Part I: Requirements for Terminal Equipment (TE) and Related Access Arrangements Intended for Direct Connection to Analog Wireline Facilities
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1. **Introduction**

1.1 **Scope**

This part sets forth the minimum technical requirements for terminal equipment (TE) and related access arrangements intended for direct connection to analog wireline facilities owned by Canadian local exchange carriers (LEC). These technical requirements are intended to protect LEC facilities and personnel from harm. Compliance with these requirements will not, however, ensure compatibility with wireline transmission services.

The technical requirements in this part apply to:

1. (1) TE intended for direct connection:
   - to the public switched telephone network (PSTN), for use in conjunction with all analog services other than party line services;
   - to channels furnished in connection with foreign exchange lines; and
   - to private line services for tie trunk interfaces and off-premises station lines;

   (2) splitters and in-line filters connected to lines furnished with DSL equipment;

   (3) secondary telecommunications protector devices (such as protectors or filters installed in power bars) intended for connection between the PSTN interface and TE; and

   (4) component devices intended for connection between the network interface and TE (e.g. stuttered dial tone detectors), for connection between telephone terminal handsets and terminal base units (e.g. receiver amplifiers), for replacement of handsets or connection to handsets themselves.

1.2 **Technical Requirements**

1.2.1 **Technical Requirements Table**

Table 1.2.2 provides a cross-reference between most TE interfaces and the requirements with which they shall comply. These are marked with a single asterisk (*).

An identified requirement shall not apply to equipment that is not capable of providing the function for which the requirement applies.

1.2.2 **Technical Requirements for Component Devices**

The technical requirements for station equipment component devices intended for direct connection to host equipment are provided in Table 1.2.2. The testing configuration is presented in Section 1.5.6.4.

The technical requirements for component devices intended for connection to registered handset telephones are provided in Table 1.2.2. The testing configuration is presented in Section 1.5.6.5.
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### Requirements for Terminal Equipment (TE) and Related Access Arrangements Intended for Direct Connection to Analogue Wireline Facilities

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3.9 Automatic Dialling and Automatic Redialling

3.10 Stuttered Dial Tone Detection

3.11 Manual Programming of Memory Dialling Numbers

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**Note:**

- LS – Loop-start
- GS – Ground-start
- RB – Reverse Battery
- TTA – Tie Trunk Type A
- TTB – Tie Trunk Type B
- OPS – Off-premises Station
- LADC – Local Area Data Channel

### 1.3 Sequence of Equipment Testing

The tests for single or multiple line equipment shall be performed in the following order:

1. Section 1.6 Connecting Arrangements
2. Section 1.7 Operational Check
3. Section 2.2 Dielectric Strength (prior to surge voltage)
4. Section 2.3 Hazardous Voltage Limitations (excluding 2.3.10.1)
5. Section 3 Network Protection Requirements
6. Section 2.1 Mechanical Shock
7. Section 2.4 Surge Voltage (Type B)
8. Section 1.7 Operational Check
9. Section 2.2 Dielectric Strength (following Type B surge)
10. Section 3 Network Protection Requirements
11. Section 2.3 Hazardous Voltage Limitations (excluding 2.3.10.1)
12. Section 2.4 Surge Voltage (Type A)
13. Section 2.5 Power Line Surge
14. Section 1.7 Operational Check
15. Section 2.2 Dielectric Strength (following Type A surge)
16. Section 3 Network Protection Requirements
17. Section 2.3 Hazardous Voltage Limitations

**Notes:**

1. Section 2.2 provides the requirements for:
   1. environmental conditioning electrical stress prior to the tests specified in Section 3; and
   2. hazardous voltage isolation.
2. The steady state voltage stress tests specified in Section 2.2 shall be performed prior to the surge voltage requirements of Section 2.4.
1.4 Operating States

Unless specifically exempt, TE that is not intended to initiate outgoing calls and/or answer incoming calls is considered to be permanently on-hook and shall meet all on-hook requirements in the respective requirements sections.

Devices with two operating states (e.g. those that have both off-hook and on-hook states) shall comply with the requirements for each of those states. In accordance with the manufacturer's manual, or as otherwise stated, the applicant shall provide a description of the operating functions that the device is capable of performing in each of the off-hook and on-hook operating states and the method by which the device is put into each of these states. The device shall not automatically change from an on-hook state to an off-hook state except in response to an incoming call, initiating an outgoing call, or as specified in sections 3.10 and 3.11.

If feature options are provided, they shall be tested in situations where they may affect the compliance of parameter values with respect to the requirements of this specification.

1.5 Testing Configuration

1.5.1 Multi-port TE

(1) Multi-port TE configured for testing shall include all equipment components necessary to provide the functions described in the manufacturer's manual and which may affect compliance with this specification.

(2) The multi-port TE shall include:

(a) at least one of each type of trunk interface.

(b) a minimum of one alerting device or alerting detection circuit across each trunk interface with incoming call capability;

(c) at least one of each type of station interface. The total number of station interfaces shall be equal to or exceed the total number of trunk interface types submitted for testing; and

(d) at least one of each type of station apparatus, including the attendant position intended to be part of the system or a unit of registered station apparatus, to be used for testing purposes to demonstrate compliance of the private branch exchange (PBX) with the requirements of this specification.

(3) Each trunk interface and station interface submitted for testing shall be terminated in a simulator circuit, a test circuit or a station apparatus, as deemed appropriate. (See Section 4.)

(4) The multi-port TE shall allow any trunk interface to be connected to any attendant’s position and station interface that should be accommodated or connected.
(5) The multi-port TE shall be tested with a power supply that is suitable for powering the system, as recommended by the manufacturer.

1.5.2 Analog Network Interfaces With Through Transmission From Digital Network Interfaces

(1) TE equipped with analog interfaces with through transmission from digital interfaces shall be configured in a loop-back connection, as shown in Figure 1.5.2.

(2) Determine, as per the manufacturer’s manual, the permissible voltage level that may be applied to receive 1.544 Mbps (DS-1) digital interface when connected to a transmit interface in a loop-back configuration. Install a suitable resistance pad or other device which may be used to obtain the required input voltage level (e.g. to reduce a 6 V output to match a 3 V input).

(3) On each TE unit, select a 1.544 Mbps (DS-1) digital interface which has through path connection to an analog network interface. Connect the digital interfaces as shown in Figure 1.5.2, with the correct voltage level, if equipped, as specified in (2).

**Figure 1.5.2 – Loop-Back Digital Channel Interface**

R1 = 600 OHM $\pm$ 1%, 5W
1.5.3 **Accessory Equipment in TE Packages**

Accessory equipment may be included as part of a TE package. It shall be connected to the TE for testing, in accordance with the manufacturer's manual. Such TE packages shall be tested in all operating states for compliance with all applicable requirements of this specification.

1.5.4 **Cordless Telephones**

The following testing considerations shall apply when testing cordless telephones to determine compliance with this specification:

1. Prior to commencing tests for compliance with Compliance Specification CS-03 requirements, the handset battery shall be fully charged, in accordance with the manufacturer's instructions.

2. The test location shall be selected to minimize any effect on the test results from known sources of electromagnetic interference.

3. If applicable, base and handset antennae shall be vertically oriented. In cases where the base unit power cord is used as an antenna, only the power cord supplied with the unit shall be used for testing purposes.

1.5.5 **Devices Connected in Series with Tip and Ring**

Devices connected in series with tip and ring shall be tested as “stand-alone” devices to determine compliance with the requirements of this specification.

1.5.6 **Component Devices**

1.5.6.1 **General**

This specification provides for a wide range of component devices intended for connection to either:

1. host equipment, either directly or via metallic channel, or other types of point-to-point facilities; or

2. registered handset telephones.

1.5.6.2 **Power Supplies for Component Devices**

Component devices shall be tested with a power supply recommended by the manufacturer as being suitable for supplying power to the device.

1.5.6.3 **Accessory Equipment**

Accessory equipment may be included as part of a component devices package. The accessory equipment shall be connected to component devices for testing purposes, in accordance with the manufacturer's manual. Such component device packages shall be tested in all operating states for compliance with all applicable requirements of this specification.
1.5.6.4 Station Equipment Component Devices

Component devices intended for connection to an equipment interface shall be assembled together with the host equipment simulator and this assembly shall be tested as TE, using the requirements specified in Table 1.2.2.

The following additional requirements shall be satisfied:

1. The intended host equipment shall be a currently registered type and shall be clearly identified in the test report.

2. An attestation and analysis shall be provided to demonstrate that the host equipment simulator reproduces the identical test results that would be obtained with the host equipment.

1.5.6.5 Component Devices Intended for Connection to Registered Handset Telephones

Component devices intended for connection to registered handset telephones shall be tested using a single telephone as a test bed. The telephone selected as the test bed shall meet the following requirements:

1. The telephone shall be representative of the telephones with which the component device is intended to be used.

2. The telephone shall consist of a handset connected via a cord with modular connectors to the base unit of the telephone.

3. The telephone shall be a currently registered device and shall be clearly identified in the test report.

4. The component device shall be fully operational when used with the telephone.

5. The component device shall be assembled together with the telephone set selected as the test bed. This assembly shall be tested as TE, using the requirements specified in Table 1.2.2.

1.5.7 Grounding Arrangements

TE with provisions for connections to ground shall be connected to ground as instructed in the applicable test. Should the provision to ground be an optional connection or if the user manual has no clear instructions for connecting the TE to ground, then the TE shall comply with all the technical requirements of this document, both with and without the provision for connecting to ground.

1.6 Connecting Arrangements

Cords and plugs for TE that are intended for direct electrical connection to the public switched network shall comply with Part III, *Acceptable Methods of Connection for Single Line and Multi-Line Terminal Equipment*. 
TE submitted for testing shall include all the equipment components necessary to provide the functions described in the manufacturer’s manual, and for which compliance with this specification may be affected.

1.7 Operational Check

When directly connected to a network laboratory equivalent and to station apparatus, as deemed appropriate, the TE shall be fully operational with respect to the features described in the manufacturer's manual and which are necessary to perform the tests in Section 3. When the operational checks are repeated following the application of the electrical stress of Section 2, the TE may become partly or fully inoperable.

1.8 Ringer Equivalence Numbers

The Ringer Equivalence Number (REN) for a TE is the value determined below as appropriate:

For individual equipment intended for operation on loop-start and ground-start telephone facilities, the following quotients shall be formed:

Five times the impedance limitation listed in Table 3.7.3.1, divided by the minimum measured AC impedance, as defined in Section 3.7.3.2, during the application of simulated ringing, as outlined in Table 3.7.3.1.

For TE with interfaces defined in this document using network-provided analog ringing, the REN value must be greater than or equal to 0.1. The termination of an interface may consist of any combination of devices, subject to the requirement for which the sum of the RENs of all the devices does not exceed five.

1.9 Registration Requirements for Telecommunications TE

Where it is determined that TE is fully operational after both types B and A surge voltages have been successfully applied, two sets of test results (before surge voltage and after Type A surge voltage) must be submitted. However, if the TE is operational after Type B surge but the device becomes damaged and/or not fully operational after Type A surge voltages have been applied, three sets of results must be included in the TE test report. If no After Type B surge tests were performed on the original sample, the Type B surge voltage should be applied to a second sample and the After Type B surge test results can then be obtained from this second sample. Both samples shall be documented in the test report.

Recognized testing laboratories shall document all test results and test methods used and prepare a CS-03 test report as per Annex D of Declaration of Conformity DC-01, Procedure for Declaration of Conformity and Registration of Terminal Equipment.
2. **Electrical and Mechanical Stresses**

2.1 **Mechanical Shock**

2.1.1 **Requirements**

Unpackaged terminal equipment (TE) and network protection devices shall comply with all the requirements specified in sections 2 and 3 both prior to and following the application of all of the mechanical stresses outlined in this section, notwithstanding that some of these stresses may result in partial or total destruction of the equipment.

(1) Hand-held items normally used at head height: 18 random drops from a height of 1.5 m onto concrete covered with 3 mm asphalt tile or similar surface.

(2) Tabletop (desktop) equipment 0–5 kilograms: six random drops from a height of 750 mm onto concrete covered with 3 mm asphalt tile or a similar surface.

2.1.2 **Method of Measurement**

(1) TE and protective circuitry equipment unpackaged:

   (a) Hand-held items normally used at head height: 18 random drops from a height of 1.5 m onto concrete covered with 3 mm asphalt tile or similar surface.

   (b) Tabletop (desktop) top equipment (0–5 kg): these tests are performed onto concrete covered with 3 mm asphalt tile or a similar surface; one 750 mm face drop on each normal or designated rest face; one 750 mm drop on all other faces; and one 750 mm corner drop on each corner.

(2) The drop tests specified in the mechanical shock conditioning stresses shall be performed as follows:

   **Face Drop**
   The unit shall be dropped such that the face which is to be struck is approximately parallel to the impact surface.

   **Corner Drop**
   The unit shall be dropped such that, upon impact, a line from the struck corner to the centre of gravity of the packaged equipment is approximately perpendicular to the impact surface.

   **Edgewise Drop**
   The unit shall be positioned on a flat test surface. One edge of the rest face shall be supported with a block so that the rest face makes an angle of 20 degrees with the horizontal. The opposite edge shall be lifted to the designated height above the test surface and dropped.

   **Cornerwise Drop**
   The unit shall be positioned on a flat test surface. One corner of the rest face shall be supported with a block so that the rest face makes an angle of 20 degrees with the horizontal surface. The opposite corner should be lifted to the designated height above the test surface and dropped.
Random Drop

The unit shall be positioned prior to release to ensure as much as possible that, for every six drops, there is one impact on each of the six major surfaces and that the surface which is to be struck is approximately parallel to the impact surface.

2.2 Dielectric Strength

2.2.1 Requirements

TE shall have a voltage applied to the following combination of points listed in Table 2.2.1. The test voltage shall be 50–60 Hz AC:

(1) all telephone connections;
(2) all power connections;
(3) all possible combinations of exposed conductive exterior surfaces of such equipment or circuitry, including grounding connection points but excluding terminals for connection to other TE;
(4) all terminals for connection to registered protective circuitry or non-registered equipment;
(5) all auxiliary lead terminals;
(6) all E&M lead terminals; and
(7) all PR, PC, CY1 and CY2 leads.

Gradually increase the voltage from zero to the values listed in Table 2.2.1 over a 30-second time period and maintain the voltage for one minute. The current through the points shall not exceed 10 mA peak at any given time during this 90-second interval.

Equipment states necessary for compliance with the requirements of this section that cannot be achieved through normal means of power shall be achieved artificially by appropriate means.

<table>
<thead>
<tr>
<th>Voltage source connected between:</th>
<th>Vac r.m.s. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) and (2)</td>
<td>1500</td>
</tr>
<tr>
<td>(1) and (3) (see notes 1 and 2)</td>
<td>1000</td>
</tr>
<tr>
<td>(1) and (4) (see note 2)</td>
<td>1000</td>
</tr>
<tr>
<td>(1) and (5) (see note 2)</td>
<td>1000</td>
</tr>
<tr>
<td>(1) and (5) (see note 2)</td>
<td>1000</td>
</tr>
<tr>
<td>(1) and (6) (see note 2)</td>
<td>1000</td>
</tr>
</tbody>
</table>
(2) and (3) (see note 1) | 1500
(2) and (4) | 1500
(2) and (5) | 1500
(2) and (6) | 1500
(2) and (7) | 1500
(3) and (5) (see notes 1 and 2) | 1000
(3) and (6) (see notes 1 and 2) | 1000
(4) and (5) (see note 2) | 1000
(4) and (6) (see note 2) | 1000
(5) and (6) (see note 2) | 1000

*Value to which test voltage is gradually increased.

Notes:

(1) A telephone connection, auxiliary lead, or E&M lead that has an intentional DC conducting path to earth ground at operational voltages (such as a ground-start lead), may be excluded from this requirement in that operational state. Leads excluded for this reason shall comply with the requirements of Section 2.3.10.1.

A telephone connection, power lead, auxiliary lead or E&M lead that has an intentional DC conducting path to earth ground for protection at the leakage current test voltage (such as through a surge suppressor) may have the component providing the conducting path removed from the equipment for the leakage current test in that operational state. Components removed for this reason shall comply with the requirements of Section 2.3.10.2.

(2) For multi-unit equipment interconnected by cables that is evaluated and registered as an interconnected combination or assembly, the specified 10 mA peak maximum leakage current limitation, other than between power connection points and other points, may be increased, as described here, to accommodate cable capacitance. The leakage current limitation may be increased to \((10N + 0.13L)\) mA peak, where \(L\) is the length of the interconnecting cable in the leakage path in metres and \(N\) is the number of equipment units that the combination or assembly will place in parallel across a telephone connection.

(3) Radio frequency (RF) filters and surge protectors on the line side of power supplies may be disconnected before making dielectric strength measurements. As an alternative to disconnecting these filters and surge protectors, this measurement may be made using a DC voltage equal to the peak AC test voltage.
2.2.2 Method of Measurement

Be advised: Adequate safety precautions should be observed.

(1) Connect the TE to the test circuit of Figure 2.2.2.

(2) Select the appropriate TE test points and connect to the output of the test setup.

(3) Place the TE in the first test state.

(4) Over a 30-second interval, the test voltage level shall be gradually increased from zero to the level required for the connections being tested. The maximum voltage level shall be maintained for an additional 60 seconds.

(5) Monitor the resulting current and the applied voltage level for the 90-second test period.

(6) Record the maximum current measured during this period.

(7) Adjust the source for zero-volt output.

(8) Repeat steps (4) to (7) for all applicable operational states.

(9) Repeat steps (2) to (8) for all specified combinations of electrical connections as listed in Table 2.2.1.

Figure 2.2.2 – Dielectric Strength Test Circuit

Notes:

(1) A 1500 Vac voltmeter or a resistive voltage divider and high-input impedance voltmeter may be used.

(2) A true root-mean-square (r.m.s.) voltmeter may be used to measure a converted r.m.s. current limit. Alternatively, an oscilloscope may be used to measure peak current. Precautions should be taken, however, to isolate high-voltage differential or current probes.
(3) The 50 kilo-ohm (kΩ) current-limiting resistor is optional but is recommended to reduce the possibility of damage resulting from possible insulation breakdown.

(4) When the TE makes no provision for an external ground, the TE shall be placed on a metal ground plane that has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the metal plane. At no point in time should any metal surface of the TE come in contact with the metal plane. If the TE has exposed metal that could come in contact with the metal plane, a thin insulating material shall be inserted between the metal plane and the TE. The metal plane shall be treated as a grounding connection, as defined in Section 2.2.1; however, it shall not be connected to ground.

