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TERMINAL ATTACHMENT PROGRAM

CERTIFICATION STANDARD

TELECOMMUNICATION REGULATORY SERVICE

This document will be revised from time to time on the basis of experience gained. The Department encourages comments and suggestions that will enhance the effectiveness of the Standards contained herein. These may be forwarded to the Director General Telecommunication Regulatory Service.

CERTIFICATION STANDARD

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CERTIFICATION STANDARD

FOR

DATA TYPE TERMINAL EQUIPMENT AND CONNECTORS

1. INTRODUCTION

1.1 Scope

This document (subject to amendments from time to time) sets forth the minimum technical requirements for the certification of terminal equipment described in the above title and is limited to network non-addressing equipment intended for connection to individual lines only. Direct electrical and acoustical methods of attachment are included in this document. The standards contained herein are intended for the protection of the communications networks and do not necessarily imply any measure of equipment performance or safety other than those covered by the CSA approval.

1.2 Related Documents

a)	CP-01	Certification Procedure
b)	CS-01	Certification Standard (voice)
c)	IEEE 455-1976	Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band.
d)	EIA RS232C	Interface between Data Terminal Equipment and Data Communications Equipment.
e)	MIL-STD-188C	Military Communication System Technical Standards
f)	CCITT-V24	Definitions of Interface Between DTE and DCE.
g)	TRC34	Terminal Attachment Program Description
h)	IEEE 167A-1975	Standard Facsimile Test Chart
i)	TRC-52	Application Notes

1.3 Sequence of Equipment Testing

The tests shall be performed in the order given below:

a)	Section 2.1	Connecting Arrangements
b)	Section 2.3	Operational Performance
c)	Section 3	Network Protective Requirements and Tests
d)	Section 2.2	Surge Voltage Application
e)	Section 3	Network Protective Requirements and Tests, qualified as follows:

The tests of Section 3 are repeated in e) to the extent the equipment is operable. All tests must be attempted. The equipment may be fully or partially inoperative but will be judged to have passed the tests if the required limits of section 3 are met. After being subjected to the surge application voltage, the data circuit-terminal equipment shall not present permanently to the Tip/Ring interface any off-hook parameters.

1.4 Definitions

For the purpose of this document data circuit-terminal equipment shall mean equipment designed to transmit and/or receive analog electrical signals in the voice frequency band and whose frequency/power distribution, when averaged over a period of three seconds or longer, differs discernably from that for voice (or music).

Network A		shall mean the Public Switched Telephone Network
Network B		shall mean Private Line Facilities
	B2	shall mean 2 wire private line facilities
	B4	shall mean 4 wire private line facilities
Network C		shall mean the Multicom 2 Network
Network D		shall mean the Broadband Exchange Service (BES) Network
	D2	shall mean 2 wire BES Network
	D4	shall mean 4 wire BES Network

Where these letters appear behind a requirement in this document, it indicates that the requirement is to be applied when certification is requested for the network so designated by the letter. A single letter shall indicate a requirement applies to both 2 wire and 4 wire networks.

2. PRELIMINARY TESTS

The requirements of this section, except for Section 2.1 shall not apply to equipment designed to be attached by acoustical means only, to any network.

The requirements of Section 2.2 shall not apply to equipment designed for electrical attachment to Network C only.

2.1 Connecting Arrangements

The data circuit-terminal equipment intended for direct attachment to any network shall be equipped with a cord and plug in accordance with Section 4.

Data circuit-terminal equipment intended for acoustical attachment shall be of such physical dimensions that it will accept the "G" Type handset which forms part of the Western Electric F-58654 Coupler Test Set.

2.2 Surge Voltage Application (A) (B) (D)

2.2.1 Requirement

High voltage surges shall be applied in accordance with Section 2.2.2 to the data circuit-terminal equipment with both on-hook and off-hook modes. Tests shall be conducted with accessories ground lines attached, power source connected and the power on.

2.2.2 Application Method

Data circuit-terminal equipment designed to be electrically connected to the telecommunications network(s) shall be surge tested as follows:

1) Connect the test circuit as shown in Figure 2-2 with the surge generator set to deliver a 1000 V, 10 x 1000 waveform. (Switch S1 should be in position "a" and switch S2 should be in position "c".)

2) With switch S2 in position "a", fire the surge generator to apply the surge voltage three times to the Tip lead with the Ring lead grounded.

3) With switch S2 in position "b", fire the surge generator to apply the surge voltage three times to the Ring lead with the Tip lead grounded.

4) Adjust the surge generator for a 1000 V, 100 x 1000 waveform and repeat steps 2) and 3).

5) Operate switch S1 to position "b" and move switch S2 to position "c". Operate the dc feed and ring-up circuit to bring the data circuit-terminal equipment off- hook. Repeat steps 2) to 4).

N.B.

(a) The designation of current or voltage impulse, a combination of two numbers as 10 X 1000 or 100 x 1000 is the standard IEEE numerical representation of a wave shape. The first, an index of the wave front, is the virtual duration of the wave front in microseconds. The second, an index of the wave tail, is the time in microseconds from virtual zero to the instant at which one-half of the crest value is reached on the wave tail. The waveform is developed across the open circuit terminals A and G as shown in Figure 3-11(a).

(b) Conducting foils shall be pressed firmly in contact with all exposed metal surfaces. All exposed metal surfaces shall be electrically grounded.

(c) When the surge voltage is applied, verify with the oscilloscope that the peak voltage (1000 V) is applied to the tip and ring terminals of the terminal equipment. If the 1000 V cannot be reached, increase the generator voltage in increments until 1000 V (applied surge voltage) is reached or 1500 V (generator voltage) is applied.

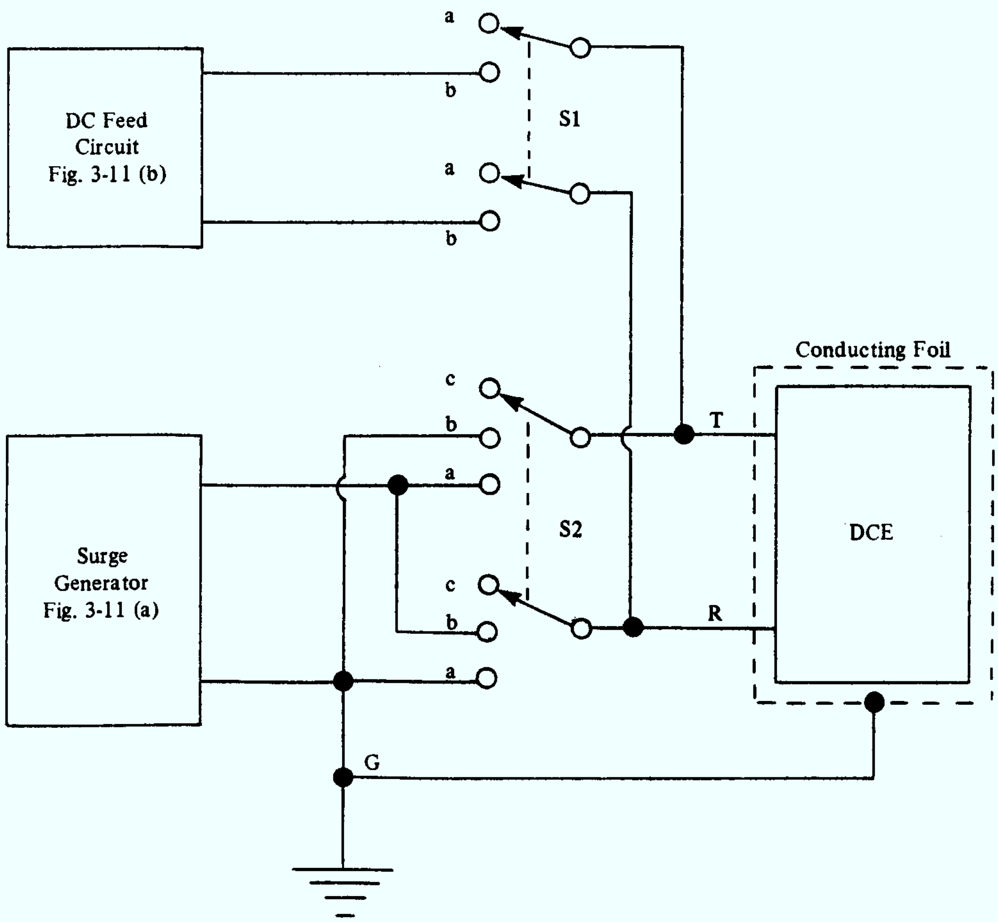


FIGURE 2-2
Surge Voltage Application

2.3 Operational Performance

2.3.1 Requirement

When directly connected to a laboratory circuit which is the equivalent of the network or facility type for which certification has been requested, the unit shall be fully operational with respect to those features described in the manufacturer's operation manual which are necessary to perform the tests in Section 3.

2.3.2 Test Method

1) The data circuit-terminal equipment shall be connected to the "terminating end" of a network equivalent circuit by means of one of the approved plugs or connectors (see Section 4).

2) A compatible receiving and/or transmitting data circuit-terminal equipment shall be connected to the "originating end" of the network equivalent circuit.

3) Tests shall be conducted to verify that the data circuit-terminal equipment is fully operational as defined in the manufacturers operational manual.

N.B. The Laboratory Circuit equivalents are shown in Appendix A. Actual Carrier circuits may be used where the Carrier permits.

3. NETWORK PROTECTIVE REQUIREMENTS AND TESTS

3.1 General

3.1.1 Laboratory Environment

All tests to determine conformance with this specification shall be conducted in a laboratory environment as follows:

Temperature 23°C ± 3°C

3.1.2 Testing Sequence

Each individual unit of equipment to be tested shall be subject to all of its requirements, with no alteration of wiring, components or internal controls permitted during the testing sequence except as specifically noted in the test method.

3.1.3 Acoustically attached Equipment

The terminal equipment designed for acoustical attachment shall only conform with the following requirements:

Requirement	Description
3.4.1	In-Band Power
3.4.2	Out-of-Band Power
3.5.1	Single Frequency Restriction

3.1.4 Direct Electrically Attached Equipment

3.1.4.1 Requirements

The data circuit-terminal equipment shall conform with all the requirements of Sections 2, 3, and 4. All tests shall be applied to the equipment through a cord and connector of a type which conforms with Section 4. When equipment is to be supplied with more than one connecting cord and plug arrangement, the terminating longitudinal balance requirement shall be checked with each cord offering.

3.2 Extraneous DC Signals

3.2.1 Metallic DC Energy

3.2.1.1 Requirement (A) (B) (D4)

In the on-hook mode and in any operating state the data circuit-terminal equipment shall not impress between its Tip and Ring terminals dc potentials in excess of 25 mV. The procedure described in Section 3.2.2.2 shall be used to demonstrate compliance.

3.2.2 Longitudinal DC Energy

3.2.2.1 Requirement (A) (B) (D)

In the on-hook mode the terminal equipment shall not impress between its Tip or Ring terminal (individually) and ground reference dc potentials exceeding 25 mV.

In the off-hook mode, data circuit-terminal equipment shall not impress voltages in excess of 0.5 V. The procedure described in Section 3.2.2.2 shall be used to demonstrate compliance.

3.2.2.2 Test Method

To test for metallic and longitudinal dc energy sources.

1) Connect the data circuit-terminal equipment to the test set up as shown in Figure 3-2

2) With switch S1 in position "a" and switch S2 in position "a", record the dc voltmeter reading.

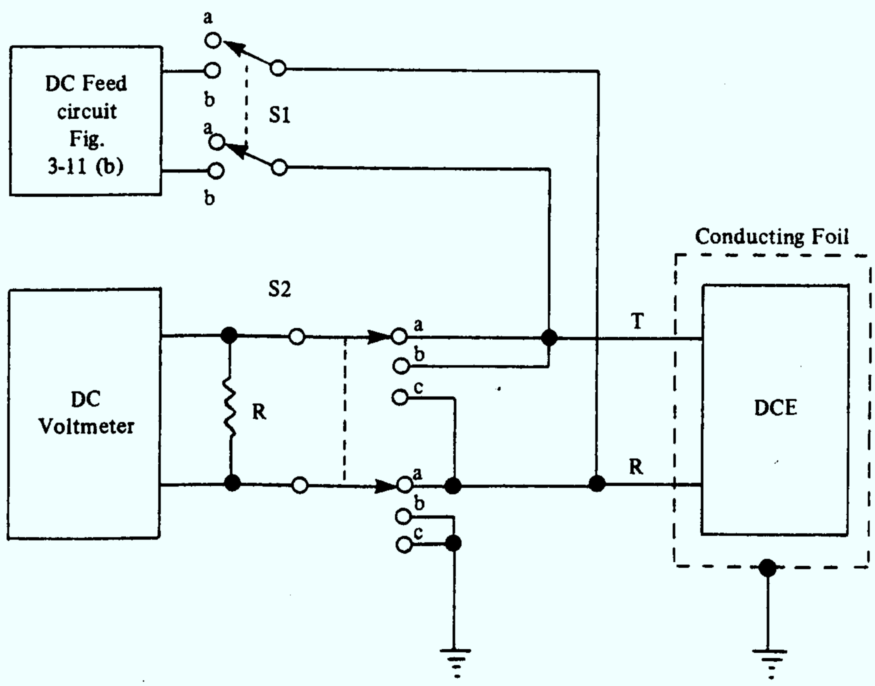
3) Operate switch S2 to position "b" and record the voltmeter reading.

4) Operate switch S2 to position "c" and record the voltmeter reading.

5) Set switch S1 to position "b" and operate the dc feed and ring-up circuit to bring the data circuit-terminal equipment off-hook and adjust the dc current to 25 mA.

6) Repeat steps 3) and 4) for all off-hook operating states.

Note-When testing equipment for networks A and D2 switch S1 of the dc feed and ring-up circuit (see Figure 3-11 (b)) must be in position b for steps 3 and 4 and step 5 shall be eliminated. When testing equipment for 4-wire networks, perform steps 1 to 5 in turn to the transmit and receive pairs.



R = 1000 Ω 1% 5 W

FIGURE 3-2

Metallic and Longitudinal
DC Energy Measurements

3.3 Extraneous AC Signals

3.3.1 Metallic AC Signals

3.3.1.1 Requirement (A)

In the on-hook mode, data circuit-terminal equipment shall not impress between its Tip and Ring terminals ac signals exceeding the limits in Table 3-3(a).

TABLE 3-3 (a)

Frequency Band	Maximum Permissible Signals
2 – 100 Hz C Message Band	–40 dBm 10 dBrnc

The procedure described in Section 3.3.1.2 shall be used to demonstrate compliance.

3.3.1.2 Test Method

1) Connect the data circuit-terminal equipment to the test setup as shown in Figure 3-3(a).

2) Set the filter to obtain a 2-100 Hz pass band and arrange the true rms voltmeter to read power averaged over 250 ms.

3) With switch S1 in position "a" record the rms voltmeter reading.

4) Set the noise measuring set (NMS) as follows:
   -Input to "Noise Termination" 600 ohm balanced impedance.
   -Noise weighting to "C - message".
   -Meter movement "damped".

5) With switch S1 in position "b" record the Noise Meter reading.

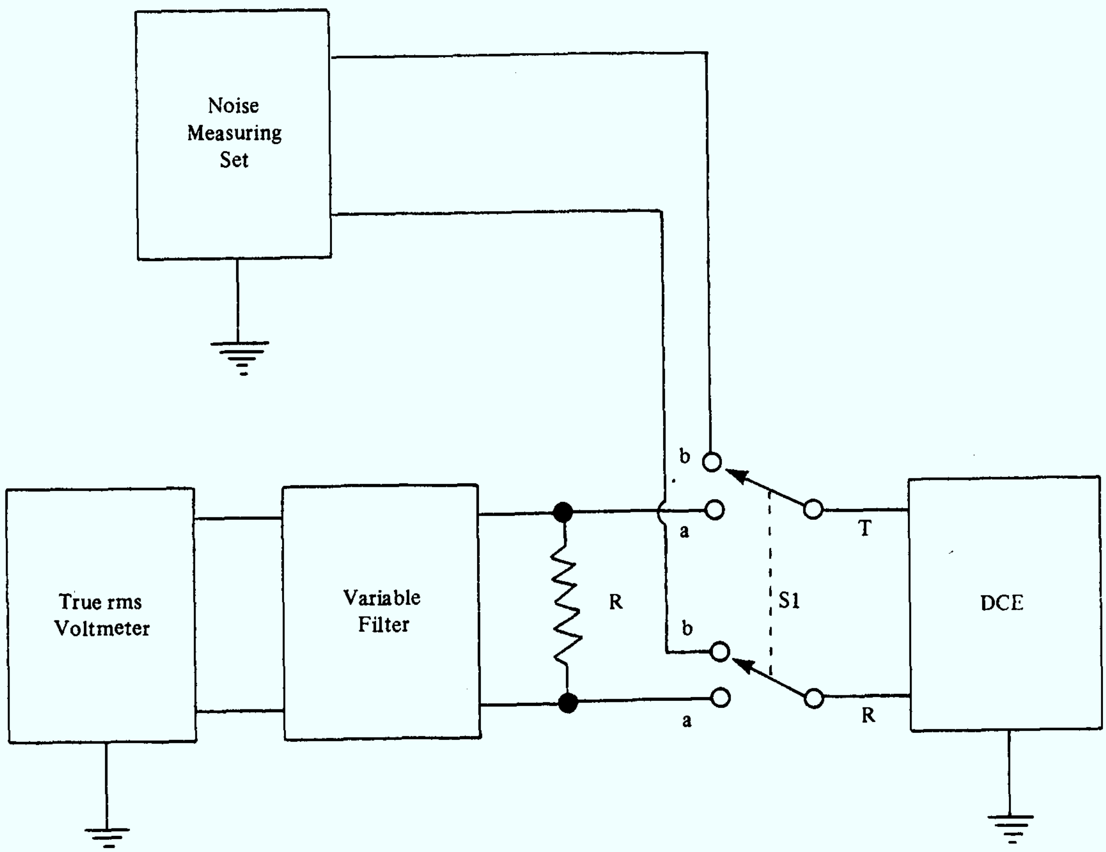


FIGURE 3-3 (a)

Metallic AC Energy Measurement

3.3.2 Longitudinal AC Signals

3.3.2.1 Requirement (A) (B) (C)

In either the on-hook or off-hook mode, and in any operating state, the data circuit-terminal equipment shall not impress between its Tip and Ring terminals and ground reference ac signals exceeding those shown in Table 3-3(b).

