COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

The many facets of testing

New light on fiber applications

December 1985


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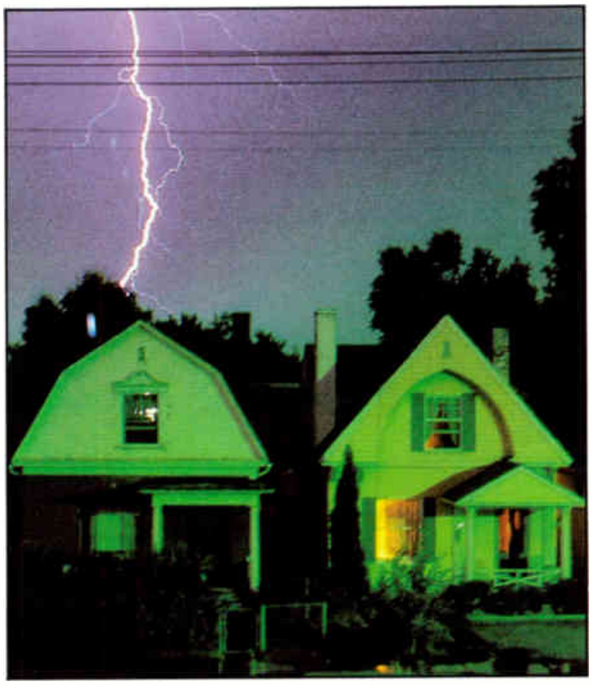
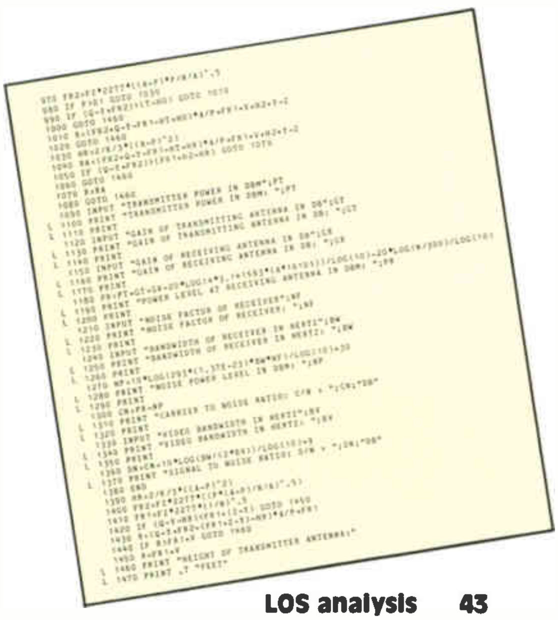


Bob Sullivan



Features

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GENERAL INSTRUMENT

An 'audited' coming out

"Welcome to BPA. It is our pleasure to inform you that *Communications Technology* is now officially a member of Business Publications Audit of Circulation Inc. Your membership has been approved by the BPA board of directors. Your publication joins more than 1,100 business, industrial, technical and professional publications which have voluntarily opened their records for independent verification and documentation of their circulation data."

So read a portion of a letter I recently received from Joseph Foley, president of BPA. The letter, and more importantly, its notification of acceptance as a member of BPA, is something we've been looking forward to for some time and are very proud of.

BPA is an independent, not-for-profit organization that prepares audited statements of a publication's circulation to provide advertisers with assurance that their ads do in fact reach the target audience they want. As well, the audit will help our editors better tailor articles to the interest of you, *CT*'s readers, by way of knowing your occupations, job titles and geographic locations, among other things.

The result of all of this will be better service for our supporters—both advertisers and subscribers. And speaking of our subscribers, I want to thank each of you—for without your support, there would be no circulation data to audit. In addition, I want to acknowledge the efforts of Greg Packer, our circulation director, for his diligence in getting us successfully through this.

Congratulations, Tom

Congratulations are in order for one of our industry's technical leaders, Tom Polis. Polis, current principal and executive vice president of RT/Katek Communications Group's Communications Construction Division, recently added the title of corporate vice president of sales and engineering to his moniker.

In his new capacity, he will be coordinating the company's national sales efforts and overseeing all engineering and telecommunications projects, in addition to his daily divisional responsibilities. An 18-year cable veteran, Polis is also the current president of the Society of Cable Television Engineers.

Stay tuned . . .

As most of you are aware, in our last issue we had the first of a four-part series entitled "Data communications and CATV," by Terry Stanard and Richard McKeon of Dumbauld &

Associates. We all had intended to run the second installment this month, but due to a sudden illness of one of the authors, McKeon, the series had to be slightly postponed. McKeon, who is recovering nicely, is back at work; so stay tuned, part two will appear in the January *CT*.

Opportunity

With the flavor of Thanksgiving still on our palates and the Western Show approaching the memory stage, we have once again reached that point in time where we can reflect on the past and look toward the future. I think most of us in the cable industry will agree that 1985 was not a banner year, but not our worst either. What then, do we have to look forward to?

The answer to that, quite simply, is another year of opportunity. The opportunity to do more, and do it better. The opportunity to set new goals and see them come to fruition. The opportunity to see ourselves and our industry mature. The opportunity to prove that cable is, indeed, the medium of choice. The opportunities are there, but will we know when opportunity knocks that it's for us? I hope so.

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BPA

Western Show meets the challenge

ANAHEIM, Calif.—"Meeting the challenge" is the theme for this year's Western Show, sponsored by the California Cable Television Association. The association is expecting approximately 8,000 attendees to converge on the Anaheim Convention Center to peruse the wares of some 175 exhibitors.

The exhibit hall will be open from 10 a.m.-6 p.m. on Wednesday Dec. 4 and Thursday Dec. 5; and from 10 a.m.-3 p.m. on Friday Dec. 6. Exclusive exhibit hall hours are from 11:15 a.m.-12:45 p.m. and 4-6 p.m. on Thursday, and 11:15 a.m.-12:15 p.m. on Friday.

In cooperation with the California association, the Society of Cable Television Engineers has coordinated the show's technical sessions. Responsible for organizing these sessions were Bob Vogel, SCTE Region 1 director (Sytek Inc.), and Pete Petrovich, past president of SCTE's Golden Gate Chapter (Viacom Cable).

Technical agenda

Thursday, Dec. 5, 1985

- 8:30-9:45 a.m.—"A Look at the LAN'scape: A Discussion of local area networks"
  Moderator: Tom Elliot, director of R&D, Tele-Communications Inc., "Satellite data delivery." *Speakers:* Cliff Schrock, president, C-COR Labs Inc., "Local area networks"; Pat Miller, marketing manager, data/LAN, Scientific-Atlanta, "Industrial LANs"; and Andy Paff, manager of new business development, Viacom Cable, "Cable operator economics of local area networks."

- 10-11:15 a.m.—"Will pay-per-view reach a busy signal?"
  Moderator: Dave Archer, director of new business development, Viacom Cable. *Speakers:* Maggie Wilderotter, vice president of sales and marketing, Cable Data, "PEP unit (automatic response unit)"; Vito Brugliera, vice president of marketing and product planning, Zenith Cable Products Division, "PhoneVision (two-way converters)"; Donna Brickell, project manager, CATV/wideband services, Pacific Bell, "ANI (automatic number identification)"; and Hal Krisbergh, vice president/general manager, Jerrold Subscriber Systems, "Star Phone (store and forward)."

- 2:30-4 p.m.—"Current engineering issues before the cable industry."
  Moderator: William Riker, executive vice president, SCTE. *Speakers:* Wendell Bailey, vice president of science and technology, NCTA, "NCTA Technical Committee on Satellite Scrambling"; Robert Luff, senior vice president of engineering, United Artists Cablesystems, "NCTA Engineering Committee activities"; Syd Bradfield, engineer, Cable Branch, FCC Mass Media Bureau, "Commission dockets affecting cable"; and Steve Ross, chief, Cable Branch, FCC Mass Media Bureau, "Technical deregulation."

Friday, Dec. 6, 1985

- 8:30-9:45 a.m.—"Customer Service: The technician's contribution."
  Moderator: Jim Chiddix, senior vice president of engineering, Oceanic Cablevision. *Speakers:* Larry Coe, manager, Viacom Cablevision, San Francisco, "Using computer reports to improve service call efficiency"; Steve Gautereaux, vice president of operations, Cox Cable, San Diego, "One stop service calls"; and John Stewart, operations manager, TCI Cable, Portland, "Improving technician productivity and customer relations."

- 10-11:15 a.m.—"Hitting pay dirt: Issues in underground construction."
  Mark Hoyal, president, U.S.A., Southern California, "Utilizing USA"; and Tom Robak, president, Robak Construction, "Contractor negotiation and coordination."

- 1:45-3 p.m.—"Roundtable discussion on the PacBell Bluebook."
  Moderator: Bill Winter, California Cable Television Association. Reps from Pacific Bell will be present to answer questions on the Bluebook.

Call for tech papers

OTTAWA—The Canadian Cable Television Association is now developing the technical program for its 29th annual convention May 13-15, 1986, in Vancouver. Original papers on topics of interest to the cable television community are invited. The convention papers will be published in a technical digest and it is planned to have the digest available for pre-registrants and during the convention.

Papers are welcome on any communications engineering topic related to cable television. Possible topics include: pay-per-view, terminal equipment, DOC regulations, two-way cable, technical standards, networking and architecture, data transmission, audio and other subcarrier services, signal leakage, and advanced techniques. Presentations will be limited to a maximum of 20 minutes including discussion. Full length and short papers will be accepted in both French and English.

Persons interested in preparing a paper for the tecnical sessions are requested to submit a one-page, 150 to 200 word abstract no later than Dec. 31, 1985. If your paper is selected, you will be notified shortly thereafter and your complete paper will then be due March 15, 1986. Please submit your abstract to: Roger Poirier, vice president of technology and planning, Canadian Cable Television Association, 85 Albert St., Suite 405, Ottawa, Ontario, Canada K1P 6A4.

Showtime/TMC scrambling dates set

NEW YORK—Test scrambling will begin on Monday Jan. 13 on the satellite feeds of both Showtime and The Movie Channel, announced Stephan Schulte, senior vice president, operations and production services, Showtime/The Movie Channel Inc. The shipment of M/A-COM Videocipher II scrambling decoders commenced in September and will be entirely fulfilled by Dec. 31, 1985, to all affiliates who have properly registered their headends. Testing will commence approximately two weeks later, first for each service's Eastern feed and later for their Western feeds. The company further expects to fully scramble all satellite signals in May 1986.

Looking ahead: SCTE's Expo '86

WESTCHESTER, Pa.—The Society of Cable Television Engineers is bringing its fourth annual Cable-Tec Expo to the Phoenix (Ariz.) Convention Center June 12-15, 1986. Breakout workshops, hands-on instruction and hardware exhibits will be among the features available for attendees' information on the latest available technical equipment.

The Phoenix Hyatt will offer room rates of $50.00/single and $59.00/double for convention attendees. The price per individual drops to $29.50 per night if rooms are shared.

The 10th annual Spring Engineering Conference kicks off the expo on Thursday, June 12, featuring technical papers written by respected industry engineers. Friday and Saturday will be filled with hands-on technical workshops. Non-commercial exhibits demonstrating the latest in state-of-the-art equipment will also be on site for the further education of attendees. The BCT/E examination covering all seven categories will be held Sunday morning along with additional workshops.

For more information, please see this month's *Interval* and circle #1 on the reader service card.

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Tests and measures: The new era

By Dennis Carlton
Engineer-in-Charge, Field Operations Bureau, FCC

Few businesses exist without some form of tests and measures. Different businesses test differently and measure different parameters, but in the end they are all looking for the same thing: information about their business and how it is performing. It could be reliability testing, market testing, or product performance testing. Nothing elaborate is required in many cases, nothing more than being alert for indications and measures of business performance. The number of complaints received, sales volume, profits, number of customers, and a myriad of other indicators can all play a part in determining business success.

Cable television systems, like many other businesses, have technical parameters that must be adhered to in order to ensure that high-quality product is distributed to its customers. These parameters must be routinely tested and adjusted when necessary. If you exceed specified tolerances, or if a piece of equipment malfunctions, prompt repair service can return the system to normal.

Technology and innovation set most of the standards in testing, while methods of technical measurements are governed by engineering principals. Regulatory agencies (the FCC and others) may set forth testing methods, specific parameters to be tested, even the tolerances to be maintained. But these requirements are usually based on interference potential, customary engineering practices, or in the case of mandated technical parameters, levels where service to subscribers would be degraded if they were not met.

Some people might disagree. But it is because people disagree about the relative importance of various technical standards and measurement techniques, that many testing programs fail. The people making the tests don't believe in them, so they ignore the results. This happens a lot in tests and measurements that are mandated by regulation. What is most important then, in any testing program, is that you test something that you believe important, and that you subsequently act on the results of your tests. Sure, you're going to have to abide by regulations, but if you don't think the required tests are good indicators of your system's performance, do something additional, meaningful to you.

Since the recent deregulation of cable signal quality standards, except for signal leakage standards, all the decisions about quality standards are going to be left up to system operators, MSOs and local regulatory authorities. The FCC won't be involved. Good signal quality means good business, and effective tests and measurements can help.

The standards evolve

In the era of the first CATV systems in the late 1940's there was really just one main objective in establishing a cable system, and that was to provide television programming to those areas that couldn't receive broadcasts directly, either because they were too far from the transmitter or they were shielded from it by terrain. Quality of the cable signal was certainly important, but it was also relative. Anything was a lot better than nothing and the ability to receive TV signals, of any quality, was the most important matter.

As it is with any new technology things improved; the purpose of cable was redefined, operations were altered and became more structured. Systems were placed in communities that already had off-air television and greater program variety became an additional selling point of cable. Subscribers were offered a selection of stations to watch and they were no longer limited to whatever the local broadcaster had to offer. So when the first cable regulations were enacted by the Federal Communications Commission they were aimed at preserving local broadcasting. Cable systems were required to carry all local TV stations, they were prohibited from same day duplication of any programs shown by local stations, and they were prohibited from importing distant signals into the top 100 television markets without hearings on their possible effects. Technical parameters also were instituted to guarantee that cable systems carrying local broadcast stations on their systems did so without material degradation of the stations' signal quality.

These 1966 regulations evolved into a comprehensive set of cable rules adopted in 1972 that included: franchising standards, signal carriage, network program non-duplication/syndicated program exclusivity and technical standards. There were several others that applied depending on the system size, and whether or not cable programming was originated.

Cable rules and regulations have changed continually since 1972; some for the better and some for the worse depending on your perspective. Most of the changes have been to remove unnecessary restrictions or to adjust existing ones to better achieve their intended purpose. This is especially true where market forces have supplanted the need for regulatory mandate. Regulatory trends in many services are shifting from signal quality and programming concerns to spectrum management considerations like electromagnetic compatibility, interference prevention and spectrum efficiency.

The changing environment

Changes in the cable television technical regulations in the past few months exemplify this shift and are ones that will surely affect your future testing programs. The most recent is the cancellation of technical quality standards and performance testing requirements contained in Section 76.605 and Section 76.601 of the FCC Rules and Regulations. Subscriber quality standards are now completely up to the system, MSO and local entities. As far as quality standards are concerned, what you test, when you test, and what you do with test results are going to be up to you. Nothing is wrong with continuing to abide by the technical parameters and testing guidelines previously contained in the regulations. They will be retained as recommended minimum standards, as opposed to being required, and will be available for use by local regulatory authorities in establishing quality standards. More stringent requirements may not be imposed, however.

This change may not be a concern for many because most MSOs and individual system operators have testing/measuring programs and operational standards far more stringent than those required. The major difference is that now no one will be much interested in the specifics of whether or not your system meets technical standards unless, of course, you are.

The regulatory scheme is not the only thing changing in cable, the market is changing and expanding too. Quality is much more important to subscribers than it once was. A slight aberration in the signal, or temporary degradation in quality is not nearly as tolerable as it once was, particularly to customers who have VCRs or large screen hi-fi televisions. And if the customer becomes dissatisfied with quality, he has other alternatives such as TVRO and multi-point distribution services to turn to. This is not a point to be taken lightly since cable is no longer the only show in town. There may have once been a time when a cable system could procrastinate repair knowing there was no other alternative available to customers, but that time is no more for most systems.

Cable subscribers will continue to demand signal quality as they have in the past, they just have more leverage today. They'll complain if something goes awry, and if it becomes completely intolerable, or if the problem is not repaired promptly enough to suit them, they'll discontinue their service and look elsewhere for video entertainment. Actually the subscriber will do most of a system's testing and measuring by complaining of degraded signals, interference, or other things that affect reception. Systems just have to be good listeners. Whether, in the end, the cause is an unauthorized cable tap or amplifier malfunction is of little consequence, as long as the situation is attended to quickly and the problem is repaired.

Signal quality and reliability are two of the more important attributes of a cable television system. If they are compromised for any reason excuses are not well received, even if justified. Subscribers become accustomed to a particular standard and they tend to react when either the signal quality deteriorates, or when a particular channel vanishes for some predictable reason. For instance, every time it rains or snows. So while it's important to periodically make performance measurements on a CATV system to check things like frequency response, visual-to-aural signal ratios, and carrier frequencies, always remember that these technical measurements only corroborate good signal quality. If a particular channel looks terrible, or if your customers think it looks bad, then probably one or more of the technical parameters have varied from the desired, and some adjustment should be made. People are going to complain if they are dissatisfied, it's inevitable. So you might just as well incorporate their complaints into your testing program and use the number and type of complaints in assessing overall quality and reliability of your system.

Looking toward tomorrow

As less attention is being placed on mandated quality standards, more attention is being directed toward fostering electromagnetic compatibility and preventing interference. This is true in all radio services and not just in the cable industry. But there have been recent changes in the signal leakage requirements for cable systems, and while there are grandfathering provisions allowing for transition to the new standards, the time to think about compliance is now, not five years from now.

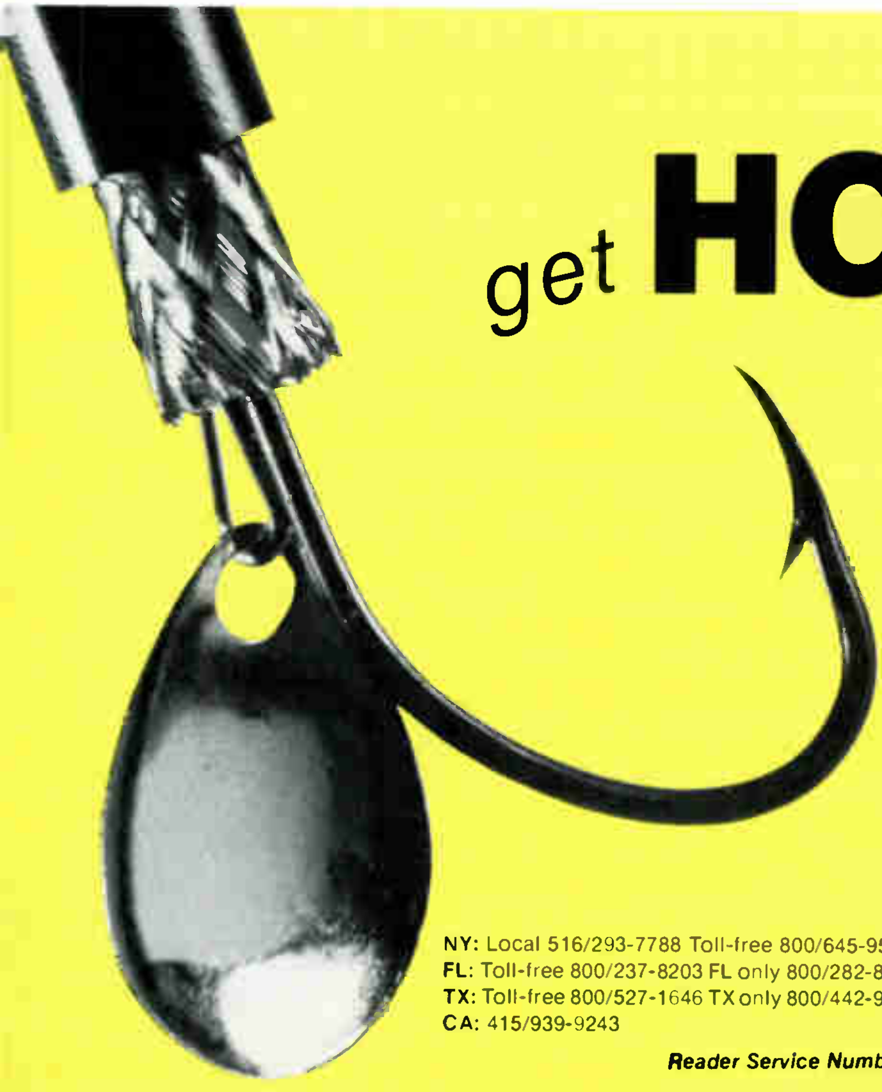
The current regulations pertaining to signal leakage require frequency offsets from aviation frequency assignments and they institute a new parameter, the CLI, to be used as an indicator of overall system leakage levels. The reasons for new regulations should not be misconstrued. They are not penalties for doing something wrong, they are compromise sacrifices for dealing with the reality of signal leakage and its possible adverse effects. It's also important to remember that ultimately the goal is to prevent signal leakage altogether, and to hopefully preclude all signal egress and ingress.

Even if regulations are complied with, and if for some reason harmful interference occurs, there still is a big problem that must be dealt with and in the end requirements may have to again be adjusted to eliminate the possibility of causing harmful interference. So think about system integrity and think about how to prevent leaks, then institute a maintenance or repair program that includes finding and repairing leakage sources as a routine function.

It's essential that there be an awareness of the significance of signal leakage control and to look at leakage repair as a means of long-term survival rather than a short-term labor burden. The social responsbility issues raised by the potential of harmful interference to aviation frequencies, or to other licensed users for that matter, are far too serious to dismiss. And even though they have to be addressed, they are not easily controlled by the market itself. The industry can become involved, however. The MSOs, the equipment manufacturers, all the way down to the individual installers, each have a role to play in reducing signal leakage. Priorities will just have to be adjusted, and innovative techniques implemented.

No amount of testing and measuring is sufficient and the existence of an elaborate preventive maintenance program is but wasted revenue if you don't see results. Increased customer satisfaction, lower number of service calls, and a minimum of signal egress and ingress, all should be objectives. An effective testing and measuring program is one way, but not the only way, to help ensure that these objectives are met. Don't forget about who the customer is and be attentive to his wants and needs. But above all, don't forget about what your business is. A cable television system is no longer just a means to bring TV programming to the geographically isolated. It's certainly not the *only* means to do this. For some systems, maintaining business is going to be a problem if quality and reliability are not attended to.

The views expressed are those of the author and do not necessarily reflect the views of the Federal Communications Commission.



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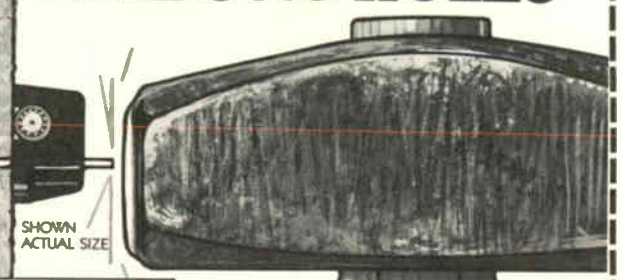
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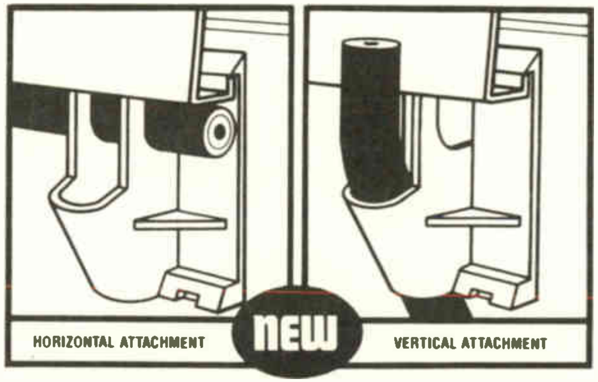

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'Average power' per FCC Part 76.610

By Robert V. C. Dickinson
Division Manager, Network Technologies

The release of the second report and order in Docket 21006 on Nov. 9, 1984, was favorable to the cable industry; particularly by the relaxation of threshold carrier power in the aeronautical bands from 10^{-5} watts to 10^{-4} watts peak power. The threshold power is that power above which frequency offsets are required. This increase in level had the effect of exempting many previously controlled signals and thereby easing the cable operator's task of complying with these rules formulated to prevent interference in the aeronautical radio bands. Certain important signals, however, usually exceed this power level and due to their specific characteristics could not be used at all. The most prominent of these is the high-level sweep. This signal is necessarily run above visual carrier level. It traverses the entire spectrum of the cable system and therefore cannot practically be subject to offsets. On the other hand, the high speed at which the signal passes through the spectrum makes it virtually inconsequential in terms of interference.

Recognizing these facts, the National Cable Television Association (NCTA) included this point in its petition for reconsideration of Docket 21006 suggesting the use of average power with certain constraints. They were successful in this matter as shown in the memorandum opinion and order (MOO) released on July 1, 1985 (which terminated the 21006 proceeding). The MOO changed references of "peak power" to "average power" as further defined below. The rationale for this approach plus some practical considerations follow.

In the mind of the Federal Communications Commission—and the cable industry as well—the primary goal has been protection of the aeronautical radio services from cable leakage interference. It has been determined by the FCC, and supported by the work of the Advisory Committee on Cable Signal Leakage (and others) that a continuous carrier level of 10^{-4} watts on a typical cable system with leakage not exceeding the regulated limits will not produce objectionable interference (see "Final Report of the Advisory Committee on Cable Signal Leakage", Nov. 1, 1979). This is taken as a "given." In addition, the FCC has determined that the nominal bandwidth of the radio receivers to be protected is 25 kHz—another "given."

Figure 1

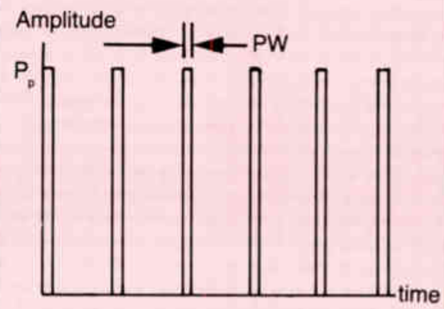
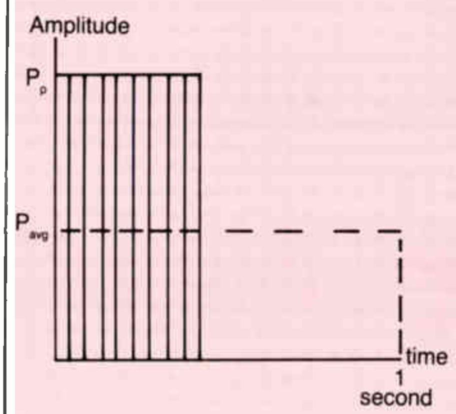


Figure 2



The rules of November 1984 specified "peak power." The peak power of high-level sweep must be in excess of the visual carrier level and almost universally exceeds the 10^{-4} watt threshold. However, a high-level sweep appears as a pulsed signal to the receiver with the 25 kHz bandwidth since it remains in that bandwidth for a very short time. One pulse is generated for each sweep of the spectrum.

