HERMON LABORATORIES

Analog Telephony

Compliance Requirements Overview

The standard two-wire telephone-set connection known as analog PSTN (Public Switched Telephone Network) (loop start) or POTS (Plain Old Telephone Service) is the oldest but still most widely used service offered by the telephone companies.
Other types of analog services offered by the telephone companies include:

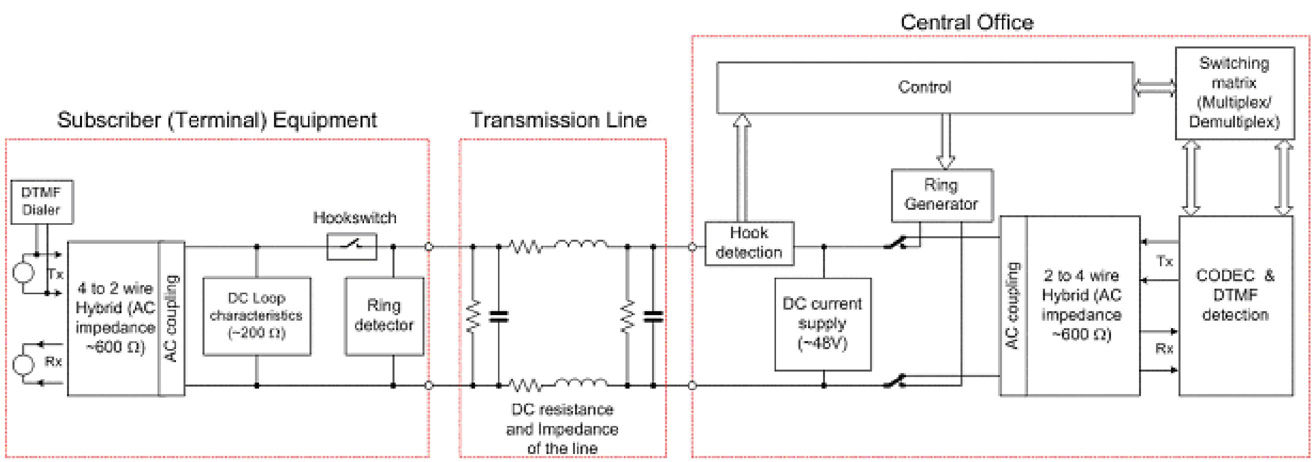
- Four-wire services, using separate pairs of wires for transmitting and receiving provides improved fidelity;
- Reverse battery services allow automated PBXs to act as localized central offices;
- Ground start and E and M tie trunks offer more reliable methods of signaling than the loop start systems.

In addition to the public switched services, where the user can dial different numbers, private point-to-point services are provided in both two-wire and four-wire formats.

Local loop

A customer equipment (also called subscriber or terminal equipment) is usually connected to the telephone company exchange (Central Office) by on average about 5 kilometers (3 miles) of a twisted pair of No. 22 (AWG) or 0.5 mm copper wires, known as the subscriber (local) loop. The resistance of 0.5 mm wire (single lead) is 16.5 ohm per thousand feet (54 ohm per 1 km). The twisted pair is used to provide a balanced line which reduces common mode interference (crosstalk) from adjacent pairs in the cable and RFI (Radio Frequency Interference). Balance is a measure of equality of impedance between each lead in the pair (called Tip and Ring) and the ground. In order to keep the balance of the line, the terminal equipment should be balanced also.

Figure 1. Local Loop.



The telephone company applies loop feed DC voltage between Tip and Ring at the Central Office (CO). This voltage is 50 Vdc on average. Terminal equipment should be able to operate with both positive and negative voltage polarity.

Table 1. DC feed voltages - Test requirements per national standards.

	USA (FCC Part 68/TIA-968-A)	Canada (CS-03)	Europe (TBR 21, 38)	Japan (JATE)	Australia (AS/ACIF S002, S004)
DC feed voltage	42.6 to 52.5 Vdc	42.5 to 52.5 Vdc	50 Vdc	48 Vdc	48 Vdc

When the terminal equipment is in on-hook (idle) state it should present a large DC resistance (several Mohms) between Tip and Ring, otherwise the CO would falsely detect an off-hook state due to the current drawn. Also if the DC resistance is too low, the line is interpreted as damaged by the telephone company automated insulation test system.

When the terminal equipment goes off-hook (by reducing its DC resistance), because the CO feed is basically a current source, the line voltage drops to between 15 V to 4 V and the loop current is 12 mA to 80 mA, depending on the length of the loop (series resistance) and the DC resistance of the equipment. The terminal equipment DC resistance in the off-hook state (about 200 ohm) should not be too low to not overload the CO and on the other hand it should not be too high so the off-hook state can be detected. The off-hook state is detected by the CO when the loop current is about 10 mA or higher. The terminal equipment DC resistance in the off-hook state may depend on loop voltage and current. When the CO detects the off-hook state it sends a dial tone. Dial tone consists of one or two frequency components in the 300 to 500 Hz range with the levels ranging from -36 dBm0 to 0 dBm0. Usually the dial tones are continuous. Cadenced (interrupted) dial tones are used some countries. Different countries use various dial tones.

