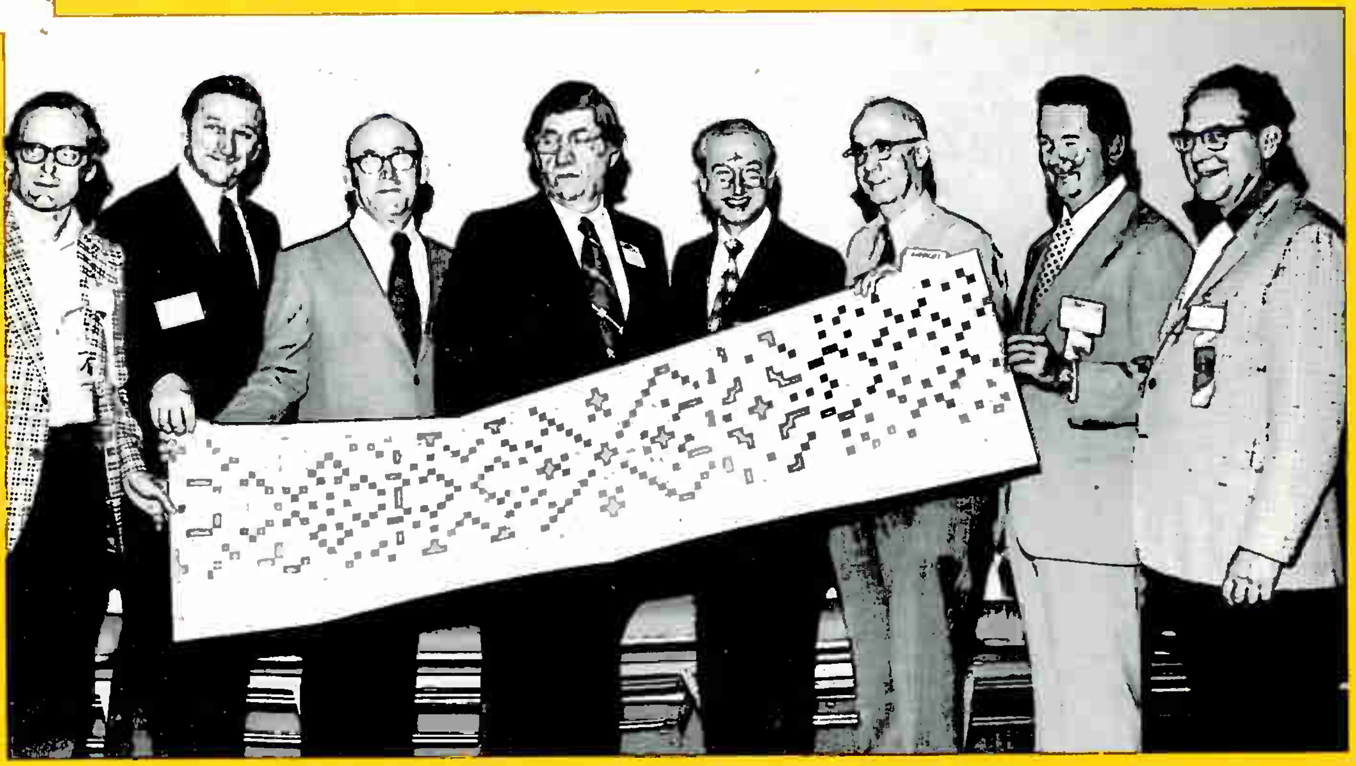
July/August '73 vol. 9/No. 2

CABLECASTING

able TV Engineering

The official journal of the
SOCIETY OF CABLE TELEVISION ENGINEERS



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Contents

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PEOPLE IN THE NEWS

• • •

FRANK DRENDEL has been named president of Comm/Scope Company, the coaxial cable manufacturing division of Superior Continental Corp. Mr. Drendel joined Comm/Scope as general manager in late 1972, moving from vice president of Cypress Communications Inc.

• • •

TORE B. NORDAHL has been named vice president, marketing for Ameco, Inc. Mr. Nordahl most recently was a co-founder of Complexicable, Inc. in Cleveland. A native of Norway, he graduated from and was an instructor at the Royal Norwegian Air Force Communications and Radar Institute.

• • •

C. RANDY LANS, who was vice president, sales at Utility Body Co., has formed his own manufacturer's rep firm headquartered in El Sobrante, California. Mr. Lans will sell equipment in the CATV and communications industries.

• • •

UTILITY GROUNDING PRACTICES

H. M. Smith, P. E.
General Electric Cablevision Corporation
San Antonio, Texas

Utility grounding practices are of concern to a cable television company for several reasons. The first reason that comes to mind is that since cable TV usually rents pole space on utility poles, the cable TV company is most often permitted, or required, to bond its messenger and grounding system to the utility's existing pole grounds. It is only reasonable to assume that it would be good if the cable TV operator were aware of the utility's grounding system and how effective it is. A second reason for looking into grounding practices is that OSHA now makes the National Electrical Safety Code law and the safety code does cover grounding practices. The third and most important reason is safety to the cable TV company's linemen and installers, the general public and electronics equipment. This safety can be best assured by bonding all pole-mounted non-current carrying metal parts to a low resistance earth ground.

That brings up the immediate question: What is a low resistance ground? As I previously stated, the National Electrical Safety Code does set forth in Section 9 rules and methods of grounding power and communications lines. Paragraph 96A states that "made electrodes" shall have a ground resistance not to exceed 25 ohms. That is one definition of a low resistance ground. Quite often, power companies choose to require lower resistance grounds where certain types of equipment are located. One power company requires a maximum ground resistance of 5 ohms on any pole that supports a transformer, capacitor bank, voltage regulator . . . essentially any pole on which there is equipment that is subject to high voltage surges (primarily from lightning strokes).

There is a very good reason why many power companies require such a low ground resistance. A statement is often heard that electricity takes the path of least resistance to ground. This is true enough; however, that is not the only path to ground that electricity takes. Electricity takes all paths to ground whether they are high or low resistance. Pole lines are continually subject to fault current flow to ground; the fault current is usually a result of power company equipment failure, temporary phase-to-ground faults from animals, or lightning surges. This fault current is usually in the order of magnitude of thousands of amperes. While the largest part of the fault current flows through the grounding system (path of least resistance); any other path to ground, such as strandmounted equipment or linemen working on such equipment, will be subject to some fault current flow. This is the importance of low resistance grounds; the lower the ground resistance, the less the fault current will divide to take the other paths to ground.

Power companies have still another benefit from low resistance ground connections. Lower ground resistances result in higher fault currents which in turn enable fuses and circuit breakers to operate faster. Fast operation of protective devices greatly reduce voltage strain on equipment and exposure time to personnel.

Having discussed some reasons for needing a low resistance ground, I would like to describe the grounding practices of several utilities with which I have been associated. I would like to show how ground resistance is affected not only by the

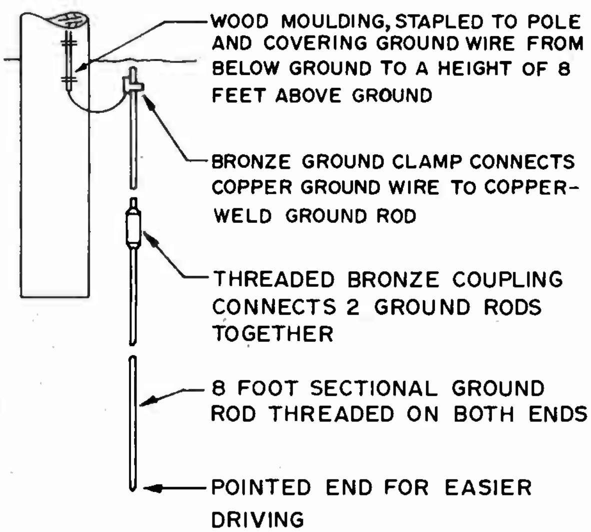


Fig. 1. Typical installation of a section ground rod.

