HP 4937S
"Product Note

HEWLETT PACKARD

NOTE: There Are No PAGES MISSING
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INTRODUCTION

The AT&T divest-me has certainly created new testing and access requirements for the traditional telephone companies, the terminal equipment (such as PBX) providers, and even the communication service users. With the divestiture, there exists, in the telephone network, a separation of responsibility at the point where the terminal equipment and the telephone lines interface. Neither party is allowed access to the "other" side of this interfacing location. Numerous problems arise such as the lack of end-to-end testing, which results in delays in bringing up the equipment and the telephone network. For the communication service user, the biggest question is who to call when the system breaks down. Another important question is: how does one know whether the PBX or the network is faulty? "False-alarm" calls can be costly to the service user nowadays.

The HP 4937S can solve some of these testing and access problems for the telephone companies, the equipment providers, and the communication service user. This product note will discuss the solution the HP 4937S provides for each group.

THE PROBLEM

The AT&T divesture has created a separation in the telephone network. The traditional telephone companies no longer have access to any terminal equipment. Their responsibility now lies in providing lines with specific transmission characteristics at the network interface. (See Fig. 1)

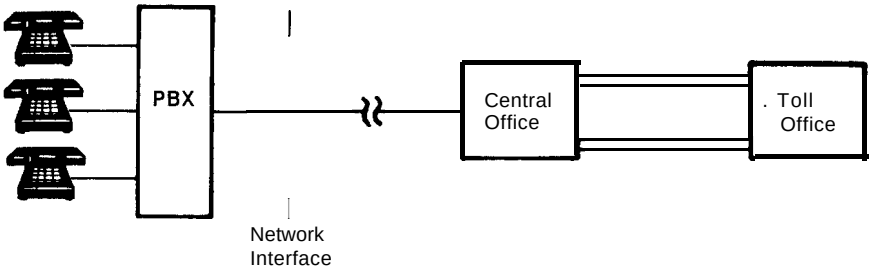


Figure 1. Telephone companies must now provide lines with specific transmission characteristics at the network interface.

After a new network is installed, there is always that one last question: will the network operate properly with the terminal equipment (in many cases, a PBX)? This is difficult to verify since telcos have no access to the PBX.

The equipment providers have similar problems on the other side of the network interface. Their access to the network is too limited to verify thoroughly that the PBX will operate properly with the telephone network.

Finally, who has the responsibility to investigate the problem when something is not functioning in the system? Will this burden be upon the shoulders of the communication service user?

THE SOLUTION AND HOW IT WORKS

The ideal solution is to simulate each side of the network interface for the equipment and the network installer. This way telcos are able to simulate terminal equipment for end-to-end testing. The equipment providers can simulate the network to test the PBX/network interface of their equipment. The service user can quickly identify the location of the problem whether in the network or in the PBX.

The most important parts of simulation are to represent the signaling functions of the PBX and the telephone network and to test the funtionality of the signaling equipment. Signaling is used in the telephone network to access the network and to establish voice path from one point to another. With this in mind, let's take a look at the HP 4937S (HP 4937A + HP 4938A) as a solution.

THE HP 4937S (HP 4937A + HP 4938A) AS A SOLUTION

For the equipment providers: The HP 4937S simulates signaling from the telephone central office. For example, in ground start signaling, the central office provides tip ground and then waits for the PBX to respond by opening the tip path and closing the switch between tip and ring. (See Fig. 2.)

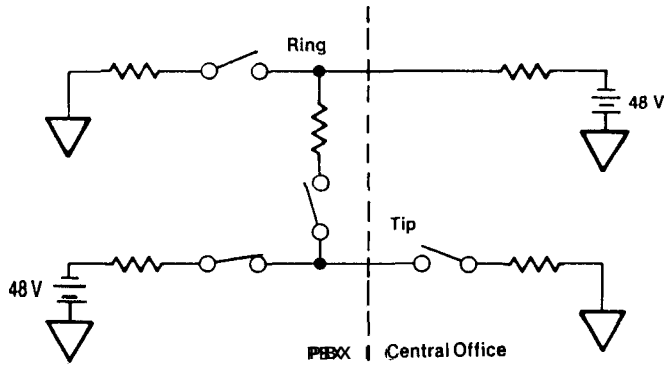


Figure 2. A PBX-to-central office ground start circuit.

It also monitors, while simulating the central office, whether the PBX is responding to the off-hook condition.

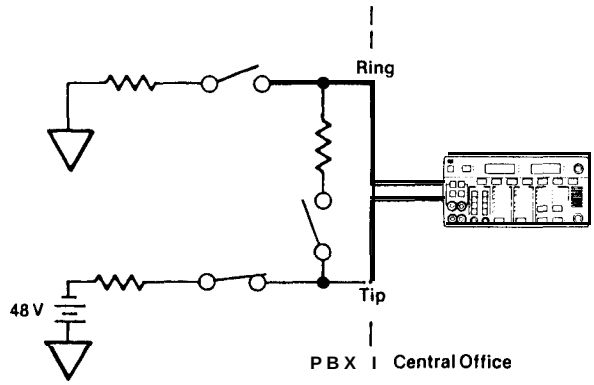


Figure 3. The HP 4937A simulates the central office part of the ground start circuit.

Similarly for other types of signaling such as loop start, loop reverse battery, and E/M types I, II, and III, the HP 4937A monitors the PBX response while simulating central office signaling.

