Transient Surges and Surge Suppressor Technologies: Comparing Apples to Oranges

Metal Oxide Varistor (MOV) versus Silicon Avalanche Suppressor Diode (SASD) Designs Discussion

The sole function of a quality surge suppressor is to protect sensitive electronic equipment from transient overvoltages that are present on AC power circuits. It is irrelevant whether or not these overvoltages are generated by lightning activity or are induced upon the AC power lines by utility grid switching, power factor correction actions, power cycling of inductive loads, or from other sources. It must limit transient overvoltages to values that do not surpass the AC sine wave peaks by more than 30% as it initially absorbs intense amounts of transient energy. The suppressor must immediately respond to transients before the impulses reach their uppermost voltage values. Its performance characteristics should not deviate or degrade with use as it is called upon to suppress very high levels of transient energy.

Transient surges are standardized by different waveforms. The surge suppression industry has adopted IEEE Power Engineering Society's IEEE C62.41-1991 document, titled IEEE RECOMMENDED PRACTICE ON SURGE VOLTAGES IN LOW-VOLTAGE AC POWER CIRCUITS, as the standard for defining the surge environment. This guide suggests several varied voltage and current waveforms as they pertain to the electrical environment. The most frequently referenced IEEE waveform is the Combination Wave. The combination wave is characterized by short duration high-frequency 8/20μs current and 1.2/50μs voltage waveforms that are typically utilized to simulate lightning induced transient activity. Longer duration, lower frequency, higher energy 10/1000μs voltage and current test impulses, also detailed within the same IEEE documentation, are recommended to simulate transient activity originating from sources other than lightning. Quality surge suppressors, regardless of their suppression technology, should be tested to both the short duration and long duration waveforms. The Combination Wave consists of two very short duration waveforms. These are open-circuit 1.2/50μs voltage and short-circuit 8/20μs current pulses. Actual voltage and current values are selected in reference to where within the electrical distribution system the surge suppressor is intended for use. The Combination Waveforms are illustrated to the right.

When these combination waveforms are utilized to test surge suppressors, the generator voltage is adjusted to an open circuit voltage of 6000 volts (See Figure 1). It raises to this value in 1.2 microseconds. The voltage decays to 50% of that value after 50 microseconds. A current pulses into a short circuit reaching its maximum value in 8 microseconds and decaying to its half-point after 20 microseconds.
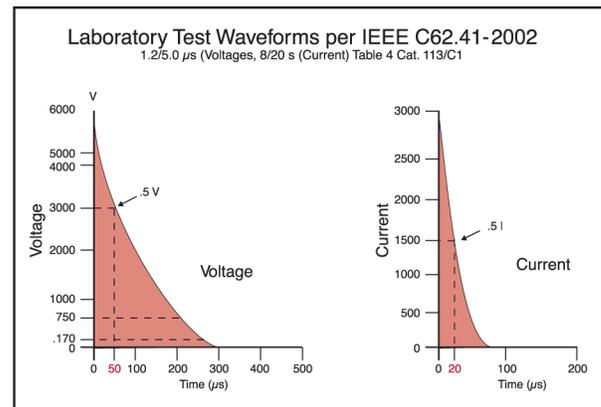

Figure 1.
Because this generation has an internal impedance of 20Ω. The peak current value will be 3000A. The suppressor is connected to the generator for testing.

The Combination Wave provides a starting point to analyze a suppressor's performance characteristics including initial clamp points, or Voltage Protection Levels (VPL), and power dissipating capabilities.

Unfortunately, short duration test pulses do not go far enough to give the suppressor user a clear idea of how the suppressor will perform when suppressing more stressful "real world" transient activity originating from sources other than lightning. It is these impulses that surge suppressors are called upon more frequently

