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COMMUNICATIONS ENGINEERING & DESIGN
THE PREMIER MAGAZINE OF BROADBAND COMMUNICATIONS

DECEMBER 1997 ◆ 1997 Editorial Index ◆ Engineering roundtable ◆ Return path

What does his cable future look like?

BROADEN YOUR BROADBAND HORIZONS.

See us at Western Cable. Booth 2646. December 10th thru 12th.

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Without Wavetek's PathTrak™ system, you could look at this return path puzzle forever and still not find the solution. Return path trouble. The problem is right there, somewhere between the home and the headend, but there's no way to know when it started or where it's coming from. Until now. Introducing Wavetek's PathTrak Performance Monitoring System. The only system that gives you the entire return path picture. Only Wavetek's PathTrak Performance Monitoring System

When the Western Cable Show convenes in Anaheim later this month, all eyes will be on the CableNet exhibit and high-speed cable data modems. Key questions on the minds of everyone will include: How close are manufacturers to churning out standards-compliant product? Do any products actually interoperate yet? How much will they cost? How soon will the modems be available in retail outlets?

In the case of high-speed modems, it's buyer beware

Of course, interoperability between modem vendors is the key question. When the MCNS consortium (consisting of cable MSOs TCI, Time Warner, Comcast and Cox) first began drafting a standards document, it was with interoperability in mind. The intent was to eventually make modems available at retail and to make sure that no matter where the subscriber lives, any vendor's device would work in any customer's house.

Interoperability tests undertaken at Cable Television Laboratories have shown that the concept is viable, but to date, it's a stretch to say that any two vendors' equipment will live in harmony together. But that hasn't stopped the marketing machine. Some of the vendors are already jumping the gun, issuing press releases touting their latest products as "MCNS compliant."

The fact is, no one is MCNS compliant. Yet.

The dirty little truth about standards documents is that they can be interpreted in different ways. Arcane technical details and nuances have to be similarly interpreted by all players before disparate products can effectively work together. Those CableLabs interoperability tests are designed to work out those interpretive differences to ensure that all players are working off the same page. But there is still work to be done.

Then, after the initial process is finished, there will still be a need for testing to ensure that one vendor's new feature doesn't gum up the works. At some point further into the future, the MCNS "certification" process is given to a third party, much like what Underwriter's Laboratories does for electrical components.

On the other hand, pity the vendors. Several, including some who have incredible retail influence, are zealously developing modems designed for the MCNS environment. They want to get the message out that these new products are at least intended to be compliant with the MCNS spec. But saying they're "MCNS compliant" isn't technically correct, because end-to-end interoperability hasn't been demonstrated.

Perhaps some acceptable nomenclature ought to be developed for vendors who want cable MSOs to know they're planning to be MCNS players. In the meantime, as you're shopping for cable modems, it's buyer beware. If someone says they're "MCNS compliant," ask them this: "Who do you interoperate with?" That's the acid test.

Roger J. Brown

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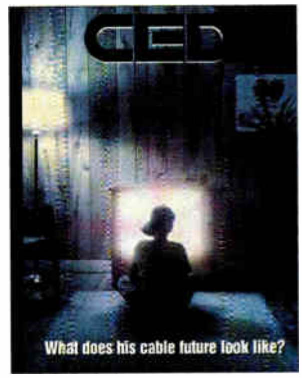

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Speed has never been as important in the race to install and maintain your return path as it is today. So the last thing you need is a problem with ingress. That's where the HP CaLan 3010R/H Sweep/Ingress Analyzer comes in.

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Cox, Comcast and Adelphia pledge to deploy digital video in 1998

As the country's major MSOs march headlong into 1998, they're beginning to deploy digitally compressed video services as a counter-offensive against direct broadcast satellite services and digital MMDS. Over the last several weeks, Cox launched its "Cox Digital TV" service in California, Adelphia began its commercial roll-out throughout its systems, and Jones Intercable began a limited roll-out in Tucson, Ariz.

With the addition of digital services, Cox now offers more than 200 video and audio channels in Orange County, including 25 new digital networks, additional channels of premium services, enhanced pay-per-view and 40 music channels. Viewers also receive an interactive program guide.

Orange County has become Cox's flagship system, offering Cox@Home high-speed data services as well as Cox Digital Telephone in addition to the digital video services.

The digital TV service is now available to 14,500 homes in Aliso Viejo, Calif. By the end of 1997, it was scheduled to be available to 175,000 homes in Mission Viejo, Lake Forest, Rancho Santa Margarita, Laguna Niguel, Laguna Hills, San Clemente and Dana Point. By mid-1998, the service should be available to all 275,000 Orange County customers. Cox is also rolling out the service in other markets.

On the other coast, Comcast in Philadelphia has begun deploying digital service, along with @Home data and CD-quality audio channels. Customers of the digital service will receive 150 channels, interactive features and 35 PPV channels.

Adelphia is taking a similar path, deploying digital services to 25 markets serving as many as 1.7 million homes. Adelphia plans to offer a service package that includes 17 premium channels, 18 PPV channels, an interactive program guide from Prevue and 40 digital music channels.

Meanwhile, Jones Intercable is taking a more cautious approach by testing digital service to 250 "friendly" customers first before it's offered to about 1,600 customers in early 1998, said Chris Bowick, Jones chief technical officer.

Jones intends to ensure that the digital hardware functions properly, and will test back-office processes and support, Bowick said.

Tucson was chosen as a test site because it's a very competitive market (DBS and People's Choice have made some in-roads), and because the system uses only coax and microwave technology for signal transport. "It's a technically challenging system," said Bowick, who added that if digital will work in Tucson, it should work anywhere.

All three MSOs are using gear from NextLevel Systems, which has now shipped more than 500,000 digital set-tops and 300 headends to operators around the country, according to David Robinson, VP and GM of NextLevel's Digital Network Systems business unit.

Debbie Thacker, director of special projects for Comcast Cablevision, shows former Philadelphia Flyers' goalie Bernie Parent the company's new digital cable TV service. Comcast premiered the service at the Chestnut Hill Fall for the Arts Festival. The service will be marketed in Philadelphia, Lower Merion and Willow Grove.

Cable data modems almost set to roll

On the eve of this year's Western Cable Show, a number of manufacturers of high-speed modems designed for use on cable TV systems have disclosed their plans to support the MCNS/CableLabs specification.

Bay Networks said it would debut its fourth-generation two-way modem and headend termination system at the show, and plans to ship product around the middle of 1998, said Karl May, VP of Bay's broadband technology division. May added that in volume shipments, the modems will be priced at less than $200 each, which should make them attractive to consumers, who are expected to be able to purchase such equipment at retail outlets in the future.

More immediately, 3Com Corp. announced immediate availability of its new telephone-return MCNS-based modem, which will be offered under the U.S. Robotics brand name.

The "Cable Modem VSP" and "VSP Plus" will enable data to be sent downstream as fast as 38 Mbps, and upstream communications as fast as 33.6 kbps. The base VSP model supports customers who want to add data-over-cable access but are satisfied with their existing analog modem. The VSP Plus includes an on-board "x2" modem and telephone connectors.

3Com is touting the simplicity of installation of the network interface card, or NIC. Levent Gun, VP of engineering at 3Com, said the modem can be installed and made ready to use within 15 minutes, and requires only a screwdriver to install.

Gun said the modems should be on the shelves of some selected retail stores as early as the first quarter of 1998. The base VSP model is expected to retail for $199, while the VSP Plus with x2 modem will be available for $249.

Intel seeks to expand service

Behind the scenes, momentum is building within other companies to accelerate the deployment of data modems for cable TV networks. Intel recently announced agreements with Cisco, @Home and Cable Television Laboratories to develop modems and write new interface specifications aimed at making installation of hardware simpler for consumers to perform.

Specifically, the Intel/Cisco agreement is intended to focus on the development and deployment of consumer-installable external cable modems using the Universal Serial Bus standard. By doing that, it should allow easy customer installation and configuration, instead of requiring a trained technician to install a card inside the PC and then configure it, according to company executives.

Forecasts say that more than 70 percent of the PCs shipped in 1997 and virtually all new 1998 PCs will be USB-capable.

"We believe that simplifying cable modem installations will help the cable industry overcome one of the major obstacles to high-volume deployment of cable modems," said Avram Miller, VP of business development at Intel.

Under terms of the agreement, Intel will provide engineering and marketing resources to develop, validate and promote the USB alternative for cable modems that comply with MCNS specs. Cisco will work to enhance the specification and validate the end-to-end capability. Intel also intends to base its USB modem design on Cisco's cable modem hardware reference design.

Cisco, which previously announced a collaboration agreement with major consumer electronics manufacturers to develop cable modems and other hardware, will endorse the Intel design and offer it to modem suppliers.

The agreement with CableLabs calls for Intel to collaborate on the drafting of two interface specifications, including USB as well as IEEE 1394, both of which were developed to simplify installation of computer peripherals in order to make them "plug and play" devices.

"We believe the USB/1394 opportunity will help our members reduce installation time and thereby improve choice, control and convenience for more high-speed Internet surfers," said Dr. Richard Green, president and CEO of CableLabs.

Intel will also work with @Home to develop such products and will also jointly develop other services, including IP telephony services, home networking and utilizing the "always-on" nature of cable data services.

MSOs focus on telecommuters, too

In the meantime, high-speed data services are rolling out to real, paying customers. Digital Equipment Corp. announced recently that it was rolling out MediaOne Express data services to its telecommuting employees by the end of the year.

"We are increasingly relying on telecommuting to meet the needs of our rapidly changing business environment, and a high-speed, secure connection to the office is absolutely critical," said Laurence Cranwell, DEC's director of corporate telecommunications, in a statement.

Cranwell said the MediaOne Express service would be combined with Digital's AltaVista Tunnel 97 software to allow the company's employees to access their network resources. The software enables the creation of a virtual private network over the Internet, which allows users to access corporate information securely.

Similarly, the @Work division of @Home reached an agreement with partners Tele-Communications Inc., Cox Communications and Comcast Corp. to develop a new service, called @Work Remote, designed for telecommuters.

According to analysts, there are 11 million telecommuters who work at home at least one day a week. It is expected that 50 percent of Fortune 1000 companies will have more than 2,000 employees accessing their corporate LANs remotely by 1999.

"Broadband to the home opens up a range of enterprise applications that were not possible before now," said Yobie Benjamin, chief knowledge officer of the Cambridge Management Labs, a division of Cambridge Technology Partners.

@Work intends to market its high bandwidth security through virtual private networks and "always-on" features to appeal to the telecommuting customer.

Tellabs, ADC win cablephone contracts

The announcements are coming piecemeal, but it's looking like North American cable operators can learn something from their international brethren when it comes to RF telephony over cable plant.

NetCom Systems AB, a Scandinavian alternative telecom services provider, has chosen to deploy ADC's Homeworx telephony equipment on its existing HFC cable TV infrastructure. The network is intended to make telephony and data services available to 320,000 homes served by NetCom through its Tele2 subsidiary, with a potential to expand to other properties throughout the region.

NetCom, which offers domestic and international telecom services as well as Internet access in Sweden, began trialing the gear in August. Service roll-out is expected to commence in 1998.

"At a time when telecommunications groups need to be more responsive, and when our customers are demanding the right to communicate, exchange information and obtain new services seamlessly and cost-effectively, this technology will support NetCom's mission to become more competitive and more customer-focused," said Anders Bjorkman, NetCom president and CEO.

Also, A2000 Cable Television and Telecommunications, a large cable operator serving the Netherlands, has begun commercial deployment of telephone services over an HFC network, using Tellabs' CableSpan 2300 equipment. The five-year purchase agreement with Tellabs is believed to be worth more than $100 million.

Subscribers in the Purmerend, Zaandam and Hilversum franchise areas are already subscribing to telephony service, and A2000 intends to offer it to more than 600,000 households and businesses located in areas throughout the country.

A2000 enjoys a cable TV penetration rate of greater than 95 percent. The company is a joint venture between US West International and United Philips Communications.

NextLevel, nCUBE bring NVOD back

Haven't we heard this before? NextLevel Communications will hook up with nCube to integrate servers and set-tops, in order to enable near video-on-demand services to allow subscribers to order and view movies and other PPV events with VCR-like control (such as pause, rewind and fast-forward).

Using NextLevel's CFT2200 set-top, subscribers can purchase programming at a time that's convenient to them. The set-top will automatically descramble the picture and tune to the proper channel.

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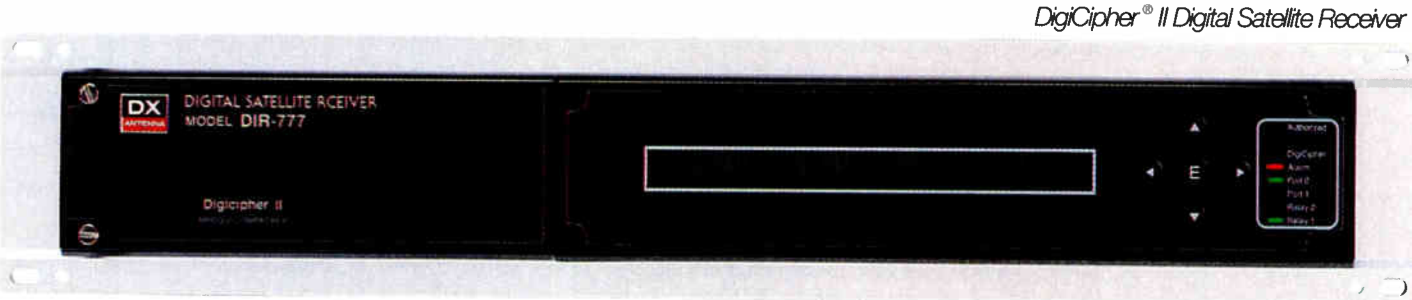

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already deployed two such systems that broadcast MPEG-2 digital programs served up by nCUBE equipment over a hybrid fiber/coax network to NextLevel set-tops.

Mass. utility uses HFC for network

Those who think the real darkhorses in the race to provide new services to the home are the utility companies were given another point to ponder when it was announced recently that Braintree Electric Light Department of Massachusetts would use a two-way, hybrid fiber/coax network to deliver energy services to customers in Braintree, a town located about 18 miles south of Boston.

The utility will use a gateway device manufactured by Scientific-Atlanta in a 12-month trial of the technology to perform automated meter reading and load management functions. But the company may not stop there: the device will allow other energy-related services to be offered, and will support LANs, WANs and low-Earth orbit satellite communications, among others.

"The (S-A) MainGate system supports our plan for the future: Keep the price of electricity as low as possible and enhance our relationship with customers by offering valuable, new services," said Walter McGrath, GM of Braintree Electric and incoming president of the American Public Power Association, in a statement.

"While automated meter reading and load management will be our initial focus, the system also supports a range of energy management and value-added services that allow us to eventually communicate with the customer inside the home," he added.

Additional services that Braintree is considering include time-of-use pricing, real-time pricing, outage detection, automatic bill payment and others.

The utility currently serves 14,000 customers.

