



SURGE PROTECTION DEVICES



Line surges may come from:

1. External sources

- Lightning strikes is the most important.
- Surges are high intensity and sort time (μs).
- Can affect power and telecom lines.
- Potential increase of all lines to earth (common mode).

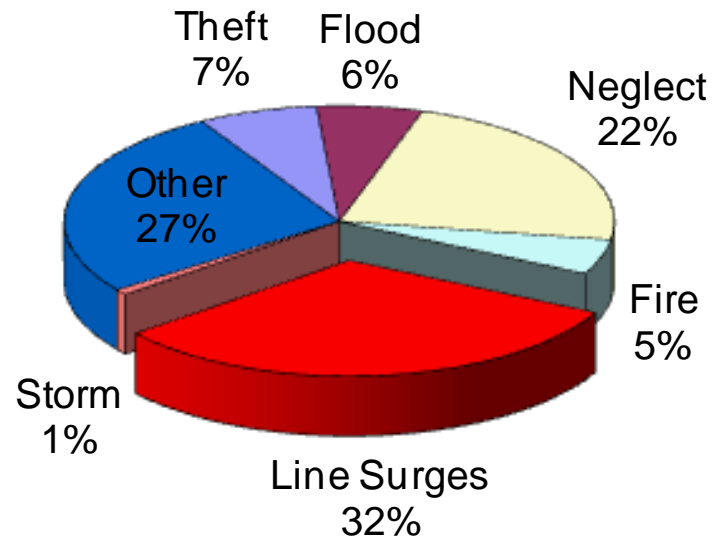


2. Internal sources

- Mainly from inductive or capacitive load switching (big motors, power factor correction capacitors) or line faults.
- They mainly affect power lines.
- Lower intensity compared to lightning, longer duration..
- May cause phase to neutral surges (differential mode).

