



IEEE Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid—Part 1 Applications

IEEE Power and Energy Society

Developed by the
Surge Protection Devices Committee

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STANDARDS

IEEE Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid—Part 1 Applications

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Surge Protection Devices Committee
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IEEE SA Standards Board

Abstract: Covered in this guide is the application of surge protective devices (SPD) and surge protective circuits (collectively called surge protectors) used to protect information and communication technology (ICT) circuits, including smart grid. This guide is not intended to cover individual surge protective components. Specifically excluded from this guide are stand-alone ac power protectors.

Keywords: coax protection, ICT, IEEE C62.43.1™, information and communication technology circuit protection, PoE, power over ethernet surge protection, smart grid communications protection, SPD, surge protective circuits, surge protective devices, surge protectors

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Introduction

This introduction is not part of IEEE Std C62.43.1-2020, IEEE Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid—Part 1 Applications.

This guide covers the application of surge protective devices (SPD) and equipment ports incorporating an SPD used to protect information and communication technology (ICT) circuits, including smart grid. This guide is not intended to cover individual surge protective components. Specifically excluded from this guide are stand-alone ac power protectors.

Contents

1. Overview	13
1.1 Scope	13
1.2 Types of surge protectors covered by this guide	13
1.3 Surge mitigation techniques	14
1.4 Surge protector configurations covered by this guide	15
2. Normative references	18
3. Definitions, acronyms, and abbreviations	18
3.1 Definitions	18
3.2 Acronyms and abbreviations	19
4. Environmental conditions	20
4.1 Service conditions	20
4.2 Test temperature and humidity	20
4.3 General environmental considerations	20
4.4 Environmental parameters for weather protected locations	21
4.5 Other parameters	21
4.6 Specific application parameters	21
5. Paired copper conductors except Ethernet	21
5.1 Telecom application types for non-linear SPDs	21
5.2 Application considerations	26
6. Ethernet	32
6.1 Ethernet configurations	32
6.2 Threats to Ethernet	34
6.3 Ethernet SPDs	35
6.4 Ethernet SPD design considerations	39
6.5 Suggestions for an Ethernet SPD	40
7. Coaxial cable systems	41
7.1 Coaxial cable SPD using a GDT only	41
7.2 Coax SPD having a resistive component	42
7.3 Other applications	43
8. SCADA and TIA-485 systems (smart grid)	44
8.1 The TIA-485 system	45
8.2 Example of protectors for SCADA systems	45
9. Multi-service surge protective device (MSPD)	47
10. Residential gateway and optical network terminal (ONT)	49
11. Mains power line communications (PLC)	49
12. Residential PLC	51
12.1 General description	51
12.2 Examples of circuits for decoupling MOV capacitance	52
Annex A (informative) IEC standards on environmental conditions	55
Annex B (informative) ATIS 0600036, Electrical Protection for Ethernet Systems	63
Annex C (informative) Guidance on placing SPDs to mitigate damage in cables serving an antenna tower ..	64

Annex D (informative) Bibliography	71
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List of Figures

Figure 1—Types of SPDs	14
Figure 2—Common-mode surge mitigation options	14
Figure 3—Differential-mode surge mitigation techniques	15
Figure 4—SPD non-linear configurations covered by this guide.....	16
Figure 5—SPD linear configurations covered by this guide.....	17
Figure 6—Two-terminal configurations	23
Figure 7—Three-terminal configurations, input and output terminals the same.....	23
Figure 8—Three-terminal configurations, input and output terminals different.....	23
Figure 9—Four-terminal configurations	24
Figure 10—Five-terminal configurations	25
Figure 11—Basic schematic of a commercially available symmetrical Ethernet SPD	29
Figure 12—Mode A powering Ethernet over data lines.....	32
Figure 13—Mode B powering Ethernet over spare pairs.....	33
Figure 14—Simultaneous Mode A and Mode B powering	33
Figure 15—Simultaneous independent Mode A and Mode B powering.....	34
Figure 16—Damage due to common mode surges	34
Figure 17—Damage due to differential mode surges	35
Figure 18—Example of an available Ethernet SPD.....	36
Figure 19—ECL V-I characteristic (blocking type and limiting type)	39
Figure 20—Ethernet PoE SPD using avalanche breakdown diodes	40
Figure 21—SPD using a GDT only	41
Figure 22—Two-electrode in line coaxial GDT	42
Figure 23—Coax SPD with a series resistance.....	43
Figure 24—Capacitive components used in coax SPDs for dc blocking or isolating	44
Figure 25—RS-485	45
Figure 26—ANSI/TIA-485 [B2] typical protection.....	46
Figure 27—ANSI/TIA-485 [B2] typical protection with ECLs and thyristors added	46
Figure 28—ANSI/TIA-485 [B2] typical protection with ECLs and GDTs added	47
Figure 29—House with separate service earth electrodes	48

