Control Panel Technical Guide

How to prevent machine malfunctions and electronic damage due to voltage surges?
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Machines face surges every day. In case of failure, is the right diagnostic always done?

Surges are hardly observable, they have multiple consequences on machines and process. Some are serious with risks of injury, others are only material. In many cases the users have difficulties to investigate the causes.

Some relevant situations...

Unexpected stops
- Stops of ventilation, elevator, lighting causing risks for people.
- Stops of other equipments causing overheating, overcooling, flooding with damage to the installation, the building.
- Stops on machines causing production loss, etc.

Strange behavior
The appropriate machine controls are sometimes unpredictable causing erratic information on alphanumeric display, engine runaway with mechanical breakdown as worse consequences.

Electrical and electronic breakdown
- Electronic devices are usually sensitive to surges conducted by supply lines, sensors and communication lines.
- Overvoltage can destroy electronic components or cause flashes between tracks of printed circuits.
- In some situation destruction can degenerate into a fire.
Machines face surges every day. In case of failure, is the right diagnostic always done?

They are invisible and transient: surges cause malfunctions and damages.

Their difference is a matter of energy.

**Atmospheric surges**

In a surge due to a lightning, the **energy is great.**

It is sufficient to destroy electronic components, even vaporize conductors.

Example: Damage on a modem motherboard due to atmospheric surge carried by the telecom line.

**Industrial surges**

> They are caused by:
> - capacitor banks switching, contactor coils or other inductive loads switching
> - motor drives.

> Their consequences:
> - superposition of noise on analog signals that generate false indications (eg wrong temperature)
> - data change in memories
> - lower transmission speed due to repetitions
> - system reset, etc.

The energy coming from industrial surges is lower but still a cause of nuisance.
How atmospheric surges are generated?

A lightning stroke can fall near a building. The earth potential around the point of impact rises dangerously.

A lightning stroke can fall in the vicinity of an electric power line: it is the electromagnetic radiation of the lightning current that produces a high current and an overvoltage on the electric power network.

Direct impact of the lightning stroke on the building

In all cases the overcurrent will flow from the power or telecom line to earth or in the reverse way, depending on which conductor is affected by the lightning stroke.

Where should the protection be installed?

The protection of the equipments against surge can be either:

- **collective**, in main and distant distribution boards
- **individual**, in each machine control panels.

Lightning rod?
It only provides protection to the building against fire by forcing the overcurrent to flow to earth via a safe conductor. Reinforced surge protection on the electrical distribution is strongly recommended.
How industrial surges are generated?

- High inrush currents, during capacitor switching.
- High overvoltages, during simultaneous activation of multiple contactor coils.

Harmonics, generated by variable speed drives.

Where should the protection be installed?

Reduction of perturbations by:
- specific contactors for capacitors with built-in damper resistors
- coils filters for contactors.

Protection by SPD in special upstream Canalis tap-off or in the control panels.

Inductor/capacitor filters reduce the harmonic distortion caused by some speed drives on the power line.
The Surge Protection Devices (SPD)
What does an SPD look like?

Cartridge technology
The SPD is composed of a varistor or a gas tube.

Varistor: its resistance decreases when the voltage increases.

Gas tube: a conductive arc appears between electrodes above a certain voltage.

How does an SPD work?

The SPD acts as a valve:
• It is closed (high impedance) when the voltage is normal (U = Un).
• It is opened (conductive) in case of surge.

What happens when the main voltage exceeds the “maximum permanent voltage” (Uc of SPD)?

The surge current is derivated directly to earth thus the surge voltage is dropped to a non-destructive value for the electrical installation which is cabled in parallel.

After a certain number of shocks depending on their intensity, the varistor will be short-circuit ed and need to be replaced. The information is usually given by a mechanical indicator.

A disconnector is a dedicated circuit breaker which isolates the SPD circuit when the varistor cartridge has come to its end of life or during maintenance.

• Cartridge-type SPD:
They have their varistors incorporated into pluggable cartridges for easier maintenance.

• Combi-SPD technology:
The built-in circuit-breaker (disconnector) automatically isolates to the SPD when its cartridges need replacement. Thus, the disconnector offers continuity of service to the rest of the installation.

Zoom on:
Combi Quick’PRD 3P+N Cartridge-type PRD 3P+N
Surge Protection Devices applications
Implementation

The SPD and its disconnector are connected between the incoming circuit breaker (usually to the distribution block) and the earth terminal block. As the voltage surge will be limited between these 2 points, the machine circuits will be protected.

Expert's tip

The impedance of the disconnector + SPD circuit must be as low as possible. Cable liaisons must be as short as possible to ensure the lowest residual surge voltage during the current flow. 50 cm of cable per phase ensure a residual voltage ≤ 500 V. Which is acceptable.