TABLE 3-3 (b)

Frequency Band (kHz)	Filter	Maximum Permissible Signal (dBm)
.002 – 4.0	Modified Band-Pass	– 40
4.0 – 10.0	Band Pass	– 46
10.0 – 25.0	Band Pass	– 54
25.0 – 40.0	Band Pass	– 66
40.0 – 200.0	Band Pass	– 70*

* Due to possible test equipment noise limitations the value of -70 dBm is a compromise from a desired level of -80 dBm. In future issues of this standard this signal level requirement may be decreased to -75 or -80 dBm as suitable test instruments become available.

The procedure described in Section 3.3.2.2 shall be used to demonstrate compliance.

3.3.2.2 Test Method

1) Connect the data circuit-terminal equipment to the test set-up shown in Figure 3-3(b).

2) With switch S1 in position "a" arrange the true rms voltmeter to read rms power in dBm averaged over 250 ms for the band .002 - 4.00 kHz.

3) With the data circuit-terminal equipment in the on-hook (or idle mode) record the maximum voltmeter reading.

4) * Operate the dc feed and ring-up circuit and bring the data circuit-terminal equipment off-hook.

Apply 70 mA (or maximum current whichever is less).

5) Where the equipment is provided with an external or programmable gain control operate the data circuit-terminal equipment at maximum gain to transmit each of its possible output signals.

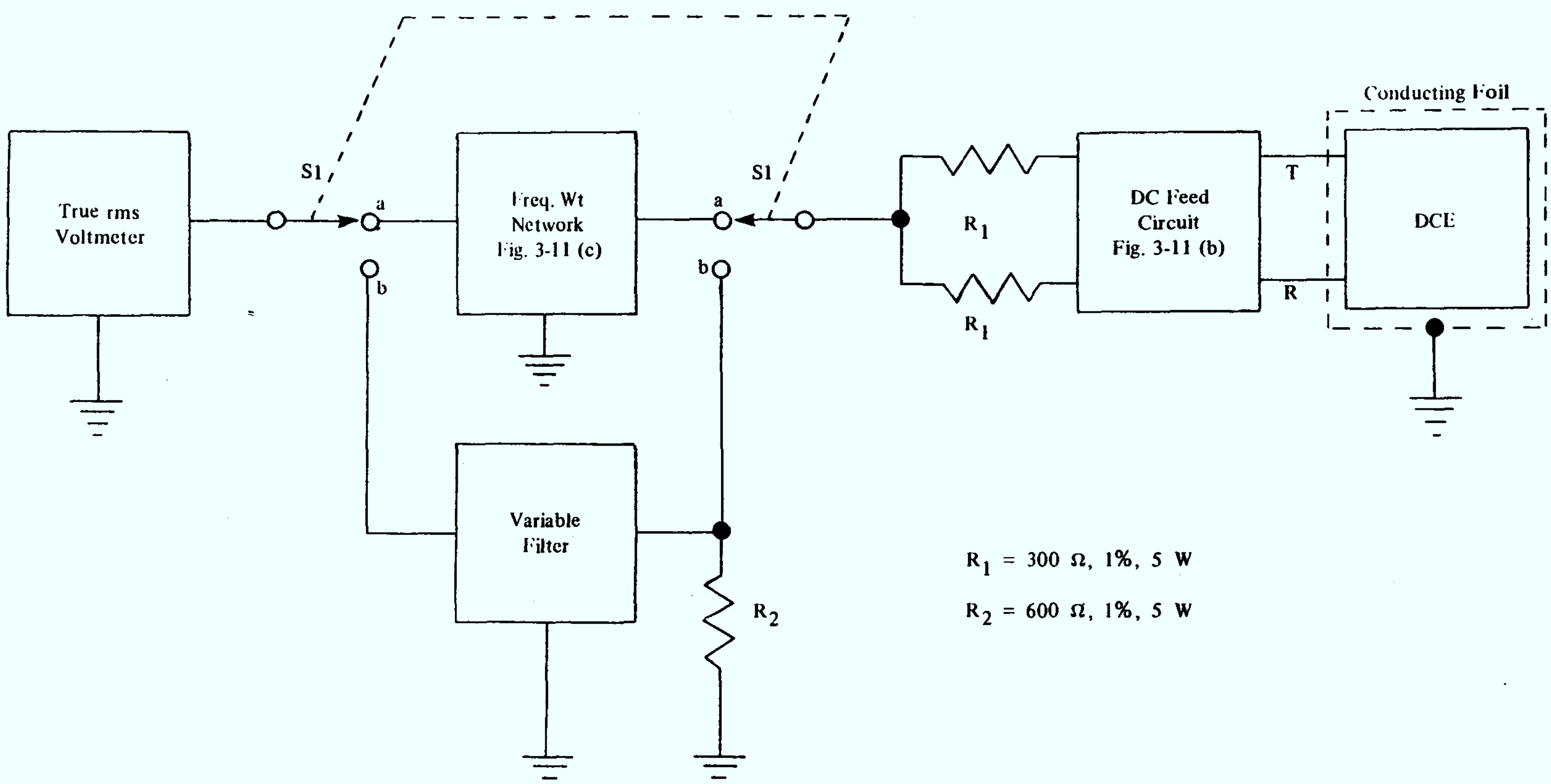
6) Record the maximum voltmeter reading.

7) With switch S1 in position "b" and for each filter setting specified in Table 3-3(c) repeat steps 3) - 6) and record the maximum voltmeter readings.

* This step applies only for equipment designed to attach to networks A and D2.

TABLE 3-3 (c)

Filter Band Pass Frequencies (kHz)
4.0 – 10.0
10.0 – 25.0
25.0 – 40.0
40.0 – 200.0



R_1 = 300 Ω, 1%, 5 W

R_2 = 600 Ω, 1%, 5 W

FIGURE 3-3 (b)

Longitudinal AC Signal Measurements

3.4 TRANSMITTER SIGNAL POWER

3.4.1 In-Band Transmitted Signal Power

3.4.1.1 Requirement (A) (B) (C) (D)

Data circuit-terminal equipment intended to electrically connect to networks A, B, C and D, when connected as shown in Table 3-4(a), shall not transmit rms signal power in the frequency band below 3995 Hz that exceeds 0 dBm when averaged over any and all three-second intervals. The following are additional special case requirements and take precedence over the general requirement.

TABLE 3-4 (a)

Network	Method of Connection (see section 4.)
A	Type 1
A	Type 2
B2 (2 wire)	Type 3
B4 (4 wire)	Type 4
C (4 wire)	Type 4
D2 (2 wire)	Type 3
D4 (4 wire)	Type 4

1) Data circuit-terminating equipment to be attached by a Type 2 plug (programmable plug) shall, in addition, not exceed the programmed levels given in Table 4-1. The rms power of these signals in the same frequency band shall not exceed +3 dBm when averaged over 250 ms. The test procedure described in Section 3.4.2.2 shall be used to demonstrate compliance.

2) Data circuit-terminal equipment intended to acoustically couple to any network, or intended to connect electrically to network A by means of a Voice type G, H, or O plug shall not transmit rms signal power in the frequency band below 3995 Hz that exceeds -9 dBm, when averaged over any and all 3 second intervals. The rms power of these signals in the same frequency band shall not exceed +3dBm when averaged over 250 ms. The test procedure described in Section 3.4.2.2 shall be used to demonstrate compliance.

3) Data circuit-terminal equipment intended to connect electrically to network D2 by means of a Type 3 plug shall not transmit rms signal power in the frequency band below 3995 Hz that exceeds -10dBm, when averaged over any and all 3 second intervals. The rms power of these signals in the same frequency band shall not exceed +3 dBm when averaged over 250 ms.

4) Data circuit-terminal equipment intended to connect electrically to network A by means of a Type 1 plug shall not transmit signal power in the frequency band below 3995 Hz that exceeds -4 dBm when averaged over any and all 3 second intervals.

3.4.2 Out-of-Band Transmitted Signal Power

3.4.2.1 Requirement (A) (B) (C) (D)

The rms power of all signal energy in the frequency band above 3995 Hz delivered by the data circuit-terminal equipment to the Tip/Ring interface shall be in accordance with those values shown in Table 3-4(b) when tested as specified in section 3.4.2.2.

TABLE 3-4 (b)

Frequency Band (kHz)	Maximum Permissible Power (dBm)
3.995 – 4.005	– 18 (1)
4.0 – 10.0	– 16
10.0 – 25.0	– 24
25.0 – 40.0	– 36
40.0 – 200.0	– 50

(1) does not apply to network D

3.4.2.2 Test Method

The data circuit-terminal equipment shall be tested using the following step-by-step procedure. Normally, message signals will be generated within the unit. In the case of equipment designed to operate from external signal sources the input signal shall be appropriate to the equipment being tested and shall be applied to simulate maximum input signal conditions.

1) Connect the data circuit-terminal equipment to the appropriate test setup shown in Figure 3-4 with switch S1 set to "b" and switch S2 set per Note * below.

2) Operate the dc feed and ring-up circuit to bring the data circuit-terminal equipment off-hook and apply 70 mA (or maximum current whichever is less). This step applies only to equipment connected through switch S2 set in position "a".

3) Set the filter cut-off frequencies to achieve a 2 - 4000 Hz band pass and arrange the voltmeter to read rms power in dBm averaged over three seconds.

4) Where the equipment is provided with an external or programmable gain control operate the data circuit-terminal equipment at maximum gain to transmit each of its possible output signals.

5) Record the maximum power level reading.*

6) Arrange the voltmeter to read rms power averaged over 250 ms. Repeat steps 4) and 5).

7) For each filter setting specified in Table 3-3(c) repeat step 4) and record the maximum power level reading.*

8) Operate switch S1 to position "a",

9) Repeat step 4) and record the maximum power level reading obtained when the wave analyzer frequency is set to 4000 Hz.

*Notes

(a) Set switch S2 to position "a" for equipment designed to directly connect to networks.

(b) When equipment under test does not require network voltage to function, operate the dc feed and ring-up circuit switch S1 of Figure 3-11(b) to position "b".

(c) Set switch S2 to position "b" for acoustically coupled equipment.

The W. E. Coupler Test Set by virtue of its internal meter in shunt with its output terminals, "T and R", will attenuate transmitted signals by 4 dB. Therefore, when testing acoustically coupled terminal equipment the power reading on the true rms voltmeter must be adjusted by adding by 4 dB. The adjusted reading must be recorded.

(d) Where plug Type 2 is used with equipment the values of programmed levels given in Table 4-1 shall be verified.

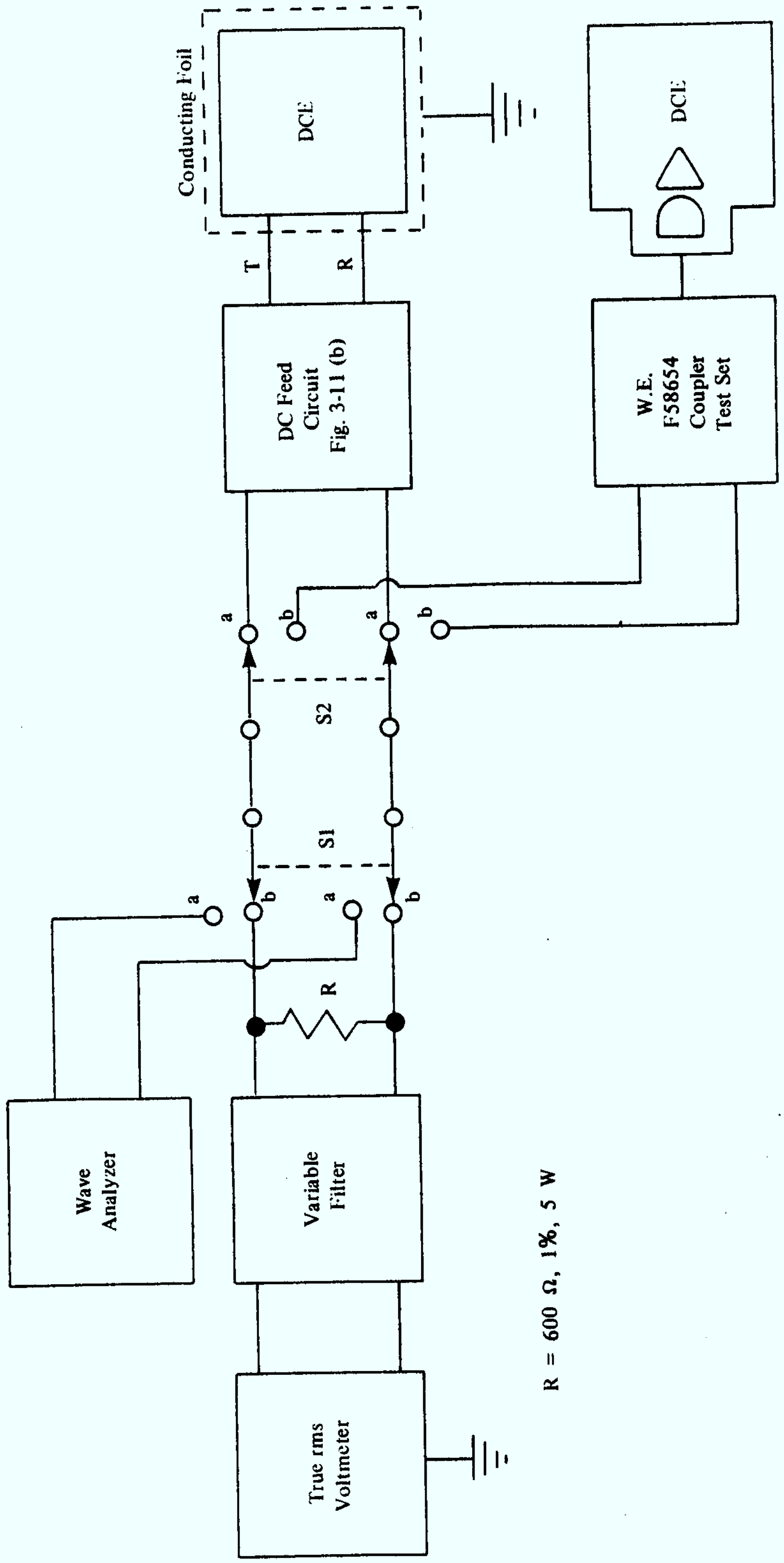


FIGURE 3-4
Signal Level Measurements

3.5 SINGLE FREQUENCY RESTRICTIONS

3.5.1 Requirement (A) (C) (D)

The signal power delivered by the data circuit-terminal equipment to the Tip/Ring telephone interface in the band 2450 to 2750 Hz shall not exceed the power present simultaneously in the 800 to 2450 Hz band. When the data terminal equipment is tested as specified in Section 3.5.2 the ratio X/Y must always be less than 1.

3.5.2 Test Method

1) Connect the data circuit-terminal equipment to the appropriate test setup as shown in Figure 3-5.

