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White Paper

ADSL Communication Line Protection

Practical Solutions for
Protecting ADSL Equipment
From the Effects of Lightning Induced Transients

presented by
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This paper reviews typical protection technologies and illustrates why classic communication line surge protectors are inadequate for high-speed ADSL applications.

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Introduction

Asymmetric Digital Subscriber Line (ADSL), like any new technology, requires special implementation considerations. Much attention has been given to ADSL modulation techniques and to managing the wide dynamic range of ADSL signals — enabling existing telephone lines to simultaneously transfer high-bit-rate ADSL signals with Plain Old Telephone Service (POTS) signals, without interfering with nearby communications services. Little attention, however, has been given to the effects of lightning induced transients on the ADSL systems that share telephone lines with POTS signals.

Recent evidence has shown that the classic telephone line surge protector that may have been adequate for protecting POTS equipment is not adequate for protecting the high-speed ADSL equipment that shares the same wire pair. ONEAC has developed a unique patented surge protection device, tailored to the protection requirements of high-speed ADSL equipment while maintaining the high breakdown voltage requirements for passing POTS signals.

The balance of this paper will explore ADSL transmission technology and describe ONEAC's ADSL protector which provides the highest level of protection for ADSL and POTS equipment sharing the same telephone cable.

ADSL Systems and the Need for Protection

ADSL equipment has been designed to operate on the extra bandwidth of POTS lines not used by plain old telephone services. While POTS lines have a usable bandwidth that extends from DC to as high

as 10 MHz, plain old telephone service uses only the bandwidth from DC to approximately 4 kHz. ADSL signals occupy the higher frequency (above 25kHz) portion of the available bandwidth of these lines. This allows ADSL and POTS to exist simultaneously on the same pair of wires as shown in figure 1.

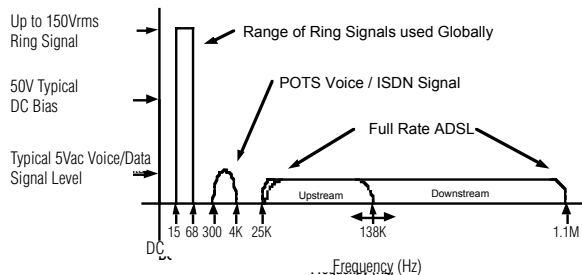


Fig 1: ADSL Service Spectrum Utilization

The Need for Protection

Lightning induced transients on plain old telephone lines contain electrical energy in the frequency band from DC to the maximum frequency that a telephone line will pass. Most of this energy is in the frequency band in which ADSL operates, with a much smaller portion of total energy in the POTS frequency band.

Since ADSL equipment is specifically designed to respond at the frequencies where lightning induced transient energy is the strongest, ADSL equipment is far more susceptible to damage from the high voltage, high frequency components of lightning induced transients.

Classic surge suppression devices installed on telephone lines do not activate until the peak voltage exceeds the combined level of the voice, ring, and DC bias present on the line. This peak operating voltage level can be as high as 270V in the United States. Protection circuits that do not operate until transient voltages exceed the peak operating voltage, offer little protection for the low voltage, high frequency equipment that may share the same communication line.

Classic Telephone Line Protection

Telecommunication lines are generally balanced lines using twisted pair cabling. In this situation, lightning strikes typically cause common mode (longitudinal) transients because the impedance of each wire of the balanced pair is identical; hence, equal voltages and currents are induced onto each wire of the pair relative to earth. Differential mode (metallic) transients, where a voltage difference appears across the pair of wires, may result directly from lightning strikes, but this is rare. Most differential transients that appear on telephone lines are a result of mode conversion that takes place because of the type of circuits that are used for protecting telephone lines.

Today, the most common protection circuits used on telephone lines are “Conventionally-Balanced” and “Star-Balanced” configurations.

Conventionally-Balanced Protectors

Conventionally-balanced overvoltage protectors for balanced telecommunication lines use individual voltage suppression devices on each wire of the twisted pair (see figure 2). Typically, these are crowbar-type devices that employ individual gas tubes or solid state thyristors. For this type of protector, the breakdown voltage across the pair is twice the breakdown voltage rating of each wire to the earth terminal. These protectors preserve the balance on the communication lines only when the breakdown characteristics of the voltage suppression devices are identical.

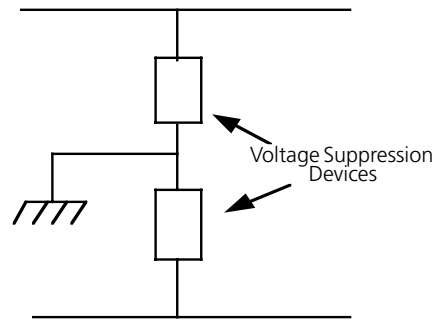


Fig 2: Conventionally-Balanced Overvoltage Protectors

When the voltage breakdown characteristics of the voltage suppression devices are not identical and only one device activates, common mode transients are suppressed on only one side of the balanced line, resulting in a voltage differential across the pair of wires. This process of converting a common mode (longitudinal) transient into a differential mode (metallic) transient is usually referred to as mode conversion. Since communications terminal equipment is designed to respond to differential mode signals, this type of equipment is usually susceptible to damage from high voltages in the differential mode. Mode conversion is responsible for much of the voltage transient damage to communications terminal equipment.

