Regulatory Requirements
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Due to the enormous cost of interrupted service and failed network equipment, telephony service providers have adopted various specifications to help regulate the reliability and performance of the telecommunications products that they purchase. In Europe and much of the Far East, the most common standards are ITU-T K.20 and K.21. In North America, most operating companies base their requirements on NEBs which contain GR 1089 requirements, TIA-968-A (formerly known as FCC Part 68), and UL 60950-1.

Note:
This section is a paraphrase of existing documents and does not cover the listed recommendation, standard or regulatory requirements in their entirety. This information is intended to be used only as a reference. For exact specifications, obtain the referenced document from the appropriate source.

Surge Waveforms for Various Standards

TIA-968-A now replaces FCC Part 68, except for hearing aid compatibility (HAC), volume control, and indoor cabling. This has become harmonized with Canadian requirements. Various countries around the world have adopted this regulation.

TIA TR41.9 subcommittee is reorganizing this document and expects to release TIA-968-B version during the 2009 calendar year. This version will incorporate the A1,A2,A3,and A4 annexes into the document.

GR 1089 is a standard generally supported by the US Regional Bell Operating Companies (RBOCs). It is updated by Telcordia Technology (formerly Bellcore). The RBOCs typically require compliance with GR 1089 for any of their telecom purchases.

The ITU is a specialized agency of the UN devoted to international harmonization. Most European countries recognize the ITU standards.

CNET is the Centre National d'etudes de Telecommunications, a French organization.

VDE is the Verband Deutsher Elektrotechniker, a Federation of German electrical engineers. VDE is very similar to the IEEE (Institute of Electrical and Electronics Engineers) but is national in scope rather than global.

ANSI is the American National Standards Institute, which is a non-government organization. The British equivalent to this is BSI.

IEC is the International Electrotechnical Commission, a result of Europe's move toward a single market structure and its drive to formalize and harmonize member countries' requirements.

FTZ R12 is a German specification.

Table 3.1 (far right column) shows the recommended *SIDACtor*® device surge rating (A, B, or C) for each standard.

Table 3.1 Surge Waveforms for Various Standards

Standard			Voltage	Voltage Waveform	Current	Current Waveform	SIDACtor® Device
			Volts	µs	Amps	µs	w/o series R
TIA-968-A	Surge A Metallic		800	10x560	100	10x560	B or C
	Surge A Longitudinal		1500	10x160	200	10x160	C
	Surge B Metallic		1000	9x720	25	5x320	A, B or C
	Surge B Longitudinal		1500	9x720	37.5	5x320	A, B or C
GR 1089	Test 1		600	10x1000	100	10x1000	C
	Test 2		1000	10x360	100	10x360	B or C
	Test 3		1000	10x1000	100	10x1000	C
	Test 4		2500	2x10	500	2x10	C
	Test 5		1000	10x360	25	10x360	A, B or C
CNET 131-24			1000	0.5x700	25	0.8x310	A, B or C
VDE 0433			2000	10x700	50	5x310	A, B or C
VDE 0878			2000	1.2x50	50	1x20	A, B or C
IEC 61000-4-5	Metallic	Class 2	500	1.2x50	12	8x20	A, B or C
		Class 3	1000	1.2x50	24	8x20	A, B or C
		Class 4 & 5	2000	10x700	48	5x310	B or C
	Longitudinal	Class 2*	1000	1.2x50	24	8x20	A, B or C
		Class 3*	2000	1.2x50	48	8x20	A, B or C
		Class 4* & 5*	4000	1.2x50	96	8x20	A, B or C
		Class 5* long-distance circuits	4000	10x700	100	5x310	A, B or C
FTZ R12			2000	10x700	50	5x310	A, B or C
YD/T 993-1998	Without Primary Protection Metallic, Single Tip and Ring Pair		1500	10x700	37.5	5x310	A, B or C
			1500	10x700	37.5	5x310	A, B or C
	Without Primary Protection Longitudinal, Single Tip and Ring Pair		1500	10x700	37.5	5x310	A, B or C
			1500	10x700	37.5	5x310	A, B or C
	Without Primary Protection Longitudinal, All Tip and Ring Pair		1000	10x700	25	5x310	A, B or C
			1000	10x700	25	5x310	A, B or C
	With Primary Protection Metallic, Single Tip and Ring Pair		4000	10x700	100	5x310	C
			4000	10x700	100	5x310	C
	With Primary Protection Longitudinal, Single Tip and Ring Pair		4000	10x700	100	5x310	C
			4000	10x700	100	5x310	C
	With Primary Protection Longitudinal, All Tip and Ring Pair		4000	10x700	100	5x310	C
			4000	10x700	100	5x310	C
			Without Primary Protector / With Primary Protector				
ITU K.20	Basic single port		1000 / 4000	10x700	25 / 100	5x310	A, B, C / B, C
	Enhanced single		1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Basic multiple ports		1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced multiple		1500 / 6000	10x700	37.5 / 150	5x310	A, B, C / C
	Basic power fault		600	50 Hz, 60 Hz	1	0.2 s	04611.25
	Enhanced power fault		600 / 1500	50 Hz, 60 Hz	1 / 7.5	0.2 s / 2 s	04611.25
ITU K.21	Basic single port		1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced single		6000 / 6000	10x700	37.5 / 100	5x310	A, B, C / C
	Basic multiple ports		1500 / 4000	10x700	37.5 / 100	5x310	A, B, C / B, C
	Enhanced multiple		1500 / 6000	10x700	37.5 / 100	5x310	A, B, C / C
	Basic power fault		600	50 Hz, 60Hz	1	0.2 s	04611.25
	Enhanced power fault		600 / 1500	50 Hz, 60Hz	1 / 7.5	0.2 s / 2 s	04611.25

* Tested with Primary Protection

GR 1089–Core

In the United States, the telecommunication network is primarily operated by the Regional Bell Operating Companies (RBOC) who follow the standards set by the Generic Requirements (GR) document referred to as GR-1089-CORE, "*Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*". This GR document provides criteria for both EMC and electrical safety for equipment that is used in Central Offices (COs), Remote Terminals (RTs), Controlled Environmental Vaults (CEVs), Electronic Equipment Enclosures (EEEs), network equipment located at the customer premises, and other such locations. This document reflects the opinion of Telcordia and participating industry representatives. The criteria in this document are intended to insure safe and reliable operation of equipment during and after nearby lightning strikes, 60 Hz power fault conditions, Electrostatic Discharge events (ESD), Electrical Fast Transient events (EFTs), and Electromagnetic Interference events (EMI). These criteria apply to wireless systems installed in telecommunication network equipment locations. The following sections apply to specific interface ports of the equipment.

Section 2 of GR-1089 addresses EFT.

Section 3 addresses conducted emission & immunity criteria

Section 4 addresses lightning and AC power fault

Section 5 addresses steady-state power induction

Section 6 addresses DC potential difference

Section 8 addresses corrosion

Section 10 addresses DC power port load equipment

These interface ports could be coaxial cable, signal, telecommunication, antenna, and power. In this document, a telecommunication port includes paired conductor interfaces such as the tip and ring leads, sleeve leads, E & M leads, and 10/100/1000 BaseT ports (including PoE).

Section 7, *Electrical Safety Criteria*, addresses the safety of personnel who have access to the equipment

Section 9, *Bonding and Grounding*, describes the requirements for grounding systems

The criteria for these standards are based on the assumption that a primary protector will limit transient voltages to 1000 V peak for surge conditions and 600 V rms for power fault conditions. All network equipment shall be listed by a Nationally Recognized Testing Laboratory (NRTL) if the equipment is directly powered by Commercial AC. Network equipment located on customer premises shall be listed by a NRTL. Equipment required to meet GR 1089 must be designed to pass:

- Both First and Second Level Lightning Surge and AC Power Fault Tests
- Current Limiter Test
- Short Circuit Test

GR-1089 compliant products shall be manufactured in accordance with the applicable requirements contained in:

Federal Communications Commission (FCC) {specifically FCC Part 68, Part 15, and TIA-968-A}

National Electric Code (NEC)

National Electrical Safety Code (NESC)

Department of Labor – Occupational Safety and Health Administration (OSHA)

And other applicable local requirements, including country (parish), state and federal law, regulations, and ordinances.

In conjunction with primary voltage protectors, operating companies also may incorporate fuse links if there is the possibility of exposing the twisted pair to outside power lines. These fuse links are equivalent to 24- or 26-gauge copper wire and are coordinated with the current-carrying capacity of the voltage protector.

The last element of protection that may be provided by the operating company are current limiters which, if provided, are found on the line side of the network equipment after the primary voltage protection device. These current limiters typically come in the form of heat coils and have a continuous rating of 350 mA.

Changes to GR-1089

Changes to Section 4 of the GR 1089 in October 2002 now require conformance with additional definitions and tests:

- Ethernet (including 10BaseT, 100BaseT, and 1000BaseT) are considered telecommunications lines and GR 1089 requirements apply.
- The 2x10 surge is not used for systems having primary protectors mounted on the side of the enclosure or within the enclosure. It also is not used if the length of the conductors between the primary protector and the circuit pack is less than one meter if a metallic enclosure is used and all terminals are bonded to the enclosure and the longest dimension of the enclosure is less than three meters.
- The 600 V and 1000 V 100 A 10x1000 surge events voltage level may be reduced for CO equipment using solid state protectors.
- The secondary protector must coordinate with the primary protector OR have a 100 A 10x1000 rating. This requirement became effective January 2006; before that date it was only an objective.
- First level power fault adds a 440 V 2.2 A two-second test and a 600 V 3 A 1.1-second test.
- Second level testing allows the wiring simulator fuse to be either the MDL 2.0 A or the MDQ 1.6 A. The second level requirement is the same for either the CPE or non-CPE.

Additional 15-minute test conditions of 3 A, 3.75 A, 5 A, 10 A, 12.5 A, 20 A, and 30 A conditions have been added. However, compliance with UL 60950 Annex NAC conditions 3, 4, and 5 are still accepted. The 2 A and 2.6 A tests are conducted without the simulator fuse in the circuit. However, it must meet applicable time-current curve.

Reasons for GR-1089-CORE, Issue 3

- Section 2, *System-Level Electrostatic Discharge (ESD)*
  Harmonize with the recent revisions to IEC 61000-4-2 (ESD), and IEC 61000-4-4. (EFT)
- Section 3, *Electromagnetic Interference*
  Add conducted emissions and immunity criteria at broadband frequencies
- Section 4, *Lightning and AC Power Fault Resistibility*
  Add a conditional requirement and objective regarding external current limiters in high-speed digital networks, add an objective to address coordination, change 1st level power fault tests 6, 7, 8, and 9 from objectives to requirements, clarify the number of samples to be tested, clarify the number of ports to be tested, revise the criteria for customer premises 2nd level power fault tests, clarify the test procedure for 1st level tests and relocate all listing requirements to Section 7.
- Section 5, *Steady-State Power Induction*
  Add criteria for coaxial port immunity to steady-state power induction.
- Section 7, *Electrical Safety Criteria*
  Harmonize electrical safety terminology with international and North American telecommunications safety standards.
- Section 9, *Bonding and Grounding*
  Provide guidance on the application of the criteria to various types of network equipment add criteria for bonding, modify the short-circuit tests clarify the number of samples required to be tested, provide test procedures related to non-switching systems, clarify test procedures where necessary.

Reasons for GR-1089-CORE, Issue 4

- Include wireless systems criteria.
- Add a new definition appendix.
- Clarify criteria and test procedures.
- Section 1, *Introduction*
  Included guidelines for evaluation and added generic criteria.
- Section 2, *System-Level Electrostatic Discharge (ESD)*
  Extended date for objective to become a requirement, revised the ESD Warning Labels and established date for EFT objectives to become requirements.
- Section 3, *Electromagnetic Interference*
  Adopted the new FCC Part 15 requirements for ac power lines, revised the conducted emissions and immunity criteria for dc power ports and revised the conducted emissions and immunity criteria for broadband leads.
- Section 4, *Lightning and AC Power Fault Resistibility*
  Clarified procedures for calibration of generators, revised test conditions for equipment with 4-wire and multi-wire interfaces, changed the number of samples to be tested for second-level tests , added intra-building criteria for equipment with multi-wire interfaces, added intra-building criteria for equipment connected to shielded cables, communications and coaxial , revised second-level tests as applied to equipment with secondary protection , added surge testing methods for equipment that delivers power over communications wiring, revised the protection coordination tests, established new equipment port type for equipment located at remote sites, added a new subsection that provides appropriate criteria for equipment with agreed primary protection, added a new subsection that provides appropriate criteria for equipment with integrated primary protection, revised lightning criteria for equipment with ac power ports and added surge criteria for dc power ports for equipment located at OSP facilities.
- Section 7, *Electrical Safety Criteria*
  revised test procedure for classifying the source limits and revised the powering limitation criteria
- Section 9, *Bonding and Grounding*
  revised the grounding requirements of embedded power sources than 150 VA for specific applications.
- Section 10, *DC Power Port of Telecom. Equipment*
  revised the grounding requirements of embedded power sources than 150 VA for specific applications. that provides criteria on dc power ports of telecommunications equipment, which are powered from a shared dc power plant.

Section 2 System-Level Electrostatic Discharge (ESD) and Electrical Fast Transient (EFT)

Circuit packs are tested for ESD immunity at the system level only (see Table 3.2). Therefore, ESD events are applied to faceplates, ejector tabs, etc. points and surfaces that are accessible during normal operation of the equipment and under installation and maintenance conditions. GR-78-CORE *Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment* contains ESD immunity criteria for stand-alone circuit cards.

The EUT shall be tested using the methods of IEC 61000-4-2 (ESD), clauses 7 and 8, with the preferred method being the contact discharge method as specified in clause 7. The EUT shall not be damaged and shall continue to operate without negatively affecting service nor requiring the need for manual intervention.

Table 3.2: ESD Immunity Requirements for Normal Operation Mode and Installation & Maintenance Mode

Test Level	Air discharge	Contact discharge	Repetitions
2	4 kV		±10*
4	15 kV		±10*
4		8kV	±10*

* For a total of 40 times for air discharge or a total of 20 times for contact discharges

The EUT shall be tested using the methods of IEC 61000-4-4 (EFT), clauses 6, 7, & 8 (see Table 3.3). The capacitively coupling clamp specified in clause 6.3 of IEC 61000-4-4 is the preferred EFT test method. IF Bit Error Rate (BER) measuring equipment is used to verify the EUT performance, then this BER measuring equipment must be able to withstand the EFT burst application.

Table 3.3: EFT Immunity Requirements by port type

Port Types	Voltage	Total Number of 5 kHz repetition frequency events
1 & 2	0.25 kV	±5*
3& 4	0.5 kV	±5*
AC & DC ports	0.5 kV	±5*
AC & DC ports on customer premises	1 kV	±5*

* For a duration of 1 minute.

Section 4 Lightning and AC Power Fault

The lightning surge and ac power fault test conditions shall be applied to telecommunications ports, antenna ports, ac power ports, dc power ports, and coaxial cable ports.

