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Official trade journal of the Society of Cable Telecommunications Engineers

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Cable modems: Your doorway to data

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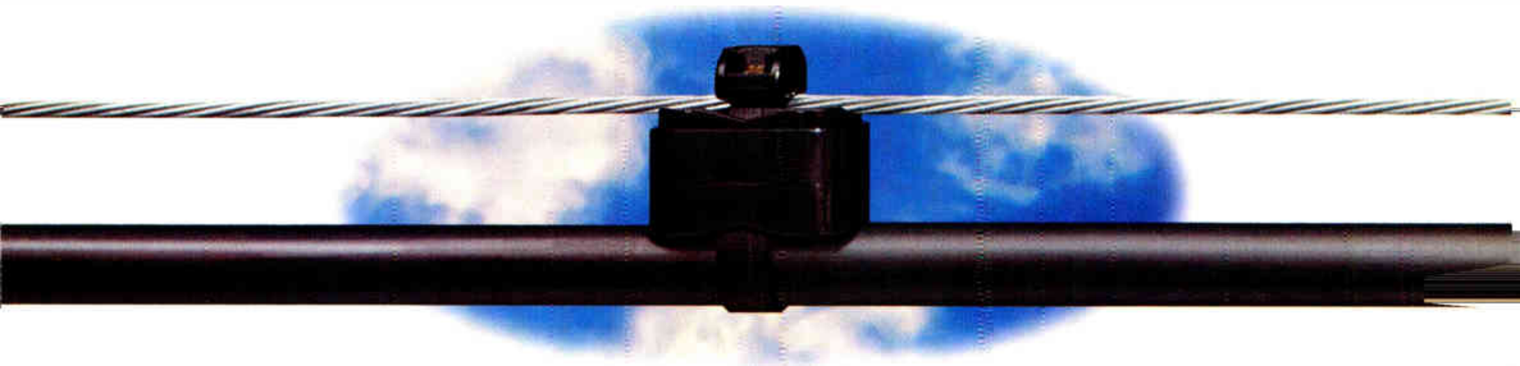
February 1996



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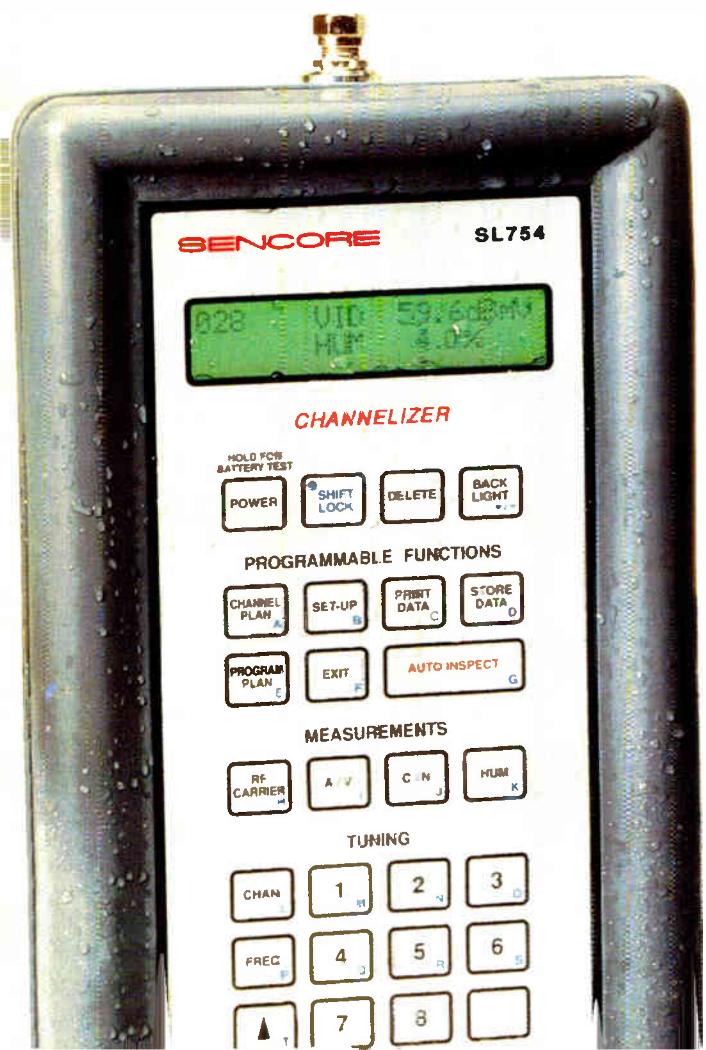

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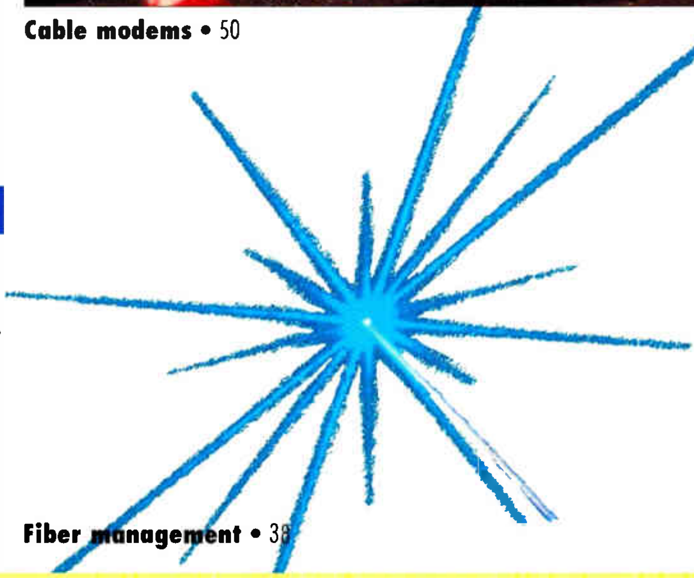

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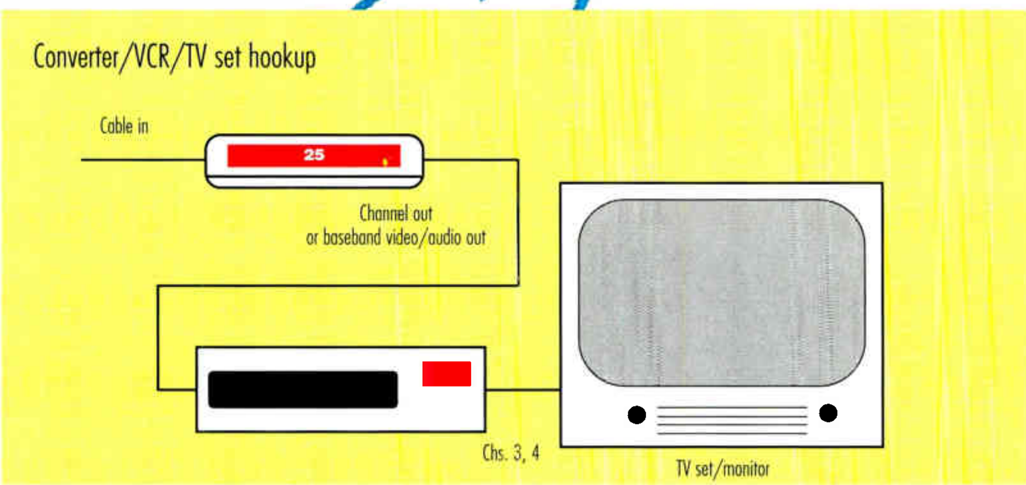

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The forest for the trees and ET '96

As of this writing, I had just returned from the Society of Cable Telecommunications Engineers Conference on Emerging Technologies in San Francisco. I could hardly wait to give you my opinions about the meeting.

First, I was happily surprised that the Blizzard of '96 didn't seem to hurt the overall attendance. And, if there was a solid theme for the conference, it would certainly be "Data Transmission via Cable." At December's Western Cable Show, in Anaheim, CA, cable modems were the subject but, at ET, we finally had the chance to see how the modems would pass the PC data to the servers, routers, and on throughout the HFC network, to the headend, and into the Internet.

Keep in mind that future demand for cable service will be caused by needs other than watching TV programs. Today's children are growing up with computers. Seldom does a parent tell the child, "Get away from that computer and do your homework" since he or she is probably using it to complete homework. When the cable operator has the data transmission equipment in place and has retrained his marketing staff to sell the new computer services to and from the home, their thinking will adapt to the new world of total communications.

One concern I now have is that cable engineers may allow themselves to begin data transmission theory and practices with inbred ideas similar to those that have historically caused telephone engineers to demand copper twisted pair cables or else! Case in point: I heard speaker after speaker begin their speeches with, "Transmission is constrained to 5 to 35 MHz, and shared amongst many growing interactive services." This certainly does not have to be the case.

We are no longer cable TV engineers! We are cable communications engineers! Do not consider the frequencies we have allocated for television to be sacred to television. When a new service promises a high revenue and there is no place other than a channel previously allocated for TV programming, that cable system will suddenly have one less channel of television. In fact, as data transmission becomes more common, look forward to seeing more spectrum dedicated to data and less to television. So, don't fall into the trap of thinking that the frequencies between 50 and 800 MHz must remain for TV programming.

Walt Ciciora covered it well in discussing decoder interface, "a compromise in a box," although he wasn't discussing data. "By the box, I don't mean the set-top box. I mean the set of constraints we find ourselves in as we try to find a solution to the consumer interface problem ... The compromise we believe we have reached has little or no options unless someone can kick out one of the sides of the box. Then other solutions may be possible."

As we enter the new arena of data transmission, let's not assume things not tested or not proven. Remember, if you don't paint yourself into the corner, you won't have to wait for the paint to dry.

Rex Porter
Editor

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Director of Marketing & Circulation Services, Maxine Minar
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CT Sales and Editorial Offices
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SCTE National Headquarters
(610) 363-6888 Fax (610) 363-5898

Corporate Offices
Phillips Business Information Inc.
1201 Seven Locks Road, Suite 300, Potomac, MD 20854
(301) 340-1520 Fax (301) 340-0542

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EchoStar DBS: Stiff competition

The late December 1995 launch of the EchoStar-I direct broadcast satellite (DBS), which its owners anticipate will begin providing programming for the EchoStar DISH Television Network early this year, is "further proof of the competitive nature of the video services market," according to National Cable Television Association Spokesperson Rich D'Amato.

"It seems that every time you turn around, there's another company competing for the same or similar market as cable," said D'Amato.

Englewood, CO's EchoStar Communications Corp. launched EchoStar-I from the China Great Wall Industry Corp.'s Xichang, China launch facility on Dec. 28. The Lockheed Martin Series 7000 satellite entered low-earth orbit at 4:51 a.m. The satellite is part of EchoStar's DISH (Digital Sky Highway) Network, which the company expects to have operational by late this month or next month. EchoStar-I can support 100 channels. By mid-1996, with the launch of EchoStar-II, the firm expects to deliver over 200 channels of digital video, audio and data services throughout the continental United States.

Carl Vogel, president of EchoStar, called the launch a "huge event" in the history of the company, which provides direct-to-home satellite TV products and services to customers worldwide. Wall Street financial analysts seemed to agree with Vogel's assessment, as stock in the company rose from $21 to nearly $25 per share following announcement of the launch.

NCTA's D'Amato commented that DBS companies such as EchoStar "are significant competitors" to cable providers. "They're financed by large companies like Lockheed Martin, Hughes and Hubbard, and they've poured money into advertising," D'Amato explained. "Their technology allows them the channel capacity to offer pay-per-view, sports packages and much of the same services that cable does under the current access rules."

However, D'Amato pointed out, "Telephone companies are still the 800-pound gorilla that's competing with everyone." With regional Bell operating companies getting involved in wired cable services and looking to provide video service to various communities, cable and DBS companies alike need to be alert to potential assaults on the market by well-heeled telco competitors, D'Amato said. — *Alex Zavistovich*

Study hypes cable technology

According to a recently published Frost & Sullivan study, *Profiles of CATV-Related Companies*, cable technology firms can expect 1999 revenues to reach $2.36 billion, a 6% compound annual growth rate from 1994 figures of $1.78 billion. What isn't predictable, however, is the success of new technologies, which are dependent upon consumer acceptance of new applications such as telephony and on-line access.

Cable industry technical services, including engineering, construction and network management, will account for 25% of the cable industry's technical market revenue in 1999, up from 10% in 1994. Transmission and distribution lines, meanwhile, accounting for 15% of 1994 revenues, will account for 24% in 1999.

TW's FSN reaches 4,000 HHs

Time Warner Cable's Full Service Network (FSN) reached its goal of installing 4,000 households by year-end 1995. This year, FSN will be testing the pricing and packaging of new services, including the recently announced NFL on Demand, The News Exchange for news on demand, and GOtv for information on movies, events and dining in the Orlando area. The range of services on the network ultimately will include not only interactive TV, but also local telephone service and high-speed access to on-line services and to the Internet.

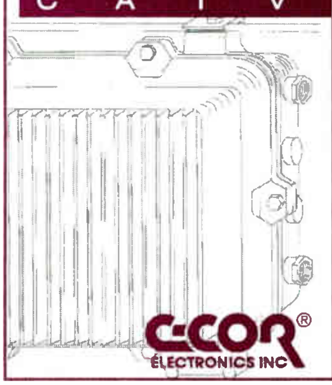
In other news, Time Warner Cable in Austin, TX, implemented Cincinnati Bell Information Systems' CableMaster 2000 subscriber management and billing solution. The subscriber base in Austin, at more than 225,000, is one of the 20 largest markets in the United States.

The installation improves service from Time Warner's customer service representatives, who will have much more information available to them. The company itself will benefit from increased functionality in its subscriber management and billing system, greater control of its customer data, and greater economy of operation.

NOTES

• The National Cable Television Institute celebrated the enrollment of its 100,000th student. Founded in 1968, 91 industry employees enrolled that year. In 1995, over 13,000 responded to the NCTI curriculum.

• Tele-Communications International Inc. filed with the Securities and Exchange Commission an S-1 registration statement to sell $200 million of convertible subordinated debentures due 2006. Sale of the debentures will be managed by Merrill Lynch & Co., CS First Boston and Morgan Stanley & Co.



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Nominations open for 1996 awards

The Society is currently seeking nominations for its 1996 Member of the Year Award. All persons nominated for the award must be active members of the Society.

Nominations must be received in writing by SCTE national headquarters no later than April 1. All nominations will be presented to the board of directors for consideration, and the selected person will receive a plaque recognizing this honor at the 1996 Cable-Tec Expo, to be held June 10-13 in Nashville, TN.

Since its establishment in 1974, the SCTE Member of the Year Award has been presented to 22 individuals. Previous recipients of the award are: James Haag (1995), Wendell Woody (1994), Bill Grant (1993), Ron Wolfe (1992), Steve Allen (1991), Richard Covell (1990), Paul Beeman (1989), Mike Aloisi (1988), Rex Porter (1987), Sally Kinsman (1986), Pete Petrovich (1985), David Franklin (1984), John Kurpinski (1983), Clifford Paul (1982), Yves Fortier (1981), Thomas Polis (1980), Kenneth Gunter and Ralph Haimowitz (1979), James Grabenstein (1978), Frank Bias (1977), Glenn Chambers (1976), James Collins (1975), and Steven Doudourfis (1974).

The Society also is accepting nominations and entries for other awards to be presented at Cable-Tec Expo '96. Among these award programs are:

Personal Achievement Award — recognizes technical personnel in our industry for outstanding job performance.

Field Operations Award — promotes technical tools and procedures used in the field to enhance the work performed by installers, technicians and linemen.

SCTE Hall of Fame — recognizes national SCTE members who, over the course of time, have made extraordinary contributions to the professional development, ideals, goals and enhancements of the Society and the industry.

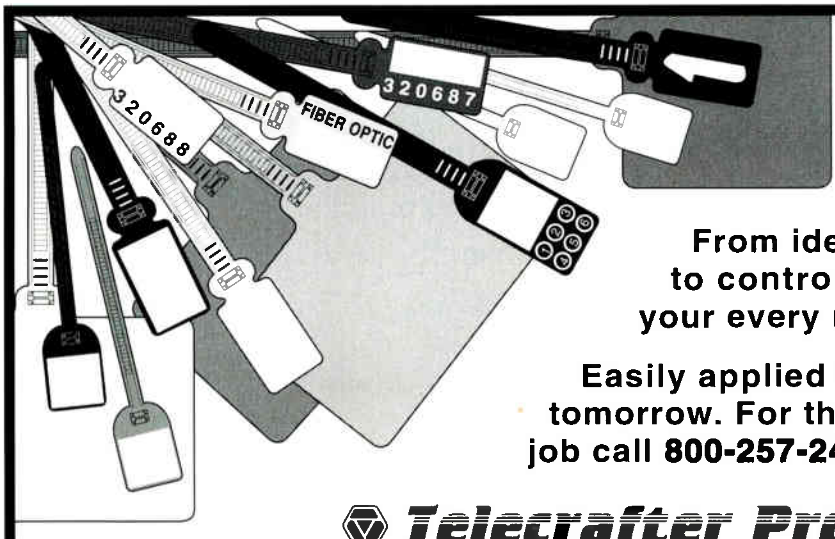
For further information, contact SCTE national headquarters at (610) 363-6888.

1996 tele-seminar schedule announced

The Society's Satellite Tele-Seminar was introduced in 1984 as a means of making technical training videotapes accessible to system technical personnel. The program, which is made possible through funding from SCTE Sustaining Member companies, has since served as a monthly benefit to the cable telecommunications industry.

All satellite tele-seminars are uplinked from 2:30 to 3:30 ET on the dates shown. They can be downlinked via Galaxy IR, Transponder 14 and videotaped for your technical training needs.

The 1996 schedule of tele-seminar programs is as follows: Jan. 11: Emergency Alert System featuring Steve Johnson, Frank Lucia, Shellie Rosser and Ken Wright (from Cable-Tec Expo '95); Feb. 8: Inside FCC Form Processing featuring Mike Lance, Priya Shrinivasan, John Wong and Priscilla Wu (from Cable-Tec Expo '95); March 14: NEC, NESC and OSHA Regulations (Part 1) featuring Ralph Haimowitz, Jim Stilwell and Chris Story (from Cable-Tec Expo '92); April 11: NEC, NESC and OSHA Regulations (Part 2) featuring Ralph Haimowitz, Jim Stilwell and Chris Story (from Cable-Tec Expo '92) and Interdiction and Other Signal Security Techniques (Part 1) featuring Paul Harr, Roger Pence, Leonard Falter and Terry Mast (from Cable-Tec Expo '91); May 9: Interdiction and Other Signal Security Techniques (Part 2) featuring Paul Harr, Roger Pence, Leonard Falter and Terry Mast (from Cable-Tec Expo '91) and CLI — Now and Tomorrow (Part 1) featuring Terry Bush, Robert V.C. Dickinson and Ken Eckenroth (from Cable-Tec Expo '94); June 13: CLI — Now and Tomorrow (Part 2) featuring Terry Bush, Robert V.C. Dickinson and Ken Eckenroth (from



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Cable-Tec Expo '94) and Painless Technical Speaking (Part 1) featuring Doug Ceballos and Rikki Lee (from Cable-Tec Expo '91); July 11: Painless Technical Speaking (Part 2) featuring Doug Ceballos and Rikki Lee (from Cable-Tec Expo '91); Aug. 8: Painless Technical Writing (Part 1) featuring Bill Cologie and Rikki Lee (from Cable-Tec Expo '90); Sept. 12: Painless Technical Writing (Part 2) featuring Bill Cologie and Rikki Lee (from Cable-Tec Expo '90) and Practical Technical Calculations Made Easy featuring Richard Covell (from Cable-Tec Expo '91); Oct. 10: Data Transmission Techniques featuring Andy Paff and Don Patton (from Cable-Tec Expo '89); Nov. 14: Telephony 101 (Part 1) featuring J.R. Anderson, Ralph Haimowitz and Justin Junkus (from Cable-Tec Expo '95); Dec. 12: Telephony 101 (Part 2) featuring J.R. Anderson, Ralph Haimowitz and Justin Junkus (from Cable-Tec Expo '95).

For further information, call SCTE at (610)363-6888.

Cable artifacts wanted for museum

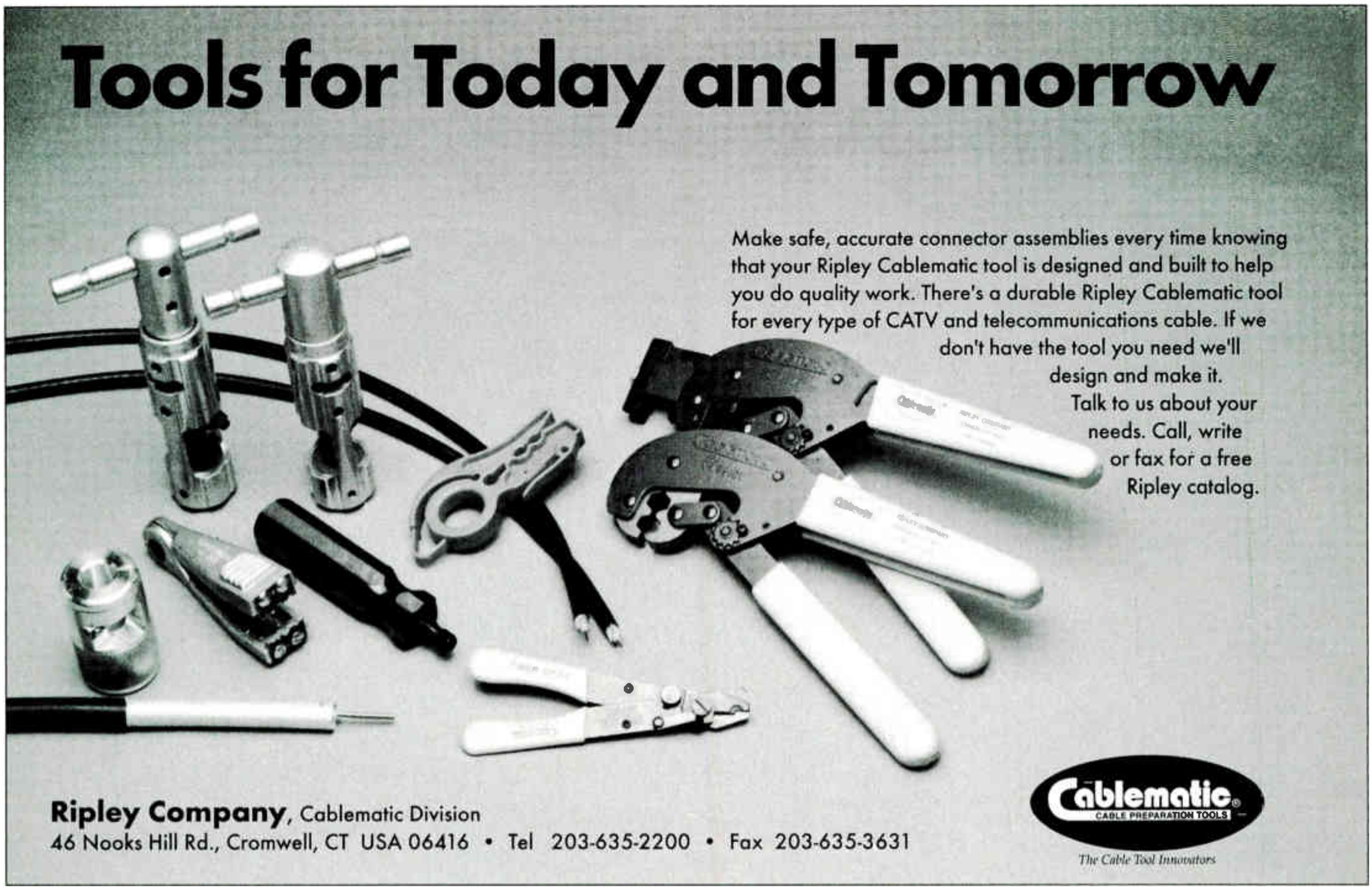
Do you have any retired test equipment, early amplifiers or set-top converters from days gone by?

SCTE is looking for quality equipment donations that show the advances of the industry's technology over time. One of the features of our new national headquarters facility will be a "museum display" room devoted to exhibits of technical equipment used in the construction and operation of cable systems.

The first piece to be donated was a 704 field strength meter, originally used over 25 years ago for RF measurement testing. If you have something appropriate, please consider making it available for the education and enjoyment of members and guests who will be visiting the building.

With each donation, the Society would appreciate your written explanation of the history and use of the piece to be shared with the viewers. With the identification of each piece, the donor will be recognized.

To arrange a donation, please contact Roberta Dainton at SCTE, 140 Philips Road, Exton, PA 19341-1318, or call (610) 363-6888.



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Number 51

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By Ron Hranac

Two-way or not two-way?

That is the question. For more than 20 years we have been designing our systems to be "two-way capable." But are they really? Probably not. First of all, designing to provide two-way capability is a lot different than actually firing up the reverse and making it work. Second, most of those designs have been for good old-fashioned tree-and-branch, hardly a desirable environment for moving signals from system extremities to the headend.

There have been only a handful of operating two-way systems during the last two decades. In some cases a few operators actually have had full-blown two-way transmission through both the feeder and trunk, usually with the help of bridger gate switching and a lot of effort paid to keeping the plant tight. Much of the rest has been on dedicated trunk routes with no active feeder, for applications such as bringing a video feed from city hall back to the headend. But for the majority of the 11,000+ systems in the United States, it's been a one-way world.

Since the introduction of fiber-optic technology for local signal distribution a few years ago, we have been migrating from tree-and-branch architectures to node-based architectures such as fiber-to-the-feeder (FTTF). These newer hybrid fiber/coax (HFC) systems divide the plant into small, more easily manageable service areas, each with anywhere from a few hundred to a few thousand homes passed. In some ways, each of these small service areas can be thought of as independent systems.

It stands to reason that a small fiber-fed service area of perhaps a thousand or so homes passed would make two-way operation much simpler. In theory, this is true and is one of the many reasons rebuilds and upgrades are usually being done with a fiber overlay. In addition to improvements in quality and reliability, fiber-based architectures bring the benefits of a network that more closely resembles a star rather than tree-and-branch.

Ron Hranac is senior vice president, engineering, for Denver-based consulting firm Coaxial International. He also is senior technical editor for "Communications Technology."

But simply upgrading to an HFC architecture does not guarantee painless two-way operation. Indeed, many are discovering that simply plugging in reverse amplifier modules after the HFC upgrade doesn't result in an operational reverse signal path. You see, there are a lot of reverse path gremlins that can cause major headaches. Those gremlins should be dealt with before trying to provide two-way services, or that's exactly what you'll be doing — trying to provide two-way services. The two-way checklist that appeared in the December 1995 issue of Communications Technology ("Editor's Letter," page 6) is must reading for anyone contemplating an operational two-way system.

Several recent industry studies have provided detailed characterization of the impairments that can affect the 5 to 40 MHz reverse path. I highly recommend CableLabs' "Two-Way Cable Television System Characterization," which is available to all CableLabs' member companies. Jones Intercable's Paul Schauer provided an overview of this particular study's results during the last Western Cable Show's technical sessions. This, too, is must reading for anyone contemplating an operational two-way system.

Your problem is ...

So what kind of problems can you expect when you try to activate the reverse plant?

