TABLE 68.306(C)—SUMMARY OF RING TRIP REQUIREMENTS

Section 68.306 (d)(4).	Ringing current (mA p.p)		Function required		Ring trip device operates per figure 68.306(a)
	R=500 ohms and greater	R=1500 ohms and greater	Ring trip	Monitor voltage	
(i)	<100	<100	Optional	Optional	Optional.
(ii)(A)	N/A	>100	Yes	Optional	Yes for both resistances.
(ii)(B)	N/A	>100	Yes	Yes	Yes for R=1500 ohms and greater. No for R=500 ohms and greater.
(iii)	>100	<100			
(1) Either Ring-Trip device or Monitor Voltage required					Yes for R=500 ohms and greater, if Ring Trip Device is used.

(e) Intentional paths to ground (as required by §68.304). (1) Connections with operational paths to ground. Registered terminal equipment and registered protective circuitry having an intentional dc conducting path to earth ground at operational voltages that was excluded during the leakage current test of §68.304 shall have a dc current source applied between the following points:

(i) Telephone connections, including tip, ring, tip 1, ring 1, E&M leads and auxiliary leads, and

(ii) Earth grounding connections.

NOTE TO PARAGRAPHS (e)(1)(i) AND (e)(1)(ii): For each test point, gradually increase the current from zero to 1 ampere, then maintain the current for one minute. The voltage between paragraph (e)(1)(i) and paragraph (e)(1)(ii) of this section shall not exceed 0.1 volt at any time. In the event there is a component or circuit in the path to ground, the requirement shall be met between the grounded side of the component or circuit and the earth grounding connection.

(2) Connections with protection paths to ground. Registered terminal equipment and protective circuitry having an intentional dc conducting path to earth ground for protection purposes at the leakage current test voltage that was removed during the leakage current test of §68.304 shall, upon its replacement, have a 50 or 60 Hz voltage source applied between the following points:

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

(ii) Earth grounding connections.

NOTE to paragraphs (e)(2)(i) and (e)(2)(ii): Gradually increase the voltage from zero to 120 volts rms for registered terminal equipment, or 300 volts rms for protective circuitry, then maintain the voltage for one minute. The current between (e)(2)(i) and (e)(2)(ii) of this section 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 carried out separately on components, subassemblies, and simulated circuits, outside the unit, provided that the test results would be representative of the results of testing the complete unit.

[62 FR 61667, Nov. 19, 1997; 63 FR 25173, May 7, 1998]

§ 68.308 Signal power limitations.

(a) *General.* Limits on signal power shall be met 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 terminations as 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.

(b) *Voiceband metallic signal power.* (1) Limitations at the interface on internal signal sources not intended for network control signaling:

(i) The power of all signal energy, in the 200–3995 Hz voiceband, delivered by registered terminal equipment or registered protective circuitry to the appropriate loop simulator—other than non-permissive data equipment or data protective circuitry shall not exceed −9 dBm when averaged over any 3 second interval.

(ii) For 2-wire and 4-wire lossless tie trunk type interfaces, the maximum power of other than live voice signals delivered to a 600-ohm termination shall not exceed −15 dBm when averaged over any three second interval.

(iii) For OPS lines, the maximum power of other than live voice delivered to an OPS line simulator circuit shall not exceed −9 dB with respect to one milliwatt, when averaged over any 3-second interval.

(iv) For registered test equipment or registered test circuitry the maximum signal power delivered to a loop simulator circuit shall not exceed 0 dBm when averaged over any 3-second interval.

(v) For voiceband private lines using ringdown or inband signaling the maximum power of other than live voice signals delivered to a 600 ohm termination shall not exceed −13 dBm when averaged over any 3-second interval.

(vi) For voiceband private lines using inband signaling in the band 2600 ± 150 Hz, the maximum power delivered to a 600 ohm termination shall not exceed −8 dBm during the signaling mode. The maximum power delivered to a 600 ohm 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 ohm termination during the non-signaling mode and for other inband systems shall not exceed −13 dBm when averaged over any 3-second interval.

(2) Limitations on internal signal sources primarily intended for network control signaling, contained in voice and data equipment.

(i) For all operating conditions of registered terminal equipment and registered protective circuitry, the maximum power in the frequency band below 3995 Hz delivered to a loop simulator circuit shall not exceed the following when averaged over any 3-second interval:

(A) 0 dBm when used for network control (DTMF);

(B) 0 dBm when DTMF is used for manual entry end-to-end signaling. When the device is used for this purpose it shall not generate more than 40 DTMF digits per manual key stroke.

(C) −9 dBm in all other cases.

