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Spectrum Management and Telecommunications

Compliance Specification for Terminal Equipment, Terminal Systems, Network Protection Devices, Connection Arrangements and Hearing Aids Compatibility

Part VII: Requirements for Limited Distance Modems and Digital Subrate Terminal Equipment

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Canada

Contents

1.0 Introduction

1.1 Scope

This part sets forth the minimum technical requirements for Limited Distance Modem (LDM) Terminal Equipment (TE) and Digital Subrate (DS) TE.

1.2 Technical Requirements

The technical requirements for LDM TE and for DS TE are given in the Table A. For each of the types of TE covered by this specification an asterisk (*) indicates which of the requirements apply.

Table A

Technical Requirements LDM TE and Digital Subrate TE

Requirement		LDM TE	Digital Subrate TE
2.0	Electrical and Mechanical Stresses	*	*
3.1.1	Signal Level Limitations	*	
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1.3 Sequence of Equipment Testing

1.3.1 Overall Sequence

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

Section 1.4	Connecting Arrangements
Section 1.5	Operational Check
Section 3.0	Network Protection Requirements and Tests
Section 2.1 (Part I)	Mechanical Shock
Section 2.2 (Part I)	Dielectric Strength
Section 2.3 (Part I)	Hazardous Voltage Limitations
Section 2.4 (Part I)	Surge Voltage (Type B)
Section 1.5	Operational Check
Section 3.0	Network Protection Requirements and Tests
Section 2.2 (Part I)	Dielectric Strength
Section 2.3 (Part I)	Hazardous Voltage Limitations
Section 2.4 (Part I)	Surge Voltage (Type A)
Section 1.5	Operational Check
Section 3.0	Network Protection Requirements and Tests

Note 1:

(a) Section 2.2 (Part I) specifies the requirements and tests for dielectric strength to assure protection of the network from hazardous voltages arising from AC powered TE as well as from non-registered equipment connected to TE.

(b) Sections 2.3 and 2.4 (Part I) specify the requirements and tests for:

- environmental conditioning electrical stress prior to repeating tests of Section 3.0;
- hazardous voltage isolation.

Note 2: The steady state voltage stress tests specified in Section 2.3 (Part I) shall be performed prior to the electrical surge tests of Section 2.4 (Part I).

1.4 Connecting Arrangements

TE intended for direct electrical connection shall be equipped with a cord and plug or chassis mounted connector in accordance with Part III identifying the connector codes used.

1.5 Operational Check

The TE shall be fully operational when checked in accordance with the operating instructions for all features which are described in the manufacturer's instruction manual and which are necessary to allow demonstration of compliance with all applicable requirements of Section 3.0.

2.0 Electrical and Mechanical Stresses

Refer to Part I, Section 2.0.

3.0 Network Protection Requirements and Tests

3.1 Requirements and Test Methods for LDM TE

3.1.1 Signal Level Limitations

3.1.1.1 Requirements

The metallic voltage shall comply with the general requirements in (1) below as well as the additional requirements specified in (2) and (3) as stated. The requirements apply under the conditions specified in Section 3.1.2. TE for which the magnitude of the source and/or terminating impedance exceeds 300 ohms, at any frequency in the range of 100 kHz to 6 MHz, at which the signal (transmitted and/or received) has significant power, shall be deemed not to comply with these requirements. A signal is considered to have 'significant power' at a given frequency if that frequency is contained in a designated set of frequency bands which collectively have the property that the rms voltage of the signal components in those bands is at least 90% of the rms voltage of the total signal. The designated set of frequency bands must be used in testing all frequencies.

(1) Metallic Voltages - Frequencies Below 4 kHz

(a) Weighted rms Voltage in the 10 Hz to 4 kHz Frequency Band

The weighted rms metallic voltage averaged over 100 milliseconds (frequency components weighted in accordance with the transfer function F/4000) shall not exceed the maximum indicated below:

Frequency Range	Maximum Voltage
10 Hz to 4 kHz	+3 dBV

(b) rms Voltage in 100 Hz Bands in the Frequency Range 0.7 kHz to 4 kHz

The rms metallic voltage averaged over 100 milliseconds in the 100 Hz bands having centre frequencies between 750 Hz and 3950 Hz shall not exceed the maximum indicated below:

Centre Frequency (f) of 100 Hz Bands	Maximum Voltage
750 to 3950 Hz	-6 dBV

(2) Metallic Voltages—frequencies above 4 kHz—LDM interface

(a) 100 Hz Bands over Frequency Range of 4 kHz to 270 kHz

The rms voltage as averaged over 100 milliseconds in all possible 100 Hz bands between 4 kHz and 270 kHz for the indicated range of centre frequencies and under the conditions specified in Section 3.1.4 shall not exceed the maximum indicated below:

Centre Frequency (f) of 100 Hz Bands	**Maximum Voltage in all 100 Hz Bands**
4.05 kHz - 4.60 kHz	0.5 dBV
4.60 kHz - 5.45 kHz	(59.2-90 log f) dBV
5.45 kHz - 59.12 kHz	(7.6-20 log f) dBV
59.12 kHz - 266.00 kHz	(43.1-40 log f) dBV

Where f = centre frequency in kHz of each of the possible 100 Hz bands.

(b) 8 kHz Bands over Frequency Range of 4 kHz to 270 kHz

The rms voltage as averaged over 100 milliseconds in all of the possible 8 kHz bands between 4 kHz and 270 kHz for the indicated range of centre frequencies and under the conditions specified in Section 3.1.4 shall not exceed the maximum indicated below:

Centre Frequency (f) of 8 Hz Bands	**Maximum Voltage in all 8 Hz Bands**
8 kHz - 120 kHz	(17.6-20 log f) dBV
120 kHz - 266 kHz	(59.2-40 log f) dBV

Where f = centre frequency in kHz of each of the possible 8 kHz bands.

(c) rms Voltage at Frequencies Above 270 kHz

The rms value of the metallic voltage components in the frequency range of 270 kHz to 6 MHz shall, averaged over 2 microseconds, not exceed -15 dBV. This limitation applies with a metallic termination having an impedance of 135 ohms.

(d) Peak Voltage

The total peak voltage for all frequency components in the 4 kHz to 6 MHz band shall not exceed 4.0 volts.

(3) Longitudinal Voltage

Requirement

(a) Frequencies Below 4 kHz

With the frequency components weighted in accordance with the transfer function f/4000, the weighted rms voltage of all frequency components, in the frequency band from 10 Hz to 4 kHz, averaged over 100 milliseconds, shall not exceed the maximum indicated below under the conditions stated in Section 3.1.4.

Frequency Range	**Maximum RMS Voltage**
10 Hz - 4 kHz	-37 dBV

(b) Frequencies from 4 kHz to 270 kHz

Centre Frequency (f) of 8 kHz Band	**Maximum Voltage in all 8 kHz Bands**	**Longitudinal Terminating Impedance**
8 kHz to 12 kHz	-(18.4+20 log f) dBV	500 ohms
12 kHz to 42 kHz	(3 - 40 log f) dBV	90 ohms
42 kHz to 266 kHz	-62 dBV	90 ohms

Where f = centre frequency in kHz of each of the possible 8 kHz bands.

(c) Frequencies from 270 kHz to 6 MHz

The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHz shall, averaged over 2 microseconds, not exceed -30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

3.1.2 Equipment Conditions Subject to Test

(1) Except during the transmission of ringing and Dual Tone Multi-frequency (DTMF) signals, LDM TE shall comply with all requirements in all operating states and with loop current which may be drawn for such purposes as loop back signalling. The requirements in Section 3.1.1.1(1) except in paragraphs (a) and (b) also apply during the application of ringing. The requirement in Section 3.1.1.1(1)(a) and (b) apply during ringing for frequencies above 300 Hz and with the maximum voltage limits raised by 10 dB. DTMF signals which are used for the transmission of alphanumeric information and which comply with the requirements in Section 3.1.1.1(1)(a) and in Section 3.1.1.1(2) or (3) as applicable, shall be deemed to comply with the requirements in

Section 3.1.1.1(1)(b) provided that, for automatically originated DTMF signals, the duty cycle is less than 50 percent.

(2) LDM TE shall comply with all applicable requirements, except those specified in Section 3.1.1.1(1)(a) and (b), during the transmission of each possible data signal sequence of any length. For compliance with Section 3.1.1.1(3)(a), the limitation applies to the rms voltage averaged as follows:

(a) For digital signals, baseband or modulated on a carrier, for which there are defined signal element intervals, the rms voltage is averaged over each such interval. Where multiple carriers are involved, the voltage is the power sum of the rms voltages for the signal element intervals for each carrier.

(b) For baseband analogue signals, the rms voltage is averaged over each period (cycle) of the highest frequency of the signal (3 dB point on the spectrum). For analogue signals which are modulated on a carrier (whether or not the carrier is suppressed), it is averaged over each period (cycle) of the carrier. Where multiple carriers are involved, the voltage is the power sum of the rms voltage for each carrier.

(c) For signals other than the types defined in 3.1.2(2)(a) and (b) of this section, the peak amplitude of the signal must not exceed +1 dBV.

(3) Equipment shall comply with the requirements in Section 3.1.1.1(1)(a) and (b) during any data sequence which may be transmitted during normal use with a probability greater than 0.001. If the sequences transmitted by an equipment are application dependent, the user instruction material shall include a statement of any limitations assumed in demonstrating compliance of the equipment.

(4) In addition to the conditions specified in paragraph (1) of this section, LDM TE which operates in one or more modes as a receiver, shall comply with requirements in Section 3.1.1.1(3) with a tone at all frequencies in the range of potential received signals and at the maximum power which may be received.

3.1.3 Method of Measurement (Metallic)

Note: Refer to Section 3.1.2 for applicable test conditions.

3.1.3.1 Frequencies Below 4 kHz (3.1.1.1(1)(a))

(1) Connect the TE to the test circuit of Figure 3.1.3(a).

(2) Select the 10 Hz to 4000 Hz band pass filter.

(3) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(4) Record the voltmeter reading.

(5) Repeat steps (3) and (4) for all possible states.

Note: The remaining steps are only applicable to 4-wire TE.

(6) Connect the TE to the test circuit of Figure 3.1.3(b).

(7) Select the 10 Hz to 4000 Hz band pass filter.

(8) Repeat steps (3) through (5).

3.1.3.2 100 Hz Bands in the Frequency Range 0.7 kHz to 4 kHz (3.1.1.1(1)(b)) and 100 Hz Bands in the Frequency Range 4 kHz to 270 kHz (3.1.1.1(2)(a))

(1) Connect the TE to the test circuit of Figure 3.1.3(c).

(2) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(3) Measure the rms voltage averaged over 100 ms with a bandwidth of 100 Hz.

(4) Record the highest measured value and its associated frequency and any test results that exceed -6 dBV for centre frequencies in each 100 Hz band between 750 Hz and 3950 Hz.

(5) Record the highest measured value and its associated frequency and any test results that exceed 0.5 dBV for centre frequencies in each 100 Hz band between 4.05 kHz and 4.60 kHz.

(6) Compare the results with the allowed limit for each 100 Hz band having a centre frequency between 4.60 kHz and 5.45 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(7) Compare the results with the allowed limit for each 100 Hz band having a centre frequency between 5.45 kHz and 59.12 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(8) Compare the results with the allowed limit for each 100 Hz band having a centre frequency between 59.12 kHz and 266 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(9) Repeat steps (2) through (8) for all operating conditions.

Note: The remaining steps are only applicable to 4-wire TE.

(10) Connect the TE to the test circuit of Figure 3.1.3(d).

(11) Repeat steps (2) through (9).

3.1.3.3 8 kHz Bands Over the Frequency Range of 4 kHz to 270 kHz (3.1.1.1(2)(b))

(1) Connect the TE to the test circuit of Figure 3.1.3(c).

(2) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(3) Measure the rms voltage averaged over 100 ms with a bandwidth of 8 kHz.

(4) Compare the results with the allowed limit for each 8 kHz band having a centre frequency between 8 kHz and 120 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(5) Compare the results with the allowed limit for each 8 kHz band having a centre frequency between 120 kHz to 266 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(6) Repeat steps (2) through (5) for all operating conditions.

Note: The remaining steps are only applicable to 4-wire TE.

(7) Connect the TE to the test circuit of Figure 3.1.3(d).

(8) Repeat steps (2) through (6).

3.1.3.4 rms Voltages at Frequencies above 270 kHz (3.1.1.1(2)(c))

(1) Connect the TE to the test circuit of Figure 3.1.3(e).

(2) Select the 270 kHz to 6 MHz band pass filter.

(3) Set the digital oscilloscope to provide:

(a) 2 µs per sample;
(b) trigger at -25 dBV;
(c) peak capture; and
(d) vertical scale 0 mV to 100 mV full height.

Note: If the baseline contains 1000 points then a single trace will take 2 ms.

(4) Program the oscilloscope to accumulate 10 traces.

(5) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(6) Record the value of the largest peak measured and convert to V rms by multiplying by 0.707.

Note: The remaining steps are only applicable to 4-wire TE.

(7) Connect the TE to the test circuit of Figure 3.1.3(f).

(8) Repeat steps (2) through (6).

3.1.3.5 Peak Voltages at Frequencies above 4 kHz (3.1.1.1 (2)(d))

(1) Connect the TE to the test circuit Figure 3.1.3(e).

(2) Select the 4 kHz to 6 MHz band pass filter.

(3) Set the digital oscilloscope to provide:

   (a) 2 µs per sample;
   (b) trigger at 0.4 V peak;
   (c) peak capture; and
   (d) vertical scale 0 V to 5 V full height.

(4) Accumulate peak readings for a 10-second period.

(5) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(6) Record the value of the largest peak measured.

Note: The remaining steps are only applicable to 4-wire TE.

(7) Connect the TE to the test circuit of Figure 3.1.3(f).

(8) Repeat steps (2) through (6).

