The Darwin awards for animals…

Standards for ICT Surge Protectors and Protective Circuits

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A little history to start

As early as 1847 Professor Joseph Henry (the same Henry that the unit of inductance is named after) described the first communications arrester in a paper on lightning and telegraph lines. So while not actually a standard, it raised the issue.

Not much happened until 1876 when the telephone was invented, and lightning protection was built into telephones.

The protection used in telephones was probably standardized at some point by the Bell System, as it did for much else; but for the industry as a whole there was apparently little interest in the standardization of protectors or protection for ICT circuits until 1929.

Then in 1929 the Bureau of Standards reported on a project to standardize lightning protection in the publication of *Miscellaneous Publication, Bureau of Standards, No. 95, Protection of Electrical Circuits and Equipment Against Lightning, Preliminary Report of the Sectional Committee on Protection Against Lightning*, which includes a section on the protection of communication and signaling circuits and equipment.

In the years following 1929 it became apparent that induced surges could cause as much or more damage than lightning. So the issue became not just lightning protection but surge protection, and the means for mitigating damage in ICT circuits became known as “surge protectors” rather than “lightning arresters”.

As the relatively robust electro-mechanical switching equipment was replaced in ICT circuits with electronic equipment which was more susceptible to surges, it became increasingly important to establish and update standards for ICT surge protectors and protective circuits. A number of organizations now deal with this standardization task, including Telcordia, the IEC, the ITU, UL, ATIS and the IEEE.

In particular, the IEEE Power and Energy Society Surge Protection Devices Committee WG 3.6.7 was established *circa* 1983 to develop standards for ICT protectors and protective circuits. The standards developed now include the latest technology and information for surge protectors and protective circuits used in ICT networks, including smart grid data networks.

The current WG3.6.7 members are listed below, and many will be recognized as participating in PEG meetings.

Chairman: Al Martin
Vice Chairman: Ernie Gallo

Members

Ardley, Tim	Drewes, Leonard	Kobsa, Peter	Tran, Thomas
Ashton, Dan	Gallo, Ernie	Martin, Albert	Travis, Bill
Basciano, Frank	Phillip Havens	Maytum, Mick	
Crevenat, Vincent	Klobassa, Bogey	Oertel, Wolfgang	

WG3.6.7 standards currently active are:

- IEEE Std C62.36™ Test Methods for Surge Protectors and Protective Circuits Used in Information and Communications Technology (ICT) circuits, including Smart Grid Data Circuits;
- IEEE Standard C62.43.0™ Guide for Surge Protectors and Protective Circuits Used in Information and Communications Technology (ICT) Circuits, Including Smart Grid Data Networks – Overview
- IEEE Standard C62.55™ Guide for Surge Protection of Power Feeds to Remote Radio Heads (RRH).

In addition there is a standard in development titled PC62.43-1 Draft Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid - Part 1 Applications. A discussion of these follows.

IEEE Std C62.36^{TM} Test Methods for Surge Protectors and Protective Circuits Used in Information and Communications Technology (ICT) circuits, including Smart Grid Data Circuits.

Where it applies

This standard applies to surge protectors intended for use on information and communications technology (ICT) circuits and smart grid data circuits.

What SPDs are covered

The surge protectors covered are generally multiple-component series or parallel combinations of linear or nonlinear elements, packaged or organized for the purpose of limiting voltage, current, or both.

What the test standard covers

This standard describes the methods of testing and criteria (where appropriate) for the characteristics and ratings of surge protectors used in ICT circuits and smart grid data circuits.

What is not covered

This standard does not cover packaged single components. For those, see IEEE PES SPDC WG3.6.1 (Low Voltage Gap Type Surge Protective Components), WG3.6.2 (Low Voltage Solid State Surge Protective Components), and WG3.6.3(Low Voltage Surge Protective Components Application Guide). In these standards "low voltage" is defined as equal to or less than 1000 V rms or 1200 V dc, based on usage in the IEEE Power and Energy Society under whose aegis the standards are developed.

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Specifically excluded from this standard are test methods for low-voltage power circuit applications (covered in other SPDC WG).

For protection of wire-line communication facilities under the specialized conditions found at power stations, consult IEEE Std™ 487 series of documents.

Test categories

The tests are divided into two categories: Those for characteristics and those for ratings.

- A characteristic is an inherent and measurable property of a device, expressed as a value for stated or recognized conditions. Characteristics might also be a set of related values, usually shown in graphical form. The Standard contains tests for characteristics in Clause 7.