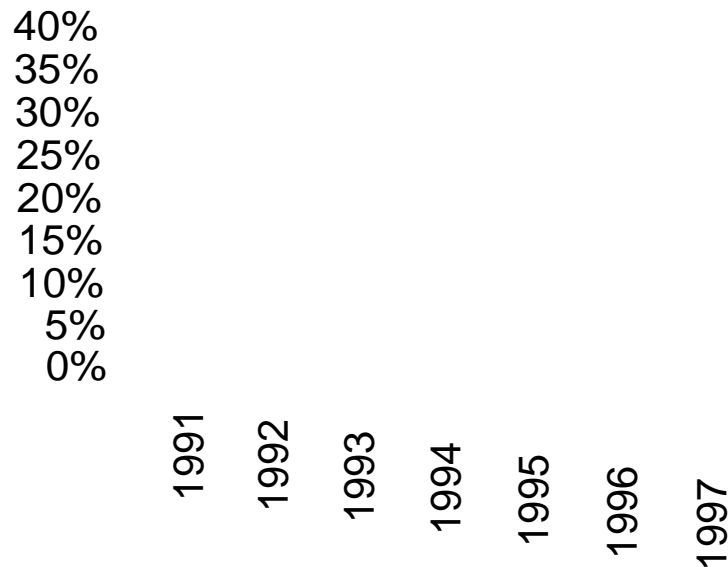


Damage to electronic devices

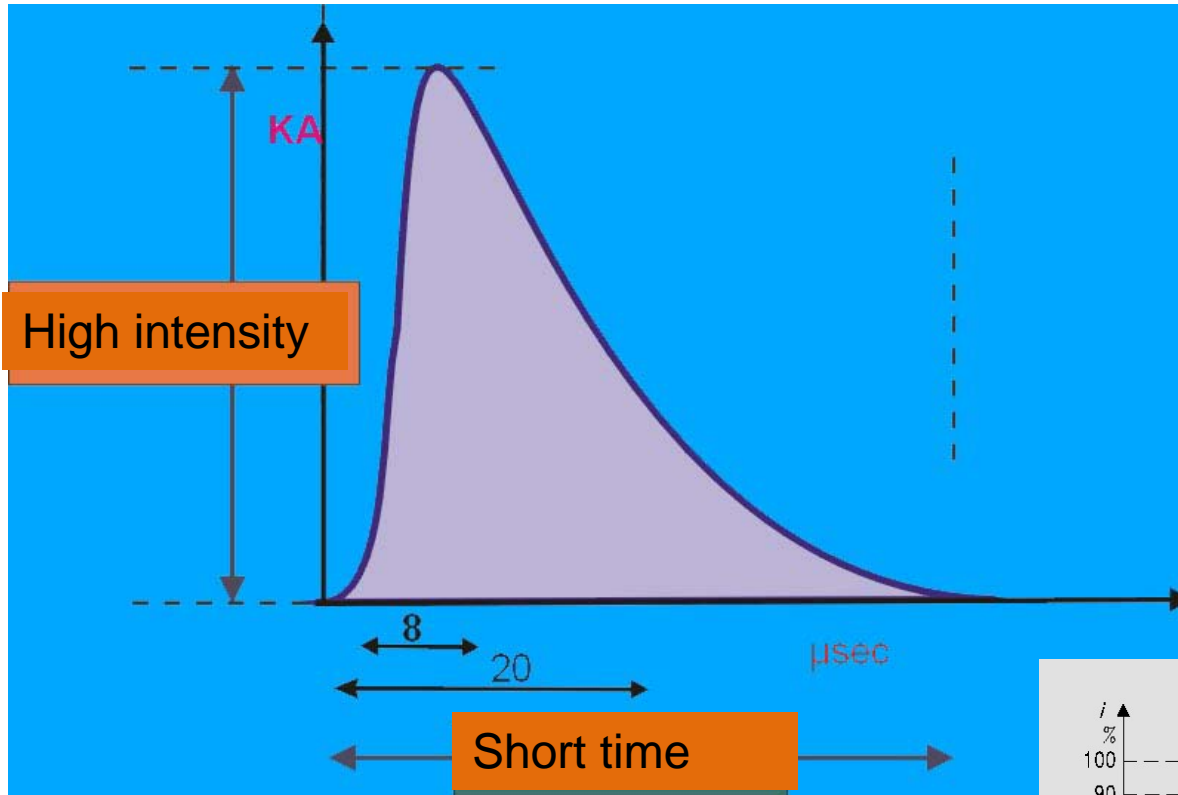


1994 Statistics for >10,000 incidents (source German Insurance Association)

Percentage of damages to electronics attributed to electrical interferences



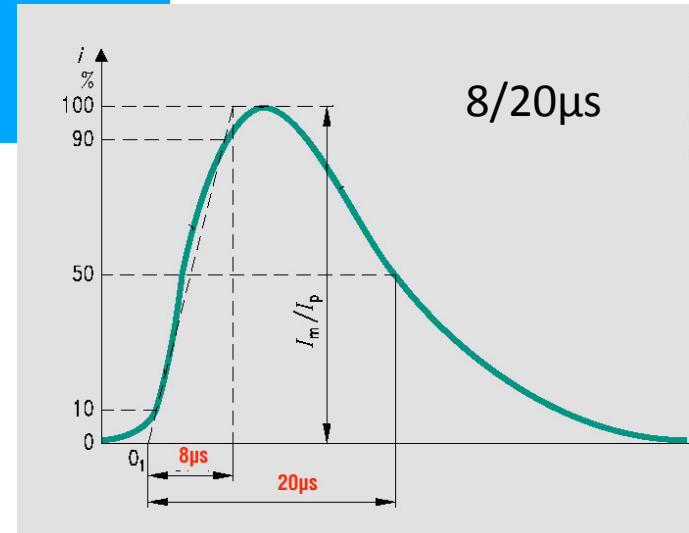
Surge waveform



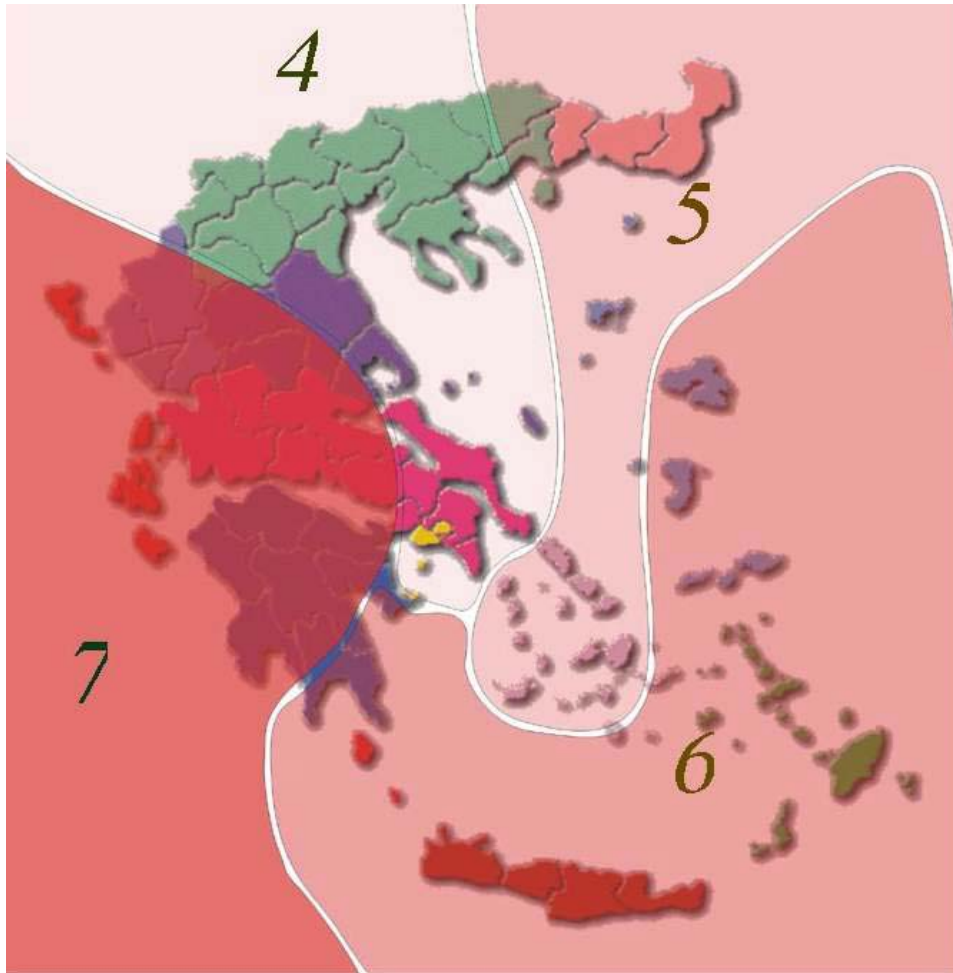
Inductive Lightning effect

Waveform 8/20µs

- 8µs rise time
- 20µs time to revert to 50% of max value



Lightning levels in Greece



- 4 to 7 strikes per sq. Km per year

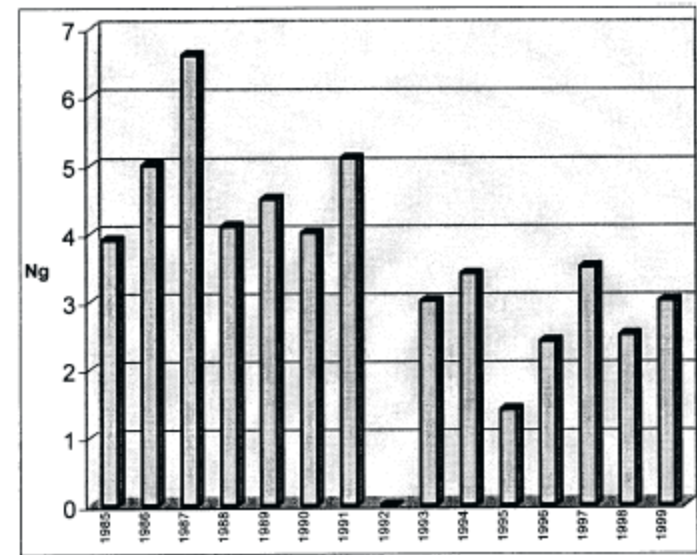
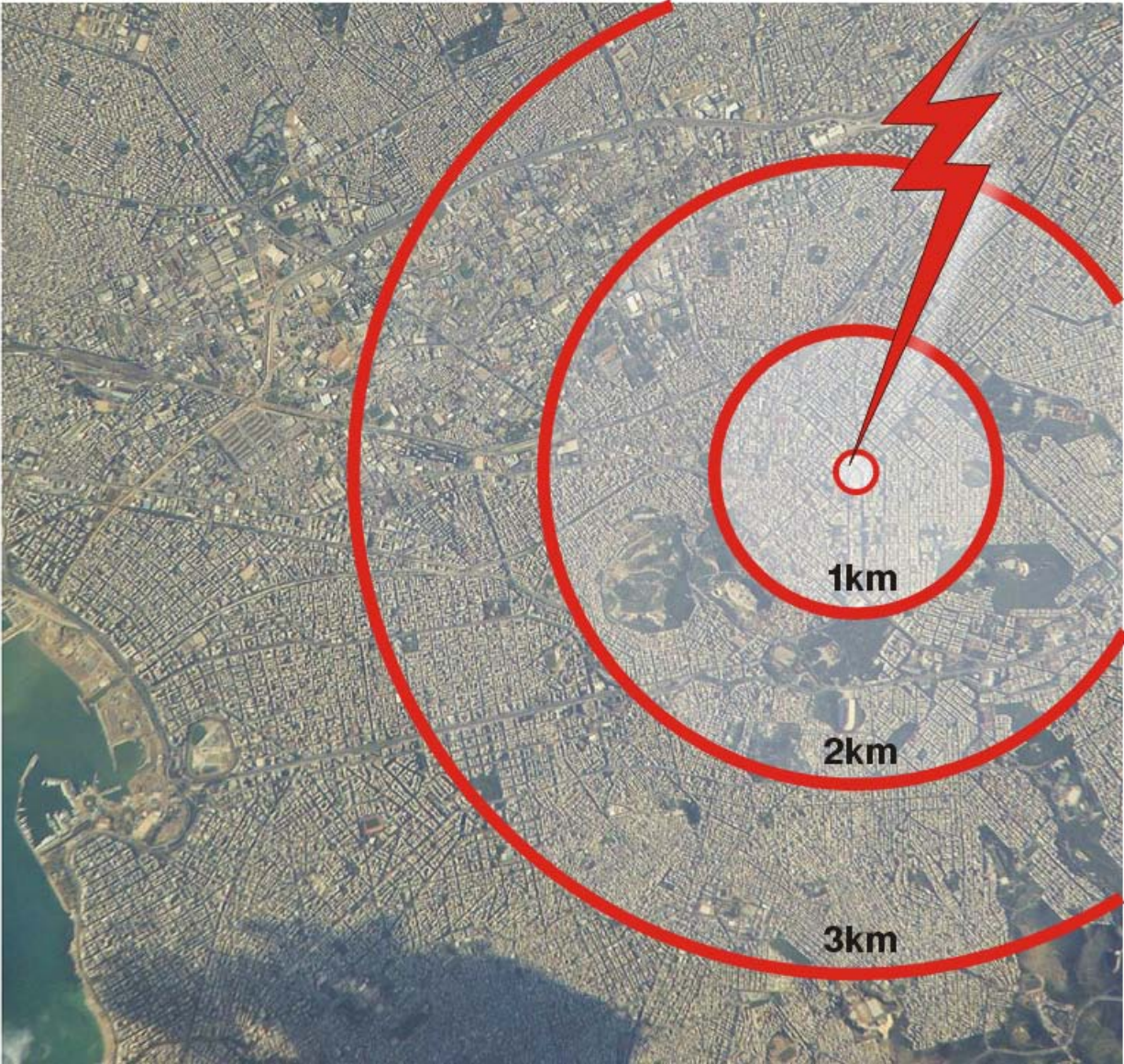


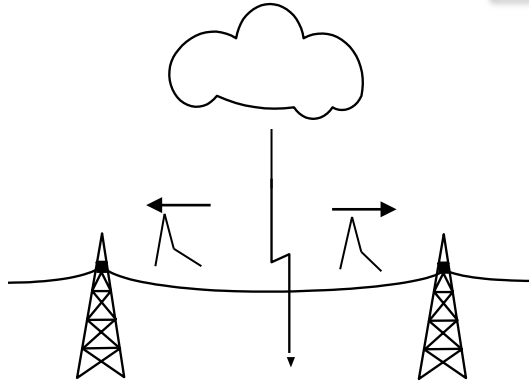
Figure 2: Lightning ground-flash density during the years 1985-1999 (N_g =flashes/km² year)

Range of Inductive Lightning Effect



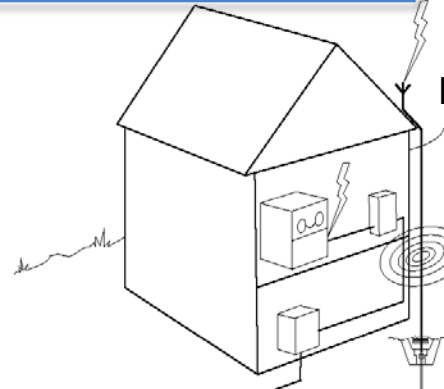
Lighting Effect

Inductive



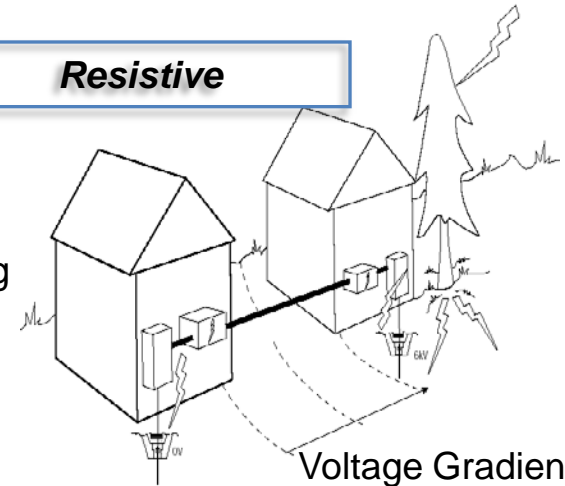
Direct Strike -> IMPROBABLE

Lightning rod

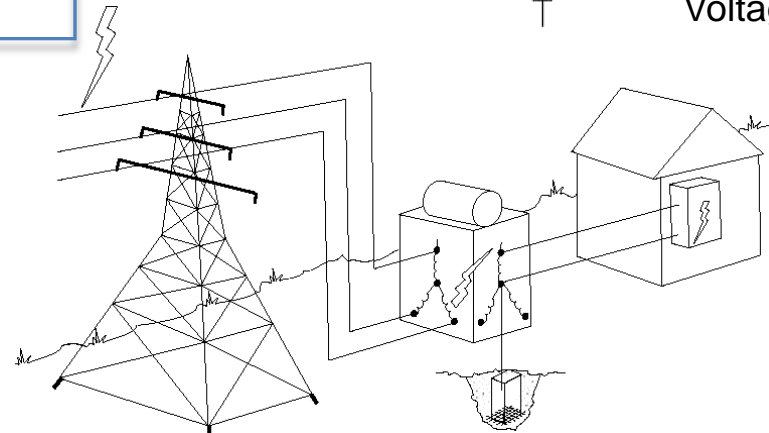
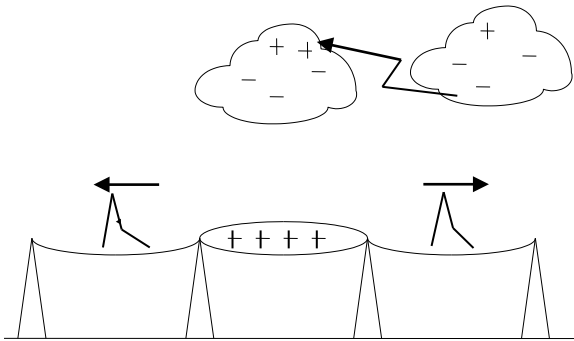


