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Official trade journal of the Society of Cable Telecommunications Engineers

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March 1997


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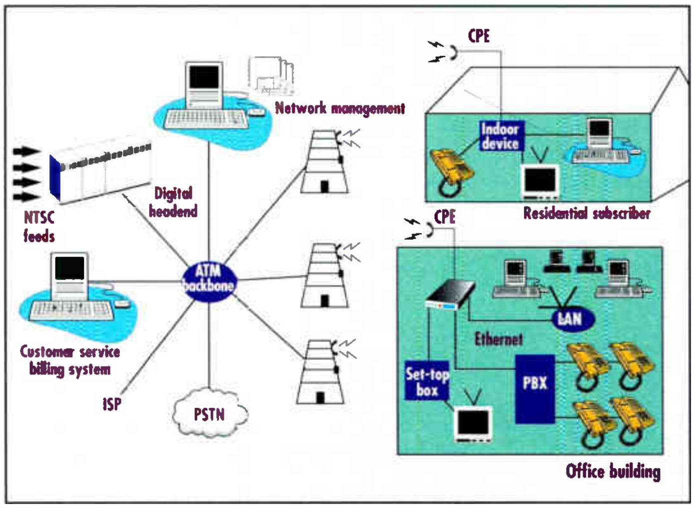

FEATURES

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Interviewing our engineers

In this issue of *Communications Technology* we begin a new effort to allow technicians and engineers to express their opinions about their jobs, new technology and the future of telecommunications.

My first interview (see page 20) was with Jim Chiddix, chief technical officer with Time Warner Cable. I asked Jim to be first because he is one of the leading industry engineers and always is involved in any study, test or application of new technology.

"I want to give all of you the opportunity to be heard."

Lately, with all of the criticism from Wall Street and the national media, I feel our morale can stand some boosting—although the engineering community certainly should not be held accountable for others who were told, "With laboratory testing, changes in specifications and efforts toward standardization, these new services can be introduced to the telecommunications systems," but heard, "These new services can be available this year." I believe the interview with Jim will help both the engineers and the system owners feel more comfortable with our future and with the successes we had last year.

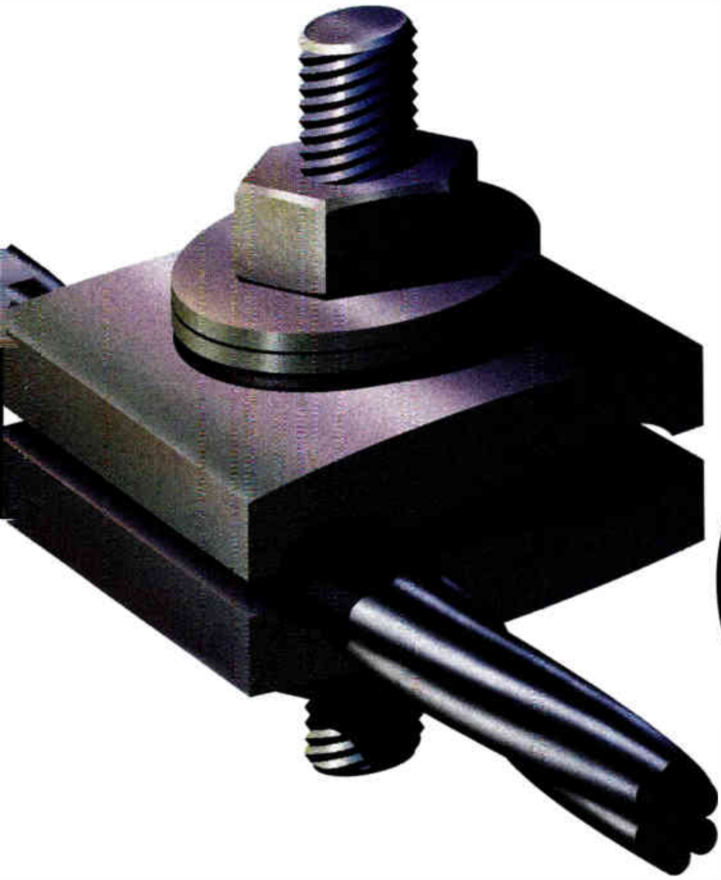
In my next interview, I'll sit down with Richard Green (president of CableLabs). Personally, I'm looking forward to that interview because Dr. Green tells me he has some particularly "good news" about breakthroughs in both specifications and standards.

But I don't want you to think these interviews will be only for high-profile engineers or just with people from the large MSOs. I plan to interview engineers (and operators) from every level. I want to give all of you the opportunity to be heard. I want to talk with you who are involved in headend upgrades and telephony service in cable systems. I'll interview those of you who have discussed the possibility of using headend in the sky (HITS) service at the home, allowing digital signals for cable subscribers but not necessitating its carriage over the system. I'd also like to hear from anyone with new ideas for better cable system maintenance.

As always, I remind you that *CT* is your magazine, especially if you are a member of the Society of Cable Telecommunications Engineers. And, if you are not, shame on you.

This new series of interviews is *CT's* effort to involve everyone in sharing ideas and thoughts. But you are not really participating if you aren't a member of the SCTE. So, go ahead and join. And that means more than paying your dues. It means you will locate the closest local chapter, attend its meetings and participate. If you work for a manufacturer or distributor, either in sales or engineering, you should belong to the SCTE. I would be ashamed to ask for business from cable systems (telling them how much I cared about them) when I didn't even care enough to support their most important industry society of engineers. And, if you disagree with that statement, perhaps I can interview you and change your mind.

Rex Porter
Editor



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Reader Service Number 13

Kudos

Just a quick note in response to your "Editor's Letter" in the December 1996 issue of *Communications Technology* in which you asked for reader response to the magazine. I've been reading your publication now for a little over a year, and find it to be the best magazine in our industry. Thanks for a quality product and keep up the good work.

Richard Bain, TCI

Editor's response: Thanks for the kind words, Richard. We appreciate hearing from you.—Rex Porter

Web talk

In *Communications Technology's* December 1996 issue you asked for feedback. I was doing some research on return paths. I found that another cable engineering trade magazine has a World Wide Web page and a search engine to locate a specific subject and allow me to narrow my search.

I don't seem to find a home page for *CT*. There are some wonderful articles written, and for research, it would be great to be able to pull up the articles I need as opposed to digging out old issues and finding I'm missing the magazines I need.

Dave Devereau is running the Society of Cable Telecommunications Engineers server and at some point wants to include a search engine for our discussions on line. It would be increasingly helpful if the articles from *CT* were on line also. Thanks for the consideration.

Ronald Larock,
Colony Communications

Editor's response: Well, you couldn't have written at a better time. Now I don't have to do a separate piece on the new "Communications Technology" home page.

Over the past few years many have rushed to "put up a site" just to follow the pack and have given little (if any) thought to future uses of this tremendous technology. To prepare for the future as well as the present, "CT" is creating a full-blown marketing and service-oriented arsenal for its place on the World Wide Web.

Our magazine's parent company, Phillips Publishing International, is in the process of tailoring its family of publications for sites on the Web. There is a Phillips site located at http://www.phillips.com where surfers can explore not only the upcoming "CT" site (click on "PBI Magazines" at the Phillips.com home page) but an array of industry-related publications and services. The "Communications Technology" on-line team is putting the finishing touches on the "site to end all sites." We'll certainly keep everyone informed of this exciting launch.—RP

Security semantics

I thought I'd write you concerning something in *Communications Technology* that has been "driving me up the walls" for some time. Let me preface by saying that I hope you won't think I'm either too picky or too arrogant. May I suggest that you change the heading in your cryptography section (December 1996 and January 1997) from "Signal Security" to "Communications Security"? I spent some time in the military during the Vietnam era in communications security (COMSET) working with digital National Security Agency cryptographic equipment. It has always been my understanding that, in the fields of communications intelligence and communications security, the terms "signal security" and "signal intelligence" refer to fields like traffic analysis and electronic security. Traffic analysis involves the analysis of who is talking to who; the level of traffic; and so forth without actually being able to read the traffic. For example, military intelligence can often predict an offensive when the level of encrypted traffic goes up and various stations start communicating with each other.

Maintaining "radio silence" would be a "signal security" (SICSEC) matter. Another signal security issue would be electronic security. For example, on older teletype machines there used to be concern that the selector magnets in the machines generated low-level "plain text" emissions that could be picked up and read outside an embassy that is sending encrypted messages. Hence, one might sit outside an embassy that is sending encrypted traffic over telephone lines and be able to pick up radio signals and read the plain text messages because the selectro magnets are broadcasting the messages before they go out through the crypto machine. A signal security measure might be to place a resistor in the selector magnet circuit to reduce the current and hence the level of any emissions. Another signal security measure might be to ground the chassis of the machine to shield any emissions before they get out.

The field of Communications Security (COMSEC) includes signal security, electronic security, cryptographic security, and the field of communications intelligent (COMINT) includes signal intelligence (SIGINT), electronic intelligence and cryptanalysis. Since you seem to be using the term "signal security" to mean "communications security," I thought you might want to consider adopting the name "communications security." It is helpful to people from various fields if they are using the same technical vocabulary.

Ronald Mohar,
Communications & Energy Corp.

Editor's response: Whew! I don't think you are too picky or too arrogant. I just think you tired me out from reading such an in-depth study on "communications security."

As you may know, signal leakage from system equipment became a concern some years ago. As a result, the Federal Communications Commission created rules and testing for cumulative leakage index (CLI) and our industry has always referred to terms such as "signal leakage," "signal security," etc. Perhaps, as we enter full-service networking, we should modify our names and definitions. I would certainly like to hear from others, if there is such an interest.—RP

Write to us

Write to the *Communications Technology* editorial staff at 1900 Grant St., Suite 720, Denver, CO 80203 or fax (303) 839-1564. Editor Rex Porter may be reached via e-mail at tvrex@coax.com.

CT reserves the right to edit letters for clarity and/or space.

Is ingress making your return path a road to nowhere?

Ingress is the major roadblock to getting your return path up and running. Fortunately, there's the new HP CaLan Sweep/Ingress Analyzer. It's the only test gear that allows you to quickly and accurately troubleshoot your system, regardless of the presence of ingress.

When ingress corrupts reverse-path communication, the headend unit (HP CaLan 3010H) senses the problem instantly, and transfers the display of the ingress problem to the field unit (HP CaLan 3010R). That means your technicians can begin troubleshooting immediately.

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So don't let ingress slow you down. To find out how HP CaLan's Sweep/Ingress Analyzer can help you identify, troubleshoot, and eliminate your ingress problems, call **1-800-452-4844, Ext. 1749**. Or visit us at: http://www.hp.com/go/catv

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Reader Service Number 10

Road Runner goes west

For the second time in less than a year, Time Warner Cable has hosted a public launch of its Road Runner Internet access service. This time, the location was the Museum of Contemporary Art in La Jolla, CA, and the operator was Southwestern Cable TV.

Jim Felhauer, president of Southwestern and Time Warner's San Diego Division, hosted the Hollywood-like festivities on February 6. Some 400 people attended the launch party, said Time Warner.

Motorola is providing high-speed CyberSURFR cable modems and cable routers for the Road Runner launch. According to a Road Runner spokesperson, the cable modem delivers up to 27 Mbps over the network, but the throughput of the PC bus and video display determines

the effective speed of the device. Road Runner can deliver up to 10 Mbps to a computer through the 10base-T Ethernet interface.

The upstream bandwidth provided by CyberSURFR is 768 kbps. The system has been designed to offer worst-case bandwidth that's still better than integrated services digital network (ISDN). The worst case was based on continuous, simultaneous, maximal usage of the service by every Road Runner user in a given neighborhood.

Systems integration for the San Diego launch was provided by Toshiba America Information Systems. Toshiba has integrated delivery and management of the on-line services, Internet access and multimedia functions, as well as network and subscriber management.

Connectivity to the Internet, as well as network monitoring and customer care through the Road Runner Help Desk and the Network Operations Center, are provided by MCI. The browser software is Microsoft Explorer version 3.0.

Southwestern began service trials in mid-January before the public roll-out. Road Runner is available to over 185,000 homes where hybrid fiber/coax (HFC) upgrades have been completed. Remaining areas will be upgraded by the second quarter of 1997. The service will be available to over 211,000 homes within Southwestern's service area.

Road Runner is available to Southwestern's cable subscribers for $44.95 per month; noncable TV customers will be billed $49.95 per month.

Southwestern has promised to provide Road Runner service and training materials to over 100 public and private schools in the company's service area. The company also will work with area businesses to develop work-at-home environments.

Time Warner Cable first introduced Road Runner September 26, 1996, in Akron and Canton, OH.

Cable museum calls for donations

Marlowe Froke, president of the National Cable and Television Center and Museum and Rex Porter, editor of *Communications Technology*, announced that they are now accepting donations of papers, publications and cable TV equipment. Rex Porter requests that the potential donor furnish a written description of the items so that multiples of the same item are not received at the museum. Contact Rex Porter in Phoenix, AZ, at (602) 807-8299 or e-mail: tvrex@coax.com.

Single-mode market explored by study

According to a study from KMI Corp., "North American Market for Single-Mode Fiber-Optic Interconnect Hardware," a forecasted growth rate for single-mode fiber optics from 1996 to 2001 will be at a compound annual growth rate of 9.8% to $457.6 million.

More than nine million single-mode connectors were installed in North America in 1996, which is nearly 40% of the single-mode

plugs installed worldwide. The study shows that by 2001, the volume of single-mode connectors installed in North America will reach 18.6 million.

The study also reports that cable TV operators are heavily using angle-polish FC connectors with AM fiber-optic systems. SC plugs also are being heavily utilized because of their lower costs and ease of alignment. The report includes an overview of the connector and cable assembly market and the termination equipment market including panels/shelves and distribution frames.

Fiber research center announced

Plans are underway for the construction of the Optical Fiber Cable Competency Center, an international research center that will be based in Claremont, NC.

Heading the project is Alcatel Telecommunications Cable, a division of Alcatel Alsthom. Alcatel is a manufacturer of fiber-optic cable products for outside plant and indoor environments. The research and development team will consist of engineers, scientists and other technical personnel.

TW systems get fiber upgrades

Time Warner Cable plants in Brooklyn/Queens, NY, and San Antonio, TX, are to be upgraded with Laser Link II 1,310 nm optical transmitters and upstream receivers developed by Antec. Both projects will increase the channel capacity in the systems and allow them to offer new services over the cable TV network.

The upgraded system in Brooklyn/Queens will be able to carry interactive and telephony service and will cover 2,500 miles and 400,000 subscribers. The 5,000 mile upgrade in San Antonio will affect close to 260,000 subscribers.

NOTES

• **Frontline Communications** acquired the All Channel Messaging System (ACM) and Dynagen product lines from **StarNet Development**. ACM is a patented device for presenting text messages on multiple TV channels. The device allows cable operators to display a crawling message on selected channels instead of shutting down all channels in an alert situation. Dynagen is a plug-in PC character generator for cable and other multichannel messaging, text and graphics displays.

• Douglas H. Morais was named executive vice president of **Ortel Corp.**, a manufacturer of RF signal transmission products.

• **InnovaCom** has developed a single-chip MPEG-2 encoder for cable, satellite, broadcast and consumer product uses involving data compression. The company is also teaming up with **Antenna Technology Communications** to boost its position in the compressed bandwidth delivery of video, voice and data information. CT

ANSI approves SCTE standard

As reported in the "News" section of last month's *Communications Technology*, the Society of Cable Telecommunications Engineers recently announced that the American National Standards Institute officially approved SCTE's first submitted standard, titled "'F Port (Female Outdoor) Physical Dimensions." After many months of editorial review and changes to refine and clarify the language detailing the standard, all members of SCTE's Interface Practices Subcommittee and five participating interest groups reached a consensus approving this first standard.

Data focus at ET '97

Data was the major focus of the Society's 1997 Conference on Emerging Technologies, held Jan. 8-10 at the Opryland Hotel Convention Center in Nashville, TN. The conference, which was held before more than 1,000 attendees, devoted its first day to the topic "Data Services Over Cable," with subsequent sessions devoted to other data-related topics, as well as telecommunications technologies for the future.

Proceedings manuals are now available for $30 for SCTE members and $36 for nonmembers. Contact SCTE at (610) 363-6888.

Annual member meeting set

The Society's 1997 Annual Membership Meeting will be held June 4 on the opening day of Cable-Tec Expo '97 in the Auditorium of the Orange County Convention Center in Orlando, FL, from 4:30 to 5:30 p.m. All SCTE members are invited to attend this meeting, which will feature discussion among the membership, board of directors and national headquarters staff.

Fiber group leader named

The SCTE named Doug Coleman as the Group Leader of the Fiber Optics Construction Working Group operating under the Design and Construction Subcommittee. This group is responsible for the maintenance of SCTE's recommended practices for optical fiber construction and testing, and developing standards for basic construction and design of optical telecommunications applications. The group is now soliciting a call for new activities. Call Doug Coleman at (704) 327-5580 or fax to (704) 327-5533.

More cities to host seminars

A number of cities that have not previously hosted an SCTE regional seminar will be included in the 1997 itinerary. By working closely with local chapter/meeting group officers, SCTE will be able to aggressively promote upcoming seminars in their area to local system management and technical personnel. The seminars include the following: Data Technology for Technicians; Introduction to Telephony; Fiber Technology for Technicians; Technology for Technicians II; and OSHA/Safety Seminar.

Anyone seeking further information on these seminars or wishing to assist with them when they are in your area, please contact SCTE national headquarters at (610) 363-6888; fax: (610) 363-7133; or visit the Society's new web site at http://www.scte.org. **CT**

By Rex Porter

Chiddix: "Good things ahead"

Jim Chiddix is chief technical officer for Time Warner Cable, which serves 12 million subscribers in 37 states. He is responsible for corporate engineering activities as well as research and development, and for enabling Time Warner's cable business objectives through its technology strategy.

Involved in the cable TV business for 26 years, Chiddix spent 15 years in technical and operations posts for two cable companies in Hawaii. He also was founder and president of CRC Electronics Inc., in Honolulu, which manufactured videotape playback and commercial insertion systems. A pioneer in exploring the use of optical fiber technology in cable TV systems, Chiddix joined Time Warner Cable's corporate office in 1986. In 1994, he accepted an Emmy Award on behalf of Time Warner Cable for this work in fiber.

Chiddix led the upgrade of Time Warner's Queens, NY, system to 150 channels in 1991 using hybrid fiber/coax (HFC) technology, and was the architect of Time Warner's "Full Service Network" interactive TV project in Orlando, FL, which began commercial operation in 1994. Today, Chiddix is involved in Time Warner's launch of telecommunications and high-speed data services and roll-out of digital TV set-top terminals.

At 51, Chiddix is a senior member and former director of the Society of Cable Television Engineers, a senior member of the Institute of Electrical and Electronics Engineers and a member of the Cable Pioneers. He holds a General Commercial Radio Telephone License, and is an amateur radio operator (K3TFX). He spoke with *Communications Technology* about the cable industry and where it's headed.

Rex Porter is editor of "Communications Technology." He can be reached in Phoenix, AZ, at (602) 807-8299 or via e-mail at tvrex@coax.com.

Communications Technology: *There is much uncertainty about the future of new technology in cable TV. How do you see the new services shaking out as potential money-making services, and when do you think the industry will really be able to provide such services?*

Chiddix: Everybody always wants to know when the new stuff is going to happen—what the future is going to be like. There is an argument for never making such predictions. I think that history shows that in this industry, predictions are generally wrong and that things that are the best news for the industry are often surprising.

Having said that, I think that there are some very interesting new services out there. The one that seems to be the closest in terms of significant revenue outside of our core business is high-speed data service. Our ability to provide that service is based on our upgrades.

At Time Warner, we have about 6 million homes passed with upgraded plant, out of 18 million, or one-third. By the end of 1997, we will have 9 million completed. Of those, we expect to have our Road Runner modem service available to 4.5 million. So by the end of '97, a quarter of our homes passed will be able to order Road Runner service (a content-oriented high-speed PC service which includes Internet access, among a number of other features). Over the next few years we expect to upgrade the rest of our cable systems. As we do that, Road Runner will become available there as well.

Wall Street keeps wanting to know when we are going to make these businesses real and we can talk a lot to them, but I think what is going to get their attention is when companies like ours and others begin to show significant new cash flow. I think that by the end of '97 we will be in a much more interesting position than we are today in terms of credibly delivering this brand new service.

CT: *What about telephony?*

Jim Chi

Chiddix: Telephony is murkier. We announced recently that we are going to aggressively pursue business telecommunications in our markets. We are going to continue to deploy residential telephony in Rochester, NY, but b moving into other systems, we re need to know more about the regu tory landscape. We know that HF telephony works technically; the q tion is what kind of a business it i given emerging regulations, inter nections agreements, and so fort Digital video can offer a number o new service opportunities to us in t next few years. The most obvious is more channels, but that leads to some interesting directions.

We are interested in using the real-time two-way capabilities of the digital boxes we are going to buy. These are real-time two-way boxes that comply with what we call the "Pegasus" spec internally; they are boxes that are ready for video-on-demand (VOD) as well as a variety of intermediate interactive services. With them, we can offer services that combine digital and analog video and Internet technologies. That doesn't necessarily mean cruising the Web on your TV set; there is a lot of information that can be generated in Web page form and presented woven in with TV programming. I think there is a real opportunity there and I am sure that our company and the industry are going to pursue that.

As for VOD, we are getting very encouraging market indications in Orlando. Having a wide variety of choices available and having VCR-type control, whether for movies or other kinds of video, is something that people understand instantly and respond to very positively. With interactive-ready set-tops in place,

the other part of the cost equation is in the headend—the servers, switch and so forth. Those economics aren't there yet, but they will be before long.

CT: *Give us your opinion on specifications and standards efforts the industry has undertaken recently.*
Chiddix: I think that there has been real progress in the last few months. The industry is coming together around specifications in the way that we deliver digital video and the way that we deliver modem-based services. This is good because such specifications give us access to multiple vendors. That gives us insurance in terms of delivery and competition to get prices down and to introduce new features.

In the case of modems, we hope that soon we will be able to work with local computer stores or other retailers to sell cable modems to customers who are already accustomed to buying PC peripherals. Unified specifications really help in that process.

CT: *As chief technical officer of a top MSO, do you have any advice for the technician working toward his goal of reaching such a position? And as far as computers go, do you think engineers ought to do everything they can to be computer literate?*
Chiddix: In terms of training for technicians and engineers in data and telephony, we are going to need a lot of new skills. Traditionally, we've operated a radio frequency plumbing system and I think we have done pretty well with the knowledge and skills required. We're just starting to deploy advanced analog set-tops, digital set-tops and cable modems that all require a much deeper knowledge of digital transmission technologies.

Beyond that is the software. For the last few years one of the problems the industry has had is that digital products have been late to market. They have been late not because people couldn't make the hardware, but because software that is stable enough to put in the hands of consumers is hard to produce.

An engineer or technician looking for a real area of opportunity might look at developing an in-depth understanding of complex network software. But all of the digital disciplines, whether transmission, hardware or software sub-specialties represent opportunities. The industry is going to need trained people, regardless of whether they are brand new in the industry, or come from other industries, or are people who have been working on coaxial systems for years and are willing to go out and learn new stuff.

CT: *It took cable TV about a dozen years before it embraced fiber optics as a viable product. How long before data transmission will be embraced as a viable system throughout?*
Chiddix: Let's talk about fiber. Fiber by itself generated zero revenue; it was simply a much better way to upgrade cable plant, when the alternatives were going back and doing a 550 rebuild with long cascades or installing amplitude modulated link (AML) microwave. Broadband fiber was a no-brainer, once the technology got developed—it was better and cheaper. →

Louis Williamson, one of our engineers, demonstrated the first really practical 40-channel broadband fiber system in our lab to the National Cable Television Association Engineering Committee in November 1987. We then spent a couple of years on the road giving speeches to encourage the laser manufacturers to put in the R&D investment to make these into cost-effective systems. But by 1990 anybody who was doing an upgrade, if they were paying attention, was beginning to use broadband fiber. So it didn't take a dozen years to take off, it really took four or five.

When we talk about high-speed cable data modem services, I think there is a much better analogy, and that's pay TV. Pay TV was technology-dependent only to a certain extent. It depended on low-cost satellite dishes, some regulatory changes, and any one of several ways of controlling services, whether it was addressability or traps. It spread very fast, because every cable operator big or small, looked at it and said, "Gee, I can make an investment of X and my cash flow will go up by Y and Y is so big that it's an obvious decision, so let's do it next month." Modem services have the same potential.

With cable modem services, there are some elements that are expensive, routers and servers and so forth, so there is a minimum number of subscribers who can support the business. A nice thing about fiber, however, is that it lets us interconnect small cable systems to regional centers. For large metropolitan systems operated by a single MSO that's irrelevant, but where there are a number of small operations scattered around the same geographical area, there is an opportunity to cooperate, to interconnect into clusters that are large enough to support the data headends.

I've taken the long way around to answer your point, but I think that data is a service that will roll out quite rapidly, once it demonstrates that it has good economics.

CT: *Do you foresee any radical changes to the Internet infrastructure that will be introduced by the cable TV industry?*

Chiddix: Yes. The thing that we will bring to the Internet infrastructure is a highly reliable managed data network at the local level. In fact, that

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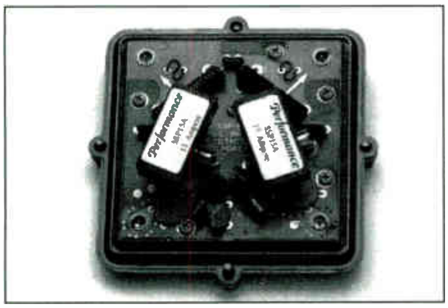

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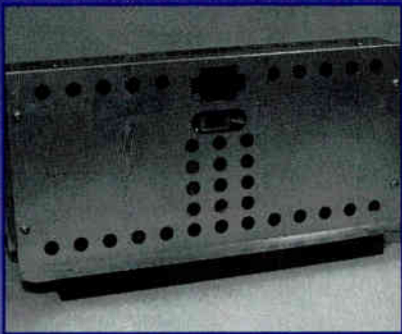

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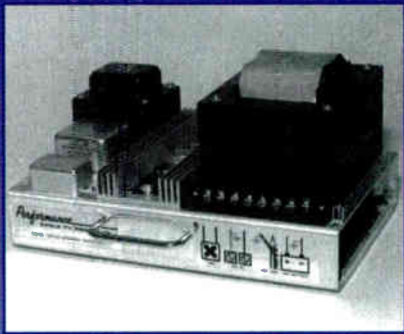

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doesn't exist anywhere on the Internet right now. The Internet is not a managed network. In particular, it is not managed with regard to quality of service and latency, which are going to be important as we get into offering time-sensitive traffic like voice and video through the Internet.

Because we are going to own and operate this local IP (Internet protocol) network, cable operators can build those enhancements into their part of the network as quickly as they would like. I think that is going to lead in some interesting directions.

At the recent SCTE Emerging Technologies Conference there was a presentation by some folks from Lucent Technologies about voice services through IP networks. What I took away from it was that voice quality is a real problem in the current Internet. If the Internet is busy, voice quality may not be great. It works; whether it is really saleable as a commercial enterprise is another question. It's a bit like ham radio, where you can set up a schedule and have a telephone conversation with your brother-in-law in Japan. Through the Internet, voice is a little scratchy and delayed, but it can work. Since we have a managed network, these packet voice technologies could turn into something much more interesting.

Lucent also said that they and others are working on hardware that could provide an interface between an IP voice network, which we might operate locally, and the public switched telephone network. In other words, someone could sit at home with a computer or a telephone plugged into a slightly modified cable modem and place a phone call. If it were going to a destination outside that IP network it would go through a gateway, and it would be translated into the appropriate signaling protocol to route the call through the local or the long distance network. That may lead to some intriguing business opportunities.

CT: *And cable's role in all this?*
Chiddix: The obvious thing cable can offer people who are used to having on-line services is much greater speed, and we can offer it to them without tying up all of their own telephone lines. We can let them leave their computer on-line all the time, so that they just need to wake it up to instantly be in contact with the local Road Runner service, or the Internet, or with their office's local area network. I think, beyond that, we can think about new services that may not be practical today.

One is video. For decent quality Moving Pictures Experts Group (MPEG) video you've got to be at 3.5 or 4 megabits per second, at least given the technologies we see near at hand. So direct broadcast satellite (DBS) really couldn't serve very many individuals with switched video service, not even with hundreds or thousands of satellites circling the earth, as proposed by Teledesic.

That's what cable is really good at. If you do the arithmetic about HFC cable serving a neighborhood node, assuming that we keep the 50-550 MHz spectrum for analog channels and use 550-750 MHz for digital downstream, we can get well over a gigabit per second to each neighborhood. In other words, we have more digital downstream throughput available through an HFC architecture to a neighborhood of 500 to 1,000 homes than a DBS satellite has to an entire country. What's more, we've got 40 or 50 megabits per second of digital throughput back upstream from that node.

CT: *Are you saying satellites are worthless?*
Chiddix: Of course not. Satellites are very good for broadcast services, and can be very good for specialized niche services. But they can't address the market that terrestrial cable can. Even in terms of interconnecting cable systems, the cheap way to get high bandwidth interconnection between terrestrial points is through terrestrial fiber.

CT: *But you could have some combination; they could work in concert.*
Chiddix: Sure, fiber and satellite could work in concert, but the thing that satellites will be best for is untethering people who want to talk or exchange data. I would be surprised if in 10 years I couldn't buy a wireless phone that looks like my little cell-phone, that would operate anywhere in the country or the world. Now it might be expensive to make those calls, but I am sure I will be able to buy it.

By the same token, I will be able to buy a little modem that clips onto my laptop, or is built in, so that my laptop communicates anywhere. Again, there will be a charge for that convenience. Is that relevant to my laptop sitting on my desk at home? Maybe not. I may be able to get much higher speed service, at a much more attractive price, by tying into a terrestrial network. My guess is that the hybrid fiber/coax (HFC) network will be a very strong candidate to be the network you'd want to plug into.

CT: *Are there any other comments that you would want to make to the members of the technical community?*
Chiddix: There is no end of challenge and opportunity out there. That means people starting little businesses have the opportunity to make lots of money and build big business. People just starting out have the opportunity to have very good and rewarding careers, both in terms of earnings and the satisfaction of being in on the beginning of something really exciting. For the industry, I think engineering is going to become more important than ever.

I remember a speech that John Malone gave once, when CableLabs was getting started, that pointed out that the cable industry is enabled by a combination of technology and politics and consumer demand. That is going to remain true. But the technology part of that equation is getting more and more complicated. More and more, we're going to prize people who are really good at either working with these new technologies, or thinking about how these new technologies will enable business opportunities.

CT: *What's ahead?*
Chiddix: I think that really good things lie ahead. I hope cable industry engineers will go out and recruit new blood and find people in other industries who will bring their specialties with them. I hope we are going to do a better job than we have in the past of bringing bright, young people into the business and educating them and grooming them as a new generation of technology leaders. But I think that there are huge new opportunities for people who have been in this business for years and are completely comfortable with our traditional technologies, as long as they are willing to learn new things and to get involved in these new technologies. **CT**

By Ron Hranac

ET '97 at-a-glance

The Society of Cable Telecommunications Engineers' 1997 Conference on Emerging Technologies, held January 8-10 in Nashville, TN, was by most accounts a success. I say most because attendance was down compared to the previous two years. That's unfortunate, because this year's conference was arguably the best ever, content-wise.

There were undoubtedly several factors affecting attendance. Recent industry layoffs and cutbacks are the obvious ones, and weather is another. It was *winter* in Tennessee, and while quite mild by, say, Colorado standards, the couple inches of snow that fell in Nash-ville during ET literally shut the place down. Also, the location itself (Nashville's Opryland Hotel Convention Center) may have kept some folks away after their experience staying there during last year's Cable-Tec Expo. In all fairness, the Opryland Hotel staff did a much better job this time around.

To give you an idea of the scope of ET '97's content, this year's proceedings manual counts some 426 pages compared to last year's 372 pages. If you'd like a copy, you can order one from SCTE, 140 Philips Road, Exton, PA 19341-1318; phone (610) 363-6888; fax (610) 363-5898. Among the goodies in the registration package was a nifty addition to any bookshelf, courtesy of Sprint Communications: *Telecommunications Terms and Acronyms* . You can get this from Sprint North Supply at (800) 639-2288.

ET wrap-up

TCI's Oleh Sniezko was this year's Polaris Award winner, recognized for his contributions in the areas of optical fiber cable standards and manufacturing requirements as well as early work on polarization mode dispersion. A $5,000 donation in Sniezko's name was made to SCTE's scholarship fund.

Pre-conference tutorials were held the afternoon of January 8, and included useful overviews of the International Organization for Standardization/Open Systems Interconnection model as a framework for inter-networking; how Ethernet works; transmission control protocol/Internet protocol (TCP/IP); and IP switching.

During Thursday's first group of presentations, the use of asynchronous transfer mode (ATM) networks directly to the home for cable modems was advocated. This raised a lot of eyebrows, as well as comments by other speakers. My favorite was from The Excalibur Group's Mario Vecchi. He asked the audience, "How many of you have ATM interfaces in your PCs, or plan to go out and buy one in the next year?" After a bit of a chuckle from the audience, Vecchi added, "I think that answers that question." I later spoke with a major cable modem manufacturer who commented that his company supports ATM to the headend router, but not all the way to the home. With regard to taking ATM to the home, one of its biggest liabilities is cost.

Intel's Matthew Diethelm, Ph.D., pointed out several interesting tidbits in "Optimal Transport of Data on Cable Plants." For example, poor data performance at the subscriber's location may not be due to the cable modem or the cable TV network. It can be a server throughput problem, most easily dealt with by the appropriate server architecture. Based on tests conducted by Intel, the fastest available CPU (200 MHz Pentium class) and lots of RAM (128+ MB) can open up server bottlenecks. Limited Internet bandwidth is another potential problem, and to some degree local caching, localized content and hybrid Internet/CD-ROM applications will help. Attendees were urged to pay attention to the type of Internet connection, too.

Security was another important topic. Lucent Technologies' Robert Rance and Network-1 Software & Technology's Bill Hancock both warned of the dangers of inadequate overall network and data security. From simple theft of digital services or subscribers credit card numbers, to outright network shutdown, determined pirates have the potential to do plenty of damage when security is not a priority. Hancock noted that 80% of security breaches are inside jobs.

Cable modem service has moved beyond the trial stage, and is now being deployed to paying customers, according to presentations by Excalibur's Vecchi and Tom Staniec, and Rogers' Frank Cotter. Vecchi provided an overview of Time Warner's Road Runner service and how it works, and Staniec discussed the issues getting Road Runner from a trial technology to a real world service. Cotter's presentation, "Business Experience in a Residential Data Network," highlighted Rogers' WAVE service.