Pirates in N.C. targeted by co-op

Cable operators all across North Carolina are banding together in an effort to reduce the proliferation of cable theft that already plagues about 10 percent of the state's customers.

North Carolinians Against Cable Theft (N.C. ACT) is the country's first statewide coalition to launch an industry-coordinated initiative against cable theft. It was formed by the North Carolina Cable Telecommunications Association.

N.C. ACT has broad support from cable systems, suppliers, programmers and customers, as well as law enforcement agencies, government officials and others. The goal is to educate North Carolinians about cable theft, encourage them to actively prevent it and garner support from local authorities in prosecuting cable pirates in an effort to eradicate it.

Cable systems in the state are launching simultaneous audits over the next several months to determine who is receiving cable services illegally, and local authorities have pledged to prosecute offenders. Under the law, this does include people who have moved into housing that already has cable service and don't realize they must pay for that service, as well as people who think they have already paid for cable by purchasing an illegal convertor box.

Estimates are that 11.5 percent of basic cable service and 9.25 percent of premium service are stolen every year in North Carolina. "Cable theft is a widespread problem" that has ramifications for all honest subscribers, said Randy Fraser, Time Warner Raleigh division president and director of the NCCTA. Theft can also result in lower quality of service for nearby subscribers, noted Fraser.

The group has set up a hotline for people who spot people stealing cable service. The number is (888) 834-6448.

Internet set-top developed by startup

In case you haven't lost count of the number of companies that are promising to develop new, multi-function set-tops, add Technauts Inc. of Cary, N.C. to the list. The company says it has developed a set-top based on its Internet Appliance software suite (dubbed "Tardis") and has targeted OEMs, VARs and ISPs to help them bring a sub-$200 box to market.

The unit is designed to connect to a TV receiver for display and a standard telephone line that connects to Internet service providers. The software suite includes a Web browser, e-mail, a personal information manager and other features.

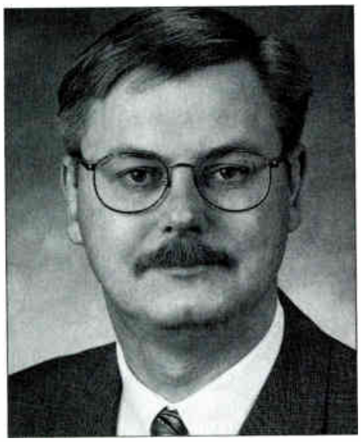
The open architecture of the software makes it easy for OEMs and VARs to customize Tardis with peripherals, including cable modems, IDSN, TV tuners and other devices, according to company executives.

The company intends to release a series of Internet appliances, including "E-mail Phone" and a "Plug-n-Play Internet" server, over the next few months, according to Ravi Periasamy, Technaut president.

Jottings

Consider the Donald Rumsfeld era at **General Instrument/NextLevel** officially over: the company announced last month that it was closing its Chicago headquarters office and moving that function into its Broadband Networks Group, which will soon be re-located to Horsham, Pa. The consolidation is part of NextLevel's newest restructuring that will make the new location on Horsham, Pa. the center of the NextLevel universe . . . While that company consolidates, **US West** has decided to separate itself into two public companies. One, US West Inc., will focus on telephone, data and wireless services; the other, called **MediaOne Group**, will control the cable networks, the investment in **Time Warner Cable,** and US West's international interests. Charles "Chuck" Lillis will become CEO of MediaOne . . . The **Consumer Electronics Manufacturers Association** has helped clear the way for data to be displayed over televisions and set-top boxes by developing the EIA-746 standard, which specifies how **Uniform Resource Locators** (URLs) are sent via line 21 of the vertical blanking interval. This will allow viewers to visit Web sites without having to type in the URL . . . Meanwhile, the FCC is planning on revising the technical rules to allow two-way use of the "wireless cable" and educational frequencies in order to foster more competition with traditional cable TV services. The Notice of Proposed Rulemaking asks for comment on allowing high-speed Internet access and other data delivery, as well as local loop bypass . . . **Com21 Inc.** has hit a major milestone by shipping its 100th ComUNITY Access high-speed data modem system after just six months of product availability. Product is now in place in 24 countries in systems with a cumulative base of more than 8 million subscribers . . . **Time Warner** has launched a business telephone service in San Diego. The all-digital Sonet fiber network is connected to more than 90 buildings . . . **Internet Ventures Inc.** will offer its "PeRKInet" Internet-over-cable service to 900 dormitory rooms on the campus of **Eastern Washington University**. Done in conjunction with **Davis Communications Inc.**, this service will give students Internet access at speeds of not less than 256 kbps. The network consists of a Cisco router feeding a Hybrid Networks Series 2000 Headend that then sends data to the telephone-return modems . . . . CED

Middlebrook is writing the digital book



Barry Middlebrook

As a young engineer, Barry Middlebrook paid some serious dues. In the early 1980s, he traveled the Arctic, installing satellite earth stations for the National Research Council (NRC) in virtually every small northern community from the East to the West Coast to the High Arctic. On a typical assignment, he and a fellow technologist would hop a snowmobile to a site, about 30 minutes away from camp, riding through total darkness in the "land of the midnight sun." Often observing huge, ominous-looking tracks in the snow around the site, one of the two would put up the earth station, while the other stood guard with a rifle to discourage any polar bears who might develop a sudden interest in young engineers.

While doing everything from pouring concrete in 40 degrees below zero, to site installation, to high-tech work, Middlebrook's view of oceans of snow made him realize how big his native country truly is, and how important satellite communication is to he and his fellow Canadians.

While we'll never know if the polar bear deterrence training was transferable, just about everything else Middlebrook has learned has served him well in the communications world. In one example of that, two years after joining Shaw Communications, Middlebrook won the highest award the Canadian cable engineering community has to bestow: The 1995 E.R. Jarmain award for technical excellence, given to Middlebrook in recognition of his work in developing and implementing digital television standards.

Today, as director of advanced technology for Shaw, he has responsibility for planning and implementing the company's digital video services, including video-on-demand, DMX and satellite systems. To smooth the way for the roll-out of those digital video services, as well as high-speed data, Middlebrook and his colleagues are busily consolidating headends, rebuilding virtually all of them to "achieve a higher level of quality assurance, signal quality and reliability," he notes. And Middlebrook is quick to credit Shaw's success in those endeavors to teamwork.

"The deployment of digital is the most significant project that Shaw has ever undertaken," explains Middlebrook, "because it is extremely capital-intensive. And, it has a direct and immediate benefit to all of our customers . . . because the conversion frees up capacity. We are on the bleeding edge, being among the first to deploy the technology. The book isn't written; we are writing it as we go along." At press time, the operator had deployed more than 27,000 boxes in its Calgary system, while the Toronto system was well on its way to completing its goal of 30,000 set-tops by the end of December.

Representing Shaw, Middlebrook is furthering the industry's goals by serving as a member of ABSOC (Advanced Broadcast Systems of Canada), which has been given a mandate by the Canadian government to define standards for digital television in Canada. He also participates with CableLabs' efforts in the U.S., and is a member of the SCTE, the IEEE, SMPTE and the CCTA.

From satellites to cable

Middlebrook is one of those lucky few who always knew what he wanted to be when he grew up: an engineer, and a Ham radio operator. Raised on a farm in Prince Albert, Saskatchewan, he spent many evenings as a young teen building his own Ham equipment and talking to people around the world. By the age of 15, Middlebrook was ready to hit the working world and signed on at a local television station as a "switcher," juggling the play-back of TV shows and commercials.

After winning several academic scholarships, he headed off to the University of Saskatchewan to study electrical engineering, while holding down a part-time job with a local aerospace company, SED Systems. At SED, he designed satellite equipment, worked on a satellite control and tracking system for the Anik and Brazilsat satellites, and was involved in some of the first VSAT developments. In fact, while working for SED, Middlebrook helped to build the main ground station and satellite test control facility for British Satellite Broadcasting in England (BSB, now BSkyB), one of the first DBS ventures in the world.

After leaving SED in 1989, he joined Canadian Satellite Communications (Cancom) as director of advanced technology, providing strategic direction for the company in its exploitation of the opportunities presented by digital video compression.

Comparing his two lives, Middlebrook says that the cable and satellite industries are "remarkably similar."

"They're both dynamic industries, and the majority of their business is entertainment video. . . . The opportunity and breadth of services available with the cable TV architecture is much greater than that afforded by satellite communications, though, so I felt it was important to take what I know about satellite, and apply it to cable TV (at Shaw)."

Is sainthood in the cards for Mrs. Middlebrook?

Though extremely dedicated to his job, Middlebrook says his family comes first. He has time for little else right now, as his five children, ranging in age from two months to 11 years, keep him hopping. He credits wife Darlene, though, with keeping the family running smoothly. A registered nurse who specializes in coronary care, she "has the patience of a saint to put up with me," he notes.

When he has a free moment, Middlebrook still dabbles in amateur radio, likes tinkering with cars, enjoys hunting and fishing, plays hockey and makes beer.

Optimistic about the future, both personal and professional, Middlebrook feels that the cable industry has a number of opportunities in new service provision just around the corner. "The information highway is wide open to us," he declares. "We can go any speed we want."

–Dana Cervenka

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Curiosity keeps technology moving

By Wendell Bailey, President, Strategic Technology International

It's so easy to forget how much technology surrounds us in everyday life. Fortunately, engineers tend to be a little more tuned into it.

One day last year, Walt Ciciora and I were getting out of a car in a parking lot. As we walked around the vehicle and headed towards the exit, Walt paused to examine a metal structure on the wall next to the car. I walked over to see what he was interested in, and he pointed out the unusual design of a coupling that was used to support a part of the structure.

A moment later, as we were riding up the building elevator to an office, Ciciora asked, "Do you find it odd that you and I were interested enough in an everyday piece of pipe that we took time to study it and discuss it?" I thought for a moment before I answered (something that I seldom do), and then asked him why he thought we did that. "Curiosity," he replied. "Well, yes, clearly that is exactly why we did it, but why," I asked, "did WE do it, as opposed to the other people in the garage?"

On reflection, I think the answer is that we work in technical positions. Engineers and technical people from other industries are often characterized by an abiding curiosity about almost everything. This is probably good, because someone has to notice and remember the contributions that others have made to the technology in the everyday things around us. For example, have you ever given any thought to the amount of technology needed to make the glass windows that you look through everyday?

The marvel of glass

Window glass is cheap–anyone with an active teenage son or daughter is probably thankful for this during summertime games of baseball or soccer in the side yard. A new pane of glass is only a buck or two. As you've installed it, have you ever noticed the marvel that is a simple pane of glass? It is completely flat and smooth and has a surprising degree of strength.

Glass has been around for at least 3,000 years. Flat glass, the kind needed for windows, was a labor-intensive industry, with the earliest efforts at making glass for windows using a technique known as "crown glass." In this process, a metal rod was used to pick up a clump of molten glass, which was then spun at high speed, causing the glass to form a large round disc. This disc was thinner at the outer edges than in the center, and the outer surface was cut into rectangular sections and used as windows. The heavy, distorted center section became what is called a "bull's-eye window." Glass made by this process was less than optically perfect. In fact, it was fairly wavy. This process was replaced by something called "cylinder glass." In this technique, a long tube of glass was blown, and while still hot and elastic, slit down the side and placed on a flat surface. This was a major technological improvement in the making of glass. The end product was still wavy and contained imperfections, but the process was more efficient than the old spun method, and the end result was thinner.

Several other technological improvements took place in the years following the end of the 1800s, but they all involved getting the plate of glass flat and then grinding and polishing until an acceptably smooth surface was produced. The improvements in the next decades were all in process changes that made these labor-intensive operations more mechanized.

The float process

It was not until 1952 that an English company which had been improving the process of making plate glass got the idea for a technique that radically improved the product and the economics. The improvement was so great that today, 95 percent or more of all the glass that you see is made by this process.

The "float process" did not make a saleable piece of glass until 1960. In this process, molten glass is drawn out of a furnace and floated on a molten bed of tin. The surface of the tin is so smooth and flat that the glass that is drawn off of the end needs no other steps to be optically clear. There are many details that I have not mentioned here, but suffice it to say, that the technology involved in this process is impressive.

What is more impressive is the comment made by the former chief scientist of the Pilkington Brothers (the firm that invented the float process) in an address to a conference at MIT some years after the private firm of Pilkington became a public company. At that MIT conference, the former chief scientist stated that as a public company, they could never have embarked on the effort needed to invent and perfect this process. It took, he said, millions of pounds, and five years to get it to work, and 12 years to make the first profit on the investment.

Today, of course, this is the only way to economically make plate glass for things like windows, but where would we be if in 1952, this imaginative company had been public instead of private?

Public companies make many advances in science and technology, but one has to ask: does the burden of the corporate form inhibit the efforts necessary to make industry-altering breakthroughs like the one detailed above? Unfortunately, we will never know.

Luckily, engineers and technicians notice the technology in simple, everyday things, and apply what their inquiring minds have noticed to their daily endeavors. This curiosity is what keeps the world of technology moving forward. CED

Have a comment?
Contact Wendell via e-mail at:
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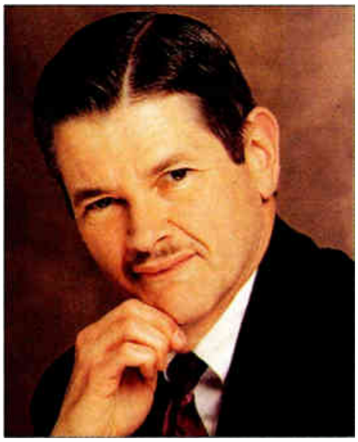
Beating competition in the new year



By Jim Farmer, Chief Technical Officer, Antec

At the end of the year, it is traditional to concentrate on family matters, but it is also traditional to look back, and forward. On New Year's Eve, we make our resolutions, which are usually broken by January 2. Many years ago, I made one resolution that I have been able to keep: to never make any New Year's resolutions again.

Anyway, this is a good time to look back, and forward, at my favorite industry. It has not exactly been a banner year in cable TV. We've been hurting from the hype that's been going around the industry for the past five or so years. We promised a bunch of new services, which we haven't been able to deliver as fast as we promised. Now, the public, press, financial community, and politicos all tend to be impatient. They assume that the cable industry is teasing them when it doesn't deliver what it promised, when it promised it. In reality, however, the new services are rolling out on a rational schedule–it's just not the schedule that everyone expects.

In addition, competition is here to stay. In the long run, that is for the best. In the short run, though, competition feels bad, because we haven't learned to live with it yet. Some of us are still in denial and want to pretend that competition doesn't exist. Unfortunately, sticking our heads in the sand won't make it go away.

Doing things right

Some operators are doing a good job responding to competition. Telephones are being answered faster, and CSRs are being trained and empowered to solve customer problems. Likewise, installations and repairs are being completed on time, and right. Channels are being added because subscribers have requested them. Picture quality is improving because technical people are being trained, and motivated, to do it right. Furthermore, levels are correct, systems are balanced and leaks have been repaired. These are all the things a successful company will do, just because they are the right things to do. Oh, by the way, doing the right things also improves subscriber retention, and signs up new subscribers.

