Survey of RF Surge Protection Technologies
– Increasing the Reliability of Your Wireless Network

PEG CONFERENCE

Robert Cid
Global Product Manager
RF (PolyPhaser), Cabinets and Mil/Aero Products

smiths microwave

10701 Airport Drive, Hayden, ID 83835, USA

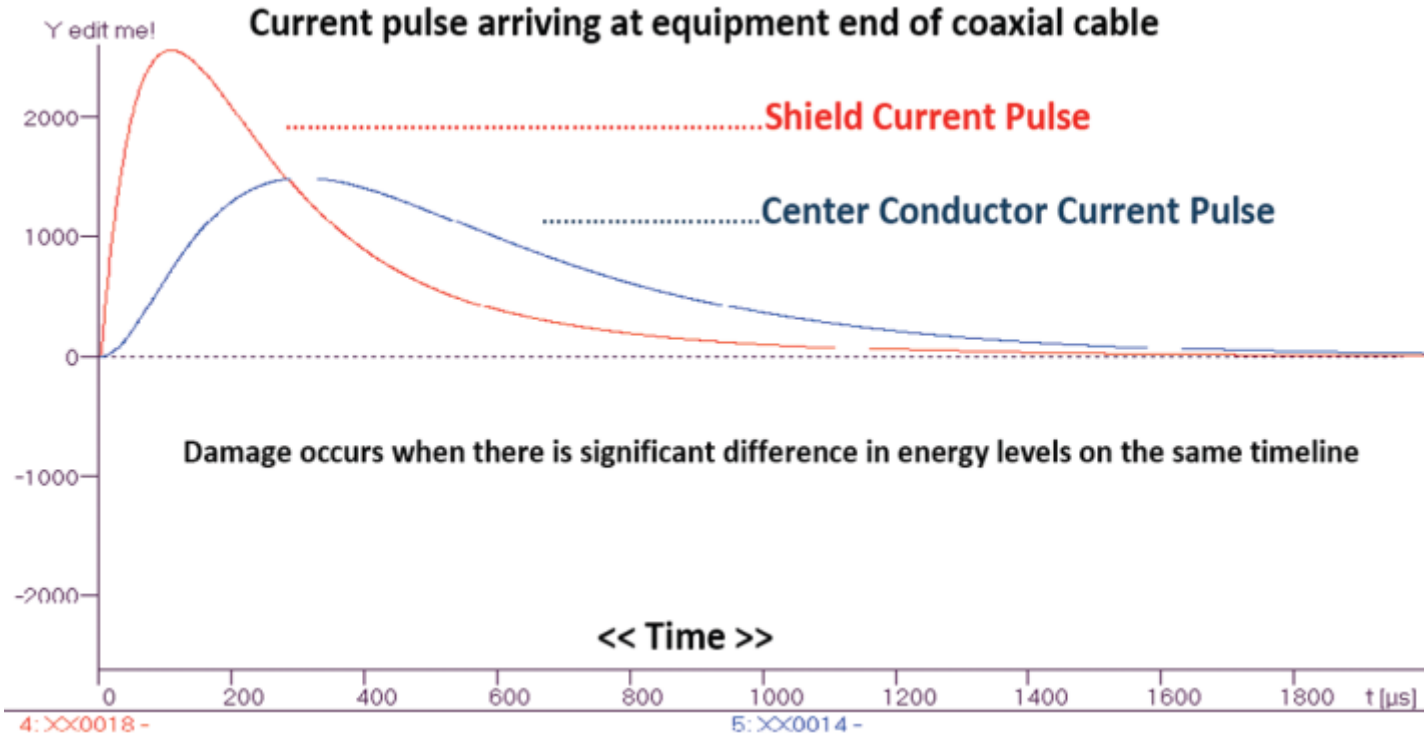
robert.cid@smithsmicrowave.com
M: +1 208 651-0977
T: +1 208 762-6508
kaelus.com | polyphaser.com | transtector.com | radiowaves.com

kaelus PolyPhaser TRANSTECTOR radiowaves

Goal of the Presentation

- Background on lightning transients in RF systems
- Introduction to different RF surge suppression technologies
- Note on grounding and bonding
- Cellular application example