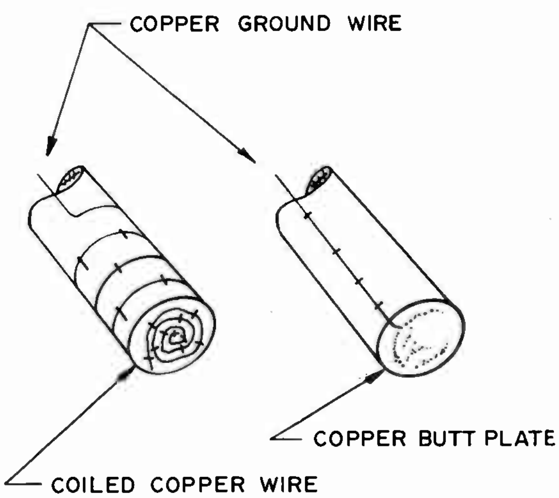


Fig. 2. Pole butt grounds.

particular grounding technique but also by several variables that can be dealt with but not controlled.

Common Pole Grounds

Utility pole grounds are usually either driven ground rod or pole butt ground. The power company in Tampa, Florida is Tampa Electric Company. Tampa Electric's primary distribution system is a 13KV grounded wye. This distribution system uses a common neutral; one neutral for both primary and secondary circuits. The common neutral (as used by Tampa Electric) is also multi-grounded. This means that there are at least 4 ground connections per mile.

At grounding points, the neutral is bonded to a #6 soft drawn copper ground wire. The copper ground wire is run vertically down the pole and connected to a driven ground rod.

The ground rod that Tampa Electric uses is a slightly oversize ½″ rod of the Copperweld type. The Copperweld ground rod is a rod with a steel core and a molten welded copper exterior. The steel core gives the ground rod good driveability. Tampa Electric went to the oversized ½″ rod after having driving problems (bending) with the standard ½″ rod. It was not necessary, in Tampa, to go to the stiffer and more expensive ⅝″ Copperweld rod. Ground rod diameters are usually chosen in this manner; the rod stiffness needed to drive in any given area is found by trial and error in the field. (Note that the safety code, paragraph 95D, sets the minimum size of Copperweld (non-ferrous) ground rods to be ½″ in diameter while ground rods of iron or steel (only) must be at least ⅝″ in diameter.)

Tampa Electric's standard ground rod is eight feet long; which is also in accordance with safety code requirements. The safety code states, in paragraph 95D, that driven ground rods" . . . shall preferably be of one piece, and, except where rock bottom is encountered, shall be driven to a depth of 8 feet . . ."

In addition to driving ground rods in this standard length of 8 feet, Tampa Electric's ground rod is threaded on both ends. Many times the 8 foot rod does not provide the specified ground resistance, such as 5 ohms at equipment installations. When this happens the groundman threads on another 8 foot section and resumes driving. (See Fig. 1) Tampa Electric, in trying to drive a low resistance ground, finds it easier (in Tampa) to drive deep grounds rather than to use multiple grounds.

Copper is used as the grounding electrode due to its good conductivity and superior corrosion resistance. Ground rods are also made with stainless steel replacing the copper in the Copperweld style rod and also of galvanized iron.

The other common type of pole ground is the butt ground. (See Fig. 2) It can either be wire wrapped around the butt of the pole or a plate stapled to the bottom of the pole. In both cases the butt ground is installed prior to pole being set. If the wrapped wire method is used, the safety code requires that at least 12 feet of wire be buried.

The municipal power company in San Antonio, City Public Service, use a 6″ diameter copper plate as their butt ground. In contrast to the usual driven grounds of 4 per mile, CPS installs a butt ground on every distribution pole that is set. This is the only practical way of grounding in this area since almost 40% of CPS's service area is solid rock underneath the top soil.

Given these standard and fairly similar grounding techniques, I would like to briefly touch on some of the factors that can cause quite large variations in grounding resistance values just within a fairly small area.

Variations in Ground Resistance

The resistance of any ground connection is made up of 3 factors:

1. Resistance in electric connections
2. Resistance of the ground wire
3. Resistance of the surrounding earth

Careful installation of electrical connectors will insure that connection resistance is negligible. Copper ground wire and manufactured ground electrodes also do their part in not adding any appreciable resistance. That leaves the third item as the biggest culprit in ground rod resistance: resistance of the surrounding earth.

In order to be sure that a grounding system minimizes, as much as possible, the earth's resistance, it will be helpful to look at the factors that affect it. Basically, there are three:

1. Type of soil
2. Moisture content
3. Temperature

The type of soil is probably the biggest variable of the three. In general, sandy soils have a very high resistivity while soils of clay, shale and loam content have a much lower resistivity. While it is possible to lower soil resistivity by the addition of salts and other chemicals, this is not too widespread a practice. One problem with soil treatment is that it is usually a temporary measure and its effects do not last. You essentially just have to live with the type of soil in which you are trying to ground.

For any given soil type, moisture content greatly affects earth resistivity. The reason for this is that the increased moisture better dissolves any natural salts present and makes the earth a better conductor.

The temperature of the earth also affects its resistivity. Higher soil temperatures decrease earth resistivity. Knowledge of these factors affecting earth resistivity helps in designing operating procedures which will insure that each ground is low resistance and will stay that way for a reasonable period of time.

I have stated that you usually just have to live with the type of soil in which you are trying to ground. This is only partially true. (See Fig. 3) At any given location, soil type varies with depth below the surface. This explains the success of the sectional ground rod. If the first 8 feet of ground rod doesn't put you into low resistivity soil, the second or third section usually does.

Next, let us see what grounding practice will be of most help in taking advantage of the other two factors affecting earth resistivity. Moisture and temperature are primarily seasonal in nature and seasonal variations are most reduced with increased depth below the surface. (See Fig. 4) This means trying to put your grounds below the frost level and permanent moisture level, if practical in your area. Again, sectional ground rods are a convenient tool for doing this.

So far my recommendations have been to drive reasonably deep grounds in order to get stable, low

Fig. 3. Relation between type of soil and resistance of driven ground rod at different depths. See Reference 4.

