Pull-out satellite wall chart

# COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

Handling the problems of lightning and power

Wrapping up a successful Tec Expo

August 1988

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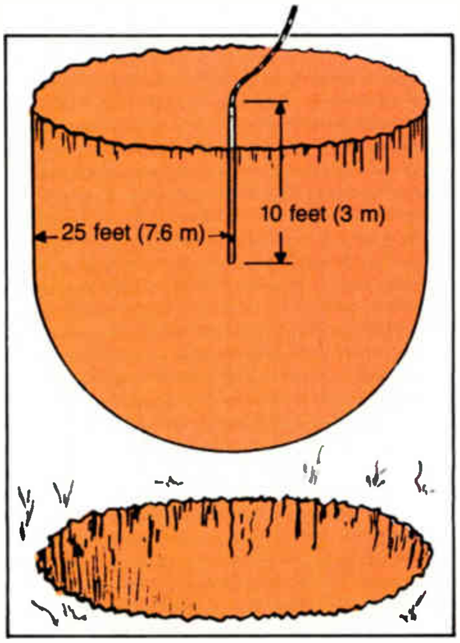
**Cover**
Top photo courtesy Spectrum Inc., Golden, Colo. Spectrum produces the color separations for this magazine. For further information about Spectrum, call (800) 426-5677. Expo photo by Bob Sullivan.



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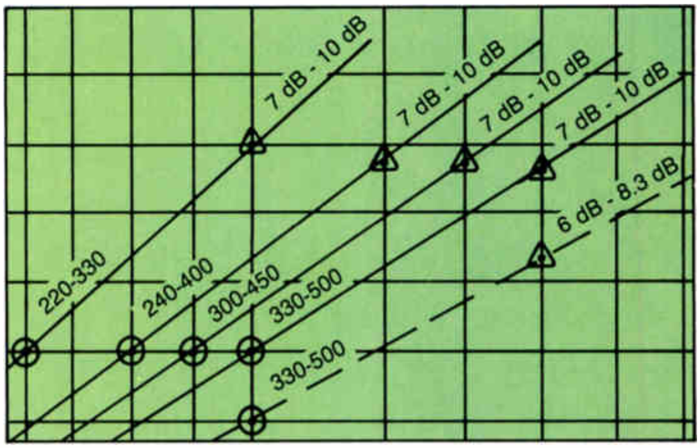

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*Communications Technology*™ (ISSN 0884-2272) is published monthly by Communications Technology Publications Corp., 12200 E. Briarwood Ave., Suite 250, Englewood, Colo. 80112 — or — P.O. Box 3208, Englewood, Colo. 80155, (303) 792-0023. August 1988, Volume 5, Number 6. Office of publication is 12200 E. Briarwood Ave., Suite 250, Englewood, Colo. 80112. Change of address notices should be sent promptly; provide old (or copied) mailing label as well as new address, including ZIP code; allow 6 to 8 weeks for change. Second-class postage paid at Englewood and Denver, Colo. POSTMASTER: Please send address changes to Communications Technology, Box 3208, Englewood, Colo. 80155.

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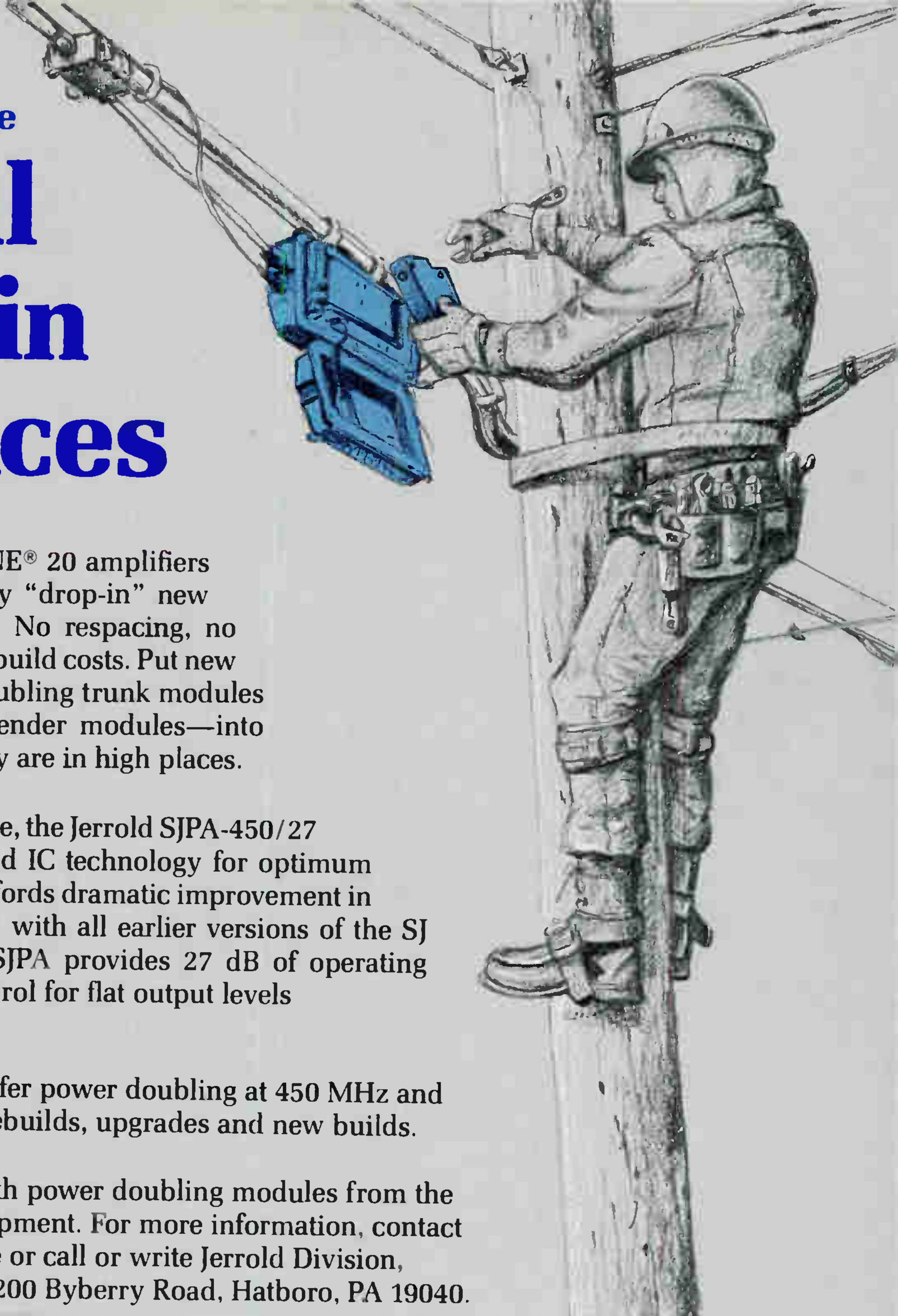

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# PUBLISHER'S LETTER


***Expo Conference Committee members Dan Pike, Paul Levine, Pete Petrovich (chairman) and Bill Riker take a photo opportunity after receiving their plaques.***

Bob Sullivan

# You had to be there

Although I didn't leave my heart in San Francisco (site of Cable-Tec Expo '88, June 16-19 at the Hilton and Towers), I did experience the heart and soul of what the Society of Cable Television Engineers has to offer: the growth of our industry through training. Whether it be the Engineering Conference panels, workshop sessions or BCT/E testing, the expo provided many opportunities for self-improvement.

If you weren't there, please try to make it next year (June 15-18 at the Orange County Convention Center in Orlando, Fla.). In the meantime, see for yourself what you've missed: our annual expo wrap-up, in words and pictures, beginning on page 62. And if you were there, you'll agree that it was the best and biggest to date.

**Congratulations to...**

...the outgoing SCTE board of directors. Everyone did a great job in bringing the SCTE to new heights under the careful guidance of President Bob Luff.

...the incoming board. We look forward to continued excellence under the dedicated leadership of new President Ron Hranac.

...Conference Chairman Pete Petrovich of Petrovich and Associates (one of the hardest working people in the industry) and fellow Expo Committee members Dan Pike (Prime Cable), Dave Large (Raynet) and Bill Riker (SCTE). These are certainly some of the most dedicated people I've worked with in a long time.

...Mike Aloisi of Viacom Networks, recipient of the Member of the Year Award. Mike's contributions to the Society and the industry exemplify what this award is all about.

...Consultant Andy Devereaux, winner of the President's Award. It's been a real pleasure to know Andy since the inception of *CT*; he's always kept us on the right track.

...Cliff Paul, consultant for RTK Corp., who was the first inductee to the SCTE Hall of Fame. When I first got into the industry in 1973, Cliff was well-known (although I really didn't get to know him until *CT* was started). He is definitely worthy of being the first hall-of-famer.

...the Outstanding Achievement Award winners, and everyone else who took a plaque home.

...the entire SCTE staff, for a job beyond well-done.

You'd think with the expo behind them, SCTE members would sit on their laurels for the rest of the year. No way; it's onward and upward with some noteworthy events.. The first "Technology for Technicians" seminar will take place Sept. 12-14 at the Harvey Hotel in Dallas. SCTE Director of Chapter Development and Training Ralph Haimowitz has put together a great seminar that he'll be taking on the road. For more details, see page 95.

And don't forget "HDTV and beyond," a seminar sponsored by the SCTE and its Rocky Mountain Chapter, Oct. 28-30 at the Sheraton Denver Tech Center in Denver. This is one you won't want to miss. For more information or to register, contact Jan Vicalvi, (303) 691-8380.

Paul R. Levine

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Bob Sullivan

*Tom Polis (RTK Communications Construction Group and expo speaker) looks on as incoming SCTE President Ron Hranac (right) congratulates Cliff Paul, consultant for RTK, for being the first inductee to the SCTE Hall of Fame during the annual membership luncheon at Cable-Tec Expo '88 in San Francisco. For more details on the expo, see the wrap-up beginning on page 62, as well as this month's 'Interval.'*

## NCTA Engineering Committee report

*"CT" is presenting a report of the bimonthly meetings of the Engineering Committee of the National Cable Television Association, written by Brian James, NCTA director of engineering.*

SAN FRANCISCO—The Engineering Committee meeting was held here June 14-15. A pre-meeting session was held at Dolby Labs, where attendees were shown developments by Dolby for the delivery of high quality audio through various transmission media.

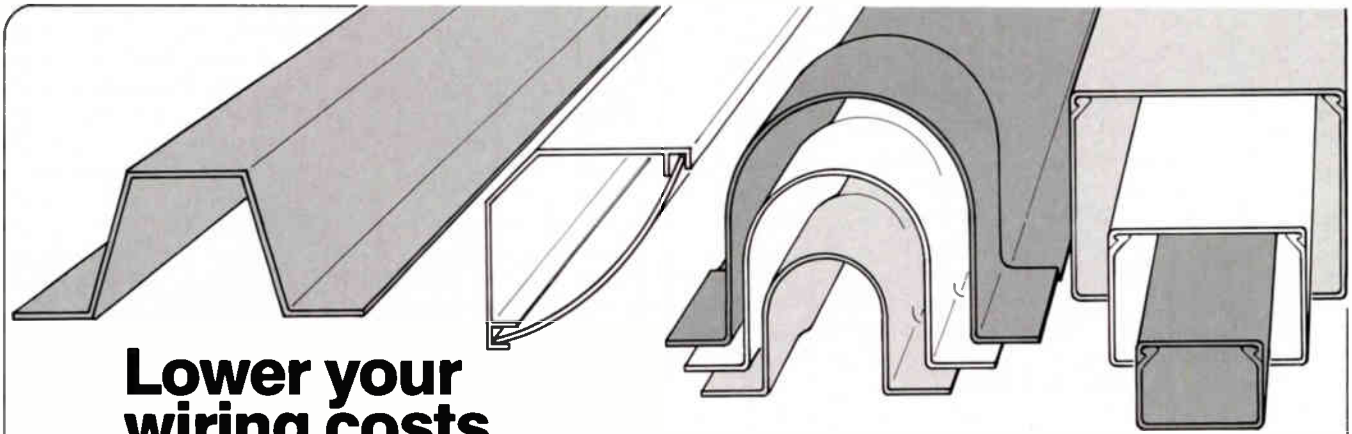
Wendell Bailey updated the members on the recent happenings in Washington, D.C. There has been no action at the FCC on the A/B switch, terminal devices or Part 15 rewrite. The appeals court ruled that the A/B switch and educational requirement remain in effect even though the must-carry rules were struck down. The commission has not announced a date for the re-implementation of the educational and A/B switch rules.

The commission adopted new syndicated exclusivity requirements but the rules have not been published. Cable operators will be required to drop programs for which local channels have exclusive distribution rights. The rules will take effect one year after they are released. Operators should begin to review switching equipment requirements in preparation for implementation of the rules.

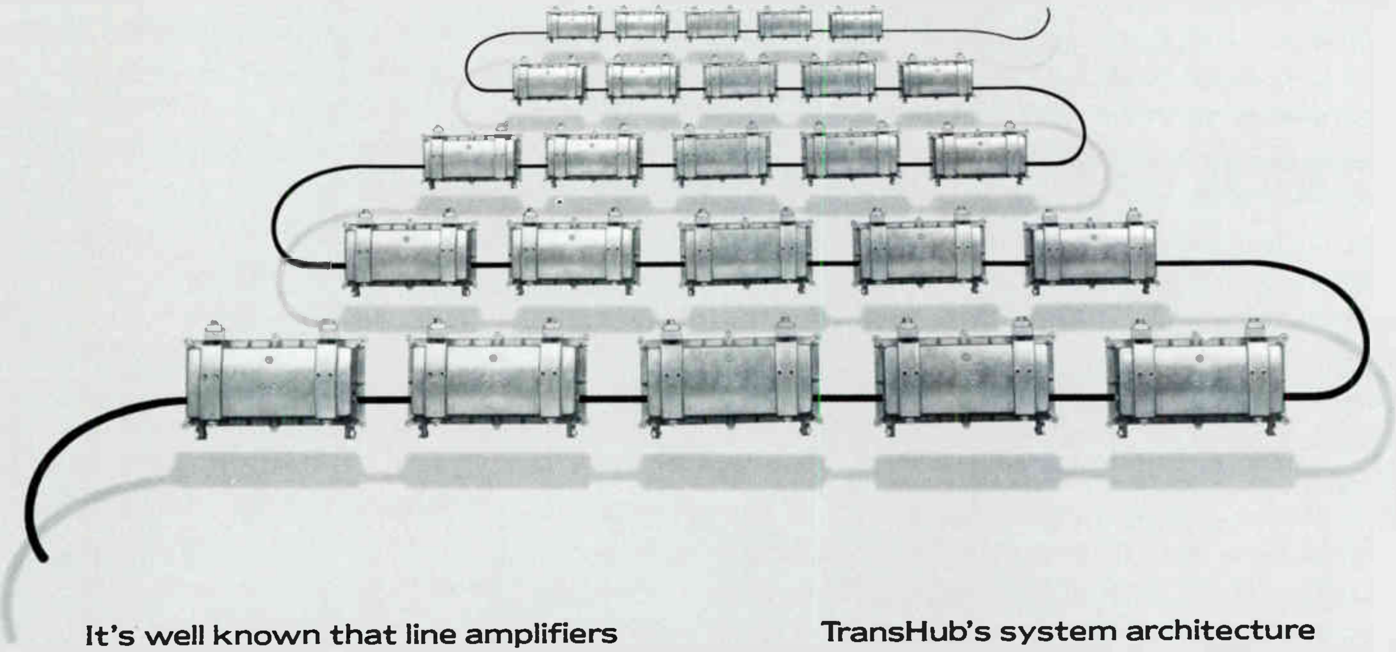
The FCC and NCTA won the technical deregulation case at the Supreme Court. The court found that the FCC had the right to pre-empt the cities and set technical standards for the cable systems to ensure uniform standards throughout the country. The status of Class 2, 3 and 4 signals is still under review at the commission.

### Subcommittee reports

*High-definition television:* The FCC Advisory



# NO SIGNAL SHOULD HAVE TO GO THROUGH ALL OF THIS



It's well known that line amplifiers directly diminish CATV signal quality. Yet today's cable distribution systems rely upon an architecture in which signals must pass through as many as 60 amplifiers before they reach a subscriber.

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Catel's TransHub fiber optic cable distribution system offers superior clarity, economy and flexibility while greatly reducing the number of amplifiers per cascade.

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**CATEL**
THE CLEAR CHOICE IN FIBER

Committee has set a Sept. 1 deadline for written proponent system descriptions. Testing of proponent systems is to begin on Dec. 1. Letters of intent have been received regarding 18 proponent systems or subsystems.

Philips Labs gave a demonstration of their system to a number of cable engineers. They have made progress in refining parts of the system and were able to demonstrate the effects of a cable system by passing the signal through the Magnavox training trailer. A number of improved definition TV sets were demonstrated at the Consumer Electronics Show in Chicago. The sets have various circuits inside to eliminate many of the NTSC artifacts. A number of sets will be at the distributors by fall, in time for Christmas sales. The NHK MUSE transmission system over a cable system was successfully demonstrated at the NCTA convention. This was possible due to the efforts of the technical staff at American Cablesystems, under Al Kuolas and NHK engineers.

*Signal leakage:* Only two years are left to bring all cable systems into conformance with the revised regulations for aeronautical frequencies (108 MHz to 137 MHz and 225 MHz to 400 MHz). A five-year grandfather period runs out July 1, 1990. At that time the carrier frequencies of all channels in the aeronautical bands must be at the new offset frequency and a report indicating the system meets the CLI or flyover requirement must be on file with the commission. If these requirements are not met then the system can expect to have to remove the channels in the aeronautical band. Failure to comply could convert a 54-channel, 400 MHz system to a 20-channel system.

*Multiport:* Development of a standard to allow pay-per-view ordering using the TV's remote control and the multiport decoder is continuing. TV manufacturers are continuing to announce dates for introduction of sets with the port while some decoder manufacturers are relucant to commit to the product.

*EIA/NCTA:* At the ICCE in Chicago a special session was held to inform foreign manufacturers about the cable industry in America. It was well-attended with a long question-and-answer period after the session. The manufacturers are becoming more aware of the special needs of the cable industry.

*National Electrical Code:* July 1 is the implementation date for the required use of listed cables in homes. Any authorities that have adopted the portion of the 1987 NEC will require the use of listed cables.

*National Electrical Safety Code:* The preprint of the next edition is now available for review and comment. One suggested change would limit the power on a communication line resulting in the cable industry having to find another way of powering amplifiers. This is just one example of how changes proposed by other industries can affect the cable industry. The participation by the cable industry on the working groups is minimal so it is imperative that the proposed document be reviewed by all who could be affected.

- Midwest CATV announced it has reached an agreement with Olson Technology Inc. to distribute Olson's fiber-optic transmission equipment.
- Intrastellar Electronics and Golden State Engineering reached an agreement in principle whereby Intrastellar will represent Golden State in converter repair and refurbishing.
- Broadband Engineering, a division of Augat, announced that its entire line of indoor distribution amplifiers for CATV and LAN applications are now UL listed or have a UL-approved Class II transformer.
- Zenith presented its 1988 Robert Adler Technical Excellence Award to Richard Citta, the inventor of two major CATV technologies. Citta, manager of electronic systems research and development, led the engineering teams that developed Zenith's proprietary RF addressable phase modulation (PM) decoding technology and the Z-View two-way interactive CATV system.
- Control Technology appointed Herrin Associates as exclusive representative for its primary, standby and uninterruptible power supplies in Colorado, New Mexico, Utah, Wyoming, Montana, Idaho, Oregon, Washington and Alaska. Roberson Sales will be the exclusive rep in Arizona, Nevada, California, Hawaii and Guam.
- Anixter Bros. entered into an agreement with Chipcom Corp. under which it will market and stock Chipcom's line of broadband Ethernet LAN connectivity products.

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*Reader Service Number 11.*

# Saluting a noble scientist

**By Isaac S. Blonder**
Chairman, Blonder-Tongue Laboratories Inc.

I am proud and humble to be able to salute the achievements of Professor Daniel Noble. All of us practitioners of the art of electronics owe a debt to him and his myriad achievements at Motorola. During an early phase in his career he was a professor of math and electrical engineering at the University of Connecticut, where I was privileged, not only to attend his courses in radio engineering, but as a 25-cents-an-hour National Youth Administration (NYA) student, to help construct wooden-framed quad antennas for FM broadcast and reception. One of his more interesting gambits was instructing me on the technique for removing the Bakelite base of a "30" tube so it would oscillate more efficiently in a battery-powered FM police radio.

While at the university, Noble built and directed the operation of WCAC—250 watts, 600 kHz—an early example of the educational college radio station. The studio was a marvelously soundproofed affair in which the walls were covered by several layers of heavy curtains. It was so free from echoes that one was tempted to shout in order to carry on a normal conversation. Noble transmitted university programs to WTIC and WDRC in Hartford, Conn., for rebroadcasting, pioneering in the first use of UHF tropospheric scattering beyond the line-of-sight communications. As a consultant to the Connecticut State Police, Noble designed and developed the world's first mobile FM police radiotelephone communications system.

In the all-invasive world of electronics today it may surprise you to learn that in the '30s one could only strive for an electronics engineering education in the electric power degree. As a physics major, I took several electrical engineering courses out of curiosity and, somewhat to my surprise, there were only two students in Noble's radio course based on the Terman text. Still, I enjoyed and benefited from what amounted to an intimate tutorial program.

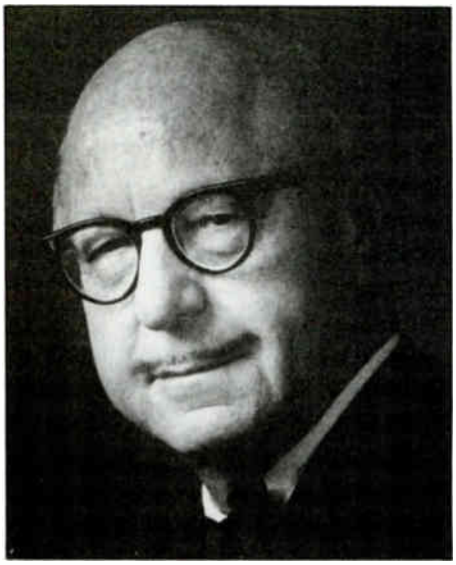
## Grassgrowers Club

Some personal insights into our professor: Not a single hair was to be seen on his noble skull. He was totally bald, as were some other professors, and in the unceasing quest for a cure they banded together in a group called the "Grassgrowers Club." The '30s spewed forth many wondrous gadgets; one of these was a vacuum pump attached to the scalp via a large helmet. It periodically sucked out the air to (hopefully) encourage the latent hair follicles into action. But, alas, no hair growth.

Another time, before a large group of ham radio enthusiasts, he launched into a lecture on the dangers of 2,000 volt power supplies. To dramatize this, he charged a large capacitor and discharged it with a screwdriver. We were suitably startled by the crack of the discharge. Noble then recharged the capacitor but fumbled with the screwdriver and managed to pass the discharge through his finger, whereupon he fell violently backward onto the floor. However, he quickly arose, showed us his finger with a visible deep burn and remarked, "I hope you will take my lesson to heart and never be as careless as me!"

Electronics was an unfathomable art to the electrical engineering professors. The 5 kW shunt-wound DC generator for the electrical laboratory was poorly regulated and had to be constantly trimmed to conduct most experiments. With $15 worth of 6L6 tubes, a meter and some other parts, and on the same 25-cents-an-hour NYA budget, Noble and I designed and built a voltage regulator that worked remarkably well as long as either of us were around. Two years later, with both of us out of the university, I happened by and was told the gadget was broken due to its inferior design. But I fired it up and found it in perfect condition.

Noble suffered all his life from many allergies and sinus pains as a teenager. In 1919, his family sent him for a year to Arizona to relieve his allergies in that salubrious climate. In 1948, he persuaded Motorola to establish a research facility in that state, probably the single most important stimulus to the financial health of Phoenix. He built his own diathermy machines and was often seen at his desk with earphone-like electrodes warming up his sinuses before class. He was living proof that non-ionizing radiation is harmless, since he lived to the age of 78.



**Noble**

> *"He was living proof that non-ionizing radiation is harmless, since he lived to the age of 78."*

Noble pioneered in FM communications, two-way FM radio, the SCR 300 FM walkie-talkie, solid-state technology in the Phoenix laboratories, and in experimental painting. He received the WEMA medal, the Franklin Institute medal and the Edison medal, and served on countless engineering committees.

Motorola's publication *Engineering Bulletin* over a period of 17 years presented his ideas on a variety of subjects written in many moods. Here are a few quotes from a 1970 editorial on my favorite subject: "How can you expect to be served by creative leadership when you depend upon lawyer rulemakers?.... What the country needs is to be rescued from the hands of the lawyers.... Lawyers aren't bad; they are stupid in terms of the systems thinking and the technological understanding necessary for undoing the mess we are in, and for creating a new and more viable culture... Today our Congress is run by lawyers who are not qualified to cope with the changes that will be wrought by the new scientific revolution. New leadership is essential. We must train future lawyers adequately in the technical sciences and in economics and sociology and train some engineers in law and politics to ensure that our political representatives are qualified for leadership roles in the excrutiatingly complex technological society to come."

Right on, Professor Dan Noble!

# Now any Albert can be an Einstein.

The new SAM 1000 signal level meter from Wavetek makes every service tech a genius.

That's because it's so advanced, you can't make a mistake.

**Easy as pi.**

From the moment you take it out of the box, the SAM 1000 is easy to use. Thanks to its direct entry keypad.

Up and down tuning with arrow keys makes channel stepping quick and simple.

And instead of a slide switch attenuator, the new SAM 1000 has a 60 dB electronic rotary attenuator with matching meter scales. There's nothing to calculate.

**Precise.**

There's no question you're tuned to the right channel, either. With digital tuning, you just punch in the channel or frequency you want. It's verified above on an LCD.

The SAM 1000 is as accurate as meters twice the price, too. At ±.75 dB level accuracy and ±20 kHz frequency accuracy.

**Hard headed.**

The new SAM 1000 comes in a high-impact ABS case.

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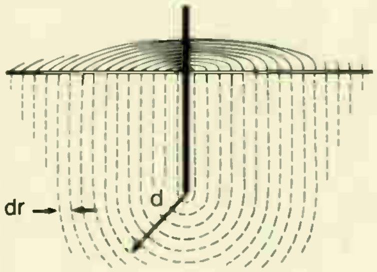
# The art of reducing grounding resistance

**By Roy B. Carpenter Jr.**
Chief Executive Officer, Lightning Eliminators and Consultants Inc.

The art of grounding a system is the process of establishing an electrical interface between a conductor and what may best be called a *semiconductor* (earth or the soil). Since earth is not a conductor in the true sense of the word, it cannot be treated as such. That is, you cannot drive a rod into earth and assume there is an electrical connection. In many situations, there may be no connection at all (in dry rock dust or sand, for example).

Since the conventional method for making an earth interface is a driven copper-clad rod, it is essential to understand the situation, control the influencing parameters and design the interface system to yield the desired contact with earth. In doing so, realize that you are not soldering (or welding) two conductors together but designing an interface assembly. That assembly involves both the conducting electrodes and the soil within the area, influencing the interface resistance. The conducting electrodes must be designed (or selected) and deployed in such a way that maximum contact is achieved with the soil of concern. The soil, influencing resistivity, must be conditioned and/or arranged so as to eliminate high resistance elements.

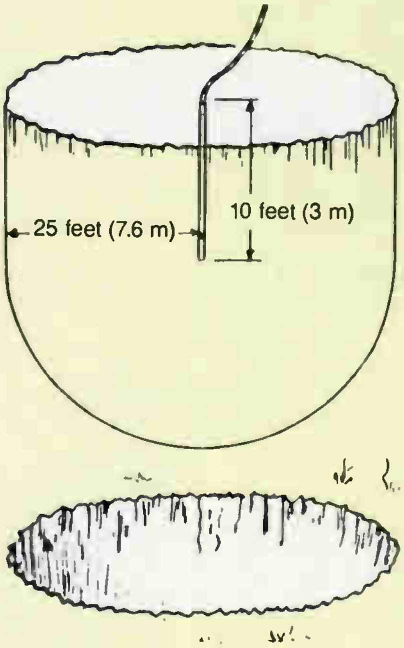
**Figure 1:** Earth resistance shells surrounding a ground rod



$$\frac{dR}{d} = \rho\frac{d}{dr}\left[\frac{l}{A}\right]$$

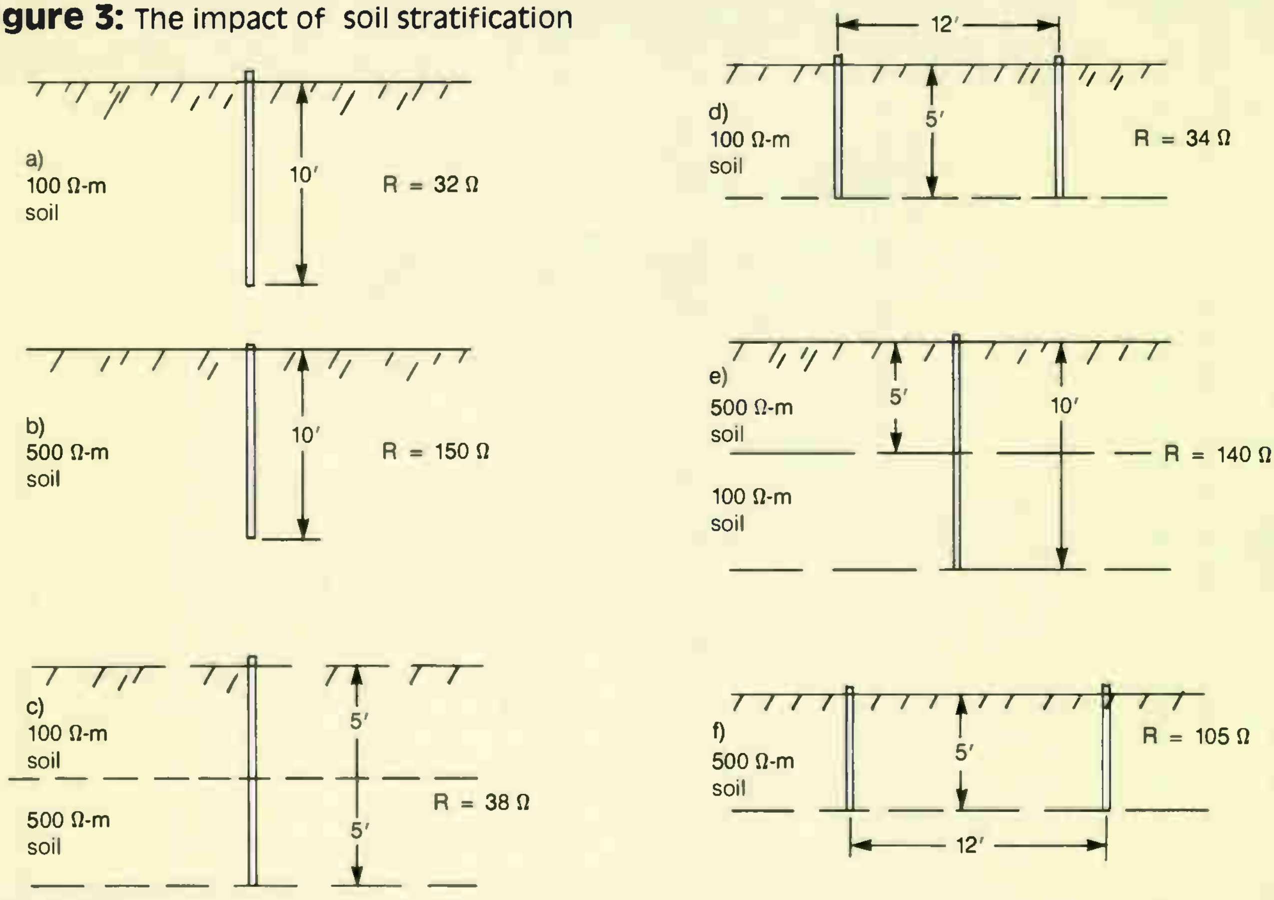
$l$ = length
A = diameter

**Figure 2:** The interfacing hemisphere



The grounding objective itself also must be considered. Very often a low resistance ground may not be required. A common point or common plane ground may satisfy your requirements. A *common point* ground (CPG) is one where a single point is used as ground reference and every electrical connection is tied directly to that point, which is tied to some form of ground.