The CO removes the dial tone when it detects dialing from the terminal equipment.

The loop presents an AC transmission line with characteristic impedance composed of distributed resistance, capacitance and inductance to the voice frequency signals transmitted over the line. The line impedance will vary according to the location of wires and the cable, type of insulation of the wire and the length of the loop. Various national standards assume different nominal (reference) impedance.

If the impedance of the equipment is mismatched i.e. differs significantly from the line impedance it results in echo and whistling (also called singing). Return loss is a measure of the impedance matching.

$$RL = 20\mathrm{Log}_{10} \frac{|Z_{REF} + Z|}{|Z_{REF} - Z|}$$

Where: RL is the Return loss of the equipment under test, *Zref* is the reference (network) impedance and *Z* is the impedance of the equipment under test. Greater return loss means better matching of the device impedance to the reference impedance.

Table 2. Reference impedance - Test requirements per national standards.

	USA (FCC Part 68/TIA-968-A)	Canada (CS-03)	Europe (TBR 21, 38)	Japan (JATE)	Australia (AS/ACIF S002, S004)
Z reference	600 Ω, Return loss measurement: 600 Ω + 2.16 uF	600 Ω, Return loss measurement: 600 Ω + 2.16 uF	TBR 21: 270 Ω + 750 Ω || 150 nF TBR 38: 270 Ω + 750 Ω || 150 nF, 82 Ω + 600 Ω || 68 nF, 220 Ω + 1800 Ω || 150 nF	600 Ω	220 Ω + 820 Ω || 115 nF

Signal level

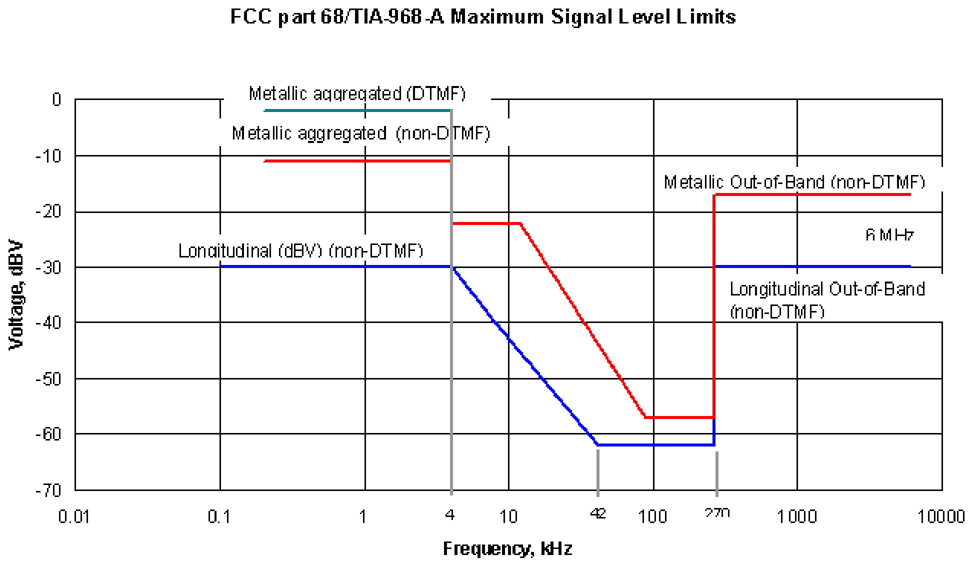
200 Hz to 4 kHz voice frequency band (or Voiceband) is used for communication and signaling between terminal equipment and CO in both directions. Telephone speech signals usually use narrower 300 Hz to 3.4 kHz band which is often also referred to as the voice frequency band (or voice frequencies). Data analog interface equipment such as modems and faxes also use the VF band to transmit and receive analog signals that carry digital data. By using modulation and coding techniques the data transmission rate can be increased up to 56 kbps (kilobits per second).

