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ORNL System for Measurement of Telephone-Line Attenuation

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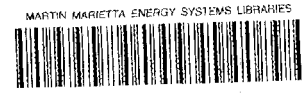

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ABSTRACT

The purpose of modifying the TS-100 Automated Tempest Test System software was to use the equipment for making radio-frequency attenuation measurements between an input port and an output port of a telephone network. One set of tests was performed to simulate the electromagnetic radiation from a secure computer terminal and its coupling to telephone lines within a building. Another set of tests was conducted to determine the procedures for measuring attenuation on telephone lines between buildings that are all within the secure zone. The measurements indicate that attenuation between the terminal and the telephone is a function of many variables; however, attenuation in the cable between the buildings is proportional to the length of the cable between the buildings.

1. INTRODUCTION

The Department of Energy/National Security Agency telephone installation requirements dictate that there be a separation of at least 2-m between a classified (secure) computer terminal and an unclassified telephone line or telephone. This separation has been necessary to ensure that compromising emanations from the computer terminal could not be picked up on a telephone line outside the control zone. While this regulation was formulated to cover all types of installations, including embassies on foreign soils, it may not be appropriate for domestic installations. For domestic installations the rule could possibly be relaxed if they have large secure areas. Tests on telephone lines that have long runs within a secure area indicate that there is sufficient attenuation to allow a relaxation of the 2-m regulation.[1]

In order to run the tests to determine the telephone-line attenuation within a secure area, an automatic means of taking the data was devised. Automated data-taking was preferred to manual because tests could be rerun to confirm data. The TS-100 Automated Tempest Test System was available and is normally used to measure the existing electromagnetic fields of equipment under test, although it is not configured to measure attenuation. When the system is in the calibration mode, the equivalent of an attenuation measurement is made, a signal generator is stepped through a set of prearranged frequencies, and the receiver measures the generator signal strength. The calibration integrity relies on the fact that there is no drift in the amplitudes or frequencies of the generators. The signal strengths are compared to those of the original set to determine if the system has remained within a specified tolerance. Modifications were made to the TS-100 software to give it the capability to measure the path attenuation, and calibration mode subroutines were then called during the sweep mode (Appendix). The generator was connected to the input of the attenuation path and the receiver was connected to the output of the attenuation path. A sweep was made and then compared to a sweep in which the generator was directly connected to the receiver. The difference in these two sweeps is a direct measure of the attenuation in the path.

2. RESULTS

After the modifications to the software were made, two types of tests were performed to determine operational procedures. The first set of tests was to simulate the electromagnetic radiation from a secure computer terminal and to determine the amount of coupling into the telephone lines within a building. The second set of tests was to determine the procedures for measuring the attenuation on the telephone lines between buildings but still within the secure zone.

2.1 INTERBUILDING TESTS

Electromagnetic-field-strength tests made on several computer terminals indicate that the predominant rf radiation emanates from the printed-wiring board and its associated components. This radiation escapes through the various openings of the metal container in which the terminal is housed. The radiation appears in the frequency range from near dc to at least several hundred megahertz. One of two types of potentially compromising emanations is the serial data transfer to and from the host computer over the shielded data line; the other is the signal representing the raster display on the face of the CRT. It was this second type of emanation that was concluded to be more easily detectable. Although the path attenuation within the control zone is much lower for the serial data, the natural noise levels are much higher. If one were unable to pick up the raster signal, then the serial data stream would be lost in the noise. Another factor that contributes to the low signal-to-noise power ratio of the serial data is the fact that the signals are not repeated (refreshed) as are those in the raster display. The CRT screen must be refreshed at a rate fast enough to remove flicker to the observer's eye. This refresh rate is 60 fields/s, and the refresh continues for as long as the screen remains unchanged.

