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NUCLEAR INSTRUMENT MODULE MAINTENANCE MANUAL

PART 19

+15 VOLT AND +25 VOLT VOLTAGE REGULATORS, ORNL MODEL Q-2619

W. E. Lingar

ABSTRACT

The +15 Volt and +25 Volt Voltage Regulator module is for use in providing regulated voltages for nuclear reactor instrumentation. The input is a dc voltage in the range of +28 to +36 v.

The regulators are packaged in a standard plug-in module of the ORNL Modular Reactor Instrumentation Series.

This report describes the circuits, applications, maintenance procedures, and acceptance tests for the regulators.

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CONTENTS

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1. DESCRIPTION

1.1 General

The +15 Volt and +25 Volt Voltage Regulator module (ORNL model Q-2619) is for use in providing regulated voltages for nuclear reactor instrumentation. The input to the regulator circuits is a dc voltage in the range of +28 to +36 v. The regulator outputs have a common electrical ground.

1.2 Construction

The +15 Volt and +25 Volt Voltage Regulators are contained in a single module 5.63 in. wide, 4.72 in. high, and 11.90 in. deep. It is a standard "4-unit" plug-in module of the ORNL Modular Reactor Instrumentation series depicted on ORNL drawings Q-2600-1 through Q-2600-5.

Each regulator circuit is constructed on a printed circuit board mounted within the module and is unshielded.

1.3 Application

The +15 Volt and +25 Volt Voltage Regulators are used to provide sources of well-regulated voltage to any instrument requiring either +15 or +25 v dc within the current rating of the regulators. The input to the regulators is normally a bank of 32-v batteries; however, the battery-bank terminal voltage can vary from 28 to 36 v, depending upon the charge condition of the battery bank.

1.4 Specifications

1.4.1 +15 Volt Voltage Regulator

1.	Input voltage:	+28 v dc to +36 v dc.
2.	Output voltage:	+15 v dc.
3.	Maximum output current:	1.5 amp.
4.	Ambient temperature range:	10 to 55°C.
5.	Load regulation:	0.01%.
6.	Line regulation:	0.01%.
7.	Maximum temperature coefficient:	0.005%/°C.
8.	Long-term stability:	0.01%/24 hours.

1.4.2 +25 Volt Regulator

1.	Input voltage:	+28 to +36 v dc.
2.	Output voltage:	+25 v dc.
3.	Maximum output current:	750 ma.
4.	Ambient temperature range:	10 to 55°C.
5.	Line regulation:	0.01%.
6.	Load regulation:	0.01%.
7.	Maximum temperature coefficient:	0.002%/°C.
8.	Long-term stability:	0.01%/24 hours.

1.5 Applicable Drawings

The following list gives the drawing numbers (ORNL Instrumentation and Controls Division drawing numbers) and subtitles and the fabrication specification number for the +15 Volt and the +25 Volt Voltage Regulators:

1.	Q-2619-1	Circuit.
2.	Q-2619-2	Details.
3.	Q-2619-3	Metalphoto Panel.
4.	Q-2619-4	Printed Circuit Board.
5.	Q-2619-5	Assembly.
6.	Q-2619-6	Parts List.
7.	SF-249	Fabrication Specification.

The following list gives the drawing numbers and subtitles for the Plug-In Chassis System.

1.	Q-2600-1	Assembly.
2.	Q-2600-2	Details.
3.	Q-2600-3	Details.
4.	Q-2600-4	Details.
5.	Q-2600-5	Details.

2. THEORY OF OPERATION

2.1 General

The +25 Volt Voltage Regulator and the +15 Volt Voltage Regulator are transistorized series-voltage regulators. These regulators are essentially high-gain feedback amplifiers. Each regulator provides a stable output voltage when either the input voltage or the output current is varied over the range for which each was designed.

2.2 Circuit Description

This circuit description applies to the +25 Volt Voltage Regulator and to the +15 Volt Voltage Regulator.

Figure 1, a diagram of the regulator circuits, is included as an illustration to supplement this circuit description. The complete circuit diagram is shown in Fig. 2.