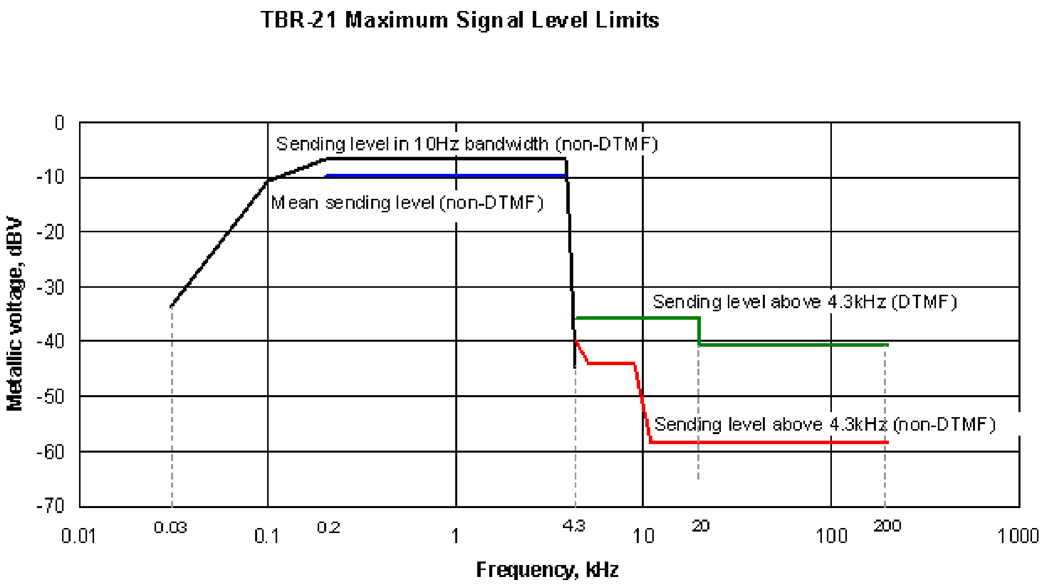
The maximum level of signals transmitted in the VF band (also called in-band signals) should be limited in order not to exceed the maximum channel level, not to overload the amplifiers (used to compensate for loop distance) and to prevent crosstalk. Different limits are set in the standards for voice and data signals than for DTMF dialing signals. These limits also differ between various standards. In US the maximum limit for non-DTMF signal power is - 9 dBm and the maximum limit for DTMF signal power is 0 dBm, when measured at 600 ohm, integrated over the VF band and averaged over 3 seconds.

The maximum level limit of signals outside the VF band (called out-of-band signals) is much less than in-band signals limit.

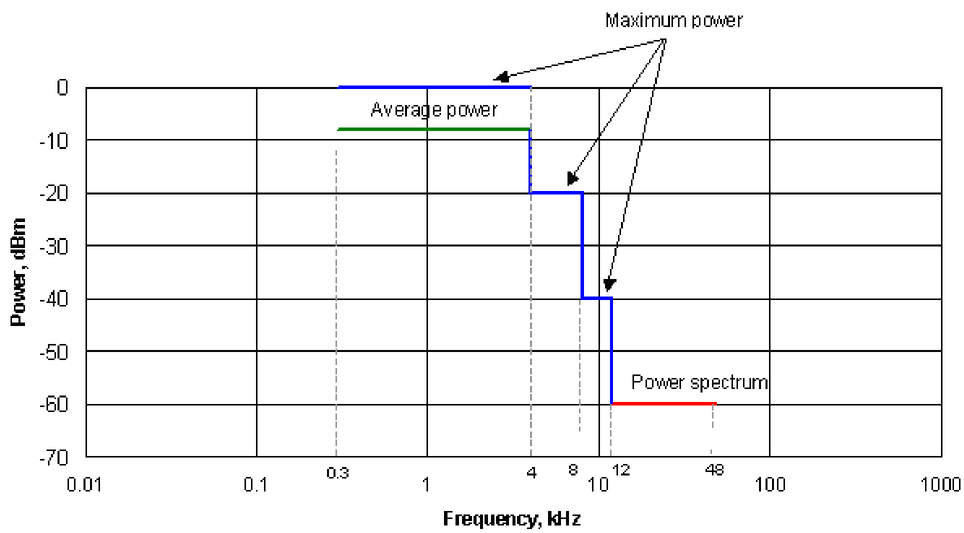
Excessive out-of-band signals can interfere with other services and network signals and can produce spurious in-band signals due to aliasing with sampling or multiplexing frequencies. According to US FCC Part 68 the out-of-band signal level is measured up to 6 MHz.

Figure 2. Maximum Output Signal Level Limits.