Several architectures have entered the marketplace, competing to deliver broadband services to the home. We offer hybrid fiber/coax (HFC). The competition offers satellites, twisted pair, and MMDS in several forms. I choose HFC as the most competitive technology available. It has the most going for it, though the other guys will be there, make no mistake.

Satellite transmission is probably the strongest competitor today. Satellite folks have one distinct advantage: they don't require cable. This advantage, though, is nullified in North America, where the wired infrastructure is already in place. Satellite TV also requires a box on every TV. Furthermore, localized content, which is a real bear of a problem for them, is a slam-dunk for us. MMDS, and its variants, use a microwave transmission scheme with either digital or analog transmission. It is strong in a few places, but off-air propagation means line-of-sight, which is not always easy. Return bandwidth is another problem, though some solutions have been proposed. Financing also continues to plague that industry.

Lastly, the twisted pair folks (telcos) are working hard, and creatively, on ways to use their embedded infrastructure. They have proposed various flavors of digital subscriber line (DSL) service to deliver high-speed digital services. A few years ago, we heard about ADSL, where the "A" was "asymmetric." We now hear about xDSL, which is whatever digital data rate is feasible. DSL works, but as the number of bits-per-second is increased, line length and conditioning become bigger problems, and the craftspeople spend a lot of time (read: dollars) getting it to work.

One of our biggest advantages over the competition is an old technology: analog video transmission. Hey, it works, it delivers decent quality, and it's cheap and convenient. Powerful advantages, friends, very powerful advantages. It doesn't need set-top convertors, at least not for basic services, and a set-top is a big problem for today's subscribers. Even in applications where subscribers need set-tops, the analog ones are less expensive than what the competitors must supply. There's no doubt that we should exploit the digital world, but we should not forget about the one that brought us to the party. Analog still does a creditable job on a lot of things, while being friendly to, and inexpensive for, our subscribers.

Probably our biggest secret weapon against the competition is the return path. I have written on the subject before, and will continue to write about it in 1998. It can be tamed and will work very well for us. If you don't already have a working return path, there should be plans to have one in your future–unless you want your competition to get ahead.

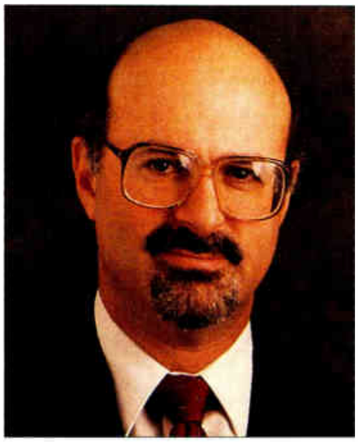
To stay competitive, never, ever forget the basics of operating a cable service: great customer service, great pictures and great selection. In the process, however, don't forget about the new things you can do. Data, for example, will play a larger role in our industry, even though it will take a few more years to perfect the recipe. Also, cable telephony is here and working. Several systems are reporting subscription rates beyond projections. And don't write the obituary for interactive video and remote services just yet.

Competition is here to stay. But it's not a bad thing, as long as you're ready for it. You can meet it, because you're backed by the best architecture in the business. Now go ahead and enter the new year with optimism! CED

Have a comment?

Contact Jim via e-mail at: jofarmer@mindspring.com

Two-way wireless cable in the works



By Jeffrey Krauss, wireless cable wiring expert and President of Telecommunications and Technology Policy

The wireless cable folks have been busy lately, figuring out how to configure their one-way spectrum to carry two-way services. One element of their plan was to get the FCC to change the technical rules for wireless cable, and that is now underway. But they still have to convince the FCC and the people who hold the radio licenses that this can be done without causing interference.

Wireless cable background

Wireless cable operates in the 2500-2690 MHz range. It is comprised of two kinds of radio licenses, Multichannel Multipoint Distribution Service (MMDS) and Instructional Fixed Television Service (ITFS). The ITFS licensees are educational institutions that use the channels for distributing educational coursework and lectures, but they are permitted to lease their "excess capacity" for pay TV distribution by a wireless cable operator. In most cities, the wireless cable service—up to 31 channels of MMDS and ITFS—is operated by the MMDS licensee.

Until now, wireless cable has used a one-way broadcast configuration from a tall tower in order to reach customers as far as 35 miles away. That's efficient for broadcasting, but not for two-way operations.

Last year, the FCC decided to allow wireless cable operators to transmit digital video as well as traditional analog video. This was permitted only after extensive field testing, to show that the digital signals would not cause interference into the traditional analog video transmissions. But even though this was a significant change, the broadcast video nature of wireless cable was retained. That clearly will not be the case if two-way services are permitted.

The two-way proposal

The FCC released a Notice of Proposed Rulemaking in October, in response to a petition submitted by a large group of wireless cable licensees, operators and equipment suppliers, seeking to establish new technical rules that would make it feasible to provide some two-way operations on ITFS/MMDS channels. These are some elements of the proposal:

- ✔permit use of ITFS/MMDS channels for response (two-way) communications
- ✔permit cellular reuse of ITFS/MMDS frequencies
- ✔permit licensees to subchannelize the 6 MHz channels or combine them into wider channels
- ✔permit use of sector antenna systems in addition to omnidirectional antennas
- ✔require submission of detailed calculations of potential interference from "response stations."

If these technical proposals are approved, 2.5 GHz wireless cable networks could end up looking like 28 GHz LMDS networks, with numerous small cells instead of a single, large, 35-mile coverage radius. But LMDS will have a single licensee in each city, while wireless cable uses ITFS channels licensed to four or five educational institutions in addition to the MMDS channels. The problem here is going to be maintaining the ITFS and MMDS broadcast video service on some channels, while operating two-way services on other channels.

The initial comments from ITFS licensees on the proposals were mixed. Some would be happy to abandon or decrease the video coursework and use their channels for Internet access and other two-way data services. But a significant number of ITFS licensees want to retain the video distribution nature of the service. They are concerned that a cellularized two-way network may not be suitable for one-way video.

There are serious interference issues. The propagation features of 28 GHz LMDS support cellular reuse of all the spectrum at every cell. In contrast, the 800 MHz cellular mobile telephone service can reuse only about one-seventh of the spectrum at each cell, because of interference from transmission in one cell into receivers in the adjacent cell. It remains to be seen whether similar interference problems will have an impact on two-way wireless cable at 2.5 GHz.

In addition, there are questions about interference between one-way video transmissions and two-way wireless cable. There will be some ITFS licensees that won't want to replace their one-way broadcast transmitters with these cellular two-way systems. So they'll be blasting away at the maximum power needed to send their video signal 35 miles, while on the adjacent channel, there will be systems using much lower power transmissions for cellularized two-way services. It will be quite a challenge to design a two-way wireless cable network that both achieves large frequency reuse and also is robust against interference from high-power ITFS.

The wireless cable folks would like the FCC to reallocate the spectrum and kick out the ITFS folks, just like the FCC kicked out the private microwave users in order to clear spectrum for PCS. But that isn't in the cards, and everyone knows it. The educational institutions may not have much money, but they have political clout through the Congress, and they've used it in the past to hold onto these frequencies.

In return for allowing the FCC to create the wireless cable service, educational institutions have promoted the idea that the wireless cable operators should pay for new ITFS transmission equipment and should pay for leasing channel capacity from the ITFS licensees. But that took place when everyone had the same goal of broadcasting video programming. It remains to be seen what kind of Christmas present it will take to sweeten the pot this time around for the educational institutions that want to use their ITFS channels for one-way video. CED

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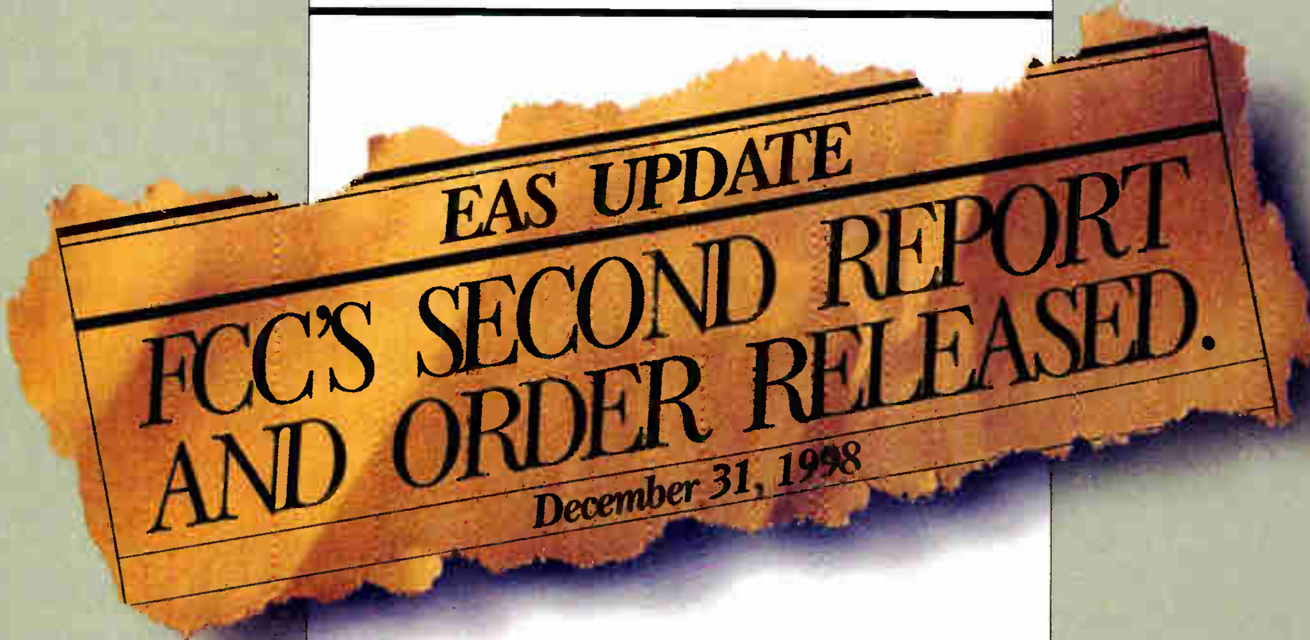

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Reader Service 14

Refining network management in a mixed system

Analog video/ Sonet delivery

By Blaine Brown, GCI, bbrown@gci.com; Bradley Beck, GCI, bbeck@gci.com; and John Phillips, Product Line Manager, Siecor Network Management Systems, john_phillips@siecor.com

Editor's note: This article was originally presented as a paper at NFOEC '97. Since that time, GCI has acquired Prime Cable.

As the use of fiber optics reaches deeper into today's telecommunications networks, the ability to manage the physical components of those networks becomes more and more critical. The myriad network topologies make a single management tool difficult to specify, and even more challenging to implement. By defining the critical elements that must be managed to achieve the required high network availability, the network manager can take the first step in implementing a comprehensive solution.

By segmenting the task of network management into passive or physical layer management and active component or element management, one can modularly build the complete suite of management applications. It is important to understand, however, that even though a modular system may be simpler to implement, all modules must be capable of integration.

This article describes a project undertaken between GCI, Prime Cable and Siecor Corp. in Anchorage, Alaska. Prime Cable and GCI Communications have installed a combination fiber optic analog video delivery system and Sonet distribution network in the greater Anchorage area. While installing the physical infrastructure, Prime/GCI also implemented a geographically-referenced fiber network management system provided by Siecor. The installed system keeps track of all fiber-related physical network components and aids in managing and troubleshooting the physical plant.

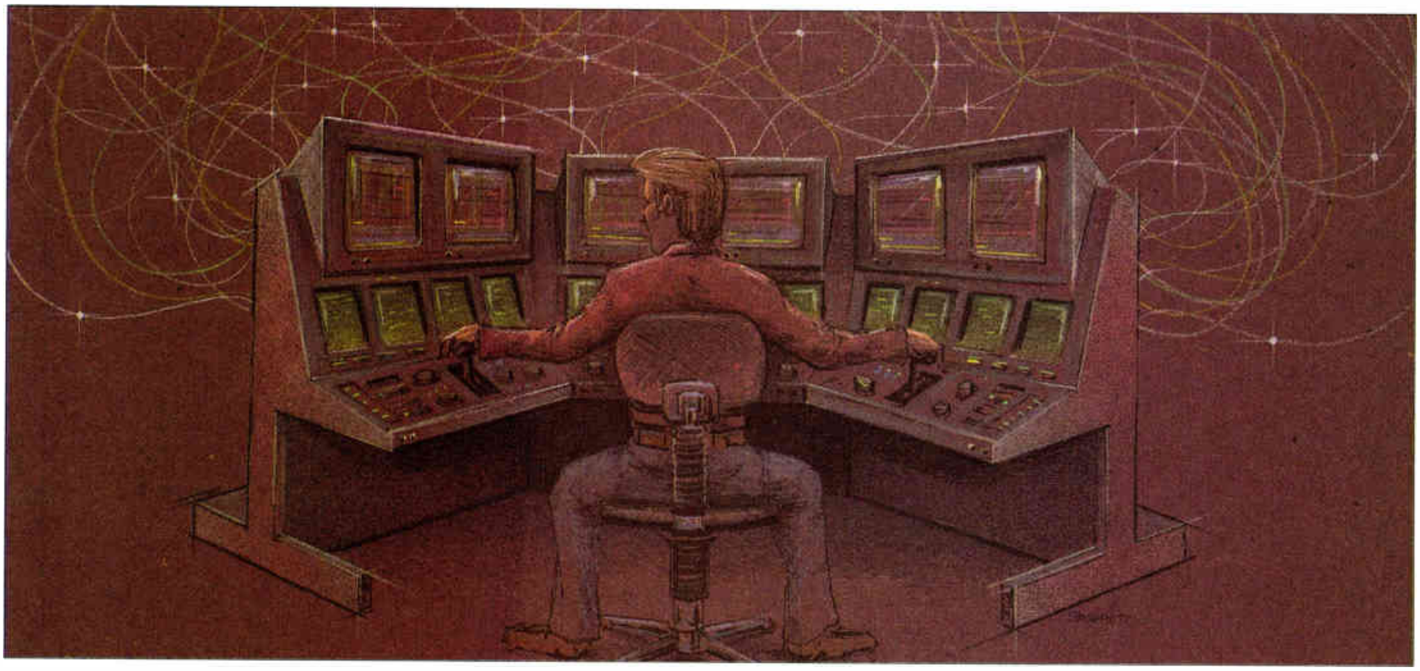
Network management systems

The term "network management system" means many things to many people. From complex element management systems that track the status of all active components to a simple recordkeeping system for port assignments, network engineers and managers must understand the core functions of any proposed system.

The International Standards Organization defines five sub-classes of total network management: System configuration management, system performance management, network asset management, network security management, and network fault management. While identifying a single system that would provide all of the functions of each of these sub-classes might be a daunting task, identifying applications that fulfill the needs of each category may be the proper approach. Again, it is vitally important to ensure interoperability and compatibility between identified systems.

