# TD1001: The best RF protector for applications not requiring dc on the coax.

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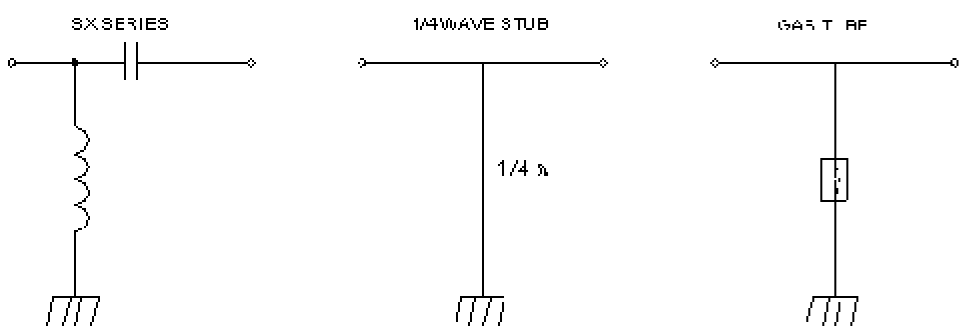
### Abstract:

*DC-Blocked RF lightning protectors have significant advantages over non-dc-blocked (Quarter-Wave stub and straight gas tube) protectors. The condition of dc-blocked or not, pertains to the RF path from center pin to center pin. Units were tested for RF performance, surge attenuation characteristics and surge suppression capabilities. Results show that dc-blocked protectors have broadband RF performance over a wide spectrum of frequencies, 80% higher surge attenuation and 1,000,000 times lower let-through energy than non-dc-blocked.*

### Introduction:

This report will show that dc-blocked RF lightning protectors are superior in RF and surge performance. RF lightning protectors are designed using either dc-blocked or non-dc-blocked technology. To compare these technologies we will use a PolyPhaser DSX protector (dc-blocked), a Quarter-Wave Stub (QWS) type protector and straight gas tube (SGT) (non-dc-blocked). The SX and QWS are designed for RF systems where dc power is not included on the coax. The SGT unit can also be used for system with dc supply on the center pin. For this comparison we will use the SGT unit as in a non-dc type application. The comparison is made to show that dc-blocked protectors outperform non-dc-blocked protectors in RF, surge attenuation and surge suppression capability. Each unit was tested for RF performance including bandwidth, Voltage Standing Wave Ratio (VSWR) and Insertion Loss. Units were also tested for surge performance, including attenuation at lightning frequencies (dc to 1 MHz) and let-through voltage and throughput energy.



## Technology and Testing Overview:

After making the decision to provide lightning protection for a RF system, one must now make the decision which technology will best suit the application. One such application is RF systems where there is no dc on the coax. Some RF systems add dc onto the coax to power up Tower Top Electronics, active antennas or other type equipment requiring dc power. This paper addresses the applications with RF distribution only.

There are an increasing number of manufacturers selling RF lightning protectors. However, two technologies are most prevalent amongst the designs. The most common is the non-dc-blocked, where a dc-shorting device (Quarter-Wave or gas tube) is connected in parallel with the center conductor. The RF path for this type of protector is a straight connection between center pins. The second technology uses a dc-shorting device (similar to the above); however the RF path is dc-blocked. This dc-block is designed in such a manner that a specific frequency band is attained with low VSWR and insertion loss.

The units were tested for RF performance (VSWR and Insertion Loss) and surge attenuation using a network analyzer (HP 8753E). The analyzer is calibrated for the correct connector, load and frequency range. Surge suppression capabilities are tested using the Haefely PSURGE 6.1; units were tested to IEC 61000-4-5, 8/20Âµsec waveform, 6kV/3kA (2â„¦ source impedance). The let-through voltage result is directly read off the display, whereas the let-through energy (Joules) is derived from integration of the let-through surge over time, divided by the impedance of the Unit under Test (UUT).

