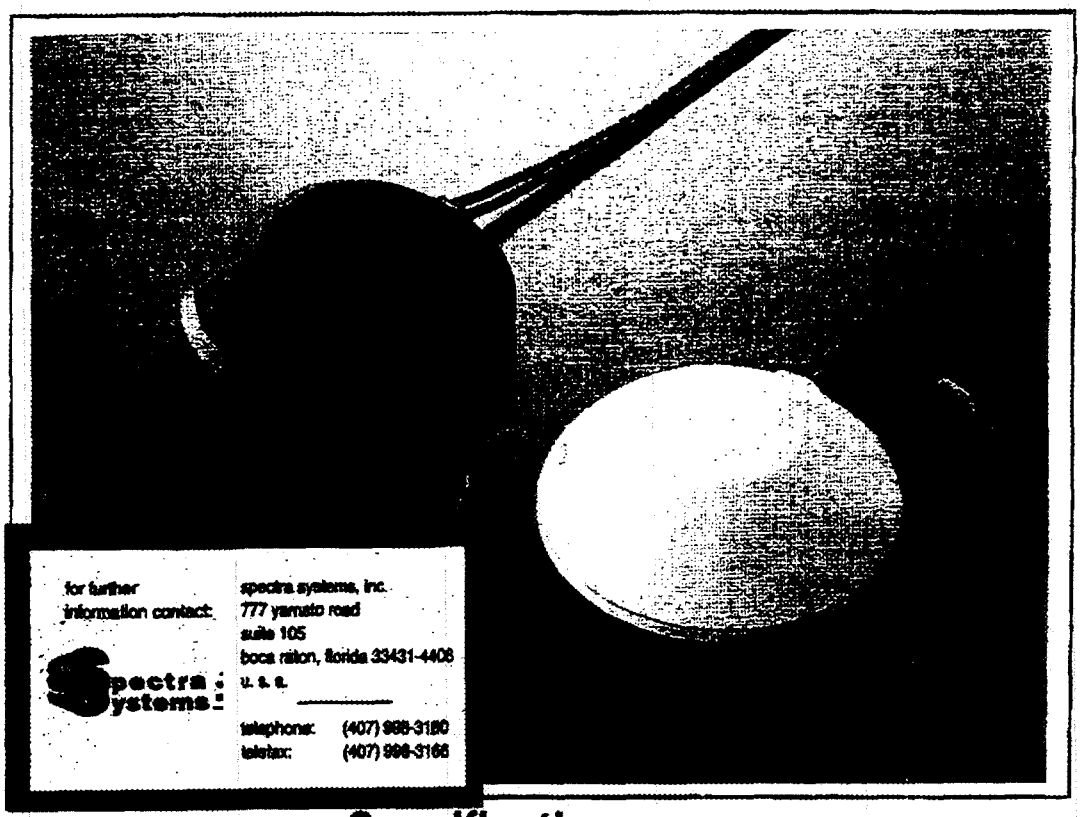


MATSUSHITA GPS ANTENNAS

New Dual Function Antennas

GPS+CELLULAR ANTENNAS

Within One Radome



Specifications

	GPS	CELLULAR	
ANTENNA TYPE	Patch	Top-loading monopole	
FREQUENCY	1575.42*±1.023 MHz	824 to 851 MHz	869 to 896 MHz
Polarization	RHC	Linear (Vertical)	
GAIN	2 dBic (Typ.)	-1 dBi (Typ.)	
LNA. GAIN	25 dB (Typ.)	NONE	
LNA. NF	2.5 dB (Typ.)	----	
	OVERALL		
OVERALL GAIN	27 dBic (Typ.)	-1 dBi (Typ.)	
POWER SUPPLY	+5 VDC 17 mA	----	
DIMENSIONS	90 mm (Diameter) x 32 mm (Height)		

***Design available for use inside & outside automobile**

– Also Available with: **GSM Frequency** 890 to 915 MHz 935 to 960 MHz
Mobitex Frequency 898 to 901 MHz 935 to 940 MHz

Matsushita Electric Works, Ltd.
International Operations Division
Electronic Materials & Devices Group
1048 Kadoma, Osaka 571 Japan
Tel: (06)906-0067 Fax: (06)906-0962

US Sales Office
Aromat Corporation
(Member of Matsushita Group)
401 River Oaks Parkway
San Jose, CA 95134
Tel: (408)432-6909 Fax: (408)433-9679

European Sales Office
Matsushita Electric Works
Deutschland GmbH
Am Albertussee, 40549
Dusseldorf 11, F.R. Germany
Tel: (0211)568-6518 Fax: (0211)504-7841

Taiwan Sales Office
Matsushita Denko Sales Taiwan Co., Ltd.
15th Floor, No. 44, 2nd Section
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Taipei, Taiwan
Tel: (02)581-6020 Fax: (02)581-6354