The introduction of an actual ground connection to the measurement setup may result in erroneous measurement data from most dielectric testers.

2.3 Hazardous Voltage Limitations

2.3.1 Requirements

Under no conceivable condition of TE failure during handling, operation or repair of such equipment or circuitry, shall the open circuit voltage on telephone connections exceed 70 V peak after one second, except for voltages for network control signalling, alerting and supervision.

2.3.2 Type I E&M Leads

TE on the A or B side of the interface (see figures 4.7.1 and 4.7.2) shall comply with the following requirements:

(1) The DC current on the E lead shall not exceed 100 mA.

(2) The maximum DC potentials to ground shall not exceed the values given in Table 2.3.2 when measured across a resistor of 20 kΩ ± 10%.

(3) The maximum AC potential between E&M leads and ground reference shall not exceed 5 V peak.

(4) M lead protection shall be provided to ensure that voltages to ground do not exceed 60 V. For relay contact implementation, a power dissipation capability of 0.5 W shall be provided in the shunt path.

Table 2.3.2 – Type I E&M

<table>
<thead>
<tr>
<th></th>
<th>E Lead</th>
<th>M Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE on B side originates signals to network on E lead</td>
<td>± 5 V</td>
<td>± 5 V</td>
</tr>
<tr>
<td>TE on A side originates signals to network on M lead</td>
<td>-56.5 V; no positive potential w.r.t. ground</td>
<td>-56.5 V; no positive potential w.r.t. ground</td>
</tr>
</tbody>
</table>
(5) If the TE contains an inductive component in the E lead, the transient voltage across the contact, as a result of a relay contact opening, shall not exceed the following voltage and duration limitations:

(a) 300 V peak;
(b) a rate of change of 1 volt per microsecond (V/ms); and
(c) a 60 V level after 20 ms.

2.3.2.1 Method of Measurement

For TE intended for connection to Type A or B tie trunks with Type I E&M signalling, which signals to the network on the E lead, A side:

(1) E lead DC current to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S1 to position “b”, switch S2 to position “a”, switch S3 to position “b”.
(c) Set the multimeter to the DC ammeter function.
(d) Measure the DC current from the E lead to ground.

(2) E lead DC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the DC voltage function.
(d) Operate switch S1 to position “b”.
(e) Measure the DC potential between the E lead and ground with the E lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for all other off-hook states of the TE.

(3) E lead AC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the AC voltage function.
(d) Operate switch S1 to position “b”.
(e) Measure the AC potential between the E lead and ground with the E lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for other off-hook states of the TE.

Note: Repeat steps (2) and (3) and measure the DC and AC voltages at the E lead on the B side.

(4) Contact Protection (only if E lead detector on the A side is inductive):

(a) Verify by examination that protection is provided across the relay winding so as to limit the peak voltage to 300 V.
(b) The rate of change of voltage is 1 V/µs.
(c) The voltage levels off to 60 V or less after 10 ms.
or:

(a) Connect the TE to the test circuit of Figure 2.3.3.2(b).
(b) Open switch S1 and record the oscilloscope trace.

For TE intended for connection to Type A or B tie trunks with Type I E&M signalling, which signals to the network on the M lead, A side:

1. **M lead DC voltage to ground:**
   - (a) Connect the TE as shown in Figure 2.3.3.2(a).
   - (b) Operate switch S2 to position “a”, switch S3 to position “a”.
   - (c) Set the multimeter to the DC voltage function.
   - (d) Operate switch S1 to position “a”.
   - (e) Measure the DC potential between the M lead and ground with the M lead switch in the TE in both the open and closed states.
   - (f) Repeat step (e) for other off-hook states of the TE.

2. **M lead AC voltage to ground:**
   - (a) Connect the TE as shown in Figure 2.3.3.2(a).
   - (b) Operate switch S2 to position “a”, switch S3 to position “a”.
   - (c) Set the multimeter to the AC voltage function.
   - (d) Operate switch S1 to position “a”.
   - (e) Measure the AC potential between the M lead and ground with the E lead switch in the TE in both the open and closed states.
   - (f) Repeat step (e) for other off-hook states of the TE.

**Note:** Repeat steps (1) and (2) and measure the DC and AC voltages at the M lead on the B side.

3. **M lead surge suppression:**

Examine a schematic of the E&M circuit and determine whether means are provided to limit the DC voltage to ground to 60 V while giving a power dissipation of 0.5 W.

### 2.3.3 Type II E&M Leads

TE shall comply with the following requirements:

1. For TE on the A side of the interface, the DC current in the E lead shall not exceed 100 mA. The maximum AC potential between the E lead and ground shall not exceed 5 V peak.

2. For TE on the B side of the interface, the DC current in the SB lead shall not exceed 100 mA. The maximum AC potential between the E lead and ground shall not exceed 5 V peak.

3. The maximum DC potentials to ground shall not exceed the values in Table 2.3.3 when measured across a resistor of 20 kΩ ± 10%.
### Table 2.3.3 – Type II E&M

<table>
<thead>
<tr>
<th>TE on B side of the interface originates signals to network on E lead.</th>
<th>E Lead</th>
<th>M Lead</th>
<th>SB Lead</th>
<th>SG Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5 V</td>
<td>±5 V</td>
<td></td>
<td>-56.5 V; no positive potential w.r.t. ground</td>
<td>±5 V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TE on A side of interface originates signals to network on M lead.</th>
<th>E Lead</th>
<th>M Lead</th>
<th>SB Lead</th>
<th>SG Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>-56.5 V; no positive potential w.r.t. ground</td>
<td>±5 V</td>
<td>±5 V</td>
<td>±5 V</td>
<td>±5 V</td>
</tr>
</tbody>
</table>

(4) The maximum AC potential to ground shall not exceed 5 V peak on the following leads, from sources in the TE:

(a) M, SG and SB leads for TE on the A side of the interface;
(b) E, SG and M leads for TE on the B side of the interface.

(5) If the TE contains an inductive component in the E or M lead, it must ensure that the transient voltage across the contact as a result of a relay contact opening does not exceed the following voltage and duration limitations:

(a) 300 V peak;
(b) a rate of change of 1 V/ms; and
(c) a 60 V level for more than 20 ms.

#### 2.3.3.1 Method of Measurement

For TE intended for connection to Type A or B tie trunks with Type II E&M signalling, which signals to the network on the E lead and SG lead, A side:

(1) E lead DC current to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S1 to position “b”, switch S2 to position “a”, switch S3 to position “b”.
(c) Set the multimeter to the DC ammeter function, grounding the E lead.
(d) Measure the DC current from the E lead to ground.

**Note:** Repeat the procedures in step (1) and measure the DC current with the SG lead grounded on the B side.

(2) E lead, SG lead, DC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the DC voltage function.
(d) Operate switch S1 to position “b”.
(e) Measure the DC potential between the lead and ground with the lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for all other off-hook states of the TE.
(g) Operate switch S1 to position “c”.
(h) Repeat step (e).

3) E lead, SG lead, AC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the AC voltage function.
(d) Operate switch S1 to position “b”.
(e) Measure the AC potential between the lead and ground with the lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for all other off-hook states of the TE.
(g) Operate switch S1 to position “e”.
(h) Repeat step (e).

Note: Repeat steps (1) and (2) and measure the DC and AC voltages at the E lead and SG lead on the B side.

4) Contact Protection (only if the E lead detector on the A side is inductive):

(a) Verify by examination, that protection is provided across the relay winding so as to limit the peak voltage to 300 V.
(b) The rate of change of voltage is 1 V/μs.
(c) The voltage levels off to 60 V or less after 20 ms.

or:

(a) Connect the TE to the test circuit of Figure 2.3.3.2(b).
(b) Open switch S1 and record the oscilloscope trace.

Note: Repeat the measurements in step (4) for the M lead, B side.

For TE intended for connection to Type A or B tie trunks with Type II E&M signalling, which signals to the network on the M lead and SB lead, A side:

1) M lead, SB lead, DC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the DC voltage function.
(d) Operate switch S1 to position “a”.
(e) Measure the DC potential between the M lead and ground with the M lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for all other off-hook states of the TE.
(g) Operate switch S1 to position “d”.
(h) Repeat step (e).

(2) M lead, SB lead, AC voltage to ground:

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S2 to position “a”, switch S3 to position “a”.
(c) Set the multimeter to the AC voltage function.
(d) Operate switch S1 to position “a”.
(e) Measure the AC potential between the M lead and ground with the M lead switch in the TE in both the open and closed states.
(f) Repeat step (e) for all other off-hook states of the TE.
(g) Operate switch S1 to position “d”.
(h) Repeat step (e).

Note: Repeat steps (1) and (2) and measure the DC and AC voltages at the M lead on the B side.

2.3.3.2 Summary of Measurements

Table 2.3.3.2 – E&M Leads to be Tested

<table>
<thead>
<tr>
<th>Interface Type</th>
<th>Type I</th>
<th></th>
<th></th>
<th>Type II</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Side of the Interface</td>
<td>A</td>
<td>B</td>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Lead to be Tested</td>
<td>E</td>
<td>M</td>
<td>E</td>
<td>M</td>
<td>E</td>
<td>SG</td>
</tr>
<tr>
<td>1 DC Current to Ground</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2 AC Volts to Ground</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3 DC Volts to Ground</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4 Open Circuit Volts to Ground</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Surge Suppression</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Contact Protection</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Notes:

(1) The input resistance of the voltmeter shall not be less than 200 kΩ.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
Figure 2.3.3.2(b) – E or M Lead Contact Protection

Notes:

(1) S1 consists of relay contacts that are designed to be free of contact bounce, such as those found in a mercury-wetted relay.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

2.3.4 Off-premises Station (OPS) and Direct Inward Dialling (DID) Interfaces Voltages

(1) Talking battery or voltages applied by a PBX (or similar system) to OPS and DID interface leads for the purpose of supervision must be negative with respect to ground, shall not exceed -56.5 Vdc and shall not have a significant AC component.*

* The AC component should not exceed 5 V peak unless otherwise specified in Section 3.4.

(2) Ringing signals applied by a PBX (or similar system) to OPS interface leads shall comply with requirements in Section 2.3.9.4. Ringing voltages shall be applied between the ring conductor and ground.

2.3.4.1 Method of Measurement

For TE intended for connection to OPS lines or DID Trunks:

(1) Tip to ring, tip to ground, ring to ground, DC measurements:

   (a) Connect the TE as shown in Figure 2.3.3.2(a).
   (b) Operate switch S1 to position “c”, switch S2 to position “b”, and switch S3 to position “b”.
   (c) Set the multimeter function to DC volts.
(d) Measure the DC potential across tip and ring.
(e) Operate switch S2 to position “a”.
(f) Measure the DC potential between tip and ground.
(g) Operate switch S1 to position “f”.
(h) Measure the DC potential between ring and ground.
(i) Repeat steps (c) to (h) for all other on-hook states of the TE.

(2) Tip to ring, tip to ground, ring to ground, applied ringing, AC measurements (OPS Line):

(a) Connect the TE as shown in Figure 2.3.3.2(a).
(b) Operate switch S1 to position “c”, switch S2 to position “b”, and switch S3 to position “b”.
(c) Set the multimeter function to AC volts.
(d) Measure the AC potential across tip and ring.
(e) Operate switch S2 to position “a”.
(f) Measure the AC potential between tip and ground.
(g) Operate switch S1 to position “f”.
(h) Measure the AC potential between ring and ground.
(i) Repeat steps (c) to (h) for all other on-hook states of the TE including applied ringing.

Note: Perform the tests specified in Section 2.3.9 to verify compliance with ringing source requirements.

2.3.4.2 Summary of Measurements

(1) In the idle open circuit state, measure the DC voltage with the DC voltmeter connected between:

(a) tip and ring;
(b) tip and ground; and
(c) ring and ground.

(2) In the idle open circuit state, measure the extraneous AC voltage with an AC voltmeter connected between:

(a) tip and ring;
(b) tip and ground; and
(c) ring and ground.

(3) In the ringing open circuit state, confirm that the ringing signal is applied to the proper lead by measuring the AC voltage with the AC voltmeter connected between:

(a) tip (OPS) and ground – for OPS leads only; and
(b) ring (OPS) and ground – for OPS leads only.

(4) Perform the tests specified in Section 2.3.9 to verify compliance with ringing source requirements.
2.3.5 Local Area Data Channel (LADC) interfaces

For local area data channel (LADC) interfaces, during normal operating modes that include TE initiated maintenance signals, approved TE shall, except during the application of ringing (limitations specified in Section 2.3.9) with respect to telephone connections (tip, ring, tip_1, ring_1), ensure that:

   (1) under normal operating conditions, the r.m.s. current per conductor between short-circuited conductors, including DC and AC components, does not exceed 350 mA. For other than normal operating conditions, the r.m.s. current between any conductor and ground or between short circuited conductors, including DC and AC components, may not exceed 350 mA for more than 1.5 minutes;

   (2) the DC voltage between any conductor and ground does not exceed 60 V. Under normal operating conditions, it shall not be positive with respect to ground (though positive voltages up to 60 V may be allowed during brief maintenance states);

   (3) AC voltages are less than 42.4 VpP between any conductor and ground. TE shall comply while other interface leads are:

       (a) unterminated, and

       (b) individually terminated to ground.

Note: Combined AC and DC voltages between any conductor and ground shall be less than 42.4 VpP when the absolute value of the DC component is less than 21.2 V, and less than (32.8 + 0.454 x Vdc) when the absolute value of the DC component is between 21.2 and 60 V.

2.3.5.1 Method of Measurement

Be advised: Adequate safety precautions should be observed.

(1) Place TE in first operating state.

(2) Connect current meter between T and R leads of the TE and measure combined AC and DC short circuit current.

(3) Repeat step (2) with current meter between T and ground and between R and ground.

(4) Repeat steps (1) to (3) for the T1 and R1 pair of the TE if testing a 4-wire interface.

(5) Connect DC voltmeter between T and ground and measure voltage.

(6) Repeat step (5) with voltmeter between R and ground.

(7) Repeat steps (5) and (6) for the T1 and R1 pair if testing a 4-wire interface.

(8) Connect oscilloscope between T lead and ground, and measure AC peak and combined AC peak and DC voltages with other unterminated network leads.
(9) Repeat step (8) with oscilloscope between R and ground.

(10) Repeat steps (8) and (9) for the T1 and R1 pair if testing a 4-wire interface.

(11) Repeat steps (8) to (10) for AC peak voltage only with other network leads that are individually terminated to ground.

(12) Repeat steps (2) to (11) for other modes of operation.

2.3.6 Ringdown Voice Band Private Line and Voice Band Metallic Channel Interface

During normal operation, TE intended for connection to ringdown voice band private line interfaces or voice band metallic channel interfaces shall ensure that:

(1) Ringing voltage does not exceed the voltage and current limits specified in Section 2.3.9.4, and is:
   
   (a) applied to the ring conductor with the tip conductor grounded for 2-wire interfaces; or
   (b) simplexed on the tip and ring conductors with ground simplexed on the tip_1 and ring_1 conductors for 4-wire interfaces.

(2) Except during the signalling mode or for monitoring voltage, there is no significant positive DC voltage (not over +5 V) with respect to ground: (a) for 2-wire ports between the tip lead and ground and the ring lead and ground, and (b) for 4-wire ports between the tip lead and ground, the ring lead and ground, the tip_1 lead and ground, and the ring_1 lead and ground.

(3) The DC current per lead under short circuit conditions shall not exceed 140 mA.

2.3.6.1 Method of Measurement

Be advised: Adequate safety precautions should be observed.

(1) Inspect the appropriate circuit diagrams to verify the following:

   (a) Ringing voltage is used for alerting only.
   (b) Ringing voltage is applied to the ring lead with the tip lead grounded for 2-wire interfaces.
   (c) Ringing voltage is simplexed on tip and ring leads, and ground is simplexed on T1 and R1 leads for 4-wire interfaces.

(2) Perform the tests specified in Section 2.3.9 to verify compliance with the ringing source requirements in the signalling state.

(3) Place the TE in the idle state.

(4) Connect a DC voltmeter between tip lead and ground of the TE and measure the voltage. Record the polarity.

(5) Repeat step (4) for the ring lead.
(6) Repeat step (4) for T1 and R1 leads of the TE if testing a 4-wire interface.

(7) Repeat steps (4) to (6) with the TE in talk state.

(8) Place the TE in idle state.

(9) Connect a current metre between the tip and ring leads and measure the short circuit current.

(10) Repeat step (9) between tip lead and ground and between ring lead and ground.

(11) Repeat step (9) for T1 and R1 leads if testing a 4-wire interface.

(12) Repeat steps (9) to (11) for talk state.

2.3.7 Connection of Non-registered Equipment to Registered TE or Protective Circuitry

2.3.7.1 Conducting Paths to Telephone Connections, Auxiliary Leads and E&M Leads

Leads or any elements having a conducting path to telephone connections, auxiliary leads or E&M leads shall:

(1) be reasonably physically separated and restrained from, and be neither routed in the same cable as, nor use the same connector as leads or metallic paths that connect power connections.

(2) be reasonably physically separated and restrained from, and be neither routed in the same cable as, nor use adjacent pins on the same connector as metallic paths to lead to non-registered equipment, when specification details do not illustrate that interface voltages are less than the non-hazardous voltage source limits outlined in Section 2.3.8.

2.3.7.2 Method of Measurement

Be advised: Adequate safety precautions should be observed.

(1) Inspect the schematic diagram and identify leads for connecting to the network interface, including telephone connections, auxiliary leads and E&M leads. Also identify power leads to non-registered TE.

Note: Leads in this case refer to any type of metallic connection.

(2) Identify leads to non-registered TE with hazardous voltages.

(3) Inspect equipment to verify that leads for connection to the network are adequately separated from power leads and from leads to non-registered TE with hazardous voltages.

(4) Verify that leads for connection to the network are not routed in the same cable and do not use the same connector as power leads or leads to non-registered TE with hazardous voltages.
(5) If leads for connection to the telephone network are in the same connector as leads to non-registered TE with hazardous voltages, verify that they are not on adjacent pins.

2.3.8 Non-hazardous Voltage Source

A voltage source is considered to be non-hazardous if it complies with the requirements of Section 2.2 and either Section 2.4 or 2.5 of this document, with all connections to the source, other than primary power connections, treated as “telephone connections”, and if such source supplies voltages that do not exceed the following under all modes of operation and of failure:

1. AC voltages less than 42.4 V peak;
2. DC voltages less than 60 V; and
3. combined AC and DC voltages less than 42.4 V peak when the absolute value of the DC component is less than 21.2 V, and less than \(32.8 + 0.454 \times V_{dc}\) when the absolute value of the DC component is between 21.2 and 60 V.