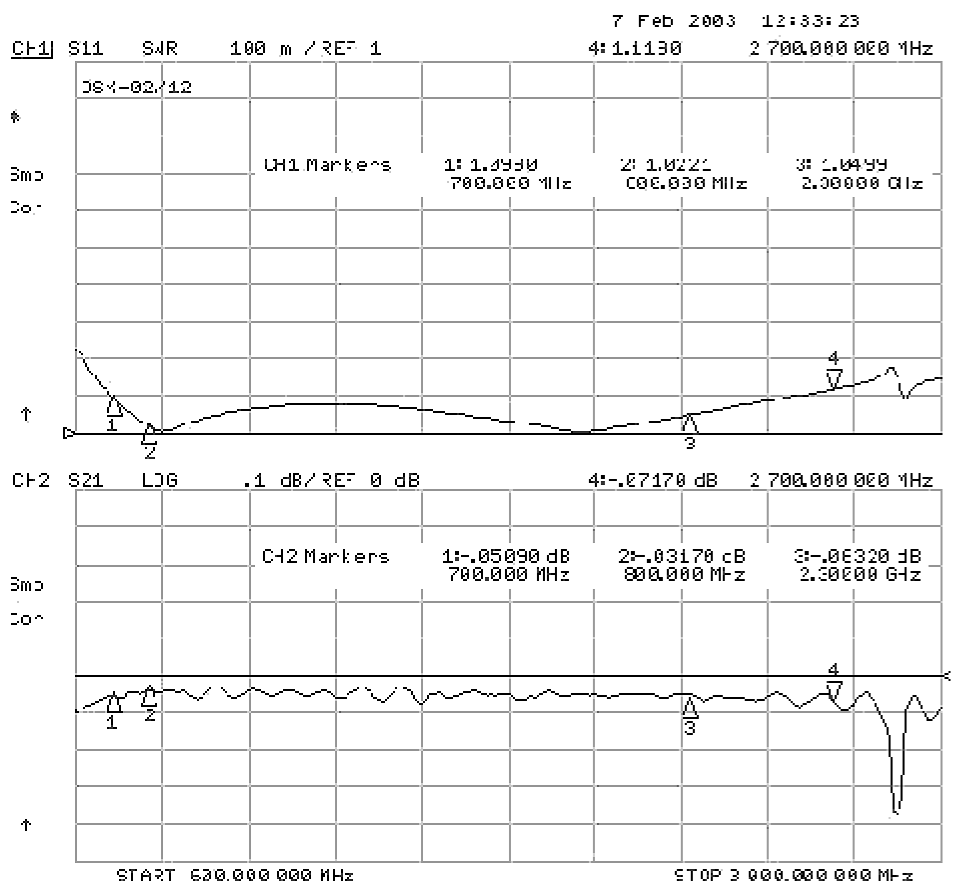
## Test Results:

The PolyPhaser DSX displayed a maximum VSWR of 1.1 to 1 and a maximum Insertion Loss of 0.1dB from 800 to 2300 MHz. A QWS protector has a very narrow bandwidth (typically 10 to 20% of center frequency), with VSWR of 1.22 to 1 (max) and 0.1dB maximum Insertion Loss. A SGT protector has a wide bandwidth (some from dc to 3.0GHz) with VSWR of 1.22 to 1 and 0.2dB Insertion Loss. The values for the QWS and SGT are typical values published for those type protectors.