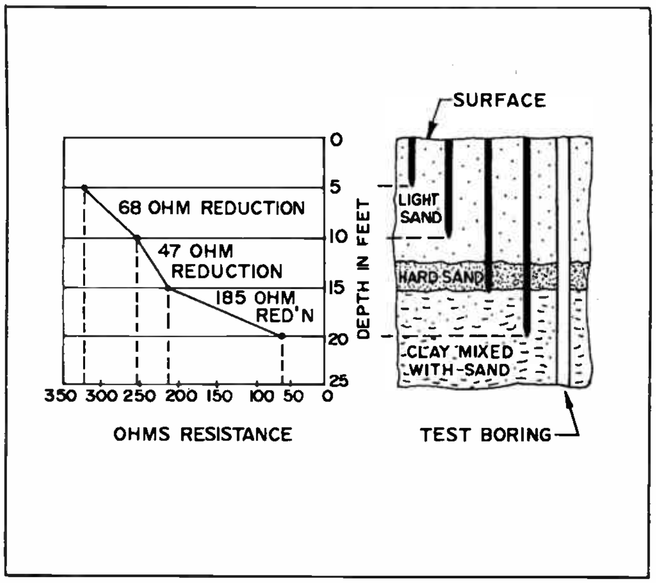
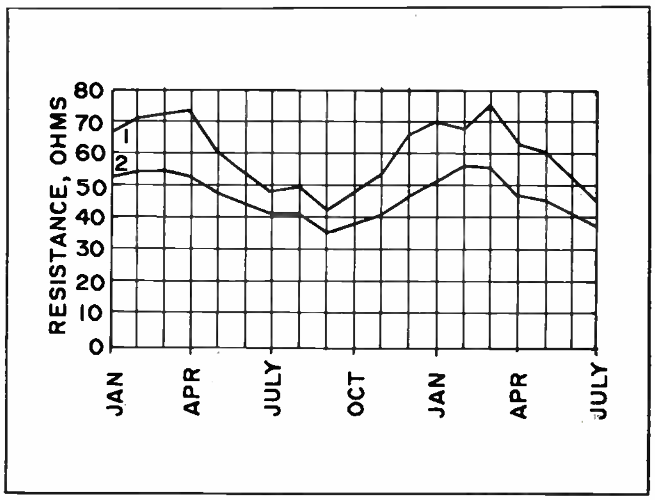


Fig. 4. Seasonal variation of earth resistance. Depth of ground rod is three feet for curve 1 and ten feet for curve 2. See Reference 3.



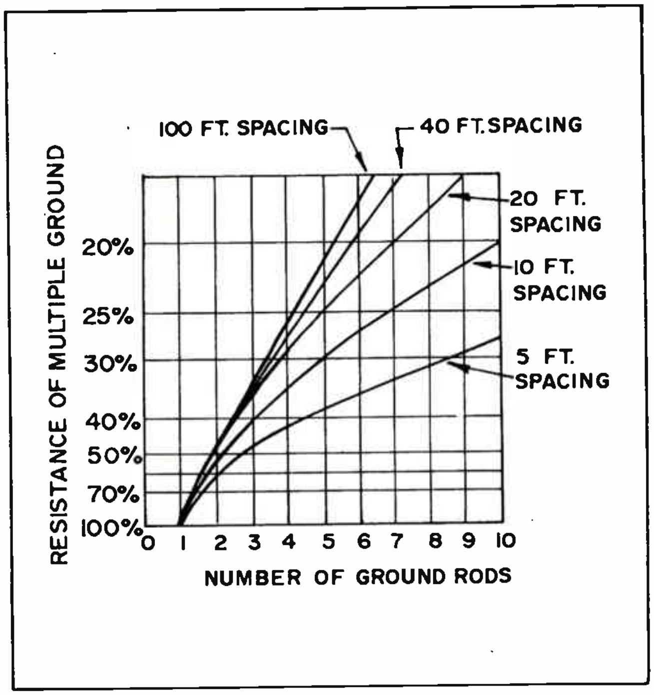


Fig. 5. Effectiveness of multiple ground rod. Single rod equals 100 percent. See Reference 4.

resistance grounds. As you know, this is not possible in many parts of the country where there are large amounts of rock. The approach here has to be through multiple grounds at each ground location or just many more individual grounds along the pole line. If 8 foot rods can be driven (but not anything longer), then multiple rods, all tied together at this one location, are effective in lowering ground rod resistance. However, the effectiveness of multiple ground rods is diminished if the rods are driven very close to each other. (See Fig. 5) The other alternative in these rocky areas, is more frequent grounding; such as the practice in San Antonio with pole-butt grounds on every pole.

Although I have emphasized how important it is to have a low resistance ground connection, I haven't indicated how you can know when your ground resistance is low enough. The only way to know is to measure it.

I'm not going to go into the theory of earth resistance testing; there are several good sources for this. (See Ref. 3) I would just like to describe one instrument that is designed for this purpose. The manufacturer of this instrument calls it a Megger, Null Balance, Earth Tester. Utility people just call it a megger. In its most common use, a method called the "Fall-of-Potential" or "Three Terminal" test is used. (See Fig. 6) Two reference electrodes are driven into the ground some distance away from the electrode or ground rod under test. One reference electrode is called the "potential" electrode and is positioned just over halfway between the ground rod and the other reference electrode (called the "current" electrode).

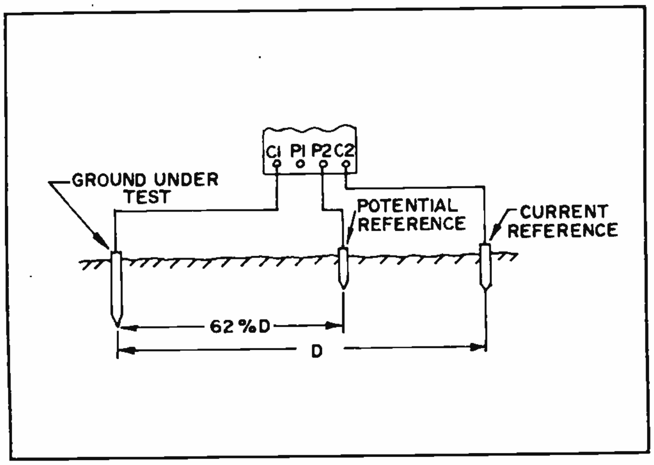


Fig. 6. "Fall of potential" or "three terminal" earth resistance test. See Reference 3.

The reference electrodes are so named because the megger actually uses them as current and potential references in arriving at the ground rod resistance. After setting up the test in this manner, all that has to be done is to turn a hand driven generator within the megger and turning resistance dials on the megger in order to null a meter. The ground rod resistance is then the resistance that was dialed in to null the meter.

This instrument is easy to use and lets you know exactly how good a ground you have just installed. Take note that individual grounds should be meggered before being connected to the power or telephone company's system ground. Otherwise you would be measuring the ground resistance of the entire grounding system.

Having reviewed methods and reasons for getting low resistance grounds, I would now like to point out a serious corrosion problem that is present in San Antonio.

Corrosion Problems

As I have indicated, a multi-grounded neutral with copper being the grounding conductor is a very common power company practice. An equally common practice is to bond down guys (for safety reasons) to the multi-grounded neutral. A classic galvanic cell is then formed (See Fig. 7). There are two dissimilar metals (copper ground electrode and galvanized iron anchor rod) electrically connected (bonded together on the pole) and emersed in an electrolyte (soil). In some areas of the country, an extremely potent battery is created.

The first metal to start corroding is the zinc galvanizing on the anchor rod. The zinc enters the soil as corrosion current flows. As the zinc is eaten up, the iron from the anchor rod then starts sacrificing itself. While you may be maintaining an excellent grounding system, the system's anchoring could be disappearing.