The new rules adopted on June 21, 1985, as a result of the reconsideration employ the phrases ". . . carriers or signal components carried at an *average* power level equal to or greater than 10^{-4} watts across a 25 kHz bandwidth in any 160 microsecond period . . ." (76.610, 76.612, 76.615). This set of conditions derives from consideration of pulsed interference and its effect upon the aircraft receiver. Well then, what happens when a pulsed signal is applied to a receiver having the prescribed bandwidth?

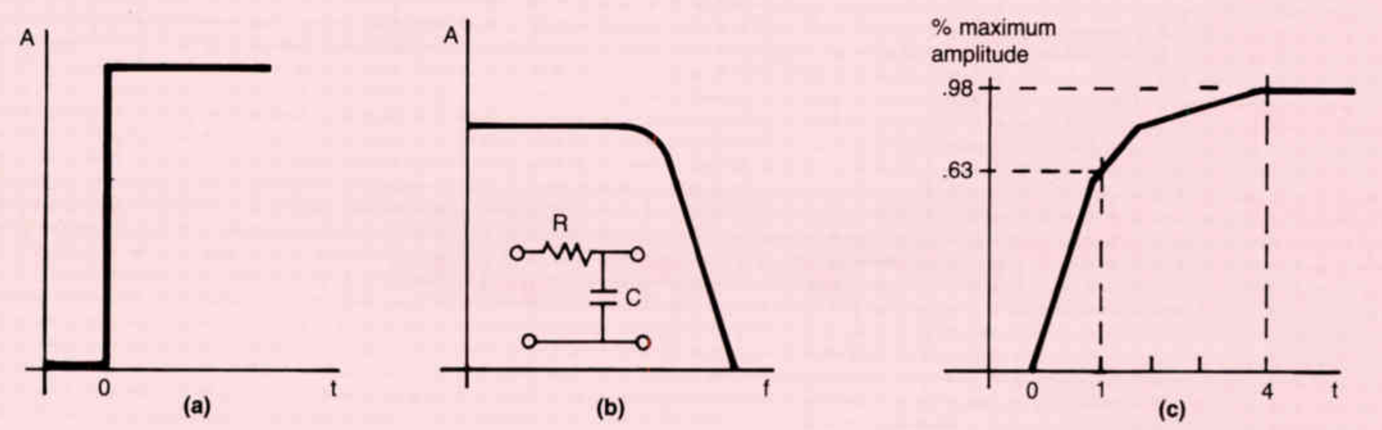
Let's start by examining average power. A string of pulses as illustrated in Figure 1 with uniform peak power produced an average power, which is represented by Formula 1.

$$P_{avg} = P_p \times PW \times f_p \qquad (1)$$

Where:
P_{avg} = average power in watts
P_p = peak power in watts
PW = pulse width in seconds
f_p = pulse repetition frequency in pulses per second.

One way to think of the average power is to take all of the pulses over a one second period as in Figure 1, push them left to the vertical axis as in Figure 2, and then squeeze them down until they have spread out evenly over the one second period. The amplitude that results is the average power given by Formula 1.

Figure 3



There is another effect that must be considered. When a steep wavefront, such as a leading edge of a single pulse (Figure 3a), is introduced into a narrowband filter (like a radio receiver) the output wavefront is not as steep since it takes a finite time for the signal to build up and reach its peak value within the narrow bandwidth.

The exact formula for this build up depends upon the type of circuits used, their tuning, etc. This effect, however, can be closely approximated by the formula for build up time in a simple RC low-pass circuit (Figure 3b) where a pulse with a steep wave front reaches a level of .63 times maximum in a period of time equal to the product of the resistance and the capacitance (the time constant $t=RC$). In order to produce an equivalent amount of interference we must determine a time interval in which the pulse can build and to equal or nearly equal its maximum value. For this purpose the value of four time constants was chosen since in four time constants the amplitude of a pulse with a steep wavefront will reach 98 percent of its full level. Relating this back to the given receiver bandwidth and approximating the time constant as one over the bandwidth (1/25 kHz or 40 microseconds), four time constants yield 160 microseconds, which is the number selected by the FCC for the integration time in the new rules.

Applying this parameter to a high-level sweep, we would like to know how much excess level (above 10^{-4} watts) we can tolerate due to the effects above, or in other words how high a sweep amplitude can we stand for the very short period in which the sweep traverses the 25 kHz bandwidth and still not exceed the average power limitation in any 160 microsecond period. To do this we must first determine the "effective pulse width" of the sweep signal in the narrowband receiver. This is essentially the amount of time required to sweep the entire spectrum divided by the number of receiver bandwidths in the entire spectrum (Formula 2).

$$PW_s = \frac{t_s}{\left(\frac{f_s}{BW_r}\right)} = \frac{t_s \times BW_r}{f_s} \qquad (2)$$

Where:
PW_s = effective sweeper pulse width in seconds
f_s = frequency range of the high level sweep in hertz
t_s = time required to sweep f_s in seconds
BW_r = bandwidth of the receiver in hertz.

The excess power (above the allowable limit) that may be employed by the sweep is expressed in Formula 3.

$$P_E = 10 \log \left(\frac{160 \times 10^{-6}}{PW_s}\right) \qquad (3)$$

Where:
P_E = excess power allowable in dB.

Note that the integration period is limited to 160 microseconds. At low repetition frequencies there will never be more than one single pulse appearing in the period so that a repetition frequency term is not needed. At repetition frequencies allowing more than one pulse to appear in 160 microsecond period (that is a frequency greater than 6,250 hertz), the repetition rate term must be added to Formula 3 to properly determine the average power (Formula 4).

$$P_{EM} = 10 \log \left(\frac{160 \times 10^{-6} \times f_p}{PW_s}\right) \qquad (4)$$

Where:
P_{EM} = excess power allowable at pulse rates of 6,250/second or greater in dB.

These two formulas apply to any type of pulsed signal. In cases where the pulse width and/or the repetition period is not uniform the computation must be made for the worst case in order to meet the Part 76 requirement of "...any 160 microsecond period...," Formula 4 is seldom if ever required relative to high-level sweeps.

To find the actual allowable level in dBmV we substitute Formula 2 in Formula 3 and add the maximum allowable power (+38.75 dBmV), yielding Formula 5:

$$P_A = 38.75 + 10 \log \left(\frac{160 \times 10^{-6} \times f_s}{t_s \times 25 \times 10^3}\right)$$

$$= 38.75 + 10 \log \left(\frac{6.4 \times 10^{-9} \times f_s}{t_s}\right) \qquad (5)$$

Using typical high-level sweep parameters, the excess level is expressed in Formula 6 and an absolute level in Formula 7. For typical high-level sweep:

f_s = 400 MHz
t_s = 10 milliseconds
$f_p \ll 6{,}250$ Hz

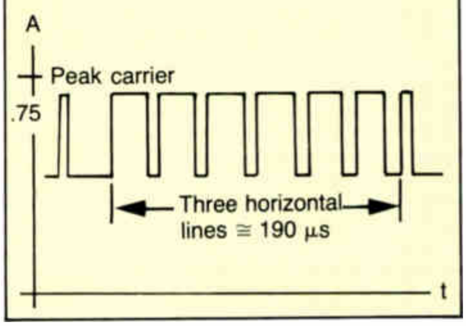
$$P_E = 10 \log \left(\frac{160 \times 10^{-6} \times f_s}{t_s \times BW_r}\right) = 24.1 \text{ dB} \qquad (6)$$

$$P_A = 38.75 + 10 \log \left(\frac{6.4 \times 10^{-9} \times f_s}{t_s}\right)$$

$$= +62.8 \text{ dBmV} \qquad (7)$$

Another case of interest relates to a standard NTSC TV signal, which employs sync pulses and various video levels. Since the sync tip is the highest energy in the modulated RF waveform it points to the worst case condition. The worst case condition, however, is not the sync pulse at the beginning of each horizontal line (since its duration is short), but the vertical sync pulse interval. Here, for a period of three horizontal lines (approximately 190 microseconds) the carrier runs at maximum amplitude except for about 20 percent of the time where it reduces to .75 of peak amplitude (Figure 4).

Figure 4



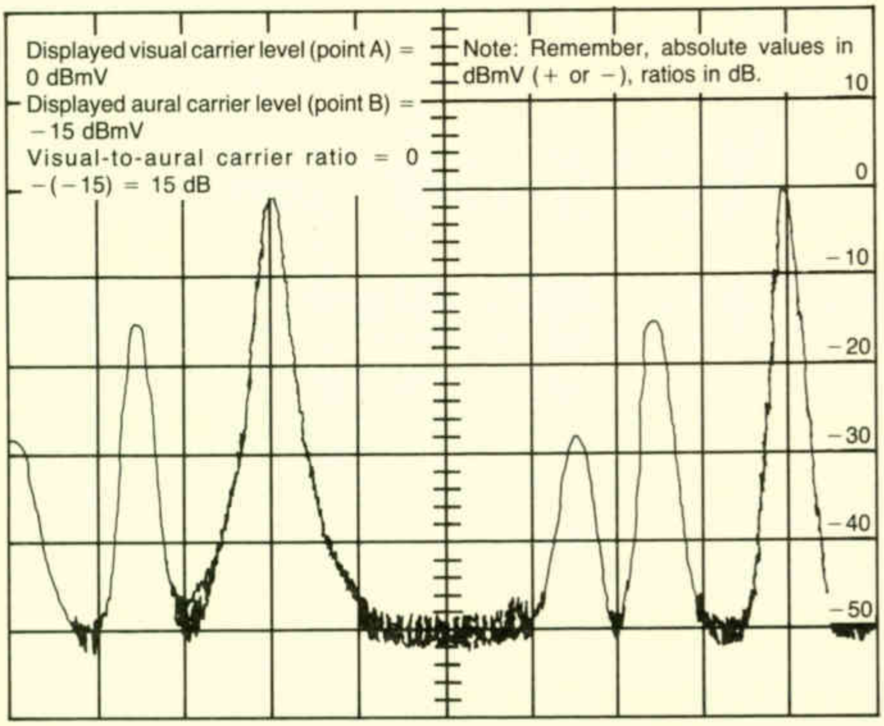
This is clearly in excess of the 160 microsecond limit. The average power of this waveform is less than peak carrier power, but it is still about 91 percent or −0.4 dB, which is insignificant in our consideration. By this it should be observed that the use of average power calculations *will not* benefit the cable operator by allowing him to run visual carriers at higher levels.

All of this is well and good, but we should consider how one might measure the average power of a given high-level sweep signal. The easiest and most straightforward way is to use a spectrum analyzer with an approximate 25 kHz bandwidth and note the maximum deflection. The measurement should be made without the video filter being sure that it is possible to see the maximum response, particularly if the signal is infrequent (a storage scope eases this problem). Should you use a spectrum analyzer with a 30 kHz bandwidth the resulting power level could be reduced by a factor of 0.8 dB (the ratio of bandwidths). Direct use of the 30 kHz bandwidth measurement gives the desired result without compensation and includes a 0.8 dB safety factor. (Note: Minor variations in measured power levels can result from different instrumentation circuitry and tuning but without further definition of the 25 kHz bandwidth" high precisions cannot be realized nor are they required by the subject at hand.)

Attempting to use a signal level meter is more complicated, particularly if one attempts to read the results from the deflection of the meter (plus correcting for the excess bandwidth). The meter movement becomes a governing time constant and, due to electrical and ballistic effects, is not easily interpreted and may vary between manufacturer's products. Use of a signal level meter is therefore not recommended. As far as the FCC is concerned a good engineering showing of equivalent results, using a different approach with a straightforward measurement procedure is sufficient to gain acceptance of an alternate method.

The rationale presented above has led to the present "average power" measurement required by Part 76. This new definition allows employment of high-level sweeps in almost all cases and may be of help for certain non-TV signals. This approach does not compromise the interference avoidance basis for protection of aeronautical radio services. ■

Figure 3: Analyzer display of a CATV channel signal where the visual-to-aural carrier ratio is being measured.



by means of the addition or subtraction of applicable values. For example:

Carrier level
(indicated on meter) = 0 dBmV
Meter attenuator = 12 dB
Amplifier test probe loss = 20 dB
Actual carrier level = 0 + 12 + 20
= +32 dBmV

Another major advantage of the measurement system is signal display range. A typical signal level meter can display 25 dB of level change. In terms of voltage, −25 dBmV to 0 dBmV = 56 microvolts to 1,000 microvolts. And, through the use of logarithmic conversion in the IF amplifier circuitry, the display is *linearly* calibrated in steps, such as 1 dB.

In practice, the following rules are worth remembering:

1) Always add test probe loss and any selected attenuation to the indicated (signal level meter) or displayed (spectrum analyzer) level in order to determine absolute values, Figure 1 illustrates this using a spectrum analyzer display.
2) When measuring ratios (carrier-to-noise, intermodulation, etc.) test probe loss is not significant (unless absolute level values are required) since the probe introduced the same amount of loss to all input signals. However, any change in input attenuation between level measurements must be considered. Figure 2 provides an illustrated example of an intermodulation measurement and Figure 3 illustrates visual-to-aural carrier measurement.
3) If an RF preamplifier is used in conjunction with the instrument, the gain (in dB) must be subtracted from any absolute value measurements. For example:

Carrier level (displayed) = −10 dBmV
Meter attenuator = 30 dB
Preamplifier gain = 26 dB
Test probe loss = 20 dB
Actual carrier level
= (−10) + 30 + 20 − 26
= +14 dBmV

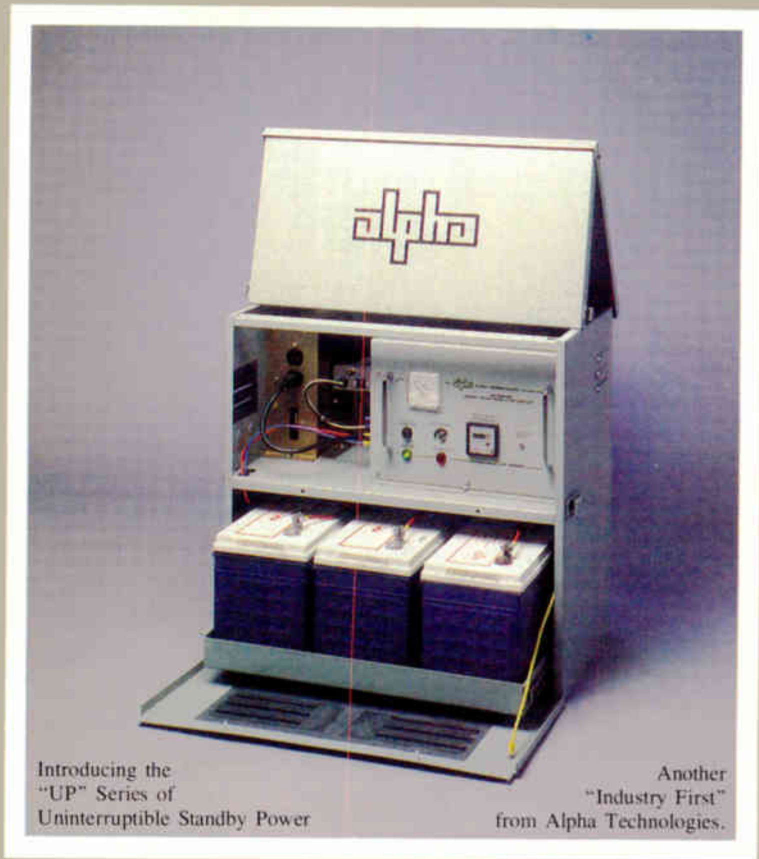
Changes in voltage levels expressed in decibels follow some rules that are interesting to know:

Voltage ratio = 2.1 or ½ = 6 dB change
Voltage ratio = 10.1 or 1/10
= 20 dB change
Voltage ratio = 100.1 or 1/100
= 40 dB change

A 6 dB pad provides half the input voltage at the output, a 20 dB trunk amplifier increases the input signal level 10 times, etc.

"What gives?" was the question asked at the beginning of this article. Hopefully, now what gives is a much better understanding of the CATV measurement system.

PROFIT BUILDER!



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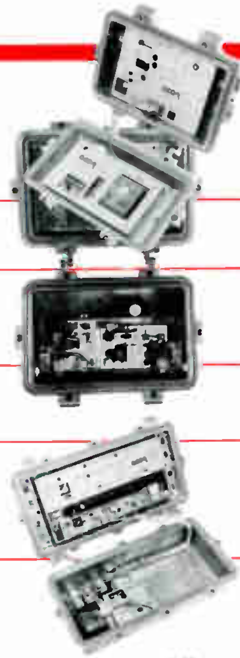

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Reader Service Number 18.

Successful bench alignment

By Hugh Bramble
Director of Engineering/West Division
United Artists Cablesystems Corp.

A system level CATV lab is one of the most often cussed and discussed items in a cable system. It is said by many that the lab results are quite esoteric and bear little if any relationship to the real world. The result of this kind of thinking by management, especially when supported by technicians' statements like, "It worked on the bench, but when I got to the field it had to be completely changed!", compound this problem. Unfortunately, back in the '60s when many current upper level managers were working in the field, this lack of correlation seemed real, and probably was.

Then, as now, the problem was more than likely the lack of calibration and/or pilot error, but the attitude persists and is now causing such things as loss of time and poor subscriber performance. Since neither of these results are in the best interest of the subscriber or the industry, the attitude must be changed if we are to survive and work efficiently. With today's much wider bandwidth systems and lower operating cash flow margins, the lab must become a cost saver. Fortunately, with a little care and planning, it can be.

If the above assertion that errors were common is true, how did system labs survive? As it turns out, what we thought we were doing and what was actually accomplished was not the same thing. Luckily, what was accomplished was what was required. We thought we wanted to "set amplifier levels as accurately as possible." What we did was set amplifier gains as close as possible to the span losses present. In other words, we created a unity gain transportation system. The subtle difference between these two actions becomes evident if we consider the accuracies possible with the equipment available at that time and even to some extent now.

In the old days, the best "field strength meter" available was barely able to claim ± 2.5 dB accuracy. They were, however, repeatable to within about 0.5 dB. The important thing was to make each amplifier output identical to the previous one, thus compensating exactly for the previous losses. The fact that the output level was not known very well makes little difference because of the headroom designed into the system and/or the minimal performance required.

It may be easier to visualize the difference in these two characteristics with the following example: On the bench, one is told to set an amplifier module's gain and slope controls to match an 1,800-foot span of cable having a loss of 1 dB per 100 feet at 220 MHz. The old rule of thumb said the loss at Channel 2 was half the loss at Channel 13, so one might measure the Channel 2 and 13 levels coming out of a system drop at the bench and record them, connect the drop to the amplifier input, and then set the Channel 13 level 18 dB higher than the input level and the Channel 2 output 9 dB higher than its input level. Sounds like the job has been done doesn't it? If an old meter was used, the input levels were known only to the ±2.5 dB tolerance and the output levels also had the ±2.5 dB accuracy. The amplifier's gain at Channel 2 could have been set anywhere between 4 dB and 14 dB and the gain at Channel 13 could be anything between 13 and 23 dB!

Good field procedure would have called for going to the first station and either verifying or setting the output level to whatever was "correct" and then traveling to the second station, installing the new module, and verifying that the output level was the same as at the first station. Small wonder that the lab settings were "crazy" and unrelated to the field situation. The field tech would then reset the gain and slope controls to exactly the same readings that he had at the previous station and go back to the lab and declare: "Don't help me like that anymore, I had to reset everything." Note that the field method only required the meter to indicate when the levels were the same (repeatability) and the lab method required four levels to be measured accurately.

Unfortunately, these sorts of errors went unrecognized and still do. Until they are corrected, labs will be of little use to the industry. The key is in understanding what constitutes an accurate measurement, where that measurement and the subsequent setting should be made, and what parameters are important. Let's rethink the previous problem and see what could be accomplished if proper methods had been used.

Correct bench procedures

First, let's define the correct bench procedure. All instrumentation has better repeatability than it has accuracy. If we expect good results, comparisons to known good standards are the way to get them. Fortunately, most CATV measurements are really gain and loss measurements, and excellent standards for loss are available from many sources. Step attenuators are typically accurate to within 0.1 dB and the costs are quite low compared to a good signal level meter (SLM).

If the lab technician mentioned before had used the precision attenuator and caused his meter to read the same with the amplifier and pad as the input without either, the amplifier would have been set to ±0.6 dB of the correct gain rather than the ±5 dB that resulted with his procedure. If the field installation as previously described had not verified that the amplifier had been set to within ±1 dB of the correct gain, a defect in the system should have been suspected.

An often overlooked part of the technician's job is to keep the system from failing, not just to make it work again if it quits. One way to avoid some outages is to detect changes in the system that have no known cause. Without accurate measurements of what *was* there to compare with what *is* there, early detection cannot be achieved. Under the first procedure the only thing known about the second station was that its loss did not exceed the available gain at the temperature when the operation was done.

With the precision pad substitution method and a little book work, it could have been known and recorded that station two did really have 1,800 feet of cable feeding it, that this cable was spliced pretty close to correctly, and that the cable performed close to its specified attenuation.

Even more information could be gained in a little more time with better procedures and test equipment than was generally available at the time of the previous example. Sweep generators and broadband detectors are quite common today and are often not considered as part of the system maintenance equipment. This equipment is commonly used to inspect new or repaired amplifiers before they are installed to verify flatness and minimum full gain are correct without the equalizers and pads in place. The amplifier is put in stock and then put in the system after a failure, and aligned as described above assuming that proper alignment will be checked the next day at more than two channels, and maybe with one of the simultaneous system sweepers available today. If this is the procedure followed, approximately the same information is gained as with the older practice.

Getting the most from your efforts

Back to our problem of gathering the maximum amount of accurate information in the minimum amount of time. The bench sweep generator used along with the precision pads is one of the most accurate devices possible. There is no magic involved here, the accuracy is a result of the equipment. First, the primary cause of the repeatability error in the meters is the friction of the meter movement and/or inaccurate retuning of the meter. Since an oscilloscope is used as the display instrument, the display has no friction, and since a broadband detector is used there can be no tuning error.

Next, one must "set a reference trace" and then try to match it. The only limit to the accuracy attainable is the accuracy of the pads, and the operator's ability to judge whether the trace is at the same place on the scope face or not. On the top half of the screen the trace width should be less than 0.1 dB. So, almost any operator should be able to match two losses to within .05 dB, or using the pads measure any gain or loss to within ±0.15 dB. This represents errors less than 1 percent! If errors occur larger than this, it can only be blamed on operator error by not correctly setting the reference, having a bad connection or different set of connections in the lash up measured compared to the reference.

With all this in mind, let's return to the original example of replacing station number two's module with one aligned on the bench. Instead of measuring two input levels, one connects the sweep generator (using f-81s and all the same jumpers, which will be required in the final set-up) to the detector and scope and makes a reference trace covering the frequencies from 50 to whatever is required. Then a duplicate (see notes at the end for details) of the cable and the amplifier module are inserted into the jumpers and the reference trace is duplicated.

Keep in mind that the deviations from the reference represent the amplifier's deviation from a true flat response, not only in a theoretical sense, but from the response that should be expected at station two. Any "tweaking" can and should be done to achieve the best response at this time. By adding and subtracting the amount of cable corresponding to the anticipated cable attenuation changes with temperature, and using only the gain and slope controls for adjustments, the behavior of the station over the full year's temperature range can be simulated. Such information as whether enough gain is available to handle the hottest day is thus available, and also whether or not the peak-to-valley will be satisfactory all year. The time required to do this operation is just a little longer than the time to install jumpers for all the pads and equalizers and perform the basic incoming receiving test. Since the "tweaking" has been done, it should not be required in the field. As well, because the bench sweep is easy to see, usually runs faster, is in a more comfortable location, and is more accurate, a better job results. Before sending the module to the field, the gain and slope controls should be returned to the settings corresponding to the nominal cable losses, and then the input and output return loss checked to be sure that it is within specifications.

Field vs. bench

How can the assertion be made that in the first case the field alignment of the module in the field location was the most accurate, when it was just stated that the bench alignment was more accurate? There are several reasons. First, before the makers of our current and quite good field sweeping systems take offense, even if the comparison between station #1 and #2 was done with the best equipment available and even if the equipment was as accurate as the bench setup, it would have had to be taken using test points. These necessary evils are typically specified as being within ± 1 dB of their stated value with a peak-to-valley of around another ± 1 dB. They may actually meet this specification if the amplifier port is terminated with a good termination.

Unfortunately, we must put things like splitters and power inserters near these ports in the field. These devices are reasonably good matches and do not have a significant effect on the real response, but the reflected energy does distort what is seen at the test point. This problem was smaller than the original bench and field strength errors, but easily can be worse than our new method of bench alignment.

The second reason that the bench aligned amplifier is preferred over the field aligned version, is that to some extent on all amplifiers, the tweaking controls interact with both the gain and slope controls and the match. On some amplifiers this effect is large enough to result in several dBs of change in response to flatness as the automatic controls work. Related to this problem are certain types of splicing errors, particularly in the systems operating above 300 MHz.

Such things as slight variations in the length of the center conductor length inside the connector pin vise can change the flatness. When the tension changes as the temperature changes, the slight variations also change. The automatic controls cannot correct for this, so a technician is forced to open the amplifier housing and retweak. The result of leaving this small defect in the splicing is a lifetime of "mop up" maintenance and a feeling that the system is either unstable or was incorrectly designed. In addition, every time the interior of the amplifier is exposed, new moisture is introduced and in many areas corrosive pollutants also get in. These factors probably will not cause an immediate problem, but could several years from now. With today's long-term paybacks, long-term reliability is more important now than ever before.

If the defect was only slightly larger, conductor pull out can result in an outage. The old (and I'm afraid still common) CATV adage—"I don't have time to do it correctly now, I'll come back to that"—strikes again. By using the bench setup to determine that this error was built-in and by correcting it now rather than after the outage, everyone would benefit.

Final notes

The results of this procedure, as they do with all lab procedures, depend on the accuracy of the simulation. Care should be used when using drop cable to simulate hard aluminum cables. Most drop cable has a thin (as little as 8 percent by weight from some vendors) coating of copper over a steel core for the center conductor. At low frequencies, the signal penetrates into the center conductor far enough to enter the steel, which is a poor conductor. While this is not a problem in its normal application, it can result in errors in this application. If the span to be simulated has "flat" loss in it, it would be wise to use an actual passive rather than a pad of the proper value because many of these devices are not really flat above 300 MHz.

I have been using this system in many situations since 1975. In several cases, the method resulted in solving what had been thought to be stability problems, which were not resolved using "standard" procedures. It can be recommended highly. It also can be used to substitute totally for sub-split return system balancing by simply reversing the signal flow through the amplifier in the simulator. If the system has been correctly documented and splicing is corrected, no field alignment is necessary to achieve proper operation.

Reader Service Number 20.

'F' connectors: Selection and testing

By Bill Down
Applications Engineer, Gilbert Engineering

When cable television was first conceived, things were very simple in the area of distribution. The first systems were run with 300 ohm twinlead. Twinlead was used for going from house to house, with various resistive networks at the junctions trying to maintain some kind of impedance match and thus keep the signal reasonably good. As systems started to grow, it was soon evident that 300 ohm twinlead was not the answer to cable television's distribution problems. It was hard to handle, very subject to ingress/egress and also very easy to tap and "steal" the signal. Along came coax, that strange wire with a center conductor, some insulation and then some braid woven about the insulation. In some mystical way coax seemed to be able to conduct TV signals to where you wanted them and not leak too much to where you did not want them.