After signaling is verified for each incoming and outgoing trunk interface, the return loss of the interface card should be checked. Poor return loss results in echoes on the line.

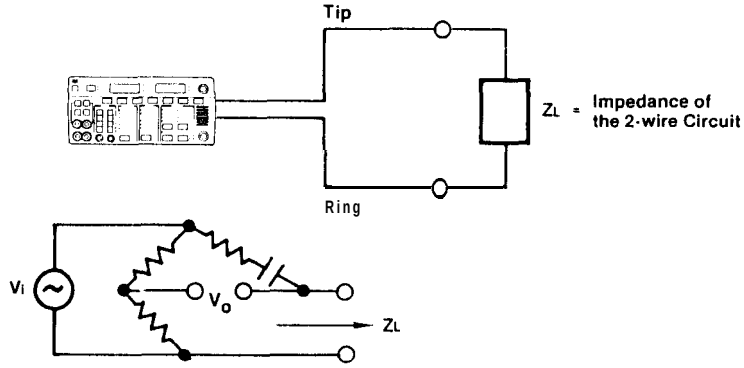


Figure 4. The HP 4937A measures 2-wire return loss with a bridge circuit.

The impedance of the interface card can be adjusted, using the LED display of the HP 4937A, to have maximum return loss. Finally the HP 4937A can be used to dial up a 1004 Hz test tone to verify the integrity of the newly-installed trunks before connecting them to the PBX.

For the telephone companies: The HP 4937S not only simulates terminal equipment signaling, but it also provides network margin testing. For example, the telephone companies have to provide 20 mA of loop current measured at the network interface using a 430 ohm loop closure.

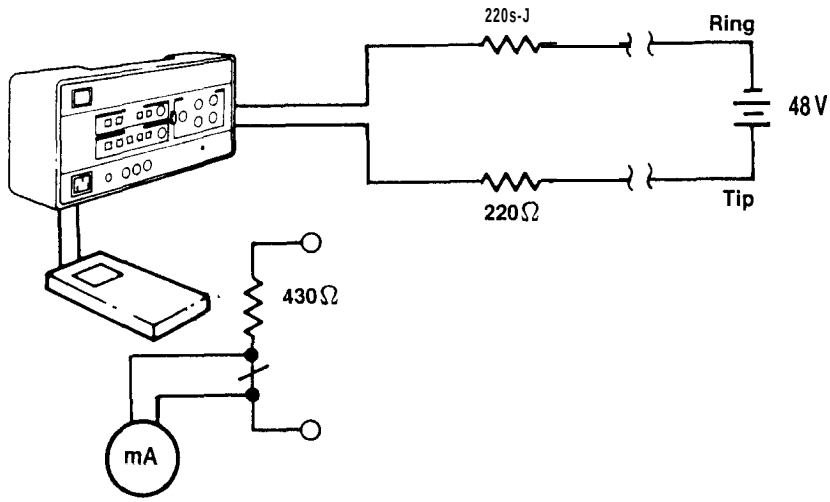


Figure 5. The 4938A provides the loop closure and access for an external multimeter to measure current.

For terminal equipment signaling simulation, the HP 4937A simulates the handshake from the equipment such as a PBX. For example, on a one-way loop reverse battery signaling trunk into a PBX, when the central office goes off-hook, the PBX should respond by reversing the battery. (See Fig. 6.)

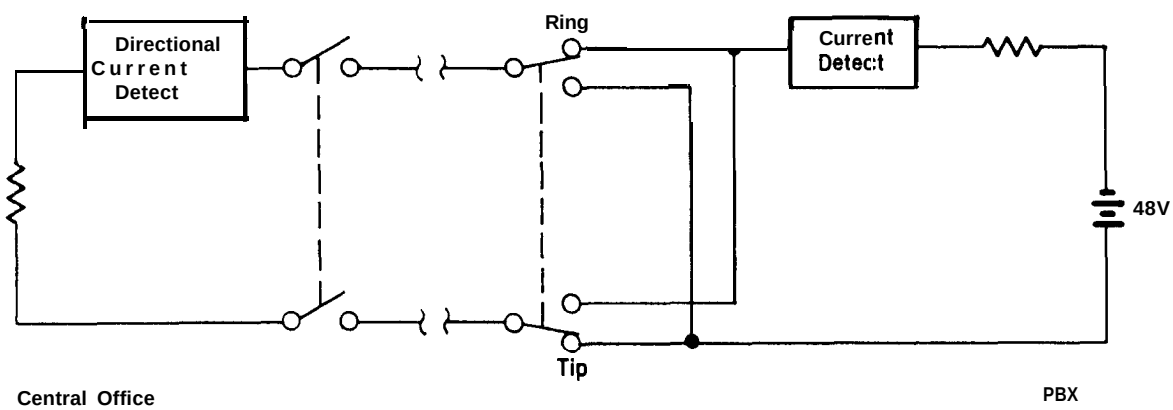


Figure 6. A PBX-to-central office loop reverse battery circuit.