**Figure 3:** The impact of soil stratification



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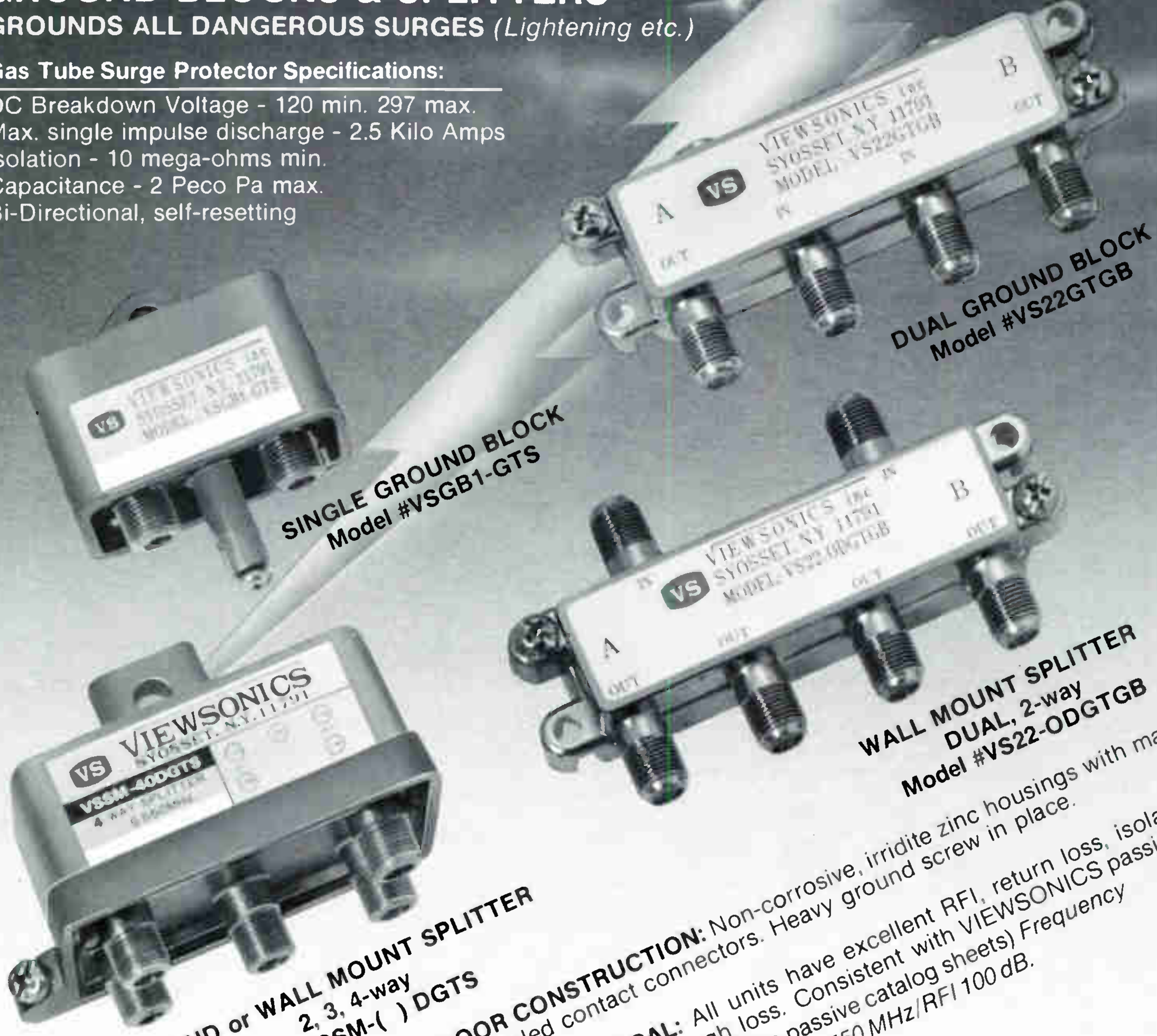

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The telephone industry calls this the "ground window." In this situation, everything in the system is at equipotential with respect to the CPG, regardless of its resistivity.

A *common plane* ground is similar to the common point, except that a large ground mat is used as the common point. An electrical substation is an example. There is, however, a danger in assuming that the common point and common plane are equal. Where the surge impedance of that mat is significant between any point in that interface and any other point in that interface, the common point objective is no longer satisfied.

**Figure 4:** Soil resistivity and moisture content

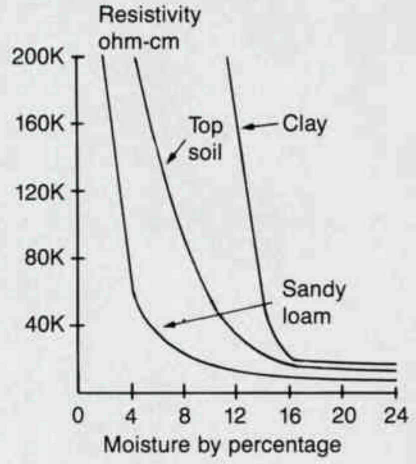


**Figure 5:** Effect of temperature on earth resistivity

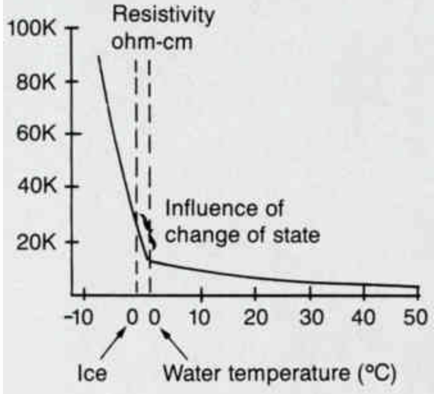
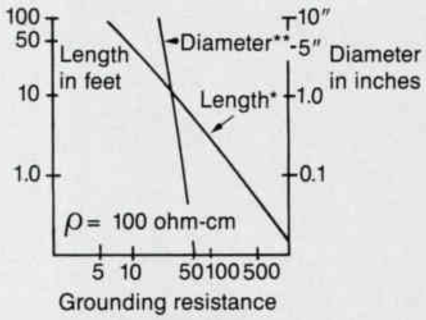


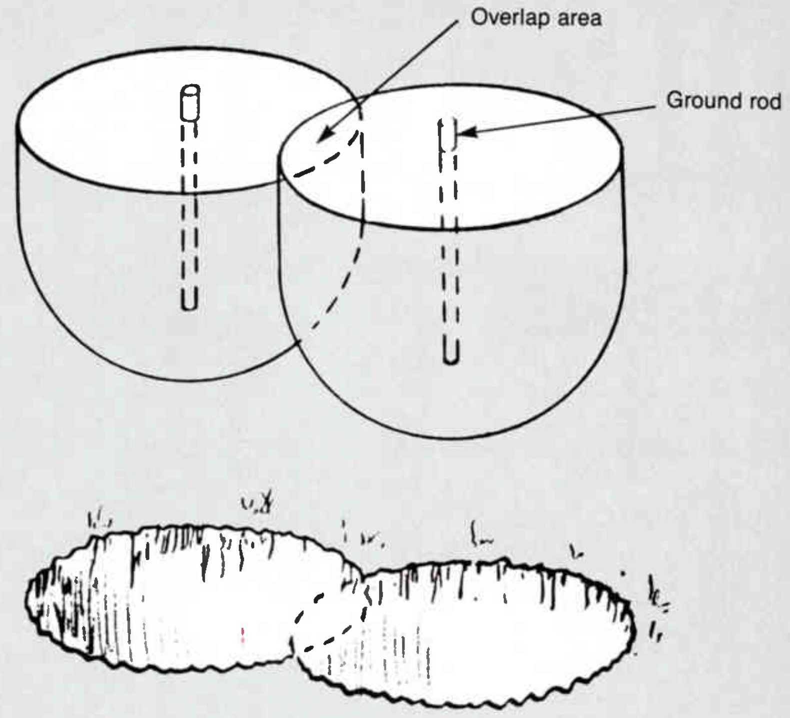
**Figure 6:** The influence of ground rod physical parameters on grounding resistance



*Based on 0.75 diameter

**Based on 10 ft. length

**Figure 7:** Overlapping interfacing hemispheres



## Assessing the situation

Prior to designing the interface, it is necessary to assess the soil situation; i.e., properly define the *in situ* parameters. It is not enough just to determine the type of soil that is present or even measure its resistivity. To properly design the interfacing system, assess the following parameters:

1) soil type (and content, where possible),
2) range in moisture content between extremes,
3) resistivity under a specific set of conditions,
4) temperature range with seasons and the frost line,
5) stratification (consistent or layered) and
6) the amount of real estate available.

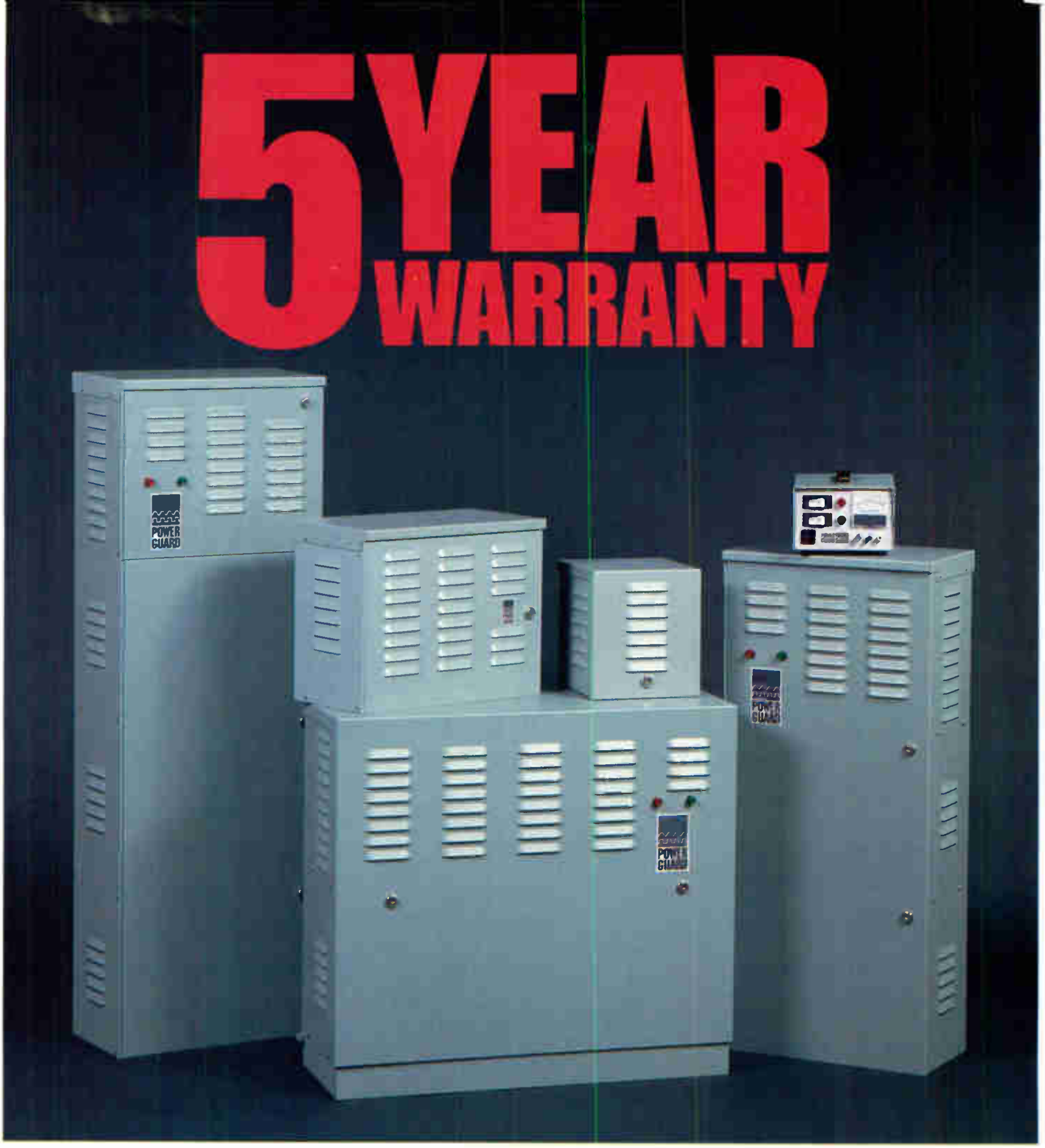
These parameters and the range of variation within them provide the required data to design the interfacing system called "grounding."

If grounding is the art of establishing an interface between a conductor and the semiconductor (earth) then we are not establishing point contact but rather connection with a body (of soil). This premise may be tested by driving a rod into earth and measuring the change in DC resistance between it and the soil as a test probe is moved on a radial away from the road. As indicated in Figure 1, with each incremental change in distance the change in resistance decreases exponentially. Finally, the change is so small that it cannot be measured easily.

As a point of significance, when the radial distance approaches about 1.1 times the length of that rod in earth, about 90 percent of the resistance change has been accomplished. This implies that the major portion of the interfacing soil is contained within a hemispherical shaped volume of that soil 2.2 times the length of the rod in diameter. This concept is called the "interfacing hemisphere," illustrated in Figure 2.

From this, the primary premise of particular significance becomes obvious. That is: For a single rod, the soil contained within its interfacing hemisphere determines the approximate grounding resistance of the given rod. For a rod/wire matrix, the soil contained within its interfacing volume determines the approximate grounding resistance of that matrix.

The soil character determines or limits the potential resistivity of a given grounding electrode system, as does the environment within which it exists. The soil characteristics of concern include: chemical content, moisture content, stratification, grain size (texture), compactness and soil type. Some of these characteristics have been assessed; others have not and/or do not lend themselves to assessable parameters. However, some generalizations can be made. For example: The chemical content may include various salts, which are very conductive. It may include various compounds such as gypsum, sodium sulfate or bentonite, which also tend to hold moisture. The grain size or texture and compactness can vary the particle-to-particle contact; therefore, the smaller the grain and the more compact the soil, the lower the resistivity. Sand, for example, has large grains and is difficult to pack; it provides poor contact with earth. Stratification may result in widely varying soil resistivities at various depths. The effects of



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stratification can best be illustrated by Figure 3, where six situations have been illustrated with only two soil resistivities. The following data was derived:

a) A ¾-inch by 10-foot rod provided 32 ohms grounding resistance in all 100 ohm-meter soil.
b) That same rod in all 500 ohm-meter soil provided 150 ohms grounding resistance.
c) That same 10-foot rod driven through 5 feet of 100 ohm-meter top soil then 5 feet of 500 ohm-meter soil results in a 38 ohm ground.
d) However, that 10-foot rod cut in half, where each piece was driven 5 feet and separated by 12 feet, provided 34 ohms resistance.
e) Reversing the strata sequence with the 10-foot rod, with the first 5 feet of 500 ohm-meter then 5 feet of 100 ohm-meter soil, offered 140 ohms of resistance (the better, lower soil provided little help).
f) In contrast, two 5-foot rods in the 500 ohm-meter soil provided a resistance of 105 ohms, significantly lower than the one 10-foot rod.

This data seems to indicate that use of the upper levels provides a lower resistivity than trying to work in the lower strata, provided the upper level soils are of near constant resistivity, with adequate moisture.

Moisture content exerts the most significant influence on resistivity. In simple terms, no moisture, no earth contact. This premise is best illustrated in Figure 4. Note that at least 4 percent by weight is required for top soil, but clay requires up to 14 percent. →

**Figure 8:** Soil resistivity and number of rods

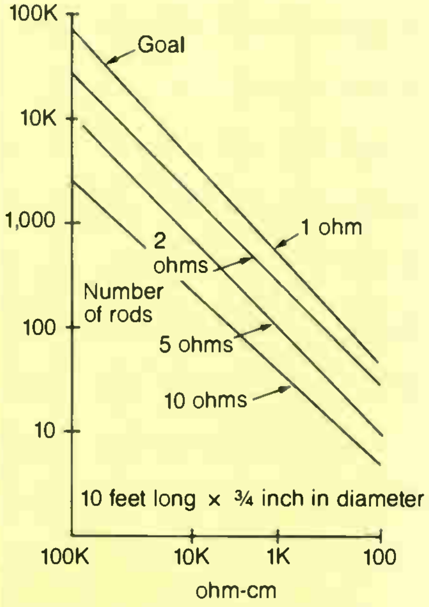
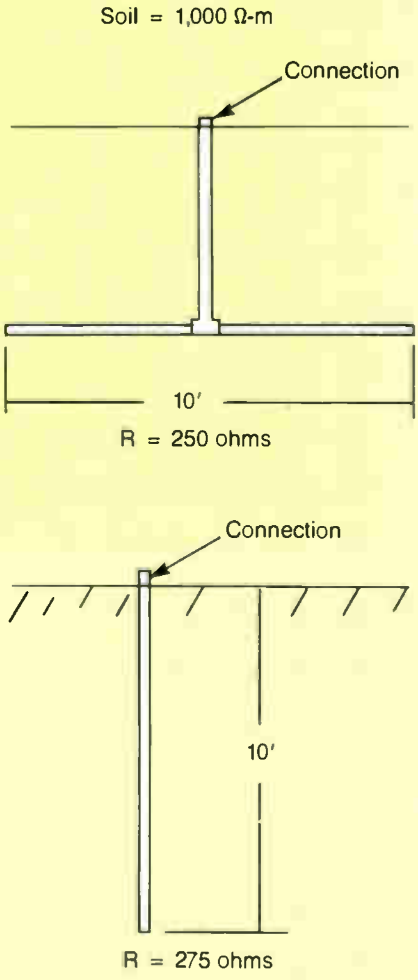


**Figure 9:** Horizontal vs. vertical rod



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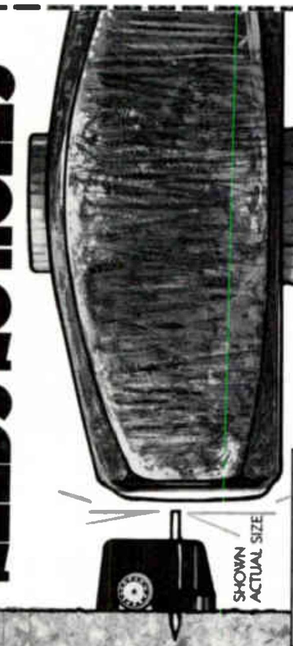

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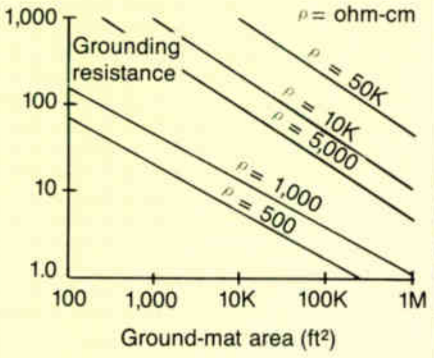
**Figure 10:** Grounding resistance for various mat areas



### Environmental influences

The environmental influences are limited to the temperature of the area throughout the system life and the rain or snow fall. Rain and snow influence the moisture content, which has already been assessed. The local temperature conditions throughout the year and for several years should be considered, particularly influence on the "frost level." That is, in the northern areas of the country, the upper levels of soil freeze; the depth of that frost increases with the higher latitudes. The arctic region has a situation called *permafrost*.

Figure 5 illustrates the influence of soil temperature on the soil resistivity. It indicates that there is little change in resistivity for temperatures above freezing, the transition from a liquid to a solid increases the soil resistivity by a factor of six, and there is no appreciable electrical contact with frozen earth. In areas where there is permafrost, the upper soil levels are of no use for grounding, while in a frozen state.

How and where each grounding electrode (or rod) is deployed also will significantly influence the ultimate interface resistivity. The factors of concern include length, number, spacing and orientation of electrodes.

The influence of length is illustrated in Figure 6, where a single rod is driven into 100 ohm-meter soil while the resistivity is measured at intervals. The deeper the rod, the lower the resistivity in uniform soil. However, the return in reduced resistivity per unit foot of driven rod drops off exponentially. In one example, a 10-foot rod provided 100 ohms resistance and a 100-foot rod reduced it to 50 ohms. Increasing length by a factor of 10 reduced the resistance to just half of the 10-foot value.

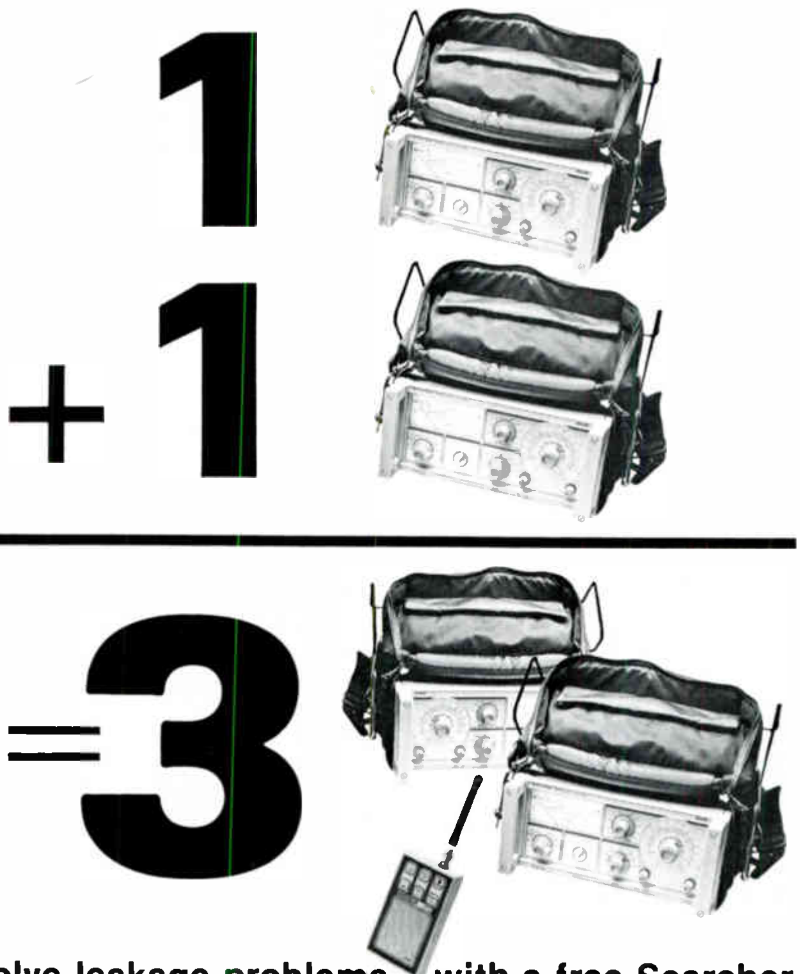
The number of electrodes used and the spacing at which they are deployed are closely related. As previously illustrated, each rod requires a given volume of soil to complete the interface. Overlapping the interfacing hemisphere, as illustrated in Figure 7, reduces the effectiveness of each rod. The greater the overlap, the lower the effectiveness. For example, two 10-foot rods spaced a few feet apart are little better than one. This factor is independent of the soil parameters.

The number of rods required in a rod/wire matrix is a function of the soil resistivity as illustrated in Figure 8. Note that for 1,000 ohm-meter soil, 800 rods may be required to achieve a 1 ohm ground, all spaced at 22 feet, for a ¾-inch by 10-foot rod. This requires a large land mass for the ground field, which may not be available.

Electrode orientation also must be considered. In some situations, horizontal electrodes may be more effective than the vertical. In Figure 9, a 10-foot vertical rod is compared to a 10-foot horizontal rod. Even disregarding the vertical connection, its resistivity is lower than the vertical where uniform soil conditions exist within its interfacing volume.

All too often, you may be required to establish a low resistance interface with earth in an area where the soil is poor and the usable area is severely limited. Figure 10 illustrates this space limitation. When this is the case, changing the effective soil resistivity is the only alternative.

After the soil has been compacted, there are only two parameters that we can influence, short of changing the soil completely: the moisture content and the mineral content. Moisture content can be improved and/or stabilized through use of some form of automated system; sprinklers or drip irrigation systems work well where a constant source is available. Mineral content can be improved by introducing automated systems that add salt (NaCl) to the soil.



# Power supply efficiency

**By Howard H. Bobry**
President, Albar Inc.

Efficiency is widely recognized as a power supply figure of merit. Aside from the obvious virtue of reduced power consumption, are there other benefits to high efficiency? How should it be measured? What are the engineering design decisions that determine efficiency?

First, of course, there is a direct correlation between efficiency and power consumption. Consider a typical cable power supply operating with an actual load of 800 watts. If the efficiency of the power supply is 90 percent, then the input power required is 800/.9 = 889 watts. If power supply efficiency is only 85 percent, however, then the input power required is 800/.85 = 941 watts. This additional loss, on a continuous basis, amounts to 458 kilowatt-hours per year or nearly $50 per year per power supply at 10 cents per kilowatt-hour. Obviously the direct power cost of inefficiency for an entire cable system can be substantial.

Perhaps more important, although less widely recognized, is the effect of efficiency on reliability. All other factors being equal, a more efficient power supply should prove more reliable. Why?

The life of any electronic component is adversely affected by heat. The life of a capacitor, for example, can be reduced by 70 percent with only a 10-15°C temperature rise. How is this related to efficiency? Temperature rise is a function of many variables, including surface area, air flow, power density and dissipation. As mentioned before, dissipation is a function of efficiency, but does a mere 5 percent difference in efficiency result in significant temperature rise differences?

At 90 percent efficiency and 800 watts output, our first power supply "wastes" 89 watts. This is simply the power that is dissipated within the power supply, due to its less than 100 percent efficiency. Our second power supply is 85 percent efficient and "wastes" 141 watts, or nearly 60 percent more. If we assume equal physical size and equally competent thermal design in both power supplies, then the less efficient supply is going to have 50 to 60 percent higher temperature rise and greatly reduced component life.

Can't the power supply designer somehow compensate for higher dissipation and provide a reliable but efficient design? The power supply can be made physically larger or troublesome forced fan cooling can be used. Premium, high temperature-rated components can be used, but at a greatly increased cost.

In a standby power supply, high efficiency offers another benefit: extended battery reserve time. With lower efficiency, power consumption increases and batteries are more quickly discharged. Compounding the problem, the ampere-hour capacity of a battery decreases with increasing discharge rate. In other words, a 5 percent increase in discharge current results in a greater than 5 percent decrease in reserve time. The cable operator must either be content with decreased reserve time or install larger, more expensive batteries.

### Efficiency measurement

*Efficiency* is defined as the ratio of output power to input power, generally expressed as a percentage. In order to properly measure power supply efficiency, it is thus necessary to accurately measure both input and output power. How is this done?

First, it must be understood that the input power factor of a power supply will not typically be unity, so AC input power must be measured with a wattmeter. Separate ammeters and voltmeters cannot be used. Output power can be similarly measured with a wattmeter. Only if a purely resistive test load is used can output watts be calculated as the product of output volts and amps as measured on true RMS (root mean square) responding meters.

Power cannot be calculated from separate ammeter and voltmeter readings in an AC circuit unless the power factor is accurately known. Typically the input power factor of a power supply changes with input voltage, load and temperature. Output power can be calculated as the product of amps and volts, but only if a purely resistive test load is used. If separate amp and volt meters are used to determine output power, they must both be true RMS responding. Typical meters, unless specifically marked "true RMS," are average responding, calibrated in RMS volts or amps. These meters are accurate only for sinusoidal waveforms and will produce erroneous, high readings when used with quasi-square wave output of the typical cable power supply. Use of these meters will result in great efficiency figures, but they will be incorrect.

All meter connections should be made directly to the power supply under test. We want to measure the efficiency of the power supply, not the lead drop on the test bench. It takes less than 50 milliohms lead or contact resistance to cause a greater than 1 percent efficiency measurement error.

If the unit being tested has standby capability and a float battery charger, than normal mode (AC powered) operating efficiency should be measured with an appropriate fully charged battery connected. This best represents typical operation in the field. If the battery is not fully charged, a deceptively low efficiency figure will result because the power supply's input power will include energy being supplied to the battery and the load.

Things get more complicated if the standby power supply is equipped with a cycle charger, rather than a float charger. Unlike the float charger, the cycle charger never settles into a constant equilibrium, but periodically switches on to bring the battery up to full charge, then cycles off. An efficiency measurement made when the charger is on would indicate lower than actual efficiency, while a measurement with the charger off would indicate higher efficiency. The solution is to make two efficiency measurements, one with the charger on, one with it off. Then, take a weighted average of the two measurements corresponding to the duty cycle of the charger in actual field operation. This weighted average efficiency figure will most nearly represent the actual power consumption of the power supply in the field.

### Reserve time measurement

In standby mode, our concern isn't efficiency per se, but rather battery reserve time. Reserve time is readily estimated from charts or tables provided by the battery manufacturer, once the discharge current rate is known. This requires only a simple DC ammeter measurement. If desired, the actual standby mode efficiency can be calculated. Input power is simply the product of DC amps and volts, while output power is measured as previously described. Note that as the battery discharges and the DC voltage falls, the DC current will increase and efficiency will decrease. If reserve time, rather than efficiency, is our primary concern in standby mode, why not measure it directly? If we simply time a discharge until low voltage shutdown or cutoff is reached, we have our reserve time measurement directly and simply.

We must, of course, recognize that this reserve time measurement tests not only the power supply but also the battery. If this test is used to compare different power supplies, the battery must be repeatedly brought to the same state of full charge before each discharge test. For a power supply equipped with a float charger, the battery should be charged for several days before any discharge test to assure that the battery is fully charged and equalized. Even with this precaution, we need to be aware that battery capacity is not fixed but changes gradually with age and cycling. This can be monitored by periodically making discharge tests with a known power supply or even a resistive test load.

For power supplies equipped with cycle chargers, things are again a bit more complicated. By its nature, a cycle charger does not maintain a battery at full charge at all times. This type of charger periodically brings the batteries to full charge and turns itself off. The batteries then partially discharge (due to leakage currents and local action), the charger once again turns on and the cycle repeats. Since the batteries are not always fully charged, as in the float system, it is important to note that a real-world discharge due to a power failure may occur at the worst time, i.e., just before the start of the charge cycle, when the battery is at its lowest state of charge.

Since our whole purpose in measuring reserve time is to determine the amount of backup time we can rely on, our discharge test should be started at this same point. This can be accomplished by monitoring the cycle and starting the discharge test before the power supply would go into its charge cycle.

### Design decisions

What tradeoffs are examined in the design process? Let's consider the

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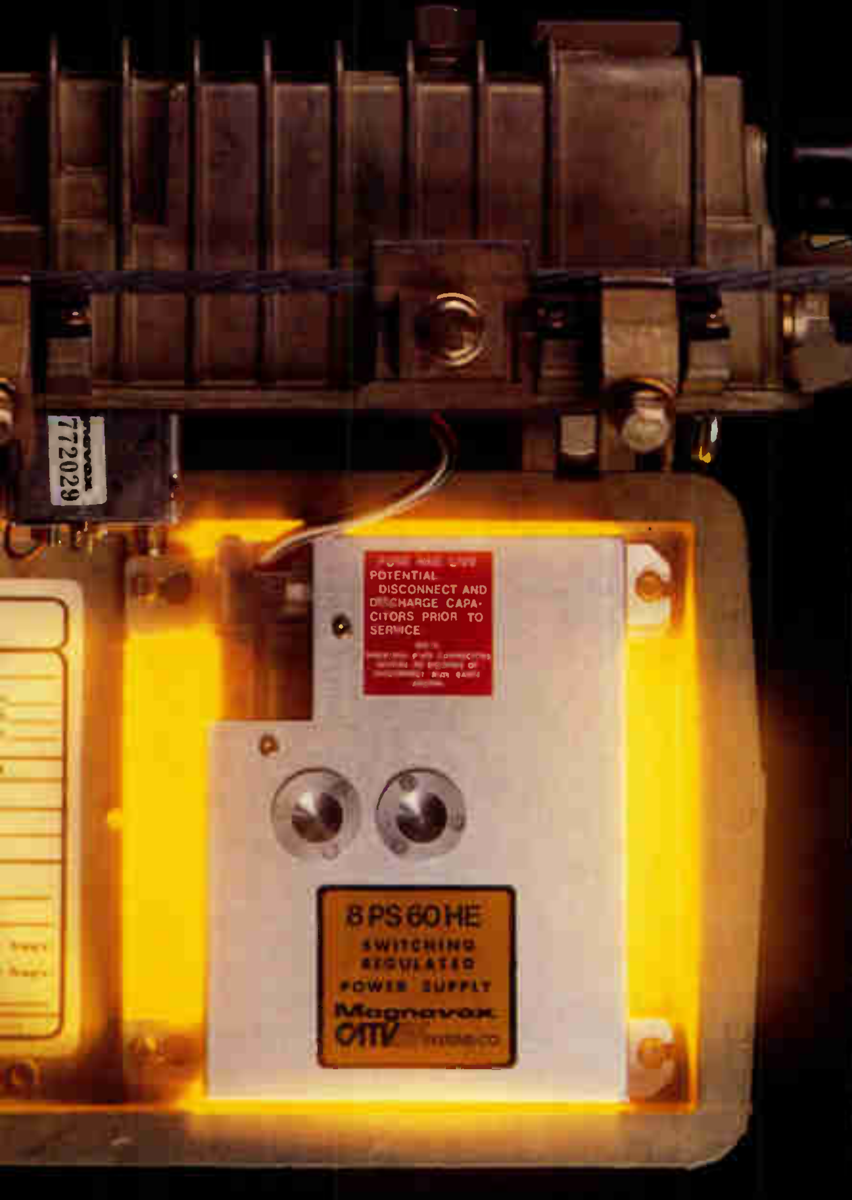

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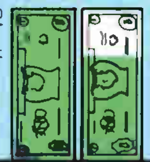

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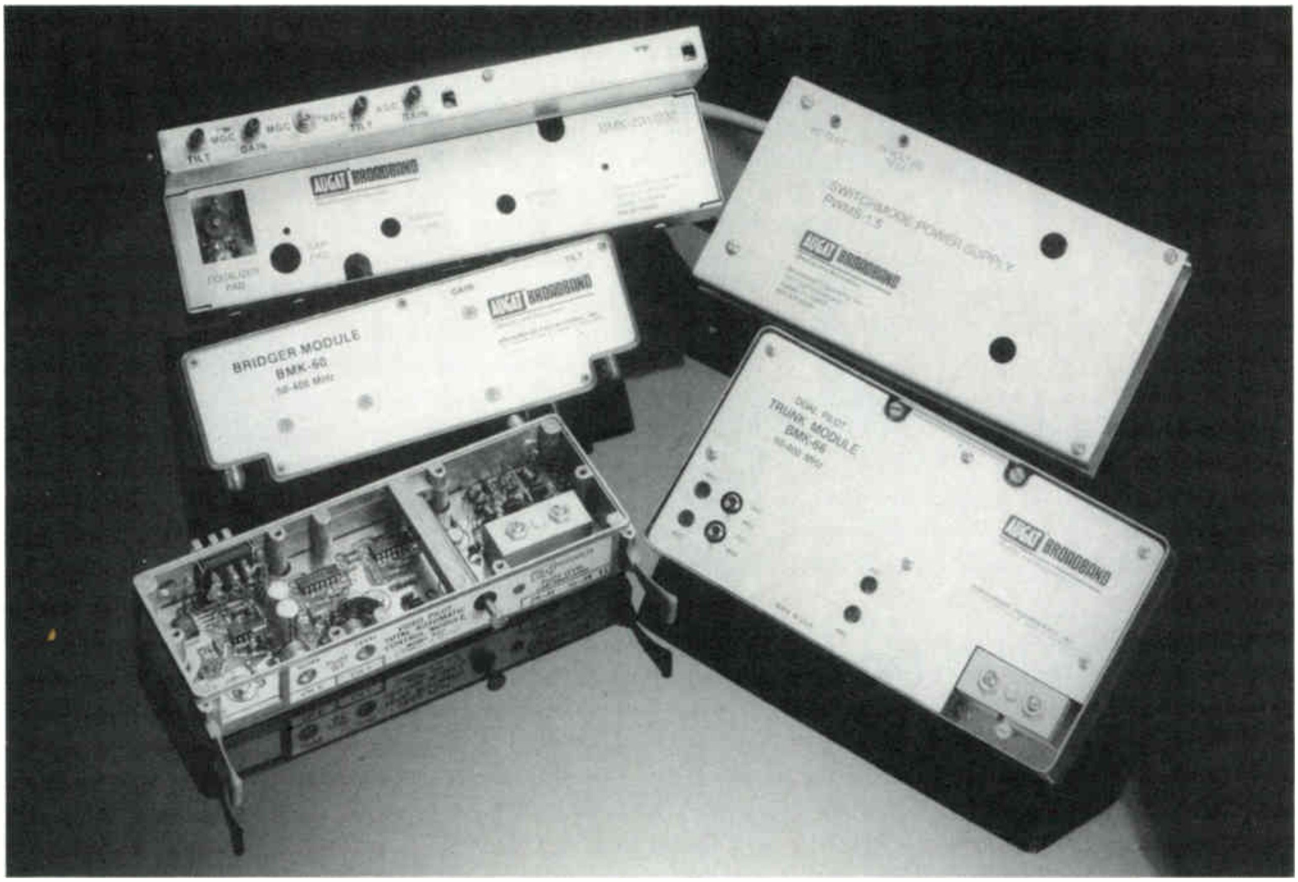

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designer's choices in three critical areas: regulation, topology and battery voltage.