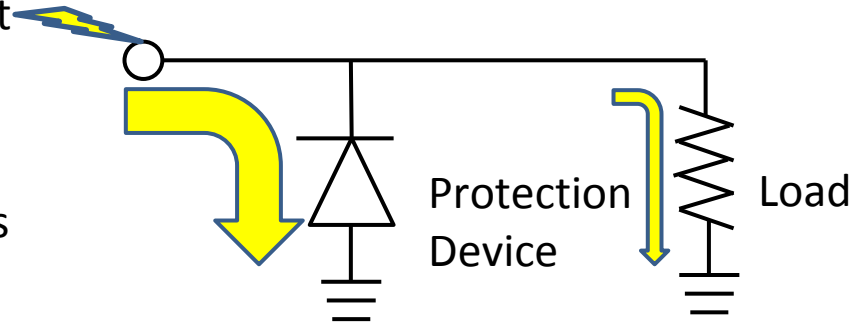
When lightning strikes nearby, what happens?

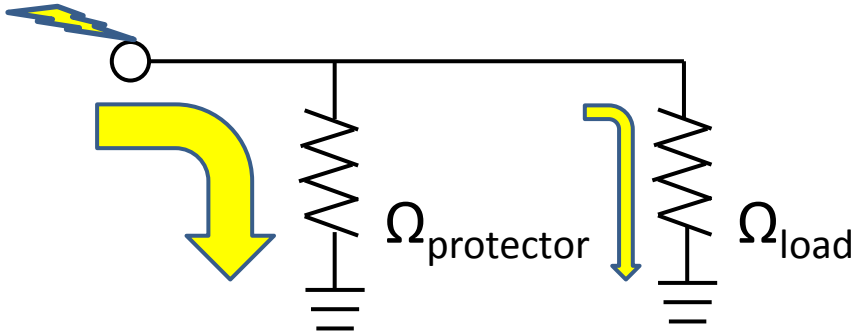


- Induced currents will flow at different rates down the shield and center pin causing a differential voltage. This voltage differential may lead transients going through the equipment.

Lightning Transients – Concept Behind Protection - Shunting

- Most circuit protection devices activate at a threshold voltage and shunts energy away to ground.
- Many familiar protection devices includes diodes, metal-oxide varistors, thyristors and gas discharge tubes.
- The goal of these devices is to protect the end product by shunting energy away.
- When the protection devices turn on, their impedances are reduced substantially. The circuit becomes a current divider with most current going through the protection device.





$\Omega_{protector} << \Omega_{load}$

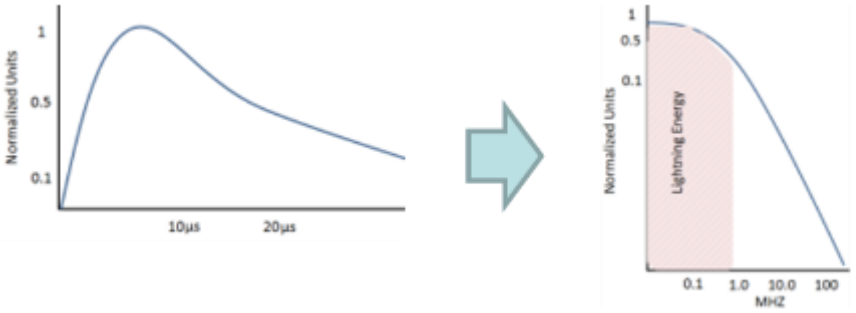
Lightning Transients – Concept Behind Protection - Shunting

- A filter can be used to remove the unwanted frequencies, and allow only the wanted frequencies to remain.

The sine wave below is made up of a single frequency.

- A lightning transient can be greatly attenuated by removing the lower frequency components.
  - But still allow the wanted signals to pass through

A lightning transient is made up of spectrum of frequencies, with most of them under 1MHz.



Two Major Categories of RF Surge Protection Devices

Circuit Protection Components

- Most common method of shunting transient energy is through circuit protection components such as diodes, gas tubes and MOVs



- Circuit protection component based RF SPDs, these would be stand alone gas tube arrestors or hybrid arrestors that incorporate two or more circuit protection component

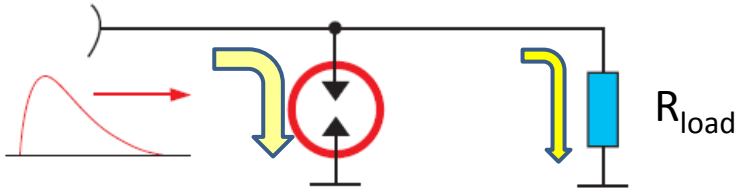
Filtering Components

- Major method of shunting transient energy is through filter components such as inductors and capacitors