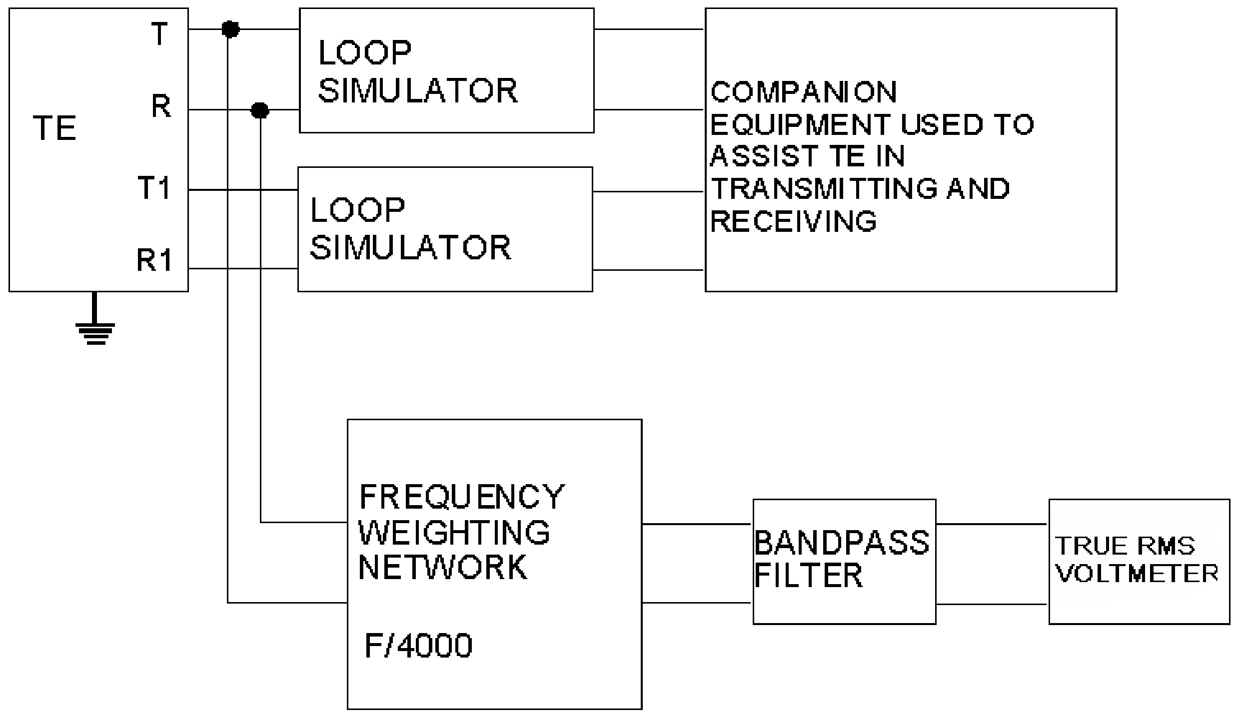


Figure 3.1.3(a)

LDM Metallic 10 Hz to 4 kHz, T & R

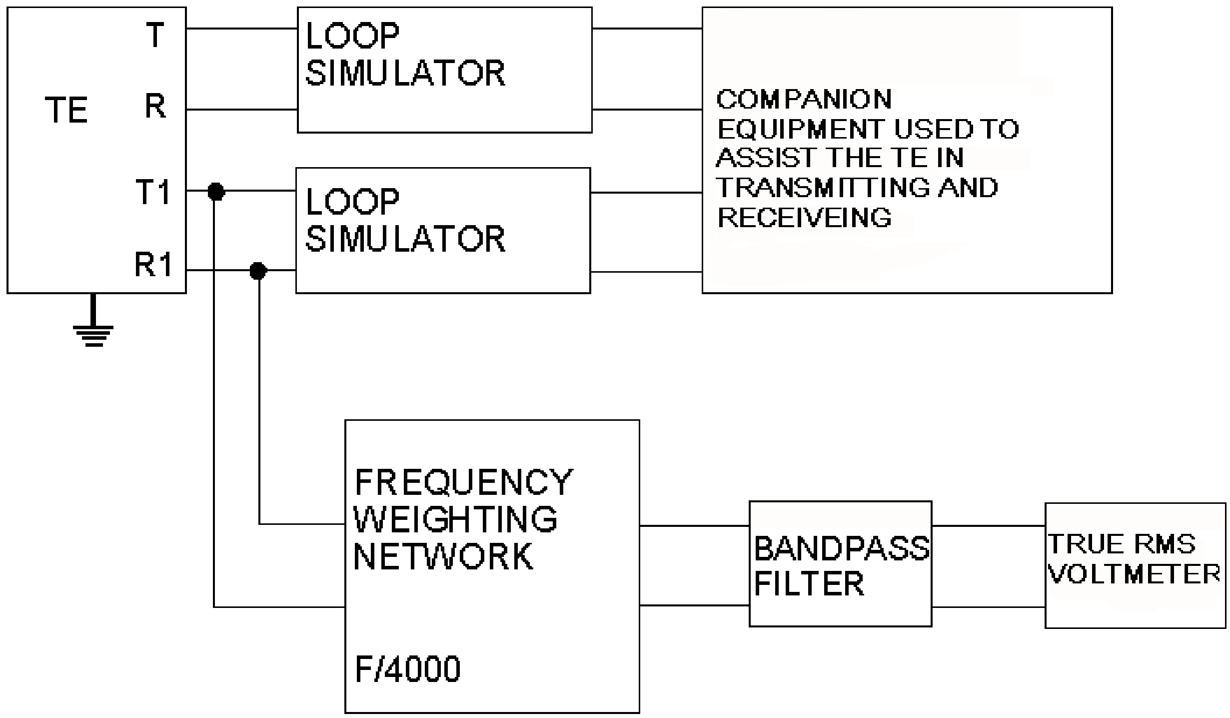


Figure 3.1.3(b)

LDM Metallic 10 Hz to 4 kHz, T1 & R1

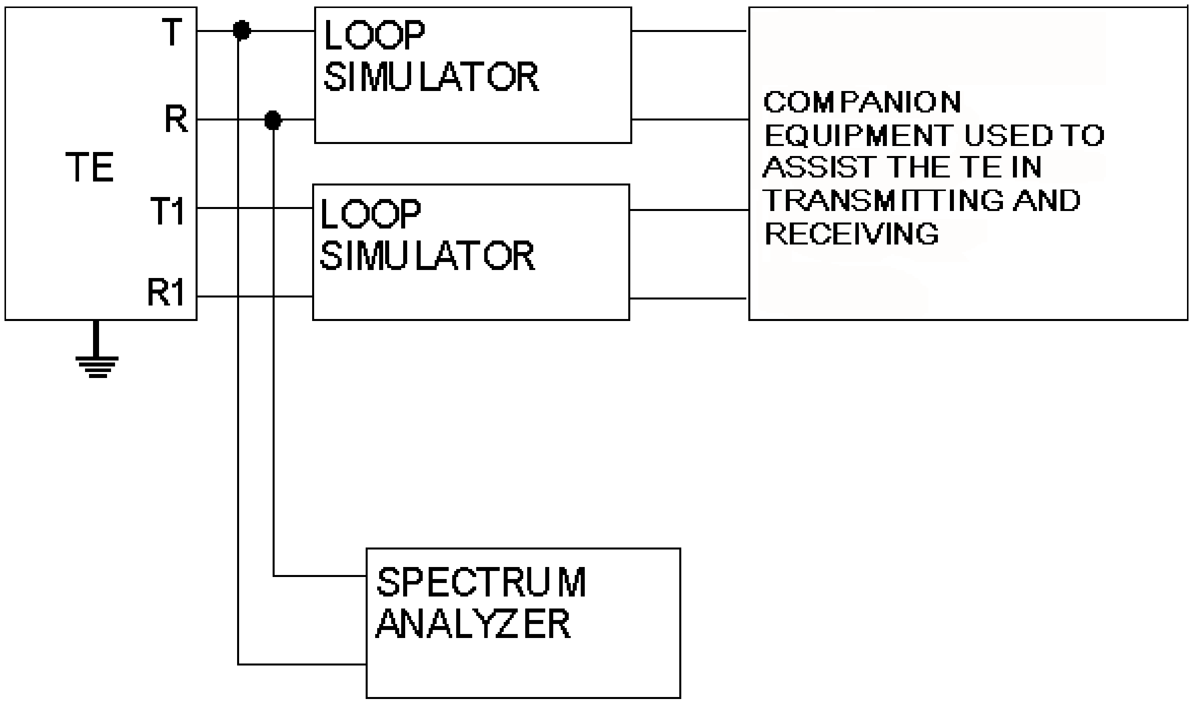


Figure 3.1.3(c)

LDM Metallic 4 kHz to 270 kHz, T & R

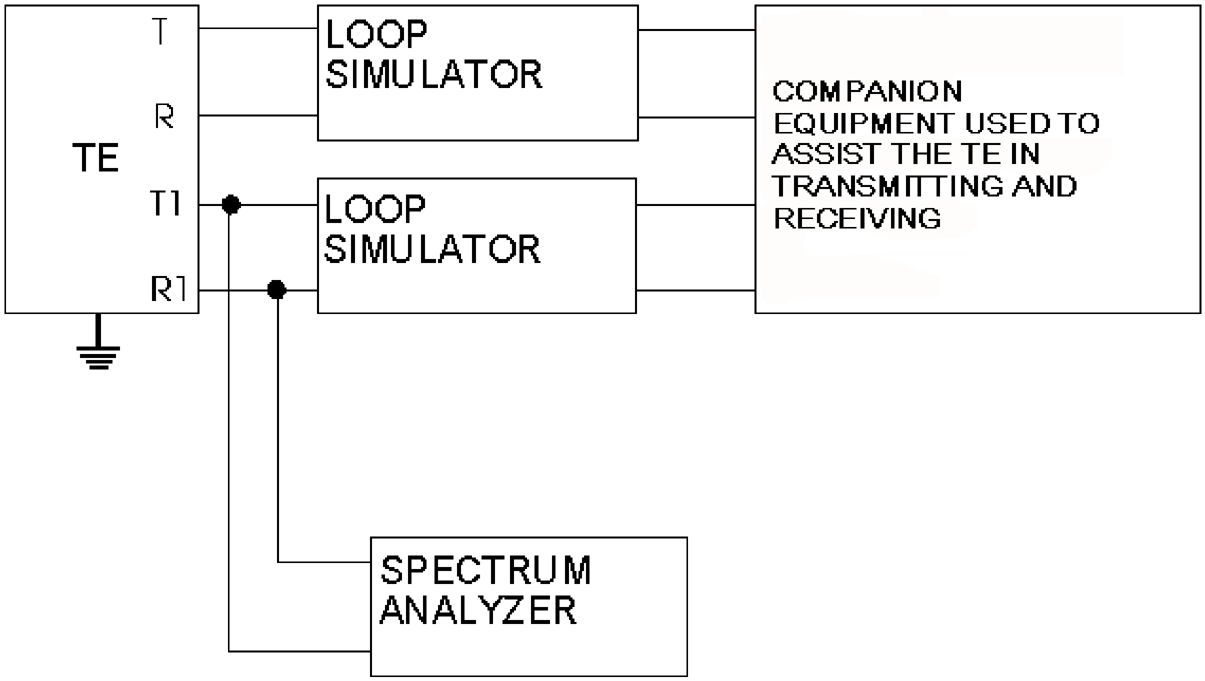


Figure 3.1.3(d)

LDM Metallic 4 kHz to 270 kHz, T1 & R1

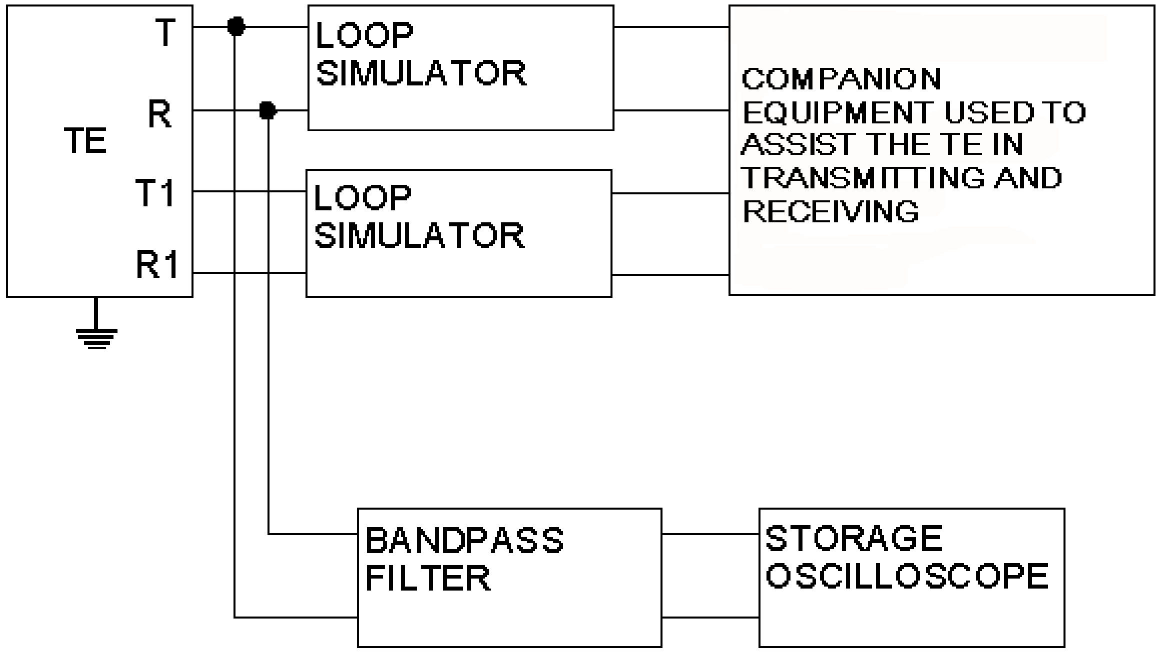


Figure 3.1.3(e)