Each regulator has a single-ended differential amplifier that samples the output voltage and compares it with the voltage drop across a temperature-compensated reference diode. The amplifier produces an output voltage proportional to the difference between the change in the reference voltage and the change in the sampled output voltage when a change occurs in the output voltage. The two differential amplifier transistors in each regulator are packaged in a single TO-5 case. These transistors are Q12A and Q12B in the +25 v regulator, and Q6A and Q6B in the +15 v regulator. The two transistors in each package are closely matched in their V_{BE} and h_{FE} characteristics.

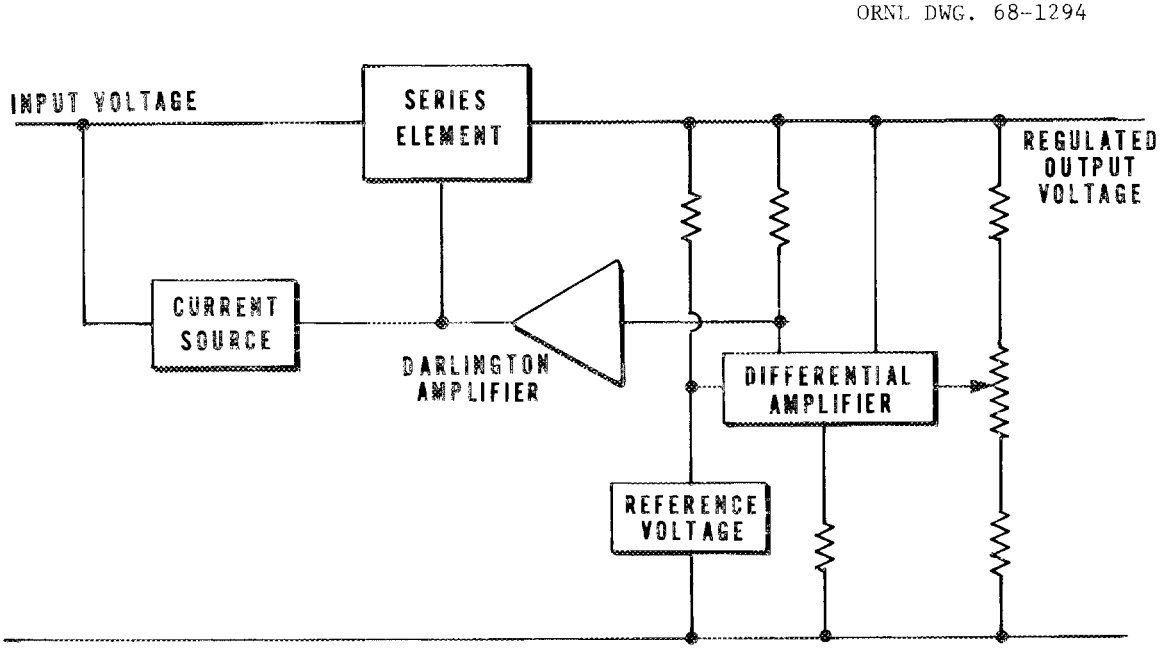
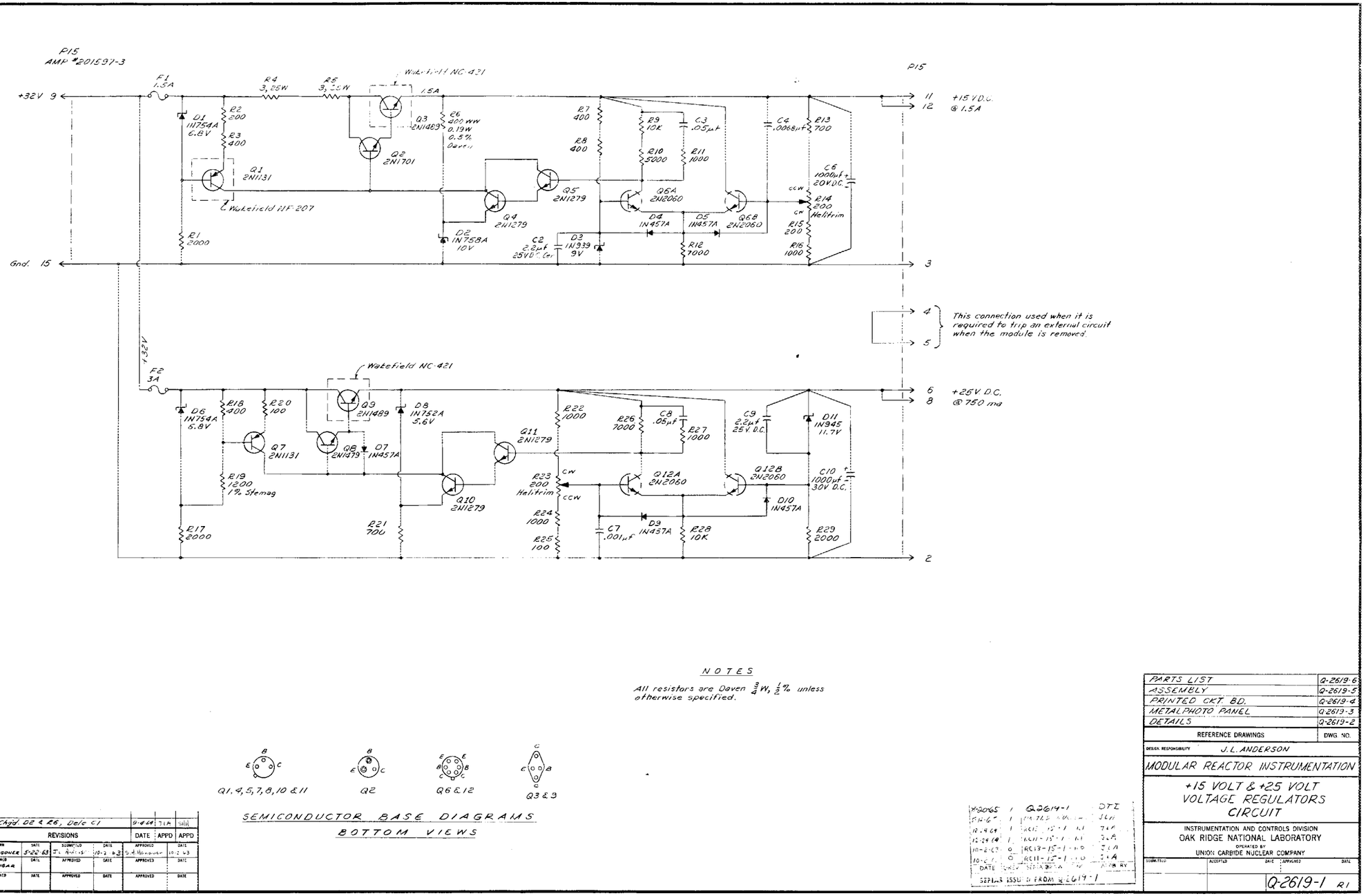