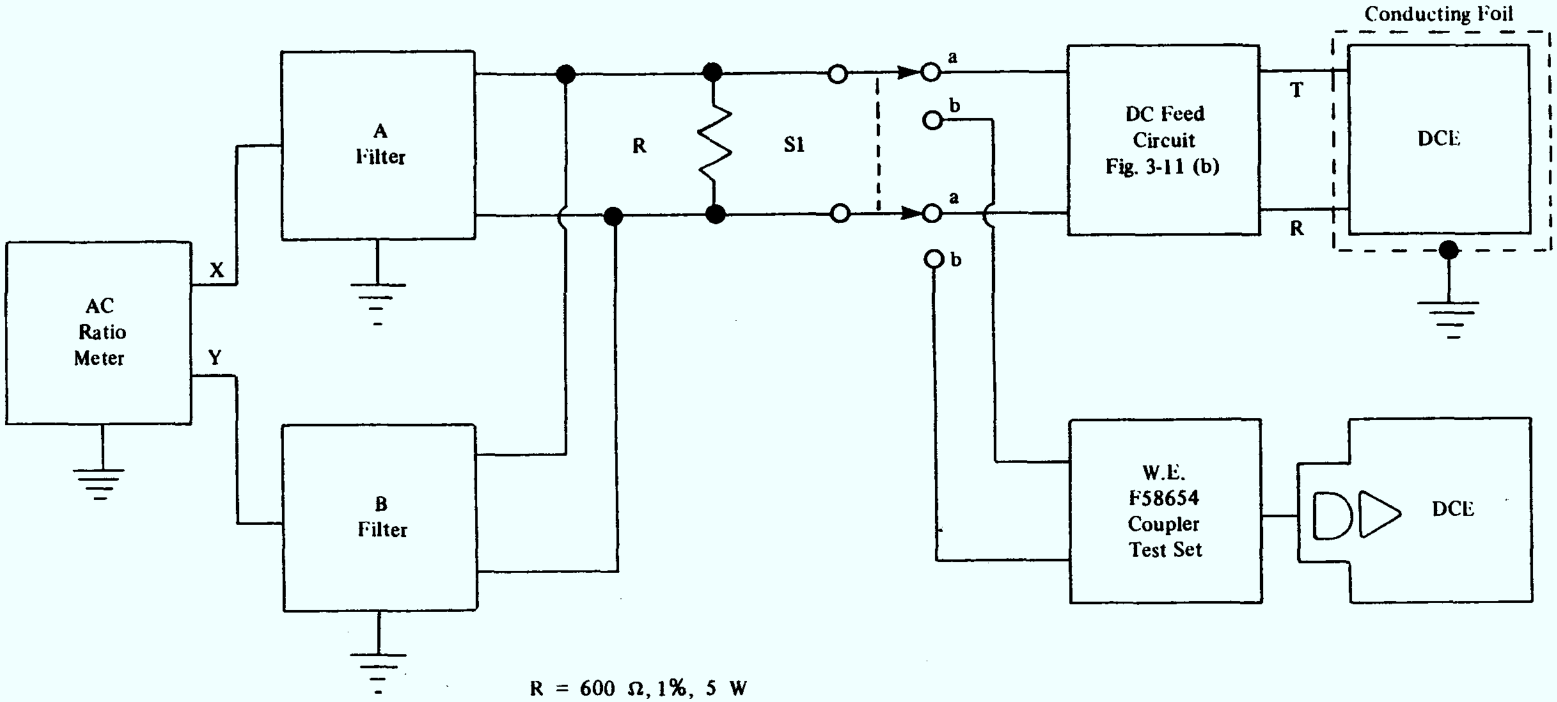
2) Arrange the filter at A for a 2450 - 2750 Hz pass band and the filter at B for a 800 - 2450 Hz pass band.

3) Operate the dc feed circuit to bring the data circuit-terminal equipment off-hook and to apply 70 mA (or maximum current whichever is less). This step does not apply to data circuit-terminal equipment acoustically coupled to the test circuit.

4) Arrange the meter to read the ratio of X and Y.

5) Operate the data circuit-terminal equipment to transmit each of its possible output signals as described in Section 3.4.2.2.

6) Record the maximum meter reading.



R = 600 Ω, 1%, 5 W

FIGURE 3-5

Single Frequency Restriction Measurement

3.6 TERMINATING LONGITUDINAL BALANCE

3.6.1 Requirement (A) (B) (C)

The longitudinal balance of the data circuit-terminal equipment, in an on-hook mode or in an off-hook mode and in any operating state, shall equal or exceed the minimum balance values in Table 3-6 when tested as specified in Section 3.6.2.

TABLE 3-6

Frequency (Hz)	Minimum Balance (dB) As Per Test Method
200	72
500	69
1000	63
2000	57
3000	56
4000	54

3.6.2 Test Method

Test must be undertaken in accordance with IEEE Standard Number 455-1976 "Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band" with the range of test frequencies extended to include 4000 Hz and shunted by 736 ohms in the on-hook mode.

It is recommended that test sets built to the IEEE Standard 455-1976 include:

a) An oscillator capable of generating frequencies up to and including 4000 Hz to allow balance measurement at higher frequencies. Article 9.2.1 of that standard specifies an oscillator with a capability of 50 to 1500 Hz.

b) A selective voltmeter as suggested in Article 9.2.2 of that standard. Active devices which inherently generate noise might fail the test if measured with test sets equipped with wideband voltmeters.

The test will be conducted for the on-hook and off-hook modes of the device, as follows:

1) Connect the data circuit-terminal equipment to the test set-up shown in Figure 3-6.

2) Operate switch S1 to position "a" and place the data circuit-terminal equipment in its on-hook (idle) mode.

3) Set the oscillator (Vs) in the longitudinal balance test set to deliver a suggested level of 10 Vrms at 200 Hz.

4) Operate the longitudinal balance test set according to the IEEE Standard Number 455-1976 to determine the data circuit-terminal equipment balance at each of the frequencies in Table 3-6, and record the results.

5) Operate switch S1 to position "b". Bring the data circuit-terminal equipment off-hook and adjust the test set to supply the necessary current to maintain this mode.

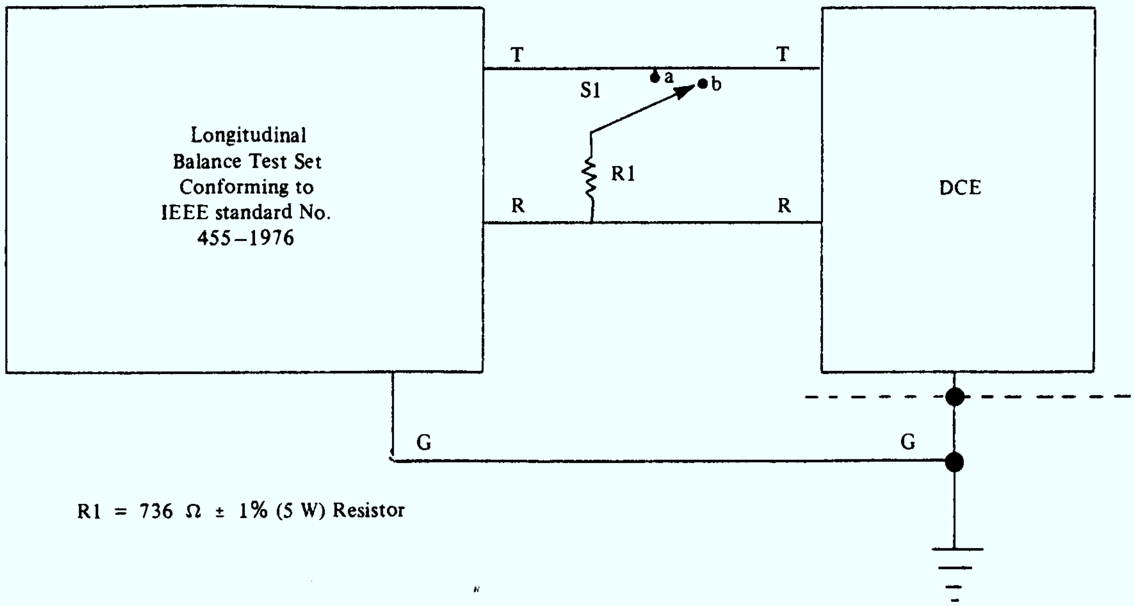
6) Condition the data circuit-terminal equipment not to transmit any signals.

7) Set the test set oscillator at 200 Hz and vary the dc current between 20 mA and 100 mA (or maximum current) to determine the current value which results in the lowest balance indication. This current value is to be maintained for the remaining test.

8) Repeat Step 4).

9) Repeat Steps 6) through 8) for all remaining data circuit-terminal equipment off-hook states.

NOTE: All equipment generated signals must be disabled for this test. The disabling operation shall be done in such a manner as not to affect the impedances. Applicants for certification must submit written instructions to the test laboratory when this operation is necessary.



R1 = 736 Ω ± 1% (5 W) Resistor

FIGURE 3-6

Longitudinal Balance Measurement

3.7 ON-HOOK TERMINAL IMPEDANCE

3.7.1 On-Hook Metallic Impedance

3.7.1.1 Requirement (A) (D2)

The magnitude of the on-hook terminal impedance of the data circuit-terminal equipment when measured between its Tip and Ring leads shall be in accordance with the values shown in Table 3-7(a).

TABLE 3-7 (a)

Frequency Range (Hz)	Minimum Impedance (kilohms)
20	7.0
200 to 3995	50.0

When tested as specified in 3.7.1.2, the measured voltages shall not exceed the values shown in Table 3-7(b).

TABLE 3-7 (b)

Frequency Range (Hz)	Section 3.7.1.2 (Step No.)	Maximum Voltage Across Test Resistor (Vrms)
20	4	5.0
200 to 3995	6	1.0

3.7.1.2 Test Method

1) Connect the data circuit-terminal equipment to the test equipment as shown in Figure 3-7(a). Set switch S1 to position "a".

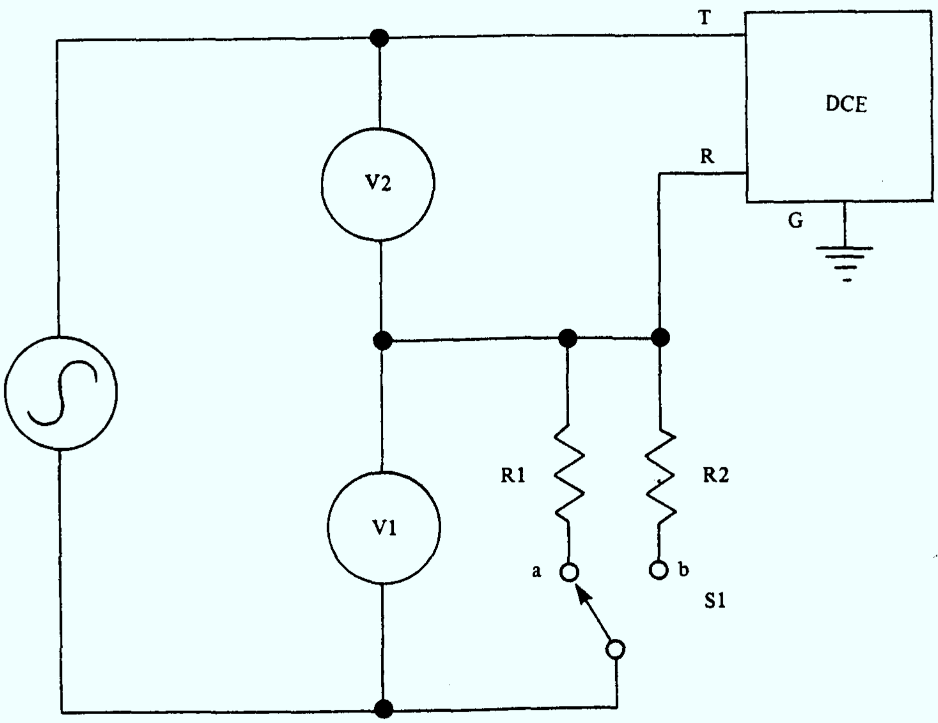
2) Arrange the data circuit-terminal equipment such that it will not go into an off-hook mode in response to ringing voltage. This may require temporary circuit modification.

3) Set the oscillator frequency to 20 Hz and adjust the output level to obtain a reading of 45 Vrms on the ac voltmeter V2.

4) Record the reading on ac voltmeter V1.

5) Set the oscillator frequency at 1 kHz and adjust the output level to obtain a reading of 1 Vrms on the ac voltmeter V2 with Switch S1 in position "b".

6) Vary the oscillator frequency slowly from 200 Hz to 3995 Hz keeping the reading on voltmeter V2 constant at 1 Vrms. Record the maximum reading on voltmeter V1.



R1 = 777 Ω, 1%, 5 W

R2 = 50 kΩ, 1%, 5 W

FIGURE 3-7 (a)

On-Hook Metallic Impedance Measurement

3.7.2 On-Hook Longitudinal Impedance

3.7.2.1 Requirement (A) (D2)

The impedance between Tip or Ring, and ground reference shall be greater than 50 kilohms in the frequency band 60 Hz to 3995 Hz, when tested as specified in section 3.7.2.2. The maximum voltmeter reading in step 5 shall be less than 10 Vrms.

3.7.2.2 Test Method

1) Connect the data circuit-terminal equipment to the test circuit as shown in Figure 3-7(b).

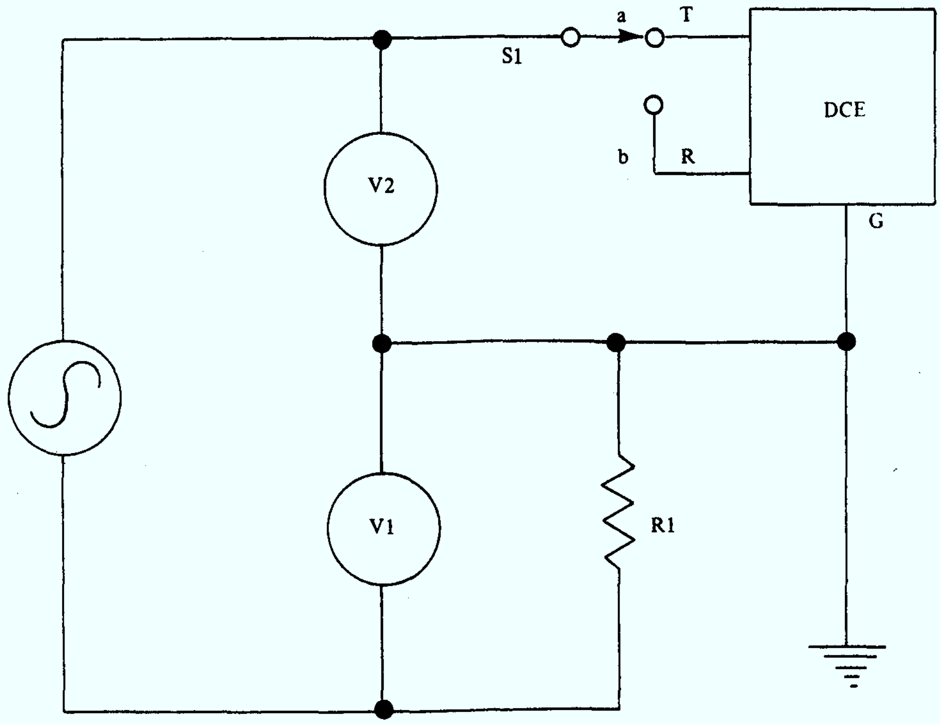
2) Place switch S1 in position "a".

3) Adjust the oscillator to obtain a reading of 10 Vrms on voltmeter V2.

4) Vary the oscillator frequency slowly from 60 Hz to 3995 Hz, keeping the reading on V2 constant at 10 Vrms.

5) Observe and record the maximum reading on voltmeter V1.

6) Switch S1 to position "b" and repeat steps 4) through 5).



R1 = 50 kΩ, 1%, 5 W

FIGURE 3-7 (b)

On-Hook Longitudinal Impedance Measurement

3.8 OFF-HOOK TERMINAL IMPEDANCE

3.8.1 Off-Hook Metallic Impedance

3.8.1.1 Requirement (A) (B) (D2)

The off-hook terminal impedance of the data circuit-terminal equipment in the frequency band 200 to 3500 Hz, when measured as specified in Section 3.8.1.2 against 600 ohms in series with 2.16 uF, shall meet a return loss objective of 3 dB.

The Tip to Ring impedance shall meet a weighted return loss objective of 11 dB in the frequency band 500 to 2500 Hz when measured as specified in Section 3.8.1.2, against 600 ohms in series with 2.16 uF.

3.8.1.2 Test Method

This test is performed in all off-hook modes of the data circuit-terminal equipment when it is not transmitting.

1) Connect the test circuit as shown in Figure 3-8(a).

2) Adjust dc feed current to 70 mA (or maximum current whichever is less).

3) Set the Return Loss Set TEST TYPE Switch to Ext.Osc. and calibrate the Set to measure return loss vs frequency against 600 ohms in series with 2.16 uF.

4) Vary the oscillator frequency from 200 Hz to 3500 Hz and record the minimum value of return loss and the frequency at which it occurs.

5) Calibrate the Return Loss Set to measure echo return loss (ERL) against 600 ohms in series with 2.16 uF. Record the meter reading.

6) Repeat steps 3 to 5 for all other data circuit-terminal equipment off-hook states.

Note: All equipment generated signals must be disabled for this test. The disabling operation shall be done in such a manner as not to affect the impedances. Applicants for certification must submit written instructions to the test laboratory when this operation is necessary.