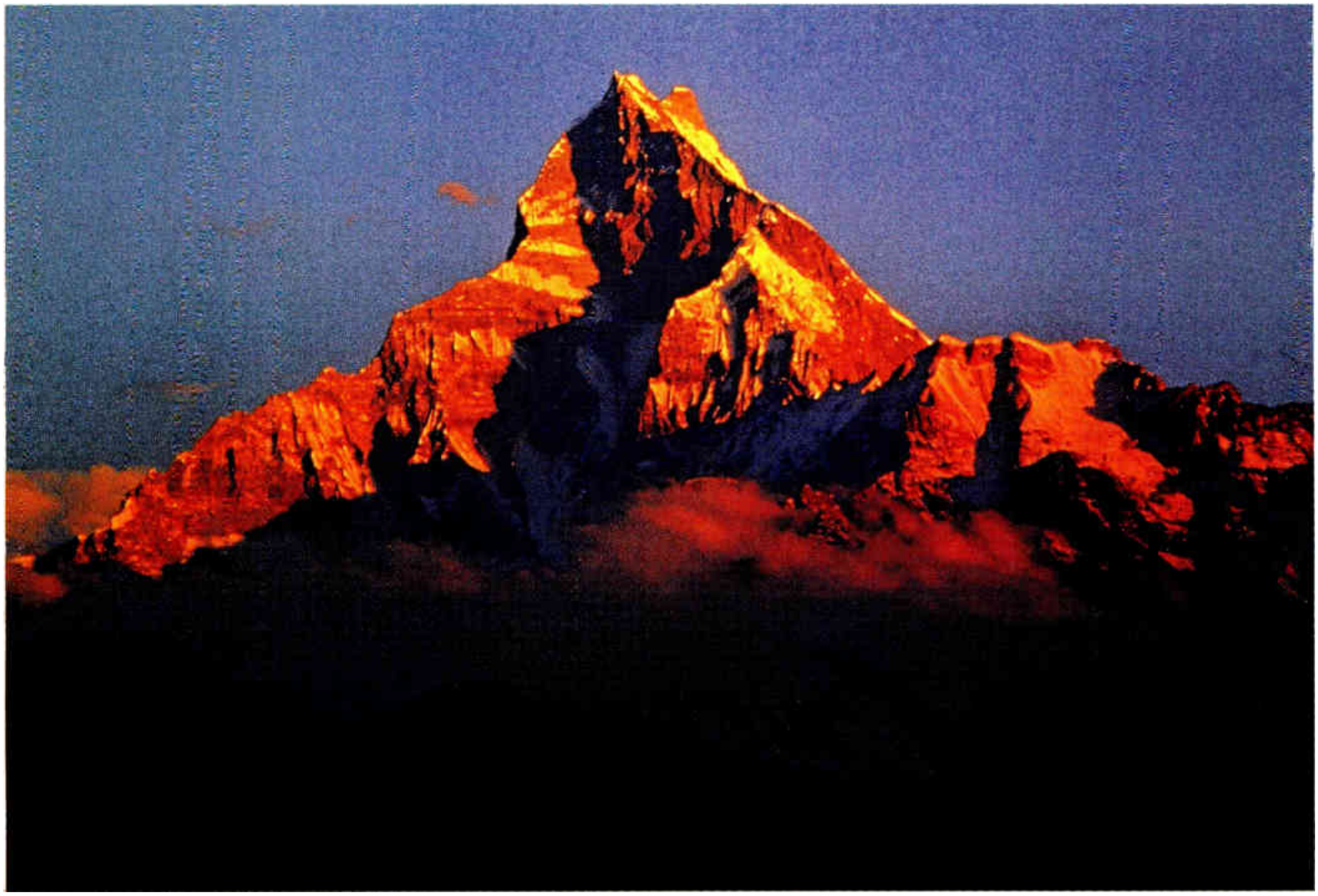
For starters, make certain that you are properly aligning the reverse amplifier modules. I've heard from some who have discovered that they knew as much about reverse amplifier setup as the equipment manufacturers. In other words, some of the manufacturers didn't necessarily know the best way — or even how — to adjust these things. That seems to be pretty much under control now, but be care-

ful that you're doing it right. Assuming correct amplifier setup, what next?

How about ingress? Common path distortion? Impulse noise? Amplifier thermal noise from combining too many nodes at the headend?

Let's start with ingress. This is the opposite of egress. (Egress is more commonly known as signal leakage.) If your system has any leaks, they are potential ingress points. Just in case you're curious about what can leak into your system, connect a spectrum analyzer to an outdoor longwire antenna and tune from 5 to 40 MHz. Everything that exists in the over-the-air RF spectrum is a candidate for trashing the reverse path. This includes international shortwave broadcasts; CB and ham radio transmission; 15.734 kHz horizontal sidebands from leaky TV sets (these can fill the 5 to 40 MHz spectrum with "birdies" spaced every 15.734 kHz); RF hash and birdies from computers; electrical interference from neon signs, electric motors, vehicle ignitions, hair dryers, garbage disposals, etc.; power line interference (the same kind that puts sparklies in your low-band over-the-air TV stations at the headend); and static crashes from lightning storms. And these are just the obvious sources of over-the-air interference!

The fact that you have a passing cumulative leakage index (CLI) and no leaks in excess of 20 microvolts/meter does not mean your system will be ingress-free. Your hardline plant should not have any measurable downstream leaks. Period. If you can drive out your system while monitor-



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Reader Service Number 27

By Fred Slowik

Two-way architecture: What you need to know

Planning system upgrades, rebuilds or new-builds based solely upon forward bandwidth expansion is no longer enough. Recent advancements in fiber-optic technology have caused radical changes in cable communications system network architectures. And with telcos entering the market, the cable industry is challenged to support a sophisticated interactive environment that includes video, Internet, information, telephony options and a host of interactive services.

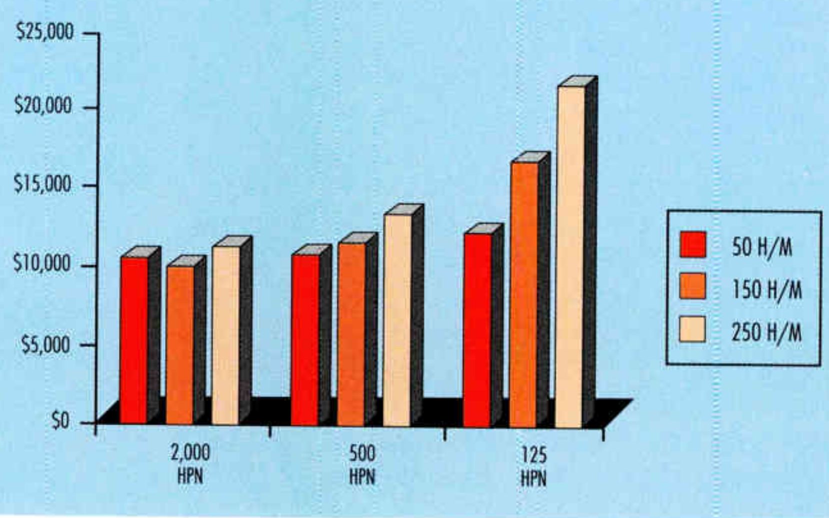
To meet the challenge of increasing competition, broadband network operators must ensure quality and reliability while expanding their services. Operators must ask themselves if their systems are ready to deliver the exciting and eagerly anticipated new services that will be evolving over the next several years.

The word "ready" can hold various meanings to different operators. Having new services is one thing. Having the capacity to deliver the new services reliably is quite another. Building a network to reliably deliver expanded services requires operators to make an investment and a commitment to the future of cable. It requires operators to build an acceptable business model to justify the cost. A phased-in approach over time is quite likely to manage costs.

As fiber-optic usage for cable communications network applications has become widespread, node sizes have decreased steadily. Since the increased deployment of fiber eight years ago, downward opto-electronics pricing trends have enabled cable operators to reduce node sizes from 10,000 or more homes passed to the most commonly accepted node size of 500 homes per node. This number is driven by factors including economics, performance, and capacity.

Fred Slowik is director of system marketing for transmissions network systems, GI Communications Division, Eastern Operations, General Instrument Corp.

Figure 1: Cost/mile vs. home/node vs. homes/mile



The right node size

What is the right node size for planning a network? Since service models and the products being deployed vary according to their bandwidth efficiency, there is not one specific answer to this question. In general, however, it is advisable for operators to plan a migration path to the smallest needed node size.

What forces will drive such migration? Numerous services are emerging—network management, set-top polling, cable modems for Internet access, telephony and interactive multimedia (IMTV), for example. Operators must keep up with these services, particularly in capacity planning, system integrity and reliability.

When planning node sizes, operators should consider available network bandwidth, homes per node, subscriber and service penetration rates, and bandwidth per service. However, these elements may not produce completely accurate estimates because various upstream service components and their different modulation schemes may alter the results. Also, levels of upstream ingress may affect the amount of usable network bandwidth from system to system or within the geographical areas of the system itself.

Timing of service implementation is another essential factor. Why invest more capital during initial system construction than the return on investment will justify? Conversely, investing too little could quickly render a system obsolete.

Figure 1 presents a cost-per-mile comparison with varying node sizes and densities. Included

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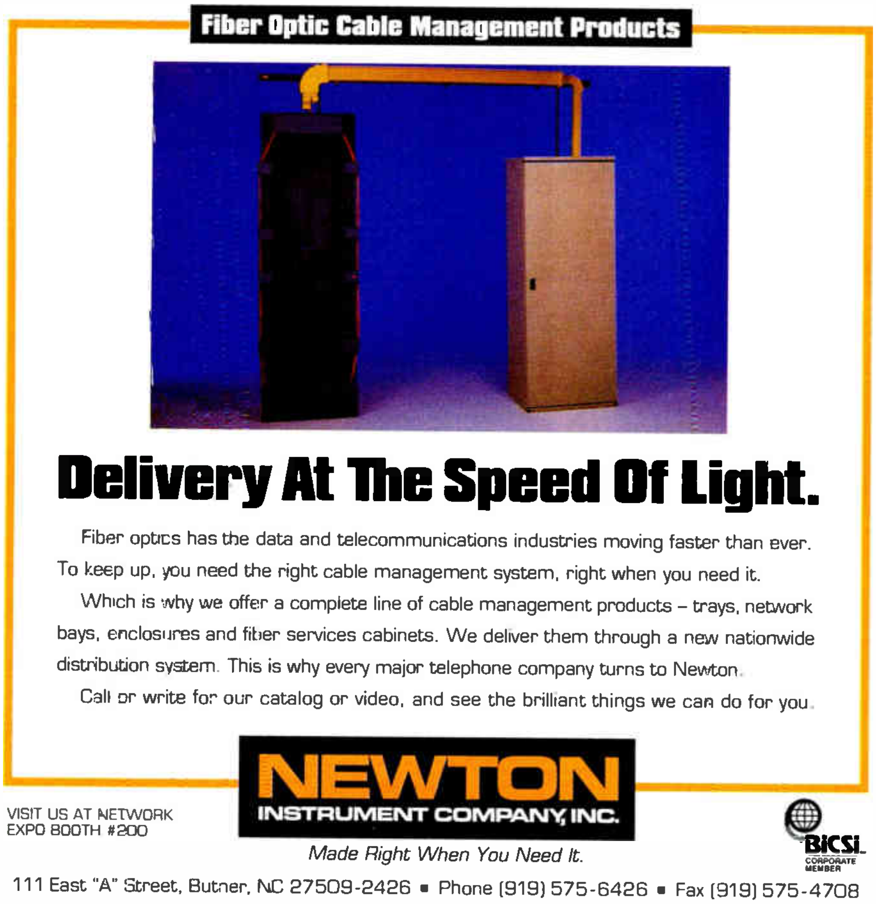


Reader Service Number 207

ing with a receiver that has 0.2 microvolt sensitivity (a ham VHF transceiver or a good scanner) and the squelch doesn't break, that's a good start. Of course, the fact that an estimated 70% of the junk in the reverse comes from subscriber drops is going to make this goal even tougher.

Remember how much money you thought you saved by using nonmessengered cable for aerial drops? The grips used to support nonmessengered aerial drops will cause leaks! At the end of the grip, wind flexing of the cable causes "tiger striping": tiny radial cracks in the shield's foil. Only messengered cable is acceptable for aerial drops, regardless of length.

Oh, yes, let's not forget the budget nonbonded foil drop cable. That kind of cable makes a reasonably effective slot antenna. For that matter, anything less than bonded foil, tri-shield drop cable is asking for trouble when it comes to reverse path operation.

Every loose F-connector is a potential ingress point.

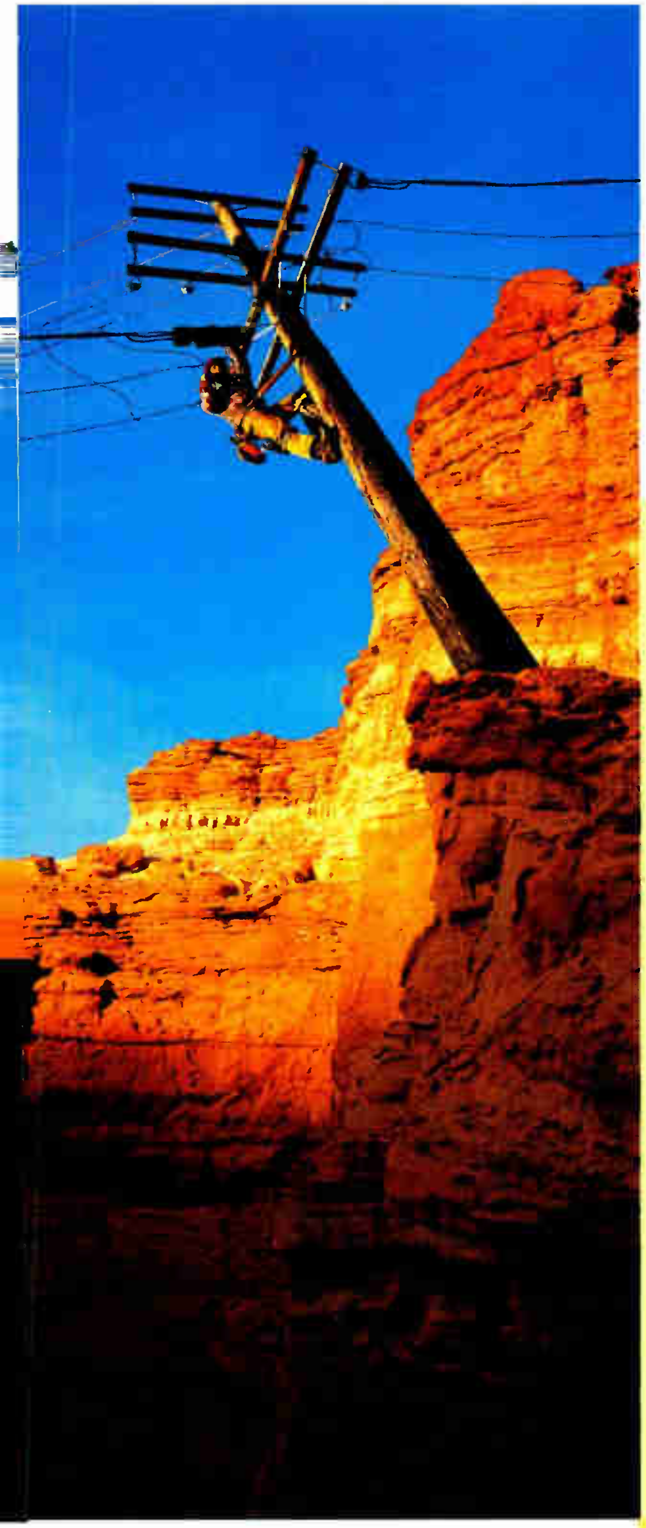
Poorly shielded TV sets, VCRs and FM tuners connected directly to the cable are potential ingress points (high-pass filters may be necessary in many cases).

Cheap drop passives are potential ingress points.

Loose or corroded locking terminators with built-in 75 ohm resistors can make dandy little antennas on each tap port. The ones without resistors are better.

OK, enough on ingress. I think you get the picture.

How about common path distortion? This is an interesting phenomenon that occurs anytime an unintentional diode effect exists in the signal transmission path. For example, if you are using feed-through connectors in conjunction with copper-clad aluminum center conductor coax, each connector is a potential diode. Here's how: If a brass seizing screw (hopefully your line equipment does not use unplated brass screws) in a tap, amplifier, etc., penetrates the center conductor's copper cladding, the brass and aluminum would come into physical contact with each other. This dissimilar metals interface could result in galvanic corrosion, which would create a thin oxide layer where the two metals meet. Voila! Instant diode. Downstream signals passing through what amounts to a nonlinear diode junction



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will generate second- and third-order beats that appear approximately every 6 MHz in the reverse path. That's why I recommend only pin connectors in the hardline plant. Frankly, any unintentional diode in the signal path can cause this problem. (At least two MSOs have discovered that a certain brand and type of 75 ohm chassis terminator can cause common path distortion. The manufacturer is working to resolve this.) Any corroded connectors in your system?

Impulse noise is a tough one that is not fully understood, but is does severely disrupt reverse path signals, especially data. Think of the flashing you see in TV pictures because of a loose connector or cracked cable. This could be one cause. I suspect another source of impulse noise may be power line switching transients, arcing and similar problems getting into the network via common mode (not common path) interference.

As for reverse path thermal noise buildup due to combining too many nodes back at the headend, I've yet to understand the logic behind this. If we're going to segregate our downstream paths with multiple fiber-fed nodes, why not also keep the reverse paths segregated?

Here are a few other potential problem areas to consider:

√ Using FP lasers to transmit reverse path signals back to the headend. (FP lasers can be pretty noisy.) One company has experimented with isolators on the FP lasers and this has improved things.

√ Poor diplex filter isolation between the downstream and reverse signal paths. Example: Downstream amplifier outputs at +48 dBmV and 30 dB of diplex filter isolation. This would result in downstream levels at the reverse module input of +18 dBmV, which might overload the front end of the reverse amp.

√ Junk from your own equipment in subscriber's homes. How clean are your set-top reverse transmitters? You might be surprised. Real surprised.

I know all of this sounds grim, but two-way operation is possible and manageable. It takes some dedication and hard work to keep the reverse path clean, but it can be done. So, back to the original question: Two-way or not two-way? The answer: Yes, if you're willing to commit the necessary time and resources. **CT**

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By Justin J. Junkus

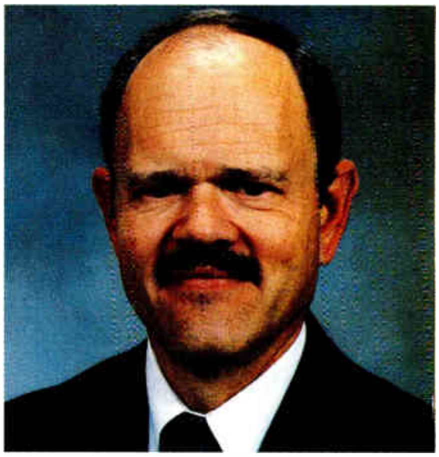
How much wood could a woodchuck chuck?

Strange start for a column on telecommunications? Maybe, but February is the month for Groundhog's Day, and the end of the woodchucks chucking is a decision on how much to chuck. Like the woodchuck, telecommunications professionals often need to determine how much of something (switches, lines, trunks) they need to get the job done. That decision is made by applying traffic engineering principles.

Subscribers to telecommunications systems do not have every piece of equipment needed for a phone call assigned to them for the duration of their subscription. Instead, telecommunications hardware is shared by a number of subscribers. Sharing reduces the cost per subscriber, and therefore lowers the cost of service, while offering potentially more profit to the service provider.

Sharing of telecommunications equipment is based on probabilities. It is unlikely that all subscribers will be making calls at the same time, so a telecommunications engineer only needs to provide enough equipment to reasonably handle the amount of calls in service at the busiest hour of the busiest day of the year. That busiest time is known as the "high day busy hour." A good possibility for the high day busy hour in a residential service area would be mid-afternoon on Mother's Day. We'll use an example of engineering switch line units to look into the benchmarks for reasonably handling all these calls.

Telephone subscribers expect dial tone (if they're not mobile phone customers!) as soon as they pick up the receiver. Truly instantaneous dial tone is only possible if each customer has his or her own dedicated tone generator and line unit at the digital switch. Since in most cases the subscriber will not be active on the line 100% of the day, this would be a waste of switch resources, and would add substantially to the service provider's cost per line. Luckily for service providers, human beings can be tricked into believing they have instantaneous dial tone if it is heard shortly after picking up the handset and bringing it to their ear — about three seconds. So if the



Justin Junkus has over 25 years experience in the telecommunications industry. Previously the AT&T cable TV market manager for the 5ESS switch, he is currently president of KnowledgeLink Inc., a telecommunications training and consulting firm. He can be contacted via e-mail at JJunkus@aol.com.

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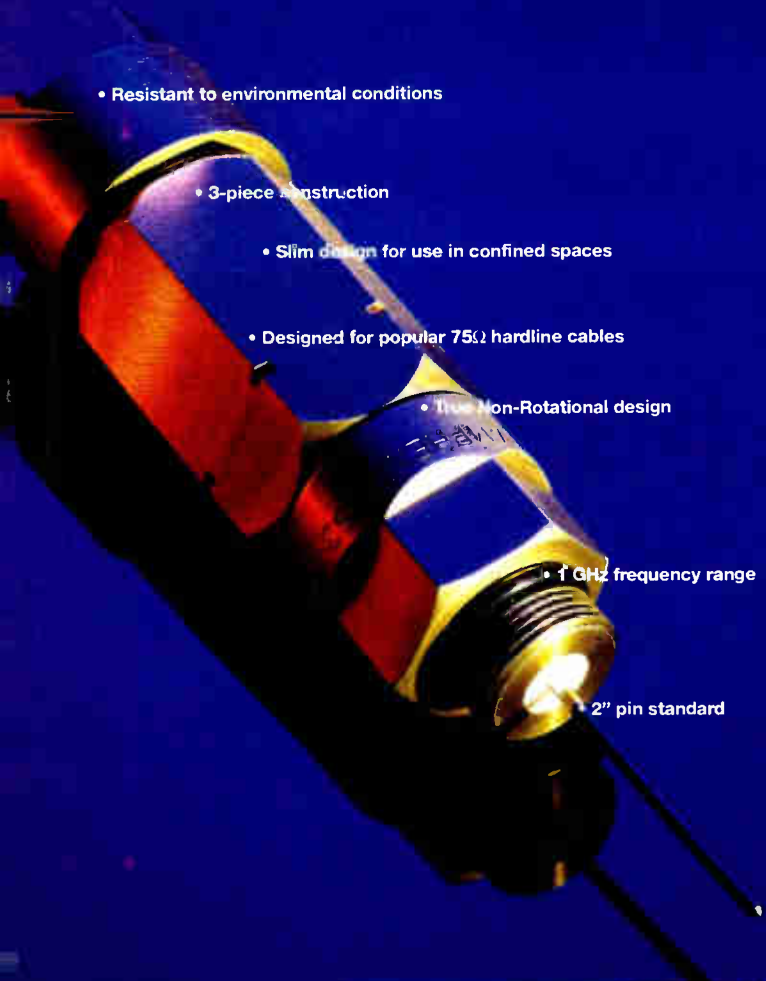

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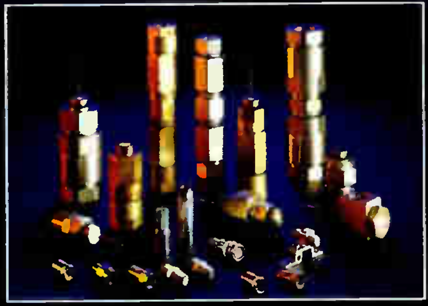

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service provider has enough line units and dial tone generators so that on average dial tone is received within three seconds, subscribers will believe the entire call path belongs exclusively to them.

How many subscribers will on the average receive this illusion of dedicated call path is known as the grade of service. A typical benchmark for grade of service is that 99% of the calls presented to a switch will experience less than a three-second delay before receiving dial tone. This is known as P.01 grade of service. (P for probability of delay and .01 for the 1% that miss the objective.) Other grades of service are also possible, such as P.03 and P.05. The higher the number, the less equipment the service provider needs. The trade-off, of course, is that 3% or 5% of the callers, rather than 1%, have to wait for dial tone.

How serious this delay becomes depends on the offered load. Remember, the service provider is building the switch based on the highest call volume for the busiest day of the year, and that only occurs (with luck!) once per year. This concept applies not only to line units and tone generators, but also to every piece of common equipment in a telecommunications network where a customer's call needs to compete with other calls for a connection. This means the traffic engineer needs to understand the offered loads throughout the entire call path. Trunks from the subscriber's switch to the rest of the world are examples of other common equipment that must be engineered to provide an appropriate grade of service.

Busy hour, busy day

Now let's look at the choice of busy hour and busy day. Call volume is measured in hundred call seconds (CCSs). Since there are 3,600 seconds in an hour, the maximum traffic that can be handled by any piece of equipment in one hour (in constant use) is 3,600 call seconds, or 36 CCSs. The traffic engineer needs to estimate the number of CCSs that will be offered to each piece of common equipment during the high day busy hour. This traffic load is the sum of call setup time and conversation time.

While the safest way to make this estimate would be to look at traffic measurements for a central office being replaced or changed to a new technology, often this is not practical. Fortunately, some benchmarks exist. For example, a typical residential load is three CCSs per hour. Skill, training and experience come into play when the traffic engineer characterizes the traffic profile for the particular service node (which is another name for the location of the switch and transmission equipment).

To begin, the traffic engineer needs to understand the service provider's customer profile. Residential traffic may peak after 3 p.m., when school lets out and teens reestablish communications via the phone. On the other hand, business traffic might peak twice a day, around 10 a.m. and 2 p.m. For a service business, the peak may be at noon and after 6 p.m., when customers are most likely to have free time to call. Different high day busy hours exist for customers.

Also, the traffic engineer needs to understand potential subscriber growth. A switch, for example, could be engineered to handle today's residential traffic at a P.01 grade of service, but rapid subdivision development could cause offered loads to change. True, the service provider would add line units and associated transmission equipment as the number of subscribers grows, but must also be careful to add trunks and other common equipment further in the call path to handle a higher total offered load. The bottom line is traffic engineers and marketing personnel need to communicate with each other.

Now a final warning to the novice traffic engineer. You can plan very well for the high day busy hour traffic and still get caught without enough equipment for every condition. Think about the last natural disaster (or even the last big snowstorm). When abnormally high volumes of calls are offered to an engineered network, more than the usual number of callers will receive more than the usual delay. Coin phones can be particularly susceptible to this problem, since their typical traffic can be lower than the typical high day residential or business traffic.

If traffic engineering sounds like an area that you'll want developed further, let me know at my e-mail address: JJunkus@aol.com. **CT**

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Reader Service Number 146

By Donald Burt

Competitive positioning with network management

Although the subject of network management has been around for years, some observers argue it is just a matter of time before the notion becomes a reality, at least in some segments of our industry.

If that is so, should we ask ourselves just what is this about? What changes are driving this new view, and how should I, as a system engineer, expect network management to influence my job?

What is network management?

The telephony and computer networking industries have given rise to two distinct types of network management. The telephony version is the oldest and most mature. In this country, it was largely dictated by AT&T when it was "the" phone company. That legacy is still the dominant force in the regional Bell operating companies (RBOCs). Telephone systems in most of the rest of the world, however, are gradually embracing the international telecommunications management network (TMN) standards. Since TMN expects to describe all aspects of the management of international telephony, it is a very large and complex set of standards. It also is far from complete today, although useful subsets are being deployed.

The network management standard that has evolved to support computer networks is far simpler. In fact, it's called the simple network management protocol (SNMP), or in the current enhanced version, SNMP2. It's simple, at least compared to TMN, primarily because SNMP standardizes fewer functions. In general, it takes a more tactical view of managing a network, staying closer to direct operation. It stops short of defining the interactions of the network state with either service definitions or business activities.

Under TMN, there are five major functions addressed by network management: configuration, fault management, performance, accounting and security.

> **"Network management provides the opportunity to proactively manage the network."**

1) Configuration is to be taken in the broadest sense, including the physical devices and their interconnections, the software loaded into them, the data directing their ability to make network connections, and the actual instantaneous state of the devices. Thus, configuration interacts with a wide variety of business processes.

2) Fault management includes both the alarms generated by devices as they detect errors (e.g., internal exceptions or loss of connection to a peer) and alarm processing. For example, because devices can generate alarms from many causes, alarms must be capable of filtering and routing as appropriate for processing, including logging and discarding, when necessary. Also, because a single network failure can generate many alarms, a useful system should be able to correlate across devices so only the actionable alarms are used for recovery. The processing can include automatic recovery processes and, ultimately, notification of network operators.

3) Two functions of performance management include capture of performance data for strategic planning and allocation of resources in response to current loads (network "balancing"). Performance management also may involve automated systems to alter the configuration in response to load.

4) Accounting systems address both authorizing and enabling the use of network resources. In addition, they capture data necessary for accounting and use charges.

5) Security addresses the integrity of the network systems themselves, as well as the user data carried on the systems.

This wide-reaching view in TMN is tempered somewhat in SNMP, which is more limited to the interaction with the actual network equipment than with the additional systems. Under SNMP, for example, performance and accounting appear only when there is direct data interaction with network devices.

In addition, TMN considers five "layers" of systems:

1) The actual devices.

2) Element management (software control of devices).

3) Network management (operates on sets of element managers).

4) Service management (implements each offered service).

5) Business management (interactions with business systems on a network policy level).

Again, this view is more extensive than SNMP, which tends to concentrate on a narrower view of the element managers and network manager.

Finally, the TMN set of network systems is expected ultimately to provide an integrated view of the network for all activities of the network operator, including all of the following:

1) Descriptions of the physical network devices and interconnections;

2) Descriptions of the logical or layered "per-service" networks;

3) Physical network processes, such as design, construction, maintenance, etc.; →

Donald Burt is president and founder of Probita Inc., based in Boulder, CO.

