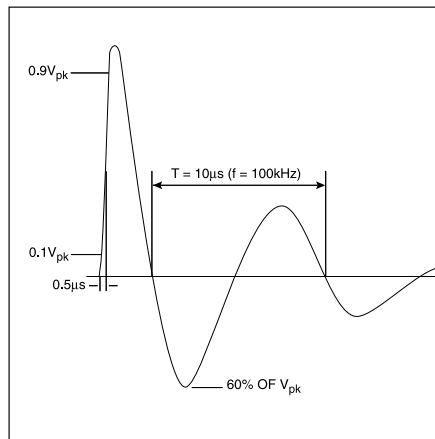
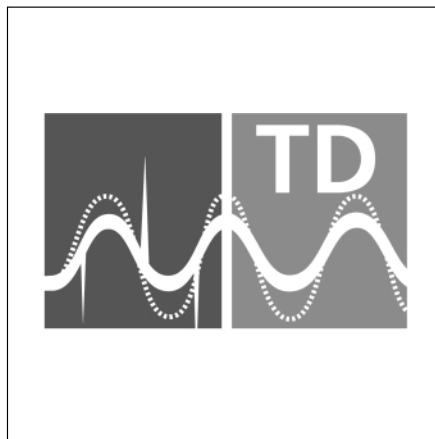
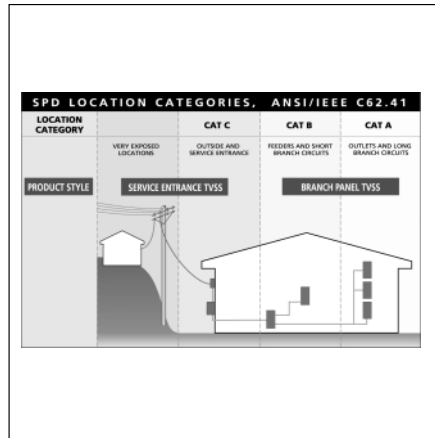
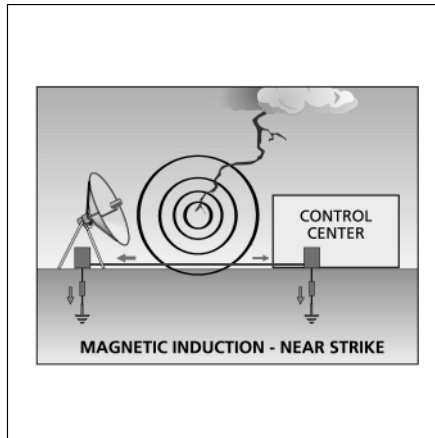
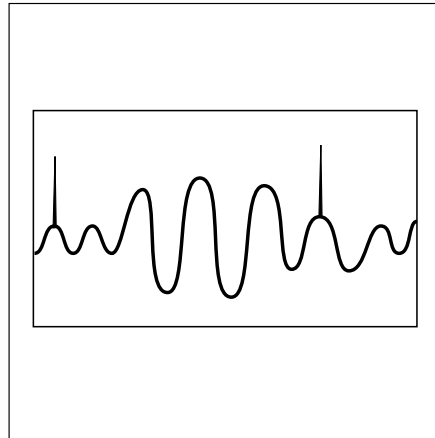
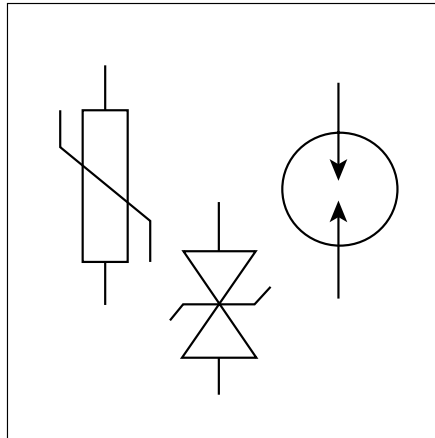


SURGE PROTECTION SEMINAR REVIEW



This publication provides a review of the presentation covering the correct selection and specification of Surge Protection Devices (SPDs).