Table 3.4 below provides the description of Test conditions "A" and "B" for both 2-wire and 4-wire interfaces. Intra-building tests apply to ports that are not directly connected to OSP (outside plant). These are designated as Type 2 and Type 4 ports. Type 1, 3, and 5 ports are directly connected to the OSP, therefore the inter-building tests apply. These three port types are subjected to short-circuit tests with 1st level criteria for compliance. These short-circuit tests are applied for 30 minutes between:

1. tip to ring
2. tip to ground with ring open
3. ring to ground with tip open
4. tip and ring to ground simultaneously

GR-1089 defines a 1st level and 2nd level criteria for the EUT (equipment under test).

1st Level Criteria:

The EUT shall not be damaged and shall continue to function properly without human intervention or power cycling after the tests

2nd Criteria:

The EUT may sustain damage but it shall not become a fire or fragmentation hazard nor an electrical safety hazard

Table 3.4: Tests Conditions

Test	Generator connections	
	2-wire interfaces	4-wire interfaces
A	1. tip to generator, ring to ground	1. tip to generator, ring, tip1, ring1 to ground
	2. ring to generator, tip to ground	2. ring to generator, tip, tip1, ring1 to ground
	3. Not applicable	3. tip1 to generator, tip, ring, ring1 to ground
	4. Not applicable	4. ring1 to generator, tip, ring, tip1 to ground
	5. tip and ring to generator simultaneously	5. tip and ring to generator simultaneously, tip1 and ring1 to ground
	6. Not applicable	6. tip1 and ring1 to generator simultaneously, tip and ring to ground
B	Tip and ring to generator simultaneously	Tip, ring, tip1, and ring1 to generator simultaneously

Figure 3.1: Application of Lightning and AC Power Fault Test Voltages

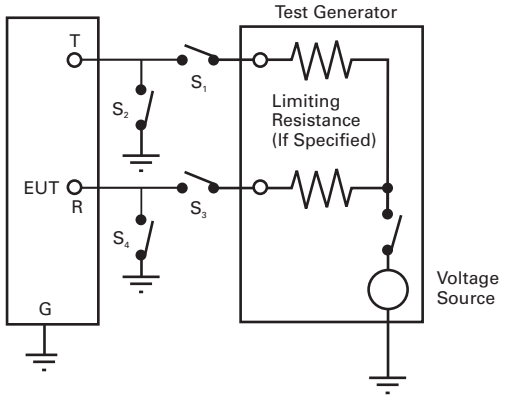


Table 3.5: Connections to Test Generator

	S1	S2	S3	S4
A1	CLOSED	OPEN	OPEN	CLOSED
A2	OPEN	CLOSED	CLOSED	OPEN
A5	CLOSED	OPEN	CLOSED	OPEN

For equipment that provides or receives remote power (i.e. span powering, PoE, etc.) over the copper conductors, GR-1089 contains an objective (NOT a requirement) that a coupling element should be used to isolate auxiliary or load equipment from the surge source for ±10 repetitions of surge test #3 (Table 3.6 below), then the remaining ±15 repetitions should be performed by applying the surge directly to the port. This coupling element is used to reduce the surge energy that would otherwise enter the power source (please see Figure 4-3, 4-4, 4-5, 4-6, 4-7, and 4-8 of GR-1089-CORE Issue 4 for more details).

First Level Lightning Surge Test

For all First Level lightning and power fault events, a total of three ports of the EUT shall be tested.

Table 3.6: First Level Lightning Surge Tests

Test (notes 1&2)	Surge Voltage (V_{PK})	Waveform (µs)	Surge Current (per Conductor) (A)	Repetitions Each Polarity	Test Connections (Table 3.4)
1	±600	10x1000	100	25	A
2 (note 3)	±1000	10x360	100	25	A
3 (note 3)	±1000	10x1000	100	25	A
4	±2500	2x10	500	10	B
5	±1000	10x360	25	5	(note 4)

Notes:
1. Primary protectors are removed for all tests.
2. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
3. Test 1 and 2 can be replaced with Test 3 or vice versa.
4. This test is to be performed on up to 24 conductors simultaneously with respect to ground.

If during test 3 (or alternatively Test 1), the EUT conducted current exceeds 95A OR the voltage measured across the EUT port exceeds 95% of the voltage-limiting value of the primary protector, then no further coordination tests are required for Type 1, 3, and 5 ports. By using the Littelfuse TeleLink fuse and SIDACtor® technology (C, D, or E rated) or Greentube™ gas plasma arresters in combination, this 95A threshold should easily be reached and thus GR-1089 testing is greatly simplified. Otherwise, a coordination test sequence is required.

Table 3.7: Protection Coordination Lightning Surge Test

Peack Voltage V	Peack Current A	Waveform µs	Repetitions
400–2000	100 A at 1 kV	10x1000	10

Refer to the equipment supplier documentation for specifications on the primary protection with which the equipment is designed to coordinate. The maximum switching voltage threshold value for this primary protector must comply with GR 974 (1 kV for a 1 kV/µs event). This coordination test procedure requires that the peak voltage of this test start at the primary protector's specified voltage-limiting value. This value must be a minimum of 400 V and a maximum of 1000 V. The primary protector must effectively turn on during each of these conditions

Second Level Lightning Surge Test

The Second Level Lightning Surge Test presented in table 3.8 does not require the EUT to pass operationally, but GR 1089 does require that the EUT not become a fire, fragmentation or electrical safety hazard. This is referred to as passing "non-operationally."

Table 3.8: Second Level Lightning Surge Test

Test	Surge Voltage (V_{PK})	Waveform (µs)	Surge Current (A)	Repetitions Each Polarity	Test Connections
1	±5000	2x10	500	1	B

Notes:
1. Primary protectors are removed for all tests.
2. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.

First Level Intra-building surges

Intra-building tests are not required for:

1. Intra-building wiring connecting equipment separated by a distance of 6 m or less within the same frame or cabinet
2. Intra-building wiring that is not grounded and has no power ports
3. Intra-building wiring used exclusively for maintenance purpose

There are two separate intra-building surge setups, one for ports having 2 ports or less (Table 3.9), and another one for ports having more than 2 ports (four conductors, Table 3.10).

Table 3.9: Intra-building lightning surge test for 2-wire interfaces

Test	Surge Voltage (V_{PK})	Waveform (µs)	Surge Current (per Conductor) (A)	Repetitions Each Polarity	Test Connections
1	±800	2x10	100	1	A1, A2
2	±1500	2x10	100	1	B

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. Surge test 1 is not applicable to Ethernet ports IF the port does not contain secondary protection referenced to ground and all unused pins of the port are not grounded.

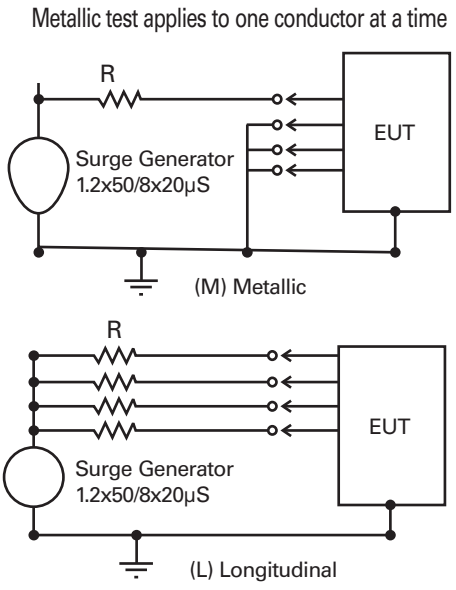
Intra-building lightning surge tests for ports with more than two pairs (four conductors) take into account the dividing factor of multiple wires in parallel. See Table 3.10 and Figure 3.2.

Table 3.10: First Level Intra-building Lightning Surge Test for EUT with greater than 2 pairs (four conductors)

Test	Surge Voltage (V_{PK})	Number of Pairs	Value of external R (ohm)	Repetitions Each Polarity	Test Connections
1	±800	3 or 4	6	1	See Figure 3.2 (M)
2	±1500	3 or 4	20	1	See Figure 3.2 (L)
1	±800	> than 4	6	1	See Figure 3.2 (M)
2	±1500	> than 4	20	1	See Figure 3.2 (L)

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. The combination wave 1.2x50/8x20 waveshape with a 2-ohm internal impedance generator as defined in IEEE C62.41.2 shall be used.

Figure 3.2: Surge Generator Setup



Regulatory

AC Power Fault Tests

Power companies and telephone operating companies often share telephone poles and trenches; therefore, network equipment is often subjected to the voltages seen on power lines. If direct contact between the telephone line and the primary power line occurs, the operating company's network equipment may see as much as 600 V rms for five seconds, by which time the power company's power system should clear itself. If direct contact occurs with the secondary power line, voltages will be limited to 277 V rms; however, these voltages may be seen indefinitely because the resultant current may be within the operating range of the power system and the power system will not reset itself.

Another risk involved with power lines is indirect contact. Because of the large magnetic fields created by the currents in the power lines, large voltages may be induced upon phone lines via electro-magnetic coupling. In this instance voltages should be limited to 1000 V peak and 600 V rms using primary protectors, while the current will be limited by the current-carrying capacity of the 24-gauge wire.

First Level AC Power Fault Criteria

Table 3.11 presents test conditions for the First Level AC Power Fault Test. The EUT is required to pass operationally.

Table 3.11: First Level Power Fault

Test	Applied Voltage, 60 Hz (V_{RMS})	Short Circuit Current per Conductor (A)	Duration	Primary Protectors	Test Connections
1 (Note 1)	50	0.33	15 min	Removed	A
2 (Note 1)	100	0.17	15 min	Removed	A
3 (Note 1)	200, 400, 600	1A at 600V	60 applications, 1s each	Removed	A
4 (Note 4)	1000	1	60 applications, 1s each	In place	B
5 (Note 2)	N/A	N/A	60 applications, 5s each	Removed	N/A
6 (Note 3)	600	0.5	30 s	Removed	A
7 (Note 3)	440	2.2	2 s	Removed	A
8 (Note 3)	600	3	1.1 s	Removed	A
9 (Note 3)	1000	5	0.4 s	In place	B

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. Test 5 simulates a high impedance induction fault. For specific information, contact Littelfuse, Inc.
3. Sufficient time may be allowed between applications to preclude thermal accumulation.
4. This test is intended to establish compatibility of the EUT with the primary protector. The maximum current is limited to 1 A rms as in Test 3, but the voltage is increased to 1,000 V to permit operation of the protector. Sufficient time may be allowed between applications to preclude thermal accumulation.

Second Level AC Power Fault Criteria

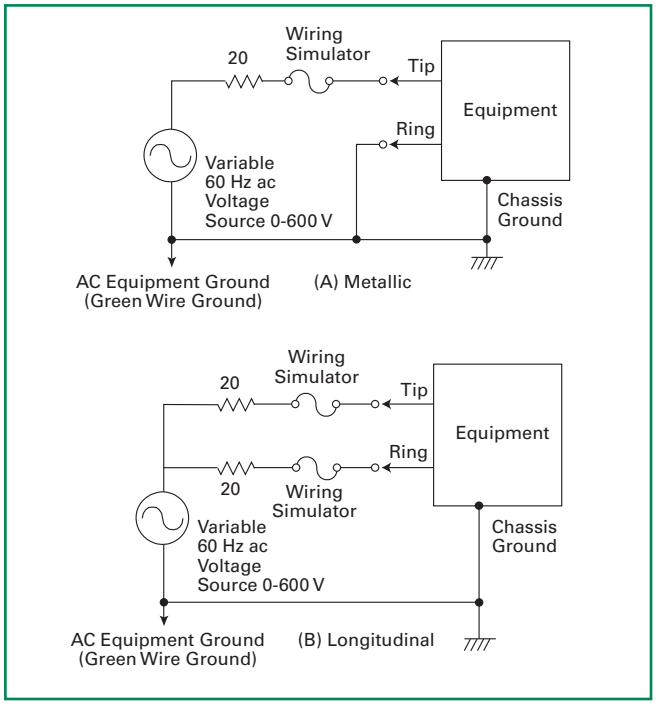
Table 3.12 below presents test conditions for both customer premises and non-customer premises equipment. (Note that test conditions 1, 3, and 4 may be omitted if the EUT has previously met UL 60950-1.)

Table 3.12: Second Level AC Power Fault Test (and Intra-building 2nd level)

Test (Notes 1, 2)	Applied Voltage, 60 Hz (V_{RMS})	Short Circuit Current per Conductor (A) (Note 4)	Duration	Test Connections
1 (Note 5)	120, 277	25	15 min	A
2	600	60	5 s	A
3	600	7	5 s	A
4	600	2.2A at 600 V	15 min	A
5 (Note 3)	N/A	N/A	15 min	N/A

Notes:
1. Primary protectors are removed for all tests.
2. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage(s) and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
3. Test 5 simulates a high impedance induction fault. Specific information regarding this test is available upon request.
4. These tests are repeated using a short-circuit value just below the operating threshold of the current limiting device, or, if the EUT uses a fuse as current limiting protection, the fuse may be bypassed and the short circuit current available adjusted to 135 percent of the fuse rating.
5. Intra-building, second level power fault test uses test condition 1 only. The applied voltage is at 120 V rms only.

Figure 3.3: Second Level AC Power Fault and Current Limiter Connection

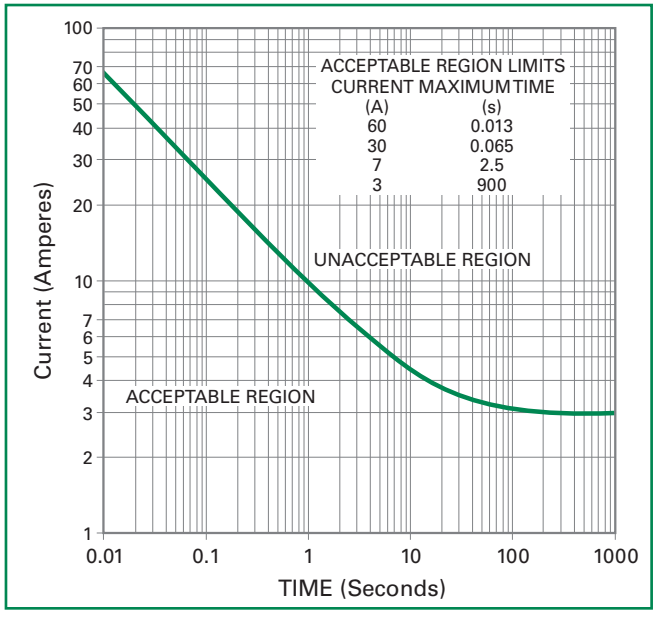


Regulatory

Current Limiting Protector Test

The purpose of the Current Limiting Protector Test is to determine if the EUT allows an excessive amount of current flow under power fault conditions. During this test, the EUT is connected to a circuit equivalent to that shown in Figure 3.3 above with a 1.6 A Type MDQ fuse or MDL 2.0A fuse as the wiring simulator. If the EUT draws enough current to open the fuse, then the acceptable time/current criteria have not been met, and external current limiting protectors must be specified for use with that quipment in the manufacturer's documentation. This test is conducted at 2.2 A, 2.6 A ,3 A, 3.75 A, 5 A, 7 A, 10 A, 12.5 A, 20 A, 25 A, and 30 A for 15 minutes at each subsequent value until the equipment interrupts the current or reduces it to less than 50 mA. IF the wiring simulator opens, the EUT does not meet the criteria.