- A rating is the nominal value of any electrical, thermal, mechanical, or environmental quantity assigned to define the operating conditions under which a device is expected to give satisfactory service. Rating tests are in three parts; first selected characteristics are measured; then the specified rating conditioning is applied to the surge protector; and then the selected characteristics are measured again to check for excessive degradation. Ratings tests are contained in Clause 8.

Tests for surge protector (inherent and measurable) Characteristics

7.1 DC series resistance

7.2 Capacitance

7.3 Inductance

7.4 Insulation resistance (IR) test

7.5 Standby current test (apply voltage, measure current. Basically a leakage current measurement)

7.6 DC ringing current (POTS lines: does the SPD clip the ringing signal and generate enough dc current to flow to cause a phone to go off hook?)

7.7 Distortion (does an applied signal cause harmonics to be generated? A check for non-linearity)

7.8 Transmission properties: insertion loss, return loss, phase shift

7.9 Longitudinal conversion transmission loss (LCTL) (how much transverse signal is generated by a normal longitudinal *signal*)

Tests for surge protector Characteristics, continued…

7.10 Voltage reset (ECL) (will an ECL reset against a powering voltage)

7.11 Impulse reset (checks for latch-up)

7.12 Transition current test for thermally activated components (at what current do they turn on?)

7.13 Time to trip test for thermally activated components

7.14 Transverse surge generation (how much transverse surge is created by longitudinal *surge*, possibly due to asynchronous component operation)

7.15 DC limiting voltage (the highest protector voltage reached by a slowly increasing input voltage)

7.16 Impulse voltage limiting (measures the ability of the protector to limit fast-rising voltages)

Tests for surge protector Characteristics, continued…

7.17 *In-line surge protector: protected port surge current let through* (this test measures the peak value of let-through current before the surge protector overvoltage protection operates, and checks that the series element survives the test.)

7.18 *In-line surge protector: surge series resistance* (measures the lowest series resistance as a function of temperature, voltage, and current – of interest for coordination)

7.19 *In-line surge protector: protected port ground potential rise* (If the SPD and associated equipment are not grounded to the same point, a GPR surge could cause them to be at different potentials. For this case, this test *verifies* the protected port *voltage surge withstand capability*)

7.20 *In-line surge protector: protected port ground lead inductive voltage spike* (The surge protector to equipment ground for a bonding lead may be equal to or greater than 1 m. For this case, this test *verifies* the protected port *voltage surge withstand capability* for inductive surges)

Tests for preferred surge protector ratings under specified conditioning

8.1 Surge protector ratings under environmental cycling with impulse surges (this test is to verify that a surge protector is able to conduct surges of specified parameters without failure, while undergoing temperature cycling at high humidity for a specified period of time)

8.2 Surge protector ratings under environmental cycling with ac exposure (this test to verify that a surge protector is able to conduct an ac current of specified parameters without failure, while undergoing temperature cycling at high humidity for a specified period of time)

8.3 Surge protector ratings under AC life (durability) (this test is to verify that a surge protector is able to withstand an ac stress of specified parameters for a given number of repetitions without failure)

Continued …

8.4 Surge protector ratings under impulse life (durability) (The purpose of this test is to verify that a surge protector is able to conduct impulse currents of specified waveforms for a given number of repetitions without failure)

8.5 Surge protector ratings under maximum single-impulse discharge (The purpose of this test is to determine the capability of a surge protector to conduct a specified high amplitude current impulse without failure)

Test organization (This standard is basically a lab manual)

Each test is organized in a manner that is probably unique to this standard:

- Background – why the test is done
- Purpose – what is the test intended to do
- Equipment required – a list of the equipment needed to do the test
- Protector states to test – conditions of the test, such as biased or unbiased
- Procedures – a step by step detail of how the test is to be done (basically a lab manual)
- Alternative methods – other possible (and perhaps less favored) ways to do the test
- Suggested test data – what values to record
- Requirements – applies to ratings, and done to verify that a rating is within a specified range after specified characteristic tests are re-done.
- Comments – usually things to observe when doing the test, e.g. cautions

Informative annexes

Annex A Examples of internal arrangements of surge-limiting components

Annex B Test measurement techniques

Discuses the characteristics and caveats for the use of oscilloscopes; and methods for making voltage measurements and current measurements.

Annex C Impulse generators

This annex is an extensive discussion of the characteristics and use of impulse generators for testing all types of SPDs.

