§ 68.308 Signal power limitations.

(a) *General.* Limitation on signal power shall be met at the interface for all 2-wire network ports, tip and ring conductors to PSDS Types II and III, and, where applicable to services, both transmit and receive pairs of all 4-wire network ports. Signal power measurements will be made using terminations as specified in each of the following limitations. The transmit and receive pairs of 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 to the network.

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

(i) For registered terminal equipment or registered protective circuitry, connected to interfaces associated with services contained in §68.2(a) (1), (2), and (7), other than data equipment or data protective circuitry which is registered in accordance with §68.308(b)(4), the maximum power of other than live voice signals delivered to a loop simulator circuit shall not exceed −9dB with respect to one milliwatt, when averaged over any 3-second interval. No manufacturing tolerance is allowed which would permit this power to be exceeded by any unit of equipment.

(ii) For tie trunk type interfaces, the maximum power of other than live voice signals delivered to a 600 ohm termination shall not exceed the following:

MAXIMUM POWER WITH RESPECT TO ONE MILLIWATT WHEN AVERAGED OVER ANY 3-SECOND INTERVAL

2-wire	4-wire Lossless	4-wire CTS [b]
−15 dB[a]	−15 dB[a]	−19 dB, nom.

NOTES: (a) The maximum signal power may be exceeded by as much as 1.0 dB by a single unit of equipment or circuitry, provided that the power averaged over all units of production, complies with the specified limitations.

(b) The 4-Wire CTS shall meet the requirements for Tie Trunk Transmission Interfaces as defined in §68.3.

(iii) For OPS lines, the maximum power of other than live voice signals delivered to an OPS line simulator circuit shall not exceed −13 dB with respect to one milliwatt, when averaged over any 3-second interval.

(iv) For AIOD channels, the maximum signal power delivered to an AIOD data channel simulator circuit in each of the following operating states shall not exceed −4 dB with respect to one milliwatt averaged over any 3-second time interval:

Simulator circuit[1]	AIOD tip and ring[2]
1	−42.5–56.5
2	0
3	0

[1] Operating state of simulator circuit.

[2] Remote terminal equipment open circuit DC volts to ground on AIOD tip and ring.

The maximum signal power may exceed −4 dB with respect to one milliwatt by as much as 1.0 dB provided that the power averaged over all units of the equipment complies with the specified maximum.

NOTE: The maximum signal power may be exceeded by as much as 1.0 dB by a single unit of equipment or circuitry, provided that the power, averaged overall units of production, complies with the specified limitations.

(v) 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. No manufacturing tolerance is allowed which would permit this power to be exceeded by any unit of equipment.

(vi) 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 −13dBm when averaged over any 3-second interval.

(vii) 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 −13dBm when averaged over any 3-second interval. The maximum signal power may be exceeded by as much as 1.0 dB by a single unit of equipment or circuitry, provided that the power averaged over all

units of production complies with the specified limitation.

(viii) For PSDS (Types I, II and III) terminal equipment when in the digital mode of transmission, the maximum equivalent power of any encoded analog signal (other than live voice) shall not exceed −12dBm when averaged over any 3-second interval. The equivalent analog power shall be derived by a zero-level decoder at the network interface to PSDS (Type II or III) facilities.

(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 delivered to a loop simulator circuit shall not exceed one milliwatt when averaged over any 3-second interval.

(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 the following:

MAXIMUM POWER WITH RESPECT TO ONE MILLIWATT, WHEN AVERAGED OVER ANY 3-SECOND INTERVAL

2-wire	4-wire Lossless	4-wire CTS
−4 dB	−4 dB	−8 dB, nom.

(iii) For PSDS (Types I, II and III) terminal equipment, when in the digital mode of transmission, the maximum equivalent power of any encoded analog signal shall not exceed −3dBm when averaged over any 3-second time interval. The equivalent analog signal shall be derived by a zero-level decoder located at the network interface to PSDS (Type II or III) facilities.

(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 which 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 §68.308(b) (1) and (2).

(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 §§68.308(b)(4) and 68.502(e)).

(4) Limitations on registered data terminal equipment and registered one-port protective circuitry with provision for through-transmission from data equipment. When such equipment or circuitry is used for the transmission of data signals to the telephone network, it shall assure in all operating conditions, other than network control signaling (see §68.308(b)(2) of this section), that one of the following limitations is met, depending upon the means of connection of the equipment or circuitry to the telephone network. The transmitted signal power, averaged over any 3-second time interval, delivered to a loop simulator circuit, shall not exceed:

(i) A maximum level adjustable to no greater than –4 dB with respect to one milliwatt, for connection to a Universal Data Jack used in the ''fixed loss loop'' configurations of §68.502(e).

