Transient protection for PV power electronics

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The need for transient protection

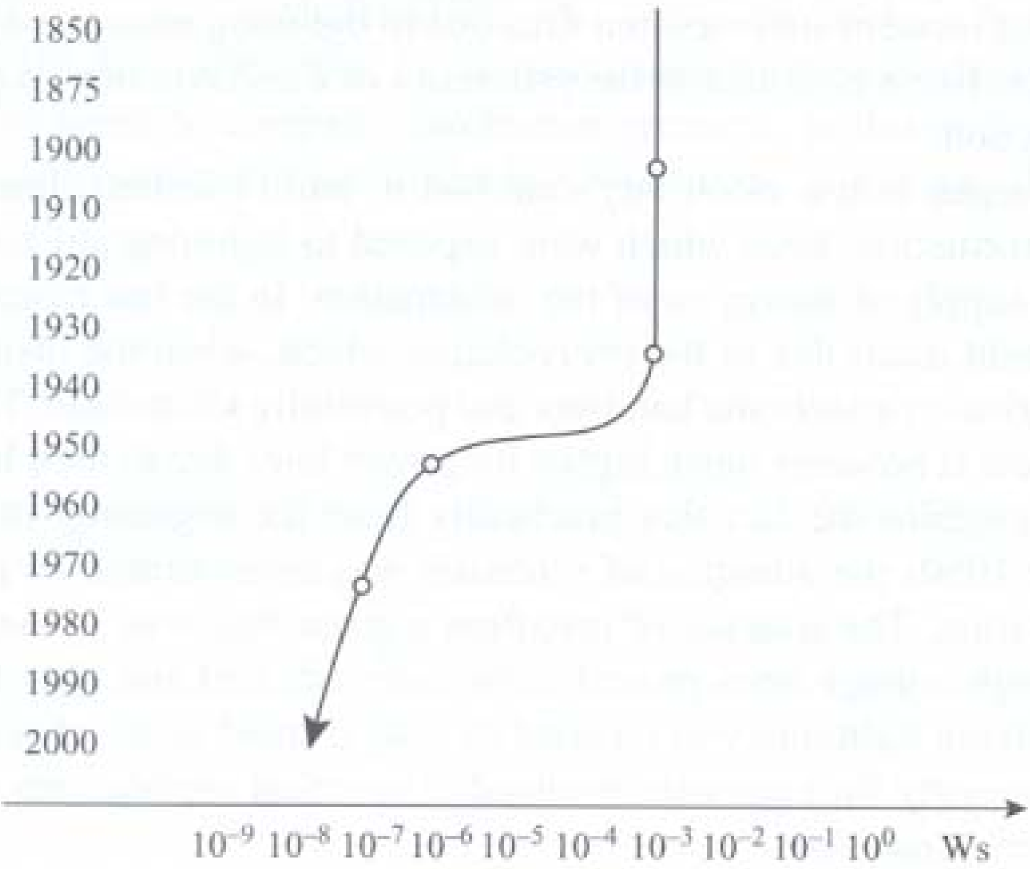

Figure 9.1 Change of the level of energy needed for the destruction of electric and electronic components

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The need for transient protection

Sources of transients

- ☒ Lightning
- ☒ Switching

Types of transients

- ☒ AC-side—fairly well quantified
- ☒ DC-side—

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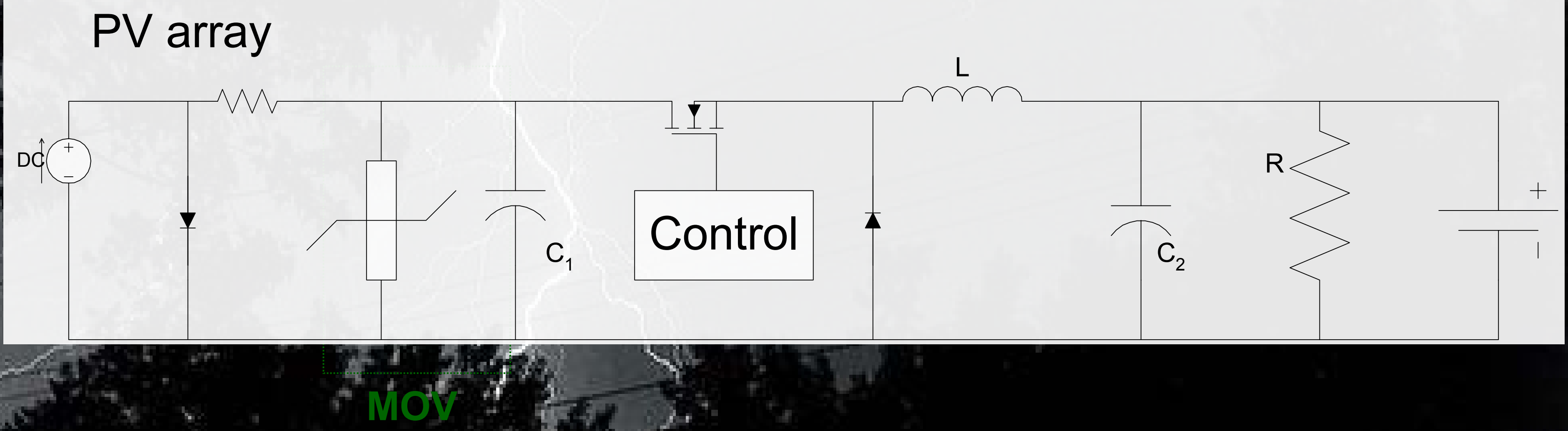
Transient suppression devices