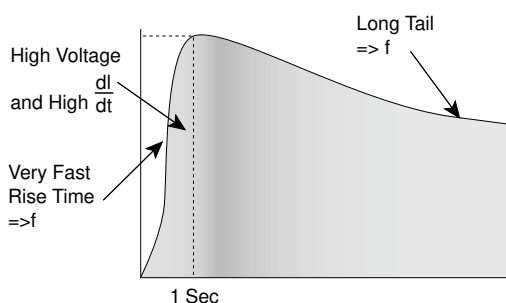
ERICO has developed detailed technical references on many subjects. They can be accessed on our website at www.erico.com, in the CRITEC Surge Protection Products Catalog and the CRITEC Surge Selection Calculator CD-ROM.

For additional information about topics covered in this booklet, we are including the Technical Note number for your convenience (e.g. TN CR 001).

Destructive Capacity of Lightning

The destructive capacity of lightning is readily seen from:

- Current rise times of up to 15 kA/ μ s.
- Peak currents capable of exceeding 100 kA with an 8/20 μ s waveshape.
- Repeat re-strikes in over 70 percent of cloud-to-ground discharges.
- Continuing currents of 200-500A lasting up to two seconds.

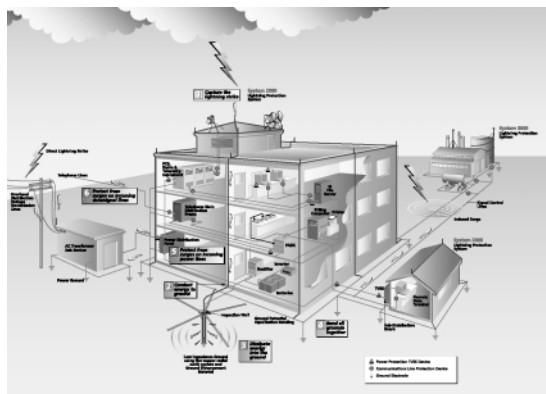


Coordinated Approach to Surge Protection

No single technology can eliminate the destructive effects of lightning or induced surge transients.

A coordinated approach to lightning protection is required, embracing all aspects of potential damage. This ranges from the more obvious direct strike to the more subtle mechanisms of differential ground potential rises and voltage induction at service entry points. ERICO's Six Point Plan™ approach of coordinated protection minimizes risk, providing the greatest value to the facility owner.

Refer to TN CR002



ERICO's Facility Electrical Protection Six Point Plan™

1. Capture the lightning strike to a known and preferred attachment point - this involves the use of an effective air terminal system on the facility to be protected.
2. Safely convey the lightning energy to ground - using a dedicated down conductor system.
3. Dissipate the energy into a low impedance grounding system.
4. Bond all ground points together - to eliminate ground loops and create an equipotential plane.
5. Protect incoming AC power feeders - using transient voltage surge suppression devices.
6. Protect low voltage data/telecommunications circuits - using transient voltage surge suppressor devices.

Refer to TN CR002

WHY DO YOU NEED SURGE PROTECTION?

Susceptibility to damage from over-voltage transients

Era	Technology	Energy (joules) Disruption- physical damage
1950-1960's	Thermionic valves	$10^{-1} - 10^{+1}$
1960-1970's	Medium power transistors	$10^{-4} - 10^{-3}$
1970-1980's	Digital IC's	$10^{-6} - 10^{-4}$
1980-2000's	VLSI	$10^{-8} - 10^{-6}$

Why Do You Need Surge Protection?

The energy level that causes failure of today's microprocessors is less than one millionth of what, in the past, could be safely sustained by vacuum tube technology.

Power distribution systems are increasingly becoming polluted due to:

- Switching surges
- Induced noise
- Lightning strikes
- Poor supply regulation

Equipment is more complex and compact, and our reliance upon it is more dependent.

Refer to TN CR 001

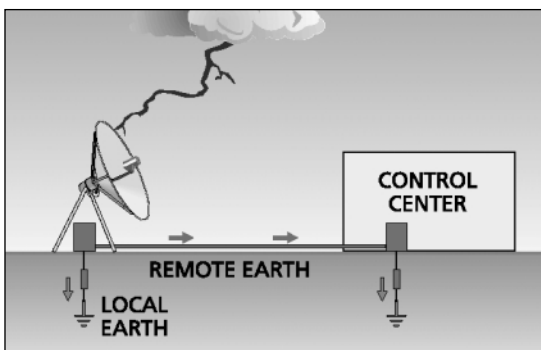
The cost of power quality problems include:

cost of repair
+ cost of replacement
+ cost of downtime
+ cost of data loss
+ cost of lost opportunities
+ cost of lost reputation...