Inherent in the design of any regulating device is a compromise between regulation and efficiency. The ferroresonant transformer typically used in cable power supplies is no exception. The objective of the design engineer should be to provide the best possible efficiency with acceptable regulation, because any improvement in efficiency is always beneficial. What cable operator does not want lower power consumption, increased reliability and more reserve time? Regulation, on the other hand, is a parameter that needs to be good enough, but what would be the benefit of 0.5 percent regulation if 3 percent is adequate?

Topology refers to the overall configuration of the power supply. Non-standby units typically consist of a ferroresonant transformer and its resonating capacitor. The advantages of this approach are simplicity, rugged reliability, high efficiency and no generation of electromagnetic interference, along with very high isolation of the power supply output from the power line. In addition, ferroresonant power supplies are virtually self-protecting. They are inherently current limiting; that is, they will automatically limit their output current to a safe level, even if the output is shorted, without requiring the action of any control circuit. Further, they will protect themselves and the load from virtually any line transient short of a direct lightning strike.

Finally, the output waveshape of a ferro can be designed to be a quasi-square wave, which is more desirable than either a sine or a square wave for driving typical cable system loads.

Standby power supplies also typically use ferroresonant transformers in the normal, AC line-powered modes of operation. Many use the same ferroresonant transformer in both line and inverter (standby) modes. Others use two separate transformers. In the single transformer designs, the ferroresonant transformer is constructed with two separate, electrically isolated primary windings. One of these primaries can be driven from the line, while the other can be driven by the inverter. Note that both primaries are not driven at the same time.

The ferroresonant transformer is essentially the same as it would be for a non-standby design, except that we now need room for the additional primary winding for the inverter. Here the designer has a choice. The transformer can be kept the same size as in a non-standby system. Smaller wire sizes will have to be used to allow space for the additional primary, and as a result efficiency will be decreased. Preferably, the designer will instead choose to increase the transformer size by about 20 percent in order to accommodate the inverter primary. This means that wire sizes do not need to be reduced, and efficiency remains essentially unchanged from the non-standby design.

Battery voltage is a significant factor in determining standby mode efficiency and reserve time. From fundamental principles, we know that power transmission or conversion is most efficient when carried out at the highest practical voltage. That is why utilities transmit power at high voltage. Medium- to large-scale uninterruptible power systems (UPS) use battery plants in the 300-400 volt range. Losses in a power conversion circuit are essentially constant with changes in voltage, but increase quickly with increases in current. Losses in an ohmic conductor increase with the square of the current; losses in semiconductor junctions increase logarithmically.

From the efficiency standpoint, battery voltage should be as high as possible. Why not then use a 400 volt battery string for a standby cable power supply? Two reasons—safety and cost. In regard to safety, it is desirable to keep the battery voltage at an inherently safe level. Considering cost, the lowest cost to the power supply manufacturer would indeed be incurred if a voltage in the 200-400 range were used.

Battery cost, however, tends to increase at higher voltages. This is simply because it is more expensive to produce many small cells than fewer, larger cells. This factor is less important as battery size increases due to a requirement for either more power or longer reserve. At one extreme, a 12 volt battery would be most economical for a very light load and only a few minutes of reserve. At the other end of the spectrum, a large UPS requiring several hours reserve time is going to require a 400 volt battery plant. Standby cable power supplies, with typical requirements for perhaps 800 watts and several hours of reserve, appear to be best served by 36 volt batteries. ■

**Figure 1:** Oversimplified lightning model

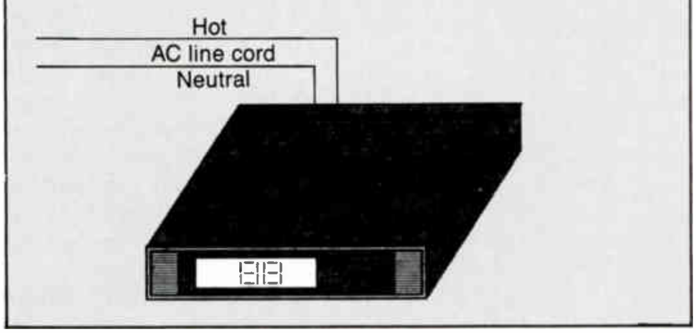
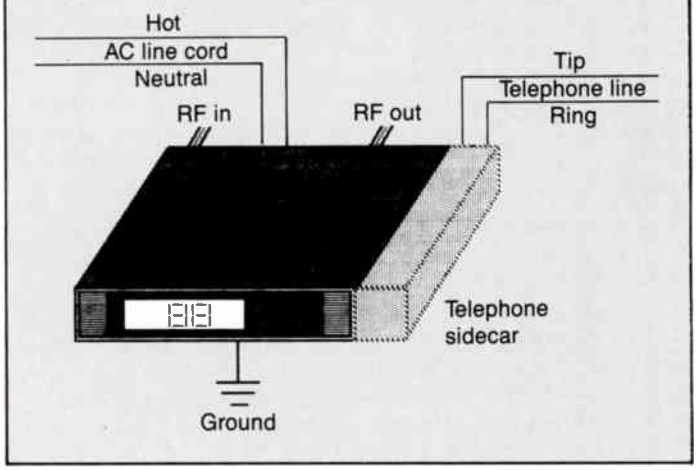


**Figure 2:** Actual lightning model



# Modeling the converter in the residential lightning environment

**By Dave Wachob**
Manager, Product Support Engineering
Jerrold Subscriber Systems Division, General Instrument Corp.

Today's state-of-the-art cable TV converters must be adequately protected to survive the harsh home lightning environment. This is essential not only from a subscriber safety and liability standpoint but also because of the frustration and cost associated with repairing damaged equipment and restoring system services. The results of lightning damage include both the obvious, such as totally non-functional equipment, and the more subtle, frequently misidentified effects, such as memory corruption, mode changes and performance degradation.

AC power line disturbances generally fall into two main categories: those of short duration (< 1 millisecond) and those of longer duration (> 1 ms). Of the two types, longer duration disturbances are more the result of load switching transients than actual lightning-induced disturbances. While protection from both long and short duration transients is necessary to ensure acceptable converter field performance, this article will focus on shorter duration lightning-related phenomena.

## Popular misconceptions

At first glance, one might be tempted to model the converter in the subscriber's home lightning environment as illustrated in Figure 1. This model shows a simple two-wire AC interface to the residential power system comprised of "hot" and "neutral." Although this oversimplified approach might be appropriate for some residential appliances, the other interfaces involved make it totally inadequate for cable TV converters.

The actual residential converter lightning model is shown in Figure 2, detailing not only the two-wire AC cord line but also the RF input/output connectors (including ground) and telephone line interconnection (if applicable). In this model, CATV ground plays a key role, serving as the major (although not only) discharge "sink." The reason for this is that the CATV ground frequently is more direct (i.e., lower impedance) than AC neutral, due to the inherent inductance of the residential AC wiring.

Another popular misconception about residential lightning is the voltage level and shape of the waveform delivered to the converter through the residential AC outlet. While it is true that lightning voltages to 20 kV might be possible at locations external to the home on the AC power grid, 6 kV is an appropriate maximum at the residential AC wall socket. This limit can be determined both theoretically and empirically from the breakdown voltage of typical residential AC wire. In addition, due to the inductance associated with the residential wiring itself, an oscillatory (100 kHz frequency) rather than pulse shape is appropriate.

In order to achieve effective converter lightning protection, one must first correctly define and test against the appropriate surge waveform and level at the corresponding converter interface.

*AC line*—The waveform of Figure 3 is appropriate for AC line surges, as described previously. Coupling of the waveform into the converter can be either normal mode (hot to neutral) or either of the three common modes (hot to ground, neutral to ground, and hot and neutral to ground). In practice, common mode surges appear to cause the most potential damage, due to their direct discharge through cable ground. Surges of both polarities also must be considered, since in nature both can occur (85 percent negative, 15 percent positive).

*RF input*—Disturbances on the RF input can originate either as coaxial sheath (ground) or center conductor lightning strikes or induced voltages. The waveform is best illustrated by Figure 4 (10 ms rise time, 1,000 ms duration) with 1.5 kV as the applicable test voltage. Here again, the 1.5 kV level originates from the breakdown of coax cables. Both polarities must again be tested, for reasons mentioned previously.

*RF output*—At first glance, the waveform of Figure 4 also might seem applicable to the RF output port. However, considering the interface between the RF output and the subscriber's TV set or VCR, Figure 3 is actually the correct choice for testing. This results from the coupling of AC surges from either the TV set or VCR in the "back door" of the converter through the output coax

*"Any test result that would have required subscriber interaction ...should be considered a failure."*

center or sheath. As in the case of a direct AC surge, ±6 kV is the correct choice of test voltage.

*Telephone interface*—The use of telephone return sidecars for two-way pay-per-view data collection represents another potential path for lightning. The waveforms and levels present on this interface are as defined in Federal Communications Commission Part 68 requirements. In summary, these are broken into two categories: longitudinal (1.5 kV, 10 ms rise time, 160 ms duration) and metallic (800 V, 10 ms rise time, 560 ms duration) types. Both categories must be tested under positive and negative polarities and all configurations of tip, ring and ground.

### Test philosophy

Lightning testing, as defined by the interface levels and waveforms described previously, should be performed on prototype, final approval and production sampled units to ensure compliance to the established specifications. Anything less than this level of vendor assurance will result in unnecessary potential field problems. In addition, due to the statistical nature of lightning in the real world and the multitude of possible interface configurations described, a minimum of 400 surges per converter should be performed.

In general, any test result that would have required subscriber interaction (service call, channel changing, etc.) should be considered a failure. Ideally, the converter also should be tested under actual operating conditions (AC powered, live video, data, phone present).

Care also should be taken in the selection of lightning test equipment to ensure that proper surge isolation protection is provided to prevent the surge waveform from damaging adjacent lab test equipment on the same power/CATV grid. More importantly, care and common sense must prevail during the testing due to the potentially hazardous voltages required. In addition, eye protection should be used during testing due to the potential for flying debris from underrated component breakdown. ■

### References

*IEEE Guide for Surge Voltages in Low-Power AC Circuits*, IEEE Std. 587-1980.
*Keytek Surge Protection Test Handbook*, 1986, Keytek Instrument Corp.

**Figure 3:** Residential AC surge

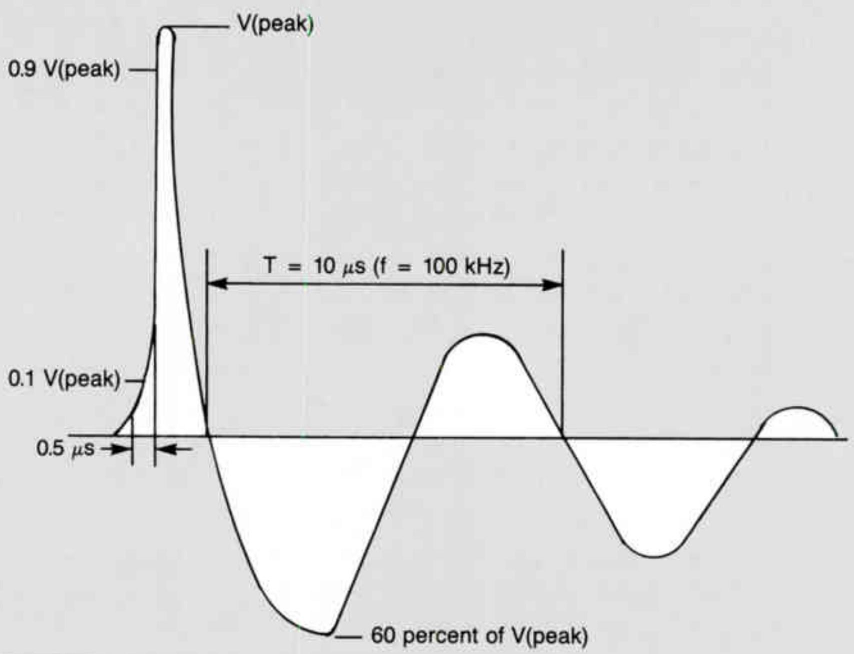
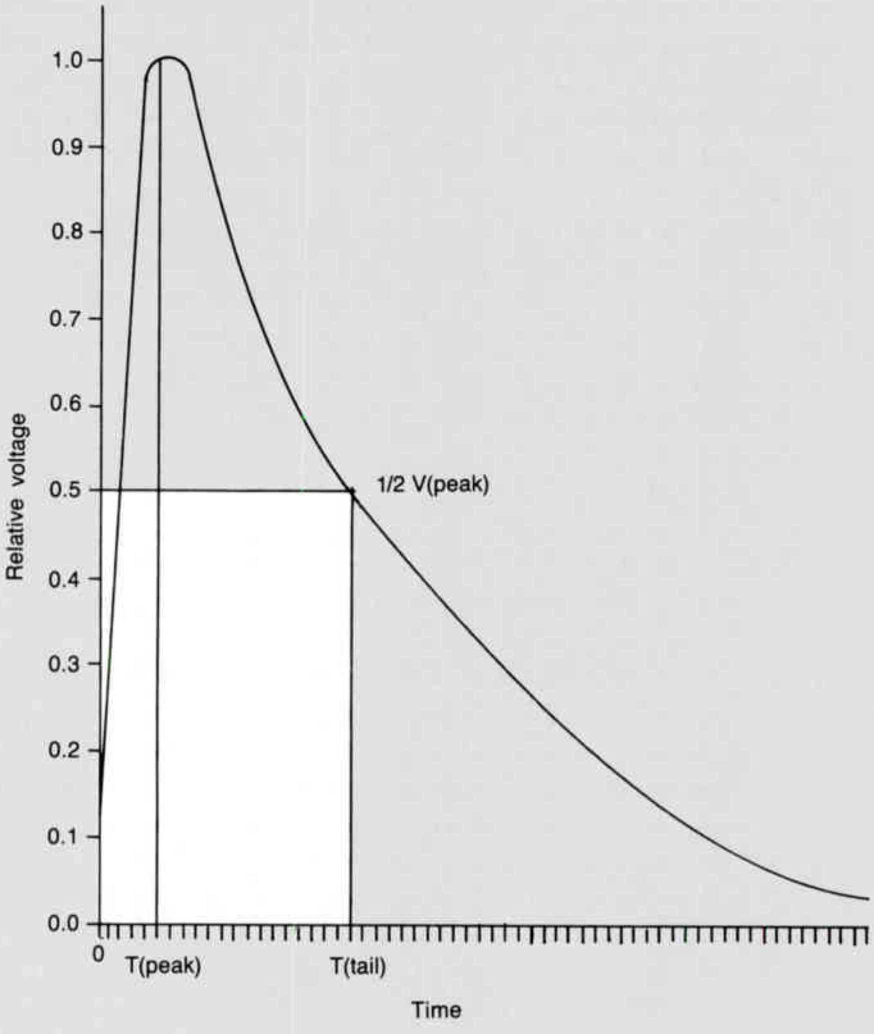


**Figure 4:** RF, telephone surge



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# Batteries in CATV standby power supplies

**By Neil Tinggaard**
Director of Engineering, Daniels & Associates

A storage battery is a device in which energy is stored in a chemical form and can be released as electricity. When charging, the battery directly converts electrical energy to chemical energy. When connected to a load the electrical energy is recovered during discharge.

The batteries typically used in CATV applications are of a lead acid ($Pb$-$H_2SO_4$) nature, with the chemical reaction occurring between lead ($Pb$) "plates" and a weak (17-35 percent) solution of sulfuric acid ($H_2SO_4$) "electrolyte."

The chemical reaction during the discharge process is such that the electrolyte ($H_2SO_4$) works on both the positive ($PbO_2$) and negative ($Pb$) plates, forming lead sulfate ($2PbSO_4$) on the plates and water ($H_2O$) in the electrolyte. This reaction is described by the formula $PbO_2 + Pb + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$. The reaction continues until the electrolyte is so diluted with water that the battery can no longer deliver a useful voltage. The battery is then said to be discharged. A battery will have a small local chemical reaction at the plates even though no load has been connected to it—a reaction known as "self-discharge," in which the battery slowly loses its charge over time. Self-discharge is the phenomenon that causes batteries not in use to discharge and is one of the limiting factors involved in shelf life.

**Figure 1:** Self-discharge and temperature

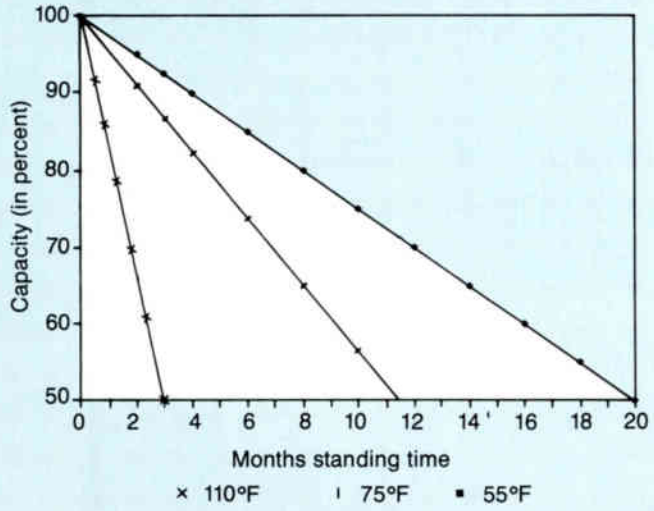
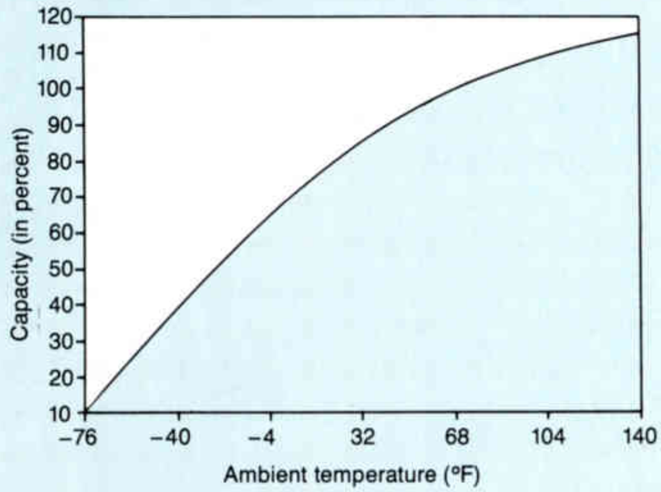


**Figure 2:** Change in capacity with temperature



The chemical reaction during the charging process is such that as electricity passes through the cell, the lead sulfate ($2PbSO_4$) on the plates recombines with the water ($2H_2O$) in the electrolyte and forms the original compositions lead peroxide ($PbO_2$) on the positive plate, sponge lead ($Pb$) on the negative plate and sulfuric acid ($H_2SO_4$) in the electrolyte ($2PbSO_4 + 2H_2O \rightarrow PbO_2 + Pb + 2H_2SO_4$). The reaction continues until the plates and electrolyte have returned to their original conditions. Past this point, further current through the battery (overcharging) would cause the electrolyte to decompose into hydrogen and oxygen gases, drying out the cell.

The chemical reaction is sometimes referred to as a "double sulfate" and can be rewritten as $PbO_2 + Pb + 2H_2SO_4 \leftrightarrow 2PbSO_4 + 2H_2O$. When written this way, it is read from left to right during discharge and from right to left during charge processes.

The plates described are of two different forms of lead—sponge lead on the negative plate and lead peroxide on the positive plate. These two active materials are crystalline in nature and are formed by mixing lead oxide with sulfuric acid and an expander to form a cohesive but very porous paste. This mixture alone has no rigid form or strength, requiring that some sort of supporting and conducting structure be provided.

The supporting structures for the active pastes are referred to as "grids" and are usually in the form of a latticework into which the pastes are worked. They are molded or wrought from a lead alloy because lead by itself is too soft to provide the rigidity required during manufacturing and installation. Historically, two elements, antimony and calcium, have been used for this purpose, with batteries constructed from lead-antimony alloys having a higher gassing rate and a higher self-discharge rate. Therefore, only batteries with lead-calcium alloys should be considered for standby power supplies.

The positive and negative plates are stacked together, separated by thin sheets of non-conducting, porous, plastic materials that allow chemical action but prevent the plates from physically touching and shorting out the cell. There may be any number and size of plates per cell, but the plates will always alternate from positive to negative, starting and ending with a positive plate. All of the positive plates are connected together and all the negative plates are connected together to form a single cell with an output of 2 volts. (The number and size of the plates within a cell will determine the amperage capacity of the cell.) The plates are then dipped into an electrolyte bath and given a "forming" charge to form the negative sponge lead and positive lead peroxide plates.

Battery housings are tanks used to contain a number of cells and the electrolyte to react with them. For example, six cells could be placed in the container and connected in series to make one 12-volt battery (2 volts × 6 cells = 12 volts). The container or housing is usually constructed from molded, hard rubber or polypropylene, to withstand extremes of temperature and shock and be resistant to the absorption of acid.

For our purposes, batteries may be grouped into two broad categories: flooded, vented cells and sealed cells (recombination), depending on how the electrolyte is maintained. The flooded, vented cell allows the gases produced to vent into the atmosphere and requires that the electrolyte be topped up (by the addition of water) as this occurs. If the electrolyte is not topped up, it becomes more concentrated, causing increased corrosion of the positive plate and drying of the paste, neither of which is recoverable.

Sealed or "maintenance-free" batteries operate in a similar manner, but the battery is sealed with a positive pressure built up during the manufacturing process. Equilibrium occurs in the battery, so that as oxygen is generated it reacts with the sponge lead at the negative plate, forming an oxide that in turn reacts with the electrolyte to form lead sulfate and water—hence, acting as a closed system. Pressure relief valves are included

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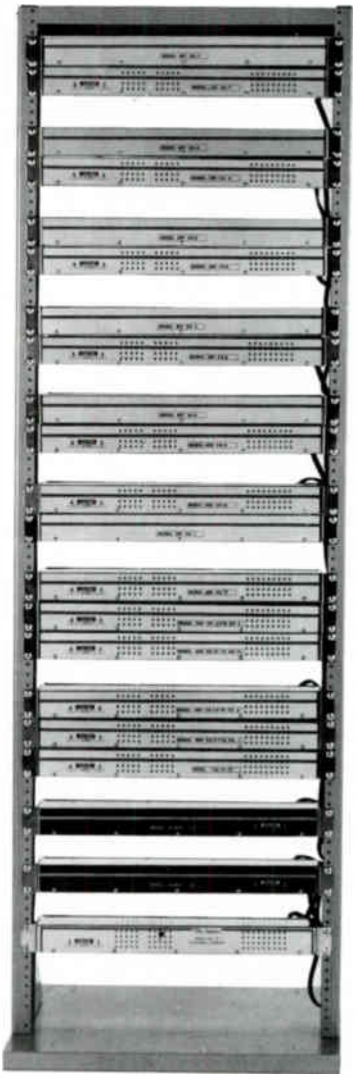

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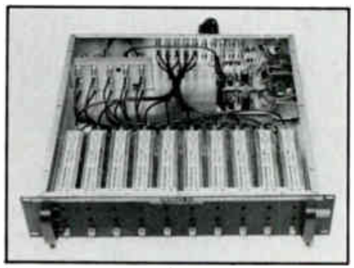

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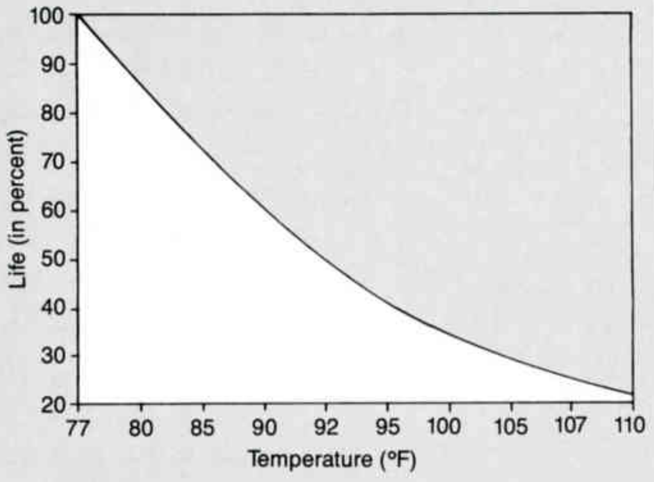


**Figure 3:** Effects of temperature on battery life

in the battery to vent any overgassing into the atmosphere. Two methods of storing the electrolyte in a sealed battery are: 1) the use of thick, highly absorbent, felt-like glass fiber mats to separate the plates and store the electrolyte and 2) the addition of a gelling agent to the electrolyte used in the battery. Sealed or maintenance-free batteries fall into two categories, depending on the pressure allowed to build: 1-6 psi and 30 psi up.

### Battery characteristics

As noted earlier, batteries self-discharge without being connected to a load. Self-discharge characteristics have improved significantly with the changes in alloys from antimony to calcium. The rate of self-discharge depends upon the temperature at which the battery is stored or maintained. Figure 1 is a sample of a manufacturer's self-discharge graph.

The chemical reaction taking place within the battery is also temperature sensitive, proceeding slowly when cool and going much faster as the temperature rises. In addition, the capacity of the battery during discharge (Figure 2) and its life are affected by temperature. As shown in Figure 3, a battery will lose about 50 percent of its life for every 15°F that it continually operates over its design temperature of 77°F. (Keep in mind that when a battery is installed in a power supply, the temperature within the supply is typically some 10 to 20°F above ambient.)

In addition, as the temperature of the electrolyte approaches 120°F, during a charging condition the battery begins to accept progressively higher currents. This will cause a lowering of the internal resistance of the battery and a buildup of excessive internal heat. The result (thermal runaway) is an uncontrolled reaction that will damage the battery and can become hazardous.

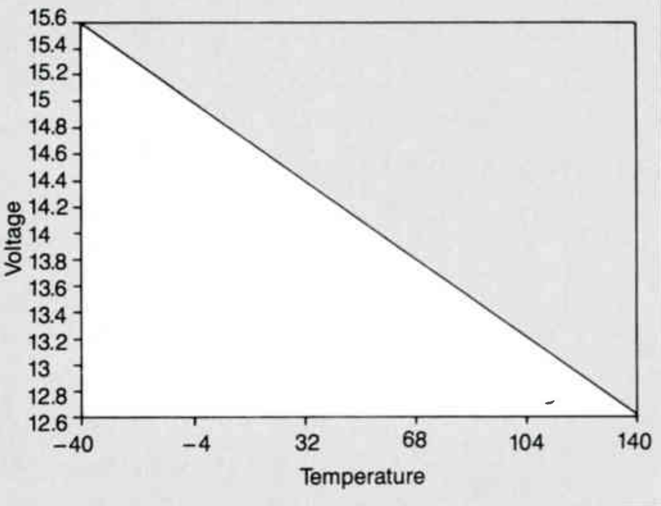


**Figure 4:** Float voltage

The following formula will allow for adjustments in battery life by calculating the months of aging at elevated temperatures vs. the months of life at design (77°F) temperature.

$$\text{Ltc} = \text{Ebl} \div \left[\left(\frac{1}{\%\ \text{life}} \times \text{months at T1}\right) + \left(\frac{1}{\%\ \text{life}} \times \text{months at T2}\right) \ldots + \left(\frac{1}{\%\ \text{life}} \times \text{months at Tn}\right)\right]$$

where:

Ltc = the temperature-corrected years of battery life
% life = from Figure 3
Months at T1 = number of months at temperature T1
Ebl = normal expected battery life in months

Note: 1) T1 + T2.... + Tn must equal 12 (1 year).
2) When the temperature is below 77°F, use 77°F.

*Example:* The electrolyte temperature of a 60-month battery in one particular installation is 92°F for four months, 85°F for four months and 74°F for four months during a year. (These temperatures include an additional 15°F increase due to the contribution of the power supply, as previously described.)

$$\text{Ltc} = 60 \div \left[\left(\frac{1}{.50} \times 4\right) + \left(\frac{1}{.69} \times 4\right) + \left(\frac{1}{1} \times 4\right)\right]$$

$$= 60 \div (8 + 5.8 + 4) = 3.37 \text{ years}$$

or 40.44 months. (Note that this "60-month" battery is actually a 40-month battery in this application.)

The batteries at this installation will age:

8 months during the four months at 92°F
5.8 months during the four months at 85°F
\+ 4 months during the four months at 74°F

17.8 months per calendar year.

As we have seen, the chemical reaction of the battery is very temperature-dependent; therefore, the charging voltage is critical and the manufacturer's recommendations should be followed closely. Temperature compensation of the charging circuit should be considered where there are extremes of temperature. Figure 4 shows a typical manufacturer's charge voltage graph.

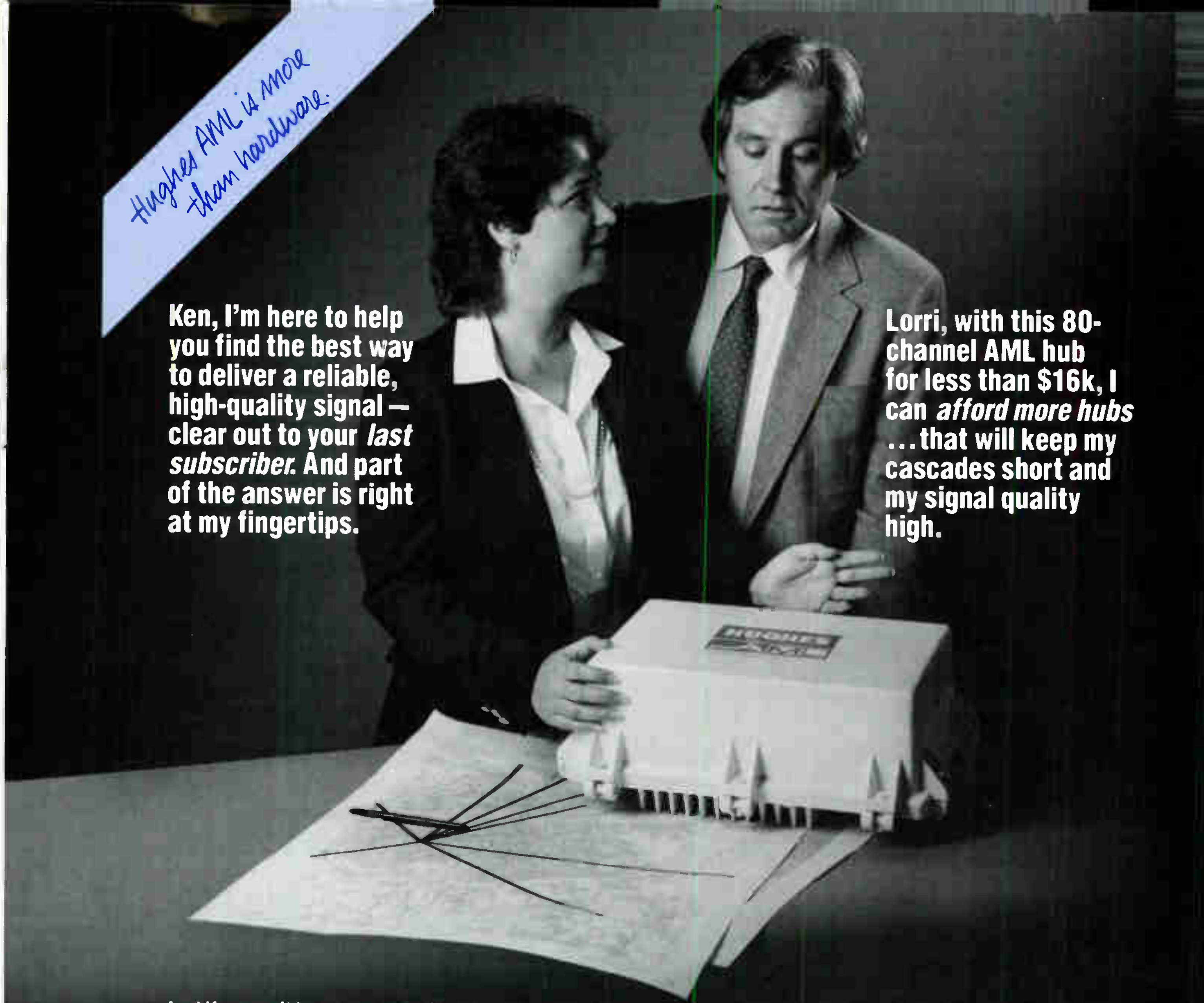
### Battery types and selection

Several categories of batteries are manufactured. We will examine two categories with significant differences in their design and operation.

The motive-SLI (automotive—starting/lights/ignition, etc.) battery is designed to provide brief, high level bursts of current. This is accomplished by using a large number of thin lead-antimony alloy plates in the battery construction. Since CATV service requires moderate amounts of current for long periods of time, early decomposition of the thinner plates and plate warpage on charge cycles would result: premature failure would therefore be predicted if this type of battery were to be used. In addition, while the antimony alloy provides faster discharge rates, the higher gassing rate is undesirable.

More appropriate for the demands of CATV usage is the stationary (deep cycle) battery, which is designed to provide moderate amounts of current for longer periods of time. This is accomplished by building the battery with a smaller number of thicker lead-calcium plates.