Coax seemed to be an answer to many of our problems but brought with it one major drawback. It was hard to splice or connect to without using the expensive connectors then available (BNC, N, etc.). It also had an attenuation loss that was higher than twinlead, but this could be overcome by making larger cable to carry the signals. This approach worked well, but installing this larger cable (about ½ inch) into each house was not easy and not very economical.

At about this time our present trunk and distribution system was starting to evolve, not as we know it today but with strip braid trunk cable, electron tube-type strip amps and pressure taps for each drop with RG-59 cable for the drop cable into each house. Now our connector problems really started to show, not in performance, but in price. The incident of so many needed and costly connectors in a cable television system demanded that an economical connector be developed.

Along came the "C" connector for drop cables. This connector crimped on the cable so it was easy to use, but seemed hard to work with because of its small size. It did not last very long and was soon replaced with the "F" connector, looking somewhat as it does today. These early F connectors had a ⅜-32 thread, a post or mandrel that slipped under the braid of the coax cable and a separate narrow ring that was crimped or smashed to hold the braid in contact with the mandrel. These connectors were used on the pressure taps where the RG-59 drop cable was connected, in splices, for drop cable and on the matching transformers needed to change the 75 ohm coax cable back to 300 ohm twinlead input used on all TV sets.

The male end on the F connector used the center conductor of the cable for its center pin and the female F connector had a machined contact which accepted the center conductor of the RG-59 cable. Notice I said the RG-59 cable, because at this point in time that was the only size cable used for drop installations in cable television.

After being used for a period of time the F connector described above was observed to have some problems, the principle one was that the small (⅛" wide) crimp ring did not hold the cable on to the connector as well as desired. These observations started the F connector suppliers on a path of improvements to this connector, principally in the width of crimp rings and methods of crimp; most of which did make the connector hold onto the cable much tighter. At this time several things started to influence the F connector design: new sizes of cable were introduced to the CATV market. These were not only larger (RG-6), but some had different insulation or dielectric, which had the effect of changing the center conductor size to maintain the needed 75 ohm impedance. These changes were all made in the interest of reducing the cable losses, which they did, but this was only the beginning of the present "hodge podge" of cable sizes available to the CATV industry.

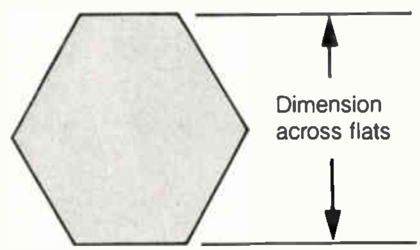
Reducing interface problems

The following are my observations from a connector supplier's point of view, as to what we, as an industry, can do to reduce our cable connector interface problems. First, as the cable suppliers will hasten to explain, all RG-59, RG-6 or whatever cable is not created equal. There are slight construction and size differences in the same types of cable that can affect connector performance. Cables are made with different braid coverages, different foil coverages, and different jacket compositions that will affect the fit of the connector. There is considerable difference between a 40 percent foil braid cable and a dual braid, dual foil 96 percent braid cable. In spite of some connector advertising to the contrary, one size does not perform equally on all sizes; it may fit all sizes, but it does not have the same holding strength on all of the cables.

Because all connector concepts involve squeezing the combination of braid and jacket in some way, any connector design that covers a wide range of sizes must sacrifice performance in some way, either mechanical or electrical. In order to evaluate F connectors and their overall performance in the system, we must first define good connector performance. The ideal connector would be transparent when used. That is, its mechanical strengths would be as strong as the cable and its electrical performance would be the same or better than the cable.

'Any connector design that covers a wide range of (cable) sizes must sacrifice performance in some way, either mechanical or electrical'

Figure 1



We have achieved this with most of the trunk and distribution cable connectors, but have a way to go to develop an F connector that will meet those objectives at the low cost dictated by the market. With past objectives of having one size female connector center contact that receives all center conductors from solid poly RG-59 (.025") to low density RG-11 (.064"), it is nearly impossible to design a connector that maintains the same electrical impedance over this great a size range. We must become more restrictive in our choice of cable applications, so that we can use the right connector for the chosen cables. If we do this, it is possible to use connectors that have electrical specifications that are better than the cable they are being attached to. Electrical performance of male F connectors for small cables is relatively simple to control, since the center conductor is the center pin and all that is necessary is to maintain the same ratio of sizes of the outer conductor to the center conductor and make sure good electrical contact is made with the shield of the cable. Larger cable (RG-11, etc.)

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generally needs a reducing pin of some sort for the center conductor so that a proper ratio of sizes can be maintained in the female portion of the connector pair.

Most of our so called "problems" with F connectors, either electrical (including EMI) or mechanical, usually start off as mechanical misfits or misapplications of the connector itself. Most, if not all, electrical problems are some form of poor contact brought on by corrosion or improper crimping or tightening.

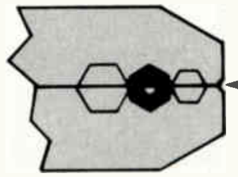
'Tools' of the trade

For the sake of this article, I will take editorial license with the definition of the word, "tools" as it applies to drop connectors. To explain—one of the best tools available to the end user of the connectors is the manufacturer of the connector itself. The manufacturer should make every effort to help you choose the right connector for the cable you have decided to use. Don't just buy an F connector, but buy an F connector to fit (manufacturer, catalog number) drop cable. As I pointed out earlier in this article, there is a large variety of cable available to the end user and there is an equally large variety of connectors to fit these cables. As one of the tools to be used, make sure you are using the connector that your connector supplier recommends for the cable selected. It is generally necessary to monitor this connector selection because it is very common for systems, both large and small, to change suppliers and/or types of drop cables being used. It is necessary to check connector fit, even if the same type or braid percentage cable is bought from another supplier.

The next tool that is generally ignored in the real world is training. We generally spend very little time in instruction or training of the installers or people who are going to use the connectors that are provided to them. Systems often are reluctant to have their people spend several hours in class on "how to install drop connectors," but generally the statement, "pay me now or pay me later," sums up what happens in the long run. Most systems that have started any kind of training for installers have reduced their call-backs enough to more than offset the cost of the training programs. I feel it is not only important to have the training but also equally important as to how the training is done. There is a great tendency to teach people "how to" do something rather than go a little further and show them why something is done. F connectors to someone who has used them for many years are a relatively simple device, but put yourself in the place of someone seeing one for the first time. We need to formalize the training, step by step, and not just have one of the people who have been putting on F connectors for two years or so, spend a half-hour showing the "new guy" how to prepare cable and crimping connectors. I have found as high as 75 percent of a group of installers putting connectors on wrong. *This is not their fault*—it is our fault for not providing the instruction on how to do it right.

When we start any instructional program we will not become involved with the actual tools that will be used to install the connector on the cable. The cable must be prepared according to the connector manufacturer's instructions in order to install the connector properly.

Figure 2



There are many tools available to prepare drop cable. Most have their pros and cons, which I will review. *If* you find a cable preparation tool that will prepare the cable to the connector suppliers specifications, then it is okay to use. I say *if* because all coax cable preparations are not equal. It is very important to have the proper exposure of center conductor dielectric and braid to assure the proper electrical and mechanical performance of the connector. If the center conductor is too long, it can affect the operation of the female portion of the mating connector by holding it open or bending it over and causing a short. If the dielectric exposure is too long, it either protrudes into the connector nut, keeping the connector from making a good shield connection, or may cause the installer to "pull-back" the connector before crimping and loose gripping areas on the braid and jacket. The proper amount of braid must be exposed so that when it is folded back under the crimp ring it provides the needed size and support for the crimp ring to grip the jacket and braid. Drop cable preparation tools come in a variety of trim dimensions and care must be used in selecting the right one.

When buying a cable preparation tool, refer to the trim dimensions required and don't buy just an RG-59 trim tool, buy one that trims the cable to the exact dimensions shown in the instruction sheets. Coax trim tools need maintenance and are not something that can be bought and ignored. Thereafter, they do not work well when dull and the buyer should plan a regular replacement of the blades and examination of the tool to assure its proper operation.

If you are not inclined to regularly check the operation of these tools, installers should be shown the proper way to prepare cable with a knife. A knife has the advantage of being able to be kept sharp by the user and is something that is readily available anywhere. There is, however, a caution that must be observed when using a knife: Care must be used when cutting the cable jacket with the knife so that no braid strands are cut. Since most connectors are designed to have the full amount of braid folded back, if it is not all there, the connector holding performance will be affected.

The tool that most people associate with F connector installation is the hex crimp tool, which comes in a variety of shapes and types. These tools have one thing in common, they all have a hex size somewhere around .324/.326 across the flats. This crimp size and the ⅜-32 thread in the nut of the connector are a few of the standards in CATV.

It has been my experience that a high percentage of the problems associated with F connectors are due to maladjusted or worn crimping tools. All F connectors in this size range are designed to be crimped to a maximum size of .330"—that is after the connector is crimped; the measurement across the flats of the connector should not exceed .330 inches (Figure 1). Most people do not have access to a micrometer, but there is another way to check if the crimp tool is doing its job. While the connector is being crimped (that is, it is under load crimping the connector) you should try to look through the crack in front of the hex on the tool and you should see no light (Figure 2). Another way is to try to hold a piece of paper (dollar bill) in the crack in the jaws while the tool is under load crimping a connector. If there is space seen or the paper will not stay in place; this indicates the tool jaws are not closing properly and therefore do not have a crimp size of .330 inches or less. This means the tool is either not adjusted properly, or that the tool is so worn that it should be replaced, or at least, rebuilt.

Crimp tools do not last forever even when in normal use and wear out even faster when they are abused (used for a hammer or allowed to get rusty). It is important to check the crimp tools quite often (once a month), but even more important to educate the installers how to check their own crimp tools. It is easy to see that if your installers do not know how to check their own crimp tools, it is possible to have many man months worth of improperly installed F connectors in your system.

Checking and maintaining integrity

An overall check for properly installed connectors that works quite well in the real world and requires no special fixtures is the following: Hold the drop cable in one hand without any looping (allow it to pass straight through your hand) and grasp the installed F connector in the center of your other hand and try to "pull off" the connector. This test does not rely on physical strength but on friction of the cable in one hand and the connector in the other. I found that it is nearly impossible to exert more than 40 pounds of pull in the above manner and a properly installed connector should not pull off the cable with less than 40 pounds. This test not only checks the crimp but also checks connector selection, cable preparation and anything else that may affect the way a connector grips the cable.

F connectors are becoming somewhat more complicated in their application. This is brought on by the advent of sealed connectors (which are more sensitive to cable size), more sizes of cable, and connectors that use other methods of application. We must upgrade the training of the people using these connectors and give them every "tool" possible to help them do their job. ■

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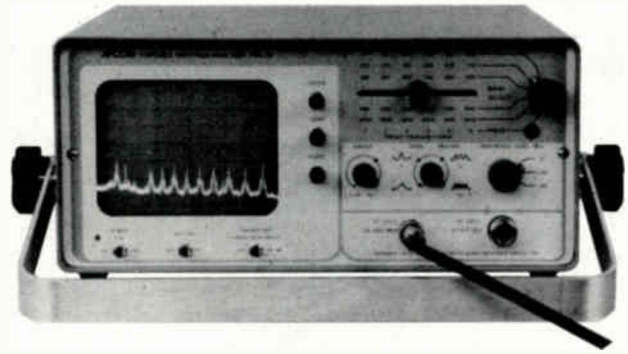

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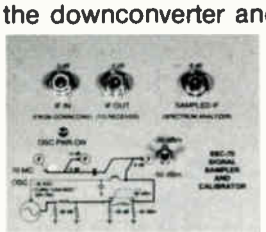

If Terrestrial Interference filters are in the IF coax line, they can be tuned precisely so that video quality is preserved while T.I. is minimized.

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Reader Service Number 23.

The changing faces of CATV SLMs

By Glen K. Shomo III
Vice President, R&D and Production, ComSonics Inc.

CATV signal level meter (SLM) evolution generally has been gradual, in response to periodic additions to RF spectrum usage as channel capacity and available programming grew. Although many SLM models have appeared on the market and later replaced by others, most of the changes and improvements until the past few years have been to internal circuitry design rather than to actual instrument features and capabilities. With acceptable reductions in cost and advancements in density and performance of digital circuitry it is now cost-effective to begin to incorporate microprocessor-based instrument functions and adjustments previously found only in expensive test equipment.

A few recent SLM introductions utilize computer circuitry to control keyboard entry of preset tuning, displayed values and function switching. Still further technological advancements and cost reductions in very recent months have made possible a major step in SLM capability, utilizing some of the best and most desirable features from several different types of test equipment. To more fully appreciate these new developments, let us first go back and look at the evolution of signal level meters.

SLM roots

Early solid-state, and even vacuum tube signal level meters, generally employed very similar tuning and switching methods. Since the internal heterodyne method of the day was a single conversion process, these meters required input RF tuning to achieve image frequency rejection. In some models this was accomplished with variable capacitor or inductor-tuned RF inputs and local oscillators, with continuously variable tuning of both sections through a typical 54-217 MHz frequency range. Other models divided the tuning range into bands, selected by a front panel rotary switch. This switch changed local oscillator (LO) ranges and routed the input signals through separate input RF bandpass filters for each band.

Most early meters had accuracies of ±2 or ±3 dB with measurement ranges of −30 to +30 dBmV. Front panel analog meters and linear detection circuits provided about 20 dB of readout range, of which only the upper 10 dB could be used to achieve published measurement accuracy. Signal level range switching was generally accomplished with a front panel in-line slide switch or rotary-type input RF attenuators. Among other reasons, the rotary-type attenuator is generally used in newer SLM designs due to its cylindrical shape, which requires much less front panel space.

Typical failures in these early meters were found in the many mechanical devices used for tuning, and frequency band and level switching. Both types of level switching attenuators have always been sources of intermittent or unreliable operation, being directly subjected to dust and dirt, moisture, and just plain hard and frequent use. Because early meters employed mechanical tuning, variable capacitors and rotary range switches also became typical failure items. Some used a system of complex plastic gear-driven mechanisms that frequently broke and required careful replacement and realignment.

Reliability and accuracy improve

With the development of lower distortion solid-state devices and improved balance mixer circuits, later SLM versions incorporated broadband RF input CATV converter-type tuning. These units typically employ dual conversion signal processing with UHF or higher first IF frequencies to eliminate image frequency interference problems. The development of this type of conversion method, utilizing a (DC) varactor-tuned local oscillator, greatly simplified input RF and LO tuning with corresponding improvements in reliability and reduction in size and cost. Tuning ease and stability also were improved with the introduction of automatic fine tuning (AFT) integrated circuits, developed for and adapted from television receivers.

DC voltage-tuned varactor circuits greatly reduced the cost and complexity of continuously variable tuning components, requiring only a DC potentiometer control, which typically exhibits better reliability and stability compared to mechanically variable capacitors or inductors. Varactor tuning also made possible relatively simple push-button tuning. However some early versions of this push-button approach were very prone to temperature and mechanical drifting due to course potentiometer tuning adjustments and drift in DC circuits used to set the DC voltage for each channel or frequency band.

Later generation meters also improved in accuracy, ±1 to ±1.5 dB, tuning range, 5-450 MHz, and level measurement range, typically −40 to +60 dBmV. Some models also provide tuning of 450-890 MHz with optional adapters. Provisions for external calibration was originally provided by a front panel compensation or gain adjust control. The user adjusted the compensator at each channel and measurement level range according to numbers listed on a calibration chart periodically generated during laboratory recalibration. While this usually resulted in acceptable accuracy, users often found this procedure cumbersome and time consuming and therefore ignored its use, or guessed at a "typical" setting if no recently updated compensation settings were available.

Most models currently produced and sold provide an internal calibration source with a front panel connector output. To calibrate the unit this signal is connected to the RF input and

> *'It is now cost-effective to begin to incorporate microprocessor-based instrument functions and adjustments previously found only in expensive test equipment'*

a front panel calibration control is adjusted to achieve a desired level meter readout according to the specified source output level. These internal calibration sources are specified at one frequency only and the resulting meter accuracy, specified at ±1 to ±1.5 dB, is dependent on the actual temperature stability of the calibration source level and the variation of the SLM's input frequency response over temperature and time. Some newer models also provide digital readouts of tuned frequency and signal level. Analog "peaking meters" are included with digital level readouts for signal level peaking during tuning, which would be extremely difficult with only a digital numeric readout. Currently produced instruments using analog level meters usually employ logging meter circuits that provide 20-30 dB of range, with 1 dB per division meter graticule marks.

A new generation: Microprocessor control

A few microprocessor-based meters have been introduced during the past several years, providing automatic control of channel tuning, frequency and level readouts, and special measurements such as hum and carrier-to-noise ratio. Even with the power and capabilities of the microprocessor, these first-generation computer-based SLMs still possess certain fundamental limitations that cost the user time and cause frustration, which can result in measurement errors. An operator still can read only one channel level at a time requiring multiple tuning, and possibly different level setups, to read several channels. Even though push-button tuning has made channel jumping easier, all of us have wished for a simultaneous display of all channels when performing amplifier setup, system balance, or troubleshooting, something until now only an expensive spectrum analyzer could provide. In addition, no SLM, or even a spectrum analyzer for that matter, afforded the user a way to directly compare level readings at different amplifier or test point locations except through written or photographic records—very inconvenient, time consuming and a possible source of errors as well.

A recent introduction to the smart SLM market, named the Window, was made by ComSonics. This CATV signal level measuring in-


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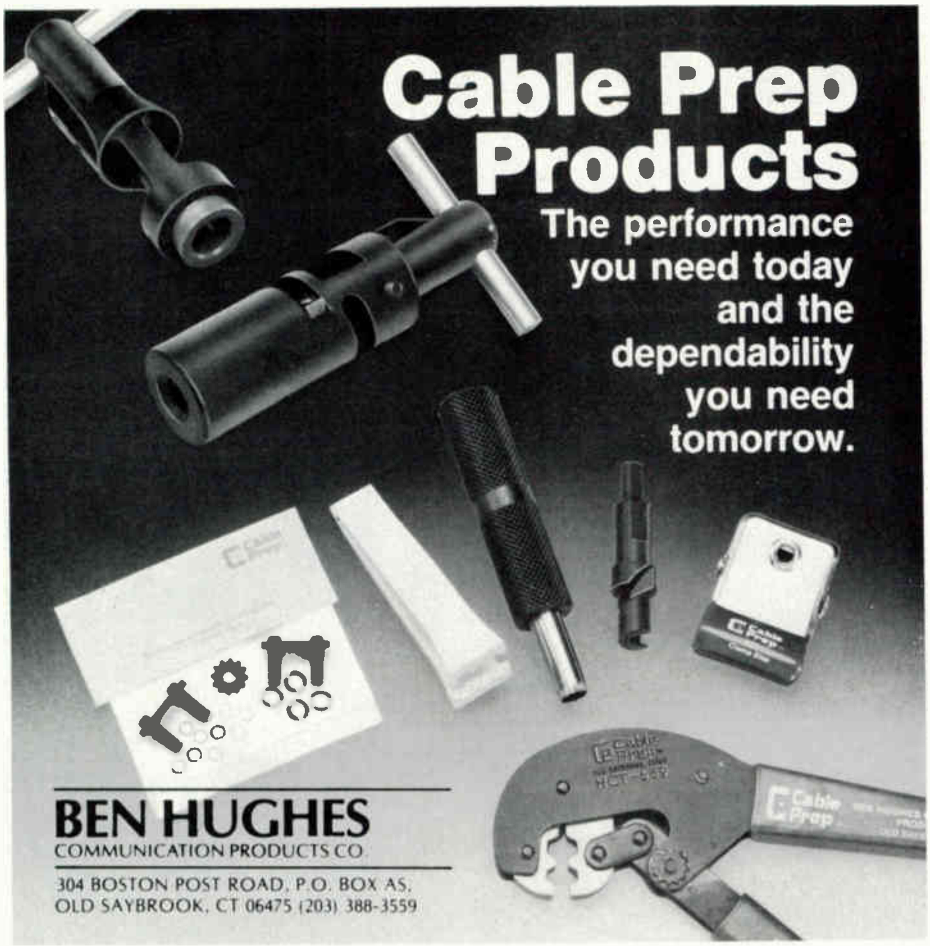

strument uses a new generation of digital circuitry, allowing internal microprocessor control of many instrument functions and adjustments previously required of the user. These include automatic tuning and scanning of all channels in a selected upstream or downstream spectrum, automatic level ranging through the use of internally switched RF attenuators, self-calibrating at each measurement frequency and temperature, and simultaneous vertical bar graph display of all measured channels on a large screen backlit LCD display.

An additional feature is the ability to store several measured scans of all visual and aural channels in internal nonvolatile memory for later recall and comparison. The user can cycle through these "snapshots" at the press of a front panel key to compare system or test point locations, which should prove to be a valuable and time saving tool for system troubleshooting and problem isolation. Since no user tuning or level setup is required, this will provide accurate pictures that can later be recalled if desired back at the office for display and discussion.

Channel carriers are displayed in a vertical bar graph form with the height of each carrier bar proportional to measured signal strength. This continuously updating display allows the user to directly view the effects of his or her adjustments or the condition of all channels, greatly reducing time for level setups, reducing errors, and preventing the unknown and unintentional introduction of system problems. On-screen numeric or alphanumeric printout of channel number and frequency, and signal level of an individual channel selected by a keyboard-controlled screen curser helps prevent operator reading errors. A separate display mode of an individual channel's visual and aural carriers also can be selected for channel setup operations.

Temperature-stable accuracy over the entire frequency range is assured through the use of an internal custom hybrid noise source and temperature measurement module, made possible by advancements in hybrid surface mount and thick film technologies. Self-calibration occurs automatically when the internal processor detects a temperature change sufficient to require recalibration. User calibration and possible misadjustments are therefore eliminated. In addition to simplifying or eliminating user adjustments and providing previously unavailable system troubleshooting and setup features, another primary design goal in the Window was to prevent the unit from being difficult to learn and use, which is common to some complex multi-function computer-based instruments. Ergonomic considerations were designed into the widely spaced, color coordinated front panel membrane keyboard, with tactile and audible feedbacks. Help screens also are provided at the press of a HELP key, which calls up easy to read and understand descriptions of keyboard functions. As each key is pressed an explanation of that key's function appears on screen.

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Reader Service Number 27.

Microwave LOS path analysis

The first part of this article (September 1985) presented the background and calculations for performing a microwave line-of-sight path analysis. In this installment, the computer program for running the analysis on your PC is offered.

By Lawrence W. Lockwood
President, TeleResources

The accompanying line-of-sight (LOS) program can be used on any IBM PC or compatible. Although it is written in BASIC A it can be used with any BASIC with simple conversions. It requires only 4,700K bytes of memory.

This program can be a particularly powerful tool in that it permits extremely easy use of "what if" techniques in the LOS problem analogous to the "what if" techniques used in spread sheet problems. As an example, path solutions can be very quickly determined for different values of K (the ratio of the effective Earth radius to the true Earth radius), different terminal locations, different tower heights, etc.

A typical example of the program output of a LOS path analysis is seen in Figure 1. The top half of the figure presents the geographical path data and the resultant receiver tower height. This example does not consider an intervening obstacle, however, such a path analysis is shown in Figures 2 and 3. The bottom half of Figure 1 displays the program output for the system performance with C/N, S/N, etc. This analysis is not performed in Figures 2 and 3.