Figure 30—House with bonded service earth electrodes.....	48
Figure 31—Equipment with local service surge protection.....	49
Figure 32—Example PLC LAN extension of ac mains wiring.....	50
Figure 33—Example of power line communication, power line coupling	51
Figure 34—Example of SPD circuit elements.....	52
Figure 35—Circuit waveforms.....	53
Figure C.1—Cable with intermediate protection.....	65
Figure C.2—Three-terminal GDT surge protectors along the cable.....	66
Figure C.3—Simulated surge voltages between pairs	67
Figure C.4—Simulated voltages with cable protectors	68
Figure C.5—Shield grounding at intermediate points in an MGN power system.....	69
Figure C.6—Shield grounding at intermediate points in a delta power system	70

List of Tables

Table 1—Environmental tests for weather protected locations	21
Table 2—Miscellaneous tests.....	21
Table 3—Application for non-linear telecom surge protectors.....	22
Table 4—Application for linear telecom surge protectors	22
Table 5—Power sourcing equipment (PSE) classifications and values	37
Table 6—Powered device (PD) classifications and values	38
Table 7—TIA-485 system parameters.....	45
Table 8—Comparison of Figure 32 circuit results.....	54

IEEE Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid—Part 1 Applications

1. Overview

1.1 Scope

This guide covers the application of surge protective devices (SPD) and equipment ports incorporating an SPD used to protect information and communication technology (ICT) circuits, including smart grid. This guide is not intended to cover individual surge protective components. Specifically excluded from this guide are stand-alone ac power protectors.

1.2 Types of surge protectors covered by this guide

This guide covers two types of surge protectors: Non-linear and linear, as illustrated in [Figure 1](#). Configurations of the surge protectors are covered in [1.3](#).