(ii) For tie trunk applications, the maximum power delivered to a 600 ohm termination for registered terminal equipment and registered protective circuitry under all operating conditions shall not exceed −4 dBm over any 3 second interval.

(3) Registered one port and multiport terminal equipment and protective circuitry with provision for through transmission from other terminal equipment, excluding data equipment and data protective circuitry that are registered in accordance with § 68.308(b)(4).

(i) Where through-transmission equipment provides a dc electrical signal to equipment connected therewith (*e.g.*, for powering of electro-acoustic transducers), dc conditions shall be provided which fall within the range of conditions provided by a loop simulator circuit unless the combination of the through-transmission equipment and equipment connected therewith is registered as a combination which conforms to paragraphs (b)(1) and (b)(2) of this section.

(ii) Through-transmission equipment to which remotely connected data terminal equipment may be connected shall not be equipped with or connected to either a Universal or Programmed Data Jack used in data configurations. (*See* paragraph (b)(4) of this section and § 68.502(e)).

(4) Registered data circuit terminal equipment shall be capable of operation in at least one of the states discussed in paragraphs (b)(1)(i), (b)(1)(ii) or (b)(1)(iii) of this section. The output power level of the data circuit terminal equipment shall not be alterable, by the customer, to levels which exceed the signal power limits specified herein.

(i) Data circuit terminal equipment intended to operate with a programming resistor for signal level control

shall not exceed the programmed levels given in Table 68.308(a).

(ii) Data circuit terminal equipment intended to operate in the fixed loss loop (FLL) state shall not transmit signal power that exceeds −4 dBm, in the 200—3995 Hz voiceband, when averaged over any and all 3 second intervals.

(iii) Data circuit terminal equipment shall not transmit signals from 200 to 3995 Hz that exceed −9 dBm, when averaged over any and all 3 second intervals.

TABLE 68.308(a)

Programming resistor (Rp)* (ohms)	Programmed data equipment signal power output
Short	0 dBm.
150	−1 dBm.
336	−2 dBm.
569	−3 dBm.
866	−4 dBm.
1240	−5 dBm.
1780	−6 dBm.
2520	−7 dBm.
3610	−8 dBm.

TABLE 68.308(a)—Continued

Programming resistor (Rp)* (ohms)	Programmed data equipment signal power output
5490	−9 dBm.
9200	−10 dBm.
19800	−11 dBm.
Open	−12 dBm.

*Tolerance) 1%.

(5) Registered one-port and multiport terminal equipment and protective circuitry with provision for through-transmission from ports to other equipment which is separately registered for the public switched network, or ports to other network interfaces.

(i) Registered terminal equipment and registered protective circuitry shall have no adjustments that will allow net amplification to occur in either direction of transmission in the through-transmission path within the 200–3995 Hz voiceband that will exceed the following:

TABLE 68.308(b).—ALLOWABLE NET AMPLIFICATION BETWEEN PORTS (A)(C)(D)(E)

To	Tie trunk type ports			Integrated services trunk	OPS ports (2-wire) (B)	Public switched network ports (2-wire)	HCC digital PBX–CO 4-wire
From (E)	2/4-wire	Subrate 1.544 Mbps satellite 4W	Subrate 1.544 Mbps tandem 4W				
2/4-Wire Tie	0 dB	3 dB	3 dB	3 dB	6 dB		
Subrate 1.544 Mbps Satellite 4W Tie.	0 dB		3 dB	3 dB	6 dB		
Subrate 1.544 Mbps Tandem 4W Tie.	−3 dB	0 dB	0 dB	0 dB	3 dB		
Integrated Services Trunk.	−3 dB	0 dB	0 dB	0 dB	3 dB		
RTE Digital	0 dB	0 dB	0 dB	0 dB	3 dB	3 dB	0 dB.
RTE (B) PSTN/OPS.	−3 dB	−3 dB	−3 dB	−3 dB	0 dB	0 dB	−3 dB
OPS (B) (2-Wire)	−2 dB	1 dB	1 dB	1 dB	4 dB	4 dB	1 dB.
Public Switched Network (2-Wire).					3 dB	3 dB	
HCC Digital PBX–CO (4-Wire).					3 dB		

(A) 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.

(B) These ports are for 2-wire on-premises station ports to separately registered terminal equipment.

(C) These through gain limitations are applicable to multiport systems where channels are not derived by time or frequency compression methods. Terminal equipment employing such compression techniques shall assure that equivalent compensation for

through gain parameters is demonstrated in the registration application.

(D) Registered terminal equipment and registered protective circuitry 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.

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

(F) Registered terminal equipment or protective circuitry with the capability for through transmission from voiceband private line channels or voiceband metallic channels to other telephone network interfaces shall ensure that the absolute signal power levels specified in this section, for each telephone network interface type to be connected, are not exceeded.