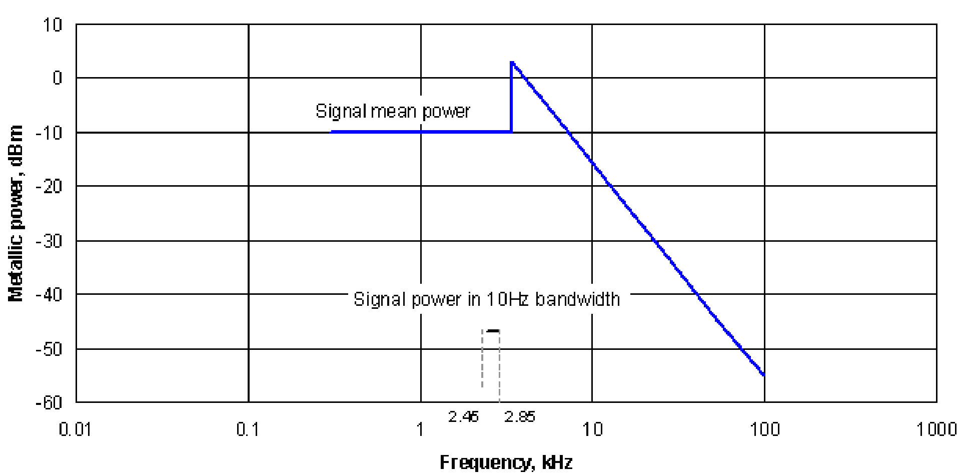




JATE Maximum Signal Level Limits



AS/ACIF S002:2001 Maximum Signal Level Limits



Telephone electro-acoustic characteristics

Because the same pair of wires is used for simultaneous transmitting and receiving (full duplex transmission) the terminal equipment should attenuate its transmitted signal towards its receiver to prevent feedback. Such feedback is called sidetone. Too little sidetone in a handset telephone can convince the callers that they are not being heard causing them to raise their voice. Too much sidetone can cause the callers to lower their voice. The standards usually limit the sidetone from above only. Thus telephones with no sidetone at all will comply with the standards. In fact, hands-free speaker phones and some cellular phones do not have sidetone.

The telephone microphone converts sound waves into electrical signals which are transmitted to the telephone line. The electrical signals received from the line are converted to sound waves by the telephone speaker.

Ideally the speech performance of a telephone would give the same perceived impression as a face to face conversation between two people of the same height, 1 m apart, in a quiet, approximately anechoic environment. In practice the limited 300 Hz to 3.4 kHz bandwidth and the mono-aural operation inherent to the PSTN and telephone design reduce the audio quality to the level just sufficient for speech to be understood. Many other factors affect the speech performance, such as talker/listener mouth and ear locations, acoustics and ambient noise of the environment, electrical transmission characteristics of the local loop and of the interconnecting PSTN path, and the electro-acoustic characteristics of the telephones.

The European TBR 38 and the Australian AS/ASIF TS004 specify the test requirements for speech performance of telephones to ensure compatibility with other telephones, with the PSTN, and to provide reasonable quality of service. Both standards are based on ITU-T P.64 and P.79. The Receiving Sensitivity (dBPa/dBV, Hz) is determined as the gain frequency response of the receiving electro-acoustic path from the voltage stimulus level applied to the telephone line interface to the measured sound pressure level at the Ear Reference Position (ERP). Similarly, the Sending Sensitivity (dBV/dBPa, Hz) is determined as the gain frequency response of the sending electro-acoustic path from the sound stimulus level applied to the Mouth Reference Position (MRP) to the voltage level, measured at the telephone line interface. The ERP and MRP simulate the caller ear and mouth positions with relation to the telephone microphone and speaker and are required for reproducible measurements. Sending/Receiving sensitivity results are normalized to best-fit between the minimum and maximum limits (Figures 3, 4). The Sending/Receiving sensitivity limits drop at the frequency band edges. These drops represent human ear frequency response and the voice frequency bandwidth characteristics.

Figure 3. TBR 38 Sending Sensitivity Limits.

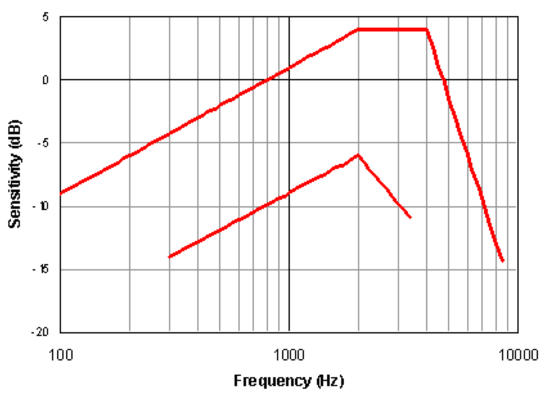
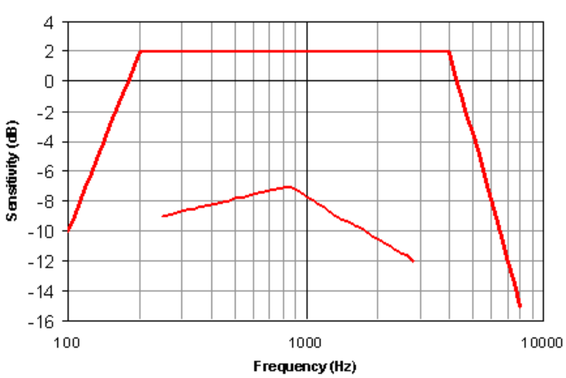
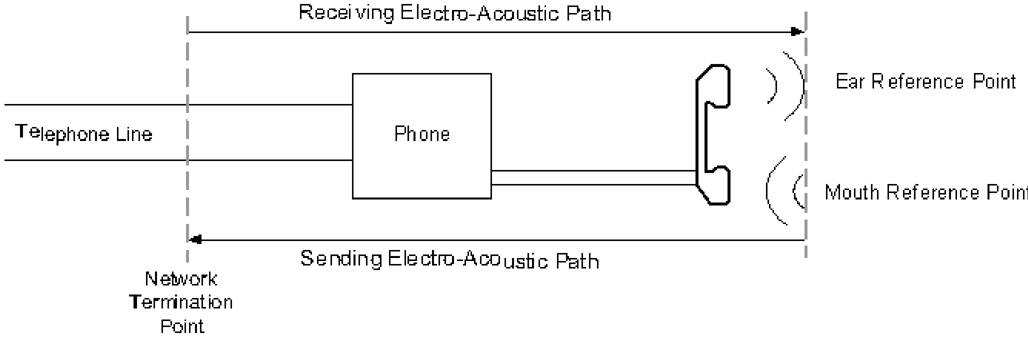