Singapore Sales Office
Matsushita Electric Works (Asia Pacific) Pte. Ltd.
101 Thomson Road #25-03/05
United Square
Singapore 1130
Tel: (65)2555473 Fax: (65)2535689

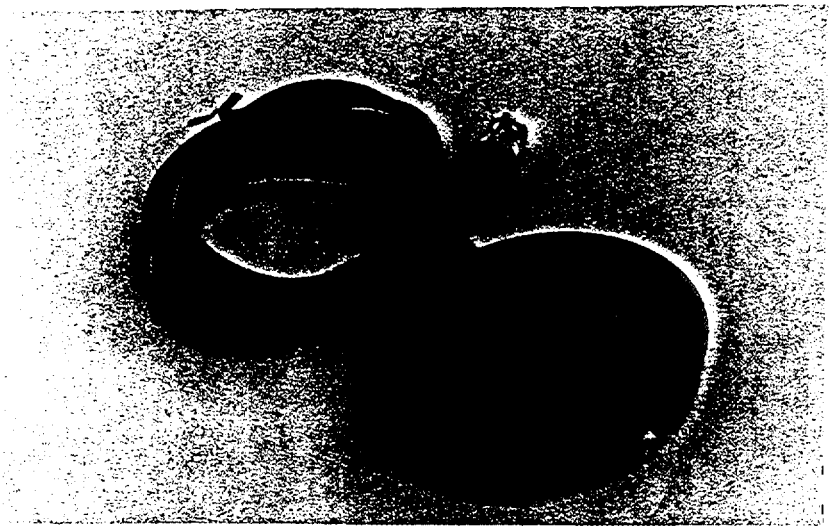
***Specifications are subject to change without notice**

MATSUSHITA GPS ANTENNA

GPS-CELLULAR ANTENNA

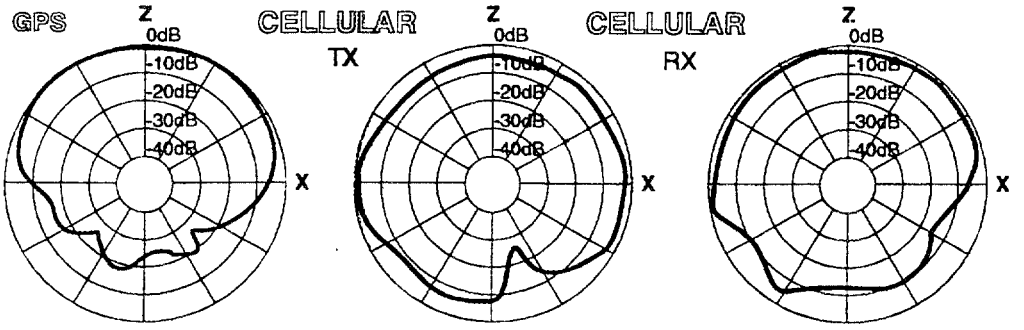
DUAL-FREQUENCY ANTENNA FOR A PORTABLE TERMINAL IN MOBILE COMMUNICATION USE

	GPS	CELLULAR TX	CELLULAR RX
ANTENNA TYPE	MICROSTIP	INVERTED-F	
FREQUENCY	1575.42±10 MHz	824-851MHz	869-896MHz
GAIN	3 dBic	0 dBic	
AMP. GAIN	26 dB	NONE	



COMMERCIAL GPS+CELLULAR "ALL-IN-ONE" ANTENNA
SIZE : 4.8 x 3.8 X 1.5 inch (122 x 96 X 39 mm)

TYPYCAL ELEVATION PATTERN:



1575.42±10 MHz | 824-851MHz | 869-896MHz

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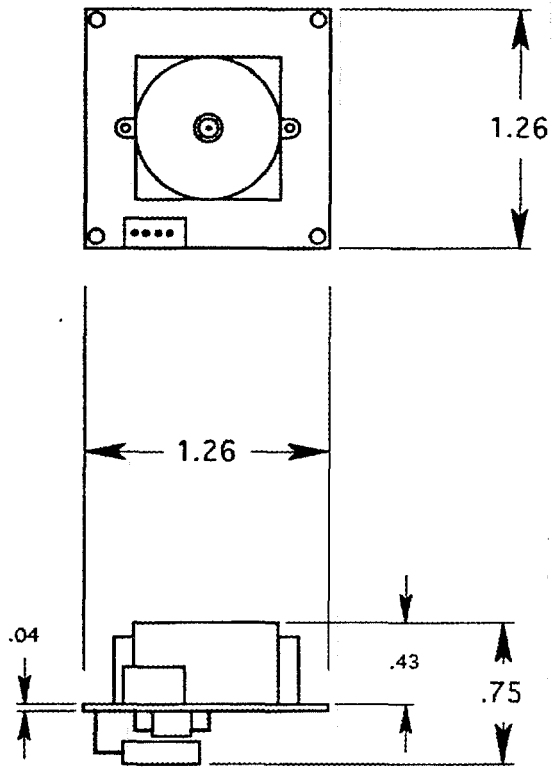
APPENDIX CC: TECHNICAL INFORMATION ON BLACK-AND-WHITE BOARD CAMERAS