In contrast to the industry's move toward smaller fiber service areas, Cotter pointed out that WAVE has worked well with 5,000 home network segmentation. He emphasized that building and maintaining two-way plant is not rocket science, but it does require a dedicated network management organization, and a massive culture change from cable to telecom. Further, Rogers manages the customer experience to underpromise and overdeliver. The service's speed is in the 150 to 200 kbps range rather than the 10 Mbps touted in most cable modem applications. Still, according to Cotter, demand is high, churn is low, and WAVE's success is expanding to a national alliance involving several other Canadian cable

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

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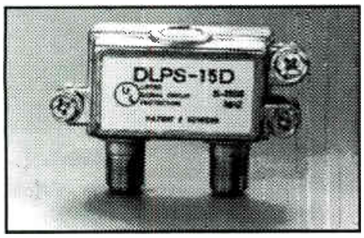

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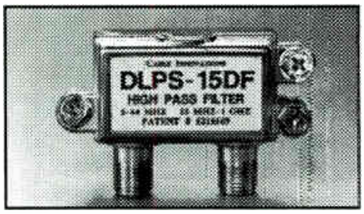

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operators and plans to sell the modems at retail.

When it comes to data transmission over hybrid fiber/coax (HFC) networks, we usually are most concerned with upstream laser clipping affecting return data. Hewlett-Packard's Rex Bullinger noted that downstream laser clipping can be a problem, too. This can occur even when RF levels appear to be normal, because of the effects of carrier phase. In a typical 80-channel system that also transmits data, carrier phases generally are random. But if the carriers happen to reach peak negative amplitude simultaneously, laser clipping can occur. Laser optical modulation index must be carefully maintained, and studies by Bullinger and co-author David Large suggest that direct measurements of bit error rate (BER) will provide the best way to do this until other methods are available.

Reverse path characterization has been a hot topic recently. TCI's Oleh Sniezko and Tony Werner co-authored "Return Path Active Components Test Methods and Performance Comparisons," a must-read for all distribution equipment manufacturers. In his presentation of the paper, Sniezko recommended that single-ended amplifiers not be used in the reverse path. He further commented that most Fabry-Perot (F-P) lasers are not a good choice for reverse, and provided a recommended specification method for both reverse RF and optical actives. These recommended specifications include:

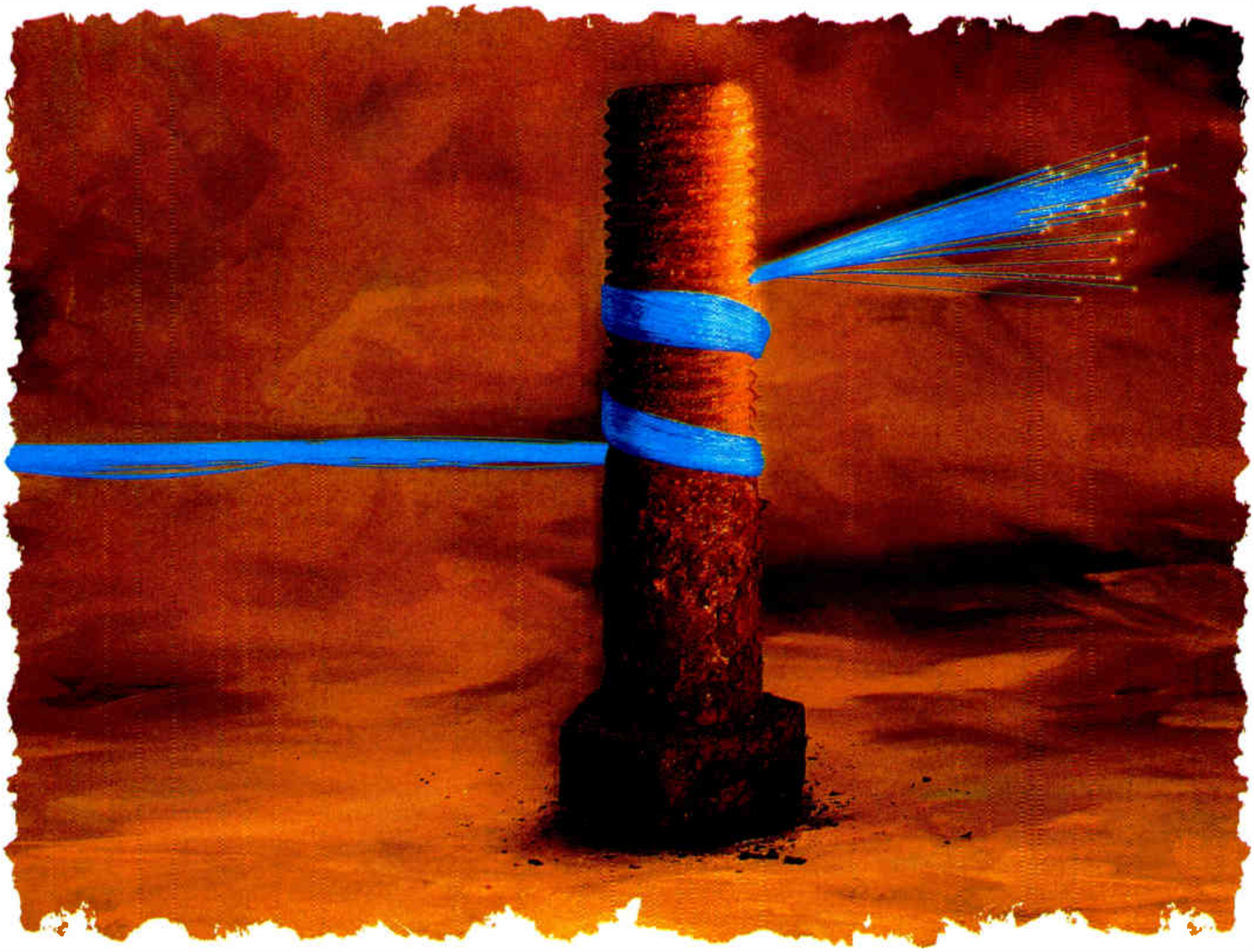
1) For RF actives noise factor; and dynamic range as a function of required C/N (carrier-to-noise ratio) + IMN (intermodulation noise) for loads occupying 35 MHz reverse bandwidth.

2) For reverse lasers dynamic range as a function of required C/N + IMN for loads occupying 35 MHz reverse bandwidth with optical fiber link loss as a parameter; C/N for the same optical fiber link loss for a particular signal power density in dBmV/Hz (assuming a standard optical receiver with 8 pA/Hz$^{1/2}$ noise performance and 8 A/W responsivity); a C/N correction factor for a recommended receiver (if different than the reference receiver); and C/N as a function of fiber loss and optical loss to the reference receiver.

Scientific-Atlanta's Lamar West presented "Composite Power and its Effect on Reverse Path Laser Clipping." This too is a must-read. Lamar observed that conventional composite second order/composite triple beat rules are not applicable to laser clipping, that laser clipping is current-dependent rather than power-dependent, and that, due to a variety of factors, it is inappropriate to use the constant power-per-hertz rule when determining proper levels for reverse path signals. Lamar recommends using a "probability density function," a kind of histogram that indicates how often something happens.

Lunch keynotes by Dave Clark, senior research scientist at MIT, and one of the founding fathers of the Internet, and Robert Lucky, corporate vice president at Bellcore were both worth their weight in gold but you had to be there.

A big tip of the hat goes to the program subcommittee, and a special thanks to SCTE for once again giving us a superb technical forum in which to learn the latest and greatest. **CT**



By Justin J. Junkus

Twisted-pair: Knowing your enemy

This month's column comes under the category of "know the competition." As an industry, cable rightfully brags about the broadband capabilities of its prevalent mediums, coax and fiber. As an almost automatic corollary, many cable people might believe that copper pair is only useful for low bandwidth voice-grade service. This just isn't so, and it's time to set the record straight. Three factors come into play. First, not all twisted-pair is identical. Different manufacturing techniques create different grades of twisted-pair. Second, a set of new technologies, collectively known as xDSL, are designed to give even low-spec twisted-pair bandwidth capability far beyond the voice range. Finally, many so-called high bandwidth applications do not require more capacity than can be provided with either a high grade of twisted-pair or xDSL.

Justin Junkus has over 25 years of 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. If you want to contact him, he may be reached at his e-mail address, JJunkus@aol.com.

"Twisted-pair is far from being just a voice-grade medium."

To understand how twisted-pair can be manufactured in different grades, we need to understand the technology of twisted-pair. The reason for a pair of wires is almost intuitive. A complete circuit needs a path out and a path back. With that out of the way, let's look at "twisted." Twisting minimizes the effects of two problems: unbalanced transmission and crosstalk between adjacent pairs in a cable.

Unbalanced transmission

With unbalanced transmission, one of the two conductors making up the pair differs electrically from the other in some way. The most common unbalanced transmission is when one wire of the pair is grounded at one or both ends. This type of transmission is adequate for low frequencies, such as voice, over relatively short distances, in noise-free environments. In locations with motors or fluorescent lights, noise is easily introduced into an unbalanced system by inductive coupling. When the pair is being used solely for analog voice transmission, the effects may be minimal. However, when any type of digital pulses are being sent on the line, the noise is interpreted as data and errors result.

Although shielding each pair is one way to minimize this type of noise on the pair, it is expensive and makes the cable bulky. A better way is to use transformers called baluns on each side of the line to create a system that sends a signal that is the difference between voltages on each wire of the pair. Any noise introduced into this type of system will appear equally on both wires of the pair, provided that both wires are identical and at the same distance from the noise source at all points. Twisting the two wires better ensures that each will have equivalent coupling to the noise source, and the tighter the twist, the better this becomes.

Near-end crosstalk

Twisting minimizes another type of signal degradation called near-end crosstalk (NEXT). This type of degradation is the result of undesired coupling of signals from one pair of wires in a cable to another pair in the same cable. NEXT can be especially detrimental in four-wire digital data systems. These circuits typically use two pairs, one for transmitting and one for receiving data. Signal coupling occurs because two pair of wires laying parallel to each other create the electrical equivalent of a capacitor. Twisting prevents the wires in one pair from laying completely parallel to an adjacent pair. In addition to preventing long parallel runs, tight twisting adds space between adjacent pairs of wires by keeping the open spaces between the wires of the pair to a minimum. NEXT coupling between cables is measured in decibels. The higher the value, the better the isolation between the pair.

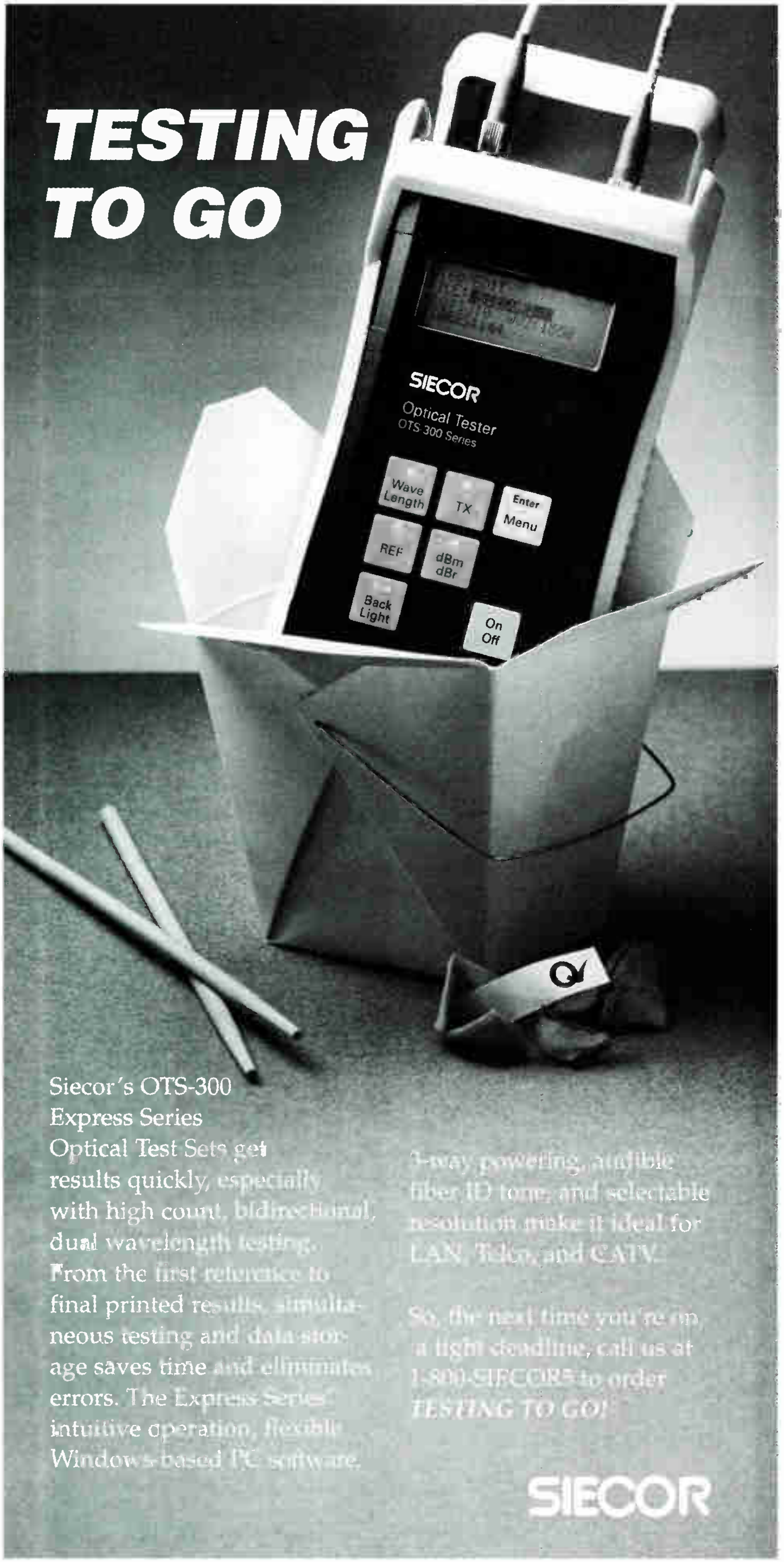
Attenuation is another parameter of twisted-pair that can be controlled by manufacturing. Attenuation is measured in decibels per unit length, typically over 1,000 feet. Unlike the NEXT parameter, the lower the attenuation in decibels, the better the cable. Attenuation is due to both the resistance of the copper conductor and the material used to build the cable. There's not much that can be done to change the resistivity of copper for any given gauge of wire. However, the rest of the materials in the cable can make a difference. Insulation and jacketing materials both contribute to attenuation by the extent to which they contain an electromagnetic field within the conductors of the pair. Polyethylene and Teflon provide optimum loss characteristics.

Both attenuation and crosstalk vary with the frequency of the carried signal. Electronic Industries Association/Telephone Industries Association specifications have been developed with maximum limits for Categories 3, 4, and 5 twisted-pair. Category 5 is the most stringent specification, and is typically used for data communications applications. At 16 MHz, Category 5 twisted-pair is specified at 25 dB maximum attenuation and 44 dB NEXT loss per 1,000 feet vs. 40 dB maximum attenuation and 23 dB NEXT loss for Category 3. At 100 MHz, Category 5 cable must meet 67 dB maximum attenuation and 32 dB NEXT loss per 1,000 feet.

xDSL in action

Now that we've looked at how twisted-pair can be performance-optimized by the way it's manufactured, let's look at how the bandwidth efficiency of twisted-pair can be improved by applying xDSL technology to the coding of a digital signal. DSL stands for digital subscriber line. There are three main varieties of xDSL, and three variations of line coding techniques to spread high bit rate information over available spectrum within the twisted-pair medium.

High-rate digital subscriber line (HDSL) is the earliest version of xDSL, and is a four-wire technology



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that delivers T-1 rates in both directions. Asymmetrical digital subscriber line (ADSL) delivers 1.5 to 9 Mbps downstream, and 16 to 640 kbps upstream over one pair. Very high-rate DSL (VDSL) is a version of ADSL that will operate at a higher rate than ADSL, but over shorter distances. VDSL optimizes bandwidth so well that it is being used as a way to transmit optical rate asynchronous transfer mode (ATM) over twisted-pair. The three-line coding methods are carrierless amplitude/phase modulation (CAP), discrete multitone (DMT), and two binary, one quaternary (2B1Q). CAP and DMT use modulation techniques similar to those used in telephony modems, while 2B1Q is a digital pulse coding method.

An example illustrates how high bit rates over twisted-pair are made possible. You may recall that a typical voice grade circuit occupies a spectrum of 4 kHz. Modems use various modulation techniques, such as quadrature amplitude modulation (QAM), to code digital signals onto a tone in this range. The upper limit on the data rate is in the 50 kbps range. The discrete multitone line coding technique used in some implementations of ADSL extends this concept by testing the characteristics of the twisted-pair at different frequencies and dividing available usable spectrum into 4 kHz bands, each capable of 60 kbps.

It then takes the information in a high-rate digital signal, and allocates a subset of the bits to each of the 4 kHz bands. A typical system would use 25 bands of 4 kHz to transmit 1.5 Mbps of data upstream, and 249 bands of 4 kHz for 14.9 Mbps downstream. These rates are available from Category 3 twisted-pair. Although Category 5 could theoretically improve performance still further, most of the currently installed twisted-pair is Category 3, and these rates are more than adequate for most Internet or even local area network (LAN) access applications.

So, twisted-pair is far from being just a voice-grade medium. When manufactured to Category 5 specifications or with xDSL access technology, this old dog can handle the new tricks that high-speed data transfer has introduced. **CT**

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Reader Service Number 45

By Alex Zavistovich

Gore on data:
A market-driven view

He's the main technology advocate in the Clinton Administration, and while his past seeming indifference to cable issues hasn't exactly made him an industry darling, Vice President Al Gore has some clear-cut ideas about the Internet and broadband data delivery.

Now, in an exclusive interview with *Communications Technology*, the vice president talks about overhauling the Internet, cooperation among telecommunications competitors, and the importance of high-speed broadband access to the home.

Communications Technology: *President Clinton has acknowledged that the Internet is straining under the load of its increasing popularity. The president's aim to make the Internet available to students, while supported by the cable community in voluntary efforts, is likely to further overload the current system. What specifically are the administration's plans to overhaul the Internet along the backbone system?*

Vice President Gore: On October 10, 1996, President Clinton and I announced a "Next Generation Internet" initiative designed to connect 100 universities at speeds 100 times faster than today's Internet, and a smaller number of institutions at speeds that are 1,000 times faster. These networks also will allow experimentation with emerging Internet standards that support real-time services such as videoconferencing. This initiative will challenge industry and our world-class research universities to develop the technologies needed to keep up with the explosive growth of the Internet—for example, all-optical networks.

Since the privatization of the NSFNET, however, the United States no longer has one Internet backbone. Instead, multiple network service providers are competing to build faster, more reliable networks while still interconnecting with each other to create a seamless Internet.

"Different segments of industry will have to collaborate on the development of standards needed to promote interoperability."

I believe that the Internet should continue to evolve in this fashion. Sponsoring advanced research and development and networking test beds that "push the envelope" is an appropriate role for government, but investing in a backbone to support commercial services is not.

CT: *The physical system used for delivering data across the Internet was originally intended for relatively short-time telephone conversations, not for the extended periods required by Web surfers. What is your view on the need for another fiber/cable system to separate data applications from conflicting telephony and television uses?*

Gore: Clearly, today's telephone networks were not designed for Internet use. It is my hope that telephone companies, cable companies, and other segments of the telecommunications industry will compete to provide customers with affordable broadband Internet access, and prevent the public switched telephone network from being overloaded by data traffic.

CT: *The cable TV industry has invested heavily in research and development of systems and technology for accessing the Internet. In particular, high-speed cable modems are seen by the cable community as a significant contribution to the future of Internet access. What is your opinion?*

Gore: The Internet is a large and rapidly growing market. Experts estimate that the Internet has generated $250 billion in new wealth (market capitalization), primarily in the last 18 months. Although there are a number of limitations to today's Internet, existing market leaders and new high-tech startups are investing billions of dollars to create new products and services to overcome these limitations: compelling multimedia applications, easy-to-use software, secure transactions for electronic commerce, and intelligent agents, to name just a few. This technology will have applications not only in entertainment, but in areas such as lifelong learning, delivery of government

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services, community networks, telemedicine, and telecommuting.

The most serious bottleneck to the further development of the Internet is the lack of affordable broadband access to the home. I applaud efforts by the cable industry to invest in the technology and network upgrades that will increase the availability of high-speed Internet access.

I particularly want to commend those companies that are providing free high-speed Internet access using cable modems to the schools in their service area. This is an investment in our nation's future that will pay for itself many times over. Students with access to the information superhighway will have access to a wealth of information and exciting educational opportunities, and will be better prepared for the workplace of the 21st century.

CT: *From the administration's perspective (and in light of the cable industry's work in the area of Internet access), what is the likelihood of a cable-based solution to upgrading the Internet, as opposed to telephony-related system architecture or satellite delivery? What do you see as the advantages of each approach?*

Gore: I think the marketplace will determine which solutions are successful. Consumers want a service that is high-speed, affordable, reliable and easy to order. The role of government is to create the environment in which any company can provide any service to any customer, not to speculate about which technologies will ultimately win out in the marketplace.

I do think that companies should invest in networks that will allow adequate two-way communications. One of the most important attributes of the Internet is that it allows people and small, entrepreneurial firms to be both producers as well as consumers of information. Offering a service with more symmetric bandwidth to the consumers that want it will lead to a more vibrant, interesting and democratic Internet.

CT: *What do you think the ideal inter-relationship among the cable TV, satellite, telephone and computer industries should be in working toward the future of data delivery?*

"Clearly, today's telephone networks were not designed for Internet use."

Gore: In the past, standardization and interoperability were guaranteed by the Bell System monopoly. In today's network of networks, different segments of industry will have to collaborate on the development of standards needed to promote interoperability.

CT: *The telephone industry is the entrenched competitor in many telecommunications arenas. What efforts, if any, the administration is considering to ensure a level playing field between the telephone industry and the cable industry in telecommunications applications such as Internet access? How specifically might the Telecommunications Act of 1996 help?*

Gore: The Administration strongly supports efforts to introduce competition into the market for local telecommunications services. We believe that this competition will lead to lower prices, more customer choice, and faster deployment of an advanced telecommunications infrastructure. We will continue to work with the Federal Communications Commission on issues such as unbundling and interconnection to realize the goal of the Telecommunications Reform Act of 1996: a fully competitive telecommunications market. **CT**

Vice President Al Gore pulls cable into a classroom, highlighting the "Next Generation Internet" initiative he and President Clinton announced last October.

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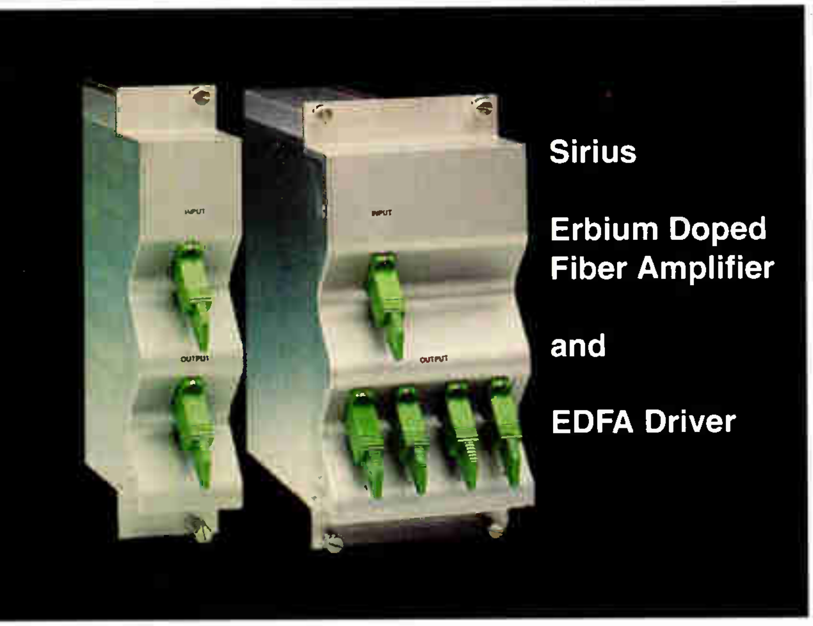

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By Alex Zavistovich

Dream Machine: HFC system offers telephony/data/cable

The following is the first installment of an ongoing series of articles in which "Communications Technology" showcases the specific architectural platforms, hardware and engineering techniques being used by a system at the technological forefront of our industry.

How far off is the cable industry from the dream of offering telephony, data and entertainment over the same hybrid fiber/coax (HFC) network? Closer than you think. That ideal is being realized now in Atlanta, where MediaOne has created two "superheadends" and central offices for delivering not only TV programming and Internet access, but telephone services as well to its customers in the metropolitan area.

Alex Zavistovich is executive editor of "Communications Technology." He can be reached in Potomac, MD, at (301) 340-7788, ext. 2134.

According to Lynn Newsom, vice president of network services for MediaOne, the company's telephony ambitions date back more than five years, with the formation of ATI—Access Telecommunications Interconnect—a company established under the Wometco name brand in 1991. (Wometco operated cable systems in Atlanta under two names: its own and GCTV.)

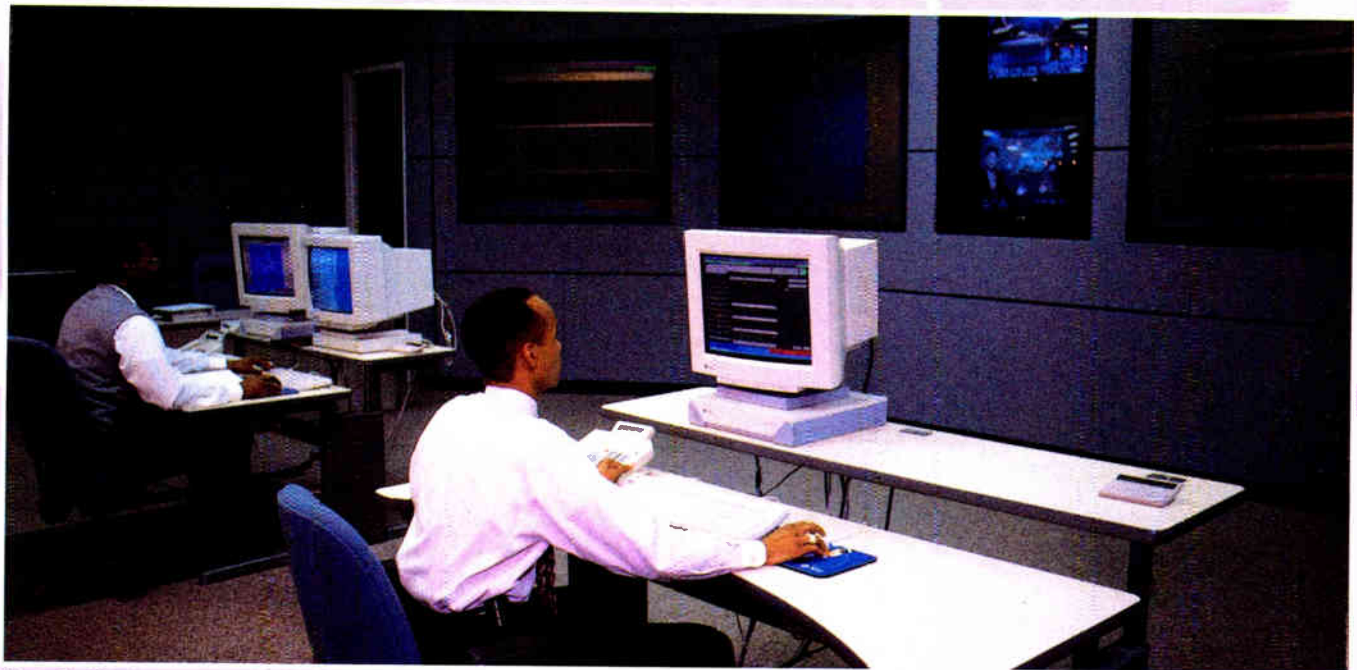
With a goal of providing local bypass service in the alternate access format, ATI was able to manage contracts from Delta Airlines, Home Depot, Airtouch Cellular, and others, providing fiber connectivity to interexchange carriers such as AT&T and MCI. The company went into direct competition with the regional Bell operating companies (RBOCs) in 1991, building the business up to $4 million per year by 1995. Even then, "we were well on our way to having a local telephony presence here in the Atlanta market," said Newsom.

The big boost

The telephony presence Newsom spoke of got a boost in December 1994, according to Reg Griffin, MediaOne's director of communications. That's when US West purchased what had been the Wometco and GCTV cable systems, at a price tag of approximately $1.2 billion. The company announced its intention of upgrading and rebuilding its systems to the tune of $350 million, to expand channel capacity and to introduce telephony services, high-speed data services and, ultimately, interactive programming.

Operating in the interim under the name Southern Multimedia Communications, the enterprise was ultimately renamed MediaOne in October 1995. Along with the name change, the company re-engineered its operations, as well. Originally, 12 separate headend locations and some eight different main offices each operated as individual cable systems, each with its own customer

MediaOne in Atlanta is delivering the "dream team" of services—cable, Internet access and telephony.



Randy Dameron looks at the CPU utilization graph for the Tellabs Tellenium NMS. This measures CPU and RISC processor utilization times.

service representatives and technicians. With the reorganization, the vast operation was consolidated all into a single billing service, with all customer service operating out of one base of operations.

What remained was to consolidate the actual technical operations of the 12 original headends into two "superheadends." By February of 1996, MediaOne opened its first superheadend in the Cobb County town of Vinings, serving the southern and western parts of the Atlanta area; the second superheadend went into Stone Mountain in DeKalb County, to serve the northern and eastern sides.

Upgrading and rebuilding

"One of our biggest challenges is integrating our existing system into a broadband telecommunications network and retaining, restructuring and reorienting a work force to keep customers on the old network, while transitioning over to the new network," MediaOne's Newsom commented. That transition means going from a 400-450 MHz system to a fully integrated 750 MHz system virtually overnight. The process is further complicated by the fact that the old system is one-way downstream—only roughly 20 miles of 12,000 system miles were ever truly bidirectional.

Upgrading and rebuilding the network is still very much a work in progress, and the scope is huge. The superheadends feed 42 distribution hubs, each of which in turn will support 20,000-30,000 homes and businesses. The network conversion process is one of the most difficult parts of the three- to four-year upgrade and rebuild process, said Newsom.

In fact, the complexity of the project is greater than MediaOne had originally anticipated. For example, MediaOne will attempt to use as much existing coax as possible. Much of the coax was placed in the early to mid 1980s. Newsom and his staff had assumed that they would be able to use some 80% of the existing coax cable for the new network configuration. However, they soon encountered difficulty with the coax not passing bandwidth they had expected it would. To correct this, MediaOne has implemented a very aggressive test program, including time domain reflectometry and sweep of the cable. To test the cable, Newsom said, MediaOne technicians are using a Tektronix time domain reflectometer, Hewlett-Packard 8593 spectrum analyzers and the Wavetek Stealth.

Testing confirmed that the older cable admitted some ingress, Newsom acknowledged. He noted, however, that testing for ingress was not a foolproof way to determine cable leakage in the existing coax. Engineers on the MediaOne project quickly found that cable can be bad and not be leaking, particularly with current levels of 90 volts or higher passing through it.

"Being on the terminating run after a line extender, a lot of this cable had never even seen voltage before," Newsom explained. "When we placed voltage on the cable, we started to see some of the cable literally burn up. We're finding some shielding integrity differences that we did not find with a leakage device."

Architecture

Newsom and his staff have taken pains to harden the entire cable plant, not only for cable entertainment signals but for the increased emphasis MediaOne has placed on telephony signals, "especially," he said, "knowing that we have 911 signals running off the network interface unit (NIU) on the side of the customer premises."

From an architectural standpoint, interconnections from the master headends to the 42 system distribution hubs are fed by Synchronous Communications 1,550 transmitters, configured in a diverse routed scenario.

"For example, you have an east feed and west feed; the two never cross paths, so there's never a single common point of failure in the outside plant," Newsom said. "We can have one cable knocked down, and through an RF switching device in the distribution hub, the signal

can automatically be switched to another feed with minimal degradation (the system is designed for approximately 3 dB of difference in the backup feed)."

Two parallel networks (cable TV and telephony) come together at the distribution hub. Video entertainment and digital telephony and data signals are mixed in the downstream direction at the hub, carried at that point on a single common fiber. In the upstream direction, the signals also are separated at the hub.

Downstream, from the distribution hub fiber, the network feeds an average of 50 nodes per distribution hub. Each node allows for approximately 50 homes passed. MediaOne is using a 1,310 nm transmitter, the ADC HomeWorx platform, with an ADC HomeWorx receiver at the optical node.

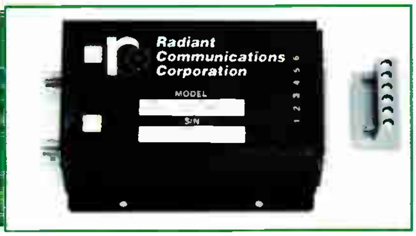
At the optical node, the signal is converted from optical to electrical, distributed to no more than five Scientific-Atlanta amplifiers in cascade. For system powering, MediaOne is using power nodes from Alpha Technologies. One Alpha power node supplies power to the entire network beyond the optical node. The 500 homes potentially passed are powered by a single 90 V power supply. For extra reliability in the event of a power outage, the power nodes have one-hour battery backup and a natural gas generator, enabling the system to run indefinitely, Newsom said.

"MediaOne is leading the charge for converging telecommunications technology over a fiber infrastructure."

Power distribution is achieved with power extension cords, which may be standard 875 75-ohm coax cable. For power performance improvement, Newsom noted MediaOne has dropped down to 50-ohm cable in some instances. In both cases, the supplier is Times Fiber.

Three to five power inserter units, carried on separate distribution runs, in turn power the S-A amplifiers. Power is extracted at the power passing taps and, via coax, runs the network interface units (NIUs) on the side of the customer premises for telephony applications.

Trying to maintain the 5-40 MHz return spectrum bandwidth is a challenge in developing this system architecture. In particular, according to Newsom, MediaOne has decided to place high-pass filters at the tap for its nontelephony customers. That solution, however, is not without its own challenges. "We have to remember we need to pass an impulse pay-per-view signal from the subscriber's S-A 8600X box, which is typically 15-17 MHz," Newsom said. "We have to bandpass that part of the spectrum, so MediaOne's filters start at approximately 18 MHz and go up to 42 MHz." →



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MediaOne's ADC DB6000 digital video equipment, that is used to digitize the video signal up to 16 channels each for distribution to remote hubs.