Cost of Power Quality Problems

The consequences of an unexpected power surge can be catastrophic to most businesses or facilities. Damages in the USA are estimated to exceed \$1.2 billion per year.

Refer to TN CR 001

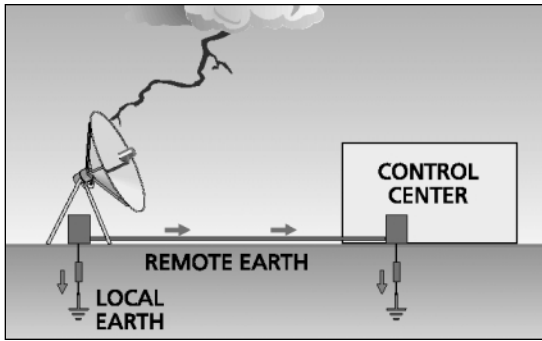


Galvanic Coupling

It is estimated that approximately 85 percent of transients are internally generated by the switching of electrical equipment within one's own facility. Most of this voltage is coupled through such events as:

- The switching of inductive loads.
- The switching of power factor correction capacitors in distribution systems.
- Ground potential rises during faults on distribution systems.
- The arcing of fuses or circuit breakers clearing power faults.
- Conducted electromagnetic interference from power switching electronics such as thyristor drives and switch mode power supplies.

Refer to TN CR 010

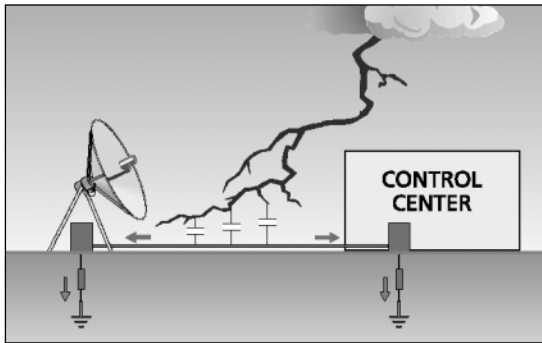


Magnetic Coupling

Magnetic Coupling is when the magnetic field of a current carrying conductor induces a current onto an adjacent conductor.

This is one reason why burying power cables does not provide adequate surge protection.

Refer to TN CR010



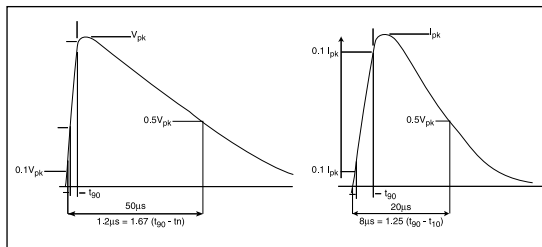
Capacitive Coupling

Capacitive Coupling is when the transient voltage is coupled due to the inherent capacitance between two circuits.

Nearby power circuits are a source for magnetic and capacitive coupled transients onto communication circuits, particularly when run together on cable trays or raceways.

Refer to TN CR010

MATCHING THE SOLUTION TO THE PROBLEM

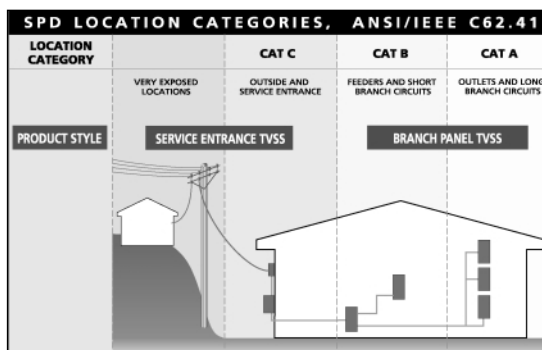


ANSI/IEEE C62.41 Waveshapes

This Standard introduces a number of waveshapes which characterize the profile of the lightning surge under various conditions including:

- The 8/20µs current pulse.
- The 1.2/50µs voltage pulse.