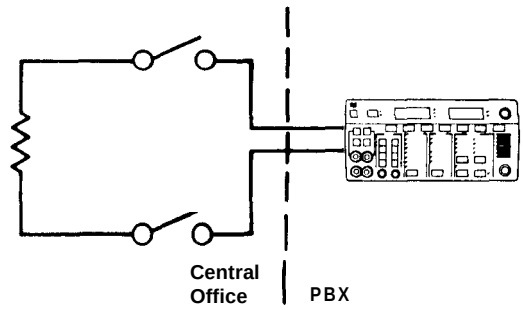


Figure 7. HP 4937A responds to the central office off-hook by reversing the battery

After the line is seized (both ends off-hook) the installer can check the transmission parameters of the line. End-to-end testing can be done with another HP 4937A at the central office. Some examples of tests are: gain slope, C-message noise, and signal-to-signal ratio.

For the communications service user: The HP 4937S can identify where the problem lies whether in the network or in the PBX. For example, if one of the DID lines is not accessible, there are some simple tests the user can do before calling in the service party One of the tests determines where the fault is located. Testing in both directions (towards the PBX and towards the central office) at the network interface gives that information. Since the HP 4937A simulates PBX signaling, it can be set up in the following way to check the signaling of the network for that particular DID line. (See Fig. 8.)

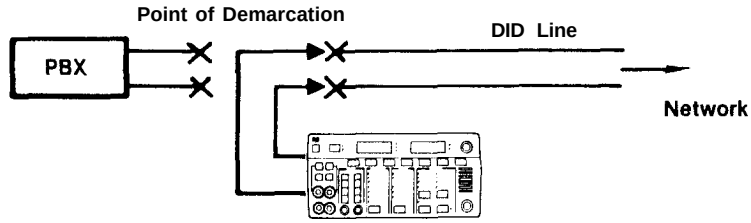


Figure 8. The HP 4937A can simulate the PBX to test the network signaling.

To check the PBX signaling, configure the 4937A to simulate the central office. (See Fig. 9.)

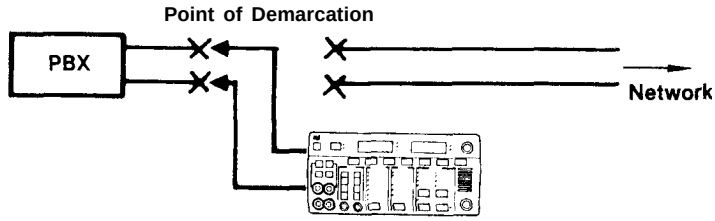


Figure 9. The HP 4937A can simulate the central office to test PBX signaling.

Being able to do these simple tests to determine the general location of the problem helps the repair crew cut down repair time. As a result, the service user saves on cost of repair, and minimizes system down time.

TESTING AT THE NETWORK INTERFACE

Where is the network interface?

The interface, or the demarc, is a designated physical interconnecting point between terminal equipment and telephone company-provided circuit.

Circuit access:

The circuit access for testing at the network interface are the following leads: T and R, T1 and R1, E and M, SB and SG.

Test objectives:

The testing objective is to assure that the circuit meets the tariff requirements. Meeting the limits of all the signaling tests verifies that the circuit meets its signaling requirements.

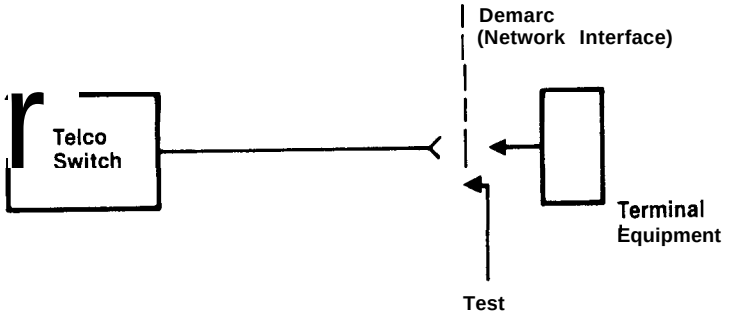
Recommended tests and test sequence:

1. Check continuity from the network interface to the terminal equipment and to the trunk lines.
2. Perform network circuit qualification tests.
3. Perform the necessary transmission tests with the circuits in talk condition.

TABLE OF CONTENTS FOR RECOMMENDED TESTS

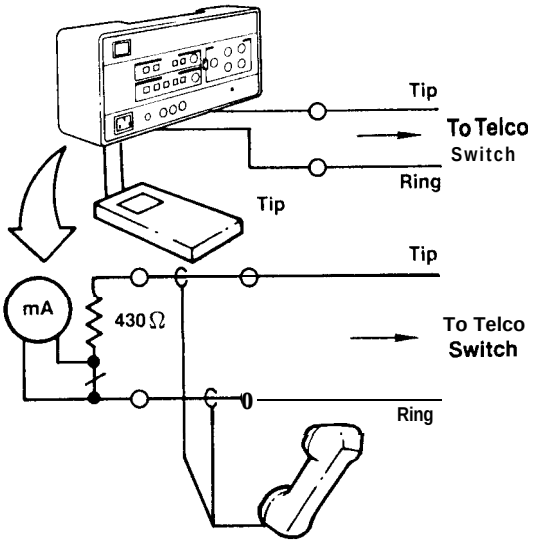
USING THE HP 4938A FOR NETWORK CIRCUIT QUALIFICATION TESTING
LOOP START CIRCUITS

Test direction: Towards the network.