Based on this, it is obvious that a deep cycle type of battery must be used. The sealed battery should be selected because it will not vent as much hazardous hydrogen and oxygen gases into the power supply compartment, which would expose components to excessive corrosion



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and create potentially explosive conditions. Also, the sealed battery will not require close monitoring and maintenance of electrolyte levels.

Next, the ampere-hour capacity of the battery should be determined. First, the battery should be sized by calculating the basic ampere-hour requirement (load × time) and then making any adjustments to its size to allow for any lowered capacity due to lowered temperature (Figure 2). An adjustment in size should also be made to compensate for aging of the battery. The battery's size should be 125 percent of its load, with good design practices calling for an additional 10 to 15 percent margin.

*Example*: Batteries are to be selected for a power supply at one particular installation where the measured current is 12 amperes, the lowest temperature is 0°F and four hours of standby time are required. (The temperature includes an additional 15°F increase due to the heat contribution of the power supply, as previously described.)

*Load calculation*:
Power supply current = 12 amperes
Standby time required = 4 hours
Amperes-hours = amperes × hours
12 amperes × 4 hours = 48 ampere-hours required
*Compensation for temperature due to the 0°F low temperature:*
Ampere-hours = ampere-hours/lowered capacity
= 48 ampere-hours/.70 (from Fig. 2)
= 68.57 ampere-hours
*Compensation for age*:
Ampere-hours = ampere-hours × 125 percent
= 68.57 ampere-hours × 1.25
= 85.71
*Allowance for margin*:
Ampere-hours = ampere-hours × 115 percent
= 85.71 ampere-hours × 1.15
= 98.57 ampere-hours

From this it can be seen that a sealed deep cycle battery in a 100 ampere-hours capacity should be used in the power supply at this location.

Batteries should *not* be purchased until the time of actual installation in the power supply. However, if storage is necessary, a cool, dry place should be selected. The stored batteries should then be checked regularly and should be charged when they have discharged to within 80 percent of their capacity. As explained earlier, the chemical reaction going on within a battery is temperature sensitive; the temperature, time in storage and condition of charge affect the discharge rate. The most accurate method of determining the present state of charge is by measuring the voltage present at the battery terminals with a digital voltmeter and comparing it with the manufacturer's OCV (open circuit voltage) chart (Figure 5).

Since the battery is very sensitive to temperature and charging voltages, the battery manufacturer's charging recommendations should always be followed when installing batteries. The OCV of each battery should be measured, and where there is no more than a 0.5 volt difference, batteries may be combined.

Should batteries with differences greater than 0.5 volts be connected together, the net effect could be as follows: For example, for three batteries, with charge of 90 percent, 70 percent and 50 percent (average = 70 percent) connected in series, over time, with temperature and a number of discharge and charge cycles, a balanced condition could occur. Or the other extreme could occur, leaving some batteries overcharged and others undercharged.

Proper maintenance is required to prolong the life of the battery and will help assure that it is capable of delivering its proper current supply when called upon. When the battery is purchased, a log should be started showing the current date, date of manufactuer, date of purchase, OCV, physical condition and charge voltage. The date of manufacturer can usually be determined from a code in the form of a combination of three or four letters/numbers on the cover of the battery. For example, G5 indicates July 1985 (G is the seventh letter in the alphabet and July is the seventh month); the letter "I" is generally omitted.

At three-month intervals, each power supply should be cycled and thoroughly checked. The batteries should be inspected for unusual swelling, distortions in shape (0.25 inches of swelling is not unusual in the sealed batteries of some manufacturers), cracking or corrosion. Any

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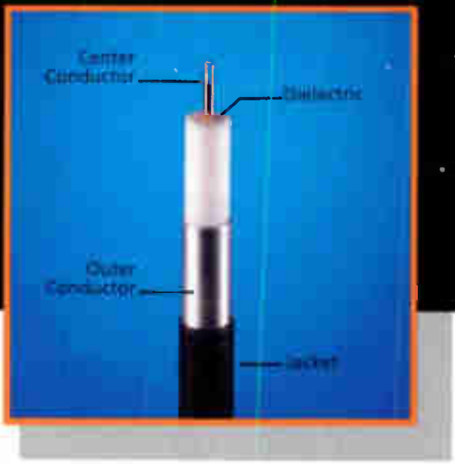

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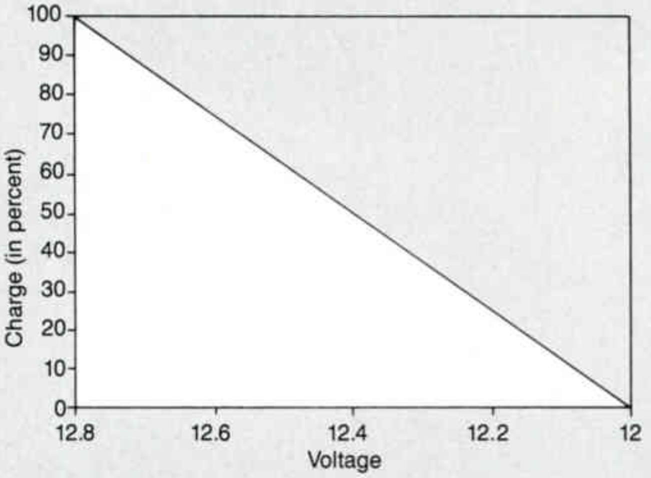

**Figure 5:** Open circuit voltage vs. state of charge

severely distorted or cracked batteries should be replaced and the cause of failure determined.

Batteries should be cleaned with a water-dampened cotton cloth to remove accumulated dust. Any electrolyte should first be neutralized with a sodium bicarbonate ($NaHCO_3$—baking soda) water solution (1 pound of soda per gallon of water), which should be applied with a cloth dampened with the solution. (Neutralization is complete when the fizzing action ceases.) The baking soda solution should be removed with a water-dampened cloth, and the area should then be wiped down with a clean, dry cotton cloth. This cleaning technique should minimize the development of leakage current.

Plastic battery cases should never be cleaned with anything but water or baking soda. Any connection found to be corroded should be taken apart, cleaned and remade. The charging voltage and OCV should be measured with a digital voltmeter, and corrective measures taken for any discrepancies over 0.5 volts. All data should be recorded in the log to provide historical reference for determining battery replacement intervals.

The power supply should be examined to verify that all fuses, circuit breakers, indicator lights and protective devices are in place and functioning. The power supply should then be operated in the standby mode to ensure its proper operation.

In addition to the prescribed three-month inspection, the batteries should be tested to determine their capacity after the first year and every six months thereafter. "Load testing" is the testing of a battery to determine its remaining percentage of capacity compared to its capacity when it was new; hence, the need for a data log. For the most accurate results, the testing should be performed using loads that closely approximate actual operating conditions. (The discharge rate can be found by examining the battery manufacturer's charts; typically two charts are given, one for low discharge rates, as in Figure 6 and one for high rates as in Figure 7.)

As can be seen from Figures 6 and 7, it takes a fairly heavy load and/or a considerable amount of time to get into the rated capacity of the battery, which must be done accurately to judge its remaining capacity. For example, if we were to try to use the standby power supply itself, it would take several hours to discharge the battery enough to determine its capacity. When using the standby power supply as a test for a few seconds, it loads the battery to less than 1 percent of its capacity, which is not a valid load test. Typically, a five- to 15-minute test is considered to be a minimum within the stationary battery industry, with many tests running hours (to discharge). Since this type of test has been difficult to perform, automotive-type load testers have been used to try to determine the condition of a battery; however, these testers are intended to be used to test cold-cranking power during a 15-second period, not the long-term capacity of the battery. Use of an automotive-type tester is about 50 percent accurate when using the minimum 100 ampere load.

Conductance testing provides the ability to test a battery's current capacity as compared to the original specification. The theory of operation

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**Figure 6:** Typical discharge curve (low rate)

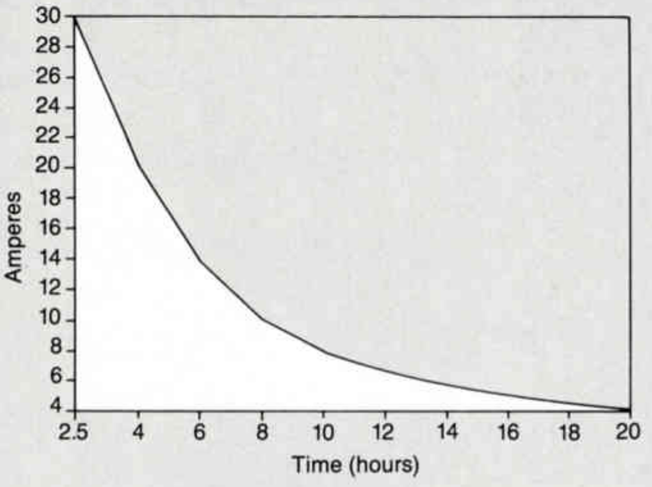
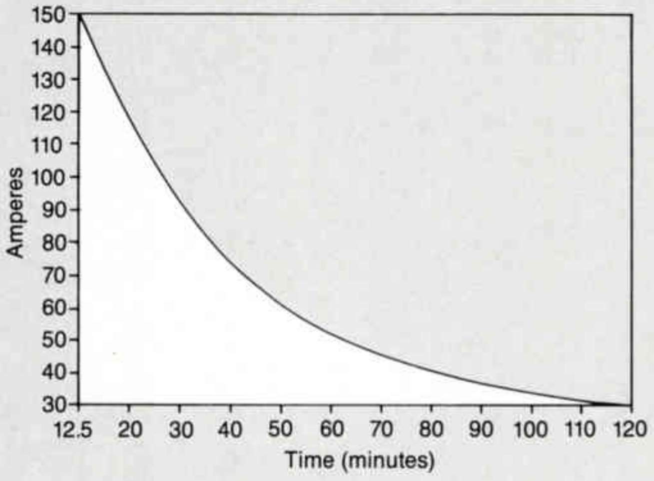


**Figure 7:** Typical discharge curve (high rate)



is based on conductance being the reciprocal of internal resistance and directly proportional to it; therefore, as the battery ages and its internal resistance rises, the conductance decreases proportionally.

Once the tester is adjusted, it is connected to a battery with two test leads and read as to the battery voltage, good/fail (based on 70 percent of its original capacity) or a reading of present capacity directly proportional to its original conductivity. The conductance test is fast, accurate, easy to perform and can be accomplished with the battery in place (but not charging).

To summarize, deep cycle sealed batteries should be selected for use in CATV power supplies. It is very important that their purchase be scheduled so that installation can take place as soon as possible after delivery. If temporary storage should be necessary, special precautions *must* be taken. For warm/hot climates, batteries should be placed in plastic battery trays located in the bottom of the power supply; top-mounting is appropriate for cool/cold climates. A battery maintenance/replacement program should be implemented, utilizing the temperature correction formula for estimating battery life, with conductance testing or load testing also scheduled on a regular basis. (Conductance testing offers both a pass/fail determination and an assessment of the percentage of capacity remaining in the battery as compared with its capacity when new.)

Power supplies should be checked out thoroughly at three-month intervals. The manufacturers' own recommendations regarding shelf life, OCV, and charging voltages should be observed, with all voltage measurements made with a digital voltmeter. Accurate, detailed records should be kept in all cases. Further, it is imperative that anyone working with batteries be made aware of their hazards, and that appropriate safety procedures be followed.

*Acknowledgements: Many thanks to all those who have helped with this article. A partial listing includes: Mike Baxa, Tom Doroty and Scott Grenner of Johnson Controls; Martin deAlminana of Burnup & Sims Cable Products Group; Steven McShane of Mid-Tronics; Ed Moore of Delco Remy; Richard Ruff of Teledyne Battery Products; and John Miller, Jim Trentor and Steve Vechie of GNB; and Bob Nelson, Gates Energy Products.*

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# Calculating TVRO expected performance

**By Jack Sanders**
Director, Telecommunications Engineering, American Television and Communications Corp.

There are two major parameters that tend to affect any communication system: noise power and signal power. Since noise power tends to be the least understood of the two, we will begin our discussion of the various noise sources that can affect the performance of a satellite receive terminal.

Sky noise, more commonly referred to as *thermal* or *white noise*, is generated by random electron motion from our hot Earth. Galactic noise generated by stars in our universe also contributes a small amount to the total effect. Thermal noise is measured in Kelvins (degrees Kelvin), which is an absolute system of measurement directly tied to Celsius, where Kelvins = Celsius + 273.15 degrees. At absolute zero degrees Kelvin (−273.15°C) there is no molecular motion and therefore no thermal noise.

Thermal noise at or near the Earth's surface is 17°C or 290°K. Typical terrestrial microwave antenna systems are aligned parallel to the Earth's surface and therefore see a fixed noise level of approximately 290°K. Satellite antennas are typically pointed up at elevation angles ranging from approximately 20° to about 50°. Since these types of antennas are relatively large, with highly directional beam patterns, they are not exposed to the full 290°K noise source. Most parabolic antennas used for satellite reception operate with clear sky noise temperatures ranging from about 20 to 40°K.

The amount of thermal noise in any electronic system is a function of its bandwidth in Hertz and the absolute noise temperature. The connecting relationship between the two is Boltzmann's Constant, where the basic equation is expressed as:

$$\text{Noise} = kTB \qquad (1)$$

where:
k = Boltzmann's Constant ($1.38 \times 10^{-23}$) Joules/°K
T = Absolute noise temperature in °K
B = Noise bandwidth in Hz

The "effective noise temperature" ($T_e$) is typically used when several noise sources are combined. For a typical TVRO system, these sources are:

1) the antenna (approximately 20 to 40°K),
2) the antenna feed assembly including loss and impedance mismatch (approximately 0.2 dB typical),
3) the low noise amplifier (85 to 120°K typical),
4) the cable and splitting loss between the LNA and the receiver, and
5) the receiver noise contribution.

### Converting noise figure to noise temperature

Equipment specs used for satellite TVROs are quite often rated in both dB and noise temperature. Therefore, one must become accustomed to converting these terms back and forth, when calculating the various parameters. For example, the noise figure (NF) of a typical LNA is rated at 1.12 dB. What is the equivalent noise temperature?

$$T_L = \log^{-1}\left(\frac{NF}{10}\right) - 1 \times 290°K \qquad (2)$$

$$T_L = \log^{-1}\left(\frac{1.12}{10}\right) - 1 \times 290°K = 85.3°K$$

Now, let's convert noise temperature back to NF in dB.

$$NF_{dB} = 10\log\left(\frac{85.3}{290} + 1\right) = 1.12 \text{ dB} \qquad (3)$$

Now, let's calculate the total *effective* noise temperature ($T_e$) for a typical TVRO satellite receive system. The system parameters are:

Antenna gain (5-meter) = 44.2 dB
Antenna noise temperature ($T_a$) = 20°K
Antenna feed loss ($L_1$) = 0.2 dB
LNA noise temperature ($T_L$) = 85°K
LNA gain ($G_L$) = 50 dB (× 100,000)
Cable and splitter loss ($L_2$) = 15 dB
Receiver noise figure (NF) = 14 dB

We will calculate $T_e$ based on these parameters. In order to illustrate the components that contribute the greatest amount of noise, let's break the system into three parts: 1) the antenna, plus feed loss, 2) the LNA, plus cable and splitter loss and 3) the satellite receiver. Since the model system rates some of the parameters in dB, we must convert to the actual numeric values in order to calculate the noise contribution.

The antenna:

$$T_e1 = \frac{T_a}{L_1} + \frac{(L_1 - 1) \times 290°K}{L_1} \qquad (4)$$

$$= \frac{20}{1.047} + \frac{(1.047 - 1) \times 290°K}{1.047} = 32.1°K$$

The LNA:

$$T_e2 = T_L + \frac{(L_2 - 1) \times 290°K}{G_L} \qquad (5)$$

$$= 85°K + \frac{(31.6 - 1) \times 290°K}{100{,}000} = 85.09°K$$

The receiver:

$$T_e3 = \frac{NF - 1 \times 290°K}{G_L} = \frac{(25.1 - 1) \times 290°K}{100{,}000} = 0.07°K \qquad (6)$$

therefore:
$T_e$ total = 32.1°K + 85.09°K + 0.07°K = 117.26°K

Note that almost 99.9 percent of the noise contributions are associated with the antenna and the LNA. The LNA's low noise figure and its associated high gain (50 dB or more) tends to offset the small contributions created by the cable, splitters and the receiver. (For further review, refer to an article written by Norman Weinhouse of Weinhouse Associates, published in the May 1985 issue of *TVRO Technology*.) The primary concern after the LNA is to provide sufficient signal level to the receiver. Most of the receiver AGC circuits are designed to accept input levels of approximately −30 to −60 dBm.

### Signal power

From the downlink side, the signal power represents the RF energy transmitted by the satellite, which has an effective, isotropic radiated power (EIRP) of about 35 dBW. This represents a power level of approximately 3,160 watts compared to a transmitter feeding a unity gain antenna system. Most of the power is lost (approximately 196.12 dB) during the 24,000-mile

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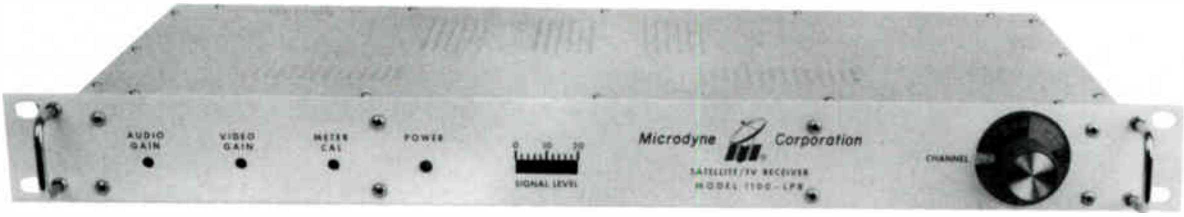

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trip to the TVRO ground station. Therefore, the input power to the TVRO LNA is:

Satellite power − space loss + receiver antenna gain **(7)**

35 − 196.12 + 44.2 = −116.92 dBW

This yields an actual received power level of:

$$\text{Log}^{-1}\left(\frac{-116.92}{10}\right) = 2.03 \times 10^{-12} \text{ watts} \qquad \textbf{(8)}$$

To calculate the noise power (B = 30 MHz), use Formula 1:

$$\begin{aligned} N &= kT_eB = 1.38 \times 10^{-23} \times 117.3°K \times 30 \times 10^6 \\ &= 4.86 \times 10^{-14} \text{ watts} \end{aligned}$$

We have calculated the expected signal power and the noise power of our model TVRO system. In order to determine the expected performance, combine the two to obtain the signal power-to-noise power ratio (C/N); therefore:

$$C/N_{dB} = 10\log\left(\frac{2.03 \times 10^{-12}}{4.86 \times 10^{-14}}\right) = 16.2 \text{ dB} \qquad \textbf{(9)}$$

As you may have gathered by now, the calculations using numeric values are lengthy and somewhat cumbersome. This was necessary in order to illustrate the basic origins and how the more modern equations were derived. The more classical equation used for C/N calculations in dB is:

$$C/N_{dwn} = \text{EIRP} - L_s + G/T + 228.6 - 10\log \text{BW} \qquad \textbf{(10)}$$

where:
EIRP = Satellite power (dBW)
$L_s$ = Space loss (dB)
G/T = Antenna gain to temperature ratio (dB)
228.6 = Boltzmann's Constant in dB = 10log $(1.38 \times 10^{-23})$
BW = Receiver noise bandwidth $(30 \times 10^6)$ Hz

The G/T term is often referred to as the system "figure of merit" since it combines the two most essential components of the system: the antenna gain and $T_e$. For example, the G/T for our model system is:

$$G/T = 10\log(G/T) \qquad \textbf{(11)}$$

Convert the antenna gain to numeric value:

$$G = \log^{-1}(44.2/10) = 26{,}302.7$$

then:

$$G/T_{dB} = 10\log(26{,}302.7/117.3) = 23.51 \text{ dB}$$

There is one other method of handling these two parameters used in the classical C/N equation. Add the antenna gain in dB and then subtract the value of 10log($T_e$), which will yield the same results. For example:

$$\begin{aligned} C/N_{dwn} &= \text{EIRP} - L_s + G_a + 228.6 - 10\log \text{BW} - 10\log(T_e) \qquad \textbf{(12)} \\ &= 35 - 196.12 + 44.2 + 228.6 - 10\log(30 \times 10^6) - 10\log 117.3 \\ &= 16.2 \text{ dB} \end{aligned}$$

### Interference considerations

As was stated earlier, the basic $C/N_{dwn}$ must be corrected for inherent interference cases, some internal to the system and, in worst-case situations, corrections for known terrestrial interference. The calculations are referred to as C/I corrections. When an interference source is combined with the desired signal, the effective carrier-to-noise is reduced by an amount proportional to the magnitude of the interference source.

If the interference source is the same level as the desired signal, the C/N is simply reduced by 3 dB. However, when the C/I is not the same level, calculating the degradation effect is somewhat more complicated. The method used is similar to adding resistors in parallel. The only difference is converting in and out of the $\log_{10}$ process.

C/I source model:
Uplink C/N (dB) = 27
Satellite intermodulation (dB) = 27
Adjacent satellite (dB) = 30
Receiver cross-polarization isolation (dB) = 30

$$C/I_{total} = 27 \oplus 27 \oplus 30 \oplus 30 \qquad \textbf{(13)}$$

where: ⊕ denotes power summation. Note: The two 30s reduce to 27 dB, the two 27s to 24 dB. So:

$$C/I_{total} = 24 \oplus 27 \text{ dB}$$

Therefore:

$$C/I_{total} = 10\log\left(1 \div \left[\frac{1}{\log^{-1}\left(\frac{24}{10}\right)} + \frac{1}{\log^{-1}\left(\frac{27}{10}\right)}\right]\right) = 22.24 \text{ dB} \qquad \textbf{(14)}$$

Now we must combine the $C/I_{total}$ with the $C/N_{dwn}$, which will provide the true "predetection" carrier-to-noise ratio for our model system.

$$C/N_{pd} = 16.2 \oplus 22.24 = 15.23 \text{ dB}$$

As can be seen, combining the four cases of C/I with the basic $C/N_{dwn}$ degraded our model system by 0.97 dB.

At this point, the signal is still at intermediate frequency (IF), typically 70 MHz, prior to the receiver's demodulation circuit. After detection, the carrier-to-noise is demodulated to video signal-to-noise, yielding several FM improvement factors. There are at least two generally accepted equations for calculating FM video signal-to-noise, as follows:

$$\begin{aligned} S/N = C/N_{pd} + 10\log\left[3\left(\frac{\Delta F}{BV}\right)^2\right] + 10\log\left(\frac{B_{IF}}{2BV}\right) + 30\log\left(\frac{bn}{bn'}\right) \qquad \textbf{(15)} \\ + P/R + E \end{aligned}$$

where:
ΔF = Transmitter peak deviation (10.75 MHz)
$B_v$ = Video baseband frequency (4.2 MHz)
$B_{IF}$ = Receiver IF bandwidth (30 MHz)
bn = CCIR bandwidth unweighted (3.357 MHz)
bn′ = CCIR weighting filter (MHz)(1.574 MHz)
P/R = Peak-to-peak to RMS correction = 6.1 dB
E = FM pre- and de-emphasis improvement = 2.93 dB

$$\begin{aligned} S/N_v = C/N + 10\log\left[3\left(\frac{10.75}{4.2}\right)^2\right] + 10\log\left(\frac{30}{2 \times 4.2}\right) + 30\log\left(\frac{3.357}{1.574}\right) \\ + 6.1 + 2.93 \end{aligned}$$

$$S/N_v = C/N_{pd} + 37.36 \text{ dB}$$

The second equation is a modification of the first, which simplifies the procedure by lumping several of the parameters together.

$$S/N_v = C/N_{pd} + 10\log 30 + 10\log\left[\frac{12(0.714 \times 10.75)^2}{(1.574)^3}\right] \qquad \textbf{(16)}$$

$$S/N_v = C/N_{pd} + 37.36 \text{ dB}$$

*(Continued on page 60.)*

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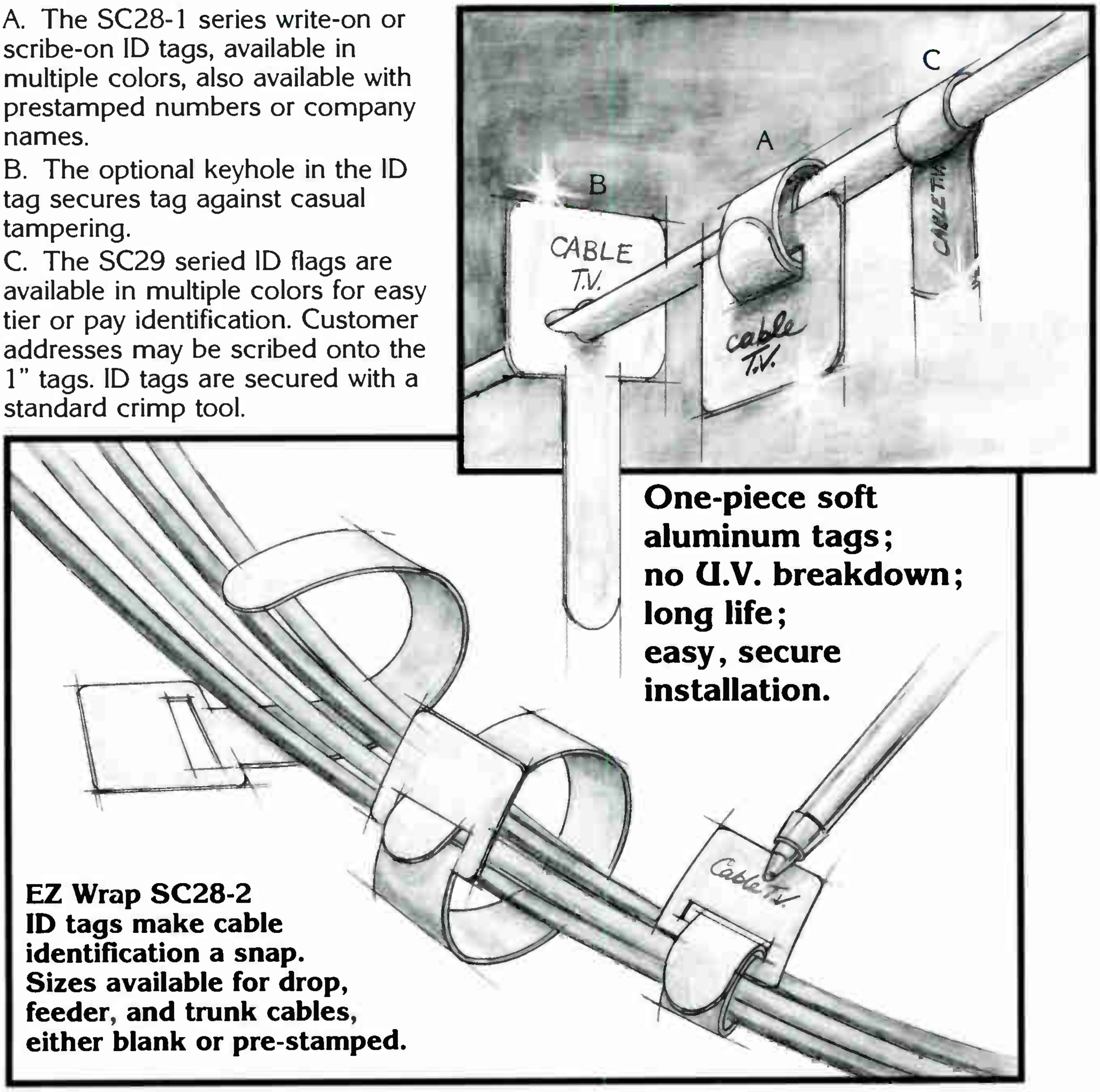

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*(Continued from page 44.)*

Therefore, for our model system:

$S/N_v = 15.23 + 37.36$ or 52.6 dB (CCIR weighted)

**FCC licensing consideration**

The FCC no longer requires a TVRO receive site to be licensed. However, in order to ensure frequency interference protection one must first frequency coordinate and license the antenna. Licensing the antenna site does not provide interference protection from any pre-existing interference. However, it can provide a degree of protection from new common carrier routes through your area. It is recommended that TVRO sites serving major CATV headends be licensed and frequency protected.

The FCC has adopted a 2° satellite spacing plan to be utilized as needed. However, at this time, most of the satellites that serve the cable industry are spaced from 2.5 to 3°. The closer spacing increases the adjacent satellite interference, which requires larger receive antennas in order to achieve the same degree of performance. It also appears that 2° spacing may restrict the use of multisatellite feeds on a single antenna.

When the FCC initially adopted the 4° satellite spacing, the antenna gain, off boresight (e.g., the sidelobe response) was limited to:

$$\text{Sidelobe gain} = 32 - (25\log\theta) \qquad \textbf{(17)}$$

where: $\theta$ = degrees off the center of the main lobe. When 2° spacing was adopted, the maximum sidelobe was changed to $29 - (25\log\theta)$. For example, let's calculate the gain of our 5-meter antenna model at 2° off the center of the main lobe, using the 2° spacing requirements.

$$\text{Sidelobe gain} = 29 - (25\log 2) = 21.47 \text{ dB}$$

Therefore, assuming our model as 44.2 dB main lobe gain,

$$\text{Isolation} = 44.2 - 21.47 = 22.7 \text{ dB.}$$

Note: This is for one satellite operating on the same polarity, adjacent to the desired satellite. Satellites operating at 2°, 4° and 6° on both sides of the desired satellite would reduce the isolation to 18 to 20 dB.

The two-degree spacing issue should not be confused with the true azimuth angle separation as viewed from the TVRO ground site. The satellite spacing is referenced from the geocentric, or the Earth's center, whereas the azimuth separation angles that the TVRO ground station sees is referenced from the Earth's surface.

The "azimuth difference" between any two satellites, as viewed from the ground, depends on the particular location of the ground station in respect to the satellite's assigned longitude position. The results of this configuration rarely produce a 2° azimuth difference when looking at two satellites with 2° spacing. The illustration that follows demonstrates a typical best-case azimuth as opposed to a typical worst-case azimuth difference between two satellites.

*Receive location:* Northern Florida
Latitude 29° 30′ 40″; longitude 85° 00′ 00″

*Satellite location:*

| | | |
|---|---|---|
| Telstar 302 at 86° arc longitude | | Az = 182.02° |
| Satcom F4 at 84° arc longitude | | Az = 177.98° |
| | Azimuth | △ = 4.04° |
| Galaxy I at 132° arc longitude | | Az = 245.22° |
| Satcom F3R at 130° arc longitude | | Az = 243.66° |
| | Azimuth | △ = 1.56° |

As can been seen from this example, satellites spaced at 2° arc longitude will not necessarily produce a 2° azimuth difference as viewed from the ground station. In fact, a relatively small antenna might perform very well looking at Telstar 302 as opposed to a much larger antenna when attempting to view signals from Satcom F3R from the same location.

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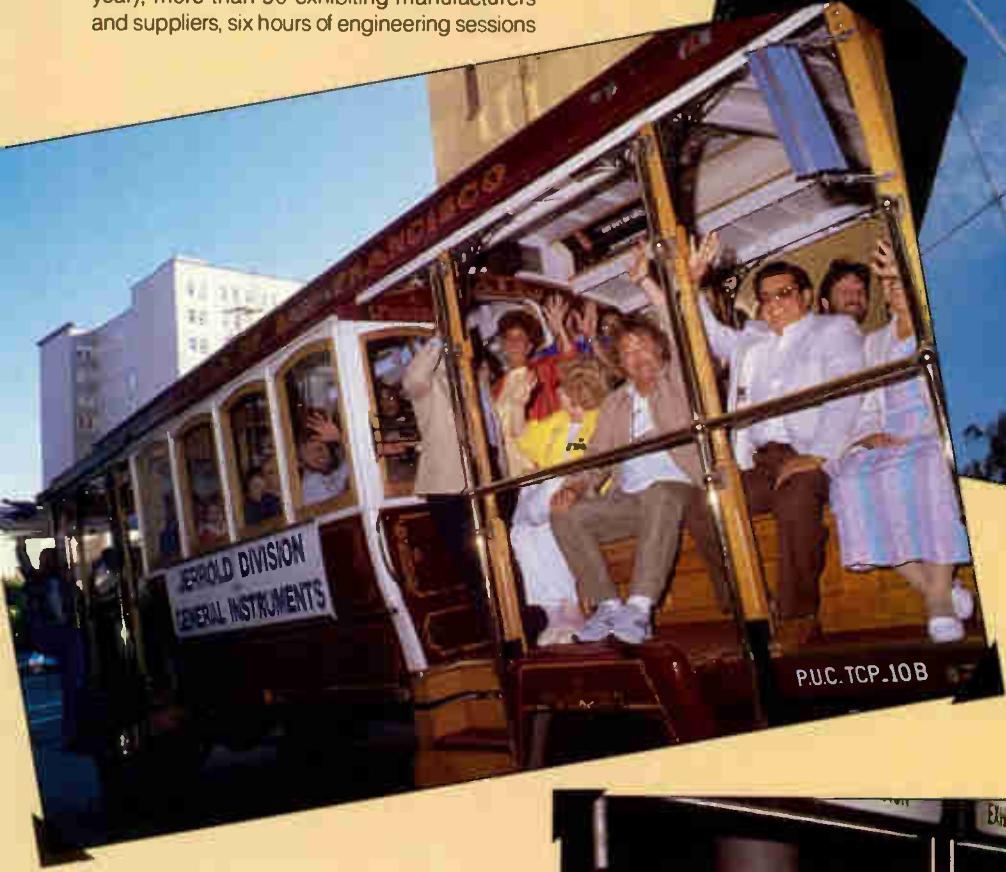
# Cable-Tec Expo '88: San Francisco treat

**By Rikki T. Lee** **Photos by Bob Sullivan**

There was a whole lot of shakin' going on at San Francisco Hilton and Towers June 16-19. Not an earthquake, but the Society of Cable Television Engineers' Cable-Tec Expo '88. Although, the activity generated at the registration booth, engineering conference, membership meeting, workshop sessions, exhibit floor, Expo Evening, etc., could have moved mountains.

Don't believe it? Just check the numbers: over 1,300 attendees (up nearly 20 percent from last year), more than 90 exhibiting manufacturers and suppliers, six hours of engineering sessions with 19 panelists, 10 technical workshops, 140 BCT/E exam takers, tons of food and millions of dollars in gambling chips.