The telephony side

MediaOne's telephony network is designed to provide total network survivability by providing dedicated synchronous optical network (SONET) ring configurations from the central office to the distribution hubs. The dual master headend/central office architecture is fully redundant: Signaling is replicated at both central offices and headends. This architectural design, said Newsom, eliminates single points of failure within the infrastructure.

The network is based on bidirectional rings from the central office, interconnecting to the local RBOCs as well as the interexchange carriers. All traffic on the dual headend rings returns to the headend and central offices. One hundred percent of the working traffic from each ring node will be split into two signals and routed in two directions around the ring: one in a clockwise direction and the other counter-clockwise.

The transport medium is single-mode fiber-optic cable, primarily at 1,310 nm. MediaOne is using Lucent Technologies' SONET intelligent multiplexers (OC48s, OC3s, OC12s and OC1), linked together in a ring configuration; according to Newsom, the inherent route diversity and self-healing properties of the ring architecture allow uninterruptible service to the customer in the event of a node or fiber failure. →

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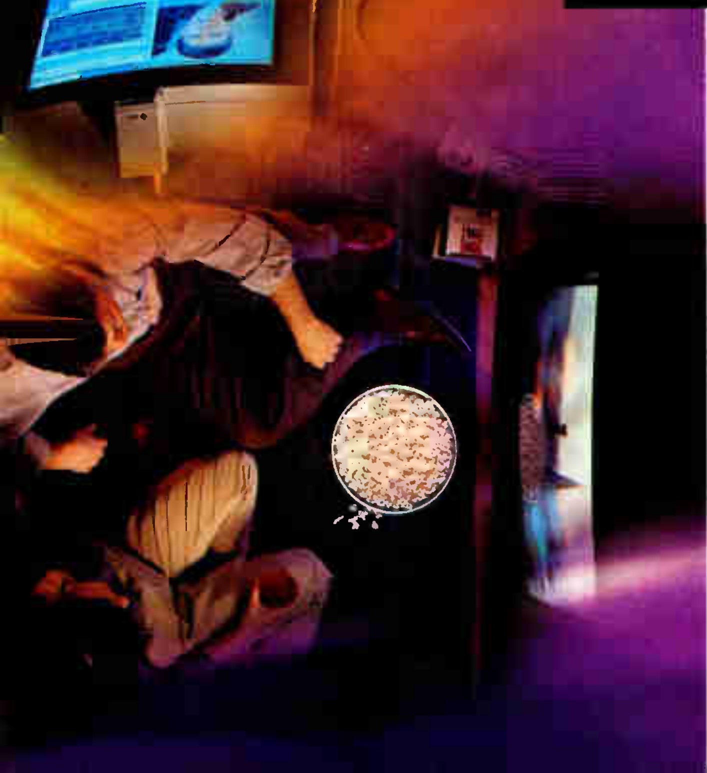

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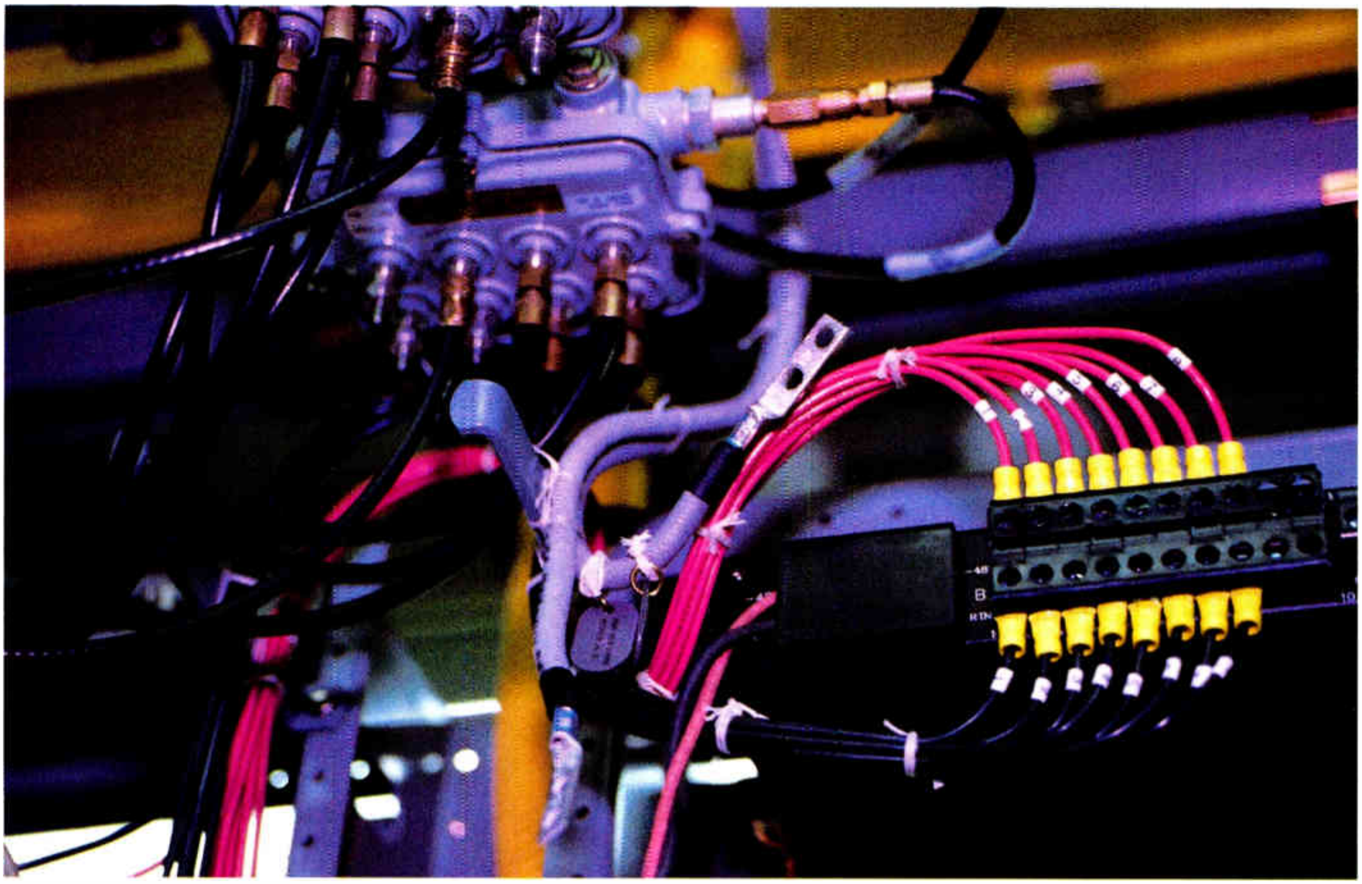


Video feeds to the 1,550 nm transmitters that lead to MediaOne's 41 distribution hubs.

MediaOne will be using the Premisys IMACS intelligent channel banks, which will break down a DS1 to DS0 signals at the end business customer premises to provide services. Telemetry data collected at the central offices will be used by local operations support systems (OSSs) and will be transmitted back to MediaOne's network operations center.

Each central office also is equipped with a Tellabs 5500 digital cross-connect switch. The switch has 1,024 port capacity, which Newsom said "eliminates the necessity of multitudes of electrical panels and allows for larger payloads at one time.

When completed, the telephony network will provide interconnection to 15 BellSouth local serving offices and to a host of interexchange carrier locations.

Adding together the telephony and cable TV optical fiber interconnections, as well as high-speed data applications, MediaOne's network will employ over 6,000 linear route miles of fiber encompassing over one billion fiber feet. Pirelli will be supplying fiber for the installation, Newsom noted.

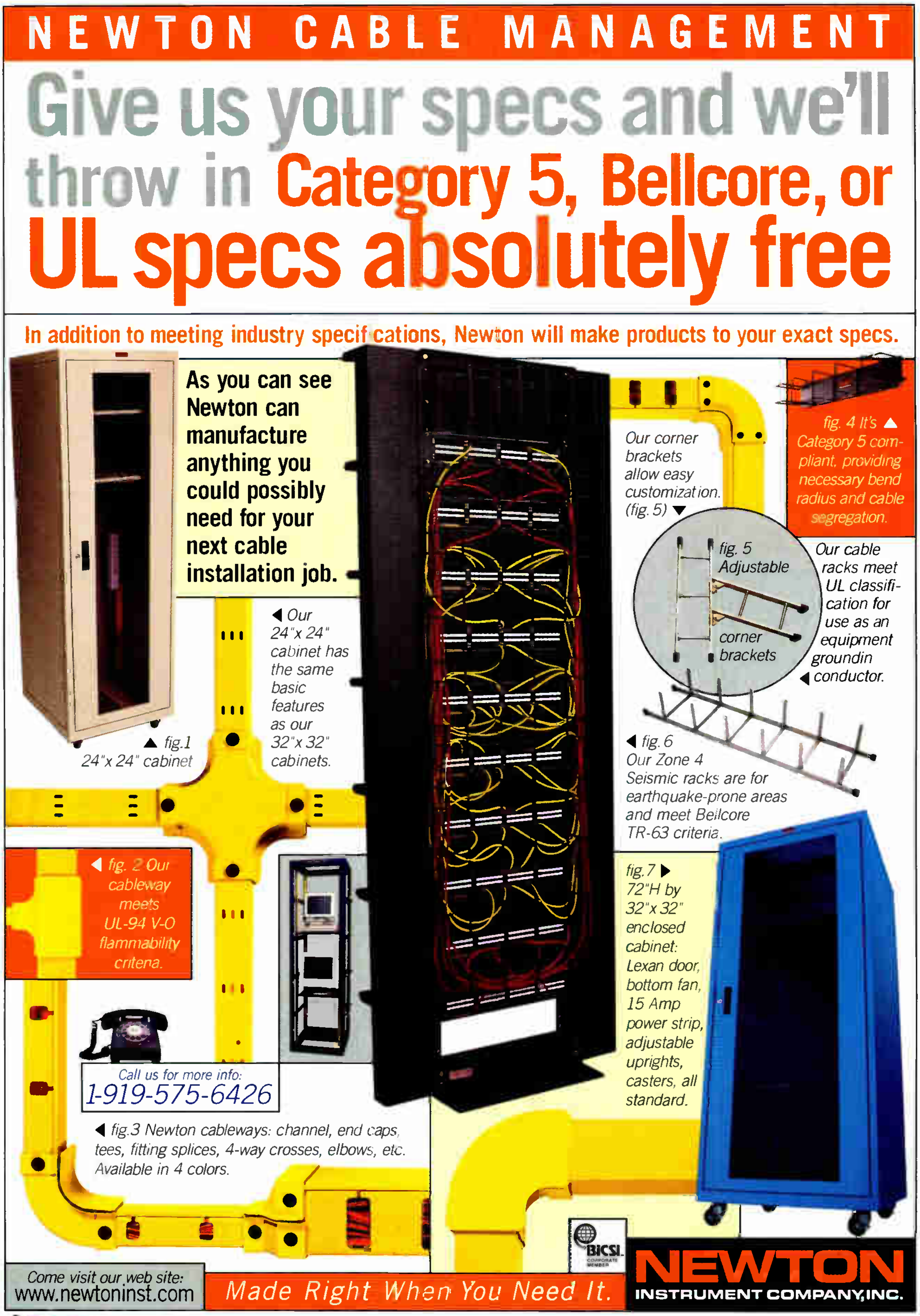
"MediaOne has created two 'superheadends' and central offices for delivering not only TV programming and Internet access, but telephone services as well."

Network operations center

Newsom was apprehensive about discussing the specific location of MediaOne's network operations center (NOC), noting, "it's the brain of our entire network system." Based in one of MediaOne's business office complexes, the NOC, which is manned 365 days a year, 24 hours a day, can monitor all telephony network elements including the Tellabs 5500 digital cross-connect switches and the 5ESS switch from AT&T. This latter is a telephony switch, which will accommodate some 30,000 lines initially, up to 100,000 lines as customer demand dictates, he said.

With the NOC, which provides switching and loopback capability, MediaOne can monitor all the way to the customer's premise on the OSS platform.

The network management platform selected by MediaOne is the MegaSys from MegaSys of Calgary, Canada. Newsom said MegaSys provides interface capability to develop other network element managers, to enable monitoring all the way to the customer premise—but only at the customer premise through the network interface units (NIUs). →



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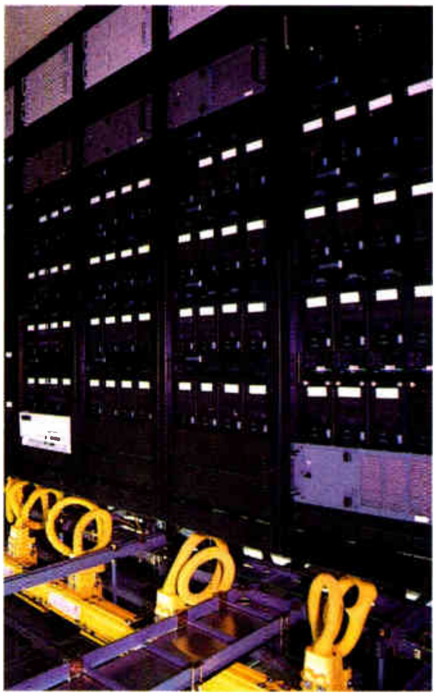
"From the NOC we could initiate a loopback at the NIU for troubleshooting," he noted. The MegaSys platform offers fault escalation, he added. "Instead of reporting 10,000 alarms, it gives the most critical or major alarm first. That frees us from filtering through alarm after alarm to get to the root call." A backup system is located at one of the central offices.

Newsom has not yet selected an RF monitoring system. His plans, he said, are to employ performance monitoring to 200 nodes, to facilitate Federal Communications Commission proofs from the headends or the NOC. For surveillance monitoring, he plans to monitor all optical nodes, all power nodes and a "multitude" of end-of-the-lines. In time, MediaOne will monitor the optical receivers and optical transmitters, as well as environmentals at the distribution hubs (AC, door alarms, security systems). In the case of the latter, the NOC will receive a tampering alarm unless work at any distribution hub is cleared through the operations center.



The headend patch panel for audio and video.

Once all the finishing touches have been added to the network and the NOC, MediaOne's strategy is to offer plain old telephone service (POTS) over the HFC network in Atlanta. Still in development, MediaOne also plans to offer data transfer rates at *n* times 64 kbps over the NIU.

In keeping with the latest trend for new services, the company also will offer high-speed data services via cable modems. The first release of service, dubbed "Broadband Internet Service," includes e-mail, news and a customized Netscape browser, numerous plug-ins and most importantly, an "always connected" high-speed Internet conduit. US West Interactive Services Group's "Dive In" will provide local content that will be enhanced and extended by MediaOne's high-speed data content development group. A Hewlett-Packard server suite will offer firewall security to the headend, with Motorola cable modems at the subscriber site, installed by MediaOne's broadband communications technicians.

All in all, MediaOne is leading the charge for converging telecommunications technology over a fiber infrastructure, turning engineering dreams into reality. **CT**

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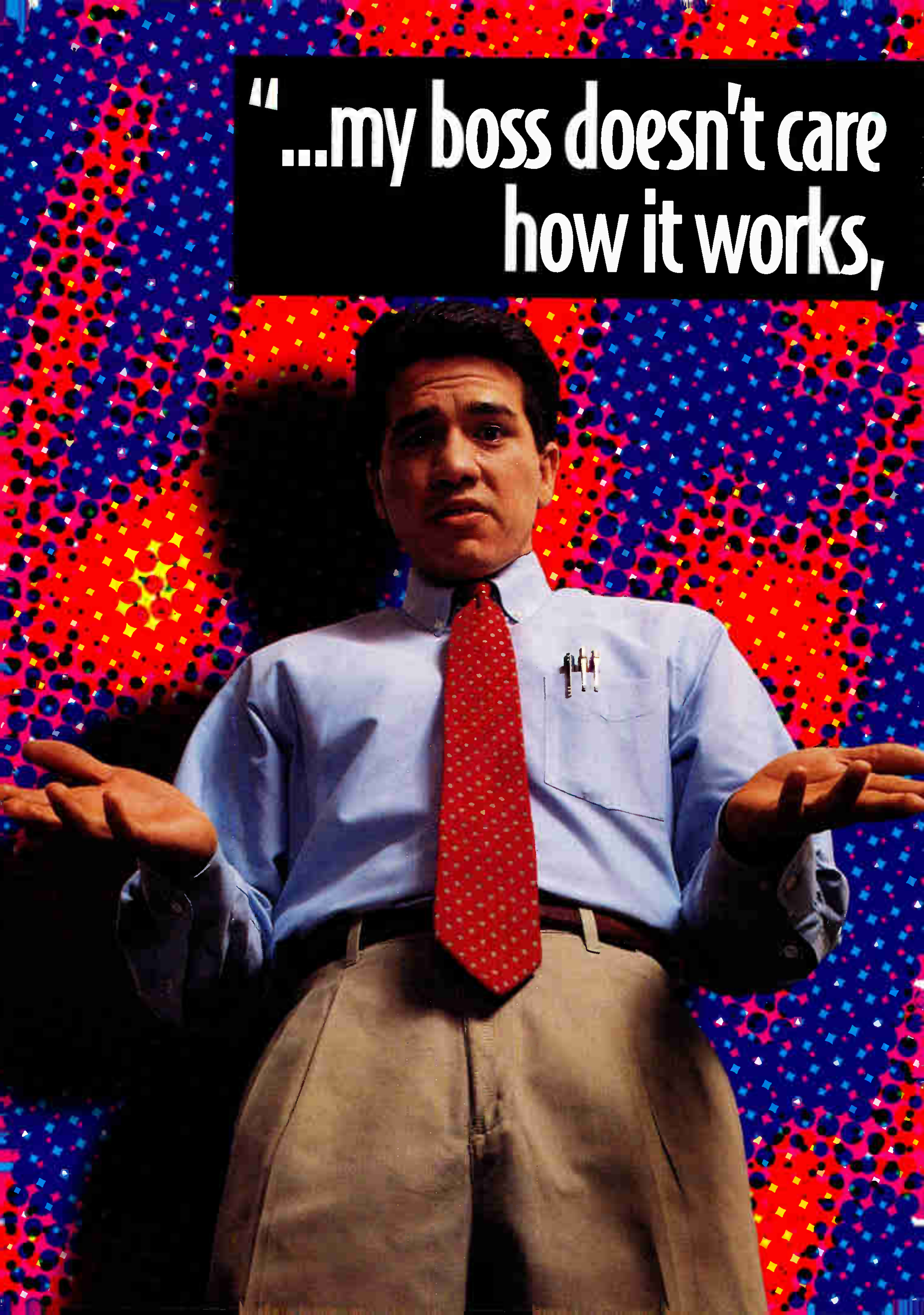
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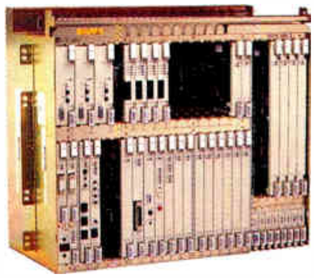

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By Paul Gemme, James O. Farmer, Charles Cerino and Mark Millet

Real-world networks: MSO two-way experiences

The following article discusses practical knowledge gained by three major MSOs—Comcast, Cox and Time Warner—at some of their systems in implementing two-way high-speed data and telephony services. It is adapted from a paper that ran in the Society of Cable Telecommunications Engineers' "1996 Conference on Emerging Technologies Proceedings Manual," which is available from the SCTE by calling (610) 363-6888.

Paul Gemme is vice president of plant engineering for Time Warner. James Farmer is chief technical officer for Antec. Charles Cerino is director of engineering at Comcast Cablevision. Mark Millet was formerly with Cox Cable in San Diego.

Cable TV plant can support two-way services if the proper attention is paid to the reverse path during design and construction, and if proper maintenance is applied. Smaller nodes generally produce fewer problems than do larger nodes. Quality drop cable and internal house wiring are important, and traps may have to be used, at least on some homes, to prevent interference introduced in the home from getting onto the return plant. Confusion exists concerning proper level management in the return path. This problem must be addressed by operators, plant designers and providers of two-way equipment.

Besides issues related to ingress, noise and level management, the operator will have to learn to deal with interface to various computers when delivering data service. Improved monitoring facilities in a cable modem system may help, but techniques must still be developed to cope with the variety of computer equipment and expertise levels held by consumers.

The industry has several years experience with RF impulse pay-per-view (IPPV) systems that use the return path. The technology has proved reliable enough for use in revenue service, but has rarely had to share spectrum with other services. Further, new services, such as cable telephony and high-speed data services, require a new degree of reliability and availability. The cable TV industry has not previously coped with these issues, having in the past been substantially an entertainment delivery service. It should be noted that cable has successfully delivered reliable data in some places for a long time. The difference now is that the data delivery is to homes, where the cost of servicing the data delivery must be low, in line with the revenue. Further, new services will be deployed more widely, and not restricted to business locations.

In order to better understand the issues involved with deployment of two-way cable, this article covers real-world experiences of several operators. The answers don't all agree. This is not a surprise given the limited experience the industry has with operating two-way plant in residential applications.

Usable spectrum

One constant indicated by all of the respondents for this article and

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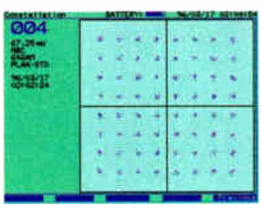

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by published references is that the lower portion of the return band, from 5 MHz to maybe 15 or 16 MHz, is generally pretty densely populated with over-the-air signals that creep into cable systems.[1] This portion of the over-the-air spectrum is occupied by many narrow band communications signals, including amplitude modulation, single sideband and low data rate radio teletype. The signals sometimes originate within the operators' area (e.g., amateur radio transmissions) and sometimes originate elsewhere, but produce high field strengths. Evidence exists that the primary point of ingress of such signals is the in-home wiring, with the drop being the next most common point of entry. Distribution plants that meet composite leakage index tests seem to have little trouble with ingress.

Paul Gemme of Time Warner also has noted a rise in ingress around 27 MHz, the citizens' band (CB), and Charles Cerino of Comcast has noted particular interference around 9.9, 12.2 and 13.7 MHz. The first and last of these frequencies are occupied by shortwave stations operating at powers up to 500 kw. Note that 12.2 MHz is not listed as having powerful stations at that frequency, but below 12.1 MHz and above 13.6 MHz we do find stations running up to 500 kw.[2] Stations in certain parts of the world are known to take power limitations lightly.

Occupancy of the shortwave spectrum tends to follow to an extent the sunspot cycle, which occurs approximately every 11 years. Of concern is the fact that the mid 1990s is a low spot in the cycle, when most activity is shifted lower in the spectrum.[3] The next peak is expected around the turn of the century, and could result in more interference at higher frequencies. Thus, we may see more interference in higher parts of the spectrum in the next five years than we have seen during the time a lot of data has been collected. In any case, the conclusion is probably valid that the lower portion of the return spectrum experiences more ingress than does the higher portion.

Drop filters

The evidence of ingress into the home wiring leads some to consider using high-pass filters at the drop. These cutoff just below 54 MHz, allowing downstream signals to enter the house, but denying exit from the house to signals in the return spectrum. This doesn't work if the operator is using RF IPPV set-top converters, since most RF IPPV systems supplied so far use the spectrum below 15 MHz for return signaling. Because this is not the prime spectrum for newer higher speed services, it is possible to add a bandstop filter that prevents energy from about 15 MHz to 40 MHz from passing, while allowing the lower frequency energy to pass.

Cerino believes strongly in using filters in his system, which involves nodes serving 1,500 to 2,000 homes. Mark Millet (formerly of Cox) served roughly the same size nodes, and found that he selectively put filters on a small number of drops. Sometimes the cost of identifying the problem drops may exceed the cost of putting filters on as a prophylactic measure. Gemme has found that higher quality drop components are important, and feels that the use of traps postpones the inevitable need to fix the problem at its source.

In another study reported by CableLabs,[4] traps were progressively added to drops, with a substantial improvement in ingress. The most dramatic improvement was obtained if the traps were put at the tap rather than at the side of the home. This raises suspicion concerning drop cable, though it is believed that good drop cable properly installed does not have to be a problem.

A further concern leading one to consider traps is the potential for malicious interference in the reverse direction. One could play havoc with two-way services by operating a signal generator or some sort of low powered transmitter (such as a CB transmitter) into the drop. A filter could help mitigate the effect of such, though one would have to use power limiting techniques to remove substantially all of the risk.

Frequency agility

In order to make reverse spectrum work, some sort of frequency agility is almost mandatory. It must be possible to detect that a return frequency is experiencing interference, and to move the

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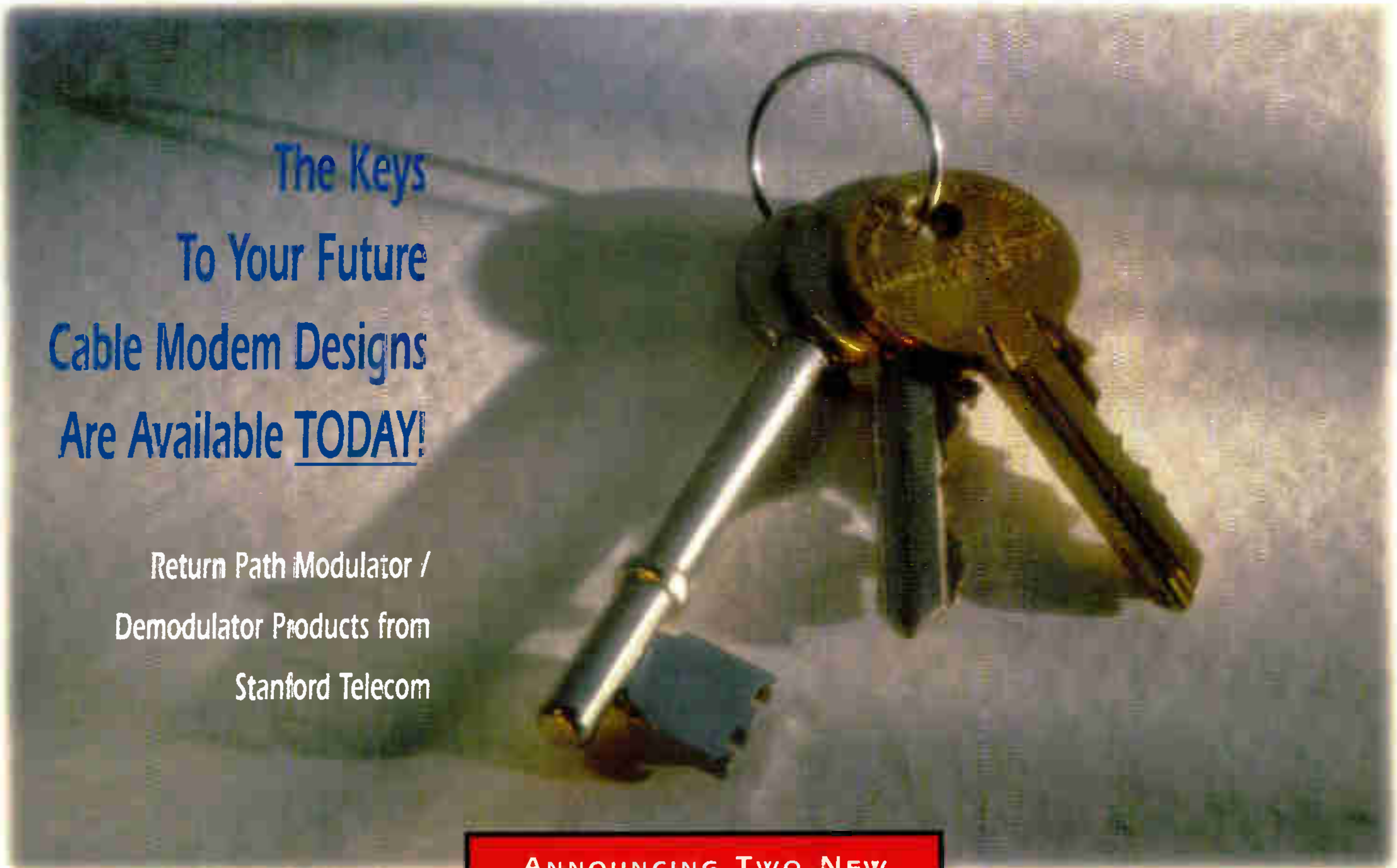

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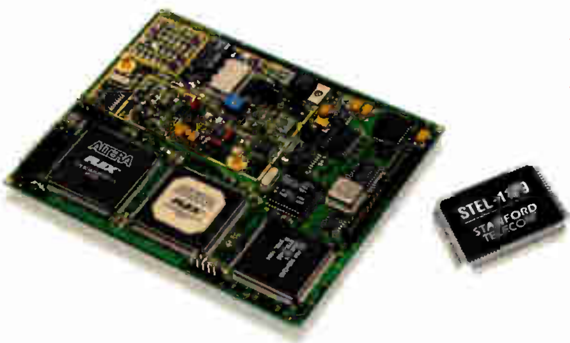

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frequency of all users of that frequency, without the subscriber noticing any loss of service. This means that some piece of intelligence must know what frequencies are available at all times, so that a frequency move will be to a usable frequency, not to another degraded frequency.

This also has implications for the number of services that can share the reverse path. If some number of channels must be held in reserve, then they are not available for other uses.

The magnitude of the problem will not be known for some time, until many more experiences are accumulated. However, it is safe to say that for near term planning, it is prudent to provide for a lot of return bandwidth. This can be done by providing either multiple fibers to each node, or by planning to use block conversion at a node as reverse traffic increases.

Loop-back testing

Respondents noted the difficulty of testing particular modem/computer combinations. It is not always easy to decide whether a problem lies with the communications link, the modem, the computer or the interface between the computer and the modem. This problem can be eased somewhat with the inclusion of self-testing in modems and a loop-back test capability in the modem. In this type of testing, data can be sent to the modem, which sends it back to the headend for checking. The modem/computer interface is not involved. This will allow the operator to eliminate the modem and communications channel as possible problems in trouble calls. The modem also should be able to report back to the headend many problems it might have, and should be able to report received signal strength and bit error rate (BER).

Modem return issues

This portion of the article is based on the experiences of Cerino of Comcast.

The cable system discussed herein is located just north of the city of Philadelphia, and is designed as a hybrid fiber/coax (HFC) network. Comcast upgraded four nodes to 750 MHz and activated the return spectrum from 5 to 30 MHz. Each node passes from 1,500 to 2,000 homes with as many as eight actives in cascade. Every amplifier has a return active. For the first part of our technical trial, we have limited the subscriber activity to only two of the four nodes and 52 connections. The return fiber lasers were upgraded to distributed feedback (DFB) devices that can handle more than eight carriers. We also activated two additional return fiber systems that link the corporate offices downtown, our cable office in the system, and a newly constructed training lab that connects an additional 18 computers. This brings the total number of active modems to 70.

When the system was upgraded, all of the actives, passives and connectors were replaced. The system was then swept, balanced and proofed to ensure that it met design specifications. Normal leakage patrolling was conducted to find any egress problems. The cable drops and in-house wiring have always

been of high quality (tri- and quad-shielded type cable) because of the very close proximity of the system to the antenna farm for the Philadelphia area. Extensive analysis was done on the return to establish base line graphs of the return signature. The results showed that the return was extremely susceptible to ingress and that during the course of any 24-hour period most of the spectrum was unusable during some portion of the period. TV sets and VCRs connected directly to the cable system were suspected as the cause of the high levels of ingress observed. It was decided that it would be necessary to isolate the entertainment devices and most of the drops by putting a high-pass filter on every drop at the tap. The traps are designed to provide approximately 60 dB of attenuation below 35 MHz. Contract installers were sent into the node to install a filter on every drop. After the traps were deployed the system was re-evaluated to determine the effect, if any, gained from the effort.

The results were dramatic but not 100%. Large areas of the spectrum are now quiet. However, some ingress is still observable and at times can be as high as the desired signal coming from a cable modem. The trial cable modem has spectrum limits that restrict its return frequency band to operate between 8 and 15 MHz. This slice of the return is also the most vulnerable to ingress, and in fact we continually observe three frequencies that come and go during various weather conditions and time of day. They are 9.9, 12.2 and 13.7 MHz. We have observed that they do not always appear on both active nodes at the same time. Other frequencies we had to avoid were 10.7 MHz, the common IF for most FM receivers, and an image frequency at 11.8 MHz.

The system uses discreet frequencies in the return that are frequency shift keying (FSK) and 200 kHz wide. The data receivers are tunable and can operate with 200 kHz spacing. Knowing the taboo frequencies and spacing requirements, we were able to establish a block of 24 frequencies that would be available and reliable within the 8 to 15 MHz slot.

When ingress gets to be a sustained problem, we try to isolate the source by first checking the return optical receiver test points to determine which node or nodes are the cause. Once a node is isolated the field technician has to try to locate which section of the node the unwanted signal is coming from.