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to suppress in actual user environments. This transient activity is typically characterized by lower frequency (up to 1 kHz) 10/1000µs duration waveforms. . These are the transient surges generated within buildings, from utility grid switching, the power cycling of inductive loads, etc. The laboratory waveforms utilized to simulate this transient activity are shown in Figure 2.
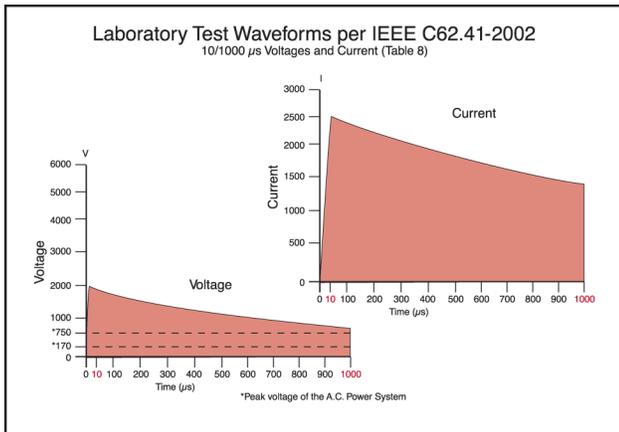

Figure 2.

The physical nature of the electrical distribution system limits how far lightning induced or other short duration transient surges can travel throughout the electrical circuit. Extremely high value transient voltages are required to drive high-energy lightning surge current very far into a facility. Transient voltages are limited (to typically 6000 volts due to air gap protection or insulation breakdown) at the meter base, which prevents these currents from propagating very far into the building. However, most transients originate from sources other than lightning and are much more likely to travel longer distances throughout the AC power system. These transient surges are more threatening to electrical loads because they are not attenuated over shorter distances as compared to lightning induced impulses.

The suppressors selected to protect at specific points along the electrical distribution system must be sized accordingly to their physical location. Higher energy dissipating products must be used at main distribution points as compared to sub panels or at electrical outlets. Even so, suppressors intended to protect at a "low exposure" main or sub-panel location inside any facility rarely need to be designed to suppress more than 3000 Amps of transient current. This is because meter base gaps are designed to limit the voltage required to drive outside currents exceeding these levels very far into a

facility's electrical distribution system. Figure 3 illustrates this point. This graph shows that high level voltages in excess of 6000 volts are required to drive surge currents exceeding 5000 amps, as defined by IEEE C62.41-1991, further than 10 meters into an electrical distribution system.
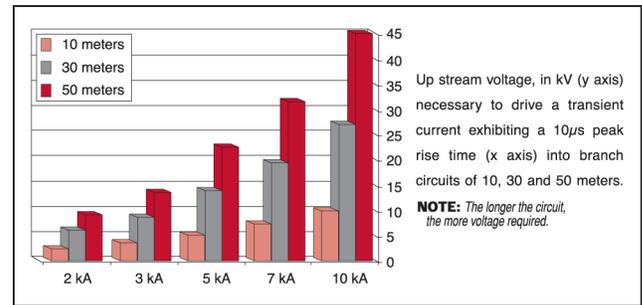

Figure 3.

While it is very important that a surge suppressor be capable of suppressing short duration impulses resembling and including those generated by lightning activity, it is equally if not more important for the suppressor to perform well as it suppresses long duration transients as well. Suppressors intended to protect at branch panels or at electrical outlets will be called upon to suppress long duration transient activity more frequently than lightning induced activity. The suppressor must be able to sustain suppression functions and dissipate the energy contained within much longer duration transient waveforms. A quality suppressor must be designed to perform well regardless if it is suppressing short or long duration surges. Surge suppressors should be tested to both long and short duration laboratory waveforms to confirm these suppression requirements

Transient suppressors made by different manufacturers utilize various suppression technologies including selenium, gas tubes, metal oxide varistors (MOVs), silicon avalanche suppressor diodes (SASDs), or combinations of the above as their suppression components. However, most suppressors utilize either MOVs or SASDs or combinations of the two. Therefore, it is important to discuss the advantages and disadvantages of the two most common suppression technologies.

Metal Oxide Varistors (MOVs)

MOVs are non-linear variable resistors with semi-conductor properties. They are typically constructed with zinc oxide fragments that produce non-linear resistive

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characteristics. The resultant metal oxide particles are compressed under very high pressure to form various sized discs. Electrical leads are bonded to the discs and the finished component is covered with an insulating material. The voltage-limiting characteristic of MOVs relates to the supposition that as the varistor conducts transient current, its internal resistance inversely increases or decreases proportionally to maintain a constant voltage drop across the MOV. Unfortunately, its non-linear resistive characteristics preclude symmetrical resistance shifts in relation to supplied current deviations. As a result, the voltage drop across the MOV increases dramatically as the varistor conducts increased current values.

