Surge Protection's Essential Role in the Cable Telecommunications Triple Play

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Surge Protection's Essential Role in the Cable's Telecommunications Triple Play

By Justin J. Junkus

The triple play of video services, high speed data, and voice services is well known as a marketing and technology strategy in the cable telecommunications industry. Cable has spent almost a decade preparing for it -- first with Hybrid Fiber Coax, then with two way 750 MHz and above systems, and finally, with protocols and standards that deliver Quality of Service and 5 nines of reliability. Because of this attention to detail, MSOs can now deliver services that connect diverse consumer electronics devices, video systems, computers, household monitoring, and telephony. While this cornucopia of choices opens the door to unprecedented revenue opportunities, it also exposes a potential chink in cable's armor. Without an additional investment of about $4.00 per home, cable operators are exposed to consumer liability that could negate years of market penetration.

Electrical surges on the coaxial cable connection to the cable subscriber's home are random events that can send over 100,000 amps of current into a line that connects to fragile microcircuits, or, worse yet, to a subscriber's telephone handset. The main sources of these surges are lightning and voltages from power lines that accidentally make contact with the communications line during storms or construction activity. Lightning surges are the more common of these two conditions, and while some regions of the U.S. are more susceptible to lightning than others, the relatively low cost of in-line surge protection justifies its application in all installations.

This paper discusses how lightning entering the home via a communications line can cause extensive damage, and presents a simple way to avoid the liabilities from personal injury and consumer electronics damage that can occur from lightning surges. It looks at historical precedence from the telephone industry that points to surge protection becoming a requirement for cable providers offering telephony, and presents a business case argument that supports making inline surge protection part of the cable drop. Finally, it discusses the standards for surge protection, and shows why TII Network Technologies surge protection devices are the optimal solution for protecting a cable company's coaxial communications lines in terms of both satisfying the standards and maintaining the electrical characteristics of the communications line under normal service conditions.

Why Lightning Should be a Concern to all Cable Operators

Lightning can be particularly damaging to a home or business because it can travel over many paths through electrical circuits on its way to ground. Not all of these electrical circuits are associated with electronics or even wiring. Lightning finds paths to ground via any conductor or combination of conductors, including water-filled plastic pipes, metal building framework, and even sap-filled wooden studs. In addition to the energy conducted in a direct strike, lightning can also cause damage by magnetic and electrical induction. Studies have shown that electric fields of up to 500 Kilovolts per meter are present 100 meters (300 feet) away from a direct strike[1].

What this means to cable operators is that they cannot assume that lightning will automatically take a path to ground through a given piece of network equipment. Believe it or not, there is a school of thought that thinks of a cable modem, for example, as a surge protector. The rationale is that the combination of a relatively low probability of a lightning strike and a low impedance path through the cable modem or MTA is cost-effective protection for subscribers and the equipment they attach to the cable network! In reality, lightning's rapid current rise time will cause a strike to seek ground based upon response times of a path, rather than impedance. That path may be through consumer electronics, telephone equipment, or the

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[1] EMC for Systems and Installations Part 5 - Lightning and Surge Protection By Eur Ing Keith Armstrong C.Eng MIEE MIEEE Partner, Cherry Clough Consultants, Associate of EMC-UK in EMC Compliance Journal, http://www.compliance-club.com/archive1/001018.html#5.2

service provider's customer, rather than service provider equipment. Unlike paths to ground in silicon or other circuitry, in-line surge protection is the only safe protection against a lightning surge. It is specifically designed to take both impedance and impulse rise time into account in providing far superior protection.

The power in a lightning strike is truly awesome. A typical lightning strike can last for over one second and consist of many 'strokes' (discharges), sometimes over ten, each with an 'arc-channel' current of between 2kA and 200kA (1% of strokes exceed 200kA).[2] A typical stroke reaches peak current in 2 microseconds, and decays to half peak in 40 microseconds.[3] This is a very short interval compared to the .16 second (160,000 microseconds) required for one cycle of commercial AC power.

Although exact prediction of a lightning strike is impossible, statistical probabilities can be derived for the likeliness of a strike, based upon past history and environmental factors. Vaisala, Inc. (www.vaisala.com) is a company that maintains a national lightning detection network. It uses data from this network to track lightning and produce maps that correlate location of strikes to the time they occur. Studies of this data over time reveal that certain parts of the United States are more prone to occurrences than other parts of the country. Some obvious local factors such as soil moisture content and elevation affect the likelihood of a strike. Other conditions are not as easy to correlate. One study, for example, indicated that ground temperature affects the likelihood of a strike. Lower ground temperatures decrease the probability that a strike will occur.