Refer to TN CR010



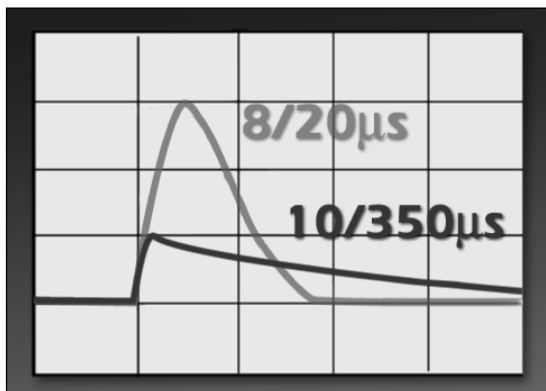
ANSI/IEEE C62.41 SPD Location Categories

ANSI/IEEE C62.41 details the exposure of different geographic zones into Categories A, B & C.

Category C is the highest category and generally describes the primary service entrance environment of a facility where circuit impedances are very low and particularly vulnerable to the influence of lightning. The exposure of such an environment is classified as 10kA 8/20µs. (100kA 8/20µs is currently under consideration.)

Category B characterizes the internal distribution system of a facility where the incoming transient energy is divided into multiple branch circuits. 3kA 8/20µs is regarded as being indicative of the energy level likely in such a zone.

Category A is typical of that encountered at the ends of internal distribution wiring to power outlets, where run lengths are often long and impedances are generally higher. Up to 200A 8/20µs with a switching ring wave of 100kHz can be expected.



10/350µs Waveform

For the next revision IEEE C62.41 is currently considering including a 10/350µs waveshape, claiming this to be a better representation of the electrical environment when exposed to a direct, rather than induced, lightning discharge.

For MOV based SPDs a conversion factor of 10 will apply where 10kA 8/20µs equates to the same energy as 1kA 10/350µs.

FROM THE FRYING PAN INTO THE FIRE!

37 Abnormal Overvoltage Tests

Must meet over-voltage conditions for prescribed periods of time without the risk of fire, ignition, charring, emission of flame or molten metal, or enclosure disintegration.

UL 1449

UL 1449 was introduced in 1985 to cover the safety listing of Transient Voltage Surge Suppressors (TVSS).

In 1998, UL 1449 Edition 2 was released. This included a number of significant improvements, particularly in the area of personnel safety pertaining to the risk of electric shock and SPD initiated fire. UL's motivation behind this change was a growing concern that TVSS devices may pose a fire hazard under conditions of sustained over voltage.

Common methods of meeting UL 1449 over-voltage tests

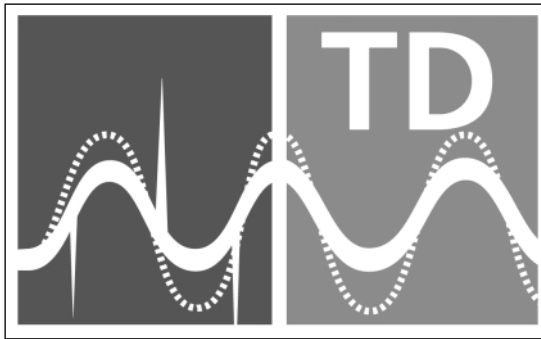
- Use of product enclosures capable of containing a fire
 - Low Cost
 - One time use
- Use of series over-current fuses
 - Limits surge rating
 - One time use
- Use of series thermal disconnects
 - One time use
- Use of over-voltage MOVs
 - Ineffective protection to equipment



Common Methods of Meeting UL 1449

SPD manufacturers meet the demands of this test in a number of ways, including:

- 1) The use of product enclosures capable of containing a fire.
 - Low cost
 - One time use
- 2) The use of series over current fuses.
 - Limits surge rating
 - One time use
- 3) The use of series thermal disconnects.
 - One time use
- 4) The use of over-voltage MOVs.
 - Ineffective protection



Transient Discriminating™ (TD) Technology

An SPD can meet UL 1449 by permanently disconnecting itself after as little as a 10% over-voltage, leaving the circuit unprotected.