2.3.9 Ringing Source Limitations

Ringing sources for all classes of OPS interfaces shall meet the following requirements:

2.3.9.1 Ringing Signal Frequency

The ringing signal shall only use frequencies for which the fundamental component is equal to or less than 70 Hz.

2.3.9.2 Ringing Signal Voltage

The ringing voltage shall be less than 300 V peak-to-peak and less than 200 V peak-to-ground across a resistive termination of at least 1 Mega-ohm (MΩ).

2.3.9.3 Ringing Signal Interruption Rate

The ringing voltage shall be interrupted to create quiet intervals of at least one second (continuous) duration, each separated by no more than five seconds. During quiet intervals, the voltage to ground shall not exceed the voltage limits specified in paragraph (1) of Section 2.3.4.

2.3.9.4 Ringing Signal Sources

Ringing voltage sources shall comply with the following requirements:

1. If the ringing current through a 500 ohm (Ω) (and greater) resistor does not exceed 100 mA peak-to-peak, a ring trip device or a monitoring voltage are not required.

2. If the ringing current through a 1500 Ω (and greater) resistor exceeds 100 mA peak-to-peak, the ringing source shall include a current-sensitive ring trip device in series with the ring lead that will trip ringing as described in Figure 2.3.9.4 and Table 2.3.9.4, in accordance with the following conditions:
(a) If the ring trip device operates as outlined in Figure 2.3.9.4 and Table 2.3.9.4 with R = 500 Ω (and greater), monitoring voltage is not required.

(b) If, however, the ring trip device only operates as outlined in Figure 2.3.9.4 and Table 2.3.9.4 with R = 1500 Ω (and greater), then the ringing voltage source shall also provide a monitoring voltage between -19 Vdc and -56.5 Vdc, with respect to ground, on the tip or ring conductor.

(3) If the ringing current through a 500 Ω (and greater) resistor exceeds 100 mA (peak-to-peak) but does not exceed 100 mA peak-to-peak with 1500 Ω (and greater) termination, the ringing voltage source shall include either a ring trip device that meets the operating characteristics specified in Figure 2.3.9.4 and Table 2.3.9.4 with 500 Ω (and greater), or a monitoring voltage as described in (b) above.

Note: If the operating characteristics specified in Figure 2.3.9.4 and Table 2.3.9.4 are not met with both the 500 Ω and 1500 Ω terminations, then the TE under test has failed.

Figure 2.3.9.4 – Ringing Protection

<table>
<thead>
<tr>
<th>CURRENT THROUGH 500 Ω resn</th>
<th>1500 Ω resn</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>NOT PERMITTED</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>TRIP DEVICE AND MONITOR VOLTAGE</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>TRIP DEVICE</td>
</tr>
<tr>
<td>A or B</td>
<td>C</td>
<td>TRIP DEVICE AND MONITOR VOLTAGE</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>NONE</td>
</tr>
</tbody>
</table>
Table 2.3.9.4 – Summary of Ring Trip Requirements

<table>
<thead>
<tr>
<th>Requirements (From 2.3.9.4)</th>
<th>Ringing Current (mA p.p.)</th>
<th>Function Required</th>
<th>Ring Trip Device Operates per Figure 2.3.9.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R=500 Ω &amp; Greater</td>
<td>R=1500 Ω &amp; Greater</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>&lt; 100</td>
<td>&lt; 100</td>
<td>Optional</td>
</tr>
<tr>
<td>(2) (a)</td>
<td>N/A</td>
<td>&gt; 100</td>
<td>Yes</td>
</tr>
<tr>
<td>(2) (b)</td>
<td>N/A</td>
<td>&gt; 100</td>
<td>Yes</td>
</tr>
<tr>
<td>(3)</td>
<td>&gt; 100</td>
<td>&lt; 100</td>
<td>Either ring trip device or monitor voltage required</td>
</tr>
</tbody>
</table>

2.3.9.5 Method of Measurement

**Be advised:** Adequate safety precautions should be observed.

1. Connect the frequency counter to the tip and ring leads of the TE and measure the frequency of the ringing voltage.

2. If the TE is a 4-wire device, connect the frequency counter to the tip and ring leads of the TE tied together, and to the T1 and R1 leads of the TE, and measure the frequency of the ringing voltage.

3. Connect the TE to the test circuit of Figure 2.3.9.5(a) if the TE is a 2-wire device or to the test circuit of Figure 2.3.9.5(b) if the TE is a 4-wire device.

**Note:** A 10x probe should be used.

4. Set switch S1 to “a” and measure:
   (a) peak-to-peak ringing voltage;
   (b) peak-to-ground ringing voltage;
   (c) ringing time interval;
   (d) non-ringing time interval.

5. Set switch S1 to position “b” and initiate ringing.

6. Measure and record the peak-to-peak voltage.

7. If ringing is tripped, measure the duration of applied ringing.

8. Convert the voltage recorded in step (6) to peak-to-peak current in mA.
(9) Set switch S1 to position “c” and repeat steps (5) to (8).

(10) Refer to Table 2.3.9.4 to determine compliance with ringing voltage and the need for a tripping device and a monitoring voltage.

Note: The peak-to-peak current and the time duration of the current measured through the 500 Ω and 1500 Ω resistors in steps (5) to (9) are used in this determination.

(11) If a monitoring voltage is required, connect the oscilloscope (DC coupled), using the 10x probe, to measure the DC voltage present during the ringing and non-ringing states.

**Figure 2.3.9.5(a) – Ringing Sources, 2-Wire**

Notes:

(1) A 10x probe is normally used to obtain the reading. The input impedance of the probe should be equal to or greater than 1 MΩ.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
Figure 2.3.9.5(b) – Ringing Sources, 4-Wire

Notes:

(1) A 10x probe is normally used to obtain the reading. The input impedance of the probe should be equal to or greater than 1 MΩ.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

2.3.10 Hazards Due to Intentional Paths to Ground

2.3.10.1 Connections with Operational Paths to Ground

TE with an intentional DC conducting path to earth ground at operational voltages that was excluded during the dielectric strength test of Section 2.2 shall have a DC current source derived from a low-voltage current source not exceeding 12 V, applied between the following points:

(1) Telephone connections, including tip, ring, tip_1, ring_1, E&M leads and auxiliary leads;
(2) Earth grounding connections.

For each test point, gradually increase the current from zero to 1A, and maintain the current for one minute. The voltage between (1) and (2) shall not exceed 0.1 V at any time.

Note: In the event that there is a component or circuit in the path to ground, the requirement shall be satisfied between the grounded side of the component or circuit and the earth grounding connection.
2.3.10.1.1 Method of Measurement

(1) Connect the TE to the test circuit of Figure 2.3.10.1.1.

(2) Connect the current source between the intentionally grounded telephone connection and the earth grounding connection.

(3) Gradually increase the current from 0 A to 1 A and maintain this current for one minute.

(4) Monitor and record the voltage drop across the connections under test. Verify that the voltage does not exceed 0.1 V at any time.

(5) Repeat steps (2) to (4) for each applicable connection.

**Figure 2.3.10.1.1 – Intentional Operational Paths to Ground**

2.3.10.2 Connections With Protection Paths to Ground

TE with an intentional DC conducting path to earth ground for protection at the leakage current test voltage that was removed during the longitudinal steady state voltage test of Section 2.2.1 shall have a 60 Hz voltage source applied between the following points:

(1) Simplexed telephone connections, including tip and ring, tip_1 and ring_1, E&M leads and auxiliary leads; and

(2) Earth grounding connections.

Gradually increase the voltage from zero to 120 Vrms for TE, or 300 Vrms for protective circuitry, and maintain the voltage for one minute. The current between (1) and (2) shall not exceed 10 mA peak at any time.
As an alternative to carrying out this test on the complete equipment or device, the test may be performed separately on components, sub-assemblies and simulated circuits outside the unit, provided the test results would be representative of the results of testing the complete unit.

### 2.3.10.2.1 Method of Measurement

1. Connect the TE to the test circuit of Figure 2.3.10.2.1.

2. Connect the voltage source between the telephone connection (1) and the earth grounding connection (2).

3. Gradually increase the voltage from zero to the specified level (120 Vrms for TE and 300 Vrms for protective circuit) and maintain this voltage for one minute.

4. Monitor and record the current between (1) and (2). Verify that the current does not exceed 10 mA peak at any time.

5. Repeat steps (2) to (4) for each applicable connection.

#### Figure 2.3.10.2.1 – Intentional Protective Paths to Ground

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### 2.4 Surge Voltage

**Be advised:** Adequate safety precautions should be observed.

For both Telephone Line Surge Type A and Telephone Line Surge Type B, surges shall be applied as follows:

1. With the equipment in states that may affect compliance with the requirements of this specification. If an equipment state cannot be achieved by normal means of power, it may be achieved artificially by appropriate means.

(2) With equipment leads not being surged (including telephone connections, auxiliary leads and terminals for connection to non-registered equipment), terminated in a manner which occurs in normal use.

(3) Under reasonably foreseeable disconnection of primary power sources, with primary power cords plugged and unplugged, if so configured.

2.4.1 Telephone Line Surge – Type A

2.4.1.1 Metallic Voltage Surge

Apply two metallic voltage surges (one of each polarity) to equipment between any pair of connections on which lightning surges may occur; this includes

(1) tip to ring,
(2) tip_1 to ring_1, and
(3) for a 4-wire connection which uses simplex pairs for signalling, tip to ring_1 and ring to tip_1.

The surge shall have an open circuit voltage waveshape in accordance with Figure 2.4.1.2(a) and a short circuit current waveshape in accordance with Figure 2.4.1.2(b).

The rise time (T_r) and the decay time (T_d) values for these conditions, as well as the peak voltage and the peak short circuit current values, shall be in accordance with Table 2.4.1.1.

<table>
<thead>
<tr>
<th></th>
<th>Open Circuit Voltage</th>
<th>Short Circuit Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (T_r)</td>
<td>8 µs ± 2 µs</td>
<td>7.5 µs ± 2.5 µs</td>
</tr>
<tr>
<td>Decay Time (T_d)</td>
<td>710 µs ± 150 µs</td>
<td>660 µs ± 100 µs</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>800 V + 80 V</td>
<td>-</td>
</tr>
<tr>
<td>Peak Short Circuit Current</td>
<td>-</td>
<td>100 A + 15 A</td>
</tr>
</tbody>
</table>

2.4.1.2 Method of Measurement (Tip to Ring)

Note: Initially, all switches in Figure 2.4.2.2(a) shall be in position “a”.

Configure the surge generator as outlined in Section 2.4.1.1. Connect the equipment to be surged to the generator terminals (see Figure 2.4.2.2(a)).

(1) Set switch S3 to position “b”. Energize and fire the surge generator.

(2) Check the TE operation and record the results.

(3) Reverse the polarity of the surge and repeat steps (1) and (2).
(4) Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.

(5) Return all switches to position “a”.

**Figure 2.4.1.2(a) – Open Circuit Voltage Waveshape, \( T_r \times T_d \)**

![Graph of open circuit voltage waveshape](image)

- \( T \) = time from 30% to 90% of peak voltage.
- Rise time (\( T_r \)) = 1.67 \( T \)
- Decay time (\( T_d \)) = time from virtual origin to 50% of peak voltage on trailing edge.

**Figure 2.4.1.2(b) – Open Circuit Current Waveshape, \( T_r \times T_d \)**

![Graph of open circuit current waveshape](image)

- \( T \) = time from 10% to 90% of peak current.
- Rise time (\( T_r \)) = 1.25 \( T \)
- Decay time (\( T_d \)) = time from virtual origin to 50% of peak current on trailing edge.
2.4.1.3 Longitudinal Voltage Surge

Apply two longitudinal voltage surges (one of each polarity) to equipment from any pair of connections on which lightning surges may occur, including the tip and ring pair and the tip_1 and ring_1 pair, to each of the following:

1. Earth grounding connections; and
2. All leads intended for connection to non-registered equipment, connected together.

The surge shall have an open circuit voltage waveshape in accordance with Figure 2.4.1.2(a) and a short circuit current waveshape in accordance with Figure 2.4.1.2(b). The rise time ($T_r$) and the decay time ($T_d$) values for these conditions, as well as the peak voltage and the peak short circuit current values, shall be in accordance with Table 2.4.1.3.

<table>
<thead>
<tr>
<th>Open Circuit Voltage</th>
<th>Short Circuit Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time ($T_r$)</td>
<td>$8 \mu s \pm 2 \mu s$</td>
</tr>
<tr>
<td>Decay Time ($T_d$)</td>
<td>$210 \mu s \pm 50 \mu s$</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>$1500 \text{ V to } 1650 \text{ V}$</td>
</tr>
<tr>
<td>Peak Short Circuit Current</td>
<td>-</td>
</tr>
</tbody>
</table>

2.4.1.4 Method of Measurement (Tip and Ring together/and to Ground)

Configure the surge generator as outlined in Section 2.4.1.3. Connect the equipment to be surged to the generator terminals (see Figure 2.4.2.2(a)).

1. Set switch S3 to position “c” and switch S4 to position “b”. Energize and fire the surge generator.
2. Check the TE operation and record the results.
3. Reverse the polarity of the surge and repeat steps (1) and (2).
4. Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.
5. Return all switches to position “a”.

2.4.1.5 Method of Measurement (Tip and Ring Together/and to Other Leads)

Configure the surge generator as outlined in Section 2.4.1.3. Connect the equipment to be surged to the generator terminals. See Figure 2.4.2.2(a).

Note: In some cases the AC main power is not connected when surging other equipment leads.
(1) Set switch S3 to position “d” and switch S4 to position “b”. Energize and fire the surge generator.

(2) Check the TE operation and record the results.

(3) Reverse the polarity of the surge and repeat steps (1) and (2).

(4) Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.

(5) Return all switches to position “a”.

2.4.1.6 Failure Modes Resulting From the Application of Type A Telephone Line Surges

TE and network protection devices shall be evaluated to determine if they can achieve an off-hook state after application of metallic and longitudinal surges. An off-hook condition is achieved by the ability to draw 16 mA or greater from a loop simulator circuit. If an off-hook state cannot be achieved, signal power, billing, and hearing aid compatibility tests need not be conducted.

Regardless of operating state, equipment and circuitry can be in violation of the transverse balance requirements of Section 3.6 and for limited distance modems TE, the longitudinal signal power requirements of Part VII Section 3.1.1 (3), provided that:

(1) Such failure results from an intentional, designed failure mode which has the effect of connecting telephone or auxiliary connections with earth grounds; and

(2) If such a failure-mode state is reached, the equipment is designed so that it would become substantially and noticeably unusable by the user, or an indication is given (e.g. an alarm) in order for such equipment to be immediately disconnected or repaired.

Note: The objective of this subsection is to permit safety circuitry to either open circuit, which would cause a permanent on-hook condition, or to short circuit to ground as a result of an energetic lightning surge. Off-hook tests would be trivial if the off-hook state could not be achieved. A short to ground is capable of causing interference from longitudinal unbalance, and therefore designs must be adopted that will cause the equipment to either be disconnected or repaired quickly after such a state is reached, should it occur while in service.

2.4.2 Type B Telephone Line Surge

2.4.2.1 Metallic Voltage Surge

Apply two metallic voltage surges (one of each polarity) to equipment between any pair of connections on which lightning surges may occur, including: (1) tip to ring; (2) tip_1 to ring_1; and (3) for a 4-wire connection that uses simplexed pairs of signalling, tip to ring_1 and ring to tip_1.

The surge shall have an open circuit voltage waveshape in accordance with Figure 2.4.1.2(a) and a short circuit current waveshape in accordance with Figure 2.4.1.2(b). The waveshapes are based on the use of ideal components in Figure 2.4.2.2(b) with S2 in position “M”. The rise time \( T_r \) and the decay time \( T_d \) values for these conditions, as well as the peak voltage and the peak short circuit current values, shall be in accordance with Table 2.4.2.1.
Table 2.4.2.1 – Type B Metallic Voltage Surge

<table>
<thead>
<tr>
<th></th>
<th>Open Circuit Voltage</th>
<th>Short Circuit Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time ($T_r$)</td>
<td>9 μs ± 2.7 μs</td>
<td>5 μs ± 1.5 μs</td>
</tr>
<tr>
<td>Decay Time ($T_d$)</td>
<td>720 μs ± 144 μs</td>
<td>320 μs ± 64 μs</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>1000 V to 1100 V</td>
<td>-</td>
</tr>
<tr>
<td>Peak Short Circuit</td>
<td>-</td>
<td>25 A to 27.5 A</td>
</tr>
<tr>
<td>Current</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4.2.2 Method of Measurement (Tip to Ring)

Note: Initially, all switches in Figure 2.4.2.2(a) shall be in position “a”.

Configure the surge generator as outlined in Section 2.4.2.1. Connect the equipment to be surged to the generator terminals. See Figure 2.4.2.2(a).

1. Set switch S3 to position “b”. Energize and fire the surge generator.

2. Check the TE operation and record the results.

3. Reverse the polarity of the surge and repeat steps (1) and (2).

4. Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.

5. Return all switches to position “a”.
Figure 2.4.2.2(a) – Surge Voltage Application

Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane that is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
Figure 2.4.2.2(b) – Simplified Surge Generator

Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane that is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

2.4.2.3 Longitudinal Voltage Surge

Apply two longitudinal voltage surges (one of each polarity) to equipment from any pair of connections on which lightning surges may occur, including the tip and ring pair and the tip_1 and ring_1 pair, to each of the following:

1. Earth grounding connections, and
2. All leads intended for connection to non-registered equipment, connected together.

For each output lead of the surge generator, with the other lead open, the surge shall have an open circuit voltage waveshape in accordance with Figure 2.4.1.2(a) and a short circuit current waveshape in accordance with Figure 2.4.1.2(b). The waveshapes are based on the use of ideal components in Figure 2.4.2.2(b) with S2 in position “L”. The rise time (T_r) and the decay time (T_d) values for these conditions, as well as the peak voltage and the peak short circuit current values, shall be in accordance with Table 2.4.2.3.
Table 2.4.2.3 – Type B Longitudinal Voltage Surge

<table>
<thead>
<tr>
<th></th>
<th>Open Circuit Voltage</th>
<th>Short Circuit Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time ($T_r$)</td>
<td>9 μs ± 2.7 μs</td>
<td>5 μs ± 1.5 μs</td>
</tr>
<tr>
<td>Decay Time ($T_d$)</td>
<td>720 μs ± 144 μs</td>
<td>320 μs ± 64 μs</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>1500 V to 1650 V</td>
<td>-</td>
</tr>
<tr>
<td>Peak Short Circuit Current</td>
<td>-</td>
<td>37.5 A to 41.3 A</td>
</tr>
</tbody>
</table>

2.4.2.4 Method of Measurement (Tip and Ring together/and to Ground)

Configure the surge generator as outlined in Section 2.4.2.3. Connect the equipment to be surged to the generator terminals. See Figure 2.4.2.2(a).