*Off to Jerrold Night (left), the cable way. The Mt. Sutro tower (above), an impressive structure. More than 1,300 attended the Engineering Conference and Cable-Tec Expo.*

If you had arrived at the Hilton on Wednesday, you probably wouldn't have noticed much going on. There were, however, the pre-expo meetings of the NCTA Engineering Committee and the SCTE Interface Practices Committee, as well as a seminar on CATV engineering for the non-engineer sponsored by SCTE and Women In Cable's San Francisco Bay Area Chapter.

Kicking off the events Thursday, June 16, the Annual Engineering Conference played to a full house in the Hilton's Continental Ballroom. In his opening remarks, SCTE Executive Vice President Bill Riker told what it took to bring the expo to San Francisco and listed the many Bay Area attractions.

Then, Expo Chairman Pete Petrovich an-

*(Clockwise from left) SCTE board members let their hair down in a rockin' rendition of "The SCTE Theme," which followed an evening of food and fun at Casino Night. Over 90 vendors filled the exhibit hall to capacity. Pre-show entertainment included a cruise on the bay sponsored by Women In Cable.*

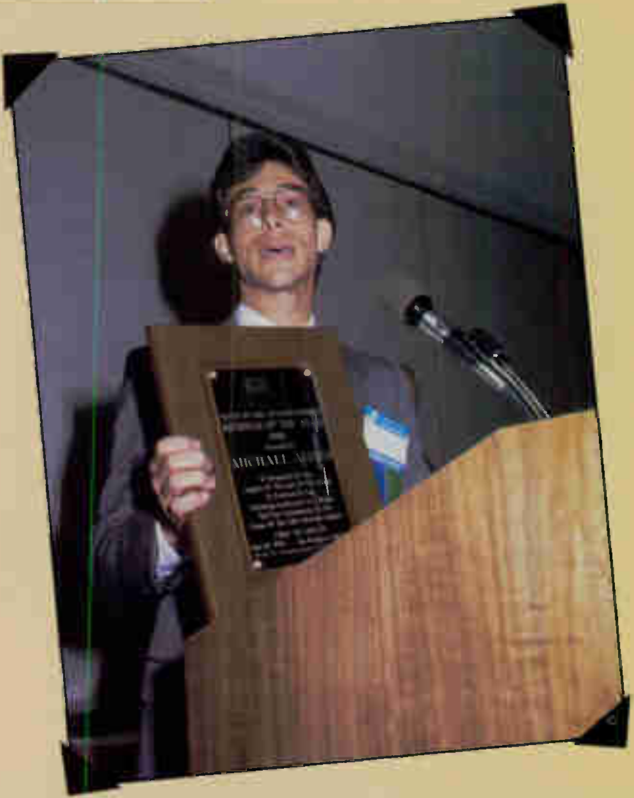
nounced the four panels of the conference: "High-definition television technology," "Frontline: Senior cable engineers," "Fiber optics: Here and now," and "The future of the CATV business." (For a detailed account of the HDTV and fiber panels, see accompanying sidebar.)

Wendell Bailey (vice president of science and technology, National Cable Television Association) moderated the panel of four senior cable engineers, each of whom identified the major issue(s) facing the CATV industry. In his talk, Vito Brugliera (vice president of marketing and product planning, Zenith Electronics) discussed the need for compatibility and marketplace standards of consumer electronics equipment.

Echoing this sentiment, Dave Large (director of video product planning, Raynet) explained the problems of improving the NTSC signal and called for support of the IS-15 interface. Consultant Joe Van Loan warned of the competition from VCRs, MMDS, DBS and broadcasters: "Our subscribers expect better from their cable service. We must keep our signals there all the time," he said.

Also on the panel, Tom Elliot, Tele-Communications Inc. director of research and development, quoted the costs of maintaining customer drops. "For example," he said, "we buy 250 million to 300 million F fittings each year—just as many as are now in service." Elliot also described the new SCTE Interface Practices Committee, which met for the first time the previous day. The committee will eventually offer suggestions for industry standards of F fittings and cable.

***(Clockwise from above) SCTE President Ron Hranac receives the ceremonial gavel from outgoing President Bob Luff, both of Jones Intercable, as Executive Vice President Bill Riker looks on. Hranac addresses expo attendees as president. Pete Petrovich of Petrovich and Associates and chairman of the Cable-Tec Expo '88 Program Committee introduces the first panel at the annual Engineering Conference. Luff expressed gratitude for being able to serve as the Society's president during such a growth era. Jim Stilwell of Tele-Services R&D presented the Outstanding Achievement Awards during the annual membership meeting and awards luncheon.***



*Andy Devereaux (above) received the President's Award in recognition for his involvement with the Building Fund and BCT/E Administration committees. Viacom Networks' Mike Aloisi (above right), who is also a regional director for the SCTE, was honored with the Member of the Year Award for his work in the Society.*

*Ron Hranac and Bill Riker congratulate Pete Petrovich (above), who was honored for his contributions to the Society and for chairing the expo's Program Committee. The expo marked the beginning of the SCTE's Hall of Fame Award and its first inductee, Cliff Paul (left).*

***SCTE President Ron Hranac of Jones Intercable at the helm with Executive Vice President Bill Riker during the Society's most successful national confab to date.***

### Looking to the future

Moderating the panel on the future of CATV, Ed Allen (general partner, InterMedia Partners) told the attendees that the industry stands on the edge of a new emphasis on engineering: fiber optics increasing the channel capacity, HDTV and impulse pay-per-view. He asked the panelists to give the state of the industry now and five years from today.

"I have to conclude that this is the best of times and the worst of times," John Goddard (president, Viacom Cablevision) said. He listed cable TV's recent victories in the regulatory environment, including the Cable Act of 1984, must-carry requirements and First Amendment court decisions. However, Goddard continued, we must be aware of increased subscriber demands, competition and possible re-regulation.

To Hal Krisbergh, president of General Instrument/Jerrold Division, the future is broadband. He said, "We must be prepared to become the pipeline for video, voice and data communications." The CATV industry can bring forth new technologies by "doing it better" (with fiber, HDTV and off-premise addressability) and providing new service (digital audio and impulse).

Finally, Bill Johnson (president, Scientific-Atlanta) asked, "What should we expect from new technology?" Among the several benefits listed were increasing the number of subs, reducing costs, increasing per-subscriber rates and gaining an edge on the competition.

The Hilton's Yosemite Room was the scene of the SCTE membership luncheon and awards ceremony. Plaques were presented to outgoing SCTE board members, technical seminar coordinators, Expo Conference Committee members, new SCTE chapters, new senior members, building fund contributors and outstanding achievement award winners.

Also, outgoing Society President Robert Luff, vice president of technology at Jones Intercable, received a mounted gavel for his service to the Society. Consultant Andy Devereaux received the President's Award for his work as chairman of the Building Fund and BCT/E Administration committees. Cliff Paul, consultant for RTK Corp., was the first inductee into the SCTE Hall of Fame. Finally, Michael Aloisi, director of field engineering for Viacom Networks, received the Member of the Year Award in recognition of his work in the Society.

Corey Busch, executive vice president of the San Francisco Giants and Giantsvision, gave the keynote speech at the luncheon. In his address, Busch discussed the effect cable TV coverage of sports has had on actual attendance. He also predicted the growth of regional pay-per-view sports channels. (For more information on the membership luncheon, see this month's *Interval*.)

### Technical sessions

Ten hour-long expo workshops, offered three times each on Friday and Saturday mornings, provided attendees with a variety of technical topics. Many were presented at the technician and engineer levels.

Perhaps the most highly touted session was "Installer Certification Program." Richard Covell (Jerrold), Ralph Haimowitz (SCTE) and Ron Wolfe (American Television and Communications Corp.) highlighted the reasons behind the conception of the program and how it will benefit installers and the industry. Said Covell, "The SCTE is strongly into training. Up to now the larger base of installers was left out." Unveiled at the session was the manual for the program, with tips on safety, tools and materials, and customer interfaces.

The engineer level of "Rebuilds and upgrades," with Michael Holland (Pico Macom) and Tim Dugan (Times Fiber), focused on the effects of problems with existing cable on system performance. For the technician level, this workshop included a review of RF splitters, as well as dealing with structural return loss, leakage and physical abuse. (Stay tuned for more on splitters from Holland in future issues of *CT*.)

In "Signal leakage and CLI testing," Tom Polis (Communications Construction Group) and Robert Dickinson (Dovetail Systems) presented a list of basic facts about leakage, as well as a brief history and description of Federal Communications Commission guidelines since 1977. On monitoring for cumulative leakage index (CLI), Polis gave suggestions for field techs in order to reduce costs.

The session "Spectrum analysis" provided hands-on demonstrations of state-of-the-art spectrum analyzers. John Cecil (Hewlett-Packard) and Bill Benedict (Tektronix) described the measurement of FM and AM modulation, spurious signals, signal leakage and carrier-to-noise. The speakers also emphasized taking into account the sensitivity of the equipment.

"FCC compliance" was an update of current FCC technical relations, including aeronautical frequencies, leakage monitoring, terminal devices, CLI testing and must-carry. Syd Bradfield (FCC) informed the attendees that "we will begin to increase our inspections, so keep your log of leaks and repairs up-to-date." Brian James (NCTA) stressed the need for filing CLI reports by July 1, 1990. He said, "If you haven't submitted your CLI by then, just turn off all your channels in the aeronautical bands."

In the "BTSC stereo" workshop (which was a joint SCTE/Society of Broadcast Engineers effort), Ron Hranac (Jones Intercable), Steve Fox (Wegener) and Dane Ericksen (Hammett & Edison and member of the SBE board) began with an overview of terminology, history and development of the BTSC standard. Other topics included BTSC myths and realities, stereo in the marketplace and components of the stereo signal. As for interfacing BTSC into the headend, Fox said, "Most cable systems using heterodyne processors will pass acceptable BTSC signals to subscribers with little or no modulation."

"Developing a technical training program" with Roger Keith (Warner Cable Communications) outlined the design and development of a system-level CATV training program. Various factors affect the success of the program—assessment, resources, goal setting, procedures, scheduling and evaluation. Other considerations discussed were management support, budget/cost awarenes and time constraints. (Look for this to appear in article form in an upcoming issue.)

In addition to these workshops, attendees could drop in on three BCT/E Certification review courses: Category III (with Tom Straus of Hughes Microwave), Category V (with Al Koulas of American Cablesystems) and Category VI (with William Cohn and Michael Long of Zenith). BCT/E exams were administered for 3½ hours on Sunday morning, the last scheduled event of the expo.

### On the floor

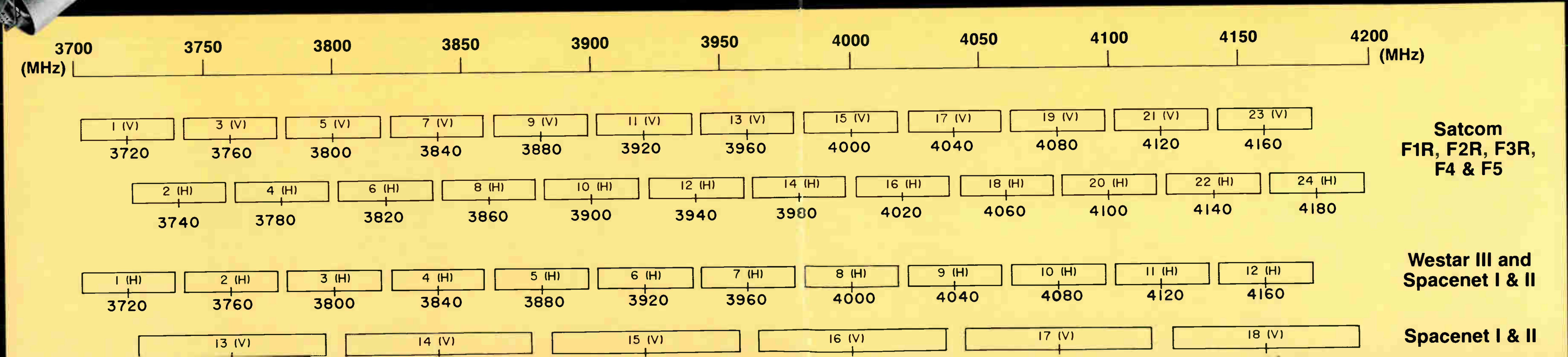
As with previous expos, activity on the exhibit floor was frenetic with elbow room at a premium. Ninety-five companies (a sell-out crowd) packed the hall with booths filled with modulators and demodulators, power supplies, crimp tools, computer-aided status monitoring, test equipment, converters, taps, traps, et al.—plus baseball caps, ballpoint pens and tweakers for all. (Before entering the Grand Ballroom, however, attendees witnessed demonstrations of the IS-15 multiport and interactive video training.)

During the exhibit hours Friday and Saturday afternoon, several companies made product announcements and demonstrated equipment at the Exhibitor Training Center located on the floor. Some of the demos were: "Signal leakage" (Texscan), "Heat shrink tubing and self-fusing tape for cable" (Polychem Electronics/Drop Shop), "CAT System" (BradPTS),

# COMMUNICATIONS TECHNOLOGY'S

# Downlink Frequencies For Domestic Satellites

(Numbers within bars indicate transponder number; letters in parenthesis designate signal polarity: H for horizontal, V for vertical.)



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COMMUNICATIONS
TECHNOLOGY'S

# Downlink Frequencies For Domestic Satellites

Pull-out Wall Chart

**Anik C2 & C3**

Full transponder → 11758.5 11817.5 11876.5 11935.5 11994.5 12053.5 12112.5 12171.5

| | |
|---|---|
| T1 (V) | 11717 |
| T2 (V) | 11743 |
| T3 (V) | 11778 |
| T4 (V) | 11804 |
| T5 (V) | 11839 |
| T6 (V) | 11865 |
| T7 (V) | 11900 |
| T8 (V) | 11926 |
| T9 (V) | 11961 |
| T10 (V) | 11987 |
| T11 (V) | 12022 |
| T12 (V) | 12048 |
| T13 (V) | 12083 |
| T14 (V) | 12109 |
| T15 (V) | 12144 |
| T16 (V) | 12170 |
| T17 (H) | 11730 |
| T18 (H) | 11756 |
| T19 (H) | 11791 |
| T20 (H) | 11817 |
| T21 (H) | 11852 |
| T22 (H) | 11878 |
| T23 (H) | 11913 |
| T24 (H) | 11939 |
| T25 (H) | 11974 |
| T26 (H) | 12000 |
| T27 (H) | 12035 |
| T28 (H) | 12061 |
| T29 (H) | 12096 |
| T30 (H) | 12122 |
| T31 (H) | 12157 |
| T32 (H) | 12183 |

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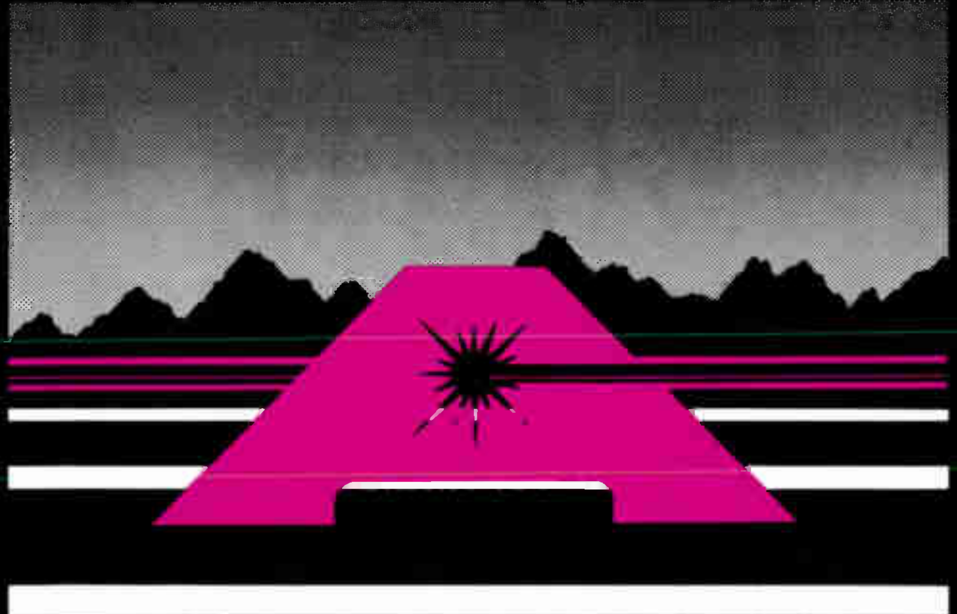

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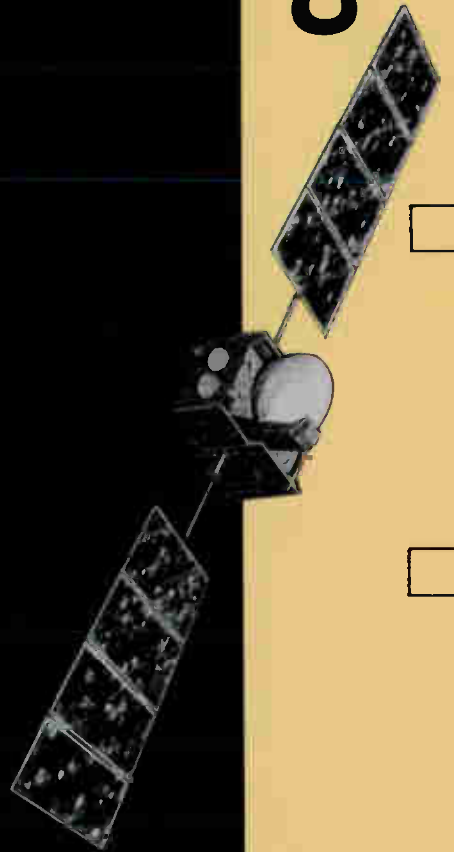
## C-Band



**Galaxy I, II & III**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 (H) | 3 (H) | 5 (H) | 7 (H) | 9 (H) | 11 (H) | 13 (H) | 15 (H) | 17 (H) | 19 (H) | 21 (H) | 23 (H) |
| 3720 | 3760 | 3800 | 3840 | 3880 | 3920 | 3960 | 4000 | 4040 | 4080 | 4120 | 4160 |
| 2 (V) | 4 (V) | 6 (V) | 8 (V) | 10 (V) | 12 (V) | 14 (V) | 16 (V) | 18 (V) | 20 (V) | 22 (V) | 24 (V) |
| 3740 | 3780 | 3820 | 3860 | 3900 | 3940 | 3980 | 4020 | 4060 | 4100 | 4140 | 4180 |

**Westar IV & V**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1D (H) | 2D (H) | 3D (H) | 4D (H) | 5D (H) | 6D (H) | 7D (H) | 8D (H) | 9D (H) | 10D (H) | 11D (H) | 12D (H) |
| 3720 | 3760 | 3800 | 3840 | 3880 | 3920 | 3960 | 4000 | 4040 | 4080 | 4120 | 4160 |
| 1X (V) | 2X (V) | 3X (V) | 4X (V) | 5X (V) | 6X (V) | 7X (V) | 8X (V) | 9X (V) | 10X (V) | 11X (V) | 12X (V) |
| 3740 | 3780 | 3820 | 3860 | 3900 | 3940 | 3980 | 4020 | 4060 | 4100 | 4140 | 4180 |

**Anik D1 & D2**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A (H) | 2A (H) | 3A (H) | 4A (H) | 5A (H) | 6A (H) | 7A (H) | 8A (H) | 9A (H) | 10A (H) | 11A (H) | 12A (H) |
| 3720 | 3760 | 3800 | 3840 | 3880 | 3920 | 3960 | 4000 | 4040 | 4080 | 4120 | 4160 |
| 1B (V) | 2B (V) | 3B (V) | 4B (V) | 5B (V) | 6B (V) | 7B (V) | 8B (V) | 9B (V) | 10B (V) | 11B (V) | 12B (V) |
| 3740 | 3780 | 3820 | 3860 | 3900 | 3940 | 3980 | 4020 | 4060 | 4100 | 4140 | 4180 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 1V (V) | 2V (V) | 3V (V) | 4V (V) | 5V (V) | 6V (V) | 7V (V) | 8V (V) | 9V (V) | 10V (V) | 11V (V) | 12V (V) |
| 3720 | 3760 | 3800 | 3840 | 3880 | 3920 | 3960 | 4000 | 4040 | 4080 | 4120 | 4160 |
| 1H (H) | 2H (H) | 3H (H) | 4H (H) | 5H (H) | 6H (H) | 7H (H) | 8H (H) | 9H (H) | 10H (H) | 11H (H) | 12H (H) |
| 3740 | 3780 | 3820 | 3860 | 3900 | 3940 | 3980 | 4020 | 4060 | 4100 | 4140 | 4180 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 (H) | 2 (H) | 3 (H) | 4 (H) | 5 (H) | 6 (H) | 13 (H) | 14 (H) | 15 (H) |

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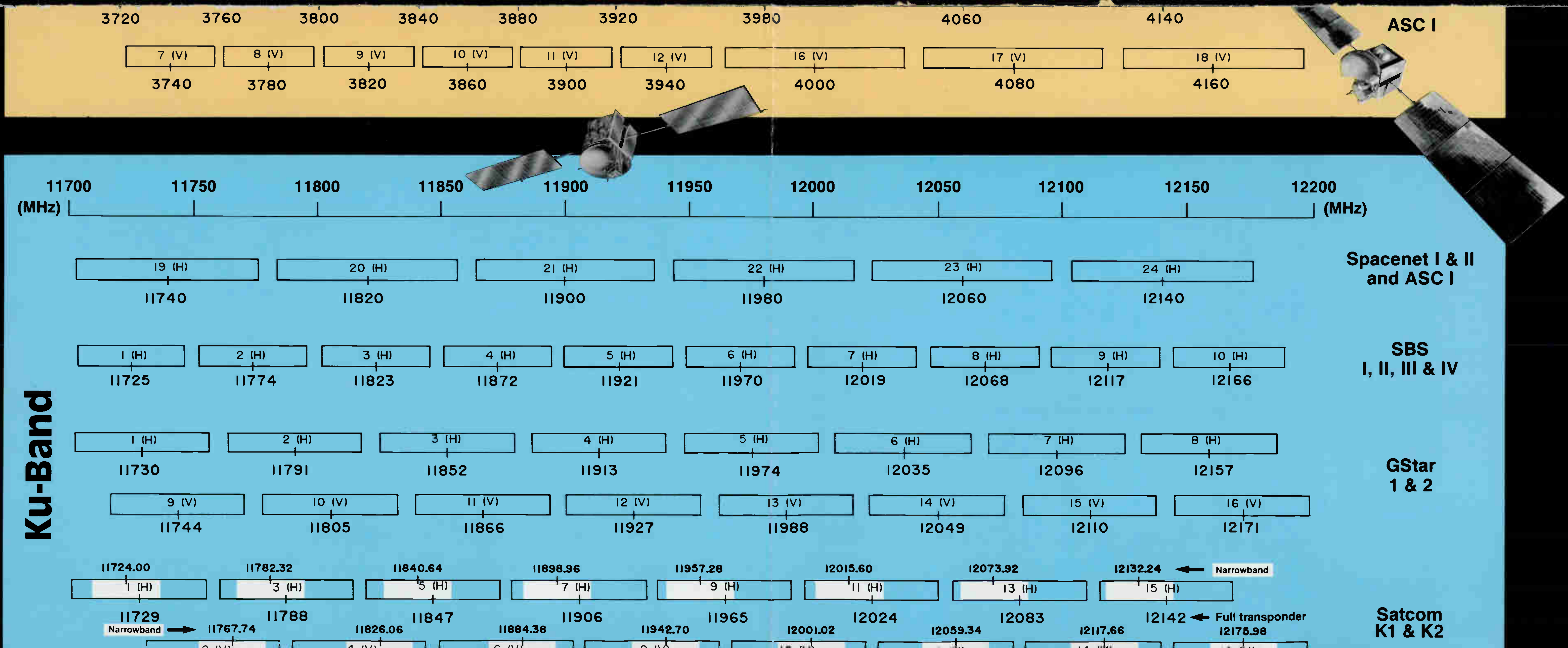3720
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12 (V)
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12132.24
Narrowband
1 (H)
3 (H)
5 (H)
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Satcom K1 & K2
Narrowband
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11826.06
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11942.70
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"Long-life installation methods" (Sachs), "Remote monitoring in one-way plant and standby battery maintenance" (Alpha Technologies) and "Non-interfering system sweep" (CaLan).

**Fun, fun, fun**

Of course, the expo had its share of fun things to do. On Wednesday evening, June 15, the SCTE and Women In Cable offered a dinner cruise through San Francisco Bay. Landlubbers were able to gaze upon Alcatraz (no hitchhikers, please) and the Golden Gate Bridge (covered in fog).

The following night, the Welcome Reception (sponsored by Anixter, AT&T and Raychem) and Hospitality (sponsored by Scientific-Atlanta) provided an abundance of food, music and an opportunity to mingle.

Friday's Expo Evening featured Italian seafood and Oriental cuisine, as well as a myriad of desserts from Ghiradelli's. Music came from Kim Olson as well as The SCTE Band (with SCTE staffers Bill Riker on drums, Howard Whitman on bass and Cosmo Bertino on guitar). SCTE board members joined with tambourines and vocals in a rousing rendition of *The SCTE Theme*. First stanza: "Banging on the back of my TV set 'cause my picture wasn't right. Hitting the selector and I'm getting upset 'cause I wanna catch some cable tonight. A technician came to see me, said he passed the BCT/E. Got my picture right—now it's clear and bright, 'cause they trained him right."

An adjoining "quiet room" featured artist Rhoda Grossman, who drew humorous (and unflattering) caricatures of those brave enough to stand in line. Several large photographs from the Society's past graced the room.

But the *piece de resistance* was for gamblers only. The 700 attendees had the chance to win big bucks at the casino set up especially for the Expo Evening. Each person was given $500 of phony money, and either increased it or blew it at the blackjack, roulette or craps tables. Based on their winnings, participants were awarded raffle tickets; raffle winners were awarded prizes donated by exhibitors.

***SCTE's Ralph Haimowitz helped shed some light on the technical side of the industry during a WIC seminar.***

For Saturday's Jerrold Night, trolley buses transported attendees to the San Francisco Cable Car Museum, which displayed the manufacture of cable, as well as historical photos. Sitting in cable cars, guests ate the local cuisine as a band dressed in turn-of-the-century garb played on.

Finally, on Sunday, many attendees took tours to Mount Sutro Tower and local manufacturing plants of Catel and Raychem.

Circle your calendar: Next year's expo will be held June 15-18 at the Orange County Convention Center in Orlando, Fla. And what will happen then? That's another story. But for now, enjoy the following pages of photos taken in San Francisco.

---

## HDTV and fiber optics at Cable-Tec Expo '88

**By Lawrence W. Lockwood**
President, TeleResources
East Coast Correspondent

There were a number of interesting sessions presented at the Society of Cable Television Engineers Cable-Tec Expo '88 in San Francisco this June, organized under the able stewardship of SCTE Executive Vice President William Riker. I was particularly interested in two sessions covering the current "hot areas," HDTV and fiber optics.

The organizer and discussion leader of the HDTV session was Dr. Walter Ciciora, vice president of technology at ATC (and chairman of the NCTA Engineering Committee). His speakers were: Paul Resch (director of engineering, The Disney Channel), William Thomas (director of engineering and technology, ATC), Donald Wilkinson (vice president and director of engineering, Fisher Broadcasting Co.) and me.

Briefly, Resch in his talk "Calibrating the eyeballs—What to look for in video quality" presented a significant set of "requirements/desires" of the programmers. Following him, in my talk "Overview of proposed HDTV systems," I reviewed some of the proposed HDTV transmission schemes and added a few personal comments. William Thomas then presented some interesting observations of problems and requirements peculiar to the MSOs and operators in general. Finally Donald Wilkinson passionately presented one of the main concerns of the broadcasters; i.e., *one standard only!*

There was general agreement that along the probable path of progression to HDTV for the consumer, an improved version or versions of NTSC would occur. Also, no one was foolhardy enough to try and predict the final system (or systems), that will be used to transmit HDTV. I say "systems" because, regardless of the broadcaster's desire for only one HDTV transmission standard as expressed by Wilkinson, there was discussion of the possibility of more than one standard and possibly "open architecture" receivers. The open architecture receiver approach has been suggested by Professor William Schreiber of MIT, one of the principals in developing HDTV transmission. Conceptually, it is to use the principle of the organization of personal computers in the HDTV receiver design. Different functions can be obtained in PCs merely by exchanging a single board. Similarly, in the open architecture TV receiver, each HDTV transmission scheme would require merely the addition of a single plug in unit.

**Fiber-optics panel**

The organizer and discussion leader of the fiber-optics session was Jim Chiddix, senior vice president of engineering and technology at ATC. His speakers were David Grubb (project engineer, General Instrument/Jerrold), Dr. James Hood (president, Catel), Vince Borelli (president, Synchronous Communications) and Dr. Lawrence Stark (vice president of marketing, Ortel). All of these speakers represented manufacturers. However, since Jim Chiddix reviewed some of ATC's thoughts and ongoing developments of fiber-optic applications to CATV from an MSO and operator's view, the overall balance of the session was most rewarding. Jerrold has been a pioneer in the coax CATV business and now is investigating this new, promising area of fiber optics. Catel is familiar to many operators because of its years of work and many installed systems (mainly for supertrunking) of FM fiber optics. Both Synchronous and Ortel are also investing heavily developing new application areas for fiber optics in CATV.

Generally, all the speakers addressed two main themes—what about AM modulation on fiber optics?—and economic projections; i.e., what are the costs going to be? As far as the first theme, the general consensus was, "Yes, it can be done, we're not *quite* there yet. But soon." As to the second theme, detailed economic breakdowns were presented, but in general, "depending on the specific architecture, the cost of fiber optics in CATV is becoming competitive with coax and in a few cases is already competitive."

This conference was a wonderful example of the contributions of the SCTE to the industry and a notice to all SCTE members: If you can get to an expo, do so. If not, and there are SCTE seminars in your area, by all means try to attend. And finally, to others, if you're in the technical end of this business and not a member of SCTE, then you should join (if nothing else but for selfish self-interest in your future).

*The SCTE's annual Engineering Conference drew an attentive group to the Hilton's Continental Ballroom.*

*SCTE's Executive Vice President Bill Riker during the opening remarks.*

*Attendance was up 20 percent for this Cable-Tec Expo from last year's.*

*The panel on "Fiber optics—Here and now" included ATC's Jim Chiddix, Dr. James Hood of Catel, David Grubb from GI/Jerrold, Ortel's Larry Stark and Vince Borelli, Synchronous Communications.*

*"HDTV technology" panel participants Paul Resch of The Disney Channel, Dr. Walt Ciciora (discussion leader) from ATC and Lawrence Lockwood of TeleResources confer prior to the Engineering Conference.*

*ATC's Jim Chiddix led the discussion in the "Fiber optics" panel by sharing some of his company's experiences.*

ATC's Bill Thomas presented concerns of operators on the "HDTV technology" panel.

Dave Large of Raynet called for support of the IS-15 interface during the "Frontline: Senior cable engineers" panel.

The high cost of maintaining subscriber drops received an airing in the "Frontline" panel by Tom Elliot of TCI.

In the "Senior cable engineers" panel, Zenith's Vito Brugliera took the opportunity to emphasize compatibility.

NCTA's Wendell Bailey led the discussion on the panel of "Senior cable engineers."

Among the Engineering Conference participants were Joe Van Loan, Vito Brugliera, Dave Large and Wendell Bailey; here, just prior to their panel.

Fighting competition with quality service was the message from "senior cable engineer" Joe Van Loan.

*Incoming President Ron Hranac received the ceremonial gavel from Immediate Past President Bob Luff.*

*The annual membership meeting and awards luncheon was standing room only.*

***Accepting awards for contributions over $500 to the Society's building fund were Richard Covell (for General Instrument), Vito Brugliera (for Zenith Electronics), Steve Flessner (for Tele-Communications Inc.), Tom Jokerst (for American Cablesystems), Malcolm Taylor (for The Lenfest Group), Robert Dickinson and Rex Porter. Not pictured: Joseph Gans, Trilogy Communications and U.S. Electronics.***

*Outgoing President Bob Luff received a plaque from Bill Riker for service to the Society.*

***Luncheon keynote speaker Corey Busch of the San Francisco Giants and Giantvision addressed sports programming on cable.***

***The former Ohio Valley Meeting Group received an award for being elevated to chapter status. Representing the chapter were Bill Holehouse, Charles Hanchett, John Wise, Jon Ludi, Bill Ricker and Bob Helm. Presenters John Kurpinski and Michael Aloisi stand at right.***

The Gateway Chapter displays its award for being elevated to chapter status. Representing the chapter were Darrell Diel, Mike Ayres, Tom Jokerst and Larry Lehman, flanked by John Kurpinski and Mike Aloisi.

SCTE's first Hall of Fame inductee Cliff Paul watches the action on the podium.

Presented by Cliff Paul (second from right), awards were given to new senior members Bill Riker, Ben Forrester, Charles Nydegger, Les Read and Bill Kohrt. Not pictured: Kip Hayes, Allen Kirby and Martin Walker.

Andy Devereaux receives the President's Award from Ron Hranac as Region 12 Director Bob Price and Bill Riker look on.

Outgoing board members Len Ecker, Andy Devereaux and John Kurpinski received plaques presented by Bill Riker for their service to the Society.

Contributors to the building fund, which helped to pay for the Society's national headquarters building, were honored with a plaque presented by Bill Riker.

Margaret Harvey and Michael Smith accepted an award on behalf of the Old Dominion Chapter for its upgrade from meeting group to chapter status. John Kurpinski and Mike Aloisi were the presenters.

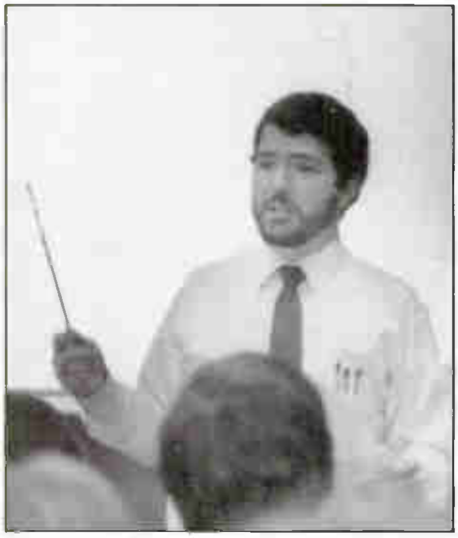
Many of the Cable-Tec Expo's workshops were videotaped for future use.