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4) Network configuration activity, including "soft" setup of network devices;

5) Provisioning of "subscriptions" or "capacity for service" activities in service delivery, the actual delivery of services and especially network connections;

6) Trouble processing such as automatic fault processes, trouble tickets, repair, fault clearance;

7) Performance activities from dynamic load balancing to strategic capacity planning; and

8) Security including protection of bearer data, purchase of services and integrity of network systems.

One of TMN's goals is a totally integrated set of systems, from the automatic activities of network elements and management of network devices in real-time through routine business processes and strategic business planning. It addresses the life cycle of network devices, including their planning, design, construction, implementation and routine management; fault isolation; repair; return to service; hardware and software upgrades; inventory tracking; utilization and capacity planning; and ultimately, replacement and retirement.

SNMP management lays only a foundation for similar activities. Consequently, higher level activities that are not defined in SNMP may be left manual or provided in proprietary ways, resulting in both benefits and challenges. Under SNMP, the scope of network management is greatly reduced and, therefore, simplified. In a way, this provides flexibility because SNMP does not understand specific service or connection models; virtually any can be added. On the other hand, it will not provide the interoperability between networks and systems that TMN specifies, which can be an important market issue — and a critical one if telephony service is considered. SNMP also does not address the level of enterprise integration that TMN does, which ultimately will mean simpler business processes, lower operating costs and faster response to anticipated market changes (and almost certainly slower response to unanticipated market changes — but that is a different issue).

Why is it being considered now?

There are a number of reasons why this complex, difficult and expensive technology of network management, avoided by MSOs in the past, is being considered today. Primary among them are both means and need. By definition, network management requires duplex communications with the network devices. In a one-way plant, only a few simple objectives from the list above can be met. As other pressures cause deployment of two-way capable plant, expanding network management into the remaining functions becomes feasible. And conversely, forces that require the two-way plant also require these other functions.

The increase in flexibility of the network is largely the result of configurable devices. These devices, of course, require more complex setup and maintenance, including loading software versions and options. They can have more things going wrong, for example software-detected faults as well as network faults. They also have more interaction around their faults, since some faults are related to software resources. →

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Along with the increase in device complexity is general network complexity. While there may be a far fewer total *number* of devices between a headend and client in a digital fiber-feeder network, there are far more *kinds* of devices. They also can be flexibly connected in far more ways than traditional FDM allowed. The basic data network is only one of many that must be accommodated. There are additional "networks" for telephony signaling, authorization data, return path data, and others. And this is not all. There also is the general increase in service-specific devices such as digital set-tops, program guide servers, Internet cable modems and gateways, local digital insertion systems and video game servers.

Concurrently, the boundaries of individual systems begin to blur with the deployment of hubs on regional fiber rings. Functions that were within the domain of a single system must now be coordinated across a larger region. New communications technologies, such as SONET and ATM, also are required for these fiber rings. These technologies come with a substantial amount of telephony infrastructure attached, including the expectation that they will be operated under a network management system.

Finally, as the number of offerings increase, and hence the size of the total customer bill, customer expectations are changing. Network reliability that was acceptable for broadcast TV and marginal for PPV may well be unacceptable when shared by a digital program guide and video games — at twice the total bill. The addition of telephony, Internet access or telecommuting will pressure network operators to improve the mean time between failures and mean time to repair.

What will it mean in operating practice?

The forces that presume a demand for greater network management are beginning to appear today, although their pace and intensity vary from one MSO to another. As many of these forces appear in actual projects at the system level, system engineers will have both the opportunity and, frequently, some responsibility for directing these projects. At the very least, therefore, engineers will be asked to set realistic expectations for operational characteristics of these networks and define requirements for project success.

Network management considerations certainly influence both the network operations and the criteria for success. This is true for both the TMN-like high-level integrated business systems and low-level SNMP-like equipment-oriented systems. Network management systems with either set of capabilities will have significant consequences in engineering organizations. Some of these consequences are difficult or unsettling.

Such systems imply more complex procedures to allow for the broader level of coordination required. They force new equipment qualifications that will sometimes disallow known and comfortable solutions. They require new standards and new vendors for which network operators will have a learning curve that must be overcome before these standards and ven-

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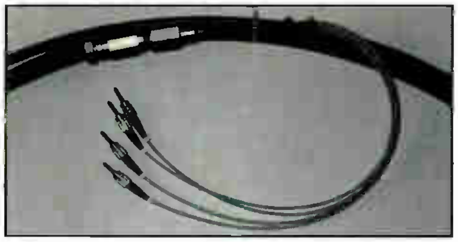

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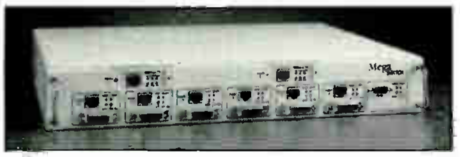

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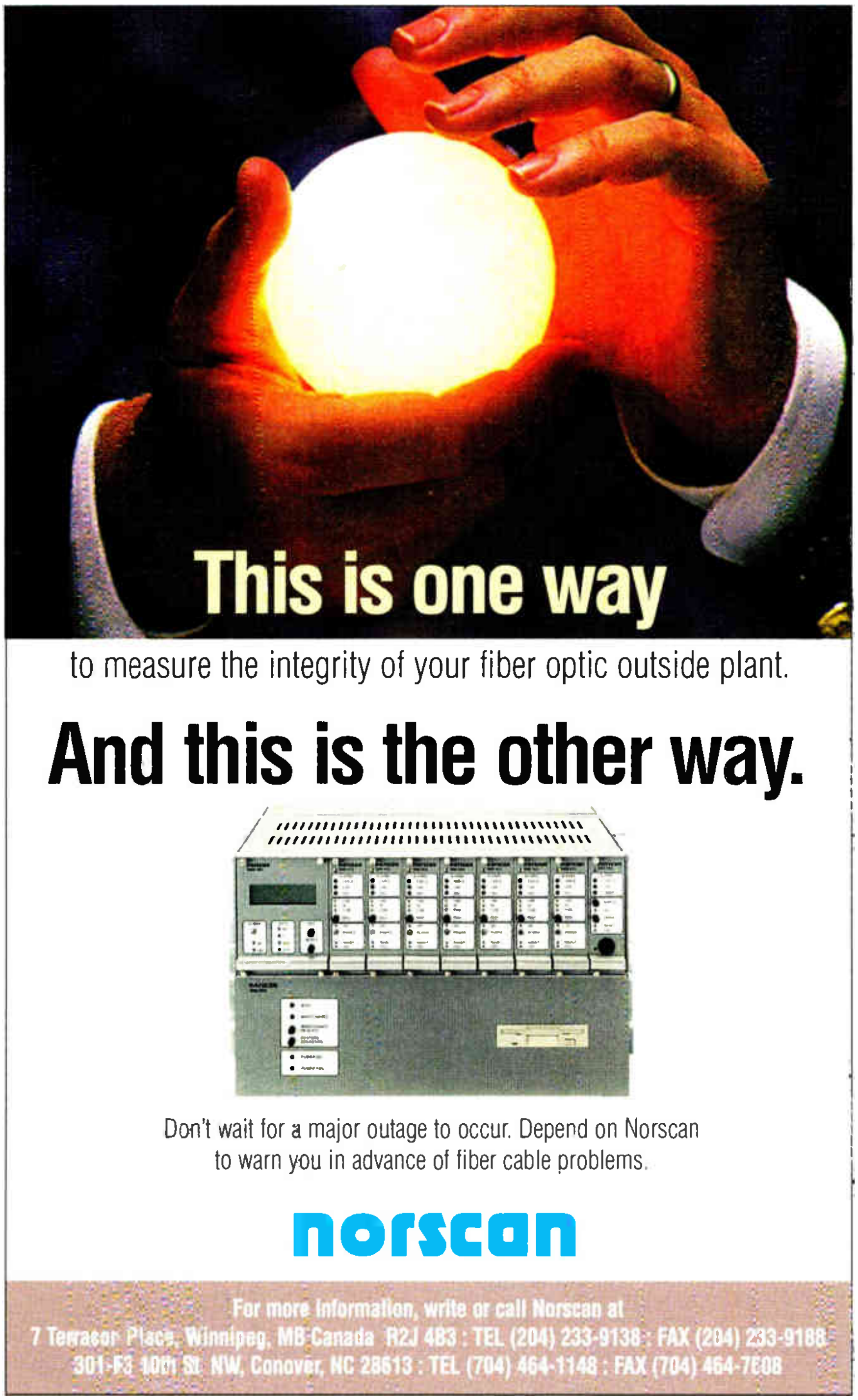
dors can be useful and effective. At some level they will require new staff with new specializations, including an increased emphasis on software. At the same time, they tend to reduce the skill level of most system technicians, who become more on-site "board swappers" directed by the diagnostic capability of the centralized network manager. On the other hand, when things degenerate past that level, even more diverse skills will be required to troubleshoot problems. Thus, it may be necessary to deploy higher skilled engineers from these centralized sites.

Finally, network management systems imply at least a minimal network operations center (NOC), possibly regionally or nationally or both. Such a centralized network manager relieves the local system for most of its routine monitoring functions and provides quick response with minimum local staffing. But it also pre-empts a great deal of local management discretion by restricting local choices, absorbing staff, standardizing functions, and getting the first look at many local problems.

At the same time, there are strong benefits to network management. For openers, there is positive assurance of network operation. This does not assure correct operation, but goes a long way in that direction. Such a system will have real-time links to subscriber and equipment data, allowing engineers access to history and descriptive comments, or even subscriber communications. This should reduce the prevalence of "no trouble found." Further, there are objective measures of performance of both the network and its support systems, enabling better management of these resources and providing a basis for capacity planning and orderly network growth. If properly deployed, there also will be a basis for trade-out of equipment as it evolves. Finally, there will be systemwide visibility and control authority.

Network management provides the opportunity to proactively manage the network, rather than simply being reactive to subscribers' problems. This is a timely development, given the increasing penetration of digital signaling. Analog signals tend to degrade gracefully with deteriorating signal-to-noise ratios, but the error recovery in digital protocols tends to work up to a threshold and then drop out abruptly. This degradation response is much less acceptable to the subscriber and should be avoided — not just corrected. Even troubleshooting techniques will change. Instead of the typical "divide and conquer" technique, especially difficult with intermittent faults, the network management system will frequently isolate the failing element directly.

It's clear that such a transition is not going to be easy. There's as much here to cause concern as reassurance. Given the pace at which technology and the market are advancing, however, it is a transition that will soon be upon us. I am confident that on the other side of these turbulent times, the network management system will be a tool of engineering in the best sense: It will help ensure a network that is positioned competitively, runs efficiently, and is a source of pride to its owners and operators. **CT**



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By Michael L. Smith

The challenge of the return path

As the broadband industry moves forward to deliver new two-way services, operators are taking on the challenge of activating, maintaining, and most importantly, controlling the return path.

Coping with change is rarely easy, and when it comes to allocating spectrum on the return path (5-42 MHz), signal ingress and noise can make the process a frustrating challenge. Fortunately, heads-up planning and network monitoring technology can be used to avoid obstacles to return path performance.

By using network monitoring tools for problem detection and trend analysis, network engineers can better allocate return path bandwidth for revenue-generating services. The same technology can be used to perform routine monitoring after additional services have been added. To get off on the right track, network monitoring should be provisioned as the initial service on the return path before proposed revenue services are allocated.

Michael Smith is the director of engineering for Adelphia Cable, in Staunton, VA. He can be reached at (540) 886-3419.

Sailing uncharted waters

So why all the fuss over such a limited frequency range? For many an unwary navigator, the return path is still uncharted waters filled with potential peril. A little background may help us understand how status monitoring tools and careful planning can help make the return path journey more pleasant and profitable.

Unlike the forward signals that originate at the headend, all reverse signals from all sources terminate in the headend. This combined input includes the desired return signals plus noise and ingress.

Sources of ingress signals include over-the-air services such as amateur and international shortwave radio, CB radio and one-way paging. Other types of ingress source include electromagnetic interference from electric motors, power line insulator arcing, and customer-generated signals from the home.

Unlike amplifier noise, ingress behaves as spikes, peaks or nulls,

and it changes with the time of day, time of year, weather conditions and the sunspot cycle. All signals, desired and undesired, find their way to the headend.

Proper planning for use of the return spectrum should incorporate a proactive strategy to combat ingress and noise. A proactive strategy presupposes a means of collecting data that can be analyzed for trends.

Consider a scenario in which proposed services to use the return path include video-on-demand (VOD), interactive games, Internet access, data services, telephony and network monitoring. Since the re-

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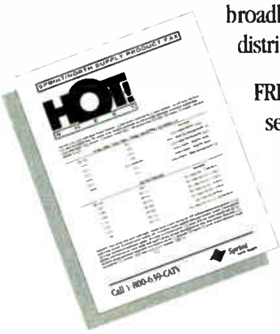

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turn range is limited, the available spectrum may be used quickly.

The proactive approach is to analyze the spectrum for ingress problems prior to allocation. For each of the proposed services in our scenario, cable plant engineers will want to determine whether or not a pattern of ingress appears on proposed service frequencies. Relocating services after they are operational may be very costly.

"Proper planning for use of the return spectrum should incorporate a proactive strategy to combat ingress and noise."

Network monitoring tools can help pinpoint problems prior to proposed service deployment. A network monitoring system equipped with a headend performance monitoring device, as well as remote line monitors, can detect the presence of ingress and collect historical data for statistical analysis.

One of the most valuable tools for overcoming ingress the is frequency agile modem. For example, an automated status monitoring system that can detect ingress and remotely reprogram frequency agile modems in transponders throughout the distribution plan will keep the monitoring system operating while maintenance crews are dispatched.

Planning services for the reverse path would not be complete without proper system test and alignment. Setup of the return path amplifiers and fiber-optic transmitters and receivers requires a backward thought process that determines how this combination operates into the headend.

If a return path planner's guide existed, it would include a review of manufacturer's specifications for the input level required, output level and routing losses. These specifications should serve as a basis for the proper balancing and alignment of the system. Test signal levels may vary due to amplifier type, insertion point or other cause.

Network modems, status monitoring transmitters and other return signal sources may have the capability to increase levels remotely as a way to overcome ingress problems, but this feature must be used cautiously. Reverse transmitters typically do not have any type of input level control similar to those found in forward transmitters to protect them from increased levels. The reverse transmitter might shut down, go into intermodulation or burn up. This could result in problems ranging from an increase in bit error rate to total loss of communications.

Even though a system might initially receive a clean bill of health, this can quickly deteriorate with the addition of drops and customers. In order to minimize the interference potential in the home, high-pass filters can be utilized at the home demarcation point.

A proactive preventive maintenance program is imperative for optimizing return path spectrum performance. Network monitoring tools with value-added performance monitoring software can analyze statistical information gathered in the status monitoring process and allow for adjustments to potential problems.

In addition to detecting ingress problems, proactive network monitoring systems will leverage the intelligence of network devices to discriminate physical layer from upper layer protocol problems associated with two-way digital services.

Rather than wait until it breaks, savvy planners will want to detect and repair network failures before they occur. That's what proactive planning and problem solving is all about. Take control early and your upstream sailing will be smoother and more enjoyable.

Until next time — read on. **CT**

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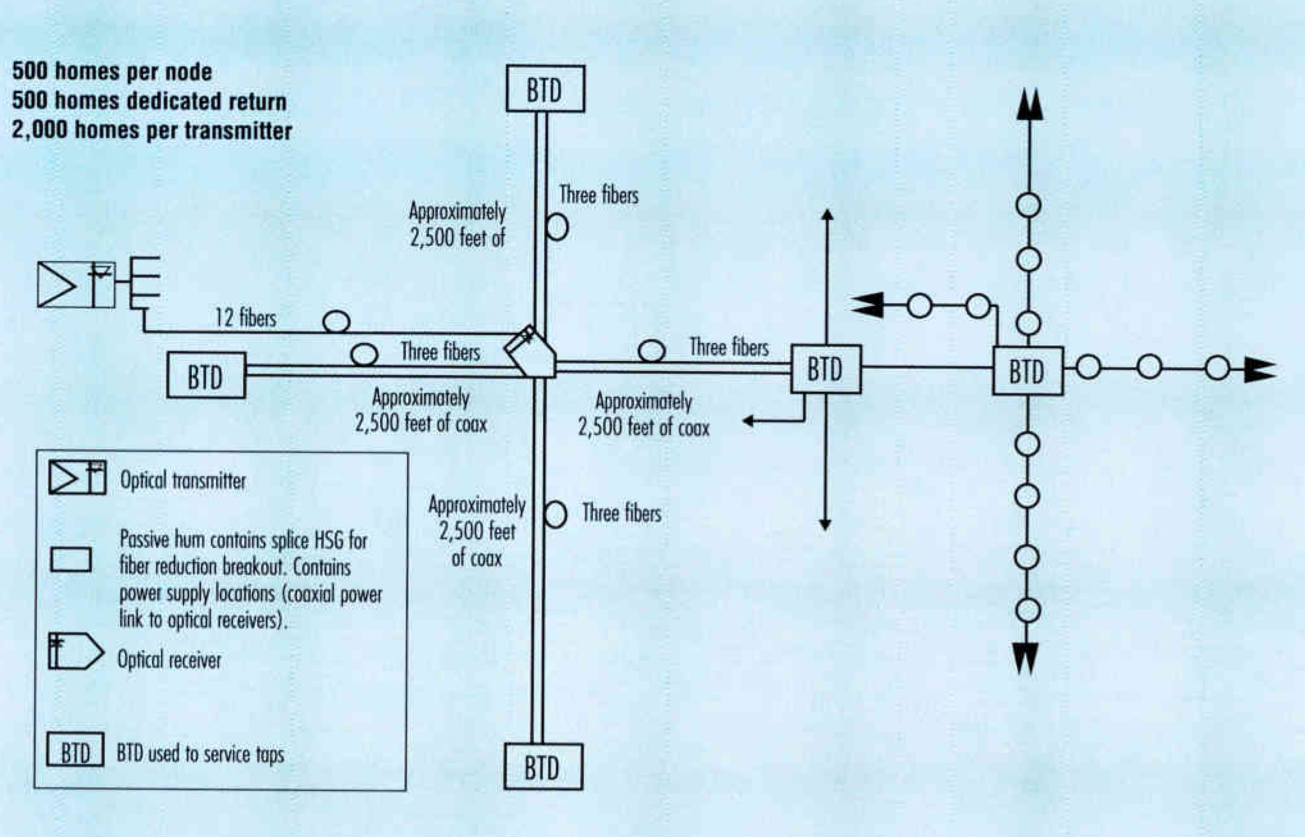
Figure 2: Initial 500-home node configuration



are opto-electronic and RF components, fiber, coaxial cable and power supplies. Excluded are headend electronics, set-top units and installation costs. Note that in lower density applications, the price per mile for 2,000 homes per node (HPN) vs. 500 HPN is relatively level. Therefore, density dictates the maximum attainable node size in this instance.

A simple model

Upon examining a typical node sized at 500 homes passed, we can create a simplistic model illustrating upstream bandwidth availability per home passed. The 5-40 MHz bandwidth is 35 MHz wide. Assuming that the 5-15 MHz region is reserved for network maintenance functions or is impaired due to unusually high levels of ingress, that leaves 25 MHz of usable bandwidth dedicated to the 500 homes passed. Each home is allocated 50 kHz of simultaneous bandwidth usage.

Now, if we assume a 50% basic service subscription rate (about 250), with 50% of those customers (about 125) using interactive services, the simultaneous bandwidth per interactive subscriber grows to 200 kHz. Realistically, if only 25% of interactive customers (31) were simultaneous users, bandwidth per user climbs to 800 kHz.

"Why invest more capital during initial system construction than the return on investment will justify?"

Data capacity for this bandwidth varies depending upon the efficiency of the selected modulation techniques. Upstream capacity also varies substantially depending upon subscriber penetration rates. However, even without knowing these potential rates, it becomes evident that network expansion capabilities are needed to keep up with increased service demands.

With all of these concerns, how does one plan the network? By selecting a scalable architecture. Initially, whether they choose to construct a light, moderate, or intensive hybrid fiber/coax (HFC) network initially, cable operators must be assured that they will be able to migrate to smaller node sizes in the future. This flexibility must be accomplished without major system rework through a reconfiguration at device locations.

Figure 2 illustrates an initial 500-home node configuration. The initial node size may be as large or small as needed and may

By Gerry Cartenuto, Bob Huckeba, Randy Reagan and Yvonne Reeves

Managing fiber end-to-end

Fiber is becoming pervasive in CATV networks. Deployment in these networks has been growing faster than 20% annually. It's already the medium of choice for major segments of telephone networks. The reason is obvious: Fiber alone can handle the bandwidth demands of new revenue-generating services. But to realize its benefits, both CATV and telephone service providers must employ careful fiber management strategies and techniques.

The best strategy is to think end-to-end — to conceptualize the entire light path that a signal traverses through the network. That means managing and conserving the signal all along its route from super headend to intermediate headend and out toward subscribers; or in a telephone network, between switching offices and then out into the feeder and even distribution network. See the accompanying figure on page 40.

Specifically, an end-to-end approach entails careful splicing and connecting at all junctions between fiber and fiber, fiber and optical equipment, and fiber and electrical equipment along the light path. It requires careful handling of fiber cables, both inside headend or central offices and in the outside plant. It also requires readily available test access for all links.

Ideally, the entire light path is also monitored and managed by an operations system located in the headend or central office. Such a system can help network managers and technicians to see each circuit as part of the network.

When the entire light path is carefully managed, the payoff amounts to more certain delivery of service and improved quality. Customer service can be more responsive because the information available from a well-managed fiber network permits faster provisioning and delivery of service and more rapid responses to problems. Providers can even fix troubles before customers call in with complaints. Time to market with new services can be shorter, and providers will be able to gain the most revenue from offerings such as pay-per-view, video-on-demand, home shopping, video game libraries, and others.

"Fiber alone can handle the bandwidth demands of new revenue-generating services. But both CATV and telephone service providers must employ careful fiber management strategies and techniques."

Starting with structure

Fiber management starts at the headend or central office with system administration. System administration takes three forms: configuration of the fiber network; management of fiber cables within the headend or central office; and surveillance, monitoring and testing of the entire fiber network from equipment in the headend or central office.

Many companies embark on a fiber management program when the cabling in their headend offices simply becomes unmanageable. Typically the problem is a jumble of fiber, coax or copper, and even power cables piled into cable trays and conduits over the years. Engineers can't find space in existing trays and conduits to pull needed new cable, and a lack of cable capacity hinders offering new services or taking on new subscribers. If a cable has been cut in the field, technicians often can't track it through the office to reroute it.

Two types of systems are now available that help manage fiber cables within headend and central offices. A structured cable management system can provide organization, routing and protection for fiber cables. Then, a fiber distribution frame can provide terminations and connections to optoelectronic equipment on another frame.

A structured cable management system in the headend or central office incorporates adequate racking and ducting, either overhead or under a raised floor, for all types of cables: fiber, coax/copper and power. Its racks and pathways include separate spaces for different types of cable, automatically protecting fiber cables from being crushed against heavier coax and power cables. Such a system also prevents forceful pulling of fiber through conduits crowded with large copper cables, another source of danger. In addition, a structured system maintains the bend radii crucial for good fiber performance — something pathways

Gerry Cartenuto is senior product planner, product management, fiber-optic apparatus-fiber management systems, AT&T Network Systems.

Bob Huckeba is senior product planner, product management, fiber-optic apparatus-splices and closures, AT&T Network Systems.

Randy Reagan is technical manager, AT&T Bell Laboratories.

Yvonne Reeves is senior product planner, product management, fiber-optic apparatus-connectors, AT&T Network Systems.

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designed for copper don't do. Too sharp an angle can produce signal loss.

The initial installation should provide room in the cableways to accommodate growth for years to come. After the initial design capacity is exhausted, a well-designed cable management system should permit modular growth.

Installing such a system is a major undertaking because it means lifting or pulling cables out of existing conduits and trays and installing them in the new racking structure. Still, many companies are finding this painful process worthwhile, especially if their service delivery is suffering. And some companies for which structured cable management systems aren't yet a necessity are installing them as a strategic move to prepare for the future.

The framework is key

Even the best-managed cables should come to good ends, of course. Many CATV companies are therefore replacing their old coax distribution frames with frames designed especially for fiber cables in headend offices. Similar systems also have been designed for central offices in telephony networks.

Fiber distribution frames make patching, rearrangement and test access easy. All three are increasingly important to CATV providers as headends route thousands of fibers out to serve subscribers.

Like the structured cable management system, the fiber distribution frame provides pathways tailored for fiber cables. These cables are no longer jumbled together with coax and power cables.

The fiber distribution frame also affords protection for fiber terminations and cross-connections to optical and optoelectronic equipment. That's because, like fiber cables, fiber jumpers need careful handling. They must not be kinked, pulled or twisted. Frames designed for copper wire connections typically don't manage fiber jumpers correctly. For example, a fiber distribution frame provides termination and connection points that position fibers to maintain proper bending radii.

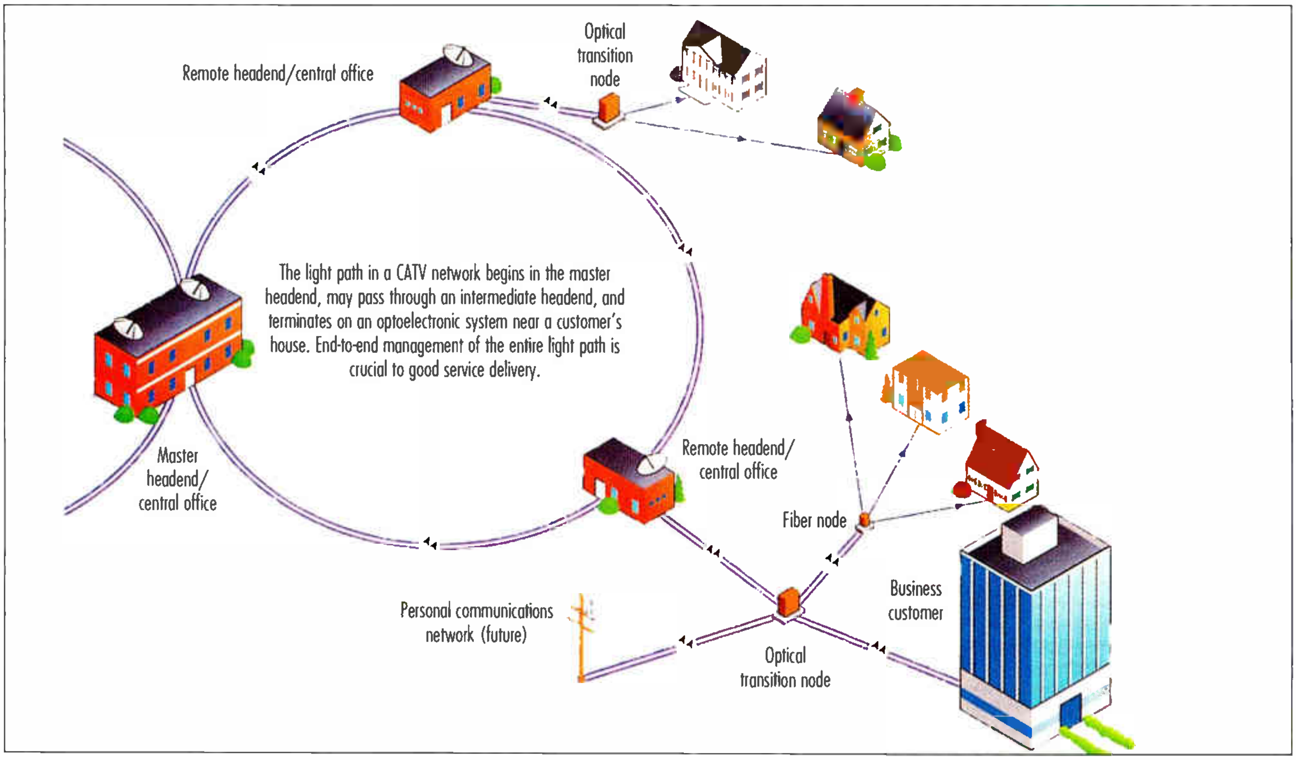
A fiber distribution frame usually spans or extends 23 inches in width, rather than the 19 inches typical of coax distribution frames used in the CATV industry. That four inches makes a big difference. As networks grow more complex, headend offices are increasingly employing multiplexers and transmission equipment designed for telecommunications networks — equipment that doesn't fit in a 19-inch frame.

If they're still using 19-inch frames, companies must string fiber pigtails and jumpers not only within the frame, but also from it to other racks holding transmission and signal conditioning equipment. These pigtails can introduce undesirable loss and disorder. The 23-inch frame holds the new equipment and also provides built-in connections.