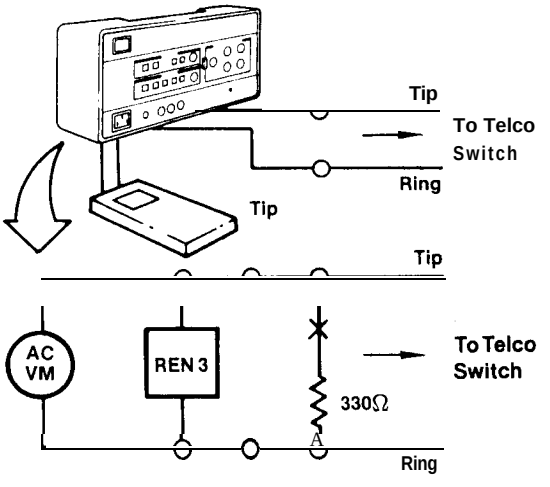
For 2-wire testing:

1. Loop current and dial tone:
   a. Connect the HP 4938A across tip and ring and close the circuit with 430 ohms by pressing the LOOP key.
   b. Connect a multimeter to the AMP and COM jacks. Measure the DC loop current by pressing the LOOP I key. This places the multimeter momentarily in series with tip and ring.
   Test limit: greater than or equal to 20 mA.
   c. Connect a handset across tip and ring to monitor for dial tone.
   Test limit: hear dial tone.



2. Ring voltage:
   a. Connect the HP 4938A across tip and ring. Close the circuit with a REN-3 load by pressing the REN-3 key.
   b. Connect a multimeter to the COM and VOLT jacks. Measure the incoming AC ringing voltage across REN-3 load.
   Test limits: greater than or equal to
   40 Vrms if 20 ±1 Hz supply;
   55 Vrms if 17 to 23 Hz supply.

3. Ringing trip:
   a. While the loop is closed with REN-3 and receiving ringing, connect 330 ohms across tip and ring by pressing TRIP key on the HP 4938A.
   Test limit: Far-end ceases to ring.

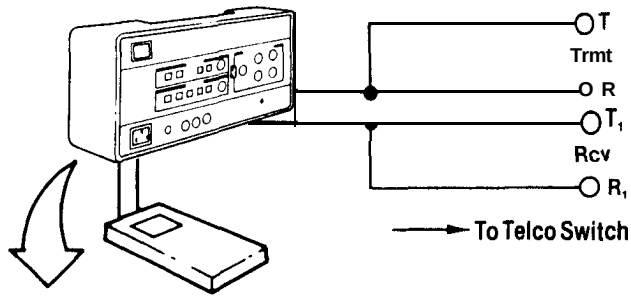


For 4-wire testing:

I. Termination:

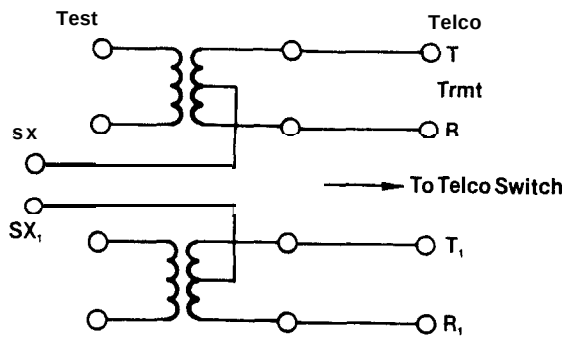
a. Terminate the transmit (T&R) and receive (T1&R1) pair with the 4-wire simplex termination. Connect transmit pair to T/R 310 jack labelled TELCO on the HP 4938A.

b. Connect receive pair to T1/R1 310 jack labelled TELCO on the HP 4938A. Slide the switch to the lower position to internally connect the ORIGINATE section to the SX/SX1 leads.
Note: The simplex of the receive pair (T1/R1) is the R lead. The simplex of the transmit pair (T/R) is the T lead.



2. Tip lead open:

a. Measure resistance between SX (transmit) lead and ground.
Test Limit: greater than or equal to 15 kohms.



3. Line seizure, dial tone and loop current:

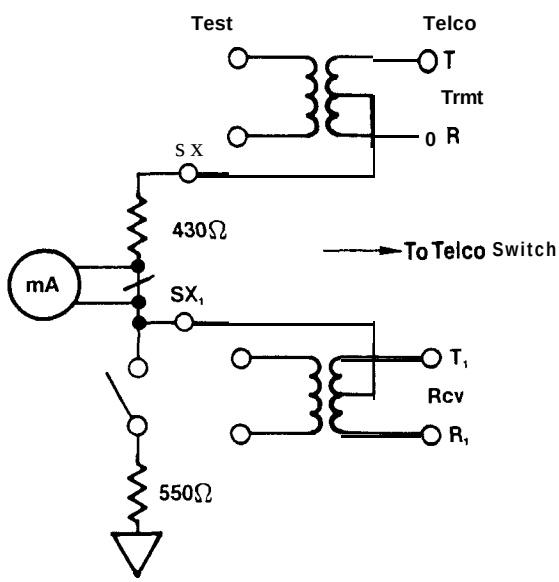
a. Connect 430 ohms across SX/SX1 leads by pressing the LOOP key

b. Connect a multimeter to the AMP and COM jacks.