Figure 4. TBR 38 Receiving Sensitivity Limits.



The sending/receiving loudness rating is calculated from sending/receiving sensitivity by applying a weighting function and integrating the corresponding sensitivity results over the VF frequency range. The sending and receiving loudness ratings represent the overall loudness performance of the sending and receiving electro-acoustic paths and are limited by the minimum and the maximum. This ensures that the speech level is not too weak and not loud in both receiving and transmitting directions.

Figure 4. TBR 38 Receiving Sensitivity Limits.



The total harmonic distortion (THD) of the telephone sending and receiving electro-acoustic paths should not exceed 7% (and 10% for higher level signals). An ideal transmission path would output a single continuous wave (CW) signal of the same frequency as the stimulus CW signal applied to the input of the path. Distortion, that can be due to transformer saturation, non-linear operation of amplifiers or clipping, results in harmonic frequencies (or harmonics) added to the output signal which are integer multiples of the frequency of the input signal (called fundamental). The THD is determined as the percentage of the sum of the harmonic levels from the sum of all frequency component levels (i.e. harmonics + fundamental). The sending and receiving THD is measured up to the 5th harmonic with fundamental (stimulus) frequencies in the 315 Hz to 1000 Hz range. The apparent effect of high percentage THD is a "distorted" sound with "metallic" tones.

The gain of the telephone sending and receiving electro-acoustic paths should be of similar value for both low and high signal levels in order to faithfully reproduce various tone levels that are present in the speech. Otherwise, usually due to non-linear operation which produces less gain of higher signals or clipping, the voice appears to be "flattened".

This difference of sending/receiving gain values for high and low signal levels, called sending/receiving linearity, should be between -2 dB to 2 dB according to TBR 38.

The telephone should not introduce noise in both receiving and sending directions. TBR 38 sets the maximum limit for sending noise measured at the telephone line interface and integrated over the VF band with psophometric weighting as -66 dBVp to - 60 dBVp (for the feed resistance 500 ohm to 2800 ohm). 0 dBVp = 20 $\log_{10}$ 1 Vp, where p stands for psophometric weighting. The maximum limit for receiving noise measured as the sound level pressure at the handset speaker integrated over the VF band with A-weighting is -49 dBdPa(A). 0 dBdPa(A) = 20$\log_{10}$ 1 Pascal, where (A) stands for A-weighting.

Instability is audible oscillations, caused by feedback to the microphone. If a sound signal, after it has passed through the microphone, is amplified and fed back to the microphone, the signal will oscillate with the sound level increasing until the electro-acoustic path is saturated. Instability can be caused by too high speaker sidetone, reflections, improper microphone and speaker directivity, poor acoustic design or mechanical vibrations.

DTMF and Pulse dialing

There are two types of dialing (also called signaling) in use in the world - DTMF and Pulse.

DTMF (Dual Tone Multi Frequency) or Touch tone is more modern and more widely used type of dialing. Compared to pulse dialing it is faster and its signals can travel down the telephone line further than the pulse. Therefore DTMF can be used for control of remote devices such as PBXs, answering machines and computers.

There are 16 different DTMF digits that can be dialed (as opposed to 10 digits in pulse dialing). Each DTMF digit is a combination of two tones (Low group frequency tone and a High group frequency tone). Each tone is a single frequency sine wave signal.

Table 3. DTMF signaling digits frequency combinations - Nominal values.

