# COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

**Local area networking opportunities and testing**

**Phase modulation scrambling**

**Ku-band antenna alignment**



September 1987

# *Only One Path Leads To The World's Most Reliable Broadband LAN Amplifiers.*

***Today's Local Area Network (LAN) marketplace offers many different systems, technologies and vendors. Choosing the right one can be confusing...like finding the right path through a hedgerow maze in an old English Garden.***

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General Instrument amplifiers have proven reliable in thousands of LAN and cable TV installations. Our X Series is the ***only*** amplifier on the market that cost effectively meets modern data demands ***and*** makes future growth simple and easy.

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Our SJ Series and JLE line extenders complete General Instrument's wide array of amplifiers and gives you the flexibility to meet all requirements and budgets.

## *We've Already Put Thousands Of Users On The Right Path.*

For over 35 years, General Instrument has been the leader in broadband communications technology, with installations worldwide.

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GENERAL INSTRUMENT

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**Jerrold Division**
**General Instrument Corporation**
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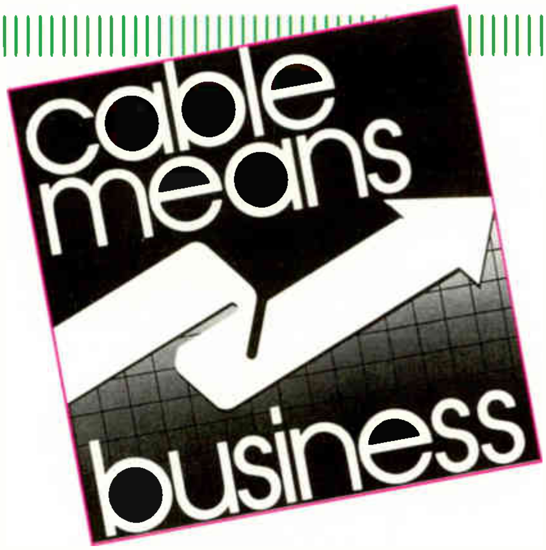
*Reader Service Number 2.*

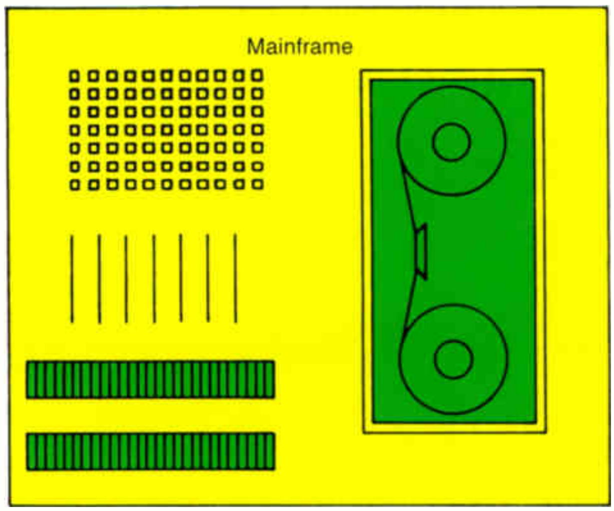
# CONTENTS

## Departments












## Features



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*Remember back in 1951, when TV stations were low in power and antennas not very efficient? Milton Jerrold Shapp, the founder of Jerrold, didn't realize he was helping to create a new industry when he developed an amplifier that Bob Tarlton needed for his Lansford, PA community antenna system.*

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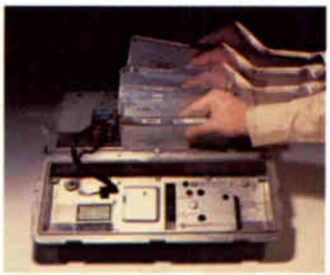

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See us at the Great Lakes Show, Booth 717-719.
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GENERAL INSTRUMENT

## New LAN OTDR maps fiber optic cable routing

**The TD-9960 high resolution OTDR is available with disk-drive mass data storage for easier cable system documentation and trouble-shooting**

Laser Precision's new high resolution optical time domain reflectometer for LAN applications offers a wide range of features and capabilities. The mass data storage option enables you to store the test trace of the total length of each fiber optic cable link on convenient floppy disks. Upon retrieval of a trace, you can obtain readout of dB loss and location at any point along the trace, such as at a splice or connector. You can also expand any point of interest along the trace for close analysis. This can be done on the TD-9960's CRT, or on an IBM type personal computer with the TD-958 OTDR emulation software to provide an easy method for maintaining and trouble-shooting the cable system. The full ASCII keyboard enables you to add notes, such as date, location, and code, as well as retrieve any trace on the floppy disk. This convenient method for mapping the routing of the cable system also makes it easier and faster to pinpoint any location of a cable problem.

The superior capabilities of Laser Precision's LAN OTDR are to the real benefit of the user. It has the capability to zoom in on any area along the total length of the trace, without having to rescan and reaverage the data. The TD-9960 eliminates the time consuming and irritating requirement of having to constantly rescan. During splicing, only a single marker is required to establish the splicing location on the TD-9960's CRT. This position is maintained, going from fiber to fiber, during sequential splicing. No reprogramming required. The TD-9960's real-time display with continuous dB readout makes it easy to optimize the fiber core alignment prior to splicing.

The TD-9960 features plug-in modules for 850 and 1300nM, ±0.01% base accuracy, 0.01dB resolution, 20dB backscatter range, 10cm resolution, short 3 meter dead zone which is compensated by the pigtail, 40 kilometer distance range, real-time display, dual cursers, built-in digital X-Y plotter, and available IEEE-488 or RS-232 interface, as well as the TD-959 mass data storage option.

For more information, contact LASER PRECISION CORPORATION, 1231 Hart St., Utica, NY 13502, or call (315) 797-4449, or telex: 646803

***Reader Service Number 5.***



# Part II: Nipping it in the bud

Last month's editorial covered the interfacing of M/A-COM's VideoCipher IIC (VCIIC) descrambler with commercial insertion equipment in conjunction with MTV using Wegener's Series 1600 FM stereo processor. This month's editorial will detail using Leaming's FMU215C and the VCIIC for MTV to deliver stereo audio via the FM broadcast band in a cable system.

Little change is required to add the VCIIC to an existing MTV channel at most cable headends when a Leaming FMU215C FM stereo processor is already in place, whether or not local commercial insertion is in use. The changes, aside from the installation of the VCIIC, are the addition of a special audio transfer relay (Leaming ATR22) external to the FMU215C and, possibly, the removal of one diode from within the FMU215C.

Certain cable systems, which have utilized the soon-to-be-discontinued second cue tone detected by the FMU215C (the one following the pre-roll tone by eight seconds) to actuate the audio/video switchover, will need to contact the manufacturer of their commercial tape controller to determine what steps must be taken to operate both the video switch and the FMU215C's audio switch from only the initial pre-roll contact closure provided to the tape controller by the FMU215C. This is now necessary because the tape controller must provide an external contact closure (to ground) to the FMU215C for the duration of the local commercial period. In addition, a very few cable systems will have to modify the FMU215C's internal video relay drive if it's being used. The vast majority already utilizes a video relay external to the FMU215C, eliminating the need to update the video relay within the FMU215C.

The reason for these modifications, as discussed in my last column, is that MTV's format on the satellites is being changed somewhat when the VCIIC is used, as the VCIIC system delivers baseband stereo audio decoded from digital data carried within the video. The audio previously frequency-modulated in sum-and-difference format onto two subcarriers above the video will no longer be available. Only the 5.8 MHz difference-channel subcarrier will remain active; it carries the 19 kHz cue tone, which indicates the tape roll/local commercial insert period.

It remains to be determined whether the 6.62 MHz sum-channel subcarrier will continue to be present, although, even if it is, it will carry no information when the VCIIC is in use. If this subcarrier is removed, it will necessitate a minor modification to the Leaming FMU215C in order to continue recognizing the 19 kHz pre-roll cue tone, as the FMU215C normally requires that the 6.62 MHz subcarrier be present in order to unmute either subcarrier's output.

This modification involves removing only one diode, D109, to separate the two subcarriers' mute functions. (If the 6.62 MHz subcarrier remains, even this modification is unnecessary.) For those who wish to remove D109 in preparation for the possibility that the 6.62 MHz subcarrier will be discontinued, it is located on the FMU215C circuit board, just to the front of U6, connecting pins 3 and 7. D109 (1N4148) and U6 (LF353) are midway between the front and rear, and 1½ inches from the left edge of the board. Removal of diode D109 causes no malfunction of the FMU215C under any conditions. (Its original inclusion was to ensure that the audio would be fully muted even if only the sum-channel subcarrier failed. However, with the advent of the VCIIC, only the difference-channel will carry information, making it desirable that it can operate singly.)

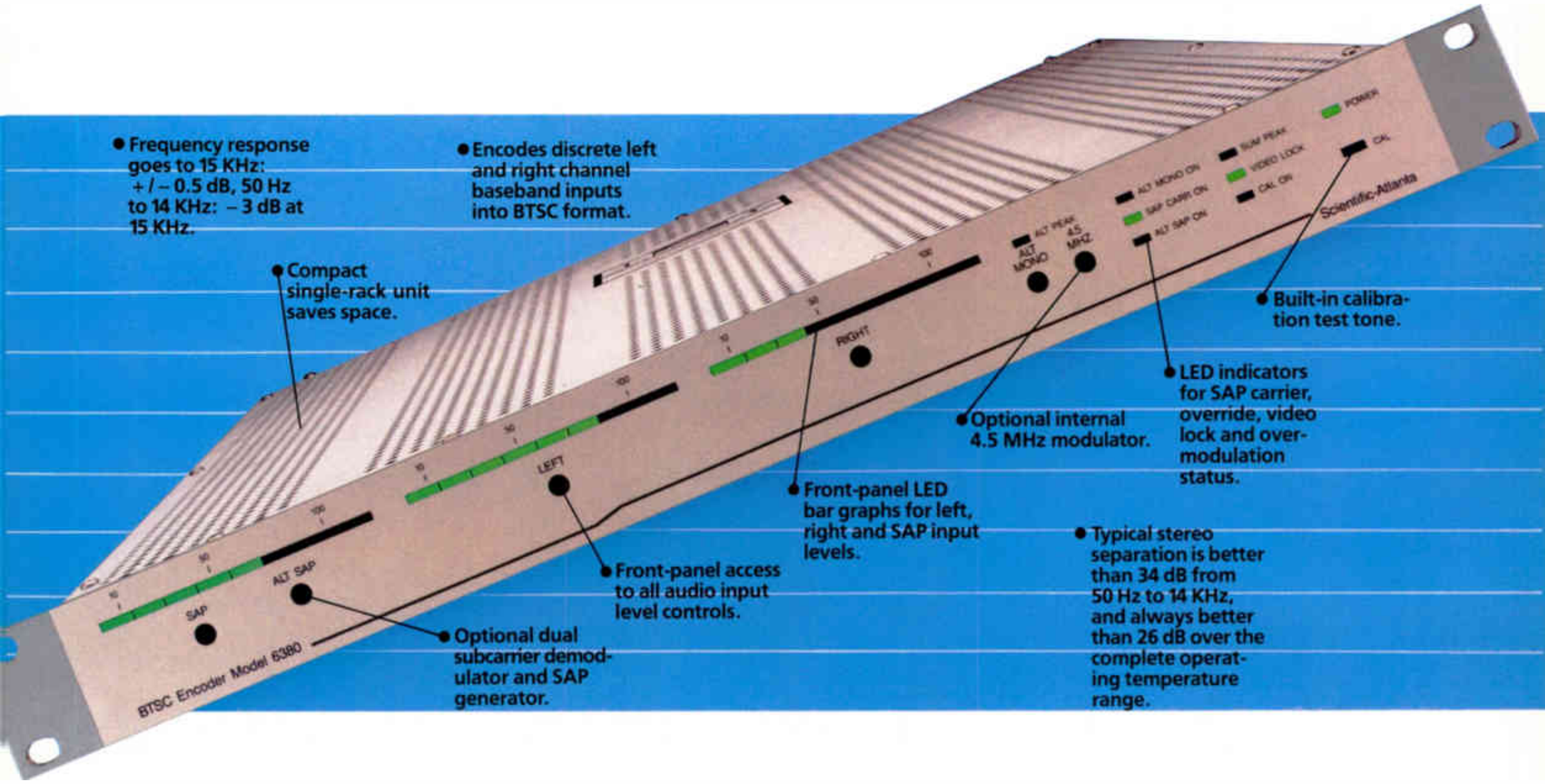
One other modification is necessary to incorporate the VCIIC with the FMU215C for MTV; this modification is external to the FMU215C. Originally the FMU215C provided only one external left-right pair of baseband audio inputs, those being for the local commercial. However, the VCIIC outputs its audio at baseband, so another input pair to the FMU215C is necessary to continue serving the FM broadcast band.

Consequently, a transfer relay, incorporating control logic, was developed to permit automatically selecting audio from the VCIIC, the local commercial tape player, or the (backup) subcarriers within the FMU215C. This transfer relay, the Leaming ATR22, connects between the existing local commercial tape controller (Channelmatic or similar) and the existing FMU215C, and it connects to the new VCIIC. The ATR22 is powered from the same KAC707 already powering the FMU215C. The ATR22 is small and lightweight; it may be suspended behind the FMU215C on its interconnecting cabling.

The ATR22 has four multiwire connectors of the Phoenix detachable-plug, screw-terminal style (no soldering or special crimping is required). Three of the connectors are used for audio (two inputs, VCIIC and local commercial,

*(Continued on page 67)*

# THE STEREO ENCODER SO ADVANCED, IT SOUNDS GOOD EVEN IN PRINT.




You couldn't pick a better time to offer stereo TV. Because there's never been a better BTSC stereo encoder than the Scientific-Atlanta 6380. And the more you hear about it, the better it sounds.

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## Great Lakes Expo '87: 'Cable means business'

INDIANAPOLIS—The 1987 Great Lakes Cable Expo is expected to outdraw last year's attendance when it meets here Sept. 21-23 at the Indiana Convention Center. According to Dan Helmick, expo chairman, the show, with the theme "Cable means business," is planning to attract over 2,000 registrants and more than 150 exhibitors.

Sponsored by the cable associations of Illinois, Indiana, Michigan and Ohio, the expo will offer technical workshops coordinated by the Society of Cable Television Engineers, as well as BCT/E Certification Program exams. The SCTE workshop sessions are: BCT/E review course on Category I (signal processing centers) with Terry Bush, Wavetek; BCT/E review course on Category VII (engineering management and professionalism) with William Riker, SCTE; "Test equipment testing techniques" with John Shaw, Texscan; "BTSC carriage over cable" with Karl Poirier, Triple Crown; and "AML transportation systems" with Dane Walker, Hughes Microwave.

A brief agenda for the show is as follows:

***Monday, Sept. 21***
**7:30 a.m.-8 p.m.**—Registration
**8:30-8:45 a.m.**—SCTE workshops open with remarks by Riker
**8:45-9:45 a.m.**—General technical session, "CLI and signal leakage monitoring," with FCC staff engineers and MSO engineers
**10-11:45 a.m.**—SCTE workshops
**11:45 a.m.-1 p.m.**—Lunch
**1-2:30 p.m.**—SCTE workshops
**2:30-5 p.m.**—BCT/E exams
**5-7 p.m.**—Grand opening of exhibit hall and reception
**7:30-11 p.m.**—Dinner and entertainment

***Tuesday, Sept. 22***
**8 a.m.-7 p.m.**—Registration
**8:30-9 a.m.**—Continental breakfast
**9-9:30 a.m.**—Keynote address by James Cownie, chairman of the National Cable Television Association and president of Heritage Communications Telecommunications Group
**9:30-11 a.m.**—Open forum with moderator Steve Effros of the Community Antenna Television Association
**10 a.m.-noon**—Exhibit hall open
**12-1:30 p.m.**—Luncheon
**1:30-4:30 p.m.**—Technical roundtables: "Preventive maintenance," "Standby power maintenance," "Signal leakage programs," "Technical training programs," "Headend maintenance/testing practices" and "Quality control"
**3:30-7 p.m.**—Exhibit hall open
**5:30-7 p.m.**—Reception in exhibit hall
**7-8:30 p.m.**—Banquet and awards dinner
**8:30-11 p.m.**—Showtime/The Movie Channel presents Glen Campbell

***Wednesday, Sept. 23***
**9-10:30 a.m.**—Panel: Washington update
**10 a.m.-12:30 p.m.**—Exhibit hall open

## BCT/E receives new endorsements

EXTON, Pa.—Three more organizations recently endorsed the Broadband Communications Technician/Engineer (BCT/E) Certification Program developed by the Society of Cable Television Engineers: the Colorado Cable Television Association, American Television and Communications Corp. and the Great Lakes Cable Association. This brings the total number of endorsements from cable industry organizations to eight.

The BCT/E Program was designed to raise the professional status of technicians and engineers by providing standards of competence in broadband communications engineering.

Organizations already endorsing the program are the Pennsylvania Cable Television Association, the Community Antenna Television Association, Women In Cable, the NCTA Engineering Committee and the Southern Cable Television Association.

## SCTE expands teleseminar series

EXTON, Pa.—The Teleseminar Committee of the Society of Cable Television Engineers recently announced its new Product Specific Teleseminar (PST) Program Series, developed to assist in training CATV engineers and technicians specifically on a company's product line. The program series will be available to all cable systems via satellite for them to downlink and record.

According to Michael Aloisi, SCTE Eastern vice president and Satellite Teleseminar Committee chairman, "The SCTE already has had an overwhelming response to the PST program from a number of cable product manufacturers and companies."

For more information, contact Aloisi at (404) 396-1333 or William Riker at (215) 363-6888.

## NCTA repeats plea on switch quality

WASHINGTON, D.C.—The National Cable Television Association recently presented an argument to the Federal Communications Commission that the FCC should adopt a 90 dB standard for A/B switches. The comments echoed a statement filed to the FCC June 10 (*CT*, 7/87, page 10). In its latest comments, the NCTA said that switches should be "life tested" to ensure a minimum loss of isolation, that cable operators should not be required to increase signal leakage monitoring and that the 90 dB standard should apply regardless of the frequencies involved.

The NCTA also asked the FCC to reconsider its rules governing terminal devices. Under these rules, stand-alone terminals are subject to Part 15 emission standards. However, cable operators remain liable for any emissions from devices that cause the cable system to exceed more stringent signal leakage standards of Part 76. In its petition, the NCTA stated that converters exceeding Part 76 limitations would have to be disconnected by the cable operator, creating "an unfair and difficult situation" for operators and subscribers.

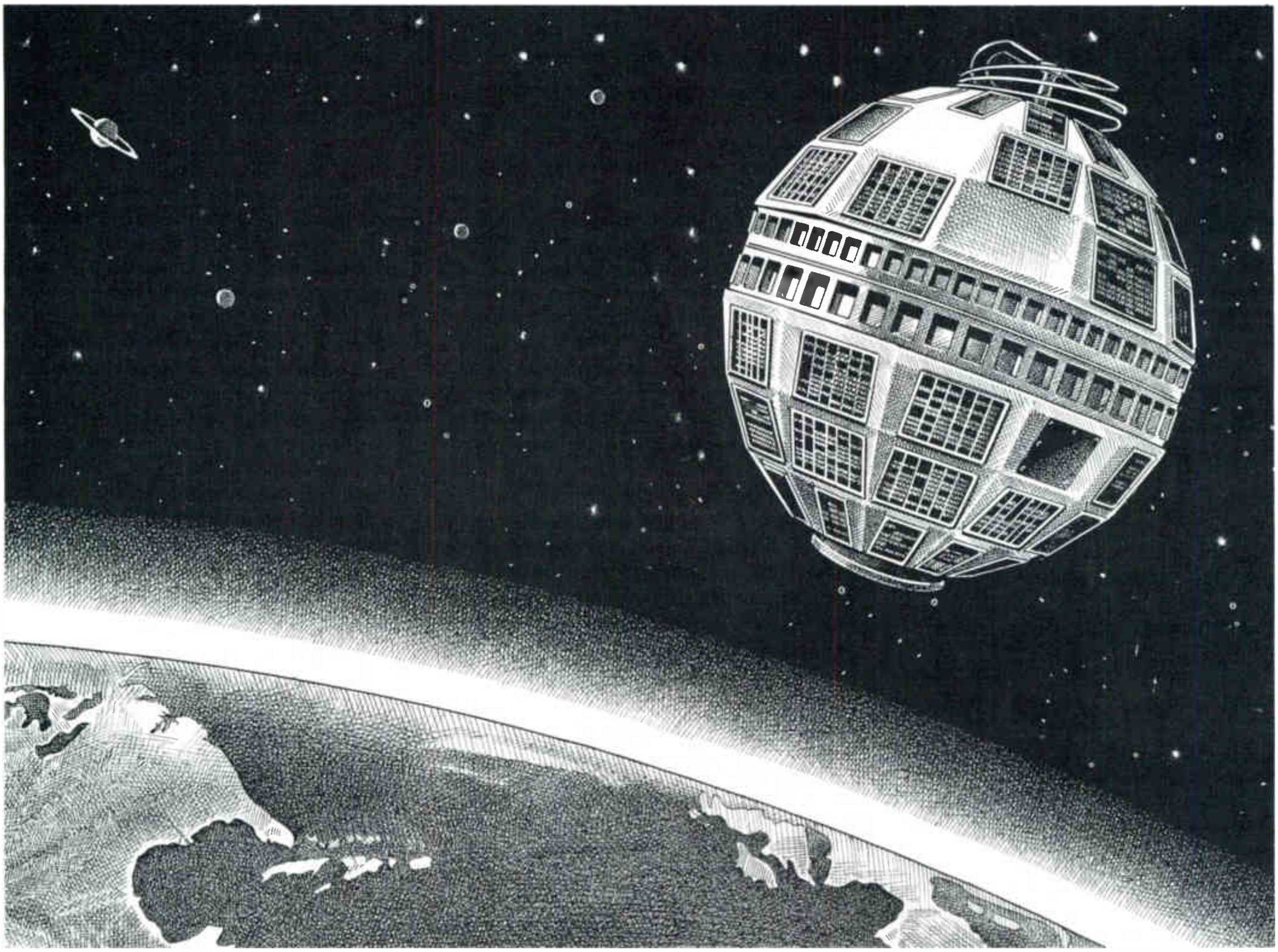
## FCC issues ruling on pole attachment

WASHINGTON, D.C.—The Federal Communications Commission recently issued its revised pole attachment formula designed to reimpose restraints on the prices charged to cable systems by public utilities for the use of poles and conduits, lacking since the commission suspended pole regulation in October 1985.

The new ruling is likely to result in marginal rate increases for a significant number of poles subject to federal regulation. The maximum pole attachment rate is calculated by a formula where cable systems pay a proportionate share of the utilities' net pole investment and adjusted for items that do not benefit cable systems. Previously, the downward adjustment was 15 percent for both telephone and electric poles; the new rules change the telephone pole adjustment to 10 percent but keep the electric pole adjustment at the same rate.

- Channelmatic was awarded contracts for its Adcart 2+2 ad insertion equipment in Continental Cablevision's Fresno, Tulare and Stockton, Calif., headends. Installation of the three systems is scheduled for the middle of the third quarter.
- Harris Corp. recently completed a $2.3 million satellite communication system for Compania Telefonica Nacional de Venezuela, the national communication carrier of Venezuela. C-band earth stations are located in two remote communities near the Brazilian border; the master station at Camatagua was upgraded. The project will provide television and voice services for the two communities.
- Hughes Microwave received an order from James Communications of Bloomfield Hills, Mich., for a 40-channel AML microwave system. The 40 channels will be distributed from one headend site at Prairie du Chien, Wis., to hub sites serving seven communities in Wisconsin and Iowa.