(ii) A maximum level determined by means of connections in the Programmed Data Jack or Universal Data Jack, used in the ''programmed'' configurations of §68.502(e), which level can be programmed in 1 dB steps from −12 dB to 0 dB with respect to one milliwatt by means of programming connections made within the jack.

(iii) A nonadjustable level no greater than –9 dB with respect to one miliwatt for connection by means other than those which implement the limitations in paragraphs (b)(4)(i) and (ii) of this section. Equipment or circuitry designed in accordance with this –9 dBm limitation shall be treated as non-live voice equipment within these rules.

The maximum signal power specified in (paragraphs (b)(4) (i) and (ii) of this

section may be exceeded by as much as 1.0 dB by a single unit of equipment or circuitry, provided that the power averaged over all units of production, complies with the specified limitations. The maximum signal power specified in paragraphs (b)(4)(iii) of this section may not be exceeded by any units of production.

(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 protectives circuitry shall have no adjustments that will allow net amplification to occur in either direction of transmission in the through-transmission path within the freguency range of 200 to 4000 Hertz that will exceed the following:

MAXIMUM ALLOWABLE NET AMPLIFICATION BETWEEN PORTS (A)(D)(E)(F)

From (F) \ To	Tie Trunk Type Ports (C)					OPS Ports (2-Wire) (B)	Public Switched Network Ports (2-Wire)	NCC Digital PBX-CO 4-Wire
	2-Wire	4-Wire Lossless	4-Wire CTS	Subrate 1.544 Mbps Satell. 4 W	Subrate 1.544 Mbps Tandem 4 W			
Tie Trunk Type Ports (C) — 2-W	0dB avg 1.5dB max	0dB avg 1.5dB max	−4dB nom.	0dB avg 1.5dB max	3dB avg 4.5dB max	−2dB avg −0.5dB max	-	-
4-W Lossless	0dB avg 1.5dB max	0dB avg 1.5dB max	−4dB nom.	0dB avg 1.5dB max	3dB avg 4.5dB max	−2dB avg −0.5dB max	-	-
4-W CTS	−4dB nom.	−4dB nom.	−8dB nom.	−4dB nom.	−1dB nom.	−6dB nom.	-	-
Subrate 1.544 Mbps Satellite Tandem 4 W	0dB avg 1.5dB max	0dB avg 1.5dB max	−4dB nom.	0dB avg 1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max	-	-
Subrate 1.544 Mbps Satellite Tandem 4 W	−3dB avg −1.5dB max	−3dB avg −1.5dB max	−7dB nom.	0dB avg 1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max	-	-
RTE (B)	−2dB avg −0.5dB max	−2dB avg −0.5dB max	−6dB nom.	−3dB avg −1.5dB max	−3dB avg −1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max	−3dB avg −1.5dB max
OPS 2-W (B)	−2dB avg −0.5dB max	−2dB avg −0.5dB max	−6dB nom.	0dB avg 1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max	0dB avg 1.5dB max
Public Switch Net 2-W	-	-	-	-	-	0dB avg 1.5dB max	-	-
NCC Digital PBX-CO 4-W	-	-	-	-	-	0dB avg 1.5dB max	-	-

(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. The numerical ''avg.'' and ''max.'' requirements mean that the net gain for each type of connection through such equipment or circuitry shall be designed not to exceed the average gain for such paths in all units; however, the gain for any path of any single unit may exceed the average by as much as the maximum provided that the net gain, averaged over such paths in all units of production, is no greater than the average. The term ''nom.'' allows for variations encountered in conventional terminating set losses as defined in § 68.3.

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

(C) The 4-Wire CTS shall meet the requirements for Tie Trunk Transmission Interfaces as defined in § 68.3.

(D) 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.

(E) 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 on this section are not exceeded.

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

(G) 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 assure that the absolute signal power levels specified in this section, for each telephone network interface type to be connected, are not exceeded.

(H) 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 Hertz band are not through transmitted unless there is at least an equal amount of energy in the 800 to 2450 Hertz band within 20 milliseconds of application of signal.