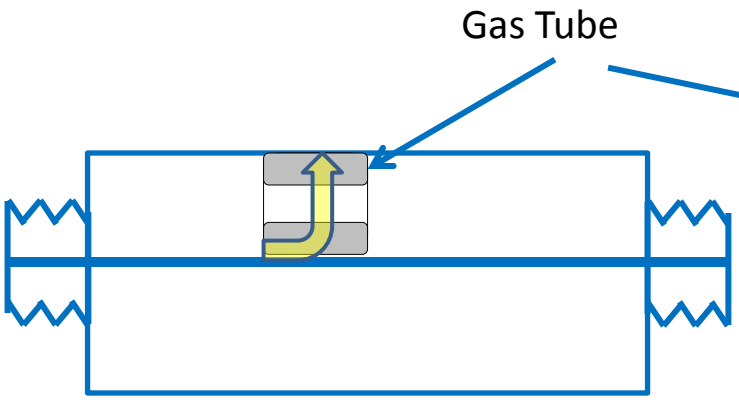

- Filter based RF SPDs would have inductors and capacitors designed to handle kilo-amp levels of surge

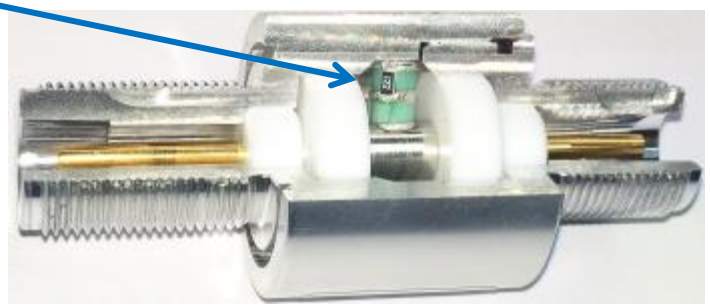
RF Suppression Technology (Component Based) – Gas Tube

- A gas tube is an over voltage device that shunts current when a threshold voltage (the spark-over voltage) is reached. These are typically rated from 90V to 600V.



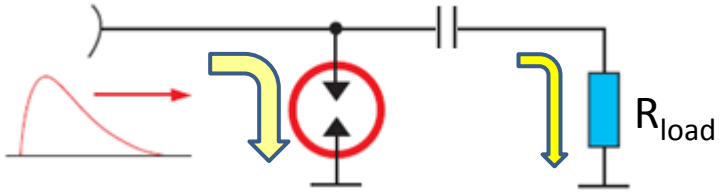
- This is a simple general purpose RF protector. Very broad band (DC up to 7GHz). Passes DC.