LDM Metallic 270 kHz to 6 MHz, T & R

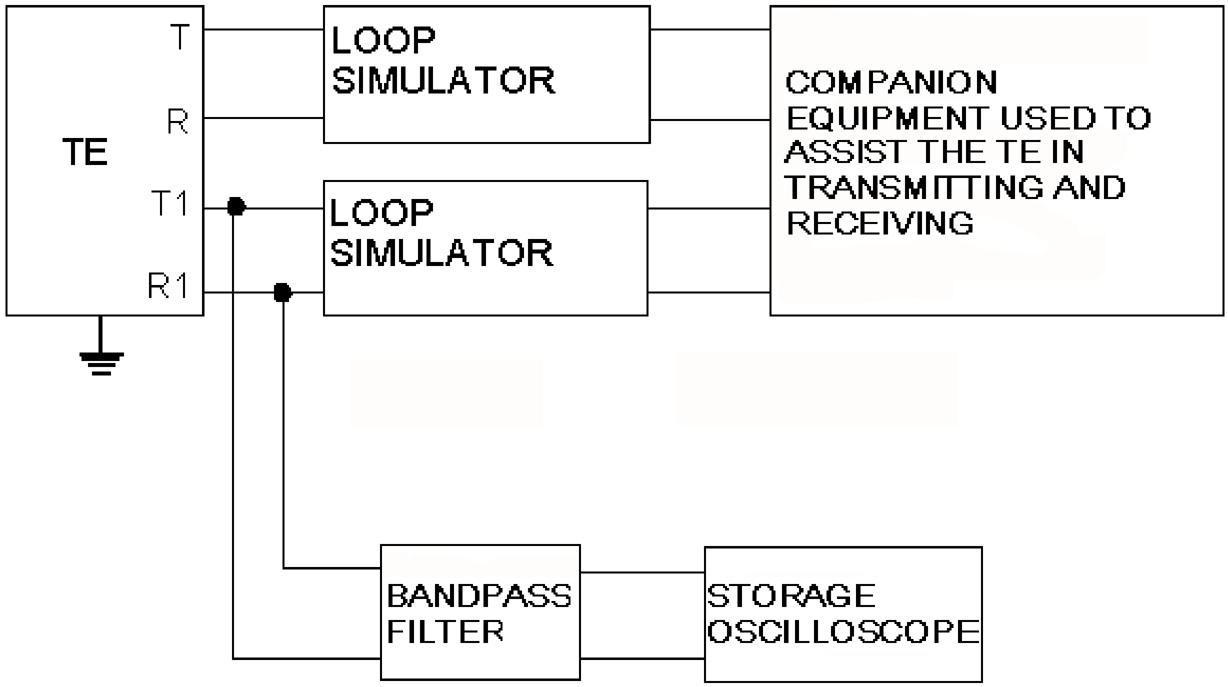


Figure 3.1.3(f)

LDM Metallic 270 kHz to 6 MHz, T1 & R1

3.1.4 Method of Measurement Longitudinal

Note: Refer to Section 3.1.2 for applicable test conditions.

3.1.4.1 Frequencies Below 4 kHz (3.1.1.1 (3)(a))

(1) Connect the TE to the test circuit of Figure 3.1.4(a).

(2) Cause the TE to transmit an output signal in accordance with Sections 3.1.2(2) and (3).

(3) Record the maximum spectrum analyzer reading in the test band.

(4) Repeat steps (2) and (3) for all possible states.

Note: The remaining steps are only applicable to 4-wire TE.

(5) Connect the TE to the test circuit of Figure 3.1.4(b).

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

Note: The measured result shall be corrected +3.1 dB for the voltage divider relationship of the termination.

3.1.4.2 8 kHz Bands Over the Frequency Range of 4 kHz to 270 kHz (3.1.1.1(3)(b))

(1) Connect the TE to the test circuit Figure 3.1.4(c).

(2) Select R1=R2=150 ohms and R3=425 ohms.

(3) Cause the TE to transmit an output signal in accordance with paragraphs 3.1.2(2) and (3).

(4) Measure the rms voltage averaged over 100 ms with a bandwidth of 8 kHz covering the frequency range of 4 kHz to 16 kHz.

Note: The measured result shall be corrected for the voltage divider relationship of the termination. Adjustment is +1.4 dB.

(5) Compare the results with the allowed limit for each 8 kHz band having a centre frequency between 8 kHz and 12 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(6) Select R1=R2=67.5 ohms and R3=56.3 ohms.

(7) Cause the TE to transmit an output signal in accordance with paragraphs 3.1.4(6) and (7).

(8) Measure the rms voltage averaged over 100 ms with a bandwidth of 8 kHz covering the frequency range of 8 kHz to 46 kHz.

Note: The measured result shall be corrected for the voltage divider relationship of the termination. Adjustment is +4.0 dB.

(9) Compare the results with the allowed limit for each 8 kHz band having a centre frequency between 12 kHz and 42 kHz, and record the measured value having the smallest margin relative to the allowed limit and its frequency.

(10) Measure the rms voltage averaged over 100 ms with a bandwidth of 8 kHz covering the frequency range 38 kHz to 270 kHz.

Note: The measured result shall be corrected for the voltage divider relationship of the termination. Adjustment is +4.0 dB.

(11) Record the highest measured value and its associated frequency and any test results that exceed -62 dBV for centre frequencies in each 8 kHz band between 42 kHz and 266 kHz.

(12) Repeat steps (2) through (11) for all operating conditions.

Note: The remaining steps are only applicable to 4-wire TE.

(13) Connect the TE to the test circuit of Figure 3.1.4(d).

(14) Repeat steps (2) through (12) for all operating conditions.

3.1.4.3 RMS Voltages at Frequencies above 270 kHz (3.1.1.1(3)(c))

(1) Connect the TE to the test circuit of Figure 3.1.4(e).

(2) Select the 270 kHz to 6 MHz band pass filter.

(3) Set the digital oscilloscope to provide:

(a) 2 µs per sample;
(b) trigger at -25 dBV;
(c) peak capture; and
(d) vertical scale 0 mV to 100 mV full height.

Note: If the baseline contains 1000 points then a single trace will take 2 ms.

(4) Program the oscilloscope to accumulate 10 traces.

(5) Cause the TE to transmit an output signal in accordance with paragraphs 3.1.2(2) and (3).

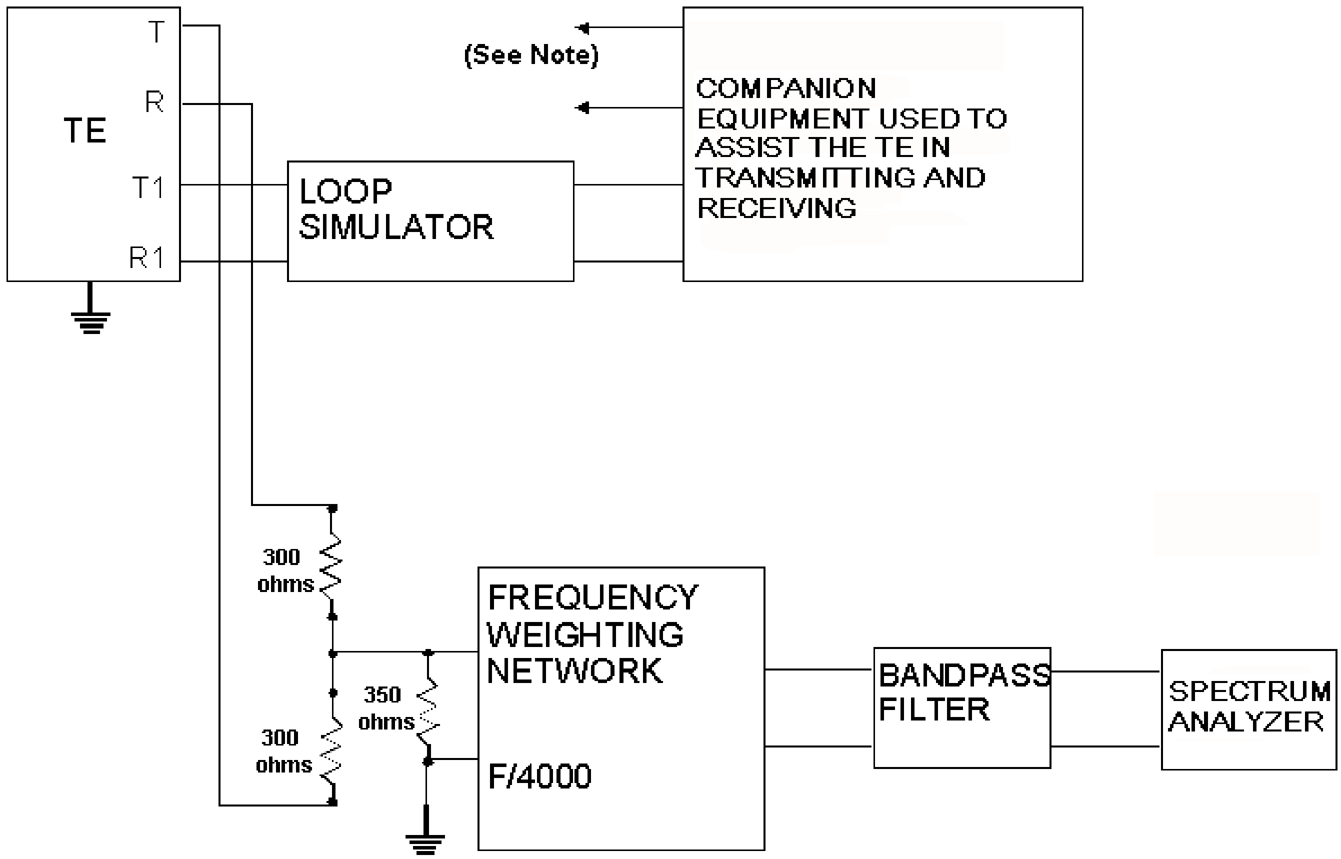
(6) Record the value of the largest peak measured and convert to V rms by multiplying by 0.707.

Note: The remaining steps are only applicable to 4-wire TE.

(7) Connect the TE to the test circuit of Figure 3.1.4(f).

(8) Repeat steps (2) through (6).

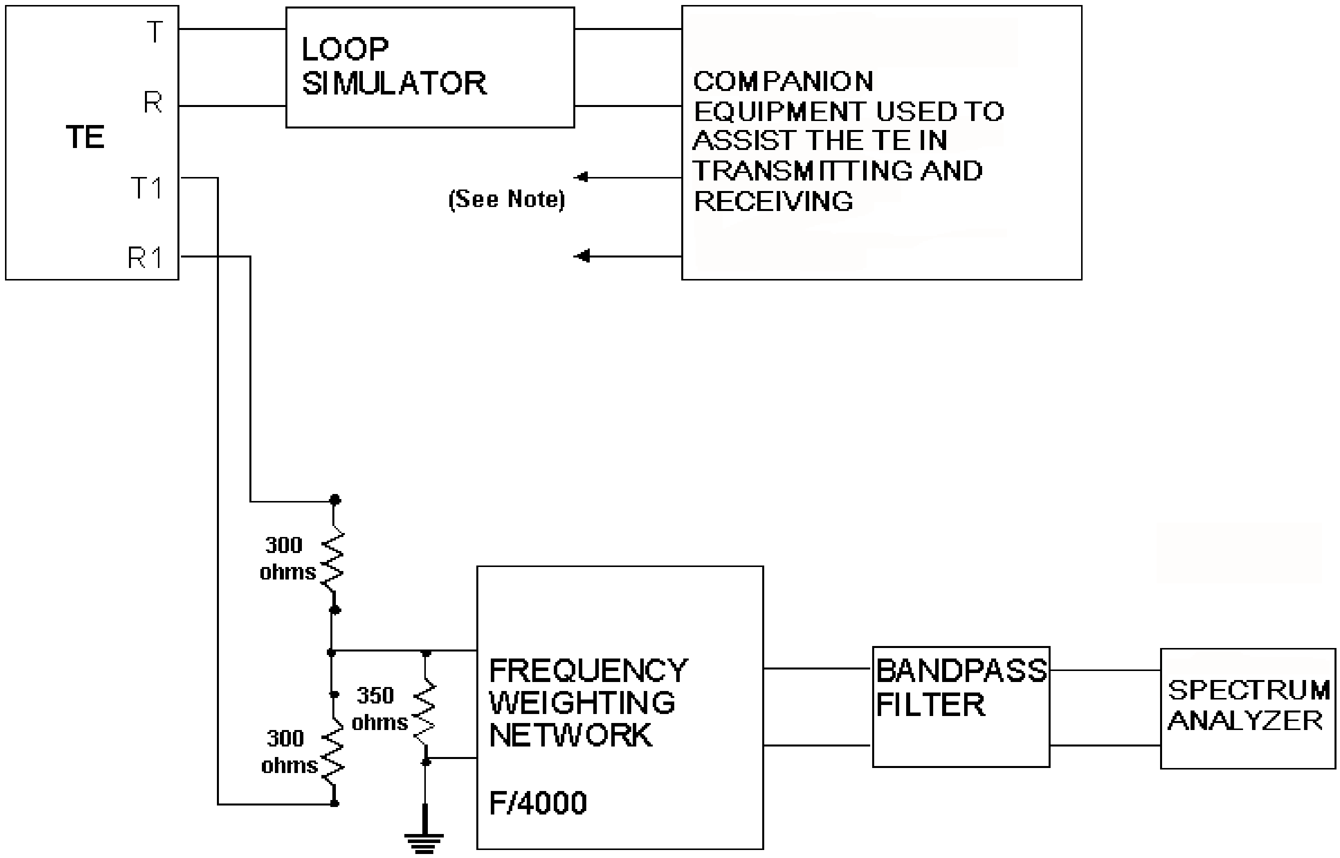
Note: The measured result of step (7) shall be corrected +4 dB for the voltage divider relationship of the termination.