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

(6) *For tie trunk type 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

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

(ii) For the four-wire lossless interface

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

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

$$RL_1, RL_o \geq 3\text{dB}$$

(iii) For the four-wire conventional terminating set interface

$$tl_f,\ tl_r \geq \begin{cases} \left(18-4\ \frac{\log(f/200)}{\log 2.5}\right)\ \text{dB; for 200 Hz} \leq f \leq 500\ \text{Hz} \\ 14\ \text{dB} \quad \text{; for 500 Hz} \leq f \leq 3200\ \text{Hz} \end{cases}$$

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

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

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

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)(6)(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 Classes A, B, and C shall not exceed 56.5 volts, and

(B) Except for class A OPS interfaces, the maximum dc current into a short circuit across the tip (T(OPS)) and ring (R(OPS)) leads shall not exceed 140 mA, and

(C) Except for class A OPS interfaces, the dc current into the OPS line simulator circuit must be at least 20 mA for the following conditions (see Fig. 68.3(f)):

R2 + RL

Condition	Class B	Class C
1	600	1300
2	1800	2500

(8) For Message Registration the requirements of §68.308(b) do not apply.

(9) 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 which incorporate signal sources other than sources intended for network control signaling, the maximum power delivered by such sources in the 3995–4005 Hertz band to an appropriate simulator circuit, shall be 18 dB below maximum permitted power specified in paragraph (b) of this section, for the 200–4000 Hertz band.

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

(3) For Message Registration the requirements of §68.308(c) do not apply.

(d) *Longitudinal voltage at frequencies below 4 kHz.* The weighted root-mean-squared voltage* averaged over 100 milliseconds that is the resultant of all of the component longitudinal voltages in the 100 Hz to 4 kHz band after weighting according to the curve of Figure 68.308(a), shall not exceed the maximum indicated under the conditions stated in paragraph (g). The weighting curve in Figure 68.308(a) has an absolute gain of unity at 4 kHz.

Frequency range	Maximum 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—4-wire CTS interface (except LADC).* Except as noted, the root-mean-squared (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) shall not exceed the maximum indicated below. For (1)(i) and (2)(i) below, ''f'' is the center frequency in kHz of each of the possible 8 kHz bands beginning at 8 kHz.

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

(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 logf) dBV	300 ohms
12 kHz to 90 kHz.	(23–40 logf) 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 logf) dBV	500 ohms
12 kHz to 42 kHz.	(3–40 logf) 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 (1) below as well as the additional requirements specified in (2) and (3) as stated. The requirements apply under the conditions specified in paragraph (g). 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 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*—(i) *Weighted RMS Voltage in the 10 Hz to 4 kHz Frequency Band.* The weighted root-mean-square (rms) metallic voltage averaged over 100 milliseconds, frequency components weighted according to the curve in Figure 68.308(a), shall not exceed the maximum indicated below. The weighting curve in Figure 68.308(a) has an absolute gain of unity at 4 kHz.

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 root-mean-squared (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 frequency (f) of 100-Hz bands	Maximum voltage
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 root-mean-square (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) shall not exceed the maximum indicated below:

Center frequency (f) of 100 Hz bands	Maximum voltage in all 100 Hz bands
4.05 kHz to 4.60 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 root-mean-square (rms) voltage as average 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) shall not exceed the maximum indicated below:

Center frequency of (f) 8 kHz bands	Maximum 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 root-mean-square (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.

(iv) *Peak voltage.* The total peak voltage for all frequency components in the 4 kHz to 6 MHz shall not exceed 4.0 volts.

(3) *Longitudinal voltage*—(i) *Frequencies below 4 kHz.* With the frequency components weighted in accordance with the curve in Figure 68.308(a), the weighted root-mean-square 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 paragraph (g). The weighting curve in Figure 68.308(a) has an absolute gain of unity at 4 kHz.

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

(ii) 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 + 20logf) dBV	500 ohms
12 kHz to 42 kHz.	(3–40logf) dBV	90 ohms
42 kHz 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 root-mean-square (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.

(g) Requirements in paragraphs (d), (e) and (f) 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(b) and *when placed in all operating states of the equipment except* during network control signaling. For message registration in the ground return mode, a termination equivalent to Figure 68.308(c) is required, and metallic voltage limitations do not apply. LADC registered terminal equipment must comply with the metallic voltage limitations when connected to the circuits of Figure 68.3(k) and must comply with the longitudinal limitations when connected to the circuits of Figure 68.308(b), as indicated.

