

The Outstanding Benefits of a UL 1283 Listed Power Quality Filter Optimized for Surge Suppression

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Introduction

Pursuing the goal of *Zero Downtime* from powerline surges, a new Power Quality Filter will be described which has the following relevant properties:

- Cancels even worst-case surges so down-stream products are unaware a surge occurred.
- Does not degrade with use. Fixed clamping voltage components are avoided.
- Preserves ground reference integrity during surges, avoiding surge suppression peripheral "side effects" damage.

Safety Standards

UL 1449-3 is the Safety Standard for "Surge Protective Devices".¹ A recent UL 1449 upgrade to a third edition pre-supposes that a "Surge Protective Device" contains voltage clamping shunt elements, and the safety testing proceeds to exercise those shunt elements. Since the technology to be described uses filter elements, NOT voltage clamping elements, and was developed to filter off surge frequencies to eliminate surge related damage, the filters are covered under UL 1283, the Safety Standard for "Electromagnetic Interference Filters".¹

Power quality is an important aspect of any equipment protection program. UL 1449 Listed surge suppressors have been an integral part of such protection programs for many years. Ironically, UL 1283 Listed filters have been developed which outperform UL 1449 Listed surge suppressors in many key respects as described herein.

Zero Downtime Requirements

- Total elimination of the surge event will offer the best possible protection for even the most susceptible products and systems.

- The surge protection circuitry must be extremely robust, avoid sacrificial components, and demonstrate a minimum 1,000 worst-case surge endurance with no degradation.
- The ground circuit integrity must be preserved to avoid introducing noise or damaging other systems on the network. If the power supply is protected but surges diverted to the ground wire damage the sensitive peripherals, we have an incomplete solution.

The Premise

- Powerline surges consist of a brief burst of high frequency energy.
- High frequency energy can be removed with a filter.

Filter Requirements

- IEEE/ANSI C62.41² describes a worst-case powerline surge within a building as a Category B3/C1 pulse with a peak voltage of 6,000 volts, and peak current of 3,000 amps.
- The 120 vac power wave peak voltage is 170 volts.
- UL 1449 minimum SVR (Suppressed Voltage Rating) is 330 volts peak.

A filter that attenuates the 6,000 volt surge by 26 dB will reduce the peak surge voltage to only 300 volts, well below the UL minimum SVR of 330 volts and 130 volts above the power wave peak voltage.

The Weakest Link

How much better than 26 dB can a filter be?

- Electronic systems are becoming increasingly interdependent and important.
- Every system is no better than the weakest link.
- If the worst-case surges can be filtered to below the power wave peak voltage (170 volts peak), damage to even the most sensitive system is avoided- *Zero Downtime* from surges becomes possible.
- Is total surge elimination possible, protecting even the most susceptible system--the weakest link?

Total Surge Cancellation

While pondering the case for total surge removal, a "EUREKA" moment occurred.

Signal cancellation using anti-phase signals have been successfully used in many low level applications.

Is it possible to apply these same principles to the power environment?

Computer Simulation

When dealing with 6,000 volts and 3,000 amps, it is much safer to rely on computer

simulation before experimenting with real world parts. Computer analysis demonstrates that 26 dB attenuation is readily achieved with commercially available filter components.

Further study showed that the input inductor could be tapped and an anti-phase voltage developed. When the anti-phase voltage was added to the output, the surge let-through voltage fell below the power wave peak voltage.

The surge danger was gone!

First Samples

The first physical samples were built using the computer design, and from scavenging some earlier filter products. To our delight, the performance was better than the computer models predicted, since those models assumed worst-case parameters.

A wonderful new technology was born!