# In 1962, AT&T brought television into the space age.



## AT&T comes through with 25 years of satellite service.

It was twenty-five years ago that AT&T first ventured into space.

Our mission was to rocket Telstar 1, the world's first active communications satellite, into orbit.

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And today AT&T continues to uphold their commitment to technical excellence by offering a variety of satellite services under the AT&T SKYNET® family name.

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# Part III: Intellectual property

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

The general public usually believes that the protective arm of the government, wrapped around useful and novel products, is expressed by the awarding of patents. But, as every patent applicant learns in short order, the time span and the high legal fees associated with the awarding of a patent limits the federal blanket one can drop over one's technology. Many innovations may thus lie naked and unprotected from industrial piracy.

*Know-how* (trade secrets) has been defined as the knowledge of the company of how to make, market, sell or distribute a product. It consists of any formula, pattern, device or compilation of information used in a business to gain an advantage over competitors. As an example, the Supreme Court explained that the subject of a trade secret must be secret and unavailable to public knowledge or general knowledge in trade or business. Disclosure of the secret is held not to destroy the secrecy if it was revealed to another "in confidence and under an implied obligation not to use or disclose it."

### Protecting trade secrets

In order to protect trade secret interest the following are important considerations:
1) confidentiality agreements signed by anyone to whom the secret will be disclosed,
2) security measures ensuring restricted access to trade secret information,
3) non-disclosure agreements and reasonable covenants not to compete signed by employees,
4) predisclosure interviews for all employees to whom the trade secret information must require that their customers or anyone else having access to the trade secret sign a similar non-disclosure agreement, and
5) the secret material kept locked in appropriate rooms or file cabinets with only those who have signed a non-disclosure agreement having access to it.

Why such elaborate and quasi-military provisions? If you wish to enforce the trade secret in court, a demonstration is necessary to prove that the information owner has actually kept it a secret and has taken positive steps to do so.

It is equally important to label all papers, descriptions and diagrams with a stamp or sticker marked "Confidential—Trade Secret." Also, an appropriate notice on the first and last page of any communication may be composed as follows: "Notice: this material is the property of the XYZ Corp. It is confidential and is a proprietary trade secret that is not to be disclosed to others without written permission from the owner."

Enforcement of the federal laws governing trade secrets may prove to be uncertain and hazardous, owing to the difficulty of proving that trade secrets were indeed kept secret. As an alternative to the federal courts one could insist on a provision in the agreement specifying an arbitration panel to settle disputes as may often arise between licensor and licensee. Most arbitration hearings can better shield the trade secret from public disclosure than the usual federal courthouse scene.

Now, all of this is necessary legalese and represents the ideal format for comingling honorable partners. But in real life there are some dirty tricks played on the licensor. From my experience just a few...

The first executive sent in by the licensee made it his primary objective to identify the experienced and key employees of my firm and offered each of them jobs about 50 percent above their current salary as well as moving expenses to their plant site. When we found this out and threw the bum out of our plant (disowned by the licensee, of course), the next representative tried the same tactics but with much greater secrecy.

It turned out they had no intentions of living up to the contract terms. We were charged with every conceivable dereliction of duty on our part. When we finally proceeded to arbitration, who were the principal benefactors of this necessary step? The lawyers!

One of the boilerplate provisions in any trade secret contract is the sale of the product to third parties. Much to our consternation, the third parties turned out to be our customers, who were approached with heady claims of improved designs and low, low prices. Rattlesnake in the nest!

### Skill and training

Finally, a word to make you wise if you hadn't already been through this one. The law upholds the right of an individual to earn a living based on his skill and training, and rightly so. However, if he happens to be one of your key designers and a competitor hires him away to pry into your trade secrets, there is little to be gained by going to court. Perhaps your only protection is to be large enough so that your trade secrets are broken into small compartments and no one except you has the key to each locked door.

*Author's note: This article contains information extracted (with the kind permission of the authors) from "Computer Jurisprudence" by M.D. Rostoker and R.H. Rines, Franklin Pierce Law Center, Concord, N.H., Oceana Publications.*

# Those Who Think They Can't Afford A Great Impulse PPV System Haven't Done Their Homework.

You might be surprised to learn that as well as offering the next generation of secure and reliable full-featured addressable converters, Zenith also offers the lowest cost impulse PPV system you can buy.

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For under $100 with remote, there's Zenith's rugged, PM-Pulse two-way store and forward decoder. And it gives subscribers more impulse PPV options than most other decoders.

So, if you didn't know Zenith impulse PPV systems are as affordable as they are dependable and profitable, look at it this way: You learn something new every day.

For more information, write Zenith CATV Sales, 1000 Milwaukee Avenue, Glenview, IL 60025. Or call 312-699-2110.

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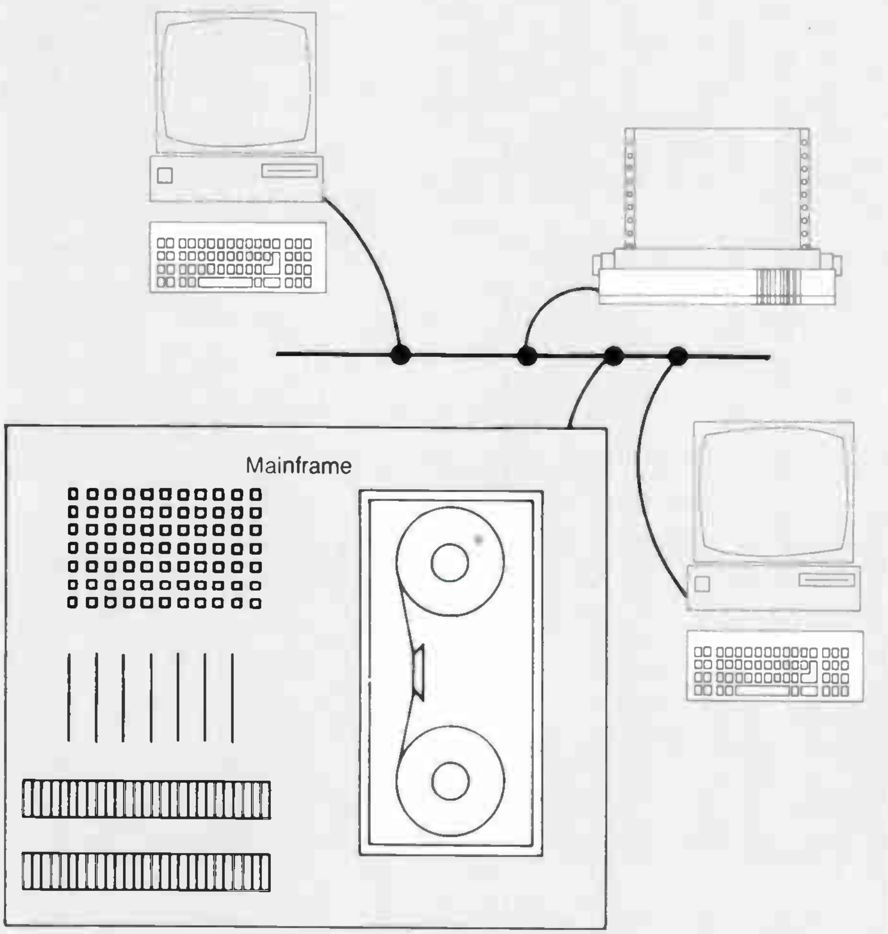
The quality goes in before the name goes on.



**Reader Service Number 10.**

# Broadband local area networking opportunities for cable television

**Figure 1:** High-speed data transmission



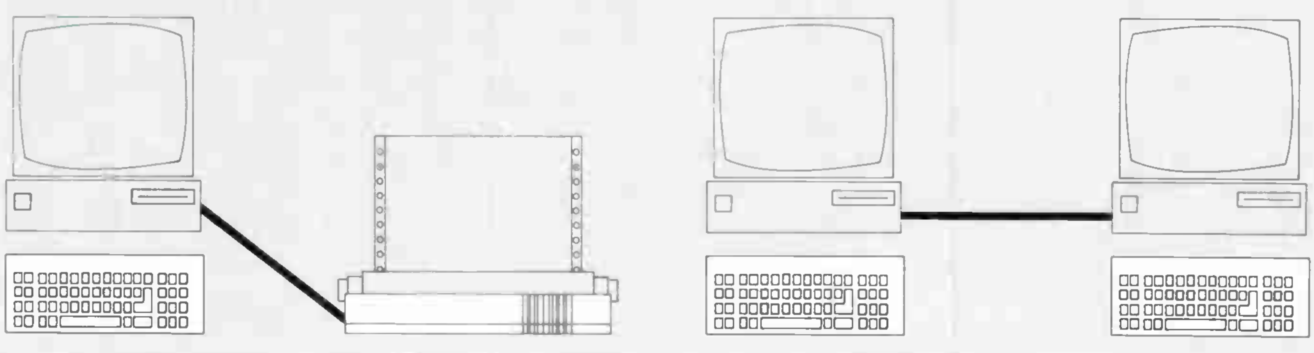

*The current interest in broadband local area networking presents many opportunities for individuals and businesses with CATV system experience. Major corporations, small businesses, factories, universities and other institutions are in the process of expanding into the area of local area networking. The use of broadband technology offers them many advantages to achieve a multipurpose network. Standards organizations such as IEEE are putting together guidelines for the use of broadband technology in local area networking. Anyone with experience in broadband CATV systems will do well to consider opportunities to expand into this arena.*


**By Norman Friedrich**
Training Engineer, C-COR Electronics Inc.


Broadband technology had its roots over 30 years ago with the installation of the first shared antenna systems and has evolved ever since to systems with 550 MHz bandwidths and bidirectional capabilities. The forerunner of the broadband local area network (LAN) looks back to several experimental networks along with the common practice of installing an institutional network alongside of the CATV system in several large city franchises. Only recently has the concept of the broadband LAN gained wide acceptance for a variety of applications including:

- *High-speed data transmission*—Many computer terminals, printers, factory robots, computer workstations and host computers share a common data channel (Figure 1) with data transmission rates as high as 5 million to 10 million bits of information per second (bps). These services occupy 6 to 12 MHz of bandwidth in both directions of the cable system.
- *Point-to-point communications*—Computer-to-computer, computer-to-terminal, computer-to-printer and other direct connections (Figure

**Figure 2:** Point-to-point communications



2) may use low-speed data channels from one point to another. Point-to-point broadband modems operating at data rates of 9,600 bps and higher interconnect these devices. Depending on data rate, many of these devices can coexist side by side in a single 6 MHz channel. Signals originate anywhere in the network, arrive at the headend via the inbound passband and are retransmitted in the outbound direction to all points in the network where a modem, set to receive at the proper frequency, receives the data.

- *Video*—Similar to CATV systems, broadband LANs often carry video channels for security purposes, entertainment and messaging. Video signals, particularly for security applications, do not necessarily originate at the headend, but may originate at various locations throughout the network (Figure 3). They arrive at the headend via the inbound passband and are then retransmitted throughout the network via the outbound passband.

*"A demand exists for designers and installers who can put together a LAN that operates within the required tolerances."*

**Inbound, outbound design**

It becomes obvious that for a broadband LAN to provide the necessary two-way services previously detailed, equal attention must be given to both the inbound and outbound passbands. There are three commonly accepted means of achieving this.

1) *Midsplit systems*—A midsplit system divides the cable bandwidth into two passbands (Figure 4). The inbound passband occupies the RF spectrum from 5 to 112 MHz from all remote points back to the headend. The outbound passband transmits signals from the headend in the outbound direction from 150 to 450 MHz. (Earlier systems only operated from 150 to 300 MHz with 107 MHz of bandwidth available in the inbound direction and 150 MHz of bandwidth in the outbound direction.)

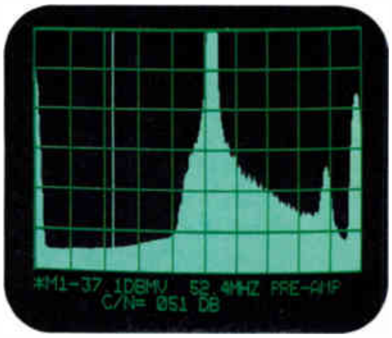
2) *Equal-split systems*—Equal-split systems operate the same as a midsplit system with the exception that the inbound bandwidth occupies 5 to 186 MHz and the outbound bandwidth uses the spectrum from 222 to 450 MHz. Newer technology allowing for higher bandwidths used in equal-split systems permits 181 MHz of bandwidth in the inbound direction and 228 MHz of bandwidth in the outbound direction.

3) *Dual-cable systems*—This technology differs from the previous two in that it uses two parallel cables for signal transmission (Figure 5) with each cable having a passband from 42 to 450 MHz. One cable is designated for inbound signals to the headend while the parallel cable is designated for outbound signals from the headend. This system finds it application in high-volume networks requiring as much as 408 MHz of bandwidth in each direction.

In CATV systems, the primary attention of the designer, installers and maintenance staff is on the outbound, video distribution portion of the system. The inbound path (if it even exists) is not given much consideration. Conversely, with broadband LANs, the inbound path shares equal importance with the outbound path. This means that starting at the time the initial design specifications are put together, one must think of both the inbound and outbound signals equally.

The designer must carefully calculate signal levels, losses and gains in both the inbound and outbound directions. A standard practice calculates the levels at both band edges in each direction. For example, someone designing a midsplit system would calculate signal levels at 5, 112, 150 and 450 MHz at all of the system nodes.

An even greater concern for the designer involves the fact that many of the network interface devices (modems) attached to a broadband network have tight dynamic range windows and adjacent channel rejection specifications. To achieve a system that operates within these tolerance specifications, the design must have even closer tolerances to allow for variances that

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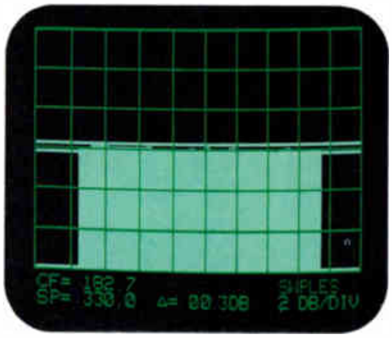


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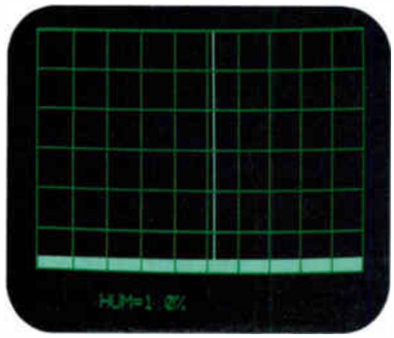

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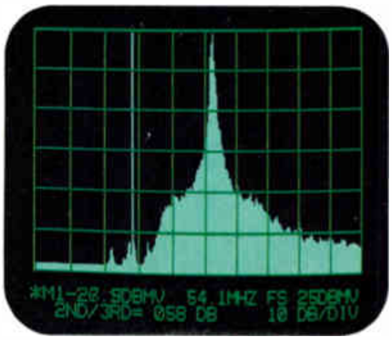
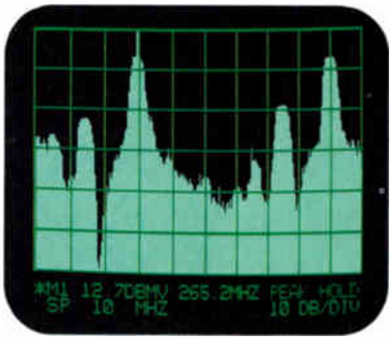



*Pinpoint distortion problems.*

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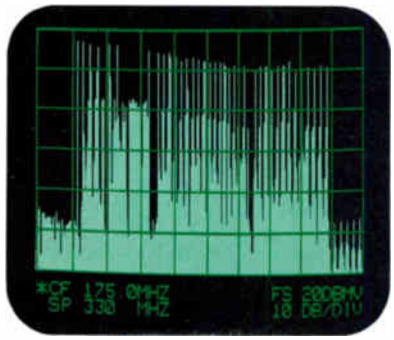


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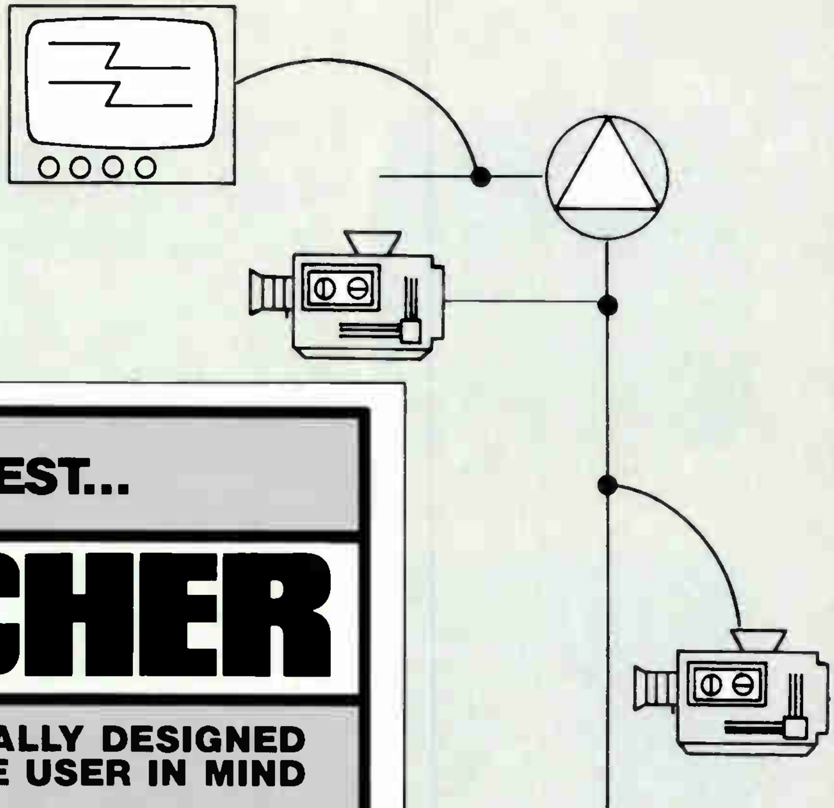
**Figure 3:** Video transmission



occur in passives, taps, coaxial cable and amplifiers. There have been many discussions on acceptable design tolerances, however, most people would agree on a design specification that calls for a tap output level within a tolerance of ±3 dB or even ±2 dB from a specific output. The same holds true in the inbound direction. A consistent signal injected into any tap in the system should arrive at the headend within a design tolerance of ±3 dB or even ±2 dB. To do both at the same time becomes rather complex, although not impossible, as any broadband network designer will testify.

Once the network goes into the installation phase, the person installing the system and balancing the network must carefully adhere to the system design for component placement, vendor selection and amplifier balancing. Deviations from the design, or a casual approach to construction and balancing, often cause systems to fall outside of reasonable tolerances. A properly installed and balanced system ensures tolerances of ±5 dB or even ±4 dB from nominal.

**Reliability considerations**

Another area of concern for broadband LANs is reliability. A large factory dependent on a high-speed data channel to control factory robots and other control systems cannot afford interruptions in the data channel. A two-hour interruption in service for a CATV system generates angry phone calls from affected subscribers; the same downtime in a broadband LAN can potentially cost a factory thousands of dollars.

There are two basic means of achieving reliability: Current technology offers amplifier back-up circuitry that switches into operation in the event of signal loss through the primary trunk amplifier circuit, while redundant cable routings address the problem of non-amplifier component failure.

A backup active failsafe module (located in the same housing as the primary amplifier) provides automatic backup capability. This eliminates the trunk amplifier as a point of failure. With redundant cable routings, critical cable runs are split before a long run and then recombined at the other end with an intelligent A-B switch. A-B switches used in conjunction with a status monitoring system can detect signal levels in both the inbound and outbound directions. If signal levels drop below acceptable thresholds, the A-B switch automatically selects the better signal

**Figure 4:** Midsplit and equal-split systems

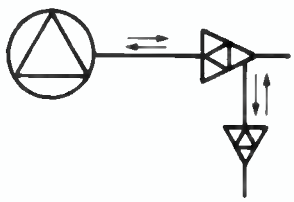
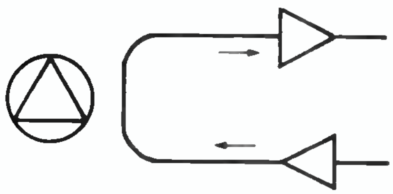


**Figure 5:** Dual-cable system

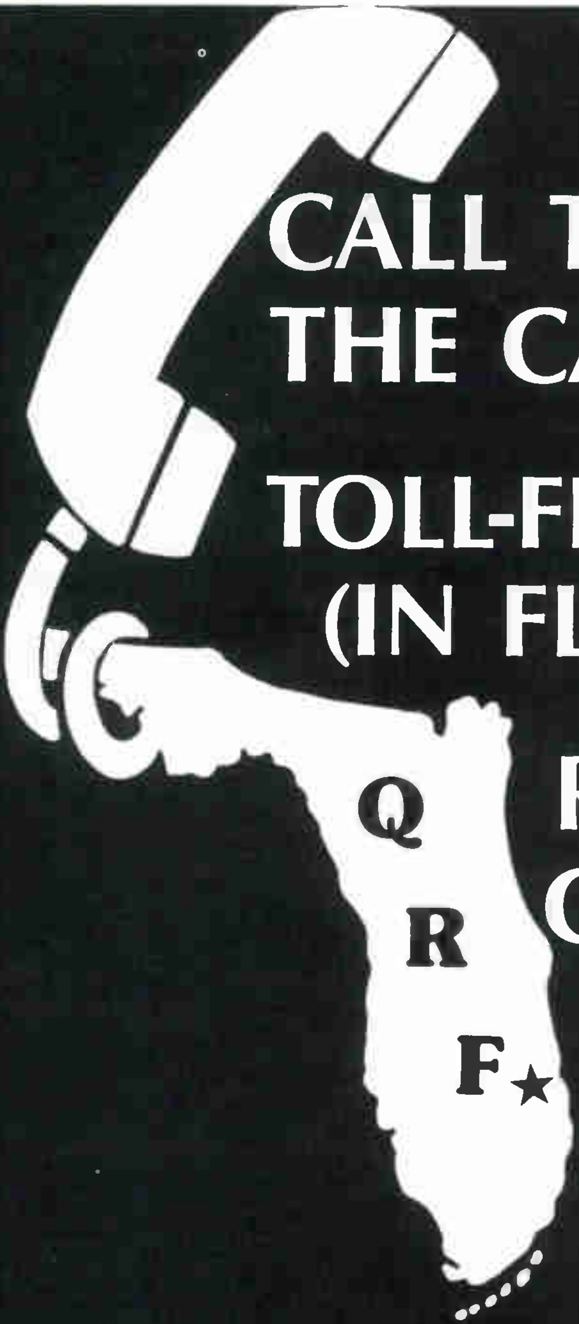


path. This concept can carry over into the headend where completely redundant headends connected to an A-B switch provide an extra measure of redundancy.

A demand exists for designers and installers who can put together a LAN that operates within the required tolerances across the entire bandwidth in both the inbound and outbound direction. They must also work with the system owner to properly address the questions of reliability and redundancy. Other opportunities exist in the area of ongoing system support. Many broadband networks are installed in locations where the system operator does not have a support staff familiar with broadband technology. When reliable system operation is critical, there exists an opportunity for an outside organization to provide necessary maintenance, periodic service and emergency repairs. Advances in network status monitoring systems allow for an outside service to remotely access information on the operation of a network, thereby providing off-site diagnostic capability.