ERICO developed TD technology not only to comply with the UL safety standard, but also to provide superior value. Unlike other SPDs, TD technology continues to provide transient protection even after repeated over-voltage events.

Refer to TN CR 005

UL 1449 Edition 2

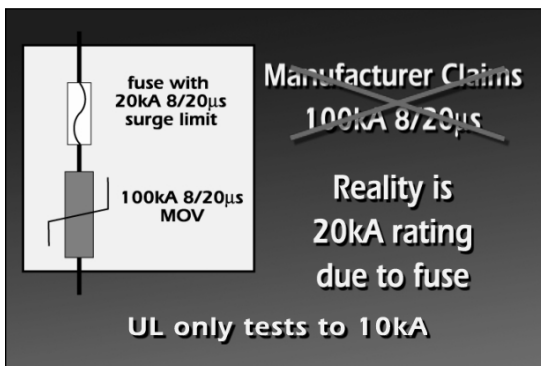
- UL 1449 Edition 2 = Safe SPD
- UL 1449 Edition 2 $\neq$ Good SPD

Limitations of UL 1449

UL is predominately a safety rather than performance standard:

- UL 1449 requires that a product need only have a Maximum Continuous Operating Voltage (MCOV) of 10% above nominal.
- Permanently connected surge protection devices are only tested to a maximum rating of 10kA 8/20 μ s. UL does not test products to the manufacturers claimed surge rating.

Refer to TN CR 005/ 009



NEMA LS1

- NEMA LS1 defines SPD specification methods and formats allowing simpler comparison of product performance.
- NEMA LS1 requires that the claimed surge rating of a product is the result of actual testing, not theoretical or calculated claims.
- More reputable manufacturers follow the voluntary requirements of NEMA LS1.

Refer to TN CR 009

MOV's, SAD's, AND SPARKGAPS

Component Characteristics

	Let-through Voltage	Energy Handling	Follow-on Current
SAD's	VERY GOOD	VERY POOR	GOOD
MOV's	GOOD	GOOD	GOOD
Gas Tubes	POOR	GOOD	VERY POOR

MOV's, SAD's, Sparkgaps

MOV's not only provide acceptable protection at an affordable price but also are particularly suited to high-energy environments such as facility service entrances.

Transient Discriminating Technology- A revolution in surge protection!

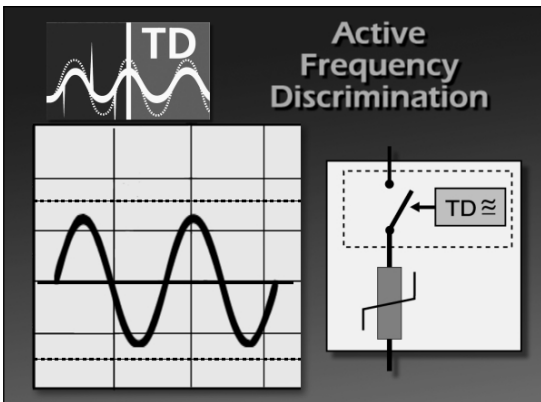
TRANSIENT DISCRIMINATING TECHNOLOGY

Ideal Surge Protector

- Minimize residual voltage
- Be safe under abnormal over-voltages
- Avoid permanent disconnection
- Indicate life status
- Reduce rate of voltage and current rise

The Ideal SPD

To meet fundamental performance, life and safety requirements, ERICO developed SPDs that utilize TD technology.



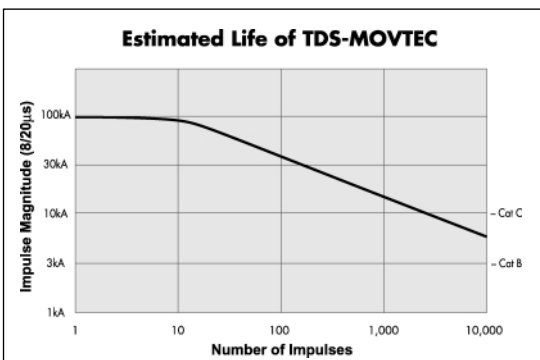
TD Technology

ERICO's Transient Discriminating technology utilizes an active frequency discrimination circuit. This discriminates between low frequency 50/60 Hz power regulation problems and the higher frequency of transient voltages. During abnormal 50/60Hz voltage conditions the TD switch isolates the surge diverting elements, ensuring that the SPD is virtually immune to the effects of a sustained over-voltage.