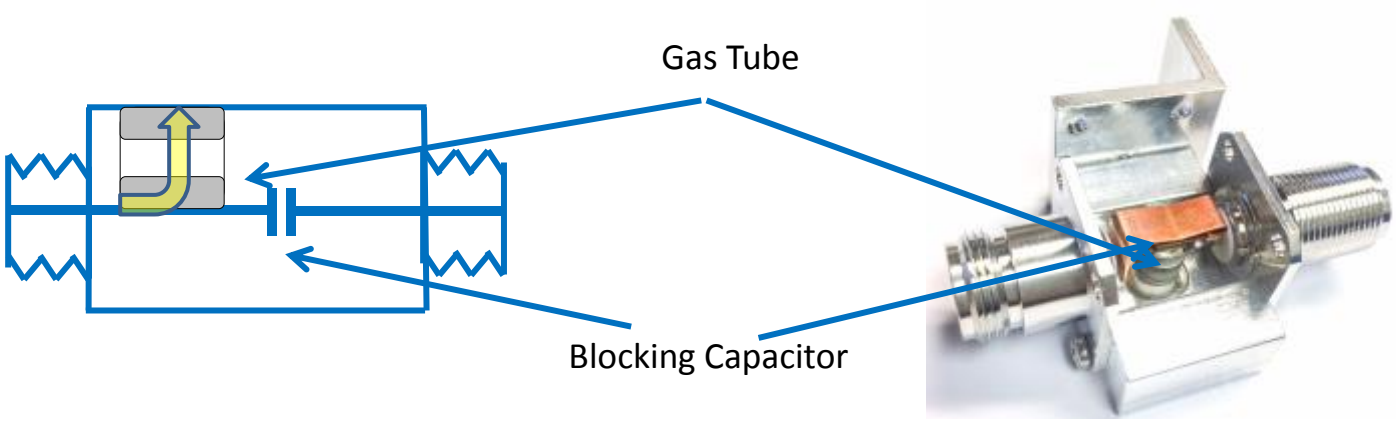




RF Suppression Technology (Component Based) – DC Block + Gas Tube

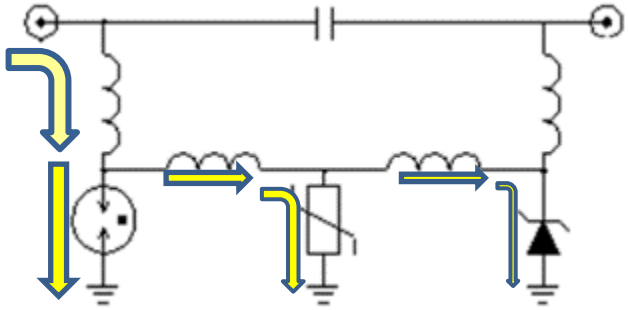
- Some RF SPDs will incorporate other electronic circuits. This is a DC-block SPD that incorporates a gas discharge tube and a blocking capacitor.

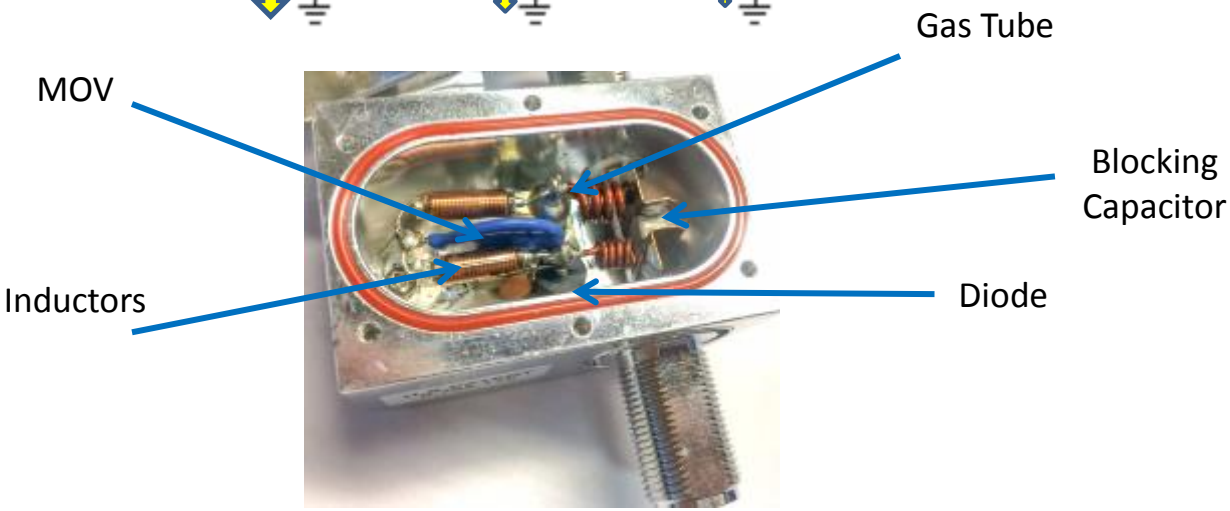




RF Suppression Technology (Component Based) – Hybrid Circuit

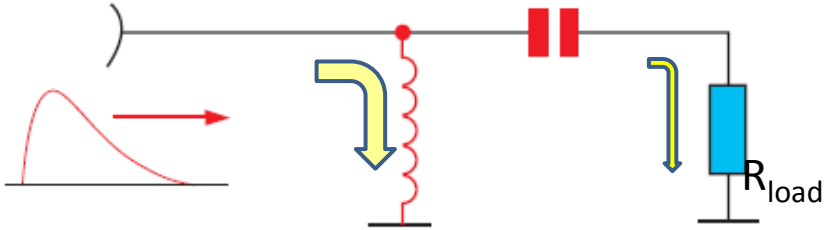
- A hybrid circuit design incorporates different over voltage devices and RF isolating technology. The DC is decoupled from the RF path, passes through coordinated protection devices, and re-coupled to the RF path.