Annex D Cable discharge events

This annex describes an installation issue where the triboelectric effect causes cables to become charged during installation, when pulled through the walls or ceiling of a facility. This action can cause a significant voltage build-up, which can damage equipment when the cable is discharged. This annex then describes tests relevant to this effect.

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Annex E GDT-based surge protector oscillation test

This annex describes an unusual but possible operation state of a GDT. During laboratory power fault testing with DSL equipment, it has been discovered that certain GDTs powerfully oscillate and generate hundreds of volts at many megahertz for long periods. This annex discusses why this happens, and a test to see if the condition can occur.

Annex F Multiport surge protector (MSP)

This annex is based on material in the IEEE Std C62.50™-2012. The multiport surge protector has been developed to protect equipment and localized equipment clusters using multiple services. This annex discusses real-life problems that can arise, suggested tests to evaluate MSPs, and applicable standards.

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Annex G Comments on characteristics and ratings

There is often confusion about what is a characteristic and what is a rating. This annex discusses what these are, and how they are used. It contains a figure which shows how the tests in the Standard are used.

Annex H Signal transformers voltage-time product

This annex discusses the transformer voltage-time product. It is a measure of how long the transformer maintains its specified characteristics. When it saturates, the permeability of the core is reduced to a small value, and the amplitude of the secondary voltage is greatly reduced compared to its presaturation value. This annex discusses how to determine the voltage-time product of a transformer.

Annex I Bibliography

IEEE Standard C62.43.0^{TM} Guide for Surge Protectors and Protective Circuits Used in Information and Communications Technology (ICT) Circuits, Including Smart Grid Data Networks – Overview

Scope

This Guide gives an overview of the application of surge protectors and protective circuits used in information and communications technology (ICT) circuits, including Smart Grid data networks.

General theory of operation of protectors

This clause provides the description and theory of operation of surge protectors (also called surge-protective devices) used in ICT circuits, including Smart Grid data networks. Surge protectors mitigate the onward propagation of surge voltages or currents or both through the use of non-linear or linear components, or both, while maintaining the system operation to a given performance level.

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Linear surge protectors

Linear attenuation circuits or components reduce all levels of surge by a given reduction factor. This clause and its subclauses describe the operation of the various types of linear SPDs often employed, including:

- Frequency selective (low-pass, band-pass, high-pass)
- Transformer action (Isolating transformer, Neutralizing transformer)
- EMC choke

Non-linear surge protectors

Multiple-component surge protectors may contain voltage-limiting devices, which are connected in parallel with the terminals to be protected. They may also contain current-limiting devices in series with the terminals to be protected. Illustrations are provided. Descriptions and theory of operation of voltage-limiting components often found in multiple-component surge protectors can be found Annex B.

General theory of operation of non-linear surge protectors

This clause of the Standard explains how the three-terminal, four-terminal, and five-terminal SPDs work. These devices have two distinct states: In the quiescent state, they are essentially transparent to the system; in the operated state, they provide voltage limiting, current limiting, or both. The devices are operated or self-triggered by the voltage or current surge and may also self-reset to their quiescent state.

Application considerations

This clause discusses some general principles involved in the use of surge protectors, using the example of a three-terminal voltage-limiting protector (configuration 3b)

Operational compatibility

An unoperated surge protector should not interfere with transmission of information, control, or test signals. This clause discusses those issues.

Voltage limiting

The protector is intended to limit the magnitude of unwanted voltage transients to levels that are below the withstand threshold of the apparatus being protected. This clause discusses that issue, and also what the fault modes are.

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Grounding and bonding

This clause discusses grounding and bonding, as it applies to ICT SPDs.

Location of protectors

The physical location of protectors should be such as to help minimize the effect of grounding conductor impedance. This clause gives examples.

Codes and standards

This clause discusses standards relevant to ICT SPDs

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Annex A Protection coordination between primary and secondary ICT SPDs

Some installations have both a primary and a secondary protector. Coordination is necessary to ensure that during a surge the primary protector will operate and help prevent the overstress of the secondary protector and any other element (e.g., current limiter, fuse) between the protectors. This annex discusses what primary and secondary protection are, what coordination is, and how to do it.

Annex B Components for surge mitigation

This annex discusses components for surge mitigation:

- Non-linear limiting
- Overcurrent limiting
- Linear surge suppression

Annex C Bibliography

IEEE Standard C62.55™Guide for Surge Protection of Power Feeds to Remote Radio Heads (RRH)

Scope

This Guide covers the application of surge protective devices used to protect the DC power feeds of Remote Radio Heads (RRH) and power supplies of fiber optic cable systems feeding the antennas.