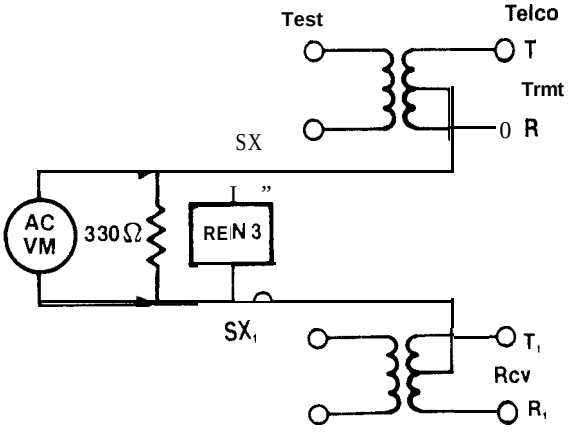
c. Provide a momentary ground on ring the SX1 (R) lead by pressing the GROUND START key on the HP 4938A.

d. Measure the DC loop current by pressing the LOOP I key. This places the multimeter momentarily in series with tip and ring.
Test Limit: greater than or equal to 20 mA.

e. Connect a handset across tip and ring to monitor for dial tone.
Test Limit: hear dial tone with 3 secs after grounding ring.

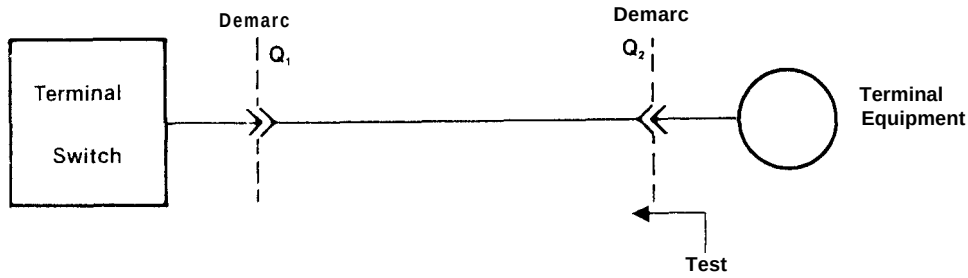


4. Ring voltage:
   a. Connect REN-3 load across SX/SX1 by pressing the REN-3 key.
   b. Connect a multimeter to COM and VOLT jacks. Measure incoming AC ringing voltage across REN-3 load.
      Test Limits: greater than or equal:
      40 Vr-ms it 20 ±1 Hz supply;
      5.5 Vrms it 17 to 23 Hz supply.
5. Ringing trip:
   a. While SX/SX1 are connected by REN-3 and receiving ringing, connect 330 ohms across SX/SX1 by pressing trip key on the HI' 4938A.
      Test Limit: Far-end ceases to ring.



6. Timing for far end to disconnect:
   a. Measure the resistance from tip 'to ground as the 330 ohms is removed by releasing the TRIP key on the HP 4938A.
      Test Limit: greater than or equal to 30 kohms with 1.5 secs atter removal of 330 ohms.

End-to-end testing (off-premises extension):
Need: Two 4938As.



1. Tip **lead** open:

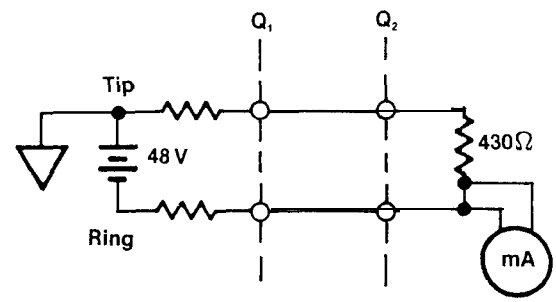
a. Measure resistance between tip to ground at Q2.
Test Limit: greater than or equal to 30 kohms.

2. Loop current:

a. Connect 48 V battery across tip and ring at Q1 by having the SIMULATE key on the HP 4938A in the UP position.

b. Connect the HP 4938A across tip and ring at Q2 and close thr circuit with 430 **ohms by** pressing the LOOP key.

c. Connect a multimeter to the AMP and COM jacks to the HP 4938A at Q2. Measure the DC loop current by pressing the LOOP I key. This places the multimeter momentarily in series with tip and ring.
Test Limit: greater than or equal to 20 mA.

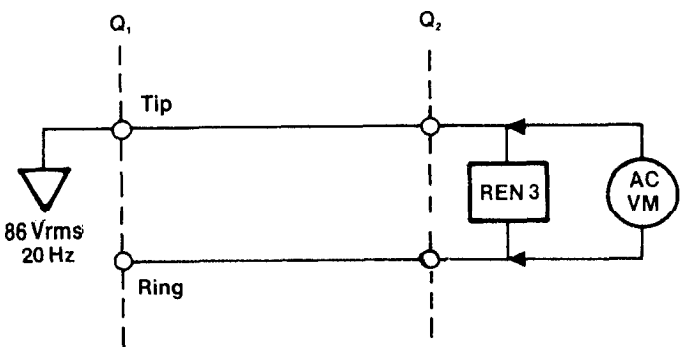


3. Ring voltage

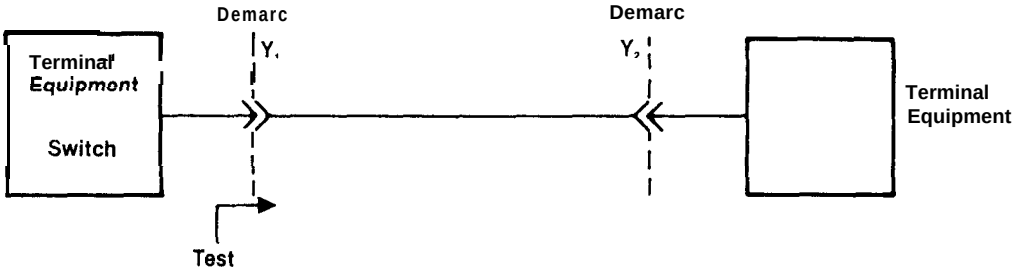
a. Connect ringing voltage (20 Hz) across tip and ring at Q1 **and** provide ground to tip. Select 20 Hz ringing on the HP 4938A by having the RING key in the UP position. Start ringing by pressing the SIMULATE key.