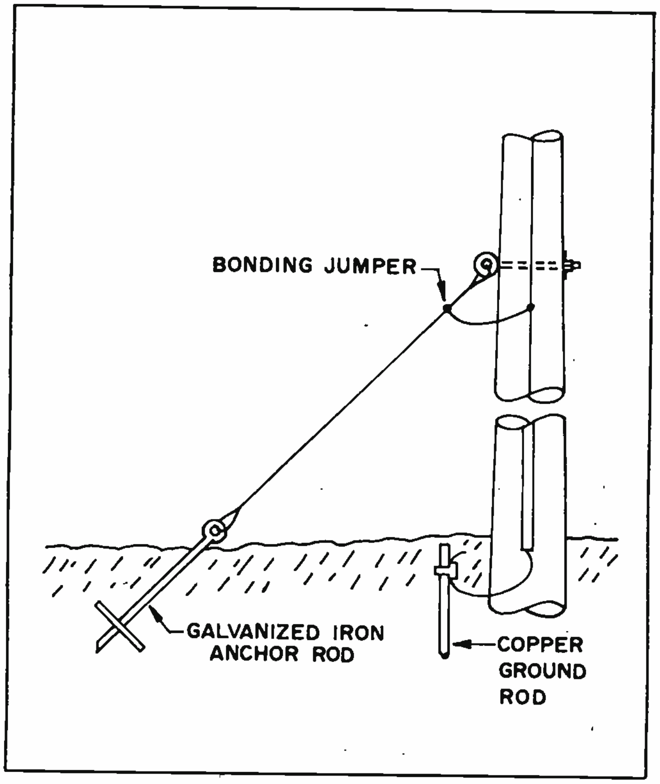


Fig. 7. Grounding practice that can lead to corrosion problems.

In San Antonio, City Public Service's policy has long been to keep their copper grounding system isolated (not bonded) from their anchoring system. However, Southwestern Bell, in this same service area, went through a period of time, when on joint use poles with power, they bonded their down guys to their messenger which in turn was bonded to power neutral. Consequently, Southwestern Bell began experiencing severe corrosion of anchor rods. During one year alone, 1968, approximately seventy-five anchor rods were replaced due to corrosion failure. Corrosion measurements were taken on over one hundred down guys thus bonded. Corrosion currents between 2 and 85 milliamperes were found; indicating extensive corrosion forces at work. Southwestern Bell reversed themselves and went to the practice of isolating their down guys from the grounding system.

There are several ways of isolating the down guy in order to break up the corrosion circuit. One way, used by both City Public Service and Southwestern Bell, is to install an insulator (called johnny-ball) in the guy lead. A second way is to guy off of a separate "through bolt" from the one used for the neutral; and not install a bonding jumper. Still a third way is by using an insulated anchor rod. This is currently under trial by Southwestern Bell in San Antonio.

Now I would like to tell you about another part of the country that has successfully used the same bonding and grounding practices that failed in San Antonio. In Tampa, Fla., Tampa Electric Company, with its multi-grounded neutral, and General Telephone Company both bond all down guys to the copper grounding system.

To this date, neither company has lost any anchor rods due to corrosion. An obvious question is: why not? The same conditions for creating a galvanic corrosion cell are present in grounding practices in the Florida utilities as in the Texas utilities. The only significant difference is the type of soil. I can only conclude that the soil characteristics are such that the soil in the Tampa area is generally of pretty high resistivity and limits the corrosion currents to very small values. Conversely, San Antonio must have some pretty low resistivity soil which allows for a fine grounding system but creates potential corrosion problems.

Getting back to grounding, I would like to end with this statement: It is only through field resistance measurements that you can be absolutely sure that you are installing a low resistance ground and it is only through periodic field measurements and inspections that you can be sure that you are maintaining a good, low resistance grounding system.

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SYSTEM ASPECTS OF STANDBY POWER

By Robert L. Cowart
Gill Cable Inc., San Jose, CA.

Standby power is a system whereby provision is made for continuation of energy supply to the system during loss of normal commercial power. The standby approach has been in use for many, many years in such applications as telephone company central office, computer system power supplies and utility company automatically operated switch gear.

It has only been in recent years that CATV systems, particularly in the larger markets, have begun to feel the need to equip their systems with another source of power to preserve signal integrity through an area that has suffered a power loss. In the past, in very small communities where off-air signals were either non-existent or of poor quality, standby power was not normally required and where it was utilized, the usage was generally restricted to such applications as remote headend supply or microwave system power. Large communities, particularly in the major market areas, are in competition with high quality and high reliability off-air signals and need to meet or exceed the performance available from competing signals. Large market subscribers are completely intolerant of loss of signal, regardless of the reason.

With the reliability of most modern day equipment, given proper maintenance, the basic component performance is usually excellent, but the energy to continuously power it has become one of the weaker links in the total signal chain. Obviously there is little that we can do about the system casualty type outages where our plant is physically destroyed by such things as car-pole accidents, broken conductors, etc.; but we can overcome the more frequent problem, the loss of commercial power.

Usage of standby power is primarily dictated by the system configuration, and in the case of a hub system, logical points of support with back-up power would be the hub input or headend, as well as primary transportation runs that extend through large areas of geography. In a conventional system, the obvious areas would be antenna site runs and areas that have demonstrated low power company reliability. In major market areas, my feeling is that standby power should be used at every power supply location as, normally, the customers have little reason to stay on the system if it demonstrates any less reliability than they have been accustomed to with their own antennas; and in fact, our experience in San Jose is that one of the primary reasons for disconnect in our older portions of the system is simply failure of the system to continuously deliver signals regardless of the explanation that we have lost power in a key portion. We have made many attempts to conform our system power flow to the commercial power distribution system. These attempts invariably result in failure to achieve any kind of reasonable match; and we have therefore adopted a policy of 100% standby supplies.

It is often very difficult to equate system expenditures to customer retention and customer acquisition. However, I think it is interesting to note that in spite of the intense off-air competition in a major market such as San Jose, we have achieved a subscriber penetration rate of 52%. A large portion of this retention, I am sure, is due to our unusual approach to standby power.

The efficiency and the cost with which standby power can be designed into a system depends primarily upon whether the system is designed for 30 volt or 60 volt operation. Our experience indicates that with a 30V system, there is approximately one mile of total plant fed from a given power supply. With a 60V system, we increase to 3.3 miles per power supply. The 60V approach obviously is the most practical kind of system to treat with standby power, as the cost differential between a 30V and a 60V standby system is very small, and in some cases the same.

Kinds of Standby Systems

Standby power supply systems are generally of two basic types. The first system is a switching system in which the battery supply and inverter are not placed in service until loss of commercial power is sensed and the only connection to the commercial line is through a charger, which provides float charge current for the batteries. The other type of system is a floating system in which the inverter and batteries are the only source of power for the system and the charger provides all of the current required to drive the system, as well as excess current to keep the batteries on charge.

Each type of system has certain advantages and disadvantages. The switching system generally depends upon relays for transferring system voltage from a resonant transformer secondary to an inverter secondary and suffers from the usual problem of any system utilizing relays. Dust builds up on contacts which, because of their low use cycle, are not kept clean, and tend to inhibit transfer. With proper design and proper relay selection, this type of problem can be minimized. The switching type of system generally requires a larger mounting enclosure, as the box must house the batteries, inverter, charger and the normal supply transformer. The switching supply's advantages are that a very small charger is required and should any fault develop in the normal transformer, the system can be switched to the inverter while repairs or replacements are made without affecting system operation. Another virtue is that the phasing of the system line can be very simply controlled, as starts and finishes of transformer windings are easy to identify.

You are probably aware of the problem of having cross phasing for two different adjacent power supplies, resulting in the generation of substantial fault current when your technician places the power pass switch in the wrong position. In this condition, when one transformer is going positive and the other is going negative, the fault current possibilities are rather awesome, and generally substantially exceed the permissible current ratings for intervening passive devices and active device base plates. This situation is analogous to connecting two batteries negative to positive and positive to negative. On the other hand, with all secondary phasings the same, paralleling the power supplies causes no damage and is analogous to connecting two batteries in parallel, positive to positive and negative to negative.