It behooves an individual or organization with a CATV background to explore the opportunities in the broadband LAN arena. A variety of training courses are available that cover the concepts unique to broadband LAN specification, design, installation and operation. Designers, installers, consultants and maintenance contractors can all benefit from the burgeoning broadband networking industry. Those who understand the differences between CATV systems and broadband networks have a distinct advantage.

*Norman Friedrich has actively participated in both MAP and IEEE broadband local area network committees. For over five years he has been with C-COR working on the implementation of broadband networking equipment and specification. Currently, he directs the external training programs for those interested in furthering their knowledge in both CATV and broadband network technology.*

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# Broadband LAN performance testing

*The final installment of this series discusses loop loss testing for local area networks.*

**By Steve Windle**
Applications Engineer, Wavetek Indiana

The RF backbone of your LAN provides a communication utility for data and other services, which may need to be shared or processed in other parts of the facility. It is important to test the network to be sure that it is performing its function according to its potential. The signals on a broadband LAN must be maintained within specific tolerances to keep bit error rates down. If signal levels are too low, the carrier-to-noise ratio will decrease; if they are too high, distortion products may interfere with data.

If there is a data communication problem, one question that should come to mind is, "How can we tell if this problem is related to data or to the RF transmission system?" In order to test the quality of signal transmission from one point in the system, around the loop and back to the same point, a loop loss test should be performed. This test is a measurement of the relative loss or attenuation of a signal as it makes its round trip from the point of transmission to its reception at the same point. It provides a means of testing the inbound *and* the outbound transmission paths at the same time. This measurement can be made directly using a network analysis meter specially designed for the application.

### Test equipment and procedure

Measurement of an RF signal present on the system can be accomplished using a signal level meter. Absolute level measurements are made by connecting the RF input port of the meter to the system test point, tuning to the frequency of the signal, setting the attenuator to the appropriate level for a good meter reading and noting the level indicated by the meter. Path loss, the attenuation of a signal from its transmission point to another test point at a different location, would be measured by inserting a signal at one point and measuring and comparing the level measurement at another point to the original reference level. The difference between the reference level measured at the insertion point and the test point level is path loss.

The Wavetek LAN 450D network analysis meter is a signal level meter with a built-in synthesized signal generator. The meter can be used to perform absolute level measurements of signals existing on the system or to generate a signal in order to measure loop loss. We will discuss how to perform a loop loss test with this instrument as measured by generating a signal at any tap port and measuring its relative loss or round trip attenuation at the same tap.

The test procedure covers two different types of broadband LAN systems: single- and dual-cable configurations. In both instances the network analysis meter is used to generate a signal that is injected on the return path of the system. This signal is then either translated to the offset frequency or turned around to be sent back on the forward path. The signal is then measured upon its return from the round trip to determine the loop loss of the system.

Consideration should be given to the fact that when the loop loss test is being performed, a carrier is being generated for measurement. This carrier could potentially interfere with data transmission if the data communication occurs at the same frequency as the test. When the loop loss test is performed on an active system, the measurement should be made as quickly as possible. The operator should be aware of the consequences of temporary interference with data communication on the system. The tests should be performed in the guard band between channels or in an unused adjacent channel when possible.

### Single-cable testing

It would be desirable in many instances to test loop loss on one tap port, in order to minimize the number of terminals or peripheral devices that have to be disconnected from ports to perform the test. One way to accomplish this is to connect the meter's RF output and RF input ports to the output ports of a splitter. Using this method, the RF will pass from the meter's signal generator through the splitter output leg and out into the system. The translated test signal will return through the other splitter output leg to the instrument's RF input (Figure 1).

Before connecting the test cable to the splitter input the operator should first calibrate the meter to compensate for splitter loss by normalizing it out of the measurement and to obtain a reference level for the test signal. (This is a "quick and dirty" calibration method [±1 dB]. For a more precise calibration, test the transmitter output level with a calibrated cable between the RF output and input connectors and consider the splitter loss when calculating loop loss.) The RF signal will travel from one splitter output to the other (reflected from the open input port) and will show the effective loss of each leg of the splitter (3.5 dB + 3.5 dB = 7 dB). The signal level can be adjusted to a level convenient for making the relative measurement. This measurement would then be noted for later loop loss calculation.

When calibrating, a 50 dBmV test signal output level is attenuated by 7 dB due to splitter loss. A +43 dBmV reference level is measured (Figure 2). The open output port of the splitter is then connected to the test point. The signal (which has been translated and has travelled around the loop) is measured at −10 dBmV. This level is subtracted from the previously measured reference

**Figure 1:** Single-cable test point

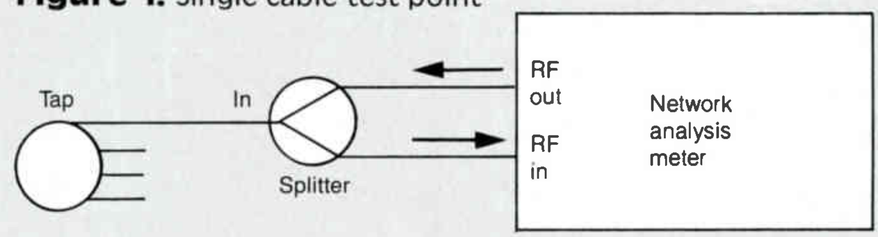



**Figure 2:** Reference level measurement

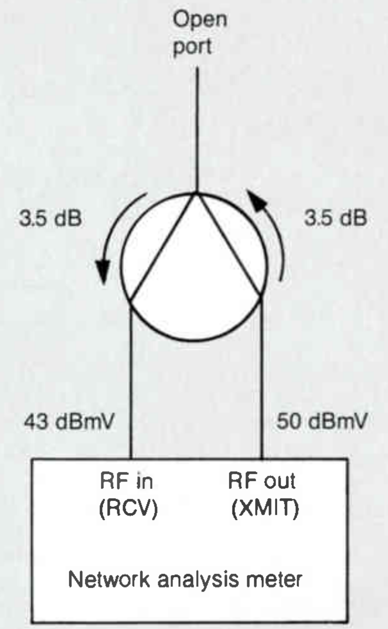



**Figure 3:** Levels affected by splitter, tap and system

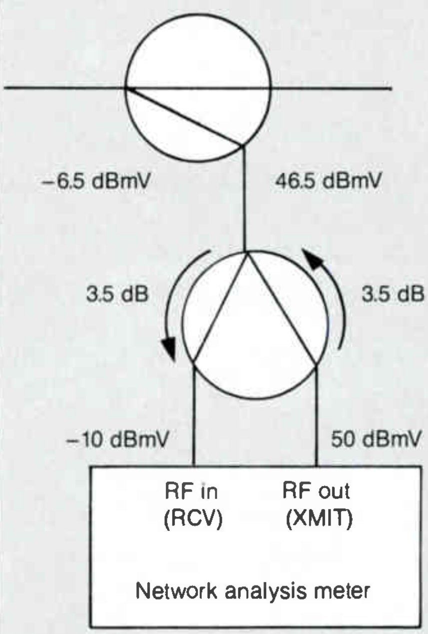


**Figure 4:** Single-cable (split) system test scenario

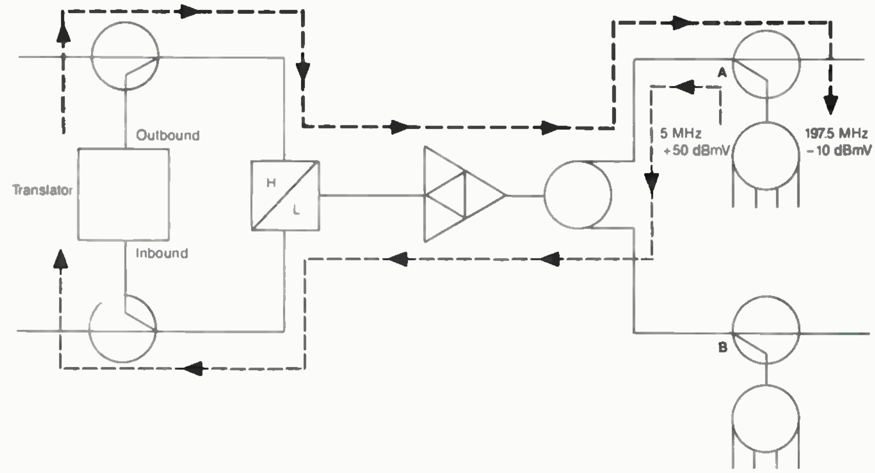
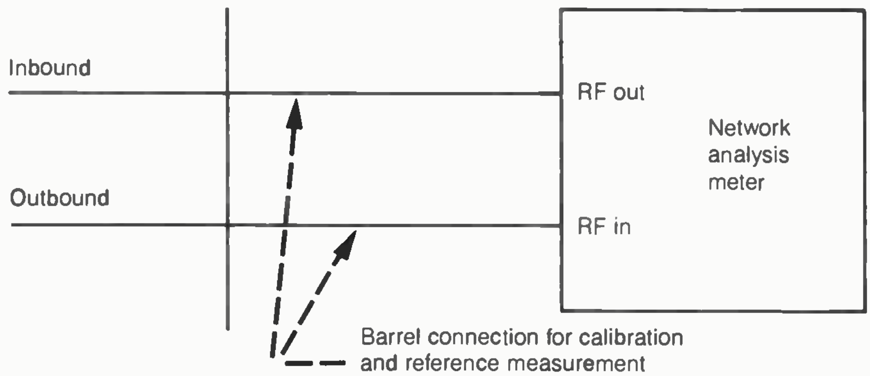



**Figure 5:** Reference measurement for dual-cable system




(+43 dBmV) to obtain a loop loss measurement of 53 dB (Figure 3).

The meter should be programmed with the translator offset frequency so the transmitted RF will be at the appropriate inbound frequency (translator input frequency). The injected test signal should be just within the upper or lower band edges of the data channel and at a low enough level not to interfere with the data transmission. It would be wise to experiment during a non-critical system operation time to find a good frequency and level to perform the test and be sure to avoid interfering with data. Broadband translators tend to have more vacant space in which to test without fear of interfering. Before measuring the loop loss by activating the test carrier, the operator should first remove input attenuation on the meter to determine the level of the noise floor. The noise floor may be a composite of noise and data modulation products. To ensure an accurate measurement, the post loop measurement should be at least 10 dB higher than the noise floor.

If two tap ports are available at the test point, the splitter can be eliminated from the test configuration. In this instance, the test is performed as specified in the dual-cable procedure, but the appropriate translator offset must still be programmed into the meter.

When the loop loss has been tested at one point (Figure 4, Point A) and tested at another point on a different leg (Point B), the functionality of the RF transmission path will have been verified. As far as the broadband backbone equipment is concerned, communication from A to B is sound.

**Dual-cable testing**

Before testing the loop loss on a dual-cable system, the network analysis meter RF output cable and the RF input cable should be connected with a barrel connector for adjustment of the RF output to an appropriate level to obtain a good relative measurement and a reference for the loop loss measurement (Figure 5).

To perform the test, the RF output of the meter is connected to the tap connection corresponding to the inbound segment of the system. The RF input is connected to the tap port corresponding to the outbound segment of the system. The offset frequency of the meter should be set to zero, since the received signal will be at the same frequency as the transmitted signal. The meter is tuned to the desired test frequency, the RF switched on, the attenuator adjusted for a good meter reading and the test level noted. This level is then subtracted from the previously noted reference level to obtain the loop loss.

# Broadband LANs for the military

By Garland R. Thomas

During the next few years, the U.S. military will be building local area networks (LANs) on all domestic bases. These networks will have to be built and maintained by someone; so why not the local CATV company? This can be an important new revenue source for any CATV company presently serving a military base. Not only can you make a profit on the construction and maintenance of these networks, but you also can gain some much-needed expertise in data transmission for the future. Excellent opportunities also will be available to improve public relations with base personnel.

*"The design maps, when completed, must be submitted to the government for its approval."*

### Bidding procedure

There are three possible sources of bids on these contracts: the local telephone company, military contractors and you (the local CATV company). You have an advantage over the other bidders, because LANs are very similar to a mid-split system. You have built a similar network, which you maintain on a daily basis. There have been many experiments with two-way systems, and you should have no problem building or maintaining one.

The bid for the LAN contract should be submitted the same as any other franchise bid. The long-term revenue stream from the maintenance and operation contract, along with the added value of a short-term profit on the construction, makes this even more desirable and profitable than the normal franchise.

The local contracting office that granted you the franchise can provide you with the information and bid package when available for the local base. Contacting the contracting office, as soon as possible, for inclusion on its list of interested companies will ensure your receiving a bid package when the contract is put out to bid.

In preparing a bid, the following items should be understood:

1) The equipment specified for use in the bid proposal can be changed to equipment with equal to or better specifications after the contract is awarded to you. In most cases you can substitute equipment you are presently using and are familiar with.
2) Read very carefully the reporting procedure and the meeting requirements of the bid proposal; include the cost for these in your bid. (Remember, these meetings will be attended by the supervisor you have placed in charge of this project.)
3) The design specifications will seem very stringent to you but will not pose a large problem if: a) you have a very accurate walkout of not only the pole line and conduits to be used but also of the inside of the buildings and b) you are very careful in the design and hold yourself to as tight a tolerance as possible (close enough will not work in these cases).
4) The testing specifications must be considered in the bid. These are very extensive and will be discussed in detail later.
5) Drafting requirements are extensive, but the only area that will be unfamiliar to you is the building interior drawings. You should contact a local architectural firm for a quote. Architects can do this much better and probably for less than you can.

With these five steps and information provided later, you should determine the following costs: design, drafting, reporting and progress meetings, materials (estimate per mile), construction, initial setup and testing, government-witnessed testing, bid preparation, and one year of warranty repair (if included in bid specifications). You should then add to the total cost approximately 25 percent for unexpected problems and 30 percent for profit.

After reaching the total cost, you might conclude that it is too high. But you should resist the temptation to reduce your bid. Government reporting and testing requirements together with profit will be the major difference between your cost and the government's cost for the same system.

You might find to your surprise that yours is the lowest bid because the other bidders have much higher overheads. Some will have to move personnel and equipment great distances to the job site.

**Design and construction**

After you receive the contract—even though the bid price seemed outrageously high—you then begin the drafting and design stage. All government drawings that are available for the building interiors, pole lines and conduit lines should be obtained. These drawings are to be used as base maps only. All measurements must be double-checked and corrected for an accurate design.

After you have corrected all measurements on the interior floor plans, these plans should be given to the firm selected to do the drafting. While it is completing its portion of the drafting, you should be making base maps of the pole lines and conduit routes. After completing the maps, select the best routes for the cable lines. You should double-check all footages with your original walkout figures for any possible errors. This review is extremely important because of the tight specifications of the RF level at the taps and the return level at the headend from each tap.

The design should be accomplished much like a normal CATV midsplit system, using the government's specifications instead of yours. If possible the system should be designed by one designer and double-checked by another.

The following are representative design specifications used in a similar government contract by the U.S. Army:

1) *Signal level accuracy*: forward outlet, +1 dBmV ±3.5 dB at 240 MHz measured at each tap with +46 dBmV applied at the headend; return outlet, +2 dBmV ±3.5 dB at 75 MHz measured at the headend with +43 dBmV applied at the tap.

2) *Carrier-to-thermal-noise ratio*: outbound, at least 41 dB; inbound, at least 40 dB.

3) *Carrier hum modulation*: outbound, less than 1.5 percent; inbound, less than 1.5 percent.

4) *Second-order distortion*: outbound, at least 60 dB; inbound, at least 60 dB.

5) *Third-order distortion*: outbound, at least 51 dB; inbound, at least 51 dB.

6) *Outlet level response across the frequency band*: inbound, ±3 dB; outbound, ±3 dB.

One item that should be considered in the design stage, if this is a trunk-only system, is amplifier output levels. Levels higher than normal trunk levels should be used. Feedforward or power doubling techniques can be used to maximize output levels, maintain specifications and reduce the number of active devices. This will not only reduce the initial equipment cost but also will reduce the cost for alignment, testing and maintenance.

The design maps, when completed, must be submitted to the government for its approval. *This is very important*! No further work should be started until written approval is received. Written approvals must be received at all points required as the contract progresses. (Verbal approvals are only as good as the person giving the approval. That person may be 10,000 miles away when that portion of the contract is questioned three months later. Military personnel move quite frequently.)

After written approval has been received, you are ready to proceed with the most familiar portion of the contract: construction. This will be very similar to your normal CATV construction, with the following exceptions.

1) The government will be inspecting the system as you build it. You should add about 5 percent to the construction time for delays caused by these inspections.
2) You will be wiring the office buildings while they are occupied by government workers. The construction delays caused by this will add about 20 percent to the building wiring time.
3) If you do not already check the resistance of each ground rod with a megger, this will

have to be accomplished and documented.

4) Only those splices shown on the design map will be allowed during construction without prior written approval.

You must remember that the government normally inspects buildings, roadways, etc. They may have no CATV experience, so patience and firm politeness is required.

### Setup and testing

The setup and initial testing procedures, along with the final acceptance test procedure, must be approved by the government prior to the starting of the work. You must include with the final acceptance procedure the number and location of all test points for the major system tests. These locations should be at the end of all the major trunk lines. The number of taps to be tested in each building should be determined at this stage. The location of the taps to be tested will be left for the government witness to randomly select at the time of the acceptance test. These approvals—as with all approvals—must be received in writing.

The following information must be recorded on a data sheet for each amplifier in both the forward and return trunk lines:

1) Input levels at the lowest frequency, the highest frequency and the frequency at the outlet level specification.

2) Output levels at these frequencies.

3) Each amplifier must be identified with a unique number that must be placed on the final as-built maps.

4) All pad and equalizer values must be noted on the data sheets.

5) Voltage levels at the power supply inputs.

All taps in all buildings must be numbered and the number placed on the as-built drawings. The following data can then be collected and recorded on the data sheets:

*Outbound tap levels*: RF carriers must be inserted at the headend for the lowest frequency, highest frequency and the frequency of the outlet level specification. Level measurements of these RF carriers must be accomplished and recorded on data sheets at all taps.

*Inbound tap levels*: RF carriers must be inserted at the tap for the highest frequency, lowest frequency and the frequency of the outlet level specification. Measurements must be accomplished and recorded at the headend for all taps.

The major tests at the previously approved test points will then be completed and recorded on the data sheets. These are: inbound and outbound thermal signal-to-noise ratios, inbound and outbound second-order distortion ratios, inbound and outbound third-order distortion ratios, inbound and outbound hum modulation, and inbound and outbound level accuracy.

After the successful completion of these tests, you will be ready for the government acceptance test. The government will schedule the acceptance test inspection using personnel from either their own or from another base. This will usually be scheduled within 30 days of your request. These inspectors will in all probability not be familiar with the type of system you have built or the methods and test equipment you will be using, unless your base is in the last 50 percent to be completed.

The acceptance test will be mainly a double-check of the data you have collected in the initial test and submitted to the government. If the inspectors are not familiar with the test methods, double the time you would normally estimate for completion of the tests. If they are familiar with the tests to be run and the test equipment to be used for the tests, only add 50 percent to the time you would normally estimate for completion of the tests. Your initial bid should take this into consideration.

Remember that all of these tests involve two of your employees for completion. One employee each will be required at the headend and the field location.

### A profitable experience

Entering into this type of contract with the government can have several advantages:

- A very good short-term profit can be realized on the initial construction contract if all of the measures previously described are carefully considered in the bidding stage.
- A long-term profit for the maintenance and operation can be established if proper care is taken in preparing the operation and maintenance bid. This contract will in all probability follow the construction contract.
- If you as the franchise holder do the work, it will not allow another company to establish a foothold on the base for future competition on the CATV side of your business.
- Both the construction contract and the operations and maintenance contract can be used to foster better relations with the higher-ranking officers and civilians on the base. You can establish the expertise and capabilities of your employees with the people on base. This will prevent future problems caused by their concern for your employees' lack of knowledge or expertise.

If possible, all CATV companies should explore the possibility of building a LAN on a local military base. The experience gained can then be used to install on college campuses, factories, etc.

You can play a large role and make a profit in the data communications field without actually owning the transmission system. You also hold the advantage of being able to connect isolated buildings occupied by a single company together through your main cable lines. The CATV industry is in a much better position to accomplish this type of work than most companies realize, but the time for action is now. If you do not take advantage of this opportunity, other progressive companies will, and the data transmission business will be lost to your company forever.

*Acknowledgements: I would like to thank Carol Sunahara, M.A., academic advisor and instructor of cooperative education and English at Hawaii Pacific College, for her encouragement, advice and editing of this article.*

*Garland Thomas is a free-lance writer living in Hawaii.*

# Enhanced RF TV scrambling using phase modulation

*Since the advent of pay TV in both broadcast and CATV environments, a secure, effective and economical method of scrambling and descrambling TV signals has been sought. Many RF techniques, while inexpensive, have proven over time to be weak in signal security and vulnerable to program piracy. Baseband scrambling systems, by supplementing basic sync suppression with video and audio manipulation, can increase security substantially but with a corresponding increase in cost. Over the last few years the market demands for addressable home terminals have been changing. Signal security is still an important issue but not as important as is cost and user features.*

**By Michael E. Long**
Manager of CATV RF Engineering
**And Richard Citta**
Manager of Electronics Systems Research and Development, Zenith Electronics Corp

In order to study and evaulate past and present system design shortcomings and to plan development of a new enhanced CATV converter to meet present and future market demands, a "wish list" of requirements was composed. The following list includes many of the desirable attributes and features home terminal should have:

- Secure
- Reliable
- Addressable
- Reliably manufacturable
- BTSC stereo compatible
- Downloadable configuration
- High-quality signal restoration
- Fully featured
- Future friendly
- Low cost

Security and low cost at first seem to be mutually exclusive parameters. Conventional RF scrambling techniques are economical but their designs are well-known and have made them easy targets of "pirate" decoders used to steal CATV services. Also, many RF systems require critical timing adjustments and have performance problems with BTSC stereo due to data and timing amplitude modulation of the pay TV channel's sound carrier.

An ideal system would have the security attributes of a baseband system and the economy of an RF system without performance degradation. Toward that goal, a new TV scrambling system was developed using video carrier phase modulation (PM) over a defined frequency range to scramble the TV signal and transmit data and descrambling information to subscriber terminals.

### Phase modulation encoding

As with other RF scrambling methods, the PM encoder processes the visual IF signal of the modulator and returns it for conversion to the CATV channel frequency as shown in Figure 1. Modulator video is also looped through the encoder to be used as a timing reference in the scrambling process. An audio loop-through is used for the purpose of enhancing the system's audio masking effect. Since the modulator's sound carrier is not modified in this scheme, an aural IF carrier is not connected through the encoder.

Figure 2 shows the typical IF modulation process performed in the CATV headend channel modulator. From the modulating video a timing pulse is generated, synchronized with each horizontal blanking period.

The generated timing pulse is used to dynamically switch the video IF signal from passing through a flat response bandpass filter (A) to one of the two alternative filters (B or C) as shown in Figure 3.

Each of these alternate filters, corresponding to two different scrambling modes, have the characteristic of not only attenuating the IF signal at the picture carrier frequency, but to completely phase reverse it 180° as shown in Figure 4. The resulting IF output looks as if it is encoded with standard sync suppression but also contains a carrier phase reversal. This phase and amplitude modified video IF is then returned to the CATV modulator for conversion and distribution to subscribers over the cable plant. This combination of sync attenuation and non-linear phase modulation provides non-authorized viewers with both video scrambling and audio distortion.