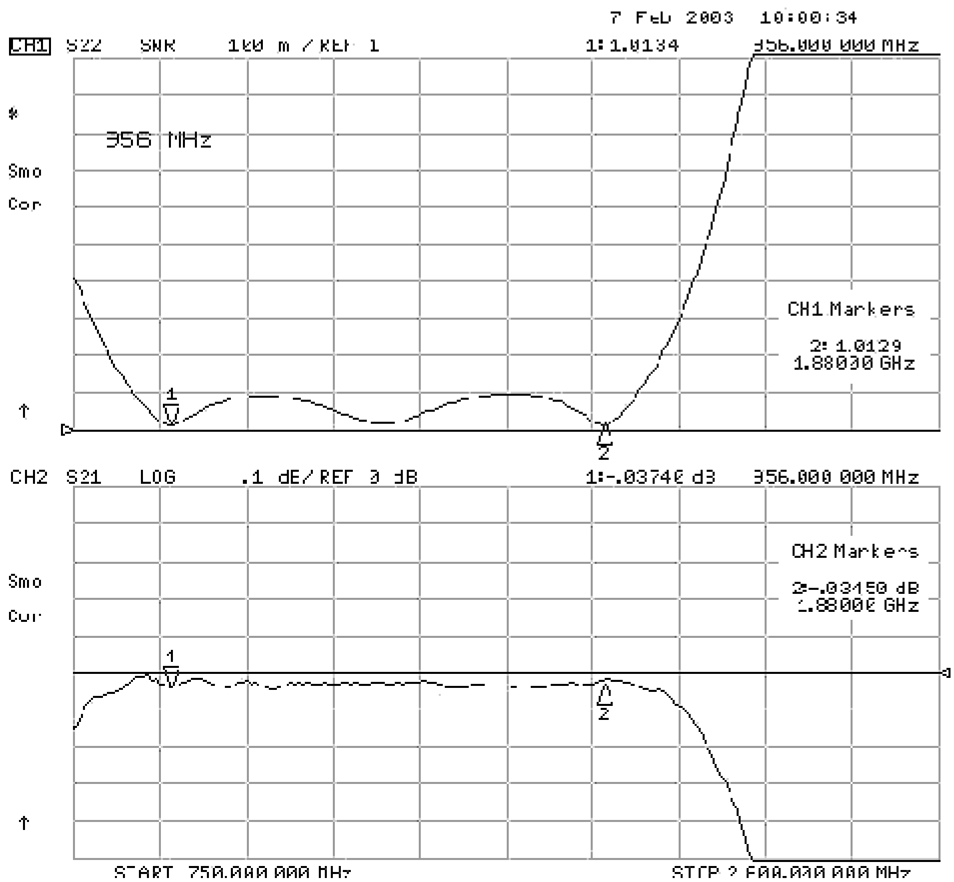
To characterize a protector for lightning surge attenuation (lightning frequencies from dc to 1MHz), we tested the units at 1MHz (Lightning Frequency component). The DSX displays approximately -98dB attenuation versus -55dB for a 1900MHz QWS. Because the SGT is designed to pass low frequencies (dc) there is no attenuation of the lightning frequencies.

Applying a 6kV/3kA 8/20Âµsec waveform to the protector resulted in let-through voltages (energy) of 195.313mV (6.29pJ) for the DSX, 6.875V (7.36ÂµJ) for the QWS and 684.375V (1.58mJ) for the SGT. NOTE: scaling on oscilloscope adjusted to maximize visual result.

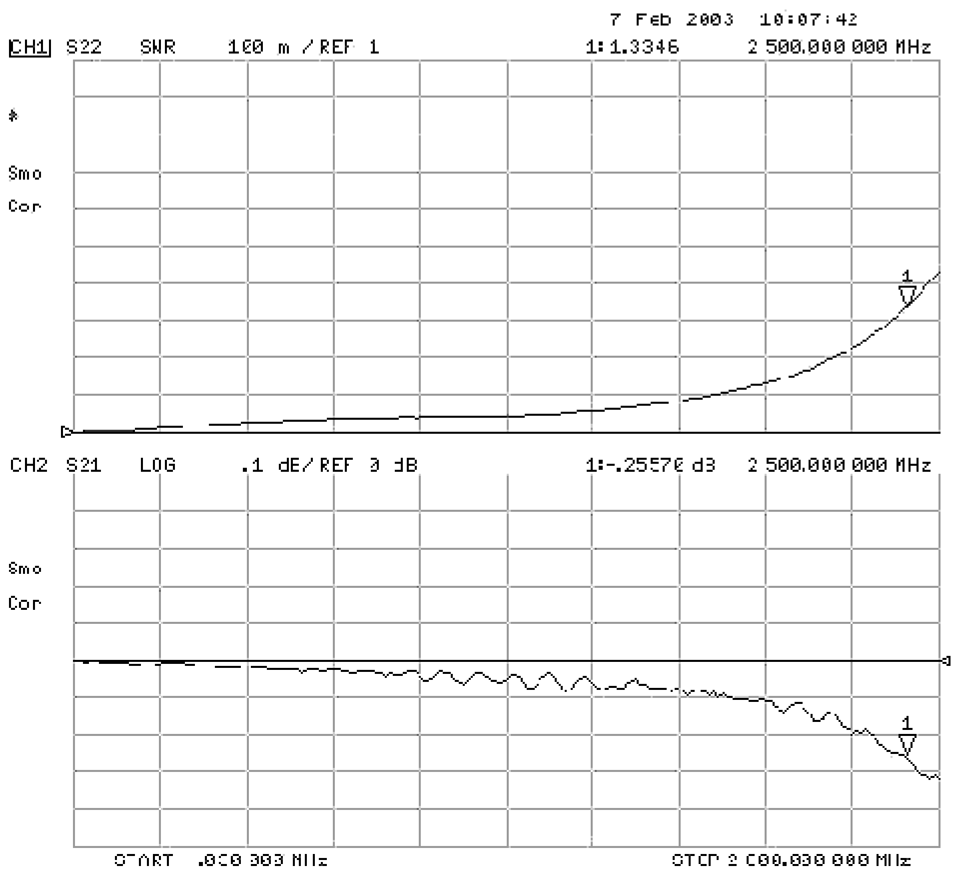
**DSX - VSWR (top) and Insertion Loss (bottom)**