1. Set switch S3 to position “c” and switch S4 to position “b”. Energize and fire the surge generator.
2. Check the TE operation and record the results.
3. Reverse the polarity of the surge and repeat steps (1) and (2).
4. Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.
5. Return all switches to position “a”.

2.4.2.5 Method of Measurement (Tip and Ring together/and to other Leads)

Configure the surge generator as outlined in Section 2.4.2.3. Connect the equipment to be surged to the generator terminals. See Figure 2.4.2.2(a).

Note: In some cases the AC main’s power is not connected when surging other equipment leads.

1. Set switch S3 to position “d” and switch S4 to position “b”. Energize and fire the surge generator.
2. Check the TE operation and record the results.
3. Reverse the polarity of the surge and repeat steps (1) and (2).
4. Set switch S1 to position “b”. Repeat steps (1) to (3) for all equipment operating states.
5. Return all switches to position “a”.
2.4.2.6 Failure Modes Resulting From the Application of Type B Telephone Line Surges

Registered TE and registered protective circuitry shall withstand the energy of surge type B without causing permanent opening or shorting of the interface circuit and without sustaining damage that will affect compliance with this specification.

2.5 Power Line Surge

Be advised: Adequate safety precautions should be observed.

2.5.1 Requirements

Apply six power line surges (three of each polarity) to equipment between the phase and neutral terminals of the AC power line while the equipment is being powered. The surge shall have an open circuit voltage waveshape in accordance with Figure 2.4.1.2(a), and a short circuit current waveshape in accordance with Figure 2.4.1.2(b). The rise time (T_r) and the decay time (T_d) values for these conditions, as well as the peak voltage and the peak short circuit current values, shall be in accordance with Table 2.5.1.

Table 2.5.1 – Power Line Surge

<table>
<thead>
<tr>
<th></th>
<th>Open Circuit Voltage</th>
<th>Short Circuit Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (T_r)</td>
<td>1.5 μs ± 0.5 μs</td>
<td>1.5 μs ± 0.5 μs</td>
</tr>
<tr>
<td>Decay Time (T_d)</td>
<td>14.5 μs ± 4.5 μs</td>
<td>14.5 μs ± 4.5 μs</td>
</tr>
<tr>
<td>Peak Voltage</td>
<td>2500 V to 2750 V</td>
<td>-</td>
</tr>
<tr>
<td>Peak Short Circuit Current</td>
<td>-</td>
<td>1000 A to 1250 A</td>
</tr>
</tbody>
</table>

Surges are applied:

1. with the equipment in all states that can affect compliance with the requirements of this specification. If an equipment state cannot be achieved by normal means of power, it may be achieved artificially by appropriate means.

2. with equipment leads not being surged (including telephone connections, auxiliary leads and terminals for connection to non-registered equipment), terminated in a manner that occurs in normal use.
2.5.2 Method of Measurement

Using the power line decoupler in series with the equipment, configure the generator as outlined in Figure 2.4.2.2(a).

1. Set switches S3 and S4 to position “a”.
2. Set switch S2 to position “b”. Energize and fire the surge generator.
3. Check TE operation and record the results.
4. Set switch S1 to position “b”. Reverse the polarity of the surge and repeat steps (1) and (2).
5. Repeat steps (1) to (4) for all equipment operating states.
6. Return all switches to position “a”.

3. Network Protection Requirements

3.1 General

3.1.1 Laboratory Environment

All tests to determine conformity with this specification shall be conducted in a laboratory environment at normal room temperature and humidity.

3.2 For Future Use

Reserved for future use.

3.3 Extraneous AC Energy

3.3.1 Metallic AC Energy

The power delivered into a 2-wire loop simulator circuit or into the transmit and receive pairs of a 4-wire loop simulator or into a 600 Ω termination (where appropriate) in the on-hook state, by loop-start or ground-start equipment, shall not exceed -55 dBm within the frequency band from 200 Hz to 3995 Hz. Network protective circuitry shall also ensure that, for any input level up to 10 dB above the overload point, the power to a 2-wire loop simulator circuit or the transmit and receive pairs of a 4-wire loop simulator circuit or into a 600 Ω termination (where appropriate) does not exceed the above limits.
3.3.1.1 Method of Measurement

(1) Connect the terminal equipment (TE) to the test circuit as shown in Figure 3.3.1.1.

(2) Set the filter to obtain a 200 Hz to 3995 Hz band and arrange the true r.m.s. voltmeter in dBm to read power averaged over three seconds.

(3) Verify that the signal level is less than the limit.

Figure 3.3.1.1 – Metallic AC Signal Measurement

Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.3.2 Longitudinal AC Signals

3.3.2.1 Longitudinal Voltage in the 100 Hz to 4 kHz Range

The weighted r.m.s. voltage (see Note in Section 3.3.2.2) averaged over 100 ms resulting from all of the component longitudinal voltages in the 100 Hz to 4 kHz band after weighting according to the transfer function of F/4000, where F is the frequency in hertz, shall not exceed the maximum indicated in Table 3.3.2.1.

Table 3.3.2.1 – Maximum r.m.s. voltage limits

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Maximum r.m.s. Voltage</th>
<th>Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Hz to 4 kHz</td>
<td>-30 dBV</td>
<td>500 Ω</td>
</tr>
</tbody>
</table>
3.3.2.2 Longitudinal Voltage in the 4 kHz to 270 kHz Range

The r.m.s. value of the longitudinal voltage component in the specified frequency bands shall not exceed the limits given in Table 3.3.2.2.

<table>
<thead>
<tr>
<th>Centre Frequency (f) of 8 kHz Band</th>
<th>Max. Voltage (see Note) in all 8 kHz Bands</th>
<th>Longitudinal Terminating Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 kHz to 12 kHz</td>
<td>-(18.4 + 20 log f) dBV</td>
<td>500 Ω</td>
</tr>
<tr>
<td>12 kHz to 42 kHz</td>
<td>(3 - 40 log f) dBV</td>
<td>90 Ω</td>
</tr>
<tr>
<td>42 kHz to 266 kHz</td>
<td>-62 dBV</td>
<td>90 Ω</td>
</tr>
</tbody>
</table>

Note: Average magnitudes may be used for signals that have peak-to-r.m.s. ratios of 20 dB and less. If the peak-to-r.m.s. ratio of the interfering signal exceeds this value, the r.m.s. limitations must be used instead of average values.

3.3.2.3 Longitudinal Voltage in the 270 kHz to 6 MHz Range

The r.m.s. value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHz shall not exceed -30 dBV. This requirement applies to longitudinal termination impedance of 90 Ω.

3.3.2.4 Method of Measurement (Longitudinal)

1. If the TE has analog interfaces with through transmission from digital interfaces, connect the TE as shown in Figure 1.5.2.

2. Connect the TE to the test circuit as shown in Figure 3.3.2.4. Place the TE in the on-hook state.

3. For multiple network interfaces, including TE with two or more interfaces (e.g. two-line telephone sets, as well as key telephone systems (KTS), PBX, etc.), the following applies:

   a. One of the interfaces not under test shall be put in the off-hook state.

   b. One of the interfaces not under test shall have a continuous ringing signal applied. TE with two or more network interfaces, one interface not under test shall have a 130 V continuous ringing signal applied during the testing of the other interface(s).

   c. One of the interfaces not under test shall be placed on hold (including audio input-on-hold, if provided).

4. Set the resistance value to $R1 = R2 = 300 \, \Omega$, and $R3 = 350 \, \Omega$. 
(5) With S1 in position “a”, arrange the true r.m.s. voltmeter to read the voltage in dBV in the 100 Hz to 4 kHz band. The weighting network shall have a transfer function of F/4000, where F is the frequency in Hz.

(6) Record the voltmeter reading and add a +3.1 dB correction factor to the measurement value.

(7) Change the resistance values to R1 = R2 = 150 Ω, and R3 = 425 Ω.

(8) Change S1 to position “b” and, using either a spectrum analyzer or an r.m.s. voltmeter and appropriate filters, measure the signal level in the 4 kHz to 12 kHz band. Add +1.4 dB to the measured value to compensate for the longitudinal termination.

(9) Change the resistance values to R1 = R2 = 67.5 Ω, and R3 = 56.3 Ω.

(10) Using either a spectrum analyzer or an r.m.s. voltmeter and filter, set the bandwidth to 8 kHz, sweep the 12 kHz to 270 kHz band and record the results. Add a correction factor of +4 dB to the results to compensate for the difference between the point of measurement and the actual longitudinal impedance. (See note below).

**Note:** If the spectrum analyzer has no 8 kHz bandwidth setting, a 10 kHz bandwidth may be used. However, it will be necessary to apply a -1 dB correction factor, or make additional measurements, or both, to compensate for the wider bandwidth being used.

(11) Compare the results with the allowed limits. (See note below).

**Note:** If a 10 kHz bandwidth is used and a failure condition is noted, it may be necessary to check that reading using a higher resolution if the spectral content had an uneven distribution. The total r.m.s. voltage over an 8 kHz band can be calculated by the following expression:

\[ V_t = \left( V_1^2 + V_2^2 + V_3^2 + \ldots \ldots \ldots V_n^2 \right)^{1/2} \]

where:

- \( V_t \) is total r.m.s. voltage over any 8 kHz band; and
- \( V_1, V_2, V_3, \ldots V_n \) are the spectral components within that band.

If the spectral content of a band is evenly distributed, then the equivalent r.m.s. power in an 8 kHz band can be found by subtracting 1dB from the measured power using a 10 kHz bandwidth.

(12) With S1 in position “c” and the bandpass filter arranged to pass the 270 kHz to 6 MHz band, measure the peak voltage. Multiply the peak voltage by 0.707 to obtain the r.m.s. voltage.
(13) For registered TE or protective circuits with provision for through transmission from other equipment, apply one of the following excitation signals (as applicable for the off-hook state):

(a) a 1004 Hz signal that results in a power output of -13 dBm delivered into a 600 Ω load at the network interface; or

(b) a standard signal or bit stream, simulating normal use of a given type of TE.

(14) Place the TE in an off-hook state. For loop-start and ground-start trunk interfaces, adjust the DC feed to provide a current equal to the value recorded in step (4) of Section 3.5.2.2. Repeat steps (4) to (13).

(15) Place the TE in an off-hook state. Adjust the DC feed to provide a current of 70 mA (or maximum current, whichever is less). Repeat steps (4) to (12).

**Figure 3.3.2.4 – Longitudinal Signal Power Measurement Method**

![Diagram of measurement setup]

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum Analyzer</td>
</tr>
<tr>
<td>RMS Voltmeter</td>
</tr>
<tr>
<td>Frequency Weighting Network</td>
</tr>
<tr>
<td>Peak Voltmeter</td>
</tr>
<tr>
<td>Band Pass Filter</td>
</tr>
<tr>
<td>Loop Simulator</td>
</tr>
<tr>
<td>Terminal Equipment</td>
</tr>
<tr>
<td>Ground Plane</td>
</tr>
</tbody>
</table>

For frequencies less than 4 kHz, R1 = R2 = 300 ohms, R3 = 350 ohms.
For frequencies 4 kHz to 12 kHz, R1 = R2 = 150 ohms, R3 = 425 ohms.
For frequencies greater than 12 kHz, R1 = R2 = 67.5 ohms, R3 = 56.3 ohms.

All resistors are 5W, ±1%.

**Note:** When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
3.4 Transmitted Signal Power

3.4.1 In-band Transmitted Signal Power – Metallic

(1) The power of all signal energy in the frequency band from 200 Hz to 3995 Hz, delivered by the TE or network protection device to the appropriate simulator (other than non-permissive data equipment or data protective circuitry), shall not exceed -9 dBm when averaged over any three-second interval.

(2) For 2-wire and 4-wire lossless tie trunk interfaces, the maximum power of other than live voice signals, delivered to a 600 Ω termination, shall not exceed -11 dBm when averaged over any three-second interval.

(3) For OPS lines, the maximum power delivered to an OPS line simulator circuit shall not exceed -9 dB with respect to one milliwatt (mW) when averaged over any three-second interval.

(4) For test equipment, the maximum signal power delivered to a loop simulator circuit shall not exceed 0 dBm when averaged over any three-second interval.

(5) For voice band private lines using ringdown or in-band signalling, the maximum power of other than live voice signals delivered to a 600 Ω termination shall not exceed -13 dBm when averaged over any three-second interval.

(6) For voice band private lines using in-band signalling in the band 2600 ± 150 Hz, the maximum power delivered to a 600 Ω termination shall not exceed -8 dBm during the signalling mode. The maximum power delivered to a 600 Ω termination in the on-hook steady state supervisory condition shall not exceed -20 dBm. The maximum power of other than live voice signals delivered to a 600 Ω termination during the non-signalling mode and for other in-band systems shall not exceed -13 dBm when averaged over any three-second interval.

3.4.1.1 Method of Measurement (Voice and Data Circuit TE)

3.4.1.1.1 Voice TE

The voice TE shall be tested as specified in Section 3.4.1.1.3 for any of the following message sources:

(1) Pre-recorded voice signals as described in Section 3.4.9.1.

(2) Messages stored permanently within the TE by the manufacturer.

(3) Messages recorded from the telephone network which can be transmitted back to the network.

(4) Tone signals originating within the TE.
3.4.1.1.2 Data Circuit TE

The data circuit TE shall be tested as specified in Section 3.4.1.1.3. Where the equipment is designed to operate in response to an external signal (electrical, optical or mechanical), the input signal shall be appropriate for the equipment being tested and shall simulate the worst case that may normally be expected.

3.4.1.1.3 Method of Measurement

1. Connect the TE to the test circuit as shown in figures 3.4.1.1.3(a) through to 3.4.1.1.3(c).

2. Operate the DC feed and ring-up circuit to bring the TE to the off-hook state and apply 70 mA (or maximum current, whichever is less).

3. Set the filter cut-off frequencies to achieve a 100 Hz to 4000 Hz bandpass and arrange the voltmeters to read power in dBm averaged over three seconds.

4. Operate the TE at maximum gain to transmit each of its possible output signals. Where data circuit TE is provided with external or programmable gain control, operate these controls to provide maximum gain for each of its possible signals.

5. Record the maximum power level reading in dBm at minimum and maximum loop currents attainable with the loop simulator, if applicable.

6. Repeat steps (4) and (5) for other operating states, if applicable.

Note: When data circuit TE is intended to operate with programming resistors for signal level control, the values of the programmed levels given in Table 3.4.3 shall be verified.

Figure 3.4.1.1.3(a) – Transmitted Signal Power Measurement, 2-Wire

```
Figure 3.4.1.1.3(a) – Transmitted Signal Power Measurement, 2-Wire
```

```
TERMINAL EQUIPMENT

LOOP SIMULATOR

VARIABLE BANDPASS FILTER

TRUE RMS VOLTMETER

R1 = 600 Ohm +/- 1%, 5W

GROUND PLANE
```

48
Notes:

(1) When the TE makes provisions for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

(2) Select the appropriate loop simulator for the interface of the terminal equipment.

Figure 3.4.1.1.3(b) – Transmitted Signal Power Measurement, 4-Wire

Notes:

(1) When the TE makes provisions for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

(2) Select the appropriate loop simulator for the interface of the TE.
Figure 3.4.1.3(c) – Transmitted Signal Power Measurement, E&M Tie

The figure shown is for a 4-wire interface; for 2-wire interface, the T1 and R1 are not present.

Notes:

1. When the TE makes provisions for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

2. Select the appropriate loop simulator for the TE interface.

3.4.2 Limitations on Internal Signal Sources, Primarily Intended for Network Control Signalling, Contained in Voice and Data Equipment

1. For all operating conditions of the TE, except tie trunk applications, the maximum power in the frequency band below 3995 Hz delivered to a loop simulator circuit shall not exceed the following levels when averaged over any three-second interval:

   a. 0 dBm when DTMF is used for network control;

   b. 0 dBm when DTMF is used for end-to-end signalling via manual entry of a keypad or repertory dialler. The term “repertory dialler” does not accommodate devices capable of generating more than 40 DTMF digits per manual keystroke;

   c. -9 dBm in all other cases.
(2) For tie trunk applications, the maximum power delivered to a 600 Ω termination for TE under all operating conditions shall not exceed -4 dBm over any three-second interval.

3.4.2.1 Method of Measurement

Refer to the test method given in Section 3.4.1.1.

3.4.3 Requirements for Data Circuit TE

Data circuit TE intended for electrical connection to a network interface shall not transmit r.m.s. signal power, in the 200 Hz to 3995 Hz frequency band that exceeds 0 dBm, when averaged over any three-second interval. The following additional special case requirements shall take precedence over the general requirement. Data circuit TE shall be capable of operating in at least one of the states discussed in (1), (2), or (3) below. The output power level of the data circuit TE shall not be easily alterable by the end user to levels that exceed the signal power limits specified herein.

(1) Data circuit TE intended to operate with a programming resistor for signal level control shall not exceed the programmed levels provided in Table 3.4.3.

(2) Data circuit TE intended to be acoustically coupled to the network or intended to connect electrically via a voice-type miniature 6-position plug, shall not transmit signals from 200 Hz to 3995 Hz that exceed -9 dBm when averaged over any three-second interval.

(3) Data circuit TE intended to operate in the fixed loss loop (FLL) state shall not transmit signal power that exceeds -4 dBm in the 200 Hz to 3995 Hz frequency band when averaged over any three-second interval.

Note: Limits on signal power shall be satisfied at the interface for all 2-wire network ports and, where applicable to offered services, both transmit and receive pairs of all 4-wire network ports. Signal power measurements shall be made using the terminations specified in each of the following limitations. The transmit and receive pairs for 4-wire network ports shall be measured with the pair not under test, connected to a termination equivalent to that specified for the pair under test. Through-gain limitations apply only in the direction of transmission toward the network.