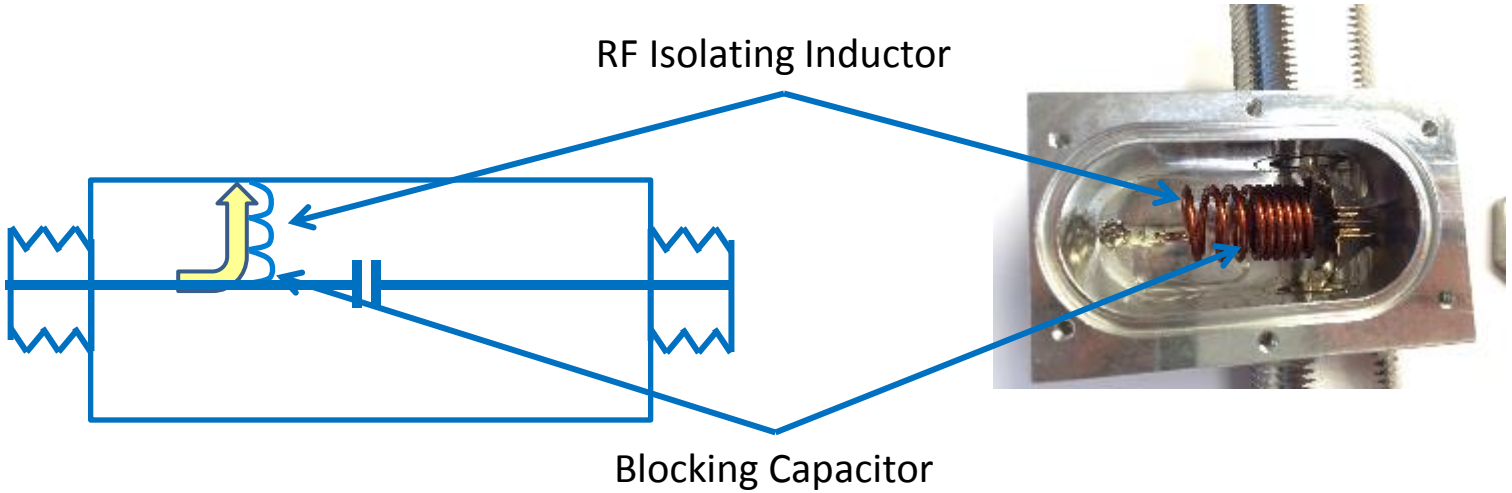




RF Suppression Technology (Filter Based) – Filter

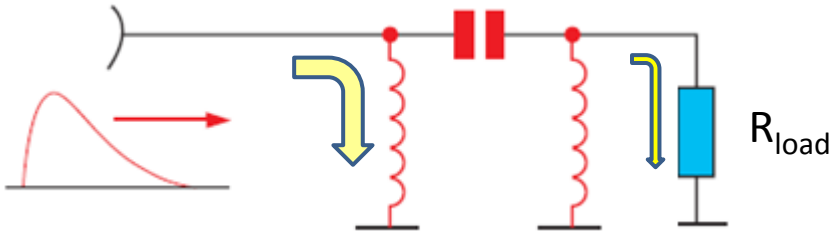
- The concept behind this filter is that the low-frequency components of the lightning surge gets shunted to ground.



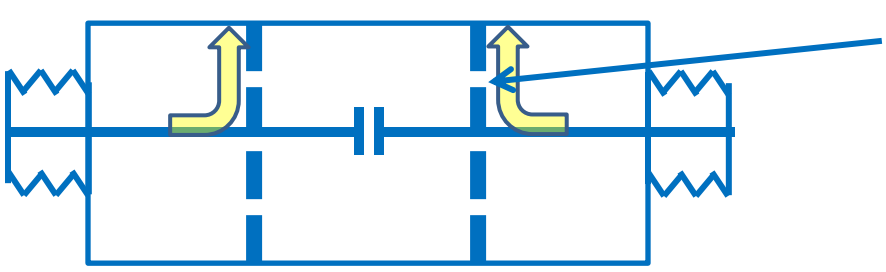


RF Suppression Technology (Filter Based) – Spiral Inductor (SX)

- High pass filter shunts DC current and attenuates unwanted frequencies.
- The concept behind this filter is that the low-frequency components of the lightning surge are immediately shunted to ground.