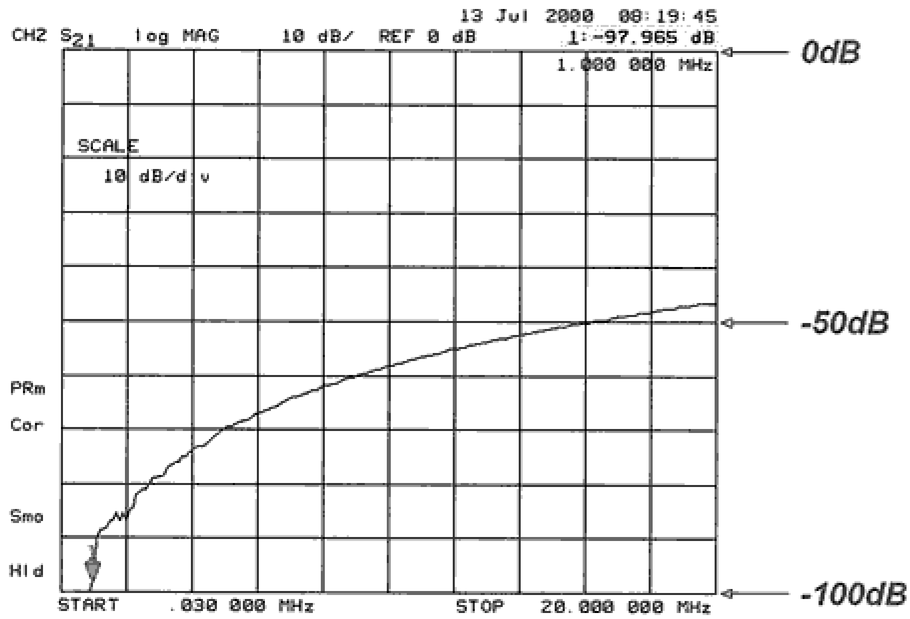
## QWS - VSWR (top) and Insertion Loss (bottom)