### Phase modulation decoding

At the subscriber's home terminal, the PM encoded channel is tuned and converted to a low VHF channel (Channel 2, 3 or 4) for processing and transfer to the home TV receiver. The phase modulated VHF signal is first filtered and passed to a phase-locked loop (PLL) synchronous detector designed to be stable for both a 0° and 180° phase lock. The output of this detector, shown in Figure 5, is a replication of the timing pulse originally used to encode the signal at the headend. Since the detected timing pulse is derived directly from the encoded signal, any timing errors are insignificant.

The regenerated timing pulse is then used to control an RF switch that selects the routing of the encoded VHF signal through either of two filters complementary to those used in the headend encoder. The result at the output of the decoder RF switch is a VHF TV signal restored to its original amplitude and phase and passed on to the TV receiver.

### Data transmission

One deficiency of conventional RF TV scrambling systems is the method of data transmission. In-band timing and program tags are normally amplitude modulated on the channel's aural carrier making them prone

**Figure 1:** Phase modulation system configuration

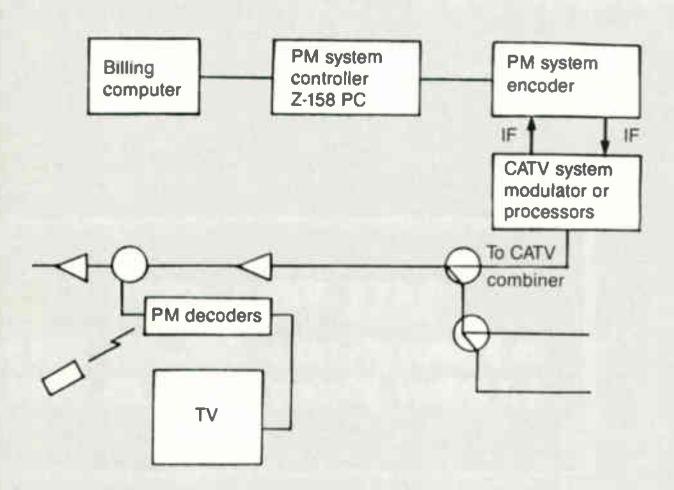



**Figure 2:** IF modulation and timing pulse generation

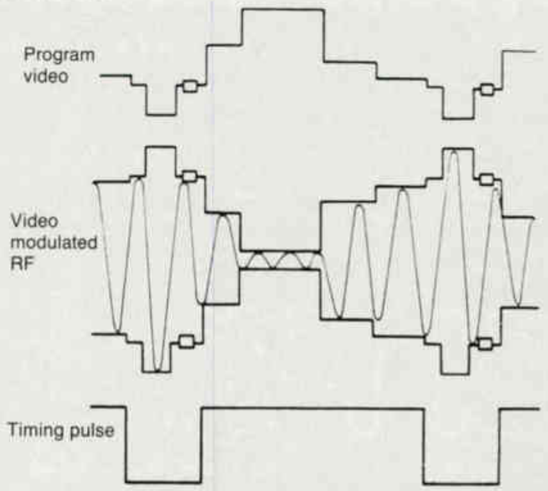


**Figure 3:** RF switch

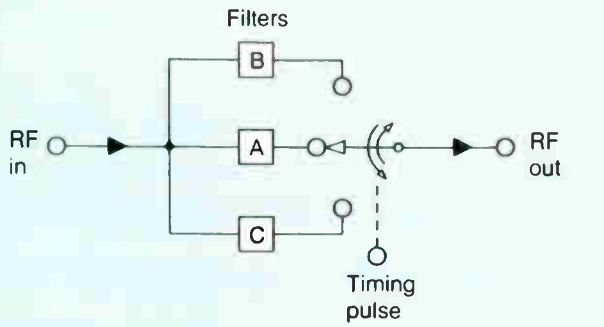
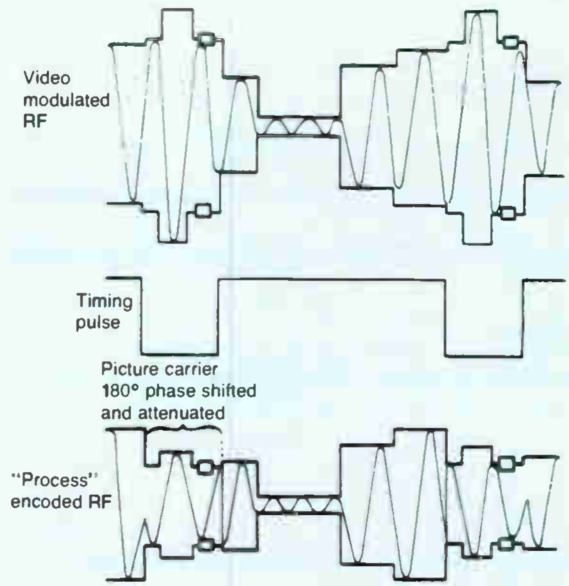



**Figure 4:** Phase modulation and sync suppression




to be noise sensitive, critical in timing adjustment and to cause performance problems with BTSC stereo encoded audio. Out-of-band frequency shift keying (FSK) of data provides a continuous communication link from the headend but takes up valuable CATV spectrum and requires decoder safeguards to protect against loss of the data carrier. Out-of-band data also requires each decoder to include the extra circuitry, cost and potential unreliability of a separate data receiver.

The phase modulated RF scrambling system provides a secure, reliable and relatively noise-immune in-band data transmission system *inherent* to the scrambling system without the need for a separate data receiver.

Phase shift keying (PSK) of data is widely recognized as an extremely noise insensitive method of communication. Since the basis of the new PM scrambling system is the phase modulation of the carrier 0° and 180°, data transmitted additionally in this fashion could constitute a very reliable communication link. As shown in Figure 6, the PM system data is encoded as pulse-width modulation of the timing pulse itself creating 262 bits of data for every vertical field of video, one bit for each horizontal period.

The data, encoded into the timing pulses and BPSK (bi-phase PSK) modulated on the RF picture carrier is transmitted on all PM scrambled channels. The data is formatted into four packets of 64 bits each per video field. This is shown graphically in Figure 7 as horizontal blanking interval data alongside the visible TV picture.

The first of the four data packets is used for global command data, time sync and channel related program tag information. This global packet is

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encrypted for data security with a variable "session" key. The session key is one of several decryption keys periodically downloaded individually to subscriber's decoders.

The other three data packets contain information addressed to individual decoders and are encrypted with a unique "address" key. The address decryption key is different for each decoder and has been factory programmed and "locked," along with the decoder's address, into each decoder's non-volatile memory. Enough address data is allocated in the individual data packets to allow for a potential of over 67 million addresses.

With an addressing rate of three subscribers per field, up to 10,800 addressable decoders per minute can be processed. Preceding each group of four data packets is a framing code used to identify each new data group.

In addition to the rugged PSK transmission system, the data is further protected by three additional "shells" of security. First, each data bit received by the decoder's synchronous detector must meet specific timing requirements in order to be accepted by the decoder as good data. If only one bit in a packet falls out of the acceptance "window," the entire data packet is discarded by the decoder.

Secondly, every packet received by the decoder must match one in the decoder's "library" of recognized packet types in order to be accepted. For the final shell of data security, to further enhance noise immunity, each packet includes 16 bits of CRC (cyclic redundancy code) for error detection. Noise tests of the system have shown accurate decoding at carrier-to-noise ratios below 14 dB.

**Multimode scrambling**

In order to ensure scrambling security, encrypted data and signal scrambling must be linked in some fashion. The system must be designed such that if the data link is broken, the TV signal cannot be descrambled. A good design requires that certain information must be present in the data necessary for the decoder to properly function.

In the PM system, there are two distinct levels of scrambling corresponding to two different attenuation levels of the horizontal sync interval. Each scrambling mode requires different signal switching between three complex filters (complementary to those in the encoder) at the correct time and in the correct sequence. Either mode can be used independently in a fixed format or dynamically random-switched at the cable operator's discretion. Encrypted downstream data is used to indicate to the individual decoders which mode is being used.

Included in the first data packet of each field is the encoder's scrambling mode definition for the next field. This data is transmitted to all decoders and encrypted with the CATV system encoder's variable "session" key. If the decoder is authorized and has the previously downloaded decryption key in its memory, it can decipher the program level and scrambling mode definition. This information is used with other available data to correctly descramble the program. If the decoder cannot decrypt the data packet or if the packet's program level does not match the corresponding downloaded decoder authorization level, the signal is not allowed to be descrambled.

Thus, the scrambling mode and authorization system is protected with three levels of security: 1) the scrambling mode is defined by difficult-to-detect downstream data; 2) the mode definition data is encrypted with a variable "session" key; 3) in order to have access to the "session" key, the decoder address must be in the headend data base; and 4) all information downloaded to addresses, including "session" keys, is encrypted with a unique "address" key for each decoder.

**Chroma inversion**

As described, the PM scrambling is accomplished by switching the CATV modulator visual IF signal through complex filters, which both attenuate and phase reverse it during each horizontal blanking period. In fact, the scrambling filters (and descrambling filters) used are complex multielement SAW (surface acoustic wave) devices of a proprietary design. Because of the particular design of these SAW filters only the channel's visual carrier, and not its chroma and aural carriers, are phase and amplitude modified during the horizontal period. This technique produces some interesting effects on the TV detected video.

The major effect of the PM scrambling on a TV receiver is the loss of horizontal synchronization due to sync suppression into the luminance


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**Figure 5:** Decoding detection of timing

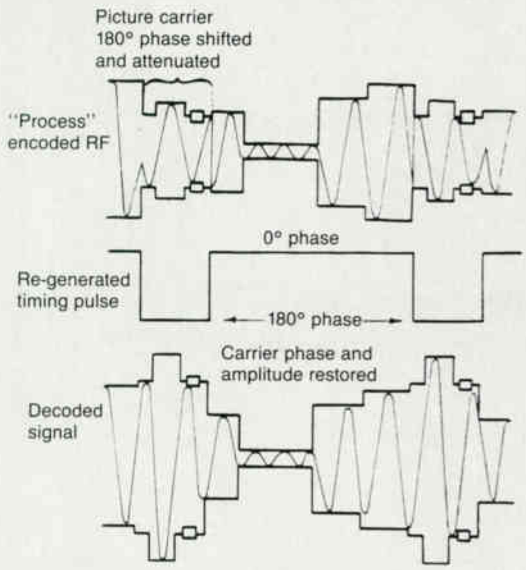
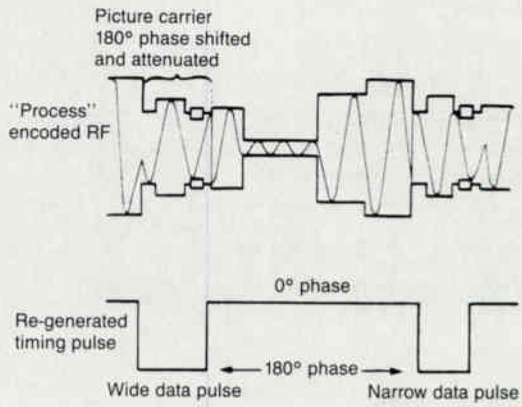



**Figure 6:** Phase modulation data transmission




video range. But in addition to this standard RF scrambling effect, the detected video chroma becomes inverted. This is due to the fact that with common intercarrier TV detection processes, phase modulation is transferred to the modulating subcarriers if only the visual carrier is phase modulated. This can be shown graphically using the simplified amplitude modulation vector diagram of Figure 8.

In Figure 8, a carrier is being amplitude modulated by a pair of sideband modulation carriers. At the point of time described by the vector diagram, the resultant main carrier is nearing its peak in amplitude due to the addition of the modulation sideband vectors. This point in time is shown in the accompanying carrier diagram by a vertical line. If at the same point in time the main carrier vector (and not the modulating sideband vectors) is 180° phase reversed, the result is that the sideband vectors *subtract* from the main carrier envelope causing it to be near its *minimum* amplitude. The resulting envelope of the 180° phase shifted modulated carrier is a sine wave of the opposite phase from the case of a 0° phase carrier.

Thus, during the PM encoded horizontal blanking interval, when the visual carrier is 180° phase shifted from normal, the color burst within that interval detected by a TV receiver would be phase inverted from normal.

*(Continued on page 48)*

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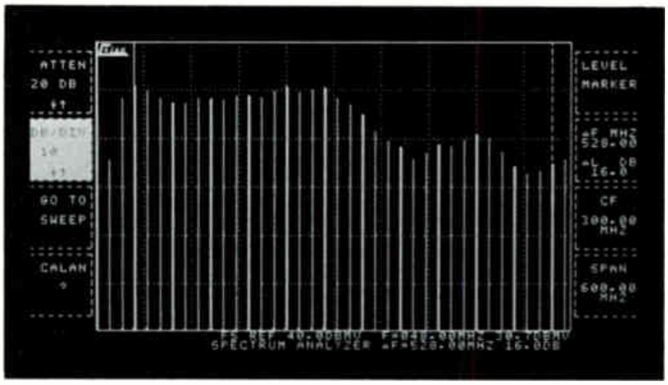
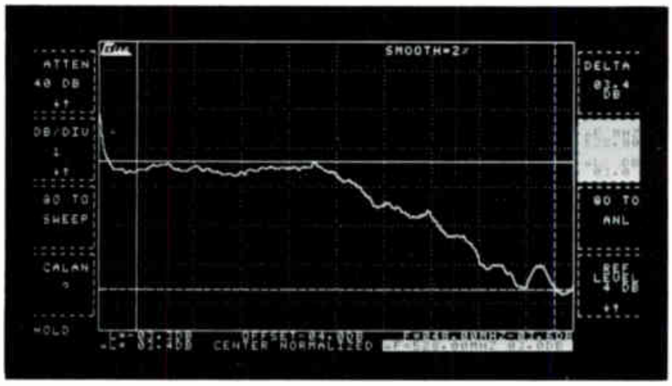



PICTURE 2
Frequency Response

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*(Continued from page 36)*

Since the TV color circuitry phase-locks to the color burst, this phenomenon would then invert the TV video chroma. In this fashion the PM scrambling system incorporates video manipulation, an attribute of baseband scrambling, into a low-cost RF system.

### Audio masking

Just as the chroma carrier becomes phase inverted during the PM encoded carrier reversal period, the aural carrier, detected in an intercarrier TV receiver, becomes phase inverted. During the fast transitions from normal phase to inverted phase (and then back again), the TV FM sound detector experiences large frequency variations as the detector tries to track the huge carrier phase shifts. This effect produces large audio transients in the TV FM detector output, driving the detector into non-linearity. The resulting effect of the scrambling on the TV receiver audio is severe audio distortion and buzz.

In an effort to enhance this audio distortion for unauthorized viewers a modulated audio subcarrier, similar to the BTSC stereo SAP (second audio program) subcarrier, is added by the PM encoder to the audio signal fed to the CATV channel modulator. Due to the severe non-linearities that the TV audio detector is driven to by the scrambling phase transients, the modulation of the added subcarrier becomes mixed with the buzz and detected baseband audio produced by the TV audio circuitry. This additional "garbling" effect on the TV audio is referred to as enhanced audio masking.

If BTSC stereo is used on the channel, effective audio masking occurs with only the standard BTSC SAP signal. When a SAP signal is detected on the encoder audio, the audio masking subcarrier is automatically turned off.

### Decoder design

For low-cost, reliability and manufacturability, the decoder design for the PM system is kept as simple as possible with few parts and minimal alignment requirements. For security, the design includes custom VLSI circuits, custom complex response SAW filters and data protection.

The design uses a one-board approach of minimal parts count requiring no factory electrical adjustments. In addition to the two power supply regulators, there are only three ICs on the module. The centralized microprocessor control and serial data output port in the design allow for extensive automated factory testing before shipment to ensure quality. Figure 9 shows a basic block diagram of the decoder design.

### Custom multielement SAW filter

The prime decoder component necessary to restore the PM encoded RF carrier to its proper amplitude and phase is the SAW filter. The use of SAW filters for both encoding and decoding was decided upon due to the complex nature of the required amplitude and phase response for the scrambling system, precluding any unauthorized replication. Additionally, SAW filters do not require alignment. Once the SAW design is finalized, production devices are virtual clones of each other.

In the development of the SAW filters used in the PM system, an iterative process was used to perfect the final designs. Of primary importance was to be certain that the decoder SAW amplitude and phase ratios between modes matched those of the encoder SAW as closely as possible. To ensure tight mode matching tolerances, the SAWs actually incorporate four independent filter elements on the same substrate. The four elements are used for data channel filtering, unencoded filtering and dual scrambling mode filtering.

Good decoded signal quality requires tight tolerances between modes in both encoding and decoding. Not only do the video sync pulses need to be restored to the proper levels but the decoding side effects on the color and audio signals must be minimized. Processing time delays also must be compensated for in order to accurately match-up decoding to encoding in the time domain. If scrambling dynamic mode switching is used, matching between encoder modes and decoder modes also must be accurate in order to avoid annoying flicker in the descrambled TV picture.

All of these requirements have been accomplished through the use of the system's custom proprietary SAW filters. The specific SAW characteristics and the lack of "off-the-shelf" parts make attempts to manufacture acceptable pirate decoders impractical.


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**Figure 7:** PM in-band PSK data

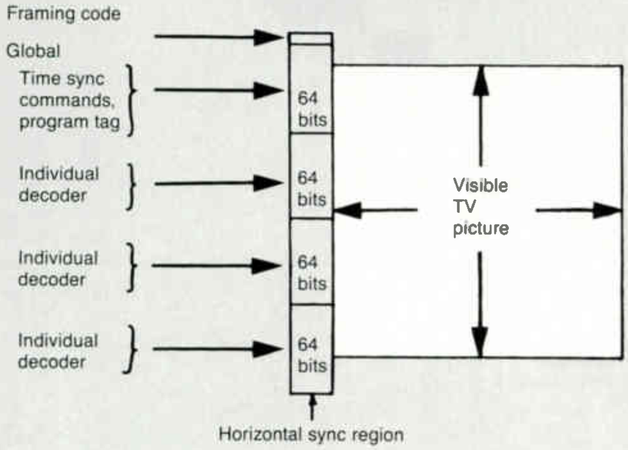



**Figure 8:** Chroma phase inversion

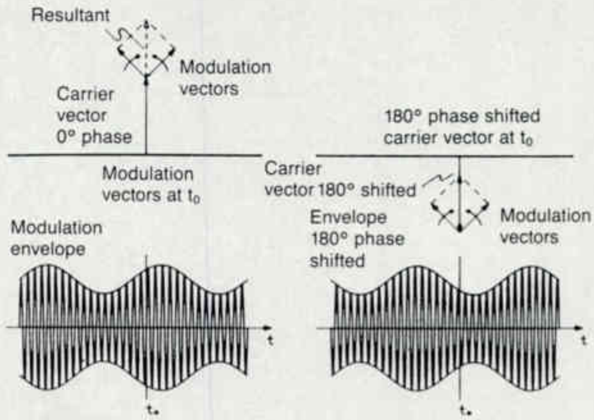



Figure 10 diagrams in simple terms the amplitude responses required of the complementary encoder and decoder SAW filters. In the encoder, the relative amplitude of the response at the picture carrier frequency is attenuated at a level (B or C) dependent upon the defined scrambling mode, while the response at color and sound carriers is flat with no attenuation. The decoder SAW provides a relative amplification at the picture carrier compensating for the encoder attenuation (B or C), while maintaining color and sound at 0 dB.

Figure 11 shows the encoder and decoder filter phase responses. Note that the encoder phase response adds a 180° phase shift at the picture carrier frequency while maintaining a 0° phase shift at color and sound carriers. The decoder response is such that it corrects for the encoder response.

**Custom RF processing IC**

The PM scrambling system phase shifts the encoded channel's visual carrier by 180° during the video horizontal blanking interval. In order to re-create the timing signal necessary for accurate descrambling and to receive the BPSK headend data, the decoder needs to monitor and accurately track the phase of the incoming RF signal. Common PLL technology has no difficulty with locking to normal signal modulation, but a signal having rapid 0° to 180° phase changes represents a problem. A phase-locked loop capable of being stable at both 0° and 180° phase states is necessary.

Such is the case in the custom, proprietary RF processing IC incorporated in the PM system decoder. Included in this IC is a patented FPLL (frequency and phase-locked loop), which is bi-phase stable. The IC's FPLL serves two purposes: It not only detects the PM signal's phase modulation for timing and data but it also provides automatic fine tuning (AFT) for the converter CATV tuner.

**Figure 9:** PM decoder block diagram

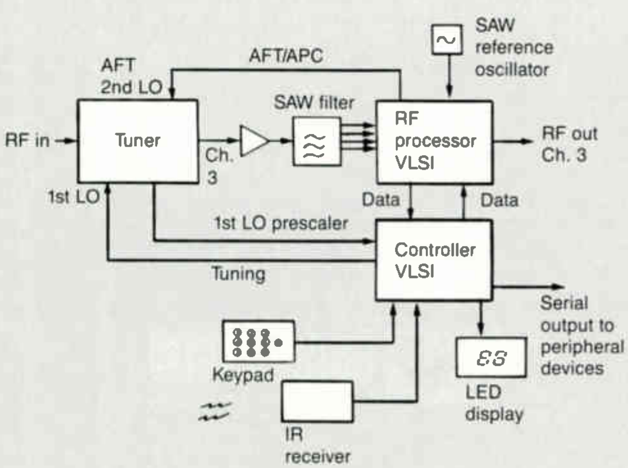



Figure 12 is a simplified block diagram of the FPLL system. In this diagram, the RF signal tuned by the CATV tuner is amplified, limited and supplied to two multipliers. The upper multiplier, used as a normal PLL phase detector, is compared to a 90° (quadrature) phase shifted reference oscillator at the picture carrier frequency. The lower second multiplier acts as an in-phase detector comparing the input signal to the 0° phase shifted reference oscillator. If the input signal is nearly in-phase with the 0° reference oscillator, the output of the lower (in-phase) multiplier produces a "+1" signal to the third multiplier in the chain. The output of this third multiplier then linearly reproduces the phase error from the upper (quadrature) multiplier and supplies it to the tuner second local oscillator (LO) as an AFT/APC.