Although the frequency of lightning strikes varies by region, it is wrong to think of lightning protection as a regional issue. The odds of a strike change, but the damage remains the same. When lightning damage occurs, it can be substantial, and consumers will look for ways to recover their losses. Insurance often provides coverage only above a deductible amount for consumer electronics. In today's legal system, personal liability is virtually unlimited in several jurisdictions.

The good news is that while lightning can enter a home or business via many paths, only one of those paths is the responsibility of the cable service provider. A cable company that blocks surge energy at its line into the customer's premises greatly reduces the possibility that the source of surge damage was the cable operator's network connection, and shows due diligence on the part of the cable system operator. As the business case later in this paper shows, an incremental investment of less than 3% per subscriber line is low cost "insurance."

Telephony Service Carries Extra Liability

Telephone service adds another dimension to the damage that can be caused by lightning and other line surges. Unlike most of the consumer electronics that historically connects to a cable system, the telephone earpiece is meant for close contact with the user's head. This almost guarantees that any surge reaching the phone will travel directly to that part of the subscriber's body.

The telephone industry recognized this problem over a hundred years ago. As telephony proliferated, it became apparent that the phone company's manual switchboard operators were increasingly susceptible to shocks from lightning carried over the metallic pairs between the subscriber and the telephone company offices. More out of concern for a continuing ability to recruit telephone operators than protecting its subscribers (liability laws were different then!), the phone company began installing simple carbon block protectors on each subscriber line. These devices consist of two carbon blocks, each connected to one of the telephone wire pairs, and separated from each other by an air gap. Within the gap, a metallic plate is connected to ground. Lightning strikes arc across the gap to ground, rather than through the subscriber's or

[2] EMC for Systems and Installations Part 5 - Lightning and Surge Protection By Eur Ing Keith Armstrong C.Eng MIEE MIEEE Partner, Cherry Clough Consultants, Associate of EMC-UK in EMC Compliance Journal, http://www.compliance-club.com/archive1/001018.html#5.2

[3] Lightning Facts, Jim Lux, www.home.earthlink.net/jimlux/lfacts.htm

telephone operator's equipment.   Although there is no known business case that supported the addition of carbon block protectors to subscriber lines, the argument must have been intuitively obvious. The ad in Figure 1 dating to the early 1900's indicates that these protectors cost around 65 cents at the time, representing far more than the 3% incremental investment required today to protect against lightning surges[4].

FIGURE 1 - Early ad for telephone lightning protection

Today, the telephone industry continues to protect its communications line into the subscriber's premises, although the technology of surge protection has changed the type of protection.   Gas-filled surge protectors are specified by Bell Communications Research specification TR-TSY-000070. Telephone company requirements for surge protection are discussed further in the section of this paper that looks at the standards for measuring surge protection.

How Likely Is Lightning Damage to Subscriber Equipment?

As this paper noted earlier, the underlying physics of lightning give it a myriad of paths to ground. This makes assigning exact probabilities to a lightning strike at any given point and time almost impossible. Fortunately, however, we can come within reasonable statistical limits by applying some historical data and simplifying assumptions.   This type of analysis is an excellent framework for making economic business decisions regarding the addition of in-line surge protection to cable plant.

As preparation for the business case, let's list some facts about lightning that will help in the analysis:

- The American Meteorological Society has published an extensive analysis of cloud to ground lightning strikes in the United States over the ten years from 1989 - 98[5]. This analysis has yielded the mean annual lightning flash density in flashes per square kilometer, for every area of the country. It is based upon data on 216 million lightning flashes as measured by a grid of sensors separated by distances ranging from 75 to 525 kilometers. That data is summarized in the map in Figure 2

[4] Ad from Sumter Telephone Mfg, Co., as displayed at www.sandman.com/images/oldground.jpg
[5] Orville, Richard E. And Huffines, Gary R., Cloud to Ground Lightning in the United States: NLDN Results in the First Decade, 1989-98, as published in Monthly Weather Review, 129, No. 5, May, 2001, pages 1179-1193.