In fact, some systems in the past have been built with no power brakes or power stops and with all power supplies in parallel, dumping into a common power pool. This approach really isn't too bad, and I have personally used it a few times in emergencies to keep a portion of the system alive while a particular power supply has been replaced; and even though the voltage in some subsections was lower than normal, found that generally a little hum in the picture caused by some amplifier power supply going out of regulation was to be preferred to no signals at all.

The floating system eliminates one excessive and bulky component from the power supply enclosure and also removes the second source of power. Thus the overall reliability is a bit less than the switching type and should any failure occur in the inverter or battery supply, the entire system fed by it loses service. The other disadvantage is that unless the inverter is phase locked to the commercial power line, the output polarity problem arises. The only real advantage to the full float system is that there is absolutely no interruption to service during the commercial power loss period, up to the ultimate discharge point of the battery source.

We have investigated the time available for switching before signal loss occurs, as ultimately many systems will be carrying data loads of one type or another and our interest of course is the preservation of the communications path. Our primary studies indicate that with the type of equipment we are utilizing, we have a minimum time interval of at least 70 milliseconds in which to do switching and produce useful output from the inverter before any change occurs in signal levels and substantially more time available before distortion production reaches a point where it would become a problem in data transmission. These time intervals exhibit some rather interesting phenomena. For example, at the lower frequencies with a Jerrold SAMPT and Jerrold SBMT, as the internal amplifier power supply begins to lose reference voltage, there is an actual increase in amplifier output of approximately 2.3 dB, 50 milliseconds after loss of power which then decays to the reference otuput level in about 160 milliseconds and it is 1 dB lower than reference at 200 milliseconds after power loss. At 270 MHz, the region in which most data will probably be carried, the increase is only a few tenths of a dB at 50 milliseconds after power loss and decays 1 dB at 60 milliseconds after power loss.

These time periods are rather substantial and as most relays complete their transfer in some 5 to 15 milliseconds, providing a switching time interval as follows: power loss sensing—16 milliseconds; relay transfer—15 milliseconds; initial cycle of inverter output—19 milliseconds. The total elapsed time is 50 milliseconds from loss of power to the availability of standby power from the inverter. This is well within the worst case decay time from common amplifiers. For these reasons, we have elected to utilize the switching type inverter as the method which provides us with the maximum reliability.

A Word About Inverters

Most inverters fall into one of two categories, determined by the type of switching element. The oldest and probably the one with which everyone is familiar is the transistor switching inverter. This type inverter is used for most vehicular applications of relatively modest power requirements. However, transistor switching inverters have been built up into the low kilowatt range.

The first inverters offered to the CATV industry were of the transistor switching type. Most of these earlier approaches failed with most failures due to the use of germanium transistors that did not have proper heat dissipation ratings. Another common problem that the germanium transistors did not handle well was the transient voltage encountered in most systems.

The other type of inverter achieves switching by the use of silicon controlled rectifiers (SCR's). This type of switching device has extremely high power ratings and is the type that is coming into most common current usage for the high power application where switching of over a kilowatt is required. The penalty paid by the use of SCR's is that they are extremely difficult to turn off and on (commutate) with the lower voltages typical of CATV supplies. However, this is essentially an engineering problem and modern circuit design generally provides ways to achieve commutation with very low error rates. We are currently using a 2½ kilowatt SCR switching inverter for our headend application with excellent results, and have also incorporated the SCR technique into all of our new construction requiring standby supplies.

A Word About Batteries

Everyone knows about batteries because we all have batteries in our cars, boats, etc.—or do we know all about batteries? Batteries are of two major categories by type of service. Most batteries with which we are familiar are designed to provide high starting currents for engines. These are composed of many thin plates separated by thin insulators and using a very high specific gravity electrolyte. This type of battery is inexpensive because of its wide use. It generally exhibits a relatively short life.

The other type of battery is one designed for stationary service. It is designed with very heavy, massive plates, very thick insulators and uses a low specific gravity electrolyte. It is designed to deliver continuously low current for long periods of time, and its lifetime is generally measured in tens of years.

Some people utilizing standby supplies apparently feel they can achieve some economies by utilizing the automotive type batteries. Generally this is a mistake, for after several replacements the cost will be higher than if they had used the slightly more expensive stationary service type battery. My personal feeling is that the design life for the entire standby package should be at least ten years and probably twenty, and our approach has been to buy the very best and longest life batteries available. Common types of batteries offered are lead antimony, which is probably the most economical to use; the lead calcium, which is probably the longest lived battery available, and the gel cell, whose only virtue is the solid electrolyte and has probably the worst energy-to-volume ratio of any, but requires the least attention.

A Word About Chargers

Most current standby systems provide, as part of the basic package, a charger of some type. However, many inverter manufacturers have not carefully researched the requirements of the battery supplies and have paid little attention to optimizing charger design for greatest battery life. The recommendations of the battery manufacturer must be followed implicitly if any warranties on batteries are to be expected. If you utilize lead antimony batteries, you *must* provide for

Fig. 1. Cost variation of D.C. voltage sources vs. operating time. List prices of stationary service lead-antimony batteries are used as a cost base, with a 30 volt system.

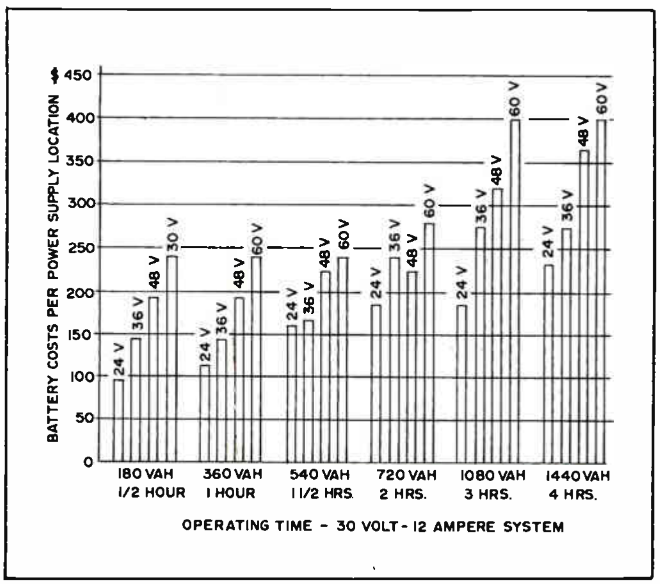
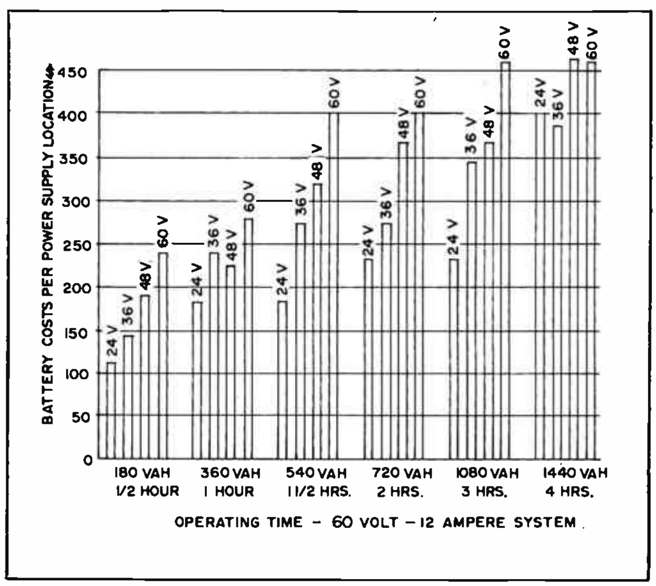


Fig. 2. These curves represent costs of D.C. voltage sources vs. operating time for a 60 volt system.