To simulate the radiation from the terminal, an EMCO Model 3104 Biconical Antenna was driven by an HP-8656A signal generator, which was modulated by an HP-3325A function generator. The HP-8236 computer, using the modified TS-100 software, controlled the frequencies of the generators and the attenuation and bandwidths of the Tempest Test Receiver (American Electronics Laboratories ATTR-2193). With this method more power could be concentrated in a narrow frequency range so that accurate attenuation measurements could be made in the presence of noise. This radiated signal was measured at two points within the building; one was at the first telephone closet (generally located 50 to 100 ft from the telephone) and the second was at the second telephone closet (located at the point where the telephone cable exits the building for its run to the telephone building). The Tempest Test Receiver was connected directly to the telephone lines at the junction box in the first telephone closet through a matching network; the tests were run and the receiver was moved to the second (exit) telephone closet and tests were rerun. For the initial tests the receiver,

computer, and signal generators were grouped in the telephone closet to reduce the length of cable feeding the receiver. The output of the signal generator was fed through a coaxial cable back to the antenna at the telephone under test.

During a test, the telephone was placed at various distances from the antenna to determine the coupling to the telephone and telephone line. A previous test of the electric field of the antenna indicated that the highest field strength was at the point where the elements of the antenna were joined. When the telephone was placed at this point, it was 0 cm from the antenna. For the first test the telephone was moved in 10-cm intervals for the first meter and in 50-cm intervals for the next meter. Figure 1 depicts the setup of equipment used. The initial tests were conducted using three different telephone lines in the same room.

The results of these tests were somewhat different than expected. The change in signal strength in moving the telephone from the tightly coupled position to several meters away and even removing and disconnecting the telephone and line at the wall only made a difference in the received signal strength of up to 10 dB. The coupling into the telephone line was essentially independent of the position of the telephone with respect to the antenna. It appeared that the antenna initiated resonances in the room. The rf emissions do not necessarily enter the telephone line at the telephone. Indications are that the radiation travels through the composition ceiling directly to the telephone line exiting the building; consequently the signal can be picked up on most of the telephone lines leaving the building. For this particular configuration, an attenuation of ~30 dB was measured in the path from the antenna to the exit telephone closet. This is not enough attenuation to ensure that the signal could not be reconstructed; therefore, one must rely on the additional attenuation afforded by the additional lengths of cable running from the test building to the telephone building.

2.2 INTRABUILDING TESTS

For the intrabuilding attenuation tests, the signal was injected directly into the telephone line at the exit telephone closet of the test building. This signal injection required that the signal generator and modulator be placed directly in the closet. For automatic data-taking the signal generator and modulator must be controlled by the computer on the Hewlett-Packard Interface Bus (HPIB). The computer and receiver, however, were located in the telephone building with the receiver connected to the telephone line from the exit telephone closet of the test building. To operate the signal generators at the remote location, an extender to the HPIB was needed. A pair of bus extenders was procured and operated over an extra pair of telephone wires, and another pair of wires was used for communications