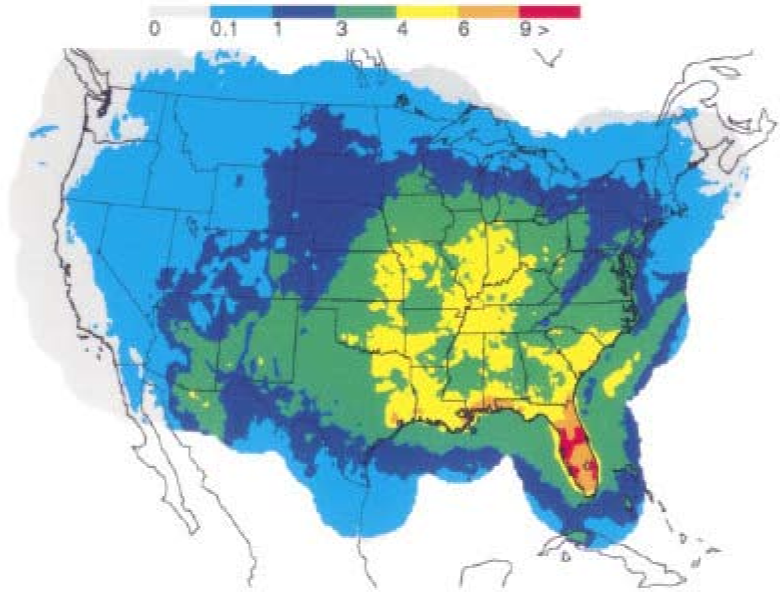


FIGURE 2
MAP OF MEAN ANNUAL FLASH DENSITY[6]

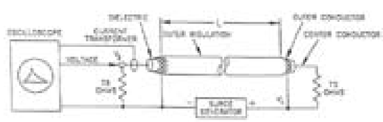
- In a perfect scenario of flat land, the probability of a lightning strike can be estimated by multiplying the number of square kilometers in the "target" area by the density data from the study.
- Within any given area, certain factors can increase the likelihood of a lightning strike. These include the presence of high structures such as trees or poles, the height of buildings in the area, the type of material used in the building's construction, and the number of these structures within the given area.
- The practical implication of these factors is that when they are present, the "lightning attractiveness" of any given area increases. The accepted way of dealing with this increased attractiveness is to adjust the lightning attractive area to a larger surface area.
- The precision of the adjustment depends upon how much is known about the mitigating factors. For example, if 30 foot metal poles with a 6 inch diameter are the only factor, a mathematical adjustment can be precisely made. On the other hand, if trees, houses, and cable plant enter the equation, the adjustment depends on intuitive, as well as mathematical, modifications.
- Sample calculations show that the probability of a direct strike to a typical house in an open area with 4 cloud to ground flashes per square kilometer per year is 1 in 200 -- meaning that 1 out of 200 houses would be struck per year[7]. For a grid of twelve 32 meter perimeter light poles in a 45000 square meter area, the probability of a strike increases to one in 17, even with a reduced flash density of .5 flashes per square kilometer per year.
- A strike does not need to be a direct strike to cause damage to consumer equipment. Strikes to the earth induce surge voltages in buried coaxial cable that can damage semiconductor components. Although the earth has inherent impedance that reduces the magnitude of surges in buried cable, one model indicates the surge from a 13 kA strike with a rise time 40 kA/microsecond, hitting the earth 10

[6] Orville and Huffines, Ground to Cloud Lightning in the United States, Monthly Weather Review, May, 2001, p. 1183.
[7] National Lightning Safety Institute, General Interest # 7, Lightning Strike Probabilities, as documented on www.lightning safety.com/nlsi_pls/probability.html.

meters away from a line termination, can be almost 300 volts in the center conductor of a cable buried 1 meter below the surface[8].

- Tests by TII Network Technologies of voltages induced on the center conductor of a length of coaxial cable by lightning surge voltages applied directly to the outer conductor indicate center conductor voltages up to 1600 Volts, with current at 2 Amperes. The magnitude of voltage and current depends upon the length and type of coaxial cable. (Figure 3-a and 3-b)
- If the strike is to a point near an aerial cable, substantial physical damage to the cable may also occur, as shown in Figure 4. (Note that even in this case, in-line surge protection can stop the damage at the entrance to the customer's premises.)

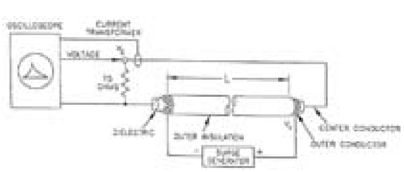
- 2KA, $^{10}/_{250}\,\mu$s surge applied on outer conductor
- Monitored induced voltage and current on inner conductor for various lengths of coax cable



Cable Length (ft)	RG 59 Induced Current (A)	RG 59 Induced Voltage (V)	RG 6 Induced Current (A)	RG 6 Induced Voltage (V)	RG 11 Induced Current (A)	RG 11 Induced Voltage (V)
20	1.8	120	1.5	110	1.2	85
50	3.0	220	2.6	180	2.0	150
100	5.0	350	4.0	300	3.0	240
200	6.0	460	5.2	400	4.5	330

FIGURE 3-A TII INDUCED VOLTAGE TEST

- Repeated Experiment 1 with inner conductor completely isolated from outer conductor
- Monitored induced voltage and current on inner conductor for various lengths of coax cable