This is no easy task because the level is constantly changing and at times the signal may even go away. This means that a quick check may not necessarily mean that no signal observed means the source is somewhere else. The technician has to either coordinate what he is looking at with someone at the headend or use the old but still very good trick of placing a camera in front of a spectrum analyzer and using a downstream channel to modulate the test setup to him in the field. Then, using a small battery-operated TV set the technician can easily simultaneously observe the offending signal without causing any system interruption. →


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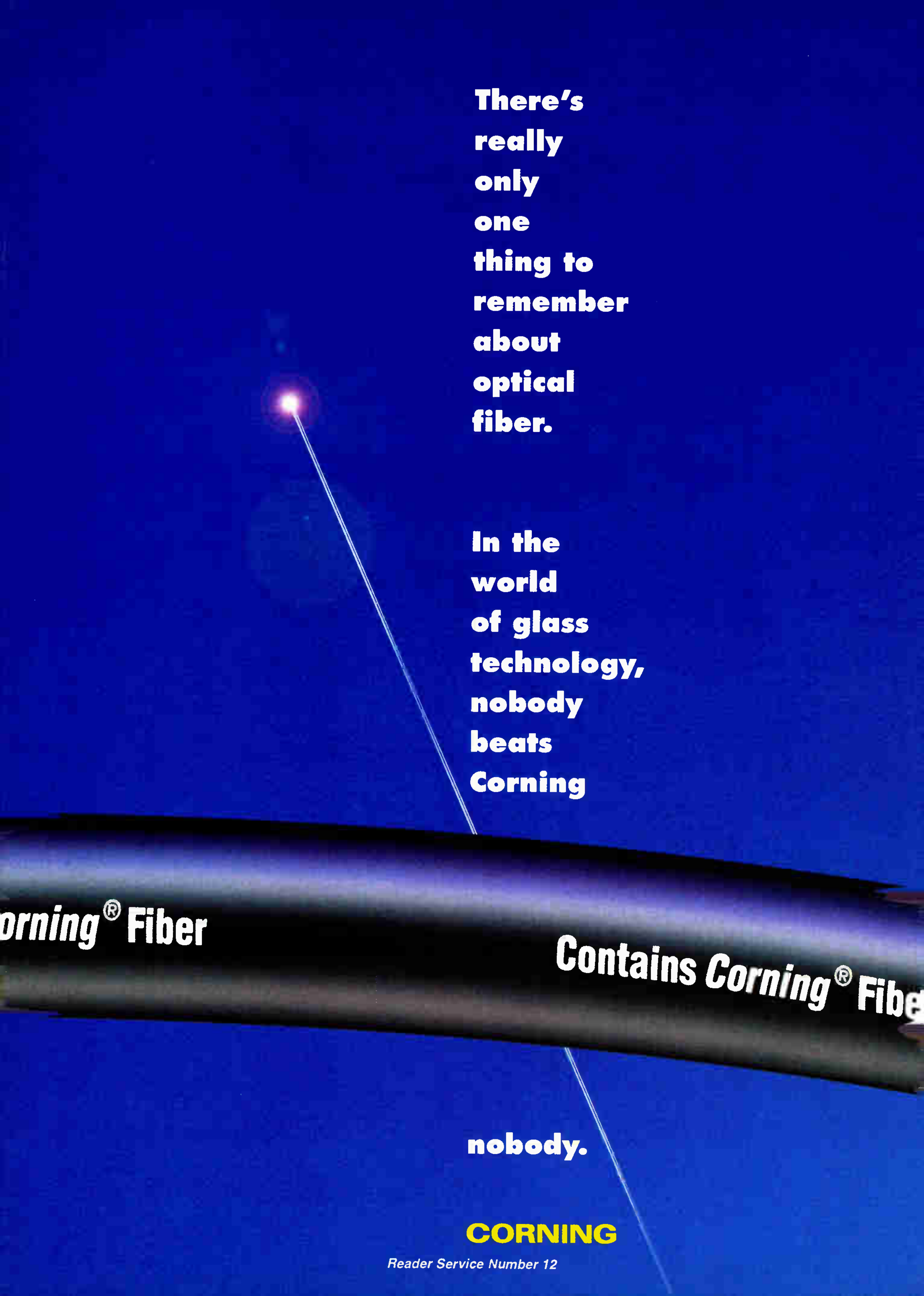
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After all, we used to solve this problem by pulling the feeder maker, pad, tap or fuse to isolate various sections of the plant. And when the signal went away, we would "divide and conquer" accordingly until the problem was found and corrected. This method is not acceptable because active sessions would be interrupted. Smaller nodes also will make solving this problem easier because there will be less plant per node.

As we connected subscribers to the data network, we would move the high-pass filter from the tap to the through leg of a directional coupler (DC-9) we installed just after the ground block. Then a dedicated coax run would be installed to the cable modem. This maintains the separation of the entertainment side from the data side. Through many months of experimentation, we established a 0 dBmV input level to the modem maximizes the data throughput. Using a signal level meter we would then add pads to achieve that level.

Occasionally we would find a location that just would not play properly. Changing modems out and double checking the setup did not solve the problem. A time domain reflectometer (TDR) was connected to the drop at the end where the modem is, and we would look back toward the tap. This helped by finding an unterminated splitter in the house and a bad piece of cable. Of course we also had a problem because we had accidentally put the high-pass filter on the data side of the directional coupler. No return, no connection.

In all of this the most unpredictable piece of this business is the customer's computer. The combinations are endless. We found that certain video boards would not play with certain software. Old versions of DOS would not support Microsoft's Windows for Workgroups 3.11, the operating system we required for this trial when we started. Some of the computers did not like the network card that links the computer to the modem. The reality is that with 52 connections in the field, we have about 30 stories to tell, some other time. To solve these mysteries, we used a hero modem connected to a portable PC to establish whether the problem was between the modem and the computer or the modem and the network. This is important because otherwise a lot of time can be spent chasing the wrong end of the problem.

First we would connect the test setup to the cable system and see if it would play. If it did then we would connect the portable PC to the customer's modem. If that played, we knew that the communications problem was inside the PC. If it didn't we would connect the PC to the hero modem. If that played we would change out the modem. Using this method through the rest of the logical combinations was very effective in reducing the time it took to pinpoint the problem.

There is no doubt that this is an exciting business opportunity. But the way we do business will have to change dramatically. Our technicians and customer service representatives will have to be much more educated to contend with the higher sophistication built into the system. We will have to develop strategies and procedures to test and repair the system without causing total interruption for normal maintenance and repairs. We also will have to find ways to make temporary repairs and cut-overs when the system has suffered a mechanical failure, no matter what the cause.

The design of the network needs to include test points that allow the technician to look at the return at key locations throughout. A directional coupler installed backwards with the fuse removed on the tap leg would work well. This would allow the technician to plug an analyzer in to observe ingress without causing any interruption of service. Preventive maintenance, status monitoring, leakage monitoring, network performance analyses, nonresponding boxes/modems/dwelling interface devices, etc., combined with a new attitude to fix it before it becomes a problem (as opposed to "if it ain't broke don't fix it") will be keys to making coax two-way communications networks a viable alternative to the consumer.

Data transmission

This part of the article is based on the experiences of Mark Millet, formerly with Cox. →

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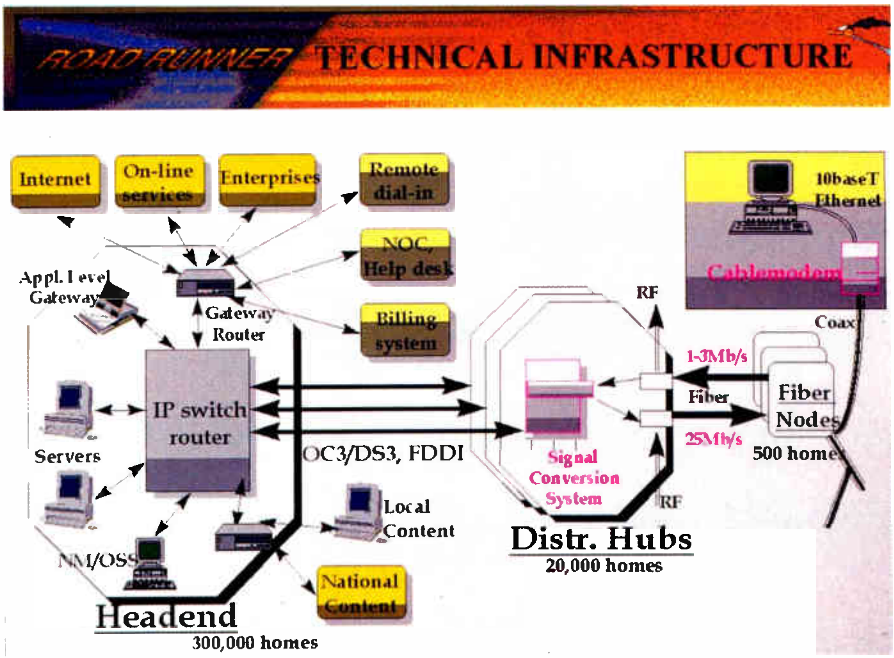
Cox Cable in San Diego has been experimenting with data transmission on its extensive HFC plant in San Diego for several years. Learning how to maintain reverse plant is somewhat analogous to learning to ride a bicycle. You can be taught, but you don't know how to do it until you do it and take your falls. Some portions of the Cox San Diego plant are up to 30 years old, so one could expect certain homes to have drops and internal wiring that are not up to today's expectations. The system is designed today as HFC nodes, with 1,000 to 6,000 homes passed per node. Two-thirds of the plant is equipped for two-way transmission, but not all of that plant is actually running two-way data. Many nodes are carrying data from RF IPPV converters, though only 24 nodes are carrying data trial traffic. Cox continues to do more maintenance on those 24 nodes than on others.

RF IPPV converters allow subscribers to order PPV events on impulse, even after an event has started. They operate by storing events purchased by the subscriber.



Time Warner's Road Runner service infrastructure overview.

Upon poll from the headend, they report usage back to the billing system, using FSK or binary phase shift keying (BPSK) modulation on the upstream RF path. The transmissions are typically short and limited to one per day or less. The transmission level from the home may or may not be controlled.

Previous to the data transmission

work, the system did employ RF IPPV converters, which used the return band to report PPV usage on a polled basis. The poll ratio has historically been under 100%, but was good enough that not a lot of effort was expended improving it. Interference between the IPPV data and the newer data services has not been a problem. The return lasers are low cost Fabry-Perot lasers intended for data service. The level at which to operate the lasers was confusing. Test points were provided before and after gain chips and pads in the return laser drivers, creating more confusion about what level should be measured at the return port. Getting valid, clear data from the manufacturer was time-consuming.

The system did find a number of drop issues. Quality drop cable is required in order to offer data services. The downstream performance was satisfactory, though a lot of effort was expended tightening up cable plant. Fittings had to be tightened, and some broke in the process. The fittings have torque specifications, but it was found that experienced assemblers don't need torque wrenches to achieve proper tightening. Inexperienced assemblers were found to have problems regardless of the use of torque wrenches.

Gain, tilt and other parameters are not engineered in the reverse direction as they are in the forward direction. The plant is engineered for the downstream direction only, and the reverse must be set up to accommodate this design. There is no tradition to sweep return optics. Equipment is available but costly and requires skills not commonly available in the system. The need is to treat the return plant as one would treat the downstream plant.

When the plant was first upgraded, the reverse was checked, but wasn't balanced as needed for data work. In order to set level, continuous wave (CW) generators were installed temporarily, and spectrum analyzers were taken to each amplifier location to measure level. The skill level required was fairly high, and a lot of work went into the process of balancing the reverse plant. In one case, four man-months were required to achieve proper operation of a node. Problem houses were found, at which TV set and VCR spurious signal egress on the antenna terminals was a problem, and 60 hertz impulse noise was a problem some places. A few homes had to have traps installed in the drop to prevent noise from getting on the reverse path, but this was necessary in only about 1% of homes. In order to find those homes, the individual drops were disconnected and inspected with a spectrum analyzer.

Bidirectional plant

These final sections in this article are based on the experiences of Time Warner's Paul Gemme.

Bidirectional plant was first introduced in the early 1970s and has, for the most part, been used with varying but certainly limited degrees of success by cable operators since. Even though the return path occupied the 5-30 MHz region from its inception,

only a small portion of the total bandwidth has ever been successfully utilized in most cases. Problems have abounded and maintaining a clean return spectrum has always been a challenge, to say the least. Part of the problems were directly attributed to the design architecture of plant while others are the result of the hostile environment in which the cable plant must operate, particularly at those frequencies.

Early problems encountered

In order to fully appreciate the challenges associated with operating and maintaining return spectrum it may be useful to explore some of the more prolific problems experienced during early deployment, since we still face many of these same issues in varying degrees today. Over the years the problems most commonly found, affecting the use of the return spectrum have been ingress, noise, and common path distortion. These problems were even further exaggerated due to the additive effect associated with the tree-and-branch architecture used at the time. It also may prove beneficial to present some of the solutions that have been implemented over the years to help mitigate these problems along the way.

Ingress has probably been one of the more difficult problems to eliminate in the return path and generally rendered a good portion of the spectrum unfit for any kind of video or high-speed data transmission to coexist without severe degradation. The worst effects generally occur between 5 and 16 MHz and again at 27 MHz. Other areas of the spectrum were affected but generally to a much lesser degree.

Over the years a number of different innovations have been employed to help reduce the effects of ingress. The first of these was the use of separate shields that were placed in the existing hardline connectors and cable. This not only reduced the ingress of unwanted signal into the plant but also did much to suppress signal leakage emitting from the plant. However, it was felt that even better shielding could be accomplished, which ultimately led to the development of better hardline connectors employing integral shields.

The better shielding effect helped eliminate some of the ingress, but it also was determined that a significant amount of ingress was actually being contributed by drops and in-home wiring. Soon connectors with integral shields also were being used on all drop cable. Drop cable was scrutinized, higher braid counts were used and bonded foils were introduced to offer better shielding and improve the overall integrity. Passive devices used on installs also were a source of ingress. Many of them possessed poor front-to-back grounding. Operators began testing these products closer to ensure they were purchasing quality materials that offered better shielding from off air signals.

Further efforts were made to reduce the effects of ingress from in-home wiring through the introduction of high-pass filters. These were placed on drops at homes not subscribing to bidirectional services, which effectively prevented ingress from the home entering the return path. This helped

but only delayed actually fixing the problem until the customer signed up for bidirectional services. Even with all these innovations, ingress has continued to be a problem and requires constant maintenance to hold it at a somewhat manageable level.

Noise has been another problem to greatly hamper the operation of return plant over the years. The main contributor to low carrier-to-noise ratio (C/N) in the return spectrum was the trunk-and-branch plant architecture itself. The long cascades of amplifiers inherent with this architecture created even greater counts of active devices in the return direction. The addition of the thermal noise from each active device associated with any given trunk run back to its source created "noise funneling." Noise funneling is the term used for the additive effect of thermal noise from each return amplifier off any given trunk run, coming bac
source. Some systems were
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amplifiers, thereby improving the
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the return.

Common path distortion (intermods of forward signals falling into the return bandwidth) was responsible for rendering even more bandwidth unusable in the return spectrum. It generally appeared only after several months of operation and was most apparent in the distribution plant where the forward signals were at their highest levels. This problem was generally created by a film that developed between two dissimilar metals of the seizure screws in the equipment and the center conductor of the cable causing a diode effect that in turn allowed the interfering carriers to be generated. This problem took an exorbitant amount of man hours to keep under control and severely limited the amount of bandwidth that was available for return signal carriage without experiencing impairment to the signals.

The introduction and use of pin-type, hardline connectors seems to have greatly reduced the potential of this problem occurring. The pin and center conductor seizure mechanism is plated with a material that offers a better galvanic match between the cable center conductor and the seizure mechanism in the connector, while also offering a better match between the center pin of the connector and the seizure screw of the taps or passive devices. However, there were certainly other passive connections in the systems that could create this problem as well.

Bridger gate switches were introduced in bidirectional amplifier stations to assist in the process of isolating distribution return legs from the return trunk, allowing easier identification of where these problems were occurring in the system. The switches were capable of placing 6 dB of insertion loss in the distribution off a given amplifier station, or could actually disconnect the distribution return from the trunk return completely at that station. This proved to be a

valuable tool in troubleshooting return problems, although initially the bridger switches had to be controlled manually from an interface unit, generally located in the headend.

Advantages of today

The same problems still exist, but there are several reasons for being more optimistic that the return path can be used successfully and there will be more available bandwidth to fill all our needs today than in the past. Today we employ a 5-40 MHz return spectrum vs. 5-30 MHz, which in itself has certainly provided a significant increase in spectrum available for interactive signals to exist. The good news is the additional 10 MHz now being used is spectrum that can be kept fairly clean without a great deal of effort and is not as susceptible to impairments as some of the lower spectrum.

Plant architecture has changed dramatically and is probably the new advancement that will have the most dramatic impact on improving operation of the reverse plant. In addition to greatly improving reliability of plant, the HFC networks currently being deployed greatly reduce the number of active devices in any one line coming back to a central point, thereby offering greater control in determining and managing C/N levels in the reverse path. Amplifier counts on a single return path have been reduced from the hundreds or even thousands found in tree-and-branch systems to less than 50 in most instances.

Additionally, the reduction in number of contributing amplifiers also will reduce the additive effects on ingress and common path distortion. The new architectures also are being deployed with excess fiber counts that can be used to effectively create more return bandwidth per home passed as the requirements grow, merely by adding return transmitters deeper into existing node areas.

The industry certainly has a better grasp on ingress as it relates specifically to the plant because of more stringent cumulative leakage index (CLI) programs being required by the Federal Communications Commission. However, even with the increased effort placed on controlling signal leakage, there are continuous leaks that appear on a daily basis, which means there will certainly be ingress into the plant at those same points.

The bandwidth that is most affected by ingress, and certainly the most difficult to keep clean, appears between 5 and 16 MHz. In fact, this spectrum should be avoided for any high-speed data or voice communications. It may be prudent to place only very robust, low-speed polling services within these frequency ranges.

Ingress from in-home wiring is still a problem that needs to be addressed further and will complicate keeping the return spectrum clean for bidirectional services. Undoubtedly, ingress will continue to be a challenge, requiring a great deal of man-hours and diligent maintenance to keep under control.

Common path distortion problems appear to have been reduced if not eliminated through the exclusive use

of pin-type hardline connectors in the plant. However, there are certainly other passive connections within the plant that could create this problem as well, which may very well have to be dealt with as they become apparent. In addition, we are using even higher output levels in the distribution portion of the plant than in the past, not to mention that the number of downstream channels present has increased dramatically. What effect if any will all this have as it relates to creating intermods at passive connections going forward? At this point, only time will tell but it is certainly a potential problem.

Other things to consider

Frequency agility is available as a useful tool and should be incorporated in all RF modems used for transmitting return carriers. This would greatly enhance the prospect for successful operation in the return spectrum. Should an interfering carrier appear at the primary frequency of the modem, it could automatically be switched to operate at a clean frequency until the interfering carrier has been removed. Of course, this also requires fairly sophisticated network management systems to be developed to monitor the return spectrum, direct modem traffic accordingly and assign priorities for different services.

There also are a number of other issues that could adversely impact the return system, for which there are no real answers on how to handle. These include a babbling box or lock-on, malicious tampering, and malicious transmissions into the system. This may emphasize the need for bridger gate switches in amplifiers to offer some sort of mechanism by which these type of problems can be isolated and allow the return from any given distribution leg to be deactivated until the problem is resolved. This is only a suggestion and maybe there are other ways of handling these problems. However, they do need to be addressed.

Conclusion

Even though many of the early problems in the operation of return plant have been significantly reduced, it is important to emphasize that they have not been totally eliminated. Therefore, successful uninterrupted delivery of interactive services using the return path, while possible, will remain a challenge and require a solid maintenance program.

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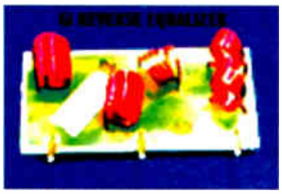

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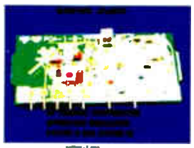

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By Kevin M. Casey

Not smoke and mirrors: Delivering hot services now

The cable TV industry has been criticized in the media—and punished on Wall Street—for first hyping and then failing to deliver new services dependent on advanced broadband technology. However, in reality, these much anticipated services already are being offered in some parts of the country. And they are not smoke and mirrors, trials or beta tests, but actual revenue-generating commercial applications.

Take for example a system in the Northeast, where US WEST Media Group's Continental Cablevision has built an advanced broadband digital hybrid fiber/coaxial (HFC) network and is using it to deliver sought-after new services to consumers, businesses and institutions.

What it offers

In September 1996, Continental rolled out its Highway1 high-speed Internet access service as a consumer product in three Massachusetts communities. By year's end, the network was capable of delivering Highway1 to 225,000 homes. It had installed cable modems in 1,000 customers' homes. And today, the service is available to customers in communities with more than 250,000 homes passed. Delivery capability over Continental's broadband digital network should exceed 500,000 homes by the end of 1997.

More than a year and a half ago, in September 1995, Continental activated an interactive broadband communications network at Boston College, which gives students, faculty and administrators access to a wide variety of video and data services, including high-speed Internet access, as well as to the college's library resources. The network connects 2,500 classrooms, 400 administrative offices and more than 6,000 dormitory rooms. A number of students, faculty and administrators also are telecommuting from their homes over Continental's residential HFC network.

Also in place and operating over Continental's network is a telemedicine network that links Exeter Hospital with affiliated New Hampshire medical practices for transmission of patient records and billing information, as well as the electronic exchange of images such as X-rays—all at speeds hundreds of times faster than conventional dial-up telephone lines.

Continental's broadband network also serves as the principal transport backbone for the signal of New England Cable News, the 24-hour regional news channel in which Continental owns a 50% stake with Hearst Corp. Through interconnections with other cable operators' networks in the six-state region, Continental delivers NECN to some 2 million subscribers. By delivering NECN exclusively over Continental's broadband digital network, the programmer has realized significant cost savings and performance improvements over satellite distribution.

The technology

Continental in the Northeast also is well along in the evolution to digital TV with the deployment of digital signal processing set-top terminals, providing customers with an interactive program guide and the capability to order pay-per-view (PPV) movies and events and program their VCRs via their cable remote control. With a plug-in set-top module, Continental's high-capacity network will be completely ready to go digital, delivering hundreds of additional channels.

Underpinning and enabling all the advanced services the operator now offers, is its broadband network in the Northeast, much of which has been upgraded to 750 MHz bandwidth. Some 2,400 linear miles of optical fiber are in place, with 77,000 fiber strand miles deployed. The network has virtually unlimited capacity through its synchronous optical network (SONET) ring configuration and digital video capability. Data transport onto and off the SONET rings is handled by high-speed routers using asynchronous transfer mode (ATM) technology.

Adding reliability, backup powering and data traffic management capability is the fiber-to-the-node (FTTN) architecture. There are 2,000 nodes in place in the Northeast, with a maximum of 750 homes—and an average of 500—served by each node.

More than 5,000 miles of two-way plant has been activated in the

Kevin Casey is vice president of engineering for Continental Cablevision's northeast region, which serves 1.2 million customers.

Northeast network. The 5 to 40 MHz bandwidth is utilized for the return signal. As Continental activates more two-way plant to more broadly offer its Highway1 high-speed data service, it is taking aggressive steps to monitor and eliminate signal ingress.

Continental's Boston College interactive network was designed with a dedicated fiber optic ring from its Needham, MA, network control center out to the college's on-campus hub site. From there, 18 independent fiber nodes are deployed across the campus, each feeding separate coaxial systems serving individual outlet locations. Ethernet access to the more than 10,000 campus service outlets can be expanded to full ATM (155 megabits per second). The network supports an 80-channel analog video system, which can be upgraded to a 720-channel interactive system.

Continental has layered local area networks (LANs) and wide area networks (WANs) on its HFC backbone to provision high-speed data service and to provide the region-wide network management, customer care and business operations support necessary to compete in the video, data and telephony marketplace.

"Some 2,400 linear miles of optical fiber are in place, with 77,000 fiber strand miles deployed."

The company's Network Operations Center in Chelmsford, MA, is currently monitoring the Internet service all the way through the network down to the individual modem level, and soon will do the same for the video, customer service and business operations networks. This year, Continental will begin status monitoring of all critical broadband network elements.

Continental has opened its largest customer call center in the Northeast, also in Chelmsford, and customer care professionals (CCPs) there have begun using advanced server-based workstations that include customer account, billing, technical troubleshooting and channel lineup/marketing information, as well as individual company-wide e-mail. Its LAN/WAN enterprise network stores critical information that strategic decision-makers throughout the region (on-line from their desktops) will be able to access, report on and analyze. Subscriber, financial, competitive and marketing information will be available to help configure customer-friendly and profitable product offerings, packages, prices and marketing initiatives. **CT**

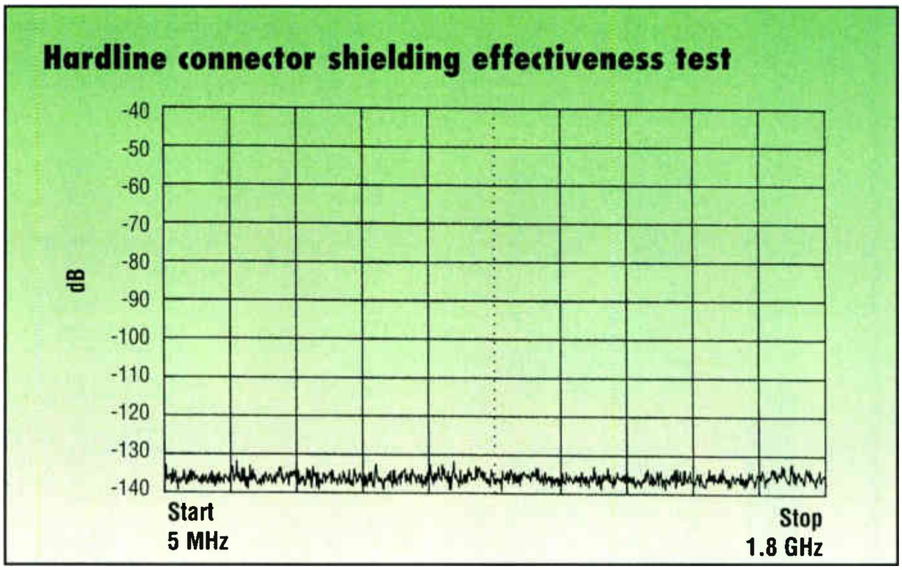
By W. Sherwood Campbell

History of holding it together

Before digital compression, before fiber optics, before satellites, before integrated circuits, and even before transistors, when the first cable TV customer received the first cable TV picture, there were connectors. Although fewer and fewer of us remember such details as the C-connector (F-connector's little brother), J-Jacks or what VSF really stands for, connectors are still with us and probably will be as long as something—amplifiers, cables or subscribers—needs to be "connected."

Connectors are vitally important to the quality and reliability of the service we provide to our customers. Connectors are not hardware. They are passive devices and key elements in the signal path. With

W. Sherwood Campbell is a member of the technical staff of Gilbert Engineering. He can be contacted at (602) 245-1050.



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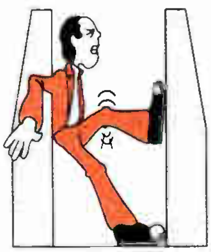

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connectors, it makes sense to do it right the first time: With a typical 1,000-mile hybrid fiber/coax (HFC) plant containing about 100,000 hard line connectors and 1.3 million F-connectors, it is certainly much easier to chase and replace headend, power supply or even amplifier and node problems than connector problems!

The most recent changes in active device technology have caused some changes in what connectors are required to do and how well they are required to do it. Some things (such as ease of installation and training, corrosion resistance, insertion loss and weather-proofing) haven't changed much. Others have, and in this article we will look at the changing requirements for return loss, RF leakage and power carrying capacity.

Enhanced services

Two changes have affected return loss requirements. One of these is the increasing top frequency of the passband. The other is the discovery with the early carriage of digital audio services that the 1953 P. Mertz echo curve is no longer good enough and—depending on the format, modulation, and error correction—data services can be very sensitive to cumulative "microreflections." However, the industry quickly learned that hardline connectors (which have return losses exceeding 25 dB at 1 GHz and considerably better at the more important lower frequencies where less cable attenuation results in stronger reflections) are not the critical element.

RF leakage is a concern for two reasons. One of these is, again, the ever-increasing top frequency. As Rocco Ficchi said in *Practical Design for Electromagnetic Compatibility* over 25 years ago, "As frequency is increased, all connectors become limiting (EMC) factors in a given circuit." The other concern is the increasing utilization of cable's 5 to 30 or 5 to 40 MHz upstream. The new services in this band are using a spectrum notorious for its ambient amateur radio, citizens' band and international broadcasting fields. They also are using a path susceptible to the tree-and-branch architecture's noise funneling characteristics. But, again, the industry was ready with hardline connectors tested to a shielding effectiveness greater than 130 dB from 5 MHz to 1 GHz. (See accompanying figure on page 82.)

Power play

Several factors have changed the role of cable connectors in power transmission. The increased power consumption of more linear amplifiers such as feedforward and power doubling devices, the use of copper clad aluminum center conductors, the power consumption of reverse amplifiers, and the need to power network interface devices (NIDs) on or in the consumer's premises are such factors.

Even with these changes and concerns—and allowing for high temperatures, which can increase the power loss in the cables themselves by more than 15%, and the statistical possibilities of a large number of telephone subscribers "going off-hook" or ringing at the same time—the worst-case current flow through any hardline connector is predicted to be less

than 10 amperes. Again, connectors were ready and equal to the task!

Hardline connectors have begun being tested to ensure that the temperature of the connector center conductor will not rise more than 10° C above ambient for a 15 ampere current through the connector and that the connector's dielectric materials will not change their electrical or mechanical characteristics at elevated temperatures. Although the voltages carried have risen from 0 to 30 to 60 and now to 90 volts, this too is not a problem: Some connectors can withstand a 1,000 volt dielectric test!

Several operators have discovered that for economic and reliability considerations, current and proposed HFC architectures can best be powered by inserting power into the coaxial distribution plant at points that are some distance from the optimal AC power supply location. This has led to the development of special coaxial cables for the delivery of power, at 90 VAC and at a maximum current of 25 amperes. Both 60 Hz and 1 Hz are being considered for the power frequency. **CT**

By Bill Gutknecht

Building a better mousetrap: Fiber receiver service cable

The evolution of the fiber receiver service cable (FRSC) is unique and was born of necessity. In the beginning, the optical receivers were fusion-spliced directly to the outside plant (OSP) cable. The technicians soon complained that they were unable to easily change out a defective receiver module, because they had to break the fiber and then resplice it. This problem necessitated the invention of a better mousetrap.

The second generation FRSC consisted of an outside plant cable fed directly into the optical receiver through a connector. This required several different size connectors to fit the various sized cables. Rotary mechanical splices (RMSs) were then installed on the bare fiber. The RMS connector required polishing by hand. This was a time-consuming procedure. One splice could take over an hour to install. The optical receiver came with a bare fiber that had to be connectorized also. With connectorization the outside plant technician was able to change a defective module in a short period of time.

The manufacturers recognized the need for connectorization and began to install RMS connectors as well as the connectors we use today. This helped to shorten the connectorization and installation time even more. However, there was no guarantee that the connection point would meet minimum requirements for cable pullout, water penetration and optical performance.

Three methods of terminating fiber at the optical receiver are presently used:

Bill Gutknecht is the network transport product specialist, fiber optics, for Antec Network Technologies. He has been in the cable TV industry since 1973 and is a member of the Society of Cable Telecommunications Engineers

• **External splice**: A factory connectorized jumper was cut in half and fusion-spliced to an umbilical cable from the receiver to a splice closure. The jumper ends are routed into the optical receiver through a feed through connector. The umbilical cable is spliced into the OSP cable inside the closure. This procedure is a parts-saver, labor-intensive and severely influences downtime when maintenance is necessary. The splices do not meet return loss specifications of -55 dB. They are approximately in the -35 to -40 dB range. This method also increases the number of optical splices in the system, and decreases the systems optical performance.

• **Internal splice:** The process is the same as the external splice, except that the OSP cable is routed into a splice tray inside the node. The cut jumpers are then spliced to the OSP cable inside the splice tray. This eliminates the need for a splice closure, saving the cost of the closure and reduces the number of optical splices in the system. This process also is a parts-saver, but is labor-intensive and severely influences downtime when maintenance is necessary. The return loss specifications and system optical performances are the same as with the external splice.

• **Fiber receiver service cable:** The FRSC comes with the optical connectors and a 5/8-inch cable connector. Specific lengths, optical connectors and fiber counts can be specified. The tail end (bare fibers) of the FRSC is then spliced into the OSP cable inside a fiber closure. This method is very simple, requiring optical splicing at the fiber closure only, and thus a minimal amount of installation time. Return loss specification will meet or exceed -55 dB, and system specifications will be improved. The improvements to return loss and system specifications are due to less optical splices in the system and high-quality optical connectors on the FRSC.

What's inside?

In order to function properly, the FRSC must be professionally manufactured under strict and consistent quality assurance conditions, using Bellcore-approved parts. The optical connectors must be machine-polished for consistently high-quality return loss specifications. Final testing to specification before shipping, as well as protective packaging to protect the FRSC during shipment also are necessary.

"Field-assembled units may save money, but they do not deliver the quality of picture our subscribers deserve."

FRSC is composed of the following:

• *Fiber cable:* Must be outdoor-rated, armored and gel-filled.

• Optical connectors: Factory-installed as specified by the cable company. There are no splices in the FRSC. This guarantees a return loss of -55 dB or better, which cannot be achieved by field installing the connector.

• *The 5/8-inch cable entrance connector:* Front nut of the connector must permit cable installation without revolving the cable or the fan out.

Choosing FRSC

The FRSC cable has become a major component of the fiber-optics network. This is demonstrated by the number of manufacturers who now include a FRSC cable with their optical receiver.

We must remember that field-assembled units may save money, but they do not deliver the quality of picture our subscribers deserve. The user must consider these important issues when selecting an FRSC. Although a seemingly simple product, careful attention to detail must be taken to deliver a well-made product high in specifications and quality. **CT**

By Timothy Kwok

Broadband Internet services: Exploring technical options

The following was adapted from a paper that ran in the Society of Cable Telecommunications Engineers' "1997 Conference on Emerging Technologies Proceedings Manual."

The current narrowband residential infrastructure using dial-up for access to the Internet—either plain old telephone service (POTS) or integrated services digital network (ISDN)—is slow for most people, which has led to the "World Wide Wait" on the World Wide Web. As we all know, high-speed Internet access has been viewed as the "killer application" for residential broadband (RBB) networks.

Increasing the performance of Internet applications such as Web browsing cannot be solved by RBB networks alone, because the bandwidth bottleneck is not only at the access point (narrowband dial-up networks), but also at the Internet backbone. The obvious solution is to upgrade the capacity of the Internet backbone.

Timothy Kwok currently manages the Broadband Network Architecture Group at Microsoft Corp. in Redmond, WA. He also is the vice president of business development strategies for the ATM Forum and serves on its board of directors.

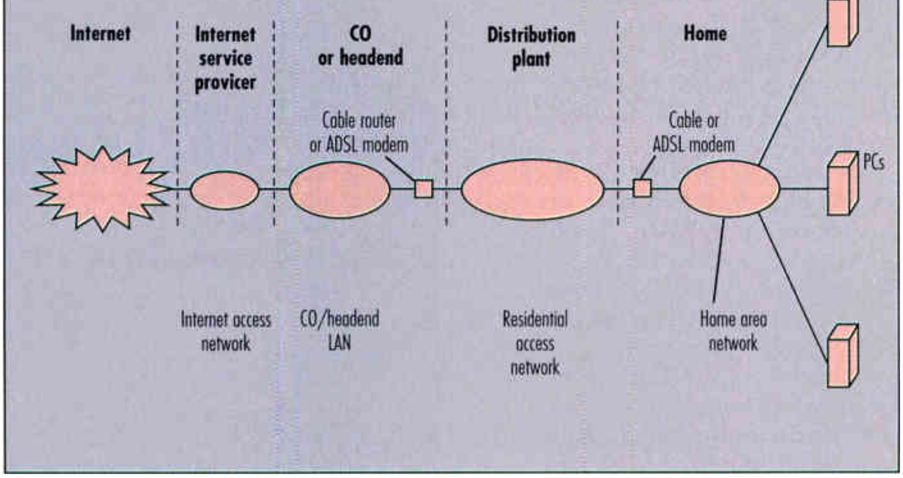
"Caching Internet content to local CO and headends together with deploying RBB networks has become the winning combination."