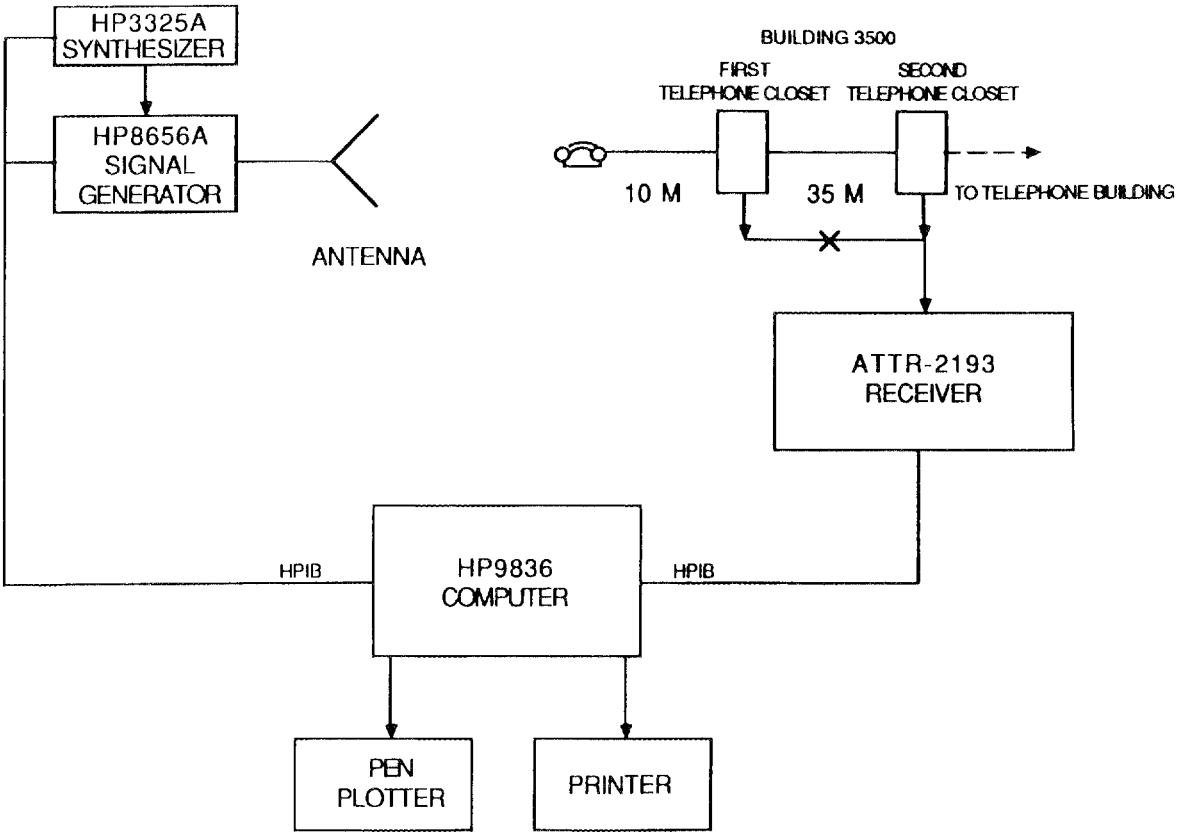

Fig. 1. System configuration for interbuilding tests.

(Fig. 2). Once the extenders were dialed up and on-line, it was a simple matter to run the sweep program. Comparison of the output of the sweep program with the output obtained when the generators were directly connected to the receiver indicated that the desired attenuation curve was produced.

Attenuation data for a number of buildings at various distances from the telephone building were taken, and from them the desired relation between attenuation and distance can be developed. Tests were conducted at the Y-12 facility to develop this relation. An estimate of the cable length to each building from the telephone building was obtained from the records of the telephone company (South Central Bell).