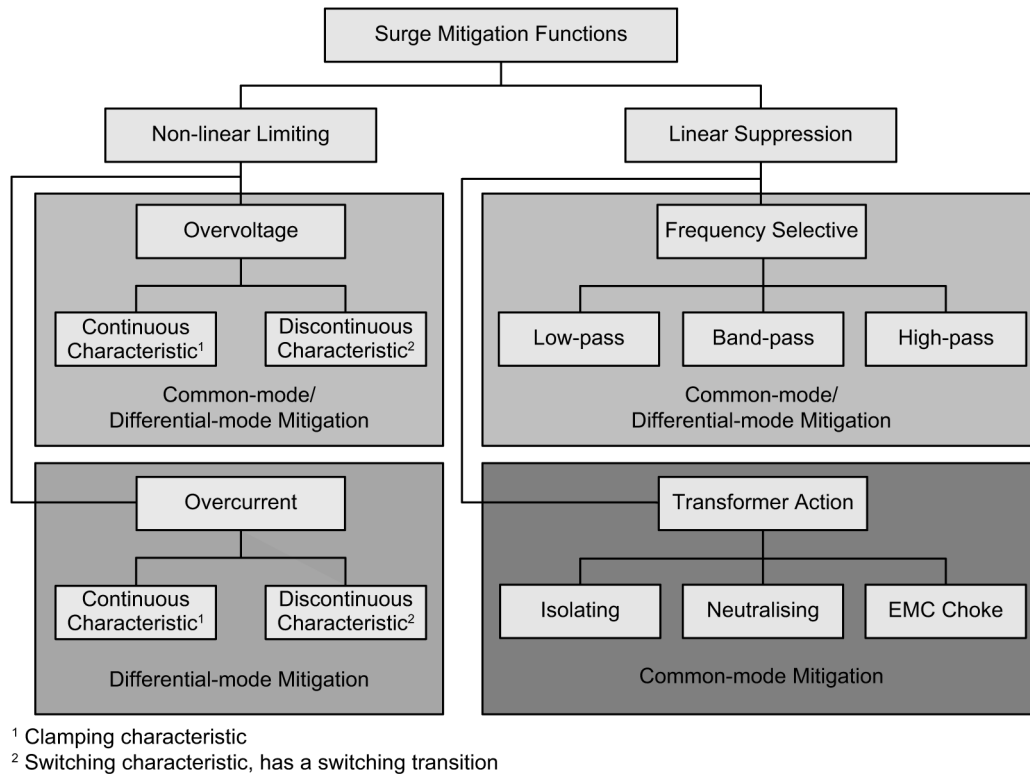


Figure 1—Types of SPDs

1.3 Surge mitigation techniques

For common-mode surge to a load with functional bonding, some mitigation options are shown in Figure 2.

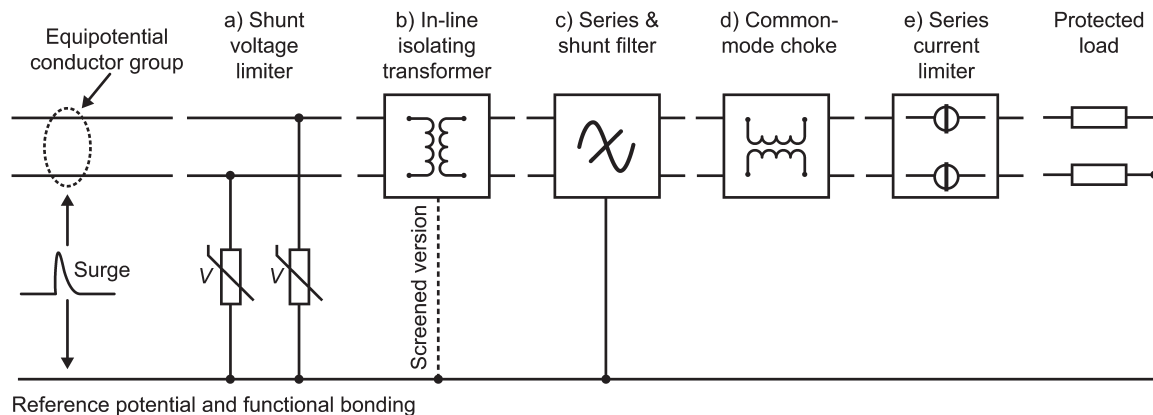


Figure 2—Common-mode surge mitigation options

The filter has both series and shunt elements, hence a bonding (C) connection (see Figure 5), and is five-terminal. The isolating transformer might have a screen connection making it a five-terminal component. The voltage limiter is shown as a metal oxide varistor (MOV) for convenience, but it could be any form of voltage limiter.

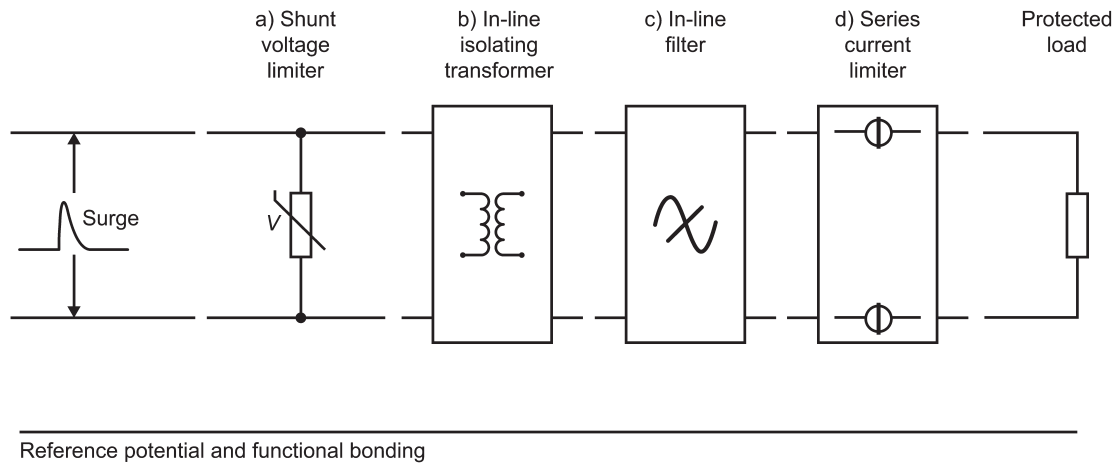


Figure 3—Differential-mode surge mitigation techniques

Differential-mode surge can be balanced or functionally bonded, so the mitigation is usually not reliant on functional bonding (see [Figure 3](#)).