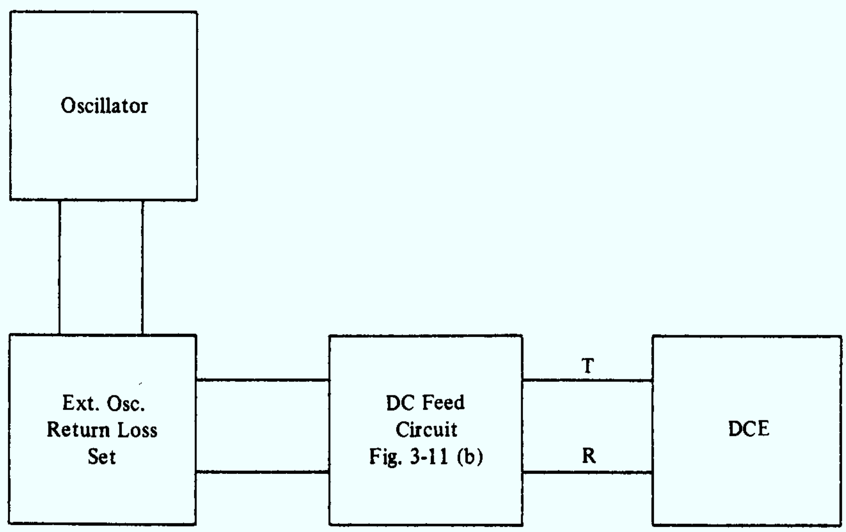


FIGURE 3-8 (a)

Return Loss Measurement (Off-Hook Impedance)

3.8.2 Off-Hook Longitudinal Impedance

3.8.2.1 Requirement (A) (B) (D2)

The minimum impedance between Tip or Ring, and ground reference shall be greater than 50 kilohms in the frequency band 60 Hz to 3995 Hz, when tested as specified in section 3.8.2.2. The maximum voltmeter reading in step 6 shall be less than 10 Vrms.

3.8.2.2 Test Method

1) Connect the data circuit-terminal equipment (DCE) as shown in Figure 3-8(b).

2) Place switch S1 in position "a".

3) Operate the dc feed circuit to bring the DCE off-hook and to apply 70 mA (or maximum current whichever is less). Condition the DCE not to transmit any signals.

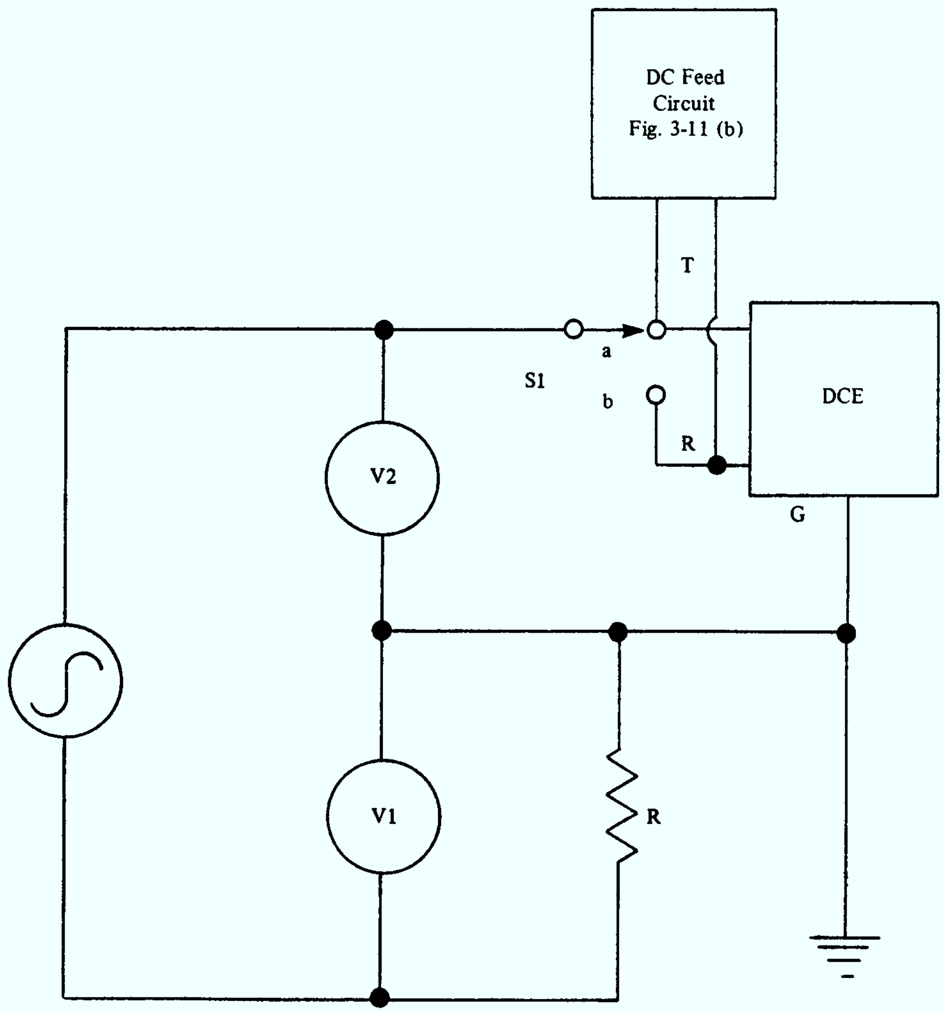
4) Adjust the oscillator to obtain a reading of 10 voltmeter V2.

5) Vary the oscillator frequency slowly from 60 Hz to 3995 Hz; keeping the reading on V2 constant at 10 Vrms.

6) Observe and record the maximum reading on voltmeter V1.

7) Switch S1 to position "b" and repeat steps 4) through 6).

8) Repeat step 2 through 7 for all remaining off-hook operating states.



R = 50 kΩ, 1%, 5 W

FIGURE 3-8 (b)

Off-Hook Longitudinal Impedance Measurement

3.9 ON-HOOK TERMINAL RESISTANCE

3.9.1 Requirement (A) (B) (D)

The on-hook terminal resistance of the data circuit-terminal equipment when measured between Tip and Ring shall be greater than 0.5 Megohms. In addition, the dc resistance from either Tip or Ring to ground shall be greater than 1 Megohm.

When tested as specified in Section 3.9.2, the dc current measured in steps 3) and 4) shall be less than 200 uA. The currents measured in Steps 5) to 8) shall be less than 100 uA.

3.9.2 Test Method

1) Connect the data circuit-terminal equipment as Figure 3-9. Place Switches S1, S3, S4 and S5 in position "a" and switch S2 in position "b".

2) Adjust the dc power supply "BB" to 100 V.

3) Operate switch S5 to position "b" and record I.

4) Operate switch S3 to position "b" and record I.

5) Operate switch S4 to position "b" and record I.

6) Operate switch S3 to position "a" and record I.

7) Operate switch S1 to position "b" and record I.

8) Operate switch S3 to position "b" and record I.

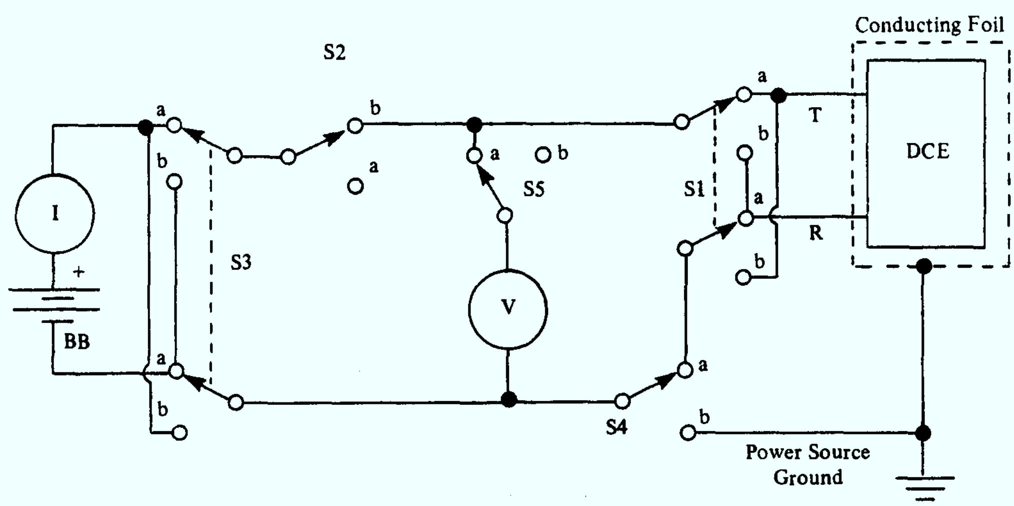


FIGURE 3-9

On-Hook Resistance Measurement

3.10 OFF-HOOK TERMINAL RESISTANCE

3.10.1 Requirement (A) (D2)

When the data circuit-terminal equipment is off-hook, the terminal resistance obtained from the voltage versus current characteristics as measured in Section 3.10.2 between the Tip and Ring terminals shall satisfy the limitations shown in Figure 3.10(a). In addition, its off-hook dc resistance from Tip or Ring to ground shall be greater than 50 kilohms. When tested as specified in Section 3.10.2 the current reading in steps 7) to 11) shall be less than 1 mA.

3.10.2 Test Method

1) Connect the data circuit-terminal equipment as shown in Figure 3.10(b).

2) Operate the dc feed circuit to bring the data circuit-terminal equipment off-hook.

3) Adjust the dc feed circuit to obtain current readings of 100 mA (or maximum current whichever is less) 80 mA, 60 mA, 40 mA, and 20 mA. Record the corresponding voltage readings and plot the operating points on Figure 3.10(a).

4) Operate switch S1 to position "b".

5) Repeat step 3).

6) Operate switchs S2 and S4 to position "b". Adjust the dc power supply "BB" to 50 V. Adjust the dc feed current to 40 mA. Operate Switch S5 to "b".

7) Record leakage I.

8) Operate switch S3 to position "b" and record leakage I.

9) Operate switch S1 to position "a" and record leakage I.

10) Operate switch S3 to position "a" and record leakage I.

11) Repeat Steps 1) to 11) for all off-hook modes of the terminal equipment.

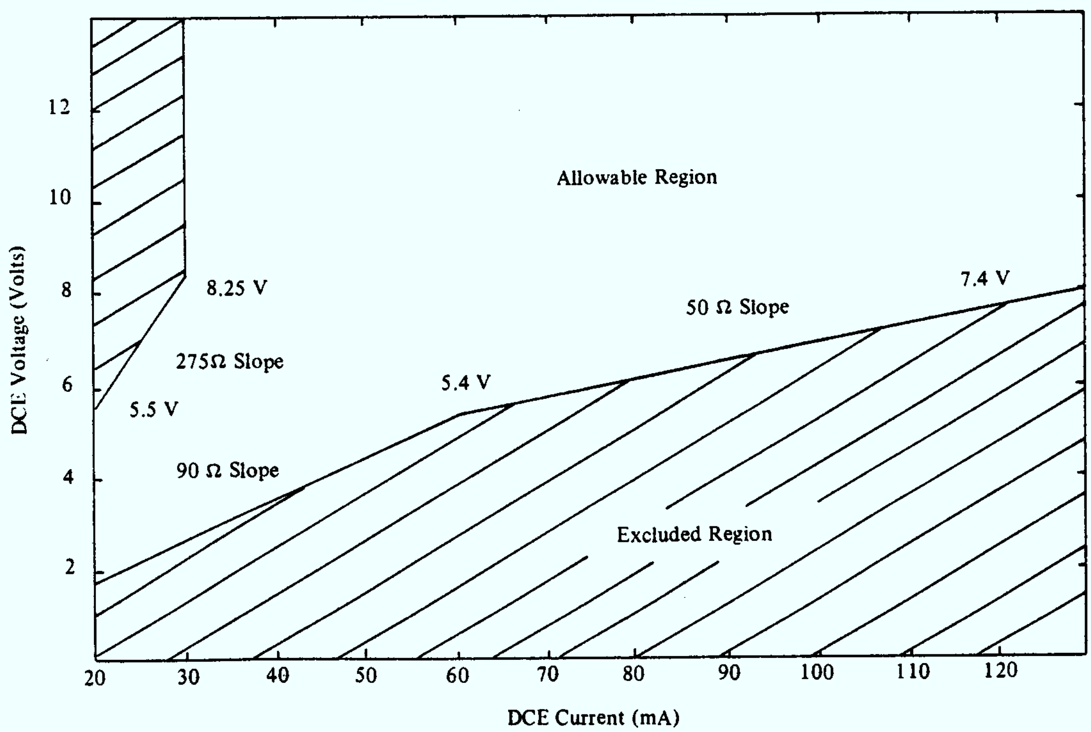


FIGURE 3-10 (a)

Off-Hook Resistance Limitations

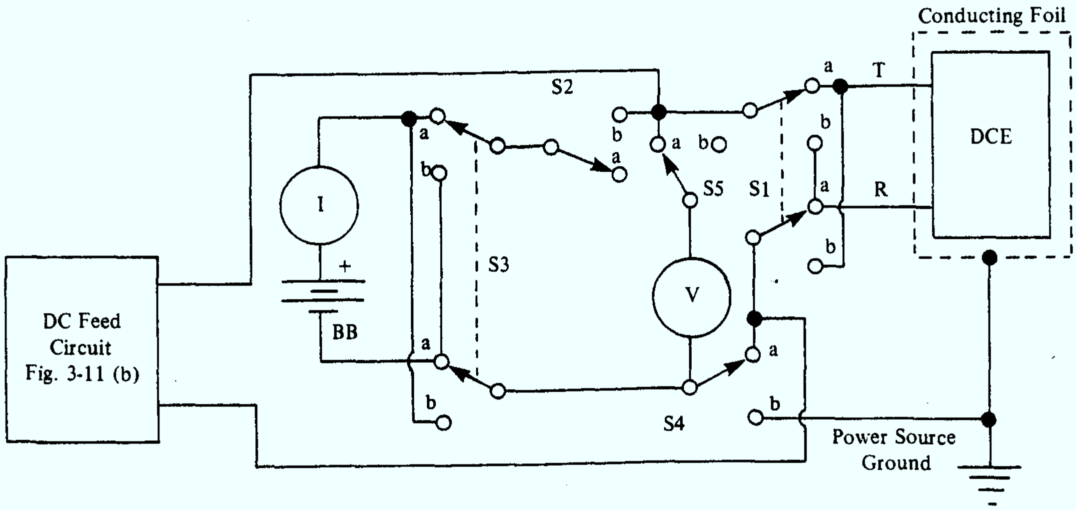


FIGURE 3-10 (b)

Resistance Measurement

3.11 <u>REFERENCE INFORMATION</u>

3.11.1 General

This section contains additional information on test equipment requirements to perform the tests outlined in Section 3.

3.11.2 Minimum Test Set Requirements (General)

The minimum performance requirements for the test equipment required to conduct the tests in Section 3 are shown in Section 3.11.3.

There are special circuits which are required for some tests. Descriptive information on these is provided in Section 3.11.4.

With the exception of certain specifically identified instruments, test sets of any type or make which meet the following minimum requirements are acceptable for the performance of the tests in Section 3 of this specification.

TEST EQUIPMENT REQUIREMENTS LIST

TEST SET DESCRIPTION	MINIMUM REQUIREMENTS	
1. Surge Generator	See Section 3.11.4.1	
2. DC Feed Circuit and Ring-up Circuit	See Section 3.11.4.2	
3. True RMS Voltmeter *	Voltage range:	1 mV to 300 V
	dB calibration:	-80 to +50
	Frequency range:	2 Hz to > 200 kHz
	Averaging time:	Fast = 250 ms ± 100 ms, Slow = 3s ± 1s
	Input Impedance:	>1 megohm
	Accuracy:	±0.5 dB
4. DC Voltmeter *	Range:	1 mV to 100 V dc
	Accuracy:	±1% of indicated value
	Input impedance:	10 megohms minimum, on all ranges.
5. DC Ammeter *	Range:	1 uA to 1 A full scale
	Accuracy:	±2% of indicated value
	Input Resistance:	decreasing from 1000 ohms on 1 uA to 0.1 ohm on 1 A range
6. Balance Test Set		Per IEEE Standard 455-1976
7. Frequency Weighting Network	See Section 3.11.4.3	

TEST EQUIPMENT REQUIREMENTS LIST (Cont'd)

TEST SET DESCRIPTION	MINIMUM REQUIREMENTS	
8. Wave Analyzer *	Frequency range:	20 Hz to 4100 Hz
	Frequency accuracy:	±5 Hz
	Frequency resolution:	10 Hz per division
	Amplitude ranges:	30 uV to 5.0 V
	Amplitude accuracy:	±5% of full scale
	Selectivity:	
	REJECTION	BANDWIDTH
	0.1 dB	>2 Hz
	3 dB	10 Hz ± 10%
	60 dB	35 Hz ± 10%
	80 dB	150 Hz ± 10%
	Oscillator Section Requirements:	as for separate oscillator shown below
	Input impedance:	>100 kilohms
9. Oscillator	Frequency range:	20 Hz to 4 kHz
	Frequency Accuracy:	Better than 1%
	Output level:	90 V into 600 ohms load
	Output impedance:	600 ohms ± 10%
	Output balance:	One terminal at ground potential
	Harmonic Distortion:	<0.5%
	Hum and noise:	<0.03% of rated output
10. Filter *	Band Pass:	Variable filter 2 Hz to 200 kHz
	Cut-off frequency accuracy to:	±5%
	Attenuation slope:	24 dB/Octave
	Insertion Loss:	0 ± 1 dB
	Input impedance:	100 kilohms in parallel with 50 pF
	Output (source) impedance:	50 ohms
	Hum and noise:	100 uVrms maximum
	Maximum input:	3 Vrms

TEST EQUIPMENT REQUIREMENTS LIST (Cont'd)

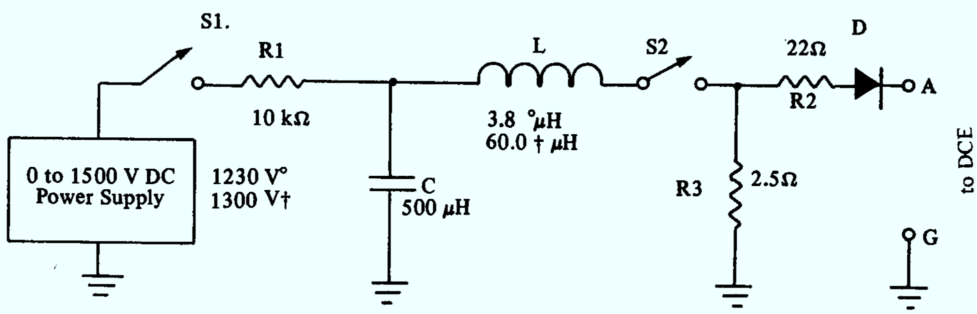
TEST SET DESCRIPTION	MINIMUM REQUIREMENTS	
11. Noise Measuring Set *	Range:	0 to 50 dBrn
	Weighting Network:	"C-Message"
	Type of noise measurement:	Metallic
	Input impedance:	600 ohms ±10% for metallic measurement
	Balance:	>80 dB at 60 Hz >70 dB at 6 kHz
12. AC Ratio Meter *	Function - Capability to perform relative rms ratio measurements of energy simultaneously present on two channels.	
	Averaging Interval Per Channel:	400 ± 100 ms
	Crest factor:	5:1
	Channel Accuracy:	0.25 dB
	Input Impedance per Channel:	> 1 Megohm
13. DC Power Supply (BB)	Rating:	0 - 110 V, 0.5 A
	Ripple & noise:	200 uVrms and 1 mV P-P
	Resistance to ground:	>500 kilohms
14. Return Loss Set	Wiltron 9040 or equivalent	
15. AC Power Supply		0 - 750 Vrms 60 Hz 10 mA max
16. Voltmeter		0 - 750 Vrms ± 5%
17. Ammeter *		0 - 10 mA ± 5%
18. Ringing Generator	Frequency range:	20-30 Hz.
	Output voltage:	0-105 Vac.
	Output impedance:	2-100 ohms.