(G) Registered terminal equipment or protective circuitry with the capability for through transmission from voiceband private line channels or voiceband 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 to 2750 Hz band are not through transmitted unless there is at least an equal amount of energy in the 800 to 2450 Hz band within 20 milliseconds of application of signal.

(ii) The insertion loss in through connection paths for any frequency in the 800 to 2450 Hz band shall not exceed the loss at any frequency in the 2450 to 2750 Hz band by more than 1 dB (maximum loss in the 800 to 2450 Hz band minus minimum loss in the 2450 to 2750 Hz band plus 1 dB).

(6) For tie trunk interfaces—Limitation on idle circuit stability parameters. For idle state operating conditions of registered terminal equipment and registered protective circuitry, the following limitations shall be met:

(i) For the two-wire interface:

$$RL \geq \begin{cases} 9 - 3\dfrac{\log(f/200)}{\log(2.5)}\ \text{dB} & ;\ \text{for } 200\ \text{Hz} \leq f \leq 500\ \text{Hz} \\ 6\ \text{dB} & ;\ \text{for } 500\ \text{Hz} \leq f \leq 3200\ \text{Hz} \end{cases}$$

(ii) For the four-wire lossless interface:

$$tl_f \geq \begin{cases} 10 - 4\dfrac{\log(f/200)}{\log(2.5)}\ \text{dB} & ;\ \text{for } 200\ \text{Hz} \leq f \leq 500\ \text{Hz} \\ 6\ \text{dB} & ;\ \text{for } 500\ \text{Hz} \leq f \leq 3200\ \text{Hz} \end{cases}$$

$$tl_r > 40\ \text{dB}$$

$$RL_i, RL_o \geq 3\ \text{dB}$$

NOTE: The following definitions apply to return loss requirements:

RL the return loss of 2-wire terminal equipment at the interface with respect to 600 ohms+2.16 μF (*i.e.*, Z_{ref}=600 ohms+2.16 μF).

$$RL \triangleq 20 \log_{10} \left| \frac{Z_{PBX} + Z_{ref}}{Z_{PBX} - Z_{ref}} \right|$$

Rl_i the terminal equipment input (receive) port return loss with respect to 600 ohms (*i.e.*, Z_{ref}=600 ohms).

$$RL_i \triangleq 20 \log_{10} \left| \frac{Z_{PBX\,(input)} + Z_{ref}}{Z_{PBX\,(input)} - Z_{ref}} \right|$$

RL_o the terminal equipment output (transmit) port return loss with respect to 600 ohms (*i.e.*, Z_{ref}=600 ohms).

$$RL_o \triangleq 20 \log_{10} \left| \frac{Z_{PBX\,(output)} + Z_{ref}}{Z_{PBX\,(output)} - Z_{ref}} \right|$$

tl the transducer loss between the receive and transmit ports of the 4-wire PBX. tl_f is the transducer loss in the *forward* direction from the *receive* port to the *transmit* port of the PBX.

$$tl_f \triangleq 20 \log_{10} \left| \frac{I_i}{I_r} \right|$$

Where I_i is the current sent into the *receive* port and I_r is the current received at the *transmit* port terminated at 600 ohms.

tl_r is the transducer loss in the *reverse* direction, from the *transmit* port to the *receive* port of the PBX.

$$tl_r \triangleq 20 \log_{10} \left| \frac{I_i}{I_r} \right|$$

Where I_i is the current sent into the *transmit* port and I_r is the current received at the *receive* port terminated at 600 ohms. Note, the source impedance of I_i is 600 ohms.

(7) Registered terminal equipment and registered protective circuitry shall provide the following range of dc conditions to off-premises station (OPS) lines.

(i) DC voltages applied to the OPS interface for supervisory purposes and during network control signaling shall meet the limits specified in § 68.306(a)(3)(i).

(ii) 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 volts, and

(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 ciruit must be at least 20 mA for the following conditions (*see* Figure 68.3(f)):

R2+RL		
Condition	Class B	Class C
1	600	1300
2	1800	2500

(8) For connections to 1.544 Mbps digital services, the permissible code words for unequipped Mu-255 encoded subrate channels are limited to those corresponding to signals of either polarity, of magnitude equal to or less than X48, where code word, XN is derived by:

XN = (255 – N) base 2
−XN = (127 – N) base 2

(c) Signal power in the 3995–4005 Hz frequency band.