Even when the breakdown voltage of the two devices is identical, mode conversion still exists unless the reaction time and characteristics during foldback are identical. Protectors, which are not well balanced during transient conditions, may limit voltages to non-hazardous levels for service personnel, but convert non-destructive common mode transients to differential mode transients — which may destroy attached communications terminal equipment. In addition, these protectors only limit differential transients to twice their longitudinal voltage breakdown rating.

Star-Balanced Protectors

The star-balanced overvoltage protection configuration (see figure 3), using crowbar type voltage suppression devices, overcomes many of the limitations of the conventionally-balanced protector. When the suppression devices on one side of the balanced line activate, the breakdown voltage on the other side of the line is reduced, causing the other voltage suppression devices to quickly activate if common mode transients are occurring. After all voltage suppression devices activate, there is no differential voltage across the wire pair; hence, mode conversion has been stopped. When the star-balanced configuration is used, mode conversion (and the potentially destructive differential signals that result) can only exist during the transition time of the voltage suppression devices.

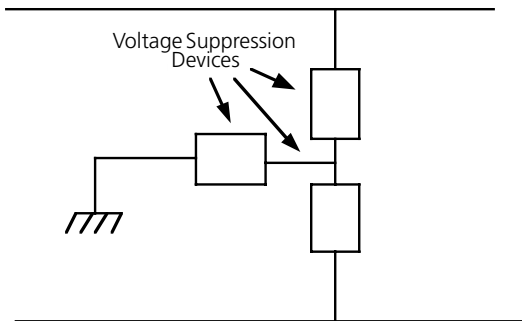


Fig 3: Star-Balanced Overvoltage Protectors

In addition, the metallic breakdown voltage of the star-balanced protector is the same as its longitudinal breakdown; so transients are limited to the rated breakdown voltage regardless of the type of transient.

The ONEAC Difference

Patented SwitchedFilter™ Technology

While the star-balanced configuration provides improved performance as compared to conventionally-balanced protectors, potentially destructive differential voltages are limited only to the device's breakdown voltage. To improve this protector performance even further, ONEAC adds a second stage to the star-balanced protector configuration.

ONEAC's ADSL protector with patented SwitchedFilter technology significantly reduces the differential transient voltage below the rated breakdown voltage of the protector, whether the differential voltage occurred directly or resulted from mode conversion. It not only reduces the differential transient voltage let-through, but also reduces edge speed of fast transients to levels which communications terminal equipment is less sensitive. Even with this significant improvement in protector performance, the low frequency, high voltage signals, and high frequency, low voltage signals of the communications services on the line are unaffected.

Overall, ONEAC's ADSL protector includes:

- The fast reaction time of solid state thyristor type overvoltage suppression devices
- Resettable sneak-current protection via ceramic PTC's for precise resetability
- Low insertion loss to preserve signal frequencies up to 30 MHz
- ONEAC's patented SwitchedFilter technology

The Test

Five protectors were tested — conventionally-balanced gas tube and solid state, star-balanced gas tube and solid state, and ONEAC ADSL protector with patented SwitchedFilter Technology. All five protectors had identical breakdown values of 335V. The transient surge waveform pictured in figure 4 was applied differentially to each of these protectors.

Note: The surge generator employed for these tests has higher-speed noise superimposed on the leading edge of the waveform (as shown in the expanded view, figure 4) to simulate the noise transients that occur on communication lines during lightning strikes.