* N.B. Testing instruments marked (*) should be capable of obtaining differential measurements. (i.e they must have floating inputs).

3.11.4 Special Circuits Required For Demonstration Tests

The special test sets required to perform the demonstration tests in Section 3 are shown in this section in schematic form. The ordering information for the W-E. F-58654 Coupler Test Set is also provided.

3.11.4.1 Surge Generator



Legend: Circuit parameters

° = Voltage for 10 x 1000 μs waveshape
† = Voltage for 100 x 1000 μs waveshape
R1 = 1% Resistor (50 W)
R2 = 1% Resistor, non-inductive (100 W)
R3 = 1% Resistor, non-inductive (400 W)
C = 1% Capacitor, non-polarized, non-inductive (1500 V)
L = 1% Inductors, Resistance ⩽0.01 Ω. Surge current ⩾600 A
D = Reverse breakdown voltage ⩾1500 V (0.5 A)
S1 = Non-bounce switch, turn on delay < 1μs.
S2 = Peak voltage ⩾1500 V, Surge current ⩾600 A

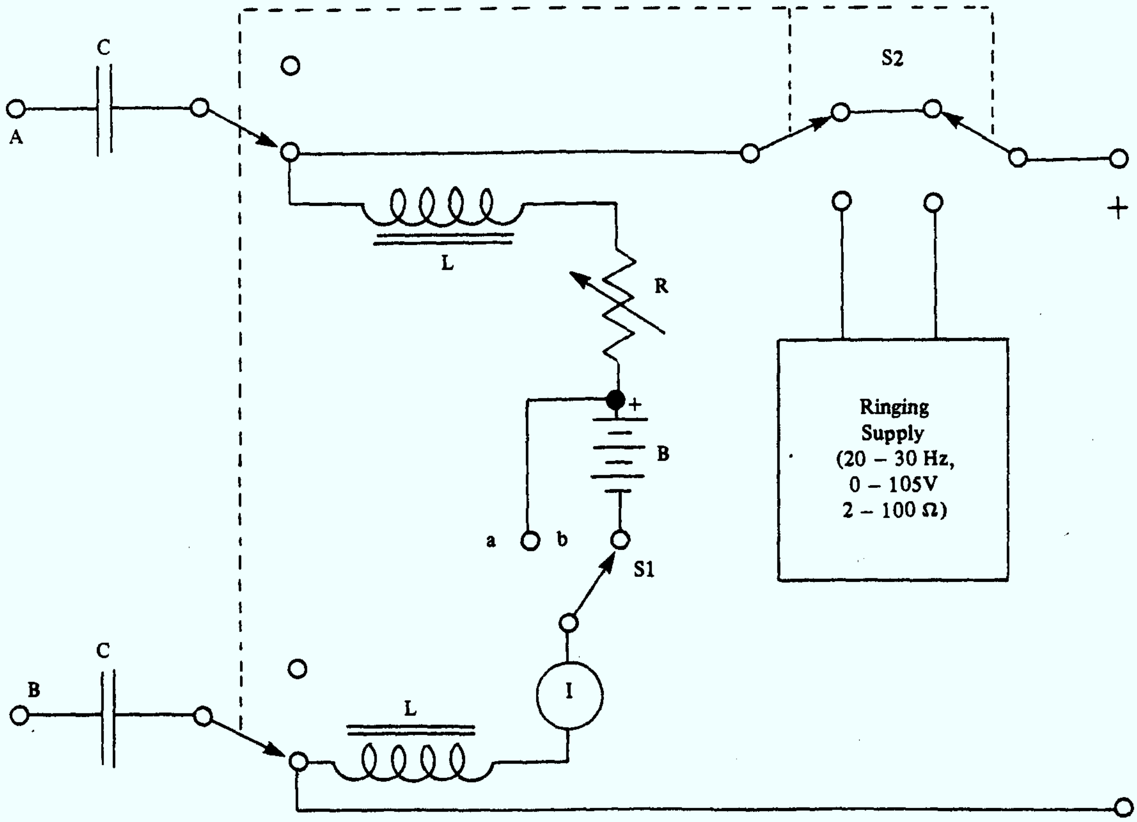
NOTE: Operate the surge generator as follows:

1. Arrange the circuit elements to produce the desired waveshape.
2. Close S1 to charge the capacitor to the desired voltage.
3. Open S1.
4. Close S2 to fire the surge generator.
5. Open S2 and close S1 to recharge capacitor to the desired voltage.

FIGURE 3-11 (a)

Surge Generator

3.11.4.2 DC Feed and Ring-up

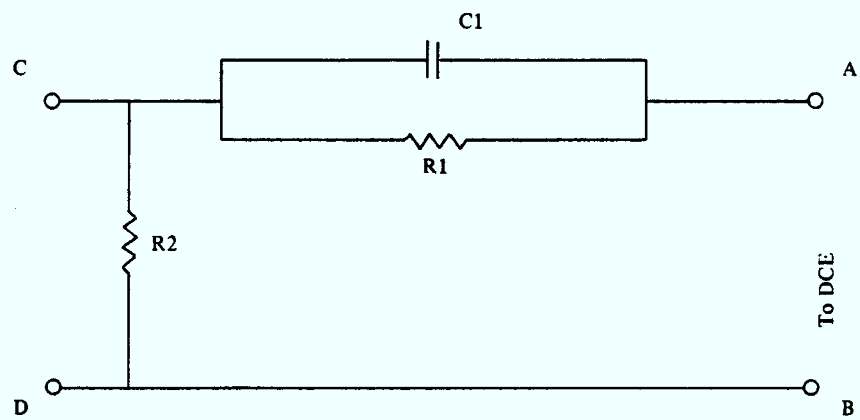


L – Inductor, 2H(min) at 120 mA DC, 200 Ω ± 10% resistance
C – Non-electrolytic capacitor, 2.0 μF ± 10%, 200 V DC
R – Linear potentiometer, 3 KΩ, 8W
B – Power Supply, 0 to 60 V DC, 500 mA
I – Ammeter, ± 1% accuracy, 0 to 150 mA range
S1 – Switch
S2 – Ring-up key

FIGURE 3-11 (b)

DC Feed and Ring-up Circuit

3.11.4.3 Frequency Weighting Network



Legend:
R1 = 2.4M Ω ± 1% (1/2 W) Resistor
R2 = 600 Ω ± 1% (1/2 W) Resistor
C1 = 0.066 μF ± 5% Capacitor non-electrolytic (100 V)

FIGURE 3-11 (c)

Frequency Weighting Network

3.11.4.4 F-58654 Coupler Test Set

The F-58654 Coupler Test Set (see Figures 3-4 and 3-5) can be obtained from:

Western Electric Co.
Commercial Sales
P.O. Box 20046
Greensboro, N. C.
U.S.A.
27420
(919) 697-5713

4. METHOD OF CONNECTION

4.1 General

The method of connection for data circuit-terminal equipment is dependent upon the associated network to which it is to be connected and upon the maximum signal level parameters of Section 3.4.

The "8 position keyed miniature plug" will be used in Type 1 and Type 2 Plug wiring arrangement. It must conform mechanically to the dimensions shown in Figure 4-1(b). and will meet the "go-no-go" mechanical requirements of the maximum and minimum gauges shown in Figures 4-1(d) and 4-1(e).

For Network A certification the data circuit-terminal equipment must be supplied with any or all of the following connecting plugs Types 1, 2, H, G, or O. For Networks B, C, D, the data circuit-terminal equipment must be supplied with either Type 3 or 4 connecting plugs.

Applicants for certification of data circuit-terminal equipment must provide the testing laboratory together with the terminal equipment one sample of each connecting cord and plug arrangement with which the unit will normally be supplied.

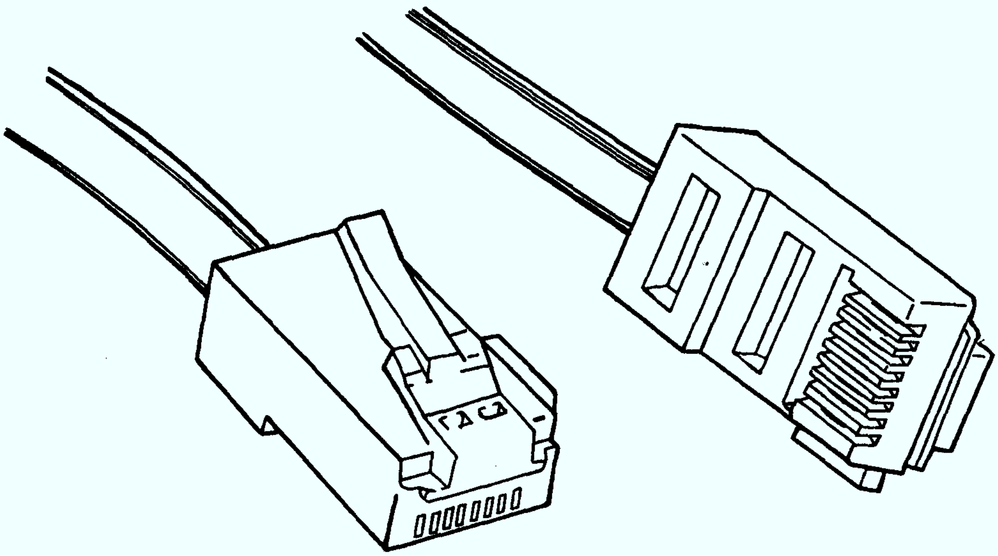


FIGURE 4-1 (a)

8 Position Keyed Miniature Plug
General View

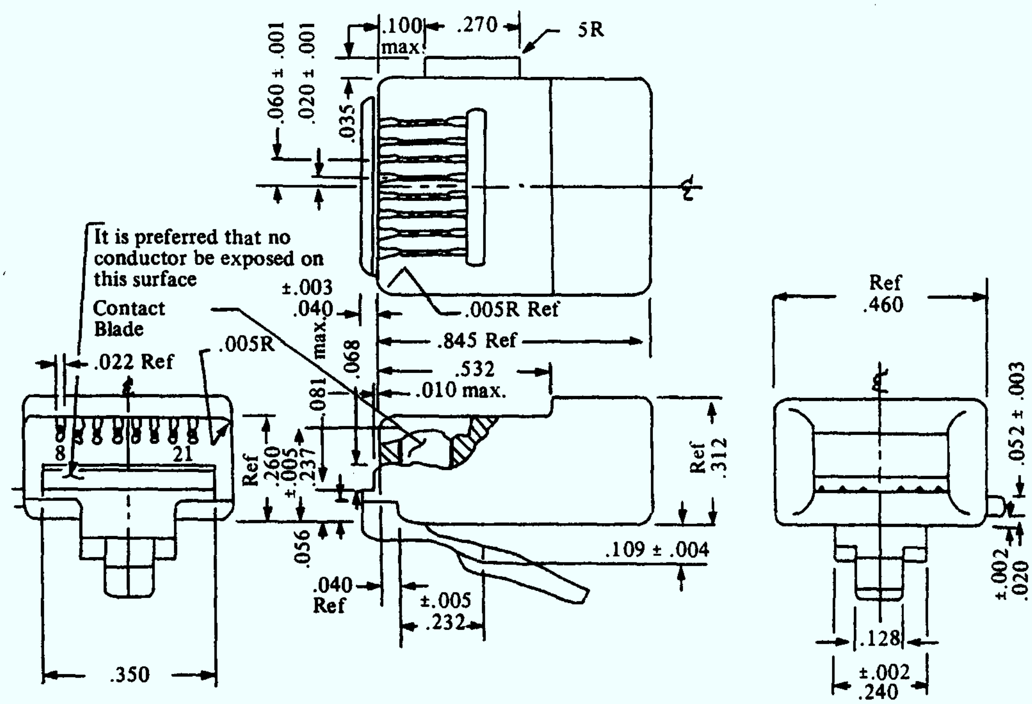


FIGURE 4-1 (b)

8 Position Keyed Miniature Plug Dimensions

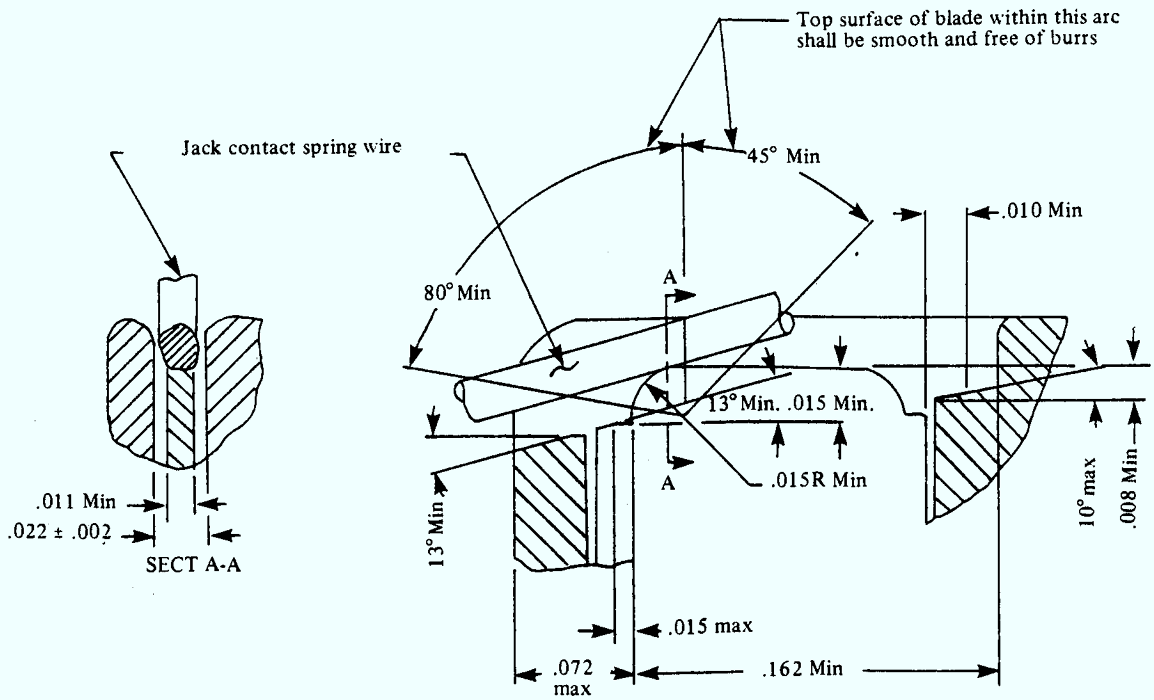


FIGURE 4-1 (c)