Cable Length (ft)	RG 59 Induced Current (A)	RG 59 Induced Voltage (V)	RG 6 Induced Current (A)	RG 6 Induced Voltage (V)	RG 11 Induced Current (A)	RG 11 Induced Voltage (V)
20	1.0	750	0.9	700	0.7	650
50	1.4	1050	1.3	1050	1.6	1000
100	1.5	1150	1.6	1300	1.7	1300
200	1.75	1300	1.8	1500	2.0	1600

FIGURE 3-B TII INDUCED VOLTAGE TEST WITH ISOLATED CENTER CONDUCTOR

[8] Lightning Induced Voltages on Buried Shielded Cables, R. Suresh Babu and M. Joy Thomas, in the Proceedings of INCEMIC, 2003.

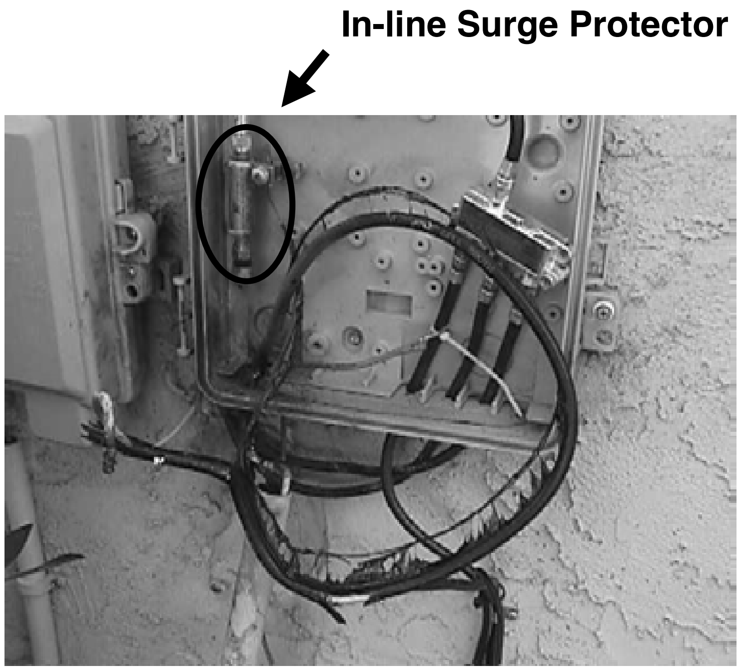


FIGURE 4 LIGHTNING DAMAGE TO COAXIAL CABLE
STOPS AT IN-LINE SURGE PROTECTOR

The Business Case for In-Line Surge Protection

There is a good business argument for adding surge protection to a coaxial cable line to the subscriber premises --- as discussed earlier, it effectively removes the cable service provider from the list of parties from which a subscriber will seek damage or injury reimbursement.

The value of being able to prove that the coaxial drop into the home was not the cause of damage to subscriber equipment can be quantified by a simple business case analysis. To be conservative, we will initially eliminate personal injury liability damages from the analysis, and will concentrate on the cost of replacing increasingly typical consumer electronics.

The ability of lightning energy to enter a structure via connecting wires greatly increases the odds of a hit. We will limit our calculations to the drop, or plant running from the tap to the customer's home or business.

A couple of properties of lightning make our calculation easier. Recall from the previous section of this paper that tall structures within the area such as poles and buildings, increase the lightning attractive area, and that lightning will travel from a direct strike to conductors within a reasonable distance. Because of these facts, the National Lightning Safety Institute (NLSI) considers hits within 10 meters (about 30 feet) to be direct strikes.[9] Also, as noted earlier, lightning will induce voltages even in buried cable.

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[9] www.lightningsafdty.com/nlsi_pls/probability.html.

Our first cut at the probability of a strike that will induce damaging voltages will therefore consider the total surface area of a typical residential lot within the cable telecommunications provider's franchise as a potential target for a damaging lightning strike.

To be conservative, consider the surface area of a residential lot in an urban or suburban subdivision. This will, of course, vary by housing density; however, since we are looking at the potential for damage to high end electronics, let's begin by assuming a subdivision with quarter acre lots. One square mile is 640 acres, and one square mile is 2.59 square kilometers, so our exposure area is .25 x 2.59/640 = .001 square kilometers.