Figure 1

Frequency: 12825 MHz
K factor: 1.333333
Fresnel zone clearance factor: .6
Distance between sites: 18.64 miles
Altitude transmitter site above sea level: 0 feet
Altitude receiver site above sea level: 0 feet
Height of vegetation at receiving site: 0 feet

Height of transmitter antenna: 100 feet
Height of receiver antenna: 45.15656 feet

Transmitter power in dBm: 30
Gain of transmitting antenna in dB: 40
Gain of receiving antenna in dB: 40
Power level at receiving antenna in dBm: -34.14835
Noise factor of receiver: 12.6
Bandwidth of receiver in hertz: 1.5E+07
Noise power level in dBm: -91.19949
Carrier-to-noise ratio: C/N = 57.05115 dB
Video bandwidth in hertz: 4500000
Signal-to-noise ratio: S/N = 68.26964 dB

A significant consideration is that this program requires no documentation to use it—it is "self driven." All the instructions for its use are contained in the program and appear as prompts during its use. For example, when the program calls for the transmission path length, if it is known it is entered; if not the coordinates are called for and the path length is determined and entered automatically. The same procedure is used for K and the Fresnel zone factor. When they are called for, the program presents values of 4/3 and 0.6 respectively. If different values are desired they are entered in response to request. Figures 2 and 3 show

Microwave line-of-sight program

(LOS)

```
L 10 PRINT TAB(20) "MICROWAVE LINE OF SIGHT PROGRAM"
L 20 PRINT TAB(25) "LAWRENCE W. LOCKWOOD"
L 30 PRINT TAB(30) "(C) 1984"
L 40 PRINT
  50 INPUT "FREQUENCY IN MHZ";N
L 60 PRINT "FREQUENCY IN MHZ"
L 70 PRINT
  80 PRINT "IF K FACTOR IS 4/3 ENTER 0 BUT IF DIFFERENT ENTER NEW VALUE"
  90 INPUT "K FACTOR";K
  100 IF K>0 GOTO 120
  110 K=4/3
L 120 PRINT "K FACTOR";K
L 130 PRINT
  140 PRINT "IF FRESNEL CLEARANCE ZONE FACTOR IS 0.6 ENTER 0 BUT IF DIFFERENT ENTE
  R NEW VALUE"
  150 INPUT "FRESNEL ZONE CLEARANCE FACTOR";FZ
  160 IF FZ>0 GOTO 180
  170 FZ=.6
L 180 PRINT "FRESNEL ZONE CLEARANCE FACTOR";FZ
L 190 PRINT
  200 PRINT "IF DISTANCE BETWEEN SITES IS NOT KNOWN ENTER 0 OR IF KNOWN ENTER VALU
  E"
  210 INPUT "DISTANCE BETWEEN SITES";A
  220 IF A=0 GOTO 230 ELSE 450
  230 INPUT "LATITUDE,LONGITUDE, TRANSMITTER SITE IN DEGREES,MINUTES,SECONDS";B,C,
  D,E,F,G
  240 S=B+C/60
L 250 PRINT "LATITUDE,LONGITUDE, TRANSMITTER SITE IN DEGREES, MINUTES,SECONDS"
  260 GOSUB 1530
  270 H=B+C+D
  280 PRINT "TRANSMITTER LATITUDE IN MINS.";H
  290 I=E+F+G
  300 PRINT "TRANSMITTER LONGITUDE IN MINS.";I
  310 INPUT "LATITUDE,LONGITUDE, RECEIVER SITE IN DEGREES,MINUTES,SECONDS";B,C,D,E
  ,F,G
L 320 PRINT "LATITUDE,LONGITUDE, RECEIVER SITE IN DEGREES,MINUTES,SECONDS"
  330 GOSUB 1530
  340 J=B+C+D
  350 PRINT "RECEIVER LATITUDE IN MINUTES";J
  360 RL=E+F+G
  370 PRINT "RECEIVER LONGITUDE IN MINUTES";RL
  380 L=H-J
  390 PRINT "LATITUDE DISTANCE IN MINUTES";L
  400 M=(I-RL)*COS(S*3.141593/180)
  410 PRINT "LONGITUDE DISTANCE IN MINUTES";M
  420 A=(L^2+M^2)^.5
  430 PRINT "TRANSMITTER PATH IN MINUTES";A
  440 A=A*(6076.11549#/5280)
L 450 PRINT "DISTANCE BETWEEN SITES:";A;"MILES"
L 460 PRINT
  470 INPUT "HEIGHT IN FEET OF TRANSMITTER ANTENNA";T
  480 INPUT "ALTITUDE TRANSMITTER SITE IN FEET ABOVE SEA LEVEL";Y
L 490 PRINT "ALTITUDE TRANSMITTER SITE ABOVE SEA LEVEL:";Y;"FEET"
L 500 PRINT
  510 INPUT "ALTITUDE RECEIVER SITE IN FEET ABOVE SEA LEVEL";Z
L 520 PRINT "ALTITUDE RECEIVER SITE ABOVE SEA LEVEL:";Z;"FEET"
L 530 PRINT
  540 PRINT "IF THERE IS AN OBSTACLE IN THE TRANSMISSION PATH, ENTER 1 BUT IF THER
  E IS NO OBSTACLE IN THE TRANSMISSION PATH ENTER 0"
  550 INPUT "IS THERE AN OBSTACLE IN THE PATH";X
  560 IF X>0 GOTO 570 ELSE 770
  570 PRINT "IF DISTANCE BETWEEN TRANSMITTER AND OBSTACLE IN MILES IS NOT KNOWN EN
  TER 0 OR IF KNOWN ENTER VALUE"
  580 INPUT "DISTANCE BETWEEN TRANSMITTER AND OBSTACLE IN MILES";P
  590 IF P>0 GOTO 720
  600 INPUT "LATITUDE,LONGITUDE, OBSTACLE IN DEGREES,MINUTES,SECONDS";B,C,D,E,F,G
  610 PRINT "LATITUDE,LONGITUDE, OBSTACLE IN DEGREES,MINUTES,SECONDS"
  620 GOSUB 1530
  630 LA=B+C+D
  640 PRINT "OBSTACLE LATITUDE IN MINUTES";LA
  650 LO=E+F+G
  660 PRINT "OBSTACLE LONGITUDE IN MINUTES";LO
  670 PRINT
  680 L=H-LA
```

```
  690 M=(I-LO)*COS(S*3.141593/180)
  700 P=(L^2+M^2)^.5
  710 P=P*(6076.11549#/5280)
L 720 PRINT "DISTANCE BETWEEN TRANSMITTER AND OBSTACLE:";P;"MILES"
L 730 PRINT
  740 INPUT "HEIGHT OF OBSTACLE IN FEET ABOVE SEA LEVEL";Q
L 750 PRINT "HEIGHT OF OBSTACLE ABOVE SEA LEVEL";Q;"FEET"
L 760 PRINT
  770 INPUT "HEIGHT OF VEGETATION AT RECEIVING SITE IN FEET";V
L 780 PRINT "HEIGHT OF VEGETATION AT RECEIVING SITE:";V;"FEET"
L 790 PRINT
L 800 PRINT
  810 HT=T
  820 HT=HT-1
  830 D1=(3*K*HT/2)^.5
  840 D2=A-D1
  850 IF D1>A GOTO 920
  860 FR1=FZ*2277*(D1*D2/N/A)^.5
  870 IF (T-HT)<(FR1+V) GOTO 820
  880 H2=2/K/3*(D2^2)
  890 R=FR1+V+H2+Y-Z
  900 IF X>0 GOTO 960
  910 IF X=0 GOTO 1460
  920 IF X>0 GOTO 1390
  930 FR2=FZ*2277*(1/N)^.5
  940 R=FR2+V
  950 GOTO 1460
  960 HO=2/K/3*(P^2)
  970 FR2=FZ*2277*((A-P)*P/N/A)^.5
  980 IF P>D1 GOTO 1030
  990 IF (Q-Y+FR2)>(T-HO) GOTO 1010
  1000 GOTO 1460
  1010 R=(FR2+Q-Y-FR1-HT+HO)*A/P+FR1+V+H2+Y-Z
  1020 GOTO 1460
  1030 HR=2/K/3*((A-P)^2)
  1040 RA=(FR2+Q-Y-FR1-HT+HR)*A/P+FR1+V+H2+Y-Z
  1050 IF (Q-Y+FR2)>(FR1+H2-HR) GOTO 1070
  1060 GOTO 1460
  1070 R=RA
  1080 GOTO 1460
  1090 INPUT "TRANSMITTER POWER IN DBM";PT
L 1100 PRINT "TRANSMITTER POWER IN DBM: ";PT
L 1110 PRINT
  1120 INPUT "GAIN OF TRANSMITTING ANTENNA IN DB";GT
L 1130 PRINT "GAIN OF TRANSMITTING ANTENNA IN DB: ";GT
L 1140 PRINT
  1150 INPUT "GAIN OF RECEIVING ANTENNA IN DB";GR
L 1160 PRINT "GAIN OF RECEIVING ANTENNA IN DB: ";GR
L 1170 PRINT
  1180 PR=PT+GT+GR-20*LOG(4*3.141593*[illegible]
L 1190 PRINT "POWER LEVEL AT RECEIVING ANTENNA IN DBM: ";PR
L 1200 PRINT
  1210 INPUT "NOISE FACTOR OF RECEIVER";NF
L 1220 PRINT "NOISE FACTOR OF RECEIVER: ";NF
L 1230 PRINT
  1240 INPUT "BANDWIDTH OF RECEIVER IN HERTZ";BW
L 1250 PRINT "BANDWIDTH OF RECEIVER IN HERTZ: ";BW
L 1260 PRINT
  1270 NP=10*LOG(293*(1.37E-23)*BW*NF)/LOG(10)+30
L 1280 PRINT "NOISE POWER LEVEL IN DBM: ";NP
L 1290 PRINT
  1300 CN=PR-NP
L 1310 PRINT "CARRIER TO NOISE RATIO: C/N = ";CN;"DB"
L 1320 PRINT
  1330 INPUT "VIDEO BANDWIDTH IN HERTZ";BV
L 1340 PRINT "VIDEO BANDWIDTH IN HERTZ: ";BV
L 1350 PRINT
  1360 SN=CN+10*LOG(BW/(2*BV))/LOG(10)+5
L 1370 PRINT "SIGNAL TO NOISE RATIO: S/N = ";SN;"DB"
  1380 END
  1390 HR=2/K/3*((A-P)^2)
  1400 FR2=FZ*2277*((P*(A-P)/N/A)^.5)
  1410 FR1=FZ*2277*(1/N)^.5
  1420 IF (Q-Y-HR)<FR1+(Z-Y) GOTO 1450
  1430 R=(Q-Y+FR2-(FR1+Z-Y)-HR)*A/P+FR1
  1440 IF R>FR1+V GOTO 1460
  1450 R=FR1+V
L 1460 PRINT "HEIGHT OF TRANSMITTER ANTENNA:"
L 1470 PRINT ,T "FEET"
L 1480 PRINT "HEIGHT OF RECEIVER ANTENNA:"
L 1490 PRINT ,R "FEET"
L 1500 PRINT
L 1510 PRINT
  1520 GOTO 1090
L 1530 PRINT "LATITUDE",B"DEGREES",C"MINUTES",D"SECONDS"
L 1540 PRINT "LONGITUDE",E"DEGREES",F"MINUTES",G"SECONDS"
L 1550 PRINT
  1560 B=60*B
  1570 D=D/60
  1580 E=60*E
  1590 G=G/60
  1600 RETURN
```

NOTE: The program can be used with or without a printer. As shown it does not drive a printer but presents the results on the display screen only. By changing each PRINT command to an LPRINT command where noted with an L, the program will drive a printer.

Figure 2

Frequency: 2174 MHz
K factor: 1.333333
Fresnel zone clearance factor: .6

Latitude, longitude, transmitter site in degrees, minutes, seconds
Latitude: 41 degrees, 49 minutes, 31 seconds
Longitude: 71 degrees, 24 minutes, 37 seconds
Latitude, longitude, receiver site in degrees, minutes, seconds
Latitude: 41 degrees, 47 minutes, 46 seconds
Longitude: 71 degrees, 20 minutes, 51 seconds

Distance between sites: 3.806761 miles
Altitude transmitter site above sea level: 10 feet
Altitude receiver site above sea level: 50 feet
Distance between transmitter and obstacle: 3.27 miles
Height of obstacle above sea level: 140 feet
Height of vegetation at receiving site: 55 feet

Height of transmitter antenna: 416 feet
Height of receiver antenna: 122.958 feet

Figure 3

Frequency: 2174 MHz
K factor: .5
Fresnel zone clearance factor: .6
Distance between sites: 3.806761 miles
Altitude transmitter site above sea level: 10 feet
Altitude receiver site above sea level: 50 feet
Distance between transmitter and obstacle: 3.27 miles
Height of obstacle above sea level: 140 feet
Height of vegetation at receiving site: 55 feet

Height of transmitter antenna: 416 feet
Height of receiver antenna: 122.6785 feet

examples of this capability. They are solutions of the same path, but in Figure 3 a different value of K is used and the path distance is entered instead of the coordinates as shown in Figure 2.

The program can be used with or without a printer. As shown it does not drive a printer but presents the results on a display screen only. The use of this program without a printer allows for many quick "what if" solutions before the desired ones are printed. By changing each PRINT command in the program to an LPRINT command (noted with an L in the left margin) it will drive a printer.

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Reader Service Number 28.

Using computer-aided design

By Jim H. Walworth
Engineering Consultant, Tampa Microwave Lab

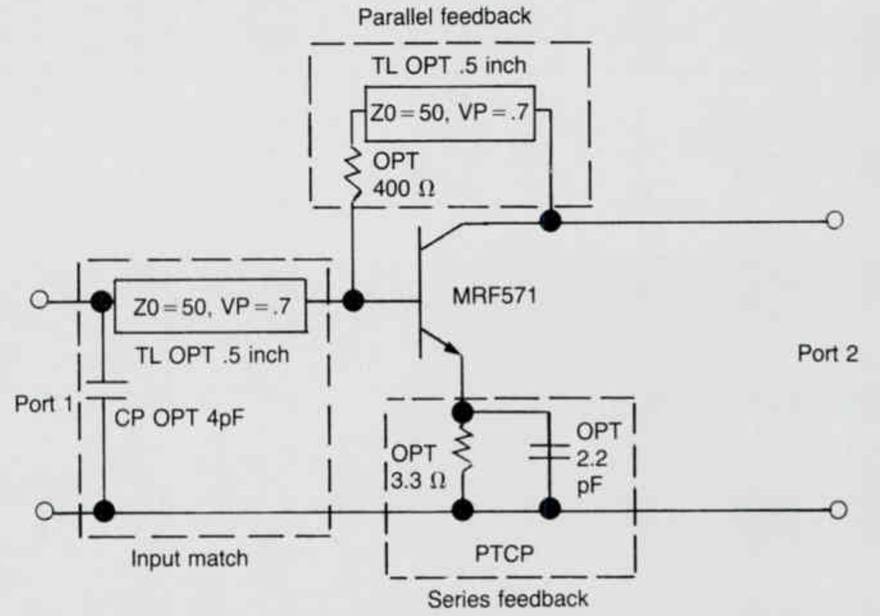
Computer-aided design (CAD) has been available for a number of years to large aerospace companies that could justify $5,000 to $30,000 for computer software. In the early years computers themselves were so expensive that engineering departments time-shared the company's data processing equipment. Later as the timesaving merits of CAD became more recognized, engineering departments were able to purchase their very own computer system and CAD software.

Now in the age of the personal computer (PC), some very good programs have become available to the individual engineer at prices he can afford. RF and microwave CAD PC software programs can vary from $300 to $10,000 depending on the sophistication of the program. Selecting the best software for your individual needs in most cases is a difficult task. The low-cost program used in the examples in this article can meet about 90 percent of the analysis needs of a sophisticated designer.

The type analysis program most used by RF and microwave designers is classified as a "two-port" or "S-parameter" program. This type is chosen simply because the most available transistor manufacturers data is in S-parameters. (Their device data is S-parameters, the easiest data type to consistently measure.) The better two-port programs also have an optimization option that allows "tweaking" to a desired performance. This means that a designer armed with a transistor manufacturer's data and some ball park component values can "let the computer do the work." (This article is not intended as a tutorial in the use of S-parameters, but merely to demonstrate their use as an example design.)

The program used in the examples in this article is called "MOP," for "microwave optimization program." The program is not limited to the microwave region since its internal frequency units can be set from the default GHz to MHz or Hz. Other parameter units can be changed in the built-in editor. For example, if you prefer to work in μH (microhenry) instead of nH (nanohenry) you simply type "UH" and carriage return while in the editor. Likewise pF can be changed to μF, F, etc.

Figure 1: Amplifier topology with initial values



To demonstrate the utility of MOP, a practical amplifier design will be optimized. The steps to follow in the design while "cheating" with optimization are:

1) Choose the proper transistor.

2) Choose a topography and some ball park values. Usually someone else's design with perhaps a different transistor will do. The best way, however, is to study some of the publications on transistor amplifier design using S-parameters.

3) Use a word processor or simple editor to create a device file containing the transistor's S-parameters.

4) Using MOP's editor, code the circuit in the proper format for the program to analyze it.

5) Optimize the circuit by responding to MOP's request for weights and goals.

The optimization used in this program is a gradient search technique. This means that we weigh the parameters of the amplifier as to which ones are most important to us and establish a goal of the desired gain of the circuit. MOP does an initial analysis with the start values you supply (result #1). Then the program changes the components to be optimized by a small amount and re-analyzes the circuit (result #2). An error function is then calculated based on the difference of result #1 and the desired parameters you specified. Based on a comparison of result #2 and result #1, MOP knows which direction (larger or smaller) and approximately how much to change the variable values for an improvement in the circuit performance. By specifying the number of iterations you can control how long and how close this program will search for the desired performance.

Let's consider a design example. Figure 1 shows the intended circuit to be analyzed and optimized. Only the RF components are shown. Their starting values are shown to the side of "OPT."

1) The Motorola MRF571 transistor is a low-cost transistor that can provide nearly 10 dB gain at 1,500 MHz. This should be a good transistor for a gain block in a 950 to 1,450 MHz BDC IF.

2) A reasonable topography for a wide-band amplifier is the "series/parallel" feedback type. This configuration uses frequency selective series feedback in the emitter and frequency selective parallel feedback around the collector to base. These two frequency selective networks allow the gain of the device

Table 1

10	LEN=.5	40	R=3.3	60	C=4
20	R=400	40	C=2.2	70	LEN=.5

S-matrix in magnitude and phase

	11		12		21		22	
Freq.	**Mag.**	**Ang.**	**dB**	**Ang.**	**dB**	**Ang.**	**Mag.**	**Ang.**
0.950	0.262	-175.6	-16.28	-20.1	11.60	48.6	0.380	-24.2
1.200	0.227	-114.5	-15.33	-38.4	10.38	14.4	0.415	-62.0
1.450	0.514	-108.9	-15.40	-58.0	8.15	-19.6	0.408	-98.1

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AN OPEN LETTER FROM THE SCTE.

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SCTE Chapters and Meeting Groups present well-structured seminars with full agendas and qualified instructors discussing industry technical issues ranging from simple procedures that can extend the life of cable drops to compliance with the FCC's new rules on signal leakage. There are also opportunities following each program for fellow engineers and technicians to discuss common problems and learn of solutions and procedures that have been implemented at other systems.

However, in order to continue providing these training sessions in your area, SCTE Chapters and Meeting Groups need your support. We are not asking for financial support, we need your support in encouraging your staff to attend and participate in our industry's technical training process. The benefits are bidirectional. The local SCTE grows stronger and more effective through increased participation, and your company's operation benefits from better educated and more contented employees at minimal expense. You could rotate sending one or two of your staff to each meeting and have them report to the others, or make seminar attendance an incentive for good job performance.

Still not convinced? Then we invite you to attend one of the training sessions and see for yourself the quality educational programs SCTE provides. We sincerely hope to see you and/or members of your staff at upcoming meetings.

Best Regards,
William Riker
Executive Vice President
SCTE National

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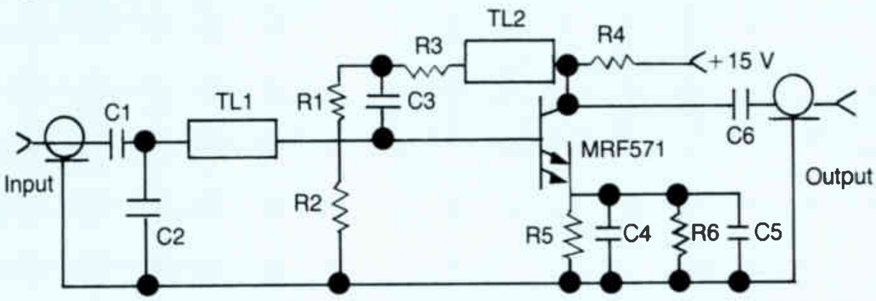
Reader Service Number 29.

Figure 2



C1, C3, C6	—200 pF chip capacitor	R4	—560 Ω ⅛ w resistor
C2	—1.6 pF chip capacitor	R5, R6	—15 Ω chip resistor
C4, C5	—1.1 pF chip capacitor	TL1	—.60" x .125" microstrip line
R1	—4.3 kΩ ⅛ w resistor	TL2	—.55" x .125" microstrip line
R2	—680 Ω resistor	Board	—1 oz. copper clad, double-sided, .0625 thick glass Teflon board
R3	—200 Ω chip resistor		

Table 2

Var. no. 1	.509945	Var. no. 3	6.89534	Var. no. 5	2.68589
Var. no. 2	225.748	Var. no. 4	2.20098	Var. no. 6	.269428

Final analysis follows:

0.950	0.420	-164.3	-14.69	-12.4	9.10	84.1	0.275	17.0
1.200	0.335	-171.1	-13.76	-18.0	8.98	60.5	0.334	-9.4
1.450	0.208	-154.7	-12.60	-27.7	8.92	33.1	0.426	-38.1

Table 3

Var. no. 1	.549845	Var. no. 3	7.94897	Var. no. 5	1.66819
Var. no. 2	199.292	Var. no. 4	2.21123	Var. no. 6	.590509

Final analysis follows:

0.950	0.283	168.6	-13.67	-24.6	8.96	79.1	0.173	19.1
1.200	0.157	134.2	-12.87	-33.9	9.06	52.0	0.189	-14.4
1.450	0.105	-6.7	-12.02	-46.2	9.05	21.1	0.215	-48.2

to be "flattened out" across a very broad band. The input impedance of the device is matched by the shunt capacitor and the series transmission line on the input. (A more detailed discussion of impedance matching is not within the scope of this article. However, the technique to determine the match is straightforward. MOP provides the calculations for the conjugate reflection coefficient in its "PRINT" output feature.)

3) The S-parameters must be saved in the proper format in a "device" file on disk prior to running any CAD program.

4) One of the features of this program is the ability to use free format entry of the circuit description. When the prompt "BEGIN" appears the amplifier can be entered by typing:

```
TL 50 OPT .7 RS OPT DEV 1 MRF571 PAR PTCP SER OPT 1000 OPT HOLD 1 CP OPT TL 50 OPT .7 USE 1 .95 1.2 1.45
```

Next the editor prompt will appear allowing the circuit to be listed and changed if necessary. The listing associated with the preceding input is:

```
10  TL CAS 50 OPT 0 .7 0 0
20  RS CAS OPT 0
30  DEV 1 PAR MRF571
40  PTCP SER OPT 0 1000 OPT 0
50  HOLD 1
60  CP CAS OPT 0
70  TL CAS 50 OPT 0 .7 0 0
80  USE 1 CAS
FREQUENCIES: .95 1.2 1.45
```

The MOP editor will use predesignated default values when one is lazy or forgets all the necessary entries (such as the assumed CAS connection if not specified otherwise). Lines 10 and 20 describe the parallel feedback network of a transmission line in series with a resistor. Line 30 describes the transistor as a two-port device named MRF571 in parallel with the previous circuitry (lines 10 and 20). Line 40 is a parallel tuned circuit with R, L, C values given. The parallel circuit is placed in series with the previous circuit (lines 10, 20 and 30). In this case L is made very high so it will not appear in the circuit analysis.

Line 50 tells the program to store the circuit built up to that point as a two-port in storage location "1." Next starting at the very input terminals of the amplifier, the components and two-port are cascaded. Line 60 is a capacitor in parallel, followed by a transmission line, followed by the two-port stored in 1 (line 80).

The "OPT" tells the computer to begin with the user specified starting values and optimize for best performance. In this case the values indicated in Figure 1 are specified with a request of a gain of 9 dB across the .95 GHz to 1.45 GHz band. The initial result with the starting values is shown in Table 1.

After 27 iterations the program prints the values and test results found in Table 2. Notice that the gain (S21) originally rolled off more than 2 dB over the band, but now varies less than 0.18 dB.

Table 3 shows the values and results achieved by running the program with 12 more iterations and weighting S11 (input VSWR) much more heavily than S21. Requesting the "PRINT" output option the input and output VSWR (IVSWR and OVSWR) are computed by the program as follows:

Freq.	Input VSWR	Output VSWR
0.950	1.790	1.419
1.200	1.373	1.466
1.450	1.234	1.546

Note that this amplifier is flat to within 0.1 dB and has input and output VSWR less than 1.8:1 across the band.

The final values can now be substituted into the amplifier design and a real world schematic derived. Figure 2 illustrates such a design where the transmission lines are actually microstrip "traces" on the PC board. Since the MRF571 is a dual emitter device, the 7.95 ohm resistor is split to become two 15 ohm resistors in parallel (one on each emitter lead). The 2.2 pF capacitor is likewise split to a 1.1 pF capacitor in each emitter. The parallel feedback network is a 200 ohm resistor in series with a microstrip line .55 inches long on Teflon board. An example layout of this type amplifier can be obtained from Motorola by requesting engineering bulletin EB-37.

References:

Application notes 95 and 154, Hewlett Packard, Palo Alto, Calif.

Engineering bulletin EB-37, Motorola Semiconductor Products Inc., Phoenix, Ariz.

MOP Instruction Manual, J.H. Walworth, Odessa, Fla.

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Safe work practices in CATV

Management and employees need to be reminded that an effective safety program is not only an integral part of the management of a cable system but ultimately can have a postive impact on the business's bottom line. This article will address the issue of safety, describing a specific safety training process and the importance of compliance with OSHA regulations.

By Leo Garcia
Corporate Safety Officer
American Television & Communications Corp.

The Occupational Safety and Health Act of 1970 requires employers to provide for a safe and healthful work environment. The Code of Federal Regulations (CFR) 1910.268 specifically addresses the training, equipment inspection and safe work practices that employers in the telecommunications industry must provide for employees.

In addition to being mandated by law, safety measures also play an important role in employee morale. Morale often will suffer when an employee is hurt on the job. Fellow employees may worry about the financial impact the accident will have on the injured employee; the overtime they must work to cover the workload of the injured employee, or they may place blame for the accident on the company or the supervisor. Institution of appropriate safety measures can serve to mitigate these problems by reducing the number, frequency and severity of accidents.

Lastly, cable television employees have a great deal of community contact, e.g., direct customer contact, driving high visibility vehicles, community programming, etc. The manner in which they conduct their business determines how they are perceived by the community. If employees are perceived to be efficient and safety conscious, the resultant positive perception by the community may increase subscriber base and/or may help in recruiting employees who value positive customer relations.

Accidents: cost, causes, frequency

When managers look at the direct costs of an accident (such as the medical bills), they are looking at the tip of an iceberg. The indirect costs of accidents are considerably greater than the direct costs. Indirect accident costs include increased overtime, damaged or lost equipment, lost productivity, retraining, accident investigation. Indirect costs of accidents are often four to 10 times higher than the direct cost.

Two of the most common types of accidents in the cable industry involve pole climbing and ladder handling. These accidents do not just happen—they are caused by either unsafe acts or unsafe conditions. Some examples of unsafe acts include: lack of systematic employee training, horseplay, failing to inspect tools and equipment, improper lifting techniques, improper body mechanics, failing to use personal protective equipment, etc. Unsafe conditions arise from defective equipment such as dull and misshaped gaffs; ladders with cracked rails, broken rungs or other defects; clearance violations between power company plant and cable plant; improper clothing; adverse weather; physical fatigue; to name a few.

Pole climbing and ladder handling accidents rank second and third respectively in accident frequency; only vehicle accidents occur more often. Pole climbing accidents include falls, gaff puncture wounds and splinters. Most pole climbing accidents (50.4 percent in a random 12-month sample) occur to employees with less than six months experience and could be eliminated with systematic training in pole climbing techniques, equipment inspection and maintenance, and use of appropriate clothing while climbing.

Some of the more common accidents include ladder slippage (42 percent), carrying material (10 percent), ladder handling (8 percent), and ladder breakage (6 percent). These accidents can be eliminated or greatly reduced by educating employees in proper ladder handling and ladder inspection methods.

Dealing with the problem

The first step in a six-step process for dealing with accidents is to *identify the targets*, for example, pole climbing and ladder handling through analysis of accident reports. The next step is to *identify the components* of the job. List them in proper sequence; examine the job components to determine how to reduce accident possibilities. Employees are an excellent source of information in this step. *Writing corrective procedures* and reviewing them with knowledgeable employees follows in the process of accident reduction. Corrective procedures may reiterate safe practices from present methods as well as present new techniques. These procedures should be reviewed by personnel experienced in that job function.

After the review process, the next step is *implementation of new procedures* which includes training, periodic retraining, certification and documentation. This step is easily accomplished if employees are allowed to participate in steps two and three. *Monitoring* and *evaluating* the effect of the new procedures are the last steps in the process. They should not, however, be considered final steps since periodic monitoring and re-evaluation are necessary in an effective safety program.

Examples of corrective procedures for targeted accident sources could include:

Ladder slippage
- All ladders will be equipped with non-slip feet.
- All ladder feet will be equipped with ice pick plates.
- Bottom rung of ladder will be tied to pole as necessary.
- Employees will use safety strap to secure themselves and ladder to cable strand.

Carrying material
- Employees will use both hands on ladder while climbing.
- Employees will use handline and bucket to raise tools, materials and equipment.

Handling ladder
- Employees will lift ladder by using leg muscles not back muscles.
- Employees should not twist upper body while carrying ladder.

Ladder breakage
- Employees will inspect ladders prior to each use.
- Employees will report, in writing, all ladder defects.

Training material

Training material can be generated within a company which addresses its specific needs by analyzing accident records.

General training materials can be borrowed from OSHA regional offices, equipment manufacturers and equipment distributors. OSHA will provide copies of their audio visual catalog at no cost along with films, video tapes, and slide programs encompassing a broad range of subjects.