MOVs were originally designed to protect electrical motor windings against wiring insulation breakdowns. There are two advantages associated with MOVs in regard to surge suppressors. That is, they are inexpensive and they dissipate reasonably high values of transient current.

Numerous drawbacks become apparent as MOV based suppressors are utilized to protect sensitive electronic circuitry.

1) The MOV based suppressor cannot maintain a stable voltage protection level (VPL) as it conducts increased current values. The requirement for the surge suppressor to limit transient overvoltages to values that do not surpass the AC sine wave peaks by more than 30% cannot be maintained as the device conducts increasing levels of transient current. Figure 4 illustrates this deficiency.
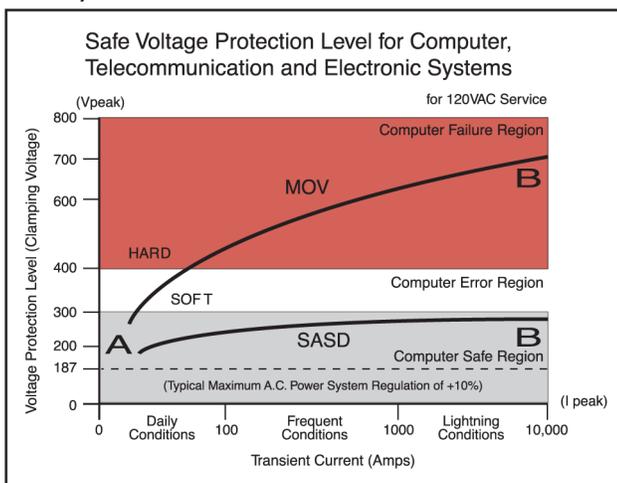

Figure 4.

Note that the curve representing the MOV's clamping action destabilizes as it conducts longer duration surge current. For purposes of comparison, note too that

a SASD based suppressor does not suffer from the same drawbacks as shown by the curve representing the SASD suppression of high current transient activity. Some MOV based suppressor products boast very high surge current capacities of up to 300,000 Amperes without reporting the voltage protection level. These figures sound impressive. However, further examination reveals that this practice is misleading, at best, and often meaningless. The individual MOV is frequently evaluated with reasonably high value "peak surge current" ratings. If a product utilizes multiple 20 mm MOVs connected in parallel as depicted in Figure 5,
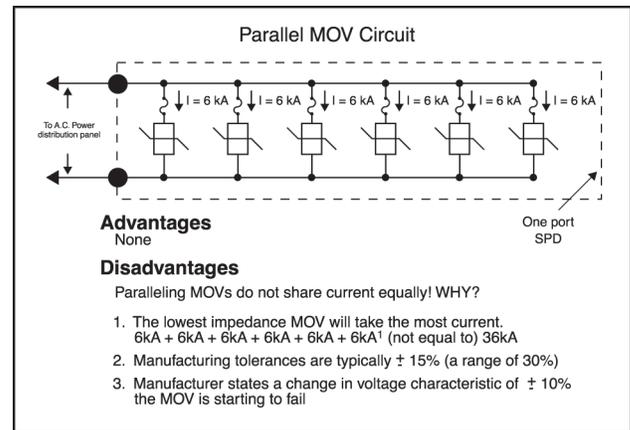

Figure 5.

then manufacturers will often simply add the individual MOV component's current ratings together to report impressively high total value suppression capacities. It is like saying that a set of tires for your car will travel 200,000 miles because each of the four tires is a 50,000 mile radial. It is simply not true because it becomes impossible to coordinate the simultaneous conduction of multiple MOVs due to varying component tolerances and degradation cycles.

Even if the suppressor is constructed with 32 mm or 40 mm MOVs capable of suppressing much greater current values, it remains difficult to determine true voltage protection levels at the maximum rated current value. It is very likely that the VPL will be at such a high value as to render the suppressor useless to protect electronic equipment.

2) Metal oxide varistors degrade with use. The MOV's current conduction paths are through the zinc oxide particles. These particles are weakened as their resistive characteristics change after they conduct current. The degradation cycle becomes more profound as the MOV conducts more frequently and as it conducts higher current values. Although larger MOVs are more robust,

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they continue to be plagued by the same problems.