The Prime/GCI/Siecor project focused on implementing a system that covered two of the five sub-classes: asset management and fault management. Asset management is loosely defined as the logical representation of the physical network layer within a relational database, and fault management is the function of using the logical network definition to identify and locate optical events within the physical plant. These optical events could be cut cables or simply areas of increased attenuation within the network that need to be addressed.

Two key areas of asset or physical layer management are system definition and/or connection management. Both of these physical layer management compo-



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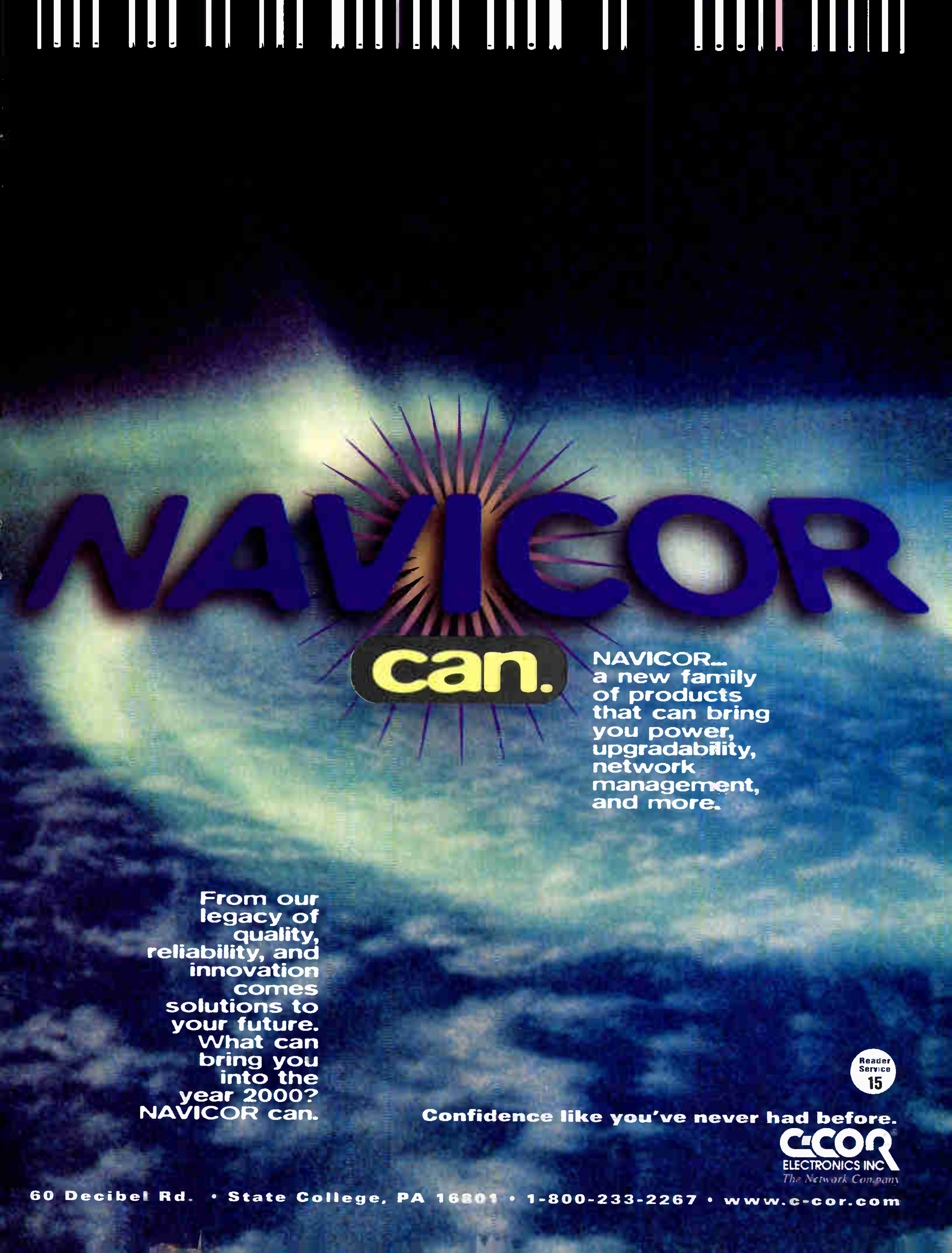
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nents were addressed in the Prime/GCI/Siecor project.

A robust management system must provide an easy-to-use, graphical method for defining an as-built optical network or for proactively designing the system and generating work orders and parts lists to build the network. Templates should be provided to define all of the relevant network components and allow the representation of multiple manufacturers' equipment. Physical layer components that should be tracked include, but are not limited to: cables; connectors; frames; fiber distribution systems and housings; electronics, nodes and receivers; splice vaults, housings and closures; cable conduit and raceways; optical splitters or couplers and wavelength division multiplexers.

Template definitions allow the system administrator to pre-define standardized network elements and provide only those supported components to the network designer. Templates also provide an easy method for reducing the time to actually define the network in the management system.

Table 1: Network component definition.

Network component	Number of elements
Optical nodes	17
Optical splice closures	26
Optical splices	10,400
Headends	4
Optical cross-connects	12
Optical cable segments	91

The system definition component of the management system should provide an intuitive interface for defining the network. This could be accomplished by allowing the user to drag-and-drop template icons on the appropriate location on street maps for outside plant components or onto a floor plan representation of a headend, central office or network data center. The system would then prompt the user to enter critical data about each network component, such as the fiber count of a cable, the splitting ratio of a coupler module, or the physical dimensions of a cross-connect frame.

The network definition phase of this project consisted of defining a limited geographical area of the video/Sonet network. The network itself is being built and simultaneously defined in the management system in phases. Phase one of the project defined the components listed in Table 1.

Connection management

Once the fiber network is completely defined to the management system, the user then defines connections between the existing components. This includes port-to-port jumper assignments, as well as cable-to-cable splicing assignments. This function establishes the relationship between all of the network elements from transmission point to receiver point. By doing so, the system can then track every fiber circuit from end-to-end.

In addition to circuit tracking, the network management system should also provide performance information on the physical network. During the connection phase, all splice losses, connector and coupler/splitter insertion losses, and cable attenuation values should be recorded. This allows for pre-build planning by providing complete, end-to-end attenuation calculations. A robust management system also allows for "what if" analysis using this information. Power output and input requirements should also be recorded.

The management system should also provide an easy-to-use, intuitive interface for establishing the multiple fiber connection relationships between network components. This could be accomplished using an additional drag-and-drop interface that allows complete or partial fiber cables to be assigned to distribution housing ports or splice closure trays.

In addition to multiple fiber assignments, the system should provide a graphical administrative function for performing connection adds/drops/moves. This would also generate work orders for assigned technicians to make the defined changes. Work orders would then be recorded and entered into the system as they were accomplished. An automated form-scanning function would greatly reduce the amount of time required to resolve work order information.

Phase one of the project included defining optical connections within a 20-square-mile area. As noted earlier, more than 10,000 splice points were recorded. Each of these splice points also tracked the loss at that splice. Based on implementation requirements, either actual or budgeted splice losses can be used.

In addition to the splice points within the physical network, more than 6,500 optical terminations were recorded in the headends and optical cross-connects. Again, each of these optical terminations was tracked along with the insertion loss of the connection. Budgetary losses were based on specified connector mated pair loss measurements.

Fault management

Once the fiber network is logically defined to the management system, one of the key functions it provides is the ability to detect and locate failing components within the network. There are two levels of fault management functionality: manual test and automatic or proactive monitoring.

In the manual testing mode, the system would allow the user to input an alarming or failing component or customer, such as "transmitter 24," "node 57A," or "Main Street Bank." The system would then identify the optical path that is affected from transmission point to receive point. After doing so, the system would prompt the user with the test access port from which to take an optical trace of the suspected link. Once the user notifies the system that the test is complete, the system would then be able to read the trace event field, determine the point of failure and then notify the user of the physical location of the problem.

Implementation of a global positioning system (GPS) module would also allow the management system to determine the proper work crew to dispatch based on physical proximity to the failing location. The project also included a complex set of algorithms to account for inherent differences in optical and physical distances within the geography.

Geographically referenced data is generally referenced in two dimensions. This lends itself to providing linear distances between network elements. A vertical component must be introduced to account for

elevation changes or cable routing transitions between aerial and buried plant.

Not only does this adjustment need to be made for accurate event location, but optical cable constructions can also introduce a change in the reported distances. The type of optical cables deployed in the Prime/GCI network actually have more optical length than sheath length. This excess fiber length (EFL) is generally expressed as a percentage of over-run to the actual sheath length. EFL percentage was tracked in the Prime/GCI network on a buffer tube level.

By accounting for differences in sheath to linear map distance and optical to sheath distance, the system implemented in this project provides accurate cable sheath marking indications for optical events.

In order to assist in comparing historical optical performance to current performance, more than 12,000 OTDR traces were cataloged. To enable easy identification of historical performance criteria, OTDR traces can then be associated with light paths or circuits.

In addition to a manual reporting system, network management systems are being developed that employ optical switches and intelligent testing methods to proactively monitor the fiber network, detect failing or degrading components, locate the physical element and dispatch a work crew as necessary. While this is the best of all possible implementations of the fault management portion of a network management system, it is also the most expensive. This should be a serious point of evaluation when considering the implementation of such a system.

Other considerations

Now that some of the critical functions that a network management system should provide have been discussed, it should be noted that there are other considerations to take into account when evaluating a system that are not directly related to functionality.

Relational database management systems. A flexible and scalable relational database management system, or RDBMS, is crucial to proper implementation of a network management system. The RDBMS platform that the system runs on should have an open architecture and support industry standards.

Many companies have existing legacy management systems that hold part of the information required for a complete network management system. The proposed replacement or additional management system should be compatible with or have facilities to integrate with existing systems.

The RDBMS should also be scalable in that it can be implemented on a variety of computer operating systems and hardware platforms. Even if the network management system today only requires a PC-based solution, the architecture should support larger networked platforms for future growth.

The relational database management system deployed for this project was Oracle7, which provides a scalable architecture that allows for a small-scale client/server implementation, yet has the capability for exponential growth.

Geographic information systems. The network management system should also be integrated with a geographic information system (GIS). This allows the physical location of network components to be managed and tracked. By providing a regional street-level view of the fiber network, the user can, by creating unlimited graphical layers, view the utilization of fiber cables, determine the best diverse route for traf-


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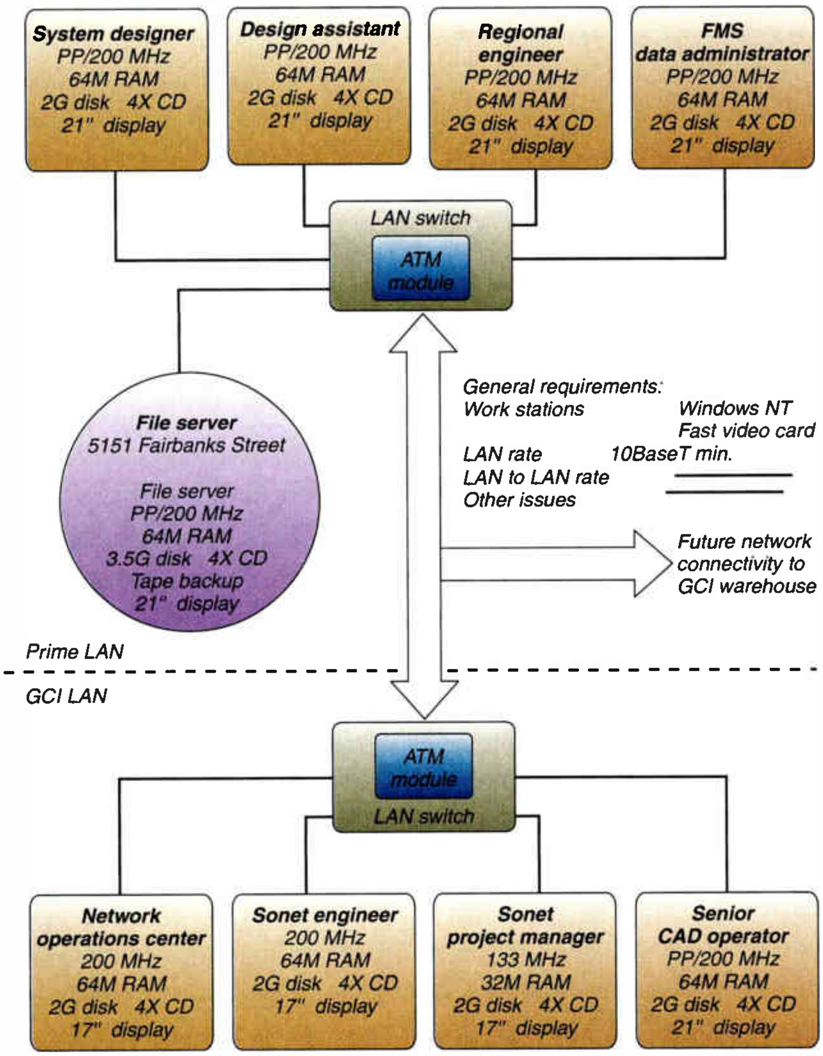
fic, or isolate trouble areas based on historical data.

The GIS should provide an easy-to-use interface and offer industry-standard interfaces with other mapping systems that may be deployed in an organization. Mapping the fiber network components makes the system much more intuitive and enables users to access critical information much more quickly than traditional menu-driven interfaces.

The geographical information system deployed at Prime/GCI was MapInfo. In addition to providing real-world coordinates for all optical elements in the network, the system also provided the capability to import more than 300 digitized CAD maps representing other network components. This flexibility allowed Prime/GCI to maintain its investment in the library of digitized maps, while at the same time, enabled the existing maps to be geographically referenced.

Client/server distributed architecture. A distributed system provides application processing power where

Figure 1: Proposed GIS fiber management system: network architecture and hardware.



the end user is physically located, while maintaining a single data repository to ensure accurate and secure data. This architecture allows the server side of the system to grow as needed, while ensuring a consistent interface for the client or end user.

In addition, a fat-client, thin-server implementation allows the majority of the processor-intensive graphical interface to reside on the client, and only database queries and results pass over the computer network from the server. This greatly enhances response time, and therefore, the overall usability of the network management system.

The project at Prime/GCI was deployed in a client/server architecture. Other applications vital to the operation of the network reside on various workstations. Access to the fiber network management system from a centralized server allowed access to multiple functions within both Prime Cable and GCI Communications. The CAD network architecture deployed for this project is depicted in Figure 1.

Installation, training and customization. Finally, system installation, training and customization services available for the network management system should be evaluated. Because of the sheer size of the data that is required to accurately define the optical network logically to the system, companies may decide that a complete, turnkey installation of the network management system and associated data entry is the best implementation method.

System usage training should also be evaluated. The network management system implemented will only be effective if used properly and in a timely manner. Comprehensive administrator and user training should be available and flexible enough to be geared toward the individual network configuration of any particular telecommunications company.