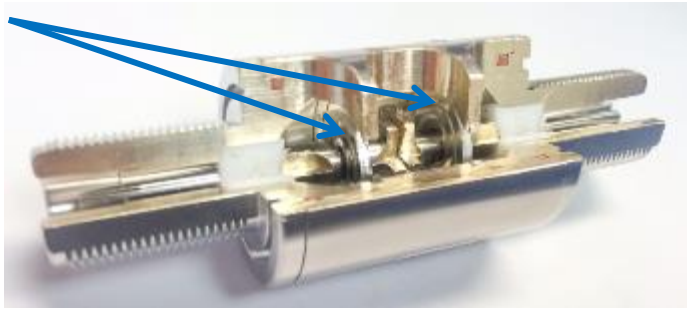


- This filter incorporates spiral inductors designed to pass RF and handle lightning surges.



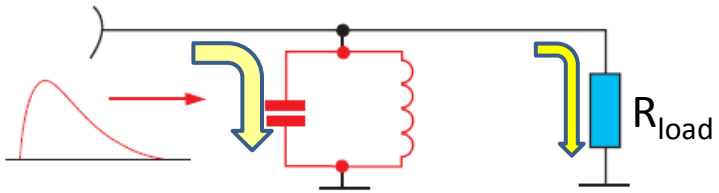
Bi-Directional Performance

Spiral Coils

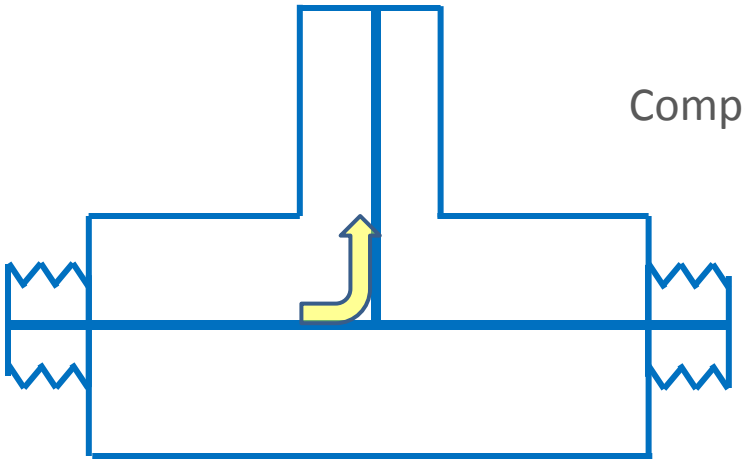


RF Suppression Technology (Filter Based) – Quarter Wave Stub (QWS)

- The quarter wave stub (QWS) acts high pass filter. This attenuates many of the low-frequency components that make up a lightning surge.



- The QWS shunts low-frequency components to ground.

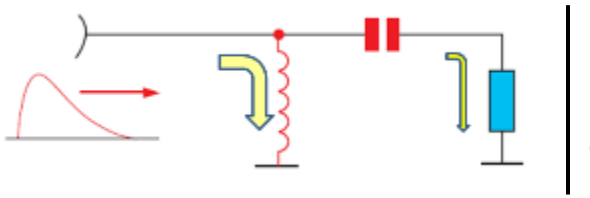


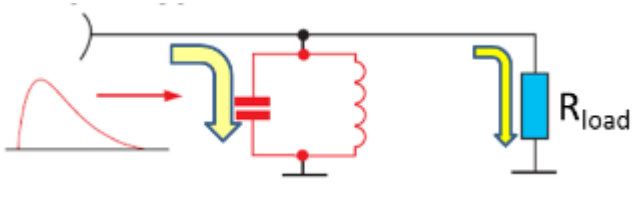
Competitive Technology

What's on a RF SPD Datasheet?

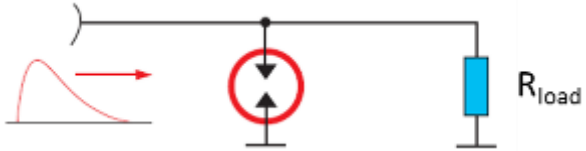
- Table below compares two typical technologies used in RF SPDs