	High group (Hz)			
Low group (Hz)	**1209**	**1336**	**1477**	**1633**
697	**1**	**2**	**3**	**A**
770	**4**	**5**	**6**	**B**
852	**7**	**8**	**9**	**C**
941	*****	**0**	**#**	**D**

For example when the caller presses "1" button on a telephone touch tone pad a signal consisting of 697 Hz and 1209 Hz is transmitted to the line. Low and High group frequency deviation from the nominal values should be within +/- 1.5%. The minimum pause and the minimum tone durations should not be less then about 70 ms to be compatible with most types of PBXs and the standards. Although many PBXs will detect DTMF tone and pause durations as short as 40 ms. The level of the High group and the Low group tones should be about - 7 dBm and - 9 dBm respectively (nominal power into 600 ohm). The difference between the High group tone and Low group level is called twist.

Pulse dialing (also known as Decadic, Loop disconnect or Rotary dialing) is accomplished by the terminal equipment opening and closing the loop at specific time intervals. Each pulse digit is represented by a certain number of makes (loop-closed) and breaks (loop-open). Usually the number of breaks corresponds to the dialed digit so that dialed "1" opens the loop once, "5" opens the loop 5 times and "0" opens the loop 10 times. Some countries use different digit vs brake/make sequence. The pulse dialing frequency is usually 10 pps nominal and the make/break ratio is 40/60. Also pulse rise and fall times, make/break durations and make/break resistances are controlled by the standards.

Ring

The Central Office sends ring signal to the terminal equipment to alert it about the incoming call. Ring signal is usually a single frequency sine wave between 15 Hz to 70 Hz. The ring signal is usually sent with 2 s to 8 s pauses between the rings. There also can be short breaks within ring-on interval. The ring on/off intervals sequence is called cadence. The ring voltage can be 25 Vrms to 150 Vrms at the terminal equipment. The voltage depends on the length of the loop, the number of terminal equipment devices connected to the line and their impedance.

The ring voltage is hazardous.

The terminal equipment should be able to detect the range of ring signal levels, frequencies and cadences that can be present in the network, by responding in its intended manner, such as ringing a bell, flashing, sending a command or automatically seizing the line.

If the called party is busy, the calling party receives a busy tone from the CO. Different countries use various cadenced (more common) and continuous busy tones. The most commonly used busy tone is 420 Hz + 620 Hz, with 0.5 s on 0.5 s off cadence and the level from -52 dBm0 to - 20 dBm0. If the called party is not busy the CO sends a ring signal to the called party. While the ring signal is sent to the called party the CO sends a progress signal, known as ring-back to the calling party. When the called party answers (goes off-hook) the ring trip equipment at the CO detects the off-hook condition and stops the ring. The ring trip equipment detects DC current or combination of AC and DC current to stop the ring. If during the ring the terminal equipment, while it is in the on-hook state, draws too much DC current or presents too low AC impedance between Tip and Ring and between each Tip, Ring to ground, the CO will disconnect the ring prematurely.

During the ring the CO may or may not remove the loop feed DC voltage.

If Caller ID service is provided, the CO can send caller ID information between the ring pulses or prior to the ringing using FSK (Frequency Shift Keying) or DTMF signaling in the VF band. The European EN 300 659-1,2,3 standards describe the subscriber line protocol used for caller ID and other services.

Ring impedance, DC current during ringing limits

If several terminal equipment devices are connected to the same line, their combined (on-hook) ring impedance may be too low for the limited current supplied by the CO to drive the ringers. REN (Ring Equivalence Number) defines a normalized current consumption value during ring for a device. Per US FCC Part 68 REN is calculated as follows:

REN = Max [5 Impedance Limit / Measured Impedance]

Where:

Impedance limit is

Type B ringer (15.3 Hz to 68 Hz, 40 Vrms to 150 Vrms):

1.6 kohm

Type A ringer (20 Hz, 30 Hz, 40 Vrms to 130 Vrms):

1 kohm at 20 Hz

1.4 kohm at 30 Hz.

Measured Impedance is the AC impedance measured during the ring with various above ringer characteristics.

The total REN of the devices connected together to the line is determined by summing the individual REN for each devices. The maximum total REN allowed in the US is 5.

The less device's REN is, the more additional devices can be connected to the line.

Example:

If device A has REN = 1.2, device's B REN = 2.7 and device's C REN = 3.2, then

devices A and B can be connected together and so A and C.

B and C can't be connected together since their total REN = 2.7 + 3.2 = 5.9 exceeds the maximum REN = 5.

Transition from on-hook to off-hook state

TBR 21 defines loop current vs time requirements during transition from the on-hook to the off-hook state. The maximum limit for the current rise time is 20 ms for 230 ohm loop resistance, 30 ms for 3.2 kohm loop resistance and 400 ms for larger loop resistances. Also the terminal equipment should not release the line when the feed current is interrupted for up to 400 ms, during the transition to the off-hook state for the purpose of making a call.

Transition from off-hook to on-hook state

According to TBR 21 the loop current should drop to at least 0.5 mA within 400 ms during transition from the off-hook to the on-hook state, when measured with the 2050 ohm loop resistance.