Voice band signal power requirements for analog interfaces apply to the 200 Hz to 3995 Hz band.
### Table 3.4.3 – Signal Power Output

<table>
<thead>
<tr>
<th>Programming Resistor (Rp)*</th>
<th>Programmed Data Equipment Signal Power Output **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short circuit</td>
<td>0 dBm</td>
</tr>
<tr>
<td>150 Ω</td>
<td>-1 dBm</td>
</tr>
<tr>
<td>336 Ω</td>
<td>-2 dBm</td>
</tr>
<tr>
<td>569 Ω</td>
<td>-3 dBm</td>
</tr>
<tr>
<td>866 Ω</td>
<td>-4 dBm</td>
</tr>
<tr>
<td>1240 Ω</td>
<td>-5 dBm</td>
</tr>
<tr>
<td>178 Ω</td>
<td>-6 dBm</td>
</tr>
<tr>
<td>2520 Ω</td>
<td>-7 dBm</td>
</tr>
<tr>
<td>3610 Ω</td>
<td>-8 dBm</td>
</tr>
<tr>
<td>5490 Ω</td>
<td>-9 dBm</td>
</tr>
<tr>
<td>9200 Ω</td>
<td>-10 dBm</td>
</tr>
<tr>
<td>19800 Ω</td>
<td>-11 dBm</td>
</tr>
<tr>
<td>Open circuit</td>
<td>-12 dBm</td>
</tr>
</tbody>
</table>

* Tolerance of Rp is +1%

** Tolerance of programmed data jack signal power output is +1 dB. These values shall be averaged over any three-second interval.

### 3.4.3.1 Method of Measurement

1. Connect the TE to the test circuit as shown in Figure 3.4.3.1.
2. Operate the DC feed and ring-up circuit to bring the TE off-hook and apply 70 mA (or maximum current, whichever is less).
3. Set the filter cut-off frequencies to achieve a 100 Hz to 4000 Hz bandpass and arrange the voltmeters to read power in dBm averaged over three seconds.
4. Operate the TE with a short between the PR and PC port.
5. Record the maximum power level reading in dBm at minimum and maximum loop currents attainable with the loop simulator, if applicable.
6. Repeat step (5) with all other programmable resistor (Rp) values in Table 3.4.3, if applicable.
Figure 3.4.3.1 – Transmitted Signal Power Measurement With Programming Resistor

Notes:

(1) For programmed data equipment, measurements should be made with the value of the programming resistor (RP) set for each of the following values: short circuit, 150 Ω, 336 Ω, 569 Ω, 866 Ω, 1240 Ω, 1780 Ω, 2520 Ω, 3610 Ω, 5490 Ω, 9200 Ω, 19800 Ω, and open circuit.

(2) When the TE makes provisions for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.4.4 Through Transmission

3.4.4.1 Requirements

(1) The loss in any through transmission path of TE at any frequency in the 600 Hz to 4000 Hz band shall not exceed by more than 3 dB the loss at any frequency in the 3995 Hz to 4005 Hz band when measured into an appropriate simulator circuit from a source that appears as 600 Ω across tip and ring.

(2) For single-port and multi-port TE and network protection devices with through transmission capabilities from other TE, excluding data equipment:

(a) Where through transmission equipment provides a DC electrical signal to equipment connected therewith (e.g. for powering of electro-acoustic transducers), the DC conditions
shall be provided in accordance with the requirement below, unless the combination of the 
through transmission equipment and equipment connected therewith is registered as a 
combination that conforms to sections 3.4.1 and 3.4.2.

(i)  The open circuit voltage shall not exceed 56.5 V.

(ii)  The short circuit current shall not exceed 140 mA.

(iii) The current provided into a 430 \( \Omega \) resistor, or the maximum external resistive load 
supported by the equipment, if greater, shall exceed 20 mA.

(b) Through transmission equipment to which remotely connected data TE may be connected 
shall not be equipped with or connected to either a universal or programmed data jack used 
in data configurations.

(3) For single-port and multi-port TE and network protection devices, with through transmission 
capabilities from ports to other equipment which is separately registered for the public switched 
network or ports to other network interfaces:

(a) TE and network protection devices shall have no adjustments which will allow net 
amplification to occur in either direction of transmission in the through transmission path 
within the 200 Hz to 3995 Hz band which will exceed the allowable net amplification as 
specified in Table 3.4.4.1.

(b) The insertion loss in through connection paths for any frequency in the 800 Hz to 2450 Hz 
band shall not exceed the loss at any frequency in the 2450 Hz to 2750 Hz band by more 
than 1 dB (maximum loss in the 800 Hz to 2450 Hz band minus minimum loss in the 
2450 Hz to 2750 Hz band plus 1 dB).
Table 3.4.4.1 – Allowable Net Amplification Between Ports

<table>
<thead>
<tr>
<th>To</th>
<th>Tie Trunk Type Ports</th>
<th>Lossless (2/4-wire)</th>
<th>Subrate 1.544 Mbps Satellite (4-wire)</th>
<th>Subrate 1.544 Mbps Tandem (4-wire)</th>
<th>Integrated Services Trunk Ports</th>
<th>Off-premises Station Ports (2-wire)</th>
<th>Analog Public Switched Network Ports (2-wire)</th>
<th>Subrate 1.544 Mbps Digital PBX-CO Trunk Ports (4-wire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lossless Tie Trunk Port (2/4-wire)</td>
<td>0 dB</td>
<td>2 dB</td>
<td>2 dB</td>
<td>2 dB</td>
<td>2 dB</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Subrate 1.544 Mbps Satellite Tie Trunk Port (4-wire)</td>
<td>1 dB</td>
<td>-</td>
<td>3 dB</td>
<td>3 dB</td>
<td>3 dB</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Subrate 1.544 Mbps Tandem Tie Trunk Port (4-wire)</td>
<td>-2 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Integrated Services Trunk Ports</td>
<td>-2 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Registered Digital TE</td>
<td>-2 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td></td>
</tr>
<tr>
<td>On-premises Station Port with Registered TE (see Note 2)</td>
<td>-2 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td>0 dB</td>
<td></td>
</tr>
<tr>
<td>Off-premises Station Port (2-wire)</td>
<td>2 dB</td>
<td>4 dB</td>
<td>4 dB</td>
<td>4 dB</td>
<td>4 dB</td>
<td>4 dB</td>
<td>4 dB</td>
<td></td>
</tr>
<tr>
<td>Analog Public Switched Network Ports (2-wire)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3 dB</td>
<td>3 dB</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Subrate 1.544 Mbps Digital PBX-CO Trunk Ports (4-wire)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0 dB</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. The source impedance for all measurements shall be 600 Ω. All ports shall be terminated in appropriate loop or private line channel simulator circuits or 600 Ω terminations.

2. These ports are for 2-wire on-premises station ports to separately registered TE.

3. These through gain limitations are applicable to multi-port systems where channels are not derived through time or frequency compression methods TE that employ such compression techniques shall ensure that equivalent compensation for through gain parameters is evaluated and included in the test report.
(4) TE and network protection devices may have net amplification exceeding the limitations of this subsection provided that, for each network interface type to be connected, the absolute signal power levels specified in this section are not exceeded.

(5) The indicated gain is in the direction that results when moving from the horizontal entry toward the vertical entry.

(6) TE or network protection devices with through transmission capabilities from voice band private line channels or voice band metallic channels to other telephone network interfaces shall ensure that, for each telephone network interface type to be connected, the absolute signal power levels specified in this section are not exceeded.

(7) TE or network protection devices with through transmission capabilities from voice band private line channels or voice band metallic private line channels to other telephone network interfaces shall ensure that, for each telephone network interface type to be connected, signals with energy in the 2450 Hz to 2750 Hz band are not through transmitted unless there is at least an equal amount of energy in the 800 Hz to 2450 Hz band within 20 milliseconds (ms) of signal application.

3.4.4.2 Method of Measurement

Where interface impedances are not obvious from the information provided by the applicant, the testing facility shall contact the applicant and request that this information be provided so that appropriate correction factors may be calculated for the through transmission loss measurements.

(1) Connect the TE to the test circuit shown in Figure 3.4.4.2.

(2) Set switch S1 and switch S2 to position “a”. Adjust the filter to pass the band of frequencies below 3995 Hz.

Note: If the device under test is band limited, the appropriate filter adjustment shall be made.

(3) Establish a through transmission path in the direction of the network interface under test.

(4) Set the output level of the white noise generator so that the voltmeter indicates -11 dBV at the network interface. This level is to be maintained for all tests.

(5) Set switch S1 to position “b” and measure the signal present at the input side of the TE.

(6) Calculate the gain of the through transmission path from the output level set in step (4) and the input level measured in step (5).

(7) Set the filter to pass the 600 Hz to 3995 Hz band of frequencies. Measure the signal level present at the input side of the TE.

(8) Set switch S1 to position “a” and measure the level of the signal present at the output side of the TE. Calculate the gain in the 600 Hz to 3995 Hz band.
(9) Set switch S1 and S2 to position “b”, set the oscillator frequency to 4 kHz, and adjust the output of the oscillator to match the level measured in step (7).

(10) Set switch S1 to position “a” and measure the signal level present at the network interface. Calculate the gain at 4 kHz.

(11) Use the results from steps (8) and (10) to determine the difference in gain between the two bands.

(12) Substitute the voltmeter for the spectrum analyzer in Figure 3.4.4.2.

(13) Set switch S2 to position “a” and switch S1 to position “b”. Use the spectrum analyzer to measure the signal in the 800 Hz to 2450 Hz band, as described in Section 3.5.3. Measure and record the signal present at the input side of the TE.

(14) Set switch S1 to position “a”. Measure and record the signal present at the output side of the TE. Calculate the gain in the 800 Hz to 2450 Hz band.

(15) Set switch S1 to position “b”. Measure and record the signal in the 2450 Hz to 2750 Hz band at the input side of the TE.

(16) Set switch S1 to position “a”. Measure and record the signal level present at the output side of the TE. Calculate the gain in the 2450 Hz to 2750 Hz band.

(17) Use the results from steps (14) and (16) to determine the difference in gain between the two frequency bands.

(18) Repeat steps (1) to (17) for any through transmission path network interface. Through transmission paths that can provide connections between two network interfaces shall be evaluated in both directions.

**Figure 3.4.4.2 – Measurement of Through Path Transmission**
Notes:

(1) For the requirements of Section 3.4.4, the alternative termination network of Figure 4.6 may be substituted for R during the off-hook measurements.

(2) Battery must be switched out of the feed when testing a station or reverse battery trunk interface.

3.4.4.3 Method of Measurement (DC Conditions)

(1) Connect the TE to the test circuit as shown in Figure 3.4.4.3.

(2) With switches S1 and S2 in position “a” measures the open circuit voltage.

(3) With switches S1 and S2 in position “b” measures the short circuit current.

(4) Set switch S2 to position “c” and measure the current through the 430 Ω resistor.

(5) If the TE supports a greater resistive load, adjust the resistor to this value and measure the current.

Figure 3.4.4.3 – Measurement of Through Path DC Conditions

3.4.5 DC Conditions to Off-premises Stations (OPS) Lines

Registered TE and registered protective circuitry shall provide the following range of DC conditions to off-premises station (OPS) lines:

(1) DC voltages applied to the OPS interface for supervisory purposes and during network control signalling shall meet the limits specified in Section 2.3.4.

(2) DC voltages applied to the OPS interface during the talking state shall meet the following requirements:

(a) The maximum open circuit voltage across the tip (T(OPS)) and ring (R(OPS)) leads for all classes shall not exceed 56.5 V.
(b) Except for Class A OPS interfaces, the maximum DC current into a short circuit across tip (T(OPS)) and ring (R(OPS)) leads shall not exceed 140 mA.

(c) Except for Class A OPS interfaces, the DC current into the OPS line simulator circuit shall be at least 20 mA for the following conditions (see Figure 4.5):

**Table 3.4.5 – DC Currents for OPS Line Simulator Circuits**

<table>
<thead>
<tr>
<th>Condition</th>
<th>R + RL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class B</td>
</tr>
<tr>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>2</td>
<td>1800</td>
</tr>
</tbody>
</table>

3.4.5.1 Method of Measurement

(1) Connect the TE to test circuit as in Figure 3.4.5.1.

(2) Place the TE into the talking state.

(3) For Class B and Class C OPS interfaces, close switch S1, and measure the short circuit current between T(OPS) and R(OPS).

(4) Open switch S1.

(5) Place the OPS simulator into condition “1”.

(6) Adjust R as given in Table 3.4.5 for Class B and Class C OPS interfaces.

(7) Record the current flowing in the circuit.

(8) Place the simulator circuit into condition “2” and repeat steps (6) and (7).

**Figure 3.4.5.1 – OPS DC Conditions**

Note: Loop current is measured with a current meter in series with an OPS loop simulator. Refer to Figure 4.5.
3.4.6 Out-of-band Transmitted Signal Power – Metallic

(1) For all operating conditions of TE and network protective circuitry which incorporate signal sources other than sources intended for network control signalling, the maximum power delivered by such sources in the 3995 Hz to 4005 Hz band to an appropriate simulator circuit shall be 18 dB below the maximum permitted power specified in sections 3.4.1 to 3.4.4 of this section for the voice band.

(2) **4 kHz to 270 kHz**

The signal level within the specified frequency band, when averaged over 100 ms between tip and ring of the TE, shall not exceed the limits given in Table 3.4.6.

<table>
<thead>
<tr>
<th>Centre Frequency (f) of 8 kHz Band</th>
<th>Maximum Voltage in all 8 kHz Bands</th>
<th>Metallic Terminating Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 kHz to 12 kHz</td>
<td>- (6.4 + 12.6 log f) dBV</td>
<td>300 Ω</td>
</tr>
<tr>
<td>12 kHz to 90 kHz</td>
<td>(23 – 40 log f) dBV</td>
<td>135 Ω</td>
</tr>
<tr>
<td>90 kHz to 266 kHz</td>
<td>-55 dBV</td>
<td>135 Ω</td>
</tr>
</tbody>
</table>

(3) **270 kHz to 30 MHz**

The r.m.s. value of the metallic voltage components in the frequency range of 270 kHz to 30 MHz shall, averaged over 2 μs, not exceed -15 dBV. This limitation applies to metallic termination with impedance of 135 Ω.

3.4.6.1 Method of Measurement (Metallic)

(1) If the TE has analog interfaces with through transmission from digital interfaces, connect the TE as shown in Figure 1.5.2.

(2) Connect the TE to the test setup as shown in Figure 3.4.6.1. Place the TE in the on-hook state.

(3) If the TE has multiple network interfaces (e.g. two-line telephone sets as well as KTS, PBX, etc.) proceed as follows:

(a) One of the interfaces not under test shall be put in the off-hook state.

(b) One of the interfaces not under test shall have a continuous ringing signal applied. For TE with two or more network interfaces, one interface not under test shall have a 130 V ringing signal applied continuously during the testing of the other interface(s).

(c) One of the interfaces not under test shall be placed on hold (including audio input-on-hold, if provided).
(4) With R1 equal to 600 Ω and using either a spectrum analyzer or an r.m.s. voltmeter with a bandpass filter, set switch S1 in position “a” and measure the signal level (dBm) in the 3995 Hz to 4005 Hz band. Ensure that the results are 20 dB lower than the value measured in sections 3.4.1 to 3.4.4.

(5) With R1 equal to 300 Ω and using either a spectrum analyzer or an r.m.s. voltmeter with a bandpass filter, set switch S1 in position “a” and measure the signal level (dBV) in the 4 kHz to 12 kHz band.

(6) Replace R1 with a 135 Ω resistor. Using a spectrum analyzer with the bandwidth set to 8 kHz, sweep the frequency band from 12 kHz to 270 kHz and record the results.

**Note:** If the spectrum analyzer being used does not have an 8 kHz bandwidth setting, a 10 kHz bandwidth may be used. Apply a -1 dB correction factor or make additional measurements, or both, to compensate for the wider bandwidth used.

(7) Measure the metallic signal power in the 270 kHz to 30 MHz frequency range using a wideband power meter along with a 270 kHz to 30 MHz bandpass filter. Alternatively, use a spectrum analyzer with band power markers set for 270 kHz to 30 MHz and record the worst-case result.

**Note:** If a 10 kHz bandwidth is used and a failure condition is noted, it may be necessary to check the reading using a higher resolution if the spectral content had an uneven distribution. The total r.m.s. voltage over an 8 kHz band can be calculated using the following formula:

\[
V_t = \left( V_1^2 + V_2^2 + V_3^2 + \ldots + V_m^2 \right)^{\frac{1}{2}}
\]

where:

- \( V_1 \) is the total r.m.s. voltage over any 8 kHz band; and
- \( V_1, V_2, V_3, \ldots, V_m \) are the spectral components within that band.

If the spectral content of a band is evenly distributed, the equivalent r.m.s. power in an 8 kHz band can be determined by subtracting 1 dB from the measured power using a 10 kHz bandwidth.

(8) Compare the results with the permitted limits.

(9) Place the TE in the off-hook state. For loop-start and ground-start trunk interfaces, adjust the DC feed to obtain both a minimum and maximum loop current. Repeat steps (3) to (8) for each current setting.
Figure 3.4.6.1 – Out-of-band Signal Level Measurement

Notes:

(1) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. The differential probe is used to isolate the ground from the measurement. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

(2) The roll-off used in bandpass filters of the CODECs in digital TEs causes the signal power in the 3995 Hz to 4005 Hz to be down at least 30 dB from the reference values at 10000 Hz. Hence this requirement does not apply to digital EUT.

3.4.7 For Future Use

3.4.8 Audio Signal Limiting

3.4.8.1 Requirements

(1) For TE with signal limiting from an internal source, the requirements of sections 3.4.1(1), 3.4.1(2) and 3.4.1(3), as deemed appropriate, shall be satisfied with the source activated.

(2) For TE with signal limiting from an external source, the overload point shall be determined and the requirements of sections 3.4.1(1), 3.4.1(2) and 3.4.1(3), as deemed appropriate, shall be satisfied with an input level 10 dB above the overload point but not exceeding 70 Vrms.

(3) The requirements of Section 3.4.6 shall be satisfied at the measurement levels determined by the overload point and, where an external source is provided, over the input frequency range of 200 Hz to 20 kHz.
(4) Where an audio output is provided from an external source, the requirements of sections 3.4.4 and 3.5.3 shall be satisfied for this through transmission path.

(5) The protective circuitry shall have no user-accessible adjustments that will allow these parameters to be exceeded.

### 3.4.8.2 Method of Determining the Overload Point

(1) Connect a sine wave input of 1004 Hz to the audio input (audio-input or on-hold port) and monitor the input and output (network interface) levels.

