

CableLabs

**Outage Reduction Task Force
Outside Plant Protection Subcommittee**

Chapter IV - Outside Plant and Headend Protection

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Outage Reduction

IV - Outside Plant and Headend Protection

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IV - Outside Plant and Headend Protection

1.0 Introduction

CableLabs' Outage Reduction Task Force conducted a considerable amount of research into practical solutions to cable system outage reduction. Chapter I of this document provides an agreed-upon definition of an outage, customer acceptability, and an outage detection and tracking specification. A critical threshold of no more than two outages in a three-month period (0.6 outages per month per subscriber) is suggested as a target for cable operators to achieve and maintain. This threshold will likely be a "moving target" in the future, since it is an entertainment model that may not be valid for other services.

Chapter II discusses reliability modeling of cable systems and includes a Lotus 1-2-3 worksheet on an accompanying diskette that can be used as a tool for system reliability analysis. Chapter III covers plant powering, including reducing power supply cascades, incorporating hardened trunk techniques, understanding and working with the local electric utility, and optimum use of standby powering.

To further reduce the incidence of outages, this chapter will focus on outside plant protection. It is important to understand that reducing system outages is a multi-faceted issue, requiring consideration of a number of items. The plant protection subcommittee researched equipment fusing, surge protection, and bonding/grounding practices. A number of recommendations are provided, including outside plant voltage and current protection. While all of the topics and recommendations of the task force are important, the group feels that implementing effective fusing policies in conjunction with the deployment of surge protection that meets the criteria described later in this chapter will provide a significant reduction of plant outages related to nuisance fuse blowing and equipment surge damage.

2.0 System Reliability

Cable system reliability depends directly on the reliability of the components that make up the system, including those in the headend and outside plant. Reliability analysis has shown that overall (cascaded) equipment failure rates must be at or better than seven percent per year to achieve outage performance that is acceptable to subscribers. This figure includes blown fuses, cut cables, and outright equipment failures.

While there may be little that system personnel can do to prevent a backhoe operator from inadvertently cutting a buried cable, achieving a seven percent or lower cascaded equipment failure rate to a large extent requires effective protection from excessive voltages and currents. Of the many things that cause outages, these two are among the easiest to prevent.

Excessive voltage conditions are typically of extremely limited duration, for example, surges or transients. They are generally caused by:

- Lightning
- Operation of power utility protection/switching equipment such as vacuum breakers, as well as utility switching faults
- Operation of industrial loads such as arc furnaces, switching of large pumps, motors, etc.
- Operation of other moderate-to-heavy loads such as elevators, air conditioners, compressors and electric appliances

Excessive current is created by short circuit conditions that are usually of longer duration than transients or surges. A common cause is an electrical short between the coaxial cable sheath and center conductor due to a cable cut, maintenance activity, or an electronic component failing in a shorted condition. A number of deficiencies in existing voltage and current protection practices have been found to be contributing to reduced system reliability.

3.0 An Examination of Common Practices

Many of today's commonly accepted over-voltage and over-current protection practices are causing more problems than they solve, either because of incorrect application or actual deficiencies with those practices. The outage reduction task force has reviewed several areas, and found the following problems:

- 1) *Surges or transients blow fuses, resulting in nuisance fuse blowing.* Fuses are technically over-current protective devices, intended to protect equipment or components from excessive current as a result of short circuits or overloads. Fuses are not intended to protect from voltage transients or surges. It is not unusual to find cable system outages caused by simple nuisance fuse blowing because of a lack of adequate surge protection or incorrect fusing.
- 2) *The life of some surge protection devices is considerably less than amplifier life, with no practical means to detect device failure.* Some types of surge protection devices installed across a line or circuit being protected can fail open. When this happens, there is usually no indication of the device's failure until a subsequent surge damages or destroys the equipment that was supposed to be protected.
- 3) *Some surge protection devices have questionable ability to handle a series of voltage surges, for example, five to 10 surges in less than a second.* Certain devices may easily survive one or two closely spaced surges, or perhaps several that occur over a relatively long period of time. But multiple surges over a very short period of time may result in device destruction.
- 4) *Fast-blow fusing is used for protection against long-duration high currents.* Equipment or situations that experience long-duration high currents or temporary inrush conditions should be protected by time-delay (also known as slow-blow) fusing.
- 5) *Excessive use of fuses, such as for routing power.* Many active and passive components in cable systems provide fusible links for power routing. Excessive use of fuses for applications such as this merely creates more opportunities for outages due to nuisance fuse blowing and the availability of too many "weak links in the chain." Power routing in many cases can be accommodated with simple buss bars when overcurrent protection is available elsewhere in the network.

From this, one can see the need to implement effective surge protection and good fusing practices in cable systems. With regard to these, the immediate question is "What methods will work the best?" Since CableLabs does not endorse or recommend any specific products or manufacturers, the outage reduction task force set out to establish a recommended practice that can be used as a guideline by cable operators and equipment manufacturers for surge

protection and fusing. The recommendation — detailed later in this chapter — is two-fold, with surge protection in the first part and fusing guidelines in the second.