Manufacturers and suppliers who provide high quality training aid, supplies and information include: W.M. Bashlin, Grove City, Pa.; Gilbert Engineering, Phoenix, Ariz.; General Cable Telsta Division, Westminster, Colo.; Lynn Ladder and Scaffolding, Lynn, Mass.; and Sachs Communications, Chaplain, N.Y. Many manufacturers and suppliers will provide safety training information or will assist in finding the information. The Society of Cable Television Engineers and the National Safety Council are also excellent sources.

Increased productivity

If management expects employees to perform their jobs safely, they must work together to design and implement effective safety training programs. Safety training will not only reduce accidents, but also will increase productivity, improve community image, and assure compliance with OSHA requirements.

Use of the six step accident reduction method will assist cable companies in implementing an effective program, one that employees will adhere to because they participated in the creation process.

Authors Note: Statistics and percentages used in this article were generated from cable TV industry loss source analyses or were obtained from insurance industry compilation.

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Cable system safety: A public concern

By Kenneth L. Foster
Chief, Division of Telecommunications
New York State Commission on Cable Television

Since its inception the New York State Commission on Cable Television has had, as a major concern, the safe construction and operation of cable television systems. The state Legislature, in adopting the law establishing the commission as a part of the executive department, charged the commission to assure "safe adequate and reliable service to subscribers" and empowered it to make and enforce rules and regulations to carry out that mandate. The commission issued its first rules in the form of "interim regulations" pending adoption of formal rules resulting from a notice of proposed rulemaking. The interim rules were substantially modified through comments filed in that first proceeding. That portion of the rules dealing with public safety was not amended and stands essentially unchanged to this day.

Interestingly, the commission was criticized by industry consultants for "grandfathering" ungrounded subscriber drop installations. It was believed by some that drop grounding should be enforced at once. However, the commission believed that a period of five years would be required for an orderly transition from virtually ungrounded drop cables to full compliance. During the first few years of its operation the commission concentrated more on technical performance of cable systems and outside plant construction practices than on subscriber drop grounding or signal leakage.

Cable commission technical capabilities

The commission built its first mobile test unit in 1973. It was the first vehicle to be designed by any regulatory agency for the sole purpose of evaluating the performance of cable systems. Presently two vehicles are used by the commission in its test and evaluation program. One is a 4-wheel drive unit intended to operate off-road in remote areas. Both are equipped with a variety of instruments. Spectrum analyzers are supplemented by signal level meters, frequency counters, a Rhode & Schwarz field strength meter, Mid-State ST-1 transmitters, demodulators, oscilloscopes and a vectorscope. Calibration equipment also is on board.

As is generally the case, the technical staff operating the equipment and interpreting instrument display is key to the validity of the data obtained. The field staff of the commission consists of former chief technicians of major cable television companies. Staff members have built several thousands of plant miles, installed TVROs and multi-hub microwave systems. Senior staff represents a combined 75 years of communications and government experience. The mobile units and staff have evaluated the performance and inspected the outside plant facilities of cable companies in New York in over 1,300 inspections to date. It is that wealth of data that forms the basis for this discussion.

Outside plant construction

The first major case involving outside plant safety came early in commission history. A cable system operating in the Village of Naples, N.Y., came to the commission's attention as a result of numerous consumer complaints regarding quality of service. As we investigated the technical performance complaints, we became aware that outside plant construction left much to be desired.

We found trunk cables so low that residents were forced to lower car radio antennae to enter or leave their driveways. Drop cables were intertwined with telephone and power cables. The company used utility poles for the first two miles of construction from the headend. From that point, for the remainder of the 13-mile system, cables were on company owned poles and trees. The only outside plant grounds were on utility poles. No subscriber drop grounds were found.

After hearings the commission ordered the system shut down. *Broadcasting* headlined that action "First cable system shutdown in the nation—If it sticks." It did stick. Subsequently, the system was acquired by another operator, rebuilt and is successfully operating.

In Niagara Falls, some trunk cables crossed major streets so low that buses and trucks were in danger of snagging them. Also, in Niagara Falls a trunk cable was pulled over a rail crossing and attached above power primaries.

We often find improper clearances. Sometimes these are caused by power utilities installing secondaries with insufficient tension. In others, the cable operator attaches improperly. In all cases we require correction. We do not regulate utility companies. Therefore, in the strictest sense, they are not required to comply with our requests. However, we find as "good neighbors," utility companies are willing to help resolve problems.

In one instance of serious safety violations we called on the New York State Troopers for assistance. A cable operator had trunk and feeder attached to fence posts and trees and in some places there were no supports. This in itself posed hazards to local residents, however, the greatest concern was that the trunk was "hot." Amplifiers were powered by 110 VAC carried on the cable. When the operator refused to correct that dangerous condition immediately, one of our inspectors, accompanied by a trooper, visited him. At that point the operator had two options: Shut down until the system could be made safe with equipment on hand, or be arrested for endangering public safety. He wisely chose to shut down and install the new equipment.

Presently the commission is overseeing the correction of numerous violations in a small system on the Pennsylvania border. Our inspectors found 75 clearance violations in the 15 miles of plant. Facilities rearrangement charges of the utility companies involved proved to be higher than the operator could afford. Therefore, he chose to vacate the utility poles and reinstall trunk and feeder on his own poles.

> *'Our signal leakage enforcement program produces better system maintenance, fewer illegal hookups, . . . and a better level of service'*

Bonding/grounding subscriber drops

Bonding and grounding is an area of great confusion to cable system operators. Not the least of the confusion results from the belief that the commission has bonding and grounding rules that are different from everyone else. That is not true. The commission rules regarding apprpriate bonding and grounding are those of the National Electrical Code (NEC). We did not invent some new requirements. However, because of the specialized nature of CATV drop installations, we interpret the code. Where methods are unclear, we provide guidance as to what is intended. We have an agreement with the New York Board of Fire Underwriter Inspectors that, in the event of dispute, our interpretation will be final.

In an effort to finally complete the bonding and grounding of subscriber drops and to reduce severe penalties being levied on operators, the New York State Cable Television Association joined with the commission in 1983 to establish a voluntary program of compliance. The term "voluntary" may be somewhat misleading. The commission had been imposing fines on cable companies found not to be compliant with the bonding and grounding rules. The joint program provided operators with an opportunity to assess the extent of non-compliance and report that non-compliance to the commission without penalty. Each operator chose a time within which his system would be brought into compliance. Upon approval of his timetable by the commission, the operator began his compliance program. Of 217 systems operated by 104 companies in the state, only 9 reported full compliance in 1983. At this writing 78 systems have reported completion of the program. It must be noted that should a company report full compliance and subsequently be found non-compliant, severe penalties are certain to follow.

An educational effort was launched as a part of the program. Five grounding seminars were held in locations across the state. Commission and state association staff offered legal and technical advice to system operators and technicians regarding the agreement, the obligations, and the means by which grounding and bonding could be accomplished. (A booklet, containing answers to many of the most often asked questions, has been prepared by the author and is available at no charge from the commission.)

It is often said that bonding the CATV drop-cable to the electrical ground of a subscriber's home is a dangerous practice. There continue to be proposals put before Panel 16 of the NEC committee to remove the bonding requirement. These proposals are based on the fear of causing house fires by bonding CATV to power neutrals, thus overheating the drop cables. Our experience does not support that position. As a standard test procedure we measure sheath currents in drop cables. When properly bonded to power ground, the sheath currents remain very low even in the presence of a multi-kilowatt electrical load in the home. Our files contain over 600 measurements of sheath currents. We find that currents range from 0.1 to 0.25 amps in typical installations. These currents are 20 to 40 times lower than is required to raise the temperature of a typical RG-59 drop cable 50 F above ambient.

For the interested reader, the subject of wood combustion is fully discussed in *The Woodburner's Encyclopedia* by Dr. Jay Shelton, professor of physics, Williams College, Williamstown, Mass.

In our experience, only one fire was due to a *properly bonded* CATV drop. In that instance, a house fire of electrical origin had occurred. The local power company cut down the triplex feeding the house. A "good neighbor" ran an ungrounded extention cord across the lawn to power a water pump in the damaged house. The only way for the neutral current to get back to the power source was through the drop. That is the only verified ignition of a house caused by overheating of a properly installed CATV drop cable.

TV set and converter damage, while not a common complaint filed with the commission, invariably is traced to non-grounded and/or unbonded drop cables. After some recent electrical storm activitiy, we investigated six complaints of TV set and VCR damage. Only one drop was properly installed. In three other cases of severe set damage, the drop cables were attached to ground rods, but not bonded to power ground. It also is important to be certain that strand bonding and grounding in outside plant is in place and effective. If strand bonding and grounding is not effective, it is likely that grounding at the house will cause hum in pictures and noise in AM radios.

As a final note on bonding and grounding, it makes great sense from the standpoint of protecting the cable operators equipment, both in the home and in outside plant. Subscriber drop grounding offers another potentially very valuable protection, that of protection from liability in the event of set damage or fire. An insurance underwriter's inspector makes no judgment with respect to the adequacy of the grounding. He looks for compliance with code. If he finds the drop installation non-compliant, the system operator may have bought a house. The cost of the proper bonding and grounding of a subscriber drop is insignificant by comparison.

Signal leakage

The debate over allowable levels of signal leakage, channelling plans, prohibitions against use of certain frequencies and the effects of these on the safety of air travel has raged for years. It cannot be argued that air safety is not a vital public concern. However, in the view of the few verified instances of interference to aircraft communications by cable systems, none of which appeared to place an aircraft in danger, it would be fair to conclude that cable systems are not a clear threat to air safety. That is not to say that signal leakage rules should be abandoned. Rather, concentration on seeking out causes of harmful interference to all public safety radio systems is in order.

When the great debate first began, cable technology and lack of programming made mid-band operation more dream than reality. That is not so today. It is a rare system now that does not have most, or all, mid-band channels loaded. Often the programming selections are

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We have not verified interference to aeronautical radio services from cable system operation in 13 years of testing and evaluation. At the request of the FAA we have investigated five aeronautical radio interference complaints in Albany, Corning, Lake Placid and Syracuse. In one instance, the interference was caused by an improperly tuned commercial FM broadcast station. In another, control tower receiving equipment was at fault. The remainder could not be found after intensive sweeps of the areas. These five are the only recorded complaints in our files and are included here for the purpose of showing that, 1) interference to aeronautical frequencies is very rare (or rarely reported), and 2) that there has been no verified interference to aeronautical radio services by cable television systems in New York.

The few instances of aeronautical interference from any source is countered by the alarming number of complaints of interference to land mobile public safety radio services. Channel F and, to a lesser extent, Channels E and G are the causes of an epidemic of verified harmful interferences to public safety radio systems.

The services most interfered with are local police, ambulance and hospital communications, fire departments and environmental conservation (ENCON) systems. Environmental conservation has three vital functions: law enforcement, search and rescue, and fire fighting coordination. In New York, the prime frequency for ENCON radio systems is 151.25 MHz. Three alternates are 151.220, 151.265 and 151.280 MHz. All frequencies are subject to interference from the Channel F visual carrier and the first and second horizontal sidebands. State police have homed in on cable system leakage when their scanners lock on the Channel F color subcarrier, and fire departments have been forced to use runners when their receivers gave them Showtime audio instead of fire fighting instructions.

These are not rare instances. They are reported by the hundreds. Over 120 interference complaints from an amateur radio RACES network, 42 complaints of interference to local police, ENCON and medical radio systems in another area and loss of communication between five fire companies in a mutual aid fire are but a few examples of the problem.

There are people in the industry who continue to believe that maintaining signal leakage at or below 20 μV/m, or meeting the cumulative leakage index (CLI) test is sufficient. That is far from the case. If a signal leaking from a CATV system causes harmful interference, it must be eliminated regardless of level. Land mobile receivers have sensitivities in the region of 0.25 to 0.3 μV. Many mobile units are equipped with antennae having 4 to 5 dB gain. That combination makes elimination of signal leakage mandatory if the cable operator wishes to continue to operate on certain frequencies.

The New York commission reacts quickly to resolve interference problems. There are two possibilities for action where interference is harmful. In the first, as chief of the telecommunication division, I have authority to order the immediate suspension of operation of an interfering channel. This is a temporary measure, followed by hearings and further commission order. In the other, where violations are harmful and continued, the commission acts after hearings to order the offending channel off the cable. No consideration is given to program content on the channel. Thus, a cable system operator may be required to turn off HBO or Showtime until he can find another channel for it. One cable system has not been able to operate on Channel F since December 1984 as a result of commission order. Another system voluntarily vacated Channel F until signal leakage could be controlled.

There are several ways in which signal leakage may be kept at a minimum. A signal leakage monitoring and correction program is a must, and the CLI tests are a good beginning. Careful theft-of-service audits minimize leakage. Correct installation of F-fittings and wrench tight connections also help. Major sources of leakage, as reported to us by cable operators, are loose, corroded or improperly installed F-connectors.

Another approach, not possible in HRC systems, is a slight offset of the channel frequency. We have found that interference to

Safety and risk management in CATV

By N. David Griffiths

Safety and risk management is a subject that evokes everything from outright laughter to very stern frowns depending on your function in the industry. Cable is such an amalgam of entrepreneurs that it is difficult to nail down all parts of the industry to a precise safety and risk standard. For you as a manager this is a costly dilemma. Much has been written on or about the subject but what have you ever been able to lay your hands on that promises executive control over the safety and risk area of your business? Those neat printed articles that take on bits and pieces of the problem are usually very accurate, but what have you in the area of controls? When you don't have controls, your only alternative is to throw money directly or indirectly (via insurance) at the problem. This, of course, has the buckshot affect—some hits the target, the majority falls to the ground.

The first and foremost item that is necessary is a total commitment (not lip service) from the number one man who sends a message all the way down the management ladder that says, "We're serious about safety and risk management." This will create up-front costs, which is precisely where many now back off. If you're still with us, the next step is organizing your team with a program that is palatable to almost all (you can't get 'em all). This program must have motivational items that can be easily accomplished by all participants: a program that upon introduction will show your team they can turn this ship around; reduce accidents and cut losses. They must be shown that the work to accomplish this is probably easier and more rewarding than whatever assortment of projects and papers they were shuffling previously. Don't forget there has got to be a motivation, a reward for the guy all the way at the end of this program. He is the one who can make or break it—he is the tail that can "wag the dog."

Implementing a program

Let's get specific now. The first major item is an easily documented safety training program for each and every vocational employee. This document becomes an integral part of their personnel folder. The program is all-encompassing with their work operation and should be done on a subject-of-the-month basis. That way you, the manager, knows what the month's subject is. (You can now identify with the program by knowing what the current subject is.) The material must be completely prepared and given to the supervisor(s) at the

'Why not a system that rewards the safest worker, the safest driver or both'

formal hands-on safety seminar. They must be able, upon leaving the seminar, to transmit the information and judge its comprehension among their people. Remember, this must be a one-on-one, hands-on training session, five to 15 minutes per month on a specified subject. No rambling!

Where is the motivation you ask? Well, did that supervisor ever feel he or she had to generate all that program themselves, did they feel that burden on their shoulders? How helpless did they feel when an accident happened and they could not stand up and prove that they "trained" him or her? By the way, what have you (Mr. Committed Manager) in your bag of tricks for the supervisor with the best accident and safety training record this year? You now have a documented program that you can audit, which means you have a bonafide basis for presenting an award or reward. The choice is yours.

By now you are asking where is the motivation for the person on the line? Well, talking about eliminating pain and suffering from accidents is not always enough to get people to work safely. How many people quit smoking because of the surgeon general's warning on every cigarette pack? But, tell 'em how it hits their pocketbook and now you are hitting home. Have you thought about competition—not yours—theirs! Why not a system that rewards the safest worker, the safest driver or both? Include opportunities for many people, not just one or two to earn this reward. One qualifier, besides a lack of accidents, could be how well they score in their monthly safety lesson over a year's time. If I know that part of qualifying for a reward is how well I perform in the safety training sessions, you know damn well I'm gonna bug my supervisor for those lessons and I'm gonna try for a good mark. Now isn't that a switch? You also might wish to tie this in to any absenteeism problem you have.

Getting results

Today's work demands much more from management than a day's pay. So, let's make it easy for all of us by getting workers, drivers, etc. on our side through motivation and a structured program. Safety is not something to play at—you have to work at it!

ENCON radio services is virtually eliminated by shifting the Channel F visual carrier to 151.321 MHz, or 151.179 if the positive offset would result in interference to state police or highway department systems. This is a measure that provides a temporary cure to a specific complaint. Elimination of the leakage, not shifting it to a different place, is the goal.

Before an offset is implemented, operators are cautioned to determine whether the offset will cause interference to other authorized radio services. An evaluation of the effect on encoders, decoders and converters also should be undertaken.

An energetic and effective signal leakage prevention program is an added expense. The assignment of one or more technicians, vehicles and test equipment adds to the cost of operation. The cable system operators who now have effective programs in place have reported significant benefits in fewer trouble calls, better picture quality and a significant reduction in theft of service. These benefits outweigh the cost of the signal leakage program. A final note on the signal leakage program. Where it is effective, the cable system operator is unlikely to lose a revenue producing channel as a result of commission action.

Benefits for all

The imposition of public safety standards by the New York commission and its active enforcement of those standards is seen by many as a great public benefit. Systems are safer in terms of outside plant construction and in subscriber installations and provide a higher quality, more reliable service. We believe these to be true. However, it is not often recognized that our safety standards directly benefit the industry.

In our inspections of outside plant we sometimes discover clearance violations. Because of our experience in construction, we often conclude that the violations are utility company responsibility. We work with the utility company to correct the violations without cost to the cable system operator.

Our imposition of standards and enforcement of subscriber drop cable bonding and grounding requirements has resulted in safer plant. It has resulted in agreements with insurance underwriter inspectors that we are the definitive interpreters of NEC requirements with regard to cable installations. Therefore, there is uniformity in code application statewide. Further, our ongoing inspections of grounding and bonding of CATV drop has blunted the thrust by underwriters, inspectors and electrical worker's unions to persuade local governments to require independent inspections and attendant fees for each installation.

Finally, our signal leakage enforcement program produces better system maintenance, fewer illegal hookups, fewer trouble calls and a better level of service to subscribers. Further, since it demonstrates that signal leakage is controllable, it may preclude further federal intervention in channelling plans or prohibitions on channel use.

Lighting the way with technology

By Mark Harrigan
Bay Area System Engineer, United Cable Television Corp.

Alameda, Calif., is a small city of 28,000 homes located on an island across the bay from San Francisco. Cable TV was late in coming to the city, and the city council was determined to have an advanced, high-capacity system that would meet both current and future needs. To meet this challenge, United Cable decided to build the system using a new product, Mini-Hub I.

Mini-Hub I (MHI) is a star-switched, off-premises CATV system that uses fiber-optic drop cable. Although MHI had been installed in a few places before, it had never been installed in an entire city. When completed, Alameda would have the world's largest fiber-optic CATV system. The Alameda Mini-Hub I system differs from a conventional system in several significant ways as will be discussed here.

Off-premises

Most addressable CATV systems place a converter/descrambler in each subscriber's home. Off-premises systems place these electronics beyond the subscriber's reach in a secure enclosure. Although this virtually guarantees that there will be no theft-of-service, we had to find places for over 770 enclosures that house the off-premises electronics. Of those, 525 were placed on utility poles; the rest were mounted on pedestals or in MDU locations. We had more than a few complaints about the amount of space these "refrigerators" took from those with small yards.

We discovered that inventory control for an off-premises system is different than for a conventional system. Even though the keypad and the optical-fiber modem in the home costs less than $70, it still must be reclaimed upon disconnect. We also must keep track of the equipment in the outdoor enclosure. Typically, we wait 60 days before we remove subscriber electronics from an enclosure. We do this because when a new tenant moves in, he may become a new subscriber, and we will have avoided rolling a truck.

Star-switched

In a star-switched system, the tuner for the converter is housed in a hub enclosure outside the customer's home. The channels available to the customers are controlled by the Mini-Hub's microprocessor, which in turn is addressed by the system's central computer. These microprocessors also relay customer requests and diagnostic information back to the headend through a two-way modem. The customer makes channel selections, vote selection or selects IPPV events via the keypad in the home.

A conventional feeder cable is connected to each enclosure and fiber-optic drop cables connect each home to these enclosures. United decided to use a conservative, although more costly approach to cabling by installing a dedicated drop from the Mini-Hub enclosure to a subscriber junction box, which acts as would a conventional tap-off point. These multi-fibers are lashed together using standard techniques and equipment to produce a very neat bundle. Another cabling technique that has been used in other off-premises systems is to delay installing drop cable until a new subscriber signs up. The installer then runs the drop cable from the hub up to four spans (usually) to the pole that will serve the home that is being installed. Each of these installations may cost a little more but the overall construction cost can be significantly less.

Star-switched systems only switch one or two channels plus FM over a single drop. While this provides ultimate security and allows control and collection of revenue for second sets, it limits us to two sets per drop. With the increasing proliferation of VCRs and extra TV sets, we have to install a second drop cable for additional outlets. Even though we gain additional revenue, installing additional fiber-optic drop cables is expensive.

A conventional CATV plant is designed to feed every home passed. While this can be done in a star-switched system, it is much more cost-effective to size the system for the expected penetration. The net result is that significant savings can be realized in the cable plant because there are fewer line extenders and trunk amps. The downside risk is that if you estimate your penetration incorrectly, you may have to add another enclosure. The Mini-Hub I system is available in groups of 24 sets, so in the worst case, you may have 23 extra spaces for the one extra user.

Fiber optics

One of the most interesting aspects of the entire system was the use of optical fiber to connect each home to the cable plant. Fiber-optic capability should provide several significant advantages over conventional coaxial drop cable. Reduced attenuation (0.21 dB/100 feet) and immunity to electromagnetic interference promised to offer high-quality pictures with low maintenance costs over long drop runs. The physical size of the cable made its use especially attractive in a dual-cable system.

Each subscriber's home is connected to the enclosure by a large core (200/250 μm), step index, duplex fiber-optic cable. One fiber is used to transmit the video and audio signals to the home; the other fiber transmits commands like channel change, on/off, etc., to the microprocessor located in the enclosure. Drop cables at the nearest take-off pole were terminated in a specially designed junction box. When a subscriber's service is activated, fiber is run from the home to the junction box where it is joined together by an optical-fiber connector.

From the very beginning, the problem of the fiber-optic connector was a major issue. Most optical-fiber connector designs were based on low-cost epoxy fasteners that are associated with high installation costs or high-cost mechanical clamp technologies, both unsuitable for a CATV fiber star network that would eventually require over 150,000 connectors. Ultimately, Times Fiber produced the TPC II (three-pin connector) that could be installed in less than two minutes in the field, had a mean attenuation loss of 0.9 dB and cost slightly more than $2 per plug. While using this connector has helped the problem, the cost of the fiber and fiber-optic connectors is still much more expensive than a coaxial system.

A light emitting diode manufactured by Motorola was used in the hub and provided from 200-400 microwatts of launched optical power. A Motorola receiver was used in the in-home, optical-fiber modem.

Two-way

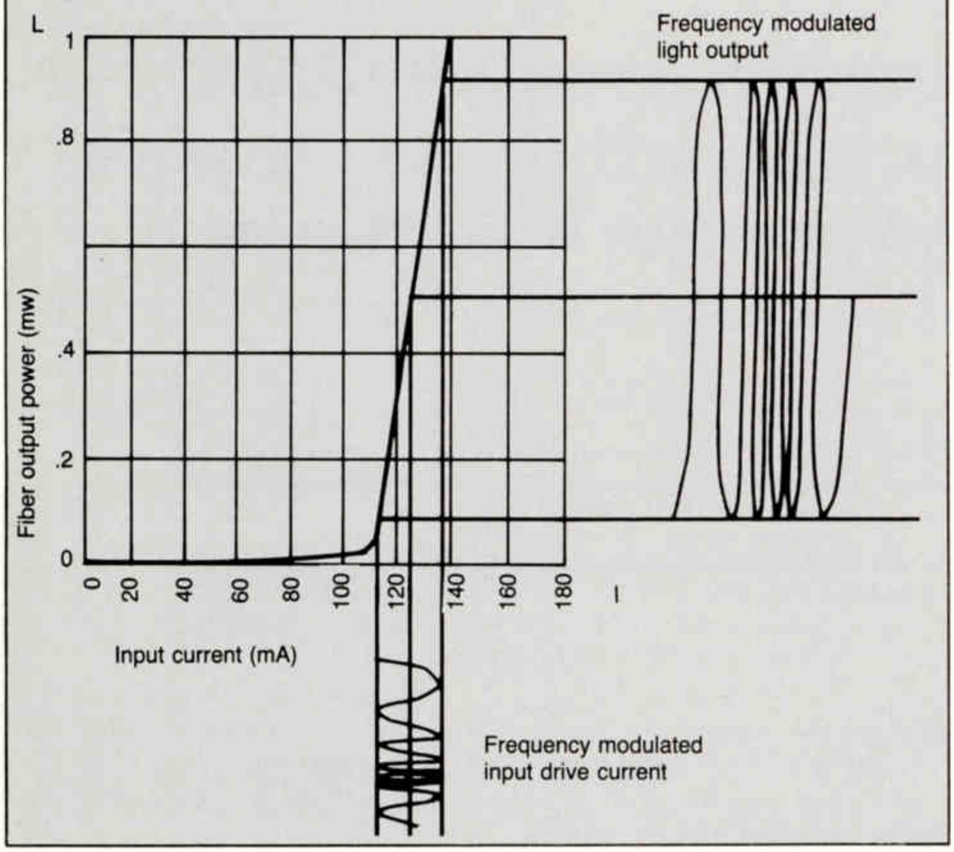
Unlike many of today's franchise requirements that require a system to be two-way capable, the Alameda system had to be two-way operable. Two-way systems are usually difficult to operate and maintain because noise entering the system can wipe out the upstream path. In a conventional two-way system, information must be collected from each subscriber's terminal so every drop cable, every fitting and every piece of terminal equipment (e.g., VCRs, splitters, converters) can allow noise to enter. In a star-switched system, the microprocessor in the enclosure sends the required information back to the headend; all drop cables are completely isolated from the upstream path. This isolation eliminates the largest contributor to return path noise.

Pros and cons

Being a pioneer is never an easy task. There were many challenges to be faced and overcome; however, off-premises has proved itself in providing absolute signal security. The use of fiber optics for this system was a unique and challenging decision. However, the revenues to be gained from enhanced services have not offset the cost of the fiber, the fiber connectors and increased skill required to install them.

Recently, United Cable of Alameda was granted the franchise for the Alameda Naval Air Station, located on the outskirts of town. We are installing TFC's Mini-Hub II system, which is the next generation star-switched, off-premises system. Mini-Hub II uses all coaxial cable and thereby eliminates the expense associated with fiber optics.

Figure 1: Laser L-I transfer characteristic



'Early acceptance of fiber optics by telcos and the hesitation on the part of the CATV operator can be attributed to the basic difference in transmission formats'

Single-mode fiber invites new friends

By George Benton
Vice President, Marketing, Catel Communications

On April 1, 1985, the first commercial, multichannel single-mode fiber-optic link for a CATV operation was activated in Indianapolis. The system links the headends of American Cablevision of Indianapolis (a division of ATC) and Indianapolis Cablevision, providing local advertisers access to eight cable networks, including ESPN, Cable News Network, MTV, Lifetime, the Nashville Network, Financial News Network, USA Cable Network, and Christian Broadcasting Network. Together, American Cablevision and Indianapolis Cablevision serve 45 percent of the 281,000 television households in Marion County, Indiana. For local advertisers, this represents more than 312,500 viewers. The commercial potential of this linkup is obviously significant. The technical potential is equally significant as this installation signals the return of fiber-optic technology to CATV.