High Pass Filters





Gas Tube

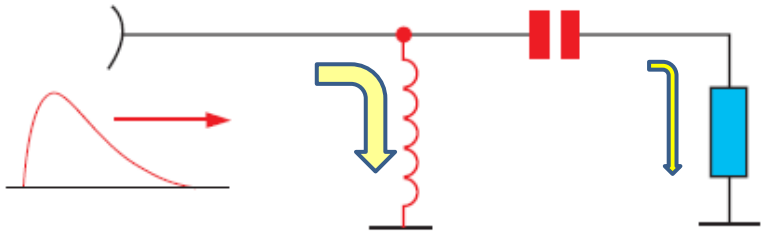


Key Performance Specifications	Typical High Pass Filter*	Typical Gas Tube
Maximum (one time)	40kA	20kA
Multiple	20kA	10kA (10 to 20 hits)**
Frequency Band	698Mhz to 2.7GHz	DC to +3Ghz
Insertion Loss	≤ 0.1 dB	≤0.2dB
Return Loss	≥ -26 dB	≥ -20 dB
Turn on Voltage	Always "on"	>150V to 700V
Turn on Time	<4ns 2kv/ns	>500ns to 2us
Energy Let Through	≤150nJ@3kA	>500uJ @ 2kA
DC Pass Voltage and Current	For DC-Pass Versions ±6Vdc thru 60Vdc, 4A to 10A	±6Vdc, 4A

*Typically DC-Short or DC-Block
**Performance decreases with each hit

Comparison of RF Protection Performance – Filter RF SPD

- RF SPDs of the same technology type (high pass filter) were tested against each other.
- Though the circuits were similar in concept, their performance under surge were different



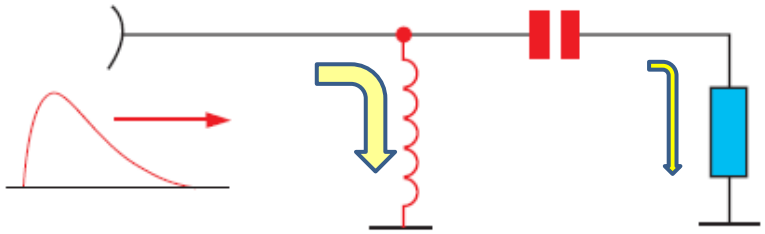
Comparison	Company A	Company B
Rated Lightning Surge Current	18kA Multiple	20kA 1x /10kA Multiple
Tested Max Current	Passed 10x at 20kA	Failed at 5x at 10kA
Max Residual Voltage Spec	<3V under 3kA	<3V under 3kA
Average Tested Max Residual Voltage	1.4V (under 3kA, 8x20us)	5.4V (under 3kA, 8x20us)
Max Let-Thru Energy Spec	≤0.5uJ for 3kA 8x20us	<150nJ for a 2kA 8x20us
Average Tested Let-Thru Energy	65.8nJ (under 3kA, 8x20us)	120.1nJ (under 3kA, 8x20us)

RF Suppression Technology Generalized Comparison

	High Pass Filter (inductor to ground)	High Pass Filter (quarter wave stub)	Hybrid Circuit	Gas Tube
Time To React	Fast	Fast	Fast	Slow
DC Pass	Yes	Yes	Yes	Typically
DC Blocked	Typically	Typically	No	Yes
Return and Insertion Loss	Excellent	Excellent	Excellent	Average
PIM	Excellent	Excellent	No PIM Rating	No PIM Rating
Maintenance	No	No	No	Yes (gas tube degrades)
Typical Max Surge	20kA Multiple (filter design – always on)	>20kA Single (filter design – always on)	20kA Multiple (does not degrade)	20kA Single (gas tube degrades)
Throughput Energy	Lowest	Medium	Low	High
Cost	Med	Med	high	Low
Most Common Application	Cellular/LMR	Cellular	Cellular/GPS	GPS, LMR

Comparison of RF Protection Performance – Filter RF SPD

- RF SPDs of the same technology type (high pass filter) were tested against each other.
- Though the circuits were similar in concept, their performance under surge were different



Comparison	Company A	Company B
Rated Lightning Surge Current	18kA Multiple	20kA 1x /10kA Multiple
Tested Max Current	Passed 10x at 20kA	Failed at 5x at 10kA
Max Residual Voltage Spec	<3V under 3kA	<3V under 3kA
Average Tested Max Residual Voltage	1.4V (under 3kA, 8x20us)	5.4V (under 3kA, 8x20us)
Max Let-Thru Energy Spec	≤0.5uJ for 3kA 8x20us	<150nJ for a 2kA 8x20us
Average Tested Let-Thru Energy	65.8nJ (under 3kA, 8x20us)	120.1nJ (under 3kA, 8x20us)