Resistive

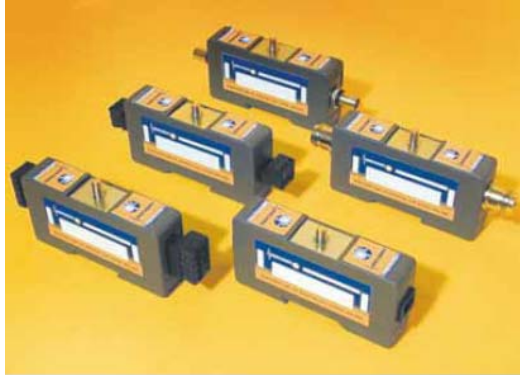
Grounding



Capacitive Coupling



Surge suppressors, Low Voltage and Signalization



AVAILABLE TECHNOLOGIES – Sparkers – Gas Discharge Tubes GDT

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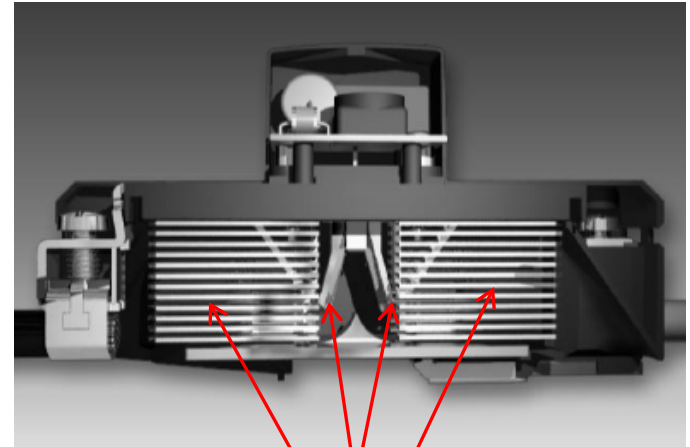
- Two electrodes in a low pressure controlled atmosphere.
- One electrode connected to phase, the other to ground.
- The overvoltage initiates a “spark”.

ADVANTAGES

- Simple design.
- High energy capacity.

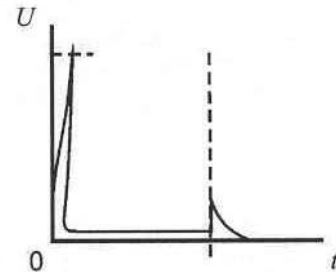
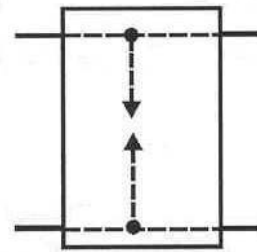
DISADVANTAGES

- A voltage spark (in the range of 4kV) passes through before sparking is activated.
- Electrodes may degrade and change the device characteristics without any indication.



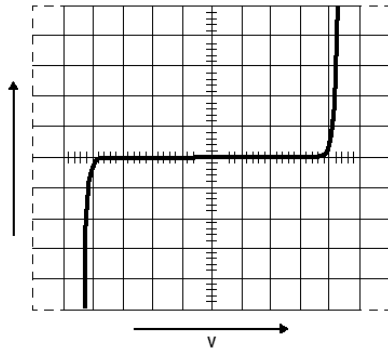
ΗΛΕΚΤΡΟΔΙΑ

ΨΗΚΤΡΕΣ

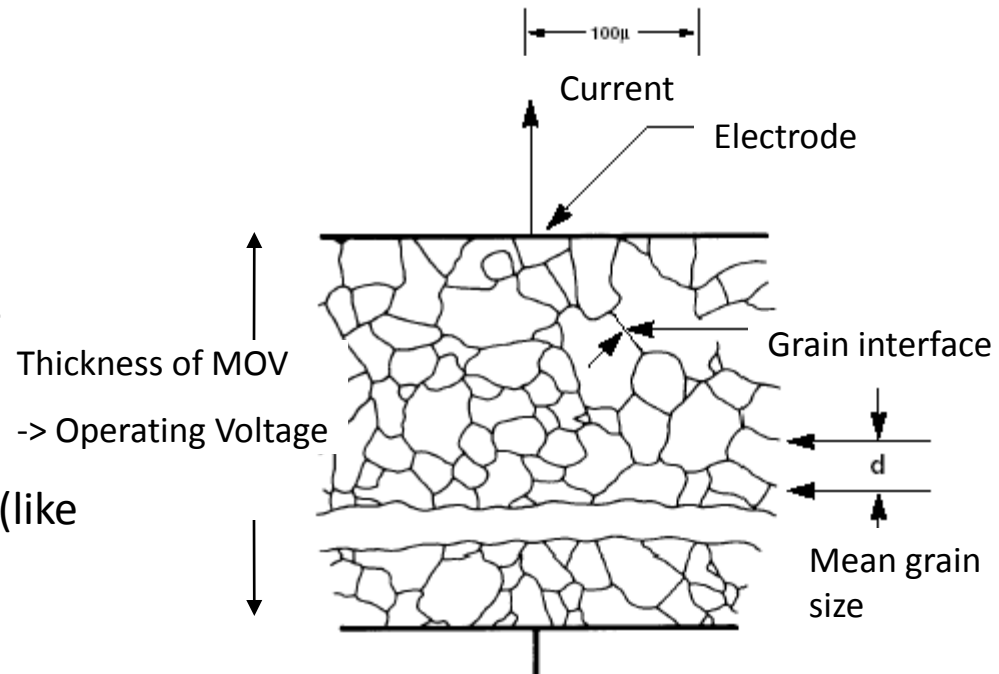
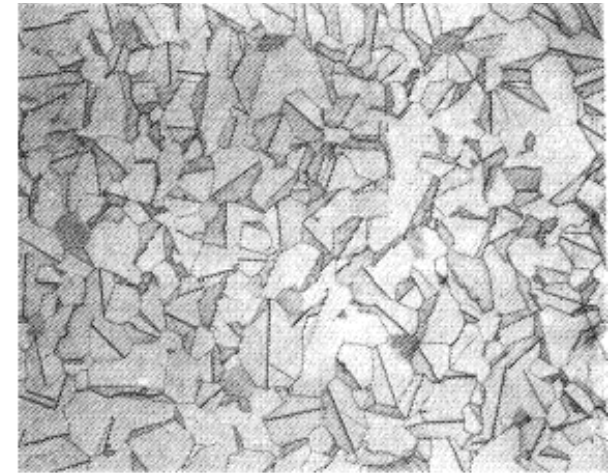


TECHNOLOGY - Metal Oxide Varistors (MOVs)

- These are semi conductive devices consisting of sintered ZnO powder with additives (like binders etc)
- Each ZnO grain interface acts like a diode.
- They have a non linear V-I behavior.



- When they are in a conductive state a voltage drop is developed between their ends (Residual Voltage).
- They do not have any voltage increase before reverting to the conductive state (like sparkers).



Description

- A semi conductive device that “locks” voltage to a predetermined level.

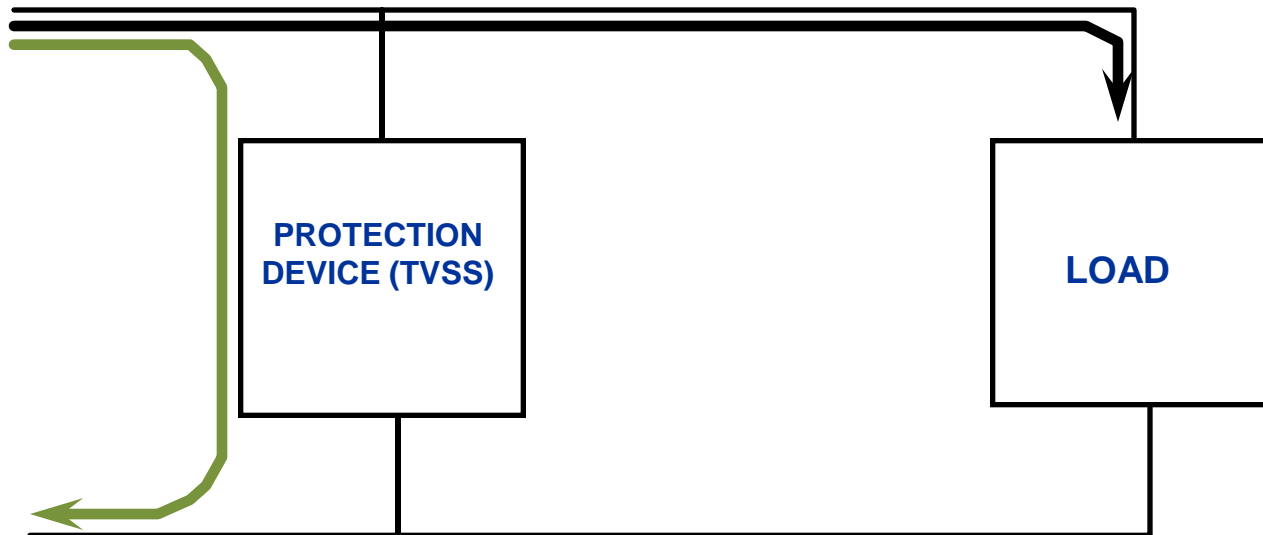
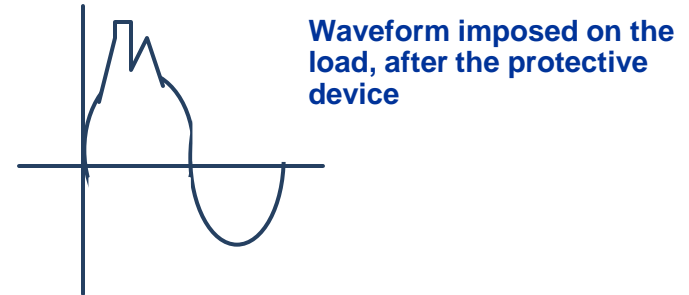
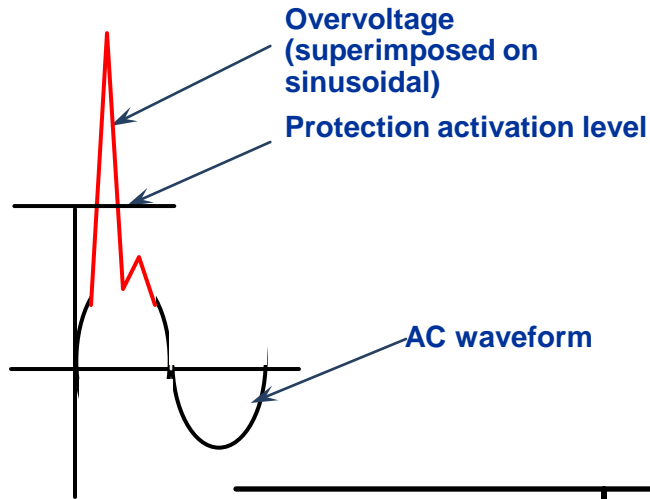
Advantages

- High energy handling.
- Fast response (in the range of 10ns).
- No voltage spike before activation (like sparkers)
- Low cost.