Edmund Scientific

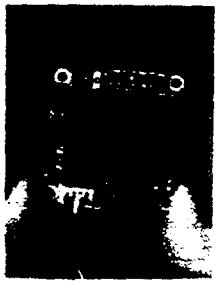
Specifications for 1/3" CCD Board B&W Camera

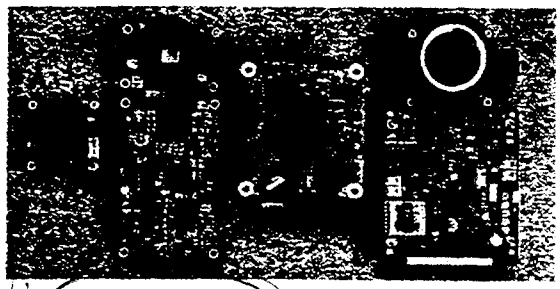
Image Sensor:	Interline transfer CCD; 1/3" format 512 (H) x 492 (V) Pixels
Scanning System:	2:1 Interlace
Internal Sync.:	15.734 KHz ±0.1 KHz 59,94 Hz ±0.6 KHz
Resolution:	380 TV Lines (H) x 350 TV Lines (V)
Field of View:	45° (V) x 60° (H)
S/N Ration:	47 dB
Min Illuminance:	0.3 lux
Video Out:	710 mV ±70 mV
Electronic Shutter:	Automatic
Lens:	3.7 mm pinhole
Ambient Operating Temp.	-10°C to 50°C
Ambient Storage Temp.:	-10°C to 50°C
Power Supply:	DC 9V
Power Consumption:	120 mA
Dimensions:	1.26" x 1.26" x 0.75" (Thick)
Wiring Diagram:	*#1 Red:* +9V DC *#2 Black:* Power Ground *#3 White:* Video Out *#4 Black:* Vidoe Ground



NOTE: THIS DRAWING IS TO SCALE

	ENGINEERING PHYSICS AND MATHEMATICS DIVISION			ornl
	1/3" CCD BOARD B&W CAMERA SPECIFICATIONS FOR DIMENSIONS			
First Draft: 10/14/94	A	SCALE =1":1"	DRAWING:	F. BARICKMAN



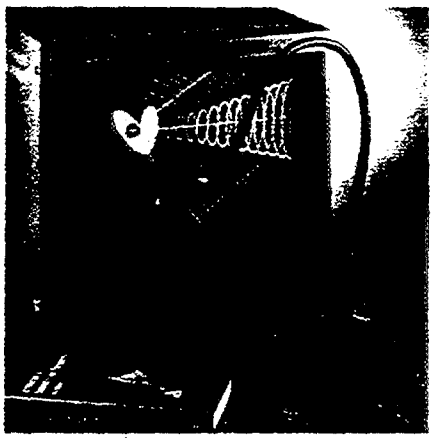


BOARD CAMERAS
Designed for direct system integration Edmund Scientific board cameras provide a variety of solutions for machine vision, image processing and surveillance. These board-level cameras yield all of the benefits of traditional boxed camera without the added weight and size.

Important: All cameras require power supplies and require some wiring for video output. Individual wiring diagrams and dimensional information can be obtained by calling our video support line at 609-573-6259

SPECIFICATIONS:	A) B&W Micro Board Camera	B) High Res. B&W Board Camera	C) Color Micro Board Camera	D) Color Board Camera
Image Sensor:	⅓" CCD*	½" CCD*	⅓" CCD*	⅓" CCD*
Horiz. Resolution:	380 Lines (H)	580 Lines (H)	330 Lines (H)	330 Lines (H)
Sensitivity:	0.3 lux	0.65 lux/0.40 lux (AGC)	5.0 lux	5 lux
AGC:	no	yes	no	yes
Picture Elements:	512 x 492	768 x 494	510 x 492	510 x 492
Signal Format:	EIA	EIA	NTSC	NTSC
S/N:	47dB	55dB	45dB	45dB
Lens Mount:	-	c-mount	-	cs-mount
Lens	3.7mm fl	-	4mm fl f/2	-
Shutter:	auto	-	auto	auto
Dimensions	32mm (w) x 32mm (h) x19.05 (d)	38mm (w) x 102mm (h) x12.5(d)	60mm (w) x 55mm (h) x51.5(d)	65mm (w) x 169mm (h) x20.0(d)
Power Supply:**	8-11 Volts DC	12 Volts DC	12 Volts DC	12 Volts DC
Power Consumption:	118mA	300mA	190mA	190ma
Stock Number:	**M52,569**	**M52,825**	**M52,827**	**M52,826**
Price:	**$230.00**	**$683.00**	**$485.00**	**$495.00**