(2) All registered terminal equipment and registered protective circuitry must comply with the limitations in the offhook state over the range of loop current that would flow with the equipment *connected* to an appropriate loop 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 that expected during normal operation.

(4) Voice terminal equipment containing electroacoustic transducers for live voice input, including recording devices, shall comply with the limitations with a 1000 Hz acoustic signal applied to the electroacoustic transducers that results in a power delivered into a 600 ohm load impedance of −13 dB with respect to one milliwatt for the 2-wire and 4-wire lossless interfaces

and −19 dB with respect to one milliwatt for the 4-wire CTS interface.

(5) Except during the transmission of ringing (§ 68.306(d)) and Dual Tone Multifrequency (DTMF) signals, LADC registered terminal equipment shall comply with all requirements in all operating states and with loop current which may be drawn for such purposes as loop back signaling. The requirements in § 68.308(f)(1) except in paragraphs (i) and (ii) also apply during the application of ringing. The requirement in § 68.308(d)(2) and the requirements in § 68.308(f)(1) (i) and (ii) 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 § 68.308(f)(1)((i) and in § 68.308(f)(2) or (3) as applicable, shall be deemed to comply with the requirements in § 68.308(f)(1)(ii) 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 § 68.308(f)(1) (i) and (ii), during the transmission of each possible data signal sequence of any length. For compliance with § 68.308(f)(3)(i), 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 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 of 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 § 68.308(f)(1) (i) and (ii) 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.

(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 § 68.308(f)(3) 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 Connecting to Subrate Digital Services*—(i) *Pulse repetition rate.* The pulse repetition rate shall be synchronous with 2.4, 4.8, 9.6 or 56.0 kilobits 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 I 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, 4.8 and 9.6 kbps, the filtered pulses shall also be passed through a filter providing the additional attenuation in table II.

TABLE I—DRIVING PULSE AMPLITUDE

Pulse rate (R) (kbps)	Amplitude (A) (volts)
2.4	1.66
4.8	1.66
9.6	0.83
56.0	1.66

TABLE II—MINIMUM ADDITIONAL ATTENUATION

Pulse rate (R) (kbps)	Frequency band 24 to 32 kHz (dB)	Frequency band 72 to 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 68.308(d). Minimum rejection is never less than 0 dB; i.e., the weight does not justify gain over the system without added attenuation.

(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 kbps or +6 dBm for 2.4 kbps, 4.8 kbps and 56 kbps.

(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 which 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 and ISDN PRA Services—

(i) *Pulse repetition rate.* The pulse repetition rate shall be within ± 75 pulses per second of 1.544 x 10^6 pulses per second.

(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.

TABLE III

Pulse Height (volts)	2.4 to 3.6.
Pulse Width (half amplitude) (nsec)	324 +/− 45.
Maximum rise or fall time; from 10% to 90% points (nsec).	100.

(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 defined in table III.

(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 table III through the following transfer function.

$$\frac{V_{out}}{V_{in}} = \frac{n_2S^2 + n_1S + n_0}{d_3S^3 + d_2S^2 + d_1S + d_0}$$

where:
n_0=1.6049 x 10^6
n_1=7.9861 x 10^{-1}
n_2=9.2404 x 10^{-8}
d_0=2.1612 x 10^6
d_1=1.7223
d_2=4.575 x 10^{-7}
d_3=3.8307 x 10^{-14}
S=j2π 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.

(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 ±4dB. 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 (dB)	Terminal equipment	
	Output pulse	Loss at 772 kHz
15 to 22	Option A	0

Cable loss at 772 kHz (dB)	Terminal equipment	
	Output pulse	Loss at 772 kHz
7.5 to 15	Option B	7.5
0 to 7.5	Option C	15.0

(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 be within the following limits:

Output pulse option	Power in 3 kHz band about 772 kHz (dBm)
A	12 to 19
B	4.5 to 11.5
C	−3 to + 4

The power in a 3 kHz band about 1.544 Mhz shall be at least 25dB below that in a 3 kHz band about 772 kHz.

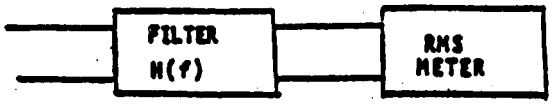
(v) *Encoded analog content.* If registered terminal equipment connected to 1.544 Mbps digital service or to ISDN PRA service contains an analog-to-digital converter, or generates signals in digital form which are intended for eventual conversion to voiceband analog signals, the encoded analog content of the subrate channels of the ISDN information bearing 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.