Figure 6 compares the single pulse life expectancy of 20 mm to 32 mm MOVs.
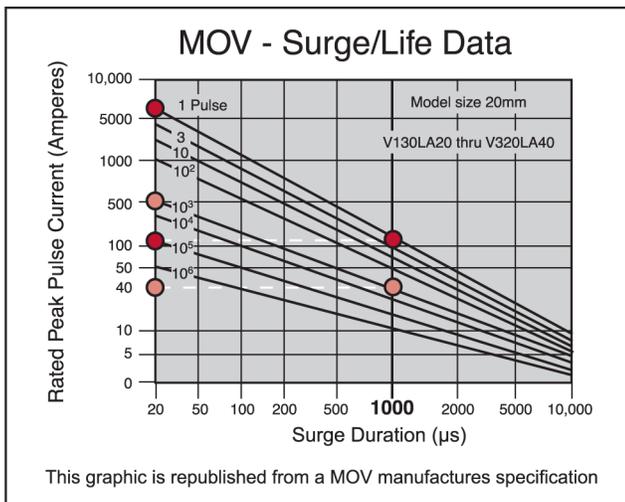

MOV - Surge/Life Data

Figure 6.

Note that while the 20mm MOV can withstand a thousand 500 amp 8/20μs current pulses it can self-sacrifice as it suppresses a single 6,500 amp 8/20μs transient current pulse. Its surge current capacity decreases significantly as it is subjected to the more common longer duration 10/1000μs transient current pulses. In this situation the 20mm MOV can be expected to fail upon being subjected to only a thousand 40 amp 10/1000μs current pulses or a single 200 amp 10/1000μs transient current pulse.

The 32mm MOV is a little more robust, but not by much. It can handle one 20,000 amp and as many as a thousand 900 amp 8/20μs current pulses but only a single 450 amp10/1000μs current pulse. As the 32mm MOV is required to suppress a thousand 10/1000μs transient current pulses its maximum surge current capacity drops to a mere 50 amp value, at which point it can fail.

The zinc oxide particles will either meld together, forming increasingly larger surface areas (pools), similar to what occurs when MOVs enter thermal runaway failure modes. Or they will increase in resistance (burn out) until current conduction can no longer be accomplished. Eventually the MOV will either short the protected power circuit, or more likely, cease current conduction altogether. Typical MOV degradation cycles begin as the component stops conducting current at its original clamp point. Higher initial voltage protection

levels (VPLs) result. VPLs continue to increase as the MOV continues to degrade. Eventually the voltage values required to activate the MOV will be at such extreme levels as to render it useless. In other words, as the MOV deteriorates, it ultimately will cease to function. In some cases the MOV no longer functions as a varistor but as a resistor. This resistor can overheat as it conducts current and introduce a fire hazard. In any event, no transient protection is provided for critical electronic loads on the effected power circuit. Most MOV manufacturers warn users that the component is considered failed after its initial VPL has moved +/- 10% from its original value.

3) Varistors are subjected to "thermal runaway" conditions when their initial clamp points or VPLs are set too close to the nominal AC line voltage. In these situations they conduct current inappropriately. MOVs conduct small amounts of electrical current as they are installed across an AC power source. They conduct more current as the VPL is set closer to the peak voltage value of the AC sine wave. As conduction continues, the MOV's internal temperature elevates and it conducts even higher current values. Over time, this spiral continues until it "shorts". This loads electrical circuits, causes circuit breakers to clear, and can trip ground-fault interrupters. MOV based suppressors have been documented as igniting fires due to thermal runaway disorders. To prevent these catastrophic failure modes, the initial VPL of properly designed MOV based suppressor products is typically set to a higher value which eliminates the device's ability to provide adequate transient protection.

Silicon Avalanche Suppressor Diodes (SASD)

Silicon Avalanche Diodes (SASD) are true solid state semi-conductors, as are the components that comprise the sophisticated circuitry of modern electronic equipment. SASDs are intended to protect these devices. SASD based surge suppressors are not plagued with voltage protection limitations or thermal runaway problems as are MOVs. The advantages associated with the use of SASDs in suppression devices, over other suppression technologies, are numerous.