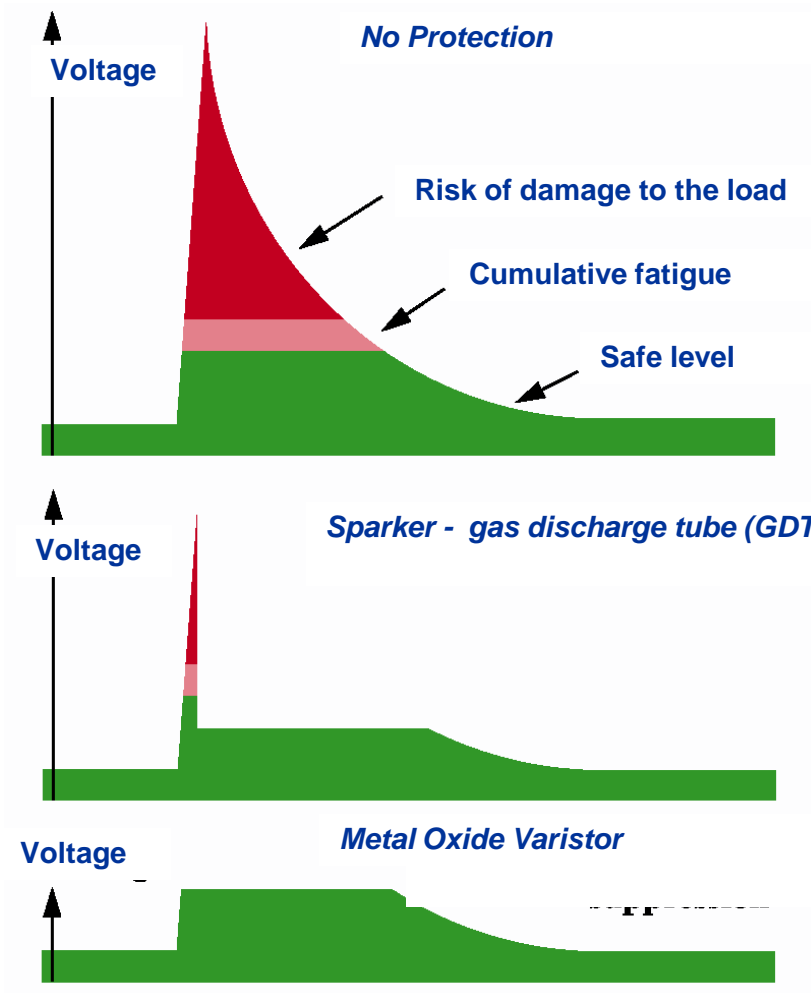
Disadvantages

- Characteristics may be altered after successive strikes
 - (During aging leaking current increases and in case of failure resistance is practically zero. It is easy to take them out of the circuit with a simple in-line fuse and provide signalization)..
- Higher resistance (and residual voltage) compared to Silicone Avalanche Diodes (SADs)

OPERATION - Metal Oxide Varistors (MOVs)



TECHNOLOGY COMPARISON Metal Oxide Varistors (MOVs) - GDTs



Silicon Avalanche Diodes – SADs

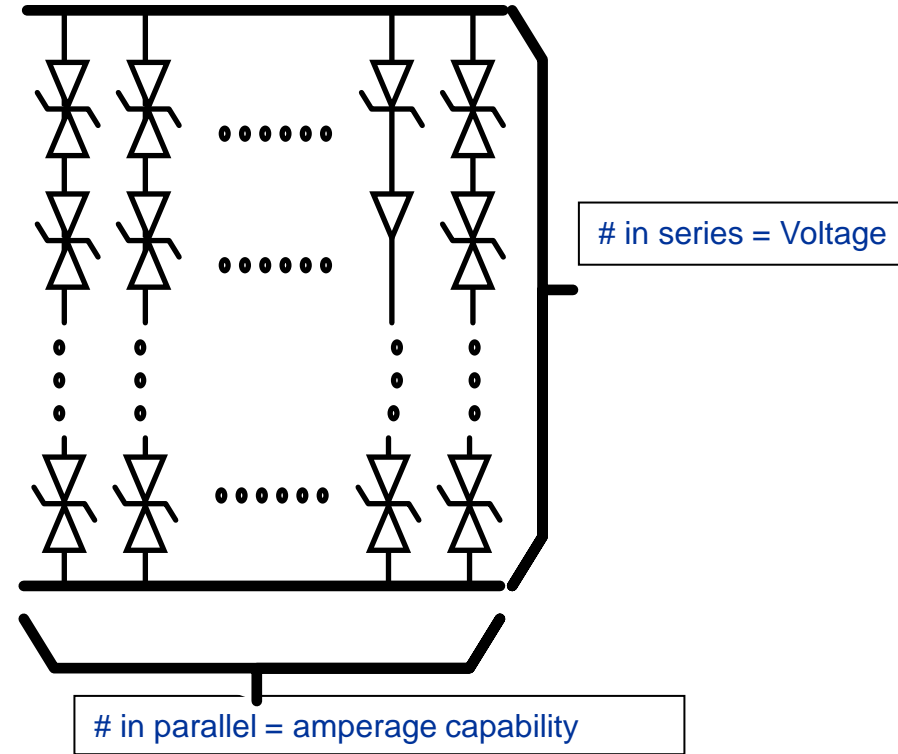
- P-N semiconductors that “lock” the voltage to a predetermined level.

ADVANTAGES

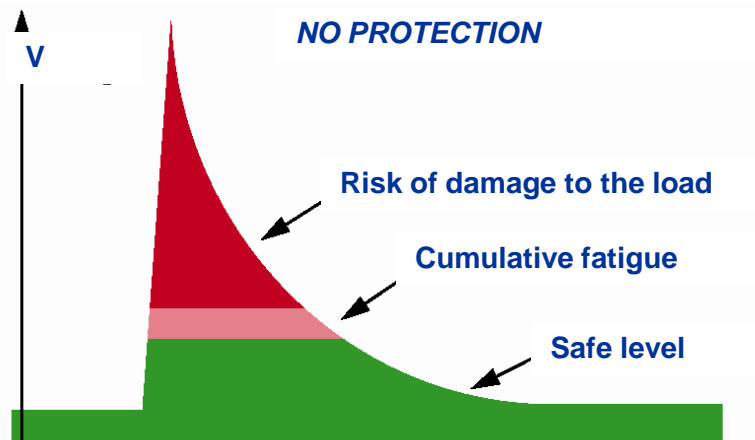
- High speed (respond in about 5ns).
- Low residual voltage.
- Low degradation with time - usage.

DISADVANTAGES

- High cost per carried Joule.
- Low unit power capacity + low unit activation voltage = need for matrix of series / parallel diodes. Surge current distribution can not be equal between branches – risk of overloading some components.

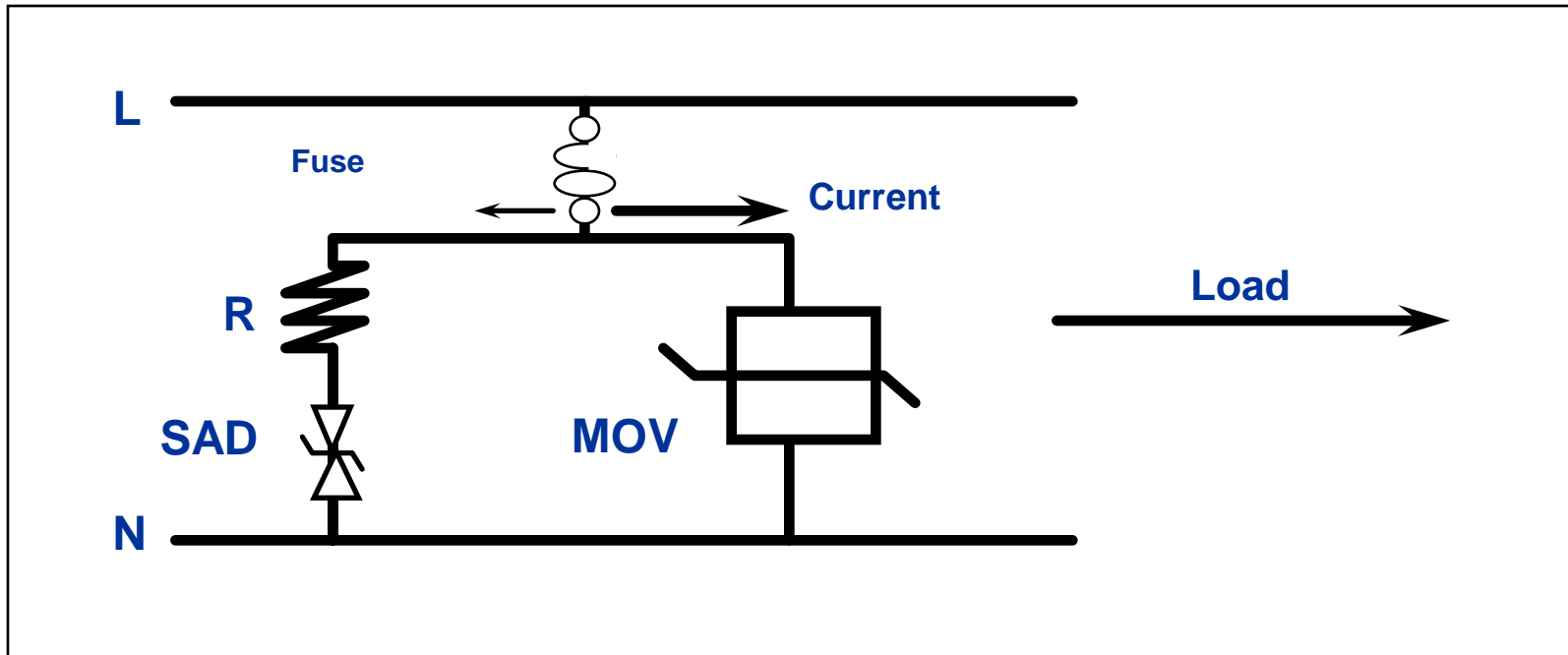


TECHNOLOGY COMPARISON MOVs – GDTs - SADs



HYBRID TECHNOLOGY (MOVs + SADs)