Automatic dialing

Additional requirements are imposed by TBR 21 for automatically dialing terminal equipment. When dial tone is not present, the terminal equipment should start dialing not earlier than 2.7 s and not later than 8 s after the off-hook state has been established. In some cases networks can’t recognize the dialing within 3 s. With dial tone present, the terminal equipment should start dialing not later than 8 s from the start of the dial tone. The terminal equipment should not try to automatically dial the same number more than 15 times in a row and should pause at least 5 s between the successive call attempts, in order not to tie up the network.

Billing protection

Requirements, that are intended to protect the correct operation of the network billing equipment, are specified in US FCC Part 68/TIA-968-A. The terminal equipment should not transmit any signals in the on-hook state. Data transmitting terminal equipment should not transmit any information within 2 s after going off-hook in response to an incoming call. These conditions are required to allow activation of the billing equipment. The maximum "no signal" limit is defined as -55 dBm in the voice-band.

The terminal equipment should not interfere with the 2600 Hz Single Frequency Signaling tone. This requirement is ensured by verifying that the signal power generated by the equipment in the 2450 Hz – 2750 Hz frequency band is not greater than that generated in the 800 Hz – 2450 Hz frequency band for the first two seconds from transition to the off-hook state as a response to a call.

When the terminal equipment seizes the line, the maximum drop in the loop current should be limited to allow the billing equipment connection and proper operation.

Leakage current and Hazardous voltages requirements

The US FCC Part 68/TIA-968-A standards are concerned with protecting the network personnel from hazardous voltages that may be caused by connection of the terminal equipment. This is verified by a series of tests.

a. The terminal equipment should not present to the telephone line a voltage higher than 70 V peak.

b. Any leads or elements having conductive path to the telephone line should be physically separated from conductive paths to power connections and to other non-registered equipment. The "telephone-line" leads should not be routed together in the same cable together with other leads and adjacent connector pins should not be used for these two types of leads and mechanically restriction should be provided to prevent accidental contact. The term non-registered equipment means the equipment that does not comply with the FCC Part 68 requirements (and can't be directly connected to the telephone network) including secondary telephone equipment.

c. The FCC Part 68/TIA-968-A leakage current test is conducted to verify that telephone line connections are adequately insulated against hazardous supply voltages of the terminal equipment or as the result of accidental contact with commercial power on exposed conductive surfaces, connections to other equipment or other connections to the network interface. High voltage (1000 or 1500 VAC, 50 or 60 Hz) is applied to the possible combinations of such connection and contact points and the leakage current is measured between these test points. The specified maximum peak leakage current limit is 10 mA. The leakage current limit serves as a threshold for determining whether dielectric breakdown has occurred. The 1500 VAC test voltage level is used when the test points combination includes power connections. It is based upon commonly used criteria for testing transformer insulation. The 1000 VAC test voltage is used for other test points and is based on the assumption that such voltages may reach the terminal equipment due to the failure of network protective devices. The leakage current test should not be confused with the leakage current, overvoltage and dielectric withstanding tests defined in the product safety standards such as UL/IEC/EN 60950.

The overvoltage protective components, such as surge suppressors are removed before the testing. Since such components are typically rated to at greater than 130 V to be transparent to ringing voltages, leaving them in place would prevent the correct testing of the dielectric strength.

d. The Intentional Protective Paths to Ground test is performed to verify that the leakage current does not exceed 10 mA peak at a lower 120 VAC test voltage representative of AC power fault. Since overvoltage protective components are removed in the leakage current test, this additional test is required to ensure that the hazardous voltages are prevented with the terminal equipment protective components in place.

e. The Intentional Operational Paths to Ground is performed to verify the ground continuity between grounded telecommunications points and the terminal equipment earth grounding connections. The voltage between the ground test points should not exceed 100 mV with 1 A applied DC current. This test also is required to verify that protective components do not pose a hazard to the network personnel.

Surges and Mechanical Shock tests

Surge tests are required by US FCC Part 68/TIA-968-A to simulate voltage and current surges induced by lightning and occurring in telephone and power lines. The terminal equipment should comply with all the requirements of the standards after application of the surges.

The surges are applied differentially (metallic surges) Tip and Ring and between other combinations of telecommunications pairs, longitudinally i.e. between telephone lines and ground, and between phase and neutral terminals of the AC power supply line.

800 V, 10 us rise time / 560 us decay time surge is applied differentially (metallic) between Tip and Ring and between other combinations of telecommunications pairs. 1500 V, 10 us rise time / 160 us decay time surge is applied (longitudinal) between Tip and Ring and the ground other combinations of telecommunications pairs.

Mechanical shock tests are performed to reveal any damages or misposition of components during shipping, installation or used. Handheld equipment is dropped from 1.5 m (60 inches) height and desktop equipment is dropped from 0.75 m (30 inches) height. The terminal equipment should comply with all the requirements of the standards after being dropped.