SASDs respond rapidly to transient overvoltages. In other words, they turn on faster than MOVs. Transient

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surges are characterized by their very rapid rise-times. A quality suppressor must respond fast enough to prevent the transient overvoltage from reaching a potential voltage high enough to degrade electronic components, disrupt equipment operation, or damage electrical loads. SASDs will, in theory, respond to transient activity in picoseconds (trillionths of a second). However, there is no physical way to measure these response times and they will impede to nanosecond (billionths of a second) ranges by the inductance introduced into the suppression circuit with component leads, solder joints, etc. So, with these considerations in mind, a SASD based transient suppressor can be reasonably expected to illustrate an "in circuit" response time of 5 nanoseconds or less. By comparison, MOV devices are also relatively quick to respond to transient overvoltages. But realistically, their "in circuit" response times fall into the 35-50 nanosecond ranges.

A surge suppressor must be designed to suppress as close as possible to the peak voltage value of the AC sine wave even as it dissipates extremely high levels of transient energy. Here lies one disadvantage associated with SASD based suppressor products. Individually, diodes cannot dissipate much energy. A properly designed SASD suppressor has to incorporate many diodes to perform their suppression tasks while not self-sacrificing in the process. The resulting suppressor becomes physically larger in size and is usually more expensive than its MOV based counterpart. Coordinating the simultaneous conduction of SASD circuits is not subject to the same difficulties that plague MOV designs. Quality SASD based suppressor product lines have no problem maintaining a stable voltage protection level at any location upon the AC power system while conducting maximum current values.

It is also important to point out that non-diode based suppressor manufacturers generally limit the testing of their products to short duration 8/20μs current impulses intended to simulate those generated by lightning activity. They often do not test their devices to long duration 10/1000μs long wave test pulses that the suppressor will be required to suppress in actual use. One reason for this is that high-energy test pulses can damage non-diode based suppressor products before they ever reach the consumers who purchase them.

SASD based products do not degrade with use or over time. As long as their energy dissipating capabilities are not exceeded, they will function forever. Quality

SASD suppressors should not be designed or expected to self-sacrifice during a typical transient surge event. It becomes apparent that a quality SASD based surge suppressor must incorporate enough diodes to handle the transient currents it will likely be subjected to under normal as well as extreme transient conditions.

Some suppressor manufacturers build products that utilize both SASDs and MOVs in hybrid designs. This is an attempt to take advantage of the positive performance characteristics, while defeating the negative drawbacks associated with the individual suppression technologies. For example, SASD circuits may be utilized to take advantage of superior response times and stable voltage protection levels, while MOV stages are introduced to handle high power dissipation requirements.

These designs generally utilize fewer SASDs as compared to pure SASD products. This design parameter is often executed for the purpose of realizing a cost advantage over a pure SASD design. However, due to the vastly different operational characteristics of the two unlike technologies, these hybrid design performance parameters fall short of their desired goals. The MOV stages cannot be coordinated to conduct reliably in conjunction with the SASD stages. The same reasons discussed in reference to coordinating simultaneous conduction between individual MOV components explain why. Often, premature suppressor failure is realized by the SASD stages because they simply do not incorporate enough diodes to dissipate proper levels of transient energy. The MOV stages continue to function, but they are still plagued with the same deficiencies of the pure MOV based product. Properly designed surge suppressors utilizing 100% SASDs as their sole suppression technology eliminate the need for hybrid designs.

Transient Surges Defined

Defining transient overvoltages deals with the response of capacitors or inductors to rapid changes in voltage or current. Rapidly changing the voltage across a capacitor produces a large current. The current level is dependent upon the capacitor size and the rate of voltage change. The following formula is used to calculate transient currents associated with capacitive circuits.

I = C dv/dt

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As the time (dt) decreases, the amplitude of the Current (I) increases.

The same basic relationship applies to an inductor as well. Here, a rapid change in current results in a large voltage transient as defined by the following formula.

-V = L di/dt

When analyzing the damaging effects of transients, it must be known where upon the AC sine wave the transient is induced. Transient voltage values add to the instantaneous sine wave voltages. Load devices on the AC power circuit are momentarily subjected to that total overvoltage value. In some cases a transient that is induced upon the zero crossover point may be harmless, whereas that same transient induced upon the peak of the sine wave can be very disruptive. For example, the peak value of a 120 VRMS sine wave is 169.68 volts. A transient measuring 150 volts induced upon the peak of that sine wave will add 150 volts to the 169.68 volts peak sine wave value. A total voltage of 319.68 volts is therefore passed along to load equipment in this example. Overvoltages at these levels can disrupt sensitive equipment operation. On the other hand, that same 150 Vp transient occurring at the zero crossover point of the sine wave subjects load devices to a harmless 150 V instantaneous voltage value that is contained well within the AC sine wave voltage envelope.