This system effectively locks the tuner output frequency to the reference oscillator, a stable SAW resonator design. If the input signal shifts 180°

**Figure 10:** Encoder/decoder SAW amplitude response

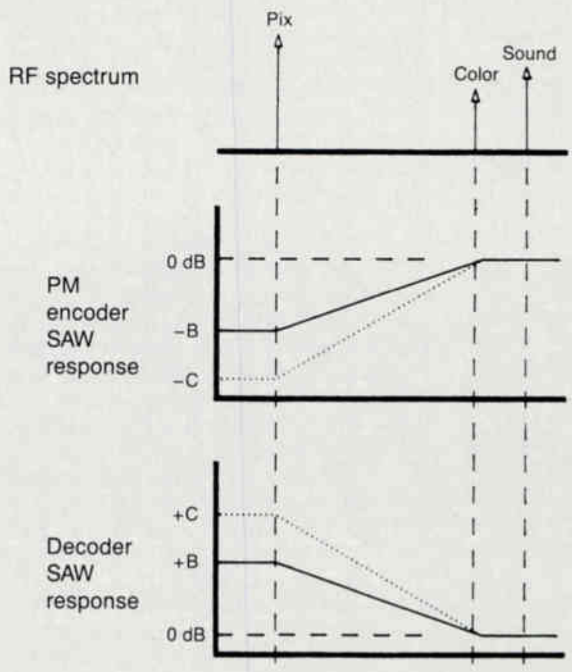


**Figure 11:** Encoder/decoder SAW phase response

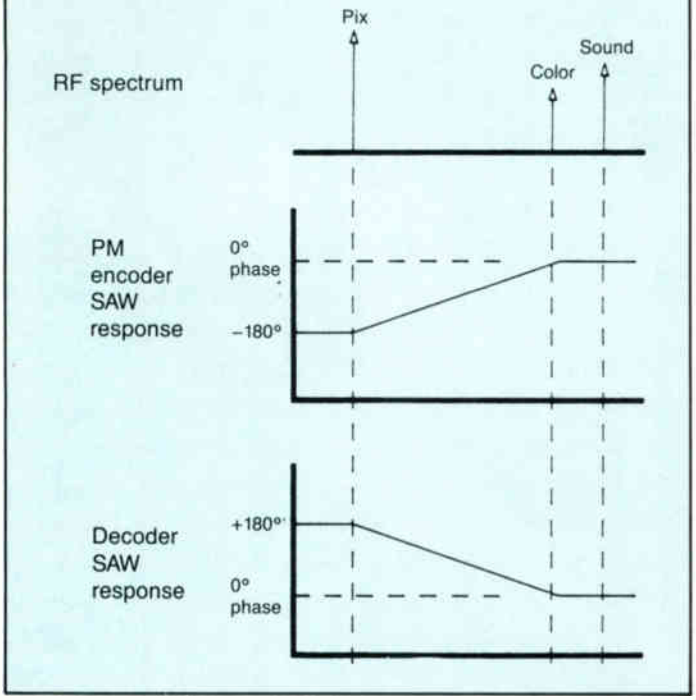
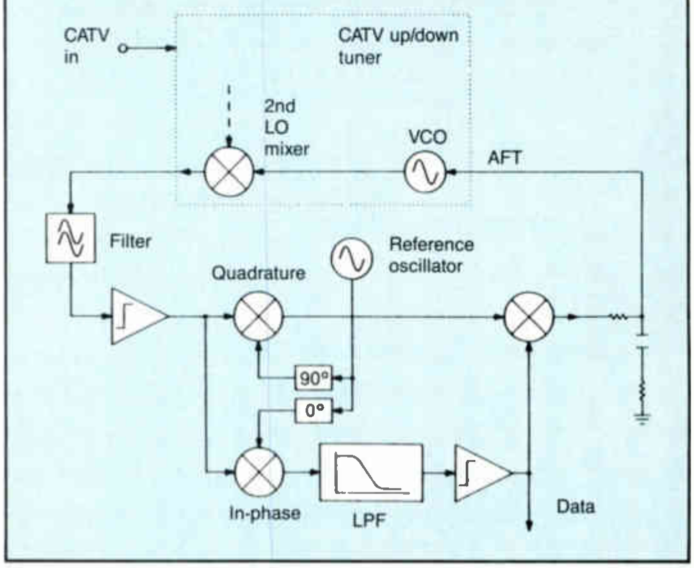



**Figure 12:** FPLL block diagram




in phase, as in the PM encoding scheme, the second (lower) multiplier produces a "−1" signal to the third multiplier in the chain. That multiplier then inverts the phase error control signal supplied to the tuner maintaining phase-lock stability. The +1 and −1 output signal from the in-phase multiplier is in fact a re-creation of the timing pulse originally used in the headend encoding for PM scrambling. This output from the FPLL is used then as the received PM data for further processing.

### Custom micro-controller IC

The processing of the PM data is one of the tasks of the third key component in the decoder design, the microprocessor. Largely due to security reasons, a custom microprocessor-controller was designed for the product and manufactured exclusively for Zenith.

A primary concern in the decoder design was tamper protection for the authorization and decoder address memory. "Off-the-shelf" parts, standard external memory ICs and battery back-up systems can all be security weaknesses in an addressable pay TV descrambler. For this reason, the PM decoder microprocessor incorporates its own internal non-volatile read/write memory, not requiring a battery back-up. Part of the memory is user-accessible for features such as "favorite channel scan memory." However, most of it is used for pay TV and IPPV authorization level storage, down-loadable converter characteristics and decoder address memory. As an additional security measure, the section of memory used to store the decoder address and address decryption key are permanently sealed off from future modification after initially being loaded in the decoder factory.

In addition to secure information storage, the microprocessor has the functions of PM data processing, decryption and error detection along with subscriber interface and headend interface through store-and-forward IPPV data communication. Keyboard, IR remote control and LED display processing is controlled for customer features and converter tuning functions. An internal tuning PLL and a self-diagnostic routine help assure reliable service. In order to make the product "future-friendly" several input/output ports are provided for feature flexibility through headend control of future peripheral equipment, for master/slave operation and for a data communication link.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*Michael Long graduated from the University of Illinois in 1969 with a BSEE and has a master of electrical engineering degree from Midwest College of Engineering. In his 17 years with Zenith, he has held positions in research and development, color TV engineering, and VCR-videodisc engineering. He holds four U.S. patents and has three additional patents pending.*

*Richard Citta obtained his BSEE degree in 1969 from Illinois Institute of Technology and his MSEE degree in 1971 from the University of Washington. He has published several technical papers and holds 12 U.S. patents with six patents pending.*


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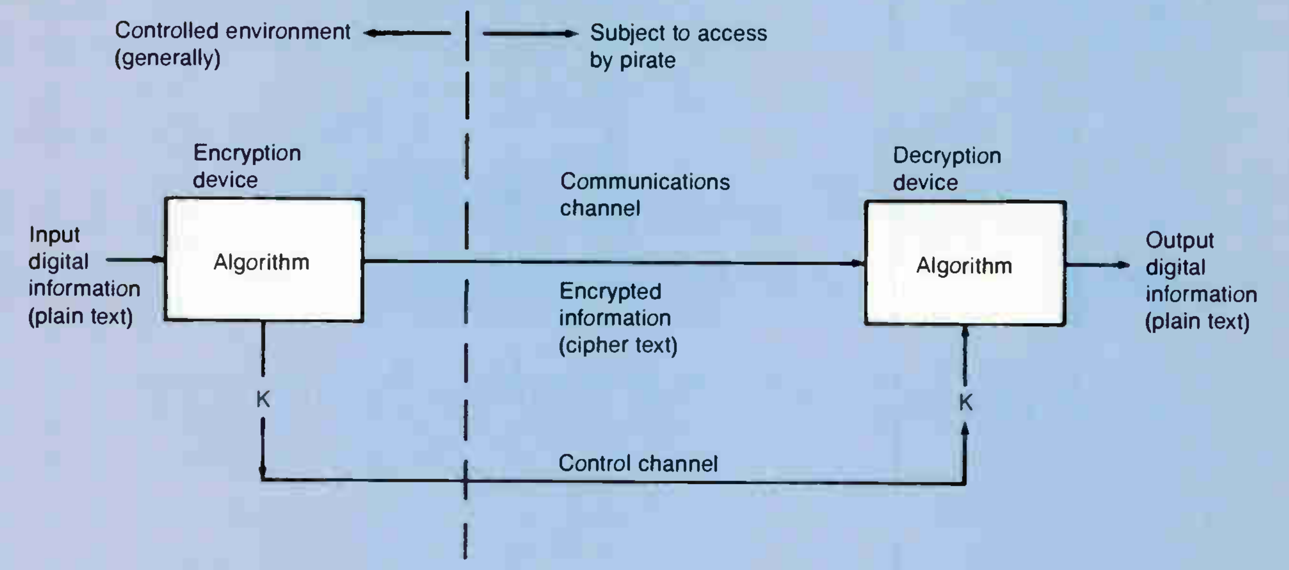
Figure 1: Classic encryption system




# Encryption-based security

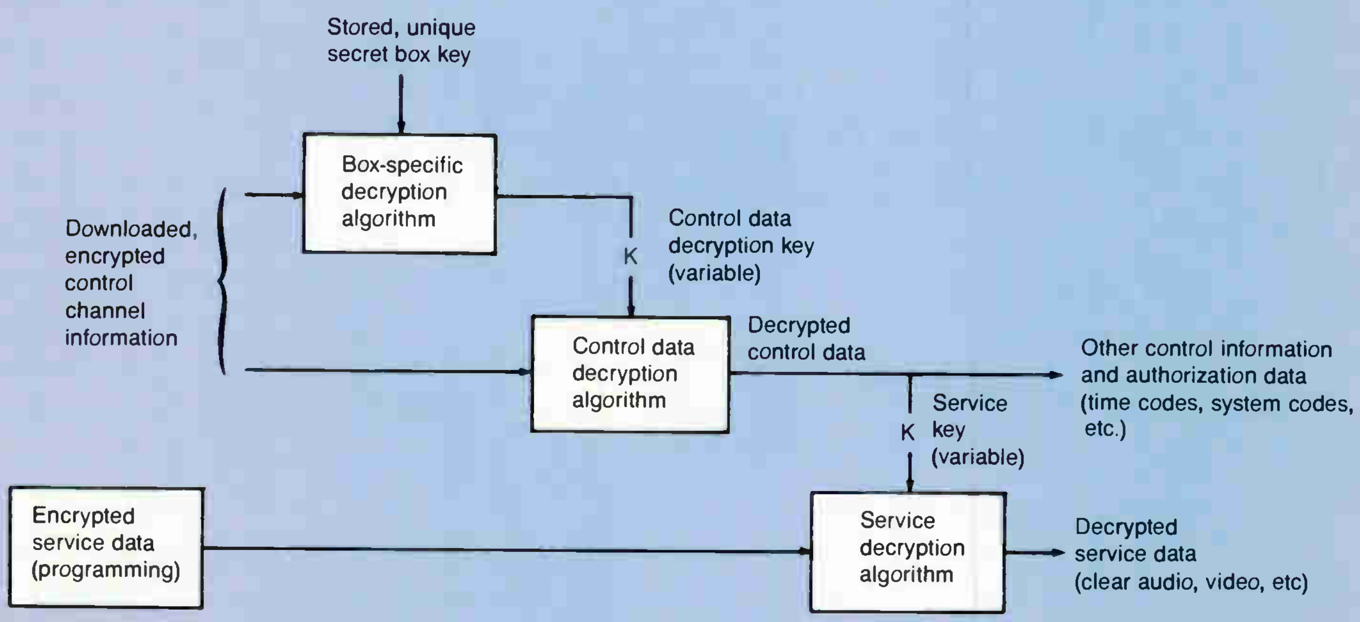
*Over the past six or more years a new genre of secure audio/video transmission equipment based on the application of encryption technology has developed. The use of encryption has been made possible by advances in technology in several areas. Developments in semiconductors and microprocessors and the evolution of low-cost digital communications and processing techniques have been married to newer industry trends such as addressability, satellite TV broadcasting and pay-per-view, which demand enhanced security.*

*This article will discuss some of the fundamental aspects of how encryption technology can be used to secure program delivery, why cryptographic methods are different from traditional scrambling techniques and how their proper application offers long-term solutions where other approaches fail. We will then test these arguments by looking at how products featuring encryption-based approaches to security are doing in the marketplace.*

**By Anthony J. Wechselberger**
Vice President, Engineering, Oak Communications Inc

A microcosm of what later became an industry trend took place within Oak in the early 1980s. This was the battle against signal theft on both legal and technological fronts. We were rapidly expanding our subscriber base in STV (subscription television) in 1980 and, while vigorously pursuing pirate activity on the legal front, were experiencing severe piracy problems in our large Los Angeles and Chicago markets.

Figure 2: Multilevel key distribution



It may be surprising but the scrambling approach being used in those days was more complex than many types still going into new cable installations today. Yet we estimate at least 50,000 illegal pirate boxes existed in our subscriber base of about 380,000 in Los Angeles alone. Illegal STV boxes were selling for $200 to $400 and were generally built from scratch. This for one channel of premium programming, when over-the-air channels were readily available for free! So we learned early to respect the degree to which pirate activity could organize and be technology-wise.

We sought a technology solution to the piracy problem through the application of encryption and in 1982 launched our Portland, Ore., and Dallas STV operations with the use of a security system based on true encryption principles. Also that year Oak introduced Orion, a broadcast-quality satellite security system. The STV markets didn't survive long enough for a true test of their encryption systems (they were on the air for only about a year), but Orion is still in use today, with approximately 20,000 units in both commercial programming and private network use. (We now market our Sigma product line, which applies similar encryption technology to the cable environment.)

With the industry looking to protect satellite-delivered premium programming services by the adoption of a de facto standard, and the broadcast networks also widely utilizing scrambling, we see a technology solution to the theft problem on a broader scale today. Pirate activity also is being combatted legally and procedurally by companies (e.g., *General Instrument vs. Cooper et al.*) as well as by collective industry efforts with groups such as the Coalition Opposing Signal Theft (COST).

Today, a cryptographic approach to securing TV transmissions is accepted as the contemporary method. Yet all products described as using encryption principles are not created equal. As we're seeing today, encryption systems can and have been compromised. The test of longevity will be those able to recover from a compromise once it has happened. So how does one know if a system is technically secure or secure enough, and by what margin? How does one get past buzzwords or generalisms in developing a figure of merit on a subject as esoteric as encryption? It's not as difficult as it might seem, once a few basic themes are examined.

### Three tests for true security

There are three areas, each a fundamental prerequisite before the system can qualify as cryptographically secure:

1) What is being secured? That is, what aspects of the total information transfer process are being (or more importantly are *not* being) protected by the use of encryption?
2) What are the actual encryption algorithms and how are they used?
3) How was the key management problem solved?

Unfortunately, the second area gets most attention in security studies but is many times the least important, at least in entertainment applications. It also happens to be the most esoteric: that is, most difficult for the average person to evaluate. For the moment let's just say an algorithm is the "lockbox" that mathematically envelops or encloses the information such that it cannot be recovered without a "key." The encryption algorithm all by itself must be evaluated in terms of its ability to withstand breaking.

Once encrypted by or through the use of the algorithm, the information must not be able to be recovered by analyzing the algorithm or the resultant encrypted information. With today's computers and high-speed logic, it is straightforward to design and implement algorithms that are low cost and extremely hard or difficult to break (although you may need some expert help in this part of the evaluation). The most popular algorithm in commercial use today is the DES or data encryption standard. DES is only an algorithm; its use does not make a secure product by any means.

The other two tests ensure that the algorithm is put to work properly. It is the objective of an encryption-based system to 1) "bottle" up or secure the information (in our case, programming and subscriber management information) by encrypting it and 2) ensure that no back doors exist allowing the information to be recovered by any means other than *d*ecrypting the *e*ncrypted information at legitimate receiver sites by 3) using a secure

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key management scheme alongside our secured signal.

When studying encryption systems one always comes back to key management, as will be discussed later in real-world systems. Since by definition the only way to recover the secured information is by using the algorithm key, the system must provide for convenient, dependable and secure methods of distributing decryption keys to legitimate receivers to recover the broadcast information.

Let's now look at some specific examples of these concepts in cable or satellite programming distribution networks. Why do traditional scrambling methods fail the first of our three tests for total systems security?

Consider a contemporary addressable scrambling system having scrambled programming and one or more control or addressing channels. When considering the piracy issue, which includes any kind of unauthorized access to programming, note that the control channel or channels have no relationship (as far as the pirate is concerned) to the service being purchased. One of the first questions to ask then about a scrambling system is: What is the function of the control/authorization channel? That is, how is it related to the scrambling approach, if at all?

In most systems the control channels direct the decoder to decode or not to decode as a function of either the channel tuned or the tier of a given program. Critical to the issue is whether any information contained in the control channel is required in the decoding process. If not, the control channel can be ignored when attempting to pirate the signal. Likewise, if the scrambling technique or decoder circuitry easily succumbs to one-time defeats (e.g., a hardwired defeat), the control channel content is of no interest. Such is the case when descrambling can be accomplished by observation of the scrambled signal alone while ignoring the control channel information.

What about time-varying scrambling? This adds a dimension of change to the scrambling process such that the decoder will not properly decode at all times unless it appropriately follows the change. Is this better security? To a degree, yes. But if the attribute that changes has few or trivial differences, then no real barrier to defeat of the system is actually created.

Consider the pirate entrepreneur who wishes to build a "universal decoder." Most positive scrambling systems use one of several techiques of suppressing the horizontal sync pulse. (*Positive* systems are those that actively scramble the premium signal and thus require a decoder. *Negative* systems remove the signal from the unauthorized viewer through traps or signal path switching). Whether the system's scrambling is at RF or baseband, our pirate's universal decoder can quite easily be designed to reconstruct the sync pulse and completely ignore all control channel information, time-varying or not.

This discussion is gearing us toward a theme: In programming distribution, security is a systems issue. The simplest method of defeat will be the path followed by the would-be pirate. The system must therefore be viewed from several angles and an adequate threshold against compromise developed for each. In so doing, one must ask what information—timing, control data, circuitry, etc.—is available at the receive location that can be used to get around (not through) the secured or encrypted material. There is usually an amazing amount of data available to tap. How much added security is afforded by random video inversion of the picture, for example, if a simple to detect "flag" exists in the vertical interval indicating current polarity?

Is any security afforded in an addressable system simply because it's addressble? Not if it's easier to address or authorize the box yourself than it is to open the box up and tamper with circuitry. This is our first test then, the notion of the backdoor entry to information. Why worry about breaking the encrypted audio out of your satellite receiver if it's coming out of your local cable drop in the clear?

**The encryption algorithm**

Let's now discuss some details of what constitutes the encryption algorithm and how keys or key variables are used. The encryption algorithm executes a digital processing function. The actual entity that undergoes encryption must be in a digital format. The output of the algorithm can then be used to perform other random processes, if desired.

In a conventional encryption system (Figure 1), a digital bit stream—the information—is passed through the algorithm that transforms the input into a seemingly unrelated output bit stream. The transformation that is performed is a function of the key variable, and in a conventional system the same key is used at both the transmit side, where encryption is performed, and the receive side, where decryption is performed. A different transformation is implemented whenever the key changes. The key is a digital word of many bits (generally in the range of 24 to 64 bits, so $2^n$ (where $n$ is the number of bits in the key) different transformations are possible by varying the key. In a properly designed algorithm, all keys are equally strong (i.e., resistant to cracking) and no detectable relationship exists between the input data, output data or key variable. Each combination of key bits represents a completely different scrambling mode and there is no such thing as "almost having the correct key." The key must be exactly correct or no decryption is possible.

The process of encryption must, of course, be reversible. That is, applying the same key at the receiver must restore the original information. The original non-encrypted data is called *clear* or *plain text*, the encrypted data is called *cipher text*. So during transmission (i.e., between headend and decoder), only non-intelligible cipher text is available to the would-be tamperer. If the decoder doesn't have the proper key, no message or clear text will be obtainable, even if the pirate has the hardware. Further, in a properly designed system based on cryptographic security principles, we can give the pirate just about anything: hardware, access to and knowledge about the control channel, schematics, any firmware and even the crypto algorithm itself. The only doorway to information access, in our case programming, should be through the key variable. Controlling access to the key variables is thus essential. This is called "key management" and is the basis for what ultimately makes or breaks the security of a cryptographically based system. The cryptographic or encryption algorithm, therefore, can be thought of as a lockbox. The message is encrypted or locked by the algorithm and can only be unlocked by the same algorithm, which means the identical digital key must be used for decryption.

Now that we have discussed some essentials, the value of encryption as a mechanism for security will be more readily evident. For encryption simply enables a complex security problem, in which many variables (audio, video, control) must be secured, to be reduced to simple protection of a few digital keys. Some advantages of digital encryption as a basis for security are:

- it can be implemented with inexpensive digital hardware;
- encryption requirements integrate nicely into the addressable CATV environment;
- it easily and natually becomes time-varying;
- security is no longer manifested in proprietary circuits; and
- level of security achieved can be orders of magnitude above analog scrambling approaches of equivalent cost.

### Key management problem

The third of our three tests for security asked about the key management problem. Encryption alone will not assure the security of information in any network in which it's used unless the key management problem is carefully addressed. In the broadcast scenario, the problems of key variable distribution are particularly challenging (in comparison to applications where only point-to-point situations exist). It probably has occurred to the reader by now that, if access to working hardware is given the pirate, it is little trouble to determine what digital key is being used for decryption. Previously it was stated that one-time defeats won't be allowed. Therefore, the encryption/decryption keys must be changed from time to time. The time interval depends on the key length, the ability of the encryption algorithm to resist analysis by computer, the expected accessibility of keys and the motivation of the system's enemy.

In an addressable system, the control channel is the obvious choice for a key distribution path. (Alternate methods might be by courier, mail, etc.) But one can't just go broadcasting the new keys throughout the network; they must remain private to all but authorized decoders. The solution for controlling key access is to encrypt the keys for transmission. By transmitting decryption keys in an encrypted form throughout the system, we have not really solved the key distribution problem, however, because to decrypt these keys requires yet another key. Such is the notion of "multilevel key distribution" (Figure 2). Various information exchange networks utilize different solutions to a multilevel approach. In the television broadcast environment, either satellite or CATV, the requirements dictate that: 1) when the keys are changed (updated), all decoders and encoders too must do so at the same time; 2) the system operation must ensure that all decoders have had the new keys properly delivered, decrypted and prepared prior to engaging them; and 3) only authorized decoders are able to perform these functions.

In fact, many types of information passing through the control channel are candidates for encryption. Authorization or tiering data, for example, also should be considered sensitive information since, as pointed out earlier, it can easily be locally synthesized and fed to the decoder by simple digital hardware or any home computer. Such control channel manipulation by other than the legitimate network controller is just as dangerous a form of tampering as hardware tampering. Attempts to subvert the system by such address channel tampering is called "spoofing." Integrated within the operational framework of the system must be a fully developed methodology for key distribution and protection against spoofing.

Spoofing can take several forms, depending on how the pirate is attempting to fool the box. Control channel mechanisms must be in place to prevent:

1) insertion of illicit control data;
2) deletion of valid control data;
3) modification of valid control data;
4) replay of control data; and
5) box swapping between systems and geographic areas, and ensure stolen boxes are or become useless.

If the first two tests or prerequisites to a secure system have been properly attended to, one has a totally secure system—for the moment. It's the ability of a system to refresh key variables securely that will then enable it to be secure over time.

In a general sense, all control data having to do with enabling or directing box functions can be thought of as a form of keys. Virtually all systems in use today rely on a hierarchical or multilevel key distribution process as previously described. At the time boxes are installed they are brought on-line by being given certain information (current keys) that allows them to join the network. Thereafter, having joined or signed up, they are kept on-line by being included whenever new network enabling codes (authorization codes, security codes, time codes, channel codes, program codes, keys, etc.) are distributed. The updating process must be performed securely, otherwise illegitimate boxes can listen in and update themselves too. Remember, having satisfied our first two tests, all boxes, legitimate or illegitimate, must have these decryption codes or key information before the signal can be recovered. If the network is distributing new keys encrypted, they must then be decrypted under existing keys already in the box. If existing boxes are suspected of being copied (cloned), then one has to consider the probability that the cloned boxes also received the updated codes or keys.

Now one of the most important points: Since all systems operate in multilevel key distribution formats, where new authorization data is distributed encrypted under "old," then how is it possible to really maintain security at all? It isn't, unless each and every decoding box has something fundamentally different about it from all other boxes. (Now we're back to the "one-time defeat" idea.) The multilevel key distribution process must begin at its most fundamental level by distributing information uniquely to each box and then build further layers on that initial unique information. This requires a unique code or box key for every box, which is unknown by any other box. Thereafter, the network can always fall back to rebuilding its key levels by starting over with each box, leaving out of the redistribution or rebuilding those boxes known to have been cloned,

stolen, etc. With the cloned box not reauthorized, all of its offspring are also not reauthorized.

One final comment about this notion of box uniqueness: When looking at any system purporting to have encryption-based security, don't let its manufacturer sidestep the question of box differentiation. Without the equivalent of a box key, which is never broadcast over the control channel (because it must be encrypted under "something" to do so), the system is fundamentally and by cryptographic standards absolutely insecure. That the process is "too complex" or "proprietary" is the usual argument when such questions are asked. These notions are basic to any sound encryption system and are not complex at all.