Most TSDs are shunt elements that operate by presenting a high impedance to low voltages, but low impedances to high voltages.

The most common ones in use today operate on the same principle as zener diodes.



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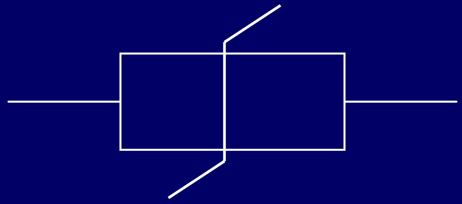
Transient suppression devices

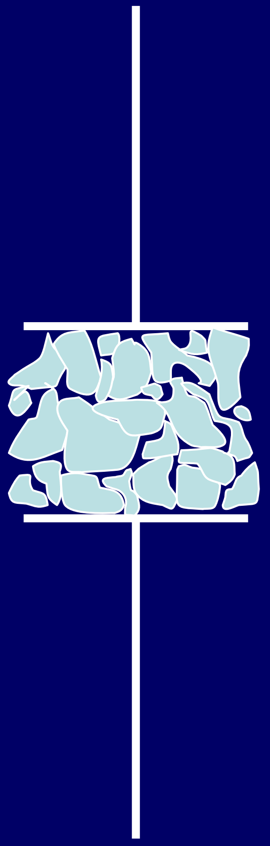
- ☑ Varistors
  - ✓ MOVs (most common TSD)
  - ✓ SOVs
- ☑ Silicon Avalanche Diodes (SADs) (”transorbs”)
- ☑ Ionizing gas tubes and spark gaps (very high voltage DC)
- ☑ Filters

Transient suppression devices

MOVs



- Generally the least expensive TSD option, and readily available from many manufacturers
- Consist of a matrix of metallic oxide (usually zinc oxide) or ceramic sandwiched between metal electrodes
- Grain boundaries in zinc oxide act as rectifying junctions, so the MOV is equivalent to an array of back-to-back diodes



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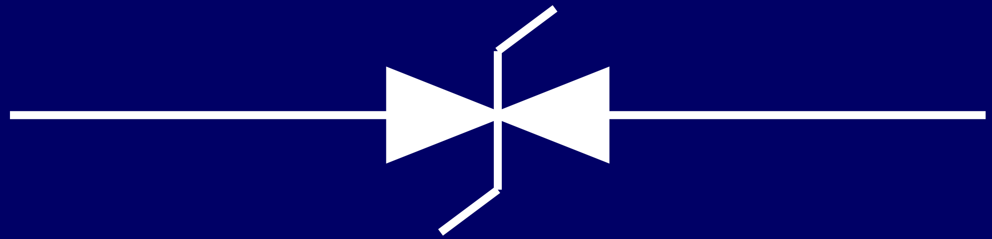
Transient suppression devices