The probability of a strike to a quarter acre lot in an area with a strike density of 4 flashes per square kilometer per year is therefore .001 x 4 = .004. The damage will be greatest if the strike is direct to the home or entry cable. However, as noted earlier, even a strike to the earth's surface can cause semiconductor-damaging surges. The economics of this damage depends upon the number and type of consumer electronics equipment in the home, as illustrated in Table 1

Type of consumer electronics in high end home	Typical cost to replace	Probability of lightning strike per year for any one high end house	Likely liability (cost x probability)	Number of homes that could be surge protected by cost of replacement of one item of this type (Liability/$4.00 protector cost)
Analog TV	$200	.004	$.80	.2
LCD HDTV display	$2000	.004	$8.00	2
DVD player	$100	.004	$.40	.1
Personal video recorder	$350	.004	$1.40	.35
Digital set top	$350	.004	$1.40	.35
Cable modem	$150	.004	.6	.15
Personal computer	$600	.004	$2.40	.6
Printer	$100	.004	$.40	.1
Telephone keyset	$50	.004	$.20	.05
Home network router	$50	.004	$.20	.05
Digital receiver	$400	.004	$1.60	.4
Cumulative for high end house			$16.80	4.35
Total liability based upon 100 high end homes in serving area (20% of those served by a 500 home node)			$1680	435 (almost entire set of homes served by the node)

TABLE 1: BUSINESS CASE FOR IN-LINE SURGE PROTECTION

The bottom line is that for new installations (for which a customer premises visit is already required), the cable company can recover the cost of protecting itself from consumer electronics lightning damage claims for the entire set of homes served by a node in a little over one year! For current subscribers, additional cost of a truck dispatch to install in-line surge protection can be avoided by scheduling this installation as part of normal move and change work required as homes are sold.

After year one, the total system savings depends upon the number of homes served. For example, in a 10,000 home system, $168,000 per year could be saved in replacement costs. A similar analysis can be made for personal liability injuries, with far more dramatic results, since the typical personal liability claim is orders of magnitude above the value of consumer electronics used in this business case.

How In-Line Surge Protection Works

In-line surge protection functions by diverting surge energy from the signal path to ground. This diversion is done by a triggered short. When the input voltage rises above a "clamping" value, it causes a change in the electrical properties of that path to ground. When the voltage is below the clamping value, the path to ground presents a high impedance (electrical resistance to current flow) for any current flowing through the device. Intended signals therefore ignore the path to ground, and flow as though the device were not present. When the clamping value is exceeded, the impedance drops to a point where the path to ground is the easiest one for current to follow. This is illustrated in Figure 5.

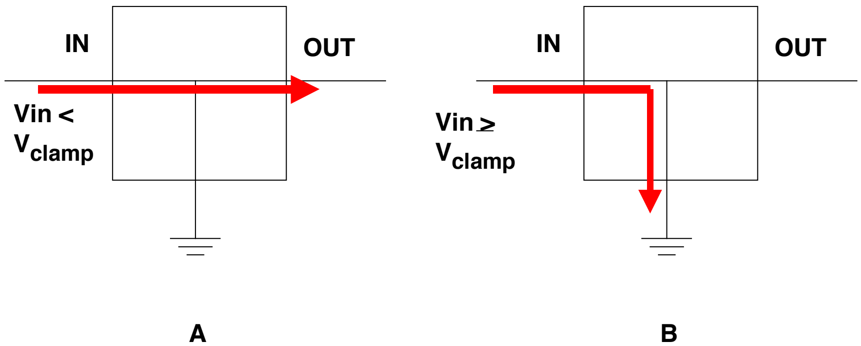


Figure 5. Current flow in surge protector
A. Normal operation B. When clamping voltage level is exceeded

There is a practical caveat in choosing devices that shunt energy to ground when voltage levels reach a trigger value. Although these devices should be completely transparent during normal conditions, any component inserted in a signal path adds some impedance and can also contribute to other types of signal degradation. It is important to analyze the specifications for a surge protector to ensure signal quality is not compromised during normal operation. For example, the Network Technologies TII 210 and TII 212 surge protectors, which are in-line devices for use on a coaxial cable line, have an insertion loss of less than .01dB over both forward and return frequencies, and a return loss of better than -50 dB in the return path and -30 dB in the forward path. This range indicates virtually no effect upon signal quality during non-surge conditions.

Standards for Measuring Surge Protection

Given that in-line surge protection makes economical sense, it is important to choose protective devices and their location based upon recognized benchmarks. The Institute of Electrical and Electronics Engineers, Inc. (IEEE), the National Electrical Code (NEC), Bellcore, and the Society of Cable Telecommunications Engineers (SCTE) provide excellent guidelines.

To begin, it is necessary to understand how surge protectors are specified and tested to ensure they will do the job. Since raising a protector on a high pole during a thunderstorm and waiting for a strike is impractical, several simulation tests have been developed. At the core of the test process is the generation of an agreed-upon waveform that approximates the effects of a lightning strike.

Specification C62.41-1991, the IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, discusses several types of waveforms that can be used to simulate surge voltages, including lightning. The waveforms can be grouped into two main categories: ringing and impulse. Impulse waveforms are applicable to lightning behavior outside a structure. Combination waveforms are a subset of impulse waveform, that specifies both voltage and current behavior.