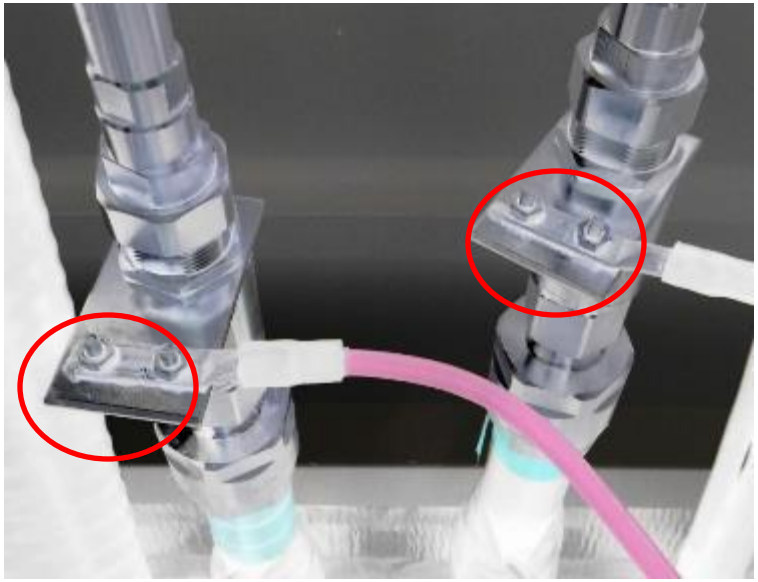
Choosing the Right RF SPD for your Application

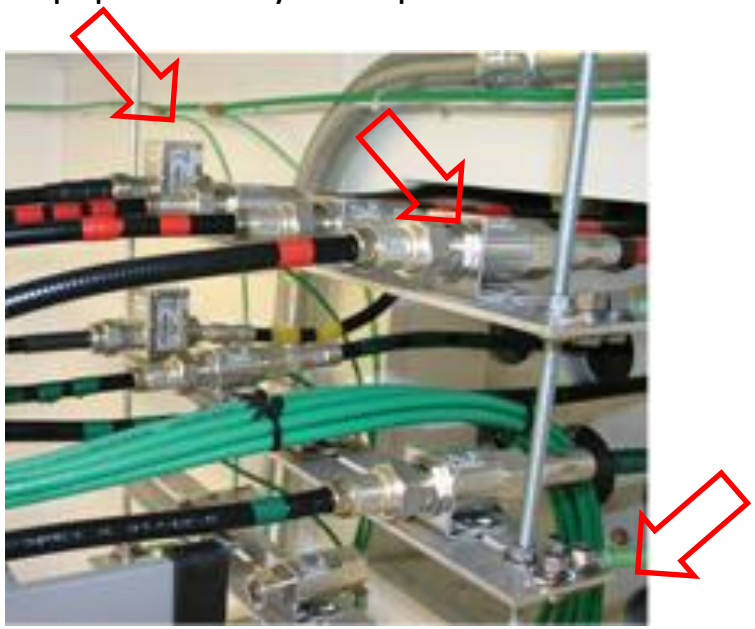
- Best circuit protection is the one that's "good enough"
  - Often times it's not known what's "good enough" as installations and locations will differ
  - Consideration of the technology is important as activation time (or peak voltages needed to turn on) needs to be considered
    - For example, a gas tube may not turn on until it reaches 300V +/- 20%

- Upfront cost is typically a concern, but often cost of ownership isn't taken into consideration
  - Some RF SPDs degrade with each surge (stand alone gas tube)
    - Results in replacement of product which often includes a roll-out to the site as well as cost of equipment damaged
  - Filters or hybrid RF SPDs are more costly, but typically don't degrade with surge events

Grounding and Bonding is a Must for any RF SPD to Work!

- Grounding and bonding are the key to effective surge protection
  - Transients need to get to ground
- Many latent failures observed in the field were attributed to poor grounding
- Even with good grounding and bonding, facilities and equipment may need protection





Manufacturers Typically Include Grounding Instructions and Offer Grounding Accessories

Example Applications for RF SPDs – Cellular Site

Grounding is a must

Filter SPDs typically used on antennas and in shelters

Grounding is a must

Hybrid or gas tube SPDs used on GPS

Survey of RF Surge Protection Technologies
– Increasing the Reliability of Your Wireless Network

PEG CONFERENCE

Robert Cid
Global Product Manager
RF (PolyPhaser), Cabinets and Mil/Aero Products

smiths microwave

10701 Airport Drive, Hayden, ID 83835, USA

robert.cid@smithsmicrowave.com
M: +1 208 651-0977
T: +1 208 762-6508
kaelus.com | polyphaser.com | transtector.com | radiowaves.com

kaelus PolyPhaser TRANSTECTOR radiowaves