(3) *PSDS Types II and III Maximum Output Pulse Templates.* For PSDS (Type II) the pulse repetition rate shall be a maximum of 144,000 pulses per second +/−5 pulses per second; for PSDS (Type III) the pulse repetition rate shall be a maximum of 160,000 pulses per +/−5 pulses per second.

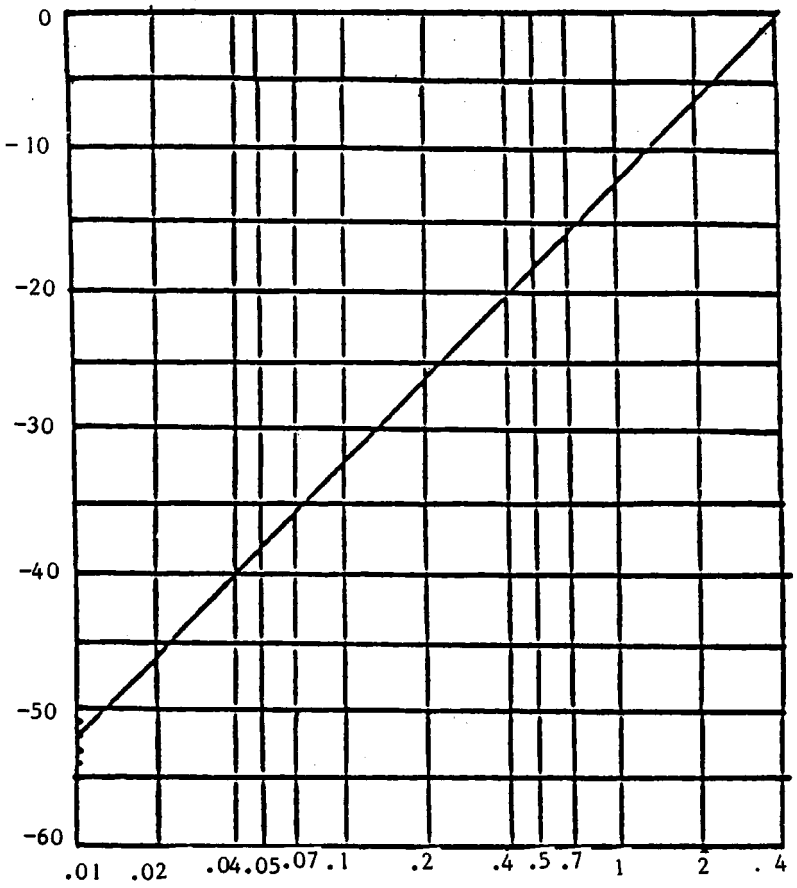
(i) *Template for maximum output pulse.* When applied to a 135 ohm resistor the instantaneous amplitude of the largest isolated output pulse obtainable from the registered terminal equipment shall fall within the template of table IV(A) for PSDS Type II or table IV(B) for PSDS Type III. The limiting pulse template shall be defined by passing an ideal 50% duty cycle rectangular pulse within he amplitude/pulse rate characteristics of table IV(A) or table IV(B) through a 1-pole low-pass filter with a 3dB frequency of 260 kHz.

(ii) Below is the template for maximum output pulse:

Pulse characteristics	Table IV(A)	Table IV(B)
Pulse Height +/−5%	2.6 volts +/−5%	2.4. volts
Pulse Width—100ns	3472.2 +/−150ns	3125 +/−.
Max Rise or Fall Time—microsecond	100ns	1.2.
(From 10% to 90% points) microsecond		+/− 0.2.