Also, the proposed network management system should be open and well-documented. The system provider should have fourth-generation language (4GL) tools available to allow for quick customization of the network management system to individual needs. In addition to programmatic customization, off-the-shelf tools should be available for the end user to enhance the system by creating customer-specific interfaces, forms and reports.

Conclusion

There are many functional and external factors to consider when implementing a network management system. The key in making an informed decision is to realize that a system that accomplishes 100 percent of the functionality for 100 percent of the network topologies is probably not available. But, by identifying the critical functional and external requirements for successful implementation, one can be assured that the system chosen today will work within the network of tomorrow.

The implementation of a physical plant network management system at Prime/GCI has allowed the network operators to more quickly and accurately report on the status of their optical infrastructure. Actual, quantifiable data was not available at the time this article was written, but should be calculable when historical data on the operation of this system is available.

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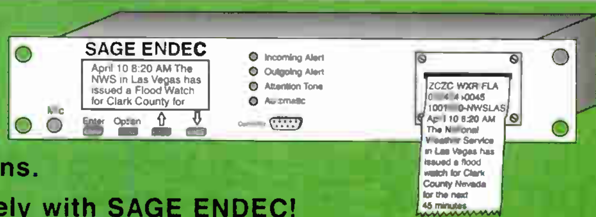

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Where do we go from here?

Four CTOs bring us up-to-speed

Heading into this year's Western Cable Show, the cable industry stands at a crossroads. It is about to embark on a historic journey that will take it into an era that includes digital video, high-speed data and potentially other services, including interactive TV and telephone-over-cable. To determine how the MSOs are preparing for this new future, we brought together four highly-respected senior engineering executives to answer a few questions related to service deployment, network construction and standards. What follows is an edited transcript of the conversation between CED *Editor Roger Brown;* CED *Contributing Editor Leslie Ellis; Tele-Communications Inc.'s Senior VP of Engineering and Technical Operations, Tony Werner; Time Warner Cable's Chief Technical Officer, Jim Chiddix; US West Media Group's Chief Technical Officer, David Fellows; and Intermedia Partners' Chief Technical Officer, Ken Wright.*

'The main thing we're doing is rebuilding just about everywhere. Rebuilds are us!' –Wright

CED: What are the top two or three issues that occupy your time and thinking these days?

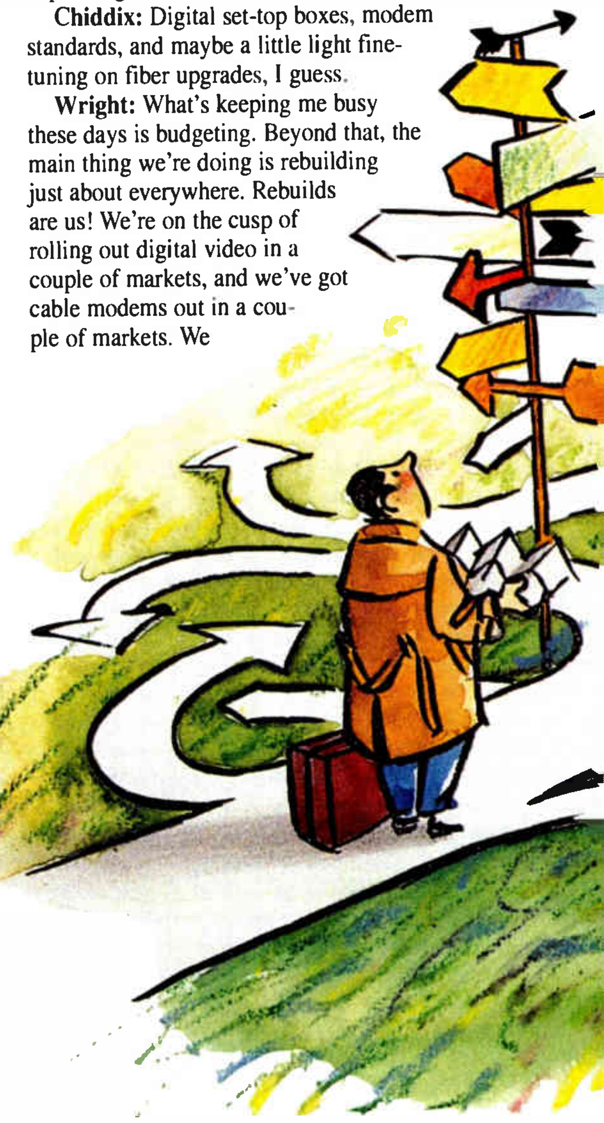
Fellows: In terms of hours spent, it's OpenCable, as it relates to the number-two thing I spend my time on, which is still MCNS. Finishing up the last pieces on the security model, keeping all of the vendors together so that there's some chance they will interoperate as we look at gray areas in the spec and do an engineering change request notice. Getting the suppliers to show up at CableLabs and do the interoperability testing. Preparing for this CableNet demo at the Western Show–all of that has taken a lot of time. I've spent the last two months reading responses to RFIs, putting out further questions to the vendors, reading those responses, sorting through the issues of what should be specified and how to come up with a specification that people will agree with.

Werner: I've been focused on our digital roll-out, and the practical aspects of that. Making sure the networks are able to carry the digital signals, making sure that we have headends either eliminated or interconnected down to the degree that it makes sense, to obviously avoid some costs in that area. We went into last fall shutting down the capital (spending) here, and shutting down the rebuilds. We're trying to get all the processes in place, the contracts lined up, network architectures set up on a market-by-market basis, so that we can start moving that ahead at a fairly rapid rate, starting late this year and into early next.

I guess a side point to that is that we have in the vicinity of 70,000 or 80,000 miles of plant that is HFC and close to being ready to be turned up for @Home service, so we've set up a group within my organization that's going out, visiting with the systems, and expediting the activation of two-way.

Chiddix: Digital set-top boxes, modem standards, and maybe a little light fine-tuning on fiber upgrades, I guess.

Wright: What's keeping me busy these days is budgeting. Beyond that, the main thing we're doing is rebuilding just about everywhere. Rebuilds are us! We're on the cusp of rolling out digital video in a couple of markets, and we've got cable modems out in a couple of markets. We



also have a few areas where we're doing some pretty massive interconnecting of systems where we're putting in regional headends.

CED: As far as high-speed data, are you pleased with the way the MCNS process has progressed so far?

Fellows: One of the things that I think amazes all of the MSOs involved is that we get along. We actually agree on things, agree on priorities and what should be in the spec or not, and on what sort of details should be there. On the other hand, it's the first time we've done something like MCNS. And so we're also flying a little bit blind, (such as) with issues like intellectual property (and how to deal with it).

Another area is the actual compliance testing. You can either go and hook one vendor's headend to another vendor's signal, and see if it works, and if it does, you do the dance of joy in the hallway. There's (also) a view that says you've got to vary all the combinations like voltage and temperature, headend distances and number of subscribers. So we're wrestling with what compliance means. I think the industry is going to have a lot of learning to do. MCNS has gone amazingly well, but that doesn't mean that there aren't all sorts of major challenges that are appearing.

CED: Dave, what's your view on when I can go down to CompUSA and buy an MCNS-compliant modem?

Fellows: I'm sticking with the story I've had for a year. And that is, if things continue to go well, there'll be some in stores for Christmas of 1998. And if there's some unforeseen problem or issue or blow-up, then we'll miss that and it'll be the middle of '99. I still think there's a good chance that all of us on this phone call will have taken MCNS modems, we'll have proved that they actually work and there's not going to be some massive recall. Then we'll get to work on getting them into stores and figuring out how the stores make money, how the suppliers make money, how customers get signed up, how we make money, and (how to) make the buying experience easy for customers.

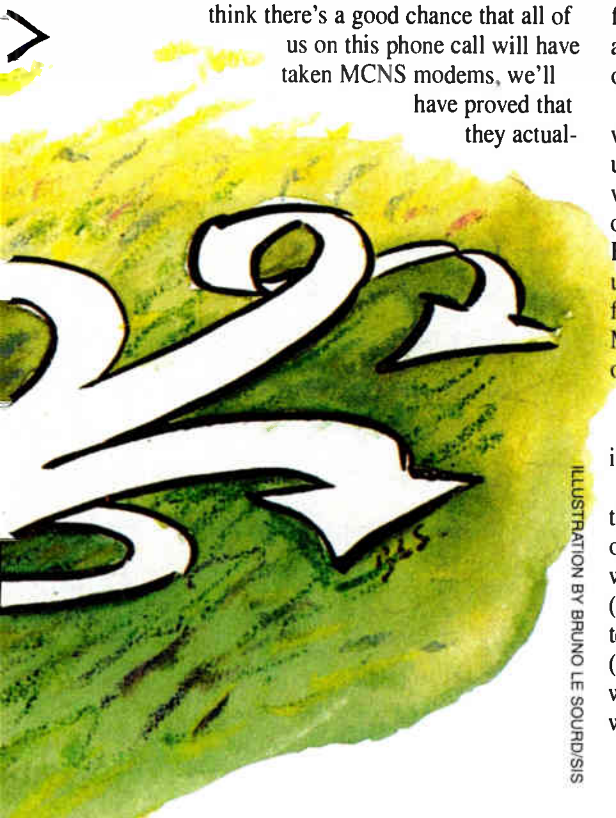


ILLUSTRATION BY BRUNO LE SOURD/SIS

CED: Outside of the retail model, how long will it be until there's a critical mass of MCNS-compliant modems that are available for you guys to purchase? What's the timeframe on that?

Fellows: I think they'll show us wares at the Western Show. Some of us may test some soon after that. But maybe the security won't be quite right, or there's another revision of the chip from gate array through to custom chip that solves a few, open, remaining items. I think the real tests come in March or April of next year, and by June-ish of next year, we'll be through the trials and find that they work pretty well. We're under pressure (from) our bosses to switch as soon as possible. We keep explaining to them that a Motorola or LANcity (now Bay Networks) modem that we take delivery on today will still be working a year from now. It doesn't suddenly stop working. But there is a definite, and probably justified, sense that as soon as we can transfer purchasing, we ought to.

CED: What do you do in the interim, between now and June? Do you roll out service in a few places and then go crazy once they're all interoperable, or do you not really wait?

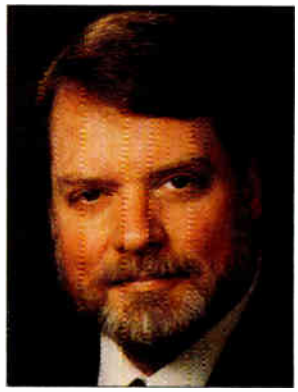
Chiddix: This is a good business. You keep going full speed. You roll out as business dictates. There's perfectly good product out there right now. And it's available in volume, and it doesn't become a boat anchor once the MCNS modems (debut). They can co-exist.

Werner: We are trying to expand footprint, both within markets and adding markets with existing product. It isn't so much whether Motorola's product today will be MCNS-compliant. I mean, there's no product out there today that will gracefully and truly map over. But I think Jim's point is that you can have the products co-exist on a common cable plant, at two different frequency allocations. Another strategy is that once MCNS-compliant product comes in, you migrate some of the legacy gear to other systems.

CED: What's your roll-out plan, Tony, from a timing point-of-view?

Werner: We're in the process of re-evaluating both the speed at which we do the two-way activations and our network upgrades in general. But as of right now, we're adding over 150,000 passings this month (November), and those are in the bank. And the guys tell me we'll have the same run rate for next month (December). We're hoping to actually ramp that up as we start to go into next year, taking the HFC plant that we've already built and getting it ready for two-way.

CED: Let's move into digital TV. What are your lat-

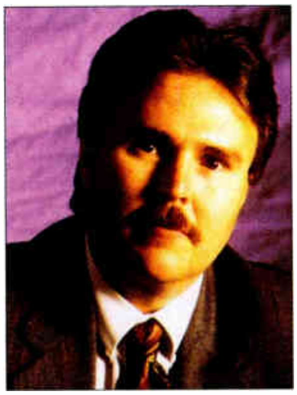


'There's perfectly good product out there right now. And it's available in volume, and it doesn't become a boat anchor.'

–Chiddix

est thoughts on roll-out plans, and how has OpenCable affected those plans, either to help or hinder?

Fellows: I'm the Luddite on the phone here, so I'll answer and get out of the way. We have plans for set-top deployments somewhere around Detroit, and we have headends installed where we think we have competition, but we are not aggressively rolling out digital set-tops across our systems at the present time. We believe that a 750 MHz upgrade with an 80- to 90-channel analog tier is compelling enough. As for waiting, it's not so much OpenCable we're waiting on, as much as prices for set-tops that we can afford, given the revenue that they bring.



'We're betting the farm on digital here. And rapidly moving ahead with deployment.' –Werner

Werner: We're betting the farm on digital here. And rapidly moving ahead with deployment. We're also very bullish on OpenCable, and what it has to bring, but we don't think that it necessarily affects the business today, nor is it a good reason to delay. So we've been rapidly installing the dishes and the headend equipment to facilitate availability of the signals to upwards of 90 percent of our customers by year-end. Whether or not we'll market to all those is another question. We've taken delivery of 500,000 boxes so far and have a fair number of them deployed. We've got the majority of the headends installed, but we don't have all the channel maps downloaded, and we don't have all the billing set up.

Chiddix: We're sort of in the middle of those two answers, I guess. We're proceeding with Pegasus, with Pioneer, Scientific-Atlanta and Toshiba. We expect to begin beta trials around the first of the year. As soon as that's done, they'll go to beta testing in the field, and then later be deployed in a number of our systems next year.

I think the significant thing the industry is doing with OpenCable is embracing the whole family of Internet standards, and leveraging off of all the energy of the Internet to develop and evolve open standards. Our task is really one of adapting those to the needs of the cable industry and the set-top box environment.

We view the set-top box a little differently than either Dave or Tony. It has potentially a defensive element, although there is a universe of early adopters out there who are our most demanding customers, with home theaters and so forth. Those are the folks who buy DVD machines and potentially DBS dishes. We want to make sure we don't lose those customers or the position of being their video provider.

Looking further down the road, I think digital set-tops offer us a lot more than a defensive position against DBS or merely a way to extend channels. Ultimately, cable's strength is the huge amount of two-way plant we have, with an HFC architecture. Digital set-tops open up an important area for the kind of services we offered in Orlando. And there indeed is revenue there.

Wright: Our first headend installation is in McKenzie, Tenn., which is a rural market that is channel-deprived because we've not done an upgrade there yet, and it's also a market where we have fairly extensive microwave distribution. So we decided to really challenge ourselves and have that be the first market we rolled out in. We also felt that that was a market where we were the most at risk with the DBS Christmas buying season. Beyond that, there will be more systems that will be firing up between now and the end of January, (including) Greenville/Spartanburg, N.C., followed closely by Nashville.

CED: What does your capital budget look like for next year? Will it be more or less than 1997?