(2) Set the signal to a level at which through transmission gain is not significantly affected by moderate changes in level.

(3) Increase the input level until the through transmission gain has dropped by 0.4 dB or until 70 Vrms is reached, whichever input level is the lesser. The input level at which this occurs is defined as the overload point.

### 3.4.9 Method Used to Generate Audio Signals

#### 3.4.9.1 Method 1 – Pre-recorded Voice Signals

An acoustic signal generated by the method shown in Figure 3.4.9.1 at a sound pressure level of 0 dB Pa (94 dB SPL) FLAT weighted, shall be recorded on the announcement recording tape using the microphone supplied with the answering device, or shall be connected directly to the network by means of an acoustic input device. The loudspeaker and sound level meter microphone in the test circuit in Figure 3.4.4.2 must be located at least 1 m from any reflecting surface, such as tables, workbenches, walls, etc. The circuit shall be calibrated as follows:

(1) Disable OSC. No. 4 (0% modulation).

(2) Disable OSC. No. 2 and OSC. No. 3.

(3) Enable OSC. No. 1 and adjust its output for a Sound Level Meter reading between -9 and -4 dB Pa (85 and 90 dB SPL) FLAT weighted.

(4) Disable OSC. No. 1. Enable OSC. No. 2 and adjust OSC. No. 2 output to produce the same reading on the Sound Level Meter as was noted in step (3) for OSC. No. 1.

(5) Disable OSC. No. 2. Enable OSC. No. 3 and adjust OSC. No. 3 output to produce the same reading on the Sound Level Meter as was noted in step (3) for OSC. No. 1.

(6) Enable OSC. No. 1, OSC. No. 2, OSC. No. 3 and adjust OSC. No. 4 to obtain approximately 50% amplitude modulation.

(7) Adjust the variable attenuator for a Sound Level Meter reading of 0 dB Pa (94 dB SPL FLAT). With the acoustic field so adjusted, the Sound Level Meter microphone is replaced
by the microphone (or other acoustic input device) of the TE. Recording of transmission is then performed.

For TE with capabilities for recording messages from the network which can be transmitted back to the network, the reference testing signal shall be obtained as follows. After calibrating the test circuit shown in Figure 3.4.9.1 by the method given in steps (1) to (7), remove the speaker from the circuit and use the connected r.m.s. level meter to measure the output signal, -12 dBV (-14.2 dBm, 600 Ω), at point A.

**Figure 3.4.9.1 – Circuit Used for Generating Audio Signals**

Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. The differential probe is used to isolate the ground from the measurement. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
3.5 Billing Protection

3.5.1 Call Duration

3.5.1.1 Requirements

Registered data TE and registered protective circuitry shall comply with the following requirements when answering an incoming call, except in the off-hook state during which the signals are transmitted and/or received as electro-acoustic transducers only.

Note: The preceding paragraph is applicable to registered TE and registered protective circuitry employed with digital services where such digital services are interconnected with the analog telephone network.

(1) Registered protective circuitry connected to associated data equipment will meet the following signal power limitations for at least the first two seconds after the off-hook condition is presented to the telephone network in response to an incoming call:

(a) The total power of signals that appear at the protective circuitry/telephone network interface for delivery to the telephone network, when measured with the appropriate loop simulator circuit or a 600 Ω termination, shall be limited to -55 dBm within the voice band; and

(b) Signals that appear at the protective circuitry-associated data equipment interface for delivery to associated data equipment shall be limited as follows: for any received signal power up to 0 dBm (within the voice band), the power of signals delivered to associated data equipment shall be no greater than the signal power that would be delivered as a result of received signal power of -55 dBm.

(2) Registered TE for data applications shall ensure that, when an incoming telephone call is answered, the answering TE prevents both transmission and reception of data for at least the first two seconds after the answering TE transfers to the off-hook condition. For the purpose of this requirement, a fixed sequence of signals that is transmitted (and originated within) and/or received by the approved TE each time it answers an incoming call shall not be considered data, provided that such signals are for one or more of the following purposes:

(a) Disabling echo control devices;

(b) Adjusting automatic equalizers and gain control;

(c) Establishing synchronization; or

(d) Signalling the presence and, if required, the mode of operation of the data terminal at the remote end of a connection.
3.5.1.2 Method of Measurement

(1) For protective circuitry for which data equipment has access to the public switched network:

(a) Connect the TE to the test circuit of Figure 3.5.1.2(a).

(b) Set the frequency generator for 1000 Hz and 0 dBm.

(c) Set the oscilloscope to trigger on transition from the on-hook to the off-hook state of the TE.

(d) Apply the ringing signal to the TE.

(e) Record the signal level that is transmitted to the network after the TE goes off-hook. Check for compliance during the first two seconds after going off-hook.

(f) Connect the TE to the test circuit of Figure 3.5.1.2(b).

(g) Set the frequency generator to 1000 Hz and -55 dBm. The specified -55 dBm limit for transmission is considered to be equivalent to no transmission and applies in both transmit and receive conditions.

(h) Place the TE in the off-hook state. Measure the signal power that would be delivered to the data equipment from the network through the TE in response to a received signal power of -55 dBm. Return the TE to its on-hook state.

(i) Increase the input signal 0 dBm.

(j) Set the oscilloscope to trigger on transition from the on-hook to the off-hook state of the TE.

(k) Apply the ringing signal to the TE.

(l) Measure the signal power that would be received by the data equipment from the network through the TE. The signal level measured in this step (l) should be no greater than the signal level in step (h).

Note: The two-second delay before transmitting the data signal, after the off-hook condition is presented to the telephone network in response to an incoming call, is to allow billing equipment to be connected and prepared for proper billing.
Figure 3.5.1.2(a) – Call Duration, PC, Transmit

Note: Select the appropriate loop simulator for the TE interface.

Figure 3.5.1.2(b) – Call Duration, PC, Receive

Note: Select the appropriate loop simulator for the TE interface.

(2) For data equipment that accesses the public switched network:

(a) Connect the TE to the test circuit of Figure 3.5.1.2(c).

(b) Set the oscilloscope to trigger on the transition from the on-hook to the off-hook state.

(c) Apply the ringing signal to the TE.

(d) Monitor the signal transmitted by the TE for at least two seconds after the on-hook to off-hook transition, under normal operating conditions. Verify that data transmission is delayed for the required time. If a signal is observed in less than the required time, verify that it is one of the allowed signals.

(e) Connect the TE to the test circuit of Figure 3.5.1.2(d).
(f) Set the TE to receive data.

(g) Set the oscilloscope to trigger on the transition from the on-hook to the off-hook state of the TE.

(h) Apply the ringing signal to the TE.

(i) Monitor the TE to verify that it does not respond to the incoming data for the time specified in the test requirement after going off-hook.

**Note:** The two-second delay after transmitting the data signal, after the off-hook condition is presented to the telephone network in response to an incoming call, is to allow billing equipment to be connected and prepared for proper billing.

**Figure 3.5.1.2(c) – Call Duration, TE, Transmit**

[Diagram showing the sequence of events involving the terminal equipment (TE), companion terminal equipment, data generator or exerciser, ringing amplifier, loop simulator, and frequency generator.]

**Figure 3.5.1.2(d) – Call Duration, EUT, Receive**

[Diagram showing the sequence of events involving the terminal equipment (TE), companion terminal equipment, storage oscilloscope, ringing amplifier, loop simulator, frequency generator, data generator or exerciser.]
3.5.2 Voice and Data Equipment

3.5.2.1 Requirements

The loop current through the TE, when connected to a 2-wire or 4-wire loop simulator circuit with the 600 Ω resistor and 500 microfarad capacitor of the 2-wire loop simulator circuit or both pairs of the 4-wire loop simulator circuit disconnected shall, for at least five seconds after the equipment goes to the off-hook state which occurs when answering an incoming call:

1. be at least as great as the current obtained in the same loop simulator circuit with a 200 Ω resistor connected across the tip and ring of the 2-wire loop simulator circuit or connected across the tip/ring and tip_1/ring_1 conductors (tip and ring connected together and tip_1 and ring_1 connected together) of the 4-wire loop simulator circuit in place of the TE; or

2. not decrease by more than 25% from its maximum value attained during this five-second interval, unless the equipment is returned to the on-hook state during the above five-second interval.

Note: The above requirements also apply to the hold state.

3.5.2.2 Method of Measurement

To verify compliance with section:

3.5.2.1 (1) follow steps (1) to (11);
3.5.2.1 (2) follow steps (1) to (3) and (12) to (21).

1. Connect the TE as shown in Figure 3.5.2.2 and with switch S1 in position “a”, S2 in position “a”, and S3 in position “a”.

2. Adjust the DC voltage of B1 to 42.5 Vdc. Operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 1740 Ω by varying R. Operate switch S3 to position “a” and operate switch S1 to position “b”.

3. With B2 set at 52.5 Vdc, unless otherwise specified in the manufacturer’s manual, operate switch S2 momentarily to position “b” to apply ringing voltage.

4. Bring the TE to the off-hook state as defined in the manufacturer’s manual. Monitor the DC current for the first five seconds after transferring from the on-hook to the off-hook state. Record the minimum current. Return the TE to the on-hook state.

5. Operate switch S3 to position “b” and repeat steps (3) and (4).

6. Replace the TE with a 200 Ω, ± 1%, 5 W resistor. Operate switch S3 to position “a” and operate switch S1 to position “b”. Allow time for the current to settle before recording the value. Measure and record the DC current. Operate switch S3 to position “b” and measure and record the DC current.
**Note:** If the current drawn by the TE in step (4) is equal to or greater than the DC current measured with the 200 Ω resistor, then the requirement is met.

(7) Reconnect the TE as shown in Figure 3.5.2.2. Adjust the DC voltage of B1 to 52.5 Vdc. Operate switch S1 to position “a” and operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 1200 Ω by varying R. Operate switch S3 to position “a” and then operate switch S1 to position “b”.

(8) Repeat steps (3) to (6).

(9) Reconnect the TE as shown in Figure 3.5.2.2. Leave the DC voltage of B1 at 52.5 Vdc. Leave switch S1 in position “a” and then operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 400 Ω by varying R. Operate switch S3 to position “a” and then operate switch S1 to position “b”.

(10) Repeat steps (3) to (6).

(11) Repeat steps (1) to (10) for all remaining off-hook states of the TE.

**Note:** This is the end of the test method for demonstrating compliance with Section 3.5.2.1(1). Steps (12) to (21) are for demonstrating compliance with Section 3.5.2.1(2).

(12) Connect the TE as shown in Figure 3.5.2.2. Adjust the DC voltage of B1 to 42.5 Vdc. Operate switch S1 to position “a” and operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 1740 Ω by varying R. Operate switch S3 to position “a” and operate switch S1 to position “b”.

(13) With B2 set at 52.5 Vdc, unless otherwise specified in the manufacturer’s manual, operate switch S2 momentarily to position “b” to apply ringing voltage.

(14) Monitor the values of DC current flow through the TE for a five-second interval immediately following the transition from on-hook to off-hook and record the minimum and maximum values. Calculate the % change.

(15) Operate switch S3 to position “b” and repeat steps (13) and (14).

(16) Adjust the DC voltage of B1 to 52.5 Vdc. Operate switch S1 to position “a” and operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 1200 Ω by varying R. Operate switch S3 to position “a” and operate switch S1 to position “b”.

(17) Operate switch S3 to position “b” and repeat steps (13) to (15).

(18) Leave the DC voltage of B1 set at 52.5 Vdc. Operate switch S1 to position “a” and operate switch S3 to position “c”. Using an ohmmeter, adjust the total resistance to 400 Ω by varying R. Operate switch S3 to position “a” and operate switch S1 to position “b”.

(19) Operate switch S3 to position “b” and repeat steps (13) to (15).
(20) Return switches S1 and S3 to their respective positions "a".

(21) Repeat steps (12) to (20) for all of the remaining off-hook states of the TE.

**Note:** This is the end of the test method for ensuring compliance with Section 3.5.2.1(2).

---

**Figure 3.5.2.2 – Billing Protection Measurement**

---

**LEGEND:**

- L – Inductor, 10H (min.) at 120 mADC, 200 ohm ±10% resistance
- C – Non-electrolytic capacitor, 500 μF, 300 Vdc, matched within 1%
- B1 & B2 – Power supply, 0-105 Vdc, 500 mA
- R – Linear potentiometer, 3 kohms, 8W
- A – Ammeter, ±1% accuracy, 0 – 150 mA range
- S1 – Switch
- S2 – Ring-up key, momentary make
- S3 – Polarity reversal / ohmmeter switch
- V – Voltmeter, ±1% accuracy, 0-105 Vdc
- Ω – Ohmmeter, ±1% accuracy, 2 kohm range
Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. The differential probe is used to isolate the ground from the measurement. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.5.3 Signalling Interference

3.5.3.1 Requirements

The signal power delivered to the network interface by the TE and from signal sources internal to network protection devices in the 2450 Hz to 2750 Hz band shall be less than or equal to the power present simultaneously in the 800 Hz to 2450 Hz band for the first two seconds after going to the off-hook state.

3.5.3.2 Method of Measurement

(1) Connect the TE to the test circuit as shown in Figure 3.5.3.2.

(2) Set the Signal Analyzer to capture the maximum signal power in the 800 Hz to 2750 Hz band (power level in dBm measured against 600 Ω with a two-second average).

(3) Initiate a call to the TE.

(4) Using band power markers, measure the maximum signal power in the 800 Hz to 2450 Hz band and in the 2450 Hz to 2750 Hz band after the TE goes off-hook for the first two seconds.

(5) Compare the energy in the 2450 Hz to 2750 Hz band to the energy in the 800 Hz to 2450 Hz band. The 2450 Hz to 2750 Hz band shall be less than or equal to the simultaneous power present in the 800 Hz to 2450 Hz band.

(6) Compute the ratio: \[
\frac{\text{GuardBand Vac}}{\text{Signalling Band Vac}}
\]

(7) Repeat steps (3) to (5) for all other call answering modes, if applicable.
Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.5.4 Answer Supervision – Operating Requirements for Direct Inward Dialling (Reverse Battery Trunk Interface)

3.5.4.1 Requirements

For TE connected to reverse battery trunk interface, the off-hook state shall be applied within 0.5 seconds of the time that:

1. The TE permits the acceptance of further digits that may be used to route the incoming call to another destination.

2. The TE transmits signals towards the calling party, except the call progress tones (e.g. busy, reorder, and audible ring) and the call is:

   a. answered by the destination station, or by another station;
   b. answered by the attendant;
   c. routed to a customer-controlled or defined recorded announcement, except for “number invalid”, “not in service” or “not assigned”;
   d. routed to a dial prompt; or
   e. routed back to the public switched telephone network or other destination and the call is answered. If the status of the answered call cannot reliably be determined by the TE through detection of answer supervision or voice energy, removal of audible ring, or some other means, the off-hook state shall be applied after an interval of not more than 20 seconds from the time of such routing.
The off-hook state shall be maintained for the duration of the call.

3.5.4.2 Network Protection Devices

(1) Network protection devices shall block incoming transmissions from the network until an off-hook signal is received from the TE.

(2) Network protection devices shall provide an off-hook signal within 0.5 seconds following the receipt of an off-hook signal from the TE and shall maintain this off-hook signal for the duration of the call.

3.5.4.3 Method of Measurement

(1) Connect the companion TE and the digital DC voltmeter to the tip and ring leads of the TE as shown in Figure 3.5.4.3.

(2) Connect the digital DC voltmeter across the tip and ring leads of the TE.

(3) Connect the companion TE (e.g. a telephone) to the called station under test.

(4) Connect channel 1 of the storage oscilloscope (between ring lead and ground) to the TE.

(5) Connect channel 2 of the storage oscilloscope (between ring lead and ground) to the called station under test.

(6) Originate a direct inward dialling call from the companion TE.

(7) Monitor the TE line loop polarity with the digital DC voltmeter.

(8) Observe and record, with the storage oscilloscope, the elapsed period between the time that the called PBX station goes off-hook to answer the call and the time required for the TE to transmit the line reversed answer supervision signal to the network.

(9) Ensure that the line reversed answer supervision state is maintained for the duration of the call.

(10) Repeat steps (6) to (9) for each call answering mode (i.e. answered by the attendant, answered by a recorded message, forwarded call to another trunk, etc.).
3.6 Transverse Balance

3.6.1 Requirements and Application

The metallic-to-longitudinal balance coefficient, Transverse Balance $M-L$, is expressed as:

$$\text{Balance } M-L (\text{dB}) = 20 \log \left( \frac{V_M}{V_L} \right)$$

where:

- $V_L$ is the longitudinal voltage produced across a longitudinal termination $Z_l$; and
- $V_M$ is the metallic voltage across the tip and ring or tip_1 and ring_1 interface of the input port when a voltage (at any frequency between $f_1 < f < f_2$, see Table 3.6.1) is applied from a balanced source with metallic impedance $Z_0$ (see Table 3.6.1).

The source voltage should be set such that $V_M = E$ volts (see Table 3.6.1) when a termination of $Z_0$ is substituted for the TE.
Table 3.6.1 – Source Voltage for $Z_0$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Analog Voice Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal Termination - $Z_l$</td>
<td>500 $\Omega$</td>
</tr>
<tr>
<td>Metallic Source Impedance - $Z_0$</td>
<td>600 $\Omega$</td>
</tr>
<tr>
<td>Lower Frequency - $f_1$</td>
<td>200 Hz</td>
</tr>
<tr>
<td>Upper Frequency - $f_2$</td>
<td>4000 Hz</td>
</tr>
<tr>
<td>Metallic Voltage for Test - $E$</td>
<td>0.775 V</td>
</tr>
</tbody>
</table>

The minimum transverse balance coefficient specified in this section (as appropriate) shall be equalled or exceeded for all 2-wire network ports, OPS line ports and the transmit pair (tip and ring) and receive pair (tip_1 and ring_1) of all 4-wire network ports at all values of DC loop current that the port under test is capable of drawing when attached to the appropriate loop simulator circuit.

An illustrative test circuit that satisfies the above conditions is shown in Figure 3.6.3(a).

The minimum transverse balance requirements specified below shall be equalled or exceeded under all reasonable conditions of the application of earth ground to the equipment or protective circuitry under test.

### 3.6.2 Analog Voice Band Equipment

All analog voice band equipment shall be tested in the off-hook state. The transverse balance requirement in the off-hook state is 40 dB throughout the range of frequencies specified in Table 3.6.1.

For some TE categories, additional requirements also apply to the on-hook state. When both off-hook and on-hook requirements apply, the transverse balance requirements are as given in Table 3.6.2.