TD technology ensures the surge suppressor keeps operating, providing safe and reliable transient protection even after abnormal over-voltage conditions. TD technology is especially recommended for any site where sustained over-voltages are known to occur, or where failure of traditional surge technologies cannot be tolerated. SPDs with TD technology last longer.

Refer to TN CR005

HOW DO I KNOW MY SPD IS WORKING?



Is my SPD working?

Surge protection devices have a finite life. In particular, the capability of MOV-based devices reduces in proportion to the magnitude and number of sustained surges.

Better SPDs include percentage status indication, monitoring contacts and/or audible alarms.

Refer to TN CR013

WHAT ELSE DO I NEED TO KNOW?

Protection of Sensitive Equipment

Lightning and switching transients are characterized by impulses with very fast rise time, up to $10\text{kA}/\mu\text{s}$.

Electronic equipment is sensitive not only to the absolute magnitude of the voltage but also to the rate of rise of this impulse. Such fast changes can cause electronic switching components to switch into conduction at the wrong point in their conduction cycle and self destruct.

Refer to TN CR 006

Low Pass Filter

A low pass filter in an SPD allows low frequencies, such as the 60Hz mains voltage to pass with negligible attenuation, while attenuating the higher frequency components associated with a transient voltage event.

A well-designed low pass filter will efficiently reduce the dv/dt of a surge from a nominal $10,000\text{V}/\mu\text{s}$ to less than $100\text{V}/\mu\text{s}$ - a one hundred-fold improvement.

Refer to TN CR 006

Not All Filters Are Equal

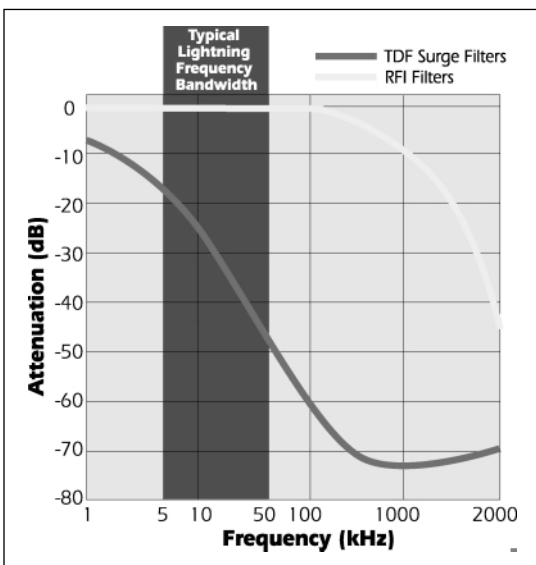
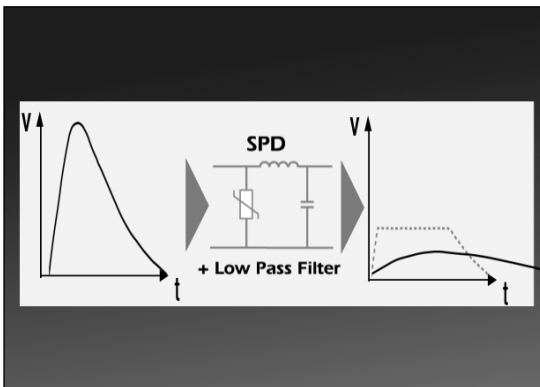
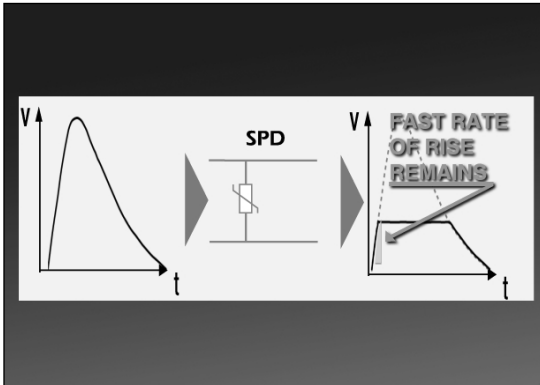
Parallel

At its simplest, an SPD may include a parallel capacitor to reduce fast rising voltages. However, for a filter to be effective, it needs to provide maximum attenuation across the band of frequencies where most of the surge energy spectrum is centered, typically 5-50kHz.