Capacity AMP/HRS	Cost	12v	18v	24v	30v	36v	42v	48v	54v	60v
		TRAY VOLTAGE								
10	24.00	120 VAH	180 VAH	240 VAH	300 VAH	360 VAH	420 VAH	480 VAH	540 VAH	600 VAH
		$48.00	$72.00	$96.00	$120.00	$144.00	$168.00	$192.00	$216.00	$240.00
15	28.00	180	270	360	450	540	630	720	810	900
		56.00	84.00	112.00	140.00	168.00	196.00	224.00	252.00	280.00
25	40.00	300	450	600	750	900	1050	1200	1350	1500
		80.00	120.00	160.00	200.00	240.00	280.00	320.00	360.00	400.00
50	46.00	600	900	1200	1500	1800	2100	2400	2700	3000
		92.00	138.00	184.00	230.00	276.00	322.00	368.00	414.00	460.00
75	58.00	900	1350	1800	2250	2700	3150	3600	4050	4500
		116.00	174.00	232.00	290.00	348.00	406.00	464.00	522.00	580.00
100	64.50	1200	1800	2400	3000	3600	4200	4800	5400	6000
		129.00	193.50	258.00	322.50	387.00	451.50	516.00	580.50	645.50
120	100.00	1440	2160	2880	3600	4320	5040	5760	6480	7200
		200.00	300.00	400.00	500.00	600.00	700.00	800.00	900.00	1000.00

Table 1. Typical costs, based on list prices, for various combinations of voltages and currents for batteries.

equalizing charge, which simply is a slight increase in charging voltage required to equalize the cell voltage. This in turn will greatly reduce the common problem of gassing excessively from one or more cells, as all cells in a given tray will outgas at about the same rate.

Most standby systems are sold less batteries, and the purchaser is required to supply his own. You should seek the recommendations of the supplier of the inverter, as the battery you may choose may not fit the characteristics of the charger supplied. I would also strongly advise you to compare the battery requirements of the various inverter manufacturers. Table 1 illustrates typical costs based on list prices for various combinations of voltages and currents, and shows that for a given voltage ampere hour rating certain power supply voltages represent optimum tradeoffs for battery costs. Our analysis indicates that the 36 volt dc source is the optimum dc value for a given battery dollar investment.

Each system must analyze its requirements individually. The first step is to determine the length of time you wish the inverters to operate from the battery supply. On the West Coast in most areas, the typical power outage interval is 28 minutes, and the worst case outage occurs with the loss of a major transformer at a substation, which can run from two to six hours. Most western power companies utilize a substation sectionalizer which is a system that, in the event of a power system failure, automatically tests each subsection feed by the station and isolates the portion originating the failure. This process takes roughly two minutes to complete on a worst case basis. Obviously, we wish our standby system to cover both the two minute and the 28 minute outage interval.

It would be rare that the major fault involving a two to six house outage time would not be readily apparent to the system operator, and in consideration of these time intervals we have chosen an operating time of 1½ hours for our standby system. This time period will provide power for roughly 95% of the outage intervals; and we maintain gasoline driven generators to support the system during the rare occurrences of a major outage greater than two hours.

With the data in hand, we can now select the proper battery system for our standby units. Let's use San Jose as an example. Since this is a dual cable system powered by 60 volts with a power supply design value of 12 amperes, we require 720 volt amperes (VA) at each location. Typical efficiencies in the inverter mode are 60%, therefore, we require 1008 VA. Furthermore, since we require the system to operate for 1½ hours, we need 2016 volt ampere hours, or, for the dual system, 3032 volt ampere hours. Examining Table 1, with 36 volt primary voltage, we find the 100 ampere hour battery would deliver 3600 volt ampere hours and would be the proper one for this system, and would represent a battery cost of $387.00 per location. Compare this for a moment with a 48 volt system also delivering 3600 volt ampere hours using a 75 ampere hour battery which would cost $464.00, and also compare it to a 30 volt system requiring 120 ampere hour batteries representing a battery cost of $500 per location; and you can thus see that the 36 volt primary source appears to be optimum.

THE CASE OF THE DISAPPEARING HEAD ROOM

By Warren L. Braun, P.E.
Com Sonics Inc.

Today's CATV system performance must be superior to that of previous years, both for new *and older existing systems*. This statement is valid because:

- Subscriber television set fidelity is steadily improving.
- Viewers are becoming more critical.
- Franchising agencies are becoming more critical of and knowledgeable about system performance.
- Increased competition in new and renewal franchise proceedings.
- System technical performance standards imposed by—
  - •• FCC
  - •• Franchising Agencies
  - •• State PUC's (or equivalent agencies)

With new systems, proper attention paid to design criteria and implementation can assure reasonably distortion free CATV transmission at least at the inception of system operation.

A large percentage of subscriber complaints traceable to system malfunctioning have their origin in the increased visibility of system contaminants, i.e., cross modulation, beats, noise, etc. The majority of these system malfunctions are directly traceable to a loss of system dynamic range. Experienced CATV system chief technicians are all too familiar with the day to day reality of short term and long term effects of shrinking CATV system dynamic range. They may not know all the causative factors involved, but they are very aware of the increased frequency of trouble calls associated with degraded performance indicators, such as visible cross modulation, beats, and excessive noise.

Even with the best system maintenance and repair, certain factors have caused originally acceptable system dynamic range to become unacceptable, i.e., the system requires excessive maintenance to achieve acceptable subscriber performance. A partial list of the factors deteriorating the technical performance of the plant with no equipment malfunction is:

- Added equivalent channel loading from multichannel stereo FM, carried at a higher system level than monaural FM to achieve noise free carriage.
- More actual channels of carriage. Many 12 channel plants started with less than 12 TV channels, are now fully loaded with no change in plant design. (Total triple beat products rise in proportion to P^3, and for 2 A-B components, total components rise proportioned to P^2, so added channels of carriage add significantly to system spurious signals).
- Television station conversion to 3.58+ MHz tightly controlled color scanning sources, changing signal status to quasi synchronous from quasi non-synchronous.
- The effects of simultaneous non-duplication. Channels so involved are in effect synchronous, increasing the equivalent system signal burden.

Dynamic Range Loss

In addition to the factors just presented which bring about an apparent decrease of dynamic range of the system, there is the *very real decrease* in dynamic range due to deterioration of the plant over a period of time. The principle causes of shrinking dynamic range are:

1. Increasing amplitude versus frequency response roughness, due to partially defective system components and cable.
2. Increased system attenuation due to partially defective cable and/or connectors and moisture immigration.
3. Addition of system legs or branches without proper system re-engineering.
4. Improper repair of amplifiers.

The latter item is the most serious source of system long term deterioration.

Since the amplifier repair is the most serious source of dynamic range loss, it is prudent to examine why this is so. Typical amplifier repair is accomplished as follows:

1. Removal of amplifier in question from the system.
2. Repair of the obvious deficiencies by replacement of apparently defective components.
3. Realignment and gain measurements (*sometimes* return loss) of the device.
4. Return of repaired device to spare stock or to system.