Table 3.6.2 – Transverse Balance Requirements for On-hook and Off-hook States

<table>
<thead>
<tr>
<th>Hook State</th>
<th>Frequency Range (Hz)</th>
<th>Transverse Balance Requirement (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-hook</td>
<td>$200 \leq f \leq 4000$</td>
<td>$\geq 40$</td>
</tr>
<tr>
<td>On-hook</td>
<td>$200 \leq f \leq 1000$</td>
<td>$\geq 60$</td>
</tr>
<tr>
<td>On-hook</td>
<td>$1000 &lt; f \leq 4000$</td>
<td>$\geq 40$</td>
</tr>
</tbody>
</table>

Both off-hook and on-hook requirements shall apply as follows:

1. For analog one-port 2-wire TE with loop-start, ringdown or in-band signalling, or for voice band metallic channel applications, both off-hook and on-hook requirements apply.

2. For analog one-port equipment with ground-start and reverse battery signalling, only off-hook requirements apply.
(3) For analog network protection devices for 2-wire applications with loop-start, ringdown, or in-band signalling; or for voice band metallic channel applications, both off-hook and on-hook requirements apply.

(4) The requirements of transverse balance shall be satisfied while in the hold state. Any internal source of audio may be inhibited for this test and any external source may be connected to a quiet termination.

These criteria shall be satisfied with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in impedance which will be reflected to the TE connection as 600 $\Omega$ in the off-hook state of the protective circuit, and the interface should not be terminated in the on-hook state. Figures 3.6.3(c) and (d) show the interfaces of the protective circuitry being tested and the required arrangement at the interface to other equipment.

(5) For analog network protection devices with ground-start and reverse battery signalling, only off-hook requirements apply.

These criteria shall be satisfied with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in impedance which will be reflected to the telephone connection as 600 $\Omega$ in the off-hook state of the protective circuit. Figures 3.6.3(c) and (d) show the interface of the protective circuitry under test and the required arrangement at the interface to the other equipment.

(6) For analog multi-port equipment with loop-start signalling, both off-hook and on-hook requirements apply.

These criteria shall be satisfied for all ports when the ports are terminated in their appropriate networks, as will be identified below, and when interface connections other than the ports are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall also be satisfied for all values of DC loop current that the TE is capable of drawing through each of its ports when these ports are attached to the loop simulator circuit specified in these rules. The termination for all ports, other than the particular port for which the transverse balance coefficient is being measured, shall have metallic impedance of 600 $\Omega$ and longitudinal impedance of 500 $\Omega$. Figure 3.6.3(e) shows this termination.

(7) For analog multi-port equipment with ground-start and reverse battery signalling, only off-hook requirements apply.

These criteria shall be satisfied for all ports when all ports not under test are terminated in their appropriate networks, as will be identified below, and when interface connections other than the ports are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall be satisfied for all values of DC loop current that the TE is capable of drawing through each of its ports when these ports are attached to the loop simulator circuit specified in these rules. The termination for all ports, other than the particular port for which the transverse balance coefficient is being measured, shall have
metallic impedance of 600 Ω and longitudinal impedance of 500 Ω. Figure 3.6.3(e) shows this termination.

(8) For analog TE and network protection devices for 4-wire network ports, both the off-hook and on-hook requirements apply.

The pair not under test shall be terminated in metallic impedance of 600 Ω. Other conditions are as follows:

(a) For analog protective circuitry with loop-start, ground-start, reverse battery, ringdown, or in-band signalling; or for voice band metallic channel applications.

These criteria shall be satisfied with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated impedance that will result in 600 Ω at each of the transmit and receive pairs of the 4-wire telephone connection in the off-hook state of the protective circuit, and the interface should not be terminated in the on-hook state. Figure 3.6.3(c) shows the interface of the network protection devices being tested and the required arrangement at the interface to other equipment.

(b) For analog multi-port equipment with loop-start, ground-start, and reverse battery, ringdown, or in-band signalling; or for voice band metallic channel applications.

These criteria shall be satisfied for all network ports when the ports are terminated as defined below, and when interface connections other than the network ports are terminated in circuits appropriate to the interface. The criteria shall also be satisfied for all values of DC loop current when the port is connected to the appropriate 4-wire loop simulator circuit. The terminations for both pairs of all network ports not under test shall have metallic impedance of 600 Ω and longitudinal impedance of 500 Ω. See Figure 3.6.3(e) for this termination.

(9) For analog multiple-line equipment (or similar systems) with Class B or Class C off-premises interfaces, only off-hook requirements apply.

These criteria shall be satisfied for all off-premises station interface ports when these ports are terminated in their appropriate networks for their off-hook state, and when all other interface connections are terminated in circuits appropriate to that interface. The minimum transverse balance coefficients shall also be satisfied for all values of DC loop current that the registered PBX is capable of providing through off-premises station ports when these ports are attached to the off-premises line simulator circuit specified.

3.6.3 Method of Measurement

(1) Connect a 600 Ω resistor to the test circuit in Figure 3.6.3(a).

(2) Set the frequency generator to 200 Hz.
(3) Adjust the frequency generator to an output level of 0.775 Vrms as measured by the frequency selective voltmeter set at 10 Hz bandwidth and balanced input, across the 600 Ω calibration resistor.

(4) Connect the frequency selective voltmeter across the 500 Ω longitudinal termination resistor.

(5) Adjust variable capacitors C3 and C4 until the minimum level across the 500 Ω resistor is obtained. This represents the highest degree to which the bridge can be balanced at the frequency being measured referenced to the level set in step (3). The result of this balance calibration must be at least 20 dB greater than the balance requirement for the TE at that frequency. See Note 2 of Figure 3.6.3(a) for more details.

(6) Remove the 600 Ω resistor and connect the balance test set to the TE as shown in figure 3.6.3(b), (c) or (d).

(7) Vary the loop current, for off-hook conditions, over the available range of loop current (maximum 70 mA), observing the worst-case balance (maximum voltage across the 500 Ω resistor).

(8) Return the loop simulator to the condition resulting in the worst-case balance noted in step (7).

(9) Measure the voltage across the tip and ring of the TE. This is the metallic reference voltage (V_M).

(10) Measure the voltage across the 500 Ω resistor. This is the longitudinal voltage (V_L).

(11) Calculate the balance using the following formula:

\[ \text{Balance (dB)} = 20 \log \left( \frac{V_M}{V_L} \right) \]

(12) Reverse the tip and ring connections of the TE and repeat steps (9) to (11). The lesser of the two results is the transverse balance of the TE at 200 Hz.

(13) Repeat steps (3) to (12) for each of the following frequencies: 500, 1000, 2000, 3000 and 4000 Hz, with the resolution bandwidth set for 10 Hz for the 500 Hz measurement and 30 Hz for all other frequencies.

(14) Repeat steps (2) to (13) for all applicable TE states.
Figure 3.6.3(a) – Transverse Balance Measurement Test Set

**LEGEND:**
- **T1** – 600 Ohm, 1:1, Line Matching Transformer.
- **C1, C2** – 0\(\mu\)F, 400 Vdc, matched to within 0.1%.
- **C3, C4** – 100 to 500 pF adjustable trimmer capacitors.
- **OSC.** – Oscillator with a source resistance \(R_1 \leq 600\) ohm.
- **R2** – Selected such that \(Z_{os} + R_2 = 600\) ohms.
- **R3** – 500 Ohms.

**Notes:**

1. \(V_M\) should not be measured at the same time as \(V_L\).

2. Use trimmer capacitors C3 and C4 to balance test circuit to 20 dB greater balance than the equipment standard for all frequencies specified, with a 600 \(\Omega\) resistor substituted for the equipment under test.

3. When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
Figure 3.6.3(b) – Transverse Balance Method of Measurement (TE)

Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on the ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

Figure 3.6.3(c) – Required Termination for Connections to Unregistered Equipment, 2-Wire TE

Notes:

1. \( Z \) is selected so that the reflected impedance at tip and ring is 600 \( \Omega \), depending on the service type of the TE.
(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on the ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

Figure 3.6.3(d) – Required Termination for Connections to Unregistered Equipment, 4-Wire TE

Notes:

(1) Z is selected so that the reflected impedance at tip and ring is 600 Ω, depending on the service type of the TE.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on the ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.
3.7 On-hook Terminal Resistance and Impedance

3.7.1 Metallic and Longitudinal DC Resistance (Loop-start Interface)

3.7.1.1 Requirements

(1) On-hook resistance, metallic and longitudinal (up to 100 Vdc).

The on-hook DC resistance between the tip and ring conductors of a loop-start interface, and between each of the tip and ring conductors and earth ground, shall be greater than five MΩ for all DC voltages up to and including 100 V.

(2) On-hook resistance, metallic and longitudinal (100 V to 200 Vdc).

The on-hook DC resistance between tip and ring conductors of a loop-start interface, and between each of the tip and ring conductors and earth ground, shall be greater than 30 kΩ for all DC voltages between 100 and 200 V.

3.7.1.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.7.1.2.

(2) Set switches S1 and S2 to position “a” and the voltage to 1 Vdc, allowing time for the circuit to stabilize.

(3) Slowly increase the voltage to 100 V and observe the current as the voltage is increased:

(a) If the current is less than 0.2 μA over this range, measure and record the current at 1 V. Use this value to calculate the minimum DC resistance from 1 V to 100 V.
(b) If the current increases suddenly at any point, record the voltage and current at these points. Calculate the DC at these points.

(c) In addition to any points recorded in step (b), measure and record the current and voltages of 1, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 V. Calculate the DC resistance at these voltages.

(4) Slowly increase the voltage from 100 to 200 V and observe the current as the voltage is increased:

(a) If the current is less than 3.3 mA over this range, measure and record the current at 100 V. Use this value to calculate the minimum DC resistance from 100 to 200 V.

(b) If the current increases suddenly at any point, record the voltage and current at these points. Calculate the DC resistance at these points.

(c) In addition to any points recorded in step (b), measure and record the current at voltages of 100 V, 150 V, and 200 V.

(5) Reverse the polarity of the test circuit and repeat steps (2) to (4).

(6) Connect the TE to the test circuit in Figure 3.7.1.2. Set switches S1 to position “a” and S2 to position “b”.

(7) Repeat steps (2) to (5), with connections made to the tip and ground leads of the TE.

(8) Set switches S1 and S2 to position “b”.

(9) Repeat steps (2) to (5), with connections made to the ring and ground leads of the TE.

Figure 3.7.1.2 – On-hook Terminal Resistance Measurement
Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.7.2 DC Current During Ringing (Loop-start and Ground-start Interfaces)

3.7.2.1 Requirements

(1) During the application of simulated ringing (as listed in Table 3.7.3.1), to a loop-start interface, the total DC current shall not exceed 3 mA.

(2) During the application of simulated ringing (as listed in Table 3.7.3.1) to a ground-start interface, the total DC current shall not exceed 3 mA.

3.7.2.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.7.2.2.

(2) Set the test equipment to supply the lowest frequency and voltage listed in Table 3.7.3.1.

(3) Record the DC current.

(4) Increase the ringing voltage to the maximum value.

(5) Record the maximum DC current.

(6) Repeat steps (3) to (5) for the other frequency.

(7) Reverse the connections of the TE to the test circuit and repeat steps (2) to (6).
Note: When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

3.7.3 Metallic and Longitudinal Impedance During Ringing (Loop-start and Ground-start Interfaces)

3.7.3.1 Requirements

(1) During the application of simulated ringing (as listed in Table 3.7.3.1) to a loop-start or a ground-start interface, the impedance between the tip and ring conductors (defined as the quotient of applied AC voltage divided by resulting true r.m.s. current) shall be greater than the value specified in Table 3.7.3.1.

(2) During the application of simulated ringing (as listed in Table 3.7.3.1) to a loop-start interface, the impedance between each of the tip and ring conductors and ground shall be greater than 100 kΩ.
Table 3.7.3.1 – Application of Simulated Ringing

<table>
<thead>
<tr>
<th>Range of Compatible Ringing Frequencies (Hz)</th>
<th>Simulated Ringing Voltage Superimposed on 56.5 Vdc</th>
<th>Impedance Limitation (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ± 3</td>
<td>40 to 130 Vrms</td>
<td>1400</td>
</tr>
<tr>
<td>30 ± 3</td>
<td>40 to 130 Vrms</td>
<td>1000</td>
</tr>
</tbody>
</table>

3.7.3.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.7.2.2.

(2) Set the frequency generator to the lowest frequency and voltage listed in Table 3.7.3.1.

(3) Record the current.

(4) Calculate the AC impedance of the TE.

(5) Increase the ringing voltage to the maximum as indicated in Table 3.7.3.1.

(6) Record the current.

(7) Calculate the AC impedance of the TE.

(8) Repeat steps (2) to (7) for the other frequency.

(9) Reverse the connections of the TE to the test circuit and repeat steps (2) to (8).

(10) **For loop-start only**, connect the TE to the test circuit of Figure 3.7.3.2 and repeat steps (2) to (9).
### Note:
When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

### 3.7.4 OPS Interface for PBX With DID – Ring Trip Requirements

PBX ringing supplies whose output appears on the off-premises interface leads shall not trip when connected to the following tip to ring impedance that terminates the off-premises station loop: terminating impedance composed of the parallel combination of a 15 kΩ resistor and a capacitor (RC) in series circuit whose AC impedance is as specified in Table 3.7.4.

#### Table 3.7.4 – AC Ring Impedance

<table>
<thead>
<tr>
<th>Ringing Frequency (Hz)</th>
<th>AC Impedance (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class B or C</td>
</tr>
<tr>
<td>20 ± 3</td>
<td>7000/N</td>
</tr>
<tr>
<td>30 ± 3</td>
<td>500/N</td>
</tr>
</tbody>
</table>

N = Number of ringer equivalence which can be connected to the off-premises station loop, as specified by the manufacturer.
3.7.4.1 Method of Measurement

(1) Calculate the value for R and C, as specified in Section 3.7.4.

(2) Connect the TE to the circuit of Figure 3.7.4.1.

(3) Cause the TE to generate ringing toward the termination.

(4) Verify that ringing has not tripped.

Note: Test the PBX equipment while it is ringing an off-premises station.

Figure 3.7.4.1 – OPS Ring Trip

3.8 Idle State Terminal Impedance-return Loss and Transducer Loss (Tie Trunk Interface)

3.8.1 Requirements

Limitations on idle circuit stability parameters: for idle state operating conditions of TE and network protective devices, the following limitations shall be satisfied:

(1) For the 2-wire interface:

\[ RL \geq \begin{cases} 
9 - 3\frac{\log(f/200)}{\log(2.5)} dB & \text{for } 200 Hz \leq f \leq 500 Hz \\
6 \text{db} & \text{for } 500 Hz \leq f \leq 3200 Hz
\end{cases} \]
(2) For the 4-wire lossless interface:

\[
\begin{align*}
  t_l_f & \geq \\
  & \begin{cases} 
    10 - 4 \log(f / 200) \frac{1}{\log(2.5)} dB & ; \text{for } 200 \text{ Hz} \leq f \leq 500 \text{ Hz} \\
    6 dB & ; \text{for } 500 \text{ Hz} \leq f \leq 3200 \text{ Hz}
  \end{cases} \\
  t_l_r & < 40 dB
\end{align*}
\]

**RL**, **RL** ≥ 3 dB

**Note:** The following definitions apply to return loss requirements:

RL - the return loss of 2-wire TE at the interface with respect to 600 Ω + 2.16 µF (i.e. Z_{ref} = 600 Ω + 2.16 µF):

\[
RL \triangleq 20 \log_{10} \left| \frac{Z_{PBX} + Z_{REF}}{Z_{PBX} - Z_{REF}} \right|
\]

RL_t - the TE input (receive) port return loss with respect to 600 Ω (i.e. Z_{ref} = 600 Ω):

\[
RL_t \triangleq 20 \log_{10} \left| \frac{Z_{PBX(\text{input})} + Z_{REF}}{Z_{PBX(\text{input})} - Z_{REF}} \right|
\]

RL_o - the TE output (transmit) port return loss with respect to 600 Ω (i.e. Z_{ref} = 600 Ω):

\[
RL_o \triangleq 20 \log_{10} \left| \frac{Z_{PBX(\text{output})} + Z_{REF}}{Z_{PBX(\text{output})} - Z_{REF}} \right|
\]

\( t_l \) - the transducer loss between the receive and transmit ports of the 4-wire PBX:

\( t_l_f \) is the transducer loss in the forward direction from the receive port to the transmit port of the PBX.

\[
\begin{align*}
  t_l_f & \triangleq 20 \log_{10} \left| \frac{I_{t}}{I_{r}} \right| \\
  t_l_r & \text{ is the transducer loss in the reverse direction, from the transmit port to the receive port of the PBX.}
\end{align*}
\]

where:

\( I_{t} \) is the current sent into the receive port

\( I_{r} \) is the current received at the transmit port, terminated at 600 Ω
\[
d_{r} \triangleq 20 \log_{10} \left| \frac{I_{i}}{I_{r}} \right|
\]

where:

- \(I_{i}\) is the current sent into the transmit port
- \(I_{r}\) is the current received at the receive port terminated at 600 \(\Omega\).

**Note:** The source impedance of \(I_{i}\) is 600 \(\Omega\).

### 3.8.1.1 Method of Measurement

#### 3.8.1.1.1 2-Wire Return Loss

1. Connect the TE to the test circuit as shown in Figure 3.8.1.1.2(a). Refer to note for devices connected in series with tip and ring.

   **Note:** When testing devices connected in series with tip and ring, terminate the output tip and ring terminals of the series device with 600 \(\Omega\) in series with 2.16 \(\mu\)F, using an appropriate simulator circuit, as shown in Section 4. Perform steps (1) to (4) at the input tip and ring terminals.

2. Set the tracking generator to 0.5 Vrms (0.6 dBV) or higher, and manually or automatically sweep the band from 200 Hz to 3200 Hz as a minimum, with the spectrum analyzer measuring the level in dBV across points A and D (switch in position “a”). This is the reference level measurement.

3. Without adjusting the tracking generator level, manually or automatically sweep the same frequency band as used in step (2), with the spectrum analyzer now measuring the level in dBV across points B and C (switch in position “b”).

4. The difference in dB between the reference level measured in step (2) and the level measured in step (3) is the return loss of the TE port at any given frequency. The return loss will be a positive value.

#### 3.8.1.1.2 4-Wire Return Loss

1. Connect the TE to the test circuit as shown in Figure 3.8.1.1.2(b). Refer to note for devices connected in series with tip and ring.