Fig. 1. Block Diagram of +15 Volt and +25 Volt Voltage Regulator Circuits.



NOTES

All resistors are Daven $\frac{3}{4}$W, $\frac{1}{2}$% unless otherwise specified.

SEMICONDUCTOR BASE DIAGRAMS
BOTTOM VIEWS

NO.	REVISIONS	DATE	APPD	APPD
1	Chgd. D2 & R6, Delo C1	9-6-64	JLA	Smith

DRAWN	DATE	SUBMITTED	DATE	APPROVED	DATE
C.E. WAGGONER	5-22-63	J. Anders	10-2-63	S. H. Hanauer	10-2-63
DESIGNED	DATE	APPROVED	DATE	APPROVED	DATE
W.E. LINDSAY					
CHECKED	DATE	APPROVED	DATE	APPROVED	DATE

X-2065	1	Q-2619-1	DTZ
12-4-64	1	RC13-15-1	JLA
12-24-64	1	RC11-15-1	JLA
10-2-63	0	RC13-15-1	JLA
10-2-63	0	RC11-15-1	JLA

DATE CHKD SEPARATE ISSUE FROM Q-2619-1 APPR BY

PARTS LIST	Q-2619-6
ASSEMBLY	Q-2619-5
PRINTED CKT. BD.	Q-2619-4
METALPHOTO PANEL	Q-2619-3
DETAILS	Q-2619-2
REFERENCE DRAWINGS	DWG. NO.

