PolyPhaser

White Paper

Comparison of RF Surge Arrestors in Rail Industry

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Comparison of RF Surge Arrestors in Rail Industry

One of the fastest-growing applications in the rail industry is intelligent, or smart, systems that enable continuous monitoring and semi-automated control. Communication in these systems is critical for safe and reliable operation. This paper compares RF lightning surge arrestors, specifically PolyPhaser RF lightning arrestors and comparable RF lightning arrestors from a competitor. All products were sourced through standard distribution channels.

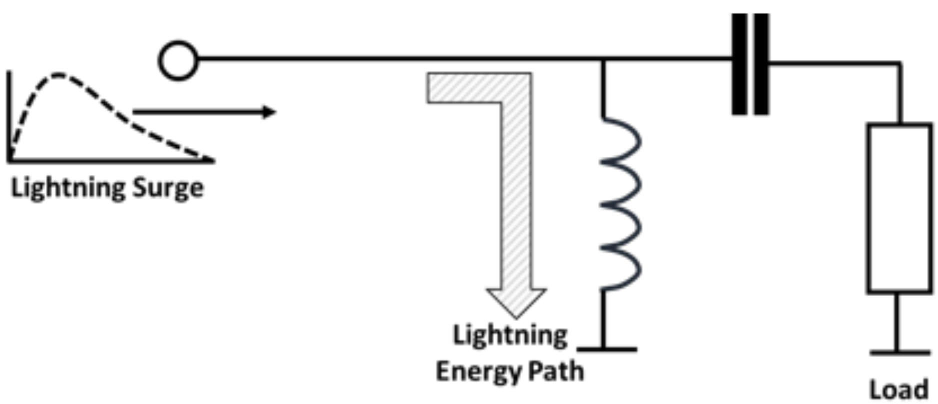
RF Lightning Arrestor Technologies

Filter-Based Technologies

RF surge arrestors based on filtering technologies are designed to withstand the high currents of a lightning strike. Filtering technology provides superior protection. These devices are always “on,” as they typically consist of an inductor to ground. Figure 1 shows the effective circuit of a RF lightning arrestor based on filtering technology.

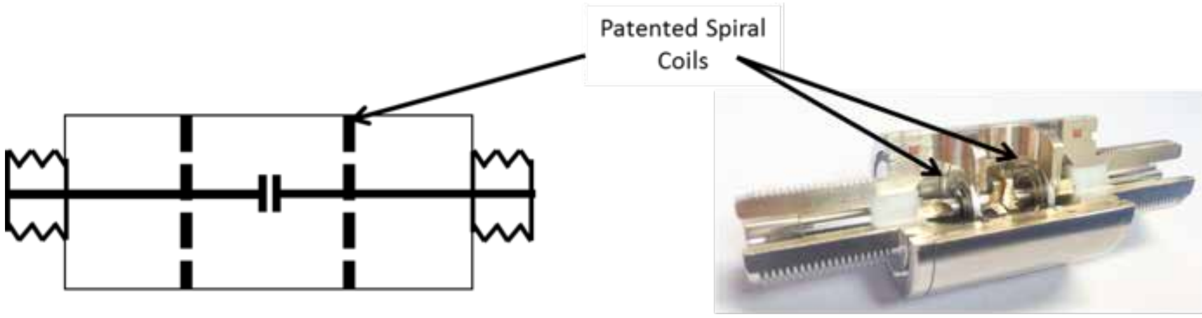
More than 15 years ago, PolyPhaser introduced its SX product family of RF surge arrestor filters. The PolyPhaser SX filtering technology incorporates a patented spiral inductor technology, whereas competitive arrestors use a simple inductor coil to ground. Typically these simple inductor coils have lower lightning surge ratings than the PolyPhaser-engineered spiral inductors. Figure 2 shows details of the PolyPhaser-patented SX technology, consisting of spiral inductors designed specifically to handle high-current lightning strikes.

Figure 1: Equivalent RF circuit if a RF lightning arrestor is based on a filtering circuit. This details a filtering technology where the inductor does not require any threshold voltage to activate. The surge arrestor from PolyPhaser uses a patented spiral inductor technology, whereas competitive surge arrestors use a simple inductor to ground.



Effective circuit of a Wi-Fi RF lightning arrestor

Figure 2: Schematic drawing and cross-section of PolyPhaser's SX technology.