Overview

This standard explores some new ideas about protecting equipment on towers. It also has some new thoughts on the failure mechanisms of MOVs

The issue

There is a high potential for damage to RRH equipment at the top of a tower due to surges on the power feed, generally caused by lightning. So surge protection is important to protect the RRH from possible damage. What needs to be considered is the nature of the surge on a DC power feed due to a lightning strike to the tower, and how that impacts the design or selection of a protector.

Lightning characteristics

There are basically four types of lightning. The important parameters of these types are the manner in which the flash is initiated, and the polarity of the flash. This clause discusses the four types of lightning, with illustrations.

Classification of towers

When discussing the types and effects of lightning on equipment installed on towers, the terms “low towers” and “tall towers” are used. How do we know which type we have? This clause discusses how to determine that.

The surge on a DC feed, a model

This clause discusses an experiment designed to model the surge on an RRH dc feed. Considering the results of the experiment, the discussion continues by developing and validating a model characterizing the surge expected on an RRH dc feed due to a lightning strike.

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Examples of how the model can be used

This clause shows the results of running the model for various lightning waveforms and tower heights.

The issue of multiple strokes and continuing current

A typical negative cloud-to-ground flash is composed of 3 to 5 strokes (leader/return stroke sequences), with typical interstroke intervals of some tens of milliseconds, and possibly continuing current. Depending on the interval between strokes and the thermal time constant of a device, the thermal energy due to the strokes might accumulate in the protection device. Generally MOVs are used to protect dc feeds to RRH. This clause discusses how this energy accumulation in the MOV can result in failure due to a localized temperature rise.

Guidance for selecting MOV SPDs

A multi-surge burst test can be performed in only a very limited number of labs; so MOVs are unlikely to be rated on this test. Alternative test methods are discussed, including those in standards such as GR-1089 CORE.

Energy delivered to a MOV

An equation is derived in this clause for calculating the energy delivered to a device for an individual stroke of the flash, and also for continuing current. This calculation can be repeated for multiple strokes. This energy is important, because it raises the temperature of the device, potentially leading to failure.

Selecting an MOV, and also a SVCD

This clause discusses a three-step process for selecting an MOV. The first step is to calculate the energy for each stroke in the flash; and methods are discussed for doing this when the surge waveform is known and when it isn't. The second step is to sum up all the calculated energies to get the total energy in the flash. The third step is to estimate the number of times the tower is expected to be hit during the lifetime of the protector, and then derate the MOV accordingly.

This clause also offers some suggestions for selecting a silicon voltage-clamping devices (SVCD).

Comments

Comments include how to select the lightning flash to use, and on the ability of the protector to survive.

Annex A Multi-surge burst parameters of silicon voltage-clamping devices

This annex discusses how to select a silicon voltage-clamping device for use in a multi-surge environment.

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PC62.43-1 Draft Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid - Part 1 Applications (in progress)

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 does not cover individual surge protective components. Specifically excluded from this Guide are stand-alone ac power protectors (covered in other SPDC WG).

Topics

Environmental conditions

A discussion of the environment in which SPDs are expected to function, and relevant test methods. Annex B offers an extensive annotated bibliography of the subject.

SPD configurations for paired copper conductors except Ethernet

A detailed discussion of the configuration of the various types of ICT SPDs, and the circuits in which they are expected to function. These include:

- Power circuits (DC only)
- ICT circuits operating up to 1.1 MHz. Services include Voice, Alarm Circuits, ADSL, HDSL, SDSL, and T1 carrier.
- ICT circuits operating up to 16 MHz. Services include ADSL2+ and VDSL
- ICT circuits operating up to 50 MHz.
- G.fast circuits operating up to 212 MHz

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Application considerations

Application considerations include those for:

- Protectors on outdoor lines (including primary protectors and secondary protectors) and GPR.
- ICT two-terminal protector module
- ICT three-terminal protector module
- ICT four-terminal protector module
- ICT five-terminal protector module,

Applications considerations include those affecting the services delivered and those affecting surge performance.