Figure 3.4: Time-current characteristics of the external current-limiter indicator.



Short-circuit Test

In addition to the AC Power Fault and Current Limiter Tests, equipment must also pass a Short-circuit Test to comply with GR 1089. During this test, a short-circuit condition is applied to the following Tip and Ring appearances for 30 minutes while the EUT is powered and under operating conditions:

- Tip-to-Ring, Tip-to-Ground with Ring open circuit
- Ring-to-Ground with Tip open circuit
- Tip- and Ring-to-Ground simultaneously for 30 minutes

At no time will the short circuit impedance exceed 1-ohm. For equipment with more than one twisted pair, the short circuit is applied to all twisted pair simultaneously. To comply with the short circuit test, the EUT must function normally after the short-circuit condition is removed, and a fire or electrical safety hazard may not be present. The equipment shall not require manual intervention to restore service.

Lightning Protection tests for Equipment located in high exposure locations (Port Type 3 & 5)

The surge generator for high exposure risk environments shall be capable of delivering 4kV into an open circuit and capable of delivering 500A into a short circuit, with a 10x250 µS waveshape. The switching voltage of the primary protector must first be determined before applying this 10x250 surge to the EUT OR the EUT must have a surge withstand capability adequate to survive these severe events. For a EUT that is preceded by a 3 mil carbon block, which is typically a worse case scenario, the maximum let-through voltage this carbon block allows would be 1 kV. Under these conditions, the EUT would see a 1 kV open circuit voltage and 125A short circuit surge event. Some primary protectors contain series elements that would further reduce the current delivered into the EUT. Therefore, the primary protector characteristics must be determined before this high exposure test is conducted. Once it surge characteristics are determined, then this 10x250 surge event is applied ±10 at the allowed let-through voltage and current levels.

Criteria for Equipment containing agreed primary protectors

This generic requirements document contains a section for customer premises and non-CO type facilities equipment that are protected by a known defined primary protector other than 3-mil blocks. This section contains four different categories for agreed primary protection. The categorization will then reduce the open circuit voltage used for lightning and power fault testing as previously defined in first and second level lightning and ac power fault tables. Please see Littelfuse for more details on this section.

Criteria for Equipment with Integrated Primary Protectors (EIPP)

This GR also contains a section for equipment that has integrated primary protection on the ports with direct connections to the OSP. Please contact Littelfuse, Inc. for more details on this section.

Lightning surge Tests for Severe Climatic Conditions

For Type 3 and 4 ports that interface with 8 or fewer OSP conductors, a more severe lightning surge event is applied. See Table 3.13 below.

Table 3.13: Severe Climatic Surge Test

Surge Level	Surge Voltage (V_{PK})	Current Waveshape (µs)	Surge Current per Conductor (A)	Repetitions Each Polarity	Test Connections
1st	±3000	10x250	2000	1	T to R; single pair only
2nd	±5000	8x20	20000	1	T to R; single pair only

Criteria for Equipment Interfacing with coaxial cable ports

Table 3.14: First Level Lightning Surge Test for Broadband Equipment over coaxial cable

Test	Surge Voltage (V_{PK})	Waveshape (µs)	Surge Current per Conductor (A)	Repetitions Each Polarity
1	±1000	10x1000	100	25
2	±2000	10x250	1000	5

Note:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltages and 2 is to be repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.

Table 3.15: Second Level Lightning Surge Test for Broadband Equipment over coaxial cable

Test	Surge Voltage (V_{PK})	Waveshape (µs)	Surge Current per Conductor (A)	Repetitions Each Polarity
1	±4000	10x250	2000	1

Note:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltages and then repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.

Table 3.16: First Level AC Power Fault Test for Broadband Equipment over coaxial cable

Test	Voltage (50 or 60 Hz)	Current (A_{RMS})	Duration (S)	Repetitions
1	600 V_{RMS}	40	1	1
2	600 V_{RMS}	10	1	5
3	600 V_{RMS}	1	1	60
4	600 V_{RMS}	0.5	30	1

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltages and then repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. For EUT containing an external protector, only Text 3 & 4 are conducted. The voltage is lowered to 400V and the repetitions for test 3 is reduced to one.

Table 3.17: Second Level AC Power Fault Test for Broadband Equipment over coaxial cable

Test	Voltage (50 or 60 Hz)	Current (A_{RMS})	Duration (minutes)	Repetitions
1	1000 V_{RMS}	5	15	1
2	1000 V_{RMS}	15	15	1
3	1000 V_{RMS}	30	15	1
4	1000 V_{RMS}	60	15	1
5	1000 V_{RMS}	120	15	1
6	1000 V_{RMS}	350	3	1

Notes:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltages and then repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.
2. For EUT containing an external protector, the voltage is lowered to 400V_{RMS}.

First Level Intra-building surge tests for coaxial ports

This test applies to both grounded and ungrounded coaxial ports. The 1.2x50/8x20 surge generator with a 2-ohm internal impedance (as defined in IEEE C62.41.2) will be connected through an external non-inductive 3-ohm resistor to the EUT. The open circuit voltage shall be 1500 V. This surge shall be applied one time in each polarity.

Table 3.18: Lightning criteria for equipment interfacing with antennas [1st Level Lightning Surge Test (Antenna Ports)]

Test	Surge Voltage (V_{PK})	Voltage Waveshape (µs)	Surge Current (A)	Current Waveshape	Repetitions Each Polarity
1	±600	1.2x50	300	8x20	5

Note:
1. For EUT containing secondary voltage limiting and current limiting protectors, tests are to be performed at the indicated voltage and repeated at a reduced voltage and current just below the operating threshold of the secondary protectors.

Table 3.19: Lightning criteria for AC power ports [First Level Lightning Surge (Power ports)]

Test	Surge Voltage (V_{PK})	Voltage Waveshape (µs)	Surge Current (A)	Current Waveshape	Repetitions Each Polarity
1	±2000	1.2x50	1000	8x20	4

Note:
1. For EUT without an external SPD, the surge voltage is increased to 6000V and the surge current to 3000A.

Table 3.20: Second Level Lightning Surge (Power ports)

Test	Surge Voltage (V_{PK})	Voltage Waveshape (µs)	Surge Current (A)	Current Waveshape	Repetitions Each Polarity
1	±6000	1.2x50	3000	8x20	1

First Level Lightning surges for DC power ports

Five repetitions of each polarity of the 0.5 µS 100 kHz ring wave surge with a peak voltage of 0.5 kV and a current level of 41.7A per conductor shall be applied. The IEEE C62.41.2 combination wave 1.2x50/8x20 at a peak of 500V applied through an external non-inductive resistance of 10-ohms may be substituted for this ring wave. These surges are to be applied simultaneously between

1) the supply lead and ground
2) the return lead and ground

Criteria for DC Power Port

This section applies to the equipment that is powered from a shared dc power plant. It is based on T1.315-2001 Voltage Levels for DC-Powered Equipment Used in Telecommunications Environments. This section contains criteria for:

- minimum operating voltages,
- under voltage transients,
- over voltage transients,
- impulse transients,
- single transient, and
- noise related issues

Table 3.21: Undervoltage Transient test conditions

Waveform	Nominal-value	Tolerance
Undervoltage transient Level	-5 V	-4 to -5 V
Fall-time	10µS	0 to 12 µS
Transient duration	10 mS	10 to 12 mS
Rise-time	< 5 µS	0 to 5 µS

Table 3.22: Overvoltage Transient test conditions

Waveform	Nominal-value	Tolerance
Overvoltage transient Level	-75 V	-75 to -95 V
Slope	10 V/mS	9 to 11 V/mS
Transient duration	10 mS	10 to 12 mS
Rise-time	< 2 µS	0 to 2 µS

Table 3.23: Impulse Transient test conditions

Waveform	Nominal-value	Tolerance
Overvoltage transient Level	-100 V	-100 to -120 V
Rise-time	< 2 µS	0 to 2 µS
Fall-time to half value	50 µS	28 to 60 µS

Table 3.24: Equipment Port Types

Type 1	Network equipment connected to the outside plant (OSP)
Type 2	Network equipment not connected to the OSP.
Type 3	Customer premises equipment connected to the OSP.
Type 4	Customer premises equipment not connected to the OSP.
Type 5	Network equipment deployed in OSP & connected to the outside plant (OSP)
Type 6	Equipment directly connected to external antennas
Type 7	Equipment directly connected to ac power systems
Type 8	Equipment directly connected to dc power systems

ITU-T K.20 and K.21

Although the International Telecommunication Union (ITU) does not have the authority to legislate that organizations follow their recommendations, their standards are recognized throughout Europe and the Far East.

ITU-T, the Telecommunication Standardization Sector of the ITU, developed fundamental testing methods that cover various environmental conditions to help predict the survivability of network and customer-based switching equipment. The testing methods cover the following conditions:

- Surges due to lightning strikes on or near twisted pair and plant equipment (excluding a direct strike)
- Short-term induction of AC voltage from adjacent power lines or railway systems
- Direct contact between telecommunication lines and power lines (often referred to as AC power fault)

Two ITU-T standards apply for most telecommunications equipment connected to the network:

- ITU-T K.20
- ITU-T K.21

ITU-T K.20 is primarily for switching equipment powered by the central office; however, for complex subscriber equipment, test administrators may choose either K.20 or K.21, depending on which is deemed most appropriate.

Note : Both specifications are intended to address equipment reliability versus equipment safety. For specific concerns regarding equipment safety, research and follow national standards for each country in which the equipment is intended for use.

K.21 covers telecommunication equipment installed at customer premises. Equipment submitted under these requirements must meet one of two levels: basic or enhanced. Guidelines for determining under which level the equipment under test (EUT) falls can be found in ITU-T K.11, but note that the final authority rests with the test administrator. ITU-T K.44 describes the test conditions used in K.20 and K.21.

ITU-T defines the following acceptance criteria:

- **Criterion A** states that equipment shall withstand the test without damage and shall operate properly after the test. It is not required to operate correctly during the test.
- **Criterion B** states that a fire hazard shall not occur as a result of the tests. Any damage shall be confined to a small part of the equipment.

Table 3.25 shows the lightning surge test conditions for ITU K.20. Figure 3.5 shows the connection schematic for the lightning surge tests. Table 3.26 shows the power fault test conditions for ITU K.20. Figure 3.6 shows the connection schematic for the power fault tests. Table 3.27 and Table 3.28 show the same test conditions respectively for ITU K.21.

Table 3.25 K.20 Lightning Test Conditions for Telecom Equipment in Central Office/Remote Terminal

Voltage (10x700 µs)		Current (5x310 µs) Basic/Enhanced (A)	Repetitions *	Primary Protection	Acceptance Criteria
Single Port Metallic and Longitudinal Basic/Enhanced	Multiple Ports Longitudinal Only Basic/Enhanced				
1 kV/1.5 kV		25/37.5	±5	None **	A
4 kV/4 kV		100/100	±5	Installed if used	A
	1.5 kV/1.5 kV	37.5/37.5	±5	None	A
	4 kV/6 kV	100/150	±5	Installed if used	A

* One-minute rest between repetitions ** Test not conducted if primary protection is used

Table 3.26 K.20 Power Fault Test Conditions for Telecom Type Ports, Metallic, and Longitudinal

Voltage Basic/Enhanced	Current Basic/Enhanced (A)	Duration Basic/Enhanced	Repetitions *	Primary Protection	Acceptance Criteria Basic/Enhanced
600 V/600 V 50 Hz or 60 Hz	1/1	0.2 s	5	None	A/A
600/1.5 kV 50 Hz or 60 Hz	1/7.5	1 s/2 s	5	None	A/A
230/230 V -- 50 Hz or 60 Hz	23/23	15 min	1	None	B/B
	11.5/11.5				B/B
	5.75/5.75				B/B
	2.875/2.875				B/B
	1.44/1.44				B/A
	0.77/0.77				B/A
	0.38/0.38				B/A
	0.23/0.23				B/B

* One-minute rest between repetitions

Table 3.27 K.21 Lightning Test Conditions for Telecom Equipment on Customer Premises

Voltage (10x700 µs)			Current (5x310 µs) Basic/Enhanced (A)	Repetitions *	Primary Protection	Acceptance Criteria
Single Port		Multiple Ports Longitudinal Only (kV) Basic/Enhanced				
Longitudinal (kV) Basic/Enhanced	Metallic (kV) Basic/Enhanced					
1.5/6 **			37.5/150	±5	None	A ***
4/6			100/150	±5	Installed if used	A
	1.5/1.5	1.5/1.5	37.5/37.5	±5	None	A ***
	4/6	4/6	100/150	±5	Installed if used	A

* One-minute rest between repetitions ** Reduce to 1.5 kV if SPD connects to Ground *** Does not apply if primary protectors are used

Table 3.28 K.21 Power Fault Test Conditions for Telecom Type Ports, Metallic, and Longitudinal

Voltage Basic/Enhanced	Current Basic/Enhanced (A)	Duration Basic/Enhanced	Repetitions *	Primary Protection	Acceptance Criteria Basic/Enhanced
600 V / 600 V 50 Hz or 60 Hz	1/1	0.2 s	5	None	A/A
600/1.5 kV 50 Hz or 60 Hz	1/7.5	1 s/2 s	5	Installed if used	A/A
230 V / 230 V 50 Hz or 60 Hz	23/23	15 min	1	None	B/B
	11.5/11.5				B/B
	5.75/5.75				B/B
	2.875/2.875				B/B
	1.44/1.44				B/A
	0.77/0.77				B/A
	0.38/0.38				B/A
	0.23/0.23				B/B

* One-minute rest between repetitions

Figure 3.5 Connection Appearances

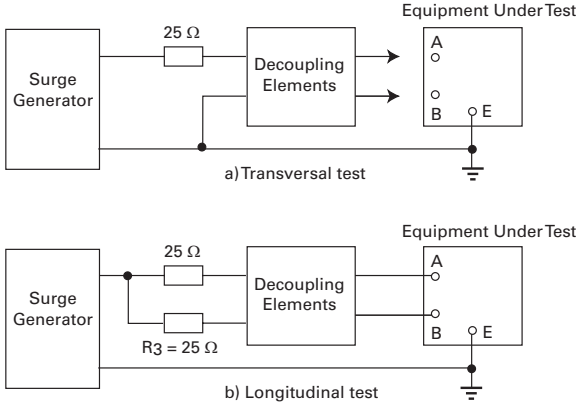
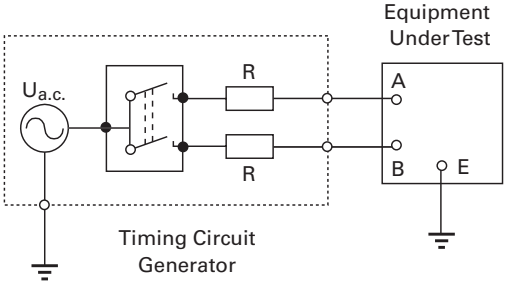
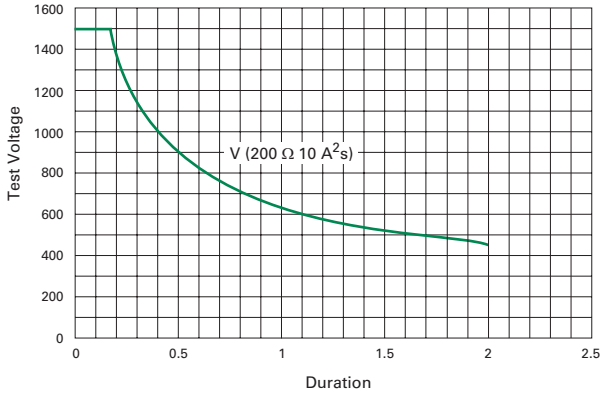


Figure 3.6 Connection Appearances (R = 10 Ω, 20 Ω, 40 Ω, 80 Ω, 160 Ω, 300 Ω, 600 Ω, and 1000 Ω for the various power fault tests)



Enhanced power fault test condition of 1.5 kV 200 W 2 second test must meet the time current curve shown in Figure 3.7.