4.0 Surge Protection Background

Different types of surge protection are available to the cable industry, each suited for specific applications and each varying in its effectiveness for the intended application. As part of the development of a recommended practice for surge protection, CableLabs commissioned independent laboratory testing of several of the most commonly used protection devices, including metal oxide varistors (MOVs), gas-filled surge arrestors (gas tubes), silicon avalanche diodes (for example, ruggedized zener diodes), and crowbar devices (circuits that incorporate thyristor-type semiconductors such as SCRs or TRIACs in a crowbar configuration).

Metal oxide varistors and silicon avalanche diodes are basically voltage limiting devices, while gas-filled surge arrestors and crowbar devices operate by clamping circuit voltage to a reduced value (in some cases they clamp to ground).

The laboratory testing was done to establish a repeatable measurement procedure that is representative of conditions that might be experienced in outside plant operation and can be used by operators and/or manufacturers to compare the relative effectiveness of various surge protection techniques. During the lab testing, the following two test setups were used.

4.1 Test Setup #1

The test samples were exposed to a series of test impulses to verify performance and their capability to withstand the impulses. Each sample was subjected to a series of 6,000 volt impulses (3,000 amperes). The impulse is described in ANSI/IEEE Standard C62.41-1980 and replicates a lightning induced over-voltage surge (Figure 1 on the facing page). This test checks clamping capability and survivability. Depending on survival, each sample was tested with up to five impulses. Figure 2 on the next page illustrates the test setup.

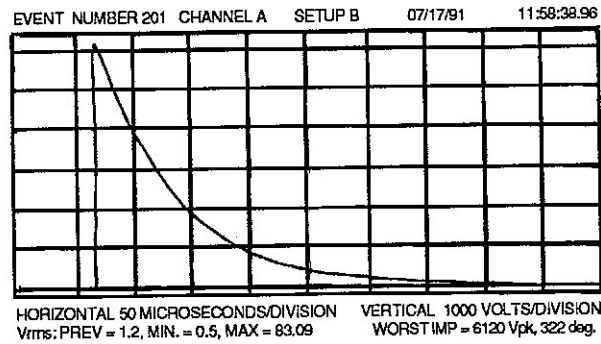


Figure 1 - Impulse Described in ANSI/IEEE Standard C62.41-1980

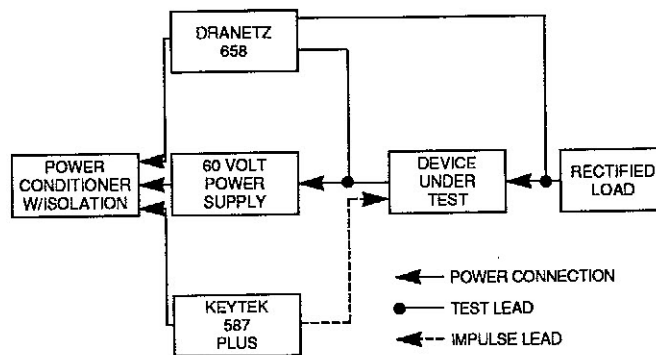


Figure 2 - Test Setup #1

A KeyTek 587 Plus test setup was used to generate the surge voltage. The surge impulse was AC coupled and injected through an RF port in a power inserter to replicate the surge condition created in the field when a lightning-induced surge couples onto coaxial cable. A Dranetz Model 658 power monitor recorded clamping voltage and surge current. For devices without a power inserter, the surge impulse was AC coupled onto the 60 VAC power from a ferroresonant power supply. Surge backfeed to the AC power source was eliminated by floating the output of the 60 VAC ferroresonant power supply and by powering all equipment from a single isolating power conditioner. The load was a simple rectified load drawing approximately 13 amperes.

4.2 Test Setup #2

Crowbar clamping devices were subjected to low-energy, repetitive over-voltage events.

The test impulse does not place a great deal of stress on the protector (impulse energy is approximately 10 mJoules), but does force the protector to continuously conduct and carry the maximum current delivered by the 60 VAC ferroresonant power supply. This test condition is a modification of UL497A (overcurrent stress test) and is intended to replicate a condition that might force the protector to turn on repetitively, such as sheath current due to AC induction.

Each test lasted 10 seconds and was repeated five times at 10 second intervals. The test verifies that heat buildup during conduction does not degrade or destroy the protector. Figure 3 shows the test impulse and Figure 4 illustrates the test setup. A Velonex 510 was used to inject repetitive signals into the protectors. Voltage limiting devices such as MOVs and silicon avalanche diodes were not subjected to this test.