Schematic cross section of a PolyPhaser SX RF surge arrestor

Actual cross section of a PolyPhaser SX RF surge arrestor

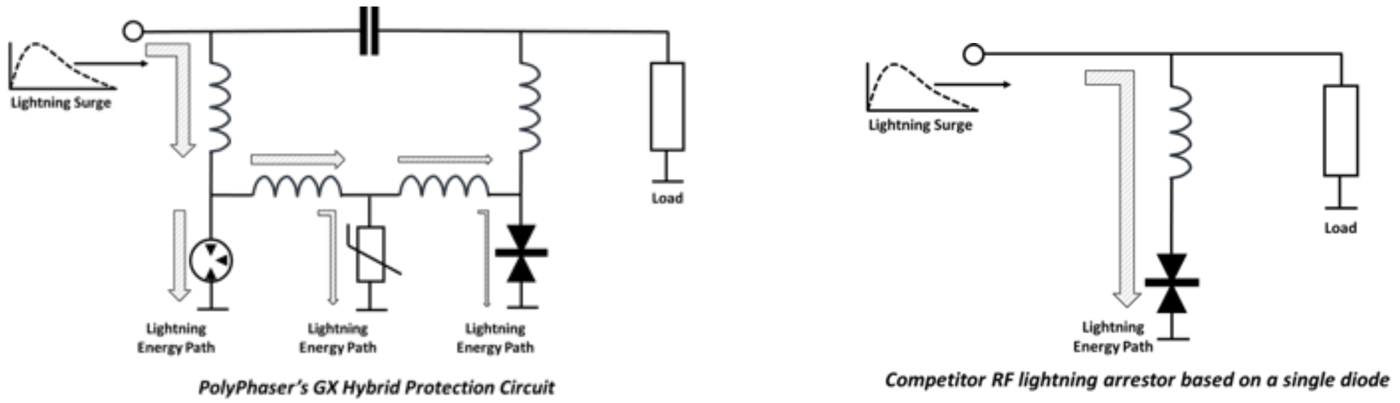
Protection Device Based Technologies

Many RF surge arrestors incorporate circuit protection devices such as gas tubes, diodes and metal oxide varistors (MOVs). A common RF arrestor may use a simple standalone gas tube. A standalone gas tube does not offer very good protection as it typically requires several hundred volts before activating.

The PolyPhaser GX series of RF lightning arrestors has been the adopted standard for GPS and active antenna applications by rail operators for more than ten years. These arrestors utilize a hybrid circuit that takes advantage of the response time of a diode, but also incorporates the current handling capabilities of an MOV and gas tube. The PolyPhaser GX hybrid circuit integrates coordinating inductors between protection devices, thus decreasing the response time. The result is fast-acting RF surge arrestor with one of the lowest energy and voltage let-through ratings on the market. Figure 3 shows the circuits used in PolyPhaser's GX RF lightning arrestor and a competitor's single-diode based RF lighting arrestor.

Competitive RF lightning arrestors have emerged on the market that rely on a single diode for protection (shown in Figure 3). These single-diode based RF arrestors have the advantage of a fast reaction time, but cannot typically handle 20 kA of lightning current or consistently handle multiple lightning strikes.

Figure 3: Comparison of lightning surge protection circuits, PolyPhaser GX hybrid circuit and a competitor's single-diode circuit. The PolyPhaser GX hybrid circuit incorporates multiple circuit protection components, resulting in one of the fastest-reacting and most robust GPS protectors on the market.



Devices Under Test

Comparison testing was done between two PolyPhaser RF lightning arrestors and equivalent lightning arrestors from "Company X". All products were sourced through standard distribution channels. The devices under test (DUT) are listed in Table 1. Tables 2 and 3 detail the RF arrestor's specifications.

Table 1: RF Arrestors used in comparison testing.

DUTs from PolyPhaser	DUTs from "Company X"
PolyPhaser LSXL	Wi-Fi Arrestor
PolyPhaser DGXZ+06NFNF-A	GPS Arrestor

Table 2: Comparison between PolyPhaser LSXL and a competitor's (Company X) equivalent arrestor.

	LSXL	Company X Equivalent Arrestor (Wi-Fi)
Connectors	N-Female, N-Female	N-Female, N-Female
Frequency	2 Ghz – 6 Ghz	2 Ghz – 6 Ghz
Max Power	50 W	50 W
Surge Current	20 kA Multiple	20 kA Max, 10 kA Multiple
Insertion Loss	≤0.1 dB	<0.2 dB
Return Loss	<-20 dB	<-20 dB
VSWR	≤1.2:1	≤1.2:1
Let Through Voltage	<3 for 6 kV/3 kA @ 8/20μs	<3 for 6 kV/3 kA @ 8/20μs
Throughput Energy	≤ 150 nJ for 6 kV/3 kA @ 8/20 μs	≤ 0.5 uJ for 4 kV/2 kA 8/20 μs
Suppression Technology	LC Filter	LC Filter
Temp Range	-40°C to 85°C	-40°C to 85°C
Weatherization	IP67	IP67

Table 3: Comparison between PolyPhaser DGXZ+06NFNF-A and a competitor's (Company X) equivalent arrestor.