Figure 3.7 Test Voltage Versus Duration for Specific Energy / Source Resistance



Regulatory

TIA-968-A (formerly known as FCC Part 68)

TIA-968-A applies to all terminal equipment connected to the Public Switched Telephone Network (PSTN) in the USA, and holds the "rule of law" by congressional order.

The purpose of TIA-968-A is to provide a set of uniform standards to protect the telephone network from any damage or interference caused by the connection of terminal equipment. This standard includes environmental simulations such as vibration tests, temperature and humidity cycling, drop tests and tests for hazardous voltages and currents, as well as tests for signal power levels, line balance, on-hook impedance, and billing protection. All these standards must be met before and after the environmental tests are applied.

Overvoltage Test

TIA-968-A compliant equipment must undergo an overvoltage test that includes a Type A and Type B Metallic Voltage Surge and a Type A and Type B Longitudinal Voltage Surge. These surges are part of the environmental simulation, and although a provision does allow the EUT to reach an open circuit failure mode during the Type A tests, failures must:

1. Arise from an intentional design that will cause the phone to be either disconnected from the public network or repaired rapidly
2. Be designed so that it is substantially apparent to the end user that the terminal equipment is not operable [A common example of an acceptable failure would be an open circuit due to an open connection on either Tip or Ring.]

For Type B surges, equipment protection circuitry is not allowed to fail. The EUT must be designed to withstand Type B surges and continue to function in all operational states.

Metallic Voltage Surge

The Type A and Type B Metallic Voltage Surges are applied in both the positive and negative polarity across Tip and Ring during all operational states (on-hook, off-hook, ringing, and so on). The Type A surge is an 800 V, 100 A peak surge while the Type B surge is a 1000 V, 25 A peak surge, as presented in Table 3.29.

Table 3.29 TIA-968-A Voltage Surge

Surge Type	Peak Voltage (V_{PK})	Rise & Decay Time (Voltage Waveform)	Peak Current (A)	Rise & Decay Time (Current Waveform)	Repetitions Each Polarity
Metallic A	±800	10x560 µs	100	10x560 µs	1
Longitudinal A	±1500	10x160 µs	200	10x160 µs	1
Metallic B	±1000	9x720 µs	25	5x320 µs	1
Longitudinal B	±1500	9x720 µs	37.5	5x320 µs	1

Notes:
- For Type A surges, the EUT may pass either "operationally" or "non-operationally."
- For Type B surges, the EUT must pass "operationally."
- The peak current for the Type A longitudinal surge is the total available current from the surge generator.
- The peak current for the Type B longitudinal surge is the current supplied to each conductor.

Longitudinal Voltage Surge

The Type A and Type B Longitudinal Voltage Surges are applied in both positive and negative polarity during all operational states. The Type A surge is a 1500 V, 200 A peak surge applied to the EUT with Tip and Ring tied together with respect to Ground. The Type B Longitudinal Voltage Surge is a simultaneous surge in which 1500 V and 37.5 A are applied concurrently to Tip with respect to Ground and Ring with respect to Ground, as presented in Table 3.29.

Note : Type B surge requirements guarantee only a minimum level of surge protection. For long term reliability of terminal equipment, consideration should be given to complying with Type A surges operationally.

On-hook Impedance Limitations

Another important aspect of TIA-968-A is on-hook impedance, which is affected by transient protection. On-hook impedance is analogous to the leakage current between Tip and Ring, and Tip, Ring, and Ground conductors during various on-hook conditions. "On-hook Impedance Measurements" (next paragraph) outlines criteria for on-hook impedance and is listed as part of the Ringer Equivalent Number (REN). The REN is the largest of the unitless quotients not greater than five; the rating is specified as the actual quotient followed by the letter of the ringer classification (for example, 2B).

On-hook Impedance Measurements

On-hook impedance measurements are made between Tip and Ring and between Tip and Ground and Ring and Ground. For all DC voltages up to and including 100 V, the DC resistance measured must be greater than 5 MΩ. For all DC voltages between 100 V and 200 V, the DC resistance must be greater than 30 kΩ. The REN values are then determined by dividing 25 MΩ by the minimum measured resistance up to 100 V and by dividing 150 kΩ by the minimum measured resistance between 100V and 200V.

On-hook impedance is also measured during the application of a simulated ringing signal. This consists of a 40 V rms through 150 V rms ringer signal at frequencies ranging from 15.3 Hz to 68 Hz superimposed on a 56.5 V dc for a class "B" ringer. During this test, the total DC current may not exceed 3 mA. In addition, the minimum DC resistance measured between Tip and Ring must be greater than 1600Ω, while the DC resistance measured between the Tip and Ring conductors and Ground must be greater than 100 kΩ. The REN values for the simulated ringing test are determined by dividing the maximum DC current flowing between Tip and Ring by 0.6 mA, and by dividing 8000 Ω by the minimum impedance value measured.

IEC 61000-4-2, 4-4 and 4-5 Summary

Part 1: Introduction, definitions, & terminology

Part 2: Description & classification of the environment

Part 3: Emission & immunity limits

Part 4: Testing & measurement techniques

Part 5: Installation & mitigation guidelines

A summary of Part 4 from IEC 61000-4-2, 61000-4-4, & 61000-4-5 follows.

IEC 61000-4-2 Testing and measurement techniques – Electrostatic Discharge (ESD) Immunity test

This standard defines test procedures to evaluate equipment ESD resistibility performance.

Table 3.30 Test Levels

Level	Contact discharge	Air discharge
	Voltage	
1	2 kV	2 kV
2	4 kV	4 kV
3	6 kV	8 kV
4	8 kV	15 kV
X	Special	Special

"x" is an open level, to be specified in dedicated equipment specification

Table 3.31 Test waveform values

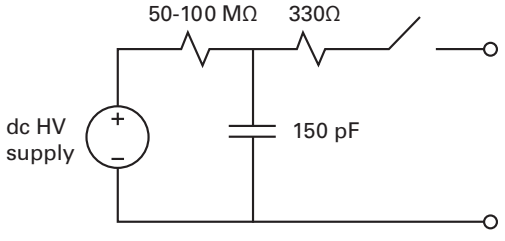
Level	Voltage	Initial current peak value	Rise time	Current at 30 nS	Current at 60 nS
1	2 kV	7.5A	0.7 to 1	4 A	2A
2	4 kV	15 A		8A	4A
3	6 kV	22.5A		12A	6A
4	8 kV	30A		16A	8A

Table 3.32 Guidelines for test level selection

Class	Relative Humidity as low as	Anti-static material	Synthetic material	Maximum voltage
1	35%	*		2 kV
2	10%	*		4 kV
3	50%		*	8 kV
4	10%		*	15 kV

The test level chosen for a particular application should consider its installation and environmental conditions.

Figure 3.8 ESD generator schematic



Regulatory

IEC 61000-4-4 Testing and measurement techniques – Electrical fast transient (EFT) Immunity test

This standard defines test procedures to evaluate equipment EFT resistibility performance.

Table 3.33 Test Levels

Level	Repetition rate kHz	Power Ports kV	I/O ports kV
1	5 or 100	0.5	0.25
2		1	0.5
3		2	1
4		4	2
X		Special	Special

Table 3.34 Test waveform values

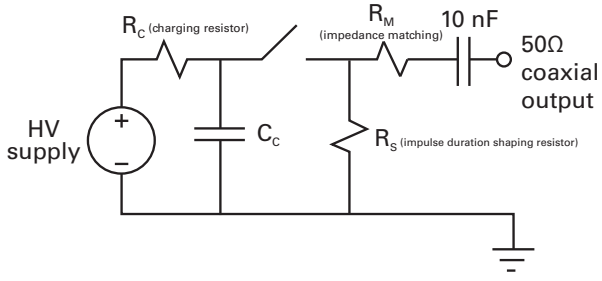
Set voltage	V_P (open circuit)	V_P (1 kΩ)	V_P (50Ω)	Repetition rate
250 V	250 V	240 V	125 V	5 kHz or 100 kHz
500 V	500 V	480 V	250 V	
1 kV	1 kV	950 V	500 V	
2 kV	2 kV	1.9 kV	1 kV	
4 kV	4 kV	3.8 kV	2 kV	

Burst duration 15 mS ± 20% at 5 kHz, 0.75 mS ± 20% at 100 kHz, burst period 300 mS ± 20%; 5 nS ± 30% rise time, 50 nS ± 30% decay to half value time

Table 3.35 Guidelines for test level selection

Level	Environment	Description
1	Well-protected	Shielded power cables, suppression of all EFT in power supply & control circuits, proper separation of application from other environments
2	Adequately-protected	Physical separation of unshielded power cables, partial suppression of EFT in power supply & control circuits
3	Industrial	Poor separation between power supply, control, signal & communication cables, no suppression of EFT in power supply & control circuits
4	Severe industrial	No separation between power supply, control, signal & communication cables, no suppression of EFT in power supply & control circuits
5	Special	Special situation that remain to be analyzed

Figure 3.9 EFT generator schematic



Regulatory

IEC 61000-4-5 Testing and measurement techniques – Surge immunity (lightning surge effects) test

This standard defines test procedures to evaluate equipment resistibility to uni-directional surges resulting from electrical switching and nearby lightning strikes. The switching transients are associated with power system switching disturbances, and various system faults. The lightning transients are associated with direct lightning strokes to an outdoor circuit; indirect lightning strokes such a cloud to cloud, and nearby lightning strikes.

Two different coupling methods are discussed in this document:

1) capacitive coupling

2) arrestor coupling

Capacitive coupling is the preferred method for unbalanced I/O circuits while arrestor coupling is the preferred coupling method for unshielded balanced circuits (such as telecommunication).

Figure 3.10 – CWG simplified schematic

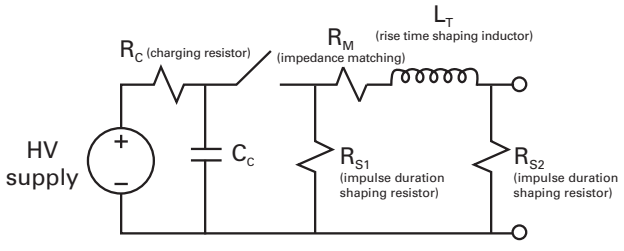


Figure 3.11 – CCITT simplified schematic

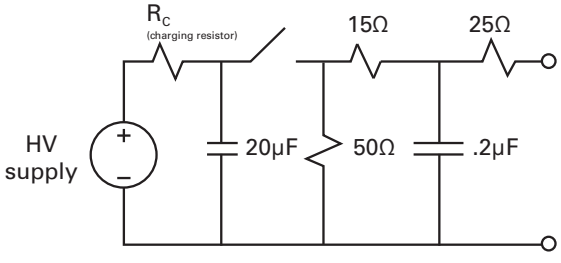


Table 3.36 – Test Levels

Level	Open-circuit test voltage
1	500 V
2	1 kV
3	2 kV
4	4 kV
X	Special

Table 3.37 – Test waveform values

Waveform Description	Voltage waveform	Current waveform	Output impedance	Open circuit voltage	Short circuit current	Repetition rate
CWG (combination waveform generator)	1.2 x 50 μS	8 x20 μS	2 Ω	500 V to 4 kV	250 A to 2 kA	1/minute
CCITT	10 x700 μS	5 x 320 μS	40 Ω	500 V to 4 kV	12.5 to 100 A	1/minute

Table 3.38 – Guidelines for test level selection

Class	Description
0	Well-protected, generally considered intra-bdlg (surge voltage < 25 V)
1	Partly protected (surge voltage < 500 V)
2	Cables well separated (surge voltage < 1000 V)
3	Cables run in parallel (surge voltage < 2000 V)
4	Outside connections running along with power (surge voltage < 4000 V)
5	Telecommunication cables and overhead power lines in non-dense populated areas

CLASS 0 – 4 uses the 1.2x50 / 8x20 CWG (10 Ω series added for longitudinal tests on power ports and 40 Ω series added for metallic tests on unshielded lines).

CLASS 5 uses 1.2x50 / 8x20 CWG for power line ports & short distance signal lines, the 10x700 / 5x320 CCITT generator for long-distance circuits

Table 3.39 – Test Level selection criteria

Class	Test Levels					
	Power supply		Unbalanced circuits		Balanced circuits	
	metallic	longitudinal	metallic	longitudinal	metallic	longitudinal
0	NA	NA	NA	NA	NA	NA
1	NA	500 V	NA	500 V	NA	500 V
2	500 V	1 kV	500 V	1 kV	NA	1 kV
3	1 kV	2 kV	1 kV	2 kV*	NA	2 kV*
4	2 kV	4 kV	2 kV	4 kV*	NA	2 kV*
5	TBD	TBD	2 kV	4 kV*	NA	4 kV*
X						

* tested with primary protection

Regulatory

Mainland China Standard—YD/T 950-1998

YD/T 950-1998 establishes the technical requirements and test methods for protection against overvoltages and overcurrents on telecommunication switching equipment for Mainland China.

This Standard is based on the ITU-T Recommendation K.20 "Resistibility of Telecommunication Equipment Installed in a Telecommunications Center for Overvoltages and Overcurrents" (1996 version).

It was approved by the Ministry of Information Industry of the People's Republic of China on August 7, 1998 and has been in effect since September 1, 1998.

Technical Requirements

The following major transmission parameters and interface feature parameters of the equipment should comply with requirements contained in GF 002-9002 or YD 344:

- Transmission loss
- Loss frequency distortion
- Gains changing with input level
- Cross talk
- Scratching noise
- Return loss
- Unbalanced earth impedance

After the following tests are conducted, the equipment should provide normal communications functions and comply with these requirements.

Without primary protection:

1. When the lightning waveform is 10/700 µs and the peak voltage is 1 kV
2. When the induction voltage of the power line is 600 V rms and the duration is 0.2 s

With primary protection:

1. When the lightning waveform is 10/700 µs and the peak voltage is 4 kV
2. When the induction voltage of the power line is 600 V rms and the duration is 1 s

Without primary protection, the equipment should be fireproof when it is in contact with power lines with a voltage of 220 V rms for a duration of 15 minutes and should provide normal communications functions after the test.

After the equipment is tested for contact discharge at an electrostatic voltage of 6 kV or for air discharge at 8 kV, it should provide normal communications functions.