Figure 6 is a general representation of an impulse waveform which will help in the interpretation of specifications for surge protection. Typically, an impulse waveform is specified in terms of its time to peak value, and its time to decay to 50% of peak. Referring to figure 6, the general designation for an impulse waveform is T1/T2. Examples are 10/100µsecond and 1.2/50µsecond. The peak value depends upon the exposure level being simulated. IEEE specification C62.41-1991 gives ranges from 6 to 20 kiloVolts.

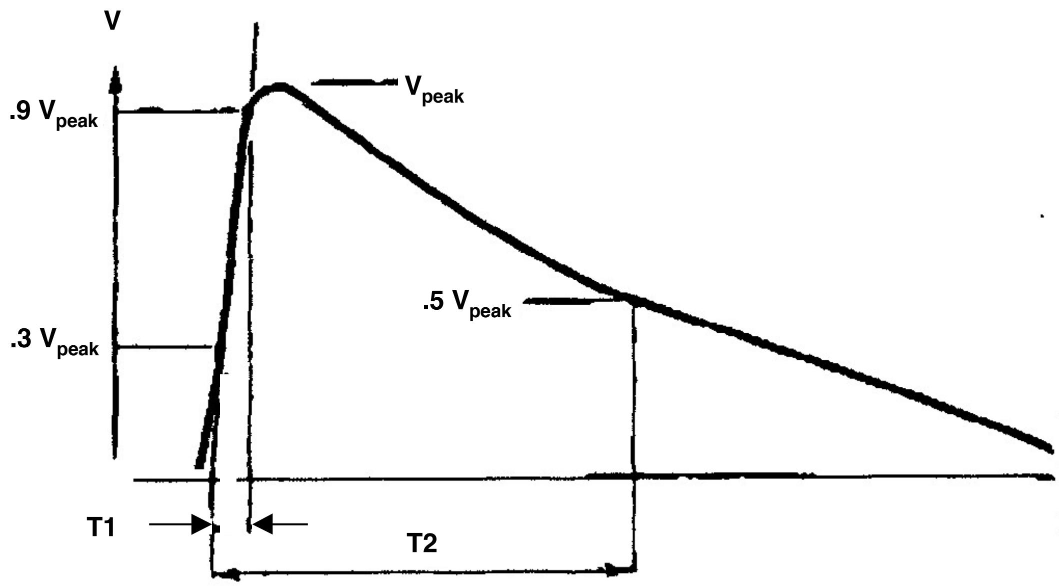


FIGURE 6 - SURGE VOLTAGE WAVEFORM

Although it has been common to represent lightning by a combination wave defined by a voltage surge of 1.2/50µseconds and a current surge of 8/20 µseconds, the communications industry has traditionally used a 10/1000 µsecond wave for surge protection requirements. Both the longer rise time and the longer decay time impose more stringent requirements on surge protection devices, and more closely simulate a lightning strike that could propagate its damaging effects beyond the entrance to a building.

Given an accurate simulation of the current and voltage in a lighting strike, the next step is to decide on the particular tests that will use this simulation. The telephone industry, having addressed the problem of subscriber line surge protection for over 100 years, is a good source for benchmarks. The technical references published by Bellcore, the first research arm of the divested Bell companies, is a good source of documentation. Bellcore specification TR-TSY-000070 specifies the acceptance tests for customer station gas tube protector units. Table 2[10] lists those tests for lightning.

Test current	Life Objective - number of operations	Life Requirements - number of operations
+/- 10 A, 10/1000 µseconds	1000	500
+/-100 A, 10/1000 µseconds	100	
+/-300 A, 10/1000 µseconds	50	10
+/-2000 A, 10/250 µseconds	5	

TABLE 2 BELLCORE LIGHTNING TESTS FOR SURGE PROTECTORS

Bellcore also specified several environmental tests, including vibration and shock, temperature and humidity, stress cracking, mechanical fit, and the maximum number of faulty devices in a year.

[10] from Table 6-1, Service Life Test Conditions, Bellcore TR-TSY-000070, Iss 1, Feb., 1985, p.6-2.

Finally, the recommended location for surge protection is covered by the National Electrical Code (NEC). Because the cable telecommunications industry has changed so rapidly, it requires some analysis to understand how the standard should be applied to in-line surge protection.