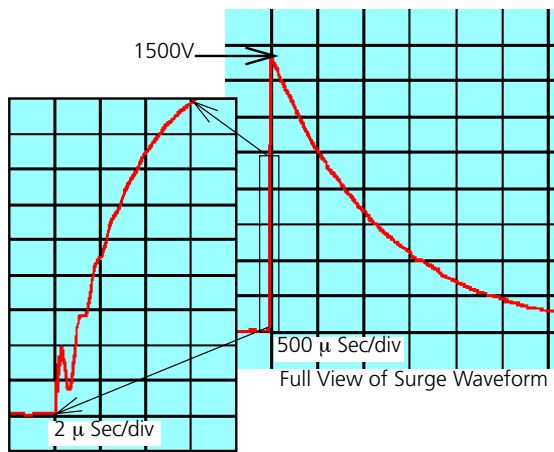


Fig 4: Surge Waveform

A Side-by-Side Protector Comparison

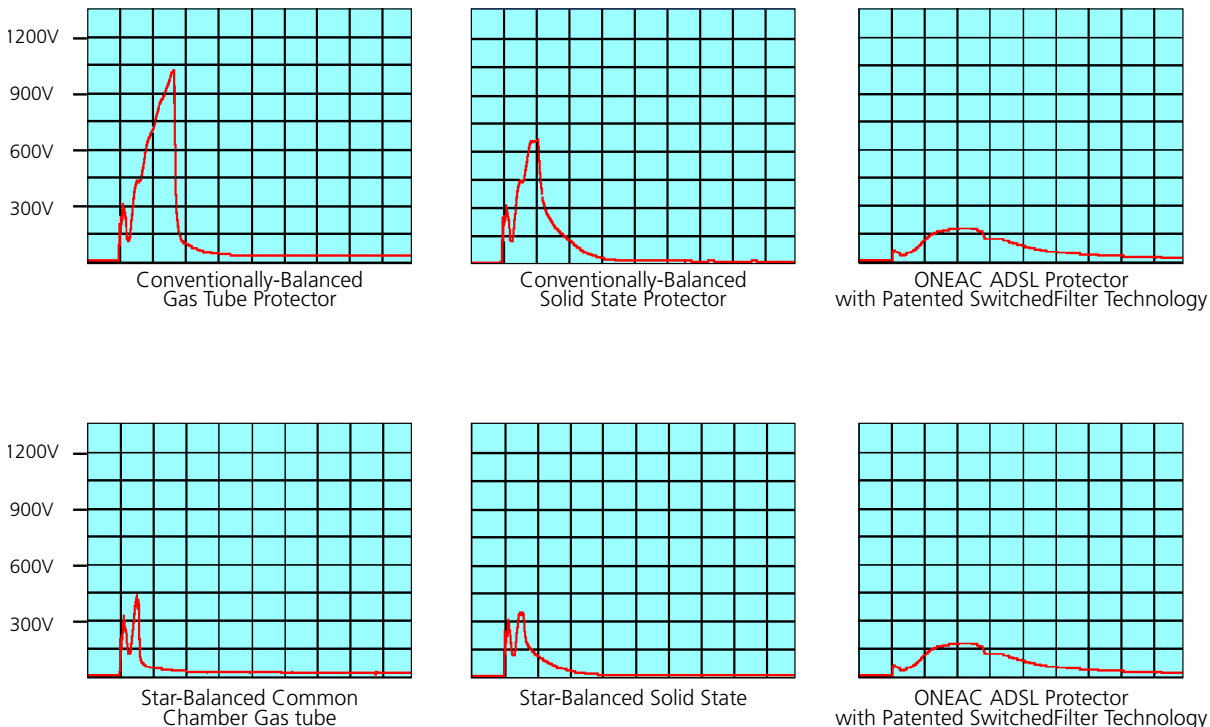


Fig 5: Metallic (Differential) Mode Let-Through Voltage Shown in 2 μ Sec Divisions

Conclusion

The oscilloscope readings pictured in figure 5 illustrate that most of the high-speed noise, superimposed on the leading edge of the surge waveform and passing through classic POTS protectors, is eliminated by the ONEAC ADSL protector. Further, the peak differential transient voltage let-through has been dramatically reduced. Two reasons why an ONEAC ADSL protector greatly increases the protection provided to the ADSL and POTS equipment that share the same telephone cable.

Case in Point

A major U.S. telephone company had approximately 15,000 ADSL service lines to protect. Recently, they conducted a test where approximately five-thousand of those lines were treated with ONEAC's ADSL communication line protectors. The remaining ten-thousand ADSL service lines were protected by classic solid state POTS protectors.

During the comparison period, two minor storms passed through the area. Dozens of the ADSL interface circuits that were protected by classic POTS protectors failed, while none of the ADSL interface circuits protected by ONEAC failed. The ADSL equipment protected by ONEAC continued to provide uninterrupted service.

Full details are available from ONEAC in North America by calling 1-800-327-8801 or online at www.oneac.com.

About the Author

Vince Knigge is an Engineering Manager for ONEAC Corporation and is responsible for design and engineering of all ONEAC's voice and data line protection devices. He has five years experience in design of medical electronic products and over twenty years experience in design and design management for telecommunications products including network switching systems and customer premises equipment. Mr. Knigge holds a BSEE degree from the University of Michigan.

About ONEAC

ONEAC, a wholly owned subsidiary of Chloride Group, PLC, was founded in 1979. ONEAC designs and manufactures products that provide the highest level of protection against power, voice and data line disturbances, regardless of conditions. ONEAC's comprehensive product lines include power conditioners, power conditioned uninterruptible power supplies and voice & data line protection devices. With ISO9001 certified manufacturing plants in the U.S. and U.K., ONEAC is dedicated to demand-flow manufacturing and the highest quality standards.

Organizations whose productivity goals allow no possibility for system downtime use ONEAC. They include many of the world's leading companies, in a wide range of applications including telecommunication systems, information technology, retail information systems, computer-integrated manufacturing systems, semiconductor test equipment and biomedical instrumentation and information systems. Information on ONEAC products and services is available on the Internet at www.oneac.com.



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