The isolating transformer here only provides mitigation through frequency response difference to surge and the wanted service or core saturation. The in-line filter also has to have a different response to surge and service frequencies.

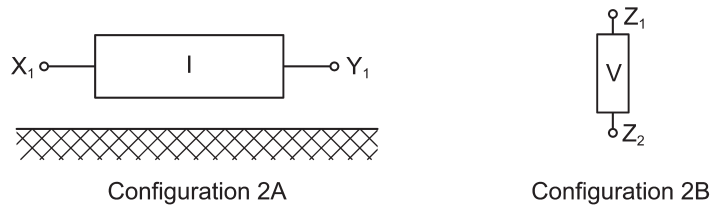
1.4 Surge protector configurations covered by this guide

1.4.1 Non-linear surge protectors

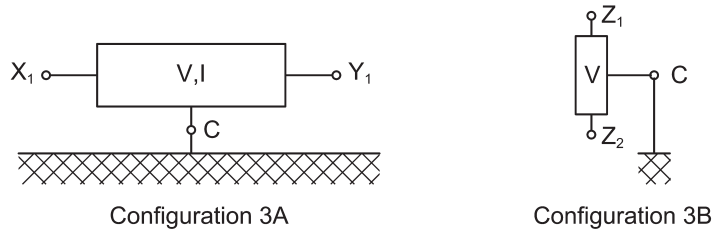
The surge protectors covered are series, parallel, or both combinations of non-linear, linear, or both elements. Non-linear surge protectors limit voltage, or current, or both. Linear surge protectors generally attenuate the effects of a surge. [Figure 4](#) is based on Figure 1 of IEEE Std C62.36™-2016 and illustrates functional block diagrams for the non-linear surge protectors covered by this guide.

The surge protectors covered by this guide are to be tested by means of the connections or terminations that are used when the surge protector is installed in the field. For surge protectors that are intended to be used with a base or connector, that base or connector is part of the tests.

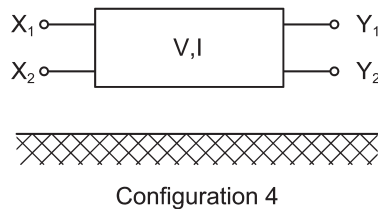
TWO – TERMINAL DEVICES



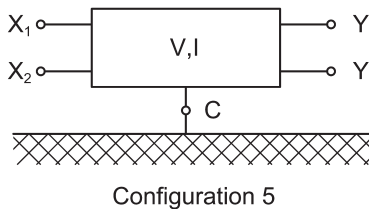
THREE – TERMINAL DEVICES



FOUR – TERMINAL DEVICE



FIVE – TERMINAL DEVICE



I = current-limiting function
V = voltage-limiting function
 X_1, X_2 = signal input terminals
 Y_1, Y_2 = signal output terminals
 Z_1, Z_2 = signal terminals shared by input and output lines
C = common terminal

NOTE 1—The V,I designation in Figure 4 indicates that a surge protector can have a voltage-limiting function, a current-limiting function, or both.¹

NOTE 2—Surge protectors intended for coaxial cable circuits are tested using Configuration 3A. Outer conductors of the transmission lines are connected to the common terminal of the surge protector during the tests.

NOTE 3—Surge protectors intended for twinaxial cable circuits are tested using Configuration 5. Outer conductors of the transmission lines are connected to the common terminal of the surge protector during the tests.

Figure 4—SPD non-linear configurations covered by this guide

1.4.2 Linear surge protectors

Figure 5 illustrates functional block diagrams for the linear surge protectors covered by this guide.