Chiddix: For us, it's pretty much even keel. Our overall capital spending is about $1.6 billion next year, which is very similar to this year. That basic level of spending will last to the year 2000, when we complete the last of our upgrades. That capital is broken into upgrades, set-tops, maintenance capital and new business, which is cable modems and such. After the upgrades are completed, we expect our spending to fall to under $1 billion.

Fellows: We're spending about $1.5 billion this year, and (about the same amount next year). You know, it's flat, but still we're spending a huge amount of money on upgrades.

Wright: For us, '98 looks pretty similar to '97. In late '96, we set out to do what for us is a pretty widespread rebuild program, and '97 and '98 were the two major years. It's nearly $350 million for '97 and '98 combined, and we'll have spent about half that by the end of this year.

Werner: We're still sticking with our plan of record. As these joint ventures we've announced get closed, they'll slide out of our plan. At the same time, we're looking to accelerate our schedule for the remaining properties. My guess is that we'll shift a lot of the 2001 and 2002 spending into the '98 to 2000 years. So our numbers right now are about $760 and $850 million for next year, and between $950 million and $1.2 billion for total capital–that includes maintenance and line extension–and upgrades may grow as we move into the upcoming two years.

CED: What percentage of your plant is currently two-way HFC, and how much will that grow next year?

Wright: At this point, we're at just under 50 percent of our plant that's two-way HFC. And by the end of next year, we'll be at the 90 percent mark.

Fellows: We are just over 50 percent where the bandwidth has been upgraded to either 750 MHz or 550 MHz, and my calculator says 26 percent are two-way HFC, data-ready homes-passed. That will grow 20 percent (per year) for forward plant bandwidth, and we'll actually end this year at about 60 percent. (On the reverse plant), we'll end the year at roughly 30 percent, and that catches up at a little bit more than 20 percent increments going forward.

Chiddix: We're at a little over 50 percent as of the end of this year, that's both two-way active and HFC. Right now, we also have non-HFC plant which is two-way active. We're mostly tracking the HFC upgrades, and currently we have 18 million homes passed. A little over 9 million homes passed that will be upgraded this year, and that grows at a rate of 3 million homes per

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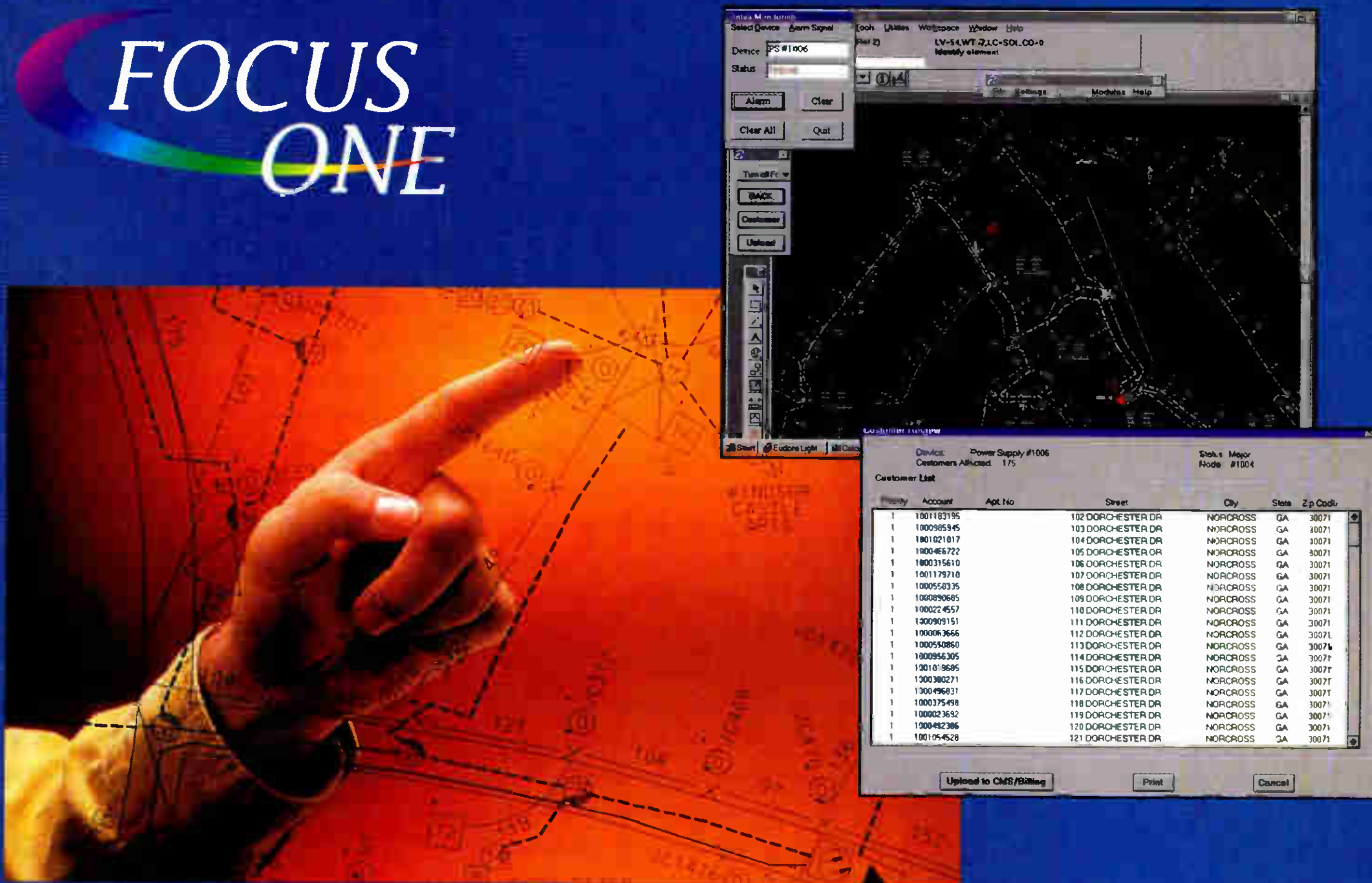

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'Dave "Band Aid" Fellows here uses filters in five of our six regions.' –Fellows

year until we're completed at the end of the year 2000.

CED: What about the return path? We keep hearing how difficult it can be to operate there. Is everybody planning to use filters for the upstream path, or going the route of clean plant?

Chiddix: We're in favor of clean plant. We've used filters in some areas where we needed to clean something up that wasn't quite up to snuff. But we're firm believers that it is quite possible and not horrendously difficult, in fact, to clean up plant to the point where you don't need to put filters everywhere in order to fire up two-way services. Adding filters is a crutch that keeps you from running plant the way that you should run it, and they become more and more operationally complex as you go down the road and get higher penetration of two-way services.

Wright: I'll just say ditto to that, Jim. We're really in the same boat. Across the board, we're firing up two-way plant without filters, and finding that we can make it work. As Jim said, if you use filters, you become your own worst enemy, because penetration grows, the filters come off, and problems then start showing up after you bring customers on.

Werner: We're leaving those decisions up to the systems. They can make that call. We obviously work with them and advise them, and for that matter, we consider filters to be a useful tool. CableLabs has done some interesting work that clearly proves that filters are a valid tool. They showed that filtering can and does remove greater than 90 percent of the interfering types of noise and burst energy. So we think filters are a good tool, but we also have plant that's very clean and doesn't need them. But we're not religious about it one way or another.

Fellows: Dave "Band Aid" Fellows here uses filters in five of our six regions. When someone signs up for a two-way service, the filter actually gets moved to one side of a new splitter we put on the house. In the sixth region, we use reverse equalization, if you will. We add loss selectively in the reverse plant, so that the transmit levels from all homes are roughly the same and roughly the maximum allowable.

Wright: We're doing that, too, in our design. We're padding at the node to bring our worst-case terminal devices near the top of the output range.

Chiddix: Yes. Reverse equalization is a very clever solution, and we're experimenting with taps that have built-in return equalization.

CED: It seems that RF telephony, though, is seeing some momentum, at least if Cox is any indication. And Tony, you say you continued to be impressed with TCI's telephony experiences in Hartford.

Werner: We don't have any further plans for it right now. We'll stick with the experiments we have in place.

Fellows: On RF telephony, we're in the process of selling our interest to Cable and Wireless, but we have over 20,000 paying telephony customers in Australia. In this country, we have some trials going on in Atlanta, but have not made the decision to roll it out yet. And then back in my role, I'm placing bets. I'm making sure that I'm not so committed to HFC telephony that if IP telephony does what we hope it does, I've not done anything stupid. On the other hand, if IP telephony only turns out to be an Internet ham radio equivalent and does not have the quality or functionality to send faxes or receive voice mail or DTMF tones, then I haven't not entered the phone business waiting for this Holy Grail. So I'm trying to balance the effort and the investment here.

Chiddix: We have thousands of HFC telephony customers in Rochester, and are very confident that the technology works well and is quite manageable by regular cable folks. But we are not deploying it elsewhere, because we're quite concerned with the regulatory structure around competitive residential POTS. It's not a very good business right now.

Wright: We're in a position where we have to watch very carefully what we do with our capital, and make sure we make the best use of it. So we made the strategic decision some time ago not to put the extra capital that's necessary into our plant to start doing HFC telephony.

CED: What about IP telephony? Does that interest you?

Werner: We're bullish on that, also recognizing that there's a few things between us and the delivery of that service. Standards for the networks, and working out the terminal equipment. But I'll echo what Jim said, which is that we're finding on the HFC side that our networks can do it, and that the technology works pretty well. Whether or not it's in the long-term cards for the company is another question.

Chiddix: One of the things that's intriguing about it is that you may be able to leverage the same infrastructure that you build for the cable modem business. But you can do teen lines and second lines and so forth with the HFC gear that's available today, as well as IP telephony. IP telephony does have another capability, which is that some of the expense can get built into the PC, thereby reducing costs, but that also very much colors how it's used.

Fellows: One of the problems is that IP telephony means a whole bunch of different things. It could be viewed as an alternate way to get ones and zeros out of the home. And to that extent, you do worry about lifeline telephony. But we are powering our cable plant so that in times of power outages, the plant still works. With IP telephony, you have to worry about a box in the home; however, I have in the lab here at the Pilot House a gateway that has an RJ-11 jack and an Ethernet jack that doesn't consume very much power. So you can imagine them lasting as long as a cordless phone or surviving a couple-hour outage.

IP telephony is also a way to get a whole bunch of features that you can't get with a 5ESS switch and a normal telephone network. Like, you're looking at a Web page and you click on something, an icon, and a phone call is connected. Or, (when) you get an e-mail from someone, you hit a button, and you've got a telephone connection back to them. If they don't happen to be there, then you e-mail a voice mail back to them. And there are other convergence kinds of features. CED


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Broadband digital solutions take center stage

CableNET keeps the focus on digital technologies

By Michael Lafferty

As most cable professionals know, technology hype often leaves a bad, if not bitter, taste in one's mouth. Over the past decade or so, the industry has been trying to clear its throat of that taste after repeatedly putting its mouth where it thought the technology would be.

This year's CableNET '97 showcase, which is co-sponsored by Cable Television Laboratories Inc. (CableLabs) and the California Cable Television Association, should go a long way in clearing things up with solid hardware and software solutions designed for the industry's broadband digital pipeline. As the coordinated exhibits will show both industry insiders and outsiders, when it comes to digital services, bandwidth rules.

Now in its fifth year, CableNET's 1997 exhibit will include advanced technologies, services and applications from more than 45 participating supplier companies. Those companies will create more than 70 active working demonstrations throughout the 6,000-square-foot showcase. The demonstrations will run on a hybrid fiber/coaxial cable system built as a part of the exhibit with the assistance of Orange County's cable provider, Century Communications.

To help attendees get where they want to go fast, the demonstrations will be color-coded based upon five separate categories (see page 46). One of the key categories sure to garner a good deal of attention is the area devoted to companies displaying their prototype interoperable, standards-based modems.

Dr. Richard Green, president and CEO of CableLabs, believes this year's CableNET exhibit marks an important milestone for the industry. "The confluence of a first-ever display of interoperable, standards-based digital cable modems," says Green, "coupled with the display of digital television, is a true indication of the cable industry's embracing the digital age."

In keeping with the overall digital theme, CableNET co-sponsors are also taking the show on the Web (http://www.cablenet.org) as of December 1. "The CableNET site," says Green, "strives to be an easy-to-access, appealing gateway to the cable television industry's expanding presence on the Web."

While a great deal of Western Show attendees' attention will be focused on cable modems at the CableNET exhibit, the exclusive technology showcase has a lot more going for it. Among the participants are a variety of companies that are officially debuting their technology

and services for the first time to the industry.

One of those companies is Video Networks Inc., a year-old start-up company with a national video content distribution network. According to Tanzy Wallace, VNI's director of product management, VNI will be showcasing two of its products at CableNET.

"What we're showing," says Wallace, "is the VNI national network and two of our products, MediaTracker and EC Tracker. EC Tracker is a system for cable advertising. For example, with the EC Tracker, what you'll be able to do is log into the system, and you will be able view the ad bank to see which version of a particular ad you need to distribute. And from that, you will select your ad and you will distribute it. At the point where it's been downloaded to the headend and where it's been played, you can do an automatic verification, and you can use the same system to send your affidavits back up for collation.

"The MediaTracker is your standard VOD or news-on-demand service. And from that, you'll be able to go in and do searches on a database that stores a variety of clips. This can include a news or sports clip you want to incorporate in a local broadcast. So it could be used for affiliates of major news organizations who would find it useful for real-time breaking news stories, or it could used for just-in-time rebuttal-type campaign pieces in the upcoming 1998 election year. That's a real hot area for this application."

Wallace says hooking into the system is made as easy and as flexible as possible. "When we bring on a subscriber," explains Wallace, "we give them a computer, Mac or PC–it doesn't matter. We configure something that will work with their system. We load our software on it. We bring in the connection.

"If they're doing MediaTracker, we drop in a T-1 line. If not, then we look at a smaller bandwidth connection, depending on what the traffic is expected to be. And then they're on the nationwide network. If they're in a very rural site, and they're doing primarily the video part, then we put them on our satellite network. The demonstration we'll be doing at CableNET will actually be over our terrestrial network from our Atlanta network operations center."

At past Western Shows and CableNET exhibits, attendees often came away somewhat frustrated that the technology they saw was still "under development" or otherwise unavailable. And, for operators looking for easy-to-deploy services that can generate revenues *now*, that frustration was often more acute.

One of this year's CableNET participants thinks it has the technology and a service that

CableNET '97 demonstration participants

Proprietary cable modem solutions:

Bay Networks Inc. — a number of demonstrations focusing on delivery of high-speed data using proprietary cable modems. Included are distance learning, multimedia, telecommuting, electronic commerce transactions such as electronic banking, mail order, Web order, Internet Protocol (IP) phones, network management, and MPEG-2 video delivery.

Com21 Inc. — demonstrates virtual private networking for residential and business applications, and high-speed Internet access with a proprietary cable modem system.

Hayes Microcomputer Products Inc. — displays multiple standards-based cable modems with a new architecture that allows cable operators to choose their Internet service providers at any location.