Article 830, Network Powered Broadband Communications Systems, was created as a standard for emerging triple play applications. At the time it was written, it appeared that cable operators would opt to power broadband customer premises equipment via the coaxial cable center conductor. The earliest broadband application was telephony, and first applications duplicated the telephone company practice of network powering to ensure reliability. Many cable companies, however, were unwilling or unable to commit to an overlay power grid, and premises powering has became a popular option. Article 830, as written at year end, 2004, does not cover the protection of cable telecommunications broadband lines that connect to premises-powered equipment. The SCTE has therefore formed a committee to examine article 830 and make recommendations for its revision.

Some idea of the intent of Article 830 and the direction of possible changes for premises-powered equipment can be gained from Article 830.30, which states that "Primary electrical protection shall be provided on all aerial or underground network-powered broadband communications conductors that are neither grounded nor interrupted, and are located within the block containing the building served so as to be exposed to lightning or accidental contact with electrical light or power conductors operating at over 300 volts to ground." This is reinforced by similar wording in Article 800.30, which covers protection devices for communications circuits in general. Even without any further revision to the code, the wording in Article 800.30 applies to the center conductor of coaxial cables.

How Do You Know Surge Protection Has Done its Job?

The best devices are those that continue to operate for multiple surges. This characteristic of continued operation makes it difficult to track the number of times that surge protection has done its job. One indication is a visual inspection that indicates damage up to the point of protection. The dramatic photo of an actual field application of TII Networks surge protection in Figure 4 is an example. Note that the coaxial cable has been seared up to the point of the TII inline protector. Beyond the protector, customer premises wiring is unaffected.

Many lightning strikes will not cause this extent of damage to the drop, and no additional maintenance will be required after the surge occurs. In these cases, the initial cost of the protector is the only cost for ongoing protection to customer premises equipment and wiring.

It is important to note that many technologies only provide protection for a limited number of surges. Visual damage to the protector and no damage in the customer equipment indicates a protector that has performed its intended role; however, replacement is necessary, which means that allowance must be made for the cost of a premises visit. Typically, this is between $50 to $100.

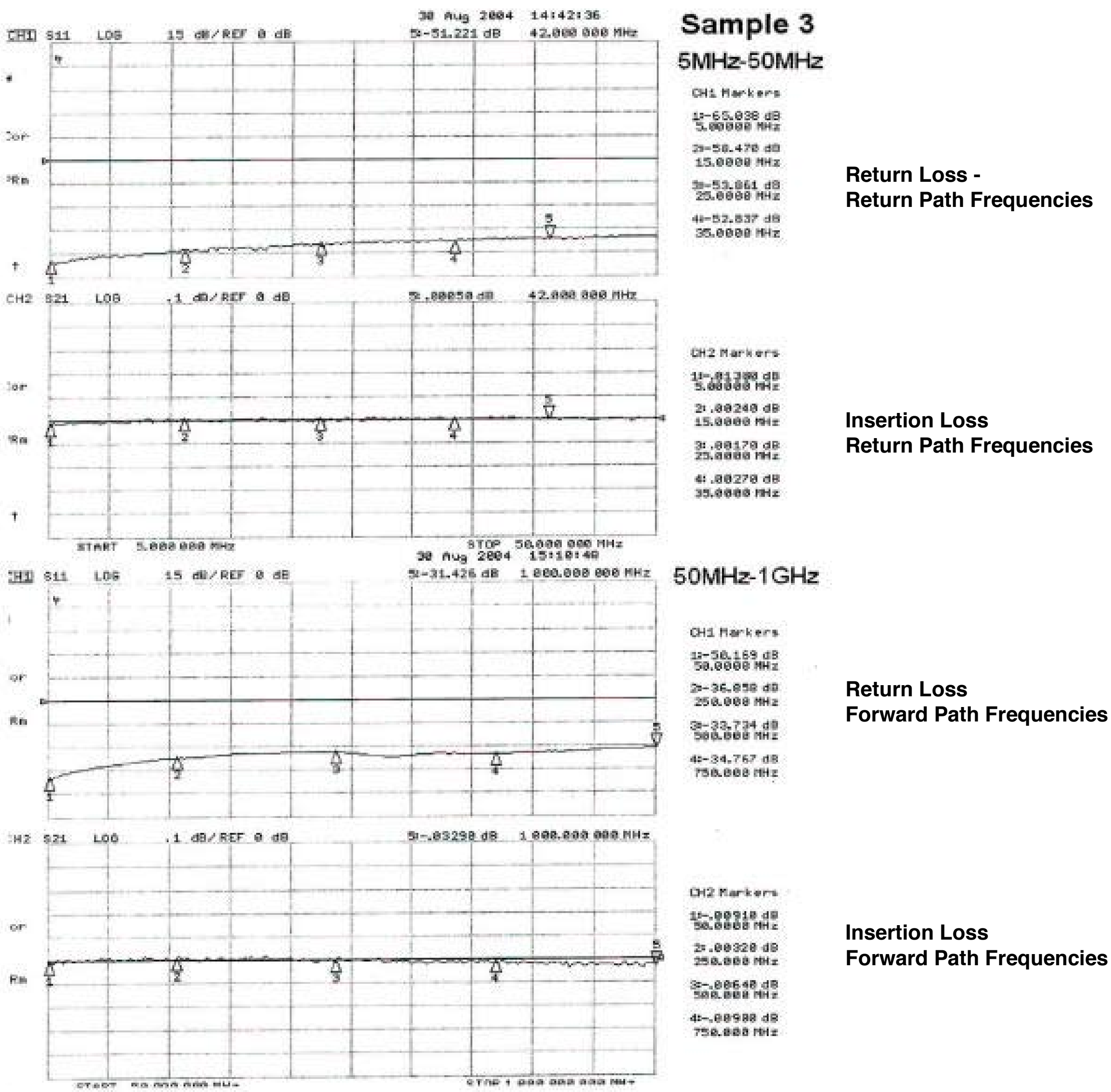
Unlike these "expendable" protectors, TII Network surge protectors have been tested for multiple successive operations. For the most stringent test of 5kA, 8/20 µsecond, the TII 210 and 212 coax protectors protect over more than 10 surges, far more than the expected number of lightning hits expected for any one house over a 20 year life.