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ±1% tolerance, 1W.

Figure 3.1.4(a)

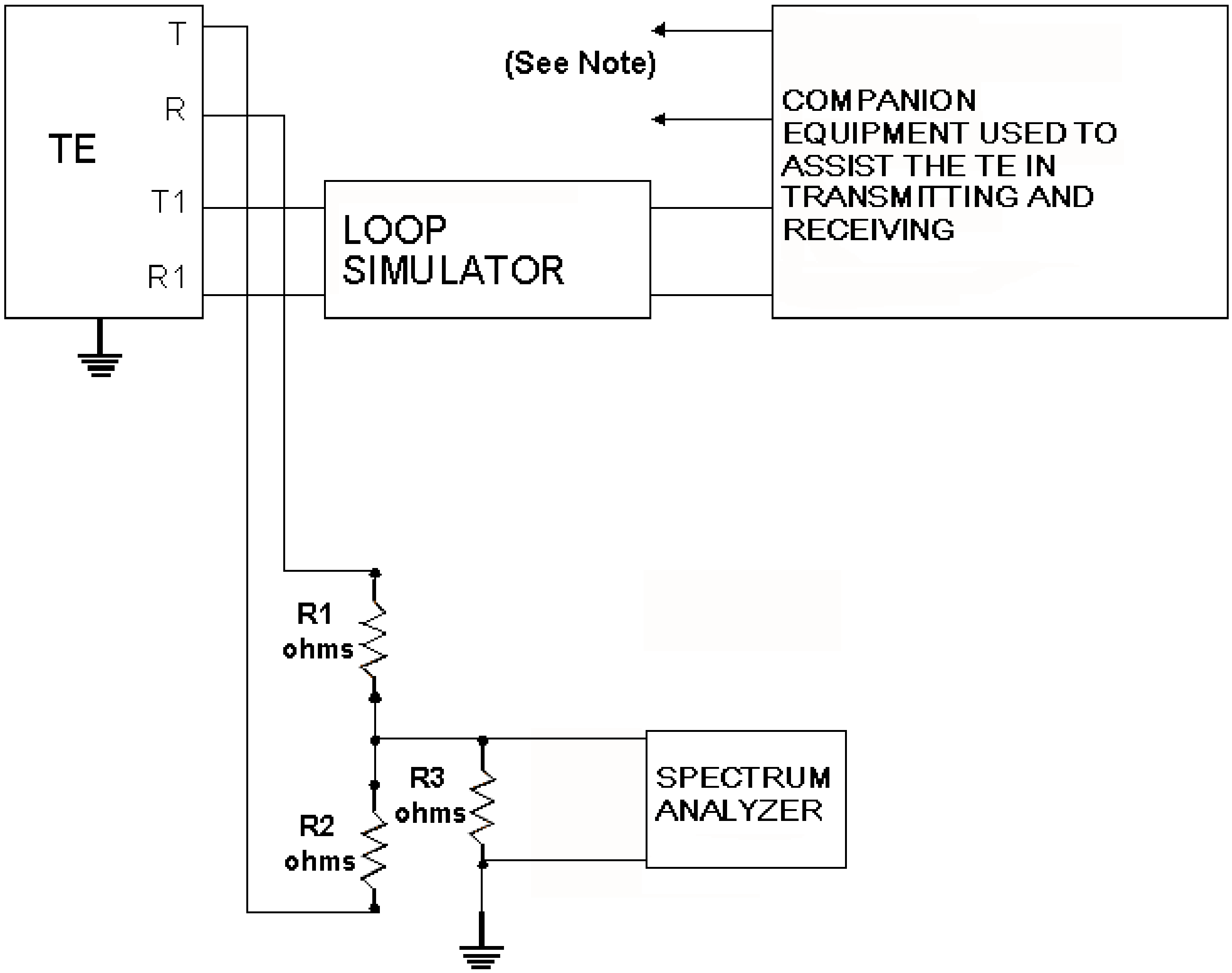
LDM Longitudinal Voltage 10 Hz to 4 kHz, T & R



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ± 1% tolerance, 1W.

Figure 3.1.4(b)

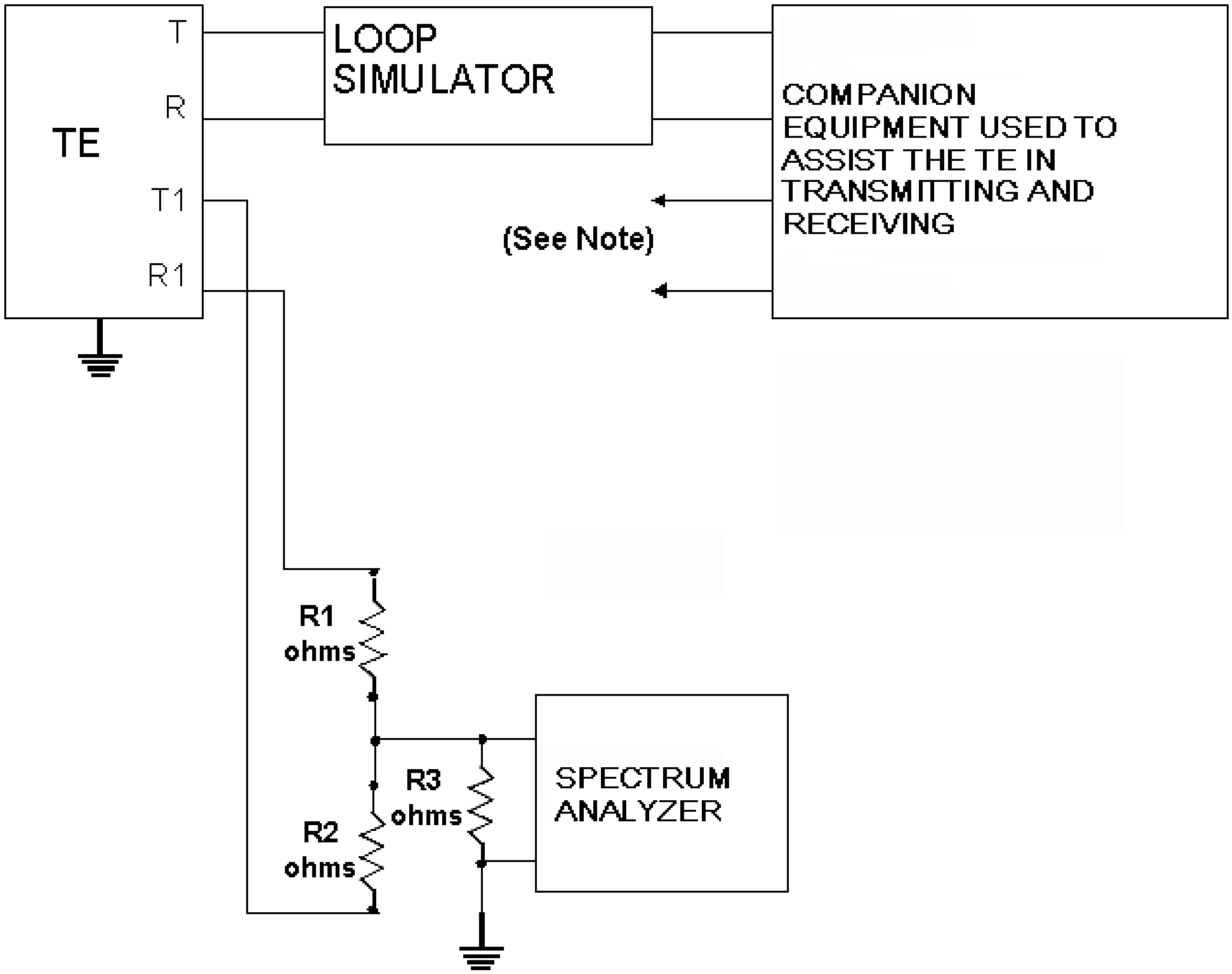
LDM Longitudinal Voltage 10 Hz to 4 kHz, T1 & R1



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ± 1% tolerance, 1W.

Figure 3.1.4(c)

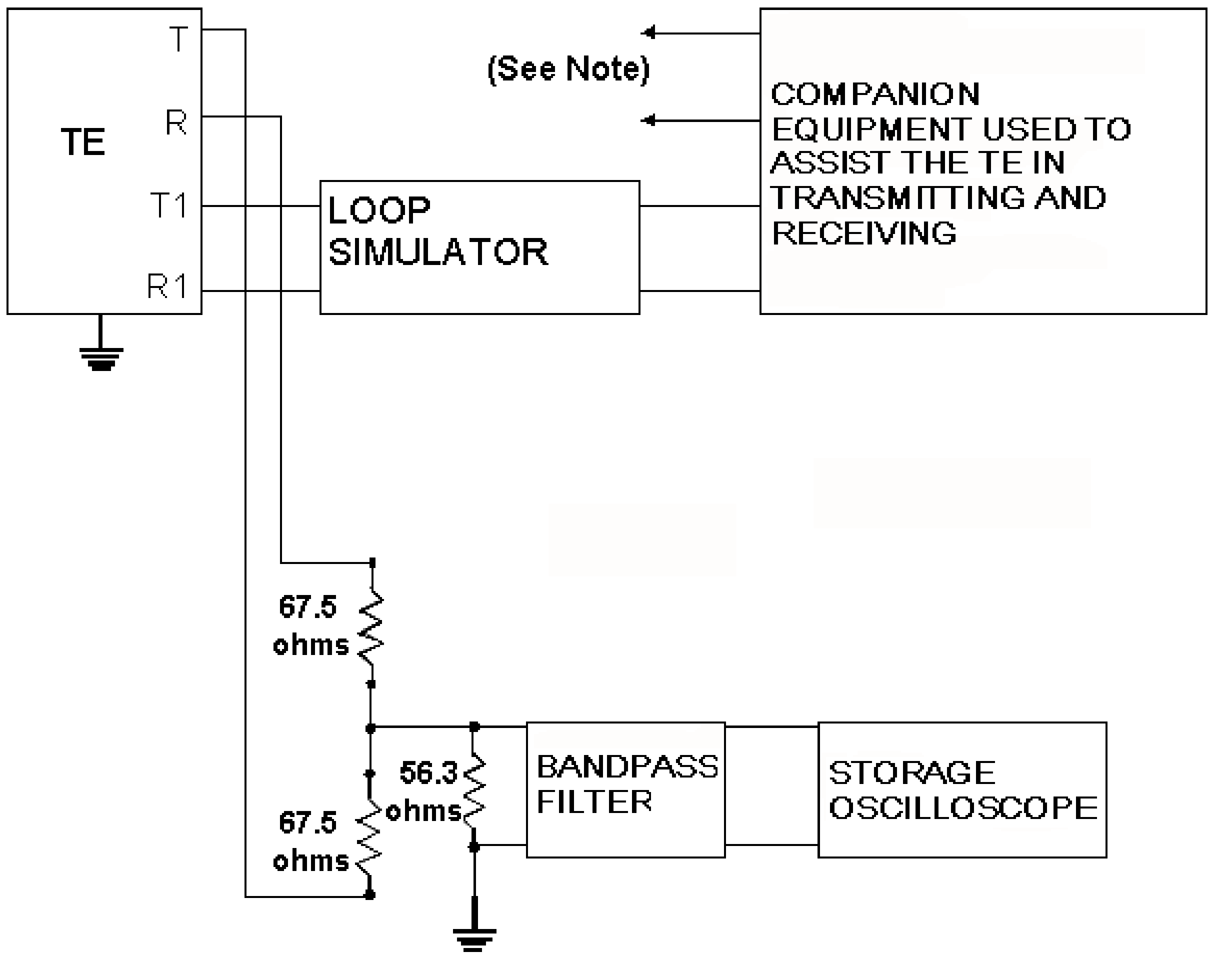
LDM Longitudinal Voltage 4 kHz to 270 kHz, T & R



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ± 1% tolerance, 1W.