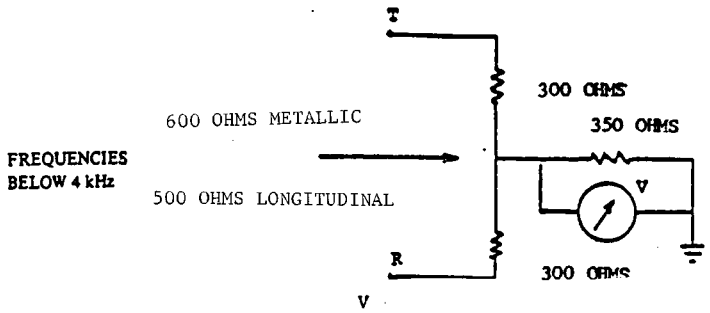
$H(f) = -12 - 20 \log_{10} f)dB$



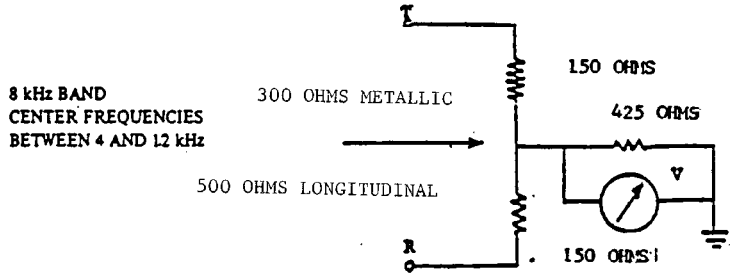
WEIGHTING FUNCTION RESPONSE

Fig. 68.308(a)

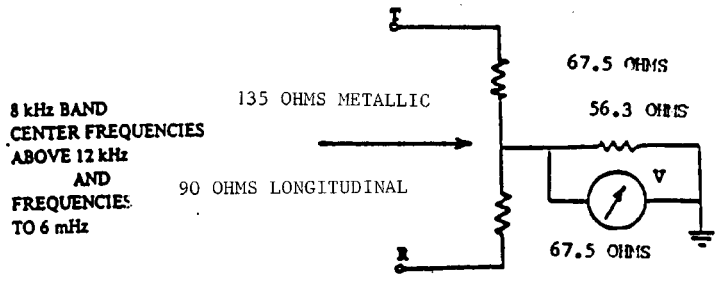
RESISTIVE TERMINATIONS
METALLIC RETURN
(MR SIMULATOR MODE 1)



Longitudinal (db) = V(dB) + 3.1 dB



VLongitudinal (dB) = V(db) + 1.4 dB

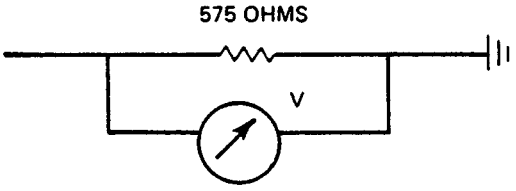


V Longitudinal (dB) = V(dB) + 4 dB

FIGURE 68.308(b)

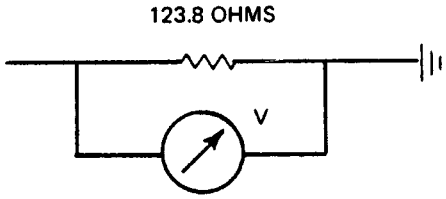
RESISTIVE TERMINATIONS
GROUND RETURN
(MR SIMULATOR MODE 2)

BELOW 12 KHz



$V_{LONGITUDINAL} = V/2$ (dBV)

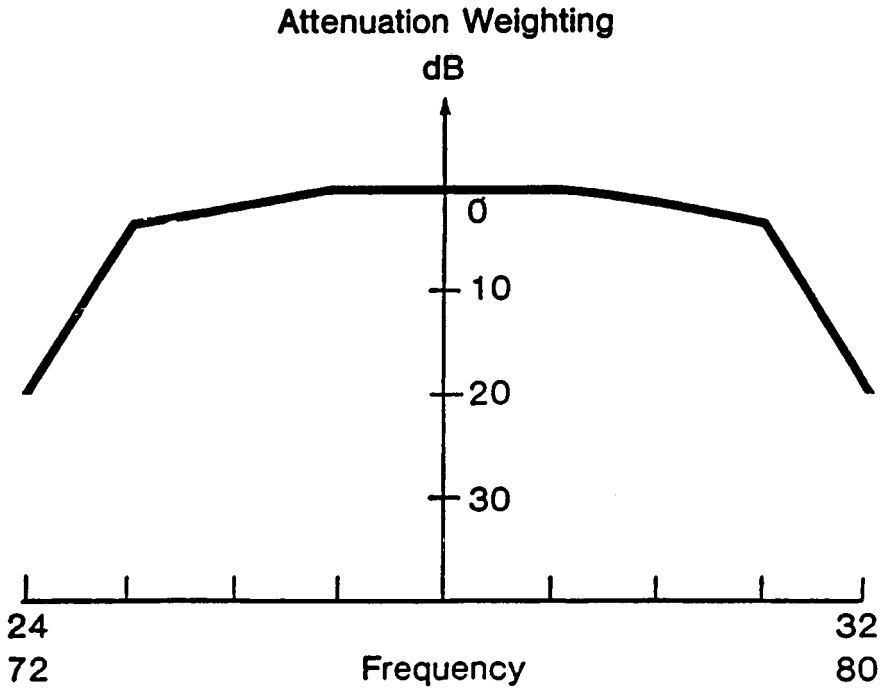
ABOVE 12 KHz



$V_{LONGITUDINAL} = V/2$ (dBV)