The installation of the cable plant, approximately 7.9 miles, was a cooperative effort between ATC and Indiana Bell. The four fiber-optical cable was overlashed by ATC along existing CATV trunk plant with one short underground section. Splicing of the cable sections along the route and at the terminal locations was done by Indiana Bell crews using standard techniques and equipment developed while implementing the conversion to fiber optics in the telco outside transmission plant over the last five years. The Indianapolis installation partnership yielded an end-to-end optical system loss after installation of less than 1 dB/km, well within system specifications and operational requirements. This was not the first fiber-optic system for either Indiana Bell or ATC. However, this joint effort using the single-mode technology developed to handle the telco's interconnect applications may signal the start of an important relationship for CATV operations in many urban areas.

Fiber optics is not a newcomer to CATV. The first documented installation of fiber-optic CATV link was at Teleprompter's Manhattan, N.Y., headend in 1976. The optical system transported video signals from the antenna site 800 feet to the headend. From 1976 to 1982 several CATV companies continued to pioneer the use of fiber optics including ATC, Continental Cablevision, Falcon Cable, Manhattan Cable, Storer Communications, United Cable, Vision Cable and Warner. The typical application was multichannel video transmission between satellite earth station and the headend or hub-to-hub interconnects. These early installations all utilized multimode graded index optical fiber with optical transmitters and receivers operating in the 850 nm wavelength region.

The typical configuration was four to six video channels per fiber, 4 to 8 km system length with repeaters required every 2.1 to 4 km. By September 1982 only 28 new fiber-optic systems had been added to the original Teleprompter system for a total of 120 cable miles and 493 channels. Obviously fiber optics did not gain acceptance from CATV operators as a viable alternate to coaxial, RF technology during this period of CATV growth. At the same time the telcos were in the process of converting a major portion of their interoffice trunking over to fiber.

The primary reason for the early acceptance of fiber optics by telcos and the hesitation on the part of the CATV operator can be attributed to the basic difference in transmission formats. During the 1970s the telcos were in the process of converting their interoffice transmission to digital PCM format from analog, while the video "interoffice" transmission of CATV remained analog. Analog optical systems, using multimode fiber and short wavelength (850 nm) devices with broader emitting areas, presented significant problems for the early manufacturers of the systems. These problems led to installation delays, increased system costs and derating of the original performance specifications.

Going optical with analog

One problem with analog transmission over optical fiber involves the conversion of the electrical signal to light. Optical communications are typically implemented using some type of intensity modulation. With digital transmission, the binary transitions can be simply represented by the presence or absence of light, i.e., the light source is either "on" or "off." Direct intensity modulation of an analog signal such as video, however, is complicated by the non-linearity of the transmitting and receiving devices; lasers and APDs. Figure 1 shows the typical transfer characteristic of a 1300 nm injection laser diode. The RF drive is transferred to intensity modulated light energy at the same frequency as the RF drive. If the transfer characteristic were truly linear no distortion products would occur and the only distortion would be the laser noise. However, as the RF drive to the laser is increased, intermodulation products occur in a fashion quite similar to other broadband analog systems. Therefore, when designing multichannel optical systems, both laser noise and laser intermodulation performance must be accounted for. Fortunately, as Figures 2 and 3 illustrate, the performance of the lasers available today is significantly improved when compared to the units available three years ago.

Another problem that arose with early analog optical systems was due to the interaction of the laser and the optical fiber. When a highly coherent source such as a laser is coupled with a multimode fiber, the light propagating in each mode is coherent with light in all other modes. Interference between these modes leads to the formation of a speckle pattern at the output of the fiber, the spatial distribution of which is continuously changing as a result of temperature or mechanical effects. When this

Figure 2

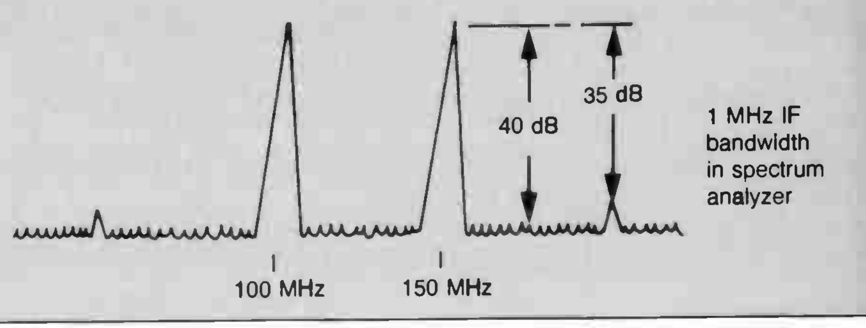
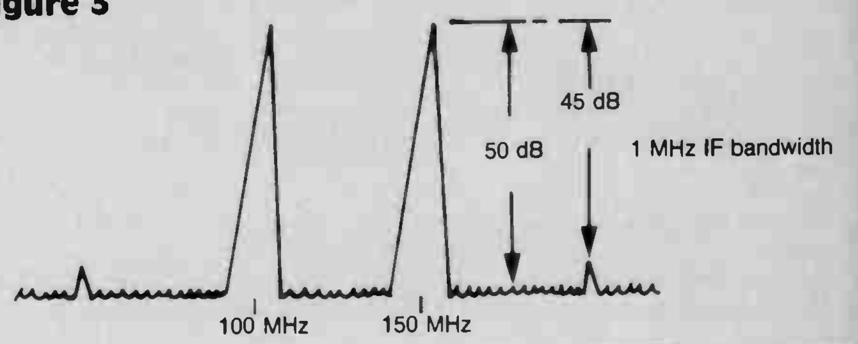


Figure 3



pattern is filtered by a splice or a misaligned connector, a form of noise called modal noise occurs and becomes a significant factor in the overall system performance. Periodic noise floor degradation due to modal noise of up to 10 dB was not uncommon in laser-driven multichannel analog systems using multimode fiber.

In addition to modal noise, an associated optical-fiber characteristic, modal dispersion, significantly affects the operation of a multimode optical system. Users of broadband analog systems such as CATV, work with available system bandwidth. With multimode fiber a 1 km section may have a useable bandwidth of 800 MHz. The addition of unrepeatered 1 km lengths, however, will continue to erode the useable bandwidth so that there is only 100 to 150 MHz of useable bandwidth remaining after 8 to 10 km (5-6 miles). This is due to the ability of multimode fiber to support many modes of light and the unpredictability of all modes arriving at the detector at the same time. This phenomena is known as modal dispersion. One method of preserving bandwidth or compensating for modal dispersion is to interrupt the fiber with a repeater. This, however, introduces other forms of distortion due to the non-linearity of the optical devices as discussed previously.

Single-mode technology has minimized the modal noise and modal dispersion problems associated with the earlier multimode systems. Single-mode fiber is designed to support only a single mode of light analogus to a bandpass filter for the analog system designer. Bandwidth reduction due to modal dispersion is virtually nonexistent. Most commercially available single-mode fiber today has the lowest dispersion at 1300 nm, although Corning has recently announced the availability of dispersion shifted fiber to take advantage of the 1500 nm region. The nominal dispersion of single mode fiber at 1300 nm is about 3.5 x 10-12 sec. per nm-km. Assuming a system distance of 30 km (18.6 miles) and a laser shift in wavelength of 3 nm when it is intensity modulated, the useable bandwidth of that 18.6-mile single-mode link would be:

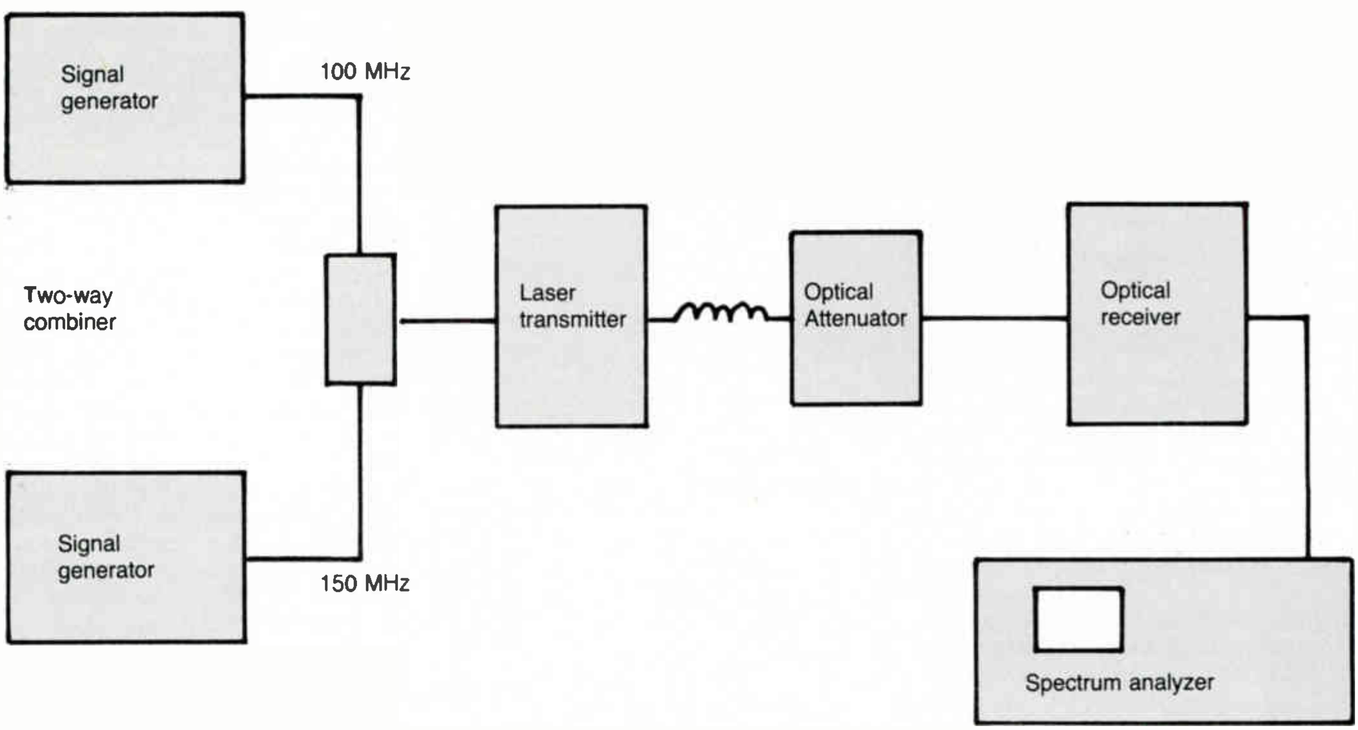
Bandwidth = 0.187/tr
tr = dispersion (psec/nm-km) * distance (km) * laser shift (nm)
tr = 3.5 × 10–12 * 30 * 3 = 315 × 10–12
Bandwidth = .0187 / 315 × 10–12
= 593.65 MHz

From this example we can see that single-mode fiber offers at least four times the available bandwidth over seven times the unrepeatered span length of the earlier multimode systems. The impact of the improvement of laser performance and single-mode fiber technology upon users of multichannel analog systems can be illustrated by the test setup in Figure 4. With the laser coupled to a multimode optical attenuator and then to the optical receiver, the attenuator is adjusted to ensure that there are no distortion products from the receiver. Figure 5 shows the typical RF system performance observed at this point on the spectrum analyzer.

If the laser is changed to single-mode operation through the addition of a single-mode optical-fiber pigtail in place of a multimode pigtail, and a single-mode attenuator is inserted in place of the multimode version and adjusted as above, the RF performance of the single-mode link as observed at the spectrum analyzer would be the same as that shown in Figure 6. In this simulated test an improvement of approximately 10 dB in both the carrier-to-noise ratio (C/N) and carrier-to-intermodulation performance was attained by merely changing from multimode fiber to single-mode fiber. This signal improvement coupled with the increased available bandwidth and lower optical attenuation of single-mode fiber are the major factors in turning multichannel, fiber-optic analog systems into a cost-effective solution for present day CATV applications.

The final part of the technical upgrade for multichannel CATV applications has taken place in the electronics themselves. When video FM was introduced to the CATV industry in the middle 1970s, questions arose as to the actual improvement the operator would see over a conventional AM supertrunk. Today, FM transmission is common on most major CATV coaxial hub or headend interconnects and an FM improvement of 15 dB in the video signal-

Figure 4

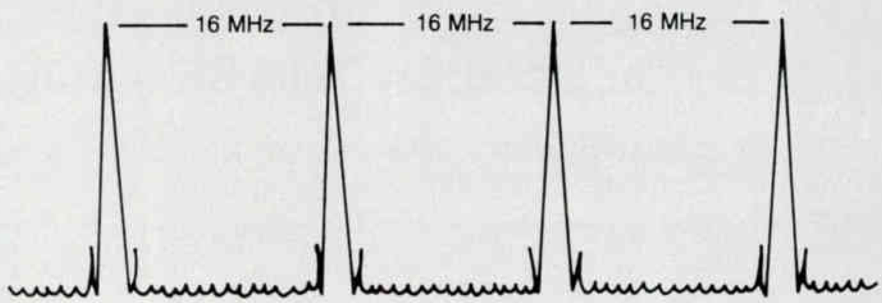


to-noise ratio (S/N) is typically assumed for planning purposes. Actually, using published data and formulas, the calculated FM improvement for a signal with an FM deviation of 0.9 MHz would be 16.8 dB over the C/N in a 4.2 MHz bandwidth. This assumes a single video channel S/N performance without any reference to intermodulation effects present in multichannel systems.

Intermodulation (IM) distortion as a single interferring carrier also affects video performance but in a widely varying fashion depending upon where the carrier is located. In a multichannel FM system with all carriers being modulated, a close approximation the noise contribution of IM products is that they have the same effect as noise. For example, a C/N of 37 dB in a 4.2 MHz bandwidth and a carrier-to-IM ratio of 37 dB will yield an equivalent C/N of approximately 34 dB. As the IM products become higher than the noise, the IM performance is the overriding factor in the video S/N performance of the system. This is especially true when all of the IM products fall into other channels as illustrated in Figure 7. In this example, all the carriers are equally spaced at 16 MHz intervals.

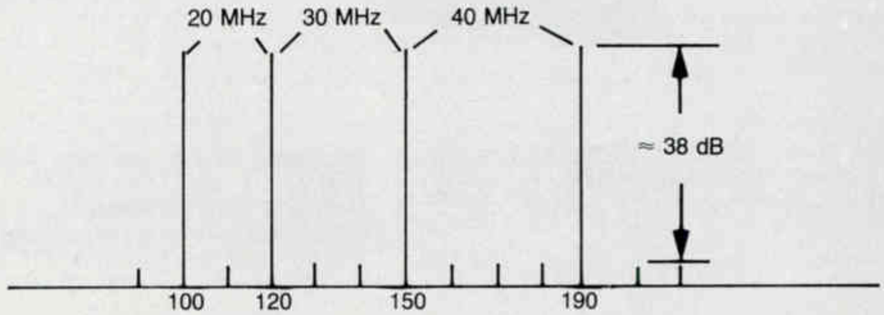
In multichannel optical systems the laser second order products are typically 6 dB higher than third order products at normal drive levels for the laser. If the RF drive band for the laser can be kept below one octave in bandwidth, third order products will be the only concern. Obviously the optimal solution would be to space the carriers such that IM products fall into areas of the spectrum where they will not cause degradation to the overall

Figure 5



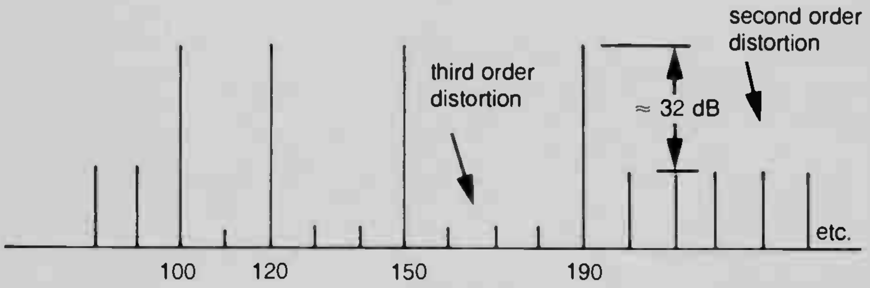
Typical equal spacing

Figure 6



Typical unequal spacing

Figure 7: Typical second order intermodulation distortion



system S/N performance. Such a channelization plan is shown in Figure 8.

As shown, all third order products fall out of the receive band for the primary carriers. Obviously, as the number of carriers in the system increases the ability to avoid all IM products becomes difficult if not impossible.

With the combination of new improvements, both optical and electronic, the CATV operator, telephone company, and yes, even the broadcaster, are now able to implement high-quality, cost-effective multichannel analog TV transportation over the same transmission medium: single-mode optical fiber. The system in Indianapolis was the first. In August, Tribune-United installed another multichannel single-mode fiber-optic system in Maryland. The system will have three separate two-way optical cable spans from the headend to the suburban hubs, distributing 33 video channels among all four sites along with additional data information channels. In October, Warner began connecting the satellite downlink and headend at its Queens, N.Y., plant with a single-mode system; and before the end of this month multichannel single-mode fiber-optic systems should be installed in Texas, Ohio and Connecticut.

Figure 8

Number of video channels	Video S/N (weighted)
1	67 dB
2	67 dB
3	67 dB
4	63 dB
5	60 dB
6	60 dB
7	58 dB
8	58 dB

Seeing the light

We've all observed that in many cases, especially when high technology is involved, solutions arrive in search of applications and/or users. In this case the solution has arrived at an appropriate time with multiple applications and users. There is an abundance of optical-fiber cable plant, both multimode and single-mode, installed within and between the major urban areas of the United States. There's also a growing use and awareness of TV/video, both for entertainment and for business applications. Multichannel analog single-mode video systems could provide the established common carriers of information—telco, CATV and broadcasters—the opportunity to cost-effectively expand their services now with existing electronics and technology.

After a couple of false starts, the CATV industry is rapidly recognizing, as their telephone counterparts did earlier on, the advantages that optical transmission could bring: better quality and reduced operating costs for the operator.

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1A. TITLE OF PUBLICATION
Communications Technology

1B. PUBLICATION NO.
0 8 8 4 2 2 7 2

2. DATE OF FILING
9/23/85

3. FREQUENCY OF ISSUE
Monthly

3A. NO. OF ISSUES PUBLISHED ANNUALLY
12

3B. ANNUAL SUBSCRIPTION PRICE
$-0-

4. COMPLETE MAILING ADDRESS OF KNOWN OFFICE OF PUBLICATION *(Street, City, County, State and ZIP+4 Code) (Not printers)*
12,200 E Briarwood Ave., Englewood, Colorado 80112 Suite 250

5. COMPLETE MAILING ADDRESS OF THE HEADQUARTERS OF GENERAL BUSINESS OFFICES OF THE PUBLISHER *(Not printer)*
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Paul R. Levine	7573 E Hampden Ave #302 Denver, CO
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'An additional feature that we incorporated in our standby power is time delay circuitry . . . which will allow the transients and spikes to settle down before we switch back'

—Bob Williams

Lightning protection: One operator's

The powers of lightning to destroy cable equipment and cause objectionable interference have plagued operators for years. In Florida, the problem is particularly acute since the state frequently suffers lightning storms. In response to the issue, the Society of Cable Television Engineers' Florida Meeting Group held a seminar on Sept. 5, in which lightning was one of the main topics. Following the seminar, Group W's Tommy Hill, district engineer, mid-Florida district, and Bob Williams, regional project engineer, Southeast district, spoke with Communications Technology *staffer Peyton Koeppel about some of their problems and solutions to the lightning problem. The following interview is an outgrowth of that conversation.*

\+ + +

CT: Is lightning a real threat for your equipment?

Hill: Yes, it is a very real threat to cable, but direct lightning hits are not the main problem. I would say out of 100 lightning-related cable equipment problems, probably 95 stem from voltage surges and not direct lightning hits.

CT: What about when lightning hits the cable itself up on the pole, doesn't it blow out the amps?

Williams: Yes, but we sustain very few lightning hits. Most commonly, we feel the secondary effect. We usually sustain electrical power-related problems to where they will drop the transformer or the secondary. When they drop the secondary and if it cycles down and up, the field that it puts out injects the voltage into our cable and this spike or transient comes down the cable and primarily what happens is it blows a fuse. In many cases all we have to do is go out and refuse. We do not normally sustain these kind of problems if we're on telephone poles; it's only on power. And anytime due to near hits or hits that they have, and it may be a hit that they had at a sub station many miles away, as their voltage drops, it will induce a voltage that will get into our cable, a secondary.

Hill: Let me add one more thing to give you an example that it is truly a real threat to our systems in Hillsboro and Pinellas counties. This area, by the way, is the lightning capitol of the United States. There, we measure our service calls in percentage to the number of customers we have. So that's the measure that we have for our monthly report, which demonstrated that three percent to five percent of our customers receive service calls in September. And during the lightning season in Hillsboro County, our service call percentage doubled. So, if we had 5 percent of our customers who normally receive a service call, it would go up to 10 or 11 percent. So, lightning is very much a threat to us; it is the primary reason our service calls increase.

CT: Do customers call because of the outages or static on their screen?

Hill: It's a lot of different things. It may be the after effects, or some portion of the system, not necessarily an amplifier but a passive device, and the signal is still passing somewhat, but it's slow and we have a snowy picture. It can be a complete outage, it can be a hit that would affect only their drop—burn it out at the ground block in other words.

CT: So, about half your service calls occur because customers don't have a picture anymore and then the other half still have a picture but it's got problems?

Hill: Yes, and a lot of problems and a lot of calls we would receive may not be our problem. Maybe the power is down and it comes back up.

Williams: There are many things associated with service calls. It may be that there is an outage in an area due to a powering problem where anything past that signal is off. Then, when those people call in, you get their addresses, etc., and when the problem is corrected, they come back up. Well, we have a method where each of those people are called back to verify their signal is back up. You would think that the service call where you went out and replaced that fuse would correct all those problems. But when this signal goes off, many times a customer will get up there and adjust the old fine tuner. And he will tune it so far out that when it comes back on he has no picture. And the CSR is helping him on the phone, and the customer says no we don't have any picture. She will tell him how to tune into Channel 3 and how to adjust the fine tuning, etc. So in many cases, just because of trying to correct a problem that really isn't there, a person can make a problem that really may not be more than fine tuning.

CT: How much has Group W spent to repair or replace equipment damaged by lightning?

Hill: It's in the thousands and thousands of dollars.

CT: Have you done any simulation of lightning testing?

Hill: No, but we have set goals of what we're going to do for next year. As far as my district, one of my goals, starting this year, is to minimize lightning problems in Florida as much as I possibly can and so we do plan to do some of this.

CT: Have you obtained any equipment to do any testing?

Hill: Nothing other than to test the grounds and those type of things.

CT: What do you use?

Williams: What we do as far as grounding of towers and electronics and that type of thing is rely on ground rods and copper grids that are all connected to earth-driven ground rods. The grids work very well. And the ground rods are normally driven four inches below the surface, always submounted.

approach

CT: Do you try to make the ground rods straight?

Williams: The ground rod is very rigid. It's a 5-inch diameter rod and we'll drive it straight down. The only time that you would run into any problem would be, and we don't have that problem here, where you're in rocky terrain and you've got some heavy rock below the surface. When we do drive the ground rods in, we wouldn't normally make a sweeping turn down to the ground. You don't put any hard 90s in it.

CT: What about the medium? What kind of soil conditions are you grounding in?

Hill: Mostly sand.

CT: Is it difficult to maintain the ground?

Williams: No, we submount to eliminate this problem. Throughout the system itself where we ground an amplifier in power spot locations, we actually sink the ground rods to the base of the pole. It's the same way for the ground rods we will put at a residential installation; there, also, it is supposed to be submounted.

CT: Do they pretty much stay intact?

Hill: There's some areas where you'll go out and the copper is cut off at the ground, and as far up the pole as they can reach. So we do have a problem with people stealing the copper. But grounding it the first time is not the end of it. Part of our maintenance program is to clean the ground connections because corrosion will build up underneath the connectors to the ground. We found that cleaning them does prevent lightning problems. So, we continually service the grounds and that's very important in Florida; maybe more so than some other places.

CT: And how often do you do that?

Hill: Our procedures for maintenance are that we visit at least twice per year, every location in our system. So, we're very careful that we ground our active devices; our amplifiers are all grounded and when we go through the system check, part of the procedure is to check to make sure that the ground is good. There's a thing in cable that occurs, which really affects the lightning problems that we have. It is called sheath current. With this effect we begin to share the neutral with the power company up above us so if their neutral and their ground is carrying 50 amps, we may have 25 of those 50 on our cable. So as the sheath currents increase, it increases the potential for us to have powering problems during a lightning storm. So the only way we can dissipate this is to have good grounds. The cleaning of the grounds is very important.

CT: And the current dissipates through the ground?

Williams: Yes. Another thing that we're doing, and Tommy referred to it, but maybe didn't say it, is servicing the grounds. One of the things we're looking for, even though it's been grounded and the ground rods sunk and we've run this #6 copper wire down the pole and it has a wooden u-guard over the first eight feet, etc., is cut wire. Being that the poles that we are on, are in right of ways, highways, runways, easements, etc., many of those easements and right-of-ways are mowed by the Department of Transportation. So, one of the things that you do have to watch is that #6 copper. You have to make sure that it has not been hit by a mower who thinks, gee, this isn't any problem bumping against that heavy pole.

CT: Do you find that problem often?

Williams: Yes, so we use split bolts and do a repair at the location. It hasn't affected the ground rod, but if the copper is cut, then no longer does the ground go up the pole.

CT: So you would never notice that unless there was lightning?

Williams: Right. But there are ways to monitor it. We break our systems up into grids and we monitor when we have lightning storms; we monitor our outages to the grid. And if our problems start increasing in a grid, then we know to check. And we break all the outages down in different categories so we know what to look for in that grid.

CT: As far as ideal tower grounding, if you had the choice, what method would you go with?

Williams: We've used a number of types—wells, counterpoise, ground wires and ground rods—and it really depends on where we are. Within this region, for instance, we have a system in Greenwood, S.C. In order to get adequate grounding in there, we had to actually have a well driller come out to drill down through the rock. And drill that casing hole, so we could then put the rods in and put salt in and so forth.

CT: Is that the most expensive of these methods?

Hill: Yes.

CT: In Florida, do you have a most common method?

Williams: Ground rods.

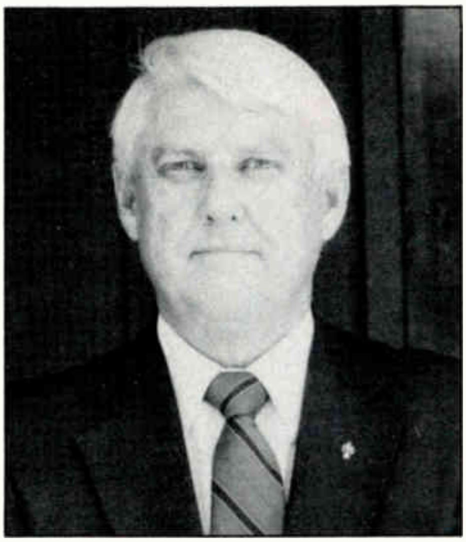
CT: Can we prevent lightning from striking?