Figure 3.1.4(d)

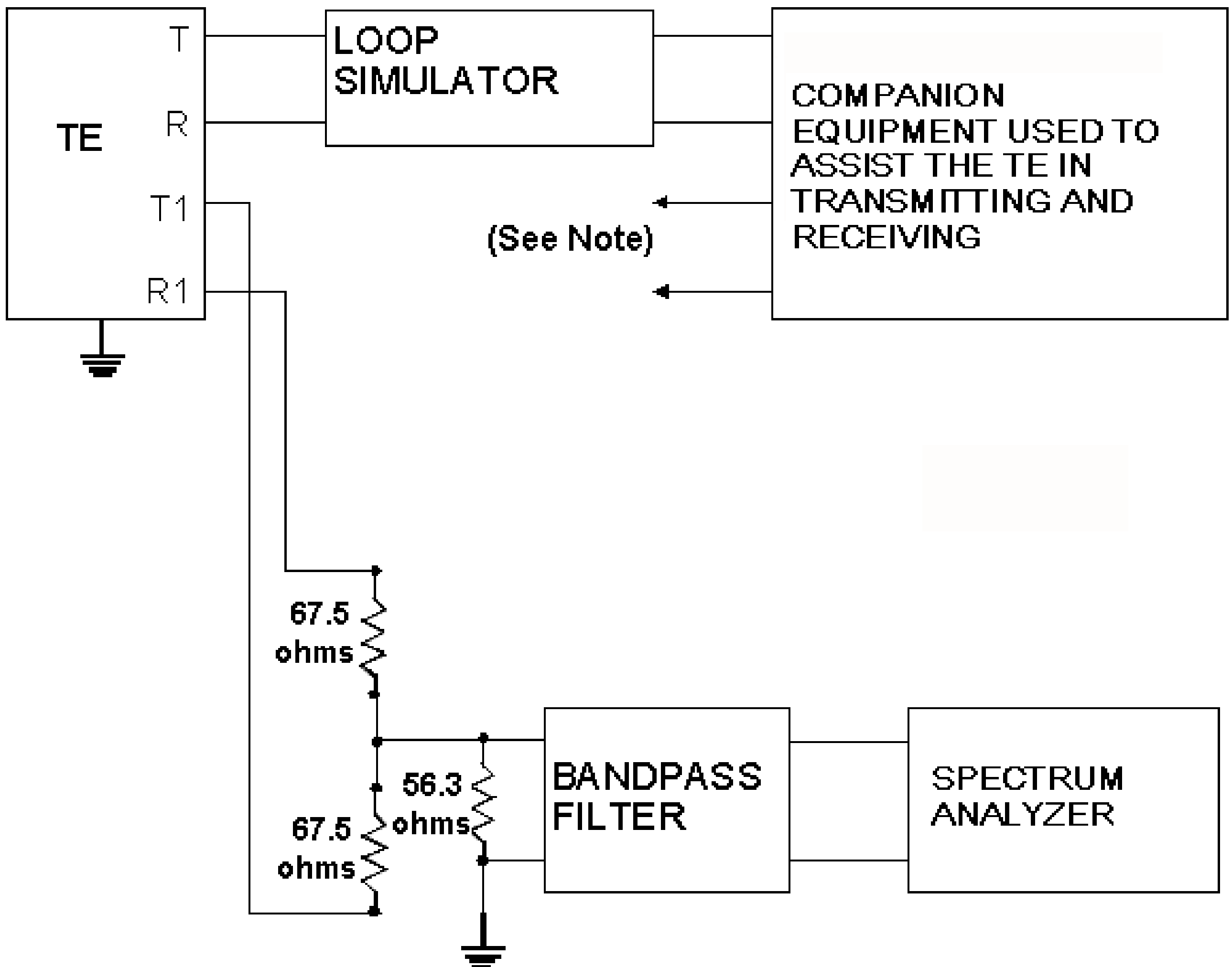
LDM Longitudinal Voltage 4 kHz to 270 kHz, T1 & R1



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ± 1% tolerance, 1W.

Figure 3.1.4(e)

LDM Longitudinal Voltage 270 kHz to 6 MHz, T & R



Note: Means should be used to ensure proper operation of the TE while the pair under test is not connected to the companion TE. All resistors ±1% tolerance, 1W.

Figure 3.1.4(f)

LDM Longitudinal Voltage 270 kHz to 6 MHz, T1 & R1

3.2 Requirements and Test Methods for Digital Subrate TE

3.2.1 Pulse Repetition Rate

3.2.1.1 Requirement

The pulse repetition rate shall be synchronous with 2.4, 4.8, 9.6, 19.2, 38.4, 56.0 or 64 kilobits per second.

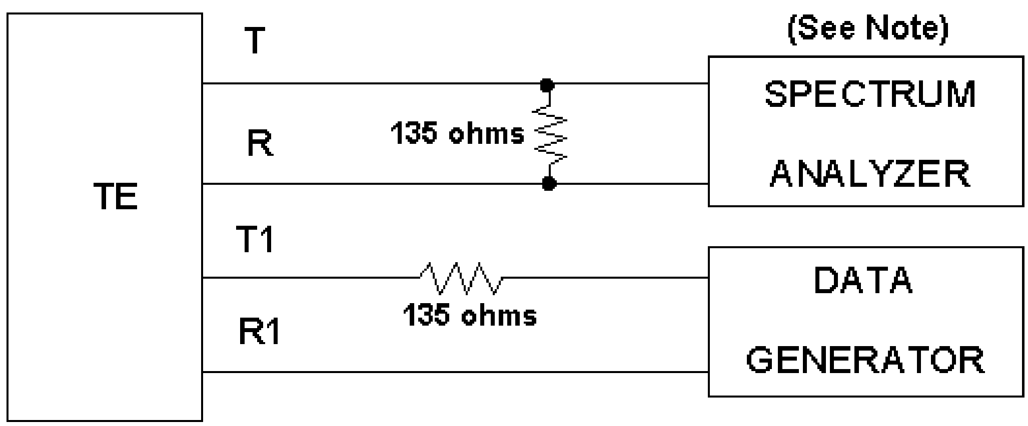
3.2.1.2 Method of Measurement 2.4, 4.8, 9.6, 19.2, 38.4, 56.0, and 64 Kilobits Per Second

(1) Connect the TE to the test circuit as shown in Figure 3.2.1(a). Both the transmit pair and the receive pair should be terminated with 135 ohms.

(2) Transmit a digital signal into the receive tip and ring leads of the TE at the appropriate data rate.

(3) Measure the resultant pulse rate on the transmit tip and ring leads.

(4) Verify that the output pulse rate of the TE is the same as the data rate input on the receive tip and ring leads.



Note: The spectrum analyzer should provide a high-impedance, balanced input. All resistors ±1% tolerance, 1W.

Figure 3.2.1(a)

Subrate Pulse Repetition Rate

3.2.2 Template for Maximum Output Pulse

3.2.2.1 Requirement

When applied to a 135 ohm resistor, the instantaneous amplitude of the largest isolated output pulse obtainable from the registered TE shall not exceed by more than 10% the instantaneous voltage defined by a template obtained as follows: The limiting pulse template shall be determined by passing an ideal 50% duty cycle rectangular pulse with the amplitude\pulse rate characteristics defined in Table 3.2.2(a) through a single real pole low pass filter having a cutoff frequency in hertz equal to 1.3 times the bit rate. For line rates of 2.4, 4.8 and, 9.6 kbps, the filtered pulses should also be passed through a filter providing the additional attenuation in shown in Table 3.2.2(b).

Table 3.2.2(a)

Driving Pulse Amplitude

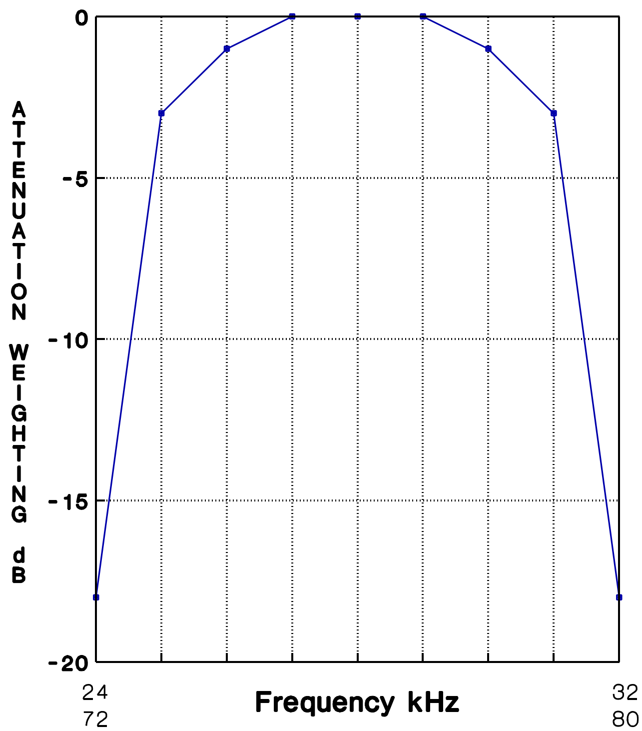
User Data Rate (kbps)	Line Rate (R) (kbps)	Amplitude (A) (volts)
2.4	2.4	1.66
4.8	4.8	1.66
9.6	9.6	0.83
19.2	19.2	1.66
38.4	38.4	1.66
56	56	1.66
64	64	1.66

Table 3.2.2(b)

Minimum Additional Attenuation

Rate (R) (kbps)	Attenuation in Frequency Band 24-32 kHz (dB)	Attenuation in Frequency Band 72-80 kHz (dB)
2.4	5	1
4.8	13	9
9.6	17	8

The attenuation indicated may be reduced at any frequency within the band by the weighting curve of Figure 3.2.2(a). Minimum rejection is never less than 0 dB (i.e. the weight does not justify gain over the system without added attenuation).



24-32 kHz Band	72-80 kHz Band	Attenuation Factor (dB)
24	72	-18
25	73	- 3
26	74	- 1
27	75	0
28	76	0
29	77	0
30	78	- 1
31	79	- 3
32	80	-18

Figure 3.2.2(a)

Attenuation Weighting Curve

3.2.2.2 Method of Measurement

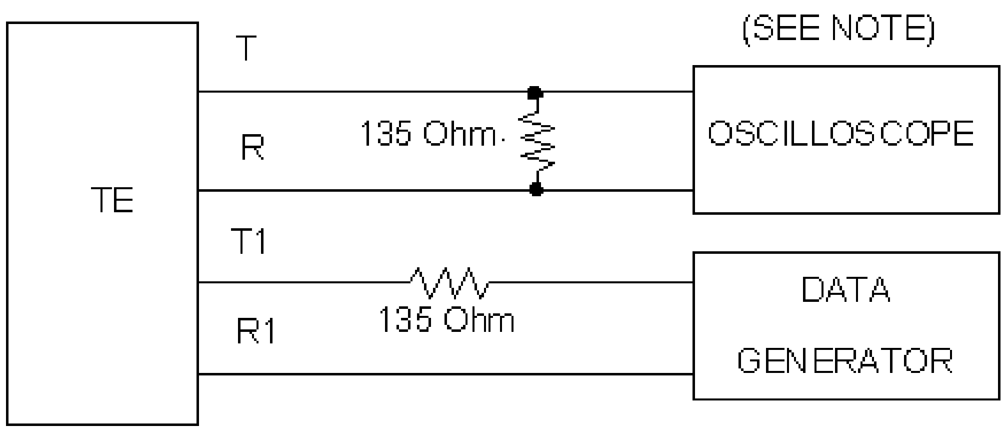
(1) Connect the TE to the test circuit of Figure 3.2.2(b).

(2) Cause the equipment under test to transmit a digital signal which will allow the capture of an isolated pulse.

(3) Record a single positive pulse on the oscilloscope, and compare the pulse shape to the criteria. (Figures 3.2.2(c) through (i) may be used as a guide).

(4) Record a single negative pulse on the oscilloscope, and compare the pulse shape to the criteria.

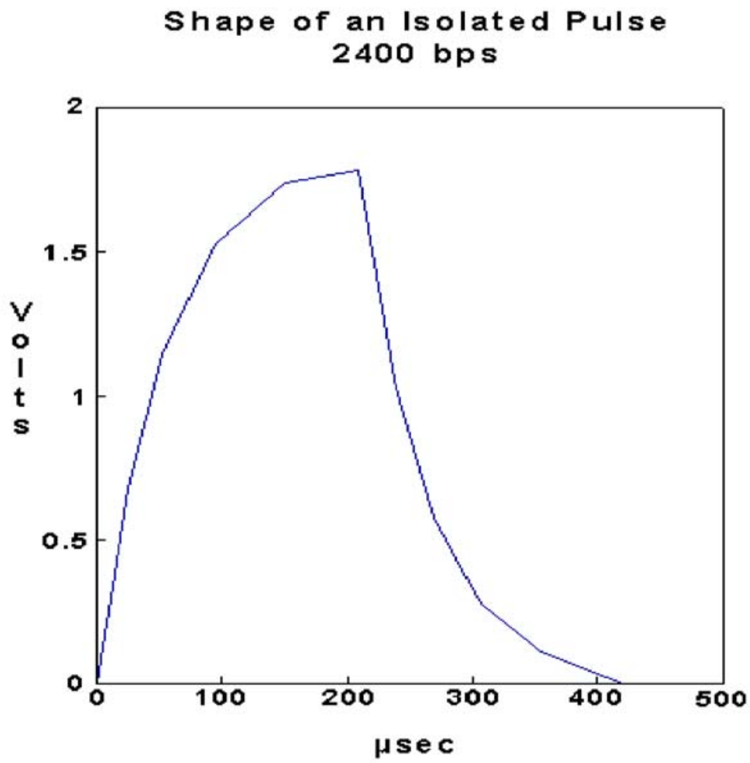
(5) Repeat steps (3) and (4) for all pulse rates at which the equipment is capable of operating.



Note: The measuring instrument should provide a high-impedance, balanced input. All resistors ±1% tolerance, 1W.