SCTE's Ralph Haimowitz accepted an award for the Florida Chapter's coordinating of the highly successful fiber-optic seminar held last January.

Ingress was just one of the areas covered by William Cohn of Zenith in the BCT/E review course on terminal devices.

Peter Rumble, Gary Malone and Norrie Bush accepted a plaque on behalf of the Cascade Range Chapter for its upgrade status from meeting group. John Kurpinski, Mike Aloisi and Bill Riker look on.

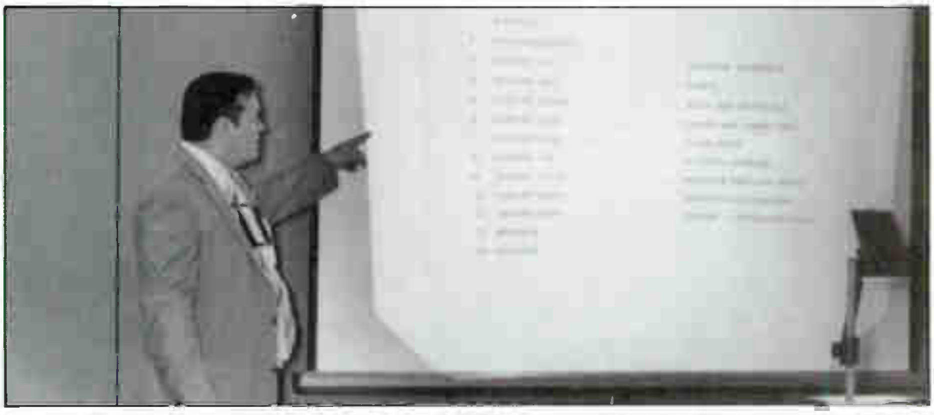
*Robert Dickinson, Dovetail Systems, and Tom Polis, RTK Communications Group, discuss some concerns brought up during their workshop on "Signal leakage and CLI testing."*



*Sound quality was one aspect covered by Ron Hranac of Jones Intercable in the "BTSC stereo" workshop.*

*At the entrance to each of the 10 expo workshops, large placards helped alleviate any questions as to what was going on inside.*

*The workshop on "FCC compliance," conducted by NCTA's Brian James (seated) and Syd Bradfield of the FCC, provided plenty of opportunity for questions from attendees.*



*The content and what to expect from the SCTE's new Installer Certification Program was covered by Ralph Haimowitz of the Society.*

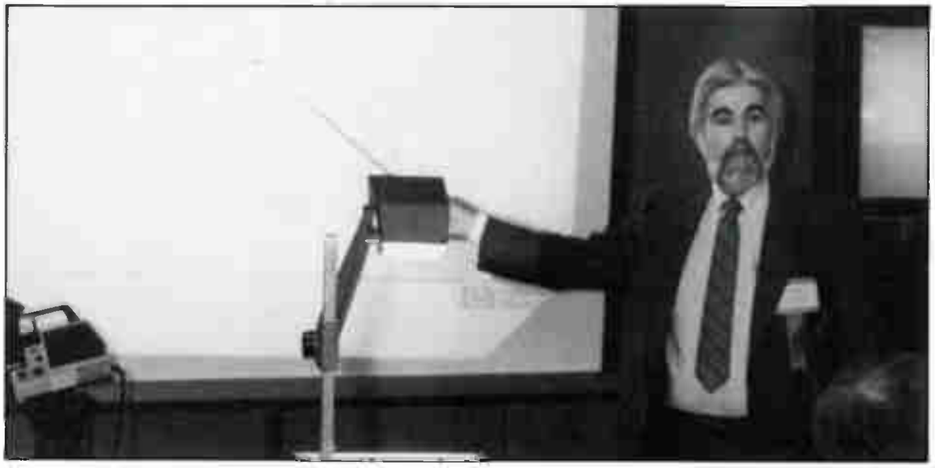
*Al Kuolas (right), American Cablesystems, addresses an attendee's concerns at the review course for Category V of the BCT/E program.*

*Following the "BTSC stereo" workshop, Steve Fox of Wegener Communications fields a question from one of the attendees.*

*Dr. Tom Straus of Hughes Microwave during the review course for Category III of the BCT/E program.*

*The finer points to "Developing a technical training program" were given in a workshop by Roger Keith of Warner Cable.*

*Providing the broadcasters' view during the "BTSC stereo" workshop was Dane Erickson, representing Hammett and Edison and the Society of Broadcast Engineers.*



*Hewlett-Packard's John Cecil covers the components of a swept-tuned spectrum analyzer during the "Spectrum analysis" workshop.*

*Joe Van Loan explains microwave frequencies in the BCT/E Category III review course.*

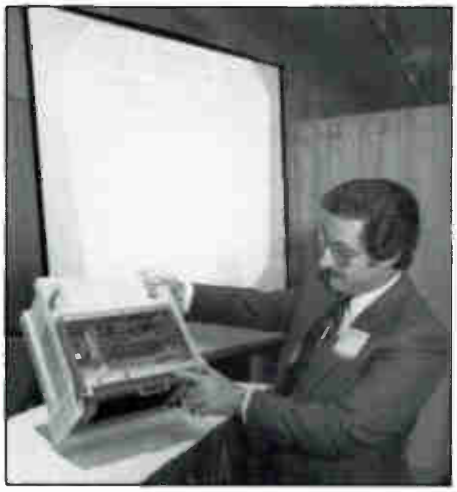
Zenith's Michael Long lent his talent as a BCT/E Category VI review course instructor.

Approximately 93 exhibitors filled the Hilton's Grand Ballroom to capacity.

CLI reporting was covered in Telecommunications Products' technical demo conducted by Tom Russell.

The "Rebuilds and upgrades" workshop featured a discussion on splitters by Pico Macom's Mike Holland (seated), with Times Fiber's Tim Dugan covering cable usage.

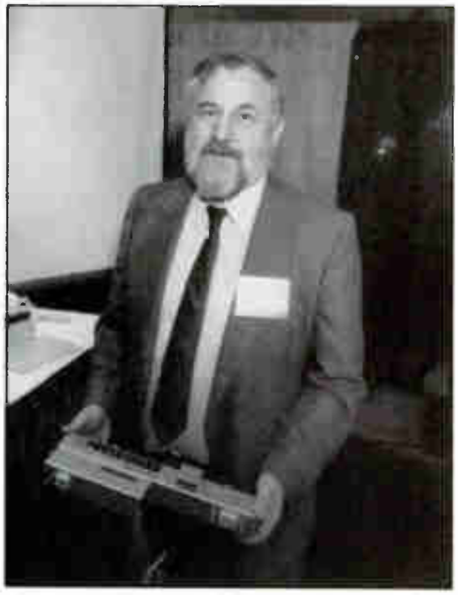
Exclusive hours for the exhibit hall gave attendees and vendors that "quality time."



CaLan's equipment for non-interfering sweep response measurements was highlighted in a tech demonstration by Bill LeDoux.


With exhibit space sold out six months in advance, vendors no doubt look forward to the expo's draw (above and right).


On-the-floor technical demonstrations changed hourly in a special area provided in the exhibit hall. Alpha Technologies' Jeff Geer (above) and Riser-Bond's Marshall Borchert (right) each led presentations.



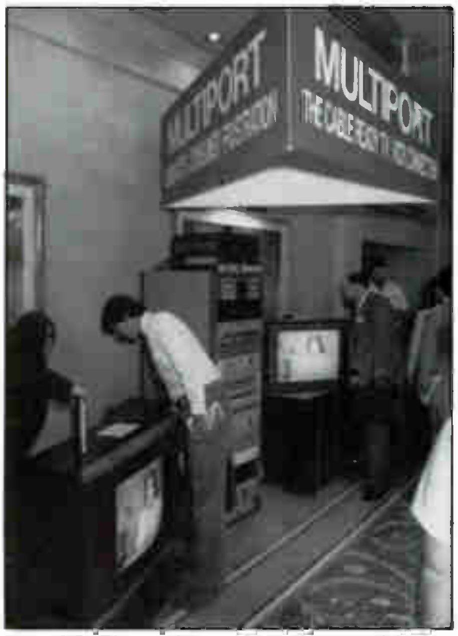
Jerry Schultz gave a hands-on technical demo featuring Power Guard's power supplies.

Although convenient having the expo under one roof, there were limitations. Next year's expo will feature a much-expanded exhibit area.

*SCTE staffers Anna Riker and Pat Zelenka helped keep the show running smoothly.*

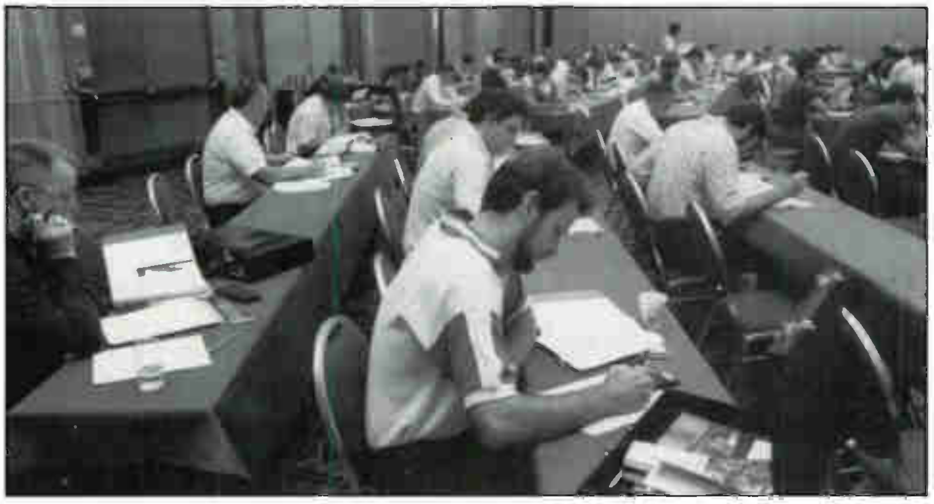
*Part of Jerrold Night at the Cable Car Museum included live music with a turn-of-the-century flavor.*

*Testing for BCT/E certification (above and below) drew over 140 participants on the expo's last day, Sunday.*



*The SCTE's multiport exhibit provided a working demo of the interim standard interface.*

*This year's expo trip winner Barry Smith with his wife Lauri during a "visit" to Alcatraz.*



Rob Stuehrk

***Applications Engineer Jim O'Leary shows cable being tested in the salt/fog chamber during Raychem tour.***

***In addition to the Mt. Sutro tower, Viacom Cablevision's San Francisco headend also highlighted one tour.***

Rob Stuehrk

***The inspection of surface-mount components for Catel's TransHub is explained by Glen Shafer, manager of quality engineering, during tour for expo attendees.***

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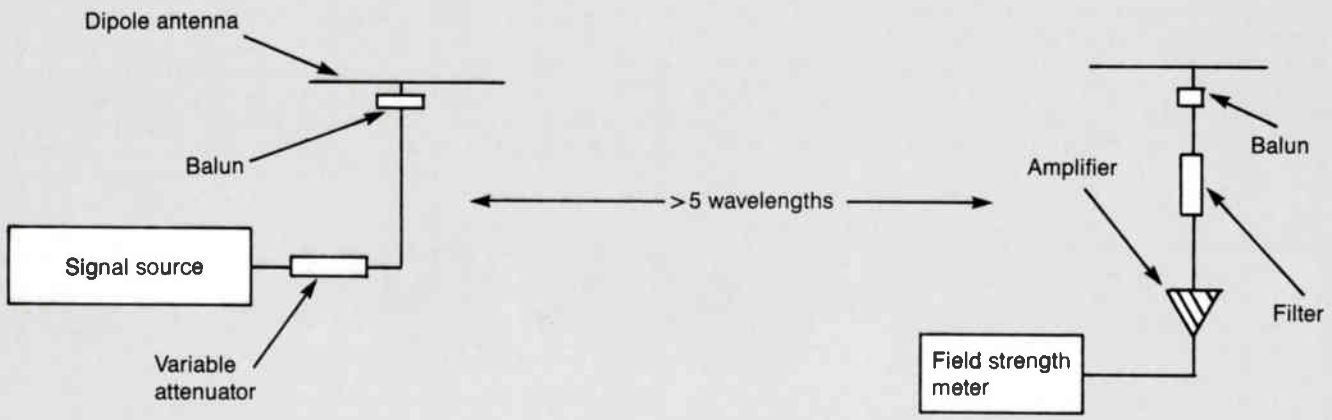
**CT 8/88**

**Figure 1:** Generating a known field



Note: The separation between source equipment and the receiving equipment should be at least 50-100 feet as an absolute minimum.

# Monitoring and locating signal leakage

> *"It may be beneficial to monitor several frequency bands simultaneously to avoid missing some... frequency-dependent leaks."*

**By Steven C. Johnson**
Senior CATV Project Engineer
American Television and Communications Inc.

George Orwell warned us in *1984* that "Big Brother" was watching. Since 1984 the Federal Communications Commission has been warning us of 1990 and the new signal leakage rules that go into effect at that time. 1990 is rapidly approaching, so it behooves all of us to prepare to meet the new requirements.

Under the new rules, we have two "magic" numbers: 20 µV/m is the maximum allowable signal leakage (54-216 MHz) when measured at a distance of three meters (10 feet) using a half-wave dipole antenna cut to the measurement frequency; 50 µV/m is the threshold level, above which measured leaks must be included in the CLI (cumulative leakage index) calculation. In addition, the rules state that the cable operator must correct any leaks that cause "harmful interference," no matter what the level of the leak.[1]

What causes the cable system to leak? The leaks can be in the trunk, feeder or drop portions of the system and can occur as a result of one or more of the following problems:

- *Broken cables*: A broken cable sheath interrupts the shielding continuity and allows a portion of the signal to leak out of the "closed" system. Drop cable damaged by staples also can be a source of leakage.
- *Corroded, broken or loose fittings*: These create breaks in the shielding integrity and allow signals to leak. Loose or improperly installed F fittings in subscriber drops are a major contributor to signal leakage.
- *Active and passive devices*: Loose or warped covers, lids and faceplates can cause signal leakage.
- *Unauthorized cable connections and peripheral devices connected to the drop*: These can be either primary or additional outlets that the customer hooks up. Often the customer will use substandard material or techniques, including poor quality RG-59 or RG-6 cable, 300 ohm twin-lead, substandard two-way splitters and A/B switches, and poorly installed connectors. Some consumer equipment (VCRs, FM tuners) is not shielded well, and may result in leakage.

Leakage signals can be frequency dependent. Any leak in the system may emit more profusely at one frequency than at others. It may be beneficial to monitor several frequency bands simultaneously with a scanner to avoid missing some of these frequency-dependent leaks.

Most operators agree that the majority of signal leaks occur from the drop to the subscriber's TV set. Fortunately, the magnitude of signal here is near the lowest of any portion of the plant (drop levels are typically +15 dBmV or less. Trunk inputs are actually lower, at 9 to 12 dBmV).

**Conversion of units**

Microvolts per meter (µV/m) is a unit of measure that may not be quite as familiar to the technician as the more common units in cable television, microvolts (µV) or decibel-millivolts (dBmV). Fortunately, the conversions from µV/m to dBmV and vice versa are not that difficult. The following equations are useful in making this conversion.

$$Ef = .021 \times E \times F \qquad \textbf{(1)}$$

where:
$Ef$ = field intensity in µV/m
$E$ = field strength in µV
$F$ = frequency in MHz

$$dBmV = 20\log(E/1{,}000) \qquad \textbf{(2)}$$

and solving for E:

$$E = 10^{dBmV/20} \times 1{,}000$$

where:
$E$ = voltage in microvolts across a 75 ohm impedance load

Example: Convert a 20 µV/m leak at 121.2625

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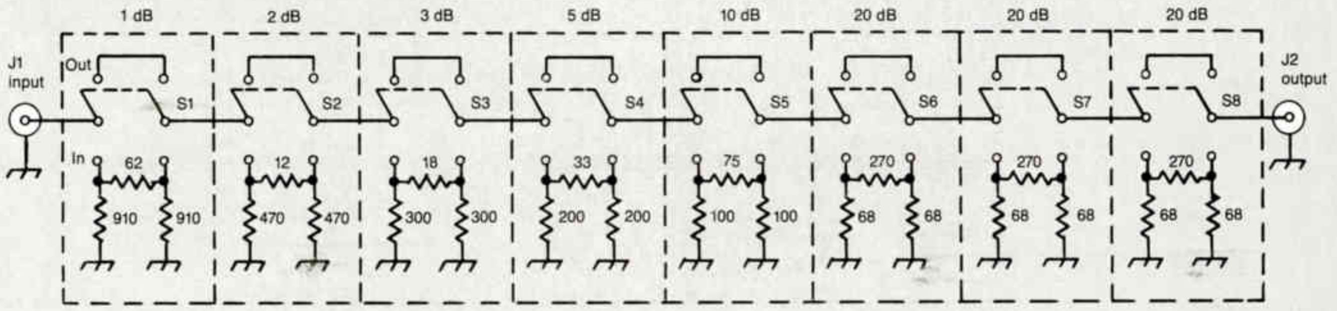
## **Figure 2:** Low-power step attenuator



Resistors are ¼ W, 5 percent tolerance, carbon composition or film types. Resistances are given in ohms. Source: *The ARRL Handbook for the Radio Amateur*, American Radio Relay League.

MHz to dBmV (assuming a 0 dB gain dipole).

$$Ef = .021 \times E \times F$$
$$20\ \mu V/m = .021 \times E \times 121.2625\ MHz$$

solving for E:

$$20/(.021 \times 121.2625) = E$$
$$E = 20/2.5465$$
$$= 7.8539\ \mu V$$

## **Table 1:** Pi network resistive attenuator (50 Ω)

| dB atten. | R1 (ohms) | R2 (ohms) |
|---|---|---|
| 1 | 870.0 | 5.8 |
| 2 | 436.0 | 11.6 |
| 3 | 292.0 | 17.6 |
| 4 | 221.0 | 23.8 |
| 5 | 178.6 | 30.4 |
| 6 | 150.5 | 37.3 |
| 7 | 130.7 | 44.8 |
| 8 | 116.0 | 52.8 |
| 9 | 105.0 | 61.6 |
| 10 | 96.2 | 71.2 |
| 11 | 89.2 | 81.6 |
| 12 | 83.5 | 93.2 |
| 13 | 78.8 | 106.0 |
| 14 | 74.9 | 120.3 |
| 15 | 71.6 | 136.1 |
| 16 | 68.8 | 153.8 |
| 17 | 66.4 | 173.4 |
| 18 | 64.4 | 195.4 |
| 19 | 62.6 | 220.0 |
| 20 | 61.0 | 247.5 |
| 21 | 59.7 | 278.2 |
| 22 | 58.6 | 312.7 |
| 23 | 57.6 | 351.9 |
| 24 | 56.7 | 394.6 |
| 25 | 56.0 | 443.1 |
| 30 | 53.2 | 789.7 |
| 35 | 51.8 | 1405.4 |
| 40 | 51.0 | 2500.0 |
| 45 | 50.5 | 4446.0 |
| 50 | 50.3 | 7905.6 |
| 55 | 50.2 | 14,058.0 |
| 60 | 50.1 | 25,000.0 |

Source: *The ARRL Handbook for the Radio Amateur*, American Radio Relay League.

converting to dBmV:

$$dBmV = 20\log(.0078539\ mV)$$
$$= -42.098\ dBmV$$

Therefore, a 20 µV/m leak will measure −42.098 dBmV on a field strength meter when connected to a half-wave antenna (neglecting transmission line loss or preamplifier gain).

But −42 dBmV is an extremely low level for a field strength meter to read. Most meters read only to −40 dBmV and have the least accuracy at range extremes. Therefore, it is usually necessary to insert a low noise amplifier to boost the measured signal's level to an acceptable level for the field strength meter to measure. A few manufacturers make a dipole antenna with a built-in battery-powered amplifier to do this. The technician also may need to insert a bandpass filter between the antenna and amplifier. This prevents overdriving the amplifier, if strong off-air signals are present near the leakage signal being measured.

### Measurement vs. monitoring

The new regulations call for quarterly routine *monitoring* of the plant and annual *measurements*, on which the CLI calculation is based. In order to expedite routine monitoring, it is suggested that monitoring equipment be set up to respond to some threshold (typically at a level correlating to 20 µV/m at three meters with a dipole antenna). If the system has excessive leakage, it may be desirable to set this threshold higher, such as 50 µV/m, in order to concentrate on the most severe leaks on the first pass through before tackling the lower level leaks. Receivers that can meet the criteria of monitoring for a predetermined threshold are available from the manufacturers. Additionally, commercial and amateur communication receivers can be put into service for this purpose.

Obviously, the receiver needs to have sufficient sensitivity to detect a signal whose level is 20 µV/m at three meters. Receiver sensitivity is usually measured in microvolts and, as illustrated earlier, the relationship between microvolts per meter and microvolts is frequency dependent. In our example, we would need a receiver sensitivity better than 7.85 µV to read 20 µV/m at 121.2625 MHz. It would be desirable to have some headroom in the sensitivity specification to allow for distances greater than three meters (backyard easements) and antennas with less gain than a dipole (so-called "rubber-duckie" antennas with 6 to 10 dB of loss compared to a dipole). Fortunately, receiver sensitivity specs are generally in the .25 to 1 µV area.

## **Table 2:** T network resistive attenuator (50 Ω)

| dB atten. | R1 (ohms) | R2 (ohms) |
|---|---|---|
| 1 | 2.9 | 433.3 |
| 2 | 5.7 | 215.2 |
| 3 | 8.5 | 141.9 |
| 4 | 11.3 | 104.8 |
| 5 | 14.0 | 82.2 |
| 6 | 16.6 | 66.9 |
| 7 | 19.0 | 55.8 |
| 8 | 21.5 | 47.3 |
| 9 | 23.8 | 40.6 |
| 10 | 26.0 | 35.0 |
| 11 | 28.0 | 30.6 |
| 12 | 30.0 | 26.8 |
| 13 | 31.7 | 23.5 |
| 14 | 33.3 | 20.8 |
| 15 | 35.0 | 18.4 |
| 16 | 36.3 | 16.2 |
| 17 | 37.6 | 14.4 |
| 18 | 38.8 | 12.8 |
| 19 | 40.0 | 11.4 |
| 20 | 41.0 | 10.0 |
| 21 | 41.8 | 9.0 |
| 22 | 42.6 | 8.0 |
| 23 | 43.4 | 7.1 |
| 24 | 44.0 | 6.3 |
| 25 | 44.7 | 5.6 |
| 30 | 47.0 | 3.2 |
| 35 | 48.2 | 1.8 |
| 40 | 49.0 | 1.0 |
| 45 | 49.4 | 0.56 |
| 50 | 49.7 | 0.32 |
| 55 | 49.8 | 0.18 |
| 60 | 49.9 | 0.10 |

Source: *The ARRL Handbook for the Radio Amateur*, American Radio Relay League.

For routine monitoring the technician can listen for a generated tone or a squelch break from the

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**Signature** ______________________ **Date** ______

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2) Please check the category that best describes your firm's primary business (check only one).
- ☐ Independent Cable Operator
- ☐ MSO (two or more cable TV systems)
- ☐ Independent Contractor
- ☐ Microwave or Telephone Company
- ☐ SMATV or DBS Operator
- ☐ MDS, STV or LPTV Operator
- ☐ Government Agency
- ☐ Educational TV Station, School or Library
- ☐ Other ______________ (please describe)

3) In the performance of my job I authorize, specify or recommend products and/or services for purchase.
☐ Yes ☐ No

4) Primarily my responsibilities involve:
- ☐ Inside Plant (working within one specific office)
- ☐ Outside Plant (working outside of your company's office environment, i.e., in a mobile unit, at various locations on a daily basis)

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(please be specific)
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**Signature** ______________________ **Date** ______

**1. Are you a member of the SCTE (Society of Cable Television Engineers)?**
Yes ☐ No ☐

**2. In the performance of my job, I authorize, specify or purchase products and/or services.**
Yes ☐ No ☐

**3. Please check the category that best describes your firm's primary business (please check only one).**
1. Cable TV Systems Operations
- ☐ a. Independent Cable TV Systems
- ☐ b. MSO (two or more Cable TV Systems)
- ☐ 2. Cable TV Contractor
- ☐ 3. Cable TV Program Network
- ☐ 4. SMATV or DBS Operator
- ☐ 5. MDS, STV or LPTV Operator
- ☐ 6. Microwave or Telephone Company
- ☐ 7. Commercial Television Broadcaster
- ☐ 8. Cable TV Component Manufacturer
- ☐ 9. Cable TV Investor
- ☐ 10. Financial Institution, Broker, Consultant
- ☐ 11. Law Firm or Government Agency
- ☐ 12. Program Producer or Distributor
- ☐ 13. Advertising Agency
- ☐ 14. Educational TV Station, School or Library
- ☐ 15. Other ______________ (please describe)

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|---|---|---|---|---|---|---|---|---|---|
| 2 | 16 | 30 | 44 | 58 | 72 | 86 | 100 | 114 | 128 |
| 3 | 17 | 31 | 45 | 59 | 73 | 87 | 101 | 115 | 129 |
| 4 | 18 | 32 | 46 | 60 | 74 | 88 | 102 | 116 | 130 |
| 5 | 19 | 33 | 47 | 61 | 75 | 89 | 103 | 117 | 131 |
| 6 | 20 | 34 | 48 | 62 | 76 | 90 | 104 | 118 | 132 |
| 7 | 21 | 35 | 49 | 63 | 77 | 91 | 105 | 119 | 133 |
| 8 | 22 | 36 | 50 | 64 | 78 | 92 | 106 | 120 | 134 |
| 9 | 23 | 37 | 51 | 65 | 79 | 93 | 107 | 121 | 135 |
| 10 | 24 | 38 | 52 | 66 | 80 | 94 | 108 | 122 | 136 |
| 11 | 25 | 39 | 53 | 67 | 81 | 95 | 109 | 123 | 137 |
| 12 | 26 | 40 | 54 | 68 | 82 | 96 | 110 | 124 | 138 |
| 13 | 27 | 41 | 55 | 69 | 83 | 97 | 111 | 125 | 139 |
| 14 | 28 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 |
| 15 | 29 | 43 | 57 | 71 | 85 | 99 | 113 | 127 | 141 |

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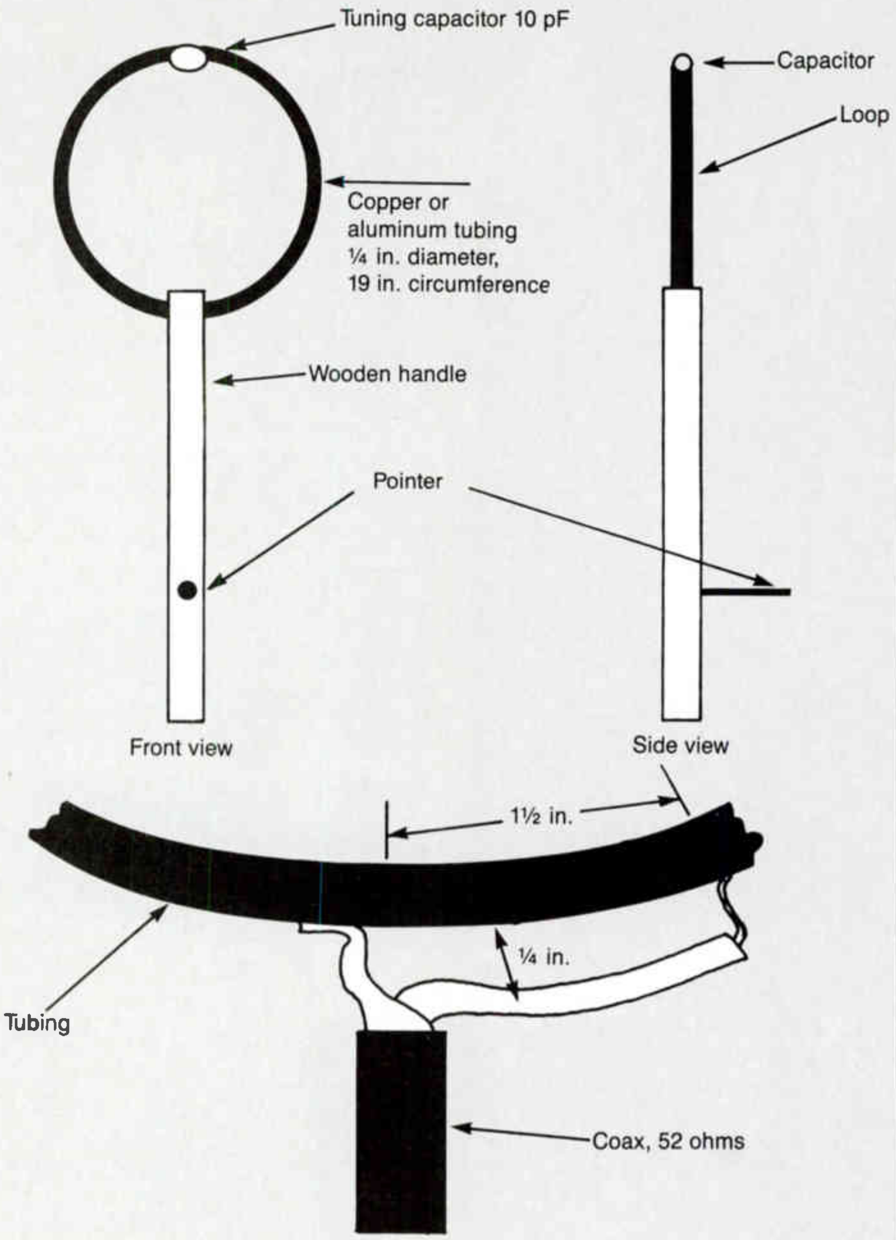
receiver and note the location where the receiver is tripped. This information can then be entered into the signal leakage log and either turned over to the leakage repair crew or fixed on the spot. If the monitoring technician is responsible for locating and fixing the leak, some type of "S meter" (or signal level meter) built into the receiver is desirable.

The receiver can be a fixed crystal-controlled unit or a tunable frequency agile one. With a fixed unit, the monitoring frequencies must be specified when purchased but can be changed by ordering new crystals at a later date. An agile receiver offers a much greater variety of tuning capability but at a greater purchase price. In either event, consider using a mixture of video *and* audio carriers to aid in locating strong leaks. If a strong video carrier saturates the receiver, tuning to the audio carrier attenuates the received signal by the 13 to 17 dB of difference between the two signals and allows getting closer to the leak without "pegging" the SLM. An attenuator between the antenna and the receiver will give the same effect.

If you purchase an amateur transceiver for leakage detection, consider disabling the transmit function. This will remove the temptation from the technician to transmit on it (unlicensed transmission is a definite no-no with the FCC; hence, the reason for the tougher stand on leakage). If the technician is a licensed ham, transmission on the radio is legal. Just don't let licensed employees use the equipment in lieu of the company's mobile radio. It is illegal for amateur radio to be used for business purposes. For more information on the amateur radio service, refer to Part 97 of the FCC Rules or contact the American Radio Relay League.

**Figure 3:** Two-meter direction finding loop antenna



### Calibration

Let's assume that we want to use an amateur two-meter receiver to find signal leakage in the 140 to 150 MHz band. In this range, we could tune Channel E's video carrier at 145.250 MHz or Channel D's audio carrier at 143.750 MHz (based upon standard channel frequencies; HRC systems will be 1.25 MHz lower). Using Equations 1 and 2, 20 $\mu$V/m equates to 6.56 $\mu$V and −43.67 dBmV; i.e., $E = 20/(.021 \times 145.25)$.

The unit dBmV requires that the impedance be held constant to 75 ohms. Most receivers are 50 ohm impedance; therefore, we must convert from the impedance-specific dBmV to a non-specific unit such as dBm. Converting from dBmV to dBm (−43.67 − 48.75 = −92.42 dBm), we find that if we insert a −92 dBm signal into the receiver by connecting it to a signal generator, we will simulate a 20 $\mu$V/m signal at 145.25 MHz. Be sure and allow for impedance conversions if the signal generator is other than the receiver's 50 ohm input impedance. Impedances must be matched in order to maintain accuracy. This −92 dBm signal should peg the receiver's signal strength meter. By inserting attenuation between the signal generator and the receiver, you can find a suitable reference point for 20 $\mu$V/m (at three meters).

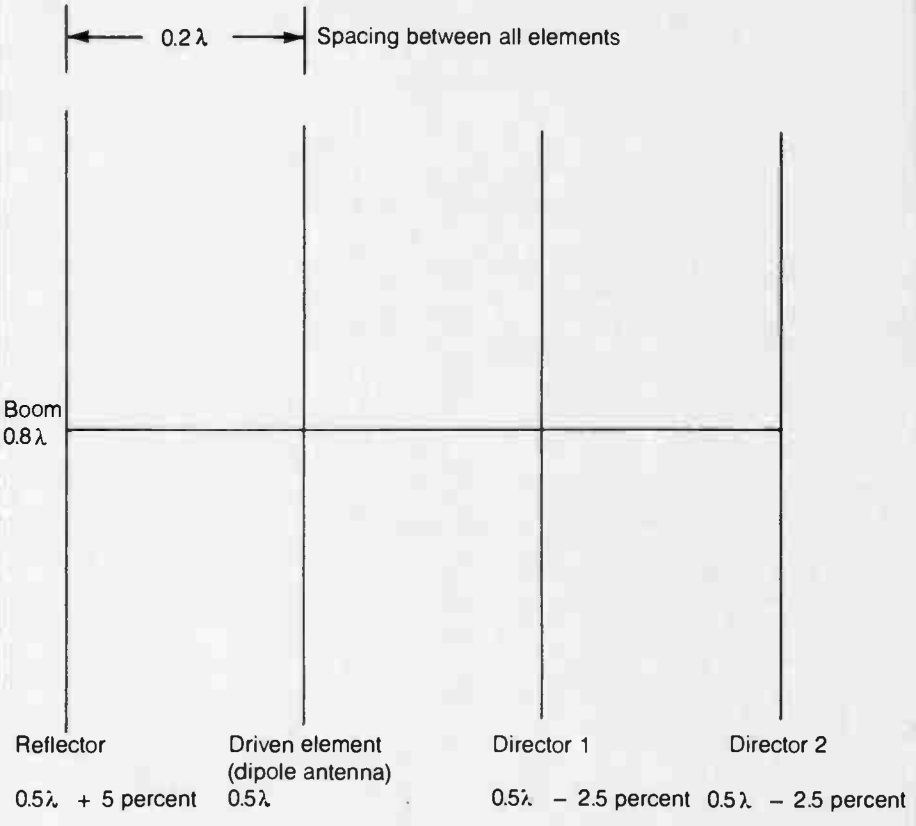
According to the free space path loss formula (loss = 36.6 + 20logF + 20logD), every doubling in distance adds 6 dB of path loss. Granted, we are not operating in a free space environment, but this should give a reasonable approximation for our purposes. Remember, we are monitoring using a threshold rather than making absolute measurements. To simulate distances of greater than three meters (10 feet), use the 6 dB rule of thumb. Therefore at 20 feet, 40 feet and 80 feet we would expect to read 6 dB, 12 dB and 18 dB lower signals, respectively. Attenuation can be switched in between the generator and the receiver to simulate this additional loss.