The frame should support the full range of transmission and signal conditioning equipment such as lasers and modulators needed to send the signal on its way. It should also support various sizes of optical and optoelectronic components, so the service provider can begin with just the capacity needed and grow to meet demand. For example, it should accept plug-in optical splitter modules that do 1 x 2, 1 x 4, and 1 x 8 splits.

The frame also should support equipment from different vendors, enabling service providers to exer-

Broadband fiber system



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cise personal preferences in hardware as well as install any complement of equipment that will provide the services their customers demand.

Systematic operations

The organization provided by the frame can help make it easy for the technician to locate terminations to be used. Available frame administration software maps all terminations on the frame, records those already assigned, and selects the best route for any desired connection. When a link is taken down, the operations system automatically returns the terminations to the inventory of available slots.

The operations system, which is adaptable to either CATV or telephone networks, thus prevents out-of-service or dead cabling that takes up space and confounds technicians. On older frames, technicians string jumpers manually and then enter the link on a paper record. But when circuit provisioning gets fast and furious, record keeping often doesn't keep up. Soon there's no way of telling which jumper links what to what, short of disconnecting the jumper to see what's affected. Many jumpers end up out of service, with new ones layered over them.

The frame operations system also can make its data base of inventory and cross-connections available to other operations systems and test and surveillance facilities, making overall network management easier. It also can provide ports for test access.

Graphical interface

The job of headend and central office technicians and engineers becomes much easier if they can get to the frame operations system through a graphical interface that gives them an end-to-end view of every light path leaving the office. One such graphical user interface provides a choice of network views. Users may select a high-level view of an entire region or narrow the picture down to a specific light path, including all the splice points along it. They may view the cross-connections within an individual fiber distribution frame or almost any other representation of network circuitry.

From this graphical interface and operations center, technicians and network managers can perform routine monitoring, surveillance and testing. For example, they can monitor light strength all along any light path continuously, or perform periodic, regular surveillance. The system also can store test data such as loss measurements — insertion and return loss figures and the total loss budget — for any given light path or circuit.

Given a trouble report, the center can help identify which trunk to test and then locate the fault to within a few meters, speeding up repair intervals. Moreover, the center can measure changes in signal loss along an entire light path or a specific span periodically or on demand. This measure is useful in perceiving both subtle signal degradation or outright loss due to a cable cut.

One study, conducted by AT&T Network Cable Systems in cooperation with a regional Bell operating company, found that use of a fiber distribution frame operations system resulted in a 37% savings in the time required to identify and locate terminations on the distribution frame, select the jumper, route the jumper properly, remove jumpers, and perform other tasks.

Connecting right to the point

Administration systems, of course, are only as good as the terminations and connections they manage. Connector performance also is crucial to the performance of the network. That's especially true as companies are installing expensive high-power lasers and trying to span longer distances between electronic equipment. They want the lowest connector loss possible.

Many CATV companies have historically used the FC connector. A number of them are now migrating to the SC connector, a similar connector that is easier to use. The SC connector uses push-pull hardware, making it easy to engage and disengage into an adapter. Easy to mount in the field or factory, the SC connector features a tunable design. The technician can minimize insertion loss by choosing the best of four available positions for fiber alignment.

The newer SC connectors decrease loss by incorporating more concentric fibers, tighter tolerance ferrules and fiber outside diameters, and more effective tuning techniques. The SC device features a zirconia ferrule with a spherical end geometry that is carefully controlled to maintain optimum fiber-to-fiber contact for low insertion and return loss. The SC polish can minimize changes in the index of refraction and thus losses due to reflections within the fiber.

Many companies are buying cable assemblies with the connector already attached at the factory. These connectorized cables also minimize loss.

Companies may install the SC connector throughout a CATV or telephony network — in the fiber distribution frame in the headend or central office, as well as in optical transition nodes, and at any place in between where fibers need joining. If a company has an embedded base of one type of connector, so-called "universal buildout" mechanisms can be used to migrate from that type to another. Universal buildouts are two-piece adapters that allow FC, SC and ST connectors to be mated to each other. (The ST is more common to data networks.)

Low-loss splices

As fiber cables leave the headend or central office, they must be distributed throughout the network. In both networks, cables taper from fiber counts of well over 200 down to a dozen or fewer fibers. Those tapers are usually accomplished by splices. Although some CATV networks originally used splices to make connections in the headend office, the availability of good quality connectors and preterminated shelves has decreased the practice. Now, splices are mostly reserved for the outside plant and the cable entrance facility.

Both mechanical and fusion splices are appropriate for single fibers. If a company prefers the mechanical type, there are two choices: rotary mechanical or cleave-sleeve-and-leave (CSL) splices. Both have advantages. The rotary mechanical splice is tunable: Rotary splicing equipment can allow the technician to rotate fiber ends to best match their cores, which may vary from perfect rounds, and then measure the insertion loss to achieve lowest

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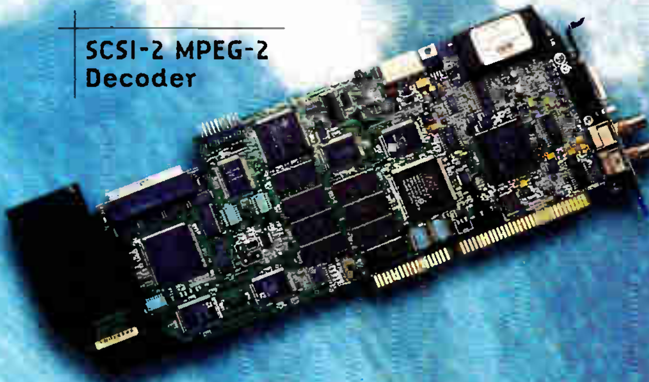

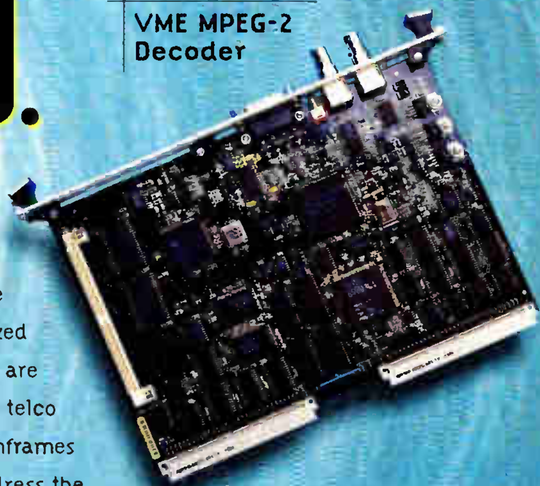

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possible loss. This type of splice can be re-entered and rearranged easily.

The CSL splice also can be re-entered and is easy for craftspeople to learn to use. CSL equipment makes almost automatic the process of stripping the fiber coating away, cleaving the fiber ends cleanly, and positioning the fiber ends together, and produces a dependable splice.

In a fusion splice, the fiber ends are stripped, cleaved, placed in a holder, and then heated and melted together.

Mass fusion splices are performed on up to 12 fibers bound together in a ribbon. A ribbon can hold up to 24 fibers within a matrix so their placement is fixed. Up to two dozen such ribbons can fit within one fiber cable, for a fiber count of more than 360. With such numbers, multiple splicing is almost a necessity, especially for CATV networks in which the constant extension of service to new streets and subdivisions may mean frequent rearrangement of cables. Fortunately, mass fusion splicers produce effective and economical splices and are easy to use. Fusion splicing units now on the market can also calculate splice loss estimation on each fiber.

After the splice is completed, it must be enclosed in a closure that protects fiber, cable and splice adequately from the elements. Different closures are designed for aerial and underground settings and for use within equipment vaults or buildings.

These closures should be easy for craftspeople to open and to reseal. They should also allow adequate space within for making and placing splices, and, of course, they should protect the splices over time. Among the types available are closures that are sealed with mastic, an externally applied heat shrink wrap, or grommet technology. In the latter type, the cable is placed into a fitting, or grommet, that is clamped within openings in the splice closure specially constructed to make a firm seal.

Especially in networks that must reconfigure cables frequently, ease of re-entry is important. Some companies find the grommet style easiest to re-enter in the field because it is reusable and does not require that shrink wrap or sticky mastic be taken off and then re-applied.

The end-to-end perspective

Consider all the splices, closures, connectors, terminations, jumpers and cables that make up a light path. All of these products must be installed and managed correctly. Then there's the sheer complexity of today's — and tomorrow's — CATV or telephony network, as well as the diversity of services and subscriber needs — those that have already emerged and those that have yet to appear. These are all cogent reasons why good fiber management is essential to any company that intends to prosper.

Fortunately, good tools and equipment are readily available, and the task is not difficult. The main requirement is careful planning and careful attention — end-to-end. **CT**

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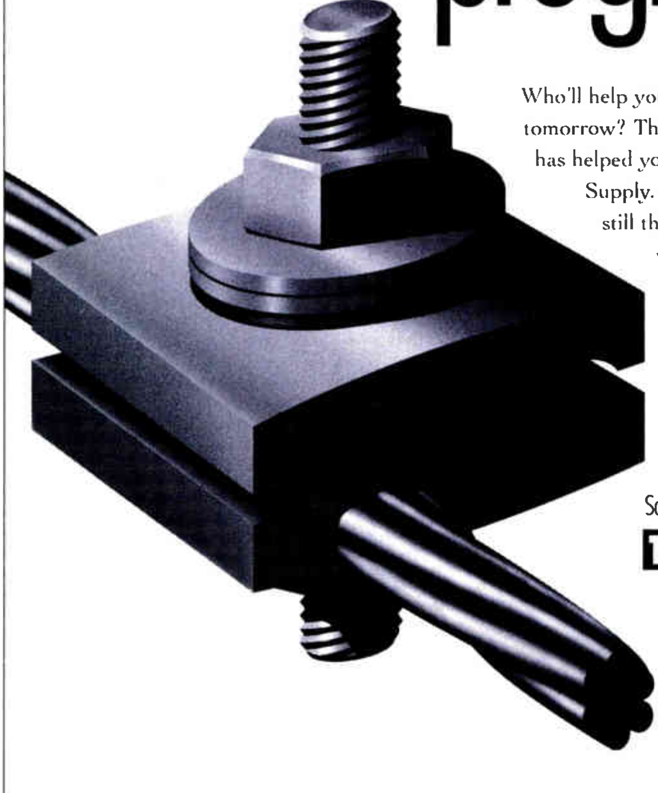

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TESTING THE CHANGING WORLD OF COMMUNICATIONS

Tektronix

By Richard A. Domalski, Larry D. Sellers and Kenneth Vidacovich

Management systems cut cost

As the fiber portion of hybrid fiber/coax (HFC) networks increases, fiber management becomes an increasingly difficult issue. Corporations continue to drive down costs and keep the lid on labor expenditures and material costs. The need for fiber headends, hubs and nodes is becoming not only a cost issue for executives, but a productivity issue for contractors.

Fiber management traditionally has been a challenge. Technicians are often confronted with a rat's nest of 3 mm cable from which they need to isolate and disentangle one cable. This problem results from the prevalence of outdated fiber management systems, which were not designed to handle large quantities of fiber. They function more as repositories than managers.

As fiber density increases and companies deploy more fiber further into the loop, traditional management systems become a financial liability. Their lack of fiber routing, organization and mapping, combined with large quantities of excess cable (due to the use of standard-length jumpers), cost technicians — and companies — hours of valuable time.

Recently introduced fiber management systems have been designed for fiber-rich environments and address many of the problems associated with high-fiber density. A major factor in dense fiber environments is fiber size. Instead of bulky 3 mm cables, new systems use cables less than 1 mm in diameter. Further, they include routing mechanisms and splice trays that house and organize fiber resulting in clean, uncongested cable runs.

In addition to better physical organization, some systems are now available with software packages that show technicians graphic representations of optimal cable routing and indicate the exact length of the jumper necessary. The software also records the location of each cable as it is installed, making it easy to avert "traffic jams" and also to locate and repair cables later.

Increased organization and less excess optical fiber result in a major benefit: future-proofing. Traditional systems typically were equipped to manage only 770 jumpers per bay. Some new systems can handle up to

Richard Domalski is applications engineer and technical sales trainer for 3M Telecom Systems Division. Larry Sellers is a technical service engineer and Kenneth Vidacovich is an advanced product development engineer.

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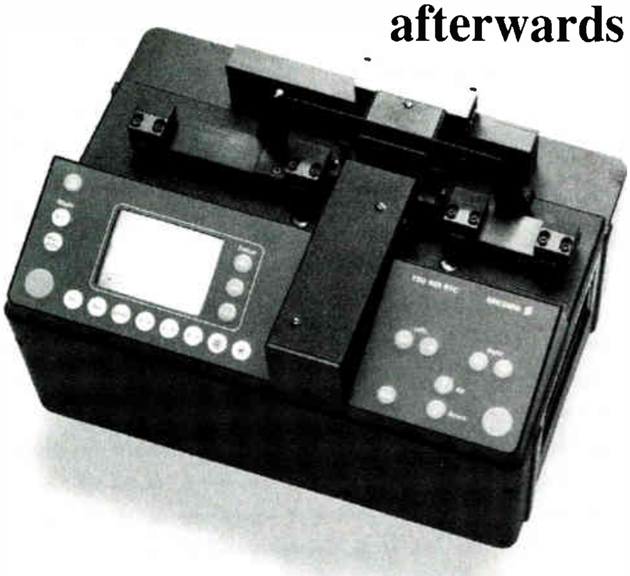

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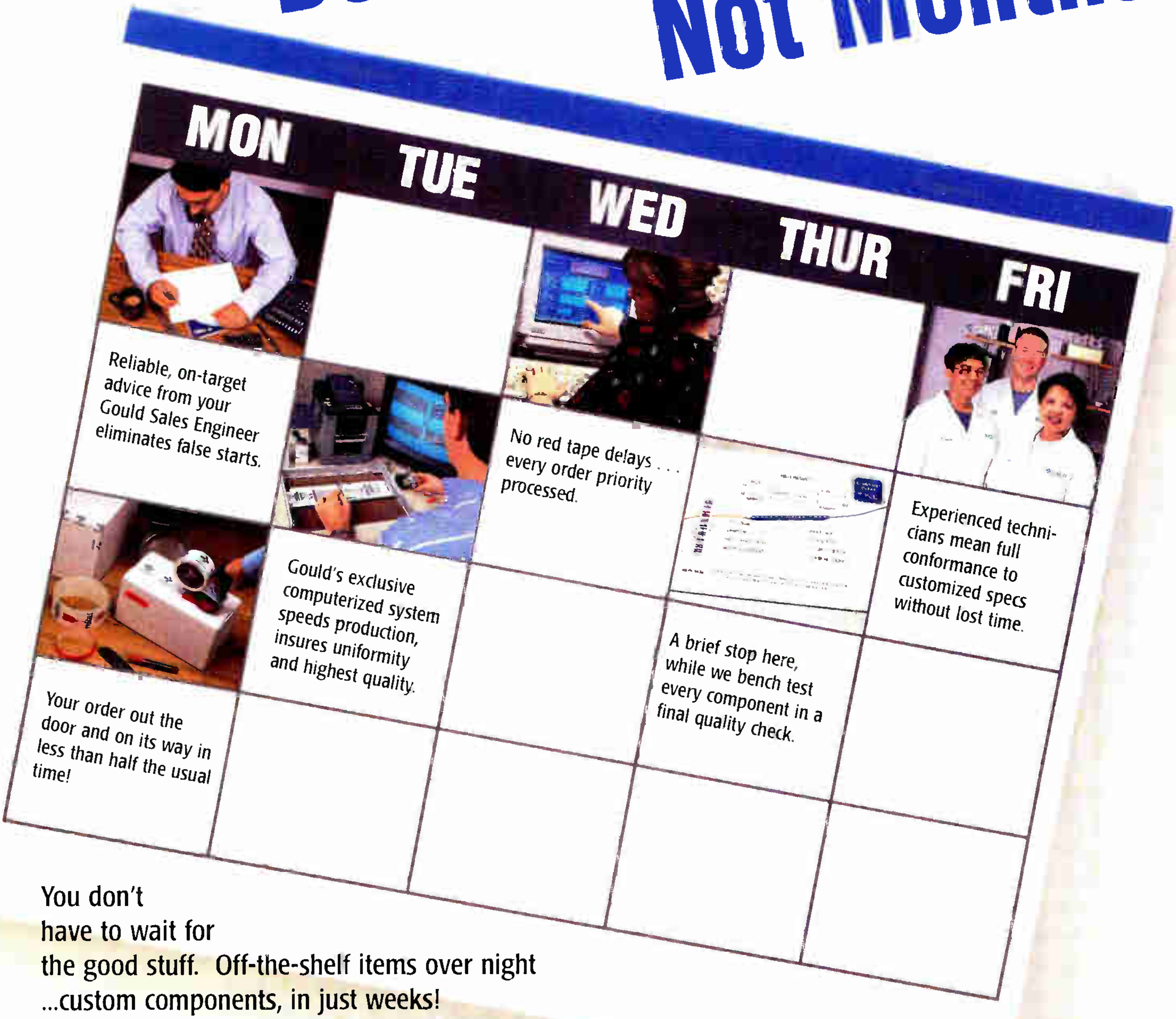

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1,440 jumpers, which makes them well-equipped to handle significant increases in fiber usage.

One of the major problems with traditional fiber management systems has been connectorization. Jumpers used in these systems are premade and all of predetermined lengths, with an adhesive-type connector at each end. Technicians need extensive field terminating skills and the proper equipment (epoxy, heating elements, polishers and usually a power source) to install them. Further, to make a connection between points only inches apart, technicians are forced to use a jumper over 3 feet long. The excess cable, which traditional systems are ill-equipped to handle, is a major cause of congestion in cable runs.

In addition, if a connection fails, the technician must discard the jumper and start all over again with another premade connectorized jumper. If he doesn't have one on hand, he cannot complete the job.

New bare-fiber connectors that have the connection quality of traditional connectors have gone a long way toward solving these problems, and are an integral part of new fiber management systems. These new connectors are inexpensive not only in terms of purchasing cost, but in terms of labor and training. They require less time and expertise to install than traditional adhesive connectors. A technician can cut jumpers to fit on-site with minimal field termination skills and equipment. All he needs is a cleaver and a stripper. If the initial connection fails, he can cut the fiber back a few centimeters and try again with the same fiber rather than discarding the whole jumper.

In addition to organizing fiber and making connections easier and less expensive, new management systems have succeeded in consolidating equipment. Traditional systems involve several pieces of equipment. Fiber comes in from outside plant, passes through a splice tray and then a splitter, is pigtailed to a cross-connect box, and is connected to the electronic equipment. All are separate components. The efficient new systems incorporate the splice tray, the splitter, the pigtail and the cross-connect box in one unit. Fiber now enters from outside plant and exits directly to its destination, resulting in a streamlined path that requires far less equipment — and space. Further, the new systems allow the addition of new couplers, attenuators, WDMs and ribbon fiber, all to one card.

Based on a per-port cost, new fiber management systems are cost-effective for systems handling 60 or more fibers. As fiber technology increases, deploying more fiber further into the loop, headends will be denser, increasing from 100 to 1,000 fibers. New systems are equipped to handle over 1,400 fibers per bay and are designed to accommodate increased fiber density well into the future.

As cable companies move toward a fiber-rich environment, fiber management systems play an increasingly significant role in managing costs. With the rise in telephone and data connections and the accompanying increase in fiber usage, new fiber management systems will go a long way toward making the new fiber standard easy — and inexpensive — to work with. **CT**

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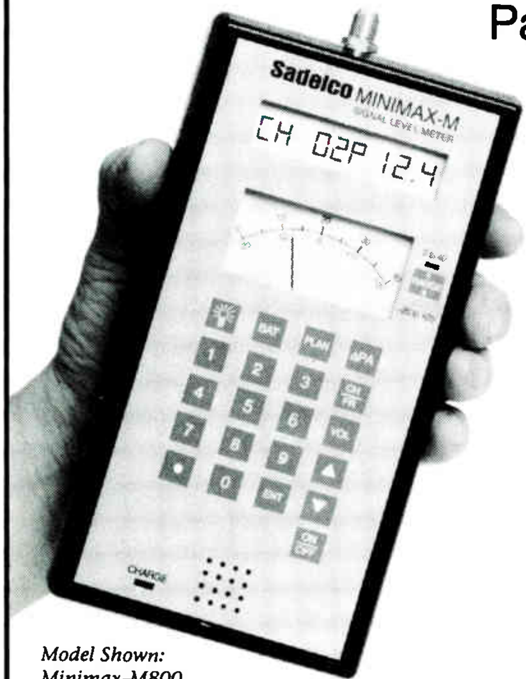

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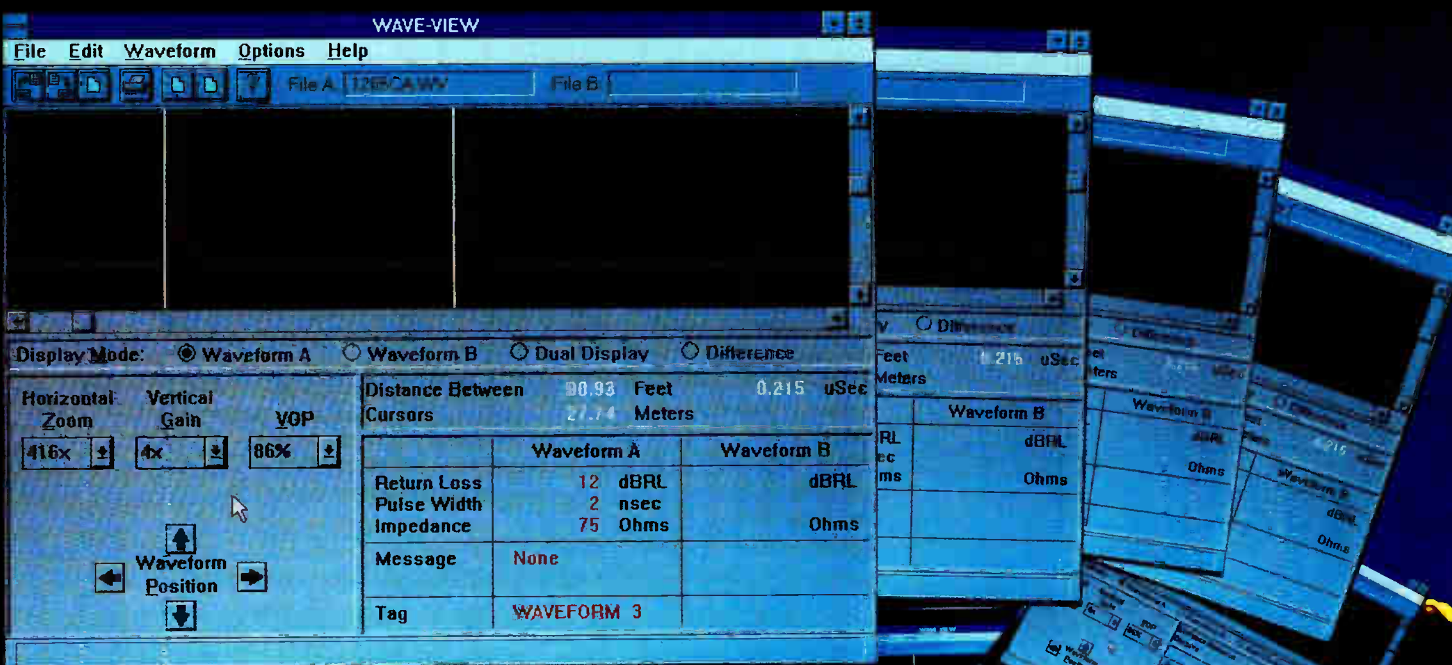

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By Alex Zavistovich

Cable modems — Part 1: The race for your PC gains speed

This is the first installment of a two-part article dealing with one of the most talked-about potential moneymakers for the cable TV industry — data delivery using cable modem technology. In this part, "Communications Technology" identifies the major players and explains why they're in the game.

Quick: What's the latest untapped revenue source for cable operators? If you guessed cable telephony, guess again. Data communications via hybrid fiber coax (HFC) networks and delivery of on-line services are likely to turn cable's HFC infrastructure from a broadcast-oriented video service to a turnpike for the information superhighway. What is the technology that's making it all possible? Cable modems.

The introduction of cable modem technology, with its promise of data throughput up to 1,000 times faster than currently available with some modems used over telco lines, has captured the industry's collective imagination. Three of the country's leading MSOs — Tele-Communications Inc., Time Warner and Comcast Cable — are experimenting with data services over HFC lines. Many of these services already have been test-marketed in select communities and are scheduled for rollout in the early months of this year. The service packages, available separately or bundled together with other cable offerings, allow subscribers access to current on-line commercial services, bulletin boards providing local content, and a gateway to the Internet.

Alex Zavistovich is senior editor of Phillips Business Information's "Communications Technology." He can be reached at (301) 340-0542, ext. 2134 in Potomac, MD.

What's more, while industry spokespersons concede that some work still remains to tighten up the return path of cable's HFC networks to facilitate optimal two-way data transfer, experts predict that consumer demand for continually faster access to data services is likely to generate so much traffic on the Internet that additional backbones — provided by the cable industry — will be needed to handle the increased capacity. TCI and Comcast refer to the process as "overbuilding the Internet," and use the term frequently in describing their plans for the future.

"It's a potential gold mine for manufacturers of cable modems."

It's a potential gold mine for manufacturers of cable modems, including Hewlett-Packard, LANcity, Zenith, Motorola, Toshiba, Scientific-Atlanta and others. In fact, the implications of the technology are so immediate that work has already begun in earnest to develop open standards to ensure interoperability of equipment, now and for the future. Rather than hiding behind proprietary technology, clamoring for market dominance, broadband equipment vendors are working cooperatively with the cable industry's leaders, to ensure that this equipment ends up in consumers' hands as quickly as possible.

Why do it?

Each of the three MSOs' on-line services (Time Warner's Linerunner, TCI's @Home, and Comcast Cable's provisionally titled Comcast Online) is in a different stage of readiness for marketing. Linerunner, test-marketed in Elmira, NY, last year, is ready for rollout in Rochester, NY, and Akron, OH; @Home is slated for commercial debut this month in Sunnyvale, CA. Only slightly farther behind, Comcast Online is undergoing technical trials in suburban Philadelphia, with plans for expanded trials this quarter.

For Jim Chiddix, vice president of engineering and technology at Time Warner Cable, the time to implement the new service is now. "All of us (developing online services) share a perception that there's a real business opportunity here," he said. "We're moving ahead as rapidly as we can. We also share a common belief that we need eventually to get to a standard for these things (cable modems)."

The explosive growth of cable modem technology, fueled by consumer demand for faster access to on-line services, has led some in the industry to speculate whether this new growth area for cable may be embraced even before the highly touted and long-anticipated arrival of cable telephony. Richard Green, president of CableLabs, pointed out that on-line services delivered by cable have a decided advantage over telephony as a growth area in that there is really no entrenched competition for data transfer, yet there is "huge consumer demand."

"From a business point of view, the prospect of data transfer by cable is very exciting," said Green. "From an engineering point of view there are a lot of the same issues (in data transfer) that you have in telephony, and they're very synergistic. I feel, however, that the market pull is going to be stronger for the data communication side than the telephony side."

What are the services?

While the technology that will bring the world of the Internet to subscribers' homes via HFC is relatively new, tests of packaged data delivery service have been underway for over six months, in some cases. Time Warner's Chiddix noted that his company, which has agreements to purchase cable modems from Motorola, Toshiba, Zenith and LANcity, has been testing a system since the summer of 1995 in Elmira, NY. Zenith modems have been used in the trials; Chiddix said initial deliveries of some 50,000 Motorola CyberSURFR modems will be made to Time Warner soon.

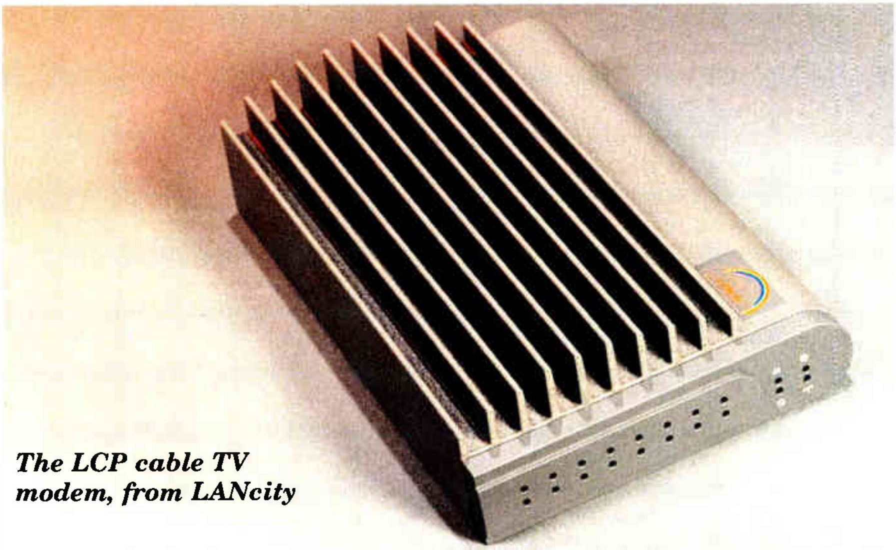
"We've been offering a variety of on-line services under the brand name Linerunner," Chiddix said of the Elmira tests. The tests provide subscribers with localized Elmira bulletin boards and information services, news and information services from Time Inc., and Internet e-mail. A premium service offers unlimited high-speed Internet access, as well as access to America Online and CompuServe. "In Elmira, pricing was $15 per month for the basic service and $9.95 for unlimited Internet access. Virtually everybody took both," said Chiddix. Subscribers buy the service and Time Warner provides the modem as part of delivering the package.