(1) Power resulting from internal signal sources contained in registered protective circuitry and registered terminal equipment (voice and data), not intended for network control signaling. For all operating conditions of registered terminal equipment and registered protective circuitry that incorporate signal sources other than sources intended for network control signaling, the maximum power delivered by such sources in the 3995–4005 Hz band to an appropriate simulator circuit, shall be 18 dB below maximum permitted power specified in paragraph (b) of this section for the voiceband.

(2) Terminal equipment with provision of through-transmission from other equipment. The loss in any through-transmission path of registered terminal equipment and registered protective circuitry at any frequency in the 600 to 4000 Hz band shall not exceed, by more than 3 dB, the loss at any frequency in the 3995 to 4005 Hz band, when measured into an appropriate simulator circuit from a source

that appears as 600 ohms across tip and ring.

(d) Longitudinal voltage at frequencies below 4 kHz. The weighted rms voltage[3] averaged over 100 milliseconds that is resultant of 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 under the conditions stated in paragraph (g) of this section.

Frequency range	Maximum weighted rms voltage	Impedance
100 Hz to 4 kHz	−30 dBV	500 ohms.

(e) Voltage in the 4 kHz to 6 MHZ frequency range-general case—2-wire and 4-wire lossless interface (except LADC). Except as noted, rms voltage as averaged over 100 milliseconds at the telephone connections of registered terminal equipment and registered protective circuitry in all of the possible 8 kHz bands within the indicated frequency range and under the conditions specified in paragraph (g) of this section shall not exceed the maximum indicated below. For paragraphs(e)(1) and (e)(2)(i) of this section, ''f'' is the center frequency in kHz of each of the possible 8-kHz bands beginning at 8 kHz.

(1) Metallic Voltage. (i) 4 kHz to 270 kHz:

Center frequency (f) of 8 kHz band	Max voltage in all 8 kHz bands	Metallic terminating impedance
8 kHz to 12 khz	−(6.4 + 12.6 log f) dBV	300 ohms.
12 kHz to 90 kHz	(23–40 log f) dBV	135 ohms.
90 kHz to 266 kHz	−55 dBV	135 ohms.

(ii) 270 Khz to 6 MHz. 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.

(2) Longitudinal voltage.

(i) 4 kHz to 270 kHz.

Center frequency (f) of 8 kHz band	Max 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

(ii) 270 kHz to 6 MHZ. The rms value of the longitudinal voltage components in the frequency range of 270 kHz to 6 MHZ, shall not exceed −30 dBV. This limitation applies with a longitudinal termination having an impedance of 90 ohms.

(f) *LADC interface.* The metallic voltage shall comply with the general requirements in paragraph (f)(1) of this section as well as the additional requirements specified in paragraphs (f)(2) and (f)(3) of this section. The requirements apply under the conditions specified in paragraph (g) of this section. Terminal equipment 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 that collectively have the property that the rms voltage of the signal components in those bands is at least 90% of the rms voltage

[3] Average magnitudes may be used for signals that have peak-to-rms ratios of 20 dB and less. The rms limitations must be used instead of average values if the peak-to-rms ratio of the interfering signal exceeds this value.

of the total signal. The designated set of frequency bands must be used in testing all frequencies.

(1) Metallic voltages—frequencies below 4 kHz.

(i) Weighted rms voltage in the 10 Hz to 4 kHz frequency band. The weighted rms metallic voltage in the frequency band from 10 Hz to 4 kHz, averaged over 100 milliseconds that is the resultant of all the component metallic voltages in the band after weighting according to the transfer function of f/4000 where f is the frequency in Hertz, shall not exceed the maximum indicated below under the conditions stated in paragraph (g) of this section.

Frequency range	Maximum voltage
10 Hz to 4 kHz	+3 dBV.

(ii) 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 center frequencies between 750 Hz and 3950 Hz shall not exceed the maximum indicated below.

Center freq (f) of 100-Hz bands	Max voltage in all 100-Hz bands
750 to 3950 Hz	−6 dBV.

(2) Metallic Voltages—frequencies above 4 kHz—LADC interface.

(i) 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 center frequencies and under the conditions specified in paragraph (g) of this section shall not exceed the maximum indicated below:

Center freq (f) of all 100-Hz bands	Max voltage in all 100-Hz bands
4.05 kHz to 4.6 kHz	0.5 dBV.
4.60 kHz to 5.45 kHz	(59.2—90 log f) dBV.
5.45 kHz to 59.12 kHz	(7.6—20 log f) dBV.
59.12 kHz to 266.00 kHz	(43.1—40 log f) dBV.

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

(ii) 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 center frequencies and under the conditions specified in paragraph (g) of this section shall not exceed the maximum indicated below:

Center freq (f) of 8-kHz bands	Max voltage in all 8-kHz bands
8 kHz to 120 kHz	(17.6—20 log f) dBV.
120 kHz to 266 kHz	(59.2—40 log f) dBV.