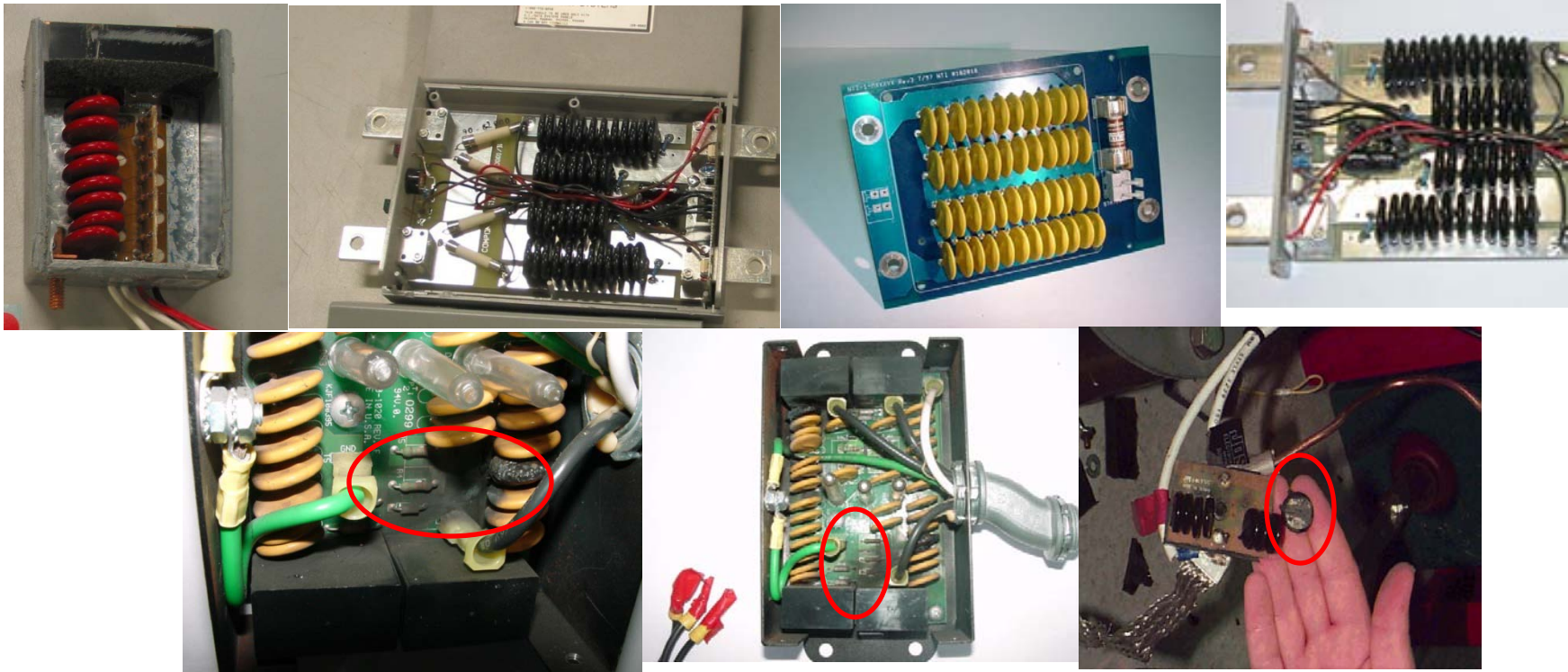
- Used mainly in telecom and signalization applications
- Combine the advantages of two technologies
- The “decoupling element” (R) makes the MOV to activate first and carry to the ground most of surge current.
- SADs will limit the residual voltage even further.



Comparison to competition devices

MULTIPLE Metal Oxide Varistors in PARALLEL

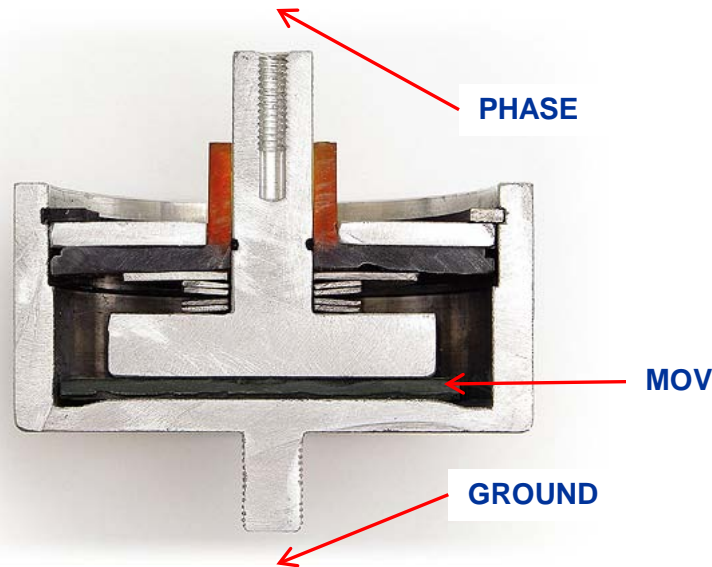
- Low capacity (and cost) in the range of 15-20mm Φ are utilized.
- In order to achieve a high surge rating many MOVs are connected in parallel.
- Fused all together or in groups.
- It is impossible to distribute evenly a surge current between parallel MOVs. Slight variances in characteristics or copper traces / cabling will overcharge some elements that will fail first.
- The result is a “domino effect” with more elements breaking down until the device is completely out of order



Comparison to competition devices

SINGLE Metal Oxide Varistor disk, NO INTERNAL FUSES

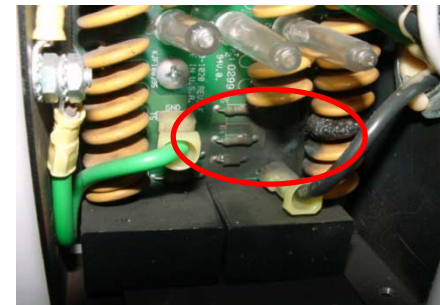
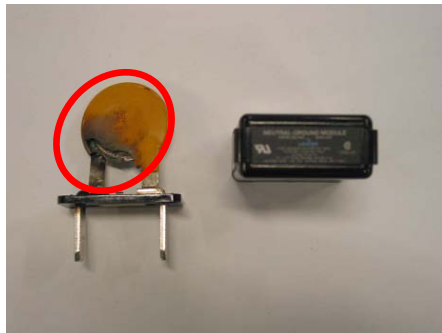
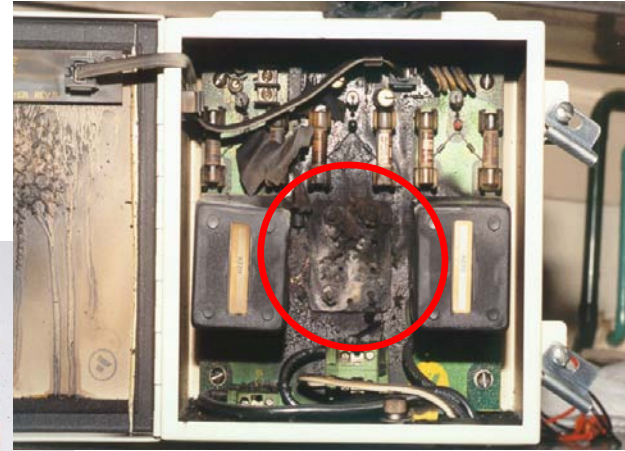
- In case of failure a phase to earth short circuit results in the activation of service entrance fuses, cutting the power to the whole plant. An alternative power source (generator ...) is a prerequisite.
- Surge carrying capacity may deteriorate with time, without any indication



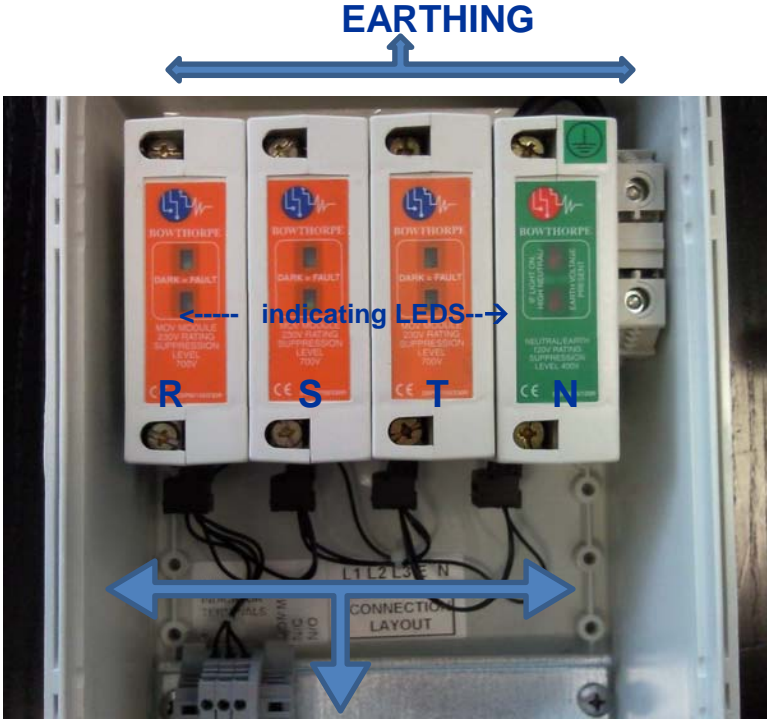
Comparison to competition devices

ALL TYPES OF SURGE PROTECTION DEVICES WILL ... EVENTUALLY FAIL

- Best choice with technical / financial criteria:
 - Safe failure mode
 - Specifications - Cost
 - Ease of installation
 - Ease of maintenance - replacement...