Although Chiddix said that, at present, there are no price breaks on the subscriber side for customers wishing only to add the on-line service package, he added that, "in time, that (pricing structure) could change." At press time, the company is targeting an expanded rollout of its Linerunner service in Rochester, NY, Akron, OH, and some other communities yet to be named. Also in Rochester, the company is contemplating offering cable modem, telephone and cable TV service, all packaged together.

At Comcast Corp., Joe Waz, vice president of external affairs, said his company is expecting delivery of Motorola CyberSURFR and Hewlett-Packard QuickBurst modems by the first half of 1996. Waz expects initial installation of the modems at the site of Comcast's technical trials in Lower Merion Township, PA, in suburban Philadelphia. Approximately 50 homes are engaged in trials of the fledgling Comcast Online service, which Waz said will increase to 300 homes in the first quarter of this year.

The Comcast Online service brings subscribers "modem access to the world, plus a proprietary local and regional content service," Waz said. Other likely places for modem installations, he said, would include Baltimore County, MD, in Summer 1996, for the first anticipated commercial deployment of the new service.

Marketing of the service has yet to be finalized, according to Waz. "We expect that consumers will want to lease cable modems. We will probably come up with a package that offers service and equipment lease." Right now, Waz said, Comcast is still figuring out how modem services will be bundled with other services, possibly as a bargain package that includes video, Sprint long distance (which Comcast also is currently marketing in select areas), and personal communications services (PCS). "Everything is very much in flux on pricing," Waz commented.



The LCP cable TV modem, from LANcity

Meanwhile, at the Denver offices of TCI, spokesperson LaRae Marsik described the introduction of @Home (pronounced "At Home"), a subscriber online service offered through the company's TCI Technology Ventures. @Home was first announced in Spring 1995 as a joint venture between TCI and Palo Alto, CA-based venture capital firm Kleiner Perkins Caufield & Byers. The first market for deployment of @Home is Sunnyvale, CA, early this year. The service provides navigational service and assistance, local content and high-speed connection to the Internet via cable modem to a customer's PC, Mac or workstation. TCI is considering a $30 monthly charge. "We're looking to price service for the mass market," Marsik noted.

Marsik sees the rapid growth of cable modem technology as a boon for travelers on the infobahn. "Due to the growth of the Internet, a service like @Home makes things like

(Continued on page 74)

By Michael Adams

ATM and MPEG-2 in cable TV networks — Part 2

This is the final installment in a two-part article describing asynchronous transfer mode (ATM) and MPEG-2 networking in cable TV systems. The author bases observations on experience garnered from Time Warner Cable's Full Service Network in Orlando, FL. Part 1 appeared in the December issue of "Communications Technology."

The Orlando FSN was designed specifically to provide interactive digital service in addition to existing analog broadcast services. The next logical step is to integrate digital broadcast services in a single network. There are two main ways to achieve this:

- Build a broadcast digital network architecture and add interactive services.
- Build an interactive digital network architecture and add broadcast services.

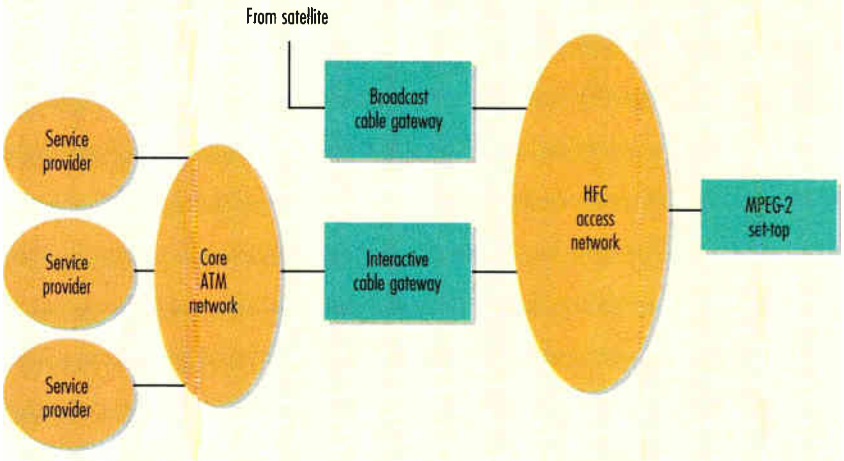
Each approach has its merits, but ultimately the decision is driven by which digital service will become pervasive first — interactive or broadcast. We believe broadcast will be first because it is a proven paradigm and does not require a change in subscriber viewing habits. However, interactive services will follow rapidly on the heels of digital broadcast deployment. In particular, the additional cost of an interactive set-top over a broadcast set-top is relatively small. Therefore, when digital set-tops are deployed, it makes sense to deploy broadcast/interactive digital set-tops.

Michael Adams is a senior project engineer with Time Warner Cable responsible for ATM networking in the Time Warner Full Service Network. Previously, he was manager of ATM switch software development for Bell Northern Research in Canada.

Of course, a broadcast digital network architecture that cannot evolve to support interactive services is a dead end. Our experience in building the Orlando FSN has earned us a set of interactive network requirements that we have used to design a broadcast digital network architecture that will gracefully evolve into an integrated digital network architecture.

In Option 2 shown in Figure 4 (page 54) the ATM path extends all the way to the subscriber residence, where it is terminated at the set-top device. An interactive cable bridge (ICB) is still required to adapt the physical media dependent layer to the HFC network, but no higher-layer protocol transformation is done. In this case, the set-top must be built to receive ATM and MPEG-2 transports, and to switch between them when switching from interactive to broadcast programming.

Figure 3: ATM protocol terminated at "interactive cable gateway"



Reference architectures

Figures 3 (this page) and 4 (page 54) illustrate the two alternative reference architectures. On the left are interactive service providers, which provide interactive multimedia services to the subscribers. They are connected to a core ATM network, which supports switching and routing (potentially over a wide area).

Option 1 is shown in Figure 3, where the ATM protocol is terminated at an interactive cable gateway (ICG), and MPEG-2 transport streams are distributed to the set-top device. The ICG strips the ATM layer and delivers an MPEG-2 transport stream into the hybrid fiber/coax (HFC) access network. Hence, the set-top receives MPEG-2 transport regardless of whether it is using interactive or broadcast programming.

Digital broadcast services are distributed using MPEG-2 transport over the same HFC network in either case. This would be used to deliver high-quality broadcast programming. A satellite feed is expected to provide most broadcast programming.

This section will summarize the advantages and disadvantages of these two alternatives and show that both can be made to work. However, for near-term deployment of cable networks the first option is better for economic and technical reasons.

Option 1

In Figure 3, the ATM path is terminated at an ICG. The ATM virtual

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channels are terminated and AAL-5 (the ATM adaption layer to support data and MPEG-2 transport) reassembly is performed to reconstruct the encapsulated MPEG-2 transport streams. Each transport stream will contain information for a single interactive subscriber — video, audio and data program streams — multiplexed together. The ICG multiplexes together a number of these transport streams to aggregate bandwidth to a convenient payload that can be carried by a 6 MHz digitally modulated channel.

The ICG terminates virtual channels used to carry Internet protocol (IP) data for application download and messaging. These IP packets are mapped into the MPEG private data section for delivery to the set-top. Note that this operation is simplified because the same adaption layer (AAL-5) is used for both MPEG and IP data.

The ICG also applies the following data transformations:

• The MPEG time stamps are corrected to compensate for jitter experienced in the ATM network and jitter due to re-multiplexing.

• Forward error correction (FEC) and payload interleaving is applied to protect from errors introduced by the HFC network. This is necessary because the bit error rate (BER) of the HFC network is in the 10-6 range. A BER of 10-10 is required to deliver MPEG-compressed material.

• The payload is encrypted as part of the conditional access scheme of the cable network. Note that extremely secure algorithms are required because the cable network is a broadcast network, and so it is subject to many more security challenges than a point-to-point network.

• The payload is randomized and then modulated onto an RF carrier.

The set-top receives a jitter-free, MPEG-2 data stream, and extracts the program identifiers that it requires and feeds them to appropriate audio and video decompression engines. (This entire operation will be performed by a single-chip device).

In the reverse direction, IP is used to carry application requests from the set-top. The return bandwidth requirements are much smaller than in the forward direction. For example, the IP packets could be aggregated by an IP router before they are injected into the ATM network. This option does not allow for ATM signaling (Q.2931) by the set-top, however the digital storage media command and control (DSMCC) protocol allows the set-top to make session requests to the network. (This protocol is designated by the MPEG-2 DSMCC Working Group under the auspices of the International Standards Organization.)

A reference protocol stack describing this option is shown in Figure 5.

Figure 4: ATM path extends to subscriber residence

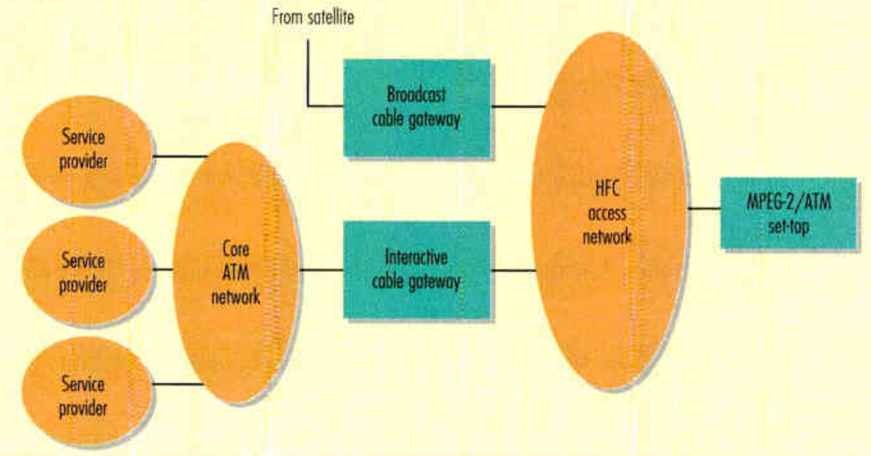
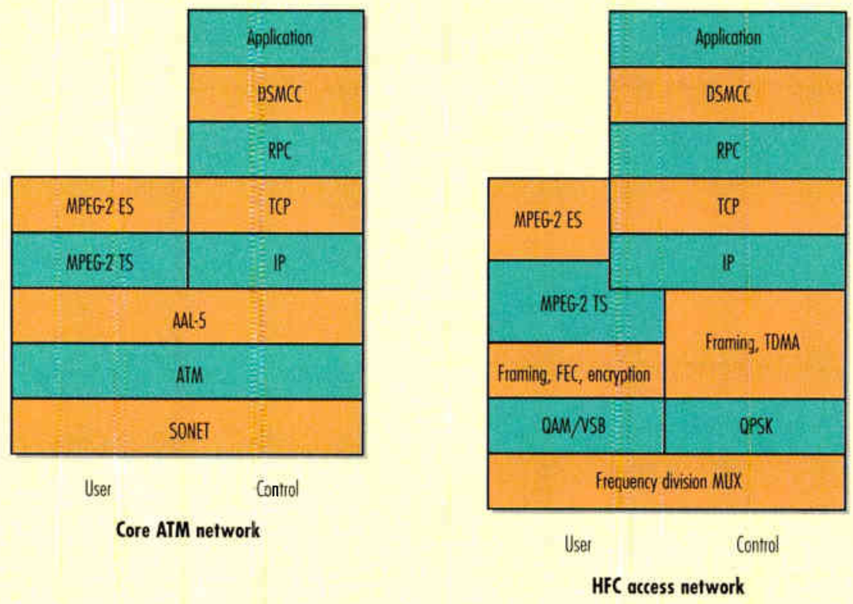


Figure 5: Reference protocol stack



Option 2

In this option, the ATM path is terminated by the set-top. Although the ICB is transparent to data-link protocols, physical layer transforms are still required to adapt to the HFC network. These are: FEC and payload interleaving, encryption and modulation.

In addition, note that Options 1 and 2 both accept OC-3 rate physical interfaces from the ATM switch. This rate is chosen because it is a readily available and efficient mapping of ATM into a physical link. Lower rates, such as DS-3 have lower efficiency and have approximately the same per-interface cost. In terms of cost per Mbps, the OC-3 interface is less than one-third of the cost of the DS-3 interface.

In Option 2, the set-top terminates an ATM virtual channel and performs AAL-5 reassembly to reconstruct the MPEG-2 transport stream. The transport stream is then de-multiplexed and fed to audio and video decompression engines as in Option 1.

The set-top also terminates virtual channels used to carry IP traffic for

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application download and messaging. Once again, a single adaption layer (AAL-5) makes this feasible.

In the reverse direction, the set-top must signal directly to the ATM network. The issue is, what address should the set-top use? The set-top wants to request a service and doesn't know which service provider might provide it. It also has no knowledge of connection parameters (QOS, bandwidth, etc.) until it is in communication with the service provider. A meta-signaling approach would probably be required to solve these issues.

Economic comparison

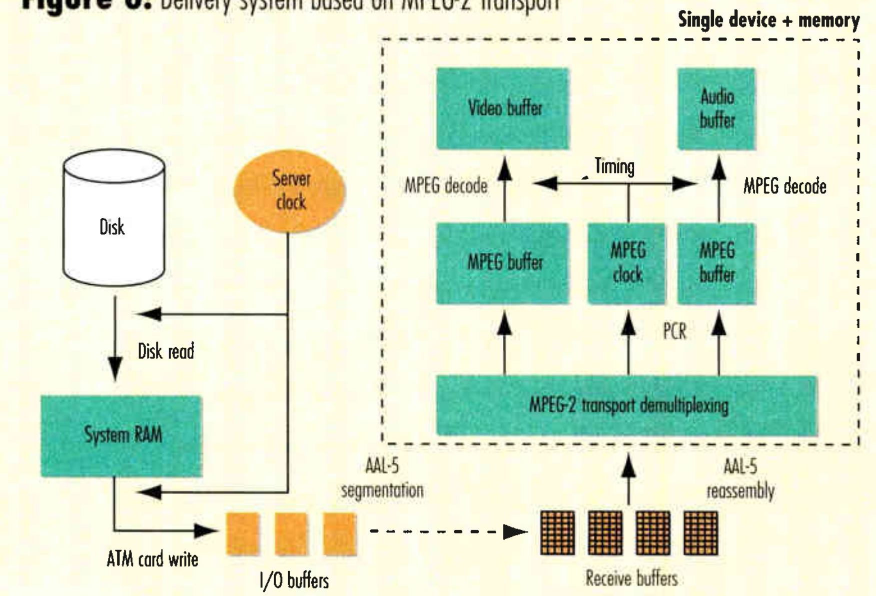
Support of both broadcast and interactive services is the key factor in deciding whether Option 1 or 2 is best. Digital broadcast feeds are already carried in MPEG-2 transport streams (by DBS providers using the Direct Satellite System, DSS), and will be available in this form at the cable system headend. Therefore, a baseline digital set-top must be able to "play" an MPEG-2 transport stream. The economics of adding ATM functionality to the set-top are still not clear, but we expect that during early introduction there will be a larger volume of digital broadcast set-tops than interactive set-tops. If an additional function, like ATM, is required by only the interactive unit, then leveraging the economies of scale offered by the broadcast unit will not be possible.

The cost of the ICG vs. the ICB is another key indicator. As shown previously, the ICG has to perform nearly all of the same functions as the ICB. So what is the incremental cost of the ICG? Actually, the cost is quite small, given that an OC-3 payload (136 Mbps after accounting for ATM overhead) can be processed by a single ASIC plus memory (at a cost of maybe $100).

Let's compare cost in the set-top vs. the ICG, based on an OC-3 payload. In the set-top, let's assume a single device can perform ATM termination and AAL-5 reassembly. In the ICG, an OC-3 payload can carry about 30 digital "channels." Assuming that the peak usage of interactive services (at any instant in time) is 10%, an ICG is required for every 300 subscriber set-tops. (Remembering that the ICG is a shared resource.) The incremental cost of the set-top must be multiplied by 300 before comparison is made with the incremental cost of the ICG. Therefore, at 10% peak usage, a $10 ATM chip in the set-top will cost $3,000 per OC-3 payload. On this basis, it obviously makes sense to minimize set-top cost and to perform ATM termination in the ICG.

The other advantage, which has not yet been mentioned, is transport efficiency. Stripping the ATM protocol in the ICG removes approximately 10% of the overhead. Therefore, an ICG could deliver 30 digital channels and the ICB could deliver 27 digital channels given the same modulators and channel bandwidth. Hence, the ICB is more expensive than the ICG in terms of modulator and spectrum usage, and this additional cost will not disappear over time.

Figure 6: Delivery system based on MPEG-2 transport



A system example

Figure 6 illustrates a delivery system based on MPEG-2 transport. MPEG-2 transport multiplexes the video and audio data and a program clock reference into a single stream of data that is carried in a single ATM virtual channel. The advantage here is that the data is implicitly locked together by being stored in that form on the server.

The ATM AAL-5 reassembly process is the same whether peformed in the ICG or the set-top.

Conclusions

The Orlando FSN is a successful implementation that uses an ATM network to carry MPEG-compressed video and audio to the subscriber residence. In view of the lessons learned from this experience, the following statements can be made about future interactive networks:

- The use of MPEG-2 transport streams mapped into ATM virtual channels that connect the servers to an ATM switching network will become the dominant architecture for interactive TV networks.
- MPEG-2 transport packets will be mapped into AAL-5 using the mapping recommended by the ATM Forum.
- MPEG-2 transport will be used to distribute compressed digital channels over the HFC access network. An interactive cable gateway will be required to perform the MPEG over ATM to MPEG conversion function. (Products are already under development by a number of vendors.) This approach allows the integration of broadcast and interactive services over the same HFC network.
- Existing, standard protocols (for example, the Internet protocol suite), will be used to support a client-server computing model in interactive networks. These protocols will be adopted because it just isn't feasible to reinvent them. These protocols will use existing mappings to AAL-5. (Progress also is being made to standardize the mapping of IP into MPEG-2 transport streams.)
- Single-chip solutions that provide MPEG-2 transport de-multiplex and audio and video decompression will help to make the digital set-top cost-effective. **CT**

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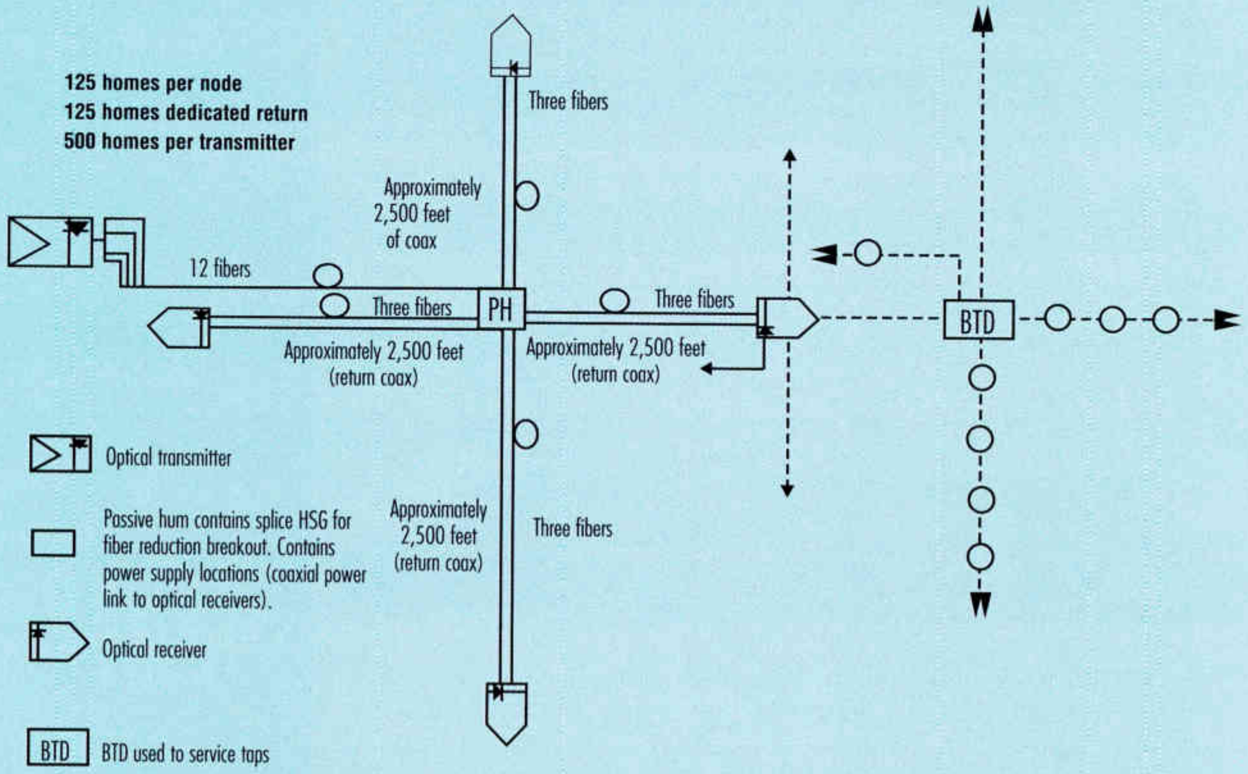
Figure 3: A possible system migration



utilize higher power lasers (optically split to feed several nodes or lower power lasers for a point-to-point configuration. Note that the 500-home initial node is segmented, ideally into four smaller cells containing 125 homes each. This segmentation often depends upon system density and geography. Each segment then uses express (untapped) cable to the first ative device in cascade and beyond if necessary.

This first active location has the potential to become a future node if necessary down the road. The operator installs the proper fiber counts to the initial 500-home node locations to provide for future migration. The usual count for initial and future nodes is a minimum of one downstream, one upstream, and one spare fiber. The operator may opt to install three additional fibers between the existing node and the future node locations, either during the initial construction or deferring until the need arises.

Active cascades range from one to five devices beyond the future node site depending on system density.

Service requirements and the operator's business plan dictate whether further migration is necessary. A system experiencing explosive subscriber growth most likely will need further migration.

Figure 3 illustrates one possibility for migration.

Note that the basic design footprint does not change. Fiber may be activated deeper into the initial 500-home area reducing node sizes to as little as 125 homes per node. Optical splitters are reallocated at the headend to serve smaller areas.

There are several alternatives to this phase to increase capacity selectively. Instead of creating additional node sites, for example, it may only be necessary to selectively downsize in high-growth areas. Another alternative is to collocate additional nodes at the existing 500-home node site and reallocate express cable connections.

Express purposes

The express cables have a purpose both initially and during subsequent migration activities. In addition to transporting signals, they may conduct power from centralized supplies at the initial node site—an advantage when using expensive battery or gener-ator-powered backup power supplies. Also, techniques such as increasing the number of reverse transmitters to improve return path capability can provide additional relief to congested areas of the network.

In designing a broadband architecture, operators must build in the flexibility to redefine the network's operational capacity without resorting to extensive system reconstruction. Low active device counts, reduced power consumption, lower maintenance costs, and improved reliability through shorter cascades to the customers also are important to consider. **CT**

By Morris Engelson and Jerry Harris

Hybrid digital/analog signals: Dynamic range theory — Part 1

The cable TV signal is sometimes analog sinusoidal, sometimes noise-like due to digital modulation and sometimes mixed analog/digital as in digital audio combined with analog video. Whatever the combination, it is a high-density spectral environment that puts a strain on the dynamic range performance of test equipment.

Dynamic range of test equipment, such as a spectrum analyzer, is a critical factor because it affects the ability to make a large range of needed measurements, such as composite triple beat (CTB), composite second order (CSO) intermodulation, occupied channel power, etc. Indeed, the situation can be even worse when an apparently proper measurement is made but the result is wrong because of spurious response generation and signal gain action or adjustment of spectrum shape or symmetry.

Other uses involve a numeric measurement of such things as CTB or digital signal adjacent channel power leakage. Whatever the application, it involves the display and/or measurement of a signal spectrum with both large and small magnitude components. Unfortunately, the spectrum analyzer is limited as to the ratio, or dB difference, between the largest and smallest signals that together can be displayed and measured. This ratio, expressed as a dB difference, is the dynamic range. The spectrum analyzer dynamic range must be greater than the cable TV signal amplitude range that can be measured and is the limiting factor for many measurements. Hence, it is important to understand how to get the best or optimum dynamic range out of an instrument and to determine its dB value.

Morris Engelson is consulting chief engineer and Jerry Harris is product marketing manager at Tektronix in Beaverton, OR.

Spectrum analyzer dynamic range depends on three factors: the smallest signal that can be observed or measured, known as the sensitivity, the largest signal that can be used, and the type of signals involved. The same instrument will exhibit a different dynamic range, and best results will be obtained at different control settings, depending on the type of signal involved—especially whether digital or analog. In addition, there are a multiplicity of dynamic ranges depending on which aspect of the signal is to be measured. Thus, the CSO and CTB will show different dynamic range limits on the same spectrum analyzer. However, while the numbers may be different, the procedures for obtaining optimum results and general formula relationships are the same. Following are just a few examples. Keep in mind there are more application possibilities than are being discussed here.

Analog signal and CTB

The simplest analog type signal is a single sine wave carrier, but this is rarely of much interest. A more interesting but still fairly simple signal consists of two sine wave carriers, say at frequencies f1 and f2. Here we can have a wide variety of interactions that introduce additional unwanted signals, known as spurious responses. These so-called intermodulation responses are identified by the order number (n), signifying the number of harmonics of f1 and f2 involved.

A spurious signal at frequency f2 - f1 is a second order response with n = 2, in the CSO category. A spurious at frequency 2f2 - f1 has n = 3 and is a third order intermodulation response falling into the CTB category.

Cable TV systems and the measuring spectrum analyzer both generate CSO, CTB and other spurious intermodulation signals. Clearly, the spectrum analyzer performance must be better than that of the cable TV system under test to obtain a valid measurement. This is indicated by the spectrum analyzer dynamic range dB value.