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

(iii) 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, averaged over 2 microseconds, shall not exceed -15 dBV. This limitation applies with a metallic termination having an impedance of 135 ohms.

(iv) 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. (i) Frequencies below 4 kHz. The weighted rms voltage in the frequency band from 10 Hz to 4 kHz,averaged over 100 milliseconds is the resultant of all the component longitudinal voltages in the band after weighing according to the transfer function of f/4000, where f is the frequency in Hz, shall not exceed the maximum indicated below under the conditions stated in paragraph (g) of this section.

Frequency range	Maximum RMS voltage
10 Hz–4 kHz	−37 dBV.

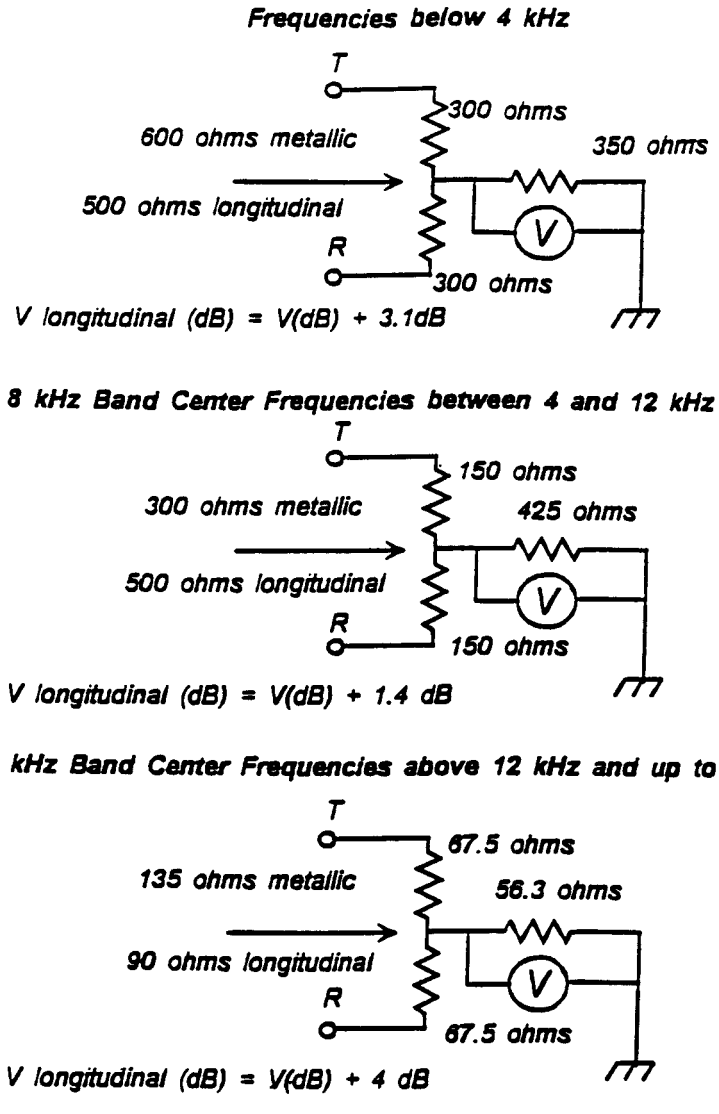
(ii) 4 kHz to 270 kHz.

Ctr freq (f) of 8 kHz bands	Max voltage in all 8 kHz bands	Longitudinal terminating impedance
8 to 12 kHz	−(18.4+20 log f) dBV	500 ohms.

Ctr freq (f) of 8 kHz bands	Max voltage in all 8 kHz bands	Longitudinal terminating impedance
12 to 42 kHz	(3–40 log f) dBV	90 ohms
42 to 266 kHz	−62 dBV	90 ohms.

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

(iii) 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.



RESISTIVE TERMINATIONS
METALLIC RETURN

Figure 68.308(a)

(g) *Requirements in paragraphs (d), (e) and (f) of this section apply under the following conditions:* (1) All registered terminal equipment, except equipment to be used on LADC, and all registered protective circuitry must comply with the limitations when connected to a termination equivalent to the circuit

depicted in Figure 68.308(a) and when placed in all operating states of the equipment except during network control signaling. LADC registered terminal equipment must comply with the metallic voltage limitations when connected to circuits of §68.3(i) and must comply with the longitudinal limitations when connected to circuits of Figure 68.308(a), as indicated.

(2) All registered terminal equipment and registered protective circuitry must comply with the limitations in the off-hook state over the range of loop currents that would flow with the equipment *connected* to an appropriate simulator circuit.