b. Connect the second HP 4938A across tip and ring at Q2. Close the circuit with a REN-3 load by pressing the REN-3 key.

c. Connect a multimeter to the COM and VOLT jacks. Measure AC ringing voltage coming from Q1 across the REN-3 load
Test Limit: greater than or equal to 55 Vrms.

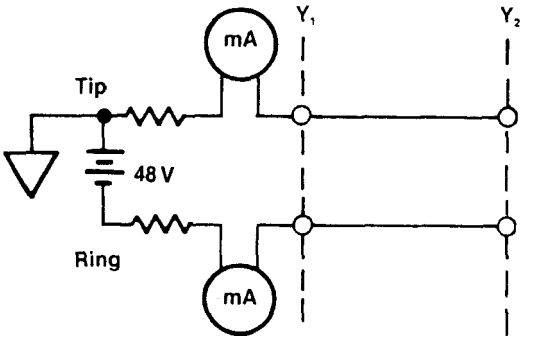


End-to-end testing (off-premises extension):
Need: Two 4938As.

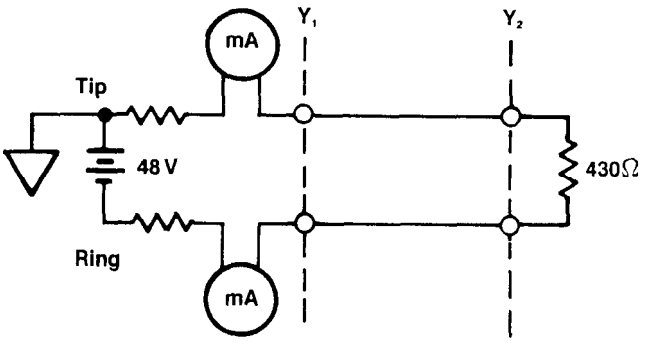


1. Loop current:

   a. Connect −48 V battery across tip and ring a Y1 by having the SIMULATE key on the HP 4938A in the UP position.
   b. Open tip and ring at Y2.
   c. Connect multimeter in series with the battery at Y1. Measure tip current and ring current.
      Test Limit: the absolute value of the tip current plus ring current is less than or equal to 6 mA.
   d. Connect the second HP 4938A across tip and ring at Y2. Close the circuit with 430 ohms by pressing the LOOP key.
   e. Measure loop current at Y 1.
      Test Limit: greater than or equal to 20 mA.



2. Disconnect :
   a. Remove the HI' 4938A at Y2.
   b. Measure tip and ring current at Y1.
      Test Limit: the absolute value of the tip current plus ring current is less than or equal to 6 mA.



To establish talk condition using the HP 4937A:

Press SIG SELECT key to select E/M signaling. Use the switch on the rear panel of the instrument to select types I, II, or III.

ORIGINATE **unit-M** lead origination.

1. Press ORIG/TERM key to select ORIG.
2. Connect handset to the dial jacks.
3. Connect the line under test to the A or B 310 jack. Connect the E/M leads to the E/M jack. For Types II and III, be sure to connect the SG/SB leads to the SG/SB jack as well.
4. Press DIAL key to go off hook. Talk condition established.

TERMINATE unit-E lead origination

1. Press ORIG/TERM key to select TERM.
2. Connect handset to the dial jacks.
3. Connect the line under test to the A or B 310 jack. Connect the E/M leads to the E/M jack. For Types II and III, be sure to connect the SG/SB leads to the SG/SB jack as well.
4. Press DIAL key to talk.

TRANSMISSION TESTS

SIGNAL-TO-NOISE RATIO

What is it?

Signal-to-noise ratio is the ratio of received signal-plus-noise power to noise power (S+N/N). It is a quick measure of the noisiness of a line.

How is it measured?

A 1004 Hz tone is transmitted at normal signal level over the circuit. At the receive end of the line, the level of this signal **plus** noise is measured. The 1004 Hz tone is then notched out so that background noise can be measured using a band limited filter. The computed signal-to-noise ratio is displayed in units of dB.

Using the HP 4937A:

Press MEAS SELECT key to display TRMT.

	HP 4937A DISPLAYS	
TRANSMIT unit		
1. Press DISPLAY key to display TRMT.	-dBm	1004 Hz
2. Adjust OUTPUT LEVEL to normal signal level (Usually about -20 dBm.)	-20.0 dBm	1004 Hz
RECEIVE unit		
1. Press DISPLAY key to display RCV. S/N is given in the right display and the received signal level is given in the left display.	-30.0 dBm	42 dB
2. Press FILTER key to select a filter. (Usually C-message on voicegrade lines.)		

What does it mean?

Since S/N ratio is relative, it can be low for two reasons-either the noise level is too high or the received signal level is too low. If the received level looks good [loss is acceptable) then further noise testing in the NOISE mode may give more information **about the** source of the noise.