Motorola — shows applications and new features for high-speed data delivery using proprietary CyberSURFR cable modems. Included are interactive gaming, electronic commerce transactions, IP multicasting, IP telephony, and 16 QAM.

NextLevel Systems Inc. — exhibits an advanced high-speed Internet networking application that enables operators to leverage Internet Service Provider (ISP) networks to deliver high-speed downstream data services to existing ISP subscribers.

DOCSIS-based cable modem solutions:

3Com Corporation — demonstrates interoperable, standards-based, US Robotics-brand telco-return and two-way cable modems for high-speed Internet access with speeds up to 38 Mbps for Web surfing, IP telephony, streaming video and other Internet applications.

Analog Devices Inc.

Assured Digital Inc. — exhibits security module proposals that seek to comply with the cable interoperable modem specification.

Bay Networks Inc. — demonstrates prototype interoperable standards-based modems.

Broadcom Corporation — displays prototype interoperable standards-based cable modems providing high-speed connectivity technology.

Cisco Systems Inc. — shows its standards-based solutions for cable system operators and consumer electronics manufacturers.

Harmonic Lightwaves — exhibits an interoperable standards-based cable modem termination system for high-speed cable data services.

Libit Signal Processing — demonstrates prototype design and components for standards-based interoperable cable modems.

NextLevel Systems Inc.

Panasonic Video Communications Co. — displays a prototype standards-based interoperable cable modem.

Phasecom Inc. — shows a prototype standards-based interoperable cable modem that allows for delivery of high-speed data services over a cable network.

Rockwell

Stanford Telecom

Toshiba America Information Systems Inc. — uses a prototype interoperable modem to demonstrate the use of streaming video and IP telephony for distance learning.

Digital video (delivery, display and measurement)

Bay Networks Inc.

Hukk Engineering — demonstrates a method of signal analysis of QAM digital signals.

Scientific-Atlanta Inc. — exhibits its Explorer 2000 digital set-top, PowerTV Operating System and interactive program guide.

SkyConnect Inc./Oracle — shows digital ad insertion using the Oracle Video Server on SkyConnect's hardware platform.

Video Networks Inc. — provides integrated video transport, network management and electronic commerce for seamless distribution and access of video nationwide.

Ward Laboratories — displays new video noise reduction system developed in conjunction with the Canadian Cable Labs Fund (Rogers Cablesystems Ltd.) and the University of British Columbia.

Education/Entertainment:

Bay Networks Inc.

Digital Camera Network — exhibits a real-time image acquisition system delivering live images to cable subscribers via the Internet.

Evolve Products Inc. — displays a two-way universal remote as a tool for tune-in promotion, pay-per-view and local advertising.

FORE Systems Inc. — demonstrates sending real-time video using ATM technology over dark fiber. Applications include distance learning, teleconferencing, remote arraignment and telemedicine.

VR-1 Inc. — shows networked games played over the Internet via cable modem connectivity.

Information/Internet technologies:

Bay Networks Inc.

CableData Inc. — exhibits two demonstrations that show on-line, real-time access and communication to customer care and billing management systems via the Internet, including access through wireless, handheld personal digital assistant (PDA) devices.

Ericsson Inc. — shows telephony, Internet access, broadcast video, switched interactive video and energy management over the cable network using ATM transport and switching.

Excite/Simon Fraser University — exhibits interactive content interfaces and developments for a cable thin-client set-top box.

Hybrid Networks Inc. — displays applications such as video conferencing, video streaming and remote access over proprietary cable modems.

ICTV Inc. — demonstrates an open platform to deliver high-speed Internet access, electronic mail and arcade-quality CD-ROM games over the cable to the television set.

Intel Corporation — exhibits a Universal Serial Bus (USB) interface for standards-based cable modems in personal computers.

International Billing Services Inc. — demonstrates interactive bill presentation.

Novell Inc./Compaq — shows a directory service, an application launcher and management software applications.

Online System Services — demonstrates a high-speed approach that allows cable operators to own and expand their on-line community with Internet access and Web services.

QNX Software Systems Ltd. — exhibits its real-time operating system and Internet Appliance Toolkit that provide a standards-based foundation for creating set-top boxes, smart phones, Internet televisions and other Web-enabled products.

RealNetworks Inc. — provides synchronized multimedia over the Internet to a computer desktop.

Sun Microsystems — displays its OEM-built Internet set-top, which connects to any standard television to provide Web browsing and e-mail.

Tut Systems Inc. — demonstrates Internet access solutions for local loop, campus, high-rise and home networking.

VideoActive Corporation — exhibits an adaptive pay-per-view schedule creator for video servers that may be located at local cable headends.

WaterLink Systems Inc. — shows a system of urban landscape water management (residential and commercial) over a cable system using narrow bandwidth cable data transmission of weather-based information.

WorldGate Communications Inc. — displays Web browsing and communications with the Internet through a high-speed connection to an Internet service provider.

High-Definition Television (HDTV):

Fujitsu

Mitsubishi

Panasonic

Pioneer

Sony

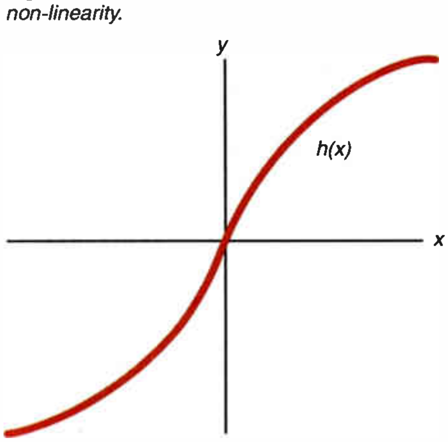
–ML

Laser loading theory for reverse path design in HFC

A model for laser clipping distortion

Figure 1: Transfer characteristic theory.

Figure 2: Transfer characteristic with some non-linearity.



By Lamar West, Ph.D., Principal Engineer, Terrestrial Network Systems, Scientific-Atlanta
lamar.west@sciatl.com

Editor's note: This article, and the one on page 58, were first presented in a series of reverse path seminars conducted by S-A.

Hybrid fiber/coax networks show great promise in their ability to deliver interactive digital services to the subscriber. However, there is still a great deal of confusion regarding the design of the upstream (reverse) path in such networks. In particular, a number of proposals have been made regarding how to load signals on the reverse optical link. Distortion in the reverse link has the potential to make the link unusable.

In order to fully understand the design of the reverse path, it is necessary to re-visit fundamental distortion theory. Once we understand the theoretical basis for the distortion, user-friendly tools can be developed to model that distortion.

The standards that have been developed for characterizing distortion performance in broadband RF networks have been based on the assumption that only mild nonlinearities will be encountered. Most RF amps for use in cable TV applications exhibit mild nonlinearities. It is worthwhile to explain what we mean by mild nonlinearities in this context.

An amplifier, such as a cable TV repeater amplifier (i.e., trunk, line-extender, system amp, etc.), may generally be regarded as a two-port device. (For the moment, we will ignore multiple output ports, such as bridger ports or multiple outputs on system amps.) A two-port device may be described by a transfer characteristic, h(x), that relates the input signal, x, to the output signal, y, as shown in Figure 1.

In the simplest case, when the device is perfectly linear, the transfer characteristic is simply a constant, A_1.

$$y = h(x) = A_1 \cdot x \qquad (1)$$

However, things get more complicated if the device has nonlinearities. One method of describing a device with memory-less nonlinearities is by means of a Taylor series.

Note: Memory-less nonlinearities are a special category of nonlinearities that are particularly easy to describe mathematically. For the purposes of this discussion, we will assume that the nonlinearities are memory-less. Cable TV optical components are indeed memory-less. However, in general, cable TV RF amplifiers do exhibit memory and require a much more complicated model than the one presented here.

The general form of the Taylor series is:

$$y = A_0 + (A_1 \cdot x) + (A_2 \cdot x^2) + (A_3 \cdot x^3) + (A_4 \cdot x^4) + \cdots \quad (2)$$

In the case of cable TV RF amplifiers, A_0 is usually equal to zero and the terms A_4, A_5, A_6, and higher are so small that they may be ignored. Therefore, the transfer characteristic simplifies to:

$$y = (A_1 \cdot x) + (A_2 \cdot x^2) + (A_3 \cdot x^3) \quad (3)$$

In this case, the term with the A_1 is the desired, linear term, with A_1 being the gain, the term with A_2 representing second-order distortion (CSO), and the term with the A_3 representing third-order distortion (CTB). Thus, we generally describe an RF amp by its gain, CSO and CTB.

Note: For those concerned with crossmodulation, XMOD is also associated with the third-order term.

One may also plot the transfer characteristic as shown in Figure 2, which depicts the transfer characteristic for a device with mild nonlinearities. One indication of such a device is the "smooth" shape to the transfer characteristic. As a general rule, devices with mild nonlinearities will have smooth transfer characteristics. On the other hand, devices that do not have mild nonlinearities typically have sharp breaks and corners on the transfer characteristic.

Optical components

A typical laser transfer characteristic is shown in Figure 3. In the case of a laser, the transfer characteristic relates laser input current, I, to laser output optical power, P. Note that the transfer characteristic has a bend at $x = I_{TH}$, the threshold current for the laser. This is an indication that the laser does not have mild nonlinearities at this point. In fact, it is necessary to consider second-order, third-order,

Figure 3: Laser transfer characteristic.

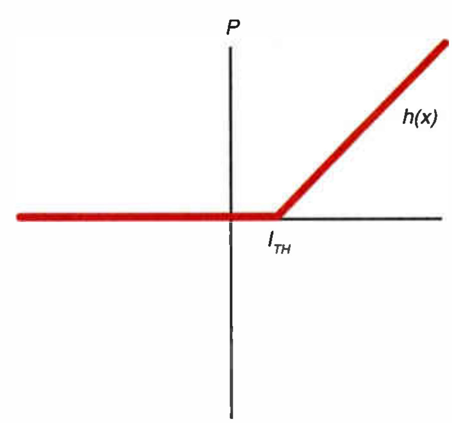
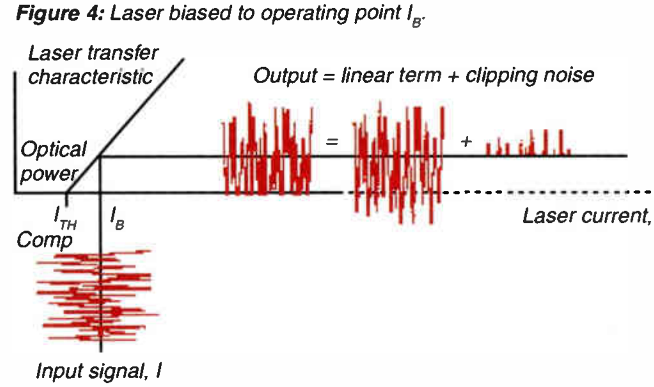


Figure 4: Laser biased to operating point I_B.



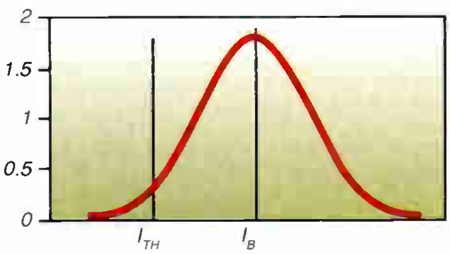
fourth-order, fifth-order, and many other higher-order terms in order to adequately describe the laser when operated at or around I_{TH}.

In typical operation, the laser is biased to an operating point, I_B, as shown in Figure 4. The input signal swings around this bias point. As long as the input signal I is greater than I_{TH}, the laser exhibits only mild nonlinearities. Therefore, we may describe the laser distortion using CTB and CSO, and apply the rules developed for RF amplifiers.

However, when the input signal swing becomes large enough so that I drops below I_{TH}, clipping occurs and all bets are off. It is very dangerous to apply the familiar rules for system design, such as CSO increases one-for-one with level, CTB increases two-for-one with level, and loading may be dealt with on a constant power-per-hertz basis.

In a downstream optical link, system operators

Figure 5: *Probability density function.*



can usually control the magnitude of the input signal swing in order to avoid clipping. This is possible by careful adjustment of the carrier amplitudes in the headend, where the laser is generally located. However, in the upstream path, it is very difficult to control signal amplitudes with extreme accuracy. Variations in path loss, transmitter setup inaccuracies, thermal variations, and ingress are just a few of the factors that might result in clipping distortion from the upstream path laser. Moreover, upstream lasers are usually physically located out in the plant where manual adjustment of levels is extremely difficult.

If we examine the laser drive signal for a laser in an upstream optical link, that current will be made up of the sum of the carriers to be sent over that link. In the case of the downstream path, measurements are made using a multi-tone generator (typically a Matrix generator) that simulates the individual channel carriers with a CW signal (i.e., a sine wave). In such a case, the mathematical equivalent of the model would be:

$I = A\cos(2\pi f_1 t + \phi_1) + A\cos(2\pi f_2 t + \phi_2) + A\cos(2\pi f_3 t + \phi_3) + \cdots$ (4)

where A is the amplitude of all of the carriers (assuming a flat spectrum), f_1 is the frequency of the first carrier (for example, 55.25 MHz), ϕ_1 is the phase of the first carrier, f_2 is the frequency of the second carrier (for example, 61.25 MHz), ϕ_2 is the phase of the second carrier, etc.

We can make a similar model for signals in the upstream path. As a simple example, consider an upstream link that is carrying a single RF impulse pay-per-view carrier and a single, high-speed (T-1 = 1.554 Mbps) data carrier. As in the case of the downstream path, we will model the carriers as CW (sine waves). Our upstream model becomes:

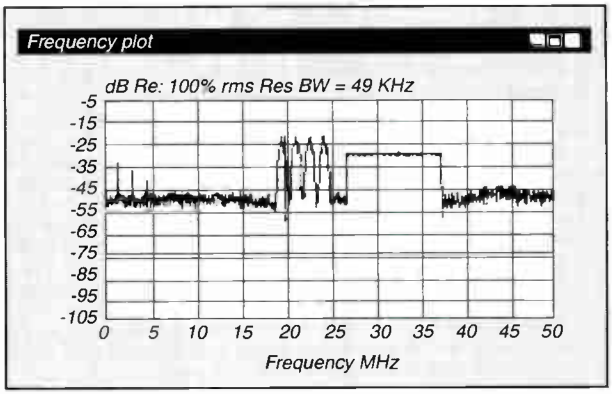
$I = A_1\cos(2\pi f_1 t + \phi_1) + A_2\cos(2\pi f_2 t + \phi_2)$ (5)

where A_1 is the amplitude of the RF IPPV carrier, A_2 is the amplitude of the data carrier, f_1 is the frequency of the RF IPPV carrier, f_2 is the frequency of the data carrier, ϕ_1 is the phase of the RF IPPV carrier, and ϕ_2 is the phase of the data carrier.

Plugging this equation for I into the Taylor series expansion shown in equation (2) would be a real mess. But this is what is required to model the laser with only two carriers applied. Take heart, though. It does get easier!