Test Methods

All tests should be conducted in the following standard atmospheric conditions:

- Temperature: 15 °C ~ 35 °C
- Relative humidity: 45% ~ 75%
- Air pressure: 86 ~ 106 kP

Test procedure sequence is as follows:

1. Normal equipment operation
2. Characteristics and parameters
3. Simulation of lightning strike
4. Check of functions
5. Power line induction
6. Check of functions
7. Check of functions
8. ESD
9. Check of functions
10. Power line contact
11. Characteristics and parameters

Power Line Induction

Without primary protection:

600 V, 1 A, 0.2 s applied between Tip and Ring to Ground five times

With primary protection:

600 V, 1 A, 1 s applied between Tip and Ring to Ground five times

Time between successive events shall be one minute. Characteristics and parameters shall be tested within 30 minutes after the completion of these events.

Power Line Contact

Without primary protection:

220 V rms @ 0.367 A, 1, 1 A, 22 A for 15 minutes applied between Tip and Ring to Ground one time each

With primary protection:

220 V rms 0.367 A for 15 minutes applied between Tip and Ring to Ground five times

ESD (electrostatic discharge)

±5 repetitions direct contact with one-second duration between successive discharges

±5 repetitions indirect contact (0.1 m distance) with one-second duration between successive discharges

For additional information, please refer to Table 3.40 and 3.41 on the following page.

Table 3.40 – Simulation of Lightning Strike

Testing Terminals	V/I Waveform	Peak Voltage	Peak Current	Number of Tests	Primary Protection
Tip to Ring Grounded	10x700 / 5x310	1 kV	25 A	±5	No
Ring to Tip Grounded	10x700 / 5x310	1 kV	25 A	±5	No
Tip and Ring to Ground	10x700 / 5x310	1 kV	25 A	±5	No
Tip to Ring Grounded	10x700 / 5x310	4 kV	100 A	±5	Yes
Ring to Tip Grounded	10x700 / 5x310	4 kV	100 A	±5	Yes
Tip and Ring to Ground	10x700 / 5x310	4 kV	100 A	±5	Yes
Tip and Ring to Ground *	10x700 / 5x310	1 kV	25 A	±5	No

* Simultaneous surge for 50% of the ports

Table 3.41 – Waveform Parameters

Indicated Voltage	Peak of Initiation of the Discharge Currents I_p	Time of Rising During Discharge Switch On / Off t_r	Current at 20 ms I_1	Current at 60 ns I_2
6 kV	22.5 A ± 10%	0.7–1 ns	12 A ± 30%	6 A ± 30%

Mainland China Standard—YD/T 993-1998

YD/T 993-1998 establishes the technical requirements and test methods for lightning protection of telecommunication terminal equipment for Mainland China.

This Chinese Standard parallels the ITU-T K.21 "Resistibility of Subscriber's Terminal to Overvoltages and Overcurrents" (1996) document very closely. This standard is the technical basis for simulated lightning induced event testing requirements for Telecommunication Terminal Equipment such as modems, fax machines, telephone sets, and so on.

Normal operation of EUT is not required during the lightning surge simulation test. However, all functions of the EUT should meet the requirements of relevant standards after the completion of these tests. All lightning surge simulation tests should be conducted at:

- Temperature: 15 °C – 35 °C
- Relative humidity: ±5% – ±75%
- Air pressure: 86 – ±56 kPa

Once the lightning surge simulation testing is completed, an electric isolation test is conducted. The power is removed from the unit for this test.

Measure the insulation with 500 V dc voltage after the completion of the insulation test. The resistance should be no less than 2 MΩ.

Table 3.42 Surge Simulations - Tip & Ring Connections

Lightning Surge Test Conditions			Voltage and Current Waveform µs	Test Voltage / Current * (kV/A)
Without Primary Protection	Metallic Test	Single Tip and Ring Pair	10x700 / 5x310	1.5/37.5
			10x700 / 5x310	1.5/37.5
	Longitudinal Test	Single Tip and Ring Pair	10x700 / 5x310	1/25
			10x700 / 5x310	1/25
		All Tip and Ring Pair	10x700 / 5x310	1/25
			10x700 / 5x310	1/25
With Primary Protection	Metallic Test	Single Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100
	Longitudinal Test	Single Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100
		All Tip and Ring Pair	10x700 / 5x310	4/100
			10x700 / 5x310	4/100

Table 3.43 Surge Simulations - Power Line Connections

Lightning Surge Test Conditions			Voltage and Current Waveform µs	Test Voltage / Current * (kV/A)
Without Primary Protection	Metallic Test	Power Line	1.2x50 / 8x20	1.5/750
			1.2x50 / 8x20	1.5/750
	Longitudinal Test	Power Line	1.2x50 / 8x20	1/83.3
			1.2x50 / 8x20	1/83.3
With Primary Protection	Metallic Test	Power Line	1.2x50 / 8x20	4/2000
			1.2x50 / 8x20	4/2000
	Longitudinal Test	Power Line	1.2x50 / 8x20	4/333.3
			1.2x50 / 8x20	4/333.3

* All tests are conducted ±5 times with at least one minute between events.

Table 3.44 Electrical Insulation Test

Equipment Type	Voltage / Current	V&I Waveform µs	Repetition
Handheld	2.5 kV / 62.5 A	10x700 / 5x310	±5
Non-handheld	1.5 kV / 37.5 A	10x700 / 5x310	±5

Mainland China Standard—YD/T 1082-2000

YD/T 1082-2000 establishes the technical specifications on overvoltage and overcurrent protection of access network equipment for Mainland China.

This Chinese Standard parallels the ITU-T K series. This Standard specifies the technical requirements and test methods for overvoltage and overcurrent protection and the basic environmental adaptability of access network equipment. This Standard does not deal with protection against radiated electromagnetic fields.

The specifications as presented here are a succinct summary of the lightning surge, power fault, and ESD testing required by this document.

The ports of the Network equipment are classified into five categories:

I. Ports used to connect the twisted pairs introduced from outside of the building, namely analog user interface, ISDN-BRA interface, ADSL interface, and so on

II. Twisted pair ports used to interconnect the different equipment inside the building, namely V.24 interface, V.35 interface, 2048 kbits/s interface connected to twisted pairs, 10/100 Base-T Ethernet interface, and so on

III. Coaxial cable port: 2048 kbits/s interface connected to coaxial cables, ISDN-PRA interface, and so on

IV. AC Power interface

V. DC power interface

The sequence of testing shall follow this order:

ESD –> EFT –> simulation of lightning strike –> power line induction –> power line contact

ESD Testing

The environmental conditions for ESD testing shall be:

- Temperature—15 °C ~ 35 °C
- Relative humidity—30% ~ 60%
- Air pressure —86 ~ 106 kPa

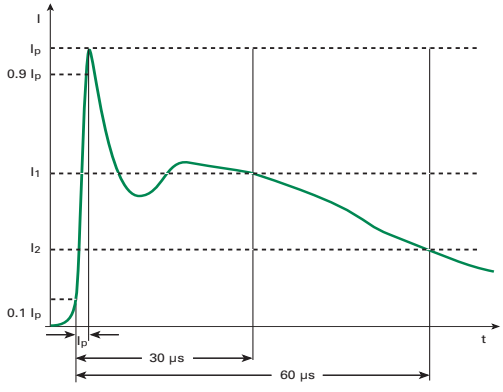
The waveform of the generator should meet the requirements of YD/T 950 as shown in table 3.45.

Establish a communications link via any port of the EUT before the test. The communications link should be capable of normal use without being attended to manually after the test.

Table 3.45 Waveform Parameters

Indicated Voltage	Peak of Initiation of the Discharge Currents I_p	Time of Rising During Discharge Switch On / Off t_r	Current at 20 ms I_1	Current at 60 ns I_2
6 kV	22.5 A ± 30%	0.7–1 ns	12 A ± 30%	6 A ± 30%

Figure 3.12 ESD Waveform



EFT (Electrically Fast Transient)

Waveform of the generator should meet the requirements of ITU-T K.34.

Table 3.46 EFT

Tested Port	Number of Ports		Test Conditions
	Remote	Central Office	
I	1	—	1 kV, 5 kHz, ≥ 1 min
II	1	1	1 kV, 5 kHz, ≥ 1 min
III	1	1	1 kV, 5 kHz, ≥ 1 min
IV	1	—	2 kV, 2.5 kHz, ≥ 1 min
V	—	1	2 kV, 2.5 kHz, ≥ 1 min
VI	—	1	2 kV, 2.5 kHz, ≥ 1 min

Table 3.47 Lightning Surge Test Conditions

Class of Port	Number of Ports		Voltage and Current Waveforms µs	Amplitude *
	Central Office	Remote		
I	—	3	10/700 – 5/310	4 kV
		8	1.2/50 – 8/20	6 kV
II	1	1	1.2/50 – 8/20	500 V
III	1	1	1.2/50 – 8/20	500 V
IV	—	1	1.2/50 – 8/20	10 kV, 5 kA
V	1	1	1.2/50 – 8/20	500 V

* All tests are conducted ±5 times with at least one minute between events.

Table 3.48 Power Line Induction and Contact Testing

Tested Port	Number of Ports		Test Conditions
	Remote	Central Office	
I	3	—	600 V, 600Ω, 50 Hz, 1 s
I	1	—	220 V, 50 Hz, 1 h, 600/200/10Ω

Regulatory

Certification and Accreditation Administration of the People's Republic of China

Type testing and initial inspection of the factory and follow-up inspection similar to UL standards shall be required in China. The formal application shall be submitted with the following documents:

1. Circuit diagram and/or system block
2. List of critical components and/or materials
3. Description of the difference between the different model/type of products in the same application unit.
4. Service manual and user's manual in Chinese
5. Nameplate and warnings in Chinese
6. Other necessary documents

Testing standards are as follows:

1. GB4943-1995 *Safety of Information Technology Equipment Including Electrical Business Equipment*
2. YD/T993 T*echnical Requirements and Test Methods of Lightning Resistibility for Telecommunication Terminal Equipment*
3. GB9254-1998 *Information Technology Equipment—Radio Disturbance Characteristics –Limits and Methods of Measurement*
4. YD1103 *Requirements and Measurement Methods of Electromagnetic Compatibility for Cordless Telephone*
5. YD1032 *Limits and Measurement Methods of Electromagnetic Compatibility for 900/1800 MHz Digital Cellular Telecommunications System Part 1: Mobile Station and Ancillary Equipment*
6. YD1169.1 *Requirement and Measurement Method of Electromagnetic Compatibility for 800 MHz CDMA Digital Cellular Telecommunications System Part 1: Mobile Station and Ancillary Equipment*

These documents require:

1. Test items for safety
2. Testing items for lightning, lightning test of telecommunication interface, and lightning test of power line
3. Testing items for EMC

Note: The test items for safety shall include all appropriate items specified in standards of GB4943-1995.

The following parameters outline testing procedures for lightning-induced surges and power fault events:

- Surge requirements:
  100 A 10x1000 waveform
  10 A, 50 Hz, 1 s
  5 A, 50 Hz, 30 s
  260 V on 100 kV/s
  400 V on 1 kV/µs
- Temperature limits: -40 to 65 °C
- Insulation leakage requirements: 0.1 µA @ 100 V dc
- Maximum load capacitance: 200 pF

The following is actual text of the circular from the Certification and Accreditation Administration of the People's Republic of China (CNCA).

Standard	Testing Item
GB9254	Radiated emissions Conducted emissions
YD1103	Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Radiated radio-frequency electromagnetic field immunity Electric fast transient / burst immunity Immunity to conducted disturbance, induced by radio-frequency fields
YD1032	Conducted spurious emissions Radiated spurious emissions Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Electric fast transient / burst immunity Surge immunity
YD1169.1	Conducted spurious emissions Radiated spurious emissions Radiated emissions Conducted emissions Electrostatic discharge (ESD) immunity Radiated radio-frequency electromagnetic field immunity Electric fast transient / burst immunity Surge immunity

YD1103 only applies to cordless telephone and YD1032 applies to GSM mobile terminal while YD1169.1 only applies to CDMA mobile terminal.

Circular Relevant to the Implementation of the Compulsory Product Certification System

by the Certification and Accreditation Administration of the People's Republic of China (CNCA) December 3, 2001

The Compulsory Product Certification System (CPCS) is jointly announced for statutory implementation by the State General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ) and the Certification and Accreditation Administration of the People's Republic of China (CNCA). This new system consists of Regulations for Compulsory Product Certification, Regulations for Compulsory Product Certification Mark, and the First Catalogue of Products Subject to Compulsory Certification (hereinafter referred to as the Catalogue), and so on. The Old System, namely, the Safety License System for Import Commodities administered by the former State Administration for Entry-Exit Inspection and Quarantine of the People's Republic of China (CIQ), and the Compulsory Supervision System for Product Safety Certification administered by the former China State Bureau of Quality and Technical Supervision (CSBTS), will be replaced. The following circular is announced concerning the transition from the Old System to the New System.

1. *The time when the New System is implemented and the Old System is annulled Regulations for Compulsory Product Certification stipulates that the New System be implemented on May 1, 2002 and the Old System be annulled on May 1, 2003 so as to ensure a smooth transition and an effective safeguard of the legitimate rights and interests of all the parties concerned.*

2. *Supervision of products applicable to either the New System or the Old System*

   1) *Starting from May 1, 2003, the Catalogue products either marketed by domestic manufacturers or imported must obtain the certificate for compulsory product certification (hereinafter referred to as the New Certificate) and be applied China Compulsory Certification mark (hereinafter referred to as the New Mark) before they are imported or marketed.*

   2) *Starting from May 1, 2003, the sales outlets or importers are not permitted to purchase, import or sell the Catalogue products that do not bear the New Certificate and the New Mark. Whereby the Catalogue products that are purchased or imported before April 30, 2003 and bear either the Import Safety License and CCIB Mark or the Safety Certificate and the Great Wall Mark (hereinafter referred to as the Old Certificate and the Old Mark) may still be sold under the supervision of the AQSIQ local branches with which such products are filed.*

   3) *Starting from May 1, 2003, if the Catalogue products that have obtained the New Certificate and the New Mark need continue to use the outer packing applied with the Old Mark, they can be marketed or imported only when the New Mark is applied along with the Old Mark.*

   4) *Prior to April 30, 2003, the Catalogue products for which the Old Certificate and the Old Mark is compulsory can be marketed or imported by either the Old Certificate and the Old Mark or the New Certificate and the New Mark.*

   5) *Starting from May 1, 2002, with regard to products for which the Old Certificate and the Old Mark was compulsory but being no longer covered by the Catalogue this time, the Old Certificate and the Old Mark will not be required when they are marketed or imported.*

3. *The acceptance of the certification application*

   1) *Starting from May 1, 2002, the certification bodies designated by CNCA (hereinafter referred to as DCBs) begin to accept applications for the New Certificate and the New Mark relevant to the Catalogue products and will no longer accept applications for the Old Certificate and the Old Mark.*

   2) *Prior to April 30, 2002, the Catalogue products for which the Old Certificate and the Old Mark is compulsory may continue to apply for the Old Certificate and the Old Mark.*

4. *Supplements*

   1) *With regard to the Catalogue products for which the application has already been filed but the Old Certificate is yet to be granted, or for which the Old Certificate has been granted, the New Certificate and the New Mark can be granted upon further application by the applicant and the confirmation of the product's qualification by the DCB.*

   2) *The cost incurred for the New Certificate an the New Mark referred to in 4.1 will be borne by the applicant based on the actual items required according to the fee chart of the New System.*

Regulations for Compulsory Product Certification Chapter I General Provisions

Article 1

Based on relevant laws and regulations covering product safety licensing and product quality certification so as to improve and enhance regulatory functions in the field of compulsory product certification as well as to effectively safeguard national and public interests in a feasible manner, the following regulations are announced for statutory implementation in accordance with the functions of the State General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ) and the Certification and Accreditation Administration of the People's Republic of China (CNCA) authorized by the State Council.