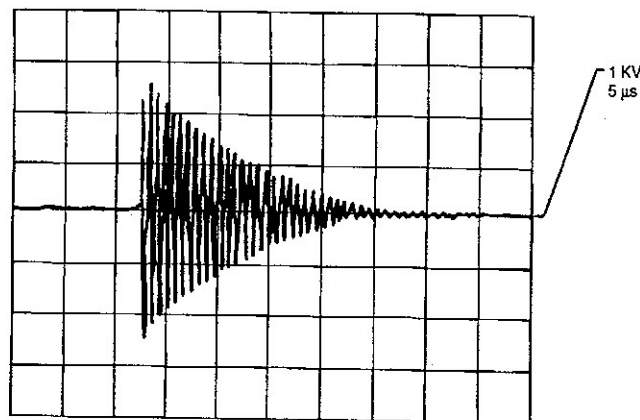


Figure 3 - Test Impulse

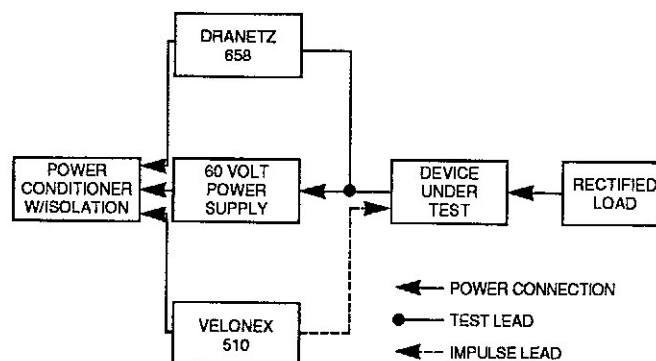


Figure 4 - Test Setup #2

Based on the outcome of the testing, the task force has decided that the procedure used in Test Setup #1 should be incorporated in the following voltage and current protection recommendations.

5.0 Plant Voltage and Current Protection Recommendations

It is the opinion of the task force that use of the ANSI/IEEE C62.41-1980 Category B2 (6,000 volt, 3,000 ampere) standard is appropriate and useful for cable operators to determine the effectiveness of surge suppression equipment. The task force recommends the use of this test in simulated plant configurations and further recommends that cable operators should ask equipment manufacturers to certify that their equipment meets or exceeds recommended performance criteria set forth in the following recommendations.

Further, it is the task force's opinion that deployment of surge suppression equipment that meets or exceeds the recommended performance criteria, *in conjunction with implementing the recommended fusing policy*, should significantly reduce limited-duration over-voltage and over-current related outages.

Cable operators are encouraged to implement the following voltage and current protection guidelines. The recommendation is based on analysis, surge testing, and very successful field testing.

I) Surge Voltage Protection: New Equipment

Vendor is to certify amplifiers to the following:

- 1) Amplifier passed five (5) 6,000 volt impulses (3,000 amperes) per ANSI/IEEE C62.41-1980 Category B2 test. Amplifier tested in configuration simulating cable plant installation.

If surge protection device(s) and/or input current carrying capacity is changed, the equipment is to be retested.

Vendor to certify this item in writing and to provide detailed testing documentation/report upon request.

- 2) Operating characteristics of the surge protection device(s) will not materially change when subjected to ten (10) voltage surges of Item 1 above, spaced one millisecond apart.

Because this condition is difficult to test, certification can be achieved by engineering analysis. The analysis is to account for, among other things, voltage drop across the device, subsequent heat buildup, and associated device operating characteristic changes.

Vendor to certify the above in writing and provide detailed testing or analysis documentation/report upon request.

- 3) Certify the number of ("Impulse Life") 6,000 volt impulses (3,000 amperes) per ANSI/IEEE C62.41-1980 the surge protection device(s) can withstand. The recommended minimum is 5,000. Certification to be based on published device specification or specific life tests.

Vendor to certify this item in writing.

- 4) Vendor to state normal and overload current carrying capacity for amplifiers, including surge protector devices, wiring, PC board traces, etc.

II) Surge Voltage Protection: Existing Amplifiers. Recommended for all trunk amplifiers and line extenders where there is a known surge problem.

- 1) Install solid state surge protection where the surge protection is certified by the vendor to meet the following:
 - a) Pass five (5) series of 6,000 volt impulses (3,000 amperes) per ANSI/IEEE C62.41-1980 Category B2.
 - b) Vendor to certify surge protection device minimum "Impulse Life" as per I.3 listed previously.
- 2) Remove gas tube surge suppressors.

Note: Most amplifier manufacturers have developed kits or optional factory-installed components that will meet the recommended criteria. Additionally, other vendors have equipment or kits available to back-fit surge protection, for example, in line power inserters.

III) Excessive Current Protection: New and Existing Equipment

- 1) Plant AC power supply output protected at 150 to 200 percent of power supply output rating with time-delay (slow-blow) fuse.* Please see note at the end of this section.
- 2) Trunk amplifier power supply module (power pack) input protected just under current carrying capacity of amplifier with time-delay (slow-blow) fuse.* Please see note at the end of this section.
- 3) Feeder protected at 150 percent of normal operation with time-delay (slow-blow) fuse.* Please see the note at the end of this section.
- 4) Line extender power supply input protected just under current carrying capacity of amplifier with time-delay (slow-blow) fuse.* Please see note at the end of this section.
- 5) Fuses used for power routing to be replaced with buss bars except feeder routing port in trunk housing (dead short in feeder should not take trunk station down).

** Note: If a circuit breaker is used instead of a fuse, its rating is to be as noted previously, and opening/trip characteristics are to be those of a time-delay (slow-blow) fuse.*

6.0 Grounding and Bonding Background

Most cable TV engineers would agree that the industry would have fewer problems with voltage surges, transients and sheath currents if the cable system could remain isolated from the utilities. Nevertheless, there also is agreement that this is not possible because it would create a safety problem.

This section covers the requirements, methods, costs, and recommendations for bonding and grounding.

Bonding to the utilities is a requirement for safety as delineated in the National Electrical Safety Code (NESC). Pole attachment agreements or local authorities may also establish specific requirements for bonding.