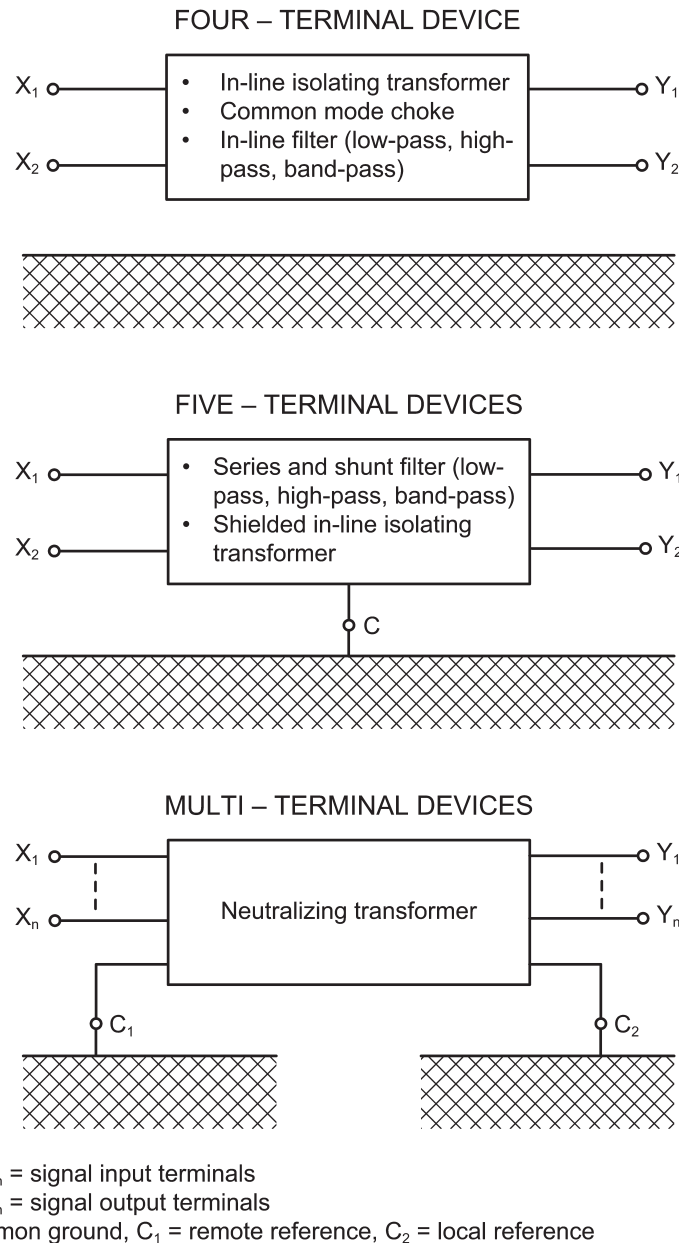


Figure 5—SPD linear configurations covered by this guide

The terms low-pass filter, high-pass filter, and band-pass filter designate categories. Filters in these categories are implemented according to design objectives, e.g., maximally flat response in the pass-band (Butterworth), steepest possible cutoff (Chebyshev), and linear phase. Of all possible designs, only linear phase preserves waveforms. This is an important consideration for filters used in digital systems, especially those employing QAM modulation, where any loss of waveform integrity can lead to transmission errors. The ability to implement any of these designs might be constrained by the need to pass dc (either for power, or because of the type of code used), which eliminates the possibility of capacitors in series with the line. Coaxial or waveguide filters are often of transmission-line design, such as a quarter-wave stub.

Neutralizing transformers perform an SPD or surge cancellation function by transferring primary winding voltage to the communications wire pairs, which opposes the common-mode surge voltage on the

communications wire pairs. See IEEE Std 487.4™ for additional information on neutralizing transformers [B20].

EMC chokes are actually two winding transformers used on paired conductors. They perform an SPD function by placing the windings in series with a conductor and poled (phased) to give a transformer action that presents high impedance to common-mode signals and low impedance to differential signals. Reference points at both ends of the cable provide the return path for the common-mode surge current in order for the EMC choke to work.

Linear and non-linear elements can be combined in an SPD.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std C62.36™-2016, IEEE Guide Test Methods for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits.^{1,2}

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* or the *IEC Glossary* should be consulted for terms not defined in this clause.³

non-resetting current limiting: Action of an SPD that limits current but does not reset after the disturbing current is removed.

self-resetting current limiting: Action of an SPD that limits current and will self-reset after the disturbing current is removed.

surge-protective component (SPC): Component specifically included in a device or equipment for the mitigation of the onward propagation of overvoltages, or overcurrents, or both.

surge protector (SPD): A specific complete surge-protective device, as opposed to a component of a surge protector or a generic surge-protective device.

voltage clamping type SPD: SPD that has high shunt impedance and will have a continuous reduction in impedance with increasing current in response to a voltage surge exceeding the threshold level of the SPD.