How it Works

Refer to Figure 1

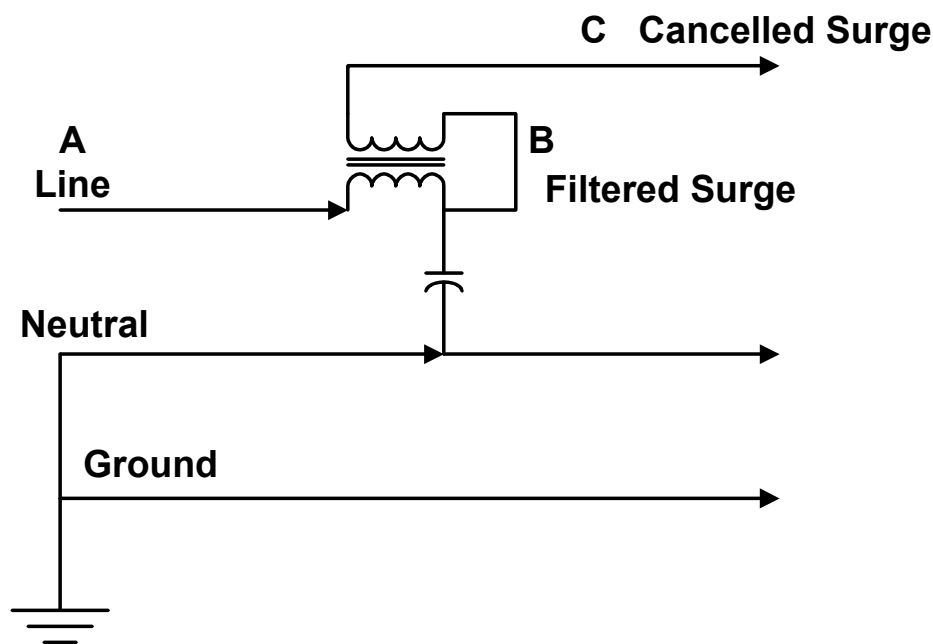


Figure 1

- A surge enters at point A.
- The tapped cancelling winding immediately starts developing a cancelling voltage due to the surge current flowing in the tapped input inductor.
- A slightly delayed 26 dB filtered surge appears at point B due to the low pass filter action of the input inductance and related capacitor which attenuate and delay the surge.
- The cancelling voltage from the tapped inductor is added to point B.
- The cancelling voltage was chosen to just offset the residual voltage from the 26 dB filtering. **The surge is cancelled out!**

Oscillogram Responses

- The following oscillograms in Appendix A compare a baseline 26 dB nominal rejection filter tested with the ANSI C62.41 Combination wave at 4kV, 2kA, with Total Surge Cancellation at 4kV, 2kA and also 6kV, 3kA, all tested with the ANSI C62.41 Combination wave. The horizontal dotted lines represent the power wave peak positive and negative values.
- Since the surge voltage is cancelled to below the power wave peak voltage, down-stream equipment will be unaware a surge event occurred!
- **Zero Downtime from worst-case surge sources can thus be assured for even the most sensitive equipment!**

This new technology using filter concepts has been patented and is described in considerable detail in US patents #6,728,089, 7,068,487 and 7,184,252 and has received Electronic Products Magazine's "2006 Product of the Year" award.

The technology **concept** is readily understood when the following is considered:

- Surges consist of a short burst of high frequency energy.
- The Power Quality Filter first filters off the higher frequencies using an adaptive filter which also delays the resulting attenuated low frequency wave.
- The remaining low frequency energy is then cancelled with the voltage from a phase cancellation winding which has not been delayed, resulting in complete surge cancellation.
- Since the level of phase cancellation voltage to be used can be controlled by the number of turns and the damping on the sensing tapped inductor, the proper voltage needed for total cancellation can be selected.

The resulting UL 1283 Listed Power Quality Filter is in production and has the following desirable characteristics:

- **Permanent** surge and noise protection. (Filter technology does not wear out with use). **10 year warranty.**
- **Total Surge Cancellation**--Surge danger is simply eliminated!
- **No danger to connected equipment.** (Mode 1 operation--no ground wire contamination).
- **No series mode filter technology failure** in 18 years using patented core technology.
- **Can operate over wide voltage ranges**--85-265 volt rms operation has been achieved.
- **Protection working indicators or alarms are not required**--no history of failure.
- **1,000 worst-case surge endurance rating** with no degradation is standard.
- **No "Joule rating" or "I Max" limitations**--MOVs are not used.
- **Enhances X-10 and other automation signals** on powerline due to compatible input impedance at carrier frequencies.
- **No history of fires or explosions.**