DESIGN RESPONSIBILITY J.L. ANDERSON

MODULAR REACTOR INSTRUMENTATION

+15 VOLT & +25 VOLT VOLTAGE REGULATORS CIRCUIT

INSTRUMENTATION AND CONTROLS DIVISION
OAK RIDGE NATIONAL LABORATORY
OPERATED BY
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SUBMITTED	ACCEPTED	DATE	APPROVED	DATE

Q-2619-1 R1

Fig. 2. Circuit of +15 Volt and +25 Volt Voltage Regulators, ORNL Model Q-2619.

The output voltage of the differential amplifier is fed into a Darlington pair amplifier which produces a large voltage gain from the differential amplifier to the series regulating element. The collectors of the Darlington pair are connected to a node that joins a current source and the series regulating element.

The series regulating element in each regulator is a Darlington pair amplifier which provides a large current gain from the node to the regulator output. The series regulating element is connected in series with the regulator input and the regulator output. The output of the series element is varied when either the input voltage or the output current is changed so that constant output voltage is maintained.

3. OPERATING INSTRUCTIONS

3.1 Installation

The +25 Volt and the +15 Volt Voltage Regulators are contained in a module of the ORNL Modular Reactor Instrumentation series. Like the other modules in this series, it has standard connectors and dimensions and has a pin- and hole-code on the rear plate so that the module will not be inserted in a wrong location in a drawer. The module is installed by placing it in its proper location, inserting the module firmly, and tightening the thumb screw. The module may be plugged in with power on without damage.

3.2 Operating Controls

There are no operating controls on the module.

3.3 Connections

All connections are made through the rear connector P15 when the module is inserted.

4. MAINTENANCE INSTRUCTIONS

4.1 General

This module is designed to operate continuously with a minimum of maintenance and no adjustments. Should a failure occur, any part listed in the Replaceable Parts List, Sect. 5, may be replaced.

4.2 Periodic Maintenance

There is no specific periodic maintenance procedure.

4.3 Calibration

Potentiometer R23 on the +25 Volt Voltage Regulator card can be adjusted to bring the output voltage to +25 v, and potentiometer R14 on the +15 Volt Voltage Regulator card can be adjusted to bring the output voltage to +15 v. For both potentiometers, clockwise rotation of the adjustment screw increases the output voltage, and counterclockwise rotation decreases the output voltage.

4.4 Trouble Shooting

The most likely source of trouble is an open fuse in the input circuit. The input fuse in the +15 v regulator is F1, and the input fuse in the +25 v regulator is F2. In addition, any of the transistor or diode junctions could become faulty under certain load conditions.

4.5 Transistor Voltage Chart

The voltages of all transistors are listed in Table 1.

Table 1. Transistor Voltage Chart[1]

Transistor	Emitter	Base	Collector
Q1	25.93	25.26	16.05
Q2	15.58	16.05	31.84
Q3	15.00	15.59	31.84
Q4	10.69	11.40	16.00
Q5	11.40	11.92	16.00
Q6A	8.61	9.17	11.92
Q6B	8.61	9.21	15.00
Q7	31.10	30.43	26.11
Q8	25.59	26.11	32.01
Q9	25.00	25.59	32.01
Q10	19.34	20.04	26.11
Q11	20.04	20.57	26.11

Table 1. Transistor Voltage Chart (Continued)

Transistor	Emitter	Base	Collector
Q12A	12.91	13.49	20.57
Q12B	12.91	13.49	25.00

[1]All voltages were measured with respect to ground with a cubic V-85 digital voltmeter. The regulator input voltage was 32 v dc and the output was unloaded.