FIGURE 68.308(c)

ATTENUATION WEIGHTING CURVE



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

Figure 68.308(d)

(4) *Limitations on Terminal Equipment Connected to ISDN BRA.* If registered terminal equipment connecting to ISDN BRA services contains a digital-to-analog converter, or generates signals directly in digital form, which 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 the encoded analog signals, other than live voice as derived from a zero-level-decoder test configuration, shall not exceed –12 dBm when averaged over a three second interval. The maximum equivalent power of encoded analog signals, as derived by a zero-level decoder test configuration, for network control signaling, shall not exceed –3 dBm when averaged over any three-second interval.

[45 FR 20853, Mar. 31, 1980, as amended at 46 FR 40192, Aug. 7, 1981; 47 FR 10219, Mar. 10, 1982; 47 FR 39687, Sept. 9, 1982; 49 FR 48721, Dec. 14, 1984; 50 FR 48210, Nov. 22, 1985; 51 FR 945, Jan. 9, 1986; 51 FR 16689, May 6, 1986; 61 FR 42392, Aug. 15, 1996; 62 FR 9989, Mar. 5, 1997]

§ 68.310 Longitudinal balance limitations.

(a) *Technical description and application.* The metallic-to-longitudinal balance coefficient, $BALANCE_{m-1}$, is expressed as:

$$BALANCE_{m-1} = 20 \log_{10} \frac{\theta_M}{\theta_L}$$

where e_L is the longitudinal voltage produced across a 500-ohm longitudinal termination 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 200< f<4000 Hertz) is applied from a balanced 600-ohm metallic source. The source voltage should be set such that e_M=0.775 volts rms (0dBm) when a 600 ohm termination is substituted for the terminal equipment. The minimum 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(a); other means may be used to determine the 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 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:

Paragraph	Equipment state	Minimum balance	Frequency range
(b)	On-hook	60	200–1000
	On-hook	40	1000–4000
	Off-hook	40	200–4000
(c)	On-hook	60	200–1000
	On-hook	40	1000–4000
	Off-hook	40	200–4000
(d)	Off-hook	40	200–4000
(e)	On-hook	60	200–1000
Voice Equipment	On-hook	40	1000–4000
	Off-hook	40	200–4000
(e)	On-hook	60	200–1000
Data Equipment	On-hook	40	1000–4000
	Off-hook	40	200–4000
(f)	Off-hook	40	200–4000
(g)	On-hook	60	200–1000
	On-hook	40	1000–4000
	Off-hook	40	200–4000
(h)	Off-hook	40	200–1000
(i)	On-hook	60	200–1000
	On-hook	40	1000–4000
	Off-hook	40	200–4000
(j)	Off-hook	40	200–4000

(b) *Registered one-port terminal equipment for 2-wire non-data applications with loop start, ringdown, inband signaling or voiceband metallic channels.* The one-port shall be driven from a 600-ohm metallic source having a 500-ohm longtitudinal impedance.

(c) *Registered one-port terminal equipment for 2-wire data applications with loop start, ringdown, inband signaling or voiceband metallic channels.* The one-port shall be driven from a 600-ohm metallic source having a 500-ohm longitudinal impedance.

(d) *Registered one-port equipment for ground-start and reverse-battery applications.* The one-port shall be driven from a 600-ohm metallic source having a 500-ohm longitudinal impedance.

(e) *Registered protective circuitry for 2-wire applications with loop start, ringdown, inband signaling or voiceband metallic channels.* These criteria shall be met with either terminal of the interface to other equipment connected to earth ground. The interface to other equipment shall be terminated in an impedance which will be reflected to the telephone connection as 600-ohms in the off-hook state of the registered protective circuit, and the interface should not be terminated in the on-hook state. Figure 68.310(e) shows the interface of the protective circuitry being tested and the required arrangement at the interface to other equipment.