However, there are two problems with this solution. One is that it is expensive. Furthermore, given the ad hoc nature of operation of the Internet, it is hard for the Internet service provider (ISPs)—both regional and national—to justify economically because there is no incentive of doing so because of the flat-rate pricing structure. Second, the explosive rate of traffic growth on the Internet makes it very difficult to keep up the pace of bandwidth growth.

The alternative solution to this is caching at the local headend or central office (CO), and at the edge of the Internet backbone network. If the data being accessed on the Internet is stored locally at the headend or CO, the content can be delivered at high speed to the homes if there is a RBB network. Hence, caching Internet content to local CO and headends together with deploying RBB networks has become the winning combination to solve many (though not all) Internet bandwidth problems for on-demand content delivery. (There are applications such as wide area real-time conferencing applications that cannot be solved by this approach because they cannot be cached due to the real-time nature of the information.)

Another advantage of deploying the RBB network for Internet access is that it is based on packet switching.[1] This can bypass the dial-up infrastructure, which is a circuit-switched network. The current architecture of using a circuit-switched infrastructure to access packet data (the Internet) is fundamentally broken. It ties up the telephone circuits for literally hours.

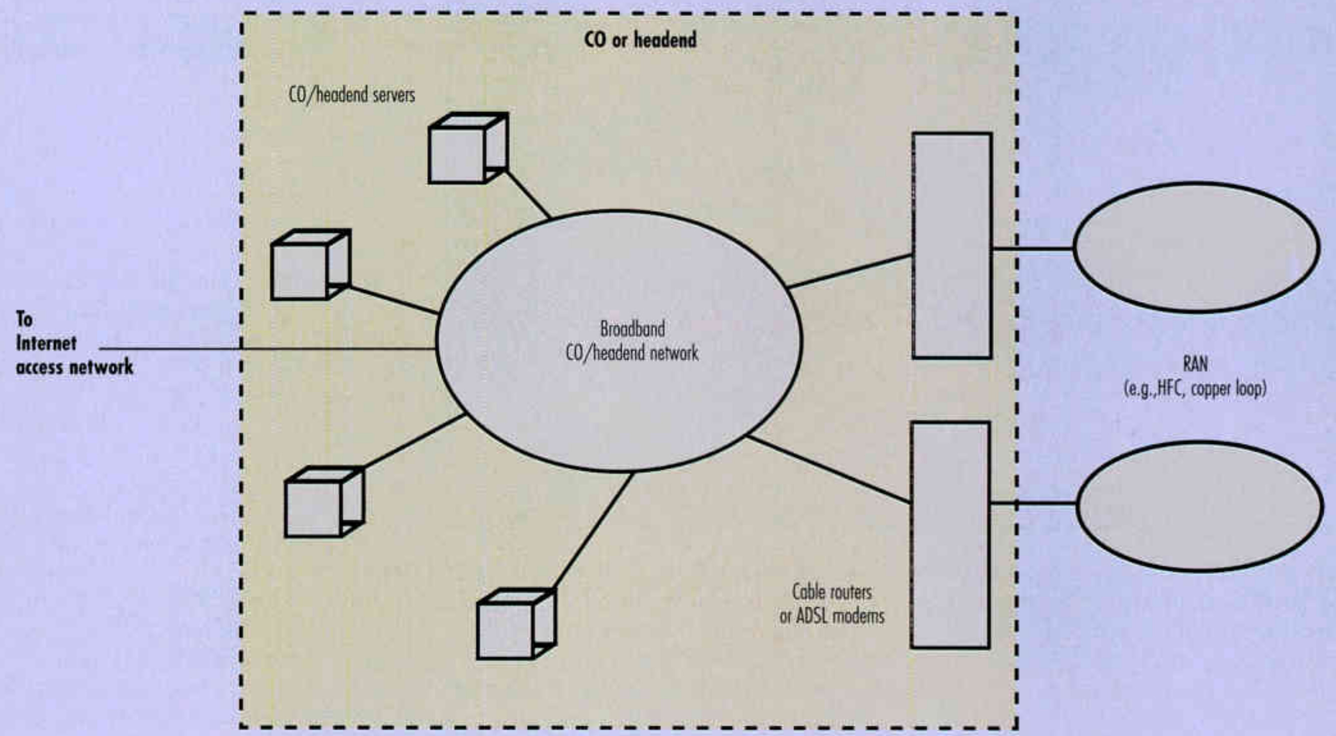
Figure 1: Residential broadband Internet access network architecture



What is PPTP?

In addition to supporting a wide range of real-time multimedia Internet-based applications, we can transform the Internet into a secured virtual private network. This is achieved using point-to-point

Figure 2: CO/headend network architecture



tunneling protocols (PPTP),[1] which is basically point-to-point protocols (PPP) running over an Internet protocol (IP). This allows a wide range of remote access applications to the corporate network, which include "roaming," "hoteling" and remote office applications. This also allows outsourcing of the corporate dial-up infrastructure to the ISPs.

For discussion purposes, we'll assume the home device connected to the Internet is a PC. However, there could be other intelligent devices that also might be connected to the Internet, such as a set-top box or an advanced telephone.

Architecture

There are four main RBB network architectures: hybrid fiber/coax (HFC), various advanced digital subscriber line (xDSL), fiber-to-the-curb (FTTC) and fiber-to-the-home (FTTH). Other options of high-speed Internet access are available (such as using direct broadcast satellite as the shared downstream channel), but they are beyond the scope of this article. (RBB architectures are discussed in more detail in Reference 1 listed at the end of this article.)

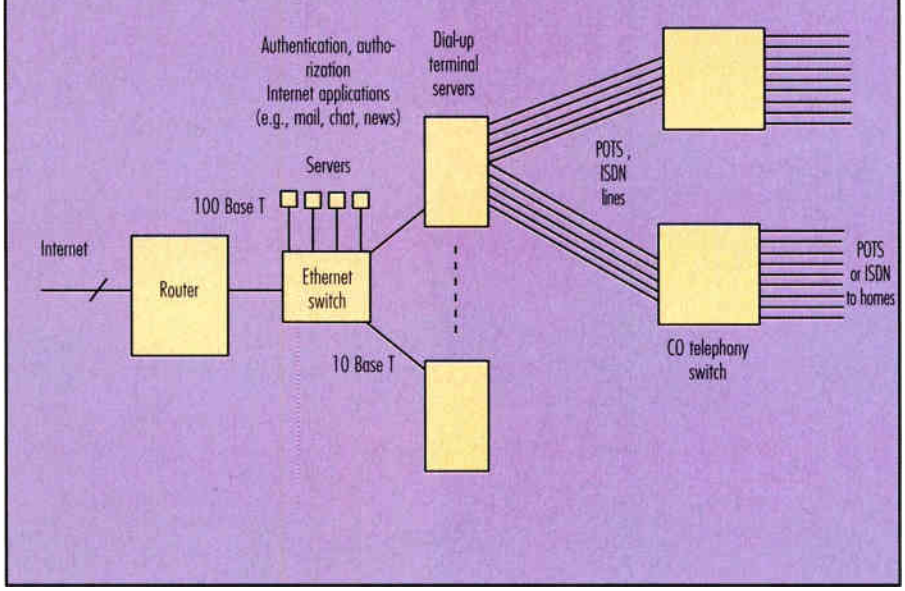
A model of the RBB Internet access network architecture is shown in Figure 1. To access the Internet, the PC at home has to go through four different physical sections: the in-home wiring, the distribution plant, the CO or headend and the Internet service provider point-of-presence (POP). Accordingly, the Internet access network architecture consists of four main subnetworks: the home area network (HAN), residential access network (RAN), the CO/headend network and the Internet access network (IAN). Although the RBB network architecture chosen by a network operator involves mainly the RAN, there are ramification to the CO/headend network and HAN because the RBB network is terminated by equipment in these two subnetworks as shown in Figure 1.

IP end-to-end

This reference model assumes the IP is running end-to-end. At the home, IP is terminated at the PCs. This IP end-to-end model also is applicable to the asynchronous transfer mode (ATM)-to-the-home model discussed in Reference 1, which explicitly assumed IP is running over ATM to provide connectivity for non-ATM endpoints that also are IP-enabled. (However, this model can be extended to PCs running non-IP protocol at home to access IP-based applications, as long as at least one of the PCs at the home is IP-capable and can act as a proxy gateway for such services.)

Figure 1 shows that the Internet is a separate network for which the other subnetworks connect to through the Internet access network. All the subnetworks within the broadband Internet access network are part of the Internet, unless there is a firewall or a network address translation (NAT) device to hide part of the network. The reason is that the Internet is by definition "a network of networks" that are interconnected by the common protocol IP. If all the PCs and routers in these subnetworks support IP and used real IP addresses, we consider them all part of the Internet, including the

Figure 3: An example network configuration of a narrowband ISP POP



PC at home. (In this case, we refer to the PC at home as being on the Internet, at least while it is communicating with the Internet using a genuine IP address.)

Cable modems

For cable companies, the RBB Internet services will be supported by upgrading their coaxial plant to HFC and enabling the return path (upstream from home to the headend) for two-way communications. (Note that the upgrade to HFC can be justified on other grounds, such as decreasing maintenance cost and supporting the emerging digital broadcast TV services.) The RBB network for cable operators consists of three components: the HFC architecture, cable modems at homes and cable switch/router(s) at the headend. The HFC architecture is a modular architecture that divides the subscriber service area into neighborhood areas of 500 to 2,000 homes passed.[1,3] For each neighborhood area, there is a fiber from the headend extending to the area and terminated at a fiber node. From the fiber node, coaxial cable extends to pass the homes in the area.

The HFC architecture uses a passband transmission system that divides the frequency spectrum into downstream (above 50 MHz) and upstream spectrum (5 to 42 MHz). The downstream spectrum, which is typically from 50 to 550 or 750 MHz, is further divided into 6 MHz channels. While the lower part of the downstream spectrum is reserved for existing analog broadcast TV services, the upper part of the spectrum can be used for digital services. The typical bandwidth available for such an architecture is about 27 Mbps downstream for each 6 MHz channel—using 64-QAM (quadrature amplitude modulation)—and about 2 Mbps upstream.[1] Upstream bandwidth as high as 16 Mbps (using more frequency spectrum than the 2 Mbps version) are being considered by the Institute of Electrical and Electronic Engineers' 802.14 Committee, which is a standard committee responsible for defining cable modem standards.

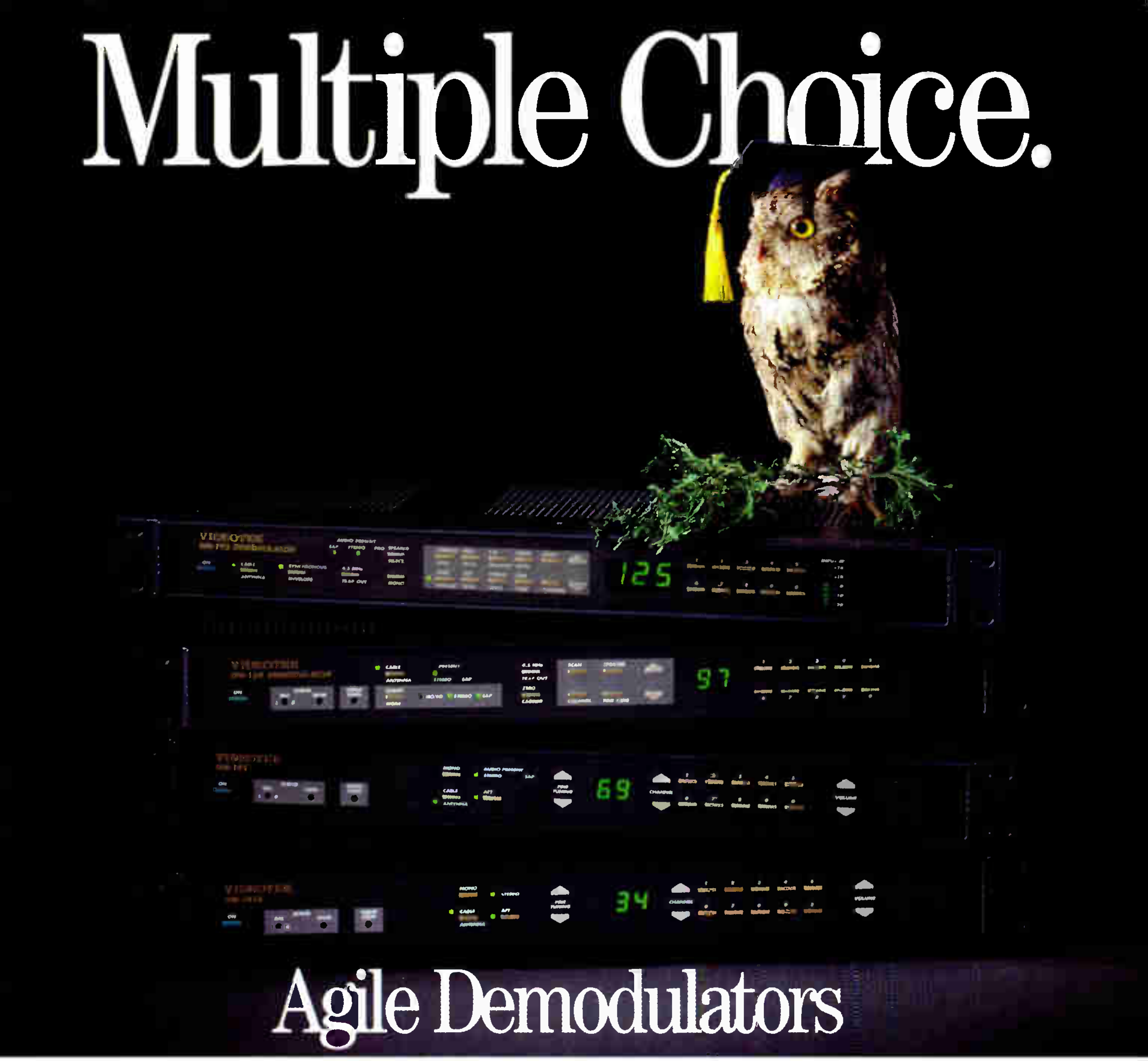
"If the network is overloaded, more downstream and upstream spectrum can be allocated to spread the load."

A basic characteristic of this architecture is that the bandwidth in both directions are shared by all the homes served by the same fiber node, which is typically targeted to pass 500 (and up to 2,000) homes. The minimum average bandwidth available is equal the bandwidth divided by peak number of simultaneously active cable modem users. For example, if the take rate (percentage of homes subscribing to cable modem service) is 10% and at peak hours 50% of the subscribers are active, the average available downstream bandwidth for a 500-home node is 1.1 Mbps. The peak rate can be as high as 27 Mbps, if not limited by the network interface speed on the PC (which can be 10 Mbps for 10 Base T Ethernet, or 25 Mbps for ATM).

Note that this is a scaleable architecture. If the network is overloaded, more downstream and upstream spectrum can be allocated to spread the load because this can be justified economically.

xDSL modems

For the telephone companies, a leading architecture for broadband Internet services is based on the xDSL high-speed modem technologies family.[3] Assymetrical digital subscriber line (ADSL) is the most popular member of the xDSL family used in current broadband trials. A key advantage of the ADSL technologies is that it can be implemented over the existing copper loops without upgrades. The RBB networks have been enabled by simply deploying a pair of ADSL modems on both ends of the copper loop (at the CO/remote and at home). The main requirement is that the loop can meet the distance limitations. In particular, ADSL with 1.5 Mbps downstream and 64 Kbps upstream can be supported up to 18 kft copper loops, which can be satisfied by approximately 75% of the American homes.[4] The higher-speed version of ADSL can support 6 Mbps downstream and 640 kbps upstream up to 9-12 kft (depending on the mix of 24 and 26 gauge loops). A key characteristics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of this architecture is that such bandwidth is dedicated to the pair of ADSL modems for each loop, instead of shared among many modems as in the HFC architecture used by the cable modems.

POTS can be supported simultaneously on the same copper loop because it uses different regions of the frequency spectrum. At the CO, the analog telephony signal from the loop is split to the CO telephone switch, while the data signals are split to the CO telephone network. A similar process takes place at the homes to split POTS and high-speed data connections.

"We should consider how an external or internal modem scenario can evolve from supporting one PC to multiple PCs in one household."

CO/headend network

The CO/headend network architecture is shown in Figure 2 on page 92. The CO/headend network architecture has four key functions.

First, it provides termination for the RAN. For example, a cable switch/router is used to terminate the HFC network to communicate with the set of cable modems at homes in the same (or multiple if multiple demodulators are used) neighborhood area, while an ADSL modem is used to terminate a copper loop at the CO (or remote) to communicate with the corresponding ADSL modem at home.

Second, the CO/headend network provides a distribution function for the services and applications supported by the CO/headend servers. The servers at the CO or headend include Web servers to store local content as well as the caching server to cache popular Internet Web pages. In addition, video and audio servers to store local content also can be located here.

Third, depending on the ISP model, the CO/headend network provides connectivity to the Internet either directly (as an ISP) or indirectly through an ISP. If the ISP is different from the cable or telco, then the responsibility of the CO or headend network is to provide high-speed IP connectivity (such as over a DS-3 or OC-3c link) to the ISP's network, referred to as the Internet access network. If the public network operator also acts as an ISP, then the CO or headend network also might provide ISP services and applications with additional servers in the CO or headend network. These servers include authentication servers for subscriber access management, as well as Internet applications by providing Internet mail, chat and news servers.

Fourth, the CO/headend network can provide direct connectivity to corporations without going on the Internet. This allows higher bandwidth and a higher level of security. The connectivity between the CO/headend network and the corporations can be through a regional broadband network, such as synchronous optical network (SONET) or ATM connectivity.

There are two approaches for supporting IP service in the CO/headend: connectionless or connection-oriented. In the connectionless approach, the CO/headend network architecture is similar to the legacy LAN architecture: an internetwork using routers and Layer 2 switches and hubs. Early implementation tends to be connectionless-based. For example, each ADSL modem at the CO can have an Ethernet (10 Mbps) interface to connect to an Ethernet switch, which in turn connects to the core router in the CO. Similarly, the cable router (which terminates many

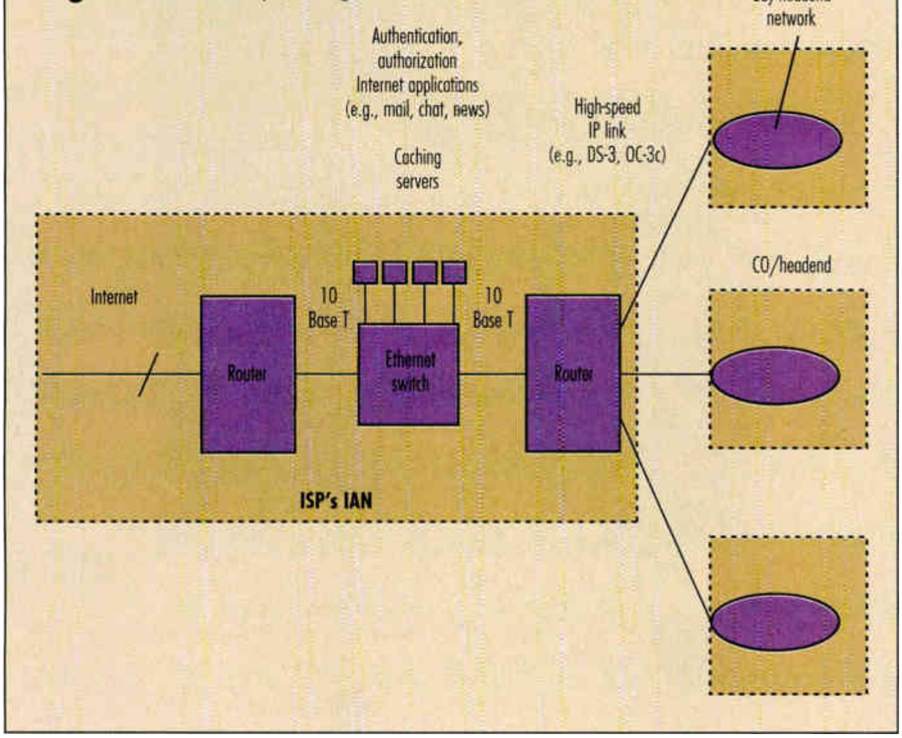
'able modems from homes) can
ıave a fast Ethernet (100 Mbps)
ıterface to the core headend net-
'ork router. Alternatively, the
ıble router can be replaced by a
ıble switch (a Layer 2 device).
More advanced implementation
ın be based on the connection-
riented architecture. This pro-
'des a virtual "dial-up" paradigm
ɪr Internet service to the ISPs.
ıstead of dial-up through the
ıblic switched telephone network
'STN), it is using virtual connec-
on (VC), such as an ATM VC.
here are many advantages to this
ɔproach. The connection-oriented
ɔproach provides much better se-
ırity, as data associated with a
articular connection can be se-
ıred easily via either end-to-end
·curity or network security or
ɪth. Also, it preserves the current
ial-up paradigm infrastructure of
ɩisting ISPs, which manage sub-
:ribers' activity based on explicit
ial-up activities. Moreover, the
ınnection-oriented paradigm sim-
ifies provision of QOS to each
ıta flow by reserving resources
ısed on connections.

An example of the connection-
iented architecture is the ATM-
-the-home architecture,[1] for
hich ATM cells are carried all the
ay to the home over the RAN. In
ıis case, the CO/headend network
ATM switch-based. For the head-
ıd network, the cable switch is
ctually an ATM switch with
ɔwnstream and upstream modu-
.tors terminated as ports on the
ıble switch. In addition, the cable
vitch has ATM interfaces con-
ected to a core ATM switch, which
so provides connectivity to the
ıternet access network. To pre-
:rve the existing dial-up security
ıd authorization paradigm of
PP, we can support PPP over
TM. This allows connectivity to
ıultiple networks simultaneously,
ıch with a different network ad-
'ess (or even protocols).

ıternet access network

The Internet access network
; defined as the network imple-
mented by an ISP for providing
Internet connectivity service to
subscribers. Currently, residential
customers are connected to the ISP
by dial-up through the PSTN. →

Figure 4: An example configuration of a broadband ISP POP



An Internet access subscriber dials up a POTS (analog) or ISDN (digital) connection through the local CO telephony switch to connect to the ISP point of presence (POP), part of the IAN.

Figure 3 on page 92 shows a typical configuration of the ISP POP. The circuit switched connection is terminated at the dial-up terminal server at the ISP, which provides termination PPP connection service (such as authentication, IP packet encapsulation on the serial line, and IP address assignment). All the dial-up connection traffic are aggregated by the terminal server to an Ethernet connection to the router. Alternatively, the terminal server is connected through an Ethernet switch to have an additional level of traffic concentration before connecting to the router. The router is responsible for providing connectivity to the Internet backbone through a network access point (NAP), where ISPs connect to exchange Internet traffic destined to other ISPs. Instead of a direct connection to a NAP, the IAN can be connected to the rest of the ISP's own backbone IP network before reaching the NAP.

Since the connection to the IAN is through a circuit switched connection, and a typical on-line session can last over an hour or more, this introduces a serious problem for telcos because this ties up their telephone switch circuits for a long time. In fact, this breaks the traffic engineering model of telephone switch designed for an average 3-5 minute holding time for voice conversations. As a result, the telephone switch capacity becomes grossly insufficient. Furthermore, such additional traffic volume does not result in increase in revenue, because local calls typically have a flat-fee structure. Hence, another model must be designed to bypass the telephone switch.

Packet-switched access

With the RBB Internet access network, subscribers are connected through a high-speed IP packet switched connection through the CO or headend, instead of the dial-up circuit switched connection, as shown in Figure 2 (page 91) and Figure 4. This has a number of advantages. First, this removes the need to tie up the CO telephony switch because it bypasses it. Second, the packet switched connection significantly increases bandwidth efficiency for Internet traffic. Third, it provides much higher speed access to the ISP. Fourth, the ISP can avoid terminal servers to terminate dial-up access. Instead, a single high-speed IP connection from the CO or headend can directly terminate onto a router. Finally, this allows PCs at homes to always be connected to the Internet, instead of the dial-up delay incurred in the narrowband case. The reason is that the IP service is either a connectionless or connection-oriented packet switched network. Even in the connection-oriented case, the PC can leave the connection up indefinitely because it is a VC (as opposed to a circuit-switched connection that ties up bandwidth and connectivity). No bandwidth resource is consumed when the PC is idle.

The IAN can be a LAN within the ISP premise, or a wide area network (WAN) for a national ISP. Such a WAN can be part of the network operator's high-speed national backbone network (such as an ATM network). In this case, not all the traffic needs to go to the Internet for access. This is desirable not only because the Internet typically has lower throughput and higher latency, but also because the network operator can provide a value-added option due to the performance gain. Furthermore, such a nationwide broadband network can provide direct connectivity to businesses. Hence, there is a synergy of providing broadband connectivity for both businesses and residences to allow high-speed telecommuting services through the same broadband network infrastructure. This is discussed in more detail in the next section.

If the public network operator who runs the CO/headend also is responsible for providing such an ISP service, then the IAN can actually be part of the CO/headend network or the broadband WAN of the network operator.

Hybrid cable modem

Recently, a hybrid form of cable modems has been introduced that uses the high-speed downstream channel of the cable network, and another analog modem for return

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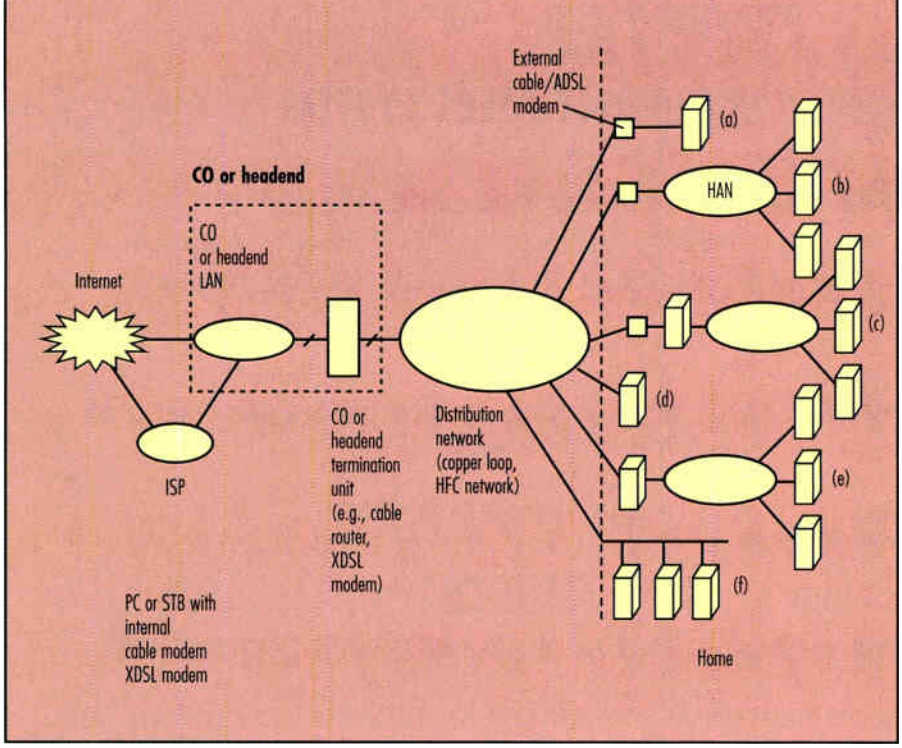
Figure 5: Home area network architectures



over the PSTN. Thus, cable plants that have not been fully upgraded with clean return capability can provide data services.

Using an analog modem over the PSTN as the return channel introduces a number of problems to the Internet access architecture. First, it reintroduces many disadvantages of narrowband dial-up Internet access, such as blocking probability in the network and tying up phone lines.

It complicates the IP address assignment issue because this might require more than one IP address to be supported separately for the upstream and downstream communications. In general, the end system protocol stacks need to be modified to support this scenario.

It introduces a complexity for coordinating the upstream and downstream as they are probably terminated at different locations in the network: upstream at the ISP, downstream at the headend.

Also, using the analog return channel increases the asymmetry of the bandwidth and can introduce a downstream throughput bottleneck because of limited upstream bandwidth. The reason is that many protocols —such as transmission control protocol (TCP)—require two-way communications that are dependent on each other. Reducing the capacity in one direction can restrict the throughput in the opposite direction.

Hence, although these hybrid modems can address much larger cable market, it introduces many open issues that need to be addressed.

Home area network

The home area network architecture is a very important consideration as we deploy RBB Internet services, especially as more than one PC or other device needs to communicate to the Internet (though it has not received as much attention). Different HAN architectures are shown in Figure 5. They are basically distinguished by supporting one or more PCs, using internal (PC card) or external modems and whether a separate home network is created to connect different home devices.

Although most of the homes that have PCs have only one currently, the number of homes that will have multiple PCs are growing. Therefore, we should consider how an external or internal modem scenario can evolve from supporting one PC to multiple PCs in one household.

Stand-alone modem

Many cable and ADSL modems are currently designed as external. They are connected to the PC via an external connection or network for a variety of reasons, as shown in the first architecture in Figure 5 (a).

It is simpler to implement a stand-alone device than to fit it into the PC, for both hardware and software integration reasons. This allows faster time-to-market. However, this reason will be irrelevant as the modem technologies become more mature.

An external modem allows for an easier demarcation point between the public network and the subscribers. This is an important consideration from the network operator's point of view. If things go wrong with the PC, it is much clearer whose problem it is.

External modems avoid the need for an installer to open up a subscriber's PC as part of the installation process. This sort of install would require significant new training that is beyond current responsibilities of the average field crew.

The external modem configuration helps reduce the upstream noise that might be generated by the PC if implemented as an internal PC card, which is extremely important in the HFC environment.[3] Nevertheless, this external PC approach implies higher cost because of the need of a network connection between the modem and the PC, as well as less integration opportunity than the internal PC options.

The external network connectivity between the PC and the modem might allow easier migration to support additional PC by connecting them to the same network. There are many different options to connect between the PC and the external modem. Due to the popularity of Ethernet and its low component costs, most external modems have an Ethernet (10 base T) interface. This also requires an additional PC network interface card (NIC) if it does not already have one for connecting to other devices such as a printer. (Even without the RBB network, it is not unusual to see a LAN such as an Ethernet already in place in existing homes with multiple PCs connecting to a printer.) Although Ethernet does not provide quality of service (QOS) guarantees, the bandwidth of 10 Mbps is going to be sufficient for many multimedia applications over the HAN, because it supports very few devices (which is not true in the corporate network case) and they may not be used at the same time. Note that a 10BaseT connection might limit the maximum downstream throughput to 10 Mbps, instead of the 27 Mbps available. However, it is unlikely that would introduce a problem for most of the applications being deployed initially. The reason is that this only needs to support one or so PCs, as opposed to the tens to hundreds of PCs that might share an Ethernet in a corporate environment. Other networking options include ATM (especially applicable for ATM-to-the-home-model) and IEEE 1394.

There are a number of ways for adding new PCs to the home with the external ADSL/cable modem connection. If the connection between the PC and the modem is an Ethernet, then additional PCs can be connected to the same Ethernet (such as by a shared hub). However, this might require multiple IP addresses supported per home (which can be a problem if real IP addresses are used). This is shown in Figure 5 (b). If the connection is a point-to-point ATM connection to the PC, then additional PCs supported by additional ATM interfaces on the modem can be expensive. A better approach to support additional PCs can be added via a separate Ethernet connected to the first PC, which acts as a dual-home host, as shown in Figure 5 (c). In that case, the first PC can act as a proxy server and a firewall for other PCs to protect them from Internet intruders. As more software functions (such as routing) are supported in today's PC operating systems, this becomes a very attractive approach as it avoids installing a separate piece router hardware at home.

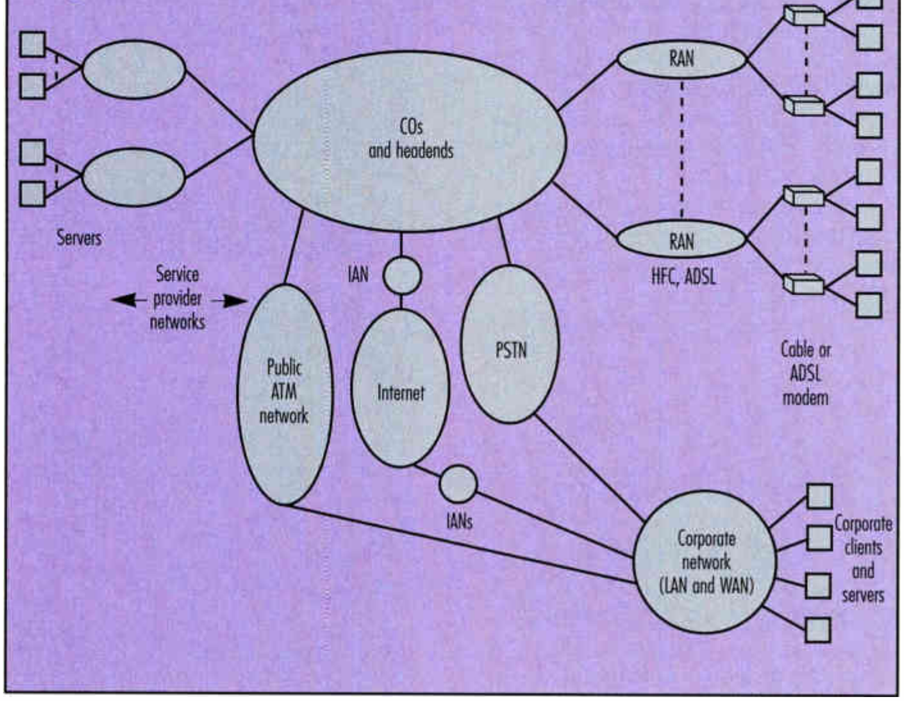
Internal PC modems

An alternative for an external modem implementation is the PC NIC implementation of the equivalent modem as shown in Figure 5 (d). In the long run, it should be cheaper from a modem cost point of view, because this allows tighter integration and avoids additional network cost. (There's no need for an additional NIC.) Also, this allows for direct access to the QOS functions on the ADSL link or the HFC link by the PC operating system. This avoids the need to provide QOS over the extra Ethernet link, in the case of the external modem connected via Ethernet.

"The current architecture of using a circuit-switched infrastructure to access packet data (the Internet) is fundamentally broken."

However, the internal modem implementation does have certain disadvantages as alluded to earlier. First, this might increase the installation cost for the network operator, who needs to open the subscriber's PC. Second, the subscriber might not like his or her PC being opened by the network technician. Third, since there is an unclear demarcation point, the subscriber cannot be clear whose problem is it when his or her PC malfunctions.

Figure 6: An end-to-end broadband network architecture model



Fourth, this requires additional software development for the PC to integrate this function, which might delay the time-to-market. However, this might not be an issue in the long run as such software support is common place. Finally, if additional PCs need to be connected, a new home network must be added or more modems are needed.