   **Note:** When testing devices connected in series with tip and ring, terminate the output tip and ring terminals of the series device with 600 \(\Omega\) using an appropriate simulator circuit as shown in Section 4. Perform steps (1) to (6) at the input tip and ring terminals.

2. Set the tracking generator to 0.5 Vrms (0.6 dBV) or higher, and manually or automatically sweep the band from 200 Hz to 3200 Hz as a minimum, with the spectrum analyzer measuring the level in dBV across points A and D (switch in position “a”). This is the reference level measurement.
(3) Without adjusting the tracking generator level, manually or automatically sweep the same frequency band as used in step (2) with the spectrum analyzer now measuring the level in dBV, across points B and C (switch in position “b”).

(4) The difference, in dB, between the reference level measured in step (2) and the level measured in step (3) is the return loss of the TE port at any given frequency. The return loss will be a positive value.

(5) Connect the TE to the test circuit as shown in Figure 3.8.1.1.2(c).

(6) Repeat steps (2) to (4).

Figure 3.8.1.1.2(a) – Return Loss, 2-Wire, T&R

\[Z_{REF} = 600 \text{ ohm in series with } 2.16\mu F\]
Figure 3.8.1.1.2(b) – Return Loss, 4-Wire, T&R

Figure 3.8.1.1.2(c) – Return Loss, 4-Wire, T1&R1
3.8.1.2 Measuring Transducer Loss

(1) Adjust the tracking generator output level to -10 dBV into a 600 Ω load, measured at 1004 Hz. Sweep the band from 200 Hz to 3200 Hz with the spectrum analyzer measuring the level in dBV. This is the reference level measurement.

(2) Connect the TE to the test circuit of Figure 3.8.1.2(a).

(3) Without adjusting the tracking level generator level, sweep the same frequency band as used in step (1), with the spectrum analyzer measuring the level in dBV.

(4) The difference, in dB, between the reference level measured in step (1) and the level measured in step (3) is the forward transducer loss of the TE port at any given frequency.

(5) Connect the TE to the test circuit of Figure 3.8.1.2(b).

(6) Repeat steps (3) and (4).

**Note:** The transducer loss measured in this case is the reverse transducer loss.
3.9 Automatic Dialling and Automatic Redialling

3.9.1 Requirements

Note: Emergency alarm diallers and diallers under external computer control are exempt from these requirements.

(1) Automatic dialling to any individual number is limited to two successive attempts. Automatic dialling equipment which employs means for detecting both busy and reorder signals shall be permitted an additional 13 attempts if a busy or reorder signal is encountered on each attempt. The dialler will be unable to re-attempt a call to the same number for at least 60 minutes following either the second or fifteenth successive attempt, whichever applies, unless the dialler is reactivated through either manual or external means. This rule does not apply to manually activated diallers which dial a number once, following each activation.

(2) If means are employed for detecting both busy and reorder signals, the automatic dialling equipment shall return to its on-hook state within 15 seconds after detection of a busy or reorder signal.

(3) If the called party does not answer, the automatic dialler shall return to the on-hook state within 60 seconds of completion of dialling.

(4) If the called party answers and the calling equipment does not detect a compatible TE at the called end, then the automatic dialling equipment shall be limited to one additional call which is answered. The automatic dialling equipment shall comply with (1), (2), and (3) for additional call attempts that are not answered.

(5) Sequential diallers shall dial only once to any individual number before proceeding to dial another number.
(6) Network addressing signals shall be transmitted no earlier than:

(a) 70 ms after receipt of dial tone at the network demarcation point;
(b) 600 ms after automatically going off-hook (for single line equipment that does not use dial tone detectors); or
(c) 70 ms after receipt of the central office (CO) ground-start at the network demarcation point.

3.9.2 Method of Measurement

(1) Consult the TE manual to determine if the equipment is capable of detecting call progress tones (i.e. dial tone, busy tone and any reorder tone).
(2) Connect the TE as shown in Figure 3.9.2 and condition it to automatically dial a pre-programmed number. Count the number of times that the TE will dial the same number. Record the reading.
(3) Set the storage scope to trigger when the TE goes off-hook. Upon the application of a busy tone, or a reorder tone, use the storage scope to observe if the TE goes back to the on-hook state in less than 15 seconds. Record the reading.
(4) Apply a dial tone to the TE when it goes off-hook, before the device automatically dials the pre-programmed number. Using the storage scope, record the time from the beginning of dial tone to dialling initiation. Record the reading.

Figure 3.9.2 – Automatic Dialling and Redialling

3.10 Stuttered Dial Tone Detection

Stuttered dial tone detection equipment places the loop in the off-hook state to check for the presence of stuttered dial tone.
3.10.1 Requirements

TE that automatically goes off-hook for the purpose of checking for stutter dial tone shall be acceptable for connection to the telephone network provided that it meets all of the applicable requirements of this part, as well as the following requirements:

1. The equipment shall not perform periodic testing for stuttered dial tone.

2. The equipment shall make a stuttered dial tone check no more than once after a completed calling event, and shall begin the check no earlier than four seconds after the subscriber hangs up.

3. The equipment shall not make a check more than once after an unanswered incoming calling event.

4. The equipment shall not perform a check after an unanswered incoming call event if the message waiting indicator is already lit or on.

5. The equipment shall operate in the off-hook mode for no more than 2.1 seconds when checking for stuttered dial tone. The measurement of the interval shall begin when dial tone is applied. The equipment should abandon the check for stuttered dial tone if dial tone is not applied within three seconds.

6. The equipment shall synchronize checks when multiple stutter dial tone detectors and visual message signalling indicators are connected to the same network interface, so that only one check is made per calling event.

7. The equipment shall not block dial tone when a calling event is initiated during a check for stuttered dial tone.

3.10.2 Demonstration of Compliance

The applicant shall present an attestation which states that the equipment meets requirements (1), (6) and (7) of Section 3.10.1. Compliance with requirements (2), (3), (4) and (5) shall be demonstrated in accordance with the method of measurement described in Section 3.10.3.

3.10.3 Method of Measurement

1. Connect the TE to the test circuit of Figure 3.10.3.

2. Simulate the completion of a calling event by means of the host or ancillary telephone set. Monitor and record the number of stuttered dial tone checks that occur and when they occur.

3. Simulate an unanswered incoming calling event by means of the loop simulator and a ringing generator. Monitor and record the number of stuttered dial tone checks that occur and when they occur. If the device has a visual message indicator, set the TE so that the indicator is lit. Simulate an unanswered incoming calling event. Monitor and record the number of stuttered dial tone checks that occur and when they occur.
(4) Cause the TE to perform a stuttered dial tone check, as outlined in step (3) above. When the device goes off-hook, apply dial tone within three seconds. Measure the amount of time from the initial application of the dial tone to when the device goes back on-hook.

(5) Cause the TE to perform a stuttered dial tone check, as outlined in step (3) above. When the device goes off-hook, do not apply dial tone within the first three seconds. Monitor and record when the TE goes back on-hook.

**Figure 3.10.3 – Stuttered Dial Tone Detector Timing Measurement Circuit**

![Stuttered Dial Tone Detector Timing Measurement Circuit](image)

**Notes:**

(1) In this method of measurement, it is assumed that the stuttered dial tone detector is part of a host message waiting telephone set. If the detector is a standalone device, a telephone set may need to be connected in parallel with the detector in order to achieve the test modes described in steps (2) and (3) of Section 3.10.3.

(2) When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

### 3.11 Manual Programming of Memory Dialling Numbers

#### 3.11.1 Requirements

TE that is placed in the off-hook state by the user for the purpose of manually placing telephone numbers in internal memory for subsequent automatic or repertory dialling, shall be acceptable for connection to the telephone network provided it meets all other applicable requirements. Such
equipment shall be able to program memory dialling in the off-hook state without providing actual network address signalling (e.g. DTMF or pulse dialling).

### 3.11.2 Method of Measurement

1. Examine customer instructions for the TE and determine if it has the capability of programming internal memory for automatic or repertory dialling.

2. Set the TE to the appropriate dial method, tone dialling or pulse dialling, and connect to the circuit in Figure 3.11.2.

3. Place the TE off-hook and perform the recommended programming sequence.

**Figure 3.11.2 – Manual Programming of Repertory Dialling Numbers**

![Diagram of Manual Programming of Repertory Dialling Numbers]

**Notes:**

1. Select the appropriate loop simulator for the interface of the TE. Refer to the figures shown in Section 4.

2. The oscilloscope should provide a balanced input.

3. When the TE makes provision for an external connection to ground (G), the TE shall be connected to ground. When the TE makes no provision for an external ground, the TE shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the TE. The TE shall be centrally located on the ground plane without any additional connection to ground. At no point in time should any metal surface of the TE come in contact with the ground plane. If the TE has exposed metal that could come in contact with the metal ground plane, a thin insulating material shall be inserted between the ground plane and the TE.

### 4. Special Test Circuits

The special test circuits required to perform the tests described in Section 3 are shown in schematic form in this section.
4.1 Loop Simulator for Loop-start and Ground-start Circuits

Figure 4.1 – Loop Simulator for Loop-start and Ground-start Circuits

![Diagram of loop simulator circuit]

Table 4.1 – Test Conditions for Loop Simulator

<table>
<thead>
<tr>
<th>Condition</th>
<th>V, volts</th>
<th>Switch Position for Test</th>
<th>R + RL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42.5 to 52.5</td>
<td>Both</td>
<td>Continuously variable over 400 to 1740 Ω</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>(b)</td>
<td>2000 Ω</td>
</tr>
</tbody>
</table>

Notes:

(1) Means shall be employed to generate, at the point of tip and ring connections to the terminal equipment (TE) protective circuitry, the parameters of DC line current and AC impedance which are generated by the illustrative circuits described above (as appropriate for the equipment under test).

(2) In performing the longitudinal balance (Section 3.6), the use of the “DC portion of the loop simulator circuit” is specified.
4.2 Loop Simulator for Reverse Battery Circuits

Figure 4.2 – Loop Simulator for Reverse Battery Circuits

\[ R + R_L = \text{Continuously variable over 400 to 2450 } \Omega \]

Notes:

(1) Means shall be employed to generate, at the point of tip and ring connections to the TE protective circuitry, the parameters of DC line current and AC impedance which are generated by the illustrative circuits described above (as appropriate for the equipment under test).

(2) In performing the longitudinal balance (Section 3.6), the use of the “DC portion of the loop simulator circuit” is specified. In such cases, components C1 and C2 shall be removed.
4.3 Loop Simulator for 4-Wire Loop- and Ground-start Circuits

Figure 4.3 – Loop Simulator for 4-Wire Loop- and Ground-start Circuits

S1 = POLARITY SWITCH
L1 = L2 = L3 = L4 = > 5H, (Resistance = RL1, RL2, RL3, RL4)
R1 = R3 = 600 ohms, ±1%
C1 + C2 = 500 μF, ±10%, matched to 5% (non-electrolytic)

Table 4.3 Test Conditions for Loop Simulator

<table>
<thead>
<tr>
<th>Condition</th>
<th>V, volts</th>
<th>Switch Position for Test</th>
<th>R2 + RL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42.5 to 52.5</td>
<td>(a) and (b)</td>
<td>Continuously variable over 400 to 2450 Ω</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>(b)</td>
<td>1740 Ω</td>
</tr>
</tbody>
</table>
4.4 Loop Simulator for 4-Wire Reverse Battery Circuits

**Figure 4.4 – Loop Simulator for 4-Wire Reverse Battery Circuits**

\[
\begin{align*}
S1 &= \text{POLARITY SWITCH} \\
L1 &= L2 = L3 = L4 = > 5\, \text{H}, (R\text{esistance} = RL1, RL2, RL3, RL4) \\
R1 &= R3 = 600\, \text{ohms}, \pm 1\% \\
C1 + C2 &= 500\, \mu\text{F}, \pm 10\%, \text{matched to 5\% (non-electrolytic)} \\
\end{align*}
\]

\[R2 + RL = \text{Continuous variable over 400 to 2450} \, \Omega.\]
4.5 Off-Premises Loop Simulator

The minimum DC current present for all resistance ranges of conditions 1 and 2 shall be 16 mA, as per the following table:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Switch Position for Test</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(a)</td>
<td>RL to 200 Ω</td>
<td>RL to 800 Ω</td>
<td>RL to 1800 Ω</td>
</tr>
<tr>
<td>2</td>
<td>(b)</td>
<td>Not Applicable</td>
<td>200 to 2300 Ω</td>
<td>900 to 3300 Ω</td>
</tr>
</tbody>
</table>

Notes:

(1) Means shall be used to generate, at the point of tip (T OPS) and ring (R OPS) connections to the PBX, the range of the resistance and impedance which are employed by the illustrative circuit depicted above.

(2) For the longitudinal balance (Section 3.6), the use of the “DC portion of the line simulator” is specified. In such cases, components C1 and C2 shall be removed.
4.6 Alternative Off-hook Termination

Figure 4.6 – Alternative Off-hook Termination

Note: This alternative termination is used to replace 600 Ω.
4.7 E&M Signalling

4.7.1 TE on Side “A”

Figure 4.7.1 – E&M Types I & II Signalling (TE Originates on M Lead)

Note: For two wire interface T1 and R1 are not used.
4.7.2 TE on Side “B”

Figure 4.7.2 – E&M Types I & II Signalling (TE Originates on E Lead)

Note: For two-wire interface T1 and R1 are not used.
4.8 Reference Information

4.8.1 Reverse Battery Trunk Interface

Direct inward dialing (DID) TE interface functions are interpreted as follows:

Table 4.8.1 – DID TE Interface Functions

<table>
<thead>
<tr>
<th>TE Response/Condition for Incoming Calls</th>
<th>Tones</th>
<th>Answer Supervision</th>
<th>Failure Mode Supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Busy 60 IPM</td>
<td>Reorder 120 IPM</td>
<td>Required</td>
</tr>
<tr>
<td>If the station answers</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If the call is answered by an attendant, a recorded announcement or other means</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If the number is busy</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If all transmission paths in the TE are busy</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If the TE returns ring back tone to the caller</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>If all incoming trunks to the TE are busy</td>
<td>N/A</td>
<td>The network will indicate all-trunks-busy to the caller N/A.</td>
<td>N/A</td>
</tr>
<tr>
<td>If the TE is out of service due to: maintenance, power failure, power disconnected or other malfunctions or conditions</td>
<td>The network will indicate all-trunks-busy to the caller. (See Note 1.)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>If the terminal TE returns dial tone to the caller (see Note 2)</td>
<td></td>
<td>The network will indicate all-trunks-busy to the caller. (See Note 1.)</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes:

(1) This condition is the result of failure mode supervision from the TE.

(2) Applicable to a TE that is arranged to return a dial prompt to the calling party for the purpose of accepting further dialled digits that may be used to re-route the incoming call to another destination.

See also Section 3.5.4 for more information on direct inward dialing.
5. Terminal Equipment (TE) Installation Wiring

Note: This section is for information purposes only and does not form part of the mandatory requirements.

5.1 Scope

This section provides guidelines for the installation and wiring of technical equipment (TE) when the installation of such equipment requires inside or in-building wiring that is not an integral part of the equipment as registered. Such installation shall be carried out under the supervision of qualified personnel and shall be in accordance with the guidelines of this section to ensure that registration requirements are met once the TE is connected to the network.

5.2 General

TE and all associated installation wiring could, under certain circumstances, become exposed to extraneous voltages, current and surges from the network and from connections to other equipment. For example, they could be subjected to lightning-induced voltage surges of up to a 1000 V peak. The average rise time of such a surge is 100 µs. The minimum rise time can be less than 10 µs. The customer is responsible for ensuring that TE is normally connected to inside or in-building wiring.

There may also be times when the TE and all associated installation wiring may be subjected to voltages and current resulting from contact with commercial power facilities under fault conditions. There should be sufficient high impedance between the tip and ring and ground reference to allow the metallic and longitudinal voltages to rise at approximately the same rate as a lightning surge. TE and the associated installation wiring should be capable of safely withstanding these extraneous voltages, currents, and surges. It shall be installed in a manner that ensures continued compliance with the network protection requirements described in Section 3.

5.3 Safety Requirements

The installation of the TE and associated wiring shall be in accordance with the most recent version of the Canadian Electrical Code – Part I (issued by the Canadian Standards Association, which is the standard used to specify safety requirements for electrical installations).

5.4 Technical Requirements

5.4.1 Demarcation Point

The demarcation point, as defined in the CRTC Telecom Decision 99-10, is the physical location (“point”) where the wires and facilities on one side of the point are under the responsibility and control of one party, while the wires and facilities on the other side of the point are under the responsibility and control of a different party. For single residences, the demarcation point is at the carrier-provided jack which shall be installed at an accessible location mutually agreed upon by the carrier and the customers. For multiple-dwelling units, in-building wiring may be owned by a telecommunications service provider or the property owner. Installation practices may vary depending on the type of building.
5.4.2 Type of Wiring

Wires, cables and connecting devices used in the installation shall be of a type designed for use in telecommunications applications and shall be suitable for the location and conditions under which they are used. The manufacturer’s published recommendations of either the wiring or TE shall be considered sufficient indication of suitability. Examples of good installation practices may be found in CSA Standards T525-94 (R1999), Residential Wiring for Telecommunications, and T568.1-05 (R2010), Telecommunications Cabling Systems in Commercial Buildings.

5.4.3 Limitations on Wiring

The total loss of the TE and the wiring from the demarcation point to the furthest TE should be limited by the following conditions:

1. if TE is intended for connection to CO lines:
   a. added resistance of 50 Ω; and
   b. transmission loss of 0.5 dB.

2. if TE is intended for connection to trunks:
   a. no added resistance; and
   b. transmission loss of 2.5 dB.

Where the above limits are insufficient to meet the customer’s requirements, the customer shall contact the service provider to determine jointly whether the particulars of the proposed installation will ensure minimum transmission specifications. In the event that transmission compensation is required, the customer may incur additional charges.

5.4.4 Communications Ground

In order to minimize the introduction of noise, TE requiring a communication ground separate from the safety (green wire) ground shall have a low-impedance path to the main building ground source, independent of that provided by the carrier for its equipment.

Note: In locations where the local building ground potential may be expected to rise to hazardous levels relative to a remote ground, due to the proximity of an electric power station or similar installation, engineering coordination with the carrier shall be required.

5.5 Qualifications of Installation Supervision

The person responsible for the direct supervision of the personnel performing the installation shall have the necessary qualifications outlined in the appropriate documents.