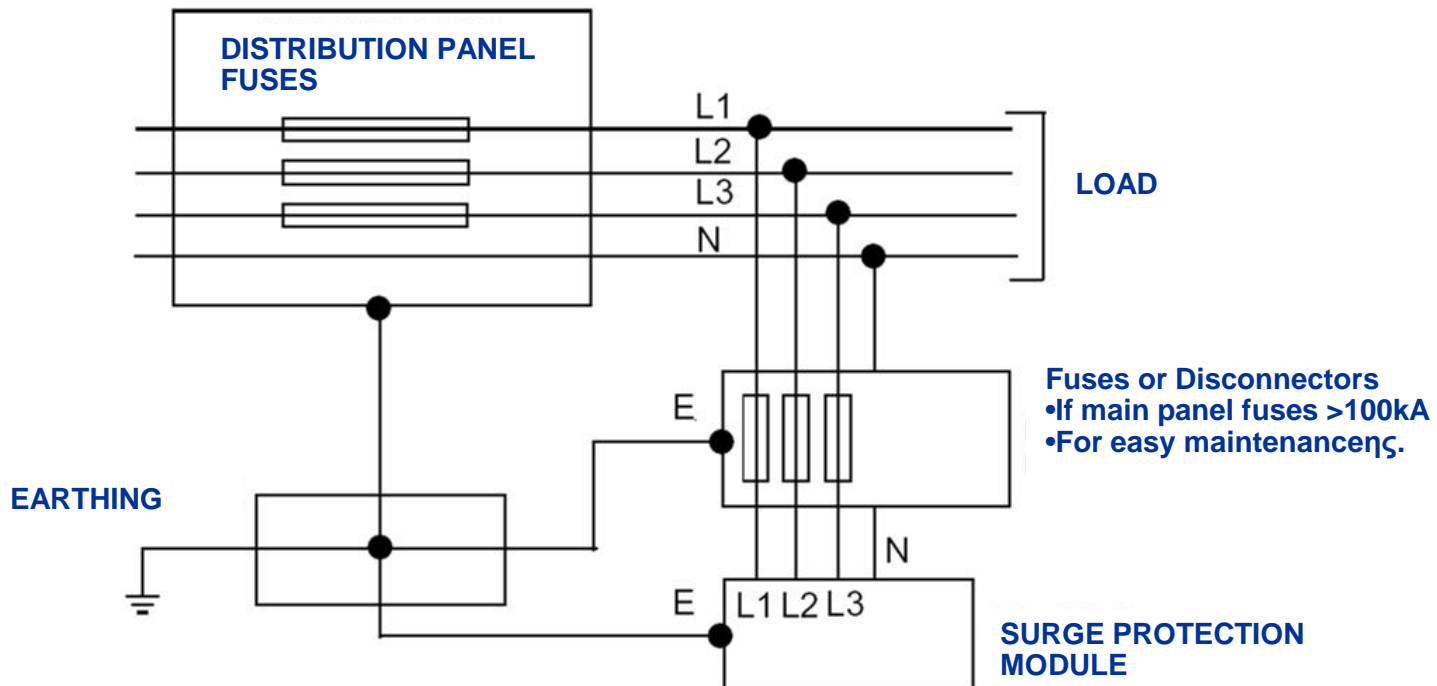


ENIA's PROPOSAL – MDSP-150

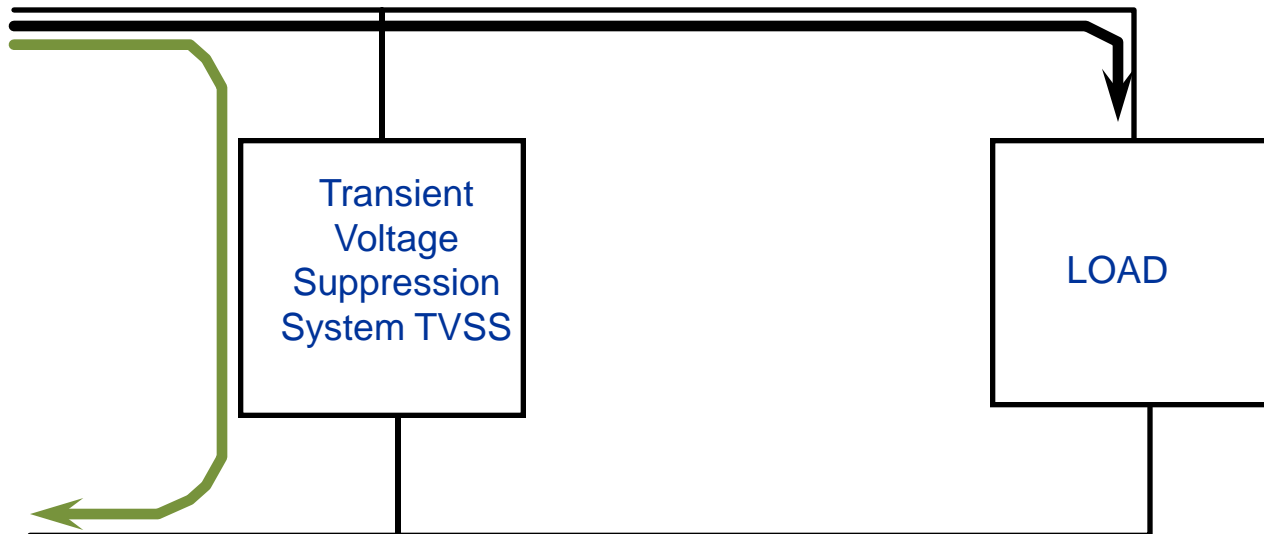
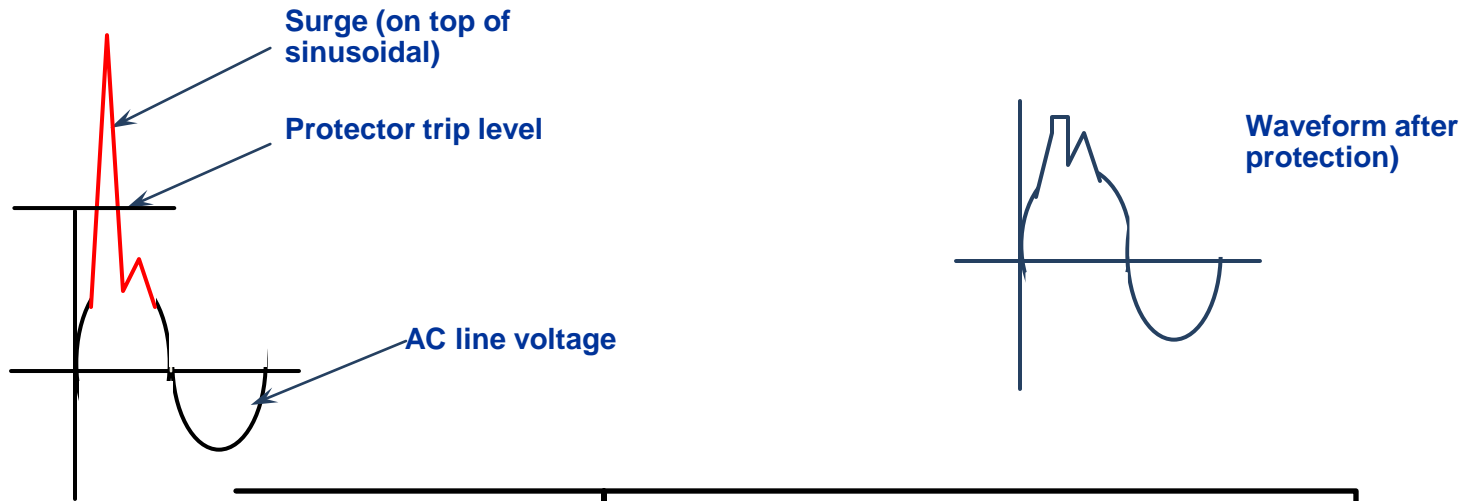


REMOTE SIGNALING

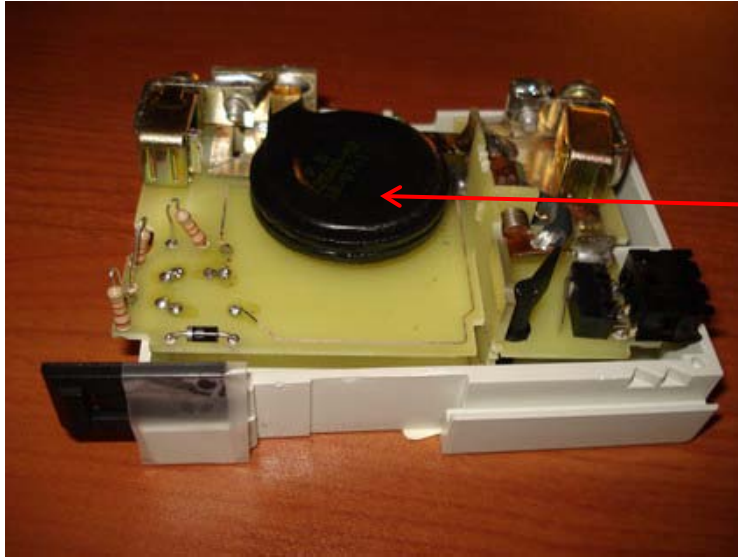
Should be installed at the service entrance panel



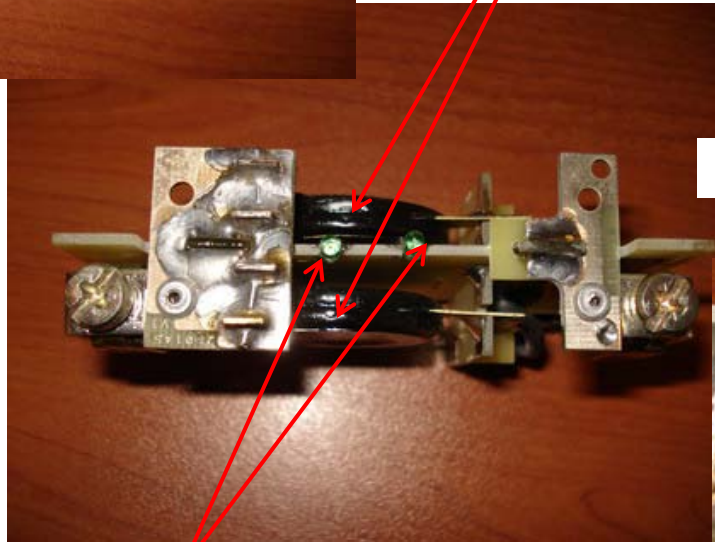
Operating principle



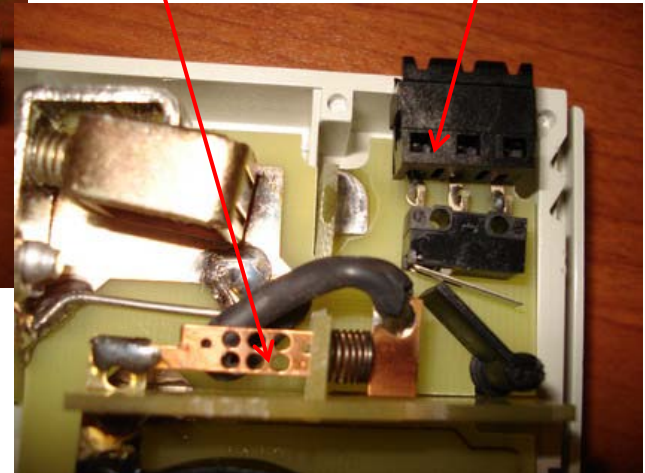
ENIA's PROPOSAL – MDSP-150 Protection Module