Series

Only "well designed" series filters can provide attenuation at these relatively low frequencies and are generally more expensive. Low cost, parallel filters are largely ineffectual at such frequencies and are really only suited to filtering at EMI/RFI frequencies.

Refer to TN CR 006



LET'S GET PRACTICAL!

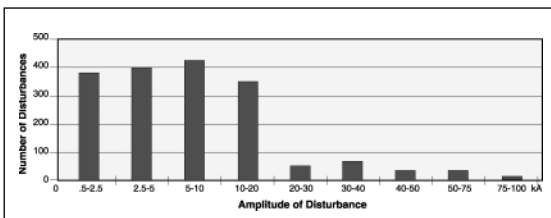


Commercial & Industrial Surge Protection

This document provides recommended selection criteria for SPDs and where to use them.

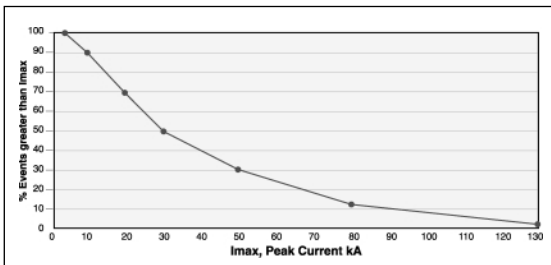
Two primary issues need to be considered in sizing a surge protection device for its application:

- 1) What is the largest surge this location needs to be protected against?
- 2) Does this level ensure adequate life under everyday operating conditions?



Field Study

A 10 year independent study completed during the 1970s confirms the observation that large surges (>75kA) are rare, but multiple smaller surges (<20kA) are common.



Lightning Magnitudes

ERICO maintains that a single shot rating at the service entrance location of 100kA 8/20 μ s per line is sufficient for all practical purposes.

Statistically, 95% of all direct lightning discharges are below 100kA in magnitude. As only a fraction of this energy ultimately enters a facility there is little need for surge protection devices rated in the hundreds of kAs.

Proposed Changes to the
ANSI/IEEE C62.41 Category C:
Scenario II Single Shot Testing Waveforms

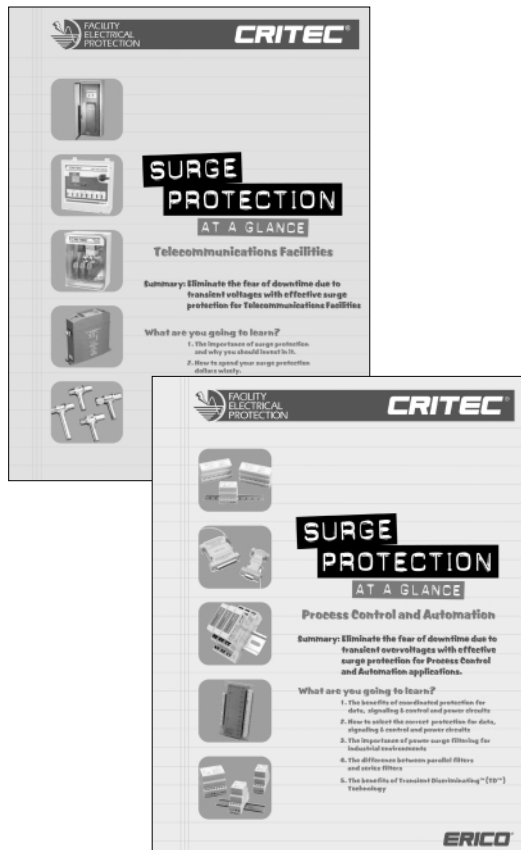
Exposure	10/350 μ s Waveshape	8/20 μ s Waveshape
1	2kA	20kA
2	5kA	50kA
3	10kA	100kA
X	As agreed between the user & the manufacturer	

ANSI/IEEE C62.41

Currently ANSI/IEEE C62.41 recommends a service rating of 10kA 8/20 μ s. This is generally accepted to be too small and industry/academic agreement has proposed a change to the next issue to include a worst case direct strike of 100kA 8/20 μ s for a direct strike condition.