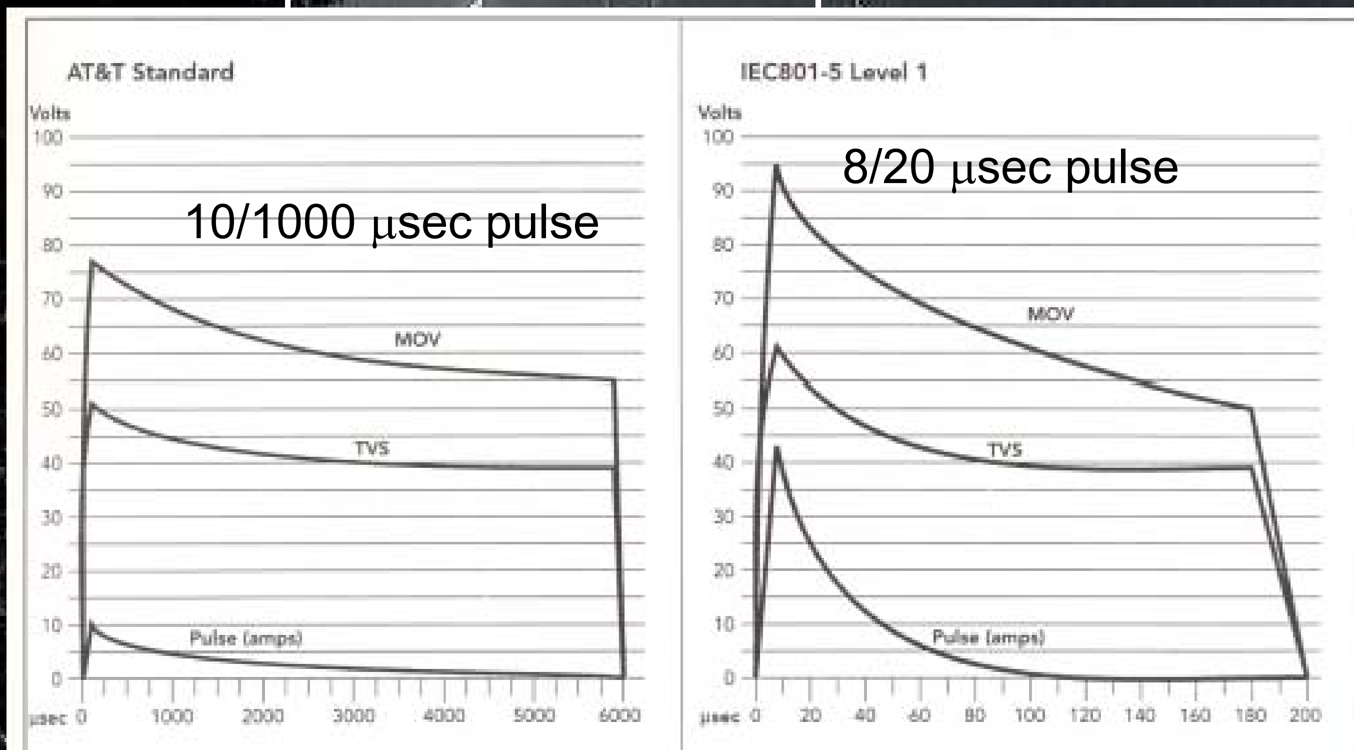
SADs



- ☑ Back-to-back zener diodes; one forward, one avalanching
- ☑ Excellent clamping properties
- ☑ Also widely available in a range of energy/voltage ratings

Critical parameters for selecting TSDs

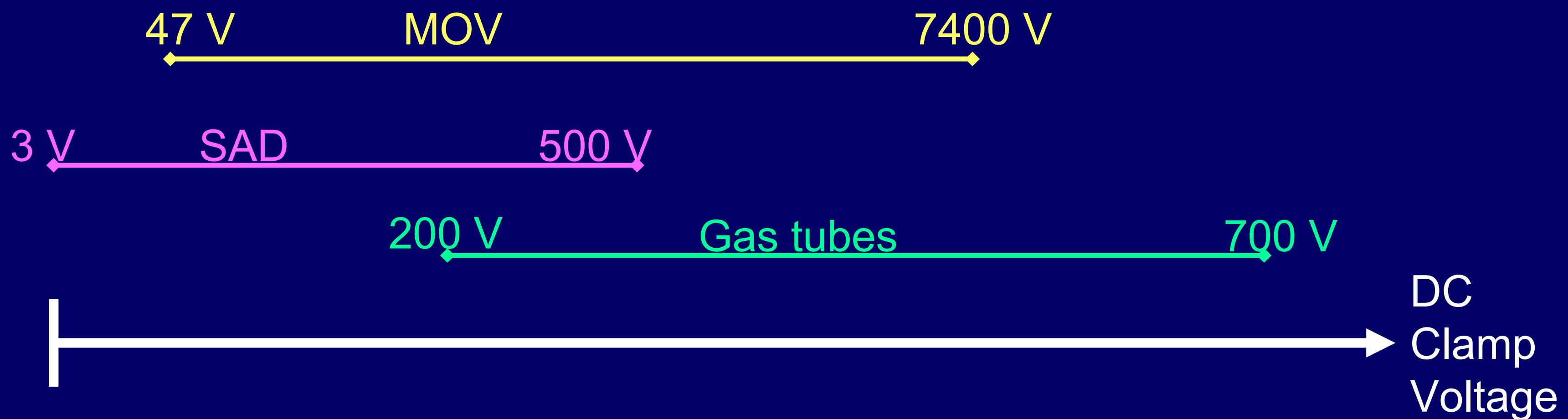
- ☑ Clamping or pass-through voltage
- ☑ Surge current capability
- ☑ Energy (MOV) or power (SAD) dissipation
- ☑ Response to standard pulses