NOTE—Examples of components used in voltage clamping type SPDs: varistors (e.g., MOV) and avalanche breakdown diodes (ABD). See IEC 61643-21, ed. 1.0, AMD1: (2008-04) [B16].

voltage limiting: SPD clamping or switching action that restricts the overvoltage level.

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voltage switching type SPD: SPD that has a high shunt impedance and will have a sudden and large reduction in impedance in response to a voltage surge exceeding the threshold level of the SPD.

NOTE—Examples of components used in voltage switching type SPDs: air gaps, gas discharge tubes (GDT), and thyristor surge suppressors (TSS). See IEC 61643-21, ed. 1.0, AMD1:1 (2008-04) [B16].

waveform: A manifestation or representation (that is, graph, plot, oscilloscope presentation, equation(s), table of coordinate or statistical data, etc.) or a visualization of a wave, pulse, or transition. (IEEE Std C62.37-1996) [B28].

3.2 Acronyms and abbreviations

AM	amplitude modulation
CATV	community antenna television
DSL	digital subscriber line
ECL	electronic current limiter
ESD	electrostatic discharge
FAST	(G.fast) fast access to subscriber terminals (G indicates a G document in the ITU-T. See [B33])
FM	frequency modulation
GDT	gas discharge tube
HDSL	high-density subscriber line
ICT	information and communications technology
IoT	internet of things
LAN	local area network
LED	light emitting diode
MOV	metal oxide varistor
MSPD	multiservice surge protective device
NEBS	network equipment building system
ONT	optical network termination
PLC	power line communications
PLN	power-line networking
PoE	power over ethernet
POTS	plain old telephone service
PSE	power-sourcing equipment
QAM	quadrature amplitude modulation
SCADA	system control and data acquisition
SDSL	symmetric digital subscriber line
SPD	surge protective device
TVS	transient voltage suppressor

VDSL very high digital subscriber line

4. Environmental conditions

4.1 Service conditions

Two categories of operating temperature and humidity for the application of surge protectors are covered in this guide. Each category has an associated range of temperature and relative humidity. If an enclosure is used for testing, it should be wired and mounted according to its intended use. The temperature and humidity listed below are the ambient air test conditions.

- a) Controlled temperature and humidity
 Temperature: 2 °C to 50 °C, unless otherwise specified.
 Relative humidity: 10% to 80%
- b) Uncontrolled temperature and humidity
 Temperature: –40 °C to 70 °C, unless otherwise specified.
 Relative humidity: 5% to 96%, except that above 50 °C the relative humidity can be reduced to 20%.

4.2 Test temperature and humidity

Where only one extreme temperature is specified for a characteristic, or if the specified range is narrower than the full range of 4.1, the extreme temperature or narrow range represents the generally accepted worst-case test condition for a generic protector technology within the application. If it is known beforehand that a particular device technology causes a surge protector to be insensitive to temperature when testing a particular characteristic, a room temperature within the range 20 °C to 25 °C can be used instead for that test.

If a temperature for a particular test is not specified, the specification value can be measured at any temperature within the range of temperatures for the application (see 4.1). Tests related to lightning-caused surges need not be done at temperatures below –20 °C.

The humidity of the test laboratory should be recorded during the test. The humidity should be in the range 30% to 60% relative humidity to avoid possible damage to test equipment, such as ESD.

4.3 General environmental considerations

After manufacture, SPDs have to be transported, possibly with intervening storage, and installed. The IEC 60721 series [B13], Classification of Environmental Conditions, covers environmental parameters and their severities for the following situations:

- Storage
- Transportation
- Stationary use at weather protected locations
- Stationary use at non-weather protected locations
- Ground vehicle installations
- Ship installations
- Portable and non-stationary use

Part 3 of the IEC 60721 series [B13] relates the estimated environmental conditions for the preceding situations to the environmental testing procedures given in the IEC 60068 series, Environmental Testing [B9]. See Annex A for more details on environmental considerations and the use of these documents.