AC SPD types according to the risk

- Very exposed area or building equipped with a lighting-rod (even in the case of an underground power line).
  - **Very strong risk**
    - Type 1
    - SPD Type 1 / 1+2
    - Preferably install SPD in the main distribution board.
  - Type 1+2
- Building with totally or partially overhead power line.
  - **Common risk**
    - Type 2
    - SPD Type 2
    - Alone or as a complement of a SPD type 1. Install SPD in main distribution board or remote panel board.
- Against self re-generated residual surges which appear over 20-30 meters of a cable connected to an already protected panel board.
  - **Very strong & common risk**
    - Type 3
    - SPD Type 3
    - As a complement of a SPD Type 1+2 or Type 2. To be placed close to the load to be protected.

 SPD disconnector

It is chosen in the range prescribed by the SPD manufacturer in order to ensure its electrical coordination with the known or presumed upstream protection. Thus, main tripping during lightning will be avoid.

Thanks to Combi SPD technology the choice of a separate disconnector is no longer needed.
Focus on...

Cabling rules of AC SPD in a machine control panel

Example in a:
Pragma plastic enclosure

Example in a:
Prisma Plus metallic enclosure

The metallic chassis is used as a conductor
Connect the cable with a lock washer to ensure a perfect contact.
This solution is only possible with enclosures complying to the IEC 60439-1 standard.

L1 (longest L cable) ≈ 12 cm
L2 (internal liaison) ≈ 0 cm
L3 (SPD earth cable) ≈ 5 cm
L1 + L2 + L3 < 50 cm

The Surge Protection Devices for AC applications by Schneider Electric

- **Perfect electrical coordination** between the disconnector and the SPD.
- **Faster cabling**.
- **Safety** is preserved as the disconnector is tripped in case of faulty or missing cartridge.
- **Quick disconnection** of the SPD before dielectric test of the distribution or the control board.

QuickPRD 40r Combi technology offers better performances than traditional technology.
Very low voltage circuits

4 channels PRI SPD protecting the inputs of a controller:


2. 4 binary sensors with common polarity are protected by a 4 channels PRI SPD.

3. 2 analog sensors or data lines without common polarity are protected by a 4 channels PRI SPD.

**Expert's tip**
Place the SPD in the control panel board, close from the sensor terminal block.
Selection guides
To select:

The SPD according to circuit voltage

**AC Power**

<table>
<thead>
<tr>
<th>Type 1+2 (+ disconnector)</th>
<th>Type 2</th>
<th>Type 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>High risk, for single machine in an Isolated and exposed shelter (pump, wind turbine…).</td>
<td>Common risk, for machine protection.</td>
<td>For complementary machine protection when a global Type 1 or 2 protection is already provided by the electrical distribution.</td>
</tr>
<tr>
<td>Icc max: 10 kA</td>
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<thead>
<tr>
<th>C120N - 80 A</th>
<th>PRF1 12.5r</th>
<th>Quick PRD 20r</th>
<th>Common surge protection tap-off</th>
<th>Quick PRD 8r</th>
<th>Common surge protection tap-off</th>
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<tr>
<td>1P+N (ref. 16632) 3P (ref. 16633) 3P+N (ref. 16634)</td>
<td>1P+N (ref. 16295) 3P (ref. 16296) 3P+N (ref. 16297)</td>
<td>Canalis KN (ref. KNBQPRD) Canalis KS (ref. KSBQPRD)</td>
<td>1P+N (ref. 16298) 3P (ref. 16299) 3P+N (ref. 16300)</td>
<td>Canalis KN (ref. KNBQPF) Canalis KS (ref. KSBQPF)</td>
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**Very low voltage AC/DC**

Series SPD for supply, sensor or data cables running along high voltage conductors or outdoor.

- Max permanent voltage: 53 V DC – 37 V AC
- Max line current: 300 mA

**High voltage DC**

Series SPD for analog telecom line, ADSL compatible.

- Max permanent voltage: 180 V DC – 130 V AC

DC SPD for photovoltaic generator

- Max permanent voltage: 600 V DC for 16434 – 1000 V DC for 16436.

**Contactors and suppressors for attenuation of switching surge**

Contactors for capacitor banks

- LC1D.K series: 3 poles contactors for capacitor switching

The capacitors are commutated in 2 phases:

- **Phase 1**: auxiliary contacts closed, the damp resistors (resistive white cables) limit the inrush current.
- **Phase 2**: less than 1 second later, the main contacts are closed shorting the damp resistors. The full current flows.

Suppressor modules for contactor coils

- Contactor coil generates transients during commutation. They can be absorbed by a suppressor module connected in parallel.
- Several types of suppressors (RC, varistors, flywheel diodes) to choose according AC or DC voltage and acceptable increase of contactor drop-out time.

How to choose the appropriate SPD > [http://www.schneider-electric.com](http://www.schneider-electric.com)

Understanding the protection principles, designing protection systems > [http://www.electrical-installation.org/wiki/Protection_against_voltage_surges_in_LV](http://www.electrical-installation.org/wiki/Protection_against_voltage_surges_in_LV)