Article 2

The Compulsory Product Certification System (hereinafter referred to as CPCS) is applied to products related to human life and health, animals, plants, environmental protection and national security.

Article 3

Authorized by the State Council, CNCA is in charge of nation-wide certification and accreditation activities.

Article 4

With regard to CPCS, one Catalogue of Products Subject to Compulsory Product Certification (hereinafter referred to as the Catalogue), one set of applicable technical regulations, national standards and conformity assessment procedures, one obligatory mark and one structural fee chart will be announced for statutory implementation.

Article 5

Any product covered by the Catalogue must first be certified by a certification body designated by relevant competent authorities (hereinafter referred to as DCB). The subject product must obtain the certificate and be applied the certification mark before it can be marketed, imported or used for any commercial purposes.

UL 497

UL 497 Series of Safety Standards

The UL 497 series is a family of three safety standards that provides requirements for protection devices used in low-voltage circuits.

- UL 497 addresses requirements for primary protectors used in paired communications circuits.
- UL 497A covers secondary protectors for use in single or multiple pair-type communications circuits.
- UL 497B addresses protectors used in data communication and fire alarm circuits.
- UL 497C addresses protectors for coaxial circuits.
- UL 497D addresses protectors located on the equipment side of a primary protector, also known as the protected side of the circuit (typically current activated devices such as TBUs.)

The focus of UL 497 is to ensure that paired communication circuit protectors do not become a fire or safety hazard. The requirements in UL 497 cover any protector that is designed for paired communications circuits and is employed in accordance with Article 800 of the National Electric Code. The protectors covered in UL 497 include solid state primary and station protectors. These circuit protectors are intended to protect equipment, wiring, and service personnel against the effects of excessive voltage potential and currents in the telephone lines caused by lightning, power fault, power induction, and rises in Ground potential.

UL 497 Construction and Performance Requirements

The "Construction" section covers the following requirements:

- General
- Components
- Protection Against Corrosion
- Field-wiring Connections
- Enclosures
- Spacing

The "Performance" section covers the following requirements:

- General
- Instrument Fuse Test
- Polymeric Material Test
- Jarring Test
- Drop Test
- Strain Relief Test
- Corrosion Test, Outdoor Use Protector
- Replacement Arresters Installation Test
- Appliqué Assemblies Installation Test
- Dielectric Voltage-withstand Test
- Manufacturing and Production Tests
- Line Fuse Test
- Arrester Test
- Rubber Materials Test
- Water Spray Test
- Cover Replacement Test
- Marking

Performance Tests

Key performance tests which concern overvoltage protectors are detailed in the arrester test section. Requirements are:

- **Breakdown Voltage Measurement**—Arresters are to be tested in the protector blocks or panels in which they are intended to be employed. Arresters are required to break down within ±25% of the manufacturer's specified breakdown rating. In no case shall the breakdown voltage exceed 750 V peak when subjected to the strike voltage test. (Figure 3.13) At no time during this test will the supply voltage be increased at a rate greater than 2000 V/µs.
- **Impulse Spark-over Voltage Measurement**—The arrester must break down at less than 1000 V peak when subjected to a single impulse potential. Arresters are to be tested in each polarity with a rate of voltage rise of 100 V/µs, ±10%.
- **Abnormal Operation**—Single pair fuseless arresters must be able to simultaneously carry 30 A rms at 480 V rms for 15 minutes without becoming a fire hazard. A fire hazard is determined by mounting the arrester on a vertical soft wood surface and covering the unit with cheesecloth. Any charring or burning of the cheesecloth results in test failure. During this test, although the arresters may short, they must not have an impulse spark-overvoltage or DC breakdown voltage greater than 1500 V peak.
- **Discharge Test**—Protectors must comply with the strike voltage requirements after being subjected to five successive discharges from a 2 µF capacitor charged to 1000 V dc. (Figure 3.14).
- **Repeated Discharge Test**—The arrester must continue to break down at or below its maximum rated breakdown voltage after being subjected to 500 discharges from a 0.001 µF capacitor charged to a potential of 10,000 V dc. The interval between pulses is five seconds. Arresters are to be tested in each polarity, and it is acceptable for the protector to short circuit following the discharge testing. (Figure 3.14)

Figure 3.13 UL 497 Breakdown Voltage Measurement

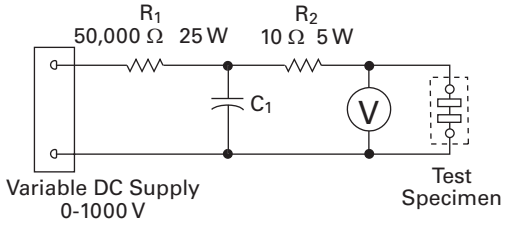
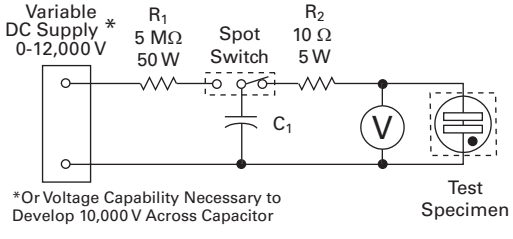


Figure 3.14 UL 497 Discharge Test



Regulatory

UL 497A

UL 497A addresses secondary protectors for use in single or multiple pair-type communication circuits intended to be installed in accordance with Article 800 of the National Electric Code (NEC) and to have an operating voltage of less than 150 V rms with respect to Ground. The purpose of UL 497A is to help reduce the risk of fire, electric shock, or injury resulting from the deployment and use of these protectors. UL 497A requirements do not cover telephone equipment or key systems.

UL 497A Construction, Risk of Injury, and Performance Requirements

The "Construction" section covers the following requirements:

- General
- Product Assembly
- Enclosures
- Internal Material
- Accessibility and Electric Shock
- Protection Against Corrosion
- Cords
- Current-carrying Parts
- Internal Wiring
- Interconnecting Cords and Cables
- Insulating Material
- Printed Wiring
- Spacing

The "Risk of Injury" section covers the following requirements:

- Modular Jacks
- Sharp Edges
- Stability
- Protection of Service Personnel

The "Performance" section covers the following requirements:

- General
- Impulse Voltage Measurement
- Overvoltage Test
- Endurance Conditioning
- Component Temperature Test
- Drop Test
- Crush Test
- Leakage Current Test
- Dielectric Voltage-withstand Test
- Rain Test
- Maximum Moment Measurement Test
- Weather-o-meter and Micro Tensile Strength Test
- Thermal Aging and Flame Test
- Electric Shock Current Test
- Manufacturing and Production Line Test
- Marking, Installation, and Instructions

Performance Tests

The following key performance tests relate to overvoltage protection of the secondary protectors:

1. **Impulse Voltage Measurement Test**—Secondary protectors must break down within ±25% of the manufacturer's breakdown rating when tested in each polarity with a rate of voltage rise of 100 V/µs, ±10%. Note that the manufacturer may assign separate breakdown voltage ratings for the Breakdown Voltage Measurement Test. This requirement only applies to secondary protectors that connect between Tip and Ring of the telephone loop.
2. **Breakdown Voltage Measurement Test**—Secondary protectors must break down within ±25% of the manufacturer's breakdown rating when tested in each polarity with a rate of voltage rise no greater than 2000 V/s. The secondary protector is to be mounted in accordance with the manufacturer's installation instructions and then subjected to the test circuit shown in Figure 3.15. This requirement applies only to secondary protectors connected between Tip and Ring or Tip/Ring and Ground of the telephone loop.
3. **Overvoltage Test**—Secondary protectors must limit current and extinguish or open the telephone loop without loss of its overvoltage protector, indication of fire risk, or electric shock. Upon completion of this test, samples must comply with the Dielectric Voltage-withstand Test.

The overvoltage test is used to determine the effects on secondary protectors and is shown in Table 3.48. Test connections are shown in Figure 3.16.

Test Compliance

Compliance with the overvoltage test is determined by meeting the following criteria:

- Cheesecloth indicator may not be either charred or ignited
- Wiring simulator (1.6 A Type MDQ fuse or 26 AWG line cord) may not be interrupted
- Protector meets the applicable dielectric voltage withstand requirements after the completion of the overvoltage tests

Table 3.48 UL 497A Overvoltage Test

Test	Voltage (V_{RMS})	Current (A)	Time	Comments
L1	600	40	1.5 s	(Note 1, Figure 4.11)
L2	600	7	5 s	(Note 1, Figure 4.11)
L3	600	2.2, 1, 0.5, 0.25	30 min at each current level	(Note 2, Figure 4.11)
L4	200 V rms or just below the breakdown voltage of the overvoltage protection device	2.2 A or just below the interrupt value of the current interrupting device	30 min	(Note 2, Figure 4.11)
L5	240	24	30 min	(Note 1, Figure 4.11)

Notes:
1. Apply Tests L1, L2, and L5 between Tip and Ground or Ring and Ground.
2. Apply Tests L3 and L4 simultaneously from both Tip and Ring to Ground.

Figure 3.15 UL 497A Breakdown Voltage Measurement Test

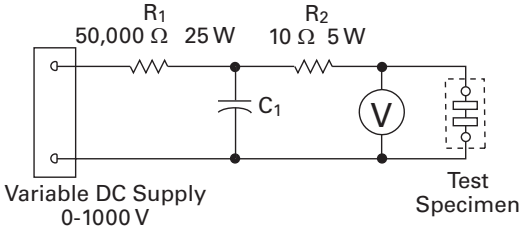
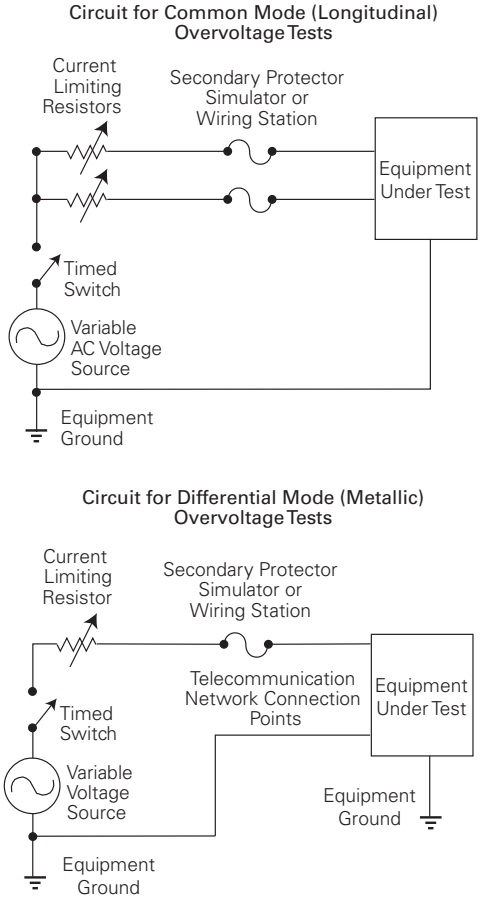


Figure 3.16 UL 497A Overvoltage Test



Regulatory

UL 497B

UL 497B provides requirements for protectors used in communication and fire alarm circuits. This standard does not cover devices for primary protection or protection devices used on telephone lines. *SIDACtor*® devices are components recognized in accordance with UL 497B under UL file number E133083.

Construction and Performance Requirements

The "Construction" section covers the following requirements:

- General
- Corrosion Protection
- Field-wiring Connections
- Components
- Spacing
- Fuses

The "Performance" section covers the following requirements:

- General
- Strike Voltage Breakdown
- Endurance Conditioning
- Temperature Test
- Dielectric Voltage-withstand Test
- Vibration Conditioning
- Jarring Test
- Discharge Test
- Repeated Discharge Test
- Polymeric Materials Test
- High Temperature Test
- Marking

Performance Requirements Specific to *SIDACtor*® Devices

1. **Strike Voltage Breakdown Test**—Protectors are required to break down within the manufacturer's specified breakdown range or within 10% of a nominal single breakdown voltage rating. (Figure 3.17)
2. **Endurance Conditioning**—Protectors are subjected to 50 impulse cycles. Each cycle is a 1000 V peak, 10 A, 10x1000 µs pulse. Pulses are applied in one polarity at 10-second intervals and then repeated in the opposite polarity.
3. **Variable Ambient Conditioning**—Protectors must comply with the strike voltage requirements after being subjected to an ambient temperature of 0 °C for four hours and again after being subjected to an ambient temperature of 49 °C for an additional four hours.
4. **Discharge Test**—Protectors must comply with strike voltage requirements after being subjected to five successive discharges from a 2 µF capacitor charged to 1000 V dc. (Figure 3.18)
5. **Repeated Discharge Test**—Protectors must not break down at a voltage higher than the manufacturer's maximum rated breakdown voltage nor lower than rated stand-off voltage after being subjected to 500 discharges from a 0.001 µF capacitor charged to 10,000 V dc. The discharges are applied in five-second intervals between one side of the protector and Ground. Upon completion of the discharge tests, protectors are once again required to meet the strike voltage requirement. (Figure 3.18)

Note : The epoxy used to construct a *SIDACtor*® device body meets UL 94V-0 requirements for flammability.

Figure 3.17 UL 497B Strike Voltage Breakdown Test

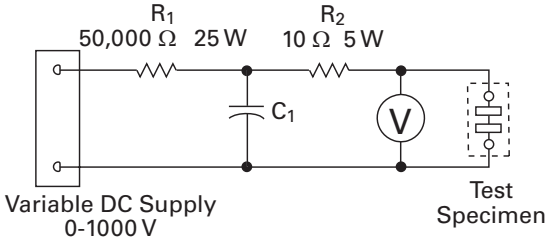
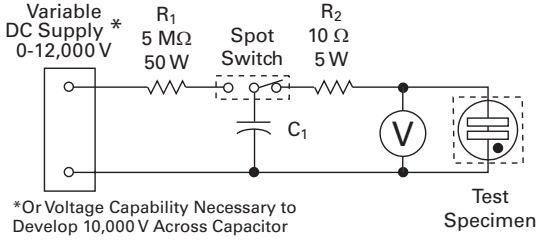


Figure 3.18 UL 497B Discharge Test



Regulatory

UL 497C

UL 497C requirements cover protectors for use on coaxial cable circuits. This standard covers construction and performance requirements.