Figure 3.2.2(b)

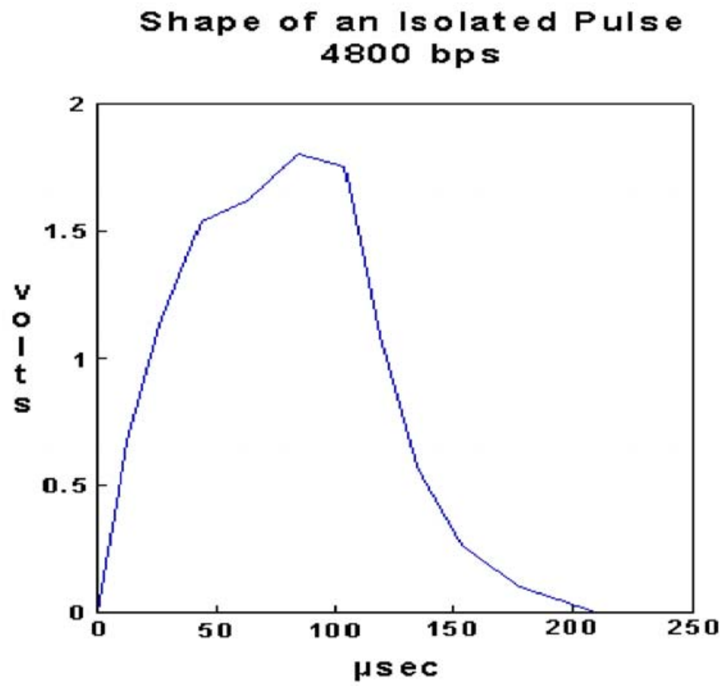
Subrate Pulse Template



µsec	volts
0	0
25.2	0.678
52.5	1.147
94.5	1.529
151.2	1.737
207.9	1.783
237.3	1.057
268.8	0.579
306.6	0.275
354.9	0.109
416.7	0

Figure 3.2.2(c)

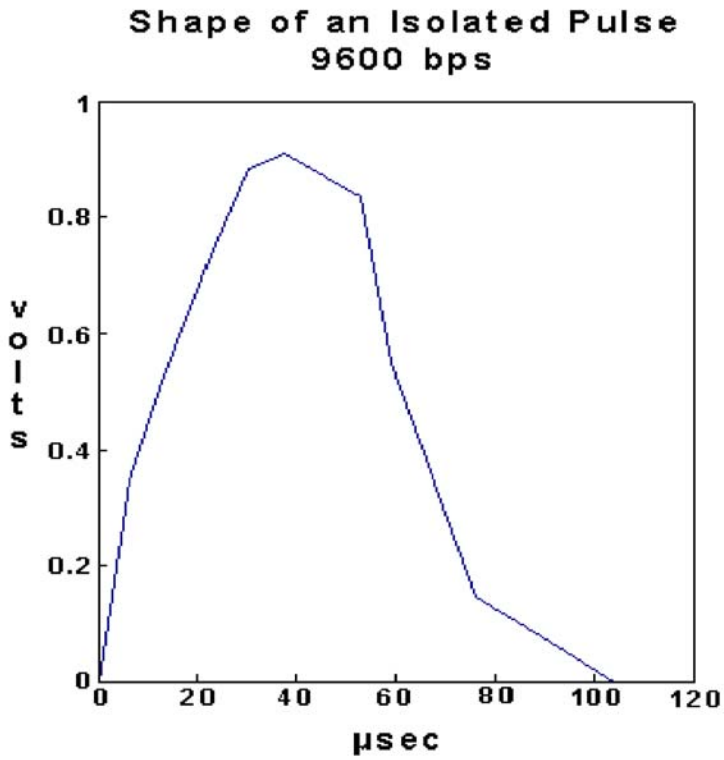
Subrate Pulse Template for 2.4 kbps



µsec	volts
0	0
12.6	0.669
26.25	1.132
44.1	1.538
63	1.619
85.05	1.805
103.95	1.75
118.65	1.087
134.4	0.571
153.3	0.261
177.45	0.01
208.3	0

Figure 3.2.2(d)

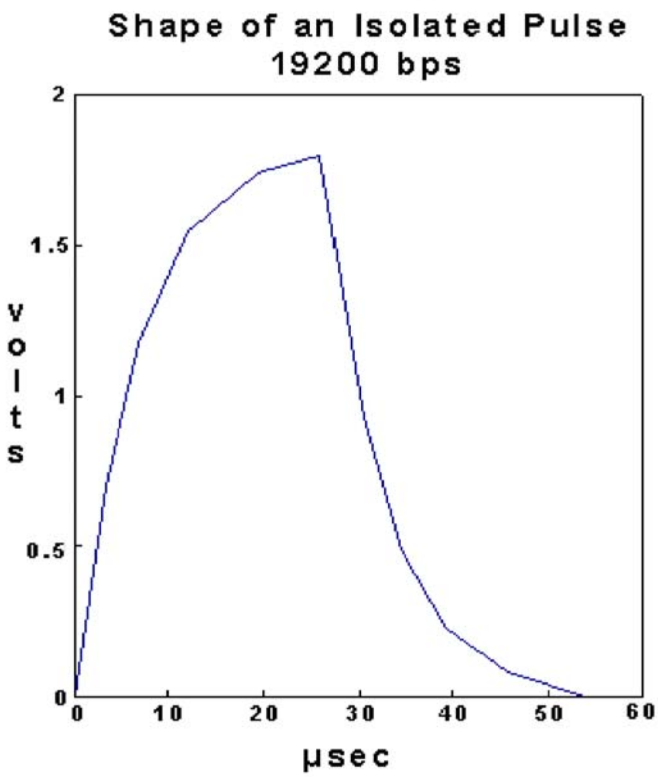
Subrate Pulse Template for 4.8 kbps



µsec	volts
0	0
6.252	0.348
13.025	0.517
23.445	0.754
30.218	0.884
37.512	0.909
52.621	0.836
58.873	0.547
66.688	0.363
76.066	0.146
104.2	0

Figure 3.2.2(e)

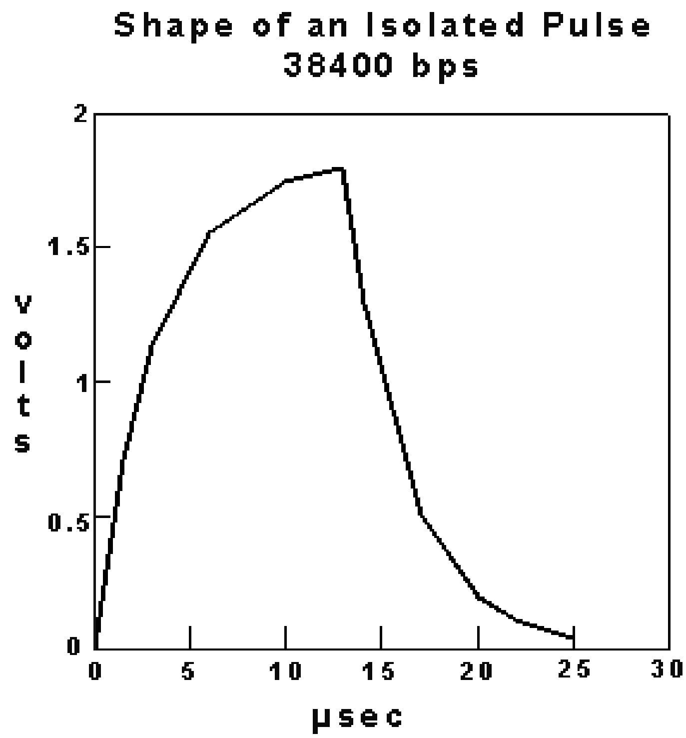
Subrate Pulse Template for 9.6 kbps



µsec	volts
0	0
3.24	0.7
6.75	1.176
12.15	1.547
19.44	1.737
25.92	1.799
30.51	0.93
34.56	0.492
39.42	0.23
45.63	0.008
52.1	0

Figure 3.2.2(f)

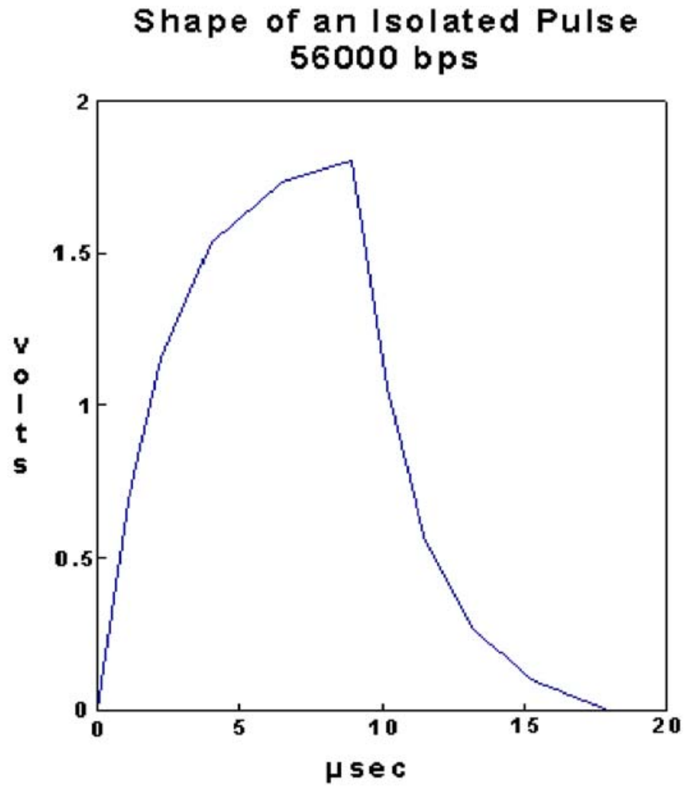
Subrate Pulse Template for 19.2 kbps



µsec	volts
0	0
1.5	0.703
3.06	1.138
6.05	1.557
10.3	1.749
13.02	1.795
14.06	1.296
17.06	0.507
20.05	0.198
22	0.107
25.06	0.041

Figure 3.2.2(g)

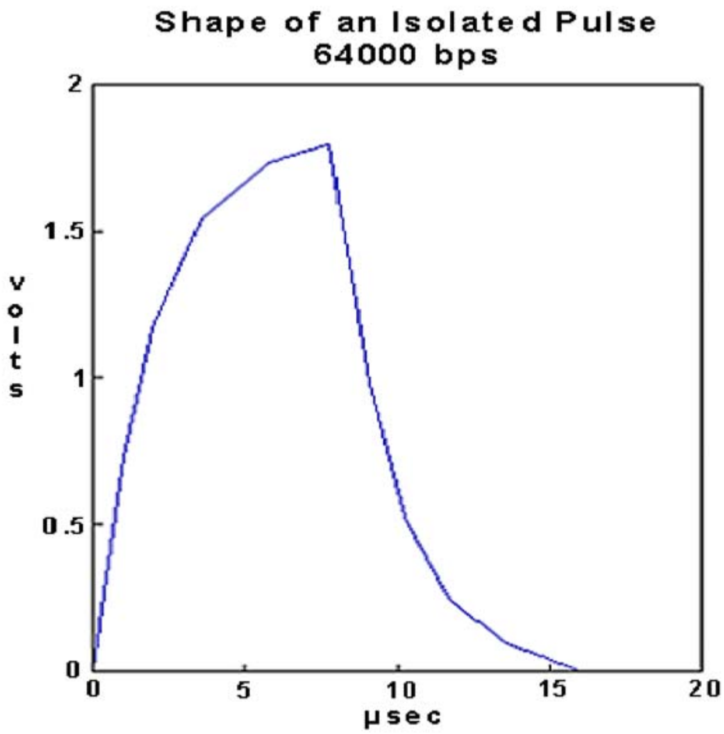
Subrate Pulse Template for 38.4 kbps



μsec	volts
0	0
1.08	0.685
2.25	1.157
4.05	1.532
6.48	1.73
8.91	1.799
10.17	1.061
11.52	0.572
13.14	2.73
15.21	0.106
17.9	0

Figure 3.2.2(h)

Subrate Pulse Template for 56 kbps



μsec	volts
0	0
0.96	0.693
2	1.167
3.6	1.541
5.76	1.733
7.76	1.797
9.04	0.985
10.24	0.526
11.68	0.248
13.52	0.009
16	0

Figure 3.2.2(i)

Subrate Pulse Template for 64 kbps

3.2.3 Average Power

3.2.3.1 Requirement

The average output power when a random signal sequence, (0) or (1) equiprobable in each pulse interval, is being produced as measured across a 135 ohm resistance shall not exceed 0 dBm for 9.6 kbps or +6 dBm for 2.4 kbps,4.8 kbps, 19.2 kbps, 38.4 kpbs, 56 kbps and 64 kbps.

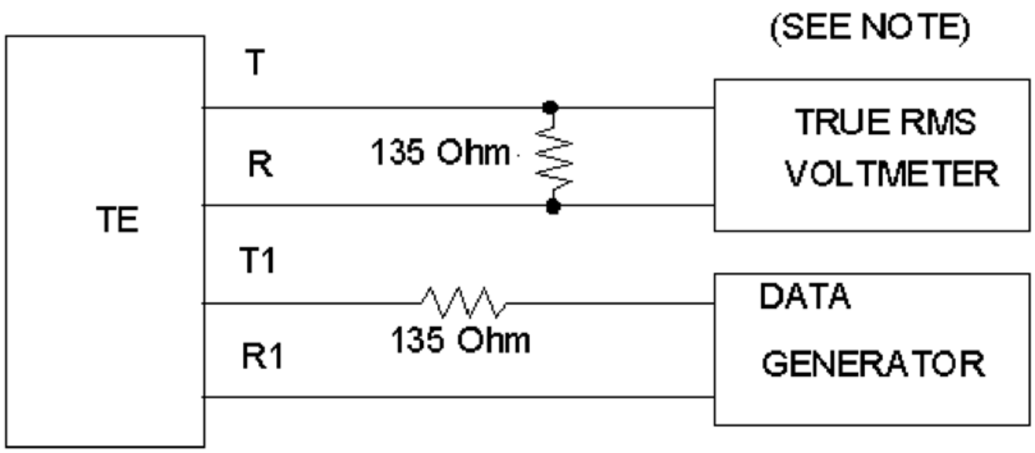
3.2.3.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.2.3.

(2) Arrange the TE to transmit a pseudo random signal sequence.

(3) Measure the power of the transmitted signal.

(4) Repeat the test at all of the transmission rates of the TE.



Note: The measuring instrument should provide a high-impedance, balanced input with adequate bandwidth. All resistors ±1% tolerance, 1W.

Figure 3.2.3

Subrate - Average Power

3.2.4 Encoded Analogue Content

3.2.4.1 Requirement

(1) If TE that is for connection to subrate services contains an analogue-to-digital converter, or generates signals directly in digital form which are intended for eventual conversion into voice band signals, the encoded analogue content must be limited. The maximum equivalent power of encoded analogue signals shall be limited as specified below when derived by a zero level decoder and averaged over a 3 second time period.

(a) -3 dBm for network control signals
(b) -6 dBm for V.90 or V.92 modems
(c) -9 dBm for all other signals other than live voice

(2) TE providing through transmission capability to other PSTN connections shall meet the requirements of Table 3.2.4.

Note: All limits are with reference to 600 ohms.

3.2.4.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.2.4. As shown, two types of signals may be transmitted:

(a) internally generated signals that are generated directly in digital form and are intended for eventual conversion to analogue form; and

(b) internally generated analogue signals that are converted to digital format for eventual reconversion to analogue form.