Protectors for Ethernet

- Ethernet system configurations
- Threats to Ethernet
- Ethernet SPDs
  - General survival requirements
  - Discussion of a commercially available SPD focusing on compatibility issues
  - Discussion of Power Sourcing Equipment (PSE) classifications and values.
  - Issues to be considered for general Ethernet applications
- Ethernet SPD design considerations
- Suggestions for an Ethernet SPD

Protectors for Coax applications

- Coax SPD using a GDT only
- Coax SPD having a resistive component
- Other coax applications

SCADA and TIA-485 systems (smart grid)

- Discussion of SCADA systems including the commonly used RS-485 system
- Example of protectors for a RS-485 SCADA system

MSPD

Brief discussion since these are covered elsewhere

Residential Gateway and Optical Network Terminal (ONT)

Brief discussion since these are covered elsewhere

Mains power line communications (PLC)

A discussion of protectors used on power lines carrying communications

Residential PLC

A discussion of surge protection for high-speed PLC equipment in residences.

Annex A Annotated bibliography of environmental conditions

Annex B Glossary

Annex C Annotated bibliography for PoE

Annex D Guidance on avoiding damage in cables serving an antenna tower

Annex E Influence of mains type on protector selection

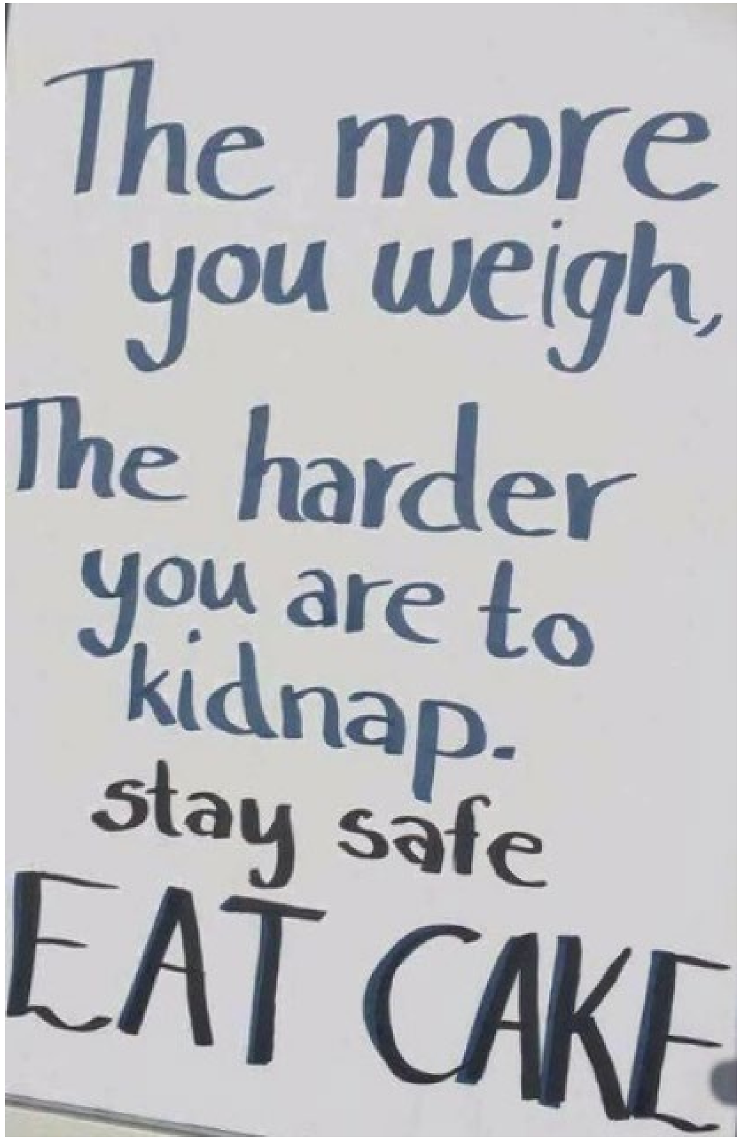
Annex F Bibliography

Conclusion

In today's world, signals in the ICT networks are generally carried over fiber in preference to copper wireline. But there is a huge legacy investment in copper plant, and it is still widely used, sometimes now being repurposed to supply power to remote cabinets. So standards for protection of the copper plant from lightning and other surges are still relevant for reliable operation of the wireline plant.

As job transfers and retirements deplete the number of engineers conversant with protection technology, it is important to capture their knowledge, which is what the standards reviewed can do.

Anyone interested in protection technology is invited to join the working group. For more information go to the SPDC website (https://pes-spdc.org) or contact the WG3.6.7 chairman at a.r.martin@ieee.org.


The more
you weigh,
The harder
you are to
kidnap.
stay safe
EAT CAKE

Questions?