Problems from bonding include the following:

- *Sheath currents:* Bonding to the power neutral reduces the ground potential differences that would be a safety hazard. But this also creates a problem for the cable system because it shares the power company's neutral load. This load generates undesirable longitudinal sheath currents.
- *Voltage surges:* In sharing the normal power company neutral load we also share the fault conditions. This can result in substantial surges for extended periods of time.

Grounding is achieved in the bonding process through the common ground at the structure to which the bond is attached.

Grounding in addition to the grounds achieved at bond locations, may be desirable in some situations. These grounds may be at locations without any other grounding electrodes. This requires driving a grounding electrode and providing a #6 or better copper conductor from the cable system to the electrode (ground rod). Additional grounds are normally placed at an active or before and after an active component. Too many grounds, however, also can create problems for the cable system.

Usually, this type of ground is added in relatively close proximity to an active component providing a lower impedance to earth ground than would a bond to an electrode located multiple spans away. The lower impedance provides an alternate path for transients.

6.1 Bonding

The NESC sections 92 C1 and C3 require messenger wires (strand, etc.) to be connected to grounding conductors at maximum intervals of four connections in each mile. The requirement of four per mile allows some flexibility in selecting which locations to use unless the pole attachment agreement or local authority has more specific requirements (e.g., first, 10th and last). Four connections per mile meet the bonding requirements for the NESC as covered in NESC Section 9, "Grounding Methods for Electric Supply and Communication Facilities." Relevant sections are reproduced on the next page for the reader's convenience.

92 C Messenger Wires and Guys

- 1) *Messenger wires required to be grounded shall be connected to grounding conductors at poles or structures at maximum intervals as the following list covers:*

Where messenger wires are adequate for system grounding conductors (Rules 93C1, 93C2, and 93C5), four connections in each mile.

- 3) *Common grounding of messengers and guys on the same supporting structure*

Where messengers and guys on the same supporting structure are required to be grounded, they shall be bonded together and grounded by connection to:

- a) One grounding conductor that is grounded at that structure, or
- b) Separate grounding conductors or grounded messengers that are bonded together and grounded at that structure.

Bonding costs will vary in different parts of the country depending on labor costs. Material costs will differ only slightly. As of late 1991/early 1992, estimated cost for labor and material for bonding at strand level is about \$7 per bond. To bond at the electrode requires a separate download and exposing and cleaning the electrode. This costs about \$20 for labor and material.

If minimum bonding is completed by bonding to the power company vertical

grounding conductor at strand level, the cost for four contacts per mile would be about \$28 per mile. On the other hand, if the preferred method of adding a new downlead is used to bond at the electrode, the cost would be about \$80 per mile.

Local regulatory authorities or the pole attachment agreement may have other specific requirements. These may require the bond wire to be a #4 rather than #6 specified in the NESC, or some specific requirement of where to bond (at strand level, at the electrode), or specify the type of connections to use.

Bonding should be avoided at pole locations where the electric utility has spark gaps, lightning arresters or primary switching. These locations have the capability to discharge extremely high electrical potential. A significant portion of that discharge could be transferred to the cable plant. Bonding also should be avoided at locations that indicate a high current in the bonding conductor.

The ideal location for bonds is where the power company has 1 Ω grounds because 80 percent of the load imbalance would be dissipated through the ground return. While we are not likely to find many locations where the power company has 1 Ω grounds, it does show that we should attempt to place bonds at the best power ground locations. With lower ground resistance, less neutral load is transferred to the cable system.

The preferred method of bonding is to use a separate #6 copper downlead connected directly to the power electrode. This procedure needs to be cleared through the engineering administrator of the pole attachment agreement and may raise the question of creating a hazard by not bonding at strand level. A downlead would typically be 25 feet long plus 25 feet back up the power ground lead for a total length of 50 feet of #6 copper or larger. Number 6 copper has a resistance of .3951 ohms per 1,000 feet. Fifty feet of #6 copper would have a resistance of .02 ohms, hardly enough resistance to create a hazard.

Parallel leads do not represent much improvement in resistance but do provide a lower impedance for transient type events. Important in the bonding process is the attachment. The cable industry has been using split bolts and other screw type devices. Most power companies have discarded those devices and are using compression-type connections that are more reliable for a much longer period of time.

6.2 Grounding

Grounding, in this case, is the use of additional grounding conductors and electrodes for the cable system. Additional grounding at or near amplifiers will provide a lower impedance ground and a better path to ground for high rise time transients. This type of additional grounding may be useful in lightning-prone areas although recent experience has demonstrated that if surge protection and fusing recommendations of the previous sections are followed then additional grounding is probably not required. If additional grounding is used then these should be periodically checked to ensure the ground resistance levels have not significantly changed over time. *However, grounding beyond the bonding requirements may have limited effect in reducing sheath currents.* (See "6.4 Longitudinal Sheath Currents," which follows this section.)

To meet the code for bonding to the multi-grounded power system, the cable system has four bonds or grounds per mile. Adding another four grounds per mile to the existing grounded bonds totals eight grounds per mile. If we assume the grounds each measured $20\ \Omega$, the neutral load carried by the cable system would be reduced by only about six percent and therefore may be of limited value.