VARISTORS



STATUS INDICATING LEDs



FUSE

SIGNALING SYSTEM

ENIA's proposal – MDSP-150 Characteristics



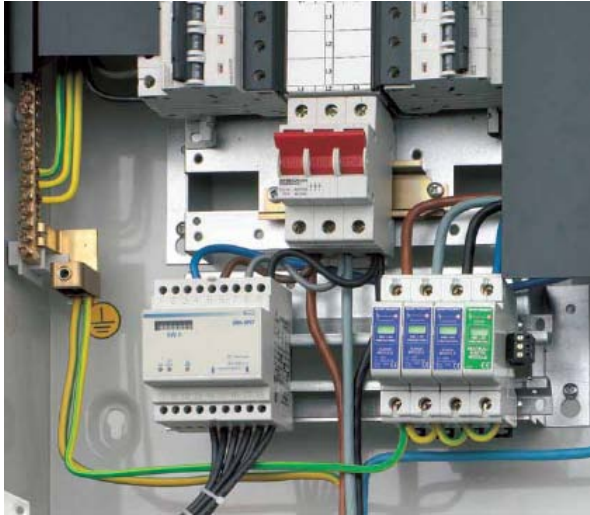
- Each protection module has two pairs of high capacity varistors ($\Phi 40\text{mm}$).
- Each varistor pairs has a “sandwich” configuration. Surge current is equally distributed between the two varistors. There is no cabling or copper traces between them.
- If one of these two varistor pairs is impaired.
 - There is an optical indication (LED).
 - The switch over contact of remote status indication is tripped.
- Power supply to the load *IS NOT* interrupted.
- The second pair of varistors remains in operation (redundant design). The module remains operational and protects the load (at 50% of original capacity) until the protection is replaced by a new one.
- Replacement of every protection is easy as they are mounted on DIN rail and the cabling is easily accessible.
- Protection modules provided are: 3Ph-G, N-G.
 - Additional 3Ph-N elements offer by some competitors are unnecessary as
 - They are equivalent to Ph-G + G-N.
 - Neutral conductor is generally grounded at service entrance.
- Protection modules are pre-installed inside plastic flame retardant boxes with an IP67 degree of protection.
 - Metal boxes are prone to corrosion, particularly in marine environments. The situation is getting much worse if minor damages are made to the paint during transportation or installation.
 - Typically metal boxes, provided by competition, are IP65 (or NEMA-4). Water tightness is much worse.
- The protection elements are mounted on DIN rails. It is impossible to get accidentally in contact with live metal parts (and replacement is greatly facilitated)
 - In many surge protection devices of the competition, once the box is opened there are live bare conductors. This increases the risks of accidents.

ENIA's proposal – MDSP-150 Specifications

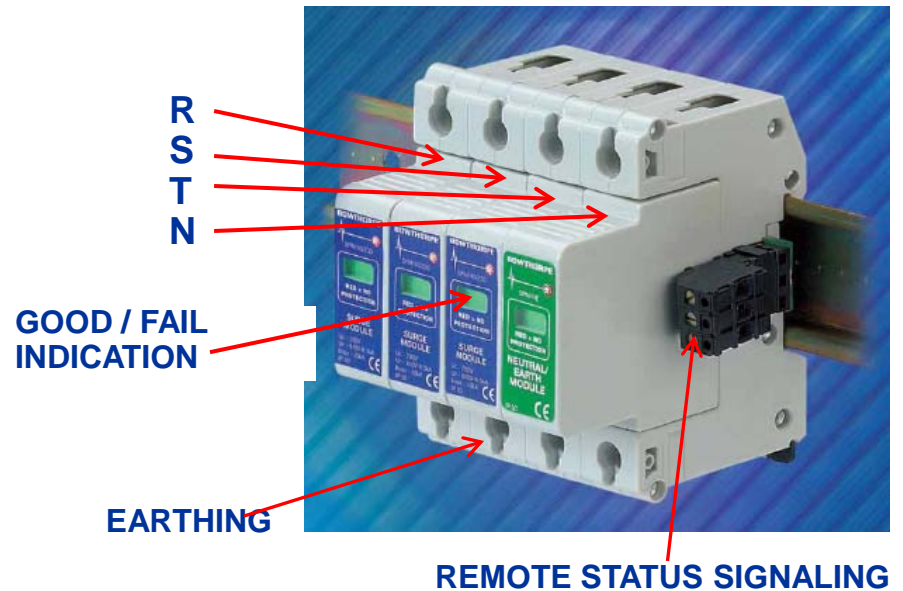
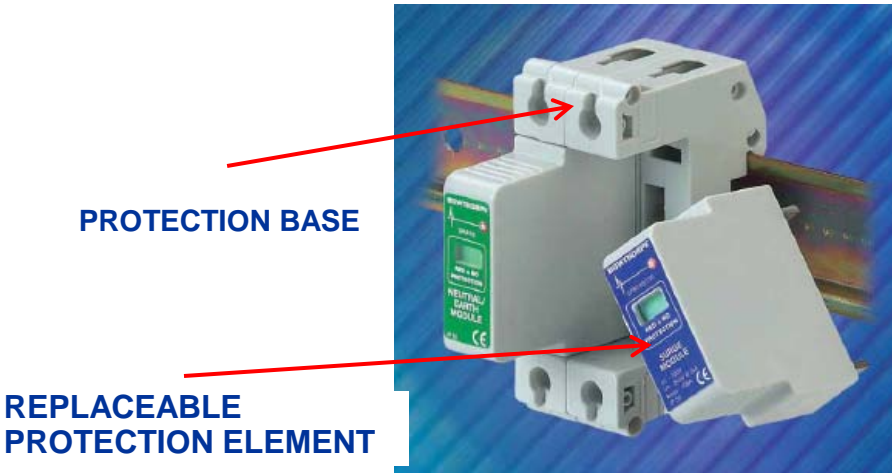


- Can be connected to a distribution panel with 100A fuses 35mm² cabling (This covers the great majority of applications)
 - For panels fused at >100A or for ease of maintenance, in line fuses or disconnectors rated at 100A should be installed.
 - The rating of each protection module is 150kA (8/20μs) via Ph-G & N-G. This covers the most severe surges generated by lightning strikes.
- Certified according to:
 - UL 1449 2nd Ed.
 - IEC 61643 -11 Class II
 - BS 6651 Annex C
 - IEEEC62.41
- Residual voltage 600V @ 5KA – 8/20μs.
- Response time <10ns.
- Operating conditions -40°C - +70°C
- Optical indication:
 - Elements Ph-G, 2 green LEDs ON: Protection at 100%
 - Elements Ph-G, 1 green LED ON: Protection at 50%
 - Elements Ph-G, LEDs OFF: Protection is disconnected
 - Elements N-G, 2 red LEDs OFF: Normal operation
 - Elements N-G, 2 red LEDs either one ON: Problem with neutral (neutral voltage above safe levels) – This feature is generally NOT provided by competition.
- Remote signaling : Free voltage switch-over contact

Rail mounted protections 40 kA (SPM)



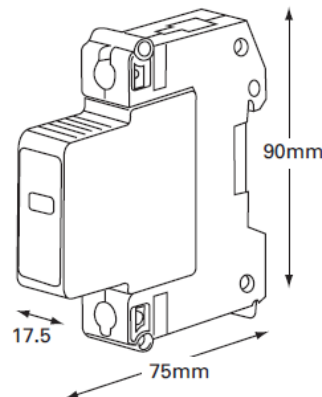
Can be installed in secondary distribution panels or at low risk or small main panels.



Rail mounted protections 40 kA (SPM) Characteristics

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- Varistor technology (also available with SAD protection modules).
- Includes disconnection device that takes the protection module out of the circuit if its function is impeded. This prevents the tripping of main panel fuses or disconnectors and power cut-out to the load.
- Each element has a visual indication of good operation.
- Remote indication of good operation is optionally provided by a switch over voltage free contact.
- Protection modules for Ph-G & N-G
- Each protection module consists of a DIN rail mounted base and a plug-in protection module.
- It is not possible to plug a Ph-G protection module on a N-G protection position (base) and viceversa..
- Protection modules may be safely replaced under tension and without interruption of service..
- Their size is equal to a rail mounted fuse/disconnector. May be easily installed to existing distribution panels if some small space is free.