(2) For signals of type (a) or (b) as described above, cause the equipment to generate each of the possible signals.

(3) Record the power of each of the transmitted signals as measured at the output of the zero level decoder or companion TE. The recorded level shall be the maximum attainable when averaged over any 3-second interval.

Table 3.2.4

Allowable Net Amplification Between Ports

TO / FROM	Tie Trunk Type Ports: Lossless 2/4-Wire	Tie Trunk Type Ports: Subrate 1.544 Mbps Satellite (4-wire)	Tie Trunk Type Ports: Subrate 1.544 Mbps Tandem (4-wire)	Integrated Services Trunk Ports	Off Premises Station Ports (2-Wire)	Analogue Public Switched Network Ports (2-Wire)	Subrate 1.544 Mbps Digital PBX-CO Trunk Ports (4-Wire)
Lossless Tie Trunk Port (2/4-wire)	0 dB	2 dB	2 dB	2 dB	2 dB	-	-
Subrate 1.544 Mbps Satellite Tie Trunk Port (4-wire)	1 dB	-	3 dB	3 dB	3 dB	-	-
Subrate 1.544 Mbps Tandem Tie Trunk Port (4-wire)	-2 dB	0 dB	0 dB	0 dB	0 dB	-	-
Integrated Services Trunk Ports	-2 dB	0 dB	0 dB	0 dB	0 dB	-	-
Registered Digital TE	-2 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
On Premises Station Port with Registered TE	-2 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
Off Premises Station Port (2-wire)	2 dB	4 dB	4 dB	4 dB	4 dB	4 dB	4 dB
Analogue Public Switched Network Ports (2-wire)	-	-	-	-	3 dB	3 dB	-
Subrate 1.544 Mbps Digital PBX-CO Trunk Ports (4-Wire)	-	-	-	-	0 dB	-	-

Notes:

1. The source impedance for all measurements shall be 600 ohms. All ports shall be terminated in appropriate loop or private line channel simulator circuits or 600 ohm 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 by time or frequency compression methods. TE employing such compression techniques shall assure 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 which results when moving from the horizontal entry toward the vertical entry.

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

7. TE or network protection devices with the capability for through transmission from voice band private line channels or voice band metallic private line channels to other telephone network interfaces shall assure, for each telephone network interface type to be connected, that 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 of application of signal.

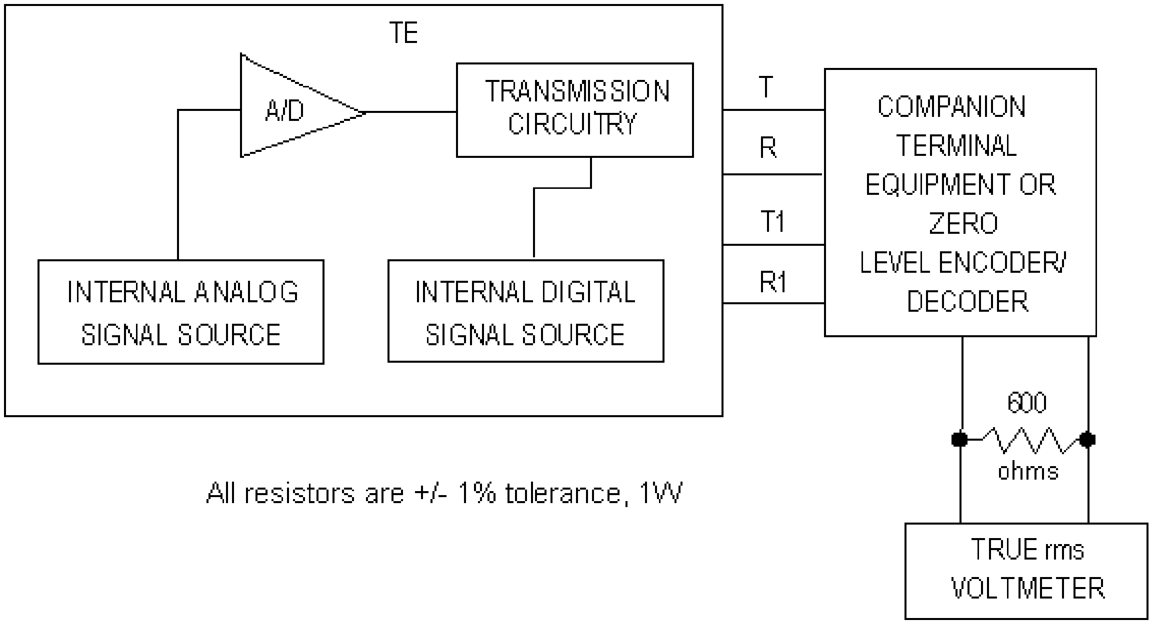


Figure 3.2.4

Subrate - Encoded Analogue Content

3.2.5 Equivalent PSD for Maximum Output

When applied to a 135 ohm resister, the instantaneous amplitude for the PSD, obtainable from the registered terminal equipment, shall not exceed the PSD defined by the following limited function, in dBm/Hz:

$$10\log\left[\frac{\left(A^2\right)\frac{56000}{fbaud}}{\left[\left(\frac{f}{f3dB}\right)^2+1\right]\left[\left(\frac{f}{fbaud\cdot k}\right)^2+1\right]}\right]-\textit{Additional Attenuation}$$

where “A” is equal to ½ for 9.6 kbps and 12.8 kbps or 1 for all other rates; “fbaud” is equal to the baud rate; “f3dB” is equal to 1.3 times the baud rate times 1.05; “f” is the frequency; and “k”is defined in Table 3.2.5. Additional attenuation is required at certain baud rates in the bands specified in Tables 3.2.2(a) and 3.2.2(b). PSD shall be measured for frequencies between ½ the baud rate and 20 times the baud rate. If 20 times the baud rate is less than 80 kHz, then the upper frequency measurement bound shall be 80 kHz. The resolution bandwidth for the PSD shall be less than or equal to 0.1 times the baud rate but no greater than 3 kHz.

Table 3.2.5
Values for k and Average Output Power

User Data Rate (kbps)	Line Rate (R) (kbps)	Values for k	Maximum Average Power (dBm)
2.4	2.4	0.00727798	6
4.8	4.8	0.00727798	6
9.6	9.6	0.00727798	0
19.2	19.2	0.00727798	6
38.4	38.4	0.00727798	6
56	56	0.00727798	6
64	64	0.00727798	6

3.2.6 Limitations on Terminal Equipment Connected to PSDS (Types I, II and III)

If PSDS (Types I, II and III) terminal equipment contains an analogue to digital converter, or generates signals directly in digital form that are intended for eventual conversion into voice band analogue signals, the encoded analogue content of the digital signal shall be limited as specified in Section 3.2.4.

(1) For PSDS (Type II) the pulse repetition rate shall be a maximum of (144,000 ± 5) pulses per second; for PSDS (Type III) the pulse repetition rate shall be a maximum of (160,000 ± 5) pulses per second.

(2) When applied to a 135 ohm resistor, the instantaneous amplitude of the largest isolated output pulse obtainable from the approved terminal equipment shall fall within the template as shown in Table 3.2.6 below for PSDS Type II or for PSDS Type III. The limiting pulse template shall be defined by passing an ideal 50% duty cycle rectangular pulse within the amplitude/pulse rate characteristics shown below through a 1-pole low-pass filter with a -3 dB frequency of 260 kHz.

Table 3.2.6

Pulse Characteristics Template	PSDS Type II	PSDS Type III
Pulse Height	2.6 V ± 5%	2.4 V ± 5%
Pulse Width	(3472.2 ± 150) ns	(3125 ±100) ns
Max Rise or Fall Time - (From 10% to 90% points)	100 ns	(1.2 ± 0.2) µs

3.2.7 Signalling Interference

3.2.7.1 Requirements

TE registered for connection to subrate digital services shall not deliver digital signals to the telephone network with encoded analogue energy in the 2450 to 2750 hertz band unless at least an equal amount of encoded analogue energy is present in the 800 to 2450 hertz band.

3.2.7.2 Method of Measurement

The TE shall be active and transmitting the encoded analogue signal. The test shall be performed on each of the internally generated signals other than DTMF signals.

(1) Connect the TE to the test circuit of Figure 3.2.7. As shown, two types of signals may be transmitted:

   (a) internally generated signals that are generated directly in digital form but which are intended for eventual conversion to analogue form; and

   (b) internally generated analogue signals that are converted to digital format for eventual reconversion to analogue form.

(2) For signals of type (a) or (b) as described above, cause the equipment to generate each of the possible signals.

(3) Read the signal energy in the 800 Hz to 2450 Hz band.

(4) Read the signal energy in the 2450 Hz to 2750 Hz band.

(5) Repeat steps (3) and (4) for each possible signal.

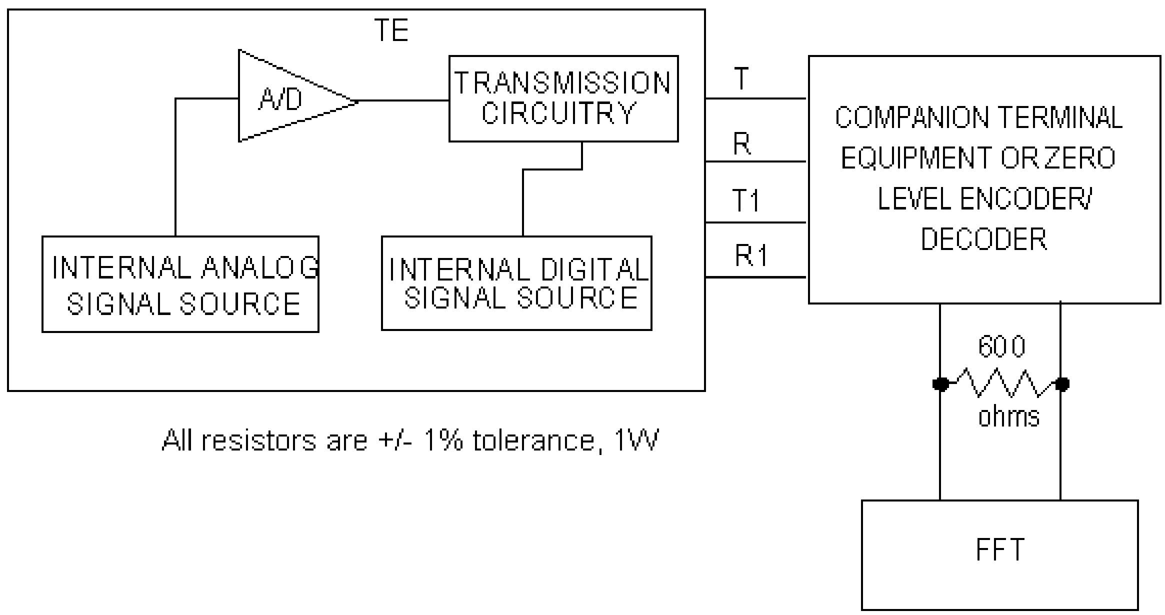


Figure 3.2.7

Subrate - Signalling Interference

3.2.8 On-Hook Level

3.2.8.1 Requirements

Digital Subrate TE shall comply with the following:

(1) The power derived to the telephone network in the on-hook state as derived by a zero level decoder shall not exceed -55 dBm equivalent power for digital signals within the frequency bank from 200 to 4000 hertz. Network protective devices shall also assure that for any input level up to 10 dB above the maximum level that is expected under normal operation, the power to a zero level decoder does not exceed the above limits.

(2) The power derived by a zero level decoder, in the on-hook state, by reverse battery equipment shall not exceed -55 dBm, unless the equipment is arranged to inhibit incoming signals.

3.2.8.2 Method of Measurement

(1) Connect the TE to the test circuit of Figure 3.2.8.

(2) Cause the digital equipment to transmit the on-hook signal.

(3) Measure the analogue transmitted signal power at the output of the band pass filter.

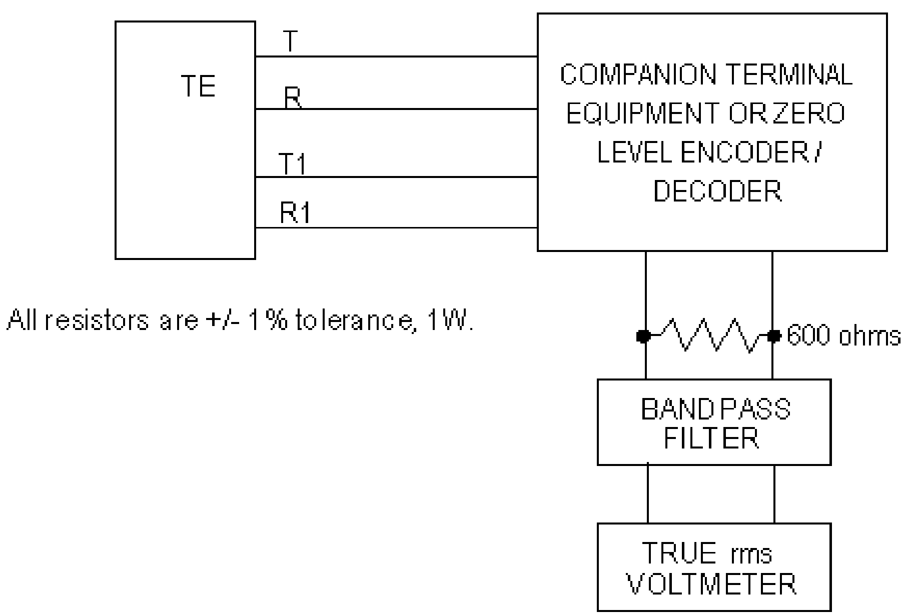


Figure 3.2.8

Subrate - On-hook Level

3.2.9 Transverse Balance Limitations

3.2.9.1 Requirement

The metallic to longitudinal balance coefficient, transverse balance is expressed as:

$$BALANCE_{m\text{-}l}\ (dB) = 20 \log_{10} \frac{e_M}{e_L}$$

Where e_L is the longitudinal voltage produced across a 500 ohm longitudinal termination and e_M is a metallic voltage across the tip and ring connection of the TE when a voltage (at any frequency between $f_1 < f < f_2$, see Table 3.2.9) is applied from a balanced source with a metallic source impedance of 135 ohms. The source voltage should be set such that e_m = .367 volts when a termination of 135 ohms is substituted for the TE.