UL 497C Construction and Performance Requirements

The "Construction" section covers the following requirements:

- General
- Corrosion Protection
- Field-wiring Connections
- Components
- Spacing
- Enclosures

The "Performance" section covers the following requirements:

- General
- I^2t Limiting
- Abnormal Sustained Current
- Component Temperature Test
- Breakdown Voltage Measurement
- Impulse Spark-over Voltage Measurement
- Limited Short-circuit Test
- High Current Ground Path Test
- Cable Shield Fuse Test
- Endurance Conditioning Test
- Induced Low Current Test
- Distortion Test
- Flame Test
- Impact Test (Polymeric Enclosures)
- Jarring Test
- Water Spray Test
- Leakage Current Test
- Dielectric Voltage-withstand Test
- Ultraviolet Light and Water Exposure
- Tensile Strength and Elongation Tests
- Air Oven Aging
- Ozone Exposure

Performance Requirements Specific to *SIDACtor*® Devices

1. **Strike Voltage Breakdown Test**—Protectors are required to break down within ±25% of the manufacturer's specified breakdown range but no higher than 750 V at ≤ 2 kV/s rise time.

2. **Endurance Conditioning**—Protectors are subjected to 500 impulse cycles. Each cycle is a 1000 V peak, 10 A, 10x1000 µs pulse. Pulses are applied in one polarity at 10-second intervals and then repeated in the opposite polarity. Then, 100 cycles of 1000 V peak, 100 A, 10x1000 µs pulse are applied to three new protectors. Finally, two cycles of 1000 V peak, 5000 A, 8x20 µs pulse are applied to three new protectors, with a rest period of one minute between surges.

3. **Variable Ambient Conditioning**—Protectors must comply with the strike voltage requirements after being subjected to an ambient temperature of 25 °C for four hours and again after being subjected to an ambient temperature of 90 °C for an additional four hours.

4. **Discharge Test**—Protectors must comply with strike voltage requirements after being subjected to a discharge of 1000 V, 100 ± 10 V/µs, 10 A impulse.

UL 497D

UL 497D covers secondary protector components for communications circuits located on the equipment side of a primary protector, also known as the protected side of the circuit. With a few exceptions, these devices shall also comply with all the requirements of UL 497A.

These components provide voltage and/or current surge protection after the primary protector but "these components do not normally provide protection for the voltage suppression device needed in the circuit to limit the voltage to less than the component ratings." It will limit current to the capacity of the protected wiring, however; they do not provide protection against excessive currents that may flow during the operation of the primary protection device. Thus, additional overcurrent protection prior to the voltage suppression device may be required.

The overvoltage test of UL 497A, Section 27, are to be performed using a reduced test voltage based on the voltage ratings of the component being tested. These tests are:

a) **Test L1** – @ Voltage rating of device, 40A, 1.5 S.

b) **Test L2** – @ Voltage rating of device, 7A, 5 S.

c) **Test L3** – @ Voltage rating of device, 2.2A, 30 M (and 1.0A, 0.5A, & 0.25A)

d) **Test L4** – 200V, 2.2A, 30 M or, when the equipment contains voltage-limiting devices operating between 200 and 600 volts AC, and the secondary protector employs other components that can be affected by the fault; at a voltage value just below the breakdown point of the overvoltage device is to be used. When the secondary protector contains current interrupting devices operating below 2.2 amperes, a current value just below the interrupting point of such device is to be used. This test is conducted for a minimum of thirty minutes. The test may be ended when during the trial it can be verified that the sample has mechanically disconnected the test current as described for Test L3.

Compliance with this test is based on the following conditions being met:

a) There shall be no ignition or charring of the cheesecloth indicator.

b) Based on the wiring simulator that is used:

1) The fuse or device used as the wiring simulator (MDQ 1-6/10) shall not interrupt the current during the test or

2) When a No. 26 AWG (0.13 mm2) solid copper wire is used as the wiring simulator, it shall not fuse open and shall not cause ignition or charring of the cheesecloth indicator.

c) The secondary protector shall comply with the Dielectric Voltage-Withstand Test:

1) one minute, without breakdown, the application of 40-70 Hz AC, between live parts and the enclosure; live parts and exposed dead-metal parts; and live parts of circuits operating at different potentials or frequencies. The test potential shall be:

a) For a unit rated 30 volts AC rms (42.2 volts AC peak) or less – 500 volts

b) For a unit rated between 31 and 150 volts AC rms – 1000 volts

UL 60950-1 2nd Edition

UL 60950-1 1st edition replaced UL 60950 effective July 1, 2006. UL 60950-1 2nd edition will effectively replace UL 60950-1 1st edition December 1, 2010. This 2nd Edition version made several changes but the most important ones to consider for telcom related applications are:

1) the reduced minimum clearances and creepage distances
2) pollution degree 2 and 3 clearance dimensions were modified so they now agree with the IEC 60664-1 Table G.2 values and
3) ringing signals test procedure for FCC Part 68 were corrected

The UL 60950-1 1st edition has an effective date of July 1, 2006, meaning that new products submitted after that date will be evaluated using the 1st edition version. However, products submitted after December 1, 2010 will be evaluated using the 2nd edition version. Therefore, between July 2006 and December 2010, the equipment may be tested to either 1st or 2nd edition. Products certified by UL to requirements prior to these effective dates may continue to be certified without further reinvestigation unless otherwise indicated specifically by UL.

The Technical Harmonization Committee (THC) 62368 is considering the development of a new U.S./Canadian bi-national standard based on a new IEC Standard (February 2010 expected completion date). The IEC is developing a new hazard-based standard for Audio/Video, Information Technology and Communication Technology Equipment, which will eventually replace the existing Telcom Standard (IEC 60950-1) and the Audio/Video Standard (IEC 60065).

This safety standard is intended to prevent injury or harm due to electrical shock, energy hazards, fire, heat hazards, mechanical hazards, radiation hazards, and chemical hazards.

After the divestiture of the AT&T/Bell system, the National Electric Code (NEC) implemented Article 800-4, which mandates that "all equipment intended for connection to the public telephone network be listed for that purpose" in order to ensure electrical safety. A manufacturer can meet this requirement by listing their product with Underwriters Laboratories under UL 60950-1 (based on IEC 60950-1,). The NEC requires all telecommunication wiring that enters a building to pass through a primary protector, which is designed to limit AC transients in excess of 600 V rms. These transients are due to the fact that telephone lines run in close proximity to AC power lines. Most telecommunication equipment uses a secondary overvoltage protector such as the *SIDACtor*® device. The secondary devices typically limit transients in excess of 350 V rms. Therefore, a potentially dangerous condition exists because of the voltage threshold difference of the primary protector and the secondary protector. To minimize this danger, compliance with UL 60950-1 is required. UL 60950-1 covers equipment with a rated voltage (primary power voltage) not exceeding 600 V and equipment designed to be installed in accordance with the NEC NFPA 70. This standard does not apply to air-conditioning equipment, fire detection equipment, power supply systems, or transformers.

It defines three classes of equipment:

- **Class 1**—protection achieved by basic insulation
- **Class 2**—protection achieved by double or reinforced insulation
- **Class 3**—protection relying upon supply from SELV circuits (voltages up to 40 V peak or 60 V dc)

UL 60950-1 also defines five categories of insulation:

- Functional
- Basic
- Supplementary
- Reinforced
- Double

UL 60950-1 Terminology

The following definitions assist in understanding UL 60950-1:

Creepage distance is the shortest distance between two conductors, measured along the surface of the insulation. DC voltages are included in determining the working voltage for creepage distances. (The peak value of any superimposed ripple or short disturbances, such as cadenced ringing signals, shall be ignored.) Clearance distance is the shortest distance between two conductive parts or between a conductive part and the outer surface of the enclosure measured through air. DC voltages and the peak value of any superimposed ripple are included in determining the working voltage for clearance distances. Creepage and clearance distances are subject to the pollution degree of the equipment:

- Pollution degree 1—components and assemblies sealed to prevent ingress of dust and moisture
- Pollution degree 2—generally applicable to equipment covered by UL 60950-1
- Pollution degree 3—equipment subject to conductive pollution or to dry non-conductive pollution, which could become conductive due to expected condensation

UL 60950-1 defines a secondary circuit as a circuit with no direct connection to a primary circuit and defines a primary circuit as a circuit directly connected to the ac mains supply.

SELV (Secondary Electrical Low Voltage) Secondary circuit whose voltage values do not exceed a safe value (voltage less than hazardous levels of 42.4 V peak or 60 V dc); regarded as not hazardous under dry conditions for an area of contact equivalent to the size of a human hand

TNV Telecommunication Network Voltage (a secondary circuit) (please refer to Table 3.49 on next page)

TNV-1 This is a TNV circuit with normal operating voltages that do not exceed SELV limits and has exposure to overvoltages

TNV-2 This is a TNV circuit with normal operating voltages that do not exceed SELV limits and has no exposure to overvoltages

TNV-3 This is a TNV circuit with normal operating voltages that exceed SELV limits and has exposure to overvoltages

UL 60950-1 Terminology (continued)

When determining the working voltage for TNV-2 & 3, it is assumed to be 120V dc unless it is specifically known for the application. For a TNV, it is assumed to be 60V dc, unless it is specifically known for the application. Telephone ringing signals are NOT taken into account for this determination.

Table 3.49 TNV Levels

Overvoltages from TELECOMMUNICATION NETWORKS possible?	Normal operating voltages	
	Within SELV CIRCUIT limits	Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits
Yes	TNV-1 CIRCUIT	TNV-3 CIRCUIT
No	SELV CIRCUIT	TNV-2 CIRCUIT

To ensure safe operating conditions of equipment, UL 60950-1 focuses on the insulation rating of the circuit(s) under consideration. Tables 3.50 and 3.51 (next page) indicate the required creepage and clearance distances depending on material group, pollution degree, working voltage and maximum transient voltage in the secondary circuit. For a typical telecommunication application with a working voltage of 200 V, pollution degree 2, material group IIIb, the creepage distance is 2 mm. In this example, the clearance distance would be 1.8 mm if the transients are limited to values less than 800 V but allowed to go higher than 71 V (and no special quality control program is in place). This clearance distance is intended to prevent arcing during overvoltage events. IF the minimum creepage distance derived from these tables is less than the applicable minimum clearance distance, then that clearance distance would be used.

The highest transient voltage in a TNV-1 or TNV-3 circuit is determined by applying a 10x700 µS voltage waveshape surge event with an open circuit value of 1.5 kV and a 5x310 current waveshape with a short circuit value of 37.5A. For a TNV-2 circuit, this highest transient voltage is determined by applying a 10x700 µS voltage waveshape surge event with an open circuit value of 800 V and a 5x310 current waveshape with a short circuit value of 20A. These surges are applied 3 to 6 times in each polarity with a minimum of one second between impulses across:

1) the positive and negative supply points
2) between all supply points joined together and protective earth
3) between tip and ring and
4) then between tip and ring joined together and earth.

A coated PCB may use the smaller separation distances as provided in the table below IF its manufacturing process is subjected to a quality control program that assures double insulation and reinforced insulation compliance.

Table 3.52

PEAK WORKING VOLTAGE ≤ X V peak	FUNCTIONAL, BASIC or SUPPLEMENTARY INSTALATION mm	REINFORCED INSULATION mm
90	0.1	0.2
180	0.2	0.4
230	0.3	0.6
285	0.4	0.8
355	0.6	1.2
455	0.8	1.6
570	1.0	2.0
710	1.3	2.6
895	1.8	3.6

Table 3.50 Minimum clearances in secondary circuits (mm)

PEAK WORKING VOLTAGE X ≤	CLEARANCES in mm																	
	Highest transient overvoltage in the SECONDARY CIRCUIT (V peak)																	
	X ≤ 71V			71V < X ≤ 800V			X ≤ 800V			800V < X ≤ 1500V						1500V < X ≤ 2500V		
	Pollution Degree																	
	1 and 2						3			1 and 2			3			1, 2 and 3		
V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	0.2	0.4 -0.2	0.8 (0.4)	0.2	0.7 (0.2)	1.4 (0.4)	0.8	1.3 (0.8)	2.6 (1.6)	0.5	1.0 (0.5)	2.0 (1.0)	0.8	1.3 (0.8)	2.6 (1.6)	1.5	2.0 (1.5)	4.0 (3.0)
140	0.2	0.7 (0.2)	1.4 (0.4)	0.2	0.7 (0.2)	1.4 (0.4)	0.8	1.3 (0.8)	2.6 (1.6)	0.5	1.0 (0.5)	2.0 (1.0)	0.8	1.3 (0.8)	2.6 (1.6)	1.5	2.0 (1.5)	4.0 (3.0)
210	0.2	0.7 (0.2)	1.4 (0.4)	0.2	0.9 (0.2)	1.8 (0.4)	0.8	1.3 (0.8)	2.6 (1.6)	0.5	1.0 (0.5)	2.0 (1.0)	0.8	1.3 (0.8)	2.6 (1.6)	1.5	2.0 (1.5)	4.0 (3.0)
280	0.2	1.1 (0.2)	2.2 (0.4)	F 0.8B/S 1.4 (0.8) R 2.8(1.6)												1.5	2.0 (1.5)	4.0 (3.0)
420	0.2	1.4 (0.2)	2.8 (0.4)	F 1.0 B/S 1.9 (1.0) R 3.8(2.0)												1.5	2.0 (1.5)	4.0 (3.0)

Note: The values in parentheses apply to BASIC INSULATION, SUPPLEMENTARY INSULATION or REINFORCED INSULATION if manufacturing is subjected to a quality control program.
Note: F = Functional B = Basic S = Supplementary R = Reinforced D = Double

Table 3.51 Minimum creepage distances (mm)

RMS WORKING VOLTAGE ≤ X	CREEPAGE DISTANCES in mm								
	Pollution degree								
	1	2	1	2			3		
	Material group								
	Printed boards		Other materials						
	I, II, IIIa, IIIb	I, II, IIIa	I, II, IIIa, IIIb	I	II	IIIa, IIIb	I	II	IIIa, IIIb
10	0.025	0.04	0.08	0.4	0.4	0.4	1.0	1.0	1.0
12.5	0.025	0.04	0.09	0.42	0.42	0.42	1.05	1.05	1.05
16	0.025	0.04	0.1	0.45	0.45	0.45	1.1	1.1	1.1
20	0.025	0.04	0.11	0.48	0.48	0.48	1.2	1.2	1.2
25	0.025	0.04	0.125	0.5	0.5	0.5	1.25	1.25	1.25
32	0.025	0.04	0.14	0.53	0.53	0.53	1.3	1.3	1.3
40	0.025	0.04	0.16	0.56	0.8	1.1	1.4	1.6	1.8
50	0.025	0.04	0.18	0.6	0.85	1.2	1.5	1.7	1.9
63	0.04	0.06	0.2	0.63	0.9	1.25	1.6	1.8	2.0
80	0.063	0.10	0.22	0.67	0.9	1.3	1.7	1.9	2.1
100	0.1	0.16	0.25	0.71	1.0	1.4	1.8	2.0	2.2
125	0.16	0.25	0.28	0.75	1.05	1.5	1.9	2.1	2.4
160	0.25	0.40	0.32	0.8	1.1	1.6	2.0	2.2	2.5
200	0.4	0.63	0.42	1.0	1.4	2.0	2.5	2.8	3.2
250	0.56	1.0	0.56	1.25	1.8	2.5	3.2	3.6	4.0
320	0.7	1.6	0.75	1.6	2.2	3.2	4.0	4.5	5.0
400	1.0	2.0	1.0	2.0	2.8	4.0	5.0	5.6	6.3
500	1.3	2.5	1.3	2.5	3.6	5.0	6.3	7.1	8.0
630	1.8	3.2	1.8	3.2	4.5	6.3	8.0	9.0	10
800	2.4	4.0	2.4	4.0	5.6	8.0	10	11	12.5

The Material Groups are defined as:
Material Group I CTI ≥ 600
Material Group II 600 > CTI ≥ 400
Material Group IIIa 400 > CTI ≥ 175
Material Group IIIb 175 > CTI ≥ 100

If the Material Group is not known, then Material Group IIIb shall be assumed.