Dynamic range (DR) is the dB difference between the smallest and largest signals that can be simultaneously observed or measured. For a sine wave, the smallest signal is determined by the basic system noise level:

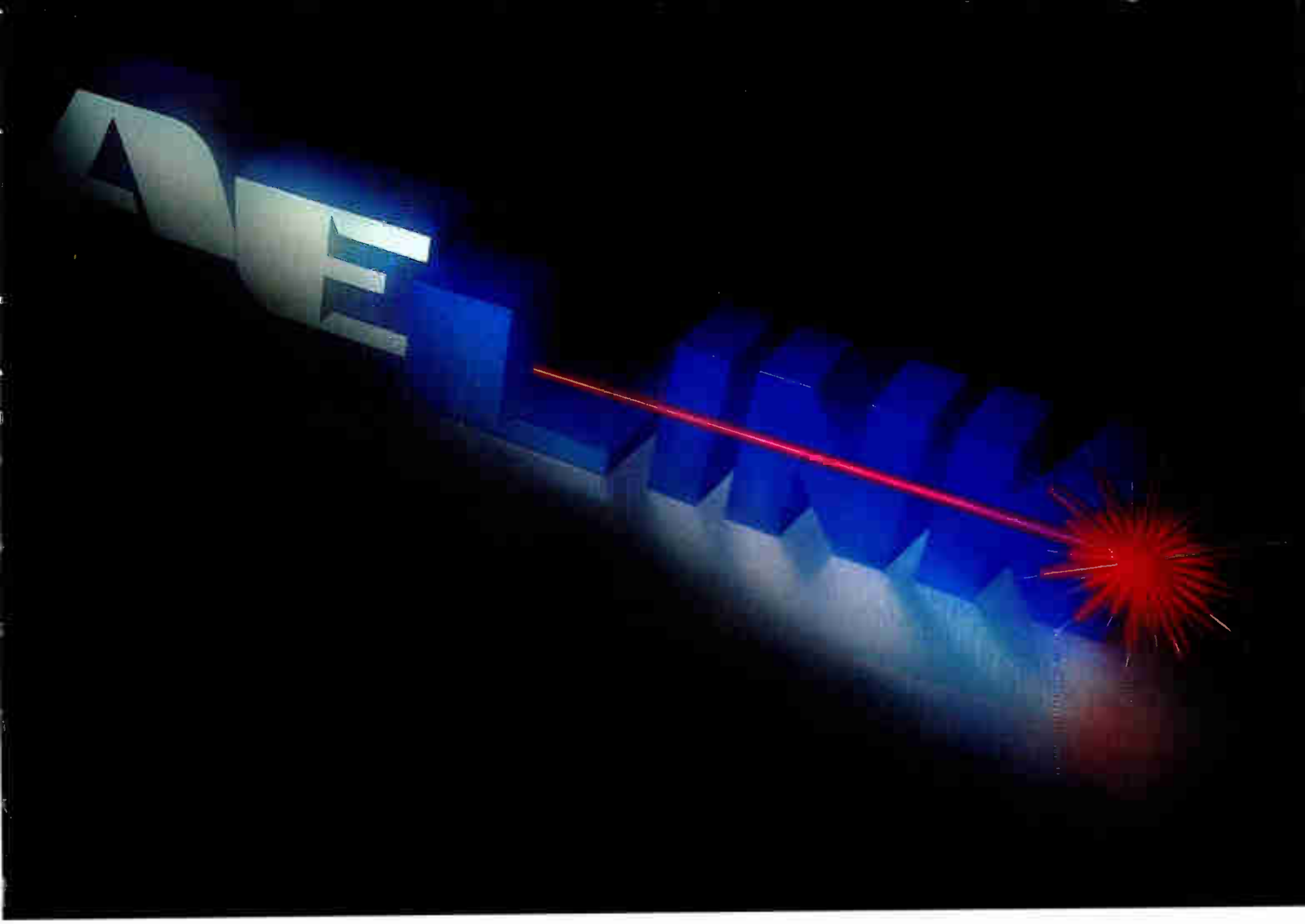
N = kTBF, where

kT = -174 dBm/Hz of noise bandwidth (B)
F = power ratio of the noise figure indicating the extra or excess noise of the system above the basic thermal noise power of kTB

The usual fundamental presentation of this relationship is dBm/Hz because dB compared to 1 milliwatt (dBm) normalized to 1 Hz is independent of application and can be used as a general expression. Cable TV systems usually deal with dBmV — dB compared to a millivolt at 75 ohms and normalized to a video bandwidth of 4 MHz — rather than 1 Hz. The conversion is: dBm + 49 = dBmV. (Most spectrum analyzers are designed at 50 ohms with input matching circuits for 75 ohm cable TV use. The conversion from dBm to dBmV may differ depending on the parameters of the matching circuit. The conversion is 48.8 dB for a lossless 75 ohm system. Various theoretical calculations that follow use dBm so as to avoid matching circuit loss issues.)

Four MHz is 10log(4 MHz) = 66 dB above 1 Hz. Thus, -174 dBm is the same as -125 dBmV, -174 dBm/Hz is -125 dBmV/Hz and -59 dBmV/4 MHz. Adding the excess system noise, FdB, will result in the smallest sine wave signal that can be observed or measured.

Assuming a lossless matching circuit, the following relationships hold: →



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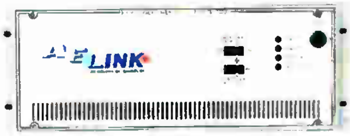

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Wavelength	1300nm	1300nm	1550nm

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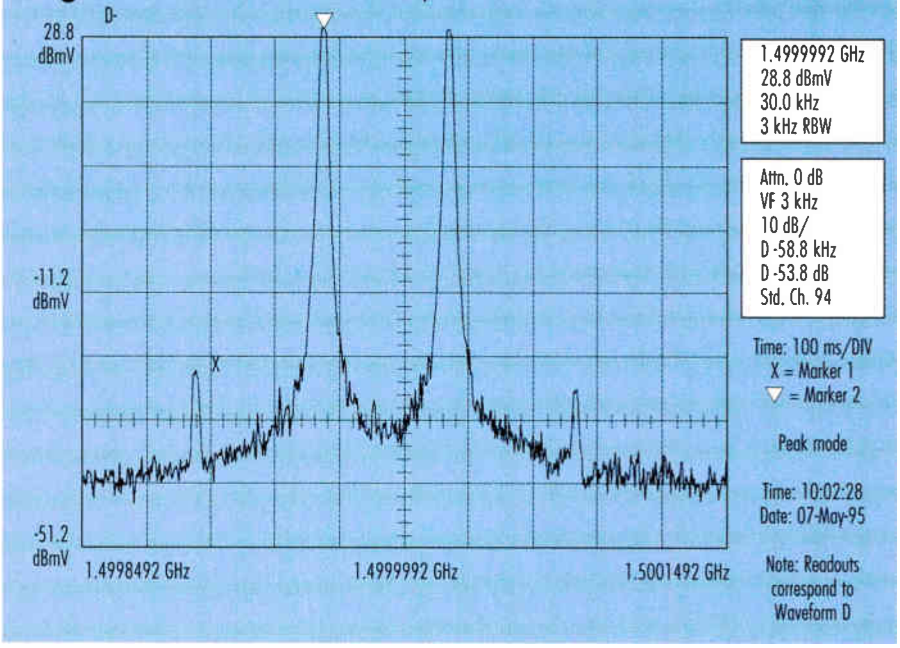
Figure 1: Two-tone intermodulation spectrum



- Conversion between 1 milliwatt (dBm) and 1 millivolt in 75 ohm (dBmV) is: dBm + 48.8 = dBmV, usually approximated as dBm - 49 = dBmV.
- The fundamental sensitivity noise level of a circuit equals -174 dBm/1 Hz of bandwidth. This is the same as -174 + 49 = -125 dBmV/Hz.
- To convert from 1 Hz to a different bandwidth, we add a bandwidth factor of 10log(BW). Thus, at 4 MHz, the bandwidth factor is 10log(4 MHz) = 66 dB. The basic sensitivity for a 4 MHz bandwidth is -125 + 66 = -59 dBmV/4 MHz.
- Excess noise and signal loss is indicated by the noise figure of FdB. Sensitivity is degraded by this amount. For F = 20 dB, the sensitivity is -59 + 20 = -39 dBmV/4 MHz.

The largest permitted signal is the amplitude that introduces a just barely observable spurious response. A larger signal will introduce a spurious response above the sensitivity level and reduce the dynamic range. The size of the large signal depends on the intercept point (I) of the circuits involved. Every circuit, or system, has its own intercept point, and no two need to be the same. Likewise, different spurious order numbers will yield differing intercept values for the same circuit. The intercept point is the hypothetical level where the spurious signal equals the input signal in amplitude. This can never be achieved in practice because the circuit will go into gain compression before this can happen. The intercept point is a useful indicator of circuit performance. The larger the intercept, the better the dynamic range of the circuit. The relationship is:

$I = DR/(n - 1) + S$, where

I = third order intercept point used in CTB calculations (dBm or dBmV)
S = input signal level in dBm or dBmV
n = spurious signal order number (n = 3 for CTB calculations)
DR = resulting dynamic range

Example: At I = 55 dBmV, S = 20 dBmV and n = 3, what is the DR?
I = DR/(n - 1) + S = 55 = DR/(3 - 1) + 20, DR = 70 dB.

Consider the result shown in Figure 1. The signal is at S = 28.8 dBmV (upper left readout), and the dynamic range difference between the signal and third order product is 53.8 dB (box right side). This yields a third order intercept of 53.8/2 + 28.8 = 55.7 dBmV or about + 7 dBm. The expected performance for such a spectrum analyzer is I = +5 dBm (54 dBmV). The measurement shows that the instrument performs better than this.

Clearly, the display settings for Figure 1 do not yield the best, or as it is known, "optimum" dynamic range. The amplitude level of the small spurious signal changes at n - 1, or 2x for n = 3, as the large signal changes level. This means that a 10 dB reduction of spectrum analyzer front-end attenuation will result in a 30 dB increase in third order distortion.

Reducing the large signal will provide a greater dynamic range until the small signal is just barely equal to the sensitivity at N = kTBF. After that, a reduction in large signal will reduce dynamic range since we cannot see the small signal below the sensitivity level. This leads to the relationship for optimum dynamic range:

$DRo = (n - 1)(I - N)/n$, where

N = spectrum analyzer sensitivity level

The sensitivity for this spectrum analyzer is specified at -78 dBmV without the internal preamplifier (-127 dBm) and the best specified two-tone third order dynamic range is computed as: (3 - 1)(5 + 127)/3 = 88 dB.

The actual result will be better because both intercept and sensitivity performance exceed specification. As an easy number to use for illustration, we will say that this spectrum analyzer has a 90 dB two-tone third order dynamic range. A 90 dB dynamic range is quite adequate for most applications. Unfortunately, this is based on the elementary case of just two carriers. The real cable TV signal has many more carriers and the composite third order, or triple beat spurious response, will be bigger and the dynamic range smaller.

The impact of multiple signals on CTB dynamic range cannot be precisely stated. The result depends on many variables. Some calculations and measurements are very device- and application-specific. Ha[1] shows that the CTB is only 22 dB down for a 200-carrier satellite system using a TWT amplifier. Nikkanen[2] optimizes his procedures specifically to a cable TV system environment. Calculations in Reference 3 listed at the end of this article are based on a worst-case analysis assuming phase coherence for maximum voltage addition of carrier levels.

Regarding a spectrum analyzer, as opposed to a TWT or specific cable TV distribution system, it is best to use a statistically neutral general procedure. Here we use calculations based on an analysis by Leffel[4], who assumes sta-

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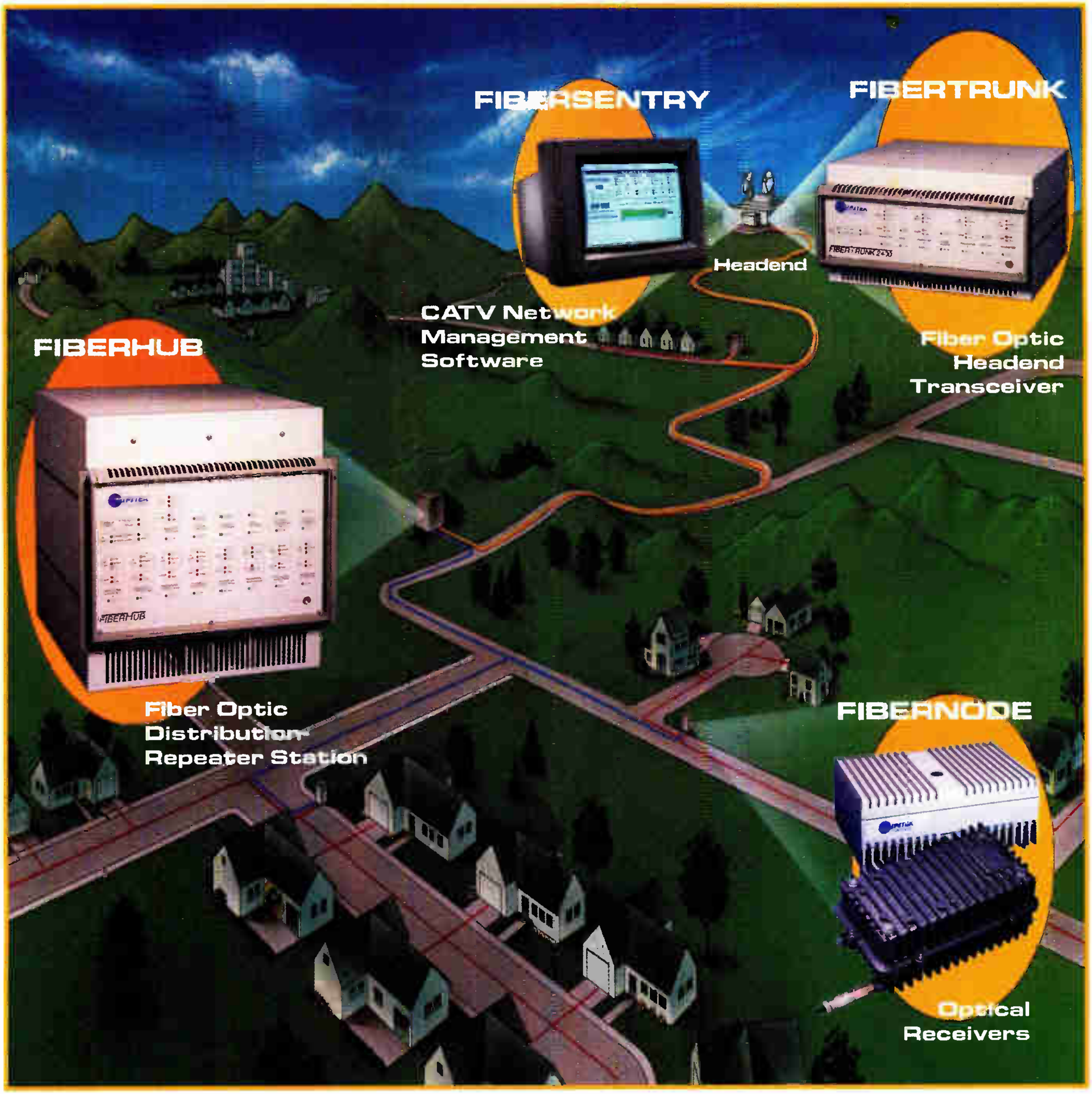

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tistically random phase distribution for multiple carriers. The reader would need to look at this reference to see all the details. But an easy set of numbers to remember is the "30 at 30 rule." We have near 30 dB CTB dynamic range loss for a 30-carrier system. Performance continues slowly to degrade by up to about 40 dB as the number of carrier tones goes up further. This means that total CTB performance could drop to an inadequate 90 - 40 = 50 dB.

Theoretically, we could get more dynamic range by going to a narrower resolution bandwidth and hence better sensitivity. But this will not work. Doing so would separate CTB components in frequency, except for those that fall right on top of each other. Normally, it is considered that a 300 Hz bandwidth is wide enough to combine all adjacent CTB components, while a narrower bandwidth might not. Hence, use of a more costly spectrum analyzer with a narrower bandwidth will not help here. There are few instruments with up to 100 dB two-tone dynamic range at a 300 Hz bandwidth. Those instruments are very costly and used primarily in basic R&D applications.

The illustrative example used here is the norm in cable TV. Nevertheless, the needed measurements can be made because actual spectrum analyzer performance is about 10 dB better than the just-calculated theoretical numbers for a high number of carriers (which will be discussed further in Part 2 of this article). Ultimately one can always use a preselector filter to limit the number of carriers impacting the spectrum analyzer to fewer than 30. Nevertheless, it should be clear that there is no dynamic range margin to spare. Consequently, it is important that the input signal level be set just right to achieve the optimum results where the CTB level is just barely at the spectrum analyzer sensitivity level. (Getting the best results from your spectrum analyzer will discussed in Part 2.)

Digital signals

The spectrum analyzer treats digital modulation signals as random noise, measured as a power density in dBm/Hz, or per 4 MHz or other bandwidth number. A critical difference for measuring analog signals is that the dynamic range does not depend on the spectrum analyzer resolution bandwidth. A change in resolution bandwidth affects the spectrum analyzer sensitivity noise level in accordance with N = kTBF, as discussed previously. The display amplitude of a sine wave carrier is not affected by the resolution bandwidth, hence carrier-to-noise ratio (C/N) and dynamic range depend on the choice of bandwidth.

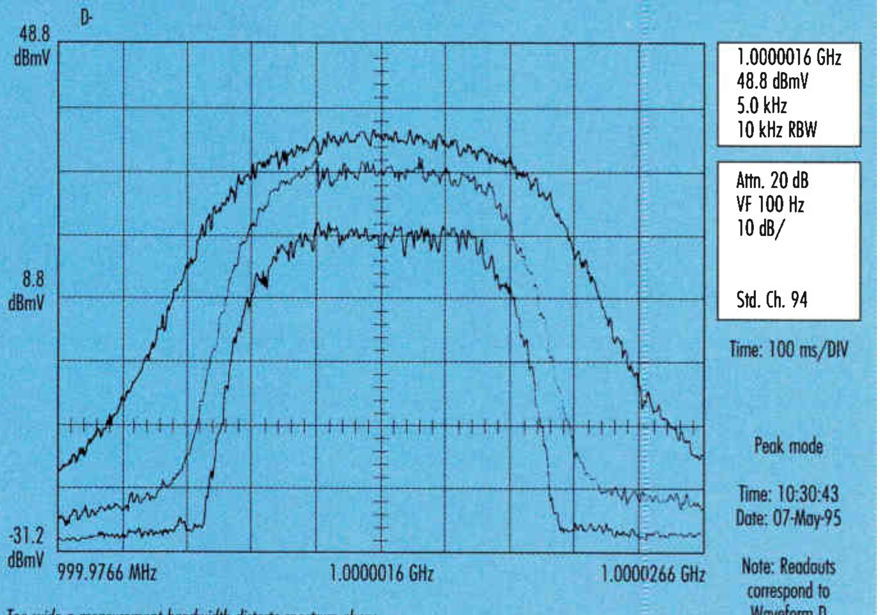
But the display level for a digital signal is dependent on the measurement bandwidth in the same way as the spectrum analyzer sensitivity noise. Therefore, a change in bandwidth will not affect the ratio of digital modulated carrier-to-noise power density or dynamic range. Rather the dynamic range depends on the excess noise of the spectrum analyzer measured by the dB of noise figure, FdB, for the "small signal," and the intercept point, I, for the large signal. This measure is known as the dynamic range factor (DRF). Thus: DRF = I - F

The reader will find many details respecting DRF in Reference 5 listed at the end of this article. All we need for this discussion is that the normalized dynamic range for digital modulation is given by (114 + DRF) dB/Hz of optimum bandwidth. We need to know two things to use this formula: the DRF and optimum bandwidth.

Using the Tektronix 2715 cable TV spectrum analyzer as an example, the DRF varies between -17 and -22 dB. We will use DRF = -20 dB. The optimum resolution bandwidth is the widest bandwidth that can be used that will yield the lowest dB loss in spectrum display amplitude for the digital modulated signal. This bandwidth can be calculated on the basis of the digital modulation signaling rate and it will result in a digital modulation amplitude spectrum spreading loss in dynamic range, compared to an unmodulated carrier, of about 20 dB (as discussed in Reference 5). Such a calculation is seldom made in actual measurements.

The simplest procedure is to increase the measurement bandwidth as wide as possible before the spectrum shape becomes distorted. This should be sufficiently close to the optimum bandwidth and is illustrated in Figure 2. The lowest trace was obtained at a 300 Hz bandwidth. The middle trace has the same shape, but is 10 dB higher, and was obtained at a 3 kHz bandwidth. The amplitude difference follows the relationship 10log(BW ratio) = 10log(3,000/300) = 10 dB. The upper trace was obtained using a 10 kHz bandwidth. It provides more amplitude than the middle trace, but the measurement is invalid because the spectrum shape is distorted at the skirts. The widest usable bandwidth for this digital modulated signal is 3 kHz. A 3 kHz bandwidth represents a 10log3,000 = 35 dB amplitude change

Figure 2: Spectrum of digital modulation signal



Too wide a measurement bandwidth distorts spectrum shape.

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compared to 1 Hz. Therefore the available dynamic range for this measurement is (114 + DRF)/Hz = 114 - 20 - 35 = 59 dB.

One very important point to note is that the measurement bandwidth does not have to be 3 kHz. This is just the widest bandwidth that can be used, and it is the bandwidth used in dynamic range calculations. Any narrower bandwidth will yield an equal dynamic range result, because the spectrum analyzer noise display level will drop at the same rate as the digital signal, and S/N will remain unchanged. This means that in a hybrid system, involving both analog and digital signals, you need to set the resolution bandwidth for the best analog signal dynamic range, provided it is not too wide for the digital signal. Otherwise, the bandwidth may have to be narrower than is usual for analog signal measurements. Or the measurement may have to be performed in two steps, once for the analog and once for the digital portion of the spectrum.

There are a number of variations in technique respecting the "best" procedure or "best" settings for dealing with a hybrid signal case. We can get to the final result in a number of ways that depend on the signal characteristics and your personal preference.

Measurement of most digitally modulated signals will allow a dynamic range calculation of 60 to 70 dB on a spectrum analyzer typically used in cable TV applications. The 59 dB example, shown previously, is toward the worst end of the range. Analog signals exhibit a calculated dynamic range for the difficult CTB measurement, which can be as bad as 50 dB. Fortunately, the theoretical calculation assumes that all circuits are impacted by all signal components. This is not the case for the spectrum analyzer, which includes variable bandwidth circuits and a time-varying signal due to a swept local oscillator. Hence, actual dynamic range performance is pretty much in agreement with the theoretical calculations for a relatively narrow spectrum width signal involving just a few carriers. But actual performance is better by about 10 dB than calculated, for a wide occupied spectrum involving a high number of channel carriers.

In all cases, the most critical instrument use factor is how to set the input amplitude level for optimum dynamic range results. These factors, and other examples on how to get the best dynamic range results for analog, digital and hybrid analog/digital CATV signals are discussed in Part 2 of this article. **CT**

Reader Service Number 220

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By Glyn Bostick, Ronald E. Mohar and Vince Cupples

Suppressing DPI — Part 2

This the second in a three-part series on direct pickup interference (DPI/DPU). Part 1 ran in December on page 54.

As we said in Part 1, with the introduction of "cable-compatible" TV receivers an increasing number of cable subs are victims of DPI. The problem also affects master antenna TV (MATV) systems. Most if not all of the TV receivers currently manufactured suffer from DPI under the right circumstances.

There are four key pieces of information critical to curing ingress: 1) identification of the interference as an ingress problem; 2) knowledge of the frequency; 3) knowledge of the source; and 4) knowledge of the ingress route.

Identification of DPI sources and frequencies can sometimes be helpful for a number of reasons. In cases involving harmonics and beats, it may be possible to suppress the problem at the source transmitter instead of at subscriber receivers. Secondly, identification of the source and its location can help the operator anticipate where subscribers may experience interference. Next, a knowledge of the frequency sometimes allows the operator to use devices specifically designed to suppress a targeted frequency or band. Finally, once DPI has been identified within an area, later testing can be abbreviated in other cases.

Ingress usually enters a circuit at a point of "discontinuity." The most likely point of entry is at the end of a signal path. The coax shield is not the only avenue through which ingress can enter a receiver. Ingress can enter equipment by either conduction or radiation. So, it is important to know the other avenues of ingress. It is equally important to be able to distinguish between DPI on the input cable and the other forms of ingress.

Glyn Bostick is executive vice president of Communications & Energy Corp. In 1967 he founded Microwave Filter Co. He later sold his interest in the firm and founded CEC.

Ronald E. Mohar is CEC's director of technical publishing.

Vince Cupples is a senior applications engineer with CEC.

The authors can be reached at (315) 452-0709.

• *Conduction.* There are three avenues through which interference can be conducted into a receiver. First, it can enter on the cable shield. Second, it can enter though the power supply on the power lines. Third, it can enter on ground leads. Most receivers have bypass circuits to prevent power line ingress. However, if the circuits are inadequate or a critical component malfunctions, ingress can result.

• *Radiation.* Interference can be radiated into critical circuitry through any openings in the tuner chassis. When interference is conducted into equipment on the shield, it is possible for the shield to emit signals. Signals propagated from the shield can enter the tuner through "tuning holes" in the tuner chassis.

The most practical diagnostic test for identifying DPI is to connect a converter box or coaxial shield filter to determine whether the problem clears or improves. In either event, additional technical investigation is usually necessary.

There are seven helpful diagnostic steps for gathering evidence about interference problems: 1) Describe the symptoms; 2) Classify the symptoms; 3) If possible, sub-classify the symptoms. 4) Analyze the symptoms; 5) Conduct appropriate diagnostic testing using the equipment controls; 6) Use deduction to fill in any information gaps; 7) Evaluate all the available evidence in relation to the specific system.

Once a preliminary test has revealed the presence of a DPI problem, three "channel scan tests" can develop additional information. The tests provide clues concerning the extent to which the problem is related to pick-up on the shield, the frequency of the interference, and the nature of the source. Notes should be kept while doing these tests to record the intensity of the interference on various channels.

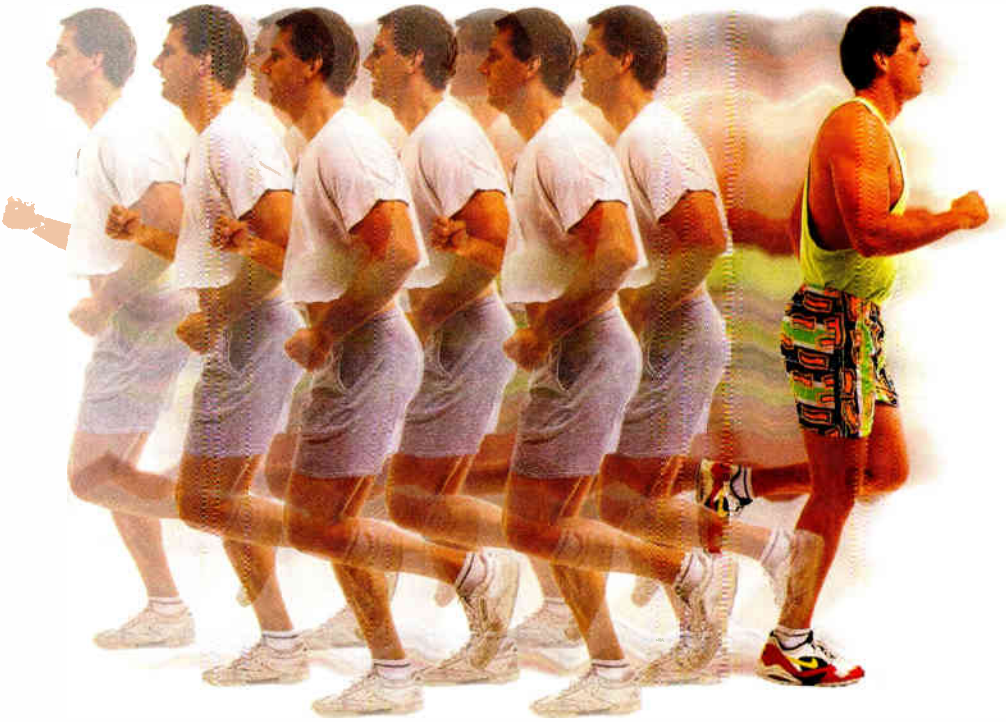
• *First test.* The objective of the first test is to determine the extent to which the interference is caused by DPI. Disconnect the coaxial input cable and do a complete channel scan. "Pure snow" on all channels indicates that the interference is not leaking into the receiver through some other route. Anything other than "pure snow" indicates that all or part of the interference is leaking into the receiver through some other route. The most likely avenue is through the power lines. This can be confirmed using an appropriate high quality power line filter.[1]

• *Second test.* The second test determines the extent to which the interference is being conducted into the shield. Scan all channels while touching the shield of the input cable to the shield of the receiver connector. Note any interference other than "pure snow." Anything other than "pure snow" indicates ingress.

• *Third test.* The third test measures composite interference. Reconnect the input cable and scan all channels. Estimate and record the intensity of the interference on each channel.

• *Coherent symptoms.* Studies indicate that coherent interference can occur whenever carrier-to-interference ratios are less than 35 to 40 dB.[2] Coherent interference occurs whenever signals of the same frequency enter the tuner and mix with signals from the cable. Whenever coherent symptoms are present, it is usually possible to analyze the content of the image to determine its source. Knowledge of the source allows determination of the frequency. As a matter of convention, coherent symptoms are sub-classified as either "ghosting" or "co-channel," even though both technically involve specific forms co-channel interference.