Numerous studies conducted during the past 25 years have all identified transient activity as the most common AC power anomaly likely to disrupt or damage critical electronic loads. G.W. ALLEN and D. Segall of IBM System Development Division conducted one of the most respected studies. They monitored AC power at 200 locations, where IBM equipment was installed and operating, in 25 cities across the United States. They recorded the number of various AC power anomalies that disrupted equipment operation during a two-year time span. They presented their findings to IEEE/PES in January 1974. Their study was summarized in IEEE Conference Paper #C 74-199-6. While this study is very old, it still serves as a good reference because it was very thorough and was conducted by professionals working outside of the AC power treatment industry.

Allen and Segall grouped transient activity into two categories. The voltage spikes (impulse transients) were those induced by lightning activity. This anomaly is characterized by very high, short duration, voltage

and current levels. The second category consists of oscillatory, decaying transients which are generated by the power cycling of inductive loads, utility grid switching activities, power factor correction, and from numerous sources internal to a facility.

Transient overvoltages are generated by internal sources such as SCR controlled light ballasts, air conditioners, furnace igniters, motor control centers, and copy machines. They differ from lightning induced transients in that they typically are lower value voltage and current pulses that last up to 50 times longer.

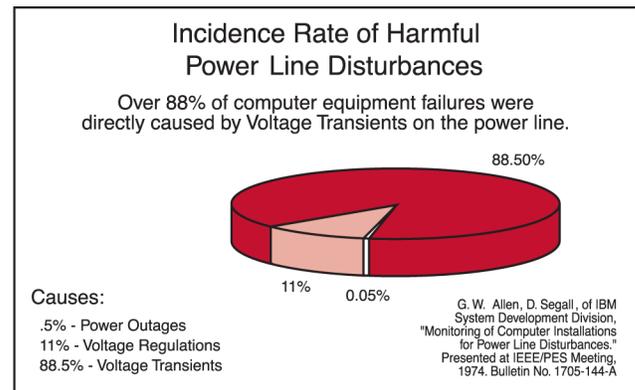A pie chart summarizing this study's findings can be referenced below:

Incidence Rate of Harmful Power Line Disturbances

Over 88% of computer equipment failures were directly caused by Voltage Transients on the power line.

88.50%

11%   0.05%

Causes:
.5% - Power Outages
11% - Voltage Regulations
88.5% - Voltage Transients

G. W. Allen, D. Segall, of IBM System Development Division, "Monitoring of Computer Installations for Power Line Disturbances." Presented at IEEE/PES Meeting, 1974. Bulletin No. 1705-144-A

Figure 7.

The Allen-Segall study concludes that 88.5% of AC power problems are transient related.

Allen and Segall found that the most disruptive power problems regard oscillatory, decaying transients that occurred 62.6 times monthly and represents 49% of the total number of AC power abnormalities. These are examples of long duration, non-lightning related, transients.

Lightning induced voltage spikes or impulse transients occurred 50.7 times a month, representing 39.5% of the total number of AC power hits.

In contrast, power outages accounted for only .5% of equipment disruptions while sags and swells were responsible for 11% of AC power problems.

Electrical distribution systems have not changed significantly from the mid-seventies while electrical and electronic equipment has become much more sophisticated. Now, power outages are becoming more infrequent while harmonic distortion has become a major concern for equipment users. Transient activity has also become increasingly more threatening to

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modern state of the art electrical and electronic load devices.

A quality transient surge suppressor limits the amplitude of transient overvoltages at all times, regardless of their points of origination, to levels that are harmless to electric and electronic loads.

Why Filter Networks Cannot Provide Ample Protection Against Transient Activity

A filter's operational characteristics are frequency dependent. It is designed to attenuate "noise" voltages occurring within a band of repeating frequency ranges at relatively low voltage and current amplitudes. It cannot adequately protect critical electronic loads from lightning induced transient surges. Nor can the filter protect against transients generated from non-lightning sources.