5. REPLACEABLE PARTS LIST

A description and an ORNL stores number for all replaceable parts are given in Table 2.

Table 2. Replaceable Parts List

Part No.	ORNL Stores No.	Description
C6		Capacitor, 1000 mf, -10 to +100%, 20 v dc w, -10 to +85°C operating temperature, 0.750 in. ida. by 2.0 in. long, type PSD, Callins Industries, Inc.
C10		Capacitor, 1000 mf, -10 to +100%, 30 v dc w, -10 to +85°C operating temperature, 0.875 in. dia. by 2.50 in. long, type PSD, Callins Industries, Inc.
C2, C9	06-802-0091	Capacitor, 2.2 mf, +20%, 25 v dc w, ceramic, monolythic, Sprague No. 5C15.
C3, C8	06-802-0435	Capacitor, 0.05 mf, ±20%, 500 v dc w, ceramic, disc, formulation C23, Sprague No. 33C58A.
C7	06-802-0390	Capacitor, 0.001 mf, ±10%, 1000 v dc w, ceramic, disc, formulation C28, Sprague No. 29C151A1.
C4	06-802-0410	Capacitor, 0.0068 mf, ±20%, 1000 v dc w, ceramic, disc, formulation C40, Sprague No. 33C68.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
R19	06-932-0099	Resistor, 1200 ohms, ±1%, 1/2 w, deposited carbon, Stemag type SLAK, double high-temperature varnish impregnated, H. E. Priester Corp.
R14, R23	06-930-8204	Potentiometer, trimmer, 200 ohms, ±10%, 1-1/2 w, conductive-glass resistance element, Helitrim series 53, with printed circuit pins, Helipot Div.
R4, R5	06-934-0684	Resistor, 3 ohms, ±5%, 25 w, ww, vitreous enamel coating, Ohmite No. 0200L.
R2, R15	06-936-0665	Resistor, 200 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R3, R7, R8, R18	06-036-0670	Resistor, 400 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R13, R21	06-936-0675	Resistor, 700 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R20, R25	06-936-0660	Resistor, 100 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R11, R16, B22, R24, R27	06-936-0680	Resistor, 1000 ohms, ±1/2%, 3/4 w at 125 °C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R1, R17, R29	06-936-0685	Resistor, 2000 ohms, ±1/2%, 3/4 w at 125 °C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R10	06-936-0692	Resistor, 5000 ohms, ±1/2%, 3/4 w at 125 °C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R12, R26	06-936-0695	Resistor, 7000 ohms, ±1/2%, 3/4 w at 125 °C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R9, R28	06-936-0700	Resistor, 10 kilohms, ±1/2%, 3/4 w at 125°C, ww noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
Q1, Q7	06-996-1710	Transistor, PNP, silicon, type 2N1131, Texas Instr. Co.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
Q4, Q5, Q10, Q11	06-996-1880	Transistor, NPN, silicon, type 2N1279, G.E.
Q3, Q9	06-996-1986	Transistor, NPN, silicon, type 2N1489, Silicon Transistor Corp.
Q8	06-996-1985	Transistor, NPN, silicon, type 2N1479, RCA.
Q2		Transistor, NPN, type 2N1701, RCA.
Q6, Q12	06-996-1994	Transistor, dual NPN, type 2N2060, Fairchild.
R6		Resistor, 400 ohms, ±1/2%, 0.19 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1273.
D1, D6	06-995-6244	Diode, zener, 6.8 v, ±5%, 400 mw, type 1N754A, Motorola.
D4, D5, D7, D9, D10	06-995-5820	Diode, silicon, type 1N457A, Electrical Ind. Assoc.
D2	06-995-6250	Diode, zener, 10.0 v, ±5%, 400 mw, type 1N758A, Motorola.
D3		Diode, zener, 9.0 v, temperature compensated, type 1N939, Motorola.
D11		Diode, zener, 11.7 v, temperature compensated, type 1N945, Motorola.
D8	06-995-6230	Diode, zener, 5.6 v, ±5%, 400 mw, type 1N752A, Motorola.
F2	06-874-3080	Fuse, micro, 3 amp, Littelfuse No. 273003.
F1	06-874-3076	Fuse, micro, 1.5 amp, Littelfuse No. 27301.5.