Ghosting occurs whenever two versions of the same signal reach the receiver at slightly different times. A faint ghost of the picture will be offset on the screen. Ghosting on a cable distribution network can be caused by multiple reflections at the headend antenna, distribution system ingress, echoes or DPI. →



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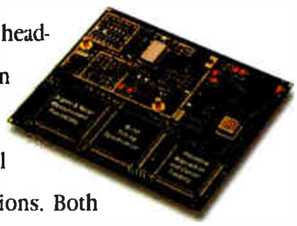

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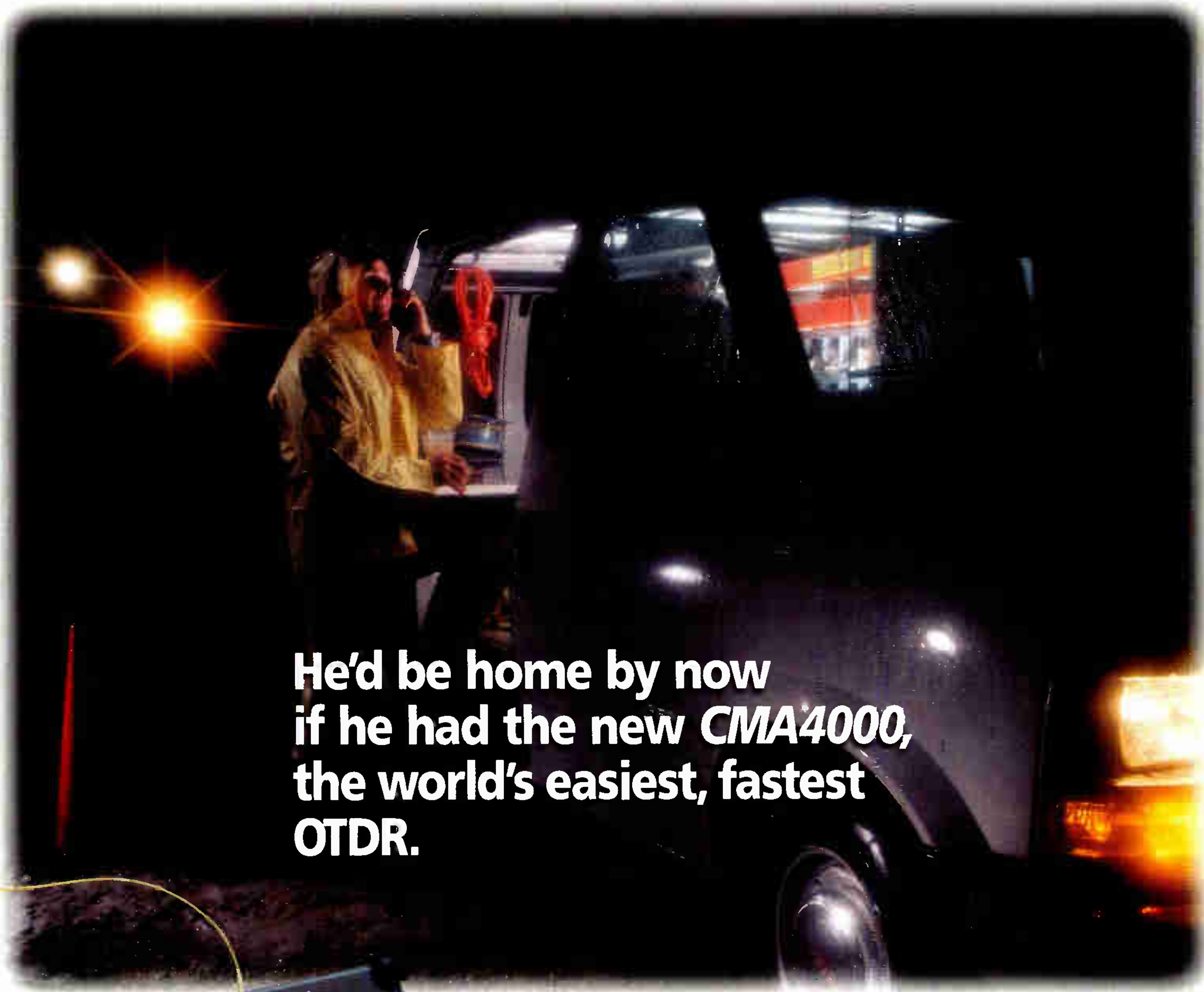

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Leading ghosts occur with DPI and network ingress. Lagging ghosts occur with multiple reflections at the antenna and network echoes. Since few if any cable operators distribute over-the-air programming on the same VHF channels used for broadcast, ghosting due to network ingress is rare on cable systems. However, some MATV systems (without sophisticated headends) distribute programming on their over-the-air channels. Multiple reflections at the headend are remedied before distribution.

Co-channel interference occurs whenever two completely different TV signals reach the receiver at the same time. The interference signals are weak creating a faint image of a different picture superimposed in the background. This is the most common form of coherent DPI.

On cable, co-channel interference can be caused by co-channel interference at the headend, distribution system ingress or DPI. Co-channel interference at the headend is usually remedied before distribution. If signals leak into a CATV distribution network, they will be processed just like the desired programming. Consequently, DPI remedy at the subscriber installation will not help. Identical coherent symptoms on all channels indicates that DPI may be leaking in on the VCR or converter box output cable.

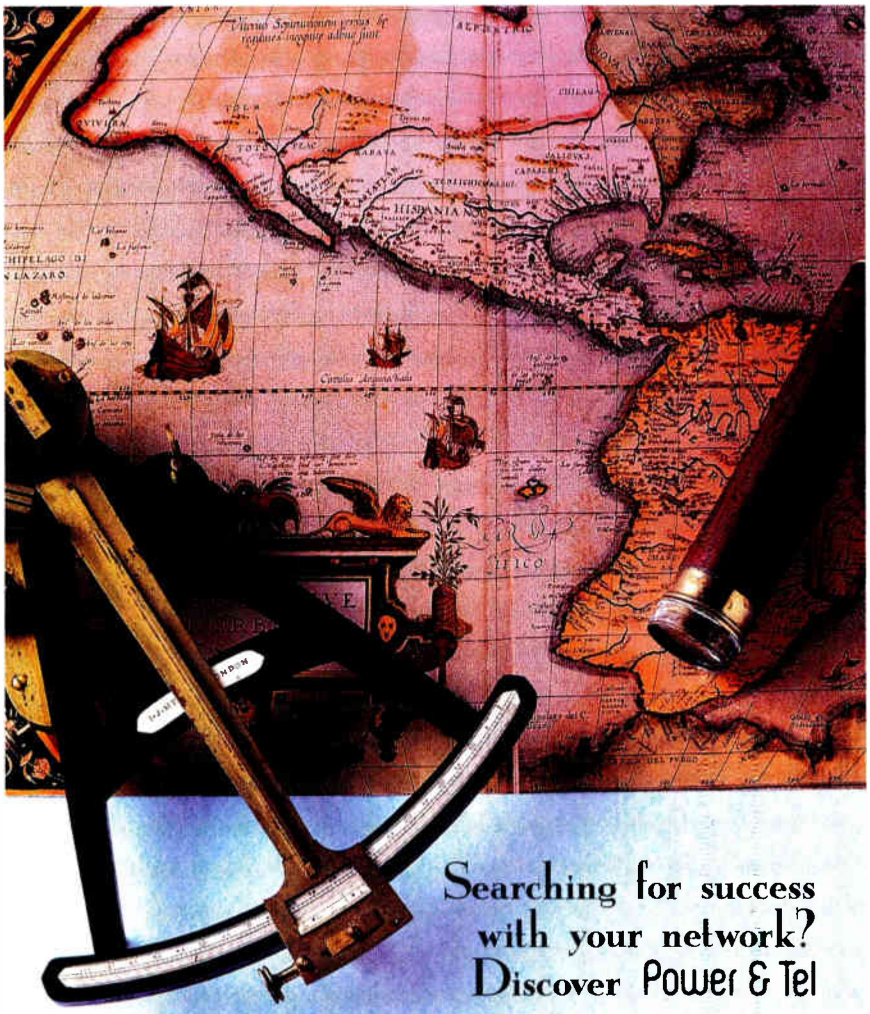
• *Noncoherent symptoms.* Studies indicate that noncoherent interference can occur whenever carrier-to-interference ratios are less than 55 to 60 dB.[2] Noncoherent symptoms can be caused by either a TV broadcast or some other type of transmitter. It occurs when TV broadcast frequencies differ from those of the cable system. Harmonics, sidebands, beat frequencies, intermodulation, cross modulation, adjacent channel interference, or co-channel interference can all cause noncoherent interference symptoms.

There are a large number of noncoherent DPI sources between 18 MHz and 450 MHz. Such sources are especially likely to cause problems if a subscriber is located in close proximity to the transmitter. Noncoherent symptoms should be evaluated using the channel scan tests outlined before. The interference patterns on the screen also should be evaluated. Stronger interference on certain channels may provide clues concerning the frequency of the source. A frequency chart may be helpful in deducing possible sources and frequencies.[3]

Co-channel TV signals with a frequency offset will sometimes be manifest as noncoherent interference. For example, over-the-air TV broadcasts mixed with IRC (incrementally related carrier) signals will usually cause horizontal beats. TV broadcasts mixed with HRC (harmonically related carrier) signals usually result in diagonal lines or color distortions.

In close proximity to a transmitter, noncoherent DPI also can be caused by FM broadcast transmitters, ham radios, CB transmitters, pagers, air navigation beacons, fixed/mobile transmitters or Harbor and Coast Guard transmitters. Ch. 20(G) is frequently affected by pagers.

If interference in the VHF low or VHF high bands is continuous or persistent, some type of a radio or TV



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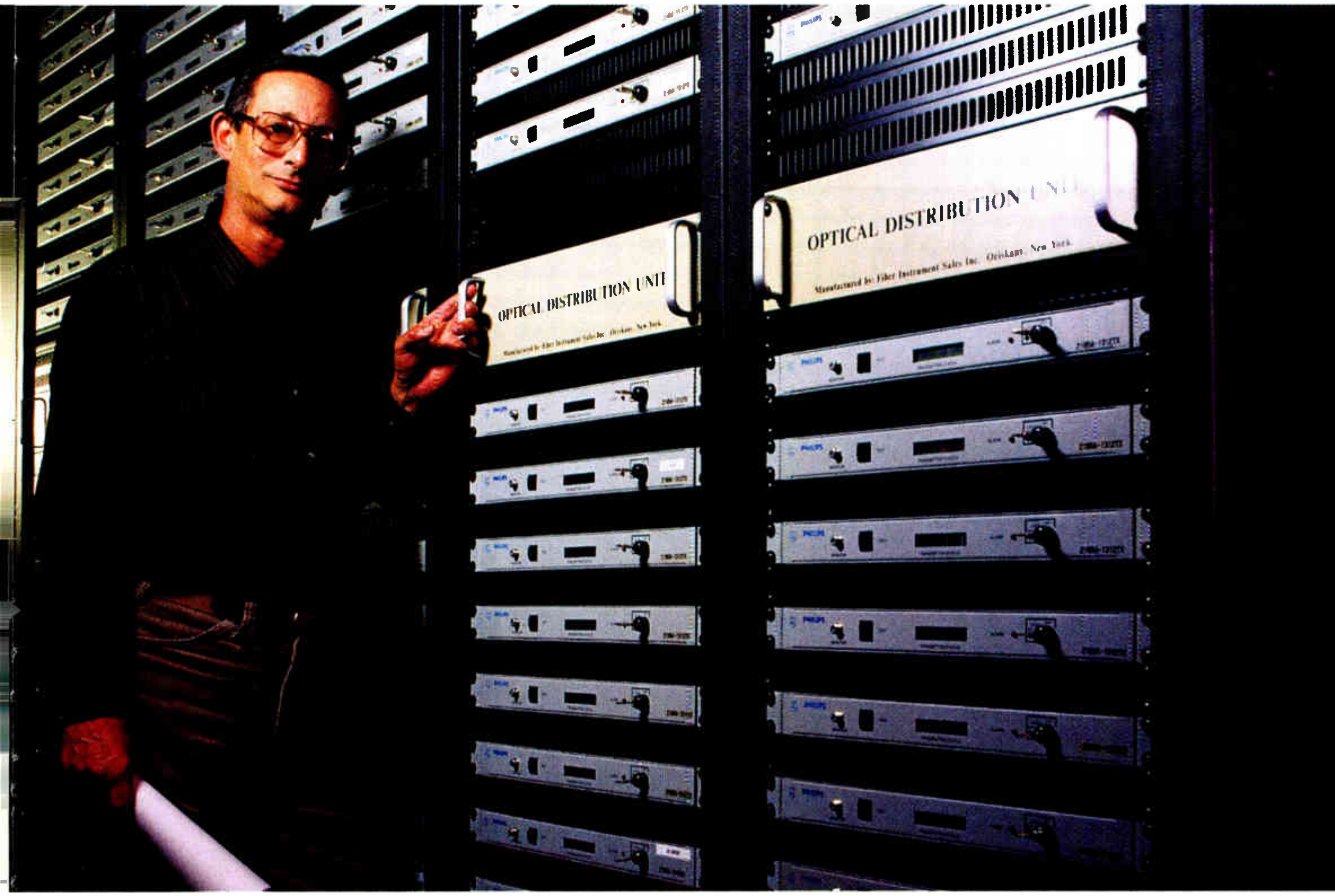

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broadcast transmitter may be indicated. On higher channels a radio navigation beacon may be the cause. FM broadcast transmitters usually cause herringbone affecting Ch. 6 and one other channel in the Chs. 2 to 13 spectrum. If the interference occurs intermittently, a two-way radio is indicated. CB transmitters usually appear as lines or bars in the picture affecting Chs. 2, 5 or 6.

Ham radio transmitters usually produce wavy lines or bars in the picture affecting chs. 2, 3, 4, 5, 6, 17(D), 18(E), 19(F), 23(J), 24(K), 57(UU), 58(VV), 59(WW), 60(XX) and 61(YY). A channel scan test may be helpful in identifying ham interference. For example, by sweeping through the spectrum using the channel selector it may be possible to identify which channels experience the most interference. If the strongest interference is noted on channels 17(D), 18(D) or 19(F), the evidence would imply a ham transmitter, because an amateur radio band is located between 144 MHz and 148 MHz. Harmonics from the 10-meter ham band (28 to 29.7 MHz) sometimes affect Chs. 2 and 6. Chs. 3 and 6 are sometimes affected by harmonics from the 15-meter band (21 to 21.45 MHz). Harmonics from the 20-meter ham band (14 to 14.35 MHz) often affect Chs. 2, 4, and 6.

Intermediate frequency (IF) ingress is indicated whenever interference is experienced on all channels at the same intensity. Most TV receivers have an IF in the 40 MHz band with video at 45.75 MHz and sound at 41.25 MHz. IF ingress occurs when signals leak into the receiver and pass through the tuner into the IF section of the receiver. Beat frequencies from the 6-meter (50-to- 54 MHz) ham band have reportedly caused this kind of problem.[4]

Similar problems also can be caused by a variety of other beat frequencies and harmonics. Interference from the 40-meter band (7 to 7.3 MHz) can affect baseband audio at 7.15 MHz. Signals from the 80-meter (3.5 to 4 MHz) and 160-meter (1.8 to 2 MHz) bands can affect base band video at 3.58 MHz and 1.79 MHz.

To the extent that optical systems are used, network ingress and echoes can be ruled out as possible causes of DPI like symptoms. **CT**

References

[1] Independent Federal Communications Commission tests demonstrate that Cornell Dubiler's power line filter #NF 1A 364-3 has exceptional suppression characteristics (more than 40 dB between 5 and 30 MHz). For published results see Ed Hare and Robert Schetgen, "Graph 47" in *RF Interference*, page 16-18. Our tests indicate that Archer's filtered power line strip and surge suppresser #61-2780 also has powerful suppression characteristics between 0.1 and 100 MHz.

[2] J.L. Stern, "Direct pickup interference," *Communications Technology*, July 1993, page 51.

[3] Magnavox CATV Systems, *Cable TV Reference Guide*.

[4] Charles L. Hutchinson, *ARRL Handbook*, pages 40-12, 40-13.

Part 3 will explore solutions for DPI along with advantages and disadvantages.

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By Ed Glover

Set-top connections

These are intense times for broadband telecommunications operators. With channel alignments, expanding pay-per-view (PPV) and near-video-on-demand (NVOD) offerings, and numerous consumer-friendly features added to addressable terminals, there is an ongoing need for education on how best to interface those terminals with the myriad of other consumer products available to subscribers.

The set-top terminal has an exciting new look and feel. Terminals can now be purchased with two tuner/descramblers built in. With an appearance more like home stereo systems, descrambling terminals are becoming more acceptable in consumer home entertainment systems. With on-screen displays, video-on-demand (VOD) and impulse/interactive technologies either here or on the near horizon, interfacing the set-top terminal to the VCR or over-the-air antenna system will become even more desirable for subscribers.

One of the more important steps in entering this new age of broadband telecommunications is helping system installers to better understand consumer products and how they will interface with RF and baseband addressable terminals. Installers are now required to know not only how set-top terminals connect to the home entertainment system, but how to connect new digital audio services through the stereo tuner and VCR.

Installers, typically, face a mild interrogation from subscribers. Will this converter work with my VCR? Can I watch one channel (premium or not) while taping another? What will I do if I want to watch television from one of my over-the-air channels using my antenna? All of these potential problems are solved by the use of various A/B switches.

Typically, the incoming cable is dropped into the "cable in" port on the converter, then connected to the TV set or monitor with either a baseband A/V signal or RF channel out to the RF input of the receiver. (See Figure 1.)

Another popular hookup, but one that limits the types of programs that can be recorded to unscrambled basic, is the "cable in" to a cable-compatible VCR. Cable-compatible VCRs usually have internal RF splitters that allow installers to connect to the cable converter. (See Figure 2.)

Many systems pass cable into the converter first, then pass the RF on a single channel directly to the VCR. If the converter is baseband, the A/V inputs to the VCR may be used. This is

Figure 1: Converter/TV set hookup

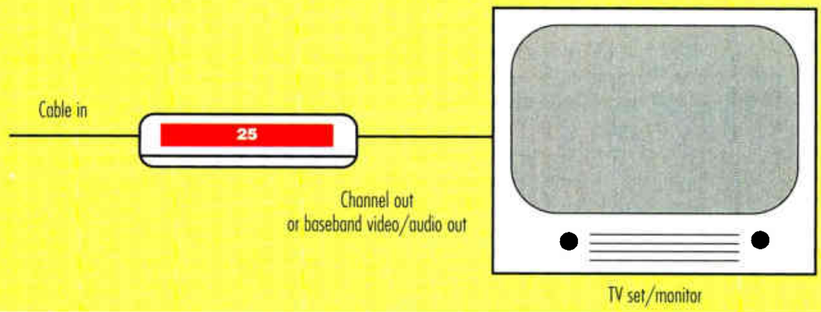


Figure 2: VCR/converter/TV set hookup

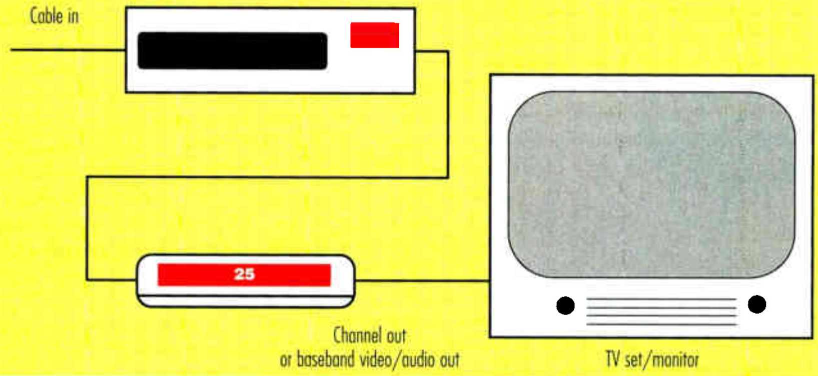
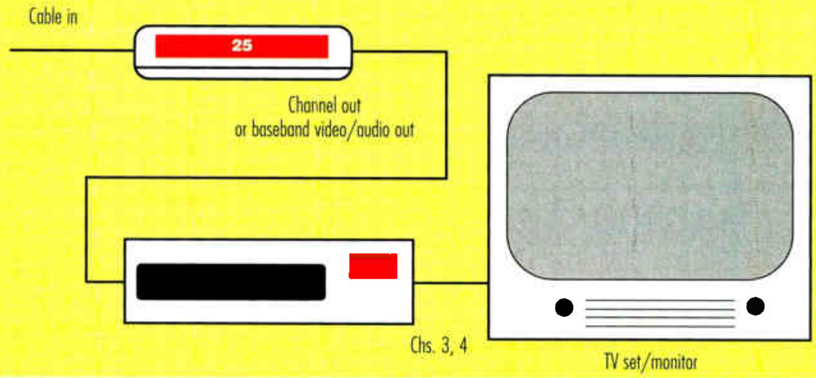


Figure 3: Converter/VCR/TV set hookup

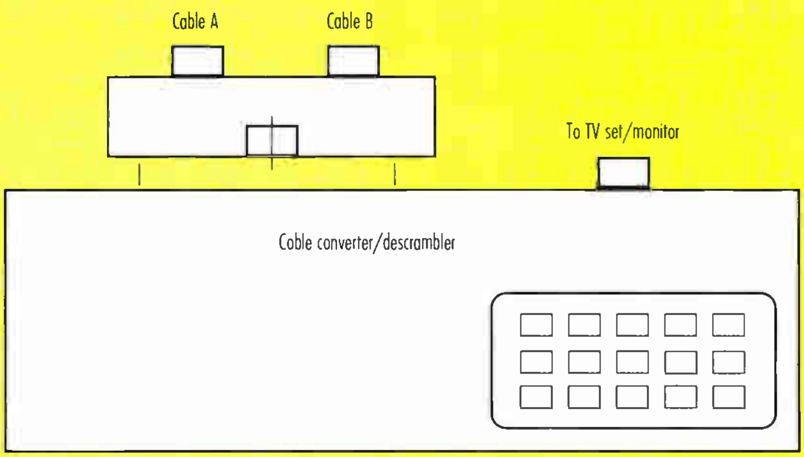


Ed Glover is a senior technical response center engineer for General Instrument's Communications Division.

preferable if customers use record-playback functions on the VCR much of the time. If a tape is played, it overrides what is being tuned by the VCR. This also eliminates problems with two-way RF converters that send sub-split return signals back to the headend via the RF input. There is no interruption from the tap to the converter. (See Figure 3.)

The A/B switch would allow many different configurations to be used with dual cable and/or consumer electronics equipment. Few systems use dual cable, but for those few who do, it could double the channel capacity in a cable plant to the converter. This means that converts must be able to switch between the A side and the B side. The switch, therefore, has two connectors. (See Figure 4.)

Figure 4: Dual cable setup

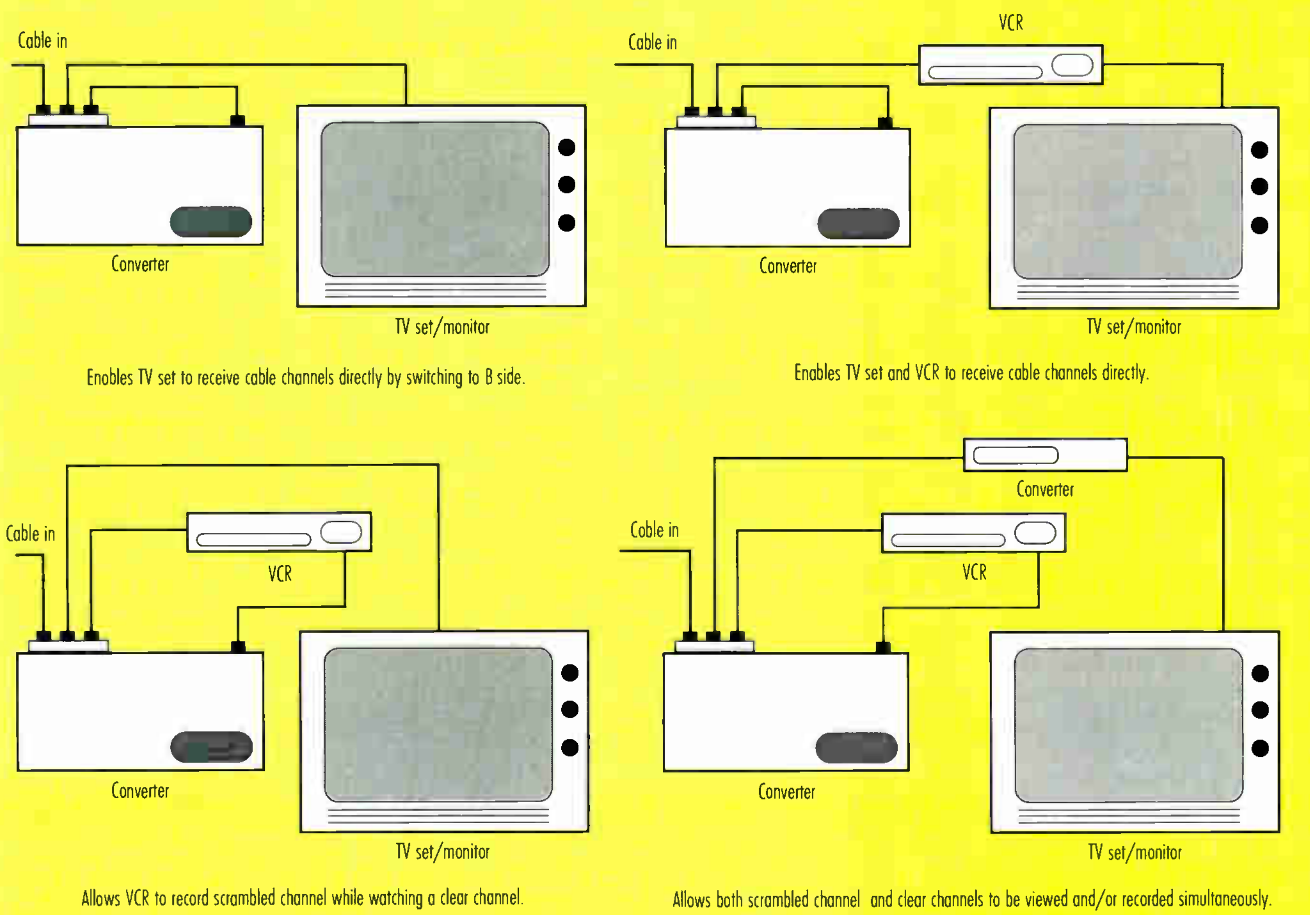


Another A/B switch type has three RF connectors. As shown in Figure 5, there is an RF input, RF output and the "converter in" port. In this use of the A/B switch, the addition of a third port allows a VCR to be added to the loop for recording of PPV events or the addition of a second converter.

Where there is a need to carry over-the-air channels, it is possible to use an A/B switch to allow over-the-air tuning or restore cable-compatible capabilities to a TV set or VCR.

The ability to interface consumer home electronics with broadband telecommunications services will only increase in importance as new programming services come on line. It will be the responsibility of the broadband systems operator — and most directly the in-home equipment installer — to make certain that these interfaces are seamless. **CT**

Figure 5: A/B switch with three RF connectors hookup



Cable modems

(Continued from page 51)

full-motion video a real-time experience. With a 10 million bit downstream connection, you can download information with greater efficiency," she explained.

Other communities are slated to come on line with the service shortly after the Sunnyvale launch. Specifically announced is Seattle, Marsik said, adding that priority markets for TCI also include the San Francisco Bay Area, Denver and Hartford, CT. Marsik had no specific rollout dates, but noted "these are locations that will see the service sooner rather than later."

Racing toward a standard

So the race is on for the development of new on-line services delivered over HFC networks. Clearly, what will help the industry embrace this new revenue source more completely would be a set of standards that all vendors could work toward — not only for specific pieces of network hardware, but for the interoperability of that hardware in broadband networks. Carly Fiorina, president of AT&T Network Systems, said in a teleconference late last year, "All of us are looking toward the day when companies will deliver the larger pipes that enable anyone from their home or office to enjoy services like Internet access, video-on-demand (VOD), home shopping, telephony, telecommuting and distance learning. Intelligent distributed broadband networks are needed to make this possible."

To that end, AT&T Network Systems and Hewlett-Packard have agreed to deliver a turnkey, end-to-end broadband network solution incorporating hardware, software and applications to telephone companies, CATV companies, and other communications and computing players. The two companies have launched their agreement with a joint offering for interactive broadband data networks that contains network elements, network and systems management software, computer systems, test instruments and cable TV modems. They, along with Intel and Hybrid Network Technologies, are part of the so-called "Broadband Link Team," announced during the 1995 Western Cable Show, which is developing interoperability specifications for broadband telecommunications equipment.

H-P's QuickBurst modem

What remains to be determined, however, is the effect the Broadband Link Team's efforts will have on the direction of the work CableLabs has undertaken on interoperability standards for cable modems and related technology. CableLabs is working with General Instrument, H-P, Intel, LANcity, Motorola, Nortel, Scientific-Atlanta, Toshiba and Zenith on the development of its own interoperability specifications. The hitch is, the earliest CableLabs expects to issue its standard is mid- to late-March, according to CableLabs President Richard Green.

H-P and AT&T Network Systems make no bones about their desire to have Broadband Link Team specifications become accepted as the industry's standard. "Our purpose is, through CableLabs, to make the Broadband Link Team's solution become *the* standard," said Wim Roelandts, senior vice president and general manager of H-P's Computer Systems Organization, during the teleconference with AT&T's Fiorina. Even so, Roelandts acknowledged that the standards-setting process has to be an industrywide effort. "Product development is going simultaneously with standards development," Roelandts said. "If there will be any deployment in the next six months, we will use whatever standard is available at the time, then upgrade the equipment. In the short term, we are looking at rapid deployment for test trials, where we can adapt later on before we go into broad deployment."