**The real-world test**

This article began by noting that encryption-based systems have been commercially utilized only since 1982. Within that period, however, more than six major types of products have seen extensive utility in several marketplaces. However, only three products have had exposure to the extent that significant piracy efforts have been mounted; these are the Oak Orion and General Instrument VideoCipher II (VC II) satellite products and the Oak cable Sigma system. The Oak STV Sigma, Scientific-Atlanta's B-MAC, Oak/Leitch Video Polaris and General Instrument Star-Lok systems are not believed to have ever been compromised, but have not had the exposure time and/or appropriate audience to have been really tested.

Let's make a distinction between a system compromised and a system broken. A *compromise* is a temporary condition that can be expected to develop, and has developed, for both the Orion and VideoCipher products. *Breaking* the system would be a condition where the headend no longer has the ability to overcome the compromise or deauthorize a decoder. This has not happened. After four years of operation and over 160,000 units installed, cable Sigma has yet to have shown evidence of any compromise.

In the cat-and-mouse game between manufacturers and pirates, the compromise of Orion and VideoCipher has been much ballyhooed in the press. But you will not hear companies like Oak and General Instrument actively responding to claims and challenges by individuals or organizations involved with the illegal activity of stealing programming. We will be quietly going about the business of ensuring that appropriate measures are taken to update keys and deauthorize modified or cloned boxes as they are discovered.

Cancom, the Canadian Satellite Communications company, chartered by the Canadian Radio-Television and Telecommunications Commission, has been using Orion since 1982 to secure eight channels of television programming to CATV systems and individual homes. Approximately 15,000 decoders are currently on-line.

Our knowledge of modified Orion decoders at the time of this writing indicates that most approaches have caused the boxes to simply ignore tiering alteration commands. This is a trivial compromise to overcome from the headend and not nearly as sophisticated as either the cloning or "Three Musketeer" attacks that the VC II has seen. We are currently in the process of performing a cycle change on the Cancom system. This means the complete rebuild or redistribution of the network decryption keys. Orion has the attribute that each box stores a secret, and unique box key under which this is done.

This has never before been executed on the Cancom system, as the headend control system has only recently been upgraded to perform this function. The original design, however, planned for this exercise and there are no decoder modifications required. Any illegal decoders still operational after the cycle change can be assumed to be clones. A subsequent cycle change will then be performed, with clones thus identified eliminated from the redistribution process. Why this simple technique can work effectively is that it's computer-controlled, passive (that is, a background function) and very easy to invoke. Pirate boxes can always crop up, but once discovered can always be shut down.

This total redistribution is not possible with any system that does not have the equivalent of a box key. If, at the deepest or most fundamental level, boxes are manufactured with hardwired keys or key seeds, once uncovered, these seeds will cause the redistribution process to be insecure and thus piratable. It may take a while—we didn't see any significant piracy in Orion for three years—but pirates will eventually break any system with hardwired or hardcoded keys.

The level of sophistication and organization behind the attacks currently being mounted against the VC II should lend credence to arguments that "OK" security is really not OK any longer. The cable industry should in fact take a lesson from what is happening in the satellite arena and understand why. The *why* is really economics. As cash flow from services increases, either through new revenue generators (impulse pay-per-view and home shopping) or increased audience, the motivations for system subversion (not just signal theft) also will increase. Along with the tests for security, there are additional considerations that relate to areas such as internal threats from employees, increased sophistication of the enemy, and advances in the state of the art. They include:

- Know the full range of possible attacks.
- Do not underestimate the enemy.
- Be aware of technology advances.
- Understand the basics of encryption.
- Understand the application of encryption.

Oak and its competitors have spent a great deal of time and energy over the past two or three years educating the cable industry with respect to the merits of encryption. There is a tendency on the part of some manufacturers to confuse the issue by jumping on the bandwagon, claiming encryption processes are employed when what is really being done is trivial to undo under some of the examinations we looked at earlier. When such products are defeated, together with the publicity about products featuring true encryption getting compromised, the public and the industry gets naturally confused and misled, and it is the consumer who eventually gets duped.

The success that Oak and other companies may enjoy in combatting piracy is due to proper attention to theory and practical considerations in the application of true encryption principles.

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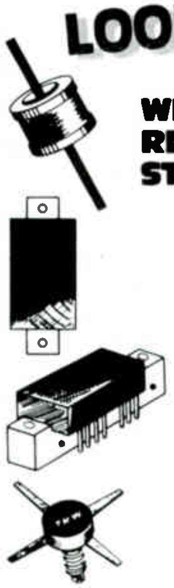


# Fear of fiber optics

**By Dave Pangrac**
Director, Engineering and Technology
American Television and Communications Corp

In order to continue as a lucrative, major communications industry—delivering desirable services to an increasing number of subscribers—the signs of the times require that cable systems increase delivery capabilities and improve on reliability ratios. As we consider the future of the cable industry, many of us believe that fiber-optic technology will play an important part in achieving these goals. We recognize that cable systems need to be more reliable, handle more channels (high definition television is coming), not interfere with other communications services, provide reliable return path from a subscriber, be more secure from cable theft and become user-friendly (not scrambled and no converters needed).

Moreover, at the present time, tree and branch architectures are often obstacles to high levels of reliability. In many systems, rather than facilitate services, cascade lengths of 30 and 40 amps deep hinder the ability of cable networks to deliver uninterrupted services over long periods of time. As a result, we are familiar with the frustration of subscribers who tell us, "Every time it rains, our cable goes off."

To begin to achieve the aforementioned goals, we need to start dealing with the concept of fiber-optic technology in our plants. Fiber is an important hardware alternative that is being developed today almost in "blitz" fashion, and the technology is rapidly entering and pervading terrestrial communication systems throughout the United States. For a cable system, fiber applications can be instituted in conjunction with current plant design, which will allow continued operations with the broadband cable system already in place while, at the same time, enhancing the delivery system by increasing its reliability. In fact, this is a logical Phase One step of a much broader program to integrate and capitalize on the potential of fiber. We will explore the Phase One concept in Part II of this series. Right now, let's address the "engineering jitters" in trying to apply something new.

### Only a handful

While there is a lot of discussion about using fiber in the cable industry, only a handful of folks are really working with this potentially powerful technology. On the one hand, we recognize that the cable industry needs to use fiber. On the other hand, we also realize the natural tendency of people to be extremely uncomfortable in having to try something new. Discussing the issues of learning and dismissing some of the myths about fiber might be a helpful way to start.

So, then, do you fear or hesitate to use fiber? Have you been cautiously avoiding involvement and experimentation, hoping fiber would be regarded as a novelty and soon disappear? Are you intimidated by new buzzwords like "fusion splicing," "glass cable" and "modal noise"? There is good news: The application of fiber is not as hard as you think. There are new terms and technical principles to explain the characteristics of fiber; but, as with most new words, they can and should be explained easily and clearly. Help is available, there are systems to visit and observe and there is written information, clearly and professionally geared to bring you up-to-speed. Two excellent sources come to mind: *A Guide to Fiber Optics*, written by and available through Belden Wire and Cable Co.; and *Optical Communications System* by John Gower, a Prentice-Hall series.

Also, there is an increasing number of systems now using fiber to interconnect hub sites together. In other systems we are seeing fiber being tried for data communications networks. Look for opportunities to visit such a system. Seeing, observing and talking to people who are using fiber are the best learning tools.

Finally, we have all seen instances in history where a new idea quickly becomes associated with a plague of myths—exaggerated and misstated descriptions. Well, fiber technology has accumulated its own share of misconceptions. Here's just one example: "Fiber is very hard to splice and each splice costs a lot of money." Not so. With the new equipment available today we can use mechanical splicers that have less than .2 dB insertion loss (or better), take about 10 to 15 minutes to install, are about the same difficulty as installing a .750 splice in our cable plant and cost about $27. (This is for single-mode cable.) Or we can use a fusion splicer on the same cable. While the machine is relatively expensive, it is not all that hard to master the required technique to accomplish a very low loss splice. Whether or not you decide to buy a fusion splicer depends on how much splicing you plan to do.

To sum up, it is of primary importance that the technical people in our industry become comfortable with the applications of fiber technology. The best way is to become involved and learn the facts about fiber-optic systems and networks and how to work with fiber. Once you have started to examine the information that is available, you will find that it's hard not to continue to explore the value of fiber in our plants. ■

(Continued from page 6)

and one output, to the FMU215C) and the fourth connector is used for power and control.

The controls are simple: One pair ("hot" and ground) goes to the FMU215C; a ground to this hot line from the ATR22 causes the FMU215C to switch from internal subcarrier audio to external baseband audio inputs. Another pair, again hot and ground, comes from the commercial insertion controller; a ground to this hot line causes the ATR22 to switch from the VCIIC to the local commercial audio. A third pair, again hot and ground, comes from the VCIIC; a ground on this hot line causes the ATR22 to open the ground on the control line going to the FMU215C and revert to subcarrier audio, unless the local commercial tape controller is commanding the ATR22 (and FMU215C) to remain on the commercial's audio input.

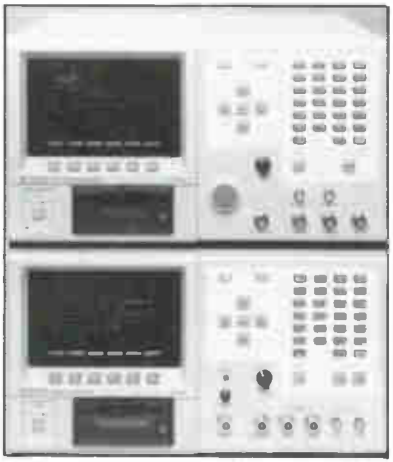
When installing the VCIIC, it will be noticed that it must be driven from the same composite video line as is already driving the subcarrier input of the FMU215C. This is no problem, as the signal may be looped-thru from either unit to the other. However, the VCIIC requires a line properly terminated in 75 ohms. In addition, the FMU215C has only a single BNC connector, not a double connector to facilitate looping-thru. To either loop-thru the FMU215C or terminate it, install a BNC tee on the subcarrier input of the FMU215C.

Most, but not very early production FMU215Cs, do not have an internal 75-ohm termination on the subcarrier input. To determine whether or not your FMU215C is internally terminated, slide the top cover off and look at the wires to the subcarrier input's BNC connector. There will be two resistors connected to the circuit board, and there may be a 75-ohm termination resistor connected directly across the BNC terminals. If the FMU215C is at the termination of your composite video feed (looped-thru the VCIIC), either this or an external 75-ohm resistor on a tee connected to the FMU215C's subcarrier input is necessary. If the feed is looped-thru the FMU215C on its way to the VCIIC, the termination resistor at the FMU215C must be eliminated, and the termination installed at the VCIIC's loop-thru.

I hope the information published here and in my column last month has been useful. Many thanks for all of the support I received and a special thanks to Keith Rauch, senior engineer for Leaming, for providing us with this material.

Toni I. Barnett

## Error rate measuring



Advantest America Inc. announced two new error rate measuring systems designed for high-speed pulse code modulation and digital communications system R&D, evaluation and adjustment applications. The Model T562A is capable of high-speed clock data generation over the range of 50 MHz to 4 GHz; Model T561A measures error over the frequency range of 50 MHz to 2.5 GHz. Both models include a pulse pattern generator and an error rate detector.

For further details, contact Advantest America, 300 Knightsbridge Pkwy., Lincolnshire, Ill. 60069, (312) 634-2552; or circle #135 on the reader service card.

## AGC module

Channelmatic recently introduced its new AGC-3001A module that automatically maintains constant audio levels, raising low levels (without increasing noise level) and limiting high levels. It operates as an automatic gain control device for signals −20 dB to 18 dB. The circuitry uses a soft noise gate technique and a log/antilog voltage controlled amplifier, which alters its gain following a direct dB per volt relationship.

When calibrated, a −20 dB input will give approximately a −1 dB output; a 10 dB input will yield a 2 dB output. The module has an attack time of 500 $\mu$s to 1 millisecond to allow sharp peaks. It operates on the average signal level, rather than solely on peaks. Also, modules can be chained for stereo operation.

For further information, contact Channelmatic, 821 Tavern Rd., Alpine, Calif. 92001, (619) 445-2691; or circle #131 on the reader service card.



## Distortion software

The DPA-1000 distortion simulation software from Step Electronics is said to be ideal for frequency allocation studies as it can identify the source of intermodulation distortion in receivers. The software calculates the second- and third-order distortion products arising from nonlinearity in multichannel systems using algorithms found previously only on mainframe computers.

The DPA-1000's user interface emulates the display screen and controls of the Hewlett-Packard spectrum analyzers. The software can be used for sophisticated applications, such as predicting distortion buildup in multirepeater television links. It runs on IBM PC/XT/AT and compatibles or on the Hewlett-Packard 200 and 300 series engineering workstations.

For more details, contact Step Electronics, 1190 Dell Ave., Campbell, Calif. 95008, (408) 379-5720; or circle #111 on the reader service card.

## RF amplifier

The Model DA-1000 RF distribution amplifier from Multiplex Technology provides a maximum output of +55 dBmV for all frequencies from 50 MHz to 1 GHz. The product amplifies all bands: VHF (low and high), FM, UHF and mid-, super- and hyper-bands. It features an internal gain control that allows the installer to match the output level to the number of televisions in the system.

For further details, contact Multiplex Technology, 251 Imperial Hwy., Fullerton, Calif. 92635, (714) 680-5848; or circle #133 on the reader service card.

## Power control guide

Howard W. Sams is offering *Practical Power-Control Techniques*, written by Irving Gottlieb. This guide discusses the latest power control techniques, such as single-chip integration.

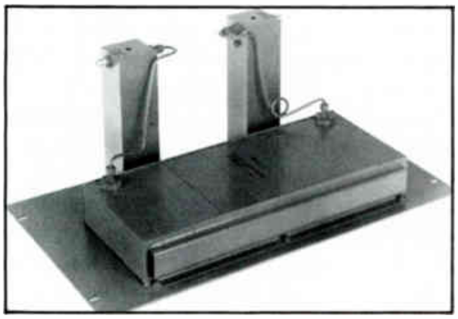
For more information, contact Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, Ind. 46268, (317) 298-5400; or circle #140 on the reader service card.

## Splice closure

The 3M TelComm Products Division is introducing its pedestal splice closure, designed to protect above-ground fiber-optic cable splices.

Constructed with a high density, blow-molded polyethylene dome and shrink tubing, the closure creates a watertight and airtight seal for pedestal fiber splices. The product accommodates most organizers and splices, including rotary, fusion and mechanical. It accepts any mix of two, three or four cables measuring ¼ to 1 inch in diameter (12 to 48 fibers).

For more information, contact 3M TelComm Products Division, P.O. Box 2963, Austin, Texas 78769-2963, (512) 834-6563; or circle #141 on the reader service card.



## Hyperband filter

Microwave Filter has introduced its new super selective hyperband filter, Model E3820UL-(channel number), which passes a hyperband channel and attenuates lower sound and upper video and beyond 50 dB minimum. The product is available for any channel in the hyperband 300-450 MHz. Impedance is 75 ohms and connectors are type F.

For more information, contact Microwave Filter Co., 6743 Kinne St., East Syracuse, N.Y. 13057, (315) 437-3953; or circle #119 on the reader service card.

## Satellite receiver

The Model 1100-CKR satellite video receiver from Microdyne is said to provide commercial quality reception of C- or Ku-band programming. The receiver occupies 1¾ inches of vertical rack space and covers the frequency range of 950-1,450 MHz. It tunes in 1 MHz steps via the front panel and is fully compatible with such scrambling systems as VideoCipher and B-MAC.

For more information, contact Microdyne Corp., P.O. Box 7213, Ocala, Fla. 32672, (904) 687-4633; or circle #125 on the reader service card.


## Video encoder

Communications Specialties announced its Model ENC-3 RGB-to-NTSC composite video encoder. It is designed for use in applications wherever standard analog RGB with sync-on green signals need to be converted to standard NTSC. The output of the ENC-3 is directly compatible with VCRs, large screen projection televisions and composite video monitors.

Features include locking of color burst to sync to minimize dot or chroma crawl on vertical color edges, an AC power supply, nine-pin DIN female input connector and BNC female output connector. The output can drive a 75-ohm load.

For more details, contact Communications Specialties, 6090 Jericho Turnpike, Commack,

# Business Directory

N.Y. 11725, (516) 499-0907; or circle #138 on the reader service card.

## Agile modulator

Cadco is introducing its Model 360H agile modulator, an upgrade version of the company's Model 360. The new model covers Channels 2 through hyper-band at 60 dBmV SAW-filtered output. It accepts BTSC stereo, mono and 4.5 MHz subcarrier audio inputs, and has separate audio and video and composite IF loop-through. Other features include function metering, PLL synthesis and phase-locked audio.

For more information, contact Cadco, 2706 National Circle, Garland, Texas 75041, (214) 271-3651; or circle #128 on the reader service card.

## ANI interface

The Jerrold Division of General Instrument Corp. has developed an interface to facilitate the use of automatic number identification (ANI) equipment in non-impulse addressable systems. This software modification for Jerrold's AH-4 and AH-4E addressable controllers facilitates communications between the ANI system, the billing computer and the addressable converter and allows up to 300 calls per minute to be processed by a system.

For more details, contact Jerrold, 2200 Byberry Rd., Hatboro, Pa. 19040, (215) 674-4800; or circle #130 on the reader service card.

## LAN system

International Microwave Corp. is introducing its Model ICM-2123 23 GHz local area network system for paths up to 10 miles. The link carries a 10 megabit Ethernet baseband data signal, is fully compatible with standard Ethernet IEEE 802.3 and interfaces with Ethernet bridges and transceivers. The system can be configured for two-way full duplex operation.

For more information, contact International Microwave Corp., 65 Commerce Rd., Stamford, Conn. 06902, (203) 323-5599; or circle #126 on the reader service card.

## LAN analysis meter

Wavetek is offering its Model LAN450D network analysis meter, a signal level meter with a built-in signal generator for loop loss analysis for broadband local area networks. The instrument measures RF signal levels from 5 to 450 MHz, as well as carrier-to-noise and percent hum modulation. It also incorporates a phase-locked RF signal generator for testing network loop loss.

The signal generator can be programmed for a specific translator frequency for testing two-way cable networks or with no translator offset for testing dual cable networks. It also has an addressable RS232 port for remote testing applications.

For more details, contact Wavetek Indiana, 5808 Churchman, Beech Grove, Ind. 46107, (317) 788-9351 or circle #139 on the reader service card.

## Noise generator

Sadelco is offering its Model SC-450 white noise generator for broadband LAN applications. Placed at the headend of the outbound or inbound networks, the white noise signal can be combined with an active network without any noticeable data degradation. The product's spectrum calibrator has an accuracy of ±0.25 dB from 4.5 to 450 MHz and can be used in either a wide-band or pulse modulated narrow-band mode of operation.

For further details, contact Sadelco, 75 W. Forest Ave., Englewood, N.J. 07631, (201) 569-3323; or circle #124 on the reader service card.

## Aerial lift

Durnell Industries is introducing its Model DFOL-33 one-man aerial lift. Its articulated over-center boom design provides 33 feet of working height (29 feet to bottom of bucket) with fiberglass upper boom rated for work up to 69 kV. According to the company, full feathering pilot-operated hydraulic controls at the bucket allow for precise movement through all functions with complete override at pedestal.

For more information, contact Durnell Industries, P.O. Box 249, Hwy. 4 South, Emmetsburg, Iowa 50536, (712) 852-3131; or circle #137 on the reader service card.

## A/B switch

Pico Macom announced its Model AB-2MG high-isolation A/B switch intended for cable interface application. It features total 90 dB isolation, gold-plated self-cleaning contacts, a gold finish case, thread protectors and self-termination. According to the company, the product exceeds FCC requirements for cable/antenna switches.

For further information, contact Pico Macom,

# SCTE TECHNICAL TUITION ASSISTANCE APPLICATION

SCTE
669 Exton Commons
Exton, PA 19341

Name: Mr. / Mrs. / Ms. ______________________________ (Last) (First) (Middle)

Telephone Numbers:

Mailing Address: ______________________________

Home: ( ) ____________

Work: ( ) ____________

Date of Birth: ___/___/___ (mo. day yr.)

Social Security No. ____-____-____

**SCTE STATUS:**

Chapter or Meeting Group Member? _____ Yes _____ No

Nat'l Member? _____ Yes _____ No

Chapter or Meeting Group Name: ______________________________

Member Number: ____________

**CURRENT EMPLOYMENT INFORMATION:** Total No. of Years in the Cable Industry: ____________

Company Name: ______________________________

Telephone Number: ( ) ____________

Address: ______________________________

Present Supervisor: ____________

Title/Position: ______________________________

Duties: ______________________________

Employment period: from ____________ to ____________

**EMPLOYMENT HISTORY:**

Employer: ______________________________

Address: ______________________________

Phone Number: ( ) ____________

Title/Position: ______________________________

Duties: ______________________________

Immediate Supervisor: ______________________________

Employed from: ____________ to ____________

Employer: ______________________________

Address: ______________________________

Phone Number: ( ) ____________

Title/Position: ______________________________

Duties: ______________________________

Immediate Supervisor: ______________________________

Employed from: ____________ to ____________

**Professional Activities & Memberships:**

Activity or membership: ______________________________

Your most significant contribution: ______________________________

Activity or membership: ______________________________

Your most significant contribution: ______________________________

Activity or membership: ______________________________

Your most significant contribution: ______________________________

Current SCTE BCT/E Certifications: ______________________________

**EDUCATIONAL HISTORY:** (Attach all appropriate transcripts)

**High School Level Completed:** ☐ 9 ☐ 10 ☐ 11 ☐ 12

Names & Locations of Schools: (Attach additional page if necessary.)

______________________________ ______________________________

Diploma Granted: ______ Yes ______ No ____________ Date
Course of Study: ______________________________
GPA ________ Dates of Attendance: ______________

Diploma Granted: ______ Yes ______ No ____________ Date
Course of Study: ______________________________
GPA ________ Dates of Attendance: ______________

**College Level Completed:** ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Names & Locations of Schools: (Attach additional page if necessary.)

______________________________ ______________________________

Degree Granted: ______________ Date: ______________
Major: ______________________ GPA: ______________
Dates of Attendance: ______________ to ______________

Degree Granted: ______________ Date: ______________
Major: ______________________ GPA: ______________
Dates of Attendance: ______________ to ______________

**Vocational/Military School:**

Name & Location of School:

______________________________

Graduated: ______ Yes ______ No ______________ Date

Course of Study: ______________________________
Dates of Attendance: ______________ to ______________
Grade Point Average (4.0 scale): ______________

**Correspondence Courses:**

Name and Location of Institution:

______________________________

Diploma Granted: ______ Yes ______ No ____________ Date

Course of Study: ______________________________
Dates of Attendance: ______________ to ______________
Grade Point Average (4.0 scale): ______________

**PERSONAL REFERENCES:** (Industry-Related)

Name: ______________________________
Title/Position: ______________________________
Company: ______________________________
Address: ______________________________
______________________________
Telephone Number: (    ) ______________

Name: ______________________________
Title/Position: ______________________________
Company: ______________________________
Address: ______________________________
______________________________
Telephone Number: (    ) ______________

**CONFIDENTIAL FINANCIAL DATA:**

Gross Annual Income:* $__________
Net Taxable Income:* $__________
Number of Dependents: __________

*As reported to the IRS in last tax year; for married couples filing separately, include both incomes.