Clause 6.1.2 *Separation of the telecommunication network from earth* contains the following test requirements:

1) For applications where the nominal ac mains supply > 130 V, a 1.5 kV insulation test is conducted with surge suppressors bridging the insulation barrier removed (applied between tip/ring and earth)
2) For applications where the nominal ac mains supply < 130 V, a 1 kV insulation test is conducted with surge suppressors bridging the insulation barrier removed (applied between tip/ring and earth)
3) IF the surge suppressors were removed then the tip and ring leads are connected together with surge suppressors connected and:
   a) for case #1 above a 230 V 50 /60 Hz signal is applied through a 5 k ohm resistor between them and protective earth with surge suppressors connected. The current must be < 10 mA.
   b) for case #2 above a 120 V 50 /60 Hz signal is applied through a 5 k ohm resistor between them and protective earth with surge suppressors connected. The current must be < 10 mA.

The voltage applied to the insulation under test for test condition 1 and 2 above is gradually raised from zero to the prescribed voltage and held at that value for 60 S.

Surge suppressors that connect to protective ground shall have a minimum operating voltage that is equal to:

1) (180 V + 20% of its rated operating voltage) for ac mains < 130 V and
2) (360 V + 20% of the rated operating voltage) for ac mains > 130V

These separation requirements do NOT apply to any of the following:

1) permanently connected equipment or pluggable equipment type B
2) equipment that is intended to be installed by a service person and has instructions requiring the equipment be connected to a socket-outlet with a protective earthing connection OR
3) equipment that has provision for a permanently connected earthing conductor and is provided with instructions for installation of that conductor

The electric strength test for telecommunication networks contains two test condition categories. Compliance is checked by testing to one of these two categories. This is intended to protect users from overvoltages on the telcom network.

1) Impulse Test

- ±10 10x700 µS voltage waveshape surge event with an open circuit value of 2.5 kV and a 5x310 current waveshape with a short circuit value of 62.5A between all tip and rings connected together and any hand-held part of the EUT (with a minimum of 60 S between surge events)
- ±10 10x700 µS voltage waveshape surge event with an open circuit value of 1.5 kV and a 5x310 current waveshape with a short circuit value of 37.5A between all tip and rings connected together and earth ground connection of the EUT (with a minimum of 60 S between surge events); surge suppressors are allowed to operate
- ±10 10x700 µS voltage waveshape surge event with an open circuit value of 1.5 kV and a 5x310 current waveshape with a short circuit value of 37.5A between all tip and rings connected together and any other conductors that are intended to be connected to other equipment all tied together (with a minimum of 60 S between surge events); surge suppressors are allowed to operate

2) Steady State

- ac test of 1.5 kV is applied between all tip and rings connected together and any hand-held part of the EUT (surge suppressor across the insulation barrier are not removed)
- the ac test of 1 kV is applied between all tip and rings connected together and earth ground connection of the EUT (surge suppressor across the insulation barrier are removed but then must pass impulse test listed above)
- the ac test of 1 kV is applied between all tip and rings connected together and any other conductors that are intended to be connected to other equipment all tied together (surge suppressor across the insulation barrier are removed but then must pass impulse test listed above)

There can be no breakdown of the insulation barrier. Any surge suppressors across the insulation barrier that was removed for the 1 kV steady-state tests but then must comply with the impulse tests.

ANNEX C of UL 60950-1 covers transformers

The secondary side is loaded for maximum heating effect. The maximum working voltage is applied to the primary. The DC peak value of any superimposed ripple shall be included. The permitted temperature limits for the windings depend on the classifications listed at right:

- Class A limit is 150 °C.
- Class B limit is 175 °C.
- Class E limit is 165 °C.
- Class F limit is 190 °C.
- Class H limit is 210 °C.

Overvoltage Flowchart

The overvoltage flowchart in Figure 3.19 shows specific guidelines for determining overvoltage requirements applicable to telcom applications that use outside cable exposed to power line fault conditions. These overvoltage events can be the result of

a) contact with a multi-earthed neutral distribution power line (4 kV to approximately 50 kV),

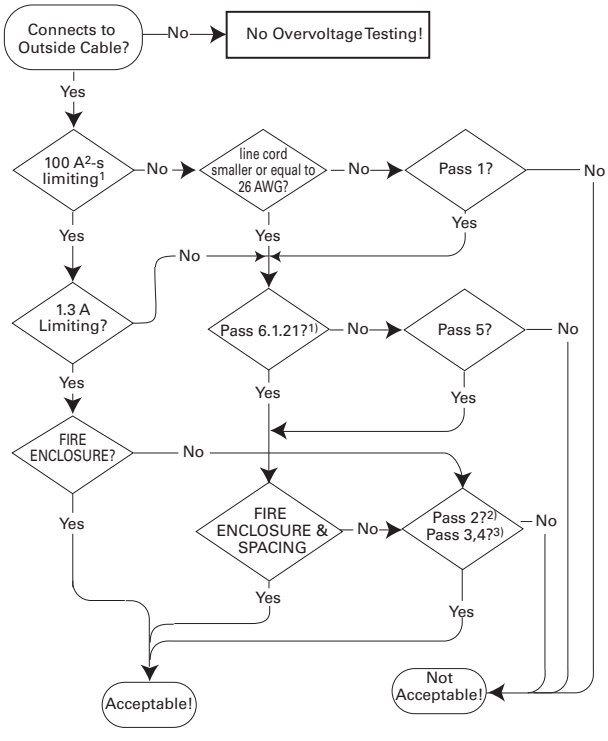
b) induction from a distribution power line fault to earth,

c) EPR (earth potential rise) due to power line fault current flowing to earth, and

d) contact with 120 V power line.

The worse case protection for inside wiring with 3-mil carbon blocks can result in a maximum longitudinal voltage of 600 V. Asymmetrical operation of these carbon blocks result in transverse (differential or metallic) voltages up to this 600 V. Furthermore, a high impedance power line fault to earth can result in a maximum induced current of 2.2A. Induction or EPR events can cause a maximum current event of 7A enduring for up to 5 S. A power line contact with a shielded telephone cable can result in an I^2t of 2,400 A^2-S. A 40 A, 1.5 S event is considered the worst case. A 120 V power line cross with a telephone line can deliver up to 25 A to the telephone wiring, limited by the wiring impedance.

Figure 3.19 Overvoltage Flowchart



Notes:
1) The telephone line is adequately isolated from earth for the operating mode being considered at a voltage of 120 V.
2) Test Condition 2 is not required for equipment containing a method for limiting current to 1.3 A max steady state (e.g., a fuse rated 1.0 A maximum).
3) Test Conditions 3 and 4 are not required for equipment whose application (because of system function, design limitations, etc.) is limited to connections to outside cable not exceeding 1,000 m (for example, equipment that connects to ISDN S/T reference points and certain proprietary telephone sets).

The questions "Passes 1, 2, 3, 4, and 5" shown in Figure 3.19 refer respectively to Tests L1 and M1, L2 and M2, L3 and M3, L4 and M4, and L5 shown in Table 3.53.

These tests are designed to simulate the following:

- Contact with primary power
- Short-term induction as a result of a primary power fault to a multi-earth neutral
- Long duration power fault to Ground
- Direct contact between the power mains and a telecommunications cable

Table 3.53 UL 60950 Overvoltage Test

Test	Voltage (V_{RMS})	Current (A)	Time	Comments
L1	600V	40	1.5 s	
L2	600V	7	5 s	
L3	600V	2.2	See Note 2	Reduce to 135% fuse rating
L4	See Note 1	2.2	See Note 2	Reduce to 135% fuse rating
L5	120V	25	See Note 2	
M1	600V	40	1.5 s	
M2	600V	7	5 s	
M3	600V	2.2	See Note 2	Reduce to 135% fuse rating
M4	See Note 1	2.2	See Note 2	Reduce to 135% fuse rating

Notes:
1 Voltage < conduction voltage of protection
2 Test for 30 minutes or until an open circuit occurs unless it appears possible that risk of fire or safety hazard may result; then continue test until ultimate results are obtained (maximum 7 hours).
General Notes:
- ISDN S/T interface only L1, L2, L5, M1, and M2.
- If Test 3 resulted in open condition, bypass the fuse, reduce current to 135% of the fuse rating and continue the test.
- L4 and M4 are conducted at a voltage level just below Vs only if *SIDACtor*® VS ≥285 V_S.
- For test conditions M1, L1, M5, and L5 a wiring simulator (MDL 2 A fuse) is used.
- Compliance means no ignition or charring of the cheesecloth, and/or wiring simulator does not open.
- Tests 2, 3, and 4 are required only if the unit is not a fire enclosure.
- EUT shall continue to comply with the requirements of Clause 6.2 (Separation requirements and Electric strength requirements) at the conclusion of these overvoltage tests.

Figure 3.20 Metallic Connection Appearances

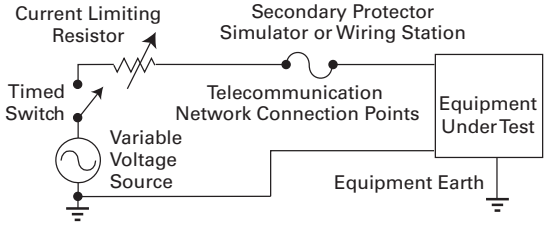
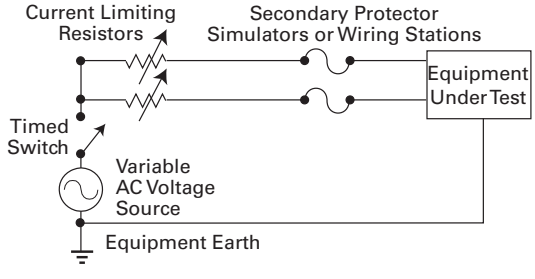


Figure 3.21 Longitudinal Connection Appearances



Regulatory

Overvoltage Test Procedures

Use the following criteria when applying the overvoltage tests presented in Table 3.53.

1. Test Set-up—Equipment is to be mounted as it is intended to be used. Tests may be conducted on either the equipment as an assembly, individual subassemblies, or a partial assembly containing those components which may be exposed to an overvoltage condition.
2. Indicators—Before testing, two single pieces of cheesecloth are to be wrapped tightly around the assembly, subassembly, or partial assembly. The cheesecloth acts as an indicator for conditions that may result in fire.
3. Line Cords—Equipment with a removable telecommunications line cord is to be connected to the test circuit with a line cord having 0.4 mm (26 AWG) or larger copper wire conductors and not more than 1Ω total resistance.
4. Functional Circuitry—UL mandates that functional circuitry must be used for each overvoltage test conducted. This allows repair or replacement of damaged circuitry before subsequent testing. Alternatively, separate samples may be used for each test.
5. Wiring Simulators—A wiring simulator is used to indicate whether the maximum I2t imposed upon telecommunications wiring has been exceeded. For Tests 1 and 5, a wiring simulator is to be used unless the equipment is specified for use with a suitable secondary protector or a secondary protector simulator. The wiring simulator can consist of one of the following:
   a. 50 mm length of 0.2 mm (32 AWG) bare or enameled solid copper wire (for test condition 1 and 5)
   b. Type MDL-2A fuse (for test condition 1 and 5) or equivalent
   c. Current probe used with a 300 mm length of 0.5 mm (24 AWG) copper wire (for test condition 1 only)

Note: Test conditions 2, 3, and 4 do not require the use of a wiring simulator or a secondary protector simulator. Any secondary protection simulators used in Tests 1 and 5 should be similar to the test fuse used in UL 497A, "*Standard for Secondary Protectors for Communications Circuits*."

Overvoltage Test Compliance

Equipment is deemed compliant if each of the following conditions is met during test:

- Absence of ignition or charring of the cheesecloth indicator (Charring is deemed to have occurred when the threads are reduced to char by a glowing or flaming condition.)
- Wiring simulator does not open during test condition 1 or 5
- For test condition 1, presented in Table 3.53, the integral I^2t measured with a current probe is less than 100 A2s.

After completion of the overvoltage tests, equipment must comply with either the Dielectric Voltage-withstand Test requirements with all components in place or the Leakage Current Test requirements.

Special Considerations Regarding the *SIDACtor*® Device and UL 60950-1

The epoxy used for *SIDACtor*® devices is UL recognized and the encapsulated body passes UL 94V-0 requirements for flammability. The only specific requirements of UL 60950-1that pertain to the *SIDACtor*® device itself are the impulse test and the mandate that components be UL recognized. All other UL 60950-1 requirements pertain to the equipment being evaluated.

Coax cable distribution Systems

The insulation between the primary circuit and the terminal or lead provided for the connection of a cable distribution system shall pass either:

1) the voltage surge test of UL 60950-1 Clause 7.4.2 for equipment intended to be connected to outdoor antennas; or
2) the impulse test of UL 60950-1 Clause 7.4.3 for equipment intended to be connected to other cable distribution system

If the EUT is intended for connection to both an outdoor antenna and another cable distribution system, it shall pass the tests of both UL 60950-1 Clause 7.4.2 and UL 60950-1 clause 7.4.3.

The following conditioning pulses are applied between:

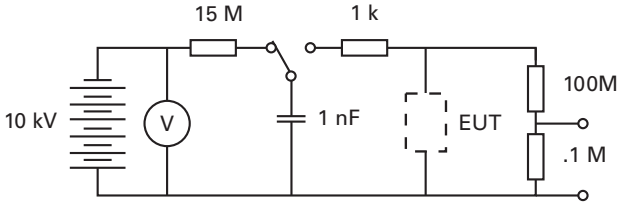
1) the connection points for the cable distribution system all joined together AND
2) the supply circuit terminals joined together with the main protective earthing terminal

At the conclusion of these surges, the electric strength tests are conducted. All components between the connection points for the cable distribution system and the protective earthing terminal are disconnected before these tests are applied.

UL 60950-1 Clause 7.4.2

The 10 kV surge generator as defined in IEC 60065 (example shown in figure 3.22) is used to apply 50 surges to the EUT. These surges are applied at a maximum rate of 12 pulses per minute.

FIgure 3.22 IEC 60065 Surge Generator



UL 60950-1 Clause 7.4.3

1) ±10 10x700 µS voltage waveshape surge event with an open circuit value of 5 kV and a 5x310 current waveshape with a short circuit value of 125A for power-fed repeaters

2) ±10 10x700 µS voltage waveshape surge event with an open circuit value of 4 kV and a 5x310 current waveshape with a short cir 100A for all other equipment

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