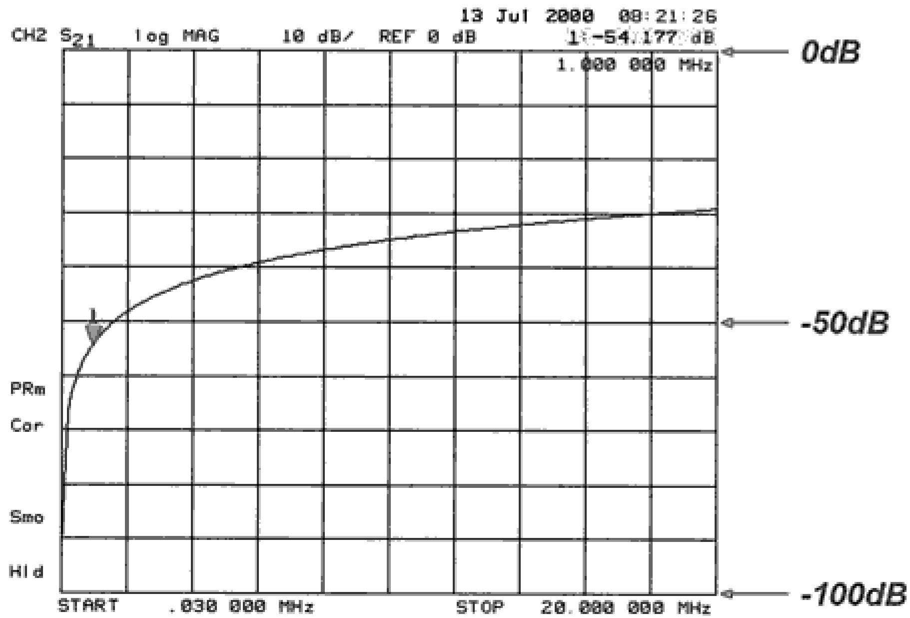
## SGT - VSWR (top) and Insertion Loss (bottom)