TII Surge Protection Devices and Test Results

In-line surge protection devices offered by TII Network Technologies, Inc. provide performance superior to any alternatives. Reaction time to surges and operational characteristics during non-surge conditions are major reasons for this claim.

Gas tube technology is the heart of TII in-line surge protection. The choice of gases within the tube determine the reaction time of the device. Recall that a lightning strike has an extremely fast rise time. Devices that do not operate within the window of peak surge power will not adequately protect downstream electronics. After extensive research, TII has chosen a mixture of hydrogen and other rare gases that provides a path to ground via ionization within a fraction of a microsecond.

Superior response time, however, does not guarantee superior performance during non-surge conditions. Two-way broadband applications have heightened the need for electrical transparency under normal operating conditions. Because RF energy travels on the surface of a conductor rather than along its entire cross section, rigorous attention must be given to the interfaces between connector and conductor. TII in-line surge protectors are built with fittings that use 360 degree crimping technology and adhere to rigorous impedance characteristics. The result is superior return loss and insertion loss. over a wide range of frequencies, including extremely critical return frequencies. Figure 7 shows the response of the TII 210/212 in-line surge protector.



FIGURES 7
GRAPHS OF TII IN-LINE SURGE PROTECTOR FREQUENCY RESPONSE.

Attention to detail ensures TII in-line surge protectors provide both superior operating characteristics both initially and over a lifetime of service. TII in-line surge protectors meet SCTE/ANSI specifications 021997 and 1032004 governing F connector characteristics, and Time Warner specifications for 30 PSI water-proof testing.

Summary and Conclusions

New services being introduced in cable telecommunications systems have the potential to generate incremental revenue, but also increase potential for liability due to surge damage. Telephony service is particularly vulnerable, because of the proximity of the telephone instrument to the subscriber's body. A business case proving the economics of surge protection can be created by probability analysis and available data from lightning strike statistics. The results of this business case indicate a payback in a little over one year for all the homes in a typical cable system node.

Not all surge protection, however, is equally effective or compatible with cable signal needs. TII Networks devices are superior to any on the market in terms of response times and signal performance during non-surge conditions.

About the Author

Justin Junkus is the President and founder of KnowledgeLink, Inc., a consulting firm specializing in cable telecommunications digital technology implementation. Since starting KnowledgeLink in 1993, he has trained thousands of technical personnel in telephony and data communications, and published numerous articles that discuss digital technology applications in cable telecommunications systems.

Mr. Junkus is a senior member of the Society of Telecommunications Engineers (SCTE), chairperson of the national SCTE training committee, and Board Member of the Greater Chicago Chapter of the SCTE. He earned his MBA from Loyola University, and a Bachelor of Science Degree in Engineering from the University of Illinois at Chicago. He has held adjunct faculty positions at DePaul University (Computer Science - Telecommunications), DeVry Institute of Technology, and the College of DuPage (Data Communications). Mr. Junkus is the author of ***DigiPoints, The Digital Knowledge Handbook, (Vol.1)****, a text on data communications published by the Society of Cable Telecommunications Engineers. His other publications include the monthly* ***Telephony*** *column on telecommunications for Communications Technology magazine,* ***DigiPoints, The Digital Knowledge Handbook, (Vol. 2)*** *covering digital cable system equipment, and* ***Cable Telephony in North America,*** *a technology and market report for Phillips Business Information LLC.*