If used, additional grounds should be placed near an active device. This could be the pole before, pole after or the pole at the active device. However, grounding before and after an active may provide a "safe area" at the amplifier, although recent field experience has shown if the recommended surge protection and fusing is implemented, this grounding is probably not needed. Additional grounding could be beneficial if a transient is induced at some location beyond the ground and the ground does in fact have a low impedance.

Surprisingly, the additional ground may provide very little protection against sheath currents. Normally a ground is considered good if it has a $20\ \Omega$ resistance. When we compare this with the parallel resistance of one span, 200 feet of .750, .500 and strand at .024 Ω , the ground's effectiveness at shunting sheath currents is questionable, especially if lower resistance grounds or bonds exist farther upstream or downstream from this point.

Number 6 copper wire is used from the strand to the ground rod, placed in a straight line with no sharp bends. The strand attachment needs to be a bi-metal connection (with the press-type preferred). The ground rod attachment needs to be a solid connection to a clean surface. (Exothermic welding to the rod will be best.) Any resistance at the connections will reduce the effectiveness of the ground.

If an existing ground is in place, it is preferable to use a separate down lead and bond at the ground rod. The parallel downloads will provide a lower impedance path for higher frequency transients. This needs to be approved by the administrator of the pole attachment agreement. Should this location be a problem area, the ground resistance could be reduced by the addition of another ground rod. The ground rods are most effective when separated by a distance of 2.2 times the length of each rod. Separate ground rods need to be bonded together with #6 or larger copper wire. If possible, all connections (except to the strand) should be done with an exothermic process.

Grounding should be avoided at pole locations where the electric utility has spark gaps, lightning arresters or primary switching. These locations have the capability to discharge extremely high electrical potential. A significant portion of that discharge could be transferred to the cable system. Grounding also should be avoided at locations that indicate a high current in the grounding conductor.

Grounding costs will vary in different parts of the country depending on labor costs. Material costs differ only slightly unless there is a requirement for exotic types of grounding such as chemical rods or extremely long rods.

Costs for labor and material for grounding to an existing electrode including a separate download and exposing and cleaning the electrode to make the bond are about \$20 for labor and material. Driving an additional separate grounding electrode can have a wide range of pricing. If access is available to drive a normal grounding electrode, labor and materials cost about \$30.

If minimum grounding is completed by installing a download and using the power company electrode, the cost for four contacts per mile is about \$80 per mile. On the other hand, if a download and newly driven electrode are required, the cost could be \$120 per mile or more. These prices were typical as of late 1991/early 1992, and do not consider the cost of removing sections of concrete and then repairing the opening after the grounding is complete, nor do they include the use of exothermic welding (if applicable).

Any area that experiences multiple failures that may be due to power-related problems needs to be investigated. Items to check include:

- Grounds should be tested using an earth null tester.
- Sheath currents should be measured.

- Bonds should be measured for current flow.
- Bonds should be lifted if high current is present.

Problems of high currents or high ground resistance should be referred to the power company and assistance requested to resolve the problem. Improving the ground resistance and lowering neutral current flow is a benefit to both the power and cable companies. If the power company is unable to provide the assistance needed, the bond could be relocated to another location. The important requirement is that four bonds per mile remain.

6.3 Longitudinal Sheath Currents

Longitudinal sheath currents (LSCs) are an unwanted electrical energy induced on the messenger and sheath of the cable. This is the result of bonding to the power company multi-grounded neutral.

Most of the power distribution systems today are wye-configured four-wire primary and three-wire secondary with one of the wires being the common neutral. When all the loads are perfectly balanced, there is zero current flowing in the neutral. The probability of all loads being perfectly balanced is unlikely. As a result, there is usually some neutral current flowing most of the time. The consequence of being bonded to the multi-grounded neutral is sharing the current flowing in the neutral system.

It is not unusual to find from 50 to 150 amperes of neutral current under normal conditions and well in excess of 300 amperes in a fault condition. The strand and coaxial cable system that has multiple cables will carry a substantial portion of the neutral currents.

6.4 Load Sharing

Not only will the cable company share the load, in many cases it will carry the major portion of the load. The typical trunk/feeder system may be strand, .750 and .625 cable, with a total parallel resistance of .099 ohms per 1,000 feet. The power company neutral may be a 4/0 aluminum, which also would have a resistance of 0.1 ohms per 1,000 feet. With the same resistance in each path and both paths bonded to the same grounding electrodes, the neutral currents would be shared equally. The cable system with a 1-inch supertrunk, .750 trunk and .625 feeder on quarter-inch strand will have a resistance of .037 ohms per 1,000 feet. Comparing to the 0.1 ohm of 4/0 aluminum, the cable system would be carrying over 65 percent of the total neutral current.

A typical system without supertrunk, but with four bonds to power per mile with grounds at about 20 Ω each, results in the cable system carrying 41.5 percent of the load, a power neutral of 41.1 percent with 4/0 aluminum, with 17.4 percent dissipated to ground.

The ratios will change if the power neutral changes, the ground resistance changes, the number of ground rods change, or the cable plant changes.

By changing the grounds from 20 to 5 Ω , the percentage of the load dissipated to ground changes from 10.3 to 45.7 percent. The same change also would occur if the number of 20 Ω grounds were increased from four per mile to 16. A greater percentage of the load can be dissipated by adding additional grounding electrodes or reducing the resistance of the electrodes, although portions of the cable system could possibly be subjected to fairly substantial neutral currents.