Explain why you should receive an SCTE Technical Tuition Assistance Grant and how it will benefit you (use additional page if necessary):

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

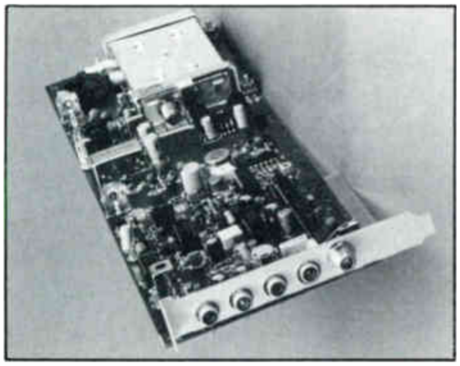
Please return
completed form to:
Society of Cable Television Engineers
669 Exton Commons
Exton, PA 19341

Signature: ______________________________

Date: ______________________________

*Reader Service Number 1.*

12500 Foothill Blvd., Lakewood Terrace, Calif. 91342, (818) 897-0028; or circle #134 on the reader service card.



## Control cards

ISS Engineering is offering its new PC-SAT series of satellite receivers and control cards. One or more receivers can be plugged into and controlled directly from an IBM PC or compatible computer's bus. The plug-in cards are the same size as standard IBM PC expansion cards.

The three models available are: RX-1, which allows for standard NTSC audio and video reception; RX-2, audio receive-only receiver with built-in expander; and RX-3, an FSK data receiver that demodulates the information being sent and places that data onto the computer's bus for display, storage, formatting or further manipulation. The units can be run stand-alone or in another piece of equipment without an IBM computer (using the ISS SC-1 controller card).

For further information, contact ISS Engineering, 104 Constitution Dr., #4, Menlo Park, Calif. 94025, (800) 227-6288 or (800) 351-4477; or circle #136 on the reader service card.

## Anti-icing system

Prodelin and Raychem have jointly developed the SoftHeat Radiant, a passive self-regulating radiant heater anti-icing system for Prodelin's 1.8-meter composite antenna. It can be installed in the field should the need for anti-icing become apparent after installation of the antenna. Anti-icing occurs without reflector distortion or performance degradation and is said to be a critical element to ensure maximum system uptime.

For more details, contact Prodelin Corp., P.O. Box 468, Rt. 2, St. James Church Rd., Newton, N.C. 28658, (704) 464-4141; or circle #129 on the reader service card.

## Ku-band feeds

Chaparral Communications announced two new additions to its line of Ku-band feeds. The 12 GHz Dual Feed allows for multiple-receiver systems to view both polarities of any Ku-band satellite simultaneously; the Offset Polarotor I-Ku is designed for smaller offset-fed, DBS-style dishes. The scalar ring design is said to optimize signal reception (for the European frequency range of 10.9 to 11.7 GHz or domestic DBS range of 11.7 to 12.7 GHz), as well as reduce unwanted noise.

For more details, contact Chaparral, 2450 N. First St., San Jose, Calif. 95131, (408) 435-1530; or circle #132 on the reader service card.

# Overlooking the obvious

**By Chris Papas**
Electrical Engineer, The MITRE Corp

After 11 years as an FCC inspector, something that never ceased to amaze me was people's ability to overlook the obvious. Sometimes very obvious problems were found with the solutions readily available, but nothing was done about them. Other times very obvious problems that should have been noticed were overlooked entirely. In some of these cases, people looked at a problem for so long that is wasn't a problem anymore. It was just "normal." All I had to do was point out what *was* wrong and both the problem and solution became readily apparent.

I have even run into a few people who identified a problem but felt they must study in great length all its facets and all possible solutions before it can be solved. Unfortunately, these people can tend to get "analysis paralysis" by over-analyzing a problem instead of working toward a solution. In doing this, these people also have a tendency to overlook obvious, simple solutions to problems. Complex problems don't always have complex solutions.

I must admit to have fallen into this trap myself a time or two. One time in particular I was helping a technician troubleshoot a faulty transmitter. We decided right away that the best action was to make some voltage measurements on the transmitter and check those against the schematic. This action seemed reasonable and should have led us right to the problem. We then spent several hours chasing unusual voltage measurements from the final amplifier back to the power supply and finally identified the faulty part: a blown fuse!

Unfortunately, this situation happens every day in the cable industry. Many people spend so much time analyzing technical data made with expensive equipment they overlook a reason for making the measurements.

## Former technical rules

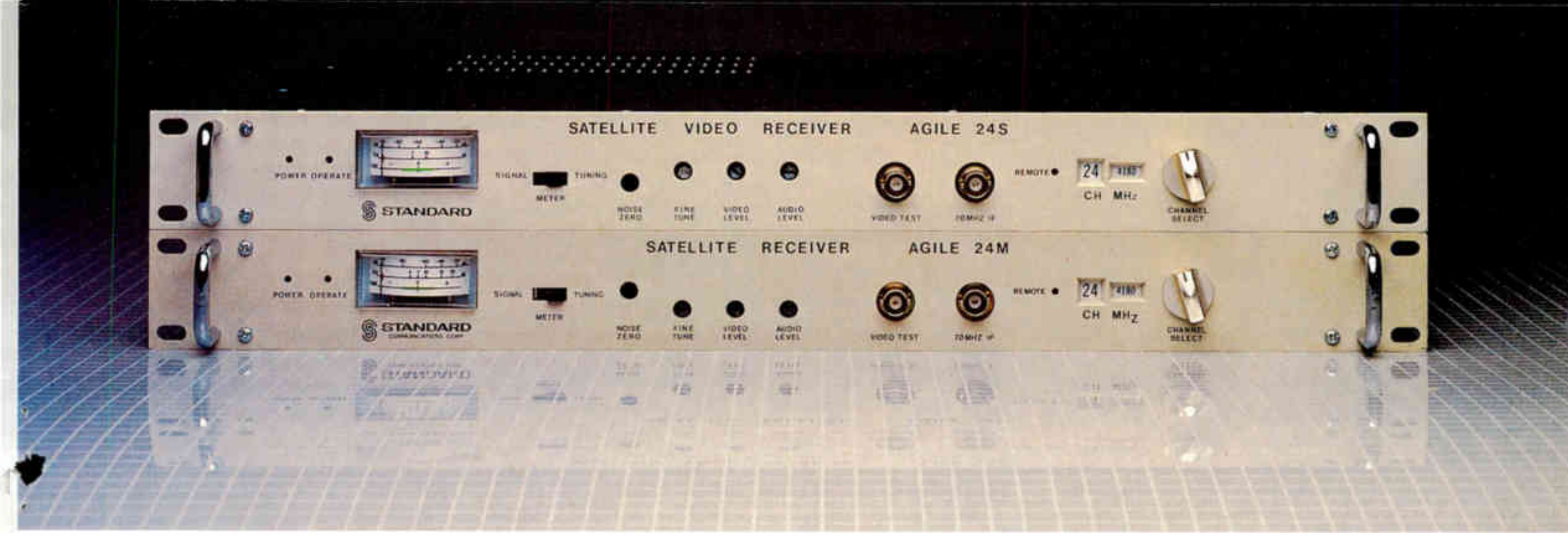
Although the formerly required FCC technical rules were intended to give a subscriber a minimum level of acceptable signal, in most cases it just made the system confirm obvious problems. Let's face it, a signal that just met the technical standards gave a pretty bad picture.

Most of the technical rules did have some relation to the quality of the picture at the subscriber's set. Frequency response, signal-to-noise, intermodulation products and hum were some of the requirements obvious to the eye when out of tolerance. Signal leakage, on the other hand, can be very obvious to the ear with a minimum amount of equipment.

When customers called to complain about snowy TV pictures, they didn't care that the carrier-to-noise measurement was 37 dB on that channel and the FCC minimum was 36 dB. They just wanted to see a good picture on their TV sets. Now that the government-mandated "How bad is it" test has been eliminated, cable systems are back to where they have always been: satisfying their customers.

I have seen more than my share of good and bad systems doing inspections. Since there wasn't time available to check the whole system for compliance with the rules, various clues were used to decide which parts to check. One of these clues was a simple evaluation of the picture quality of the channels at the headend and at several subscribers' sets. This gave me a good idea of how the system was doing and where the good and bad parts of the system were located. Driving across town and tuned to a signal radiating from the cable was another clue.

These checks were usually started at the headend of the cable system since any problems found there will affect the whole system. During these headend checks, it never ceased to amaze



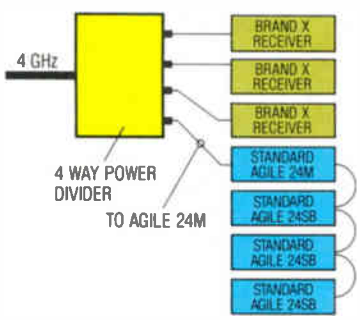

# GROWING BIGGER SHOULDN'T MAKE YOUR SIGNAL GROW WEAKER

With Standard's Agile 24 receivers' loop-thru IF circuitry, upgrading your system doesn't have to mean degrading your signal, blowing your budget, or accumulating lots of downtime.

Instead of replacing your present 4-way splitter with an 8-way splitter, thus attenuating your 4 GHz signal output by half, Standard's loop-thru feature allows you to maintain full power as your system expands.

All your need is a one-port jumper from your splitter to our Agile 24M master receiver.

Our loop-thru feature lets you drive up to 12 Agile 24SB slave units from the master **without expensive power dividers, and without losing signal strength.**




## Our most relied-upon receiver

Known industry-wide for dependable operation, the Agile 24M is a dual-conversion 4 GHz receiver that block downconverts to 760-1260 MHz.

Its active loop-thru design supplies the entire 500 MHz wide block of frequencies to Agile 24SBs.

The Agile 24M's phase-locked loop synthesizer and effective AFC circuit combines with a temperature-stabilized dielectric resonator oscillator (DRO) to ensure rock stable operation. In areas where microwave interference is a problem, optional 60 MHz and 80 MHz filters can be easily installed.

## Simple installation, testing and maintenance

The Agile 24 M/SB Series features a low-profile 1¾″ chassis that occupies a single rack space. The front panel includes a three function meter that displays signal strength, C/N, and center tune; as well as convenient test connections and performance adjustment controls. It is Video-Cipher II™ tested and approved for all programs being scrambled.

## Backed with the industry's strongest warranty/replacement program

Our satellite receivers are built to last, and our warranty program shows it.

If a unit fails, call us and an immediate replacement will be shipped within 24 hours.

If it's within our one-year warranty, the replacement is free. Within years two through five, the replacement is only $100.

For more information on improving your system, and on the full line of Standard Communications TVRO products, call us toll free at 800/243-1357 (in Calif. call direct, 213/532-5300, ext. 275), or mail in the coupon below.

**Standard Communications**
**SATCOM Division**
**P.O. Box 92151**
**Los Angeles, CA 90009-2151**

***Engineered to a new standard***

**I'm planning to add satellite channels**
☐ **Please send me a detailed brochure**
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**CT 9/87**

Name ____________________
Title ____________________
Company ____________________
Phone ____________________
Street ____________________
City __________ State ______ Zip ______

*Reader Service Number 58.*

me how many problems could be found just by turning the TV dial and looking at the pictures. In one inspection, a cable system had severe intermod beats in the picture of a local off-air channel. The system's chief technician analyzed the beats and felt that they were coming from the TV station itself and not from any cable equipment. He then called the chief engineer of the TV station to complain. After a lively discussion, the chief technician was convinced that it *could* be in his system.

After a lengthy troubleshooting period, a 20 dB amplifier that was being overloaded by the local TV signal was found at the pickup antenna. This amplifier was followed by a 20 dB pad at the input to the processor. Nobody seemed to know why they were there, but taking both out of the circuit produced a good picture in the cable system. Had an off-air TV set been checked first, the beats would not have been noticed and the problem would have been found sooner.

During another inspection, a quick evaluation of headend picture quality showed that one channel looked pretty bad. The picture was washed out but a check of the off-air signal of that station looked good. The multiburst test signal showed quite a significant dip in the middle of the signal when observed on the cable. Because of this, the headend processor was swept and a 38 dB notch was found in the middle of the channel bandwidth. An FCC notice of violation was issued to the cable system because the frequency response of that channel was out of tolerance.

Occasionally, I have checked a subscriber's set first before making any measurements. If a problem was observed, then it was confirmed with technical measurements to find out how bad it was. These measurements were made just to determine what number to put on the violation letter to the system, since the problem area was already known by then.

A sample of obvious picture problems that were found on a subscriber's set and resulted in a violation to the system was: bright hum bars—actual measurement 15 percent hum; mid-band channels not viewable through the snow—frequency response out of tolerance; super-band channels disappearing into snow as the channels get higher—frequency response out of tolerance; land mobile radio stations interfering with Channel G—break in cable causing signal leakage and signal ingress. I could go on with more examples but you get the general idea. These problems were originally found just because the picture looked bad. The question is, why did it take an FCC inspector to identify them?

**Simple equipment, obvious results**

One of the greatest and simplest pieces of equipment available to the cable operator is a good quality battery-operated television set. It has solved many an argument over what is or is not on the cable. Although it doesn't provide a large amount of technical data it can graphically display problems when they become obvious.

The TV set also can detect signal leakage by tuning the set to a channel that is carried only on the cable in that area. When a viewable picture is received, then it can only be coming from a leak in the cable. It is a simple way to indicate signal leakage without a great deal of effort. During one cable inspection, the system manager just wouldn't believe that his system had a signal leakage problem no matter how many facts and figures were presented. As far as he was concerned, the *dB*s being talked about referred to *d*ollar *b*ills going out the door.

To demonstrate the leakage problem, the chief technician and I took the manager to a parking lot of a large apartment complex where we earlier had measured a substantial leak. We dialed up his pay channel on the portable TV set and the reception was quite good. The manager observed the signal leakage problem himself and also realized what it meant in manager's language.

Other signal leakage monitoring equipment can provide the same results. Some provide various audio signals and some provide visual signals but all can tell you that something is wrong without much effort. Some leakage monitoring equipment, such as the ComSonics Sniffer system, seems to scream at you when a bad leak has been found. In this case, not too much interpretation is needed by the technician; a problem has been found.

I did an inspection at one cable system that had this type of leakage monitoring system installed for only a week. They sent it back to the factory because, they said, "It wouldn't shut up," and thought the unit was bad. After the cable system received its violation letter for all the leaks that I found, they understood why the equipment worked that way. (Need I say more about obvious?)

When the customer calls with reception problems, don't overlook the simple clues to obvious problems. If an obvious problem is found, then spend time correcting it, not analyzing it to death to determine how bad it is.

# Aligning Ku-band TVROs

**By Robert E. Baker**
Plant Manager, Cooke Cablevision

Most cable companies that are affiliated with HBO and/or Cinemax and who are on the Western feed have by now received their new Ku-band TVROs. Not everyone has assembled them and placed them into operation yet. I have, and I learned a few things worth passing on that may make the task easier for others. I also will include a few basics that may need refreshing.

The best place to start is with the LNB polarization. Correct polarization is not as one might think, looking at the WR-75 waveguide. Horizontal polarization is achieved with the elongated sides of the waveguide in the vertical position. The opposite is true for vertical polarization.

Acquisition angles are important. Given the actual location of a satellite over the equator with its look angles is one thing; look angles are usually given in "true" values. To get actual aiming coordinates for the azimuth, one must make corrections for the magnetic deviations experienced in the various parts of the United States. This may be done by contacting your nearest Federal Aviation Administration or military facility to determine what that deviation factor is, or by referring to the accompanying map. Since aiming angles in the Ku-band are more critical, guesswork is not advised. Note that the deviations are given in plus or minus degrees, depending where in the continental United States you are located. Be sure to add or subtract (as required) this deviation to your true azimuth.

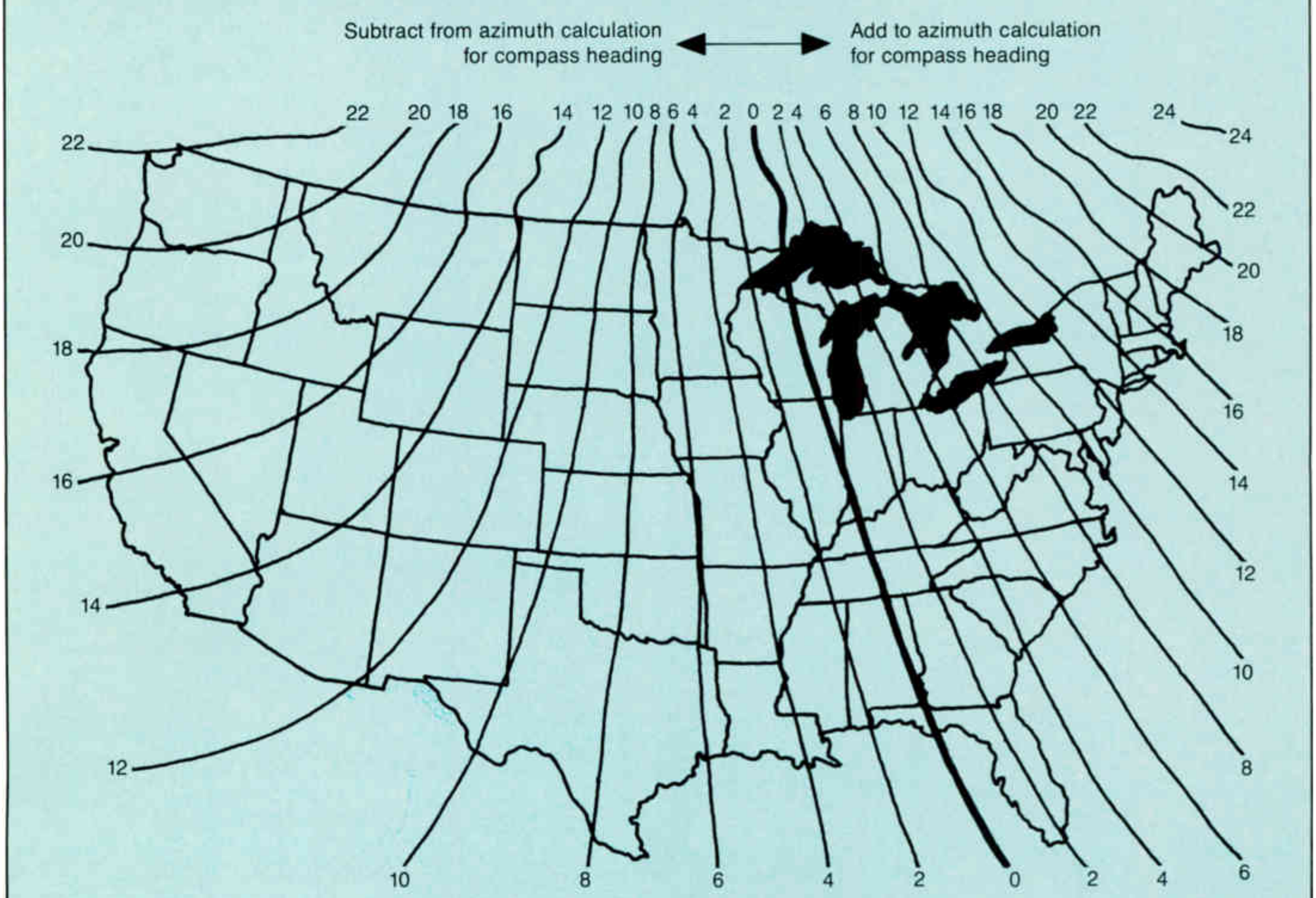
If you are attempting to acquire Satcom K1, I recommend that you polarize vertically to begin with. The reason is that all existing carriers but one are scrambled and on the horizontal polarization. Satcom K1 has a test carrier on Transponder 12 (vertical polarization) that is not scrambled and will make acquisition and antenna alignment much easier. Repolarization then is a simple process.

### Antenna alignment

After acquisition, antenna alignment is a must. Since the orbit of the spacecraft is in the pattern of a figure 8 over the equator, it is possible to acquire the satellite at the top or bottom of that orbit pattern. Should you lock your dish in place at that alignment, it is probable that your carrier-to-noise and resultant picture and audio quality will deteriorate or be lost when the orbit extreme is reached. To assure optimum alignment, the antenna should be fine tuned when the spacecraft is at the center of its figure 8 orbit (or "box," as it is sometimes referred to). To obtain center of the orbit predictions for RCA spacecraft (Satcom), call (800) 526-4214; for Hughes spacecraft (Galaxy), call (213) 607-4610.

One last tip: When assembling the dish, be sure to follow the manufacturer's instructions *to the letter.* Of particular importance is the actual focal length between the feed aperture of the LNB and the center of the dish. Be sure to check these closely after assembling the dish. An error of ±0.25 inches here can mean the difference between crisp, clean signals and searching the skies in vain. If you find an error in the specifications here after assembly, be sure to check the alignment of the mounting brackets to which the quadrapod legs (holding the LNB) are attached. It is easy to assemble these 180 degrees from the correct alignment.

**Magnetic deviation for azimuth compass indications**



*Ciciora*

The **National Cable Television Association** announced **Dr. Walter Ciciora** as chairman of its engineering committee for 1987-88. Ciciora is vice president of strategy and planning at American Television and Communications Corp. Contact: 1724 Massachusetts Ave., N.W., Washington, D.C. 20036, (202) 775-3629.

**Dr. Eugene Gordon** has joined **Hughes Aircraft Co.** as corporate vice president and director of Hughes Research Laboratories. Prior to this, he was director of the Lightwave Device Laboratory at Bell Labs, then founded Lytel Inc. in 1983. Contact: 3011 Malibu Canyon Rd., Malibu, Calif. 90265, (213) 568-6307.

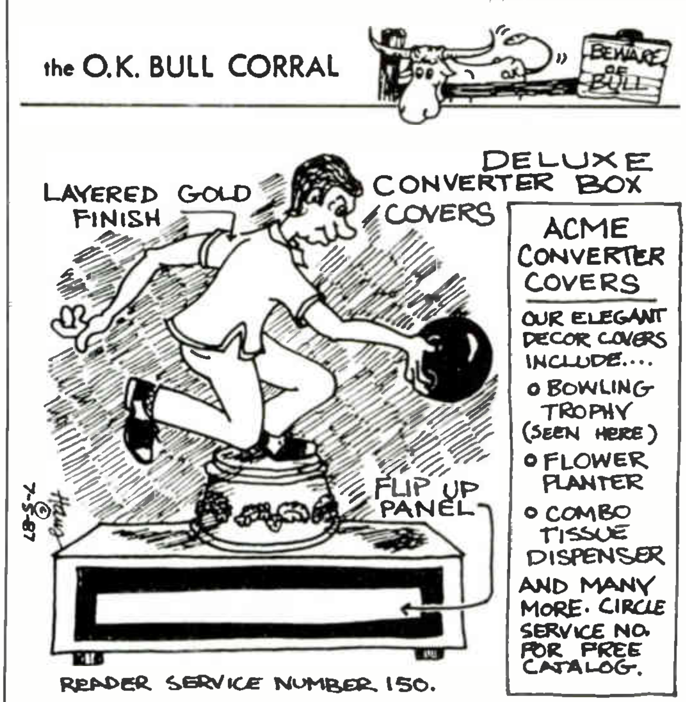
The **General Cable Apparatus Division** of Central Telecommunications Corp. named **Van Walbridge** vice president and general manager. Prior to this, he was director of sales and marketing for General Cable.

Also, **Dan King** was named national sales manager of the company's Telsta aerial lifts. Previously, he was Telsta Western regional sales manager. Contact: 5600 W. 88th Ave., Westminster, Colo. 80030, (303) 427-3700.