LOSS (ATTENUATION DISTORTION)

What is it?

Loss is the difference between the transmitted signal level and the received signal level. It is caused primarily by impedance impairments of the transmission media. Attenuation distortion is the profile of loss vs. frequency across the bandwidth of the line.

How is it measured?

Absolute loss is the difference between the transmitted level at one frequency and the received level at that same frequency. The telecom industry has developed the concept of relative loss or distortion. The loss at one frequency is compared to the loss at some reference frequency, usually 1004 Hz. For example, if at 3000 Hz there were 6 dB more loss than at 1004 Hz, the attenuation distortion at 3000 Hz would be +6 dB. Note the convention of a + sign for more loss and a − sign for less loss (relative gain).

Using the HP 4937A:

Press MEAS SELECT key to select LEVEL FREQUENCY.

	HP 4937A DISPLAYS	
TRANSMIT unit		
1. Press DISPLAY key to display TRMT.	dBm	Hz
2. Adjust frequency to 1004 Hz.	dBm	**1004** Hz
3. Adjust OUTPUT LEVEL to normal signal level. (Usually about **-20** dBm.)	-20.0 dBm	1004 Hz
RECEIVE unit		
1. Press DISPLAY key to display RCV.	-36.0 dBm	1004 Hz
2. Press LEVEL ZERO key.	0.0 dB	**1004** Hz
3. Change the frequency of the transmit unit to the frequencies of interest across the bandwidth and record the relative loss at each frequency, The HP 4937A has two other pre-programmed frequencies, 404 Hz and 2804 Hz, for quick check of voice grade lines.		

What does it mean?

Different types of lines have different specs for attenuation distortion. Refer to the back of this document for examples of attenuation distortion (gain slope) specs for several types of voice band channels.

NOISE-WITH-TONE (NOTCHED NOISE)

What is it?

Noise measured with a single frequency holding tone present to activate compandors and/or quantizers in the transmission system. This way, noise levels that exist during normal operation can be duplicated.

How is it measured?

A 1004 Hz tone is transmitted while the noise is measured. At the receive end, the usual band-limited filters (C-message and 3 kHz) are used and the 1004 Hz tone is notched out before the detector. Noise-with-tone is measured in dBrn where −90 dBm = 0 dBrn.

Using the HP 4937A:

Press MERS SELECT key to select NOISE W/TONE.

	HP 4937A DISPLAYS	
TRANSMIT unit		
1. Press DISPLAY key to display TRMT.	dBm	**1004** Hz
2. Adjust OUTPUT **LEVEL to** normal signal level. (Usually about -20 dBm.)	-20.0 dBm	**1004** Hz
RECEIVE unit		
1. Press DISPLAY key to display RCV.	40 dBrn	1004 Hz
2. Press FILTER key to select a filter. (Usually C-message on voice-grade lines.)		

What does it mean?

The guidelines for notched noise vary with length of the circuit and types of facilities in the circuit. Since some facilities have compandors and some do not, as a general rule of thumb, 40 dBrn would be about the maximum.

RETURN LOSS

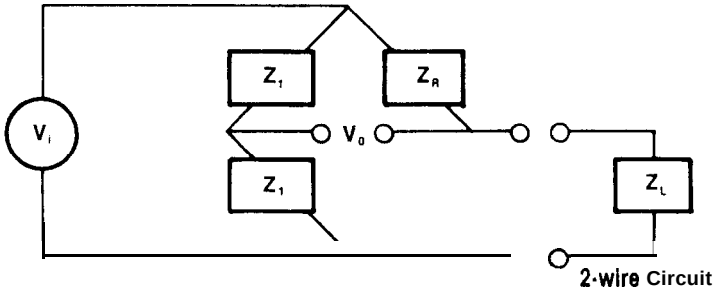
Return Loss-2-wire

What is it?

The 2-wire return loss is an indication of how well the impedance of a 2-wire circuit matches the reference impedance. The reference impedances are either 600 ohms + 2.16 μF or 900 ohms + 2.16 μF.

How is it measured?

An internal triangle bridge similar to the diagram below, is **used.** The transmitter is internally connected to V(i) and the receiver to V(o). The transmit signals are bands of frequencies in the voice band: echo-mid band, singing low-lower-band, singing high-upper band. Reference impedances used are either **600** or 900 ohms in series with a 2.16 μF capacitor. The difference in Z(L) and Z(R) is measured in dB.



Using the HP 4937A:

	HP 4937A DISPLAYS	
1. Press MEAS SELECT key to select RET LOSS 2W.		
2. The instrument displays TRMT.	-dBm	blank
3. Select reference impedance.		
4. Adjust OUTPUT LEVEL to **-16** dBm.	-16.0 dBm	blank
5. Press FILTER key to select a transmit spectrum.		
6. Press DISPLAY key to display RCV. The return loss measurement is shown on on the left display.	16 dB	blank

What does it mean?

In theory, a perfect line should have infinite return loss. In actuality, 30 dB is probably the best that will be seen. For trunks, the return loss spec is 15 to 17 dB. For 2-wire subscriber loop, the spec is 7 to 9 dB.