Rail mounted protections 40 kA (SPM) Specifications

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- May be installed inside a distribution panel with 65A and 35mm² cabling.
- The rating of each protection module is 40kA (8/20μs) for Ph-G & N-G.
- Certified per:
 - IEC 61643 -11 Class II
 - BS 6651 Annex C
- Residual voltage < 1kV @ 5KA – 8/20μs.
- Response time <10ns.
- Operating conditions -40°C - +70°C
- Status indication:
 - Elements Ph-G & N-G Green visual indication: Protection at 100%
 - Elements Ph-G & N-G Red visual indication : Need replacement
- Remote signaling : Free voltage switch-over contact

Protections for Telecom, Data and Signalization lines



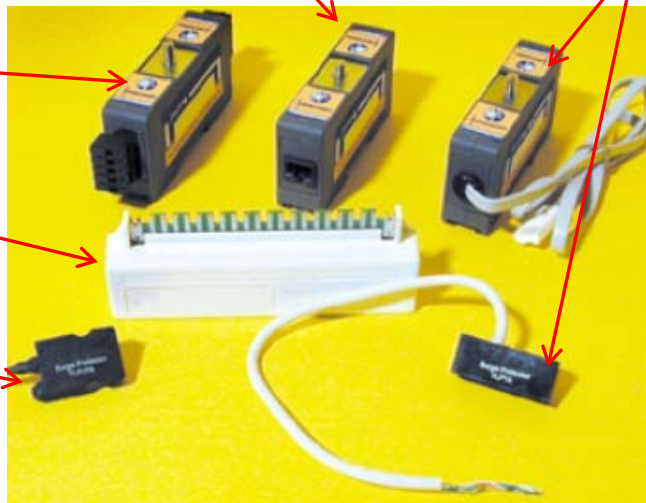
Single pairRJ11

Single pair - precabled

Two pairs, rail mounted

Ten pairs for LSA+ modules

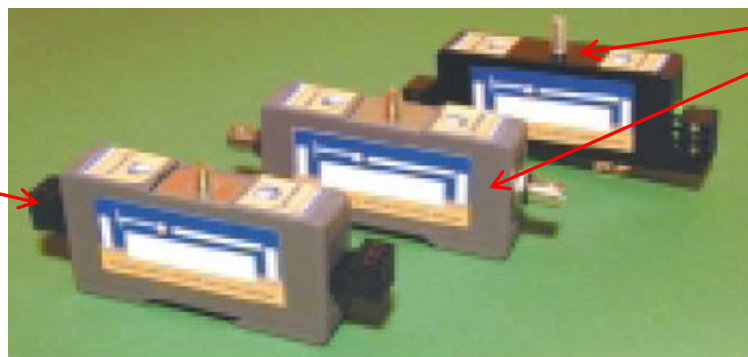
Plug-in single pair



10kA SURGE CAPACITY

CCTV & Video

RS422



LOW VOLTAGE SURGE SUPPRESSORS - *SECONDARY OF TRANSFORMER*



- Suitable for indoors & outdoors applications.
- Continuous operating voltage 440V.
- Varistor technology.
- Compatible to IEC 61643-1 (Class II)
 - Nominal discharge current I_n : 10kA (Complete duty test trial).
 - Max discharge current I_{max} : 40kA.
- RESIDUAL VOLTAGE
 - 1.26KV 1KA
 - 1.32KV 2KA
 - 1.44KV 5KA
 - 1.60KV 10KA
 - 1.79KV 20KA
- Clear failure indication



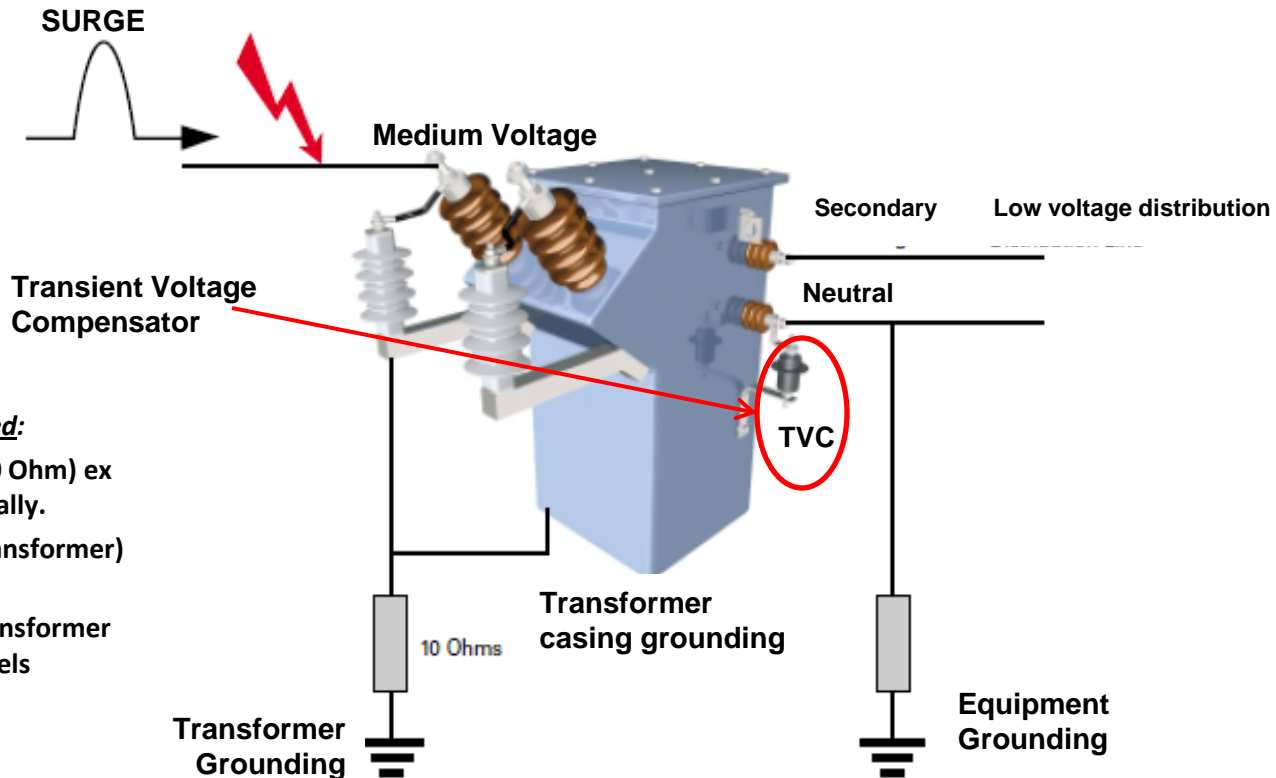
Normal operation



Needs replacement

TRANSIENT VOLTAGE COMPENSATOR TVC - TRANSFORMER SECONDARY - N->G

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Where TVC surge suppressor is recommended:

- When transformer grounding is poor (>10 Ohm) ex rocky ground, dry sand and varies seasonally.
- When equipment grounding (after the transformer) is lower than the transformer grounding .
- This protection is ADDITIONAL to MW transformer input protections and LV distribution panels protection.

LV surge suppressors - Other applications

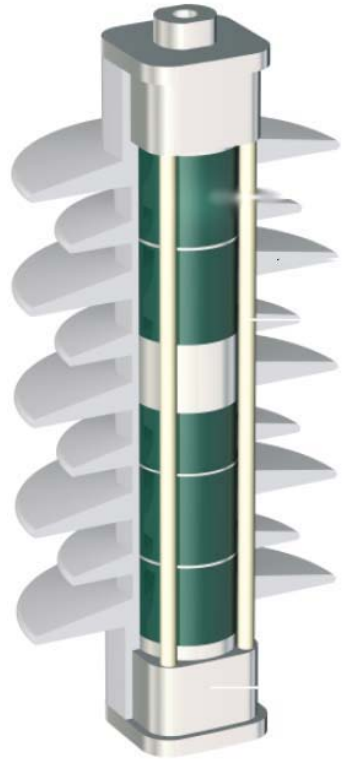
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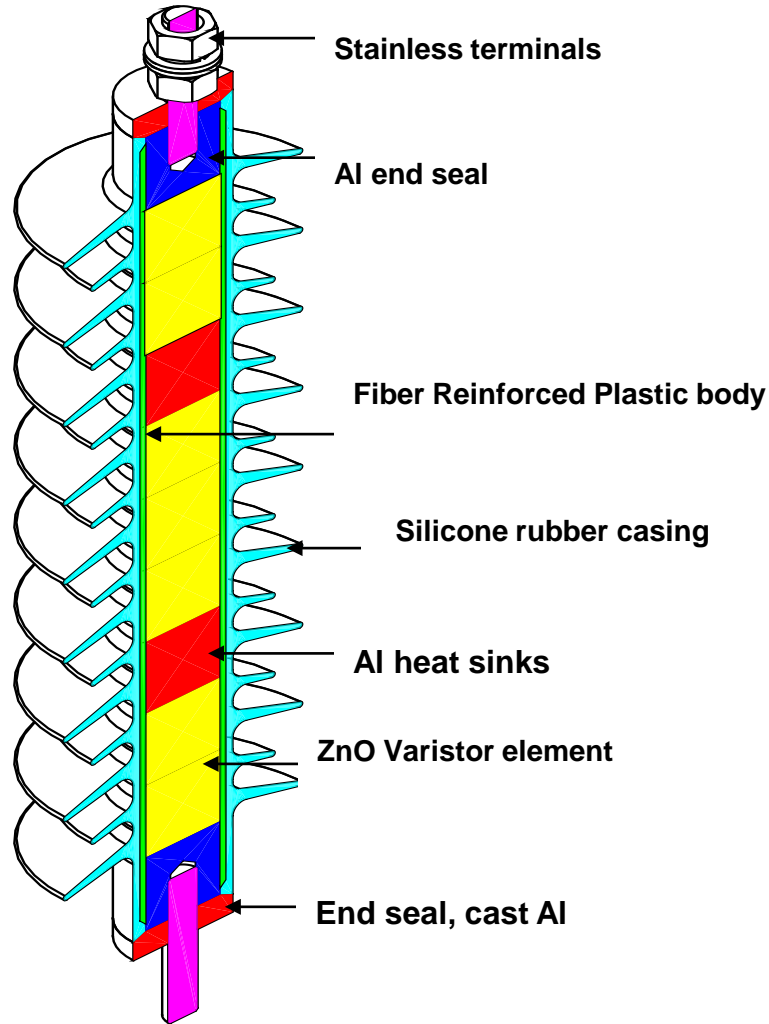
OVERHEAD POWER NETWORKS



Medium Voltage Protections - Transformer's primary - (OCP2)



Medium Voltage Protections (OCP2)- Design



Low weight element

Medium Voltage Protections (OCP2)- Design



Self cleaning,
hydrophobic surface.
Inhibits the
accumulation of
conductive dirt
causing current
creepage and damage
of insulation



Safe fail mode. The
plastic casing is split,
no dangerous
splinters are emitted
(as is the case of
porcelain
insulations).

Are connected in-line to the ground connection of the protection module.

Number of surges the have safely been grounded



Ground leak current



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