(3) Registered terminal equipment and registered protective circuitry with provision for through-transmission from other equipments shall comply with the limitations with a 1000 Hz tone applied from a 600-ohm source (or, if appropriate a source which reflects a 600-ohm impedance across tip and ring) at the maximum level that would be applied during normal operation. Registered protective circuitry for data shall also comply with the tone level 10 dB higher than the overload point.

(4) For registered terminal equipment or registered protective circuitry with non-registered signal source input, such as music on hold, the out of band signal power requirements shall be met using an input signal with a frequency range of 200 Hz to 20 kHz and the level set at the overload point.

(5) Except during the transmission of ringing (§68.306(d)) and Dual Tone Multi-frequency (DTMF) signals, LADC registered terminal equipment shall comply with all requirements in all operating states and with loop current that may be drawn for such purposes as loop back signaling. The requirements in paragraph (f)(1) of this section except in paragraphs (f)(1)(i) and (f)(1)(ii) of this section also apply during the application of ringing. The requirement in paragraph (d) and the requirements in paragraphs (f)(1)(i) and (f)(1)(ii) of this section 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 paragraph (f)(1)(i) and in paragraphs (f)(2) or (f)(3) of this section as applicable, shall be deemed to comply with the requirements in paragraph (f)(1)(ii) of this section provided that, for automatically originated DTMF signals, the duty cycle is less than 50 percent.

(6) LADC registered terminal equipment shall comply with all applicable requirements, except those specified in paragraphs (f)(1) (i) and (ii) of this section, during the transmission of each possible data signal sequence of any length. For compliance with paragraph (f)(3)(i) of this section, the limitation applies to the rms voltage averaged as follows:

(i) 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.

(ii) For baseband analog signals, the rms voltage is averaged over each period (cycle) of the highest frequency of the signal (3 dB point on the spectrum). For analog signals that 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.

(iii) For signals other than the types defined in paragraphs (g)(6)(i) and (ii) of this section, the peak amplitude of the signal must not exceed +1 dBV.

(7) Equipment shall comply with the requirements in paragraphs (f)(1)(i) and (ii) of this section, during any data sequence that may be transmitted during normal use with a probability greater than 0.001. If the sequences transmitted by the equipment are application dependent, the user instruction material shall include a statement of any limitations assumed in demonstrating compliance of the equipment.

(8) In addition to the conditions specified in paragraph (g)(5) of this section, LADC registered terminal equipment which operates in one or more modes as a receiver, shall comply with requirements in paragraph (f)(3) of this section with a tone at all frequencies

in the range of potential received signals and at the maximum power which may be received.

(h) *Interference limitations for transmission of bipolar signals over digital services.*—(1) *Limitations on Terminal Equipment Connection to Subrate Digital Services*—(i) *Pulse repetition rate.* The pulse repetition rate shall be synchronous with 2.4, 3.2, 4.8, 6.4, 9.6, 12.8, 19.2, 25.6, 38.4, 56.0, or 72 kbps per second.

(ii) *Template for maximum output pulse.* When applied to a 135 Ohm resistor, the instantaneous amplitude of the largest isolated output pulse obtainable from the registered terminal equipment 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 68.308(c) through a single real pole low pass filter having a cutoff frequency in Hertz equal to 1.3 times the bit rate. For bit rates of 2.4, 3.2, 4.8, 6.4, 9.6 and 12.8 kbps, the filtered pulses shall also be passed through a filter providing the additional attenuation in Table 68.308(d).

TABLE 68.308(c)—DRIVING PULSE AMPLITUDE

Line rate (kbps)	User data rate (R) (kbps)	Amplitude (A) (volts)
2.4	2.4	1.66
3.2	2.4 with SC [1]	1.66
4.8	4.8	1.66
6.4	4.8 with SC [1]	1.66
9.6	9.6	0.83
12.8	9.6 with SC [1]	0.83
19.2	19.2	1.66
25.6	19.2 with SC [1]	1.66
38.4	38.4	1.66
51.2	38.4 with SC [1]	1.66
56	56	1.66
72	56 with SC [1]	1.66
72	64	1.66

[1] SC: Secondary Channel.

TABLE 68.308(d)—MINIMUM ADDITIONAL ATTENUATION

Line rate (R) (kbps)	Attenuation in frequency band 24–32 kHz (dB)	Attenuation in frequency band 72–80 kHz (dB)
2.4	5	1
3.2	5	1
4.8	13	9
6.4	13	9
9.6	17	8
12.8	17	8

Note: The attenuation indicated may be reduced at any frequency within the band by the weighting curve of Table 68.308(e). Minimum rejection is never less than 0 dB; i.e., the weight does not justify gain over the system without added attenuation.