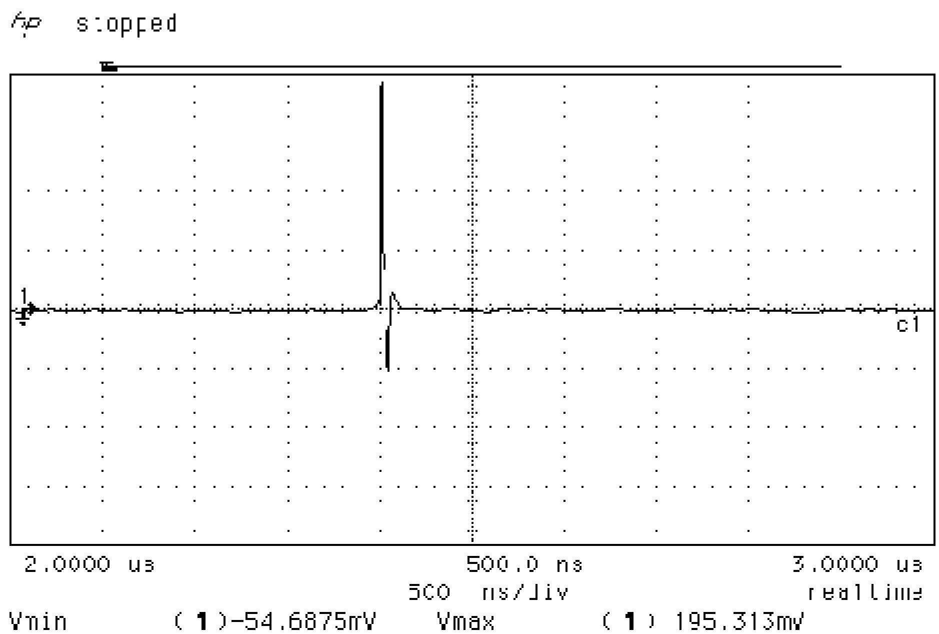
**SX (-97.965dB) surge attenuation**



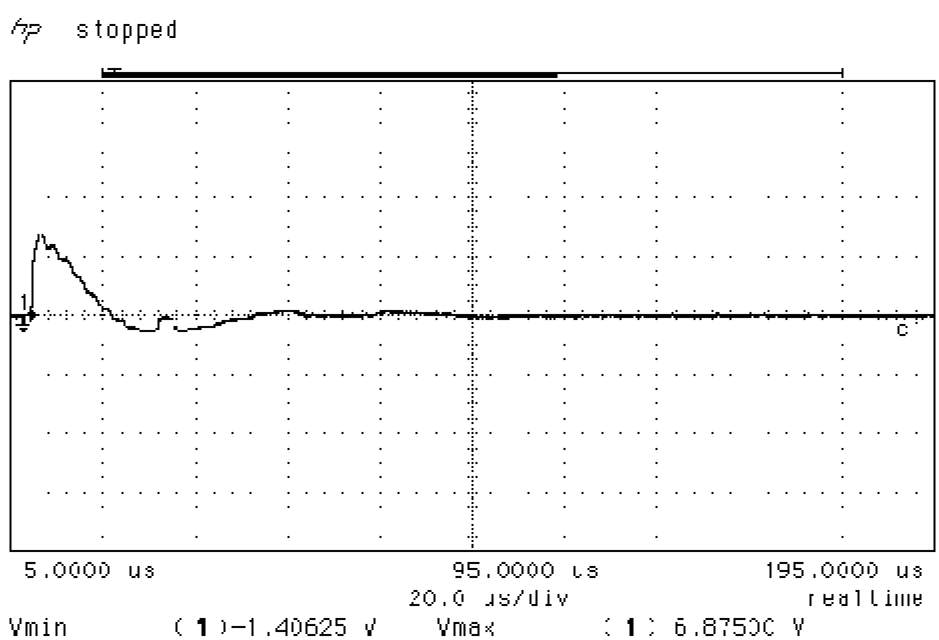
**QWS (-54.177dB) surge attenuation**



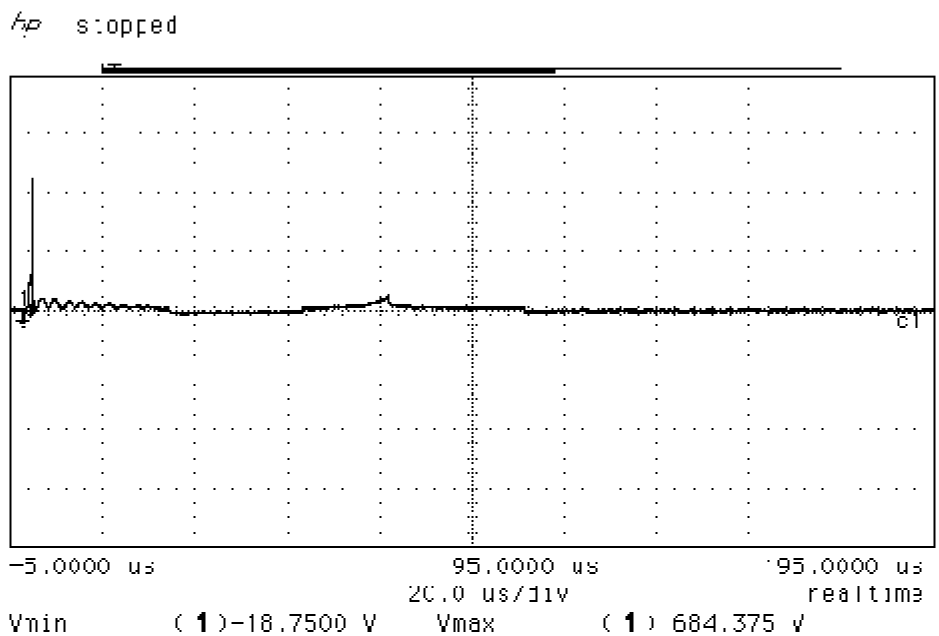
## SX let-through voltage (Scale: 50mV/div)




## QWS let-through voltage (Scale: 5V/div)



**SGT let-through voltage (Scale: 300V/div)**




## Conclusions:

1. Both DSX and SGT have wide bandwidth, while the QWS has specific operating frequency bands. Bandwidth alone does not affect surge performance.
2. The DSX attenuates lightning frequencies at almost 10,000 times the amount of that of the QWS. Due to the dc-pass design of the SGT, there is no attenuation.
3. The let-through voltage of the DSX is 35 times lower than the QWS and 3,500 times lower than the SGT.
4. The throughput energy of the DSX is 1,000,000 times lower than the QWS and 1,000,000,000 times lower than the SGT.

## Nomenclature:

1. RF Bandwidth: Measured in Hertz, MHz (megahertz is 1,000,000 Hertz)
2. Voltage Standing Wave Ratio: amount of reflected signal due to impedance mismatch
3. Insertion Loss: measured in Decibel (dB)
4. Attenuation: measured in Decibel (dB)