6. ACCEPTANCE TEST PROCEDURE

6.1 Test Equipment

The following test equipment is required:

1. A dc regulated power supply adjustable from 28 to 36 v dc and capable of supplying 2.5 amp.
2. An oscilloscope, dc to 10 Mc, 1 mv/cm sensitivity.
3. A differential voltmeter capable of resolving 10^{-4} v with inputs from 10 to 25 v dc.
4. A temperature test chamber.
5. A 33-ohm, 25-w resistor and a 10-ohm, 25-w resistor for dummy loads.

6.2 Acceptance Test

1. Adjust the power supply for 32 v dc output. Connect the positive terminal of the power supply to pin 9 of the regulator connectors, and the negative terminal to pin 15 of the regulator connector (P15).
2. Connect pin 8 of the regulator to the positive input terminal of the differential voltmeter, and pin 2 of the regulator to the negative input terminal of the voltmeter.
3. Adjust potentiometer R23 until the voltmeter reads 25.000 v.
4. Connect the oscilloscope probe to pin 8 of the regulator, and connect the probe ground lead to pin 2 of the regulator connector. Observe the oscilloscope trace for any evidence of oscillations with the oscilloscope sensitivity at 1 mv/cm.
5. Change the power supply output voltage from its 32-v dc setting to 28 v dc and observe the oscilloscope trace for evidence of oscillations. Next, while observing both the differential voltmeter for changes in regulator output voltage and the oscilloscope trace for oscillations, adjust the power supply voltage slowly until 36 v dc output is reached. The change in regulator output voltage should not be greater than 2.5 mv from its value of 25.000 v. A typical change is less than 0.25 mv. Reset the power supply output voltage to 32 v dc.
6. Connect a 33-ohm, 25-w resistor across pin 8 and pin 2 of the regulator connector and observe the voltage change on the differential voltmeter. The voltage change should not be greater than 2.5 mv. The typical change is 0.25 mv. Also, observe the oscilloscope trace for evidence of oscillations while the regulator is loaded.
7. Connect pin 12 of connector P15 to the positive input terminal of the differential voltmeter, and pin 3 of connector P15 to the negative input terminal of the voltmeter.
8. Adjust potentiometer R14 until the voltmeter reads 15.000 v.
9. Connect the oscilloscope probe to pin 8 of connector P15, and connect the probe ground lead to pin 3 of connector P15. Observe the scope trace for any evidence of oscillations on 1 mv/cm sensitivity.
10. Repeat step 5 of the acceptance test. The change in the regulator output voltage should not be greater than 1.5 mv. Reset the power supply voltage to 32 v dc.

11. Connect a 10-ohm, 25-w resistor across pin 12 and pin 3 of connector P15, and observe the voltage change on the differential voltmater. The voltage change should not exceed 1.5 mv. The typical change is 0.5 mv. Observe the oscilloscope trace for evidence of oscillations while the regulator is loaded.

12. A temperature stability test can be made by placing the module in a temperature controlled oven. Approximately 15 minutes should be allowed for the module to reach equilibrium after the oven temperature is changed.

The +25 volt voltage regulator can be tested by making the connections indicated in steps 1, 2, and 4 of the acceptance test. The oscilloscope trace should be observed for evidence of oscillations during the test. The output voltage of the +25 v dc voltage regulator should not change more than 22.5 mv from its 25.00 v dc value over the temperature range 10 to 55°C. The typical change is 7 mv.

The +15 v dc voltage regulator can be tested by making the connections indicated in steps 1, 7, and 9 of the acceptance test. Observe the oscilloscope trace for evidence of oscillations during the test. The output voltage of the +15 v dc voltage regulator should not change more than 33.75 mv from its 15.000 v dc value over the temperature range of 10 to 55°C. The typical change is 12 mv.

ORNL-TM-1638
Part 19

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