8 Position Keyed Miniature Plug Details

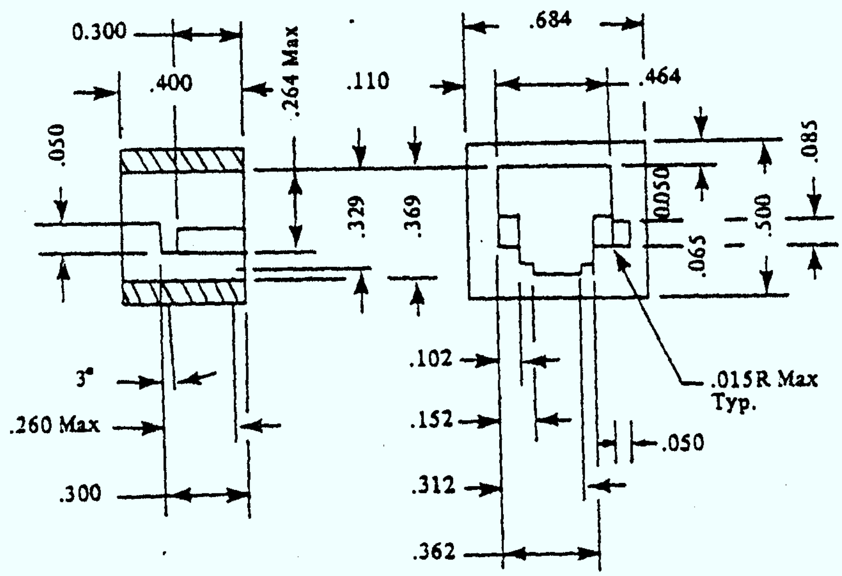


FIGURE 4-1 (d)

8 Position Keyed Miniature Plug
Maximum Clearance Gauge

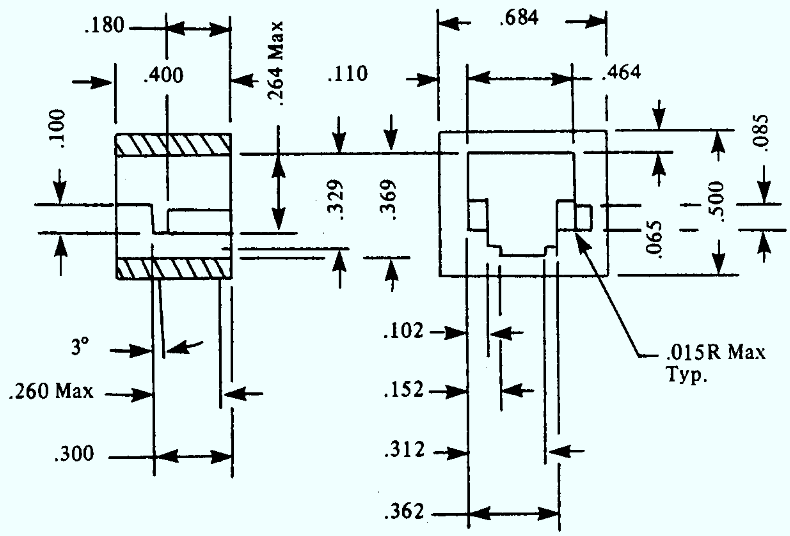


FIGURE 4-1 (d)

8 Position Keyed Miniature Plug
Maximum Clearance Gauge

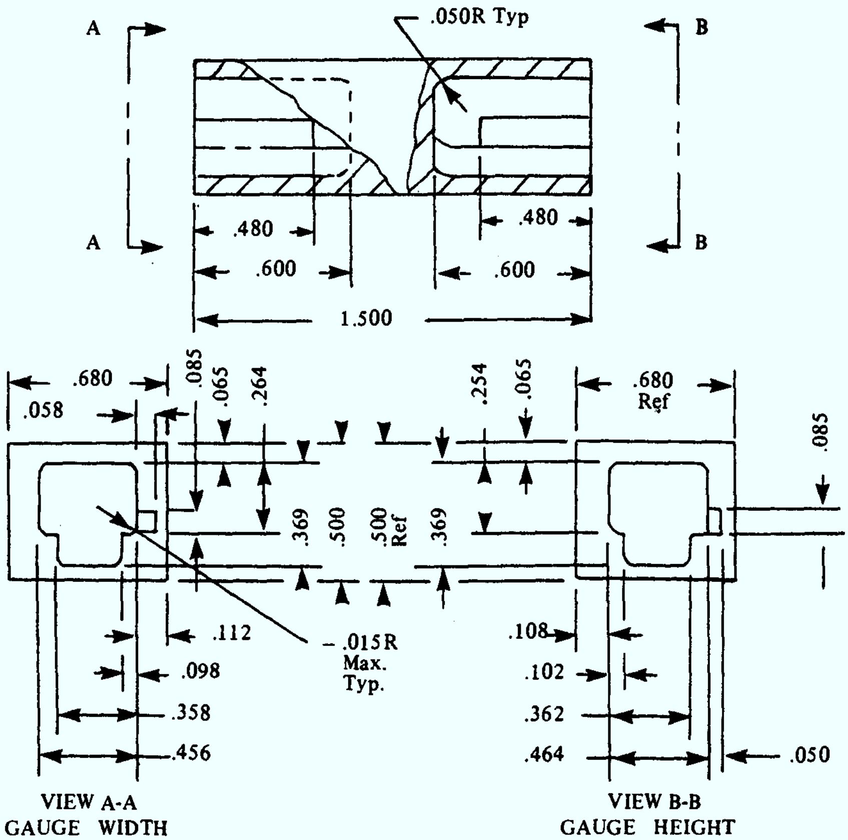


FIGURE 4-1 (e)

8 Position Keyed Miniature Plug
Minimum Clearance Gauge

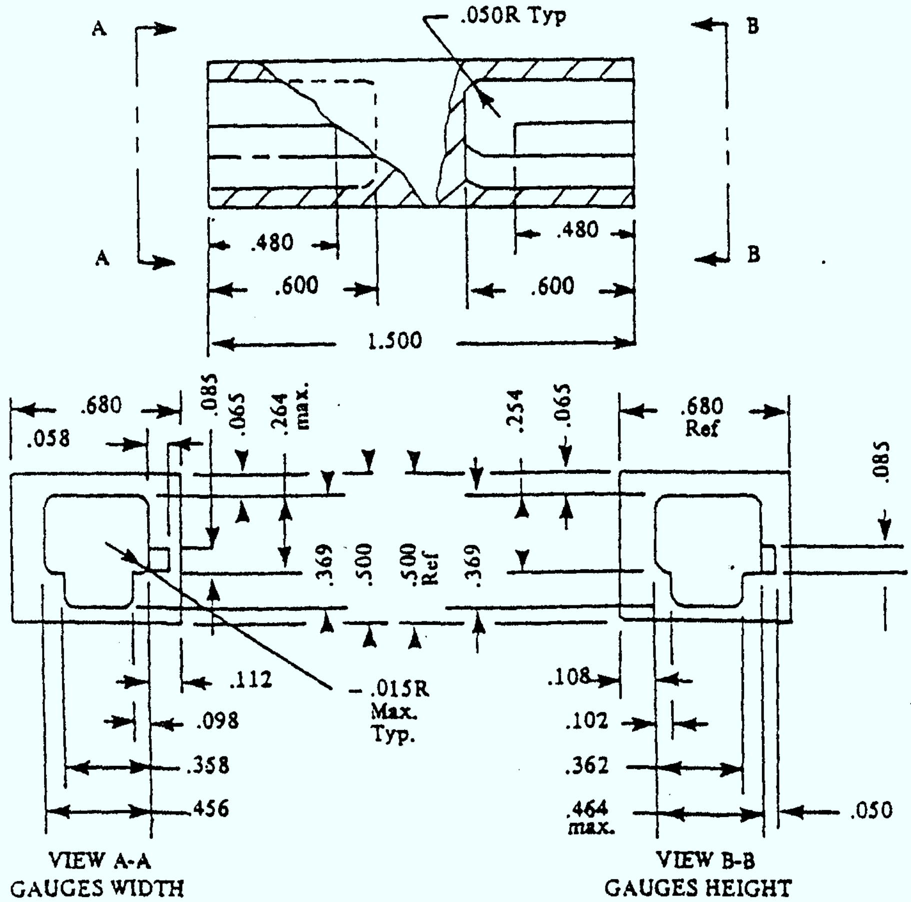


FIGURE 4-1 (e)

8 Position Keyed Miniature Plug
Minimum Clearance Gauge

4.1.1 Electrical Requirements

This standard does not provide for the electrical testing of individual plugs. Plugs are subjected to all electrical tests in combination with the unit of data circuit-terminal equipment to which it is to be permanently connected.

4.2 Type "1" Plug

This plug shall connect to data circuit-terminal equipment having a signal output not exceeding -4 dBm averaged over 3 seconds. The plug wiring shall be as follows:

1	2	3	4	5	6	7	8
R	T	A	NC	NC	A1	NC	NC

NC - No Connection

Terminals 3 and 6 will be wired only when equipment is designed for Key Telephone operation.

4.3 Type "2" Plug

This plug shall connect to data terminal equipment having a programmed signal output. The plug wiring shall be as follows:

1	2	3	4	5	6	7	8
NC	NC	A	R	T	A1	PR	PC

NC - No Connection PC - Program Resistor Common
PR - Program Resistor.

Terminals 3 and 6 will be wired only when equipment is designed for Key Telephone operation.
The programming resistor (Rp) will be provided by the carrier across terminals 7 and 8 on the carrier provided jack.
The value of this resistor will be selected by the carrier based on the attenuation of the particular subscriber loop. The value selected will be found in Table 4-1 and should be of such a value as to provide an optimum signal at the Central Office without exceeding -12dBm.

TABLE 4-1

Programming Resistor (Rp)*	Programmed Data Equipment Signal Power Output**
short	0 dbm
150 ohms	– 1 dbm
336 ohms	– 2 dbm
569 ohms	– 3 dbm
866 ohms	– 4 dbm
1,240 ohms	– 5 dbm
1,780 ohms	– 6 dbm
2,520 ohms	– 7 dbm
3,610 ohms	– 8 dbm
5,490 ohms	– 9 dbm
9,200 ohms	– 10 dbm
19,800 ohms	– 11 dbm
open	– 12 dbm

* Tolerance of Rp is ± 1%

**Tolerance of programmed data signal power output is ± 1 dB. These values are averaged over any and all 3 second intervals.

4.4 Type "G" and "H" plugs (Voice Types)

The type G and H plugs shall conform mechanically with the dimension information of figure 4-4(b) and 4-4(c) and shall be compatible with the "go-no-go" gauges shown in figures 4-4(d) and 4-4(e).

Type "G" plugs shall be wired as follows:

Position	Line Designation
1	NC
2	A
3	R
4	T
5	A1
6	NC

Type "H" plugs shall be wired as follows:

Position	Line Designation
1	NC
2	NC
3	R
4	T
5	NC
6	NC

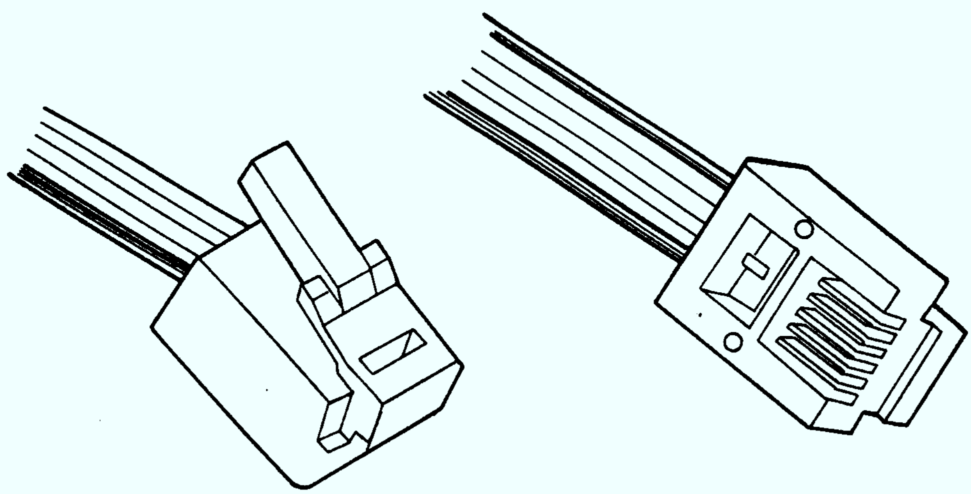


FIGURE 4-4 (a)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
General View

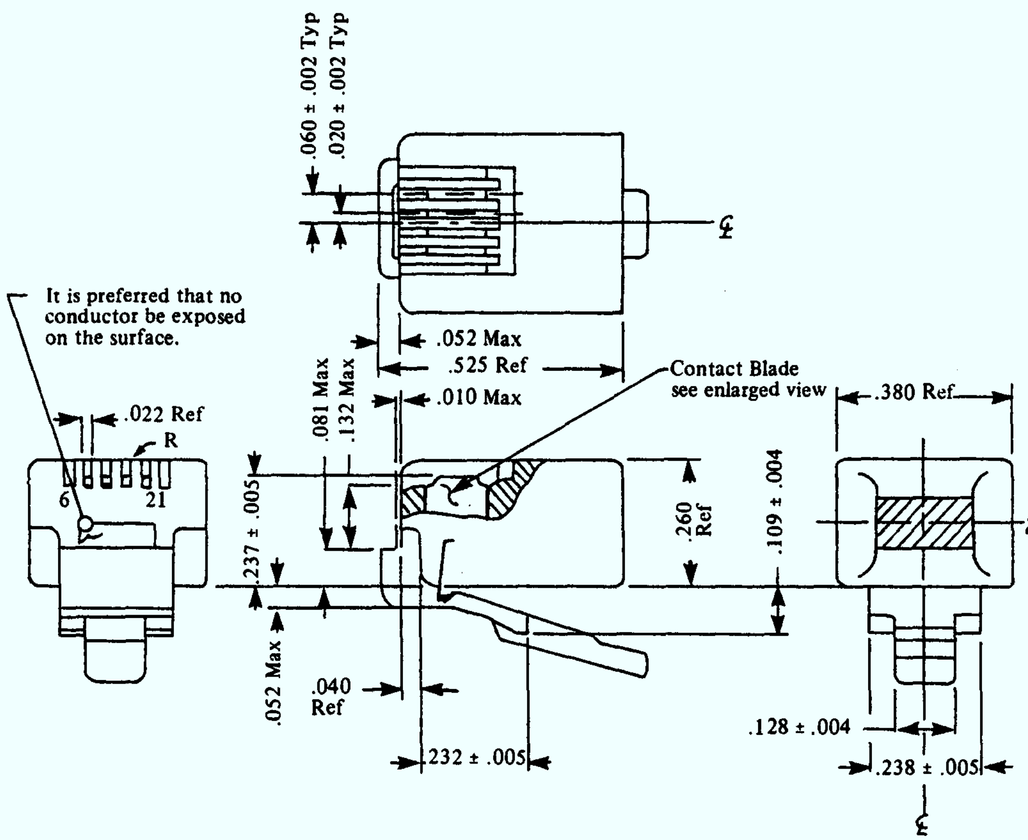


FIGURE 4-4 (b)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
Dimensions

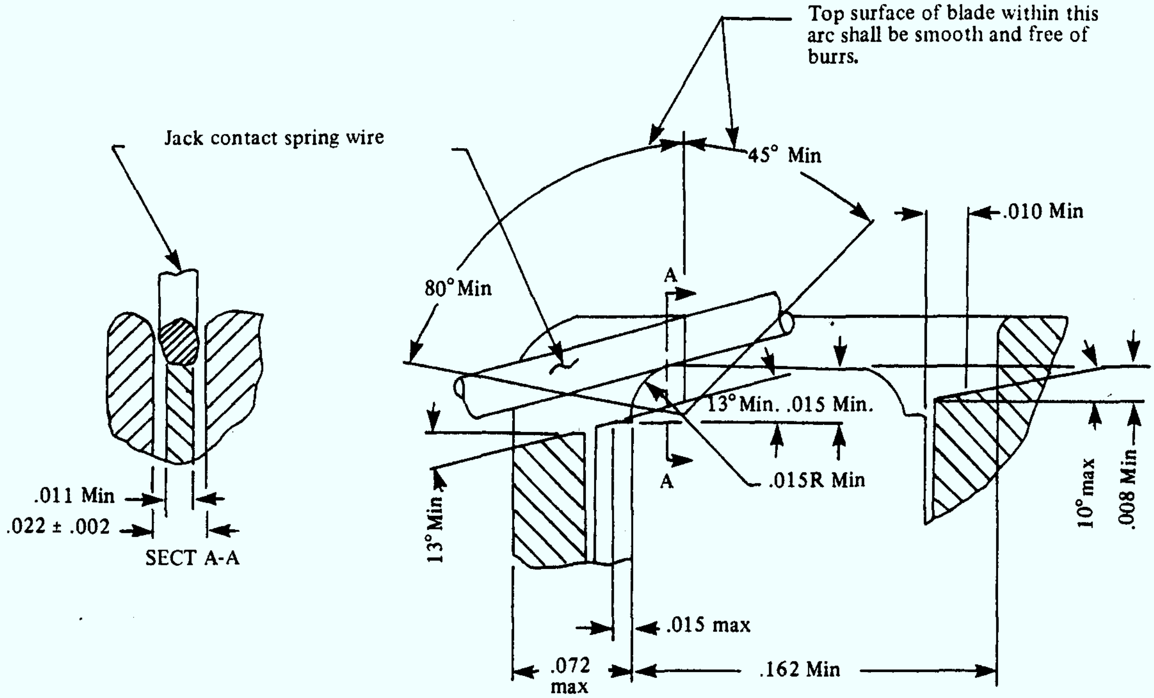


FIGURE 4-4 (c)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
Details

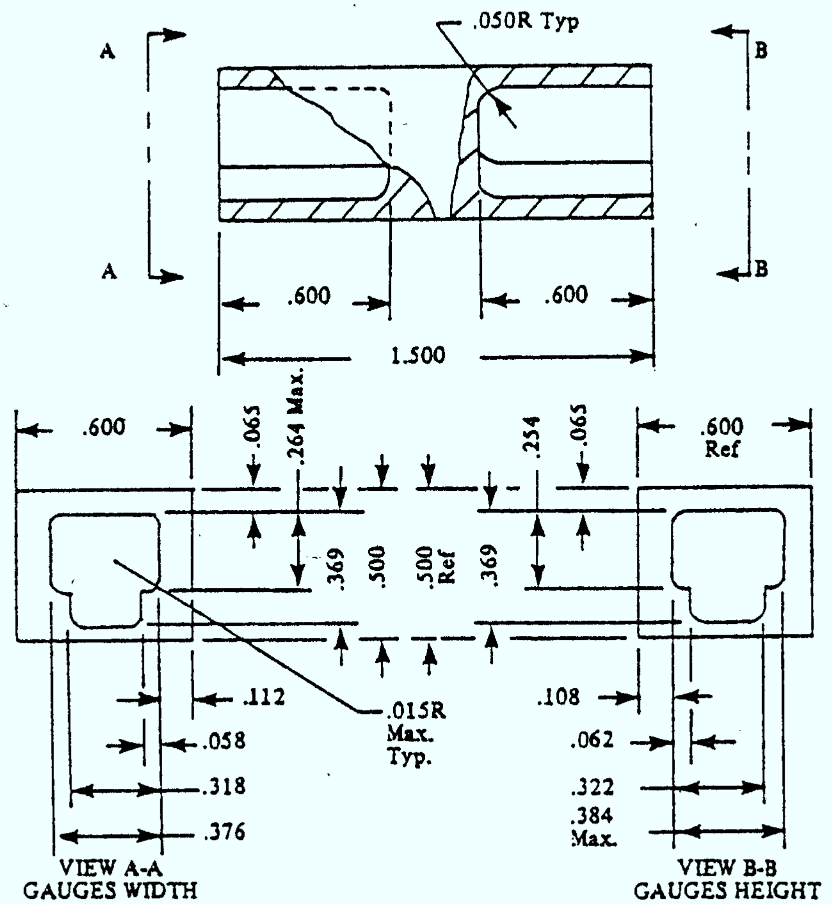


FIGURE 4-4 (d)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
Minimum Clearance Gauge

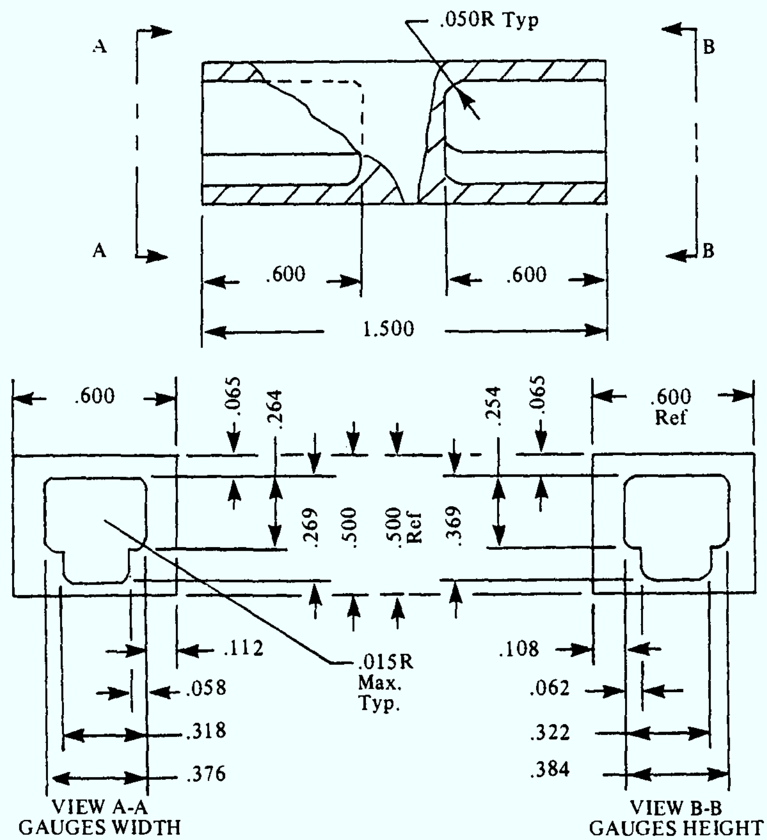


FIGURE 4-4 (d)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
Minimum Clearance Gauge

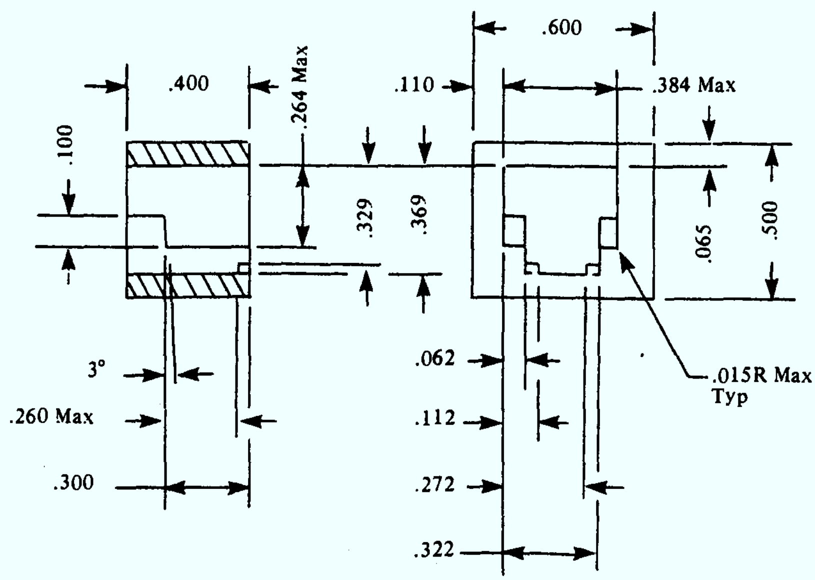


FIGURE 4-4 (e)

Miniature 6 Position Plug
(Equipped with 4 Contacts)
Maximum Clearance Gauge

4.5 Type "3" Plug

Type 3 plugs shall be capable of connecting with ease to and shall be compatible with the jack outlined in Figure 4-5 and shall be wired to conform with Table 4-5. This plug shall be used to connect equipment to 2 wire Networks B2 and D2.

Pin dimensions shall be:

1. Pin length 0.500" max.
2. Pin diameter 0.118" ± 0.003"

TABLE 4-5

(R)	Ring (R)
(GN)	Tip (T)
(Y)	Ground (GND) where applicable

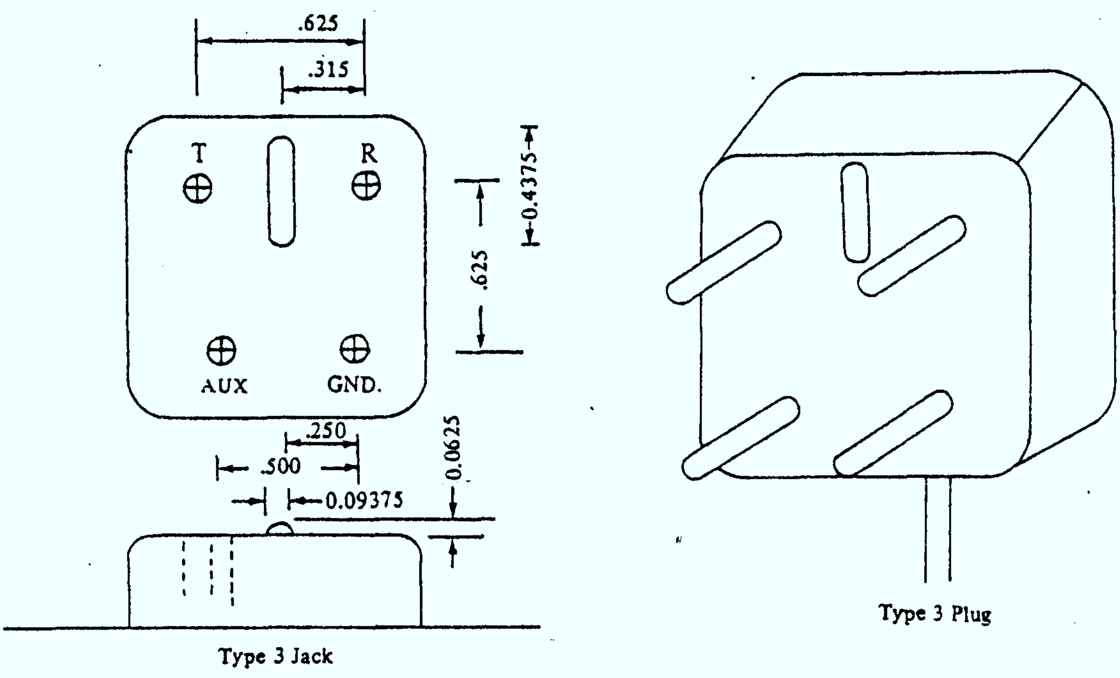


FIGURE 4-5

4.6 Type "4" Plug

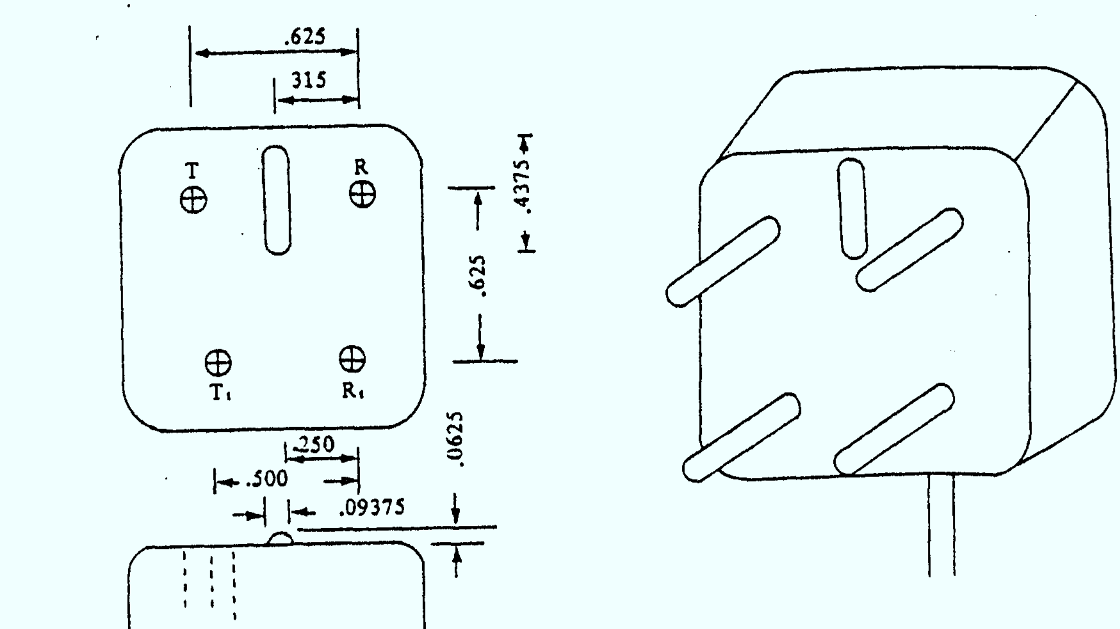
Type "4" plugs shall be capable of connecting with ease to and shall be compatable with the jack outlined in Figure 4-6 and shall be wired to conform with Table 4-6. This plug shall be used to connect equipment to 4 wire Networks B4, C and D4.

Pin Dimensions shall be:

1) Pin length 0.500" max.
2) Pin diameter 0.118" $\pm$ 0.003"

TABLE 4-6

(GN)	Ring (R) Transmit
(R)	Tip (T) Transmit
(BK)	Ring (R1) Receive
(Y)	Tip (T1) Receive



4 position jack
404B Type)

Type 4 plug.

FIGURE 4-6

4.7 Type "O" Plugs

Type "O" plugs shall mate with ease to an Amphenol type 57-20500-16 connector connector or equivalent and shall be wired in accordance with table 4-7. Type "O" plugs shall be used only for traffic measuring equipment.

TABLE 4-7
Connection for 25 lines

Line Pair	Connector Terminal Tip	Connector Terminal Ring
1	26	1
2	27	2
3	28	3
4	29	4
5	30	5
6	31	6
7	32	7
8	33	8
9	34	9
10	35	10
11	36	11
12	37	12
13	38	13
14	39	14
15	40	15
16	41	16
17	42	17
18	43	18
19	44	19
20	45	20
21	46	21
22	47	22
23	48	23
24	49	24
25	50	25

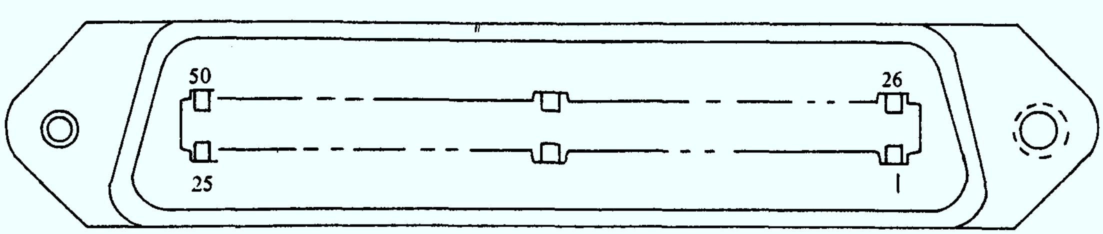


FIGURE 4.7
50 position miniature ribbon plug

5. COMPATABILITY INFORMATION

(For Information Purposes Only)

5.1 Public Switched Telephone Network (DDD)

5.1.1 Envelope Delay Distortion

Envelope Delay encountered on subscriber to subscriber connections is a function of distance and of the type of transmission facility. On most connections the Envelope Delay vs frequency characteristics encountered should be as shown on Figure 5.1

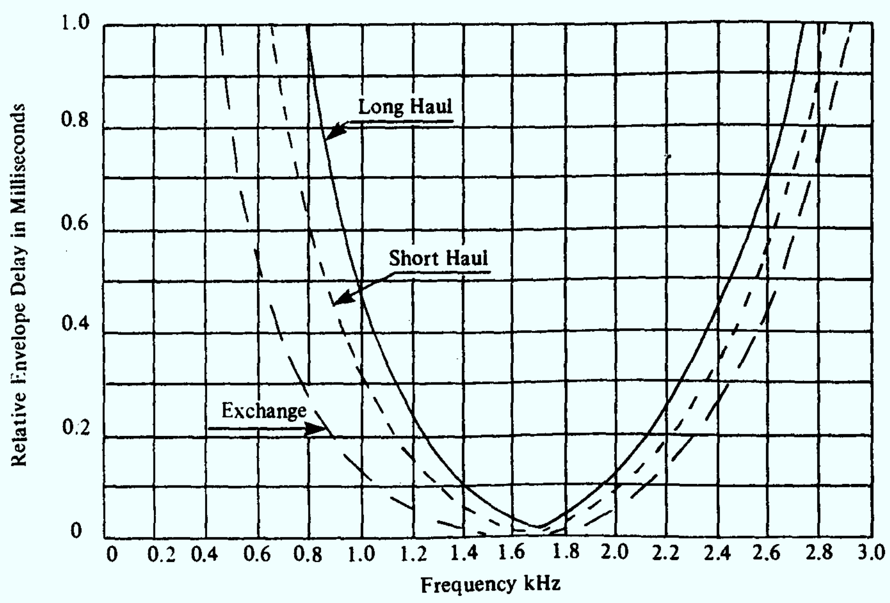


FIGURE 5-1

Envelope Delay Characteristics

5.1.2 Impulse Noise

Impulse noise is probably the major transmission impairment caused by switching equipment. Work is currently in progress to further understand and reduce this impairment. Data customers using customer provided data sets should be aware that these potentially noisy switching systems exist and that unsatisfactory performance may result.

5.1.3 Propagation Delay

The one-way propagation delay (absolute delay) of a terrestrial connection can vary widely depending on the length of the transmission path but should not exceed 50 milliseconds. On satellite connections, this one-way propagation delay can be as high as 300 milliseconds.

5.1.4 Non-Linear Distortion

Nonlinearities, such as compression in amplifiers, nonlinear elements in compandors, and foldover distortion and quantizing in PCM systems, can exist on the switched network. Normally, they are low enough so that voice bandwidth data transmission is not affected. It is expected that harmonic distortion will not generally be greater than five percent of the fundamental frequency on network calls.