TABLE 68.308(e)—ATTENUATION CURVE

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

(iii) *Average power.* 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 and 12.8 kbps or +6 dBm for all other rates shown in Table 68.308(c).

(iv) *Encoded analog content.* If registered terminal equipment connecting to subrate services contains an analog-to-digital converter, or generates signals directly in digital form that are intended for eventual conversion into voiceband analog signals, the encoded analog content of the digital signal must be limited. The maximum equivalent power of encoded analog signals for other than live voice as derived by a zero level decoder test configuration shall not exceed −12 dBm when averaged over any 3-second time interval. The maximum equivalent power of encoded analog signals as derived by a zero level decoder test configuration for signals intended for network control signaling shall not exceed −3 dBm when averaged over any 3-second interval.

(2) *Limitations on Terminal Equipment Connecting to 1.544 Mbps Digital Services*—(i) *Pulse repetition rate:* The free running line rate of the transmit signal

shall be 1.544 Mbps with a tolerance of ±32 ppm., *i.e.*, ±50 bps.

(ii) *Output pulse templates.* The registered terminal equipment shall be capable of optionally delivering three sizes of output pulses. The output pulse option shall be selectable at the time of installation.

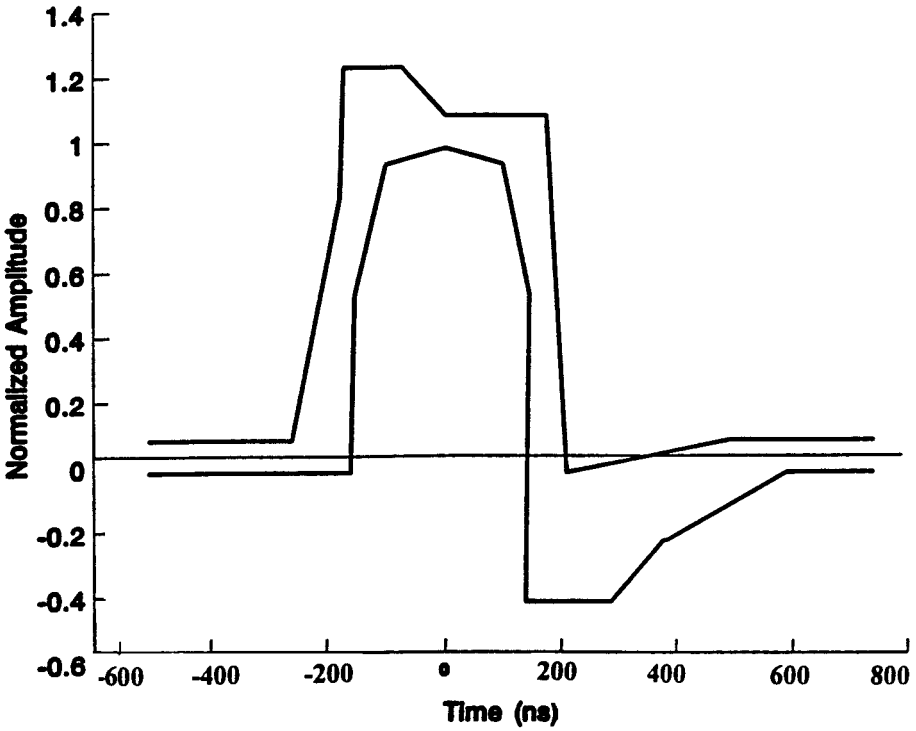
(A) *Option A output pulse.* When applied to a 100 ohm resistor, the instantaneous amplitude of the largest output pulse obtainable from the registered terminal equipment shall fall within the pulse template illustrated in Figure 68.308b). The mask may be positioned horizontally as needed to encompass the pulse, and the amplitude of the normalized mask may be uniformity scaled to encompass the pulse. The baseline of the mask shall coincide with the pulse baseline.

(B) *Option B output pulse.* When applied to a 100-ohm resistor, the instantaneous amplitude of the output from the registered terminal equipment obtained when Option B is implemented shall fall within the pulse template obtained by passing the bounding pulses permitted by Figure 68.308(b) through the following transfer function.

$$\frac{V_{out}}{V_{in}} = \frac{n_2 S^2 + n_1 S + n_0}{d_3 S^3 + d_2 S^2 + d_1 S + d_0}$$

where:
$n_0 = 1.6049 \times 10^6$
$n_1 = 7.9861 \times 10^{-1}$
$n_2 = 9.2404 \times 10^{-8}$
$d_0 = 2.1612 \times 10^6$
$d_1 = 1.7223$
$d_2 = 4.575 \times 10^{-7}$
$d_3 = 3.8307 \times 10^{-14}$
$S = j\ 2\ \Pi\ f$
f=frequency (Hertz)

(C) *Option C output pulse.* When applied to a 100-ohm resistor, the instantaneous amplitude of the output from the registered terminal equipment obtained when Option C is implemented shall fall within the pulse template obtained by passing the pulses obtained in Option B through the transfer function in Option B a second time.