An illustrative test circuit that satisfies the above conditions is shown in Figure 3.2.9(b); other means may be used to determine the transverse balance coefficient specified herein, provided that adequate documentation of the appropriateness, precision, and accuracy of the alternative means is provided by the applicant.

The minimum transverse balance requirements for TE connected to digital services shall be equalled or exceeded for the range of frequencies applicable for the equipment under test and under all reasonable conditions of the application of earth ground to the equipment. All such TE shall have a transverse balance in the acceptable region of Figure 3.2.9(a) for the range of frequencies shown in Table 3.2.9 for the specified digital service in question. The metallic impedance used for the transverse balance measurements for all subrate services shall be 135 ohms. The longitudinal termination for subrate services less than 12 kbps shall be 500 ohms and for subrates greater than 12 kbps the longitudinal termination shall be 90 ohms.

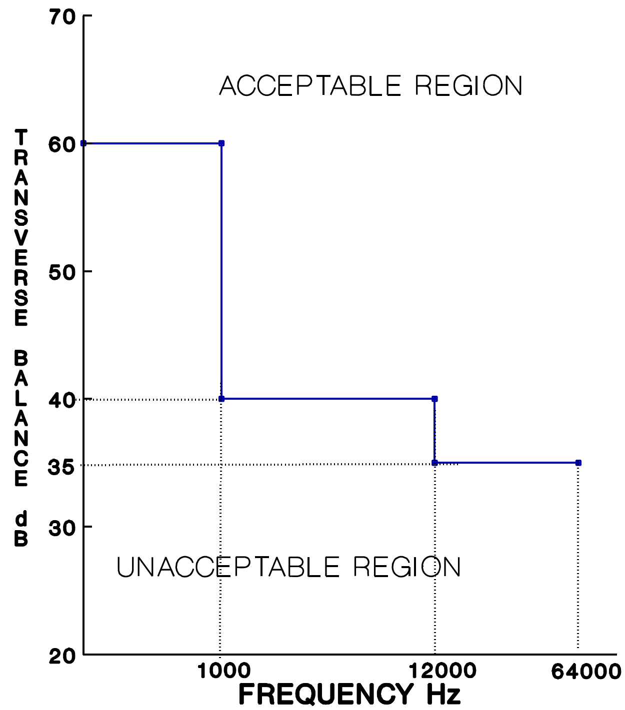


Figure 3.2.9(a)

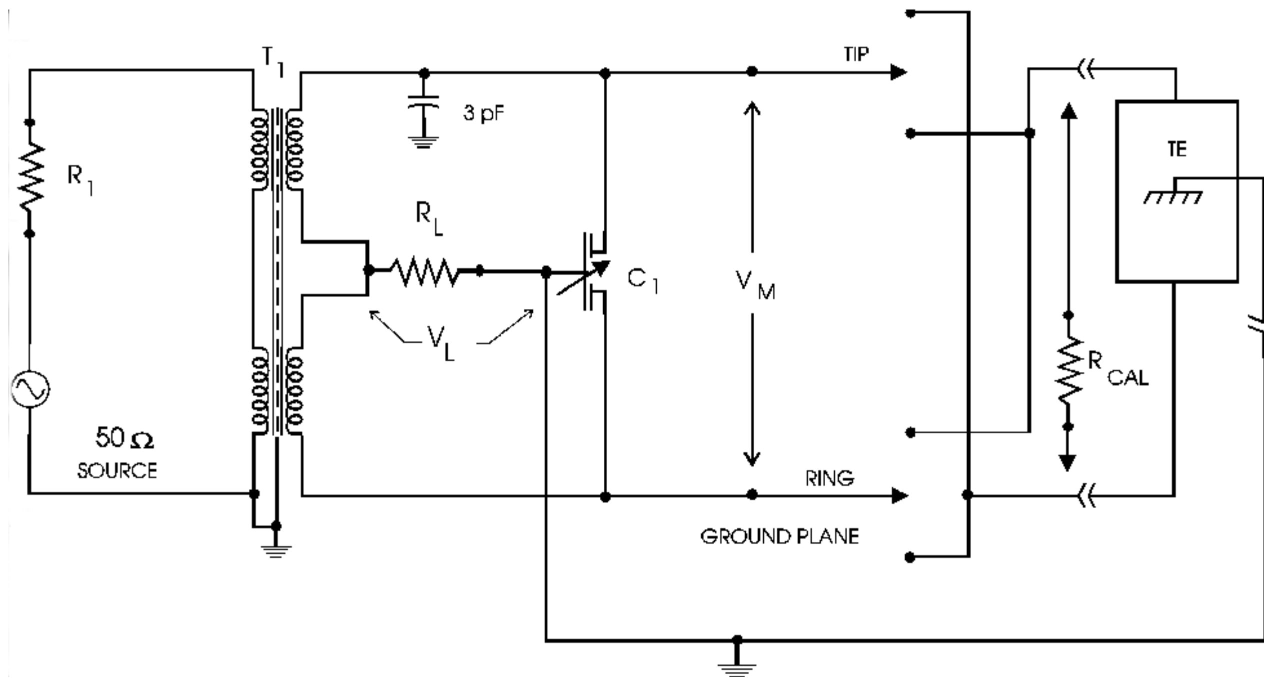
Transverse Balance Requirements

Table 3.2.9

Frequency Ranges of Transverse Balance Requirement

Service kbps	Lower Frequency Hz	Upper Frequency Hz	Longitudinal Termination ohms	Metallic Termination ohms
2.4	200	2.4	500	135
4.8	200	4.8	500	135
9.6	200	9.6	500	135
19.2	200	19.2	500/90	135
38.4	200	38.4	500/90	135
56	200	56	500/90	135
64	200	64	500/90	135

Note: For 200 to 12 kHz the longitudinal termination shall be 500 ohms and above 12 kHz the longitudinal termination shall be 90 ohms.



T_1	100 Ω: 100 Ω C.T. Wide band transformer
C_1	2.4 to 24.5 pF Differential trimmer
R_L	Longitudinal termination, from Table 3.2.7
R_{CAL}	135 Ω
R_1	Selected so that R_1 + 50 Ω = 135 Ω

Note: All resistors are ± 1% tolerance, 1W.

Figure 3.2.9(b)

Transverse Balance

3.2.9.2 Method of Measurement

TE may require special attention to ensure it is properly configured for this test. For example, if the equipment would normally be connected to AC power ground, cold-water-pipe ground, or if it has a metallic or partially metallic exposed surface, then these points shall be connected to the test ground plane. Similarly, if the TE provides connections to other equipment through which ground may be introduced to the equipment, then these points shall be connected to the test ground plane. Equipment which does not contain any of these potential connections to ground shall be placed on a conductive plate which is connected to the test ground plane. This applies to both none powered and AC powered equipment.

(1) Connect the TE to the test circuit of Figure 3.2.9(b) with the calibration test resistor (135 ohms) in place.

(2) Set the spectrum analyzer and tracking generator to the appropriate frequency ranges:

(a) For 2.4 kbps subrate TE - 200 Hz to 2.4 kHz.
(b) For 4.8 kbps subrate TE - 200 Hz to 4.8 kHz.
(c) For 9.6 kbps subrate TE - 200 Hz to 9.6 kHz.
(d) For 19.2 kbps subrate TE - 200 Hz to 19.2 kHz.
(e) For 38.4 kbps subrate TE - 200 Hz to 38.4 kHz.
(f) For 56.0 kbps subrate TE - 200 Hz to 56.0 kHz.
(g) For 64.0 kbps subrate TE - 200 Hz to 64.0 kHz.

(3) Adjust the tracking generator voltage to measure -10 dBV (316 mV) across the calibration test resistor.

(4) Connect the spectrum analyzer across the 500 ohm resistor.

(5) Adjust capacitor, C1, until a minimum voltage across the 500 ohm resistor is obtained. This represents the highest degree to which the bridge can be balanced. The result of this balance calibration shall be at least 20 dB better than the requirement for the applicable frequency band. If this degree of balance cannot be attained, further attention should be given to component selection for the test circuit and its construction.

(6) Reverse the polarity of the tip and ring pair under test. If the longitudinal voltage (Vl) changes by less than 1 dB, the calibration is acceptable. If the longitudinal voltage changes by more than 1 dB, it indicates that the bridge needs further adjustment to accurately measure the balance of the TE. Repeat the calibration process until the measurements differ by less than 1 dB while maintaining the balance noted in step (5) above.

(7) Replace the calibration resistor with one tip and ring pair of the TE.

(8) Measure the voltage across the tip and ring of the TE; this is the metallic reference voltage (Vm).

(9) Measure the voltage across the 500 ohm resistor; this is the longitudinal voltage (Vl).

(10) Calculate the balance using the following formula:

$$\text{Balance (dB)} = 20 \log \frac{Vm}{Vl}$$

Note: If the readings are, for example, taken in dBV, then the equation may be simplified to:

Balance (dB) = Vm (dBV) - Vl (dBV)

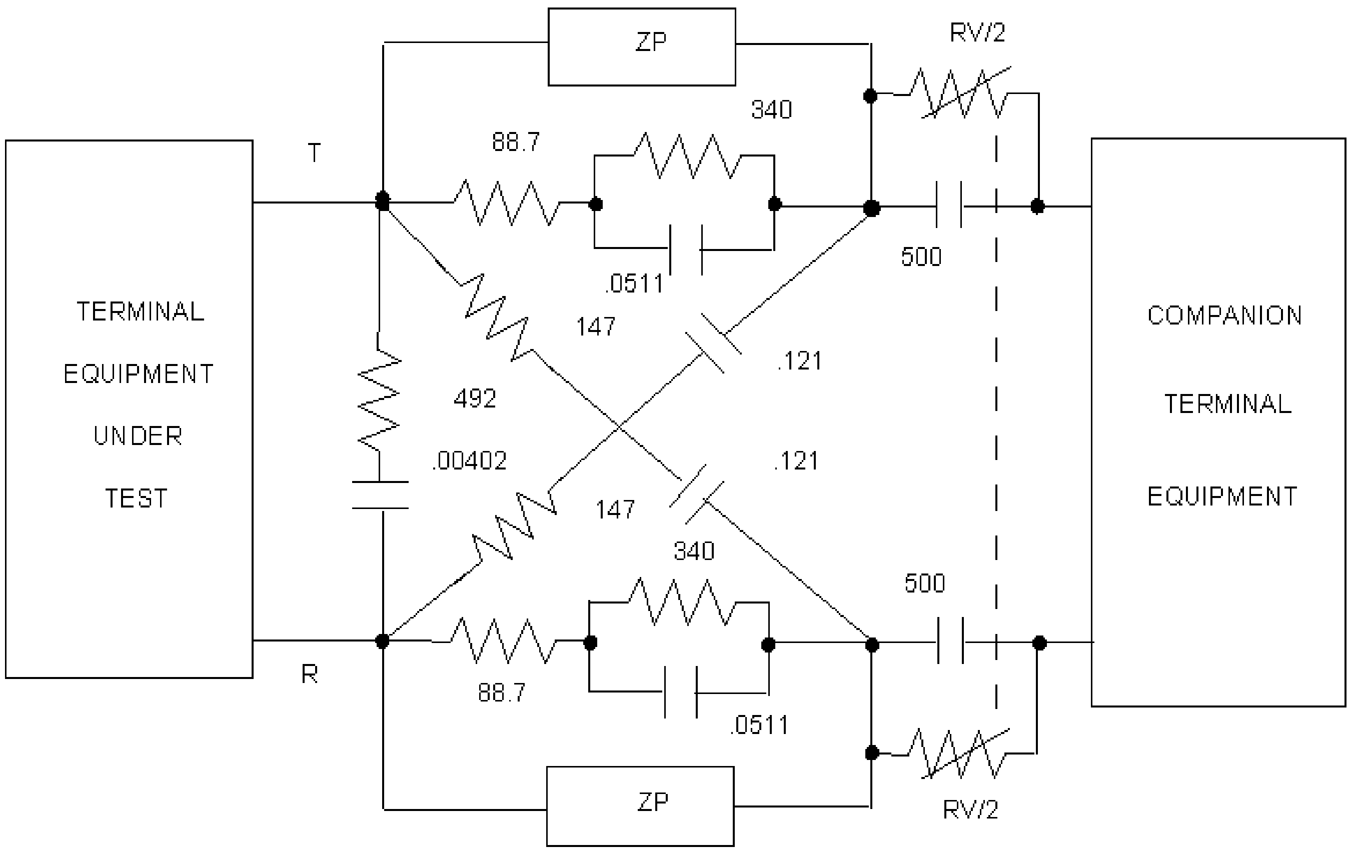
(11) Reverse the tip and ring connections of the TE and repeat steps (8) through (10). The lesser of the two results is the longitudinal balance of this pair of the TE.

(12) Connect the other tip and ring pair of the TE to the balance test set.

(13) Repeat steps (8) through (11) for this pair.

4.0 LDM Loop Simulator for Metallic Voltage Tests

The loop simulator circuits to perform the tests described in Section 3.0 are shown in schematic form in this Section.



Resistances (ohms), Capacitances (uF), Tolerances ± 2%.
RV + RP = 50 thru 3000 ohms.
ZP is the magnitude of the low pass filter impedance which is 〈 25 ohms DC; 〉 3 kohms from 10 Hz to 6 kHz.
RP/2 = DC resistance of low pass filter, ZP in parallel with 428.7 ohms.

Figure 4.0

**LDM Loop Simulator
for Metallic Voltage Tests**