5.1.5 Frequency Shift

Many carrier systems used in the switched network operate in a single sideband suppressed carrier mode. Because the carrier is not transmitted and must be re-inserted locally, there can be differences in frequency between the modulating and demodulating carriers. These carrier systems employ a frequency lock arrangement which holds any frequency shift to within 1 Hz. On an end-to-end connection frequency displacements greater than 5 Hz may be encountered, but these occurrences are very unusual.

5.1.6 Phase Jitter

The instantaneous phase of a received data signal is likely to jitter at rates of 180 Hz and below. This phase jitter will generate sidebands with magnitudes of approximately 18 dB below the level of the primary signal.

5.1.7 Dropouts

Momentary large drops in signal levels or degradations in signal to noise ratios should be expected on microwave radio systems due to fading and switching. The duration of these dropouts are usually on the order of milliseconds for large changes in level and in the order of seconds for relatively small changes.

5.1.8 Gain and Phase Hits

Sudden changes in the received signal of ± 3 dB in level and up to 90 degrees in phase may be encountered.

5.1.9 Echo Suppressors

Echo suppressors are disabled by a tone transmitted at a power level exceeding -29 dBm (while no other signal is transmitted). The frequency of this tone should be between 2010 and 2240 Hz and its duration should exceed 400 milliseconds.

To keep echo suppressors disabled, the signal transmission, in either direction, must not be interrupted for longer than 100 milliseconds.

To reverse the direction of echo suppressors when they have not been disabled, a signal transmission from the opposite direction is required. The time taken for this reversal to occur may be as long as 100 milliseconds.

5.1.10 Interface Impedance

To minimize echoes and optimize signal transmission (minimize matching losses), data terminal equipment electrically connected to the network should maintain a terminating impedance of 750 ohms ± 10 percent in the frequency band 200 Hz to 3995 Hz.

5.1.11 Off-Hook Resistance

A desirable objective for the maximum off-hook resistance of terminal equipment is 200 ohms or less at current values below 30 mA. The 275 ohms limit shown on the voltage-current graph in the Requirements section, is a maximum value and not a nominal design value. Therefore manufacturing tolerances, ageing etc must be taken into account to ensure compliance.

5.1.12 Longitudinal Impedance

The values of longitudinal impedance (Tip to ground or Ring to ground) shown in the following table, if equalled or exceeded, will ensure that longitudinal unbalance due to asymmetric longitudinal impedances, will comply with the balance requirements for terminal equipment.

These values are considerably higher than the minimum requirement of 50 k ohms, and will limit the magnitudes of longitudinal currents such that even with total asymmetry of longitudinal impedances, the balance requirements will be met. Note that this does not take account of common mode coupling effects which may be present in active devices.

Table 5-1

Frequency (Hz)	Minimum Longitudinal Impedance (M ohms) (Tip or Ring to gnd. reference)
200	1.7
500	0.9
1000	0.4
2000	0.19
3000	0.18
4000	0.16

5.2 PRIVATE LINE FACILITIES

5.2.1 Transmission Characteristics of Private Lines

The transmission characteristics of two-point and multipoint private line data circuits will vary with the type of channel ordered by the user. Four types of voice band channels are offered by the common carriers. These are categorized as Schedule 4: Type 4, Type 4A, Type 4B, and Type 4C. The characteristics of each of these channels are given in sections 5.2.2 to 5.2.3 following.

5.2.2 Envelope Delay Distortion

The delay distortion is a function of the type and length of transmission media comprising the private line. Table 5-2(a) describes the maximum variation in envelope delay over a band of frequencies that can be expected for each channel grade.

TABLE 5-2 (a)

Type of Channel	Maximum Delay (us)	Frequency Range (Hz)
Schedule 4 – Type 4	1750	800 – 2600
Schedule 4 – Type 4A	1000	1000 – 2400
	1750	800 – 2600
Schedule 4 – Type 4B	500	1000 – 2600
	1500	600 – 2600
	3000	500 – 2800
Schedule 4 – Type 4C	300	1000 – 2600
	500	800 – 2800
	1500	600 – 3000
	3000	500 – 3000

Envelope delay variations outside the frequency bands covered can not be specified. Normal circuit configurations and system tolerances make such a specification impractical.

5.2.3 Attenuation Distortion

Transmission facilities exhibit variation in loss with frequency. The limits of attenuation distortion relative to the loss at the 1000 Hz reference frequency are specified in Table 5-2(b) for the type of private line channels commonly available.

TABLE 5-2 (b)

Type of Channel	Loss Variation (dB)*	Frequency Range Hz
Schedule 4 – Type 4	–3 to +12	300 – 3000
	–2 to + 8	500 – 2500
Schedule 4 – Type 4A	–3 to +12	300 – 3000
	–2 to + 6	300 – 2700
	–1 to + 3	1000 – 2400
Schedule 4 – Type 4B	–2 to + 6	300 – 3000
	–1 to + 3	500 – 2800
Schedule 4 – Type 4C	–2 to + 6	300 – 3200
	–2 to + 3	500 – 3000

* (+) indicates loss with respect to 1000 Hz.
(-) indicates gain with respect to 1000 Hz.

5.2.4 Propagation Delay

The one-way propagation delay (absolute delay) of terrestrial connections can vary widely depending on the length of the transmission path, but should not exceed 50 milliseconds. On satellite connections this one-way propagation delay can be as high as 300 milliseconds.

5.2.5 Non-Linear Distortion

Nonlinearities, such as compression in amplifiers, nonlinear elements in compandors, and foldover distortion and quantizing in PCM systems, can exist on private line facilities. Normally they are low enough so that voice bandwidth data transmission is not affected. It is expected that the fundamental-to-third harmonic ratio limit should not exceed 30 dB.

5.2.6 Frequency Shifts

Some carrier systems comprising part of the total private line channel may operate in a single-sideband, suppressed-carrier mode. Because the carrier is not transmitted and must be re-inserted locally, there can be differences in frequency between the modulating and demodulating carriers. These carrier systems employ a frequency lock arrangement which holds any frequency shift to within 1 Hz. On an end-to-end facility frequency displacements greater than 5 Hz may be encountered, but these occurrences are very unusual.

5.2.7 Phase Jitter

The instantaneous phase of a received data signal is likely to jitter at rates typically 180 Hz and below. This phase jitter will generate sidebands with magnitudes of approximately 18 dB below the level of the fundamental signal.

5.2.8 Dropouts

Momentary large drops in signal levels or degradation in signal-to-noise ratios should be expected, due to fading and switching on microwave radio systems if they comprise part of the end-to-end private line. The duration of these dropouts is usually on the order of milliseconds for large changes in level and in the order of seconds for relatively small changes.

5.2.9 Gain and Phase Hits

Sudden changes in the received signal by $\pm$ 3 dB in level and up to 90 degrees in phase may be encountered on all grades of private lines. The occurrence of such events, however, is rare.

5.2.10 C-Notched Noise

C-Notched noise is a measure of the amount of noise on a channel when signal is present. The nominal C-Notched noise at the receiver of a private line channel is 50 dBrnc.

5.2.11 Impulse Noise

The impulse noise at the receiver of a private line circuit should not exceed 15 counts in 15 minutes above 68 dBrnc.

5.2.12 Echo Suppressors

Long half-duplex private line channels may include echo suppressors in the 4-wire portion of a 2-wire terminated channel. Echo suppressors function by increasing the loss in the transmission path opposite in direction to the path being used. To eliminate echo suppressor loss when full-duplex transmission is required a disabling tone in the 2010 to 2240 Hz band with no significant energy simultaneously present outside this band must be transmitted. The power of this tone must be between the maximum data terminal equipment transmit power (0 dBm) and 16 dB lower. Its duration should exceed 400 milliseconds.

To keep the echo suppressors disabled, the signal transmission, in either direction, must not be interrupted for periods longer than 100 milliseconds.

5.2.13 Interface Impedance

To minimize echos and matching losses, Data Terminal Equipment, when connected to a private line facility, should exhibit a terminating impedance of 600 ohms ± 10 percent in the frequency band 200 Hz to 3500 Hz.

To reverse the direction of echo suppressors when they have not been disabled, a signal transmission from the opposite direction is required. The time taken for this reversal to occur may be as long as 100 milliseconds.

5.3 MULTICOM 2 NETWORK

5.3.1 Insertion Loss

The nominal 1000-Hz insertion loss of any connection shall be 12 dB. In some circuits these losses can be exceeded but are unlikely to be greater than 19 dB.

5.3.2 Attenuation Distortion

The attenuation distortion of any frequency within the bandwidth specified below, relative to a 1 kHz signal, will not normally exceed the following limits:

300 to 3000 Hz	-2 to +6 dB
500 to 2800 Hz	-1 to +3 dB

(relative to 1 kHz loss (+) indicates more loss and (-) less loss).

5.3.3 Envelope Delay Distortion

The delay distortion is a function of the type and length of the transmission media comprising a connection. Normally the delay distortion between any two frequencies within the bandwidth specified below should not exceed the following limits:

1000 to 2600 Hz	500 us
600 to 2600 Hz	1500 us
500 to 2600 Hz	3000 us

5.3.4 Impulse Noise

The impulse noise at the Multicom 2 receiving end should not exceed 15 counts in 15 minutes above 65 dBrnc.

5.3.5 C-Notched Noise

C-Notched noise is measure of the amount of noise on the circuit when signal is present. The nominal C-Notched noise at the Multicom 2 receiver is 47 dBrnc.

5.3.6 Frequency Shift

The 1000-Hz frequency shift on any connection should not exceed 5 Hertz.

5.3.7 Phase Jitter

The phase jitter on any connection should not exceed 15 degrees peak-to-peak.

5.3.8 Harmonic Distortion

The second harmonic of a 700 Hz tone on any connection should be at least 30 dB below the fundamental.

5.4 BROADBAND EXCHANGE SERVICE

5.4.1 Central Office Voltages and Currents (2 wire/4 wire)

For 2-wire operation only, the Central Office applies voltage and current to the subscriber loops for ringing and talking.

During ringing the Central Office applies a nominal potential of 90 Vrms at a frequency of 20 Hz $\pm$ 3 Hz between the Tip and Ring leads. The voltage is interrupted periodically (removed) to provide a ringing period of 2 seconds on and 2 seconds off. Ringing signals can be detected across the Tip and Ring leads.

The "Talk" battery has a nominal value of 48 V dc and is applied between the Tip and Ring leads. In some instances the voltage could be nominal 130 V dc (e.g. on facilities serving subscribers remote from the Central Office). The Ring lead is normally negative with respect to the Tip lead.

The Data Terminal Equipment should not be dependent on dc voltages and currents from the Broadband Exchange Network as these will not normally be provided to the customer.

5.4.2 Polarity Reversals 2 Wire

Although the Ring lead is normally negative with respect to the Tip lead, the polarity of dc voltage seen by any station apparatus can reverse without warning.

5.4.3 Minimum Local Loop Current 2 Wire

The minimum local loop current delivered to an electrically coupled data terminal equipment of 200 ohms dc resistance under normal operating conditions will not be less than 20 mA.

5.4.4 Maximum Local Loop Current 2 Wire

The maximum local loop current delivered to an electrically coupled data terminal equipment of 90 ohms dc resistance under normal operating conditions will not exceed 200 mA.

5.4.5 Insertion Loss 2 Wire/4 Wire

The 1000 Hz insertion loss between subscribers is 10 dB ± 2 dB.

5.4.6 Frequency Shift 2 Wire/4 Wire

Some carrier systems comprising part of the Broadband Exchange Network may operate in a single-sideband, suppressed carrier mode. Because the carrier is not transmitted and must be reinserted locally, there can be differences in frequency between the modulating and demodulating carriers. These carrier systems employ a frequency lock arrangement which holds any frequency shift to within 1 Hz. On end-to-end connections frequency displacements greater than 5 Hz may be encountered, but these occurrences are very unusual.

5.4.7 Envelope Delay Distortion 2 Wire/4 Wire

Envelope delay distortion on a subscriber to subscriber connection is a function of the distance and type of transmission media. Subscriber-to-subscriber envelope delay distortion is determined on the Broadband Exchange Network in accordance with the requirements of the subscriber's data terminal equipment. Normally, however, the delay distortion limit between any two frequencies within the bandwidth specified in Table 5-4(a) will not be exceeded.

Table 5-4 (a)

Maximum Delay (us)	Frequency Range (Hz)
300	1000 – 2600
500	800 – 2800
1500	600 – 3000
3000	500 – 3000

5.4.8 Attenuation Distortion 2 Wire/4 Wire

Transmission facilities exhibit variations in loss with frequency. Subscriber-to-subscriber attenuation distortion is determined in accordance with the requirements of the subscriber's data terminal equipment. Normally, however, the loss variation between any two frequencies relative to the loss at the 1 kHz reference frequency will not exceed the limits specified in Table 5-4(b).

Table 5-4 (b)

Loss Variation (dB)*	Frequency Range (Hz)
–2 to + 6	300 – 3200
–2 to + 3	500 – 3000

* (+) indicates loss with respect to 1000 Hz.

(–) indicates gain with respect to 1000 Hz.

5.4.9 Impulse Noise 2 Wire/4 Wire

Not more than 15 counts in 15 minutes will be observed at a level exceeding 63 dBrn0 (Voice Band) on a long term average as measured with a 6A Impulse Counter or equivalent.

5.4.10 Noise 2 Wire/4 Wire

Noise within the channel bandwidth of 300 Hz to 3200 Hz measured at the subscriber's receive terminals with the distant transmit terminal terminated in a 600 ohm resistor shall not exceed the following limits:

45 dBrnc0 (C-Message weighted at 0 dBm TLP)

47 dBrn0 (unweighted at 0 dBm TLP)

5.4.11 Gain and Phase Hits

Sudden changes in the received signal of ± 3 dB and up to 90 degrees in phase may be encountered. This occurrence, however, is rare.

5.4.12 Phase Jitter

The instantaneous phase of a received data signal may jitter at rates typically 180 Hz and below. This phase jitter would generate sidebands with magnitudes of approximately 18 dB below the level of the fundamental frequency.

5.4.13 Propagation Delay -2 Wire/4-Wire

The one-way propagation delay (absolute delay) of terrestrial connections can vary widely depending on the length of the transmission path but should not normally exceed 50 ms. On satellite connections this one-way propagation delay can be as much as 300 ms.

5.4.14 Dropouts

Momentary large drops in signal levels or degradation in signal-to-noise ratios should be expected on the Broadband network on an infrequent basis. The duration of these dropouts is usually in the order of milliseconds for large changes in level and in the order of seconds for relatively small changes.

5.4.15 Interface Impedance 2 Wire/4 Wire

To minimize echos and matching losses when connected to Broadband Exchange Service the data terminal equipment should exhibit a terminating impedance of 600 ohms ± 10% in the frequency band 200 Hz to 3500 Hz.

Issued under the authority
of the Minister of Communications

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Director General
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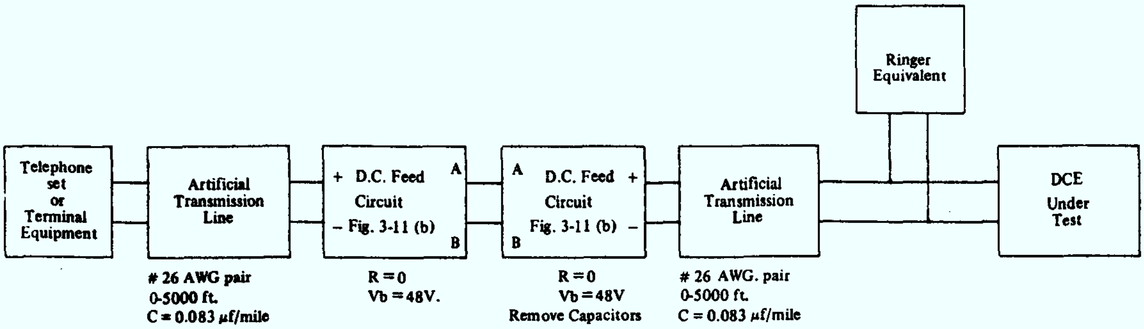
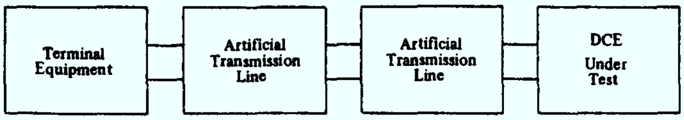
LABORATORY CIRCUIT EQUIVALENTS

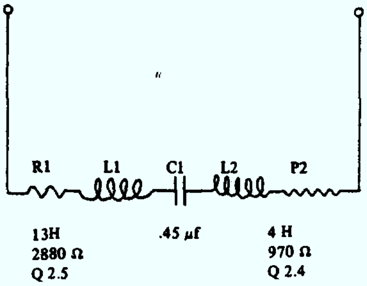
One or more of the following test circuits shall be used when performing the tests of section 2.3.2.



Public Switched Telephone Line
2 Wire Private Line with Battery



Private Line without Battery
2-wire As shown
4-wire Duplicate Second Pair.



Ringer
Equivalent
10% Tolerance