Table 4. Analog interface regulatory standards requirements

	USA (FCC Part 68/TIA-968-A)	Europe (TBR 21, ETSI ES 203 021)	Japan (JATE)	Australia (AS/ACIF S002)
On-hook state				
DC resistance	DC resistance between Tip and Ring, Resistance to earth	DC resistance between Tip and Ring, Resistance to earth	DC resistance between Tip and Ring, Resistance to earth	DC resistance between Tip and Ring, Resistance to earth
Ringing impedance	Metallic AC Impedance, longitudinal AC impedance , DC current during ringing, REN	Metallic AC Impedance, longitudinal AC impedance , DC current during ringing	Metallic AC Impedance, longitudinal AC impedance , DC current during ringing, Capacitance	Metallic AC Impedance, longitudinal AC impedance , DC current during ringing
Balance / Longitudinal conversion loss	Transverse balance	Longitudinal Conversion Loss	Longitudinal Conversion Loss	Longitudinal Conversion Loss
Transient response		Transient response		
Ringing detector sensitivity		Ringing detector sensitivity		Ringing detector sensitivity, No detection of small ring signals
Impedance				Impedance
Off-hook steady state requirements				
DC characteristics		Metallic DC Voltage vs Current, Resistance to earth	DC resistance between Tip and Ring	Metallic DC Voltage vs Current in line seizure and hold states
Impedance / Return loss	Return loss	Return loss, Reactance	Return loss	Return loss
Balance / Longitudinal conversion loss	Transverse balance	Longitudinal Conversion Loss	Longitudinal Conversion Loss	Longitudinal Conversion Loss
Output signal balance		Output signal balance		
Voiceband (in-band) signal level	Metallic power, Longitudinal voltage	Metallic voltage	Metallic power	Metallic power and voltage
Out-of-band signal level	Metallic and Longitudinal voltage	Metallic voltage	Metallic power	Metallic power
Through transmission	Insertion loss, Net amplification, SF cutoff			
DTMF signaling	High and Low group frequency, level, tone and pause duration, twist, spurious noise	High and Low group frequency, level, tone and pause duration, twist, spurious noise	High and Low group frequency, level, tone and pause duration, twist	High and Low group frequency, level, tone and pause duration, twist, spurious noise, rise and fall time, Return loss during DTMF
Pulse signaling		Pulse speed, Make/Break ratio, Inter-digit pause, Make/Break current	Pulse speed, Make/Break ratio, Inter-digit pause	Make and Break durations, Inter-digit pause, Pulse shape
Automatic dialing	Maximum of call attempts	Pause between call attempts, maximum of call attempts, Delay after line seizure	Delay after line seizure	Pause between call attempts, maximum of call attempts, Delay after line seizure
Automatic answering	Call answer	Ring signal detector sensitivity		Maximum response time, Acknowledgement signals
Line Liberation through power failure				Line Liberation through power failure
Transition from on-hook to off-hook states	Loop current characteristics	Acceptance of breaks, Loop current characteristics		Acceptance of breaks
Transition from off-hook to on-hook states	-	Loop current characteristics		

	USA (FCC Part 68/TIA-968-A)	Europe (TBR 21, ETSI ES 203 021)	Japan (JATE)	Australia (AS/ACIF S002)
Environmental simulation	Metallic and Longitudinal surges on telephone and power lines, Drops (unpackaged)			
Leakage current and Hazardous voltages	Leakage current, Hazardous voltages, Ground continuity			
Billing protection	On-hook signal power, Signaling interference, Loop current			
Hearing aid compatibility	Magnetic field			
Prevention of outgoing DC voltage			Prevention of outgoing DC voltage	
Prevention of the occurrence of Excessive Acoustic Shock			Prevention of the occurrence of Excessive Acoustic Shock	
Crosstalk attenuation			Crosstalk attenuation	

Table 5. Handset and Hands-free telephones standard requirements

	Europe TBR 38 (Handset telephones)	Australia AS/ACIF S004 (Handset telephones)	ITU-T P.340 (Hands-free telephones)	ITU-T P.313 (Cordless and mobile digital telephones)
Sending Sensitivity	Yes	Yes	Yes	Yes
Receiving Sensitivity	Yes	Yes	Yes	Yes
Sending Loudness	Yes	Yes	Yes	Yes
Receiving Loudness	Yes	Yes	Yes	Yes
Sidetone	Yes	Yes	Yes	Yes
Sending Distortion	Yes	Yes	Yes	Yes
Receiving Distortion	Yes		Yes	Yes
Sending Linearity	Yes			
Receiving Linearity	Yes			
Sending Noise	Yes		Yes	Yes
Receiving Noise	Yes		Yes	Yes
Instability	Yes			
Echo Return Loss	Yes			