Another important component to the mix is what the power company is using for a neutral conductor. Changing from a 4/0 aluminum neutral to 4/0 copper at 20 Ω , the percent of load carried by the neutral changes from 41 to 59 percent. Conversely, if the neutral were changed from 4/0 aluminum to #4 copper the neutral load would change from 41 to 22 percent and the cable load would increase from 41 to 55 percent.

It is worthwhile to calculate all these numbers to understand the possibilities. However, it does not reflect the real-world. All grounds are not 20 or 5 Ω . There are different combinations of cables and there may be different combinations of power-company neutral conductors. Other differences are changing power loads and load balance. For the cable system to carry 60 percent of a 5-ampere neutral load would probably not be a problem, but 60 percent of a 300-ampere or greater fault condition load is a serious problem. Because of this, *unless absolutely necessary*, bonding or grounding the cable plant more than required by NESC is not recommended.

7.0 The Headend

No discussion of outside plant protection would be complete without comments about the headend. While efforts to reduce outages in the system will have obvious results, the failure to do so in the headend also will have obvious results. Because headend outages affect all subscribers, it is of equal importance to take appropriate steps to minimize headend outages, including those that affect single channels as well as those that affect all channels. As is the case with the cable network, particular attention must be given to headend surge protection and grounding and bonding practices. Headends (except for in the smallest systems) should

be configured with on-line backup power so the headend does not go down because of loss of commercial power. Very small systems should have ready access to a standby generator that can be made operational in 15-30 minutes.

7.1 Surge Protection

All lines entering or leaving the headend — power, telephone, antenna downlead, microwave waveguide, TVRO feeds, and the outbound cable trunk — are potential paths for damaging surges and transients to reach equipment in the headend. Because of this, steps must be taken to ensure that each of these paths has suitable protection.

Internally generated transients from air conditioners, power tools, pumps, motors, elevators, office machines, and various appliances also present risks to headend equipment. Here, too, preventive measures are important.

Any of several manufacturers can provide suitable surge and transient protection devices. It is not the intent of CableLabs or the outage reduction task force to recommend specific products, but rather to encourage the use of effective protection in the first place. System staff should take care to consider all possible headend input/output lines that represent likely paths for surges and transients. Among these are the following:

- Power line
- Telephone/data lines
- Feed from backup generator
- Over-the-air antenna downleads
- Rotor control lines for search antenna
- TVRO feeds
- Two-way radio or repeater antennas
- Tower lighting wiring
- Microwave waveguide
- Broadcast, translator or MMDS transmitter feedlines
- Incoming supertrunks or hub interconnects
- Outbound trunk and feeder cables

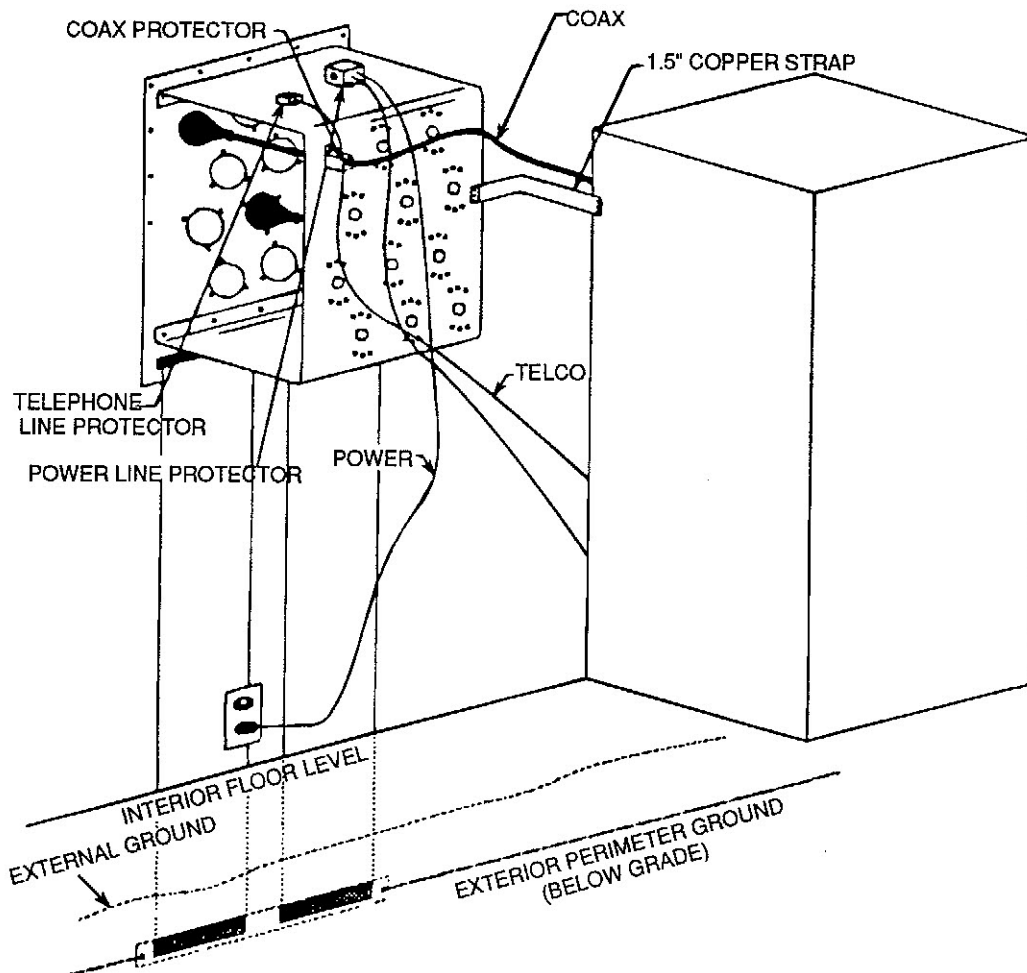


Figure 5 - Typical Bulkhead Panel System, Inside View (Courtesy PolyPhaser Corp.)