The 20 $\mu$V/m reading assumes the use of a half-wavelength dipole. If other types of antennas are used, a calibration correction will be required to adjust for the actual gain (or loss) of the antenna in use, compared to the specified dipole.

Another method of calibration is to compare the reference on the receiver with a known 20 $\mu$V/m signal. Figure 1 illustrates how this can be done. Using a signal generator, an attenuator and an antenna, temporarily generate a leak. At the receive end (greater than five wavelengths away), measure the leak using a dipole, bandpass filter, amplifier and field strength meter. Have an assistant adjust the attenuation at the leak transmitter so that the reading on the field strength meter (in dBmV) correlates to 20 $\mu$V/m at the receive antenna (even though we are at a distance of greater than three meters).

Now remove the field strength meter and accessories, making careful note of the antenna location. Bring the monitoring receiver to the previous antenna location to establish your 20 $\mu$V/m reference on the receiver. If the receiver is to be used in a vehicle, drive it to the same spot where the dipole was located. This is done so that you can establish the reference under similar

**Figure 4:** Four element yagi antenna



conditions to those that will be encountered in the field. Refer to the previous discussion of path loss relative to distance and add the appropriate attenuation to the receiver to simulate the distance from the plant to the street.

Since the monitoring receiver probably has a 50 ohm input, a 50 ohm cable such as RG-58 or RG-8 must be used to maintain the impedance match. Additionally, due to impedance mismatches, the 75 ohm variable attenuators used in most CATV applications will not yield the loss indicated on the attenuator box when used with 50 ohm devices. Figure 2 shows a schematic with component values for building a 50 ohm switchable attenuator for use in monitoring.[2] High quality (low tolerance) resistors should be used and lead lengths should be kept as short as possible. The circuit should be properly shielded in order to provide the best accuracy.

In many cases, the resistor values specified in Figure 2 and Tables 1 and 2 are not standard values. The nearest available value can be substituted at a sacrifice in accuracy. Another technique is to buy a carbon resistor of slightly lower value and, while measuring the resistance, slowly file away portions of the carbon until the proper value is obtained.

Commercially manufactured 50 ohm attenuators are also available. Again, these attenuators are used to establish a threshold reference, so accuracy is not as critical as if we were making quantitative measurements. If the 50 ohm attenuator box is used with a commercial receiver having an AC or DC voltage on the antenna connector for powering preamplifiers, some provision for power blocking the line will be required. Other methods of powering the preamplifier will be necessary as well.

### Direction finding techniques

Radio direction finding (RDF) techniques can be used to locate leaks. These can range from the relatively simple directional antennas to the extremely sophisticated and complicated systems using multiantennas, electronics and Doppler effect principles. Various books are available for an in-depth coverage of RDF.

One simple antenna that can be used for leakage location is the loop antenna in Figure 3[3]. This particular antenna is cut for the two-meter amateur band (145 MHz) but the design can be modified for other frequencies as well. The circumference of the antenna is roughly .3 times the wavelength of the desired frequency. The 10 pF trimmer is adjusted after construction of the antenna so that the received signal is peaked on the receiver meter or field strength meter. Once the peak is found, the trimmer should not need adjustment again. The mast must be nonmetallic for the antenna to function properly.

The loop antenna is directional and has a very broad peak in a plane parallel to the loop. A sharp null (signal drop) will be found in a plane perpendicular to the loop and this is the signal that is used for direction finding. By manually rotating the antenna mast back and forth, a deep null will be found on the SLM. By noting the antenna orientation at the null, one can obtain a bearing to the leak.

The antenna is bidirectional—it cannot differentiate between a signal in front or behind it. Although its null is more directional, it is less sensitive than a dipole and may work favorably for only locating leaks of high magnitude. Therefore, it may have limited applications in CATV.

A dipole antenna is fairly directional and can be used for leakage location in many instances. The dipole can be used to look for a *peak* signal perpendicular to the antenna either in front or behind the antenna, but the null method may provide a sharper bearing. An attenuator may be useful for strong signals.

Near field detectors are used to find leaks in the less than 10-foot range. Commercial units are available or a short piece of wire coiled into a loop will often suffice. This detector is a very insensitive antenna but that characteristic makes it very useful in close-in applications near housings and cable breaks.

One final antenna to consider is the yagi (Figure 4). The reference books listed contain information on construction of yagi antennas. Very good commercial and amateur-grade yagi antennas in the 144 to 160 MHz range are available for purchase from various radio dealers.

The yagi's disadvantage is that it can be rather unwieldy, especially at lower frequencies, due to the size of the antenna. Its advantages are that it is highly directional with a good front-to-back ratio and has a gain over a dipole antenna. A three- to four-element yagi has 7 to 8 dB of gain, so it is very useful for tracking distant leakage sources.

Preliminary testing done at ATC shows that a three-element antenna seems to be the best yagi configuration for leakage locating. A two-element yagi (driven element and reflector) does not seem to have enough directivity. A four-element yagi has too much gain in most instances, and attenuators are required to keep from saturating the receiver. The three element antenna has sufficient gain and directivity and is easier to maneuver than antennas having additional elements.

*Warning*: Before connecting any accessory antenna to a commercial signal leakage device, check to make sure the antenna input connector on the receiver does not have voltage on it. Some manufacturers place voltage on the antenna connector to power preamplifiers contained in their antennas. Often antennas such as those we've described appear as a short to ground at DC. Placing a voltage on such an antenna may damage the signal leakage receiver.

A leak will propagate peaks and nulls (standing waves) down the cable, which may make it difficult to find the source of the leak. The level will get successively stronger as the antenna is brought closer to the leakage source. Near the source, it may be difficult to differentiate between the source and successive peaks.

In the course of this article, the discussion has focused on monitoring and locating leaks rather than on performing quantitative measurements. For CLI calculations, quantitative measures *are* necessary. FCC Rules specify that measurements will be taken using a dipole antenna (or correlating back to a dipole). The CLI ride-out will out of necessity be a separate ride-out from your routine monitoring and will follow different procedures.

Monitoring procedures will normally be used to find leaks that are over the 50 $\mu$V/m threshold. Once these are found, quantitative measurements with the dipole antenna must be made and levels recorded. These levels will then be used in the CLI calculation.

Another CLI method that warrants mentioning is the flyover technique. Low-flying aircraft, equipped with the proper test equipment, can quickly determine the CLI index of a large plant. The technique involves making parallel passes over the system at some uniform elevation, typically 1,500 feet above ground. The expense of a flyover can be much less than the manpower-intensive ground measurement method in larger systems. A few companies offer this service presently, but one should ensure that the company offering the flyover can warrant that the FCC will accept its methodology and final report as a valid CLI test.

### Making use of resources

Various techniques and resources are available for tracking signal leakage; make use of any and all of them when possible. The radio direction finding techniques described are just an introduction to the subject; the references listed will offer more detail for a greater in-depth look. One resource that is often overlooked is the local amateur radio community. These are the people who call you up with interference complaints, but here can be a technical resource waiting to be tapped. Many radio amateurs participate in hidden transmitter hunts and have developed proficient skills in radio direction finding. Through a cooperative environment, their help can be enlisted in training and assisting in leakage location[4,5].

*Thanks to Raleigh Stelle of ATC for his assistance in field testing and his comments and suggestions during the writing of this article.*

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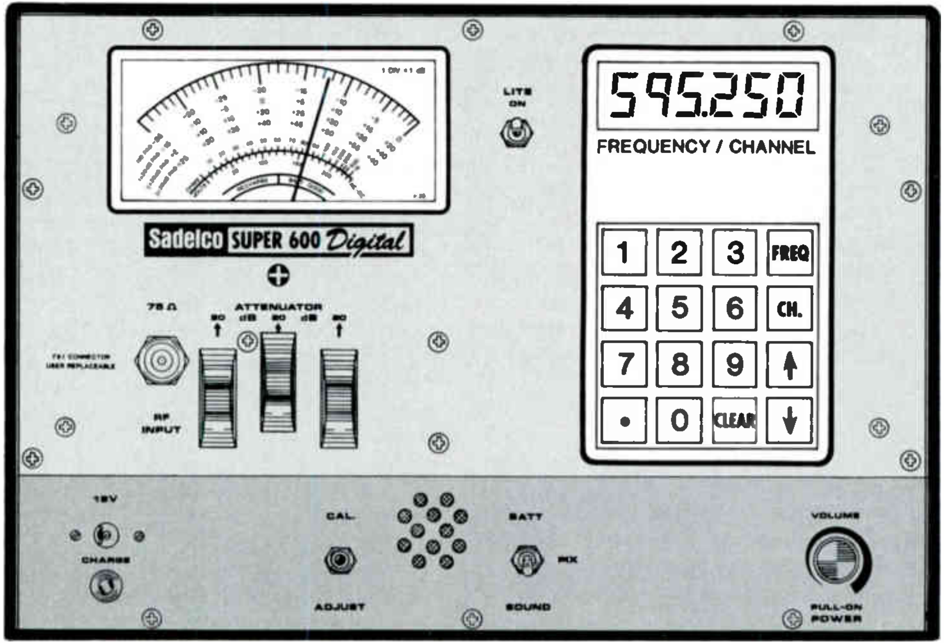


# Energy consumption of power supplies

**By Paul Barth**
FCC Coordinator, United Cable Television Corp.

In the transition from a high growth industry into an operating industry, cable TV is becoming much more service-oriented and cost-conscious. One of the considerations is the cost-effectiveness of installing meters on power supplies. With the cost of power approaching or even exceeding 10 cents per kilowatt-hour, it certainly warrants close analysis.

Many new systems already utilize metering; it is predominantly the older systems that should be analyzed. In those systems, the billing is based on initial usage levels established by one of the following criteria:

a) The power company metered several locations then established an average consumption in kilowatt-hours per location.
b) The cable system provided the necessary data to the power company and charges are calculated in accordance.
c) The power company uses the nameplate ampere rating of the power supply to calculate the monthly consumption in kilowatt-hours. (This, of course, is the worst case.)
d) The power company has other cable operators as customers and has established a flat rate for everyone. This flat rate may have to be reassessed.
e) The monthly charge may be entirely arbitrary and cannot be logically traced to the kilowatt-hour consumption or nameplate rating. (Usually no one at the power company or cable system can remember who or why it was set up this way, but it's always been done in this manner, so that makes it right.)

## Comparisons

In one system recently surveyed, it was calculated that approximately $2,000 per month could be saved by metering 154 power supplies. This particular system had several metered supplies; however, the majority were unmetered and billed at the full 12 ampere nameplate rating. This figure is conservative, as the calculated usage of each metered power supply was more than the actual monthly power consumption. When comparing the unmetered power supplies, the full calculated amount was used. The following are methods to calculate your own system's consumption.

*Calculating watts*—The actual power equation for determining watts is P (power in volt-amperes) = E (potential in volts) × I (current in amperes) × cos θ (power factor). For our purposes we will consider the power factor to be unity (i.e., 1) and concern ourselves with the energy used by the active cable plant and the overall efficiency of the power supply. The simplified version of the formula is:

$$\frac{\text{Amperes} \times \text{volts}}{\text{power supply efficiency}} = \text{watts} \tag{1}$$

The manufacturer's specifications on all your active devices (amplifiers, line extenders, etc.) will give you watts or amperes. Many modern design techniques will compute amperes since the power supply is rated in amperes and care must be taken not to overload the unit. Of course, we start out with 60 volts AC and, since a voltage drop occurs throughout the system, we end up with voltage as low as 40 VAC. We have used 52 VAC on an average.

Most power supplies on the market today operate in an efficiency range of approximately 85 percent, although some older units may be at 80 percent or even less. Newer transformer designs have achieved transformer efficiencies to the magnitude of 94 percent. Allowing for internal consumption for the logic circuitry, pilot lights and status monitoring, overall efficiency is approaching 93 percent. We will use .85 as an efficiency factor for our following equation.

Now that we have three elements of the formula we can compute watts:

$$\frac{\text{Amperes} \times 52\text{ VAC}}{.85} = \text{watts (total effective watts)}$$

If you have the combined wattage of your actives you can get the total effective watts by dividing by the efficiency factor of the power supply.

*Determining actual usage*—Of course, the previous method will give you the *calculated* value of your power consumption. To obtain *actual* value the obvious method would be to install a meter. But since we want to see if it's worth the cost, we'll cover another method.

Using a true RMS meter we can measure the current flow for any particular power supply. These meters are available for around $300 and must be used in the following manner:

1) A clamp around current probe must be placed around one of the 120 volt wires (hot, not ground) leading into the power supply. Obtain the current reading in amperes.
2) Measure the voltage across the two lead-in wires (normally 120 VAC).
3) Multiply the two readings to obtain watts.

Be sure these readings are obtained from the AC power input side of the power supply. Remember, the current readings will be approximately half of the output amperes because the voltage is double the nominal CATV plant voltage.

> *"Most communities require a licensed electrician to install meters; in addition, the power company may charge new or additional hookup fees."*

*Computing kilowatt-hours*—Since the power company will bill you in kilowatt-hours we must now compute this figure. For simplicity, 30 days per month has been used. If you are auditing your actual power bills you can use the exact number of days for that particular billing period. The formula is:

$$\frac{\text{Watts} \times \text{hours}}{1{,}000} = \text{kWh} \tag{2}$$

or

$$\frac{\text{Watts} \times 24\text{ (hours)} \times 30\text{ (days)}}{1{,}000} = \text{kWh/month}$$

We will use the system mentioned earlier as an example. The known facts are:

- Power supply ampere rating = 12 amperes
- Average loading = 7 amperes
- Power costs = $.0583/kWh
- Number of power supplies = 157
- Number metered = 3
- Monthly charge for unmetered units = 121 at 520 kWh
  = 33 at 537 kWh

The monthly charge for the unmetered units at first appears to be arbitrary and the difference of 17 kWh is a complete mystery. We can, however, work back to where these numbers may have originated:

$$\frac{12\text{ ampere power supply} \times 52\text{ VAC}}{.85} = 734\text{ watts}$$

$$\frac{734 \times 24 \times 30}{1{,}000} = 528.5\text{ kWh/month/ power supply}$$

A survey of approximately 80 percent of the system's power supplies revealed that the average loading was 7 amperes. This seems low, but the design criteria for this system was 80 percent loading, which brings the maximum load to 9.6 amperes. The remaining 2.6 amperes are designed in to accommodate future use of status monitoring and other two-way modules.

This figure is the *calculated* value, not actual power consumption. These figures were considered accurate because the metered units actually used less power than their calculated value. Determination of the power usage was as follows:

$$\frac{7 \text{ amperes} \times 52 \text{ VAC}}{.85} = 428 \text{ watts}$$

$$\frac{420 \text{ watts} \times 24 \times 30}{1{,}000} = 308.2 \text{ kWh/month/ power supply}$$

It is now a simple matter to convert the difference to dollars.

*Present charges:*
121 supplies × 520 kWh × $.0583 = $3,668
+33 supplies × 537 kWh × $.0583 = $1,033
154 Total $4,701

*Calculated charges:*
154 supplies × 308 kWh × $.0583 = $2,765
Difference = $1,936/month

Now is the time that judgment must be used. Many older systems may actually be using more power than they are being charged for. In the previous example, additional loading may not have been noted in the design calculations, thus making the difference abnormally high. In almost all cases the following steps are recommended when deciding if metering is worth the costs:

1) Calculate the kilowatt-hours.
2) Measure actual usage to ensure accuracy of this calculation (random sample of at least 25 percent of system).
3) Compare this to what the power company is charging.
4) Obtain cost of installing meters in your area.
5) Check for monthly service charges (such as meter reading fees) that are above the actual energy usage.

Note: Most communities require a licensed electrician to install meters; in addition, the power company may charge new or additional hookup fees. Non-standby power supplies will require a generator or other device to keep the customers on-line while changing over—you also will need additional manpower for this. All of this must be considered when computing the metering charges. For this example a $400/unit was arbitrarily chosen as a cost for metering.

154 × $400 = $61,600 (cost of metering power supplies)

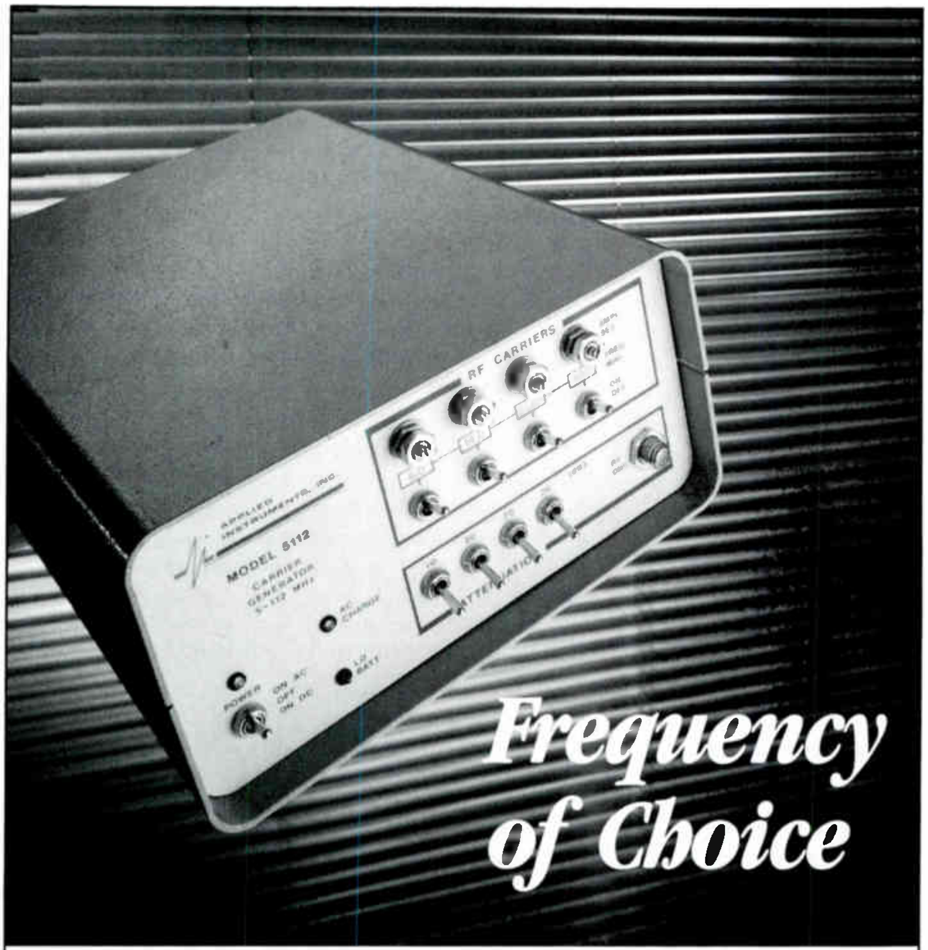
$1,936 × 12 = $23,232/year (additional charges now being paid)

$61,600/$23,232 = 2.65 years for payback

This is a rather obvious decision even for an engineer to make. I believe they call it a "no brainer": "Yes, put the meters in."

Keep in mind this example is for a 12 ampere power supply. With the industry moving to 14, 15 and even 18 to 24 ampere devices you could be in for even higher costs if the power company continues to charge for the nameplate rating of the power supply. When reviewing your power company's rate schedule watch for wording such as "energy used by CATV amplifiers will be determined by the nameplate rating..." In most cases, they will be charging for the nameplate rating of the power supply, not the amplifiers. This is a significant difference and it gives you a starting place for a dialogue with the power company.

Remember the points mentioned previously should be used as a guide. Each power company has its own rules and rates, so every situation will be different and needs to be individually researched.



# Upgrading for increased capacity

*This is the second installment of a two-part series. Part I covered output capability improvement.*

**By Richard Covell**
Applications Engineer, General Instrument/Jerrold Division

The best method I've encountered to determine what effect adding channels will have on your system's CTB performance is: Obtain the three-tone triple beat measurement for the highest channel presently carried by your amplifier. Note: If you can't get this information from the manufacturer of the amplifier or integrated circuit (IC), measure it yourself. Here's an example of how to proceed: If the highest channel on your system is W, then put a working amplifier on the bench and insert carriers at 289.25, 301.25 and 307.25 MHz. (This combination of frequencies—the next two channels above and the next one below—will produce the three-tone triple beat at 295.25 MHz.) Measure and record the beat level. (You will have to run the amplifier at high enough levels to provide a measureable beat, then adjust the results for your system's operational level.)

Take 10log of the number of 2A−B and A+B−C beats (the quantity of these beats can be found beginning on page 35 of Jerrold's *RD-15 CATV Reference Guide*) that fall in this channel and subtract this number from the carrier-to-three-tone-beat ratio (corrected to normal operating levels).

> *"Obtain the three-tone triple beat measurement for the highest channel presently carried by your amplifier."*

**Table 1:** Output capability requirements for higher bandwidth on trunk due to increased channel carriage

The following table will show the output capability improvement needed for a flat system to carry the additional channels the higher bandwidths allow. (Requirements for 27 dB are highlighted.)

| **Bandwidth (MHz)**<br>**Channel carriage** | **220**<br>**23** | **240**<br>**27** | **270**<br>**32** | **300**<br>**37** | **330**<br>**42** | **400**<br>**53** | **450**<br>**62** | **500**<br>**70** | **550**<br>**78** | **600**<br>**87** |
|---|---|---|---|---|---|---|---|---|---|---|
| | **22.0** | 0.7X | 1.5X | 2.1X | 2.7X | 4.5 | 6.4 | 8.5 | 10.9 | 13.9 |
| | | **22.0** | 0.8X | 1.4X | 2.0 | 4.0 | 5.9 | 8.0 | 10.5 | 13.4 |
| | | | **22.0** | 0.7 | 1.5 | **3.5** | 5.4 | 7.5 | 10.0 | 12.9 |
| | | | | **22.0** | 0.9 | 2.9 | **4.8** | 6.9 | 9.4 | 12.3 |
| | | | | | **22.0** | 2.0 | 3.9 | **6.0** | 8.5 | 11.4 |
| | | | | | | **22.0** | 1.9 | 4.0 | 6.5 | **9.4** |
| | | | | | | | **22.0** | 2.1 | 4.6 | 7.5 |
| | | | | | | | | **22.0** | 2.5 | 5.4 |
| | | | | | | | | | **22.0** | 2.9 |

**Table 2:** Total output capability requirement for higher bandwidth on trunk

The total cumulative output capability improvement necessary to maintain same distortion and input levels when increasing bandwidth is contained in the following chart. (The 22 dB and 27 dB spacings are highlighted.)

| **Bandwidth (MHz)**<br>**Channel carriage** | **220**<br>**23** | **240**<br>**27** | **270**<br>**32** | **300**<br>**37** | **330**<br>**42** | **400**<br>**53** | **450**<br>**62** | **500**<br>**70** | **550**<br>**78** | **600**<br>**87** |
|---|---|---|---|---|---|---|---|---|---|---|
| | **22.0** | 1.7 | 3.9 | 5.7 | **7.6** | 12.2 | | | | |
| | | **22.0** | 2.1 | 4.0 | **5.8** | 10.4 | 14.0 | | | |
| | | | **22.0** | 1.8 | 3.8 | **8.3** | 11.8 | | | |
| | | | | **22.0** | 2.0 | 6.3 | **9.7** | 13.9 | | |
| | | | | | **22.0** | 4.2 | 7.6 | **10.1** | 15.8 | |
| | | | | | | **22.0** | 3.2 | 6.6 | 10.3 | **14.3** |
| | | | | | | | **22.0** | 3.3 | 6.9 | 10.9 |
| | | | | | | | | **22.0** | 3.5 | 6.4 |
| | | | | | | | | | **22.0** | 3.9 |

Note: In the examples highlighted that maintain the same minimum input levels, a flat trunk and increased spacing by approximately 5 dB, the output capability of the replacement trunk module must be between 6 and 14 dB better than the one being replaced. If the new modules have a lower noise figure, then input levels can be reduced by an amount equal to the noise figure improvement, which will maintain the original C/N ratio and allow a reduction in output levels; i.e., less output capability improvement required.

**Table 3:** Output capability improvement (dB) by amplifier type

| From/to | | SE | PP | PD | QP | FF |
|---|---|---|---|---|---|---|
| Single-ended | (SE) | 0.0 | 3.0 | 6.0 | 8.5 | 13.0 |
| Push-pull[1] | (PP) | — | 0.0 | 3.0 | 5.5 | 10.0 |
| Power doubling[2] | (PD) | — | — | 0.0 | 2.5 | 7.0 |
| Quadrapower | (QP) | — | — | — | 0.0 | 4.5 |
| Feedforward[3] | (FF) | — | — | — | — | 0.0 |

[1] Push-pull provided a 20 dB improvement in second-order output capability over single-ended.

[2] Power doubling assumes single integrated device.

[3] Feedforward is not recommended for levels above 50 dBmV if channel carriage is 60 or more, as the internal ICs operate approximately 3 dB higher than the output of the gain block (in power doubling the ICs operate 2.5 to 3.0 dB lower) and begin to go into compression at this level.

Note: Devices assume the same transistor dies are used. Later devices have better performance than earlier ones.

Perform the same procedure on the amplifier that you plant to substitute in your system at the "new" highest frequency. If the two results are equal, you have enough output capability in the new amplifier to handle the additional channels, but not enough to accommodate the higher output levels you will need to overcome the increased cable attenuation. Hopefully you'll have sufficient reserve to cover both.

Figure 1 graphically illustrates how carrier-to-composite triple beat (C/CTB) varies as a function of channels carried for a push-pull IC of recent manufacture. The first plot is the C/three-tone triple beat vs. frequency at a typical "flat" operating level. Notice that this ratio doesn't degrade 10 dB from the value at 220 MHz until reaching 500 MHz; good performance when compared to earlier devices.

The second plot is the sum of the number of 2A−B and A+B−C beats that fall next to the visual carrier of the highest channel carried for the quantity of channels carried. The third plot is the result of subtracting 10log of Plot 2 from Plot 1 and displays the calculated C/CTB performance of the device as a function of the number of channels passed through it. As you can see, the logarithmic increase in the number of three-tone beats as you increase channel carrier has had a pronounced effect on C/CTB performance and degrades it 10 dB by the time the channel carriage has reached 55, an upper bandwidth of less than 400 MHz.

Table 1 is derived from the formula expressed in Figure 1 and shows the typical output capability improvement required when adding channels above your present upper bandwidth. Although these numbers may not be exact for your particular circumstance, they will give you an indication of where you need to be. Since X-MOD distortion is visible before CTB with carriage of less than 35 channels, the output capability requirements followed by an "X" indicate improvement necessary to maintain the more stringent X-MOD performance at the indicated frequencies.

Table 2 simply sums the output capability requirements for increased spacing *and* increased channel carriage. The table assumes the same levels are desired at the replacement amplifier's input. To increase trunk bandwidth from 300 to 450 MHz, for example, an amplifier with a 9.65 dB improvement in output capability and 27 dB of gain is indicated.

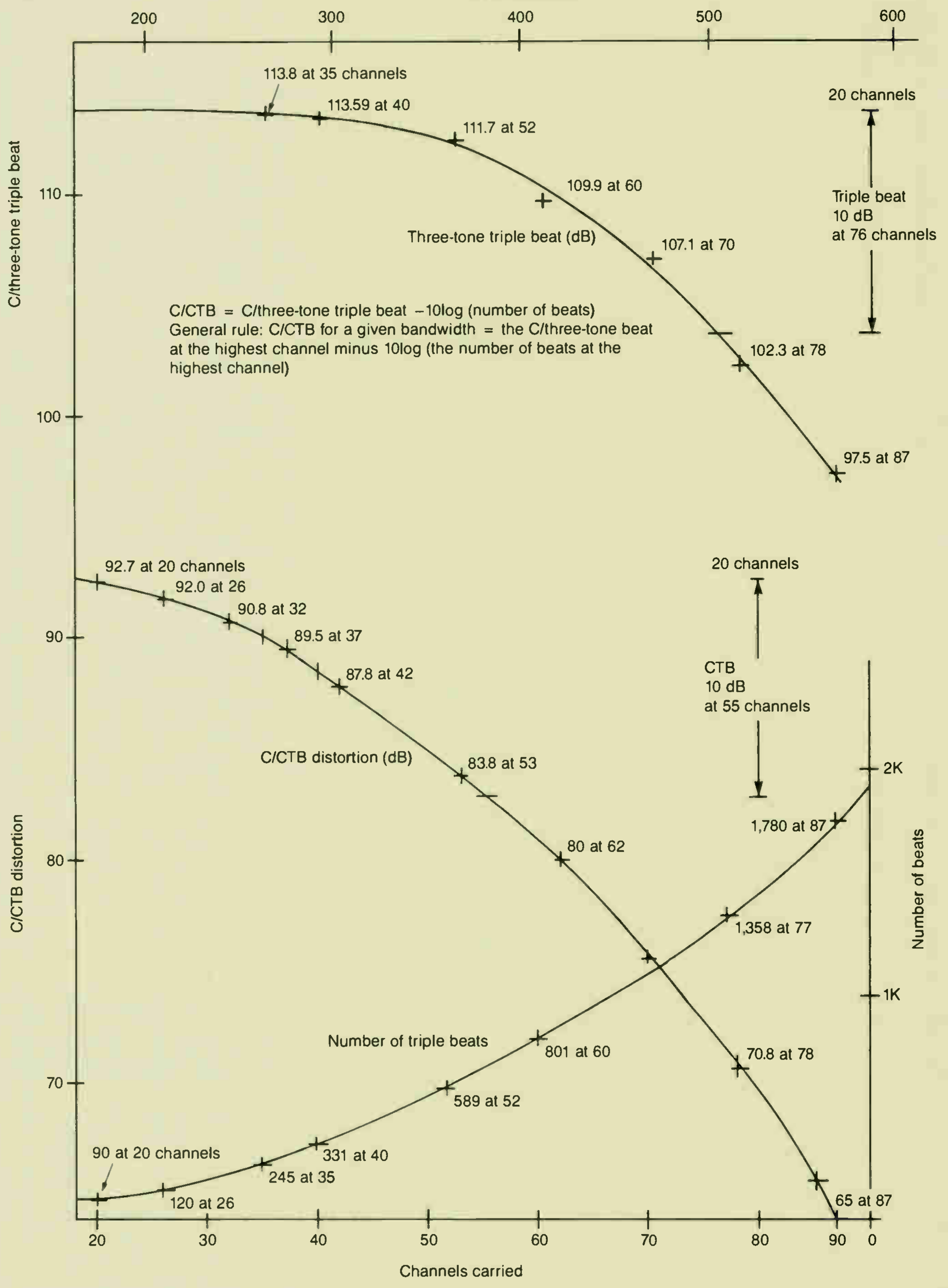
Which amplifier technology will allow a nearly 10 dB improvement in output capability over your present push-pull or single-ended equipment? Feedforward will certainly qualify; however, this may be an expensive overkill. First, the output capability improvement tables assumed the same amplifying devices were used for both the old and new channel carriages. If your equipment was manufactured 10 years ago, the latest push-pull ICs may provide you with much of your output capability requirement. Utilizing power doubling with its additional 3 dB of output capability may serve your requirements. Second, if the amplifier you choose for your upgrade has a better noise figure (NF), you can afford to lower your station input by an amount equal to the NF improvement for the same system carrier-to-noise ratio. A lower input allows a lower output and provides another way to effectively improve output capability.

Table 3 shows what improvement can be realized if we use the same discrete transistor(s) in single-ended, push-pull, power doubling, quadrapower and feedforward configurations. Coupled with the latest improvements in the devices themselves, these technologies provide an arsenal of high-power choices to satisfy most trunk requirements.