Williams: Well, I know that we can reduce our chances of being struck, but I would say we cannot prevent it. But we can take all the steps that we've been discussing to reduce the effects of lightning strikes.

CT: Basically that would be maintenance and good grounding procedures?

Williams: Right.

Hill: My belief is having a well-grounded tower, and at all of our headends we have them grounded very well in Florida. We hardly ever sustain a lightning hit in a tower location that knocked out equipment.



'The best protection that a cable system has against lightning at this point is to make sure that the basic grounding and bonding are done well'

—Tommy Hill

CT: It never arced across like a side strike and damaged anything in the building?

Hill: It's rare anymore. We have learned enough that we can ground it sufficiently.

CT: And bond it?

Williams: Keeping in mind that one of the things that we feel is maybe adding to the fact that we're not having those effects is that we now common bond everything. The electronics within the headend building that are in the racks are grounded and they're bonded to the earth station into the tower. So for a voltage induced by a lightning strike coming down the tower to come over horizontally to the building is unlikely because the building or the equipment in the building has the same ground potential as the tower.

CT: What kind of material is used for bonding?

Hill: Copper.

CT: Does bonding of it break?

Williams: You have to watch the stuff at the base of the poles, as I said before, especially after the area has been mowed. If it was never touched by a human being, it'll probably set there forever. But, there's always a chance of machinery cutting through, or theft.

CT: As far as interference caused by lightning, do you have people call and describe it to you and say, "you know, my picture is getting worse and worse and it looks terrible and then the lightning strikes and the picture clears and then it gets bad again" because there is a whole storm going on?

Williams: Most of the interference that I've experienced due to lightning is just the flashing you'd see during the electrical discharge—a flash across the screen—but not a build up of static charge that would put snow or sparkles on the picture that would then be discharged after a lightning strike and dissipate that voltage and build it. A reason is possible that we do not see this. I believe that there is, during a thunderstorm, a static electricity buildup that we do not experience here because of our humidity. Now, if you're out in the desert where the relative humidity is five percent, it could be a problem.

CT: What type of standby power do you recommend, battery backup (the most common method) or another method?

Hill: We have standby generators in our headends. But, out in the systems, we have the battery backup—three-battery backup standby power supplies.

Williams: We have as a company come a long way with this. The one thing that we do on just about all our main trunk lines in our larger systems is install standby backup power. We do go one further, an additional feature that we incorporate in our standby power is time delay circuitry. Normally, the switching transients will get you. Whenever the power goes off, our standby power comes up and picks it up and runs the system, then whenever the power comes back on, the equipment would sense that and make the switch immediately. But, what happens whenever power comes back up is that a transient or a spike is sent down the line. We've experienced equipment that would fail, that would go off when the power came back on because the transient spike would hit our equipment and blow it. So here everything is back up fine and you just went off. What we do is to have a time delay circuit that is adjustable anywhere from 10-20 seconds, but say an average of 15 seconds delay. Whenever the power comes back on, this time delay circuit will hold our system on battery power for approximately 15-20 seconds, which will allow the transients and spikes to settle down before we switch back.

CT: And in the home?

Hill: This also protects us against power going on and off in the home, because everytime it comes on, you're getting a spike of some sort. What protects our equipment is that we delay it for about 15-20 seconds. The power usually is settled down by that time and we're in pretty good shape.

Williams: We hold it because of a lot of times when they restore power, there may be another short on the line or a problem on the line they are not aware of. And there's another transient down. So all that's going to happen usually does so within the first 20 seconds. One other thing I wanted to mention on these standby power supplies and not only the standby power supplies but any power supply that we do. In addition to this time delay circuit, we also make a point, because in most cases it is not standard equipment with power supplies, to use surge arresters on our power supplies.

CT: On a closing note, what do you consider to be the most important thing a system can do to protect itself against lightning?

Hill: Let me give you my philosophy. The best protection that a cable system has against lightning at this point is to make sure that the basic grounding and bonding are done well. What we found in our company, and I'm sure it's true in other companies, is that when we go out and start looking for these problems, we find we haven't done the basics. The basic good grounding practices and procedures and bonding will take care of a tremendous amount of these problems.

Alarm/controller unit

Broadband Engineering Inc. is now offering an alarm/controller system. Designed to operate over one- and two-way CATV or LAN systems or with a direct coaxial connection, the alarm/controller lets the operator monitor any function that initiates a contact closure. This could include such functions as temperature, standby power, or security (such as door opening). It also acts as a controller to remotely operate electrical or electronic equipment over the coaxial network.

The system consists of a transmitter and a receiver. On a one-way system the transmitter may be located anywhere upstream from the receiver. In a two-way system, two alarm/controllers operating on different frequencies may be operated back-to-back. This will provide monitoring or control from any location in the system to any other system location. The receiver can be configured for on-off operation of equipment as well as notifying the user of an alarm condition at the transmitter location. Any number of receivers can be operated from one transmitter. This permits monitoring at several locations within the system.

For more details, contact Broadband Engineering, 1311 Commerce Lane, Jupiter, Fla., 33458-5636, (305) 747-5000.

Telescoping aerial van

Armlift introduced a one-man aerial truck (or van) with working heights from 28 to 34 feet. It is available insulated or all steel and employs an electro/hydraulic PTO fanbelt or auxiliary engine hydraulic operation. No outriggers or stabilizers are necessary when mounted in accordance with factory specification.

For further details, contact Armlift, Division of TG Industries, P.O. Box 108, Armstong, Iowa 50514, (712) 864-3737.

TVRO traps, notch filter

Microwave Filter's 4616-45 IF terrestrial interference trap incorporates a 35 MHz trap and a 55 MHz trap both switchable in and out. It may be used as a diagnostic tool during installation to determine which traps to leave in the system, or as a receiver accessory to optimize reception channel by channel. Impedance is 75 ohms and connectors are type F. Notch loss is 20 dB minimum and 3 dB bandwidth is approximately 4 MHz.

MFC also introduced the Model 5020-1 terrestrial interference notch filter, which tunes the 950-1,450 MHz block downconverter band to suppress microwave telephone carriers. The 5020-1 tunes with a single hex socket ("allen-head") adjustment. At any tuned frequency, it has a 15 dB (minimum) notch and bandwidth of approximately 4 MHz to match the bandwidth of most interference carriers.

For more information, contact Microwave Filter Co., 6743 Kinne St., East Syracuse, N.Y. 13057, (315) 437-3953.

Power supply

Alpha Technologies announced its new "UP" series of uninterruptible CATV standby power supplies. These standby power supplies provide continuous uninterruptible power, which will allow cable networks to carry high-speed data transmissions, according to the firm. The uninterruptible power feature of the UP series is made possible by a circuit design that eliminates the break in power to a cable network.

For more information, contact Alpha Technologies, 1305 Fraser St., D-5, Bellingham, Wash. 98226, (206) 647-2360.

TVRO accessories

Four accessories that provide the satellite TV viewer with greater convenience have been designed by the R.L. Drake Co. for use with block system earth station receivers. Drake's two-way block splitter (Model 2603) permits independent channel selection on two receivers in the same system. This splitter will pass a power feed from either receiver to the system's LNB, eliminating the need to turn on the master receiver when viewing the auxiliary receiver.

The firm's new four-way amplified block splitter (Model 2604) was designed for systems with three or four receivers. This splitter performs the same functions as Model 2603, plus it contains an amplifier that compensates for the loss of power that comes from dividing the signal three or four ways.

Model 2605 is a dual polarity input adaptor that was created for use with Drake's ESR 324B earth station receiver. This accessory allows automatic horizontal/vertical input switching in dual feed installations.

The polarizer expansion module (Model 2606) allows up to four earth station receivers to adjust polarity skew and format on a priority basis. This module ranks the receivers on a scale of one to four and gives control of the polarity skew to the master receiver whenever it is operating.

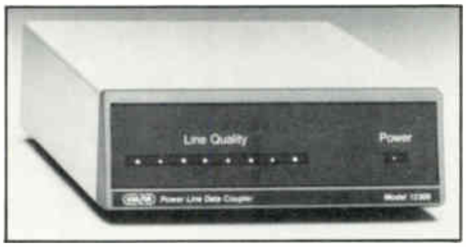
For more information, contact R.L. Drake Co., P.O. Box 112, Miamisburg, Ohio 45342, (513) 866-2421.

Scrambler/ descrambler system

The new Impulse scrambler/descrambler system by Syrcuits International Inc. will permit the cable system operator to scramble one or more television channels before distributing the signal over the cable system, and can selectively authorize descrambling on any one or more such channels at any addressed descrambler unit. The brain of the Impulse system is a pre-programmed computer that will keep track of each address in the system and the services to which each address subscribes. The descrambler unit of the Impulse system is designed as an add-on to your present converter.

The Impulse system has the capability of pre-authorizing up to 15 pay-per-view events. This means that a subscriber, by telephone or correspondence, can order (or pre-pay) up to 15 events (or "credits") on a PPV channel. Once pre-authorized, the subscriber can elect to view any particular event of his choice by pressing a button on the descrambler unit. The computer will then automatically subtract a credit from the subscriber per event viewed. When the number of credits is reduced to a predetermined number, an indicator will alert the subscriber that he will soon run out of credits unless he places another order.

For additional information, contact Syrcuits International Inc., 829 Molloy Rd., Syracuse, N.Y. 13211, (315) 455-2346.



Local area network

HanZon Data Inc. is offering a local area network system in which the data travels along existing AC power lines and is retrieved via normal wall sockets. Every computer (or other data handling device) plugs into the network at the socket, using a data coupler that acts like a modem. Error checking protocol ensures error free data transmission, according to the firm. The data is sent on the AC lines at 4,800 baud.

The power line coupler (PLC) and HanZon-provided PC software are designed to turn AC lines into a data highway with a PC directing the traffic. Data can be sent and received between as many as 32 different devices, at a distance of 1,000 feet or more. The modem may be set a 300 baud, the printer at 1,200 baud, and the computers at 9,600 baud and 19.2K baud. The PLC allows the user's equipment to communicate without matching all the baud rates, parity, word size and software handshakes of each piece of equipment in the PLC network.

For more details, contact HanZon Data Inc., 18732 142nd Ave., NE, Woodinville, Wash. 98072, (206) 487-1717.

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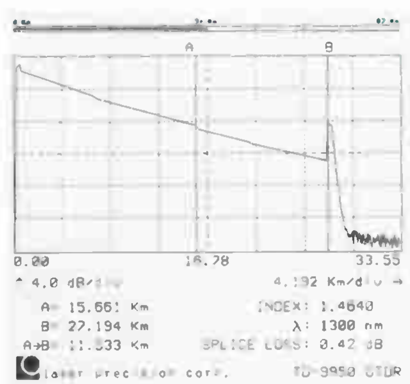

(printout shown at half actual size)

In the **automatic splice loss mode,** the amount of splice loss is accurately measured and instantly displayed on the CRT. The TD-9950 measures to within 0.01dB loss, whether they are closely spaced or long distance splices. During splicing or connectorization, the real-time display trace and continuous dB readout function as a "live monitor" for optimizing the fiber core alignment. It maximizes the cable's transmission capabilities.

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The TD-9950 features ±0.01% base-accuracy, 0.01dB resolution, 131 kilometer range, one meter distance rsolution, and dual cursors, for highly precise and repeatable measurements—long range or short.

For fault locating, the 0.01db resolution can even detect small micro-bends or cable stress defects. The dual cursors can be used to accurately measure the distance of a fault from any point along the cable, such as a documented splice, to help pinpoint the exact location. All of the data is clearly spelled out in easy to read alphanumerics on the CRT and hardcopy printout, so that cable problems can quickly be corrected. The TD-9950 gets the job done faster, easier, and with greater accuracy.

Designed for all wavelengths, the TD-9950 offers plug-in 850, 1300, 1550, and dual wavelength 1300/1550nM modules.

For more details or demonstration, contact: LASER PRECISION CORPORATION, 1231 Hart Street, Utica, NY 13502, or call (315) 797-4449, or telex: 646803

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Reader Service Number 52.

Establishing a PM program

This article is the second of a two-part series on the development of an effective preventive maintenance program. Part 1, which appeared last month, presented general guidelines to aid that development—setting goals, putting a program together and documenting it. This month we'll look at a preventive maintenance program that was successfully implemented in Castro Valley, Calif. The cable system, a 15-year-old dual plant in the San Francisco Bay area, is operated by Jones Intercable.

By Ron Hranac
Corporate Engineer, Jones Intercable Inc.

Preventive maintenance had been attempted on a limited basis in other systems in the past, often with questionable results. But the opportunity to start fresh with a recently acquired system provided perfect testing grounds for a full-fledged PM program. Jones Intercable's Bruce Catter took on the task of developing such a program, along with tracking mechanisms that could be used to monitor the program's effectiveness. Early in 1984, Catter implemented his program.

The plan developed for Castro Valley consisted of six major parts: goals, system maintenance, mechanical integrity, training, quality control, and documentation.

Goals

The goals of the program were fairly straightforward:

- Decrease the number of service calls performed; reduce overhead.
- Decrease the incidence of system failure and outages by detecting potential problems early.
- Improve picture quality; maintain high quality pictures.

Figure 1: Individual on-the-job training schedule for 1984

J.B.—Continue FCC License course and obtain FCC License. Become proficient with basic data transmission theory and application, headends, earth stations, converter repair.

J.S.—NCTI Tech I course. Training in sweep techniques, headend maintenance, and signal leakage correction; skilled in use of Avantek system sweep.

J.R.—Continue customer service training, signal leakage correction, Avantek training, system operation, and headend maintenance. NCTI course.

M.L.—Customer service training, signal leakage, system maintenance including set-up and balance, splicing techniques, some headend training, NCTI course.

C.A.—NCTI Installer course. Begin basic troubleshooting, some system maintenance including set-up and balance, work on supervisory skills, also splicing.

K.P.—System set-up and balance, construction techniques, TVRO installation. Work on supervisory skills.

A.T.—Proper installation techniques, basic troubleshooting, NCTI course.

M.R.—Drafting, system design, inventory control, purchasing, converter repair.

Figure 2: Timeline for scheduling and tracking program

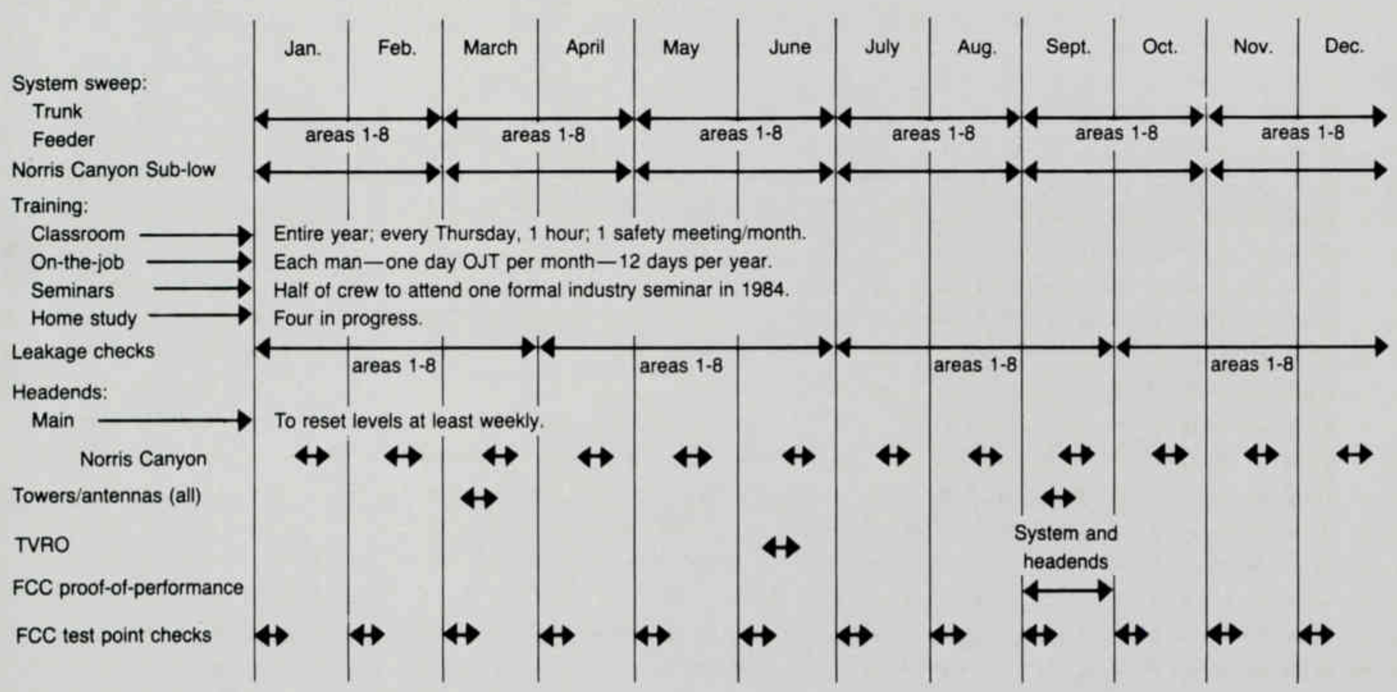

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Figure 3: Preventive maintenance report form

Review preventive maintenance program and document progress below.

A) System sweep
1) Areas completed ____
2) Problems noted ____
3) Corrections made ____

B) Radiation checks
1) Areas completed ____
2) Problems noted ____
3) Corrections made ____

C) Headends "A" and "B"
1) List dates of headend realignment ____
2) Problems noted ____
3) Corrections made ____

D) Norris Canyon headend
1) List dates of headend realignment ____
2) Problems noted ____
3) Corrections made ____

E) Antenna tower, TVRO, all antennas
1) Corrosion control ____
2) Tighten hardware ____
3) Housekeeping ____
4) Realignment ____
5) List other work performed including any repairs made ____

F) FCC proof-of-performance testing
Annual proof completed ____
Monthly checks

	TP-1		TP-2		TP-3	
Cascade	___TR	___LE	___TR	___LE	___TR	___LE
	Cable A	Cable B	Cable A	Cable B	Cable A	Cable B
Bandwidth	___	___	___	___	___	___
Peak-to-valley	___	___	___	___	___	___
Xmod	___	___	___	___	___	___
C/N	___	___	___	___	___	___
Hum	___	___	___	___	___	___
Other___	___	___	___	___	___	___

G) Training
Classroom ____

On the job training (See attached)

Seminars ____
Correspondence courses ____

H) Quality control
Attach Q.C. report forms.

I) Mechanical integrity
List mechanical preventive maintenance performed ____

This report compiled by ____
Date ____
Approved ____

- Increase subscriber satisfaction.

The only possible limiting factor was that the goals had to be accomplished using existing personnel. To circumvent this restriction, Catter rewrote the job descriptions of the entire technical staff to include portions of the program in each individual's daily tasks.

System maintenance

The entire distribution system was divided into eight areas. The areas, although not physically the same size, were similar in system complexity.

System sweeping—The line technician swept all trunk and feeder in each area every two months, made necessary repairs, and maintained a log of all work accomplished. The sublow trunk run from the Norris Canyon headend to the main headend was swept every two months and repaired as necessary. All swept plant was maintained within peak-to-valley tolerance defined by the formula:

$$\left(\frac{\text{Number of amplifiers in cascade}}{10}\right) + 1 = \pm \text{ tolerance in dB}$$

Signal leakage—Areas one through eight were monitored for leakage with the "Cuckoo" receiver every three months. Results were logged, and problems corrected within one week of being found.

Leakage monitoring was increased during worst case conditions—for example, after a period of dry, calm weather. (On windy days, the cable can work around in loose or corroded connectors, establishing a temporary "good" ground. The newly established "good" ground surfaces corrode very quickly, and the degree of grounding effectiveness diminishes with a resulting increase in signal leakage.)

Headends—Signal levels were adjusted as necessary, at least weekly, in the main headend. Housekeeping and visual inspection were performed at this time, also. FCC proof-of-performance headend testing was scheduled during the month of September, at which time all modulators, processors, and other equipment would be inspected and aligned to ensure desired performance. Signal levels were reset monthly in the Norris Canyon headend, and the equipment checked and aligned during the September proof-of-performance testing.

Towers and antennas (all headends)—Every six months all hardware was checked for tightness; corrosion control was performed as required, as were necessary repairs and general housekeeping.

TVRO—The earth station was checked annually for roundness and warpage, and realigned to satellite "box center." The pressurization unit's dehydrator crystals were dried out as necessary.

FCC proof-of-performance tests—The annual tests were included in the preventive maintenance program. In addition, during the first week of every month, the system's Avantek CR-2000 was used at each FCC test point to record signal levels, frequency response, cross-modulation, carrier-to-noise and hum. These

results were recorded to allow monitoring of gradual deterioration of system performance.

Mechanical integrity

Mechanical preventive maintenance was performed on an on-going basis, with at least five man-days per month spent on:

- Hardware tightness
- Shrink boot inspection
- Broken lashing wire repair
- Corrosion control
- Correct span sag
- G.O. 95 infractions (utility clearances)
- Bonding and grounding
- Tap port terminations

Training

One hour of in-house classroom training was held every Thursday for the technical staff. One class each month was devoted entirely to safety. Highlights of the technical topics that were scheduled for the weekly meetings included: fundamentals of a cable TV system/channel allocation; coaxial cable; cable loss and equalization; dB vs. dBmV, logarithms; cross-modulation noise; hum modulation and power requirements, grounding; signal leakage; field strength meters; antennae theory; headend; climbing school; system design, passive functions; distortions, trouble shooting; amplifiers; safety; and TV receiver fundamentals.

A separate on-the-job training program was established based upon the needs of each individual (Figure 1). This program provided each employee a minimum of one day of on-the-job training per month in addition to regular duties. As well, 50 percent of the crew was scheduled to attend a formal industry seminar each year. This included SCTE meetings, vendor-sponsored seminars, and industry conferences.

Figure 4: On-the-job training report form

Name ____________________
Date ____________________
Description of training ____________________

Name of person conducting training __________
Hours of training ____________________
Comments ____________________

Signed:
Trainee __________ Trainer __________

At the time the program was implemented, four employees were involved in job-related correspondence courses. Additional participation was encouraged, and by the end of 1984, most of the technical staff were involved in home study courses.

Quality control

A quality control inspection program was developed to ensure that new equipment was tested prior to being used in the system:

- Trunk/feeder cable (all): damage inspection, return loss, impedance, attenuation, bandwidth, peak-to-valley.
- Drop cable (10 percent sample): same as trunk/feeder cable.
- Active devices (all): visual inspection, hardware tightness, bandwidth, peak-to-valley, return loss, second order, noise figure, current consumption, hum, control adjustment range.
- Passive devices (5 percent each container): test as applicable.
- Drop material (10 percent sample): test as applicable.
- Other (10 percent sample): test as applicable.

Documentation

A timeline (Figure 2) was used to schedule various parts of Castro Valley's preventive maintenance program and track them simultaneously. The chart was posted at the system's business office.

A preventive maintenance report form (Figure 3) also was used to track the program's progress; copies were sent to the division office monthly. Included with the preventive maintenance report form were an on-the-job training report form (copies of this were added to each individual's personnel file) and a quality control inspection form (Figures 4 and 5).

Working to save

Casto Valley's preventive maintenance program worked! The system's monthly service call percentage before the program averaged about 4.5 percent (approximately 360 service calls per month). Several months after the program was implemented, the monthly service call percentage leveled off to about 3.6 percent (approximately 290 service calls per month).

That 20 percent reduction in service calls was

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5	14	23	32	41	50	59	68	77	86	95
6	15	24	33	42	51	60	69	78	87	96
7	16	25	34	43	52	61	70	79	88	97
8	17	26	35	44	53	62	71	80	89	98
9	18	27	36	45	54	63	72	81	90	99
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2	11	20	29	38	47	56	65	74	83	92
3	12	21	30	39	48	57	66	75	84	93
4	13	22	31	40	49	58	67	76	85	94
5	14	23	32	41	50	59	68	77	86	95
6	15	24	33	42	51	60	69	78	87	96
7	16	25	34	43	52	61	70	79	88	97
8	17	26	35	44	53	62	71	80	89	98
9	18	27	36	45	54	63	72	81	90	99
10	19	28	37	46	55	64	73	82	91	100

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Reader Service Number 56.

Figure 5: Material received technical quality control evaluation form

1) P.O. number ______

2) P.O. date ______

3) Material received date ______

4) Visual inspection by: ______

5) Any physical damage noted: ______

6) Electrical tests:

Quantity	Item	Percentage tested	Bandwidth	Sweep test: Peak-to valley	Sweep test: Return loss	Hum	2nd order	Impedance	NF	Current draw

The equipment listed above was tested and ____ does ____ does not meet corporate engineering specifications.

Comments: ______

Signed ______ Date ______

Approved ______ Date ______

estimated to be worth about $21,000 annually to the system (based on $25 per service call); and it was accomplished without hiring additional staff. The success of this program indicated the potential savings that could be realized elsewhere.

As a result, the preventive maintenance program that Bruce Catter developed for Castro Valley was adapted and implemented in several other cable systems. To date, the average reduction in service calls has typically been in the 25 to 30 percent range; one system realized a 50 percent reduction in service calls!

Effective preventive maintenance will work. But it requires careful assessment of each system's particular needs, thorough planning and documentation. The money is out there—waiting to be saved!

Editor's clarification: In last month's installment of this article a reference was made to maintenance costs exceeding $200 billion. It should be noted that that amount refers to an annual amount spent by U.S. industry nationwide.

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NEXUS — DEFINITELY AHEAD OF OUR TIME

Reader Service Number 58.

Start with the foundation

By Robert S. Long
President, Burnup & Sims Cable Com Inc.

To rebuild, retrofit or delash/relash—that is the question. The answer is not quite as simple. There are many aspects to be considered in the answering of this question. The first usual consideration, understandably, is economics, followed closely by electronic or technical considerations. One area that may not be receiving adequate consideration is the strand and poleline hardware itself, or "foundation plant" if you will. In the strictest definition of the total CATV plant, the strand and poleline hardware would have to be defined as the foundation plant. As we all know, a good foundation is essential in any building application to assure a secure and dependable structure. This truth is no less applicable to CATV plant than it is to a high-rise.

Aerial foundation plant is for the most part pretty sturdy stuff, and we at least think of it as being almost impervious to the effects of aging. But let us take a closer look. What does most poleline hardware have in common? The common point is zinc plating. This plating is applied to protect the coated metal or host material from rapid deterioration and is commonly, though in some cases not accurately, known as galvanizing. What may not be as widely known is the fact that a zinc coating is in fact a sacrificial coating and is subject to deterioration as a result of exposure to the various elements and conditions just the same as the host material to which it is applied to protect.