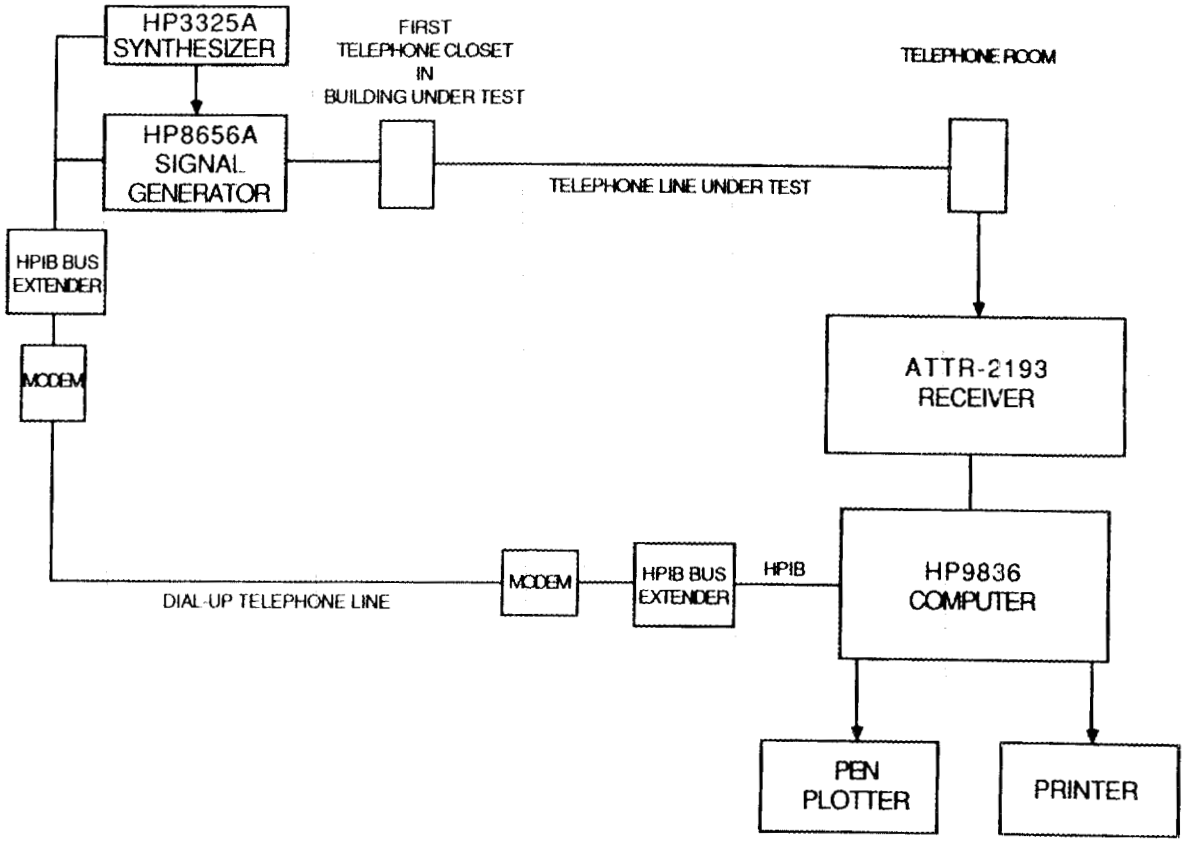

Fig. 2. System configuration for intrabuilding tests.

3. CONCLUSIONS

The interbuilding tests show that pickup on a telephone line of simulated compromising emanations from a computer terminal is not directly correlated with its distance from the source. Whether the telephone is off hook or on hook appears to have little effect. In fact, the telephone and line can be removed all the way to the wall jack and substantial signals can be picked up on the telephone lines at the building exit closet. In the frequency range of 20 to 200 MHz the source sets up resonances in the room, and the signals can be picked up at considerable distances from the source. For the case where the exit telephone closet was ~70 ft from the simulated source, the average attenuation was ~60 dB.

The intrabuilding tests indicate that there was substantial attenuation and that this could be correlated with the length of cable between the buildings. It was concluded that if there is sufficient distance between the exit point of the building containing the terminal and the telephone cable exit point from the secure zone, then placement of the telephone and telephone line near a terminal will not cause the loss of compromising emanations.

REFERENCE

1. ORNL, "Telephone-Line Attenuation Tests at the Oak Ridge Y-12 Plant" (U), ORNL/TM-10594 (Unclassified).

APPENDIX

MODIFICATIONS TO TS-100 SOFTWARE FOR MAKING ATTENUATION MEASUREMENTS

APPENDIX

MODIFICATIONS TO TS-100 SOFTWARE FOR MAKING ATTENUATION MEASUREMENTS

By making a few modifications to the TS-100 software, which runs on the Automated Tempest Test System, the system can be used to measure attenuation while in the automatic data-taking mode. To facilitate making the changes, it is recommended that the Softkeys on the HP-236 computer be programmed with some additional definitions. These new Softkey definitions will help with the editing process and will be described below.

It is best to start with five blank initialized disks, which will be called volume 1 through volume 5. The volumes can be initialized by putting the Basic 3.0 system program (SYSTEM_BA3) in the left drive and turning on the computer. To initialize volume 1, put volume 1 in the right-hand drive and issue the following command:

```
INITIALIZE ":INTERNAL,4,0"
```

Remove the volume after all of the 32 tracks have been initialized and repeat for the next four volumes.