It is important not to be lulled into a false sense of security after protecting one or two lines (for example, power and over-the-air antennas) that may have been the only source of surges in the past. Any of the remaining lines can become the new weak links and produce entirely new problems.

A transient suppression plate (bulkhead) is recommended as a surge/transient "shock absorber." The plate must be in common with the equal potential grounding system (more on this in Section 7.2) as well as the outer shields of all incoming/outgoing cables. Center conductor protection of these same cables is most effective at a sub-chassis or sub-bulkhead attached to the inside of the primary bulkhead. Telephone/data, power and other line protectors also should be mounted on this sub-chassis. (See Figure 5.)

7.2 Headend Grounding and Bonding

Transient and surge protection, (as well as lightning protection) will be ineffective without the implementation of good grounding and bonding practices. The concept of common-point grounding to form an equal potential grounding system at the headend is very important, especially with regard to protection from lightning. While no form of complete protection from a direct lightning strike is available, high quality grounding/bonding practices will be a good place to start.

At the very least, a perimeter ground system (ring) around the headend building can serve as the basis for creating an equal potential grounding system. It should be buried at least 12 inches to keep it below grade, and deeper if necessary to place it below the frost line. (Frozen earth is a poor conductor.) All building, tower, antenna, power, bulkhead, and other grounds must be bonded to this perimeter ground. It is recommended that all outdoor grounding attachments, especially those underground, be done using an exothermic process instead of mechanical connections. Ground rods should be spaced periodically (about 2.2 times the length of a single rod) along the perimeter ring, with connections between the ring and the rods via an exothermic weld process.

In some cases tower manufacturers will void windload certifications or structural warranties when ground attachments to the tower legs are done using exothermic welds. It is important to discuss this with the manufacturer of your tower beforehand. If this is the case, the tower manufacturer may be able to recommend or provide suitable alternatives. If exothermic welds will be used for tower grounding connections, remember that the area of each leg where the attachment occurs must be cleaned to bright steel before the

welding process. After welding, the weld areas must be protected with a cold galvanize compound, and the tower ground connected to the common perimeter ring.

If the tower is guyed, the guy wires also must be grounded (avoid the use of dissimilar metals when making the ground attachments to the guy wires) to the common system. (See Figure 6.) The grounding conductor will be attached to the guy wires with suitable mechanical connections, but where it attaches to the ground rod(s) and perimeter grounding system exothermic welds should be used.