	DGXZ+06NFNF-A	Company's X Equivalent Arrestor (GPS)
Connectors	N-Female, N-Female	N-Female, N-Female
Frequency	800 Mhz to 2.5 Ghz	1000 Mhz to 2000 Mhz
Max Power	300 W	50 W
Surge Current	20 kA Max	
10kA Multiple	10 kA Multiple	
Insertion Loss	≤0.1 dB	<0.1 dB
Return Loss	<-26 dB	<-20 dB
VSWR	≤1.1:1	≤1.2:1
Let Through Voltage	<10 V for 6 kV/3 kA Pulse	<12 for 6 kV/3 kA @ 8/20 μs
Throughput Energy	≤ 175 uJ for 6 kV/3 kA @ 8/20 μs	≤ 110 uJ for 4 kV/2 kA 8/20 μs
DC Voltage	DC Pass	DC Pass
Suppression Technology	Hybrid Circuit Using Diode, MOV and Gas Tube	Single diode
Temp Range	-40°C to 85°C	-40°C to 85°C
Weatherization	IP67	IP67

Test Plan

Tables 4 and 5 summarize the test plan. The plan calls for RF characterization of the arrestors, and then subjects them to lightning surges. A single DUT will be tested at the max strike surge level and at the multiple strike surge level.

Table 4: Test plan for PolyPhaser LSXL and Company X's equivalent arrestor.

Test	Test Parameters
RF Characterization (RL and IL)	Sweep from 2 Ghz to 6 Ghz
Surge at Multiple Strike Level	5 strikes @ 10 kA 8/20 us
Surge at Max Strike Level	20 kA 8/20 us until unit fails (10 hits max)

Table 5: Test plan for PolyPhaser DGXZ+06NFNF-A and Company X's equivalent arrestor.

Test	Test Parameters
RF Characterization (RL and IL)	Sweep from 800 Mhz to 2.5 Ghz (PolyPhaser) Sweep from 1 Ghz to 2 Ghz (Company X)
Surge at Multiple Strike Level	5 Strikes @ 10 kA 8/20 μs
Surge at Max Strike Level	20 kA 8/20 μs until unit fails (10 hits max)

Test Results

RF Characterization

All RF surge arrestors were tested for return loss and insertion loss within their respective specifications.

Multiple Surge Test

Table 6 summarizes the test results. Each unit was subjected to 5 strikes of a 10k A 8/20 us waveform.

None of the PolyPhaser RF surge arrestors showed any change in RF performance after 5 strikes of a 10 kA 8/20 us waveform.

Company X’s RF surge arrestors showed inconsistent performance, with only one arrestor passing its rated multiple-surge specifications.

Max Surge Test

Units that passed the 5x 10 kA 8/20 μs test were subjected to a single 20 kA strike. After passing a single 20 kA strike, they were subjected to 9 more strikes of 20 kA surge.

None of the PolyPhaser RF surge arrestors showed any change in RF performance after 10x 20 kA strikes.

Company X’s arrestor failed on the 8th strike. This arrestor did meet their max-strike rating of 1 strike, but was not able to survive multiple strikes at 20 kA.

Voltage and Energy Let Through

Each device was subjected to a 3 kA 8/20 μs waveform. The device response was recorded using an oscilloscope. The traces from the oscilloscope were used to measure the voltage let through, and to calculate the energy let through of each device. Table 7 summarizes the results.

Table 6: Summary of multiple and max surge strikes using a 10 kA or 20 kA waveform.

Device Under Test	10 kA Multiple Strike	20 kA Strike
PolyPhaser LSXL	Pass	Pass
Company X Equivalent	Failed on 5th Strike 2nd Unit passed 5 Strikes	2nd Unit Failed on 8th Strike
PolyPhaser DGXZ+06NFNF-A	Pass	Pass
Company X Equivalent	Failed on 1st Strike 2nd Unit Failed on 3rd Strike	Not Tested (Not part of specification)

Table 7: Voltage and energy let through results under a 3kA 8/20µs waveform.

Device Under Test	Peak Voltage Measured	Peak Let Through Voltage On Spec Sheet	Energy Let Through Measured	Energy Let Through On Spec Sheet
PolyPhaser LSXL	1.4 V	<3V	66nJ	≤150nJ
Company X Equivalent	5.4 V	<3V	120nJ	<500nJ
PolyPhaser DGXZ+06NFNF-A	9.4 V	<10V	105uJ	<175uJ
Company X Equivalent	60.5V	<12V	236uJ	<110uJ

Conclusion

Tables 6 and 7 summarize the test results between PolyPhaser RF surge arrestors and competitive RF surge arrestors from “Company X”. The results show that under the same test conditions, the surge arrestors from PolyPhaser provided better lightning surge performance. Under multiple and single max surge pulses, PolyPhaser surge arrestors showed no degradation. Furthermore, the response of PolyPhaser surge arrestors enables lower voltage and energy let through under lightning surge tests.