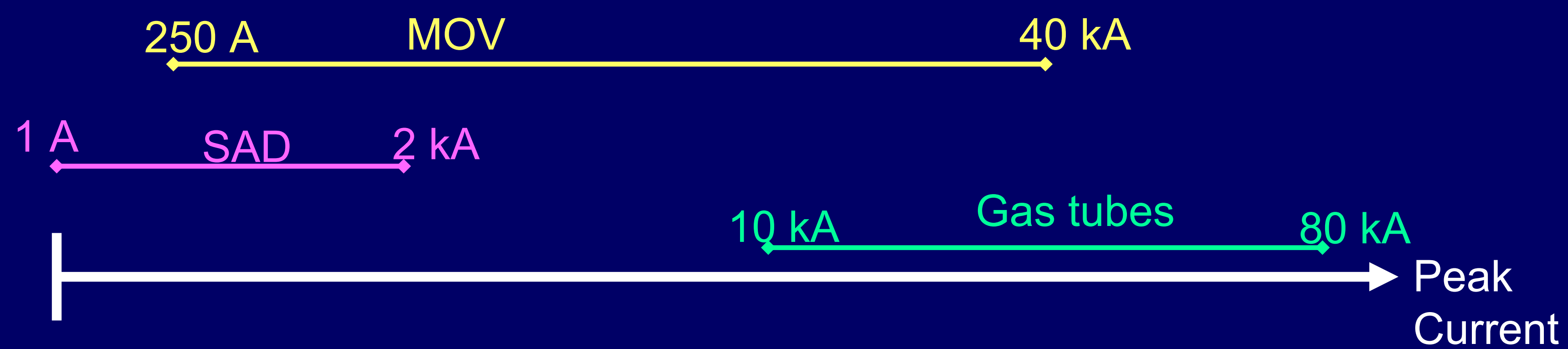


TSD comparison

Device	Rel cost	Degradation	Effect on normal op	TS effectiveness
MOV	Low	High	High	Good
SAD	Moderate	Low/mod	Low	Excellent
Ion tube	Moderate	Low	Low	Good
Filter	Moderate	Moderate	High	Moderate

TSD comparison





Critical issues for transient suppression

- Proper device selection—need to know what you're protecting against. This is a problem for PV; DC-side transients aren't well specified.
- Lead is critical—at transient frequencies, L dominates, not R. Want very short, straight wires. (Story of our lives in power electronics….)
- TSDs do affect circuit design—capacitance of TSDs can be significant. This is true for MOVs, less so for SADs.
- Capacitors don't work well as TSDs—especially aluminum electrolytics—because of their tendency to look more like inductors at very high frequencies (ESL).

UL and TSDs

UL does list TSDs. Applicable standard: UL-1449.

UL suppression voltage ratings (SVRs) based on:

"…the average let-through voltage of two 6 kV 1.2/50m msec, 0.5 kA 8/20m msec impulses, separated by a duty cycle test of ten 6 kV 1.2/50m msec, 3.0 kA 8/20m msec impulses".

Also: IEEE-C62.41.1 and IEEE-C62.41.2—standard covering TVS in AC circuits of 1 kV or less

Future trends in TSDs

- ☑ Doesn't appear to be a particularly active area of research, but some developments
- ☑ "New" materials
  - ✓ Selenium? (actually used in 1928!)
  - ✓ Nanostructured materials?
- ☑ New device structures based on thyristors, cellular structures
- ☑ Incremental performance improvements

Future trends in TSDs

Major issues remaining for TSD application:

☑ Lead length: finding ways to minimize inductance

☑ End of life issues
- ✓ SADs can fail open or shorted; monitoring?
- ✓ Explosion protection
- ✓ Monitoring MOV degradation over time

☑ Long-term energy absorption: **GROUNDING**
- ✓ Preventing "slow burn"; thermal control
- ✓ New structures with better long-term properties?