VOLUME 1

Put volume 1 back in the right-hand drive and leave the system disk in the left-hand drive. Copy the system to volume 1 with the following command:

```
COPY "SYSTEM_BA3:INTERNAL,4,1" TO "SYSTEM_BA3:INTERNAL,4,0"
```

The volume now needs an "AUTOST" program that will be automatically executed on start-up. Execute a SCRATCH command to clear the computer memory and type in the following program:

```
10 !THIS IS THE "AUTOST" PROGRAM
20 LOAD "STRTUP:INTERNAL,4,1"
30 END
```

Store the program on volume 1 by executing the following command:

```
RE-STORE "AUTOST:INTERNAL,4,0"
```

VOLUME 2

Set volume 1 aside and put volume 2 in the right-hand drive. Find the Basic 3.0 Drivers Disk that contains the BIN file HPIB and put it in

the left-hand drive. Copy the file to volume 2 with the following command:

```
COPY "HPIB:INTERNAL,4,1" TO "HPIB:INTERNAL,4,0"
```

On the Language Extensions Disk find IO, GRAPH, ERR, KBD, PDEV, and MS; copy these also to volume 2 using the COPY command.

The AUTOST program calls the file STRTUP; therefore, this file needs to be on volume 2. Issue the SCRATCH command and type in the following program noting that the special characters needed in lines 180 and 250 are obtained by pressing the CRTL, SHIFT, and CLR SCR keys simultaneously:

```
100 !This is the "STRTUP" file
110 LOAD BIN "HPIB:,4,1"
120 LOAD BIN "IO:,4,1"
130 LOAD BIN "GRAPH:,4,1"
140 LOAD BIN "ERR:,4,1"
150 LOAD BIN "KBD:,4,1"
160 LOAD BIN "PDEV:,4,1"
170 LOAD BIN "MS:,4,1"
180 OUTPUT 2;"   "                          ! Clear screen
190 PRINT TABXY(1,9);"PUT VOLUME 3 IN RIGHT DRIVE AFTER"
200 PRINT TABXY(1,10);"REMOVING VOLUME 1 AND VOLUME 2."
210 PRINT TABXY(1,11);"THEN PUT VOLUME 4 OR APPROPRIATE DATA"
220 PRINT TABXY(1,12);"DISK IN LEFT DRIVE."
230 DISP "PRESS CONTINUE WHEN LOADING HAS STOPPED."
240 PAUSE
250 OUTPUT 2;"   "                          ! Clear screen
260 PRINT TABXY(1,9);"PUT LIBRARY DISK (VOLUME 5) IN LEFT"
270 PRINT TABXY(1,10);"DRIVE WHEN LOADING STOPS."
280 LOAD "AUTOST"
290 END
```

Store the program STRTUP on volume 2 with the following command:

```
RE-STORE "STRTUP:INTERNAL,4,0"
```

Remove volume 2 from the drive and set it aside.

VOLUME 3

Place volume 3 in the right-hand drive and place the TS-100 version A disk in the left-hand drive. Execute the following command:

```
COPY ":INTERNAL,4,1" TO ":INTERNAL,4,0"
```

VOLUME 4

This volume needs a special file that will define the Softkeys, which are especially helpful when editing volume 3. The file will be called KEYAIDS and is constructed as follows.

First, turn the system off and insert volume 1 in the right-hand drive and volume 2 in the left-hand drive. Now turn on the system, and the screen should ask for volumes 3 and 4. Insert them at the proper time but do not insert volume 5.