**Michael Nelson** was named vice president of construction and technical services for **Media General Cable of Fairfax**. Prior to this, he was operations manager for the system. Contact: 14650 Lee Rd., Chantilly, Va. 22021-1799, (703) 378-8400.

**Richard Waterman** was named vice president and general manager of **ML Media Cable TV**'s Southern California cable television systems. Prior to this, he was director of corporate affairs at the Santa Ana, Calif., office of Westinghouse Broadcasting.

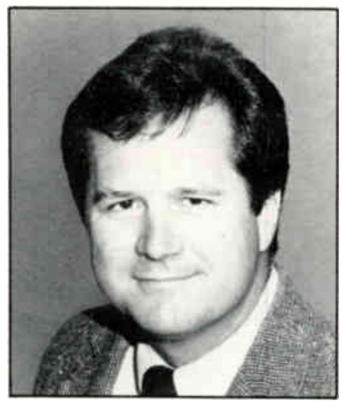
**Stefan Peleschuk** was named controller of ML Media Cable TV. Previously, he was supervisor of corporate accounting for the Dixie Northern division of James River Corp. Contact: 7 W. 51st St., Sixth Floor, New York, N.Y. 10019, (212) 245-8335.




Courtesy Parallex

**George Klopp** was named vice president of value added services in **Anixter**'s manufacturing division. Prior to this, he was regional vice president for the Southeast region.

Anixter also named **Bob Spratt** as Midwest regional sales vice president for contractor sales. Previously, he was telephone cable sales manager for the company. Contact: 4711 Golf Rd., 1 Concourse Plaza, Skokie, Ill. 60076, (312) 677-2600.



*Kinsman*

The **VideoCipher Division** of General Instrument Corp. appointed **Kenneth Kinsman** as vice president of DBS operations. Prior to this, he served as vice president of finance for the company. Contact: 6262 Lusk Blvd., San Diego, Calif. 92121, (619) 455-1500.

*Lay*

**Channelmatic** announced the appointment of **John Lay** as senior software engineer. Prior to this, he worked at Data Communications Corp., where he developed the BIAS PC traffic and billing software package for cable ad sales programs. Contact: 821 Tavern Rd., Alpine, Calif. 92001, (619) 445-2691.

**The Comm/Scope Division** of General Instrument Corp. announced the promotion of **Christopher Huffman** to senior applications engineer. He has been with the company about seven years.

Also, **Ernie Massei** was appointed regional sales manager. Prior to this, he was a district sales engineer for the company. Contact: P.O. Box 1729, Hickory, N.C. 28602, (704) 324-2200.

**American Television and Communications Corp.** named **Vic Scarborough** marketing director. Previously, he was vice president of marketing for the MSO's Austin division.

**Gregory Drake** and **Linda Weiler** were named associate counsel for ATC. Drake will specialize in labor relations; prior to this, he practiced with Hill, Farrer and Burrill. Weiler will handle securities and general corporate matters; she was previously assistant counsel in ATC's corporate law department.

**Jonathan Myers** was promoted to assistant general counsel. Prior to this, he was senior counsel in ATC's corporate law department. Contact: 160 Inverness Dr. West, Englewood, Colo. 80112, (303) 799-1200.

**Pioneer Communications of America** appointed **Lance Belcher** as manager of national accounts and will be stationed at the company's Irving, Texas, office. Prior to this, he was an accounts manager for Burnup and Sims. Contact: Sherbrooke Office Centre, 600 E. Crescent Ave., Upper Saddle River, N.J. 07458-1827, (201) 327-6400.

**LBA Technology**, a subsidiary of Lawrence Behr Associates Inc., named **Ron Chaffee** general manager with responsibility for antenna products. Prior to this, he was director of client services for the parent company. Contact: 210 W. Fourth St., Greenville, N.C. 27834, (919) 757-0279.

# C/N ratios in a cable system

By Ron Hranac and Bruce Catter
Jones Intercable Inc.

The formula to calculate the carrier-to-noise (C/N) ratio of a single amplifier is

$$C/N = \text{Input} - (-59.21 + NF + L) \quad (1)$$

where:

Input = amplifier input in dBmV
−59.21 = thermal noise level in dBmV of a 75-ohm impedance at 68°F
NF = amplifier noise figure in dB
L = miscellaneous amplifier input losses (e.g., diplex filter, equalizer)

The formula to calculate the C/N ratio at the end of a cascade of identical amplifiers is

$$C/N_{CASCADE} = C/N - 10\log_{10}(N) \quad (2)$$

where:

C/N = single amplifier carrier-to-noise ratio
N = number of amplifiers in cascade

$10\log_{10}(N)$ can be found by determining the base 10 logarithm of N then multiplying that answer by 10, or by referring to the following table:

| Number of amplifiers in cascade (N) | $10\log_{10}(N)$ | Number of amplifiers in cascade (N) | $10\log_{10}(N)$ |
|---|---|---|---|
| 1 | 0 | 21 | 13.2222 |
| 2 | 3.0103 | 22 | 13.4242 |
| 3 | 4.7712 | 23 | 13.6173 |
| 4 | 6.0206 | 24 | 13.8021 |
| 5 | 6.9897 | 25 | 13.9794 |
| 6 | 7.7815 | 26 | 14.1497 |
| 7 | 8.4510 | 27 | 14.3136 |
| 8 | 9.0309 | 28 | 14.4716 |
| 9 | 9.5424 | 29 | 14.6240 |
| 10 | 10.0000 | 30 | 14.7712 |
| 11 | 10.4139 | 31 | 14.9136 |
| 12 | 10.7918 | 32 | 15.0515 |
| 13 | 11.1394 | 33 | 15.1851 |
| 14 | 11.4613 | 34 | 15.3148 |
| 15 | 11.7609 | 35 | 15.4407 |
| 16 | 12.0412 | 36 | 15.5630 |
| 17 | 12.3045 | 37 | 15.6820 |
| 18 | 12.5527 | 38 | 15.7978 |
| 19 | 12.7875 | 39 | 15.9106 |
| 20 | 13.0103 | 40 | 16.0206 |

# Examples

**Problem**
What is the carrier-to-noise ratio of a single trunk amplifier operating with the following parameters?

Input = +12 dBmV
NF = 7 dB
L = 1.3 dB (diplex filter 0.5 dB, equalizer 0.8 dB)

**Solution**
Use Formula 1:

$$\begin{aligned} C/N &= \text{Input} - (-59.21 + NF + L) \\ &= 12 - (-59.21 + 7 + 1.3) \\ &= 12 - (-59.21 + 8.3) \\ &= 12 - (-50.91) \\ &= 62.91 \text{ dB} \end{aligned}$$

---

**Problem**
What is the carrier-to-noise ratio of a single bridger amplifier operating with the following parameters?

Input = +20 dBmV
NF = 10 dB
L = 0 dB

**Solution**
Use Formula 1:

$$\begin{aligned} C/N &= \text{Input} - (-59.21 + NF + L) \\ &= 20 - (-59.21 + 10 + 0) \\ &= 20 - (-59.21 + 10) \\ &= 20 - (-49.21) \\ &= 69.21 \text{ dB} \end{aligned}$$

---

**Problem**
What is the carrier-to-noise ratio at the end of a cascade of 16 identical trunk amplifiers, assuming the following conditions for each amplifier?

Input = +11 dBmV
NF = 8 dB
L = 1.2 dB (diplex filter 0.5 dB, equalizer 0.7 dB)

**Solution**
First calculate the C/N ratio of a single trunk amplifier using Formula 1:

$$\begin{aligned} C/N &= \text{Input} - (-59.21 + NF + L) \\ &= 11 - (-59.21 + 8 + 1.2) \\ &= 11 - (-59.21 + 9.2) \\ &= 11 - (-50.01) \\ &= 61.01 \text{ dB} \end{aligned}$$

Then calculate the C/N ratio of the cascade of amplifiers using Formula 2:

$$\begin{aligned} C/N_{CASCADE} &= C/N - 10\log_{10}(N) \\ &= 61.01 - 10\log_{10}(16) \\ &= 61.01 - 10(1.20) \\ &= 61.01 - 12.04 \\ &= 48.97 \text{ dB} \end{aligned}$$

# CALENDAR

## September

**Sept. 1-3: Magnavox CATV** training seminar, St. Louis. Contact Amy Costello, (800) 448-5171.

**Sept. 2-4: Missouri Cable Television Association** annual meeting, Lodge of the Four Seasons, Lake of the Ozarks, Mo. Contact Charles Broomfield, (816) 453-3392.

**Sept. 7-9: Satellite Broadcast Communications Association** and **Satellite Television Technology International** annual trade show, Opryland Hotel, Nashville. Contact Becky Seaton, (800) 654-9276.

**Sept. 9: SCTE Rocky Mountain Chapter** seminar with local broadcasters, Jones Intercable, Englewood, Colo. Contact Joe Thomas, (303) 978-9770.

**Sept. 9-10: Wisconsin Cable Communications Association** annual convention, Holiday Inn, Stevens Point, Wis. Contact Lynne Walrath, (608) 256-1683.

**Sept. 9-11: Magnavox CATV** training seminar, Memphis, Tenn. Contact Amy Costello, (800) 448-5171.

**Sept. 10: SCTE Cactus Chapter** seminar on construction techniques and safety, Republic Cable, Glendale, Ariz. Contact Chris Radicke, (602) 938-0777.

**Sept. 15-16: Nebraska Cable Communications Association** annual convention, Sheraton Inn, Omaha, Neb. Contact Dick Bates, (402) 467-2356.

**Sept. 15-17: Jerrold** technical seminar on applying problem-solving technology, Kansas City, Mo. Contact Jerry McGlinchey, (215) 674-4800.

**Sept. 15-17: Magnavox CATV** training seminar, Memphis, Tenn. Contact Amy Costello, (800) 448-5171.

**Sept. 16-18: Iowa Cable Television Association** annual convention, Ramada Inn, Davenport, Iowa. Contact Sylvia Wikle, (309) 797-2820.

**Sept. 16-18: Alabama Cable Television Association** annual convention, Wynfrey Hotel, Birmingham, Ala. Contact Mary John Martin, (205) 288-1821.

**Sept. 16-18: South Dakota Community Television Association** annual convention, Sylvan Lake Resort, Custer, S.D. Contact Rich Davis, (605) 886-7990.

**Sept. 21-23: Great Lakes Expo**, Convention Center/Hoosier Dome, Indianapolis. Contact Daniel Helmick, (614) 461-4014.

**Sept. 22-24: Magnavox CATV** training seminar, Greensboro, N.C. Contact Amy Costello, (800) 448-5171.

**Sept. 22-24: C-COR Electronics** technical seminar, Des Moines, Iowa. Contact Shelley Parker, (814) 238-2461.

**Sept. 27-29: Pacific Northwest Cable Association** annual convention, Sheraton Tacoma Hotel, Tacoma, Wash. Contact Dawn Hill, (509) 765-6151.

**Sept. 27-29: Microwave Communications Association** annual convention, Ramada Renaissance Hotel, Washington, D.C. Contact Elena Selin, (301) 464-8408.

**Sept. 27-29: Kentucky Cable Television Association** annual convention, Radisson Hotel, Lexington, Ky. Contact Patsy Judd, (502) 864-5352.

**Sept. 28-30: Systems Technology Forum** seminar on local area networks, Sheraton Crystal City, Washington, D.C. Contact Sherry Armstrong, (703) 591-3666.

**Sept. 29: SCTE Satellite Tele-Seminar Program**, "Ku-band technology and TVRO calculations," 12-1 p.m. ET on Transponder 7 of Satcom F3R. Contact (215) 363-6888.

**Sept. 29-Oct. 1: Magnavox CATV** training seminar, Greensboro, N.C. Contact Amy Costello, (800) 448-5171.

**Sept. 29-Oct. 1: International Construction and Utility Equipment Exposition**, Kentucky Fair and Exposition Center, Louisville, Ky. Contact (312) 321-1470.

**Sept. 30-Oct. 3: Hawaii Cable Television Association** annual convention, Royal Lahaina Resort, Maui, Hawaii. Contact Kit Beuret, (808) 834-4159.

## October

**Oct. 1: SCTE Cactus Chapter** seminar on subscriber connection, Republic Cable, Glendale, Ariz. Contact Chris Radicke, (602) 938-0777.

**Oct. 5-7: Ontario Cable Telecommunications Association** annual convention, Constellation Hotel, Toronto, Ontario, Canada. Contact (416) 498-1515.

**Oct. 5-8: Third International Conference on High Definition Television**, Ottawa Congress Centre, Ottawa, Ontario, Canada. Contact (613) 224-1741.

**Oct. 6-8: Atlantic Show**, Convention Center, Atlantic City, N.J. Contact (609) 848-1000.

**Oct. 6-8: Magnavox CATV** training seminar, Baltimore. Contact Amy Costello, (800) 448-5171.

**Oct. 13-15: Mid-America CATV Show**, Hyatt Regency at Crown Center, Kansas City, Mo. Contact (913) 841-9241.

**Oct. 14: SCTE Heart of America Meeting Group** hands-on technical seminar, Hyatt Regency, Kansas City, Mo. Contact Wendell Woody, (816) 474-4289.

**Oct. 20-22: Magnavox CATV** training seminar, Boston. Contact Amy Costello, (800) 448-5171.

### Planning ahead

**Oct. 6-8:** Atlantic Show, Convention Center, Atlantic City, N.J.

**Oct. 13-15:** Mid-America CATV Show, Hyatt Regency at Crown Center, Kansas City, Mo.

**Dec. 2-4:** Western Show, Convention Center, Anaheim, Calif.

**Feb. 17-19:** Texas Show, Convention Center, San Antonio, Texas.

**April 30-May 2:** NCTA Show, Convention Center, Los Angeles.

**June 16-19:** SCTE Cable-Tec Expo, Hilton Hotel, San Francisco.

# AD INDEX

# Digital future shock

**By Walter S. Ciciora, Ph.D.**
Vice President of Strategy and Planning
American Television and Communications Corp

Cable technologists are most knowledgeable and experienced in the area of RF technology. This is their forte, their bread and butter. In addition, their expertise includes (but is not limited to) powering, grounding, construction practice and video. Acquiring this knowledge and experience takes time, effort and smarts. In what little time is left, many cable technologists have tackled the digital and computer world. But of necessity this comes after building skills in other areas.

Life for the cable technologist gets increasingly more complicated and challenging. Technology moves on and unforgivingly demands that we keep up. It is likely that the need for digital skills will rise on the priority list to a spot that is a lot closer to the top in the next few years. Those who see this as an adventure are in for an exciting period of learning and accomplishment. Others, who fail to pick up the challenge, may face "digital future shock." The time to begin preparing is upon us.

While the belief that digital technology will become increasingly important to cable has been a long-standing conviction, two things recently drove the point home forcefully. The first was the keynote speech at the 15th Montreux Television Symposium and the second was a news item from the July 9 issue of *Electronics* magazine. The Montreux keynote speaker was Dr. Masahiko Morizono, deputy president of Sony; he is responsible for all of Sony's R&D. His speech considered technological trends for television's future, and most of the technology he discussed had strong digital implications.

Both of these events predict an increasingly digital world. Digital technology becomes both an opportunity and a threat to cable. The opportunity lies in our applying the technology to cable's best advantage. The threat is that a competitor may beat us at this game. As cable technologists, it is our job to ensure that cable's digital opportunity is maximized while the threat is minimized.

### Megabits and gigabits

Since the *Electronics* news item sets the stage for the cable relevance of the keynote speech, I'll discuss it first. A West German firm, Standard Elektrik Lorenz AG (SEL), constructed an experimental fiber-optic link that can transmit five gigabits of digital signals per second over 90 kilometers (almost 56 miles) without amplification. Bits become especially relevant to cable when they are used to carry video. So the critical question becomes, how much video can be carried by five gigabits per second? Briefly in review, a gigabit is 1,000 megabits, whille a megabit is 1,000 kilobits and a kilobit is simply 1,000 bits. (Just in passing, a terabit is 1,000 gigabits!) So five gigabits per second are five times 10 to the ninth power ($5 \times 10^9$) bits per second.

There are important analog techniques for carrying video on fiber. They should not be ignored. The focus of this discussion on digital techniques should not be interpreted to imply that digital has won the struggle. Life is not that simple. The cable technologist must track both analog and digital technologies to understand which is best for a particular cable application.

Back to the issue of how many bits per second are required to carry entertainment quality video. One benchmark is described in a 1986 NCTA paper by Jim Chiddix, "Optical Fiber Supertrunking." He describes two optical fiber systems that he installed in the Oceanic cable system in Hawaii. Both digital and analog implementations were installed. In the digital links, video is sampled at a 9.28 MHz rate and each sample is converted into seven bits. Multiplying this out yields about 65 megabits per second (Mbps). About another five Mbps are used to encode four audio channels, yielding a total of 70 Mbps ( $70 \times 10^6$). A five gigabits per second (Gbps) fiber link would carry 71 of these video channels:

$$\frac{5 \times 10^9}{70 \times 10^6} = 71.4$$

Two other digital television schemes are commonly considered. Both use eight bits per sample. One samples the analog video at three times the color subcarrier frequency while the other samples at four times the color subcarrier. The color subcarrier is at 3.58 MHz. So the first scheme requires about 86 Mbps ($8 \times 3 \times 3.58 \times 10^6 = 85.92 \times 10^6$) while the second scheme demands about 115 Mbps ($8 \times 4 \times 3.58 \times 10^6 = 114.56 \times 10^6$).

But let's not forget sound. If we assume compact disc quality, we need to sample at 44.1 kHz and 16 bits per sample. For stereo, double this to get about 1.4 Mbps ($2 \times 44.1 \times 10^3 \times 16 = 1.411 \times 10^6$). So we see that video is the power hog and audio is comparatively less demanding of bit capacity. Adding in the audio bits and rounding a little yields 87.5 Mbps and 116.5 Mbps for the two schemes. Five Gbps will carry about 57 channels of the first kind of video and 43 channels of the second.

It's important to realize that in all three examples we've not considered any techniques to "compress" the video. Only a brute force conversion from analog to digital form was considered. Depending on how much digital signal processing is incorporated in the design, modest bit rate reductions of 20 to 30 percent can be achieved or severe reductions of better than 50 percent are possible. These result in a corresponding increase in the ability to carry video channels.

*"As cable technologists, it is our job to ensure that cable's digital opportunity is maximized while the threat is minimized."*

What about high definition TV (HDTV)? Since we don't have an HDTV standard, all we can do is speculate. Current estimates are that a compressed HDTV signal would require from 100 to 140 Mbps. A five Gbps fiber link would carry from 36 to 50 of these HDTV channels.

So what does this all mean for the cable technologist? To put things in perspective, it's important to emphasize that the news item was about an experimental fiber-optic innovation now in its laboratory phase of development. Many innovations never make it out of the lab into the real world. But this development is not unique. There are many researchers around the world trying to accomplish much the same thing in different ways. It is highly likely that multiple Gbps capacity over fiber will be available for cable application in our professional lifetimes. What's not clear is how soon and at what price. When first available, it's likely to be expensive, but affordable for demanding supertrunking applications. As the price comes down, it can be more pervasively applied to our systems.

Maybe someday we'll be running it to subscribers' homes. When will this be practical? The answer shouldn't be given in years. A more meaningful way to think of this is in rebuild cycles. If your system is relatively old, this technology probably won't be ready for the next rebuild. But if your system is brand new, you may be using this technology in the next rebuild. The tough choice will be if your rebuild comes due while high-capacity digital is in its emerging stage. That's where the risk is greatest and the need for pioneering is maximum.

What should the cable technologist be doing now? You undoubtedly spend quite a bit of your time keeping up with cable technology. Otherwise you wouldn't have this in your hands! You should consider allocating a significant part of your technology reading time to building your digital skills. This will prepare you to make your judgments on the appropriateness of digital techniques to your future system needs.

Now that the digital stage is set, next month I'll get into the trends to digitize consumer electronics products.

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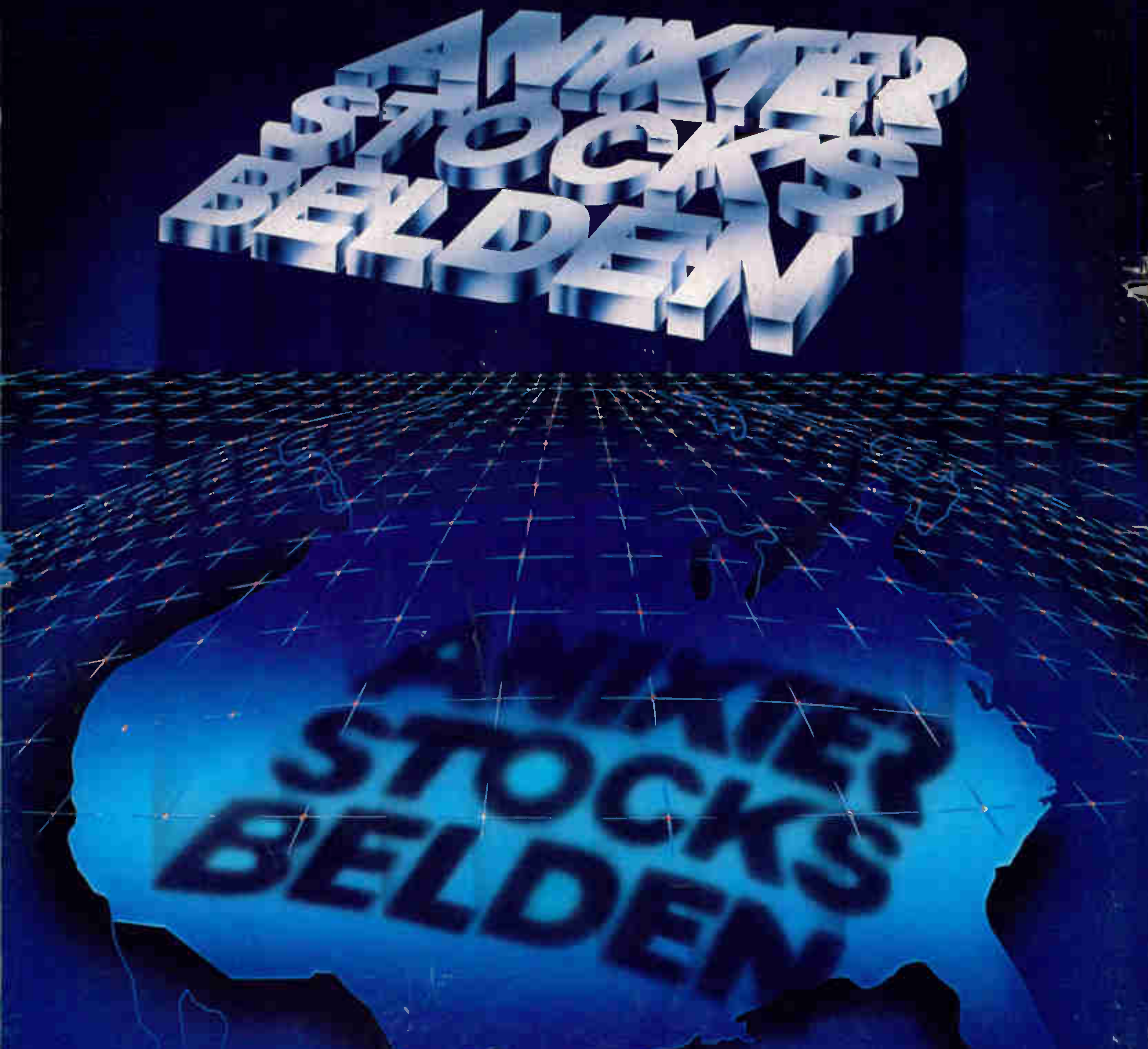
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