Let's discuss two ways to support multiple PCs in this environment. First, we can add a separate network to the first PC that contained the internal modem, such as in Figure 5 (e). This network can be an Ethernet, which means a new NIC for each PC in the home. In that case, the first PC can act as either a router to forward IP traffic to the Internet, or as a proxy server to relay Internet traffic. This allows the gateway PC to negotiate QOS on behalf of the rest of the PCs. This can take advantage of the routing functions in today's PC operating systems.

Second, we can acquire a new internal modem for each new PC added as shown in Figure 5 (f). However, there are two drawbacks for this architecture. First, all communication between the PCs within the home must go through the headend (or CO), potentially wasting a lot of the valuable bandwidth in the HFC RAN. This makes this architecture less of a HAN, even though it appears this way physically. Second, it requires multiple cable modems for each home, which is not cost-effective. Hence, the first approach is more desirable.

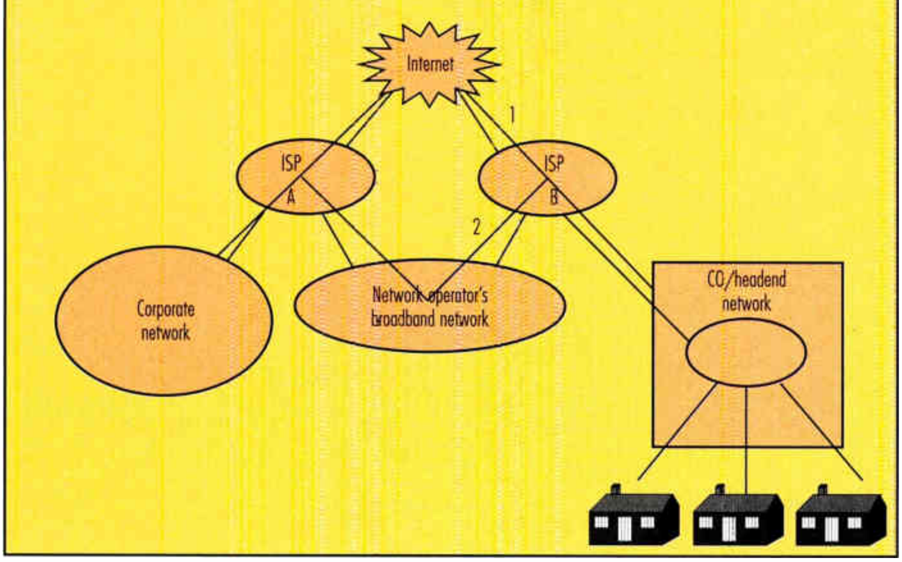
Telecommuting

Telecommuting has become a very important application. Currently this is mainly achieved by dial-up POTS or ISDN through the PSTN to the corporate network boundary that has terminal servers. This also is known as remote access service (RAS). The RAS is very similar to the one being provided by the ISP for its dial-up subscribers. In both cases, authentication (the person is who the person claims to be) and authorization (has the privilege) functions are required. The corporate network must ensure that the person dialing in is authenticated and authorized (such as an employee). On the other hand, the ISP also must provide authentication service to the subscriber to make sure he or she has permission to use the ISP service. Both can use PPP for encapsulating IP packets over the dial-up link, authentication services, IP address assignment and optional data compression. Since both might need to support roaming users (traveling), the user dials a long distance number or 800 number, or local access number to access the destination network (corporate network or Internet). Both need to manage a terminal server to terminate analog and ISDN modem dial-in to their network.

PPTP

Instead of the corporate network providing similar support as the ISP provides dial-up access,

Figure 7: Two future scenarios for corporate access from homes



it is very desirable to have a single external link connecting to the corporate network for all remote access service, without supporting a huge modem bank. This can be achieved using PPTP,[2] which allows PPP to be carried over IP instead of dial-up connection. This implies that PPTP can be supported across the Internet. One of the key requirements of remote access is privacy. Since going through the Internet is not secure, a key feature of PPTP is the encryption capability. It requires a PPTP server at the boundary of the corporate network to the Internet to terminate PPTP sessions from PC clients across the Internet. These clients can dial up to the local ISP to access the Internet, after which a PPTP session is established to the desired corporate network's PPTP server visible on the Internet.

There are two options for running PPTP. PPTP client software can run at the ISP's terminal server, in which case it is transparent to the user. Alternatively, PPTP software can run directly to PC clients, which is then transparent to the ISP.

Hence, PPTP effectively allows corporations to outsource their dial-up infrastructure to the ISPs. The Internet becomes a secure virtual private network for the corporations, which is shown in Figure 6 on page 100. This applies not only to telecommuting applications, but also roaming, hoteling and remote office connectivity applications. At the same time, the ISP can provide a value added service.

PPTP via RBB

Today, the RAS from home is primarily through dial-up access through analog modems or ISDN. This will change as RBB networks become available to bypass the slow dial-up connection. PPTP can go straight on the Internet, as the home PC clients are always connected to the Internet.

As we move from narrowband to broadband, there are two routes PPTP can be used between corporate networks and remote users: over the Internet and over a public broadband network, as show in Figure 7.

PPTP over the Internet

As in the case of the narrowband dial-up case, PPTP can be used directly over the Internet to connect a corporate network to employees' homes. In the broadband case, there is no dial-up. Instead we have the PC connected directly on a packet-switched RBB network running IP. In general, the ISPs serving the corporate network can be different from the one serving the home users or traveling employees. Also, the ISP can be operated by a telco or cable company. There can be more than one ISP connected to the CO and one of them can be owned by the telco operating the CO.

PPTP over public broadband

If the corporate network and homes are served by the same ISP, the ISP has a choice of passing its traffic through the ISP's internal network, instead of using the Internet. This is used especially if they are all connected to the same ISP POP and there is no need to go the Internet. This situation can be further extended to the wide area scenario. If the ISP serving both the corporate and home user has a national backbone network, it can retain all the traffic going through its own network. These can be national ISPs.

As telcos are building their own public broadband network infrastructure based on ATM, it is desirable for the telco to offer connectivity between the home and corporate network through such an infrastructure, without going through the Internet, and more importantly, without an ISP in the middle.

There are both technical and financial advantages for this model. Technically, the performance should be better and more controlled than going through the Internet, especially for services that require QOS guarantees. Financially, the telcos do not need to split the revenue with the ISPs in the middle. Furthermore, it allows the telcos to provide tiered service.

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By Jerry Harris

Avoiding the plague: System degradation and failure

Signal degradation and the threat of failure. They cause sleepless nights for cable system engineers anticipating installation of digital video, data and telephony services. System engineers are looking for test methods that will make them confident in the integrity of the network. However, while bit error rate (BER) tests provide important performance data points, they often fail to provide the information needed to positively identify sources of impairments.

While the encoding/decoding scheme for digital signals systematically prevents noise and other interference from directly modulating the baseband signal, it cannot eliminate the effects on the modulated radio frequency (RF) signal. This results in changes in the phase and amplitude relationships of transmitted symbols and, ultimately, the generation of symbol errors. In fact, many impairments can affect the quality and reliable delivery of digitized signals, and this necessitates measurements to verify system performance.

The purpose of this article is to examine several available tests for verifying system performance prior to activating digital services. Through this examination, the article identifies means to clarify noise, ingress, intermodulation distortion (IMD) and other channel impairments.

BER

BER testing is a traditional measure of system performance. BER establishes a confidence level that there is an accurate representation of the transmitted digital information reaching subscribers. If the BER is worse than target, a constellation plot (a representation of the amplitude and phase variations of the modulated carrier highlighted at sampling instants coincident with symbol arrivals) may provide some definition regarding what kind of impairment is degrading the BER. For instance, a coherent spur will cause a symbol landing—normally a resolved dot in the constellation—to be enlarged and appear donut-like.

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"RF measurements can provide information to quickly troubleshoot digital channel impairment problems."

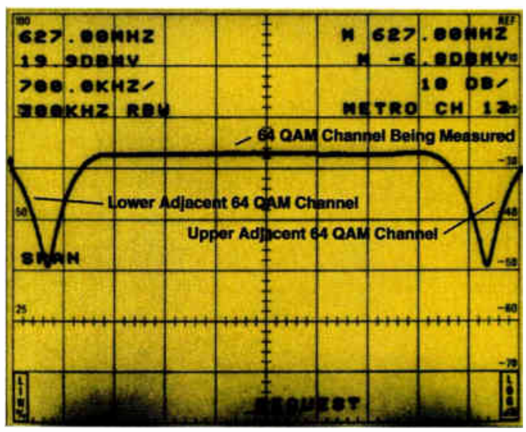
However, BER and constellation tests may not provide a complete picture. Information about the exact frequency at which the spur appears, or whether it's IMD or ingress, may not be readily apparent. Also, there may be times when an instrument capable of producing a constellation may not be available, particularly in the field. RF measurements can provide information to quickly troubleshoot digital channel impairment problems.

RF measurements

Several RF tests are automated and available today to help streamline deployment of digital transmission on cable networks. An RF measurement capability needs to account for the effects that analog channels will have on digital transmission and impairments resulting from the digital channels alone. Additionally, the measurements will provide greater utility if they can be used on a variety of modulation formats, such as 64-QAM (quadrature amplitude modulation), quadrature phase shift keying (QPSK) and quadrature partial response (QPR).

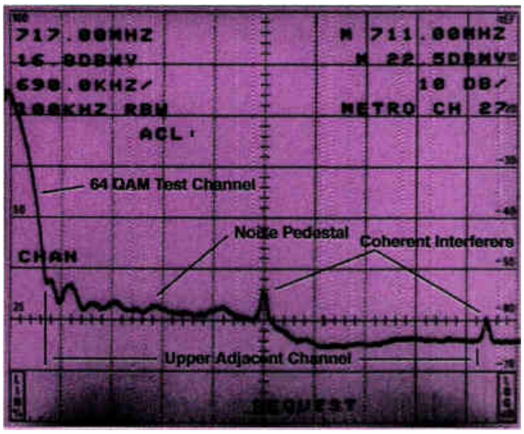
• **Averaged power:** Maintaining exact level on digital channels for proper broadband system power balancing is just as important as it is on analog channels. Typically, the *averaged power*—an assessment of a channel's contribution toward system power loading—of digital channels should be 4-10 dB below the peak power of analog channels. Digital channels should be leveled to within 1 dB of adjacent digital channels. We measure *averaged* or

Figure 1: Averaged power measurement in progress



Heavy video filtering is used to average the noise-like signal.

Figure 2: Adjacent channel leakage test



This test is at modular test port in progress. (Upper adjacent channel showing narrowband and noncoherent emissions.)

mean power for digital signals because this is equivalent to a measurement made with a thermal power meter. Since digital modulation appears as noise to the spectrum analyzer, the averaged power algorithm uses the same basic considerations in its calculations as a noise power measurement. Figure 1 on page 104 shows an averaged power measurement on a 64-QAM signal in progress. Notice that a very narrow video filter is used to maximize signal averaging. The same precautions used in assessing analog channel power measurement should be applied to digital. Averaged power measurement can be made in-service.

• **Adjacent channel leakage test (ACL):** Potential adjacent channel interference due to modulator problems can be measured using the ACL test. These include: excessive phase noise sidebands; inadequate output filter attenuation; generation of coherent spurious signals by oscillator circuits; or nonlinear operation. During the ACL test, the output from a test port on the digital modulator is fed directly to the spectrum analyzer input. The technician needs to ensure the test port power does not exceed the maximum input rating of the spectrum analyzer. It may be necessary to disconnect the test modulator from the headend to ensure there is no backfeed from other modulators.

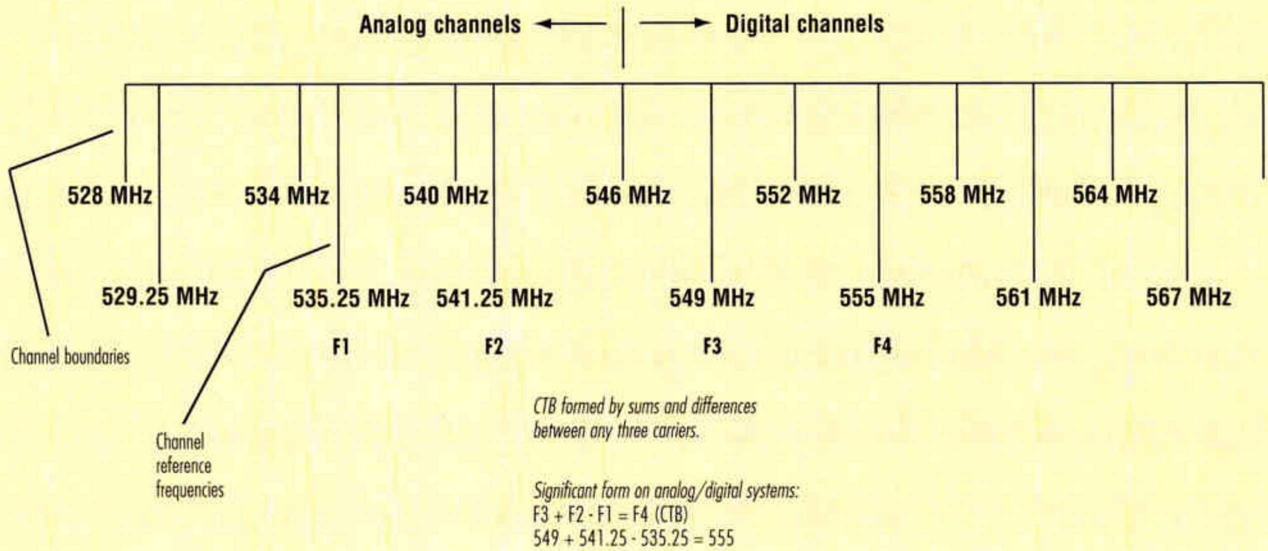
> **"Maintaining exact level on digital channels for proper broadband system power balancing is just as important as it is on analog channels."**

The ACL test will first establish a reference power by measuring the averaged or mean power of the intended transmission from the modulator. Independent sub-routines then measure coherent (CW-like, that is, continuous-wave-like) and noncoherent (noise-like) interfering signals in each adjacent channel space. The powers of the interfering signals are summed and then divided into the reference power to indicate, in dBc, the potential interference amplitude. Figure 2 shows the upper adjacent channel space being measured on a 64-QAM channel. Headend ACL measurements can be made in-service as long as backfeed from other modulators does not interfere with the measurement.

• **Desired-to-undesired signal ratio (D/U):** D/U is a noise and distortion test for digital channels. This test does not isolate individual impairments. Instead, it sums the powers of individual signal elements that comprise *undesired* power, including: analog-generated composite second order (CSO) and composite triple beat (CTB); digital channel composite intermodulation (CIM); ingress; headend-generated spurii; and system noise.

Digital channel CIM (due to mixing of channels in a nonlinear device) may result in what appears to

Figure 3: Significant third-order IMD on analog/digital HFC

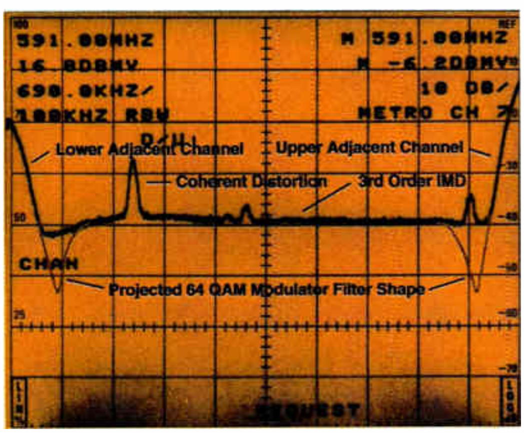


be a rise in the system noise floor of the test channel. Because the input data stream is essentially random, data values appear across the channel spectrum instantaneously and the intermodulation appears as noise. This distortion is difficult to differentiate from system noise and it affects the desired digital signal the same way. Therefore, intermodulation and system noise can be measured together. If a complete system characterization is desired, the noise should be isolated. This can determine if the noise problem is worsening. Another third-order IMD function involves the mixing of analog and digital channels where they coexist on a single RF broadband system. Figure 3 illustrates the intermodulation function. As shown in Figure 4, the resulting product is a spectrum that approximates the filtered shape of the digital modulators used in the system and is centered in the test channel.

During the course of the measurement it is possible to view the spectrum to qualify what kind of distortions are in the channel spectrum. Individual coherent distortions can be measured by a version of CTB/CSO measurement for digital channels. "U" sub-routines measure coherent and noncoherent distortions and the summed power is divided into "D," which is the averaged power of the intended transmission of the test channel.

Desired-to-undesired ratio minus threshold is an approximation to operating margin. For instance, if D/U is 38 dB and threshold is at 28 dB for a 64-QAM channel, the approximate operating margin would be 10 dB. D/U is an out-of-service test. After "D" has been measured, the modulator needs to be turned off to see the underlying distortions and noise in the channel. Figure 5 on page 110 shows a D/U test in progress.

Figure 4: Third-order IMD product



This results from mixing analog and digital channels as per illustration in Figure 3.

• **Digital CTB/CSO:** This measurement provides a means to determine the power ratio between the averaged power of a digital channel and individual analog channel-generated composite distortions, coherent ingress and headend-generated spurii. The measurement itself is no different than conventional analog transmission, except the reference power is in terms of *average* rather than *peak*.

• **Carrier leakage measurement:** Carrier leakage is the difference between the channel signal averaged power and CW power of the residual, unmodulated carrier. One method of measurement is to determine channel *averaged* power, obtain a reference and set the modulator's I and Q inputs to zero. The power of the remaining carrier is then measured and divided into the reference power to derive carrier leakage in dBc.

If the carrier leak is significantly high, it's possible to make the measurement in-service by exactly centering the channel in the spectrum analyzer display, then reducing both resolution bandwidth and span/division. Since the digital modulation is noise-like, less modulation power is being passed through the IF filter and, therefore, its amplitude is reduced relative to the residual carrier signal. This process "reveals" the

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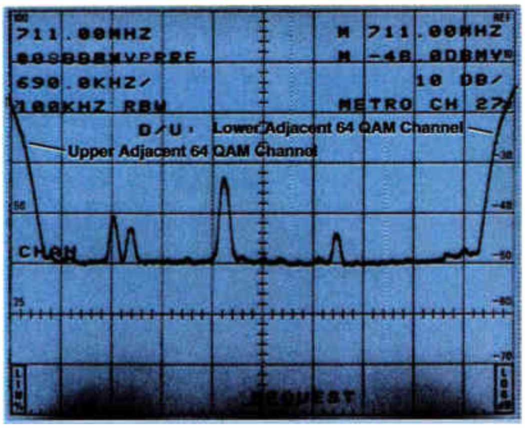
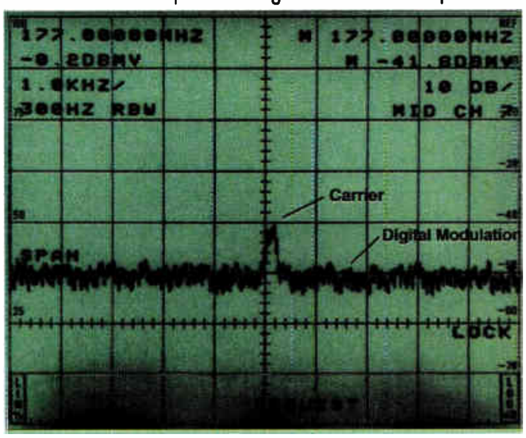
Figure 5: Desired-to-undesired signal ratio measurement on hybrid analog/digital system



Note coherent distortions generated by analog plant. Test channel modulation is removed for a few seconds during the measurement.

Figure 6: 1% of averaged power carrier leak exposed using in-service technique



Narrow resolution bandwidth and span/division are used.

carrier leak. Figure 6 shows a carrier leak of one percent of averaged power on a digital signal using the in-service technique. The noise-like spectrum surrounding the CW carrier is the bandwidth-limited digitally modulated signal.

• **Channel frequency response:** Passive and active system component defects can result in frequency dependent variations in amplitude and delay. These defects can cause inter-symbol interference (ISI) that, in turn, can cause symbol errors. ISI also can result from locating a digitally-modulated channel close to a skirt of a system bandpass or diplex filter.

A cable system engineer can conduct an approximation test for channel flatness in-service as long as the modulator test port flatness represents actual modulator output. Here's how:

1) Using the most narrow video filter possible while maintaining amplitude calibration, display the test channel to fully occupy the span of the spectrum analyzer, then save the modulator test port spectrum to the analyzer's display memory.

2) Use B Minus Save A to subtract the same channel spectrum acquired at a downstream test point, such as at the input of an integrated receiver decoder (IRD).

3) Observe any variances from a flat line difference display and measure using marker functions. Variances near the digital signal null points between channels are not terribly important since the signal power at those points is quite low.

Summary

Network integrity is a top concern for cable system engineers responsible for the installation of digital video, data and telephony services. They can't afford to be plagued by signal degradation or the threat of failure. While traditional digital transmission tests of BER, constellation and eye diagram provide important performance data points, they often do not provide all the information needed to positively identify sources of impairments. A solution is RF measurements, which can supply needed information to clarify noise, ingress, IMD and other channel impairments. Several automated RF tests are available today that can streamline deployment of digital transmission on cable networks. **CT**

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Reader Service Number 83

GE Capital

Test Equipment Management Services

Our Business is Helping Yours®

By Robert E. Baker

A guide to the 1997 NESC

In the cable telecommunications industry, we are often faced with meeting code requirements during the construction of new outside plant. Just where do these code requirements come from? How do we find them to assure they are met? This article will attempt to provide a quick reference guide to the National Electrical Safety Code (NESC), some of its more frequently used code tables, and as required, a brief explanation of the application to us.

This article will not cover all the applicable codes, nor will it attempt to explain fully all of the possible deviations due to different applications. The reader should refer to the full NESC text, tables and footnotes for a complete understanding. Please remember that the NESC applies to our outside plant only. For communications wiring and equipment in, on or attached to structures, please refer to the National Electrical Code (NEC).

Grounding

The requirements for grounding communication apparatus (that's us), have not really changed for many years. NESC Rule 94 first dictates that we use "existing electrodes" in the following order: bonding to the main electrical service ground, bonding to a metallic water piping system, or bonding to steel reinforcing bars in concrete foundations and footings.

Secondly, if the previous is not possible, we go to "made electrodes." Made electrodes consist of driven rods, buried wire, strips or plates and pole-butt plates and wire straps. In Rule 94, the driven rod

Bob Baker is chief technician for TCA Cable TV in Clovis, NM. He is Broadband Communications Technician/Engineer (BCT/E) certified by the Society of Cable Telecommunications Engineers.

"Remember that the NESC applies to our outside plant only."

must be 5/8-inch diameter and 8 feet long. However, NESC Rule 99A3 has an exception for communications apparatus, which, if we must go to a driven rod for lack of a better choice, we are permitted to use a 1/2-inch diameter 5-foot rod. It should be noted that the NESC remains in concert with the NEC and if a rod is driven, it is required to be bonded to the main supply electrode using #6 AWG copper wire.

There are additional grounding requirements for messenger wires and guys. Refer to NESC Rule 92 for details.

Fiber-optic cable

While fiber-optic "conductors" within a cable are nonmetallic and do not conduct electricity, such cable frequently are carried by conductive messengers or energized phase conductors and may include auxiliary metallic conductors within the cable. Therefore, fiber-optic cables are treated the same as a conductor of the voltage that can be carried on the cable messenger or its interior auxiliary conductors. Such cables must be treated as supply or as communication and be located accordingly. For the purpose of these rules, the following definitions apply:

- **Fiber-optic cable communication:** A fiber-optic cable meeting the requirements for a communications line and located in the communication space of overhead or underground facilities.

NESC Rule 230F2 says "Cable defined as 'fiber-optic-communication' shall have the same clearance from supply facilities as required for a communication messenger."

- **Fiber optic cable supply:** A fiber-optic cable located in the supply space of overhead or underground facilities.

NESC Rule 230F1 says "Cable defined as 'fiber-optic-supply' supported on a messenger that is effectively grounded throughout its length shall have the same clearance from communications facilities as required for a neutral conductor meeting Rule 230E1."

NESC Rule 230F1b says "Cable defined as 'fiber-optic-supply' that is entirely dielectric, or supported on a messenger that is entirely dielectric, shall have the same clearance from communications facilities as required for a neutral conductor meeting Rule 230E1."

NESC Rule 230F1c says "Fiber-optic supply cable supported on or within messengers not meeting Rule 230F1a or 230F1b shall have the same clearances from communications facilities required for such messengers."

NESC Rule 230F1d says "Fiber-optic-supply cables supported on or within a conductor(s), or containing a conductor(s) or cable sheath(s) within the fiber-optic cable assembly shall have the same clearances from communications facilities required for such conductors. Such clearance shall be not less than that required under Rule 230F1a, 230F1b, or 230F1c, as applicable.

NESC Rule 230F1e says 'Fiber-optic-supply cables meeting Rule 224A3 are considered to be communication cables when located in the communications space.' "

NESC Rule 224A3 says "Communications circuits located in the supply space in one portion of the system may be located in the communication space in another portion of the system if the following requirements are met:

NESC Rule 224A3a: "Where the communication circuit is at any point located above an energized supply conductor or cable, the

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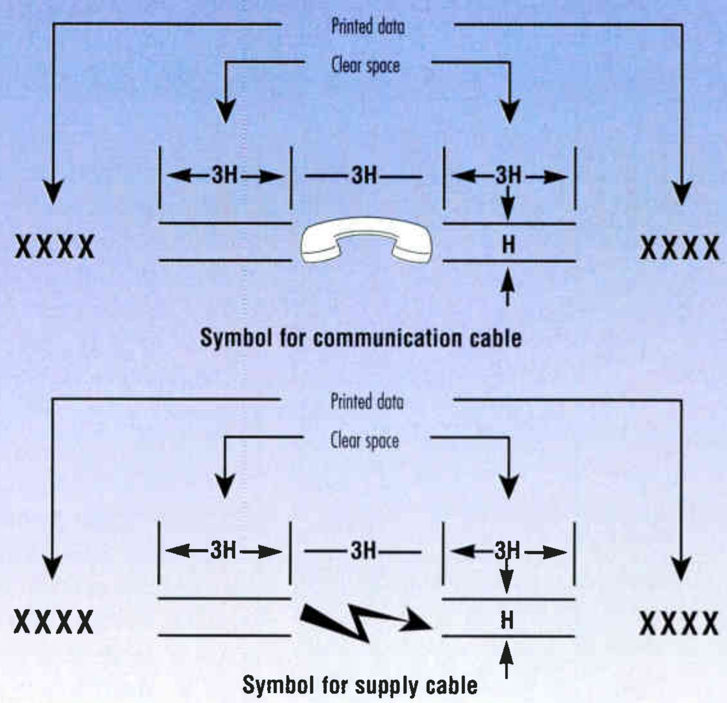
Symbols for identification of buried cables



H = Height of printed characters; determined by cable manufacturer.

communication circuit shall be protected by fuseless surge arresters, drainage coils, or other suitable devices to prevent the communication circuit voltage from normally exceeding 400 V to ground."

NESC Rule 224A3b: "Where the communication circuit is always located below the supply conductors, the communication protection shall meet the requirements of Rule 223."

NESC Rule 224A3c: "The transition(s) between the supply space and the communication space shall occur on a single structure; no transition shall occur between line structures. Exception: Service drops meeting Rule 224A3a and Rule 224A3b may originate in the supply space on a line structure or in the span and terminate in the communications space on the served structure."

Ground clearance

NESC Table 232-1 covers the vertical clearance of our plant above ground, roadways, rails or water surfaces. Basically if you have grounded guys, messengers, or insulated (jacketed) communication cables, the clearances are: Category 1, tracks of railroads (nonelectrified): 23.5 feet; Category 2, roads, streets and other areas subject to truck traffic: 15.5 feet; Category 3, driveways, parking lots and alleys: 15.5 feet; Category 4, spaces and ways subject to pedestrians or restricted traffic only, 9.5 feet. Trucks are defined as any vehicle exceeding 8 feet in height. Rules apply whether streets or roads are paved or unpaved. Distances are greater for noninsulated communications cables.

Clearance from structures

NESC Table 234-1 covers clearance of our plant adjacent but not attached to buildings and other installations. Again for insulated (jacketed) communications cables, messengers and grounded guys, the clearances are: Category 1a(1), horizontal from buildings, walls, projections and unguarded windows: 4.5 feet; Category 1b(1), vertical over roofs or projections not readily accessible to pedestrians: 3.0 feet; Category 1b(2), over roofs and balconies readily accessible to pedestrians: 10.5 feet. A roof, balcony or area is considered readily accessible to pedestrians if it can be casually accessed through a doorway, ramp, window, stairway, or a permanently mounted ladder whose bottom rung is less than 8 feet from the ground. Distances are greater for non-insulated communications cables.

Clearance between

NESC Table 235-5 covers vertical distances between conductors at supports (poles). When talking about communications cables, this table refers to NESC Rule 224A2a that in turn refers the reader to NESC Rule 230E1. This simply says it applies to communications cables supported by an effectively grounded messenger. The clearances are: Category 1, for communications cables located in the communications space: 40 inches and Category 2, for communications cables located in the supply space: 16 inches.

Mid-span sag

The distances listed are typically at the support structure. NESC Rule 235C2b(1)(a) gives the 75% rule; that is, the sag related clearance between conductors running above and parallel to one another, for voltages of less than 50 kV, the clearance may be reduced to 75% of that required at the support per NESC Table 235-5.

There is an exception to this: Neutral conductors (effectively grounded) and supply cables meeting NESC Rule 230C1 (cables that are supported on an effectively grounded bare messenger, that is, a triplex service drop) may have a clearance of 12 inches at any point in the span, provided that a clearance of 30 inches is maintained between the supply conductors and cables and the communications cables at the supporting poles. A special point should be made that cables tend to look like they have less sag than they actually have, so the natural tendency is to leave the wire too slack, unless sag or tension is actually measured.

Also, if the wire is installed the same on a cold or hot day as it should be on a "NESC blue bird" day (60° F), the result can be catastrophic. Pulling too tight on a hot day causes structural problems on cold days. Pulling too loose on a cold day produces too much sag on a hot day. Cables and messengers should be checked at installation to assure appropriate sag and tension.

More clearances

The NESC refers to street lights as "luminaire" throughout its text. NESC Rule 238D states that "if a drip loop of conductors entering a luminaire bracket or traffic signal bracket from the surface of the structure is above a communication cable, the lowest point of the loop shall be at least 12 inches above the communication cable or through bolt."

Underground conduit systems separations

Separation of communication conduit systems from supply conduit systems are: NESC Rule 320B2a—3 inches of concrete; NESC Rule 320B2B—4 inches of masonry; and NESC Rule 320B2c—12 inches of well-tamped earth. There is an exception to this that allows lesser separations when all parties concur.

Underground direct buried separations

These rules apply to cables or conductors when the radial separation between them will be less than 12 inches, which is usually the case in joint use trenching.

NESC Rule 354C: "The cables or conductors of a communications circuit (CATV) and those of another communication circuit (telco) may be buried together with no deliberate separation between facilities, provided all parties involved are in agreement."

NESC Rule 354D: "Supply cables or conductors and communications cables or conductors may be buried together at the same depth with no deliberate separation between facilities, provided all parties involved are in agreement and the applicable rules in 354D1 are met and either Rule 354D2 or 354D3 is met."

This situation is most likely to apply to service trenches where the supply service drop (secondary voltages) and the CATV and/or telco drop share the same trench from the pedestals to the home. Rule 354D1 states that communications cables and communication service wire having metallic conductors or metallic components shall have a continuous metallic shield under the outer jacket. It goes on to limit voltages that can be on the supply cables. The other two rules, 354D2 and 354D3 are safety requirements for the supply cables.

Direct-buried cable

The requirement of embossed identification symbols on supply and communications cable first appeared in the 1993 edition of the NESC. Because of industry implementation problems and to allow time to use up existing unmarked supplies, its implementation was delayed until Jan. 1, 1994, and then again until Jan. 1, 1996. The 1997 edition clarifies the ability to separate or combine sequential markings.

NESC Rule 350G: "All direct buried jacketed supply cable...and all direct-buried communication cables shall be legibly marked as shown in Figure 350-1 (page 114). The appropriate identification symbol shown in Figure 350-1 shall be indented or embossed in the outermost cable jacket at a spacing of not more than 40 inches. The symbol may be separate or sequentially combined with other data, or symbols (or both) printed on the jacket. If the symbol is sequentially combined, it shall be separated as indicated in the accompanying figure. This rule shall become effective for cable installed on or after 1 January, 1996."

There are two exceptions noted, one that cables which cannot be effectively marked (too small or the jackets too thin) need not be marked; and the other that unmarked cable from stock existing prior to January 1, 1996 may be used to repair unmarked direct-buried jacketed ... communication cables. This means you can't install it after Jan. 1, 1996, but you can use it for repairs only to already installed unmarked cables.

Summary

The NESC is the national standard for safety in the installation, maintenance and operation of electric supply and communication system facilities. It is published by the Institute of Electrical and Electronic Engineers and updated about once every three years. Copies may be obtained by contacting the IEEE customer service, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331; phone: (800) 678-4333; and fax: (908) 981-0060.

References

[1] *1997 National Electrical Safety Code,* ISBN 1-55937-715-1.

[2] *NESC Handbook, Fourth edition,* ISBN 1-55937-724-0. **CT**

By Bill Wignall

True multimedia through the air

Editor's note: Multichannel multipoint distribution service (MMDS) and local multipoint distribution service (LMDS) have long been considered the cable telecommunications industry's sworn adversaries.

But as part of this article details, it doesn't necessarily have to be an adversarial relationship. Think creatively. In part, this article proposes that if you're looking for an affordable "last-mile" solution to full-service fiber-optic networks, you might consider using LMDS as a wireless fiber-optic plant extension. You may find it goes up quickly, and could cost less in the long run than deploying a full-blown fiber-optic network.

What are two of the hottest segments of the communications industry today? Many people would answer wireless and broadband.

What would happen if these two segments were then brought together? You would have a new hybrid segment called "wireless broadband!" You also would have MMDS and LMDS, because that's exactly what they are: wireless broadband, digital networks capable of delivering high-bandwidth, multimedia signals over the air.

Such systems have become possible because of recent advances in various key technical areas of our industry, including high frequency RF transmission, cellular architectures, digital compression and broadband switching.

Talking the talk

MMDS operates typically from 2.5 to 2.686 GHz but has been used in the 3 to 4 GHz frequency band as well. Although MMDS systems currently are deployed primarily for broadcast video applications, recent advances in technology and in the regulatory arena have allowed these digital networks to evolve, with greater channel capacity and the potential for two-way communication.

"LMDS networks represent wireless fiber plant extensions for a fraction of the capital costs inherent in the deployment of fiber networks."