Refer to TN CR011

LET'S GET PRACTICAL!



Telecommunications Surge Protection

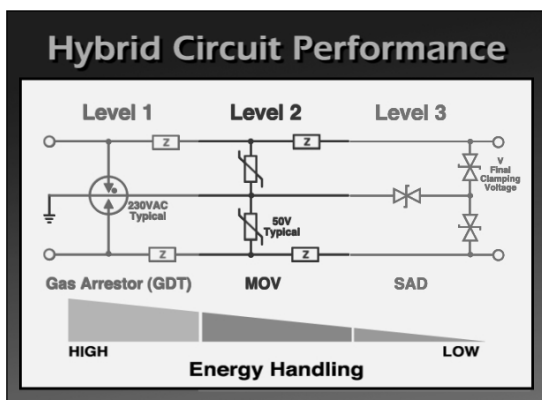
Telecommunications facilities are particularly susceptible to damage due to lightning strikes to tall metallic antenna towers. The strikes result in ground potential rises, which cause the ground to neutral surge suppression devices to conduct large amounts of energy. In addition, the lightning energy can be induced onto wiring such as the RF coaxial feeders and aircraft warning beacons.

Process Control & Automation Protection

The sophistication of industrial controllers and their associate sensors and transducers makes for systems that are increasingly vulnerable to transient damage. Much of this can be attributed to the sensitive nature of the I/O ports and the long lengths of exposed external wiring.

Such controllers require protection of both the control circuits and the power supply. Control or signal lines require a protection circuit capable of clamping to very low voltages, while at the same time being able to handle significant surge energies.

This document details the application and selection issues for Process Control & Automation SPDs.



Since a single technology is unable to provide low protection voltages and high energy, a hybrid circuit employing a number of different components is used. Commonly encountered are:

- **Gas Discharge Tubes (GDTs).** These are ceramic tubes filled with an inert gas. When a sufficient voltage is impressed across any two of the legs, the arrester “fires” into a low impedance mode. The breakdown voltages vary from 70 volts to thousands of volts. The three terminal version enables the surge to be clamped to ground irrespective of which line the surge is present on. These devices are comparatively slow to activate so higher residual voltages occur.
- **Metal Oxide Varistors (MOVs).** These voltage-limiting devices clamp the surge once the clamping threshold is exceeded. MOVs respond faster than GDTs, however on their own they are still not fast enough to limit to levels low enough for the sensitive inputs of I/O interfaces.
- **Silicon Avalanche Diodes (SADs).** These exhibit extremely fast turn on characteristics and have very precise clamping characteristics. Their low energy capability requires that they be used in coordination with an MOV or GDT.

CRITEC SUPPORT MATERIALS



CRITEC Surge Protection Catalog

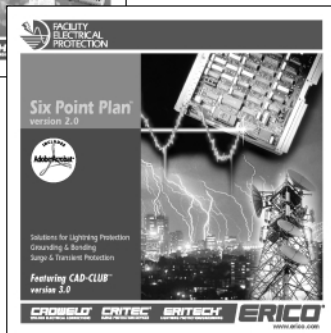
This catalog details the extensive range of CRITEC Surge Protection Devices for such industries as Commercial & Industrial, Process Control & Automation and Telecommunications. It also includes a comprehensive technical reference section on general aspects of surge protection as well as a guide on making the most appropriate product selection.



CRITEC Surge Selection Calculator

The CRITEC Surge Selection Calculator is an interactive tool designed to help select the most appropriate surge protection device (SPD) for most applications.

A risk assessment calculator is also provided to assist the user in understanding the potential lightning exposure of the facility.



Six Point Plan CD-ROM

The Six Point Plan CD-ROM is an interactive and educational tool that introduces ERICO's Six Point Plan of protection - a coordinated approach to lightning protection, surge protection and grounding.