It is quite evident that the two most important parameters of the amplifier have not been measured, namely, the cross modulation and noise figure. While relatively expensive equipment and skilled personnel are necessary to make meaningful measurements of these important parameters, it is instructive to inspect the enormous penalty the system operator pays for *not* making such measurements.

In the following table, data is shown comparing typical field repaired amplifiers (Jerrold TML series) with those repaired under carefully controlled conditions including cross modulation and noise figure tests.

TABLE I

Output Level 43/40

Worst Case Average Cross Modulation[1]

Ch.	61 Units Repair Without Cross Modulation & N.F. Test	53 Units Repair With Cross Modulation & N.F. Test
2	-51 dB	-63 dB
6	-50 dB	-64 dB
9	-52 dB	-65 dB
11	-52 dB	-64 dB

Worst Case Noise Figure

Ch.		
2	10	8.0
11	11	10.0

While the above data is not presented in a statistical form, the tabulated data does present a correct representation of the true contribution to total system performance. From the previous, it is evident that field repair without cross modulation and noise figure analysis costs the typical system operator *14dB* in dynamic range!

The system technician, who is of the opinion that his "head room" has decreased since construction is entirely correct, and in most cases, the source of the decreasing head room has come from the in-house field repair or outside repairs made by others not working to fixed cross modulation and noise figure criteria.

Factors in Amplifier Failure

Since this problem was brought on by the need to repair the amplifier, it would be useful to research some of the factors involved in amplifier failure. Amplifier failures traceable to source of supply are:

- Flaws in original design.
- Vendor problems in manufacture.
- Inadequate quality control in production.
- Mishandling in shipment.

These sources of failure can be reduced radically by:

- Detailed and careful evaluation of devices before purchase for selection of an optimum vendor.
- 48 hour burn in upon receipt prior to equipment test.
- 100% QC check of *all* significant amplifier parameters after burn in.
- Storage of amplifiers in a proper environment until safely inside the properly waterproofed housing in the system.

A recent average taken from our laboratory notebooks indicate the following reasons for new amplifiers of various manufacturers failing to meet published specifications:

TABLE 2

PERCENTAGE SHOWN OF TOTAL POPULATION NOT MEETING PUBLISHED SPECIFICATIONS

Trunk Amplifiers		
*	Test points -	39% (out of tolerance)
*	Cross Modulation -	15% (3% seriously defective)
Distribution Amplifiers - All Types		
*	Test Points -	27% (out of tolerance)
*	Cross Modulation -	20% (4% seriously defective)

It would be totally erroneous to assume from these data that the manufacturers are doing a sloppy job. The fact is that these tests were conducted *after storage, shipment,* and a *48 hour burn in.* It behooves the wise system operator to set up a product acceptance testing system, either in house, or contracted, for any new system construction, *or* new equipment purchase. Obviously, tight system performance criteria tend to ferret out marginal equipment performance, and this technique does assure greater longevity of initial system performance than "boiler plate" performance criteria.

Unfortunately, the majority of the cross modulation failures in the previous data were marginal (approximate average 3dB), and therefore, when co-mingled in the system, would have a relatively

[1]—NCTA Synchronous 12 channel loading.

small overall effect initially. What *is* serious was discovered when detailed analysis was made of the amplifiers failing to meet the cross modulation standards. *In almost all cases*, the poor performance was traceable to partially defective active devices, or components which had drifted out of tolerance after manufacture. In other words, each of these amplifiers would contribute to the "disappearing head room" after installation.

Transients

After the equipment has been installed, additional environmental factors lead to loss of head room. Although not truly representative of all systems, the following data has been developed from a composite of systems subjected to close scrutiny located in the Southeastern U.S. Keep in mind that these devices under this *analysis* had "failed" by the usual system definition.

- Transient Intrusion — 33%
- Improper field installation (11%) — 28%
- Improper diagnosis (17%) (device operative)
- Water damage — 6%
- Component failure — 16% (Other than obviously transient related)
- Alignment drift — 8% (Including technical maladjustment)
- Residual manufacturing defects — 4%
- Misc. — 5%

100%

It is quite evident that transient intrusion is a large factor in the system reliability problem. It is important to note that the second category of problems does not appear until a technician attempts to locate a problem! From the previous it is quite evident that beyond the prior checkout of equipment upon receipt, a very large percentage of the system outages can be prevented simply by improving transient intrusion immunity of the system. It is also quite obvious that proper technician training and supervision can avoid much unnecessary system equipment "maintenance." It is also interesting to note that most water damage is due to poor system workmanship, or a lack of proper moistureproofing technology.

Transients find their way into the CATV plant via the cable powering points *and* through direct injection, due either to instantaneous sheath potential drop, or via collapsing magnetic flux, *or* both. In most cases, the transients via the cable power point tend to be of the asymmetrical half supply cycle—roughly 3X applied voltage variety. The latter variety of pulses are extremely high

(Continued on page 22)

AT THE NATIONAL NCTA CONVENTION

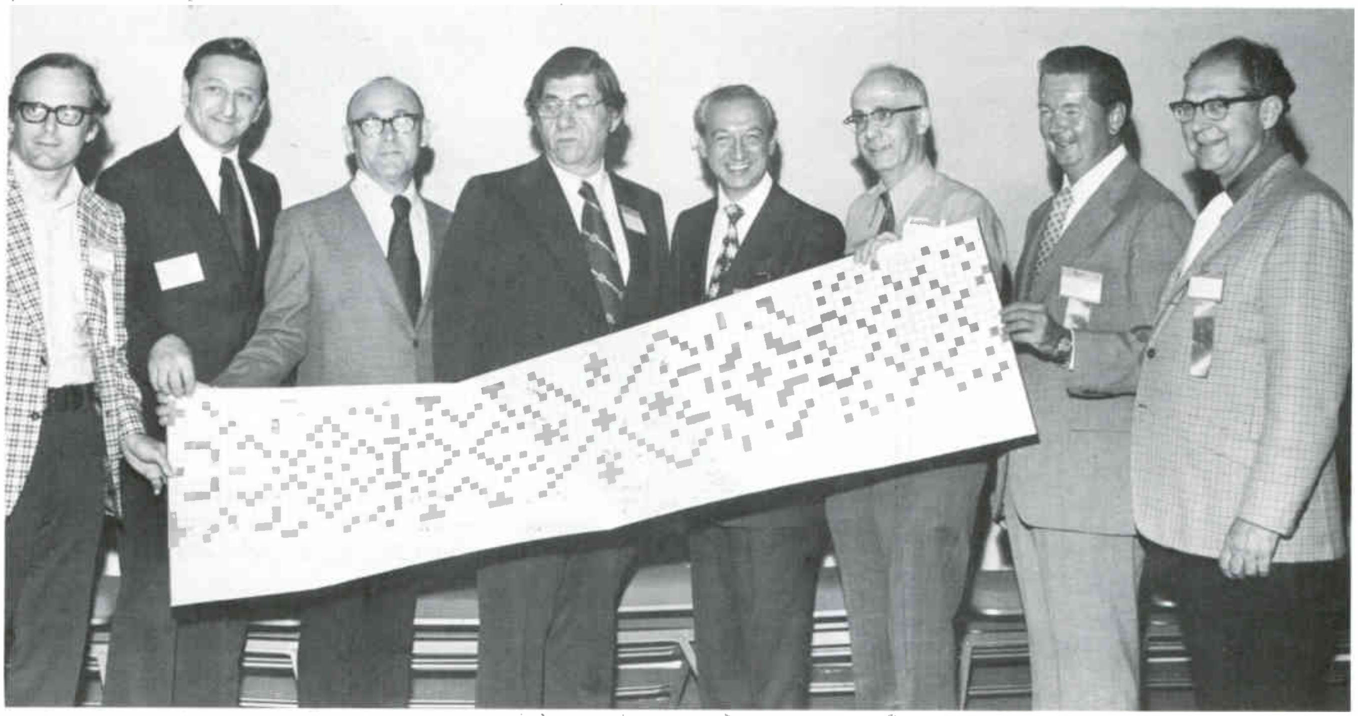
The Society of Cable Television Engineers was invited by the National Cable Television Association to participate in the National Convention in Anaheim, from June 17 to 20, in the preparation of the technical program and other activities for attending technical people. In response to this invitation from Delmer Ports, vice president for engineering of the NCTA, Robert Bilodeau, President of the SCTE, organized three "eye-opener technical workshops", which were very well attended. The subjects covered at these workshops were: Stand by power—what price reliability?, moderated by Loyal Park of the North Central Chapter; The Relationship between Federal/State/Municipal control in technical standards, moderated by Joe Hale of California; and The Elusive subscriber terminal—How much and when?, moderated by Steve Dourdoufis of the Midatlantic Chapter and Eastern Vice President of the SCTE.