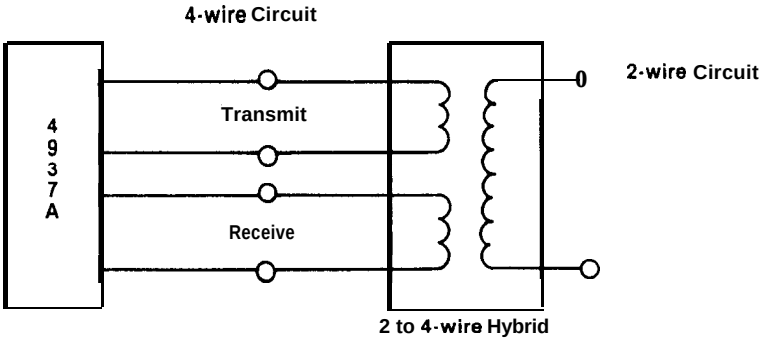
Return loss- 4-wire

What is it?

Four-wire return loss measures the 4-wire to 2-wire hybrid balance using either a 600 ohms or 900 ohms reference impedance.

How is it measured?

A band limited signal spectrum of known level is transmitted and compared with the received signal level. The difference, adjusted for hybrid and circuit loss, is return loss.



Using the HP **4937A:**

	HP 4937A DISPLAYS	
1. Press MEAS SELECT key to select RET. LOSS 4W.		
2. The instrument is in display TRMT.	-dBm	blank
3. Select reference impedance for both TRMT and RCV.		
4. Adjust OUTPUT LEVEL to -20.0 dBm.	-20.0 dBm	blank
5. Press FILTER key to select a transmit spectrum.		
6. Press DISPLAY key to display RCV.	XX.X dB	0.0 dB
7. Adjust for transhybrid loss, THL:		
a. Enter the THL if the value is known. Use the STEP UP and DOWN keys. (Right display.)		
OR		
b. Short the 2-wire side of the hybrid. Press LEVEL ZERO key. THL is automatically calculated. Remove the short.		
8. After THL is entered, all subsequent return loss measurements on the same 4-wire circuit will have the same adjustment. (Left display)		

What does it mean?

For a trunk, a typical return loss measurement is 25 dB. For a very good trunk, it measures about 30 dB.

NOISE

What is it?

The noise measurement is also known as message circuit noise or background noise. It is used most often to identify noise in the local loop. There are no tone activated components in this loop. To identify the source of noise, the telephone company **wants** to distinguish the noise contributed by the local loop from the noise contributed by other parts of the circuit and noise due to power line interference.

How is it measured?

The line is quiet terminated in one end and a receiver with a weighting filter (C-message or 3 kHz) is used at the receiving end. Noise level is measured in dBrn.

Using the HP 4937A:

Press MEAS SELECT key to select NOISE.

	HP 4937A DISPLAYS	
TRANSMIT unit		
1. Press DISPLAY **key** to display TRMT. (Quiet termination)	blank	blank
RECEIVE unit		
1. Press DISPLAY **key** to display RCV.	36 dBrn	blank
2. Press FILTER key to select a filter. (Usually C-message on voice-grade lines)		

What does it mean?

The guidelines for noise vary with types of circuits. As a rule of thumb, 36 dBrn is a good level for a local loop.

NOISE-TO-GROUND

Noise-to-ground measures the longitudinal noise present on a line. This is usually caused by poor balance of the line.

How is it measured?

The line is quiet terminated in one end and a receiver with a weighting filter (C-message or 3 kHz) is used at the receiving end. The difference between Noise and Noise-to-ground is a ground reference is used in the latter measurement.

Using **the HP 4937A:**

Press MEAS SELECT key to select NOISE/GROUND.

	HP 4937A DISPLAYS	
TRANSMIT unit		
1. Press DISPLAY key to display TRMT. (Quiet termination.)	blank	blank
RECEIVE unit		
1. Press DISPLAY **key** to display RCV.	XX dBrn	blank
2. Press FILTER key to select a filter. (Usually C-message on voice-grade lines.)		

What does it mean?

Noise-to-ground measurements are usually made for troubleshooting purposes; to measure the magnitude of longitudinal signals, which may indicate the susceptibility of a cable pair to electrical coupling from external sources. The relative line balance of an end loop can be calculated by subtracting the measured noise-to-ground value from the measured message circuit noise value. This assumes that the message circuit noise is caused by longitudinal noise converted to message circuit noise by line imbalance.

RECOMMENDED TESTS AND TEST LIMITS

CIRCUIT TYPES

Recommended Tests	Voiceband switched trunks	Voiceband switched lines
Continuity	Required	Required
Loss (1004 Hz)	± 1.0 dB	± 1.0 dB
C-msg noise	40 dBrn	40 dBrn
3-tone slope (rel. 1004 Hz)		
404 Hz	-1.5 to +5.0 dB	-1.5 to +8.0 dB
2804 Hz	-1.5 to +5.0 dB	-1.5 to +8.0 dB
Impedance balance		
2-wire ERL	22 dB	8
SRL	15 dB	5
It-wire ERL	22 dB	—
SRL	15 dB	—

The above table consists of recommended tests and test limits. These are examples of specifications of types of circuits available. The HP 493% is by no means limited to testing the circuits described above.

TESTING VOICEBAND DATA CIRCUITS WITH THE HP 4937A

The HP 4937A can be used in testing voiceband data circuits. It performs some of the tests and measurements described in Bell system technical reference 41009 (Transmission parameter affecting voiceband data transmission-measuring techniques). The measurements include: level and frequency measurements, C-message noise, signal-to-noise ratio, and notched noise.