The definition of "noise", as it relates to an AC power distribution system, is: " a low voltage, low current, signal characterized by a repeatable frequency pattern riding along the 60 Hz sine wave." It typically measures less than 50 volts/peak and its current values generally do not extend beyond milliamp ranges.

The perfect filter used on AC power lines would have the capability to attenuate all noise voltages above and below the 60 Hz fundamental power frequency from DC (direct current) to light frequencies. Unfortunately, it is impractical to design a filter to that specification. In reality, any filter design will provide maximum attenuation at a specified frequency. Lesser attenuation levels are accorded for noise frequencies above and below that "center" frequency.

Filter manufacturers may design their products to target and to provide maximum attenuation to specified test waveforms in order to justify marketing their devices as surge suppressors. In these cases filter networks may be designed to provide maximum attenuation to a .5µs-100kHz Ring Wave, or to a 1.2/50µs waveform, or to an 8/20µs current pulse that are utilized by the suppression industry as test parameters.

The .5 microsecond -100kHz Ring Wave is defined in IEEE C62.41-1991 (IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits). It is utilized to test suppressor products that are intended to protect at electrical outlets.

The 1.2/50µs and 8/20µs waveforms are also defined in IEEE C62-41-1991. They comprise the IEEE Standard 1.2/50µs - 8/20µs Combination Wave used to test suppressors intended for use at main and branch distribution panels. The 1.2/50µs waveform is an open-circuit voltage pulse that reaches its peak value in 1.2µs and decreases to 50% of the peak voltage value after 50µs. To properly test a surge suppressor the device should initially be pulsed with that voltage waveform. It should also be pulsed with the associated short-circuit 8/20µs current waveform.

To adequately determine how a suppressor product will perform in "real world" applications it must be further tested to 10/1000µs pulses. The long duration waveform parameters are also included in IEEE C62.49-1991. This waveform can be used as a "stress test" to determine how suppressors perform under worst-case scenarios. Most filter/suppressor manufacturers do not test to this long pulse and their products do not perform well when subjected to that long duration stress test.

A filter cannot provide ample protection against transient activity. This is because transients differ from noise in that they are high voltage, high current impulses that are not frequency dependent. The definition of a "transient" is: "a random burst or bursts of energy, lasting for less than 1/2 cycle of AC input, that are induced upon any portion of the AC sine wave." They exhibit very fast rise times. They can reach their maximum voltage amplitude in one (1) microsecond and typically do not display any identifiable repeating frequency pattern.

Lightning induced transients are characterized by very short duration waveforms. However, most transients originate from other sources. Transient surges result from utility grid switching activities, power factor correction actions, and the power cycling of inductive loads. Most non-lightning induced transient overvoltages exhibit much longer durations that last up to a full millisecond or longer. Therefore, transient overvoltages can exhibit both high and low frequency elements. Lightning induced surges exhibit higher frequency components than those generated by non-lightning activity.

A filter intended to protect against long and short duration transients would have to be capable of

providing maximum attenuation for all frequencies falling within the kilohertz through megahertz ranges.

Take for example the corresponding frequencies of the previously mentioned suppressor test waveforms that simulate transient surge characteristics. The frequency of the 100kHz Ring Wave is self-evident. However, repeating the 1.2/50µs, the 8/20µs, or the 10/1000µs pulses would correspond to 20kHz, 50kHz, and 1kHz frequency patterns. If a filter targets 50kHz as its center frequency, as is commonly done, then lower levels of attenuation are provided for the lower frequency 1kHz as well as the higher frequency 100kHz pulses. Filters generally advertise very low attenuation for frequencies falling below a 5kHz threshold.

AC power lines and distribution systems tend to naturally attenuate the higher frequency surge elements while passing the longer duration surge components. An 8/20µs surge current spike (50kHz) is composed of high frequency ingredients that are reduced as the surge travels along the distribution system. Only a fraction of the original surge current remains as that surge propagates deeper into the power circuit. In contrast, the more common 10/1000µs (1kHz) waveform retains much more energy due to the lesser effect that line attenuation has on lower frequency transient energy. The typical filter is designed to attenuate the 50kHz pulses when it is equally, if not more, important for it to protect against the 1kHz pulses. While a filter cannot accomplish this, a suppressor utilizing "clamping" components can.