In addition to this service to the engineers of the cable television industry, the SCTE was involved in the selection of cable TV engineers to receive the first annual Outstanding Technical Achievement Awards. Keneth A. Simons, director of research and development at Jerrold Corp., was given the award for outstanding achievement in engineering and manufacturing. He is the author of numerous articles and a "Technical Handbook for CATV Systems." Receiving the award for the outstanding achievement in the area of systems operation was Donald W. Levenson, president of Wheeling Antenna Co. in Wheeling, West Virginia. He is known for his design of the simultaneous sweep technique used for cable systems analysis.

One more award, presented at the NCTA Convention, which won the approval of all engineers present, was a six-foot crossword puzzle to Sid Lines, who has just retired from the staff of the Office of the Chief Engineer of the FCC. The award was presented with the comment that . . . "anyone who can find his way through the FCC technical standards for cable television systems, as Mr. Lines can, should have no trouble with the six-foot crossword puzzle."

At the annual members and directors meeting of the SCTE, held on Tuesday, June 19, elections were held for national offices. Elected president was Robert Bilodeau of Suffolk Cablevision in Central Islip, New York. Elected Eastern Vice President was Steve Dourdoufis of Vision Cable in Fort Lee, N.J. Western Vice President is Robert L. Cowart of Gill Cable Inc. in San Jose, Calif. Re-elected Secretary/Treasurer is Charles S. Tepfer of Cablecasting—Cable TV Engineering of Ridgefield, Conn.

SCTE AND NCTA officials and recipients of Outstanding Technical Achievement Awards. From left are Robert Bilodeau and Steve Dourdoufis of the SCTE, Ken Simons of Jerrold, Don Levenson of Wheeling Antenna Co., Charles Tepfer of SCTE, Sid Lines who was with the FCC, Bill Karnes and Delmer Ports of the NCTA and SCTE. The six-foot crossword puzzle they're all holding was awarded to Sid Lines in recognition of his ability to unravel the FCC technical standards for cable television.



APPLICATION FOR MEMBERSHIP

in

THE SOCIETY OF CABLE TV ENGINEERS

(Please Print, fill in completely and mail to the SCTE. 607 Main St., Ridgefield, Conn. 06877)

Date....................................

First Name | Middle Initial | Last Name | Date of Birth

Home Address | City | State | Zip

PRESENT EMPLOYER

Company | Date Employed

Company Address | City | State | Zip

Your Title

Description of Duties

PROFESSIONAL HISTORY

(Give Company Name and Address and Brief Description of Duties)

From	To	

EDUCATION

College or School | Date Graduated

Degree or Certificate

College or School | Date Graduated

Degree or Certificate

Other Schools

(Turn Page Please)

REFERENCES

(Three Society Members Required as References for Grade of Member)

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Annual Dues ($10 per year) .... $________

SCTE Pin ($3.) .... ________

SCTE Tie Clasp ($3.) .... ________

TOTAL ENCLOSED .... $________

I agree to abide by the Constitution and Bylaws of the Society of Cable TV Engineers if admitted to membership.

Signature

Do Not Write Below This Line

Chapter ....

Admissions Committee Action .... Date ....

Membership Grade:

- ☐ Member
- ☐ Associate Member
- ☐ Sustaining Member

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26		

DISAPPEARING HEADROOM
(Continued from page 17)

speed pulses of very high amplitude. The former type of over-voltage can be controlled by careful attention to amplifier power supply design (or revision), and appropriate protective circuitry at power insertion points.

The latter type of transient intrusion is most destructive in its subtlety. By example, if the original source of transient intrusion was lightning, the cable sheath can experience "pin hole" puncturing. Quite often the effect of such sheath puncture is not seen until months later when the cable dielectric becomes water soaked. Jacketed-flooded cable is a great assist in reducing damage from this source.

If the source of the transient is from adjacent AC power company primary breaker operation, the sheath current can become large enough to destroy or seriously damage passive devices for several thousand feet in each cable direction from the area of transient origin. Reducing co-mingling of plant grounding is of enormous assistance in reducing the system vulnerability to transients of this source.

Irrespective of the origin of the high speed transient, the rise time and energy content of these transients are such that R.F. transistors and power supply devices alike are damaged by their presence. Most insidious of all is the "secondary breakdown" effect, where the R.F. device dies slowly, after being exposed to this type of transient, with failure usually precipitated by the next high temperature stress period. Various attempts have been in the past to improve the transient resistance of amplifier circuitry, but unfortunately, only careful analysis after failure is of any real value in determining circuit revisions necessary to improve transient resistance.

In any case, this is the point where conventional bench repair fails most miserably. After an active device has been exposed to a high speed transient, several of the active devices, diodes, I.C.'s, discrete devices alike, even regulators, will have been overstressed. Unless the amplifier is carefully checked for performance after repair there is a substantial opportunity for the device to be returned to service with *partially* defective devices still in the circuitry. The only sensible solution to this problem is to completely check every amplifier for compliance with performance criteria (or have it done). It should be obvious that critical criteria are cross modulation and noise figure, as these parameters are the most device performance sensitive. For systems with beyond 12 channel capacity, a second order performance test is imperative as well. Recent experience with implementation of such system practices has shown over a ten fold improvement in amplifier reliability. I must hasten to add that this experience involves systems in the Southeastern U.S., with high lightning exposure. A secondary benefit of the system reliability has been the substantial improvement in system dynamic range, and consequently higher overall day to day quality.

From the previous it can be seen that CATV system dynamic range can be assured by:

- Adequate initial quality control of:
  - System design
  - System devices
  - System proof
- Initial system implementation of:
  - Optimum system grounding
  - Optimum power protective devices
  - Proper training of maintenance personnel
  - Proper calibration of system measurement equipment.
- Careful and sophisticated repair and rehabilitation with all device parameter qualification *after* a 48 hour burn in.
- Failure analysis coupled with device reengineering to improve transient immunity where needed.
- Periodic surveillance of total system distortion with particular emphasis on second and third order product evaluation.
- Plant reengineering to solve dynamic range problems not uncovered in original design.

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