LMDS utilizes frequencies allocated somewhere in the 23 GHz to 30 GHz range, the precise band differing for various areas of the world. Bandwidth allocations have ranged from 250 MHz to over 1,000 MHz. The combination of large bandwidth allocations and digital technology can provide very effective solutions for video, voice and data services. LMDS will provide a full complement of broadcast entertainment, and two-way video, voice and data communication. While nationwide licenses have already been allocated in Canada, the United States is still awaiting announcement of LMDS auction rules.

MMDS in action

MMDS has been delivering wireless cable service in analog format in the United States for years. Channel capacity typically was limited to less than 31 channels because of the 6 MHz bandwidth requirement of each analog channel. The new digital MMDS network employs digital compression technology to increase channel capacity and provide laser disc-quality programming. Such a network is comprised of three main portions: the digital headend, the transmission network, and the customer premises equipment.

Each headend consists of an integrated MPEG-2 digital signal compression, statistical multiplexing, and quadrature amplitude modulation (QAM) system that provides the foundation for the signal generation. The use of International Standards Organization-compliant encoding and digital video broadcasting-compliant modulation ensures the scalability of the architecture.

The transmission network employs outdoor, tower-mounted broadband transmitters. Utilizing solid-state power amplifiers (SSPA) at each trunking and distribution site eliminates the need for shelters and support equipment. These transmitters are tied back to the headend site and constantly monitored through the system supervisor software. Multiple overlapping sites can be employed in a digital MMDS network to improve line-of-sight penetration of "homes passed."

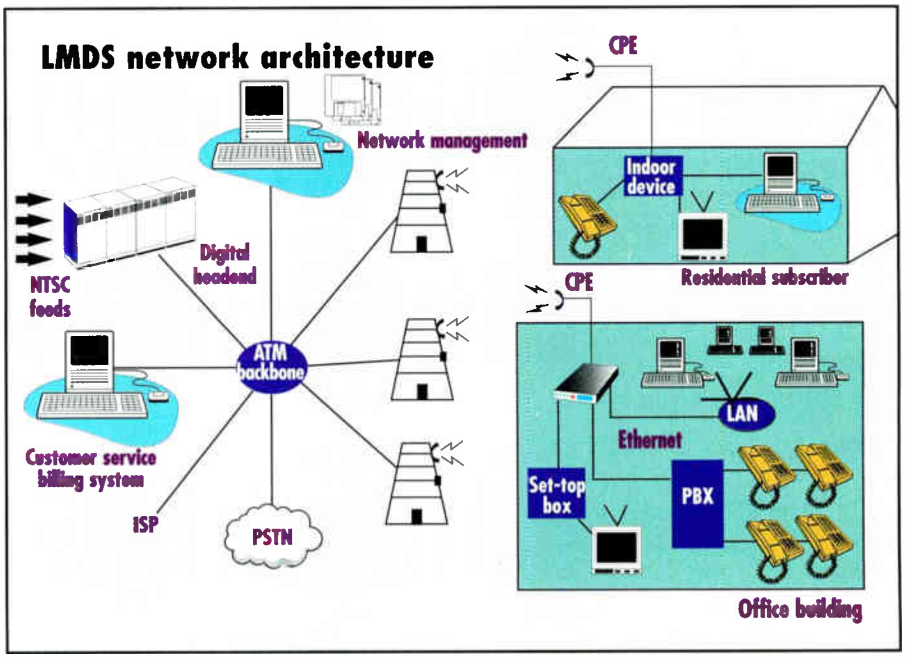
At the customer premise, the digital signals are received by an antenna and downconverted for connection to the consumer set-top box, which is fully addressable and controlled from the operator's customer service facility. These set-top units provide full resolution MPEG-2 (Moving Pictures Experts Group) decoding, on-screen display and support V-chip and closed captioning service. The installed data port will be used for return path transmissions when full two-way services, including Internet access currently in field trials, are deployed later this year.

A conditional access and control system, using smart card technology and software downloaded from the headend, gives the operator complete authorization over the entire network and protects it from piracy.

The largest, most advanced such MMDS network is located in Manitoba, Canada. The Manitoba system

Bill Wignall is vice president of sales and marketing for Broadband Networks Inc. He can be contacted at (204) 982-8480.

covers an area of more than 36,000 square miles, encompassing more than 300,000 line-of-sight (LOS) homes. The network operates from two headends that provide signals to the eastern and western parts of the system and also provide redundancy to each other in the event of network problems. A unique in-band trunking system interconnects the nine transmit towers, using the same frequency as the distributed signal, allowing the network to expand its coverage on demand. The rapid success of this service has led to subsequent deployments of the technology around the world.



LMDS lowdown

LMDS networks, due to the propagation characteristics of signals in this frequency range, are based upon cellular-type architectures, and are used as a wireless access technology for fixed (not mobile) applications.

A typical LMDS cell size will run from a few kilometers up to about 10 km, based on factors including environment and terrain, population densities and traffic capacity requirements. Very large traffic capacities—in excess of 10 Gbps—are achieved through the use of sophisticated modulation technologies (16/64-QAM), excellent frequency reuse (N = 1), and cell sectorization. Overlapping of cells within the network maximizes subscriber accessibility via LOS from multiple cell sites.

Service applications available for such systems include MPEG-2 broadcast and interactive TV, high-speed Internet access and telephony for residential applications as well as content-independent data services based on asynchronous transfer mode (ATM) at multiples or fractions of OC-3 (155 Mbps) levels for commercial applications.

Given the enormous capacity and high data rates that will be handled by the RF portion of the LMDS system, the network backbone must be equally capable. A broadband switching technology, such as ATM, is therefore the most likely candidate for interconnection of the cells. In that case, an ATM multiplexer is collocated with the wireless equipment at each cell site. For sites not accessible on fiber, a microwave link can serve as an alternative (See the accompanying figure.)

This ATM backbone also provides the function of interfacing to the various other networks with which LMDS will need to communicate to provide a fully competitive offering of video, voice and data services. Examples include the public switched telephone network for voice services or Internet service providers for Internet access. A number of key LMDS networks can be attached via the ATM backbone, including the digital video headend, network management platforms and customer service/billing systems.

This range of applications indicate that LMDS networks represent wireless fiber-optic plant extensions that can be deployed very quickly and at a fraction of the capital costs inherent in the deployment of fiber networks. In essence, such wireless networks can be viewed as an affordable last-mile full service solution by many potential operators.

LMDS in the house

Customer premise equipment supporting the LMDS network is made up of three primary parts. The RF portion mounts outdoors and includes the appropriately sized antenna (starting at about 30 x 30 x 4 cm for a flat panel) and transceiver for interfacing to the RF network. This equipment is connected to an intelligent indoor device capable of separating the downconverted signal into a voice, data and video component for connection to the telephone, computer and cable TV wiring respectively.

For return path transmission, this device combines the same three services into one signal for connection to the RF portion to enable transmission from the customer premise. The final portion of the customer premise equipment is a video set-top box capable of decoding the digitized TV signal back into NTSC format for input to a standard TV.

International applications

While digital LMDS networks are just beginning to be deployed in Canada and the United States, the benefits associated with this system have been proven internationally. In Kobe, Japan, where a 1994 earthquake destroyed much of the city's wired infrastructure, LMDS has been used as a lower cost, easily deployed restoration. Digital compression was incorporated, based on the operator's desire to maximize use of the 600 MHz of allocated spectrum.

The deployment of this network was planned in three stages: 1) Delivery of cable TV services to 250,000 MDU subscribers; 2) Provision of interactive services, including Internet and videoconferencing, in the existing service area; and 3) Delivery of interactive ATM services including video, voice and high-speed Internet access. The network is currently in its first stage with the provision of interactive services awaiting the required licensing. **CT**

By Marv Nelson

How to prepare for technical certification

The Society of Cable Telecommunications Engineers' Broadband Communications Technician/Engineer (BCT/E) certification program stands alone in its recognized value as an unencumbered vehicle for demonstrating true lasting knowledge.

Certification as defined by the Society is "the formal recognition by a cognizant peer group of the demonstrated accomplishment of proficiency with and the comprehension of the uniquely defined body of knowledge at a point in time." It is not a measure of competence. It is not solely the passing of an examination. Rather, it is the demonstration of the prescribed level of knowledge as defined, through a combination of experience, education and examination.

Certification is not a course of study per se. While there is no doubt that study and research are integral parts of the process, the intention of the BCT/E program is to certify the acquisition of knowledge in definable disciplines. There are many examples of training programs that have a final exam that is required to pass the course. BCT/E certification is an independent method of showing command of technical material apart from a specific course of study.

By providing an independent exam, the BCT/E program is not influenced by factors that can detract from the accomplishment of passing an exam. Examples of other issues that are often involved in specific courses of study are things such as: good attendance record for the class, quizzes or class projects that contribute points toward the final grade, and even in some cases the level of comfort the instructor has with the student. These are not necessarily inappropriate in and of themselves, but they do not show the full accomplishment in actual learning that took place as a result of the class.

Assess current knowledge

Since there is not a specific course of study for BCT/E exams, it can be difficult to know what material you are expected to understand. BCT/E exams are developed from an outline of topics germane to each category. These outlines are published from time to time and are, of course, always available from SCTE national headquarters. As an example, the outline for Category I, "Signal Processing Centers," is shown in the sidebar. It consists of six major sections covering all aspects of headend equipment and maintenance. Within each of these major divisions there are specific topics that may be covered in the exam.

"Since there is not a specific course of study for BCT/E exams, it can be difficult to know what material you are expected to understand."

In preparing for certification you should start by reviewing the appropriate outline for the category you are going to test in. Look at each topic and ask yourself, "Am I comfortable with the subject title to the extent that I could explain it to someone who is not knowledgeable in this area?" This will help you to identify any areas that may need further study prior to taking the exam.

Seek additional training

When you have identified areas that you wish to study further, you will want to find a source or two for researching that topic. In addition to the outline for each BCT/E category, there is a corresponding bibliography. Included are books, published papers, videotapes or courses of study that have been identified as being helpful in preparing for the exams. In some cases these have been used as sources for generating exam content.

Do not look at the bibliography and think that you must acquire all of the listed references. Many of the references contain duplication of topic coverage. Often you will find that these books and videos are readily available to you through your company library or your local SCTE chapter. Check around and see what you have available first. Then, if you find that you are not able to find material on the topic, check with others who have tested or are knowledgeable in that particular area and find out what books or courses they found helpful.

Take the exam

Now that you have reviewed the outline and studied up on weak areas, you are ready to take the exam. Prior to sitting for the exam you should make sure you have done the following:

- Made sure that you are an active national member of SCTE.
- Reviewed the rules of the BCT/E program.
- Applied to the BCT/E program for the level of certification you wish to pursue.

Marv Nelson is vice president of technical programs for the Society of Cable Telecommunications Engineers.

• Contacted your local chapter to sign up for the next testing session.
• Made sure that you are thoroughly rested prior to sitting for the exam. Your performance on the exam can be severely impacted by a lack of sleep.

You may take any reference material that you think may be helpful into the exam session. The only thing that is not allowed is anything that takes on the form of an exam. This includes quizzes and final exams you may have taken previously as part of a course (i.e., National Cable Television Institute chapter quizzes, practice exams and final exams).

What to expect

Obviously there is a difference in exam content based on whether you are taking a technician- or engineer-level exam. For the engineer exam (other than the exam being more difficult) the questions will delve deeper into theory and application whereas the technician exam is geared more to basic understanding and application of equipment. Categories I through VI consist of 50 multiple choice questions. (Category VII consists of three scenarios that you must address in essay style.) You will need to score 75% correct or better in order to pass each exam.

In the event that you do not pass the exam (many have had the opportunity to experience the fail letter so you are not alone) you will be sent a bar graph that shows how you did in each area of the outline for that category. Take this information and compare it to the outline for the category to help you see where further study is needed. SCTE national headquarters staff stands ready to assist you in any possible way. You also may want to contact your regional director or your local chapter officers since many of them have been involved in the certification program themselves.

Above all, don't give up! There is an old saying that goes something like this: "That which you work hardest for is that which you cherish most." Ask any BCT or BCE certified candidate and they will tell you just how much the achievement of certification has meant to them. And there are not too many of them who found it to be a cake walk. **CT**

BCT/E Category I program outline

I. Design
- A. Site selection
- B. Building requirements
- C. Heating and cooling
- D. Grounding and bonding
- E. Powering
- F. Layout and cabling
- G. Channelization

II. Antenna types and theory
- A. Off-air
- B. Microwave
- C. Satellite

III. Channel equipment
- A. Processors
- B. Modulators
- C. Demodulators
- D. Emergency alert systems
- E. Scramblers and descramblers

IV. Satellite equipment
- A. Satellite receivers
- B. LNAs, LNBs, LNCs
- C. Powering

V. Laser transmitters and receivers
- A. Laser types
- B. Receiving equipment
- C. Setup and operation

VI. Maintenance
- A. Test equipment
- B. Measurement techniques
- C. Monitoring and record keeping
- D. Federal Communications Commission rules and regulations

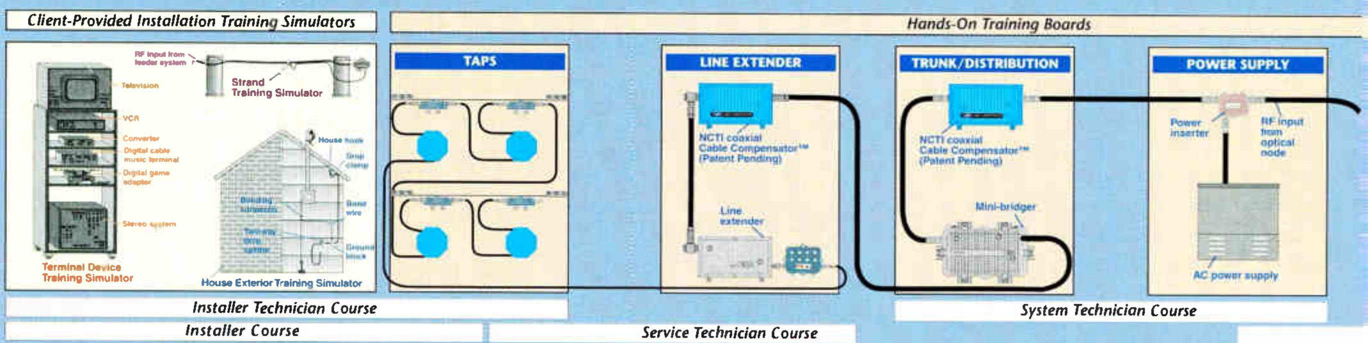
By Wayne H. Lasley

Preparing for career advancement

As with most endeavors, preparation is one of the single-most important steps to success. In the case of having a knowledgeable technical work force, this especially is true. Gone are the days of techs learning "everything they need to know" on the job. Providing a comprehensive technical training program can be a challenge, one that requires a major commitment from both company and individual. Our industry has matured, and along with that, today's broadband systems have become increasingly complex. That little side road leading from tubes to transistors to integrated circuits to fiber optics to digital, has become the "information superhighway."

Yes, it's a superhighway, but with the right preparation it can be navigated successfully. A well-trained staff is a first step. How does one approach the complexities of this task? Break it down. Borrowing some mathematical nomenclature, take the whole and reduce it to sets and then those into subsets. (Using exponents to describe very large numbers is akin to this.) Taking an evolutionary path to technical proficiency can be accomplished in the same manner. The accompanying figure is a model of an industry-recognized career path evolution. It presents the whole (technical proficiency with the entire broadband cable system) and its sets (the courses for each of six system segments) and their subsets (the lessons within each course).

NCTI broadband interactive training system



Installer Course

Assumed Industry Knowledge: None

- Cable Services
- How a Cable System Works
- Customer Service
- Safety Equipment
- General Tools
- Cable Installation Tools
- Ladders and Handling
- Pole Climbing
- * Installation Preparation
- * Coaxial Drop Cable & Connectorization
- * Digital Multimeters
- * Signal Level Meters
- Signal Leakage Detection
- * Bonding and Grounding
- * Aerial Installation
- * Underground Installation
- * Cable Routing & Attachment
- * Interior Installation
- * Terminal Device Installation
- TV Picture Analysis
- Basic Drop Troubleshooting
- * Digital Audio Installation & Testing
- * Digital Games Installation & Testing

Installer Technician Course

Assumed Cable System Knowledge/Skills: Installer Course

- Electrons and Electricity
- Magnetism and Electromagnetism
- Mathematics Refresher, I, II, and III
- Electrical Circuits
- Resistance
- Ohm's Law, Power, & Energy
- DC Series Circuits
- Introduction to Decibels
- * Decibels in Broadband Cable Systems
- * Signal Level Meters
- Signal Leakage Detectors, I & II
- * Signal Leakage Detection
- * Troubleshooting TV Problems
- * Troubleshooting Drop Cable
- * Troubleshooting Drop Passives, I, II, and III
- * Troubleshooting Picture Distortions, I, II, and III
- * Troubleshooting MDU Picture Distortions
- * Line Extender Amp Operation

Service Technician Course

Assumed Cable System Knowledge/Skills: Installer Technician Course

- Prevention Programs
- Alternating Current
- AC Waveform Fundamentals
- Resistive AC Circuits
- Inductance and Transformers
- Capacitance
- Reactances
- * Digital Multimeters
- * Signal Level Meters
- * Coaxial Cable
- * Coaxial Cable Connectorization
- * RF Line Splitters
- * RF Directional Couplers and Power Inserters
- * RF Taps
- TDR Fundamentals
- * TDR Operations
- * Cable Powering
- * Line Extender Amplifier Setup, I and II
- * Distribution Amplifier Operation
- * RF Bridger Amplifier Setup
- * Signal Leakage Basics
- Fiber Optics

System Technician Course

Assumed Cable System Knowledge/Skills: Installer Technician & Service Technician Courses

- Introduction to Electronics
- Power Supplies
- Regulated Power Supplies
- * RF Amplifier Operations, I and II
- * RF Trunk Amplifier Setup
- * Distribution Amplifier Setup, I and II
- Amplifier Troubleshooting
- Introduction to Electronic Communications
- Amplitude/Single-Sideband Modulation
- Frequency Modulation
- * Automated Spectrum Analyzer Basics
- * System Measurements
- * Signal Leakage Analysis
- * System Sweeping & Testing
- * Manual Spectrum Analyzer Distortion Measurements
- Underground Construction, I and II
- Principles of Supervision
- Supervisor/Employee Relations

An asterisk (*) designates that a hands-on lab practice is also available.

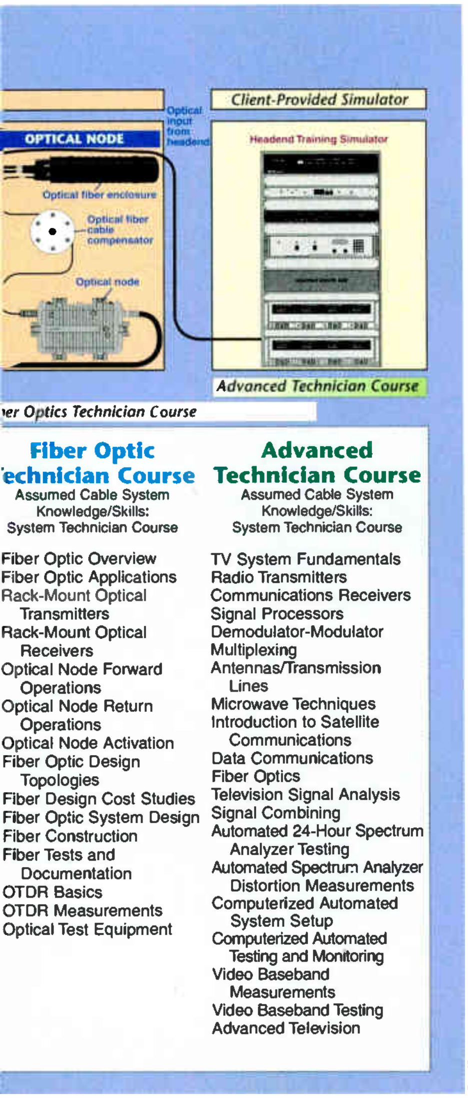
Implementation

Now that that "task" has been simplified, the same can be done with the implementation (or training) process. Here, the sets include knowledge- and performance-based training. Knowledge-based training refers to that good ol' book learnin' and performance-based is the hands-on portion. How comprehensive the training process is, will be reflected one way (good if it's comprehensive) or another (poor ...) in the results. To help ensure success, both knowledge- and performance-based training need to have measurable objectives. Clearly stated proficiency objectives for each lesson and hands-on lab practice help set the tone for that measurability.

While the figure shows the career path model for our traditional distance-learning curriculum, it also serves to illustrate the content

© NCTI

A comprehensive approach employing instructor-led classroom/lab training for lesson review and hands-on practice with training boards can help achieve the best results from a training program.



© NCTI

subsets of the knowledge-based training. With these, students read the lessons, study the material, pass the exams; and in this way they're preparing for the next step. As simple as it appears here, this part of the training process cannot be trivialized—it's the beginning of a solid career foundation and the training materials will serve as a valuable resource.

An important learning tool that deserves mention here is one that "crosses over" between knowledge- and performance-based training; i.e., the classroom/lab. With any training, it's a proven benefit for retention to reinforce what has been read/studied in a setting that provides a structured review. A significant aspect of the classroom/lab is the fa t that it is instructor-led. This is a critical component in making the training and its results repeatable, consistent and standardized. (More on this later.)

OK, the text has been read/studied, the exams passed, the review completed—it's time for performance training. In the past, very likely this aspect of training primarily occurred on the job. Today, however, most companies agree that for the sake of repeatability and the customers, performance training is best accomplished initially in a controlled environment using simulators/training boards. This is then followed by structured on-the-job training. The complexity and makeup of the training boards/simulators will vary with the area of focus. Examples of these are shown across the top of the figure. (Note how the individual boards/simulators coincide with a specific area of study. This not only makes it more manageable to accommodate future changes, but also allows for custom configurations.)

Hands-on training should be just that—the time to get those hands dirty. The quality of service delivered to subscribers is still very dependent upon craft-sensitive procedures to construct/install and maintain a modern broadband cable system. Even though the performance training starts in a controlled environment, the goal is to be as "real world" as possible. The test

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Wayne Lasley is a curriculum developer with the National Cable Television Institute in Littleton, CO. © NCTI. To inquire about NCTI career path course training, contact (303) 797-9393, or http://www.ncti.com for its web site.

equipment, electronics and hardware used in the classroom/lab should mirror that of the actual system and be available in sufficient quantity. (Obviously, this requires a significant financial commitment.) Students won't get hands-on training if they can't get their hands on the equipment. Don't neglect the written word here either. Each student should be provided with a lab manual covering all procedures in a step-by-step format, as well as any company policies and government regulations that are applicable to technical operations and safety.

Prior to the structured on-the-job training, proficiency testing needs to administered for each lab practice. The object of the skills assessments is to quantify and validate the level of each student's achievement thus far.

From the top

Remember that one of the goals of any training program is the repeatability of results. So far, all the components of the program have been standardized. It's time to examine the role of the instructor, or more probably the instructors. Most training facilities will be in some central location so that a number of systems can benefit from each. This means in all likelihood that instructors will come from different systems. Yet, it is imperative for the sake of standardization and repeatability that they are all on the same page, so to speak. "Train-the-trainer" programs are available and should be seriously considered—an instructor knowledgeable in teaching methods and proper technical procedures is no less important than the technical work force being taught.

It is not realistic to just hope for good results from a training program—you have to prepare for success. It requires a comprehensive approach that is educationally balanced. While the accompanying figure begins to illustrate this, such a program incorporates: 1) structured curricula, 2) needs analysis, 3) audience analysis, 4) subject matter expert participation, 5) measurable objectives, 6) various learning styles, 7) review mechanisms to reinforce retention, 8) job/visual aids, 9) guided lab practice, 10) testing devices to quantify and validate learning, 11) feedback mechanisms and 12) follow-up methods.

And yes, all of this requires a commitment from the company and individual. But the real question is: Can either afford not to? **CT**

Why commit?

Committing to training is not always easy. But as the following quotes help to illustrate, there are very good reasons to do it.

"I came to the realization that nobody controlled my training better than me: It's out there and I'm going to get it. Once I made that commitment, it (my career) all started to come together. You have to be proactive—you can't wait for someone to just drop it in your lap."

Jim Kuhns, Regional Engineering Manager, Comcast; and National SCTE Board Member

"Be it on a company-basis or on your own, you have to get involved in training. The more knowledge you acquire the more valuable you are. Here, we're really big with training because technology is progressing so rapidly and there's always something new to learn. Personally, I believe training is an investment in the future. Being a third-generation cable TV operator, I found I needed to understand more about the technical side of cable, so I started with NCTI courses and then enrolled in the BCT/E (the SCTE's Broadband Communi-cations Technician/ Engineer certification program). Training helps one stay competitive in the ever-changing world of telecommunications."

Maggie Fitzgerald, Vice President and General Manager, DAVI Communications Inc.; and National SCTE Board Member

"As an industry, we have to be committed to training our people in order to meet the challenges of technology issues, subscriber expectations and increased competition. Training budgets will likely increase in order to maintain basic skill levels plus provide advanced training as needed. Adelphia is committed to training and uses a variety of training material (NCTI, SCTE participation, vendor workshops, company-structured programs, etc.) and methods to achieve our goal of a well-trained work force."

Michael Smith, Director of Engineering, Adelphia Cable; and SCTE Senior Member

"It is our commitment to provide customers the highest quality service possible. The key to accomplish this goal is through the training of our employees. While in-house, hands-on training is essential, I also encourage taking NCTI courses and participating in the SCTE's BCT/E and Installer certification programs. I myself have participated in both, and it's my experience that the NCTI courses have helped employees to pass the BCT/E exams. In 1987 when I became a technical supervisor, I was committed to providing training and information to technical employees, and to gaining as much knowledge for myself. That's when I enrolled in my fist NCTI course. Since that time, I have completed all (six) of the career path courses NCTI offers, as well as some of its specialty courses. More than 100 employees at our system have completed at least one NCTI course, including CSRs, installers, warehouse employees, service techs, system techs, dispatchers and even clerical employees. The real benefactors to our training efforts are our customers."

Jerry Fargione, Technical Operations Manager, TCI Cable of Brookhaven; and SCTE Active Member and NCTI Golden Grad

Set-tops

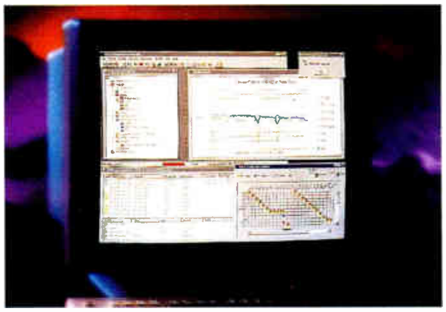
Cable operators providing near-video-on-demand (NVOD) movies and special events to subscribers are the focus of a partnership between TVN and TV/COM, a subsidiary of Hyundai Electronics America, to allow digital delivery of pay-per-view (PPV) programming. As part of the alliance, TV/COM will manufacture digital set-top converters (DCTV set-tops), which will receive, decode and decompress TVN's digital PPV programming delivered to consumers of TVN's newly launched Digital Cable Television.

The initial digital set-top units deployed for the DCTV system beta tests and for service implementation by early DCTV affiliates are manufactured by General Instrument. Mass production of DCTV set-tops will begin for delivery of digital programming and interactive services to subscribers in small- to mid-size cable systems. DCTV features include multiplexed CD-quality audio channels, an electronic on-screen program guide to access new channels and digital services coupled with cable's local broadcast channels and existing analog signal programming.
Reader service #311

RF monitor

AM Communications released the "Echo" Model 9013 end-of-line monitor, a monitoring transponder that verifies the presence of RF at end-of-line locations. The Echo is installed in-line, like a multiport tap, and takes its operating power and RF directly from the coaxial distribution network.

The system supports downloadable firmware with user-definable alarm limits for the forward RF signal level, the return RF signal level and the system AC voltage. "Echo" then continually monitors these parameters and sends an alarm to the monitoring computer if a signal malfunction occurs. The system is integrated into the OmniVUSoftware System and is compliant with the Omnistat network monitoring system.
Reader service #310



OSS software

ROSA 2.0, a new generation software version of Barco's ROSA cable TV management system was released. The operations support system (OSS) software provides headend automation, communicates with other servers in a cable TV/telco system and supports third-party proprietary protocols, which allows for integration of third-party equipment into the monitoring system.
Reader service #309

Data kit

The Bay Networks DataReady Kit is a new package that incorporates the basic data network and cable TV equipment elements a small- to mid-sized cable TV operator needs to offer high-speed data and Internet access services.

Bay Networks and its LANcity Cable Modem Division launched the new package. The kit includes a plug-and-play multiprotocol hub/router supporting Ethernet local area networks (LANs) and wide area networking (WAN); LANcity personal cable modem; LANcity Headend Master data converter; LANcity Headend Node; a network provisioning server (including On Net server software and Kernel, and PC SNMP Manager); all required cables; and a rack kit.
Reader service #308

Remote protection

To combat the memory loss inherent in universal remote controls, US Electronics developed the Memory Lock universal remote control code protection and computer mouse remote control technology and software for Windows 95-based PCs.

The new technology works this way: Once cable subscribers program their universal remote control with the device codes for their equipment, Memory Lock will capture and retain codes for at least 40 years.
Reader service #307

Noise reduction

Communication & Energy Corp.'s Model 4001-WPB-972.5(40)DC "F" custom bandpass filter isolates any 40 MHz segment of the TV receive-only (TVRO) block downconversion band (950 to 1450 MHz) to reduce noise. The 3 dB bandwidth is 40 MHz with a passband insertion loss of 1 dB. Connectors are 75-ohm type F. The unit measures 1.5 x 5 x 15 inches and weighs one pound.
Reader service #306

Phone test set

Progressive Electronics introduced the Model 390 telephone test set, the latest addition to a complete line of wire and cable locating and test equipment. Used to establish and test communication on an active analog line, the Model 390 features a built-in ringer, 10-number programmable memory with battery backup, tone and pulse dialing, last number redial, mute, polarity test and line disconnect.
Reader service #305

Connector

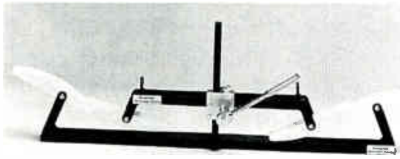
The Optimax SC is a field-installable optical fiber connector developed by Cable Design Technologies. The connector can be installed using the NORDX/CDT Optimax kit and can be assembled using just a fiber cleaver and a fiber stripper. Its design incorporates a pre-polished fiber stub and splice mechanism, which provides a fast, secure and reliable termination on optical fiber cables. It includes a "push-pull" feature with a floating ferrule that prevents optical disconnection if the cable is pulled.

The SC connector has been standardized by American National Standards Institute/Telecommunications Industry Association/Electronic Industries Association as the connector for all new structured cabling installations. The connector is available for multimode 62.5 AM fiber and its typical insertion loss is 0.3 dB per mated pair. A new installation tool, preparation guide and installation manual are included with the connector.
Reader service #304

Return data system

The Series 4100i/4200i/4300i multiplexer from Meridian Technologies transmits four video channels one way and up to 3 PTZ (Manchester, RS-232 or RS422 data) in the opposite direction on one fiber. Multimode, 2 km and 4 km units employ 1,300 nm light emitting diodes (LEDs); single-mode 40 km use 1,310 nm lasers.

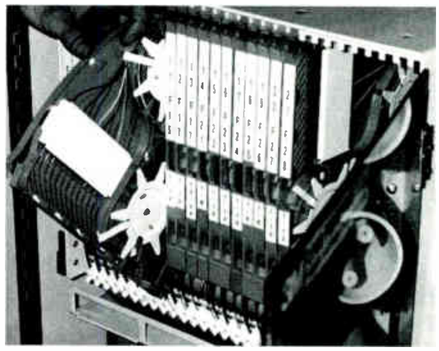
Single-mode versions meet RS-250C medium haul. Specs include 10 MHz video bandwidth, greater than 60 dB signal-to-noise (S/N) ratio, 17 dB optical budget and optical dynamic range. Standalone modules are powered by 12 VDC or 24 VAC; card units are rack-mountable in Electronic Industries Association 19-inch x 3-unit x 18-slot or 6-unit x 36-slot subtracks and feature SpectraSmart, a microprocessor-based, link status monitoring, diagnostics and network management system.
Reader service #303



Loop forming tool

In response to the need for proper signal transmission in today's high-bandwidth systems, Jackson Tool Systems introduced the UltraBend 1000. It is the latest addition to Jackson's family of expansion loop forming tools for coaxial cable. The new tool creates the required expansion loops in one or two cables up to and including 0.75 diameters.

The loops formed are 6 inches deep, 43 inches long with a radius of 11 inches, and a flat bottom of 12 inches. It maintains the round in coaxial cable and creates expansion loops that meet or exceed all current coaxial construction requirements and cable manufacturer specifications. The UltraBend 1000 weighs 19 pounds and comes with a 25-foot handline.
Reader service #302



Fiber distribution

The 3M brand 8400 series fiber distribution system includes of the 3M brand 8425 fiber distribution unit, which holds up to 144 fibers and allows fiber to be stored in large sweeping curves providing a three-inch or greater bend diameter to prevent crowding and macrobends. The unit is pre-loaded with interchangeable coupling plates available in all common configurations. The plates are attached at the top, and the bottom plate locks easily into a groove allowing for easier fiber installation without the need to reach under installed fibers.

3M's new 8425-BP provides an added space-saving feature to eliminate the need for separate splice housing. The unit comes with one 3M brand 2425-FT splice tray that allows all enclosed fiber to maintain a 1.5-inch bend radius. The splice tray fits into a drop-down shelf in back of the unit to accommodate up to 72 fused or mechanically spliced or terminated fibers when used with three 2524-FT splice trays.

Another key component of the 8400 fiber distribution system is the 3M brand 8470 fiber management system, with five vertical fiber organizers as well as one upper horizontal fiber trough and one lower horizontal fiber trough.

Reader service #301

Compression products

Looking for solutions for transmission of digitally compressed video? The new MPEG-2 (Moving Pictures Experts Group), Digital Video Broadcast (DVB)-compliant digital compression product line from Tadiran Scopus Ltd., a subsidiary of Tadiran Ltd., is being billed as a new generation of compression products.