**Feeder**

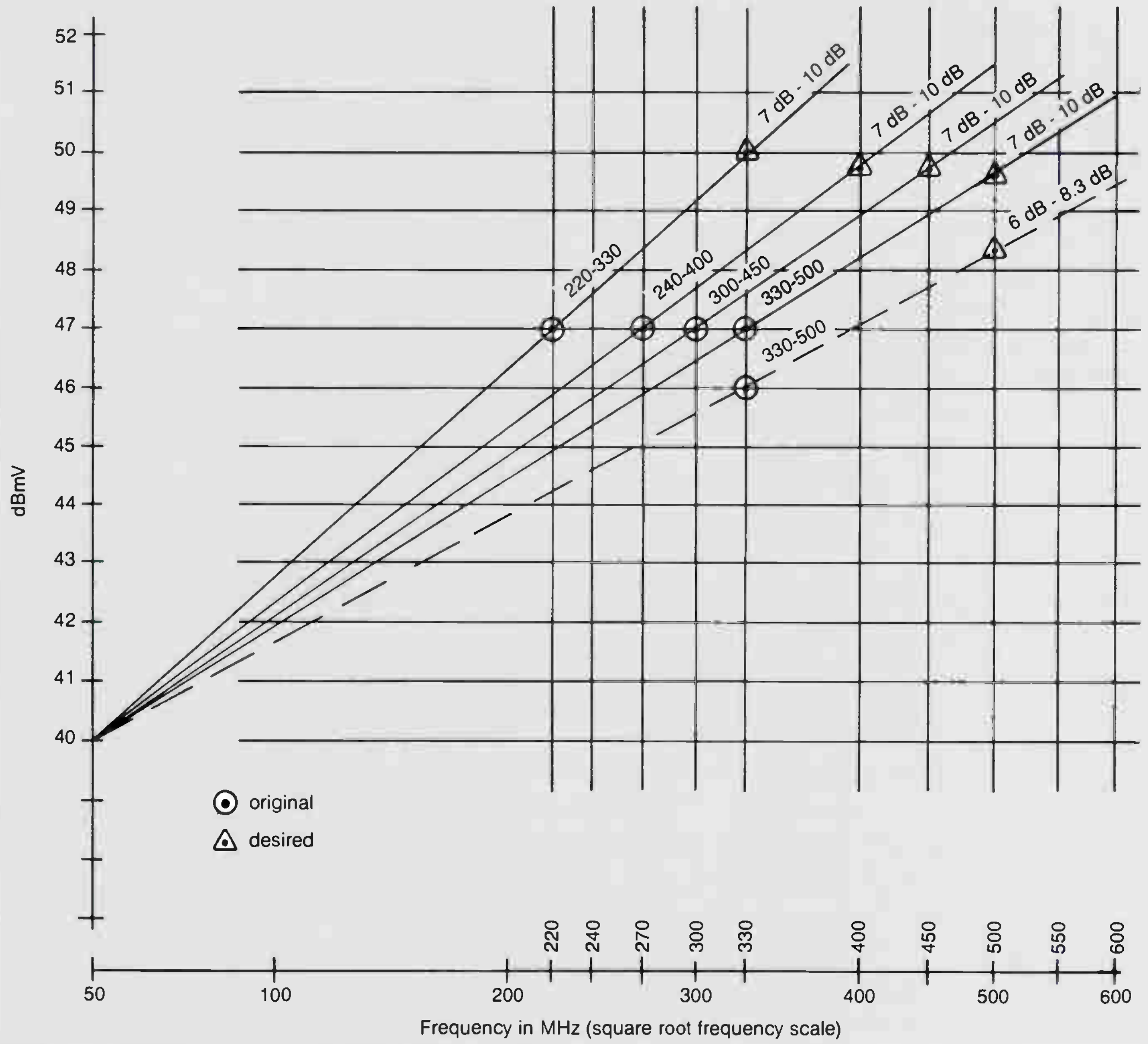
To keep line extenders in their original location

**Figure 1:** C/CTB variance



C/CTB = C/three-tone triple beat −10log (number of beats)
General rule: C/CTB for a given bandwidth = the C/three-tone beat at the highest channel minus 10log (the number of beats at the highest channel)

**Figure 2:** Distribution considerations (bridger/line extender and output/slope)



may be difficult. The same parameters that affect the trunk may affect the feeder system. As well, the insertion loss of the taps at the higher frequencies (if they pass them at all) must be considered. Once the tap decision has been made, Figure 2 may be used to determine feeder levels.

This square root of frequency chart allows plotting output levels vs. frequency on a straight-line basis. Put a mark where your present upper bandwidth crosses your present bridger output level. Do the same for Ch. 2 at its output level. Connect these two points with a straight line, and continue this line until it crosses the proposed new upper frequency. A horizontal line at this juncture will indicate the required output level for the highest channel of your new carriage. This same chart can be used for plotting your line extender levels as well.

One of the examples shows a bridger that is operating at an output of 47 dBmV at 330 MHz with a 7 dB slope. If upgraded to 500 MHz (70 channels), the new output level would be 50 dBmV with 10 dB slope. Despite its great output capability, a feedforward would not be a good choice in this situation, since this technology requires the ICs of the gain block to operate 3 dB higher than the modules output; i.e., at 53 dBmV. At this output and channel carriage, the devices would now be approaching saturation. At a module output near 52 dBmV (depending on tilt) the amplifier may have a 5 dB increase in CTB for the next 1 dB level increase, with subsequent increases progressively worse. Power doubling or quadrapower configurations are far better choices where high output/high channel carriage is required, since the individual ICs operate at *lower* levels than the output of the gain block of which they are a part.

In summary, options for the trunk are plentiful. A feedforward gain block has an 8 to 10 dB improvement in output capability over the push-pull ICs used to make it, and station gains of 22, 27 and 31 dB are available. If you now operate a flat trunk and slope it when upgrading, you can improve output capability for the trunk portion of a 60 channel system by an amount equal to 70 percent of half the amount of slope. For carriage of 77 channels or more, the improvement drops to 60 percent of half the slope.

If your trunk spacing is increasing by 5 dB, you're almost guaranteed that line extenders will have to be moved and taps or tap plates changed. Rather than put three line extenders in cascade in your upgrade because "two won't make it," consider some extra trunk cable and a terminating bridger. Performance will be better and total cost will be about the same as adding the third line extender assuming you would have derated levels for three of them in cascade and will now operate all line extenders in the system at the same level.

The real secret to a system upgrade? Once you decide on what equipment you want to use, make sure the vendor agrees that it will perform, then review the results of a chamber test or have one performed to prove it! ■

# BCT/E certification

**By Ron Hranac**
President, Society of Cable Television Engineers

Shortly after I joined the cable industry in 1972, I was told, "With an FCC license, you can write your own job ticket." In the "old days," less emphasis was placed on formal technical education, since many in the industry gathered valuable field experience as they worked their way up through the ranks. An FCC license was considered a good milestone in one's career and often a demonstration of technical proficiency.

We've since seen the relative demise of the FCC licensing process. While a license once was an important document, it never really was cable TV-specific. Over the years, the FCC encouraged the development of technical certification programs by the private sector. The Society of Broadcast Engineers was among the first to develop such a program, tailored for the broadcast industry. Certification programs in other communications industries soon followed, including the Broadband Communications Technician/Engineer (BCT/E) Professional Designation Certification Program developed by the Society of Cable Television Engineers.

The SCTE's certification program was designed to be more than a replacement for the FCC licensing process. It also was established to raise the professional status of technicians and engineers by providing standards of professional competence in cable TV engineering and to recognize individuals who meet those standards. As well, it was established to encourage technicians and engineers to continue their professional development and to be used as a tool by management to assess the competency of applicants for technical positions.

BCT/E certification is available at two levels: technician and engineer. (At this year's Cable-Tec Expo in San Francisco, the SCTE introduced an Installer Certification Program.) Technician certification requires two years of technical experience in cable TV, three professional references, national SCTE membership and successfully passing written examinations in seven categories. Engineer certification requires five years of industry experience plus formal electronics training, as well as three professional references, national SCTE membership and successfully passing seven categories of written examinations. Nearly 1,000 people are currently enrolled in the program and over 3,000 examinations have been administered since its inception. To date, 13 candidates are fully certified: seven at the technician level and six at the engineer level. Individuals must recertify every three years, either by retesting or by accumulating the required number of recertification units.

If you're not yet participating in this program, I encourage you to consider it. Contact the national SCTE headquarters for information about enrollment. (The November 1988 *Interval* will be a special issue on BCT/E certification, complete with updated program outlines and study bibliographies.) Achieving full certification in one or more of the levels of this program is a worthwhile goal that will demonstrate your commitment to self-improvement. Certification also demonstrates that you have a firm grasp on the technical side of the business.

During your involvement in the certification process, you'll have the opportunity to take BCT/E exams at state and regional association conventions, SCTE seminars and functions, and chapter and meeting group seminars. If you don't have a chapter or meeting group in your area, I encourage you to start one; chapter development information is available from SCTE headquarters.

It wasn't that long ago that help wanted ads in industry trade publications said something like: "Wanted—Chief Technician. FCC license desirable." I wouldn't be too surprised to see future ads read, "Wanted—Chief Technician. BCT/E certification desirable." Good luck in the BCT/E program; I look forward to hearing about your becoming the next certified candidate! ■

# Business Directory

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**Harold Bigham**
**President**

## Bigham Cable Construction, Inc.

**Complete CATV Construction**
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**Gulf Breeze, FL 32561**

**(904) 932-6869**

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*Reader Service Number 57.*

## Help Wanted

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### Syosset, NY

To design electronic components for use in Broadband Local Area Networks, ie. system monitors, modems, headend translators and diplex filters. 40 hr/wk, $34K/yr. Required: M.S. Elec. Eng., minimum 4 credits microprocessor-based systems (Intel 8086/8088 microprocessors), 4 credits in-circuit emulation, 3 credits diplex filter design. Send resume in duplicate to: RG #285, Room 501, One Main St., Brooklyn, NY 11201

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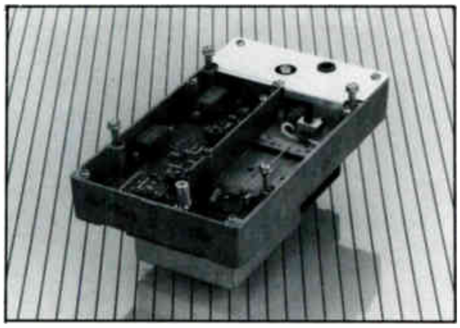
Blind Boxes are available.

## AML transmitter

Hughes Aircraft Co.'s Microwave Products Division introduced its Model AML-SSTX-145 transmitter that utilizes gallium arsenide power amplifier technology. It operates in the CARS (12.7 to 13.25 GHz) band, has been granted equipment authorization by the FCC and is compatible with all Hughes AML microwave receivers.

Up to eight TV channels can be mounted in a single rack and each channel dissipates less than 100 watts. This translates to half the floor space and less than one-fourth the prime power used by current AML-STX-141 high power arrays, allowing for channel expansion, according to the company.

For further information, contact Hughes Microwave Communications Products, P.O. Box 2940, Torrance, Calif. 90509-2940, (213) 517-6233; or circle #137 on the reader service card.



## Line extender upgrade

Broadband Engineering introduced the BMK-70 to upgrade the Jerrold JLE series two-way line extenders. This full board modification will extend the present bandwidth and significantly improve system distortions by utilizing the latest in push-pull and power doubling hybrid technology, according to the company. The BMK-70 utilizes the existing JLE chassis and DC power supply.

For more information, contact Broadband Engineering, 1311 Commerce Lane, Jupiter, Fla. 33458, (407) 747-5000; or circle #122 on the reader service card.

## Subcarrier transmitter

ISS Engineering released its FAST1 frequency agile subcarrier transmitter. The unit can place an FSK data subcarrier on any frequency from 50 kHz to 8 MHz in 100 Hz steps. Any deviation can be selected from 1 kHz to 99.9 kHz in 100 Hz steps and any data rate from 1 bps to 19.2 kbps. All frequency generation is through the use of a numerically controlled oscillator, eliminating phase noise and frequency drift.

For additional information, contact ISS Engineering, 104 Constitution Dr., #4, Menlo Park, Calif. 94025, (415) 853-0833; or circle #132 on the reader service card.

## Standby battery

The GNB Inc. Watchman II deep cycle standby power battery with Absolyte sealed acid technology delivers more than 300 cycles to CATV stations. Because it is sealed, there is no need to add water, no leakage or acid spillage and no damage from freezing.

According to the company, it offers good charge acceptance, resistance to deterioration from cycling and overcharging and low stand loss. It also supplies 160 minutes of peak discharge capacity, 25 amps at 80°F with an ampere-hour rating of 95. It utilizes binder-free separators made from Manville Tempstran glass microfibers.

For more information, contact GNB Inc., P.O. Box 64100, St. Paul, Minn. 55164-0100, (612) 581-5000; or circle #125 on the reader service card.

## Sealing system

Polychem introduced the Canusa-CFTV heat shrinkable sealing system that includes three major components—tubing, sealant and heat reactive green stripes. This system provides a moisture barrier and mechanical protection for CATV connections.

According to the company, the sealant is smooth flowing and helps create a strong bond. It will not bond to itself or drip from the tubing and strips clean from connectors during re-entry.

For further information, contact Polychem Electronics, 420 Boulevard, Mountain Lakes, N.J. 07046, (201) 316-5775; or circle #130 on the reader service card.

## RF amplifiers

Viewsonics expanded its line of RF amplifiers from 50 to 550 MHz with 71-channel capacity in F and hardline connectability. There are 25 models with gains from 10 to 40 dB; among these are multiple self-contained four-, six- and eight-way splitter/amps with operating voltages of 110/60/30/24 VAC sine or square wave. Power insertion models for long drops and headend rack mount forward/reverse and bidirectional amplifiers are also available.

For additional details, contact Viewsonics, 170 Eileen Way, Syosset, N.Y. 11791, (800) 645-7600; or circle #128 on the reader service card.

## Headend scrambler

Jerrold's modulating video processor (MVP) is a multiple-mode headend scrambler capable of scrambling both RF and baseband CATV signals. It has several new levels of audio and video security and operates in a static 6 dB or 10 dB mode as well as dynamic 6/10 dB scrambling mode. Features include scene change detection, timing camouflage and data camouflage. The MVP also provides constant video, dynamic and scene change inversion as well as audio privacy.

For more information, contact Jerrold Division, General Instrument Corp., 2200 Byberry Rd., Hatboro, Pa. 19040, (215) 674-4800; or circle #136 on the reader service card.

## Coaxial cables

Blonder-Tongue introduced its FAVC-59X and FAVC-6X coaxial cables. These cables meet the required National Electrical Code Article 820 for community antenna television and radio distribution systems.

For further information, contact Blonder-Tongue Laboratories, 1 Jake Brown Rd., Old Bridge, N.J. 08857; or circle #127 on the reader service card.

## 300 MHz o-scope

The Tektronix 300 MHz 2440 digital oscilloscope combines eight-bit vertical resolution with 500 megasample per second, dual-channel, simultaneous acquisition. This provides more horizontal and vertical waveform detail than has been available in compact oscilloscopes, according to the company. Features include automatic scope setup, measurements, building and running of measurement sequences, and pass/fail waveform testing. It also offers full GPIB programmability, 2 nanosecond glitch capture and advanced triggering.

For further information, contact Tektronix, Portable Instruments Division, P.O. Box 1700, Beaverton, Ore. 97075, (800) 426-2200; or circle #138 on the reader service card.

## Legal guide

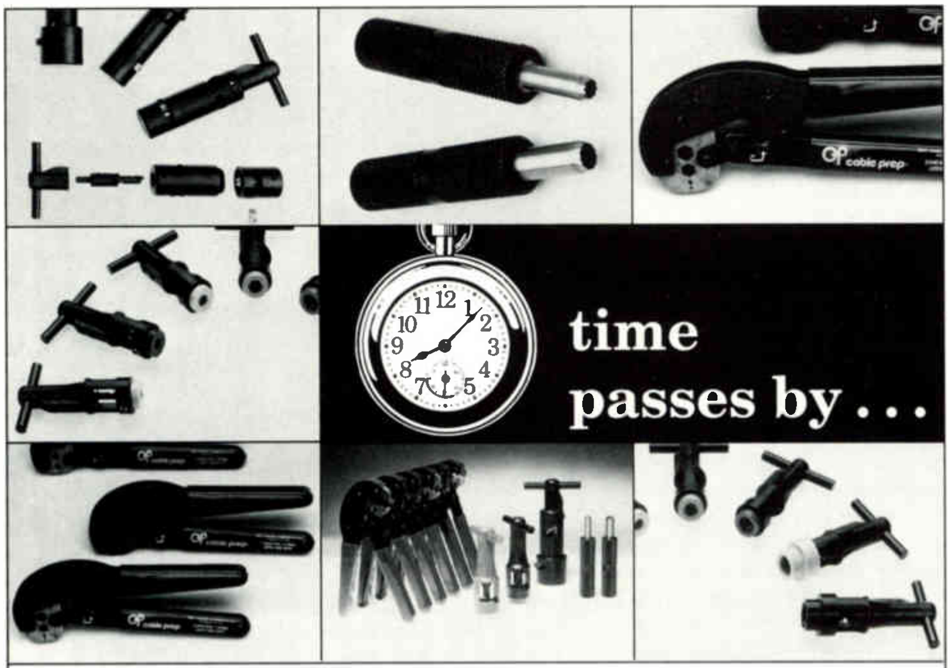
Available from Penn Institute, *Protecting Engineering Ideas & Inventions* is a new 223-page legal guide for engineers, scientists and managers who must know how to legally protect a company's engineering work. Written by Ramon Foltz and Thomas Penn, this guide covers legal issues including patents, copyrights, trademarks, trade secrets and secrecy agreements and how to work with outside consultants and handle outsiders' ideas. It is written in nonlegal language and is organized specifically for R & D activities.

For more information, contact Penn Institute, P.O. Box 41016, Cleveland, Ohio 44141, (216) 237-2345; or circle #129 on the reader service card.

## Tool catalog

The Ripley Co. released a new catalog featuring its complete line of cable preparation tools, including jacket and coax cable strippers, coring and combination coring/stripping tools, hex crimping tools, conductor cleaners and accessories for trunk, distribution and drop cables. According to the company, there are tools in all sizes for all applications and cable made by every manufacturer.

For additional details, contact Ripley Co., 46 Nooks Hill Rd., Cromwell, Conn. 06416, (203) 635-2200; or circle #140 on the reader service card.



*Schmeck*

**Pioneer Communications of America** appointed **Richard Schmeck** as Central region account manager for its CATV division. He was formerly Western regional service manager for General Instrument's Jerrold Division. Contact: Sherbrooke Office Centre, 600 E. Crescent Ave., Upper Saddle River, N.J. 07458-1827, (201) 327-6400.

**Anixter Communications** named **John Dallesandro** regional sales manager for its Northeast region. He was most recently district manager for the company's New York City CATV accounts. Contact: 4711 Golf Rd., 1 Concourse Plaza, Skokie, Ill. 60076, (312) 677-2600.

*Rounce*

**John Rounce** was named vice president of marketing for **Biddle Instruments**. Prior to joining Biddle, he served as national sales manager for Kustom Electronics. Contact: 510 Township Line Rd., Blue Bell, Pa. 19422, (215) 646-9200.

**ADC Telecommunications** named **Robert Nyholm** account manager for its Mid-Atlantic district. Prior to joining ADC, he was the Mid-Atlantic regional account representative for Plantronics of Portland, Ore. Contact: 4900 W. 78th St., Minneapolis, Minn. 55435, (612) 835-6800.

**David Leonard** was appointed president and general manager of **United Cable Television of Colorado**. He was formerly vice president of Western division operations for United Cable Television Corp. Contact: 4700 S. Syracuse Parkway, Denver, Colo. 80237, (303) 779-5999.

**C-COR Electronics** appointed **Richard Faulkner** to product manager for the data group. Prior to this, he was Western regional account executive.

**John Tucker Jr.** was promoted to Eastern regional account executive. Most recently, he was data sales representative. Contact: 60 Decibel Rd., State College, Pa. 16801, (814) 238-2461.

*Novy*

**Russell Novy** was named advertising coordinator for **Mitsubishi Electronic Sales America**'s professional electronics division. He previously served in sales support and sales training positions. Contact: 110 New England Ave. West, Piscataway, N.J. 08854, (201) 981-1414.

# CALENDAR

## August

**Aug. 3: SCTE Rocky Mountain Chapter** technical seminar on distribution systems, Jones Intercable, Englewood, Colo. Contact Steve Johnson, (303) 799-1200.

**Aug. 7-10: New Mexico Cable Television Association** annual convention, Inn of the Mountain Gods, Mescalero, N.M. Contact Raymond Davenport, (505) 983-5885.

**Aug. 8-11: Siecor Corp.** technical seminar on fiber-optic installation and splicing for utility applications, Hickory, N.C. Contact (704) 327-5539.

**Aug. 8-12: Hughes Microwave** technical training seminar on channelized AML equipment, Torrance, Calif. Contact (213) 517-6244.

**Aug. 9: SCTE Chattahoochee Chapter** BCT/E review course on Categories I and VII and testing, Perimeter North Inn, Atlanta. Contact Dick Amell, (404) 394-8837.

**Aug. 10: SCTE Wyoming Meeting Group** technical seminar. Contact Jim Niswender, (307) 324-2286.

**Aug. 11: SCTE Central California Meeting Group** technical seminar on troubleshooting power problems. Contact Andrew Valles, (209) 453-7791; or Dick Jackson, (209) 384-2626.

**Aug. 16: SCTE Oklahoma Meeting Group** technical seminar. Contact Herman Holland, (405) 353-2250.

**Aug. 16: Oklahoma Cable Television Association** annual convention, Marriott Hotel, Oklahoma City. Contact Steve Lowe, (405) 943-2017.

**Aug. 17: SCTE Delaware Valley Chapter** technical seminar on HDTV, Super-VHS and impulse pay-per-view, Williamson Restaurant, Horsham, Pa. Contact Diana Riley, (717) 764-1436.

**Aug. 17: SCTE Ohio Valley Chapter** technical seminar on HDTV, Ramada Inn East, Columbus, Ohio. Contact Jon Ludi, (513) 435-2092.

**Aug. 17: SCTE Hudson Valley Chapter** technical seminar and BCT/E testing, Holiday Inn, Kingston, N.Y. Contact Wayne Davis, (518) 587-7993; or Bob Price, (518) 382-8000.

**Aug. 17-19: Rocky Mountain Cable Television Association** annual meeting, Snowbird, Utah. Contact Tom Bork, (801) 486-3036.

**Aug. 22-25: Siecor Corp.** technical seminar on fiber-optic installation and splicing for LANs, building and campus applications, Hickory, N.C. Contact (704) 327-5539.

**Aug. 23-24: SCTE Cascade Range Chapter** technical seminar "Hands-on equipment workshop," Red Lion Inn at the Quay, Vancouver, Ore. Contact Randy Love, (503) 370-2770.

**Aug. 23-27: Wyoming Cable Television Association** annual convention, Jackson Hole Racquet Club, Jackson Hole, Wyo. Contact Mike Ross, (307) 742-8258.

**Aug. 24: SCTE Appalachian Mid-Atlantic Chapter** technical seminar. Contact Ron Mountain, (717) 684-2878.

**Aug. 24: SCTE Greater Chicago Chapter** technical seminar on power supplies, batteries and grounding. Contact William Gutknecht, (312) 690-3500.

**Aug. 26: SCTE Heart of America Chapter** technical seminar. Contact Wendell Woody, (816) 474-4289.

**Aug. 30: SCTE Satellite Tele-Seminar Program**, a BCT/E review course on Category V, 12-1 p.m. ET on Transponder 7 of Satcom F3R. Contact (215) 363-6888.

## September

**Sept. 7-9: Eastern Show**, Atlanta Merchandise Mart, Atlanta. Contact Nancy Horne, (404) 252-2454.

### Planning ahead

**Sept. 7-9:** Eastern Show, Atlanta Merchandise Mart, Atlanta.

**Sept. 27-29:** Great Lakes Expo, Cobo Hall, Detroit.

**Oct. 4-6:** Atlantic Show, Convention Center, Atlantic City, N.J.

**Oct. 18-20:** Mid-America Show, Hilton Plaza Inn, Kansas City, Mo.

**Dec. 7-9:** Western Show, Convention Center, Anaheim, Calif.

# AD INDEX

# Distance calculations

**By Ron Hranac**
**Jones Intercable Inc.**

It sometimes is necessary to determine the distance between two geographical points. For example, microwave license applications require path length information to the nearest 0.1 mile. One extremely accurate way to calculate distance between two locations is the great circle method. It makes use of the geographical coordinates of the two locations, and the following formula:

$$\text{Distance (nautical miles)} = 60 \times \left(\cos^{-1}[\sin(\text{lat}_1) \times \sin(\text{lat}_2)] + [\cos(\text{lat}_1) \times \cos(\text{lat}_2)] \times [\cos(\text{long}_2 - \text{long}_1)]\right)$$

where:
$\text{lat}_1$ = latitude of first location
$\text{long}_1$ = longitude of first location
$\text{lat}_2$ = latitude of second location
$\text{long}_2$ = longitude of second location

**Problem:** Calculate the distance between a headend whose coordinates are 41°22′03″ north latitude, 105°38′56″ west longitude, and a remote hub site whose coordinates are 41°35′17″ north latitude, 105°39′32″ west longitude.

**Solution:** You must first convert the geographical coordinates from degrees-minutes-seconds to decimal degrees.

| Headend | | | Hub site | | |
|---|---|---|---|---|---|
| 41° = | | 41.000000000 | 41° = | | 41.000000000 |
| 22′ | = 22/60 = | 0.366666667 | 35′ | = 35/60 = | 0.583333333 |
| 03″ | = 3/3600 = | 0.000833333 | 17″ | = 17/3600 = | 0.004722222 |
| | | $\text{lat}_1$ = 41.367500000° | | | $\text{lat}_2$ = 41.588055555° |
| 105° = | | 105.000000000 | 105° = | | 105.000000000 |
| 38′ | = 38/60 = | 0.633333333 | 39′ | = 39/60 = | 0.650000000 |
| 56″ | = 56/3600 = | 0.015555556 | 32″ | = 32/3600 = | 0.008888889 |
| | | $\text{long}_1$ = 105.648888889° | | | $\text{long}_2$ = 105.658888889° |

Next calculate the distance (nautical miles) using the formula:

$$\begin{aligned}\text{Distance} &= 60 \times \left(\cos^{-1}[\sin(41.367500000^\circ) \times \sin(41.588055555^\circ)] + [\cos(41.367500000^\circ) \\ &\quad \times \cos(41.588055555^\circ)] \times [\cos(105.658888889^\circ - 105.648888889^\circ)]\right) \\ &= 60 \times \left(\cos^{-1}[0.660886272 \times 0.663770305] + [0.750486066 \times 0.747936483] \\ &\quad \times [\cos(0.010000000)]\right) \\ &= 60 \times (\cos^{-1}[0.438676682] + [0.561315909] \times [0.999999985]) \\ &= 60 \times (\cos^{-1}[0.999992576]) \\ &= 60 \times (0.220778552) \\ &= 13.246713110 \text{ nautical miles}\end{aligned}$$

To convert the distance to statute miles, multiply the nautical mileage by 1.1508: 13.246713110 × 1.1508 = 15.24 miles

To convert the distance to kilometers, multiply the statute mileage by 1.609: 15.24 × 1.609 = 24.52 kilometers

# Windows on the future

**By Walter S. Ciciora, Ph.D.**
Vice President of Technology
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We should never lose sight of the fact that our subscribers enjoy (or are frustrated by) our cable service through the consumer electronics they own. For this reason it is very important to keep a sharp eye out for trends in consumer electronics. It is also important to try to influence those trends in cable's best interest.

There are two important windows on the future of consumer electronics: the Electronic Industries Association's Consumer Electronics Show (CES) and the Institute of Electrical and Electronic Engineers' International Conference on Consumer Electronics (ICCE). CES gives us a peek at six months to a year from now, while ICCE tells us what is coming one to three years down the pike. Both of these important events take place in Chicago in the first week of June. ICCE is deliberately scheduled to follow CES so that engineers can cover both with one plane ticket.

Just four or five years ago, it was very unusual to see a cable technologist at either ICCE or CES. I'm happy to report that a number of cable folks now attend; in fact, they regularly contribute papers and presentations. It is important for cable technologists to attend CES and ICCE at least once every few years to get a grip on what subscribers will be using in their homes.

> *"It is important for cable technologists to attend CES and ICCE... to get a grip on what subscribers will be using in their homes."*

### Setting trends

While there were a lot of interesting developments on display at this year's CES, two can be considered trend setting for cable: IDTV and really great projection TVs.

IDTV is improved definition television. It is one of the members of the family of the advanced television system. IDTV has the specific requirement that it be 100 percent compatible with good old NTSC, our current TV transmission standard. In fact, IDTV permits no changes in the broadcast signal. All the improvements must be accomplished in the receiver.

There are three fundamental improvements implemented in IDTV receivers: 1) raster line doubling, 2) NTSC artifact reduction and 3) noise processing. Since IDTV is not in any way a "standard," each manufacturer will implement it in its own way. Hence, there will be a wide variety of levels of achievement. The danger in this is customer confusion. A likely marketing strategy to avoid this is for the manufacturers to come up with clever names for their separate versions of IDTV.

Raster line doubling has as its goal the elimination of the visibility of picture line structure. The methods for doing this range from simple-minded to very sophisticated. The simple-minded approach simply repeats each raster line twice. This may be worse than doing nothing at all! Diagonal lines become jagged stair steps. The result is very annoying, but it's cheap. Only one horizontal line (53 microseconds) of memory is required. It can be implemented digitally, with analog charge-coupled devices, glass delay lines or surface wave delay lines. Sophisticated line doubling stores whole frames (16 milliseconds) and computes the information for the newly introduced lines using complex algorithms. While this is expensive to implement, the results are startling. Sophisticated line doubling is done exclusively in digital form.

The same digital circuits that do the line doubling are used to reduce the NTSC artifacts. These are the crawling dots and extraneous rainbows of color that make a TV picture inferior to a photograph. "Three-dimensional comb filters" are the primary tools for separating the signals into components free of these annoying features that are never seen in nature.

Noise reduction is the most difficult feat to be achieved. This is because once noise pollutes an analog signal, it is almost indistinguishable from the signal itself. Popular techniques involve averaging parts of the signal that should be the same. This approach works well with still pictures, but it has difficulties when faced with moving picture elements. Often, picture resolution is lost in the process of noise reduction.

The Advanced Television Systems Committee has had a subcommittee working on IDTV. That subcommittee made very little progress, for a very understandable reason. Since the transmission standard was not changed, all the improvements became proprietary competitive tools for the individual manufacturers. These fierce competitors were not about to give any of their secrets away to a committee of their rivals.

The second trend-setting development at CES was greatly improved projection television. While "garbage units" are still available for the undiscriminating, true quality is now obtainable. Large-screen projection sets have in the past suffered from a lack of brightness and poor color purity. The brightness problem has been addressed in the past with lenses and a screen that focus the light in a "sweet spot" in the center of the room. Viewers who didn't get in the best location suffered with dim and defocused pictures. That has all changed. The subscribers willing to part with $2,000-$3,000 will be able to put a bright, quality display in their viewing rooms and not have to close the drapes.

A very powerful combination arises when these two advances are combined. The IDTV projection viewer receiver is a compelling piece of hardware. Over the next few years, the image quality of large-screen receivers will improve dramatically.

Two developments at ICCE regard cable and are worth noting. First, I presented a three-hour course on cable TV and its relationship to consumer electronics. It was well-attended; our friends in the consumer electronics technical community are genuinely interested in working with us to provide our subscribers and their customers with the best possible pictures. The second item worth noting is a number of papers on digital VCRs for consumer use. ICCE papers generally precede product introduction by one to three years. Sometimes the products never appear. But there is sufficient activity on digital recording of video to predict that this one will happen. Truly high quality prerecorded video will be the result.

### You can't hide

Just 10 years ago, consumer electronics could not fully utilize all the quality there was in an NTSC signal. It was possible for the signal defects introduced by older or poorly maintained cable systems to go unnoticed. That is no longer the case. To quote an overused phrase, "You can run but you can't hide." Poor signal quality will be obvious and unacceptable. ■

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**Group Vice-President/Technology**
**Jones Intercable**

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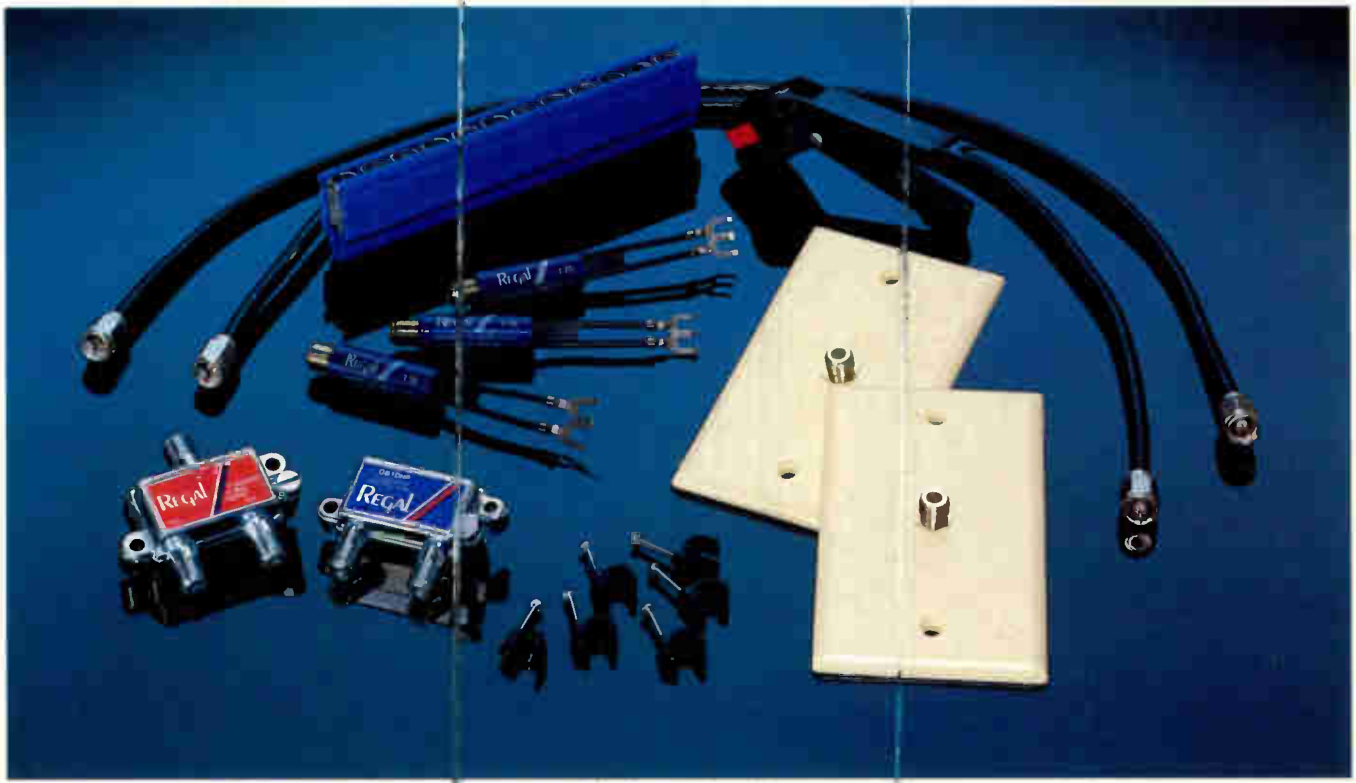
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