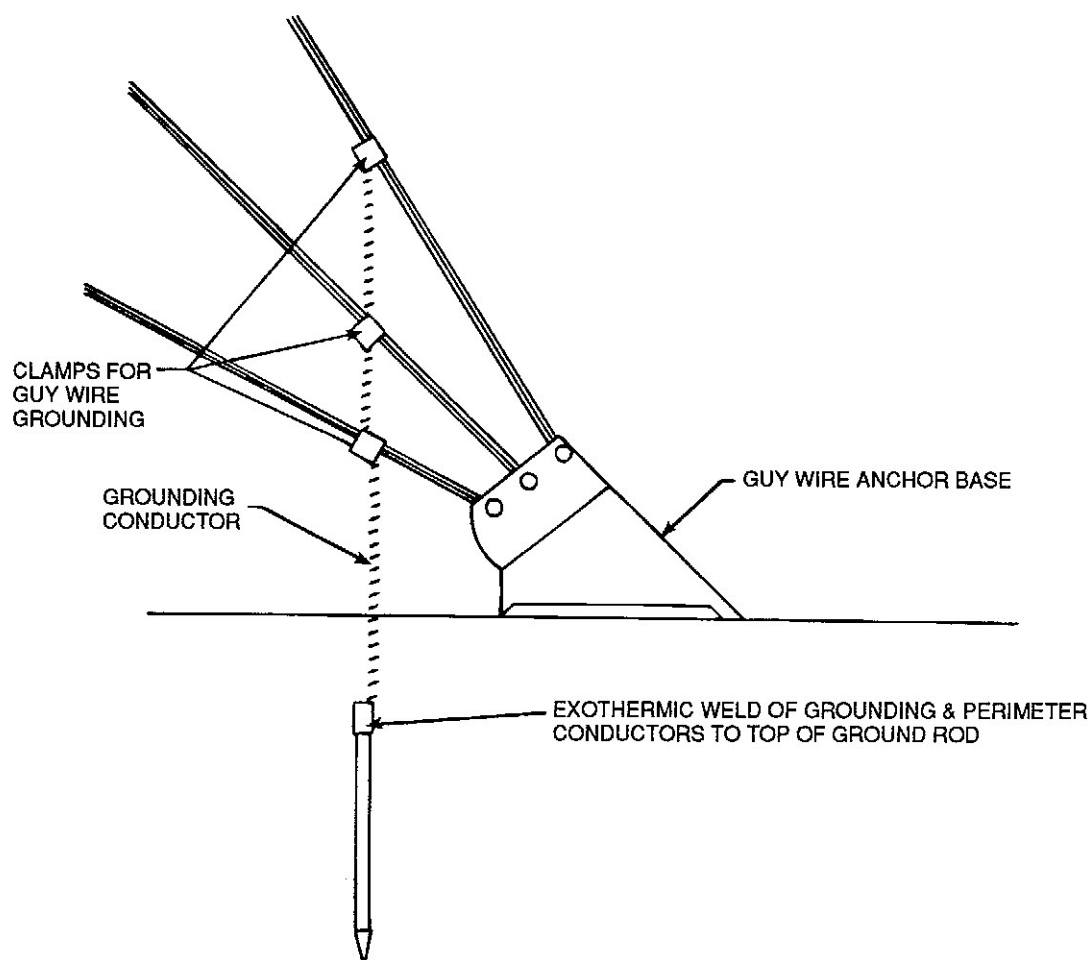


Figure 6 - Guy Wire Grounding Detail

Wiring and cable grounds (shields) on the tower must be bonded to the structure at the top and bottom using suitable grounding kits, and every 100 to 150 feet in between where applicable. Metallic security fencing around the headend also must be bonded to the common grounding system. Here, too, exothermic welding is recommended for permanent connections.

Ground wires should be large and run as straight as possible and separated from other conductors by six to eight inches. Ground wires should not be run inside or through a conductor or metallic conduit unless bonded to it (preferably at both the entrance and exit). For metal walls, it is recommended that the ground wire be bonded to the wall on both sides rather than passed through it.

There is generally no need to run ground wires up the side of a tower because the resistance difference between copper and galvanized steel becomes negligible as a result of the difference in inductance because of each one's surface area. Even a separate grounding conductor for tower-mounted lightning rods will likely arc to the tower unless spaced about 24 inches from the tower leg. In any case, bare copper wire should never come in contact with galvanized steel because of the dissimilar metals corrosion that will occur.

Buried ground radials extending away from the perimeter ring and the tower(s) should be connected to ground rods (5/8 inch x 8 feet minimum) that are spaced 2.2 times their length apart. For example, if eight-foot rods are used, they should be spaced about 17.6 feet apart. The more radials available, the better the grounding system.

When soil conductivity is poor, the use of chemical ground rods is recommended. These are hollow pipes with weep holes that allow replaceable chemical salts inside the rod to leech out into the soil and improve its conductivity. The salt mixture inside the rod has to be replaced every two to five years. Chemical rods are considerably more expensive than conventional rods, but they will work when poor soil conditions are present.

The objective is to achieve an overall grounding system resistance of 5 Ω or less. This can be measured with an earth null tester.

7.3 Backup Power

An easy solution to loss of signal due to commercial power outages at the headend is to provide backup power, usually in the form of a standby generator with an automatic

transfer switch. This arrangement will sense the loss of commercial power, start the generator, then switch to the generator for electrical power for the headend. Some packages include provisions for automatic operation of the generator to periodically exercise the equipment and ensure that it works correctly.

While very effective as an alternative to the complete loss of headend operation, there is usually a brief period — perhaps only a few seconds or so — between the failure of commercial power and the availability of electrical power from the generator. In addition to being a source of irritation to subscribers, these brief losses of power are believed to contribute to reduced life with some types of headend equipment.

The task force therefore recommends that an uninterruptible power supply (UPS) be incorporated in the headend to maintain operation during the brief switch-over between commercial power and generator operation. The UPS only needs to have sufficient reserve for perhaps 15 minutes of backup, which is enough to allow the standby generator to stabilize before being switched on-line.

In any event, consideration should be given to some form of status monitoring to allow system personnel to know when the headend is operating on standby power. This is especially critical for remote or rural headends, where extended commercial power outages could exceed the fuel capacity of the standby generator. As with other headend inputs and outputs, the generator lines should be equipped with suitable surge/transient protection.

8.0 Outside Plant Protection Summary

The reduction of outages in today's cable systems is a goal that must be on every operator's agenda. Achieving the recommended target of no more than 0.6 outages per month per subscriber will require that a number of important tasks be completed. Among the easiest is outside and headend plant protection.

While the operator must understand the definition of an outage and have effective outage tracking procedures in place, the simultaneous deployment of solid-state surge protection that meets the guidelines presented in this chapter, and implementation of the task force's recommended fusing practices, will result in a fairly significant reduction in outages. The recommendations for headend protection also should be performed, because headend problems will affect all subscribers simultaneously.

Although not directly related to outside plant protection, headend and system maintenance practices that result in system downtime on one or more channels need to be coordinated and scheduled in a manner that will cause the least disruption to customers, particularly in prime viewing times. Even maintenance downtime is perceived by the subscriber as a form of an outage. Proper scheduling of maintenance "outages" can become part of a system's outside plant protection practices, contributing to the overall reduction of system outages.