The obvious advantage of the zinc plating is the fact that in most cases and conditions it is eroded away at a much slower rate than the host material would have, left unplated. Because the zinc is applied as a means of protecting its host, the deterioration of the zinc does not affect the structural integrity of the host device. When the zinc plating has completely sacrificed or expended itself, then obviously the deterioration begins to work on the functional part or host. That part or host begins to suffer structurally as a result of the corrosive action. This corrosive action on the host material, given the purpose of the foundation plant in the overall CATV plant picture, could lead to unsafe and technically unsound conditions in the trunk and distribution plant (i.e. cable and equipment on the ground).

How long does zinc plating last? There is no sure answer. Many factors affect its useful life. Some of these are: thickness of coating; amount of dust in the air; average annual temperature; amount of precipitation; acid content of the soil; proximity to the sea; proximity to marine environment; and proximity to heavy industrial area. The point is that there are guidelines, but no rules on how long zinc plating will last. One thing is certain, the speed at which the zinc is sacrified is directly proportional to the sulphur oxide content in the air. Another concern that has recently received much international attention is acid rain.

Below is a table published by ATSM which may help to answer some fundamental questions on this subject. Though not revealed in the tables exposure to sea water greatly accelerates the corrosion rate. Additionally, stress causes accelerated corrosion.

Atmosphere	Mean corrosion rate
Industrial	5.6 microns (.22 mil)/year
Urban, non-industrial or marine	1.5 microns (.06 mil)/year
Suburban	1.3 microns (0.5 mil)/year
Rural	.08 microns (.04 mil)/year
Indoors	Considerably less than .05 microns (.01 mil)/year

Most of us are familiar with and use "Class A" strand, so how do we determine its useful life? First, Class A strand has an average zinc coating of .0258 millimeter thickness. It follows then that in an urban environment the approximate useful life of Class A strand is 17.2 years.

Zinc thickness		Urban corrosion rate		
.0258 millimeter	+	1.5 microns	=	17.2 years

Now, if you are planning to retrofit or delash/relash, assuming a 10-year life for the existing plant and an anticipated 10-year life for the newly installed electronics or cable, your strand life will have run out (so to speak) three years before the cable and/or electronics are anticipated to last. Also consider other conditions that adversely affect strand life, such as electrolysis and stress.

Bright looking strand does not mean that your strand does not need to be replaced. You may do a visual survey, do a corrosion rate calculation, or hire a metallurgist to do random tests, but check your strand and hardware prior to making your decision. Remember, the trunk and distribution plant is no better than the foundation plant.

Headend security for improved reliability

Presented here is an outline to help evaluate and improve headend security and reliability. Passive measures will be proposed to improve site resistance to intrusion and vandalism. Active devices will be suggested that report intrusion, hazard, equipment malfunction and will sound an alarm.

By Thomas L. Gimbel P.E.
Quality Engineer Consultant, PECA Inc.

There are over 4,000 cable television systems in the United States, each with its own headend. The headend is the central signal processing center for a cable system. The headend is where the local off-air television signals are received, where the satellite dish antenna is located and where the automated channel character generators, microwave relay equipment and addressable control computer usually are housed.

The geographic location of the system headend is dictated by the strength of the local television signals. In the 100 or so metropolitan cable television systems serving large cities the headend generally is located in town. This is because off-air reception of local television stations is good in town. However, in the remaining 3,900 cable systems the headends are of a different variety. These headends serve smaller communities and generally are located outside of town. They are placed on top of the highest available hill, in order to receive television signals from distant stations over rough terrain. These headends have tall towers and are difficult to reach for service. Many sites require special four-wheel drive or track vehicles to climb long rugged roads. Bad weather may make them inaccessible.

Larger metropolitan cable systems can support a more elaborate headend facility; therefore, security systems are designed into these installations. Burglar alarm, fire alarm, fire extinguisher and signal monitoring systems are commonplace. But in the smaller remotely located headends, security and supervision are often overlooked even though these isolated sites are locations that attract skiers, hikers, bikers, four-wheelers, hunters, teenage daredevils and thieves.

Preventive maintenance is a management technique used to avoid cable service outages. This principle most often is associated with electronic test procedures but security of the headend site and equipment monitoring can significantly improve service reliability.

Intruder protection

Site security is based on the perception created in the mind of a potential intruder. The intruder contemplating a trespass must ask himself: Is the reward worth the work involved, and can he get away with it? Though irrational people are capable of futile acts of destruction, most intruders are rational and will consider their fate.

The defenders objective is to present the best practical barrier to intrusion and to create the impression that escape would be unlikely. There are usually three major exposed structures to protect at the headend: the headend building, the tower and the satellite dish antenna. The most obvious and very effective first step to provide protection is a chain link fence surrounding the compound. The fence should be at least six feet high and the gate should be securely locked with a rugged lock.

Appearance also is a key, inexpensive part of intrusion security. Keep the enclosed compound neat, clean and the brush cleared. If the place looks cared for a vandal must consider the possibility that someone may be making their inspection rounds at this time.

Signs are a valuable psychological barrier. A "bad dog" sign can be as effective a deterrent as the dog itself. Post signs on the fence: "Caution high voltage," "keep out," "this site operated by (your name) cable TV company under regulation of the FCC." If you have a burglar alarm system, advertise by putting a sign on the building door: "This premises protected by an electronic security system." "Surveillance provided from aircraft." Post the signs even if you do not have a security system. The signs should look professional and be credible. Some usable signs are available from your pole line hardware supplier.

Towers are a climbing attraction. If the tower has a ladder, remove the bottom section to discourage climbers. Your technician can use his own ladder to bridge the gap when servicing the tower. Install a climbing shield on small faced towers. This can be done by bolting three sheets of plywood 10 feet high, against the three faces of the tower bottom section, leaving no exposed members to climb on. Put a "high voltage" sign on the tower and the dish antenna.

Satellite antennas seem to have two major shortcomings: amateur earth station builders steal the low-noise amplifiers (LNAs) and children like to throw stones at them to hear them "bong." I heard of a dish located near a school that was hit and dented so much that the dish had to be replaced because the reflective surface distortion reduced the gain below usable levels.

Conceal the LNAs if you can. Use security screws for mounting. Wire the LNAs into the burglar alarm system with traps. A broken pressure window is the most common stone damage and this loss of air pressure could be reported by a pressure switch wired into the burglar alarm system. Put a sign on the dish indicating the equipment is alarmed.

The headend building should be windowless and of masonry construction. The door should be steel with a padlock that is protected from cutting. Window air conditioners and ventilator fan openings should be covered with steel bars. The headend building and electronic equipment should be protected with a security system. The system should have three features: 1) sound a local alarm to scare off the intruder before he can complete his work, 2) monitor equipment operation to minimize or prevent service outages, and 3) summon help by reporting the condition to repair personnel.

Equipment monitoring

Because the headend operates unattended, repair service is not provided until a catastrophic failure occurs and one of the services is lost. Though some failures cannot be predicted there are parameters, which, if monitored, could warn of a coming failure before service is lost.

A primary example is room temperature. The air conditioner is a mechanical device prone to wear out. Failure of the air conditioner can result in failure of other pieces of the electronic equipment. As a monitoring device a home thermostat can be used to sense air temperature and the contact closure reported by the security system. Repairs could be made before any electronic equipment fails.

Towers, because of their visibility, are often targets for shooters. Though there is little that can be done to prevent the shooting, monitoring of tower lights and waveguide pressures can initiate gunshot repairs before additional problems develop.

If primary headend power is lost and the standby generator takes over, an outage will be delayed if power company repair service is not initiated or the generator refueled. A contact closure could signal the condition.

Air pressure on an earth station can be monitored as can signal switches, where individual processors have gone into standby mode. AGC voltages and sump pumps can be monitored. A smoke detector would provide early warning of overheated transformers or equipment fires. A help button could summon aid in a personal emergency.

An ounce of prevention...

The headend is the single most important part of a cable system. It is usually in a remote location attractive to vandals and it is operated unattended. Deliberate measures should be taken to provide for intrusion protection and equipment monitoring, which can be accomplished by using the cable system for communications. These steps will maximize overall system reliability and reduce costly problems.

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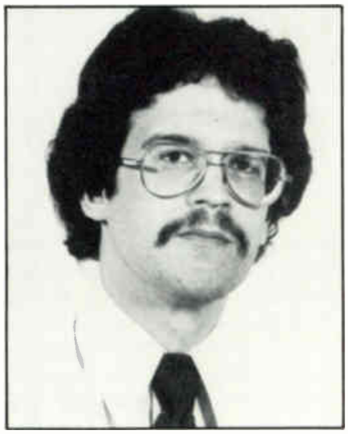
Texscan
INSTRUMENTS

Reader Service Number 61.

C-COR Electronics Inc. has hired **Thomas Teeter** as controller. Prior to joining C-COR, Teeter was corporate controller for Giant Food Stores Inc. for four years, the position he attained after being an accounting manager there for one year. Prior to that he as an accounting superivisor for Laventhol & Horwath, CPAs. Contact: 60 Decibel Rd., State College, Pa. 16801, (814) 238-2461.

Pioneer Communications of America Inc., the cable television division of Pioneer North America, has announced the promotion of **Dan Wiltshire** from engineering aide, to systems engineer in its engineering department. He will be responsible for development of selected CATV products as well as performing lab and field testing of prototype CATV equipment. Contact: 2200 Dividend Dr., Columbus, Ohio 43228, (614) 876-0771.

Larry Smith, manager of material resources, Cablevision Industries, has been elected to the board of directors of the **Hudson Valley Meeting Group of the SCTE**. He will serve in this position for the entire year of 1986. Contact: 6 Wierk Ave., Liberty, N.Y. 12754, (914) 292-7550.



Coyle

Regency Cable Products announced the appointment of **Larry Coyle** to fill the post of technician. Coyle will be responsible for conducting quality control tests and collecting data to support all Regency Cable headend equipment and converters. Contact: 4 Adler Dr., East Syracuse, N.Y. 13057, (315) 437- 4405.

Wavetek Indiana Inc. announced several appointments in its broadband cable communications sales organization. **Jack Webb** was named national sales manager. Webb brings to the position 10 years of engineering and manufacturing experience in the broadband cable test equipment market.

Three regional sales managers were appointed. **Greg Marx**, Midwest regional sales manager, has three years of sales experience with Wavetek. Previously, he managed the service and organization departments for a pay TV company and broadcast television production. **Tony Shortt**, Eastern regional sales manager, has three years of sales experience with Wavetek. He has been with the firm for 10 years in various supervisory and management positions. **Phyllis Thompson**, Western regional sales manager, has 17 years experience in cable television including five years in sales with Wavetek, seven years in operations with a large cable television company, and five years in sales with a coaxial cable manufacturer. Contact: 5808 Churchman, P.O.Box 190, Beech Grove, Ind. 46107, (800) 622-5515 or (317) 788-5965.

The Cable Products Divison of **Times Fiber Communications** has announced the appointment of **Jill Maple** as sales administration manager. Maple came to Times Fiber from Coleco Industries Inc. where she served as supervisor, marketing planning. She also has worked in several capacities for the Wire Association International.

TFC also announced the appointment of **Jaye Kasmin** as Northern New England sales representative. Kasmin has worked for Times Fiber for the past 10 years in both the telemarketing and customer service functions.

Finally, the Cable Products Division of TFC announced the appointment of **Lloyd Vande Lune** as sales representative in the states of Iowa, Kansas, Missouri, Minnesota, Nebraska, and North and South Dakota. Prior to joining Times Fiber, Vande Lune was sales manager, Industrial Division of the Iowa Paint Manufacturing Co. Inc. Before that, he was account manager of the John Deere account of Valspar Corp. Contact: 358 Hall Ave., P.O. Box 384, Wallingford, Conn. 06492, (203) 265-8500.

Stephen Taylor and **Terry Phipps** have both recently been appointed vice presidents for **Satellite Syndicated Systems Inc.** Taylor was formerly an assistant vice president. Prior to joining the firm, he worked as a project manager for Video Star Communications.

Phipps has been involved in television broadcasting since his discharge from the U.S. Army in 1971. After four years as an account executive in local sales for KJRH-TV, Tulsa's NBC affiliate, he founded Phipps & Company Productions, a TV production facility, to produce a national outdoor show. SSS acquired a majority interest in Phipps & Co. earlier this year. Contact: P.O. Box 702160, Tulsa, Okla. 74170, (918) 481-0881.

Don Wyckoff recently joined **Tele-Wire Supply Corp.** as western sales representative. Based out of a regional office in Walnut Creek, Calif., Wyckoff will market CATV, telephone and related communications hardware and electronics. He was formerly employed as a factory representative and has been involved in the CATV industry for the past 20 years.

In addition, **Temple Hamm** joined Tele-Wire as a sales representative in the Grand Prairie, Texas, regional office. Hamm is responsible for the marketing of CATV, telephone and related communications hardware and electronics.

Janice Cowan also recently joined Tele-Wire as a sales representative in the Sarasota, Fla., regional office. She will be responsible for the marketing of CATV, telephone and related communications hardware and electronics. Contact: 7 Michael Ave., East Farmingdale, N.Y. 11735, (516) 293-7788.

Synchronous Communications announced the appointment of **Al Johnson** as national sales manager. Johnson, formerly of Catel, will be responsible for the introduction of Synchronous' new line of FM modems. Contact: 1701 Fortune Dr., Suite O, San Jose, Calif. 95131, (408) 262-0541.

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NEW!

Reader Service Number 63.

CALENDAR

December

Dec. 10-12: Jerrold technical seminar, Philadelphia. Contact Beth Schaefer, (215) 674-4800.

Dec. 10-12: Texscan Instruments training program, Indianapolis. Contact (317) 545-4196.

Dec. 11: SCTE Chattahoochee Meeting Group's presentation of the BCT/E exam, Holiday Inn Airport South, College Park, Ga. Contact Gary Donaldson, (404) 949-7370.

Dec. 11: SCTE Golden Gate Chapter seminar on back to basics. Contact Pete Petrovich, (415) 463-0807.

Dec. 12: SCTE North Jersey Chapter BCT/E tutorial for distribution systems. Contact Ed Buckman, (201) 239-8183.

Dec. 12: Pennsylvania Cable Television Association scrambling symposium. Contact (717) 234-2190.

Dec. 16: SCTE North Central Texas Meeting Group BCT/E exam on distribution systems, Quality Inn-DFW South, Irving, Texas. Contact Lynn Watson, (214) 241-1421.

Dec. 18: SCTE Delaware Valley Chapter meeting on test equipment: Field and bench, Willow Grove, Pa. Contact Bev Zane, (215) 674-4800.

Planning ahead

March 15-18: National Cable Television Association annual convention, Dallas.

May 13-15: Canadian Cable Television Association annual convention and cablexpo, Vancouver.

June 12-15: Society of Cable Television Engineers', Cable-Tec Expo '86, Phoenix (Ariz.) Convention Center.

AD INDEX

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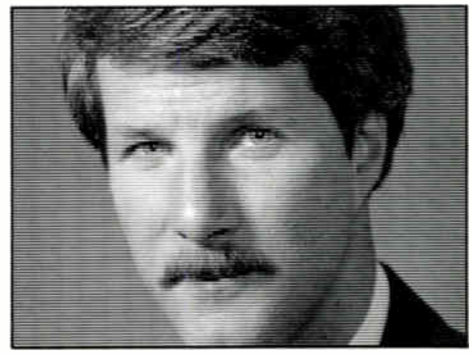


By Robert A. Luff
Senior Vice President, Engineering
United Artists Cablesystems Corp.

There are two separate electronic entertainment systems in a typical household: the TV and the stereo. The TV is primary; the stereo system (receiver, cassette, turntable and amp) is secondary.

Television's impact on us is so great that in a room, the TV and furniture are positioned with TV viewing as the first consideration, thereby resulting with the television as the center of attention and the stereo on a side wall. The positioning of the stereo speakers is usually a problem. No doubt this probably sounds like your house.

However, the TV's unique geographic favored position in any room and its large size also resulted in TV's domination as the electronic hub of all TV-related accessories and important ancillary CATV revenues—set-top converters, descramblers, remote control, volume/mute controls. Even video games and VCRs are not only connected to but are usually sitting on the TV's convenient flat top. All of this may be changing now—and for the betterment of CATV.

The new breed audio equipment

Have you seen the new breed of audio equipment? I am sure you have seen, or rather heard, the new compact discs (CDs). They are absolutely terrific, but I am not talking about them per se, although they are part of what is happening on our side wall. I am talking about the complete audio systems for $599 and $899 (both soon to be discounted). These systems include a CD, cassette deck and an AM/FM digital receiver/amplifier with up to 50 watts RMS.

I know you are still wondering what all this has to do with cable TV. Well, these AM/FM receivers have a new revolutionary feature—Video 1 and Video 2 selector positions. These positions allow baseband video coax cables to be looped through the audio receiver, but for what purpose? The audio receiver is capable of painlessly extracting standard TV audio—and BTSC TV stereo audio if so formatted—from the looped coax composite video/audio signal and providing the homeowner with exceptional TV audio quality and convenience through the existing superb audio equipment normally dormant and wasted during TV hours—the majority of time.

Future trends

As convenient as Video 1 and 2 may be to some already, consider the following: Suppose the stereo receiver employed a channel 2/3 set-top output loop-through TV audio detector/extractor instead of the present baseband circuit; or suppose the already wireless remote audio receiver incorporated a full CATV-type tuner into or part of its total matching equipment with TV audio already extracted and a convenient video baseband output for a monitor? Suddenly we see all the electronics except the CRT shifting from the boob tube box to the side wall.

Such a development could change the focus of the all important electronic hub in the home from the TV to the new total package: component stereo systems. The video screen in the form of a dumb monitor without even speakers may indeed stay about where the TV is placed today, but all ancillary devices and switching electronics and important revenue base may shift over to the other wall—including CATV converters/decoders, remote control, VCR interfaces, etc. Many of the new circuits display channel number, time and VCR vital data superimposed on the video, so who needs all the red LED indicators on separate boxes anyway?

The wrong wagon

Maybe the CATV industry has hitched its wagon to the wrong horse. Instead of focusing on the sluggish, mature U.S. television manufacturers for the illusive cable-ready TV, we should be working with the progressive and aggressive audio equipment manufacturers for the cable-ready CD!

The CATV/TV receiver manufacturer relationship has been a bit like a bad marriage all along. When cable needed greater tuning range in the '60s, TV receiver manufacturers did not listen and cable developed set-top converters. When cable needed more shielding and more cable friendliness in the '70s, TV manufacturers still did not listen. When TV manufacturers saw the impact of the CATV remote control and descramblers' unfriendliness to big set features in the '80s, they wanted to talk but cable was now hard of hearing. The TV manufacturers' attitudes are so slow to change and always seem out of sync with cables'; one wonders if the marriage just wasn't meant to be.

All the while TV's little sister, the audio industry, has done miracles in high-tech developments like cassettes, Dolby sound, digital tuning, CDs, and features like wireless remotes and creative expansion like Video 1 and 2, as well as keeping the total package price amazingly low.

For every long, nearly unchanged TV model year there are several giant-steps-forward audio equipment releases. With today's ICs and digital tuning, it is not at all out of our narrow bandwidth friends' capability to successfully incorporate full CATV subscribers' needs into middle-priced total audio equipment. They seem interested in change, progress and courting cable as a partner. The subscribers' interest to audio is awakening and clearly cable stands to gain by such a progressive technological partner.

Super highway to new audio services

The cable industry is just beginning to explore the audio region of our capacity. The public has shown a strong awareness and interest in high-quality stereo audio as indicated by landslide CD player and disc sales. Stereo TV has equally strong signs as seen by the public's awareness to rent or buy hi-fi VCRs and tapes that produce near CD quality stereo sound tracks—and what a difference it makes to program enjoyment!

There are many CATV industry devices on the market to address our public's higher TV audio quality appetite but sales have been slow—not because the public does not want better TV audio, but because the CATV company must foot the up-front commitment and money to a non-standard technical format.

The new full-feature audio systems with Video 1 and 2 loops allow subscribers their own super highway to better TV audio without having to involve a reluctant or cash poor cable operator. The operator should be pleased because he has made a subscriber more pleased with his CATV signal, without spending any money.

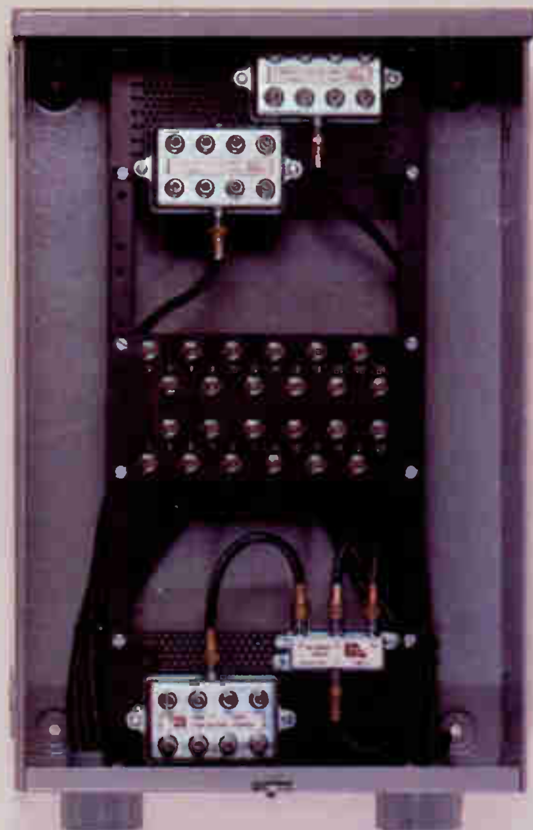
Choice

What we are talking about is more choice to both the industry and subscribers. The industry may no longer be totally dependent on TV manufacturers' "cable friendliness" or on a sluggish existing set-top manufacturer to provide relief to the public's growing demand for a stereo-friendly box. The operator has the choice to wait for stereo cable-ready TV penetrations, go set-top stereo, or with a cable friendly stereo system stereo. The subscriber has the choice to rent a stereo set-top, buy a stereo TV, or loop the system through the new full-feature inexpensive stereo component equipment to receive the enhanced stereo TV audio. No one answer is best for the industry operators, or individual subscribers.

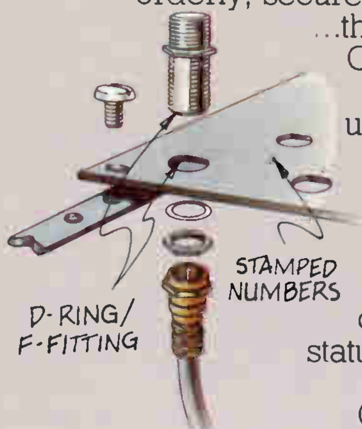
The subscribers' interest in enhanced audio is awakening. Cable clearly stands to gain by courting our newfound friendly audio allies, especially when they are such progressive and aggressive technological partners.

Messed Up.

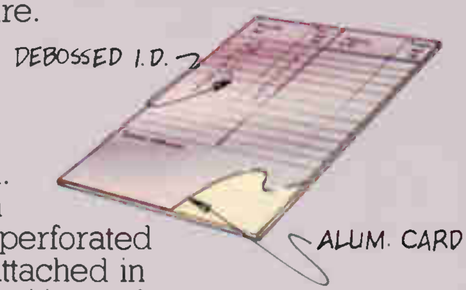
Dressed Up.



CWY created a way to make tangled, inefficient multiple dwelling enclosures orderly, secure and easy to service ...the revolutionary new Omni-Rack™ system*. The Omni-Rack's unique panel and rail design means quick and easy auditing, connecting, disconnecting and changing subscriber status. Leads connected to the underside of Omni-Rack punched panels are labeled permanently by stamped numbers on the tops of the panels. Once leads are connected, they need never be touched again—checking or changing status means handling only jumper cables. Plus, for additional security, the Omni-Rack comes with exclusive aluminum-coated log cards which may be kept away from the enclosure.



No dangling leads...no missing labels... no searching for the right lead. Any combination of punched and perforated panels may be attached in any of five rail positions...the Omni-Rack's inherent design flexibility means you've finally got a secure, easy to service system. Service personnel save time...and that saves you money.



To find out more about Omni-Rack and CWY's complete line of CATV solutions, call or write today.

*Patent pending

Not just supplies. Solutions.

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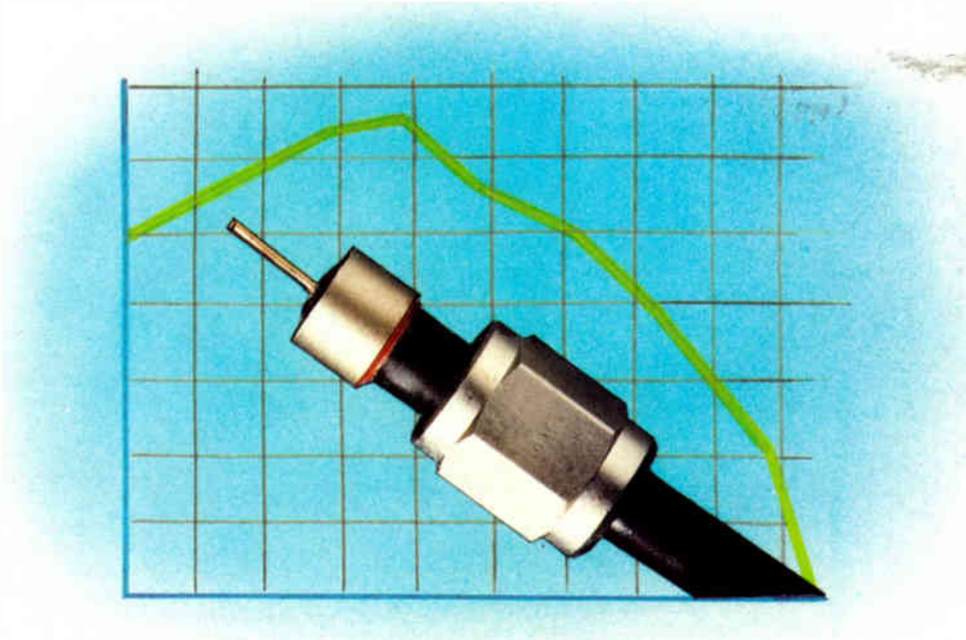
Reader Service Number 67.

Reduce maintenance budgets with the EZF™ Connector System...



Raychem's new EZF Connector System addresses the problems of F-Connectors — RF leakage and moisture penetration — which are among the leading causes of maintenance problems for a cable-TV operator.

EZF is not just a connector, but a system that provides complete, long-lasting performance. Its new design assures superior mechanical strength, tight electrical connections and environmental sealing.

The EZF Connector System has gone thru extensive environmental testing. UV exposure, waterhead testing, thermocycling and salt spray exposure are some of the tests that the EZF System has been designed to pass and still provide exceptional RF shielding.

Features of Raychem's EZF Connector System.

1. One connector fits RG-59, cable and one connector fits RG-6 cable.
2. The only connector available today that provides RF shielding of 100 db at 300 MHz after thermal cycling and salt spray exposure.
3. The system provides an environmental seal at both the cable jacket and port thread interfaces.
4. Reduces finger tight connections and subsequent trouble calls.
5. Crimp tools are no longer needed. A common 7/16" wrench does the final tightening and installation.
6. Cable preps are accurate each time with the EZF Cable Preparations Tool. (For use on both RG-59 & RG-6)
7. Identify customer service with different colored EZF Sealing Boots.

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