*Interline transfer; **Power supplies are not provided



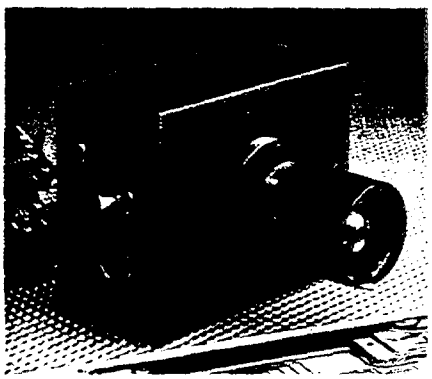
FLEXCAM SCIENTIFIC CAMERA
- **Unique Ergonomic Desktop Design**
- **C-mount and Microscope Adaptable**
- **Stereo Microphones for Video Conferencing**

Designed to accommodate desktop applications, the FlexCam is versatile and easy to use. Mounted on a 24" flexible gooseneck wand, the ⅓" CCD camera head can image objects from 1" to infinity. The unit includes an 8mm lens, and will accept standard "C" mount components such as microscope relay lenses (Page 140, Stock Numbers 37,820 and 39,925).
Stereo microphones allow clear voice transfer at arm's length, facilitating video conferences and remote medical diagnoses. Signal format is interchangeable between NTSC and Y-C. White balance is optimized for excellent color reproduction in classroom uses and document import/presentation.

SPECIFICATIONS:

Signal Format:	NTSC/Y-C
Minimum Illumination:	2.5 lux
Horizontal Resolution:	300 TV Lines
Picture Elements:	510 (H) X 492 (V)
Video Output:	1.0Vp-p, 75 (RCA)
Audio Output:	1.2V, 600 (RCA)
Power Requirements:	340 mA @ 12 VDC
Dimensions:	Head: 1.6 X 1.3 X 3" Base: 7 X 7.25"
Weight:	4.1 lbs.
Special Features:	Separate audio gain control left/right Built-in electronic iris LED power indicator

Flexcam Scientific Camera
M52,843 $1245.00



DVC-0A Monochrome Video Camera
M52,837 $2,801.00

DVC-0A SCIENTIFIC GRADE MONOCHROME VIDEO CAMERA
Designed for today's demanding imaging applications, the DVC-0A goes far beyond standard of-the-shelf cameras. With a Signal to Noise ratio of greater than 62dB, it offers a true 1024 gray level response. In addition, the higher signal to noise offers a quieter signal when gain is added. The result is a dramatic increase in sensitivity. The DVC-0A utilizes Frame transfer CCD technology in place of more common interline transfer technique. The result is a 100% fill factor. No dead space between pixels! In addition the CCD is physically mounted to the front plate for optimal thermal transfer and reduction of dark current.

SPECIFICATIONS — OPTICAL:
Optical Filtering: IR filter
Sensitivity (without IR filter) @ 2850°K:
0.5 Lux (0.05 fc) @ CCD surface for full video
0.05 Lux (0.005 fc) for usable video (10%)

ANALOG VIDEO OUTPUT
RS-170 Composite Video: 1Vp-p; 75 :
Resolution: 565 TVL (H); 350 TVL (V)
Gamma 0.45 (standard); 0.6 (optional); 1.0 (optional)
AGC: None (standard); 20 dB (optional)
Signal to Noise Ratio: (no AGC) Gamma = 1.0: 62 dB (LPF on; Bandwidth = 8 MHz)
ELECTRICAL
Timing: RS-170, 2:1 Interlaced
Power Supply Voltages & Current Requirements: ±12VDC each @ 250mA steady state; +5VDC @ 250mA steady state
Synchronization: Internal crystal @ 14.31818MHz
MECHANICAL
Weight (without lens): 1 lb. (approx.)
Temperature Limits (operating): -10°C to 50°C
Dimensions: 4¾" x 3¾" x 2½"
Lens Mount: Industry Standard C-mount
Camera Mount: ¼-20 threaded hole
Analog Video Connector: BNC female connector

DVC cameras are also available in 8 and 10 bit versions. Please contact an Edmund Scientific Applications Engineer for details.

INTERNAL DISTRIBUTION

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22 - 26. Frank S. Barickman, Transportation Research Center, Incorporated, P.O. Box B-37, East Liberty, OH 43319-0337

27 - 31. Michael J. Goodman, National Highway Traffic Safety Administration, 400 7th Street, SW, NRD-50, Washington, D.C. 20590

32 - 33. Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, TN 37831