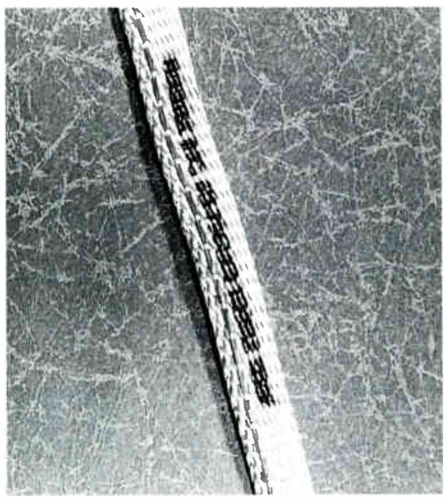
The new products include the MPEG-2, DVB-compliant encoder (CODICO E-110) based on C-Cube third-generation compression chipset, transport multiplexer and remultiplexer (CODICO RTM-360), commercial grade integrated receiver/decoder (CODICO IRD-250), network management system (CODICO NMS-400) and conditional access system (CODICO CAS-500), which provides security and address ability for TV networks.

Reader service #300

Monitoring products

Network monitoring products that support the Diamond Hub and Diamond Net optical node products are being shipped as the result of a joint venture between AM Communications and Philips Broadband Networks. Key monitoring and control features include frequency agility, downloadable protocol and control software, redundancy switching, return noise isolation, return switching, bridger switching, bypass and remote testing.

Reader service #299



Pull tape

Tracertape, the new, pull tape product from Fibertek, incorporates a corrosion-resistant copper conductor. A tone can be put on the Tracertape and conventional detection equipment is used. Once detected and located, the product serves as both measuring line and high tensile pull line.

Reader service #298

Power management

Cable TV networks that are expanding into broadband services such as Internet access and telephony will be interested in a new offering from Exide Electronics Group in Raleigh, NC. The Lectro Powernode for MSOs can accommodate up to four Lectro ZTT (Zero Transfer Time) uninterruptible power supply modules.

The inverters employ special sequencing logic to provide staggered "start-up" when transferring to the generator power source; this reduces generator stress. The Lectro ZTT is equipped with a high-speed AC detector unit.

Reader service #297

Modulator

Passive Devices added a 60 dBmV "T" channel modulator to its line of proprietary headend products. The PDI 60CMT is a fixed channel, sub-band, "SAW" filtered TV modulator that offers video and audio linearity and over modulation protection. The unit is BTSC stereo compatible and is 19 x 1.75 x 12.25 inches.

Reader service #296

High-speed products

A full suite of products and services for the design, activation, deployment and network management of two-way hybrid fiber/coax (HFC) networks is being developed by C-COR Electronics. The C-COR DataSelect initiative to develop high-speed data involves building partnerships with other industry providers of products required for delivery of high-speed data such as cable modems, routers, headend local area networks (LANs), and integrated network management packages.

Network operators will be able to select any or all of the following services: market assessment/trunk-node prioritization; network design; HFC distribution equipment designed for two-way (fiber-optic transmitters, AM fiber nodes, RF amplifiers), activation of the reverse path (balancing, sweeping, etc.) or network management of HFC distribution equipment.

Reader service #295

Couplers

Amphenol Fiber Optic Products added four-channel dense wavelength division multiplexer (DWDM) couplers to its optical coupler product line. DWDM couplers are primarily intended for use with optical amplifiers and transceivers, where four-channel operation is made possible in the 1,550 nm bandpass window. Applications include

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4	30	56	82	108	134	160	186	212	238	264	290
5	31	57	83	109	135	161	187	213	239	265	291
6	32	58	84	110	138	162	188	214	240	266	292
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14	40	66	92	118	144	170	196	222	248	274	300
15	41	67	93	119	145	171	197	223	249	275	301
16	42	68	94	120	146	172	198	224	250	276	302
17	43	69	95	121	147	173	199	225	251	277	303
18	44	70	96	122	148	174	200	226	252	278	304
19	45	71	97	123	149	175	201	227	253	279	305
20	46	72	98	124	150	176	202	228	254	280	306
21	47	73	99	125	151	177	203	229	255	281	307
22	48	74	100	126	152	178	204	230	256	282	308
23	49	75	101	127	153	179	205	231	257	283	309
24	50	76	102	128	154	180	206	232	258	284	310
25	51	77	103	129	155	181	207	233	259	285	311
26	52	78	104	130	156	182	208	234	260	286	312

A. Are you a member of the SCTE (Society of Cable Telecommunications Engineers)?
01.__yes 02.__no

B. Please check the category that best describes your firm's primary business (check only 1):

Cable TV Systems Operations
03.___ Independent Cable TV Syst.
04.___ MSO (two or more Cable TV Systems)
05. ___ Cable TV Contractor
06. ___ Cable TV Program Network
07. ___ SMATV or DBS Operator
08. ___ MDS, STV or LPTV Operator
09. ___ Microwave or Telephone Comp.
10. ___ Commercial TV Broadcaster
11. ___ Cable TV Component Manufacturer
12. ___ Cable TV Investor
13. ___ Financial Institution, Broker, Consultant
14. ___ Law Firm or Govt. Agency
15. ___ Program Producer or Distributor
16. ___ Advertising Agency
17. ___ Educational TV Station, School, or Library
18. ___ Other (please specify)_____

C. Please check the category that best describes your job title:
19. ___Corporate Management
20. ___ Management
21. ___ Programming

Technical/Engineering
22. ___ Vice President
23. ___ Director
24. ___ Manager
25. ___ Engineer
26. ___ Technician
27. ___ Installer
28. ___ Sales/Marketing
29. ___ Other (please specify)_____

D. In the next 12 months, what cable equipment do you plan to buy?
30. ___ Amplifiers
31. ___ Antennas
32. ___ CATV Passive Equipment including Coaxial Cable
33. ___ Cable Tools
34. ___ CAD Software, Mapping
35. ___ Commercial Insertion/ Character Generator
36. ___ Compression/Digital Equip.
37. ___ Computer Equipment
38. ___ Connectors/Splitters
39. ___ Fleet Management
40. ___ Headend Equipment
41. ___ Interactive Software
42. ___ Lightning Protection
43. ___ Vaults/Pedestals
44. ___ MMDS Transmission Equipment
45. ___ Microwave Equipment
48. ___ Receivers and Modulators
47. ___ Safety Equipment
48. ___ Satellite Equipment
49. ___ Subscriber/Addressable Security Equipment/ Converters/Remotes
50. ___ Telephone/PCS Equipment
51. ___ Power Suppls. (Batteries, etc.)
52. ___ Video Servers

E. What is your annual cable equipment expenditure?
53. ___ up to $50,000
54. ___ $50,001 to $100,000
55. ___ $100,001 to $250,000
56. ___ over $250,000

F. In the next 12 months, what fiber-optic equipment do you plan to buy?
57. ___ Fiber-Optic Amplifiers
58. ___ Fiber-Optic Connectors
59. ___ Fiber-Optic Couplers/Splitters
60. ___ Fiber-Optic Splicers
61. ___ Fiber-Optic Transmitter/Receiver
62. ___ Fiber-Optic Patchcords/ Pigtails
83. ___ Fiber-Optic Components
64. ___ Fiber-Optic Cable
65. ___ Fiber-Optic Closures & Cabinets

G. What is your annual fiber-optic equipment expenditure?
66. ___ up to $50,000
67. ___ $50,001 to $100,000
68. ___ $100,001 to $250,000
69. ___ over $250,000

H. In the next 12 months, what cable test & measurement equipment do you plan to buy?
70. ___ Audio Test Equipment
71. ___ Cable Fault Locators
72. ___ Fiber Optics Test Equipment
73. ___ Leakage Detection
74. ___ OTDRs
75. ___ Power Meters
76. ___ Signal Level Meters
77. ___ Spectrum Analyzers
78. ___ Status Monitoring
79. ___ System Bench Sweep
80. ___ TDRs
81. ___ Video Test Equipment

I. What is your annual cable test & measurement equipment expenditure?
82. ___ up to $50,000
83. ___ $50,001 to $100,000
84. ___ $100,001 to $250,000
85. ___ over $250,000

J. In the next 12 months, what cable services do you plan to buy?
86. ___ Consulting/Brokerage Services
87. ___ Contracting Services (Construction/Installation)
88. ___ Repair Services
89. ___ Technical Services/ Eng. Design
90. ___ Training Services

K. What is your annual cable services expenditure?
91. ___ up to $50,000
92. ___ $50,001 to $100,000
93. ___ $100,001 to $250,000
94. ___ over $250,000

L. Do you plan to rebuild/ upgrade your system in:
95. ___ 1 year
96. ___ more than 2 years

M. How many miles of plant are you upgrading/ rebuilding?
97. ___ up to10 miles
98. ___ 11-30 miles
99. ___ 31 miles or more

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18. ___ Other (please specify)_____

C. Please check the category that best describes your job title:
19. ___Corporate Management
20. ___ Management
21. ___ Programming

Technical/Engineering
22. ___ Vice President
23. ___ Director
24. ___ Manager
25. ___ Engineer
26. ___ Technician
27. ___ Installer
28. ___ Sales/Marketing
29. ___ Other (please specify)_____

D. In the next 12 months, what cable equipment do you plan to buy?
30. ___ Amplifiers
31. ___ Antennas
32. ___ CATV Passive Equipment including Coaxial Cable
33. ___ Cable Tools
34. ___ CAD Software, Mapping
35. ___ Commercial Insertion/ Character Generator
38. ___ Compression/Digital Equip.
37. ___ Computer Equipment
38. ___ Connectors/Splitters
39. ___ Fleet Management
40. ___ Headend Equipment
41. ___ Interactive Software
42. ___ Lightning Protection
43. ___ Vaults/Pedestals
44. ___ MMDS Transmission Equipment
45. ___ Microwave Equipment
46. ___ Receivers and Modulators
47. ___ Safety Equipment
48. ___ Satellite Equipment
49. ___ Subscriber/Addressable Security Equipment/ Converters/Remotes
50. ___ Telephone/PCS Equipment
51. ___ Power Suppls. (Batteries, etc.)
52. ___ Video Servers

E. What is your annual cable equipment expenditure?
53. ___ up to $50,000
54. ___ $50,001 to $100,000
55. ___ $100,001 to $250,000
56. ___ over $250,000

F. In the next 12 months, what fiber-optic equipment do you plan to buy?
57. ___ Fiber-Optic Amplifiers
58. ___ Fiber-Optic Connectors
59. ___ Fiber-Optic Couplers/Splitters
60. ___ Fiber-Optic Splicers
61. ___ Fiber-Optic Transmitter/Receiver
62. ___ Fiber-Optic Patchcords/ Pigtails
63. ___ Fiber-Optic Components
64. ___ Fiber-Optic Cable
65. ___ Fiber-Optic Closures & Cabinets

G. What is your annual fiber-optic equipment expenditure?
66. ___ up to $50,000
67. ___ $50,001 to $100,000
68. ___ $100,001 to $250,000
69. ___ over $250,000

H. In the next 12 months, what cable test & measurement equipment do you plan to buy?
70. ___ Audio Test Equipment
71. ___ Cable Fault Locators
72. ___ Fiber Optics Test Equipment
73. ___ Leakage Detection
74. ___ OTDRs
75. ___ Power Meter
76. ___ Signal Level Meters
77. ___ Spectrum Analyzers
78. ___ Status Monitoring
79. ___ System Bench Sweep
80. ___ TDRs
81. ___ Video Test Equipment

I. What is your annual cable test & measurement equipment expenditure?
82. ___ up to $50,000
83. ___ $50,001 to $100,000
84. ___ $100,001 to $250,000
85. ___ over $250,000

J. In the next 12 months, what cable services do you plan to buy?
66. ___ Consulting/Brokerage Services
87. ___ Contracting Services (Construction/Installation)
88. ___ Repair Services
89. ___ Technical Services/ Eng. Design
90. ___ Training Services

K. What is your annual cable services expenditure?
91. ___ up to $50,000
92. ___ $50,001 to $100,000
93. ___ $100,001 to $250,000
94. ___ over $250,000

L. Do you plan to rebuild/ upgrade your system in:
95. ___ 1 year
96. ___ more than 2 years

M. How many miles of plant are you upgrading/ rebuilding?
97. ___ up to10 miles
98. ___ 11-30 miles
99. ___ 31 miles or more

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telecommunication and cable TV WDM networks or any 1,550 nm fiber system with constrained bandwidth capacity.

The couplers are offered in two 1 x 4 module versions—a standard flat pack or the 948 Series fiber management coupler cartridge. Termination options include FC, SC and ST connectors with standard polish choices. The inherent wavelength sensitivity in the couplers is optimized to produce devices that perform as wavelength division multiplexers (WDMs) between the 1,533, 1,541, 1,549 and 1,557 nm wavelengths. High isolation and low insertion loss are achieved in either unidirectional or bidirectional operating modes. The devices also exhibit excellent thermal and polarization stability, according to the company.
Reader service #294

DACs

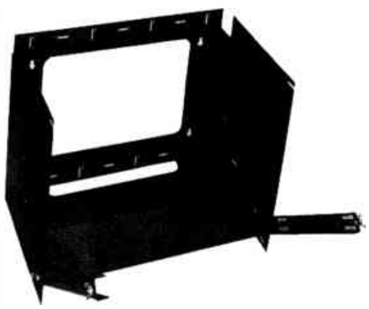
Analog Devices introduced a low-cost family of digital-to-analog converters (DACs) designed for use in the transmit path of communications and other signal generation applications. The AD976x product line consists of pin-compatible, high-speed CMOS DACs.

The AD976x TxDAC family includes the 8-bit AD9708, 10-bit AD9760, the 12-bit AD9762 and the 14-bit AD9764 125 MSPS converters, along with the 10-bit AD9760-50 50 MSPS device. These DACs operate off power supply rails from 2.7 to 5.5 V, dissipate 190 mW at 5 V (45 mW at 3 V) and include a power-down mode that utilizes only 25 mW.
Reader service #293

Comb generator

An audio/video comb generator was introduced by Idea/onics. The AV-70 is designed to simplify compliance with the Federal Communications Commission mandate requiring cable TV compliance with the Emergency Alert System (EAS).

The generator covers 70 channels with audio and video and requires no switchers or headend rewiring. The AV-70 used in conjunction with a receiver/encoder/decoder and character generator package requires less than 12 inches of rack space and can be installed in several hours.
Reader service #292



PPM racks

Designed for patch bays, hubs and routing networks, the new 19-inch pivoting panel mount (PPM) racks from Datatel are constructed using .060-inch steel for both the chassis and crossmembers. Each PPM unit is equipped with .125-inch thick multi-rails tapped with 10-32 threads on one side and 12-24 on the other.

To facilitate punching down on mounted components, each of the racks is equipped with a pivoting hinge system that has a positive stop that permits the entire rail assembly to be tilted down away from the chassis. The unit is delivered with velcro cable loops for use with the tie points comprising each unit's internal cable management system. All PPM racks are finished with a black powder coating.
Reader service #291

Multiplexer

Lightwave Microsystems introduced the LightWeaver MDM-16, a dense wave division multiplexer (DWDM) and demultiplexer for high-speed telecommunications networks. The LightWeaver can multiplex and demultiplex up to 16 high-speed channels over a single fiber-optic line and is readily scalable to 32 channels. The new product meets all International Telecommunications Union standards for dense wave multiplexers.
Reader service #290

Transceivers

Radiant Communications now has available fiber-optic transceivers that interface with all the popular status monitoring and control equipment for the cable TV industry. This allows systems to use their dark fibers to replace leased phone lines. Fiber-optic interfaces are available for the following: Scientific-Atlanta System Manager; General Instrument Omnistar; AM Communications; General Instrument set-top control (Manchester Data); and others. These bidirectional systems are available on two fibers with transmission distances of up to 50 km.
Reader service #289

Frequency conversion

The newest additions to Quintech Electronics Corp.'s family of ultrastable PLL frequency conversion products are the PUL 070D (70 MHz to L-band) and the PDL 070D (L-band to 70 MHz). They are based on QEC's PUL/PDL 070 fixed channel converters and feature improved phase noise and stability performance. The new models are suitable for all currently used high-speed data transmission rates and advanced digital modulation schemes.
Reader service #288 CT

The following is a listing of some of the videotapes currently available by mail order through the Society of Cable Telecommunications Engineers. The prices listed are for SCTE members only. Nonmembers must add 20% when ordering.

☛ *Data Transmission Techniques*—Andy Paff and Don Patton discuss alternative access and the cable industry's competition with the telcos for the lucrative data transmission market, providing an analysis of the regulatory and operational problems that cable companies will face in this market. Required equipment also is discussed. (70 min.) Order #T-1076, $45. **(Reference for BCT/E Category VI)**

☛ *Installing Fiber-Optic Cable*—If your system is planning to install fiber, or would just like to see the techniques, this presentation, which features Ken Carter, Larry Nelson and Dan Pope, is for you. This practical overview also offers solutions to common problems encountered in such installations. (1 hr.) Order #T-1077, $35.

☛ *Digital Data Transmission*—Join Robert V.C. Dickinson and Harry Perlow as they offer a lively discussion of why cable systems are an excellent medium for data transmission, as well as the binary numbering system, the hexadecimal system and ASCII. (5 hrs.) Order #T-1080, $95.

Note: The videotapes are in color and available in the NTSC 1/2-inch VHS format only. They are available in stock and will be delivered approximately three weeks after receipt of order with full payment.

Shipping: Videotapes are shipped UPS. No P.O. boxes, please. SCTE pays surface shipping charges within the continental U.S. only. Orders to Canada or Mexico: Please add $5 (U.S.) for each videotape. Orders to Europe, Africa, Asia or South America: SCTE will invoice the recipient for additional air or surface shipping charges (please specify). "Rush" orders: a $15 surcharge will be collected on all such orders. The surcharge and air shipping cost can be charged to a Visa or MasterCard.

To order: All orders must be prepaid. Shipping and handling costs are included in the continental U.S. All prices are in U.S. dollars. SCTE accepts MasterCard and Visa. To qualify for SCTE member prices, a valid SCTE identification number is required, or a complete membership application with dues payment must accompany your order. Orders without full and proper payment will be returned. Send orders to: SCTE, 140 Philips Rd., Exton, PA 19341-1318 or fax with credit card information to (610) 363-5898. **CT**

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COURSE SCHEDULE

APRIL	7-8	Wash D.C.	Introduction to LAN Cabling Systems
	7-8	Phoenix	Wireless Telecommunications Networks
	7-11	Chicago	Designing Telecom Distribution Systems
	9-10	Phoenix	Telecom Project Management
	9-11	Wash D.C.	Design and Installation of Ethernet and Token Ring LANs
	14-15	Wash D.C.	Introduction To Internetwork Design
	14-18	Wash D.C.	Designing Telecom Distribution Systems
	16-18	Wash D.C.	High-Speed Campus Backbone Design
	21-25	Raleigh	Designing Telecom Distribution Systems
	28-29	Chicago	Introduction to LAN Cabling Systems
	30-5/2	Chicago	Design and Installation of Ethernet and Token Ring LANs
MAY	5-6	Chicago	Introduction to Internetwork Design
	5-9	Montreal	Designing Telecom Distribution Systems
	5-9	Long Beach	Designing Telecom Distribution Systems
	7-9	Chicago	High-Speed Campus Backbone Design
	12-14	Long Beach	Telecom Distribution Systems Review

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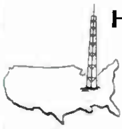

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We Need Your Help...

The Society of Cable Telecommunications Engineers (SCTE) and the Women in Technology subcommittee need your help.

The SCTE's membership currently exceeds 17,000. However, less than 5% are women. The Society needs your feedback to learn how it can better promote the technical achievements and training of female engineers, technicians, installers and other women in technical positions.

The Society strives to provide standards, certification, education and networking opportunities for ALL of its members. By filling out this short questionnaire, or passing it on to your female colleagues, you'll help us improve our programs for our entire membership.

Thank you for your assistance and continuing support of the SCTE.

Sincerely,

The Women in Technology Subcommittee, SCTE

Name ______________________________

Title ______________________________

Company ______________________________

Address ______________________________

City/State/Zip ____________________ E-Mail __________

Phone __________ Fax __________

Are you a member of the SCTE? Yes No

Are you a member of WICT? Yes No

What issues should the SCTE be addressing to better support Women in Technology (i.e. training, job placement opportunities, networking)?

____

____

____

What else can the SCTE do to improve opportunities for women?

____

____

____

(Attach an additional sheet if necessary).

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CALENDAR

March

4-7: The Light Brigade training course for installers, maintenance personnel and engineer designers, "Fiber Optics 1-2-3: Installation, Design and Maintenance," Sunnyvale, CA and Chicago, IL. Contact (800) 451-7128.

5: Society of Cable Telecommunications Engineers telecommunications vendor show and workshop, Holiday Inn Central, Omaha, NE. Contact (402) 393-3950.

5-6: Society of Cable Telecommunications Engineers Northern California Vendors' Days and Technical Presentation, Concord, CA. Contact Andy White, (707) 448-7478.

11-14: Siecor fiber-optic training course, "TR-07-S Hands-on Fiber-Optic Installation for Local Area Networks," Milwaukee, WI. Contact (800) 743-2671, ext. 5539 or 5560.

12: SCTE Oklahoma Chapter technical seminar, digital converts and HITS, Norman, OK. Contact Doug Huston, (405) 348-4225.

13: Society of Cable Telecommunications Engineers Satellite Tele-Seminar program, "BCT/E Category IV Overview," Galaxy 1R, Transponder 14, 2:30-3:30 p.m., ET. Contact Janene Martin, (610) 363-6888, ext. 220.

16-19: The National Cable Television Association's Cable '97, New Orleans, LA. Contact NCTA, (202) 775-3669.

20: SCTE Ohio Valley Chapter, Installer certification exams, Columbus, OH. Contact Dan McKay, (614) 236-1292, ext. 222.

25-27: Communication Design Engineering Conference, Washington, DC. Contact (617) 821-9219.

26: SCTE Smokey Mountain Chapter technical seminar, OTN technology fiber design/return, Johnson City, TN. Contact Dan McKay, (614) 236-1292, ext. 222.

April

5-10: National Association of Broadcasters' NAB '97, Las Vegas, NE. Contact Patricia McNeill, (202) 429-5479.

8: Society of Cable Telecommunications Engineers regional training seminar, "OSHA/Safety," Portland, OR. Contact (610) 363-6888.

9-11: Society of Cable Telecommunications Engineers regional training seminar, "Introduction to Fiber Optics," Portland, OR. Contact (610) 363-6888.

19: SCTE Llano Estacado Chapter technical session, headend tests and measurements, Lubbock, TX. Contact David Fielder, (806) 793-7475, ext. 4518.

28-29: Society of Cable Telecommunications Engineers regional training seminar, "Introduction to Telephony," Tampa, FL. Contact (610) 363-6888. **CT**

Planning ahead

June 1-5: Supercomm '97, Ernest N. Morial Convention Center, New Orleans. Contact David Swanston, (703) 734-3300.

June 4-7: SCTE Cable-Tec Expo '97, Orange County Convention Center, Orlando, FL. Contact (610) 363-6888.

Aug. 18-20: 1997 Great Lakes Cable Expo, Indianapolis Convention Center, Indianapolis, IN. Contact show management, (317) 845-8100.

Oct. 14-16: Mid-America Cable Show, Kansas City, MO. Contact (913) 841-9241.

Oct. 20-22: Eastern Cable Show, Atlanta. Contact the Southern Cable Television Association, (404) 255-1608.

Dec. 2-4: Converging Technologies Expo & Conference by Expocon Management Associates and Gartner Group, Los Angeles Convention Center. Contact John Golicz, (203) 256-4700, ext. 121.

Dec. 10-12: The Western Show, Anaheim, CA. Contact the California Cable Television Association, (510) 428-2225.

By the National Cable Television Institute

Return path in distribution amps: Part 1

This month begins the first part in a series on the return path in distribution amplifiers. Its purpose is to provide useful information complemented by training suggestions to reinforce the material in a classroom setting. The top portion is excerpted from a lesson in NCTI's Service Technician Course. The hands-on training suggestions are modeled after NCTI's new facilitator training courses for administering the hands-on labs. © NCTI.

The reverse amplifier section of an RF amplifier module processes and amplifies the reverse RF signals to optimize the output signals. These reverse RF output signals are typically in the range of 5-42 MHz for newer and upgraded (750 MHz) broadband cable systems. A basic understanding of the reverse amplifier operation of one typical distribution amplifier enhances your ability to perform reverse amplifier setup and maintenance on most distribution amplifiers. Always learn the reverse amplifier operation of your system's particular distribution amplifiers.

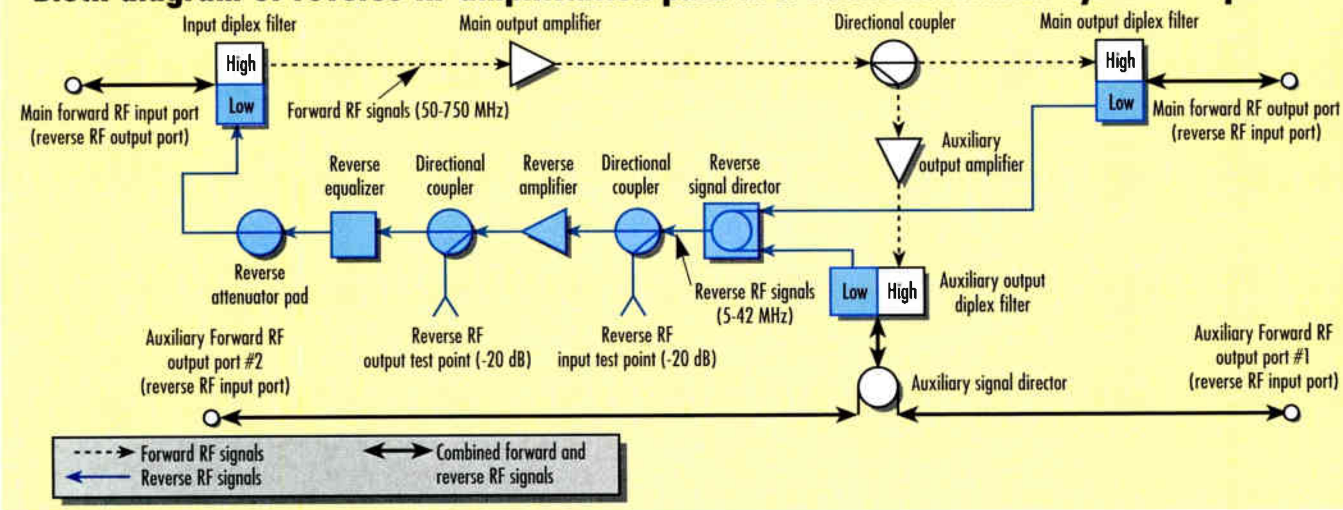
Reverse amplification path

One example of a return RF amplification path is illustrated in the block diagram of the Scientific-Atlanta System Amplifier II in the figure. The reverse RF signals are received at one or more of the three RF output ports and are directed to the main and/or auxiliary output diplex filters. The diplex filters keep the higher frequency outgoing forward RF signals separate from the lower frequency incoming reverse RF signals. The reverse signals are then combined together (if reverse signals are received at more than one output port) at the auxiliary and/or reverse signal director(s). The reverse signals pass through a directional coupler (DC), where a small portion of the signals is directed to the reverse RF input test point via the DC's tap-leg. The main portion of the reverse signals (passed on the DC's through-leg) is amplified in the reverse amplifier.

The figure shows the reverse RF signals are divided by another directional coupler. A small portion of the reverse signals is directed to the reverse RF output test point via the DC's tap-leg. The main portion of the reverse signals is directed via the DC's through-leg to the reverse equalizer, where slope is added to compensate for the known upstream cable tilt. The reverse RF signals are then attenuated to the proper output level, as required, by the reverse attenuator pad. Finally, the reverse signals are directed to the input diplex filter and then on to the main forward RF input/reverse RF output port for upstream transmission.

Next month's installment will cover return path setup in distribution amplifiers.

Block diagram of reverse RF amplification path in a Scientific-Atlanta System Amplifier II



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Hands-on performance training

Proficiency objectives: *Identify the frequency band, signal flow and major components and their functions in the return path of your distribution amplifier(s).*

Provide each student with a block diagram of your system's distribution amplifier(s) and the specs for the return frequencies used.

Use the block diagram (and if possible, the actual amplifier) to show the return signal flow through the major components, while describing what each does and how it affects the signals in the amp's return path.

Verify that each student knows the return frequency band and signal flow, and can identify the major components and describe their functions in the return path of your system's distribution amplifier(s). **CT**

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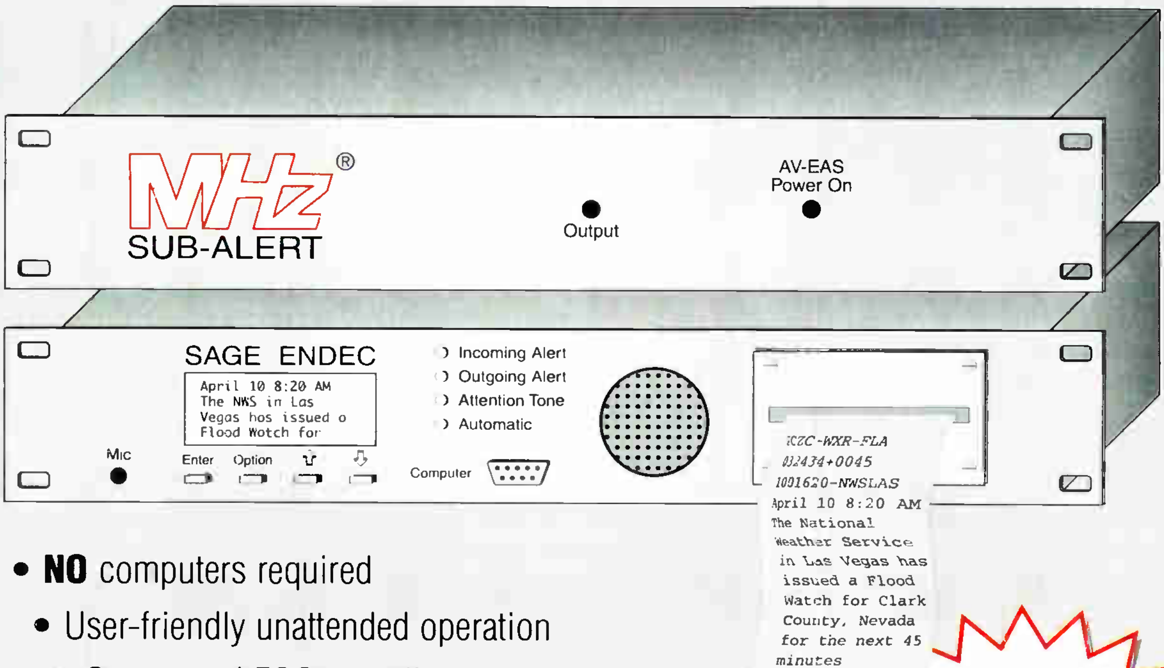

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By Bill Riker

Getting your money's worth

Next month, the Society will begin accepting registrations for its annual trade show, Cable-Tec Expo, the cable telecommunications industry's premier hardware trade show. Cable-Tec Expo '97 will be held from June 4 to 7, 1997, at the Orange County Convention Center in Orlando, FL

Survey says...

Every year, SCTE surveys both Cable-Tec Expo attendees and exhibitors to hear their comments on the Expo they have just experienced. This feedback is crucial to us in determining which features of Expo are successful and which may need some alteration, as well as ways to further improve the show and make sure that attendees and exhibitors get more out of Expo.

Cable-Tec Expo '96 attendees and exhibitors alike expressed their strong desire for Expo to offer more exhibit hours. This is a testament to the success and growth of Expo, because as the number of exhibitors and attendees has increased, the amount of time needed to thoroughly examine the many technical products featured at Expo also has increased. In response to the request for more time, options for addressing the situation were presented to SCTE's board of directors and Expo '97 program subcommittee.

You asked for it

After reviewing different proposals, the board and subcommittee reached a consensus that would accommodate the need for longer exhibit hours while maintaining the integrity of the technical activities held during Expo. The decision was to make the Annual Engineering Conference a half-day general session and provide more time for exhibits.

Previously, the Annual Engineering Conference was held on the first day of Expo from 8 a.m. to 5 p.m. and the exhibit floor was open on its second and third days. This year, the conference will be held from 8 a.m. to 12 noon on Wednesday, June 4. Following the Awards Luncheon from 12 to 2 p.m., the exhibit floor will open from 2 to 6 p.m., providing exhibit time that has never before been offered on the first day. The change in the Expo exhibit floor schedule will add an additional three hours of exhibit time, which is expected to meet the needs of both Expo attendees and exhibitors.

Expo '97 topics

The Society is presently finalizing topics and speakers for the three preconference tutorials. At press time, one of the tutorials will cover technical standards development and feature SCTE Engineering Subcommittee chairmen who have been very active in the development of new standards for the telecommunications industry. A second tutorial will explain and clarify the multitude of technical terms and acronyms used in our industry.

Topics for the Annual Engineering Conference also are being reviewed, and potential subjects include two-way and return path issues, cable modems, digital TV and system reliability. By the time you receive this issue of *Communications Technology*, topics and speakers should be confirmed, and registration packages will be in the mail to our membership. Anyone requiring more information on this event can call SCTE national headquarters at (610) 363-6888 or visit our Web site at http://www.scte.org.

In addition, booth assignments have already begun and companies intending to exhibit are encouraged to complete and mail in their contracts as soon as possible to reserve their desired booth space. Contracts should be mailed to SCTE at 140 Philips Road, Exton, PA 19341-1318. Remember, first choice in booth assignment is given according to accumulated "exhibitor points" that are earned each year a company exhibits and right now, space can be reserved on a first-come-first-served basis.

Expo Evening

Cable-Tec Expo '97 will have a very different ambiance from last year's country-music-influenced Expo in Nashville. This year's Expo Evening is scheduled to be held at the Disney Village Marketplace, where attendees are invited to a "café" located within a rain forest setting. Attendees at the Rain Forest Café will be surrounded by a recreated rain forest comprised of both live and animated wildlife and special effects.

The realism of the setting is enhanced by the lush vegetation, live tropical birds, simulated thunder and lightning, rain showers and large rock formations. There are even many interesting characters living in the forest, including an animated gorilla who greets guests as they enter, crocodiles, talking trees, dolphins, playful primates and butterflies. A nearby cave plays host to animated bats that fly around the stalagmite and stalactite formations.

See you in Orlando!

Other customary events that attendees can look forward to at Expo '97 will include the Welcome Reception, Cable-Tec Games, Exhibitors' Reception and Ham Radio Operators' Reception. On the last day of Expo there will be a golf tournament on two of Disney World's championship courses, Osprey Ridge and Eagle Pines. There will be a shotgun start on each course at 8 a.m. An awards lunch is scheduled afterward for all golf participants.

I am once again looking forward to the exchange of technical knowledge that occurs at Cable-Tec Expo and is the primary purpose upon which SCTE was founded. Of course, I always enjoy meeting SCTE's members who travel from around the world to attend. I hope to see you there. **CT**

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

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