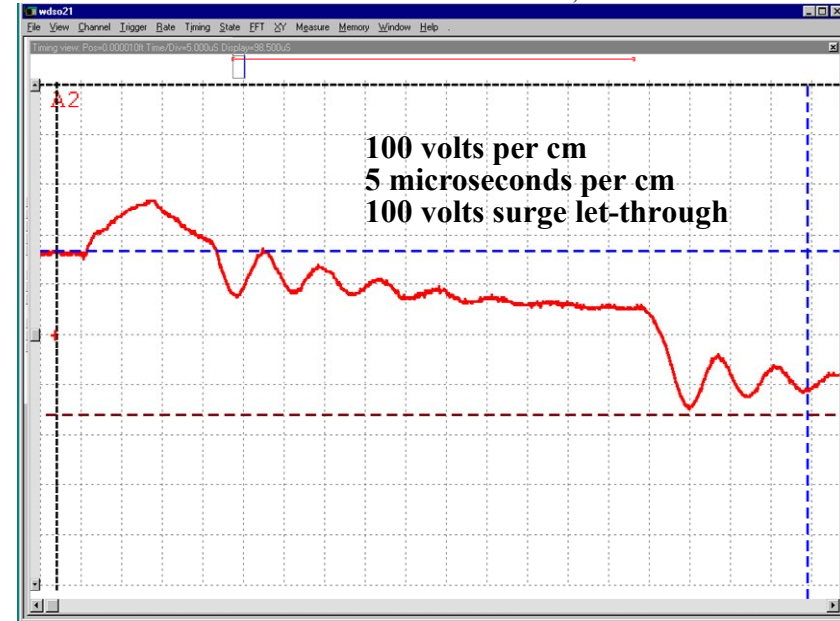
References:

¹ Underwriters Laboratories, Melville, NY
Tel. #631-271-6200

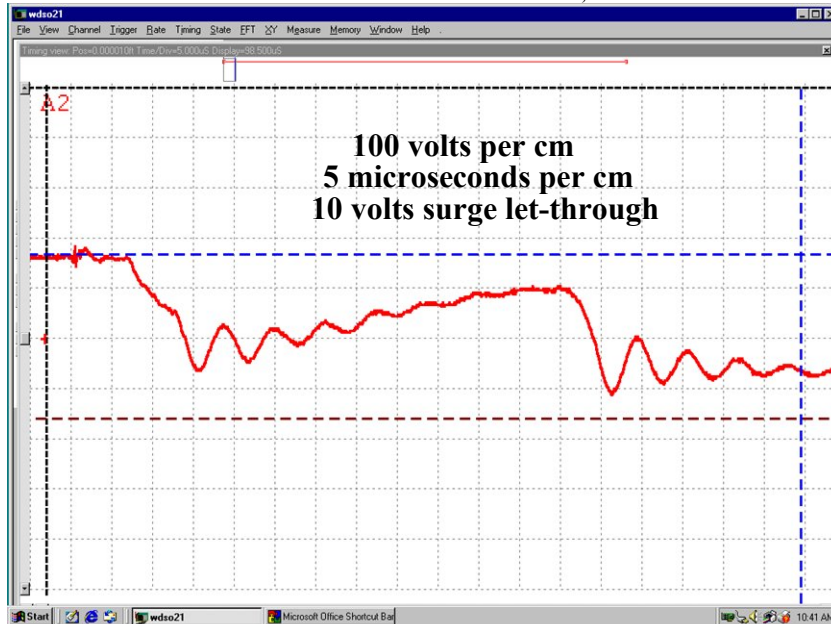
² IEEE/ANSI C62.41, 3 Park Avenue, NY, NY

Appendix A: Oscillogram responses to dangerous surges

BASELINE RESPONSE TO 4KV, 2KA SURGE



TOTAL SURGE CANCELLATION RESPONSE TO 4KV, 2KA SURGE



TOTAL SURGE CANCELLATION RESPONSE TO 6KV, 3KA SURGE