To develop the definitions for the Softkeys, press the (Shift) RESET key, which resets the system. Two Softkeys will be added. The first turns the blinking cursor on; the cursor should be on whenever the EDIT command is used. The second clears any graphics from the screen. The first five Softkeys are blank and can be defined. To define Softkey 0, press the EDIT key, then Softkey 0, and then ENTER. The definition of the key should now be typed in.

```
CTRL _ CLR LN CONTROL 1,10; 1 CTRL _ EXECUTE

Press ENTER to complete the definition.
```

To define Softkey 1, press the EDIT key, Softkey 1, and then ENTER. Type in the following definition for the key:

```
CTRL _ CLR LN GCLEAR CTRL _ EXECUTE

Press ENTER to complete the definition.
```

Be sure that volume 4 is in the left-hand drive and copy the definitions into a file called KEYAIDS on volume 4 by executing the following command:

```
RE-STORE KEY "KEYAIDS:INTERNAL,4,1"
```

VOLUME 5

Copy the TS-100 Library disk onto volume 5 with the following command after putting volume 5 into the right-hand drive and the Library disk into the left-hand drive:

```
COPY ":INTERNAL,4,1" TO ":INTERNAL,4,0"
```

MODIFICATIONS TO VOLUME 3

The last task is to make a few modifications to volume 3. Make sure that volume 3 is in the right-hand drive. Type EDIT 44 and press ENTER. Line 44 should read:

```
44      Revision$="TS-100 Rev 2.53 A     "&Rev_date$
```

Move the cursor to the line after 44 and press the INS LN key. Type in the following line:

```
45      LOAD KEY "KEYAIDS:INTERNAL,4,1"  ! For editing purposes
```

Be sure to ENTER this line. Now press PAUSE, type EDIT 1421, and press ENTER. Line 1421 should read:

```
1421    COM/Swp_intr/Intr_flag
```

Move the cursor to the next line and press the INS LN key. Type in the following two lines:

```
1422    COM/gens/@Hi_rfgen,@Mid_rfgen,@Lo_rfgen,@Mod_gen
1423    COM/gens/Hi_rfgen,Mid_rfgen,Lo_rfgen,Mod_gen
```

Check to see if the lines are entered correctly. If so, move the cursor to the next line by pressing ENTER. Then type PAUSE to exit the EDIT mode.

After line 1660, which has the command Init_attr, add the following seven lines:

```
1661    Init_gens
1662    Gen_config
1663    CALL Hp8656_ampl_mod(@Hi_rfgen,"ON",30)
1664    CALL Hp8656_ampl(@Hi_rfgen,-20)
1665    CALL Hp3325_set_ampl(@Mod_gen,2.0,"VOLTS")
1666    CALL Hp3325_set_outs(@Mod_gen,"F")
1667    CALL Hp3325_set_freq(@Mod_gen,200.)
```

Check to see that the lines were inserted properly.

After line 1880, which has the command CALL Attrsetfreq, add the following line:

```
1881 CALL Hp8656_freq(@Hi_rfgen,Swp_freq)
```

The final modification is in place of line 5352, which is:

```
5352    OUTPUT @Attr USING "B,B";Cmd_code+1,Bw_sel+48
```

Line 5352 is removed by typing EDIT 5352 and pressing DEL LN. Press INS LN and add the following five lines in place of line 5352:

```
5349    IF Setmod=1 THEN
5350        OUTPUT @Attr USING "B,B";Cmd_code+1,Bw_sel+48
5351      ELSE
```

```
5352         OUTPUT @Attr USING "B,B";Cmd_code+1,49
5353     END IF
```

Check to see that the lines are entered correctly.

After line 5852, which has the command GOSUB Clearsoftkeys, add the following line:

```
5853     Setmod=1            ! VIDEO BANDWIDTH EQUALS IF BANDWIDTH
```

After line 28365, which has the command Suffix$="MZ", add the following line:

```
28366    LET Switch_freq=1.E+4      ! LETS HP8656 BE THE SIGNAL
```

Move the corrected version to volume 3 by typing the commands:

```
PURGE "AUTOST"

RE-STORE "AUTOST"
```

This completes the modifications to the TS-100 software. The five disks can now be used to measure the attenuation as described in the text of this report.

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