Transient overvoltages can be very high in energy content. This excessive energy can "saturate" filter elements, changing the filter's operating characteristics, and provide dramatically reduced levels of attenuation over the entire duration of the transient overvoltage.

Suppressor products must utilize "clamping" components in their designs to adequately protect electronic equipment from transient overvoltages. These "clamping" components attach in parallel with the AC power source and are intended to shunt excess voltages away from protected devices. They must not load the AC circuit and they must not distort the AC sine wave as they perform their intended function. Filter elements contained within any suppressor product can be counter-productive as they can introduce some of these problems into the protected AC power circuit.

Why High Value Suppressor Surge Current Ratings Are Misleading

Some suppressor product specifications boast very high surge current capacities of up to 300,000 Amperes, or more. These figures sound impressive. However, further examination reveals that this practice is misleading, at best, and often meaningless. Most surge suppressors utilize Metal Oxide Varistors (MOVs) as their suppression components. The individual MOV is frequently evaluated with reasonably high value "peak surge current" ratings. If a suppressor utilizes multiple MOVs, as do most MOV based suppressor designs, manufacturers will often simply add the individual MOV component's current ratings together to report impressively high total value suppression capacities.

Typically, a 20mm MOV may stipulate a 6500 Amp peak surge current rating as one of its performance characteristics. That rating will be based upon a single short duration 8/20 microsecond transient current waveform that is often used to simulate a lightning induced current pulse. The chart below, taken from a MOV manufacturer's data book, illustrates the performance tolerances of a 20mm MOV at it is subjected to short and long duration surge current at varying values.

Note that the MOV is more likely to fail as it is stressed to conduct increased current values. As the chart illustrates, this MOV can withstand a thousand 500 Amp (8/20 microsecond) current pulses. However, it can only tolerate a single 6,500 Amp (8/20 microsecond) surge. The MOV's life expectancy also decreases dramatically as it is subjected to longer duration surge current waveforms. It can be further noted that this MOV will not perform nearly as well as it suppresses longer duration current waveforms. Referring again to the chart, it can be seen that this MOV is expected to fail after suppressing only one 200 Amp surge current pulse lasting for a full millisecond time duration. Long duration transient surge currents are induced on AC power circuits by utility grid switching activities, the power cycling of inductive loads, and from numerous other sources within buildings and inside facilities. This type of transient activity is much more common, as documented by IEEE WM85-243-1, in the "real world".

Any suppressor, regardless of its manufacturer, will be called upon more frequently to suppress these longer duration transient currents than any other type of transient activity.

A surge suppressor utilizing six MOVs attached in parallel with each other may report a total surge current capacity of over 36,000 Amps.

The manufacturer legitimizes that high current value by simply adding together the individual component's rated current values. However, it misleads the suppressor user since all of the MOVs do not conduct simultaneously. Coordinating the activation and conduction of each individual component becomes impossible due to stress and degradation factors

In another example, a basic suppressor may be constructed with three (3) MOV components. One MOV may be attached between the Phase and Neutral conductors, another one between the Phase and Ground conductors, and still one more MOV between the Neutral and Ground conductors. Since three MOVs, each carrying a 6500 Amp current rating are utilized, the suppressor manufacture may report a total suppressor current capacity that approaches 20,000 Amps. Needless to say, this suppressor will never see all three components conducting simultaneously. In fact, the MOV between the Neutral and Ground should never activate. Therefore, this total current capacity statement is misleading, at best, and blatantly false in the worst case scenario.

The suppressor selected to protect at a specific point upon an electrical distribution system must be sized accordingly to its physical location. In other words, higher energy dissipating products must be used at main distribution points as compared to sub panels or at electrical outlets. IEEE C62.41-1991 is accepted as an industry standard pertaining to the transient voltage and current test waveforms to be utilized to test surge suppression devices at various physical locations throughout an electrical distribution system. It specifies that surge suppression equipment intended to protect at "low exposure" main or sub-panel locations inside any facility rarely need to be designed to suppress more than 3,000 Amps of transient current. It further specifies that a quality suppressor will only be called upon to suppress from 5,000 to 10,000 Amps of surge current as it protects at medium and high exposure locations.

Therefore, the need for surge suppression products capable of suppressing surge currents beyond these ranges does not even exist.

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