4.4 Environmental parameters for weather protected locations

The controlled temperature and humidity service condition is similar to the IEC 60721 class 3K3 environment [B13]. The uncontrolled temperature and humidity service condition is similar to the IEC 60721 class 3K7 environment [B13] that has the possibility of condensation and ice formation. See Table 1.

Table 1—Environmental tests for weather protected locations

Recommended test	Test method	Severity	
		Controlled (3K3)	Uncontrolled (3K7)
Dry heat	IEC 60068-2-2: Bb/Bd [B9]	+ 40 °C, 16 h	+ 70 °C, 16 h
Cold	IEC 60068-2-1: Ab/Ad [B9]	+ 5 °C, 16 h	− 40 °C, 16 h
Damp heat	IEC 60068-2-56: Cb [B9]	+ 30 °C, 85% RH, 96 h	+ 40 °C, 93% RH, 96 h
Condensation	IEC 60068-2-30: Db variant 2 [B9]		+ 40 °C, 90%–100% RH, 2 cycles

4.5 Other parameters

Table 2 lists some tests that the SPD might require. See Annex A for a list of the standards.

Table 2—Miscellaneous tests

Test	Test method
Vibration (sinusoidal)	IEC 60068-2-6 Fc [B9]
Test Ea and Guidance: Shock	IEC 60068-2-27 [B9]
Wire and tag solderability	IEC 60068-2-20 Clause 4 [B9]
Salt spray	IEC 60068-2-52 [B9]
Bump	IEC 60068-2-29 Eb [B9]
Flammability	IEC 60695-2-2 [B12] or UL-94
Abrasion of marking	IEC 60068-2-70 Xb [B9]
Damp heat, steady state	IEC 60068-2-78 Cab [B9]
Change of temperature	IEC 60068-2-14 N [B9]
Enclosure protection (IP code)	IEC 60529 [B10]
Screw- and screwless-type conductor clamps	IEC 60999-1 [B14]

4.6 Specific application parameters

Some industry standards define a complete test suite, for example Telcordia GR-974-CORE [B47].

5. Paired copper conductors except Ethernet

5.1 Telecom application types for non-linear SPDs

This clause covers surge protectors intended to be installed at the end of paired-conductors ICT circuits, central offices, and customer premises. For code requirements, see Article 725, Article 800, and Article 840 in the National Electrical Code® (NEC®) (NFPA 70) [B41]. For NEBS requirements, see GR-63 [B46] and

GR-1089 CORE [B48]. The general theory of operation of protectors and filters is covered in IEEE Std C62.43.0™ [B31]. Applicable standards are covered in the IEEE PC62.43.0™ bibliography [B31].

Table 3—Application for non-linear telecom surge protectors

Main characteristics of an ICT circuit	Type of surge protector	Example of services provided	Reference clause
For use on dc only	Only voltage limiter	Power circuits	5.1.1
	Voltage limiter and current limiter		
For use up to 1.1 MHz	Only voltage limiter	Voice, ADSL, HDSL, SDSL, T1 carrier, low frequency 4 mA to 20 mA current loop	5.1.2
	Voltage limiter and current limiter		
Up to 16 MHz	Only voltage limiter	ADSL2+, VDSL	5.1.3
	Voltage limiter and current limiter		
Up to 50 MHz	Only voltage limiter	VDSL, VDSL2	5.1.4
	Voltage limiter and current limiter		
Up to 212 MHz	Only voltage limiter	G.fast	5.1.5
	Voltage limiter and current limiter		

Table 4—Application for linear telecom surge protectors

Main characteristics of an ICT circuit	Type of surge protector	Example of services provided	Reference clause
For use up to 1.1 MHz	Low-pass filter	Voice, ADSL, HDSL, SDSL, T1 carrier, low frequency 4 mA to 20 mA current loop	5.1.2
	EMC choke		
	Neutralizing transformer		
Up to 16 MHz	Band-pass filter	ADSL2+, VDSL	5.1.3
	High-pass filter		
	Isolating transformer		
	EMC choke		
Up to 50 MHz	High-pass filter	VDSL, VDSL2	5.1.4
Up to 212 MHz	High-pass filter	G.fast	5.1.5