Clearly, the industry will benefit from an interoperability standard for PC interconnectivity, and CableLabs welcomes the Broadband Link Team's involvement, said CableLabs President Richard Green. He was quick to point out, however, that "We (CableLabs) are working on the specification for cable."

"(The Broadband Link Team) is working to develop technology so they can have input into what will become the final standard," Green said, adding, "The cable industry is the purchaser here. We're developing the purchasing specifications." Green confirmed working with the Broadband Link Team but noted, "we're working with everybody to come up with a universal specification. Two or three companies can't just get together and decide what the cable industry is going to do."

Green acknowledged basic agreement among participants in their standardization efforts in some areas, but pointed out that

HOMEWorks by Zenith

there is "still a lot of work to be done, especially on the modem to the headend link. That's one where there's no existing standard." Preliminary specifications may come as early as March 15, according to Green, but all the details may not be available until later. "We're on a very fast track," Green maintained. "The idea is to get hardware as soon as possible. Remember, this is intended to be an international standard. If it gets off to a good start here, it has a good chance of being adopted internationally."

(*Editor's note:* In the next installment of this look into data delivery via cable modems, *Communications Technology* will explore how this new technology is brought into the home, and why some companies say the next logical step in the process is "overbuilding the Internet.") **CT**

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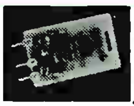

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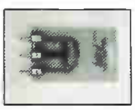

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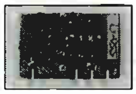

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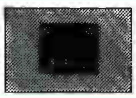

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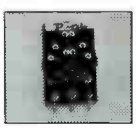

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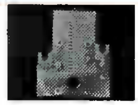

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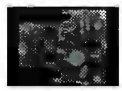

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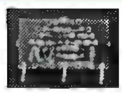

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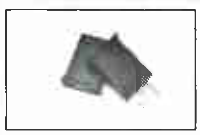

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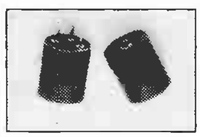

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Cable modems and high-speed data

This month's product focus is on cable modems, the hot topic at the Western Show '95. For an in-depth look at the trend, see Alex Zavistovich's article on page 50.

Zenith

Zenith Electronics announced a family of cable modems that will deliver up to 40 Mbps of digital data over a 6 MHz cable channel. Zenith has joined forces with Cisco Systems Inc., a leading supplier of internetworking solutions.

The company says its flexible bandwidth-on-demand system will allow cable operators to provide high-speed data services to tens of thousands of subscribers simultaneously, at speeds as much as 1,500 times faster than today's fastest telephone-based modems. This will make more advanced multimedia applications available, including very high-speed Internet access and videoconferencing.

Versions for 40 Mbps data delivery will be available for 16 VSB (vestigial sideband) and 256-QAM (quadrature amplitude modulation) cable systems. The 16-VSB digital modulation was developed as part of Zenith's high definition TV (HDTV) research, which was recommended by the HDTV Grand Alliance system to the FCC. The flexible architecture also has been designed to work with 64 QAM transmission technologies.

For upstream data, Zenith plans to offer a range of options and speeds, including both telephone and RF (radio frequency) return path technologies. Its upstream data rate will be adaptable to user requirements with a maximum rate of 10.76 Mbps using a CDMA spread spectrum modulation.

Reader service #312

Antec

Antec introduced a low-cost T-1 modem that gives cable operators a chance to try out interactive services with minimal cash outlay. The modem allows cable operators to provide point-to-point telecommunications services over hybrid fiber/coax infrastructure.

Headend and customer premise modem units allow for up to 24 individual voice or data channels. Applications include long distance access, data connectivity, distance learning or private networking, as well as traditional video services.

Reader service #311

Westec

Westec Communications unveiled a high-speed frequency agile universal data modem that transmits data, T1, E1, T2 and E2 over AM/FM fiber, broadband coaxial cable and microwave. The unit uses data rates from 56 kbps to 10 Mbps.

Reader service #310

Reader Service Number 223

LANcity

LANcity Corp. announced a 750 MHz cable modem system, citing the cable industry's recent standard increase for channel space from 550 MHz to 750 MHz to accommodate new services. The company correspondingly increased its product line's frequency so that cable modem services can be deployed across the widest possible bandwidth.

The new equipment is based on the company's existing cable data equipment, which is currently capable of delivering 10 Mb/s upstream and downstream across the network. The headend equipment for a 500-node system costs less than $10 a subscriber.
Reader service #309

ADC

ADC Telecommunications rolled out its new cable data delivery system, made possible by adding a family of cable data modems to its multiservice hybrid fiber/coax (HFC) architecture Homeworx system. Homeworx is designed to deliver the complete gamut of analog and digital services from broadcast and interactive video to voice and data telephony.

The cable data modems support fully symmetrical service, providing the needed upstream capacity for services such as videoconferencing, as well as security at the physical, data and network levels. The units are available in both low- and high-speed versions and in single or multi-dwelling configurations.
Reader service #308

Scientific-Atlanta

Scientific-Atlanta announced its high-speed data communications system, designed to be capable of rates up to 27 Mbps utilizing its digital communications terminals and digital headend equipment.

The system is built upon the company's 65-/256-QAM modulators and QPSK demodulators supported by an advanced digital network control system. All operate over an economical HFC network.

By operating at data rates of up to 27 Mbps, S-A says the modem would significantly outperform current modems for high-speed access to the Internet, FTP (file transfer protocol), World Wide Web and on-line services with their increasingly video and graphics-rich home pages and other multimedia applications.

The modem is planned to operate nearly 1,000 times faster than current 28.8 kbps modems, and many times faster than an ISDN (integrated services digital network) line, which operates at 128 kbps.
Reader service #307

General Instrument

The best way for cable operators to ride the wave of growing PC use, GI maintains, is with the company's new SURFboard broadband connectivity solution. SURFboard uses 64 QAM downstream transmission with MPEG-2 compression, delivering 27 megabits/s of information on a single 6 MHz cable TV channel. A user-supplied telephone modem return path enables users to initiate sessions and make requests to network gateways and Internet servers.
Reader service #306

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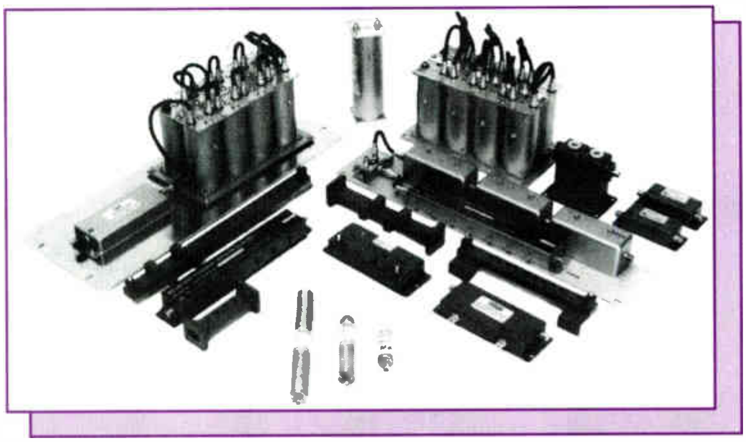

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Reader Service Number 224

By Alan Gordon

Adding return path analysis to your HFC plant

As hybrid fiber/coax (HFC) networks evolve to carry new revenue generating services, a robust return path is a requirement. Ingress and noise on the return path frequencies where these services are carried can result in disruption of service (telephony, cable modem, set-top messaging, etc.) and can result in loss of revenue and possibly rebates to customers. The challenge for cable operators is to quickly identify sources of ingress and noise on the return path, and then take steps to either eliminate the source of the noise or move services to quieter frequencies.

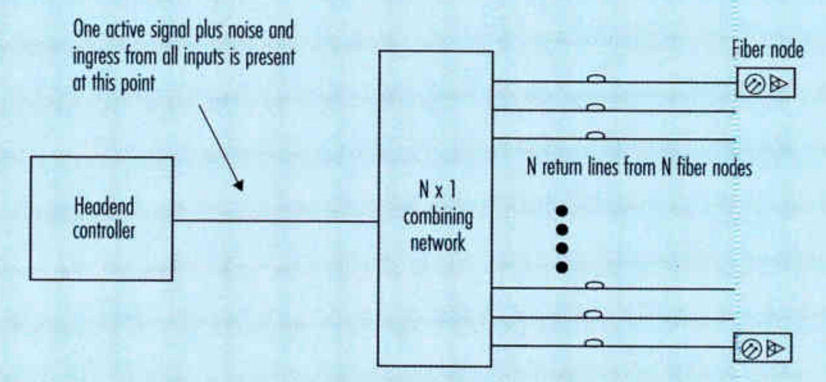
Current two-way cable systems combine large numbers of return paths from many fiber-optic nodes, as shown in Figure 1. At the point where all the return paths from each of the nodes are combined, their collective noise and ingress also is combined.

This combined noise causes two problems: Services such as set-top traffic, telephony or data modem traffic may experience interference, bit errors or be totally disrupted. Also, network monitoring systems may lose communications with devices in the field. (The headend controller may have difficulty hearing the polling responses from transponders in the plant.)

Operators typically try to overcome this combined noise problem by running their return communications at higher output levels. This can potentially cause clipping in the return laser, which may result in loss of communications as well.

Alan Gordon is director of the analog video systems business unit of Superior Electronics Group Inc.

Figure 1: Combining multiple return paths



Locating the noise

The traditional approach to identifying the source of noise in the return path is to use a combined strategy of spectrum analysis at the headend and hand-held portable test equipment in the field. A spectrum analyzer deployed in the headend can only measure the composite noise level, not the noise coming from each individual node, unless the operator is prepared to shut off legs of the network. A composite noise level does not accurately relate the noise characteristics on individual nodes, and does not point the operator directly to the offending node.

Searching for noise and ingress manually throughout the system is a trial-and-error process that is time-consuming, costly and—for large networks—impractical.

When telephony traffic is being disrupted, the mean time to pinpoint the exact location of ingress must be seconds, not hours or days. Once the source of the ingress or noise is known, individual legs of the return path may be shut down and truck rolls can be targeted to the source of the problem.

Automated approach

To locate and isolate the source of noise and ingress in the return path in seconds, it is obvious that an automated approach is required. The search for potentially disruptive interference in the return path must go on 24 hours a day, seven days a week.

In addition to immediate location and isolation of the noise source, a seamless tie-in to popular geographic information system (GIS) mapping, trouble-ticketing and fleet maintenance software is needed to initiate an immediate truck roll directly to the source of the problem.

The most effective way to search, detect, and trouble-ticket the source of noise and ingress on the return path is to integrate

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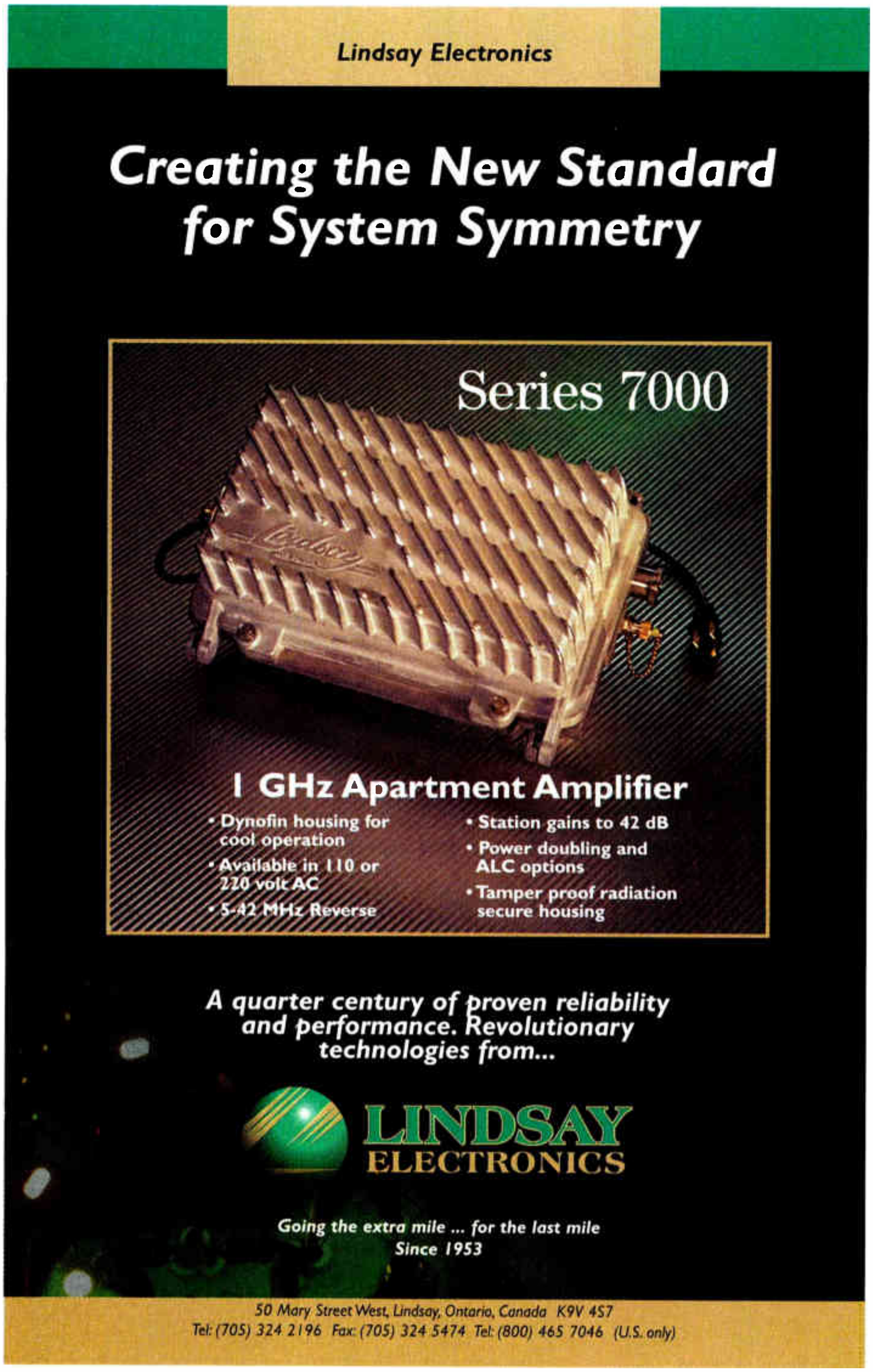

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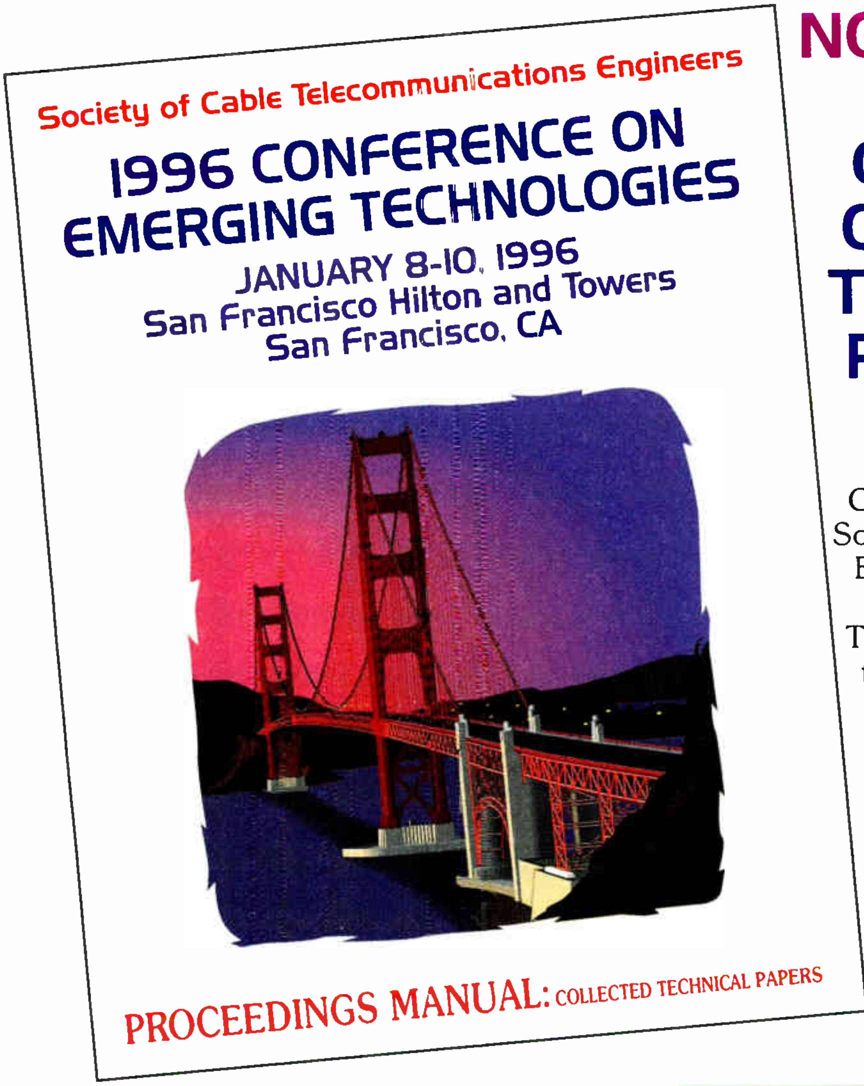

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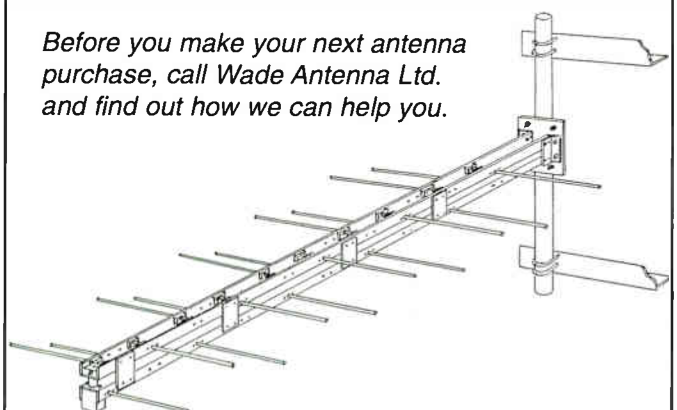

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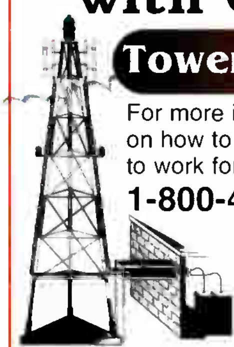

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6-7: Arizona Cable Television Association Show, Doubletree Suites Hotel, Phoenix, AZ. Contact (602) 955-4122.
7: SCTE West Virginia Chapter annual meeting and technical program, Ramada Inn, South Charleston, WV. Contact Steve Johnson, (614) 894-3886.
8: ADC Telecommunications T1 Technology Seminar, Minneapolis. Contact Katie Eastman, (800) 366-3891.
8: SCTE Satellite Tele-Seminar Program, *Inside FCC Form Processing*, videotaped at Cable-Tec Expo '95, to be shown on Galaxy 1R, Transponder 14, 2:30-3:30 p.m. ET. Contact SCTE national headquarters, (610) 363-6888.
8: SCTE Hudson Valley Chapter seminar, broadband TV applications and connectors, and cable security procedures, Century House Inn, Latham, NY. Contact Robert Price, (518) 355-3086.
12-13: The Cable Television Association of Georgia Annual Convention, Westin Peachtree Plaza Hotel, Atlanta. Contact Patti Hall, (404) 252-4371.
12-13: SCTE seminar, *Introduction to Telephony*, the basics of telephone system operations, telephone networks and customer equipment for cable TV personnel, along with various interconnect and service options, Milwaukee. Contact SCTE national headquarters, (610) 363-6888.
13-14: Idaho Cable Telecommunication Association winter meeting, Boise, ID. Contact (208) 375-7836.
13-15: SCTE Wheat State Chapter meeting, BCT/E exams to be administered, Wichita, KS. Contact Joe Cvetnich, (316) 262-4270.
14: SCTE Dakota Territory Chapter seminar, headend video and subscriber proofing, Mandon Service Center, Bismark, ND. Contact Tony Gauer, (605) 426-6140.
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15: SCTE Michiana Chapter seminar, BCT/E Category III, transportation systems, Comfort Inn, New Buffalo, MI. Contact Russ Stickney, (219) 259-8015.
16: SCTE North Country Chapter meeting, BCT/E and Installer exams to be administered, Columbia Heights, MN. Contact Bill Davis, (612) 646-8755.
21: SCTE New England Chapter meeting, Installer exams to be administered, Worcester, MA. Contact Tom Garcia, (508) 562-1675.
21-23: Texas Cable Show, San Antonio Convention Center, San Antonio, TX. Contact (512) 474-2082.
22-23: ATM '96, Orlando, FL. Contact Sheri Mead, (312) 540-3859.
23: SCTE Wheat State Chapter meeting, BCT/E exams to be administered, Great Bend, KS. Contact Joe Cvetnich, (316) 262-4270.
25-Mar. 1: OFC '96, San Diego. Contact (202) 223-8130.
27: SCTE Desert Chapter meeting, BCT/E and Installer exams to be administered, Palm Desert, CA. Contact Bruce Wedeking, (909) 677-2147.
28-29: North Carolina Cable Telecommunications Association winter meeting, legislative and technological issues, Washington Duke, Durham, NC. Contact (919) 834-7113.

March

4-5: SCTE seminar, *Introduction to Telephony*, telephone system operation basics, telephone networks and customer equipment, various interconnect and service options, Oconomowoc, WI. Contact SCTE national headquarters, (610) 363-6888.
6-8: SCTE seminar, *Introduction to Fiber Optics*, general fiber optics, fiber-optic systems and fiber-optic test equipment, Oconomowoc, WI. Contact SCTE national headquarters, (610) 363-6888.
14: SCTE Satellite Tele-Seminar Program, *NEC, NESC and OSHA Regulations (Part I)*, videotaped at Cable-Tec Expo '92, to be shown on Galaxy 1R, Transponder 14, 2:30-3:30 p.m. ET. Contact SCTE national headquarters, (610) 363-6888.

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Reader Service Number 226

By Bill Riker

Have your say — Vote!

By now, most SCTE members should have received their 1996 election packages, so I would like to take this opportunity to express the importance of your participation in the Society's election process. The Society's board of directors, committees, subcommittees and national headquarters staff are here to serve you. But we need your input to do so properly.

Not only is it important that all members vote, but it also is vital that you fill out and return the member survey enclosed in the election package. We read every completed survey and take your comments and suggestions very seriously.

Over the last five years, member participation in board elections has been steadily declining, as indicated by the accompanying chart. For those who feel your one vote won't make a difference, I'd like to share with you some facts from an article by Sharon Barnes that appeared in *Uniformed Services Journal:*

- It was one vote in 1776 that decided English would be the language of America rather than German.
- Texas was brought into the Union in 1845 by only one vote.
- Adolph Hitler gained control of the Nazi party in 1923 by one vote.

With regard to the election, members should only vote for representatives within their own regions. If your regional director's term is not about to expire, then you do not vote for a regional director. Every member, however, should vote for the open at-large director position regardless of region.

The following seats will be open for the 1996-1998 term election: At-Large Director, representing the entire U.S.; Region 3 Director, representing AK, ID, MT, OR and WA; Region 4 Director, representing OK and TX; Region 5 Director, representing IL, IA, KS, MO and NE ; Region 7 Director, representing IN, MI and OH; Region 8 Director, representing AL, AR, LA, MS and TN; Region 10 Director, representing KY, NC, VA and WV; Region 12 Director, representing CT, MA, ME, NH, NY, RI and VT.

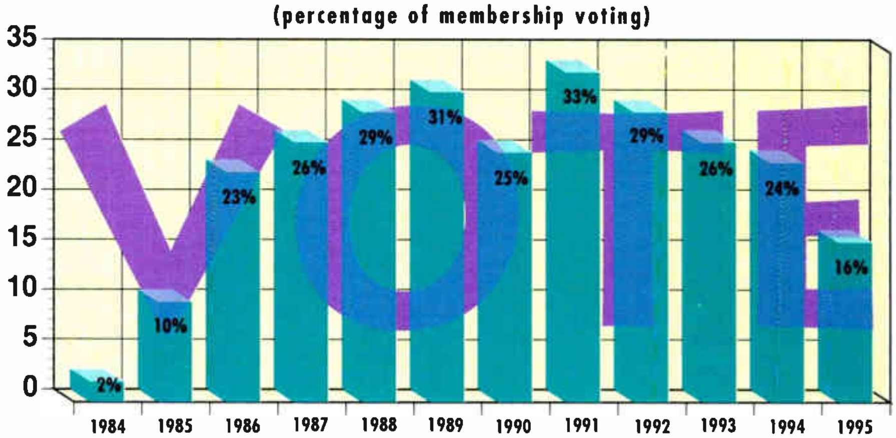
The following directors were elected last year to serve 1995-1997 terms and will remain in office until our 1997 election: At-Large Director, Wendell Bailey, representing the entire U.S.; At-Large Director, Wendell Woody, representing the entire U.S.; Region 1 Director, Patrick O'Hare, representing CA, HI and NV; Region 2 Director, Steve Johnson, representing AZ, CO, NM, UT and WY; Region 6 Director, Robert Schaeffer, representing MN, ND, SD and WI; Region 9 Director, Hugh McCarley, representing FL, GA, SC and the Caribbean; Region 11 Director, Dennis Quinter, representing DE, MD, NJ and PA.

Included in the election package is a referendum vote proposed by the board. The proposal is to amend our current national bylaws to ensure that: 1) Regional directors remain in the region they were elected to represent; 2) Board nominees have had sufficient tenure as SCTE members; and 3) The board will not be dominated by any one company. I urge you to read the information on the back of the ballot and vote on this proposed amendment.

Also included in the package is an entry form for the 1996 Field Operations Award. The innovative spirit of this competition manifests itself in the creative and ingenious inventions and improvements developed by industry members. First, second and third place prizes will be awarded, and all entries will be published in *Interval*. Entries must be received before March 1, 1996, so if you have something you would like to submit, send your entry in soon to the new SCTE national headquarters: 140 Philips Rd., Exton, PA 19341-1318.

Additionally, the election package contains a calendar of SCTE national events to be held in 1996, including our Conference on Emerging Technologies and Cable-Tec Expo, Satellite Tele-Seminar Programs, and regional seminars.

SCTE ANNUAL ELECTION
(percentage of membership voting)



On the reverse of the calendar sheet, you'll find a flyer on Cable-Tec Expo '96. Don't forget to mark your calendars for what is sure to be the best Expo yet! It will be held June 10-13 at the Opryland Hotel in Nashville, TN. Four engineering conference sessions will be offered, as well as 10 breakout workshops focusing on timely technical issues. In addition, the Society is expecting over 350 hardware vendors to exhibit on the 1996 exhibit floor. Expo registration packages will be mailed in March.

I urge you to participate in these valuable SCTE activities, and thank you for your support and feedback. **CT**

Bill Riker is president of the Society of Cable Telecommunications Engineers.

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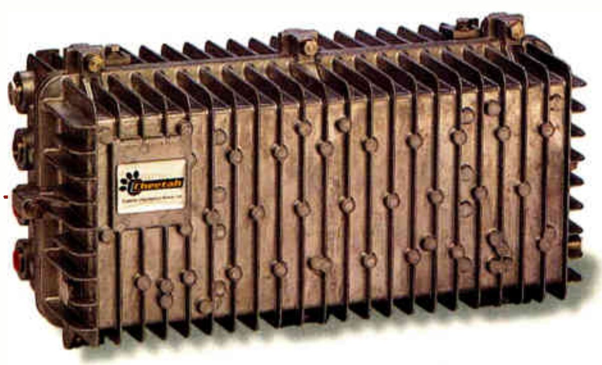

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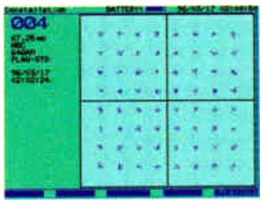

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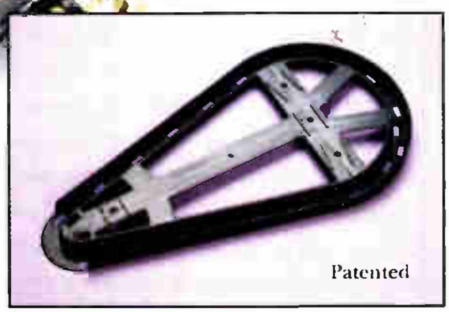

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