MAXIMUM CURVE

Nano-seconds	−500	−250	−175	−175	−75	0	175	220	500	750
Normalized Amplitude	.05	.05	.8	1.2	1.2	1.05	1.05	−.05	.05	.05

MINIMUM CURVE

Nano-seconds	−500	−150	−150	−100	0	100	150	150	300	396	600	750
Normalized Amplitude ..	−.05	−.05	.5	.9	.95	.9	.5	−.45	−.45	−.26	−.05	−.05

FIGURE 68.308(b) (REF. EIA/TIA 547–1989)—ISOLATED PULSE TEMPLATE AND CORNER POINTS FOR 1.544 MBPS EQUIPMENT

NOTE TO FIGURE 68.308(b) The pulse amplitude is 2.4 to 3.6 V. (Use constant scaling factor to fit normalized template.)

(iii) *Adjustment of signal voltage.* The signal voltage at the network interface must be limited so that the range of pulse amplitudes received at the first telephone company repeater is controlled to ±4 dB. This limitation is achieved by implementing the appropriate output pulse option as a function of telephone company cable loss as specified at time of installation.

Cable loss at 772 kHz (dBV)	Terminal equipment	
	Output pulse	Loss at 772 kHz
15 to 22	Option A	0
7.5 to 15	Option B	7.5
0 to 7.5	Option C	15

(iv) *Output power.* The output power in a 3 kHz band about 772 kHz when an

all ones signal sequence is being produced as measured across a 100 ohm terminating resistance shall not exceed +19 dBm. The power in a 3 kHz band about 1.544 MHz shall be at least 25 dB below that in a 3 kHz band about 772 kHz.

(v) *Encoded Analog Content.* If registered terminal equipment connected to 1.544 Mbps digital service contains an analog-to-digital converter, or generates signals directly in digital form that are intended for eventual conversion into voiceband analog signals, the encoded analog content of the subrate channels within the 1.544 Mbps signal must be limited. The maximum equivalent power of encoded analog signals for other than live voice that are not intended for network control signaling as derived by a zero level decoder test configuration shall not exceed −12 dBm when averaged over any 3-second time interval. The maximum equivalent power of encoded analog signals as derived by a zero level decoder test configuration for signals intended for network control signaling shall not exceed −3 dBm when averaged over any 3-second interval.

[62 FR 61671, Nov. 19, 1997; 63 FR 25173, 25174, May 7, 1998]

§ 68.310 Transverse balance limitations.

(a) *Technical description and application.* The Transverse Balance$_{m-1}$, coefficient is expressed as

$$\text{BALANCE}_{m-1} = 20 \log_{10} \frac{e_M}{e_L}$$

(1) Where e_L is the longitudinal voltage produced across a longitudinal termination Z_1 and e_M is the metallic voltage across the tip-ring or tip 1 and ring 1 interface of the input port when a voltage (at any frequency between f_1 and f_2, see Table 68.310(a) is applied from a balanced source with a metallic impedance Z_0 (see Table 68.310(a). The source voltage should be set such that e_M = E volts (see Table 68.310(a) when a termination of Z_0 is substituted for the terminal equipment.

(2) 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 (See §68.3). An illustrative test circuit that satisfies the above conditions is shown in Figure 68.310–1(a) for analog and 68.310–1(b) for digital and subrate; 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.

(3) 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.

TABLE 68.310(a)

	Analog voiceband	Subrate digital	1.544 Mbps digital
Longitudinal Termination—Z_1	500 ohms	See Table 310(b)	90 ohms.
Metallic Source Impedance—Z_0	600 ohms	135 ohms	100 ohms.
Lower Frequency—f_1	200 Hz	200 Hz	10 kHz.
Upper Frequency—f_2	4 kHz	(1)	1.544 MHz.
Metallic Voltage for Test—E	0.775 V	0.367 V	0.316 V.

[1] The upper frequency equals the digital line rate for the subrate service under test (See Table 68.310(b)).

(b) *Analog voiceband equipment.* All registered analog voiceband equipment shall be tested in the off-hook state. The minimum transverse balance requirement in the off-hook state shall be 40 dB, throughout the range of frequencies specified in Table 68.310(a). For some categories of equipment, additional requirements also apply to the