As stated earlier, it is dangerous to use the familiar rules for distortion (i.e., assuming it behaves like CTB and CSO) in a situation involving potential laser clipping. When clipping occurs, it is necessary to consider the higher-order terms of the transfer characteristic. This makes measurements quite difficult, as many of these higher-order terms fall at the same frequencies as CTB and CSO. Therefore, CTB/CSO measurements no longer make

Figure 6: *Clipping distortion performance.*



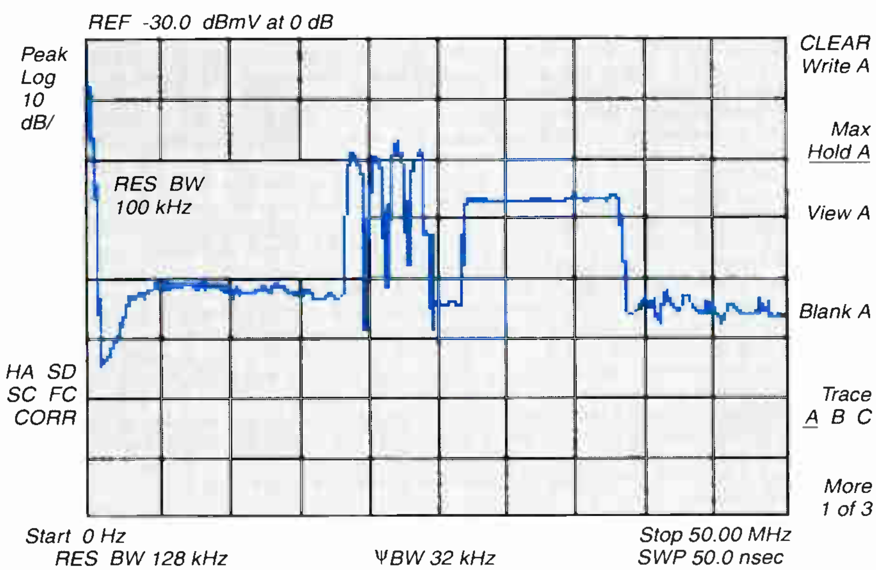
sense. New methods must be developed to deal with the case of clipping distortion.

The critical factors for clipping distortion are related to the way in which the input current to the laser, I, crosses the threshold current, I_{TH}. It is important to understand not only how far below the threshold current the input signal may go, but how often this event may happen. Such an understanding will allow us to determine the amount of distortion power generated by the laser.

A better method to deal with this problem is made by borrowing tools from probability analysis. One may describe the amount of time that the input signal current stays at any one value using a probability density function (PDF). The PDF is a kind of histogram that indicates how often something happens. An example of a PDF is shown in Figure 5.

Each different input to the laser will have its own unique PDF. The height of the curve at any point is proportional to the amount of time that is spent at that value. For example, in Figure 5, you can see that the laser input signal that is associat-

Figure 7: *Clipping distortion experiment.*



ed with this PDF spends most of its time at the bias point, I_B. However, it does spend a small amount of time at or below the value I_{TH}. Therefore, some amount of laser clipping will take place if this input signal is applied to a laser.

It requires some sophisticated mathematics in order to determine the PDF from a given set of input carriers to be applied to a laser. It requires even more tough math to get to the clipping distortion power levels and their effect on the signals. But it is important to remember that it takes equally difficult mathematics to create a fully analytical description of a cable TV RF amplifier. In the case of the RF amplifier, a series of measurements using a multi-tone signal generator can simplify the problem into something practical.

Obtaining a PDF

Determining a PDF is simply a matter of determining how often a given signal takes on a given value. It is much like keeping a history of a signal and counting how often it crosses a particular value and repeating the process for all of the values of interest.

A powerful technique for determining a PDF does exactly that. A model is generated of the desired signal. This model could consist of the sum of a group of sine waves where the amplitudes and phases of the sine waves represent the amplitudes and phases of the carriers that make up the laser drive signal. Such a model is presented in equation 5. Although it looks complicated, it can be handled easily on a computer.

Once the model is developed, it is simply a matter of counting how often it takes on a particular value. In the case of a real system, we generally don't know what the absolute phase of any of the carriers will be. This is taken into account in the model by letting the phase be a random number that takes on a value between 0 degrees and 360 degrees. Repeating the counting process for several values of the random phases results in a PDF. This type of simulation using repeated trials is referred to as a Monte-Carlo simulation.

It's also possible to apply that model to a model of the laser transfer characteristic. By doing so, it's possible to accurately predict the clipping distortion performance of the optical link. An example of such a prediction is shown in Figure 6. This is a Monte-Carlo style simulation of a group of four high-speed data carriers (seen centered at 22 MHz) and 217 narrowband QPSK telephony carriers (centered at 32 MHz). The clipping distortion can be seen in the simulation. The telephony carrier-to-clipping distortion ratio is approximately 20 dB. This scenario was set up and measured in the laboratory. The results of this experiment are shown in Figure 7.

Note the excellent agreement between the simulation and the measured data. CED

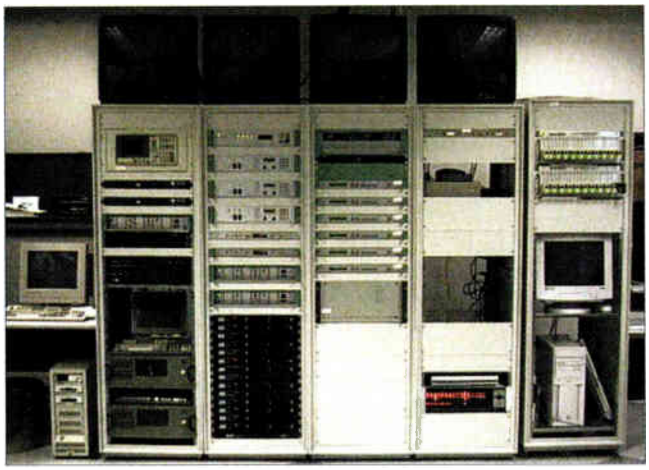
Broadband telecom center explores last-mile technology

Education and industry

By Craig Kuhl

The Georgia Institute of Technology's Broadband Telecommunications Center (BTC), with nearly $3 million in funding from the Georgia state lottery, is establishing itself as a valuable research center for the cable and telecommunications industries, and has the attention of a growing number of member cable operators and telecommunications companies.

The center is a collaboration between Georgia Tech University, Georgia State University and the University of Georgia, with state support from the Georgia Research Alliance. BTC is a center within the Georgia Center for Advanced Telecommunications Technology (GCATT). Its mission is to explore technologies which eventually could bring advanced interactive services to the home and complete the "last mile" of digital communications.



At left is BTC's Hybrid Fiber/Coax lab. Above, Daniel Howard, associate director of BTC.

What has inspired a group of cable and telecommunications companies to participate as members of BTC is the diversity and depth of research occurring at the center, and a somewhat unique approach to its mission: To *inexpensively* provide complete, scalable systems and services including distance learning, telecommuting, community services, interactive games, on-demand movies and more. Currently, nearly 20 companies are members of BTC, including Cox Communications, BellSouth, Sprint, GTE and others.

Each member company has a seat on the BTC advisory board and works with the center to define the technical directions of the program, and assists in the transfer of technology. The center is organized around a set of projects that are partially funded by the industry members.

Low-cost technologies

The idea for BTC sprung from what its founders felt was a need for a university like Georgia Tech to address a number of specific technology needs, such as last-mile services for the cable and telecommunications industries. With the sterling reputation of Georgia Tech behind them, Daniel Howard and John Limb, both faculty members at the school, embarked on their mission of creating BTC.

"We felt there were no universities addressing cable issues, so we proposed BTC to the Georgia Research Alliance. Our whole idea was to create a partnership between the university and member companies and make a connection between graduates and those companies. Our goal is to be as relevant as we can be to the industry," says Daniel Howard, associate director of BTC.

Using three major access laboratories, projects are funded by the center and are determined by its members. The labs focus on three specific applications: Hybrid fiber/coax; switched access technology such as fiber-to-the-home and digital subscriber line (xDSL); and broadband wireless technology. Yet, according to Howard, the center's uniqueness is not just in cable. "Ours is the first center targeting broadband telecommunications to the home and real challenges such as how to get the high-speed pipe into, and out of, the home. We don't pursue the highest technology available. Our emphasis is on low-cost technologies."

The center's first challenge was to convince a diverse group of researchers at Georgia Tech that these technological issues were important to both the cable industry and to the university, and that took time, admits Howard.

"Part of the challenge is once you cross departmental lines academically, it becomes difficult. However, the merging and converging technologies in the past have been just in television. Now, the opportunities go beyond that and are huge, and some aren't even tapped yet."

For the university, coordinating the academic departments into one group working with BTC towards the same objective was a daunting task. "It was like herding cats, but we had the right message and good timing," says Howard.

The message to potential members was sent via demonstrations of cable modems, rooftop-to-rooftop wireless cable links, digital photography, distance learning and other applications. The message, Howard says, was received loud and clear: "Following the demonstrations, we built a cadre of companies interested in supporting us." The center is now in its third year of operation, with funding expected to continue from its growing membership roster and Georgia state funds.

BTC's research program is divided into five areas:

The *physical layer*, which addresses the media to, and within the home, with twisted pair, coaxial cable, wireless, satellite and optical fiber. Typical projects are characterizing and modeling channels and sources of interface on the various media, and noise cancellation in twisted pair.

Networking issues, which include scalability of network resources, new protocols for shared media, network management and network security. Projects in this discipline include two-way data transmission to the home via satellite, and network and security architectures for the home and residential gateway.

Systems and software focuses on middleware and storage systems support for scalable ser-

BTC's Network Application Integration Lab allows member companies access to valuable testbeds.

vices, i.e., evolving a platform on which to build new multimedia services. BTC's projects include new uses for very large personal storage systems.

The *applications* segment includes links between the school and the home, the office and the home, new applications of information technology and efficient management within the home.

Business impact modeling assesses the economic impact of residential broadband telecommunications. Its purpose is to better understand the demand characteristics for new services and applications, and develop cost benefits. BTC is currently working on projects such as large demographic surveys of potential users, and the development of taxonomy of electronic commerce transactions.

A key benefit to members, Howard says, is the opportunity to work with the center's testbed and tools, which interconnect homes with

The Home Infrastructure room emphasizes links to, from, and within the home.

an information infrastructure lab and broadband ATM backbone using four distinct last-mile technologies. The testbed includes ATM networks, video servers and the campus video network. Tools include simulation packages, traffic models and noise models.

"The idea is for a broad range of industry ideas and benefits," explains Howard. "If a project only benefits a small number of companies, we submit a separate research proposal for 'non-core research,' and it's up to the small group of companies to fund it. For broad range research that will benefit all of the member companies, we submit a 'core research' proposal. In addition, all of the intellectual property rights belong to the member companies."

Good neighbors

One of the member companies, Cox Communications, is a neighbor of Georgia Tech and BTC, and has been active with the center since its inception. "We were introduced to BTC through the Georgia Center for Advanced Telecommunications Technology and have been able to direct work on at least one project, distance learning," says Alex Best, senior vice president of engineering for Cox Communications.

With the center being so close to Cox, the company developed a working relationship with BTC, leading to a number of joint projects. "It's been a good opportunity for us to make improvements in hybrid fiber/coaxial networks for a modest investment," says Best. "And when you work with a highly-respected institution like Georgia Tech, there are a lot of good students. We definitely think there is a benefit." Cox, and other members, are given an opportunity on an annual basis to participate, and according to Best, the company plans to continue its partnership with BTC.

The benefits to Cox, and to both the cable and telecommunications industries, may be even greater in the long-term. Students currently working on specific research projects today will be the industry engineers, technicians and leaders of tomorrow, gaining invaluable, hands-on experience through their work on the myriad projects at BTC.

Adds Howard, "Our goal is to be the CableLabs of broadband telecommunications, or the research arm for the industry, and enable our students to work for a cross-section of industries. Once our mission is understood, our job is to then provide a competitive advantage to our member companies. Typically, universities have not done that. In the past, they have developed 'cable-compatible' graduates. We want to develop 'cable-ready' graduates."

What members of BTC receive

✔Access to BTC's intellectual property, which remains with the individual company members
✔Visiting staff on-site
✔Consultations with faculty
✔Invitations to workshops and seminars
✔Access to students for recruiting
✔Preferential access facilities for collaborative research
✔Enhanced opportunities for joint proposals to federal and state agencies

–CK

The Wireless Lab is allowing BTC and member companies to test wireless media services.

As those graduates move into engineering and technical positions within the telecommunications and cable industries, companies and graduates could benefit from their BTC experience.

"Broadband to the home is a new area for students, so they really aren't aware of the job potential in this discipline," says Mike Cummins, director and CEO of the Georgia Center for Advanced Telecommunications Technology (GCATT). "BTC has done very well in terms of building capabilities, test beds and services, and is very well-organized with a range of multi-functional capabilities. Its projects are challenging and rich enough to attract more quality students, who should become very marketable."

GCATT assists BTC in its marketing efforts and provides leads to the center for potential corporate members. Adds Cummins, "Attracting and keeping quality engineers and technicians is a real challenge for the cable industry. BTC has done extremely well thus far in combining real research efficiency and long-term thinking."

The real results may not only be in the form of cost-efficient technologies applicable to the cable industry, but in the long-view, could inspire quality graduates to pursue careers in the cable and telecommunications industries. CED

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Balancing the return path: From the sub to the headend

How to meet design goals

By Kevin Murphy and Luis Rovira, Systems Engineering Team, Terrestrial Network Systems, Scientific-Atlanta Inc. kevin.murphy@sciatl.com luis.rovira@sciatl.com

The high-speed return path of a hybrid fiber/coax (HFC) network is a key strategic advantage of cable systems vs. other methods of connecting over that "last mile" to subscribers' homes. However, the full promise of this inherent advantage is not easy to realize. Although it is relatively straightforward to accomplish the transport of a few digital signals on an HFC return path, the behavior changes substantially when the path is heavily loaded. In this case, it is important that proper design levels are selected and proper alignment procedures are performed to maintain levels within tight tolerances of the design goals.

***Figure 1:** Headend/hub network.*

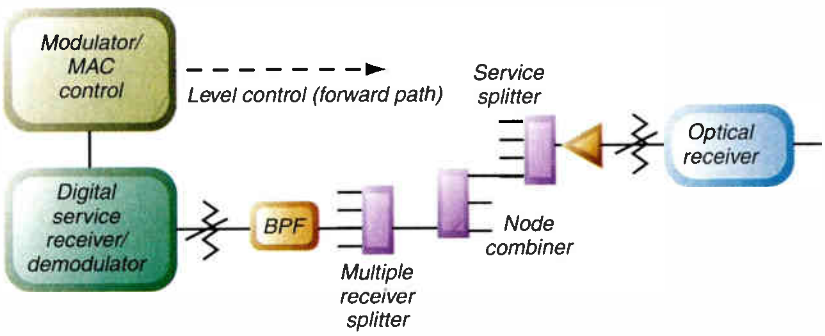
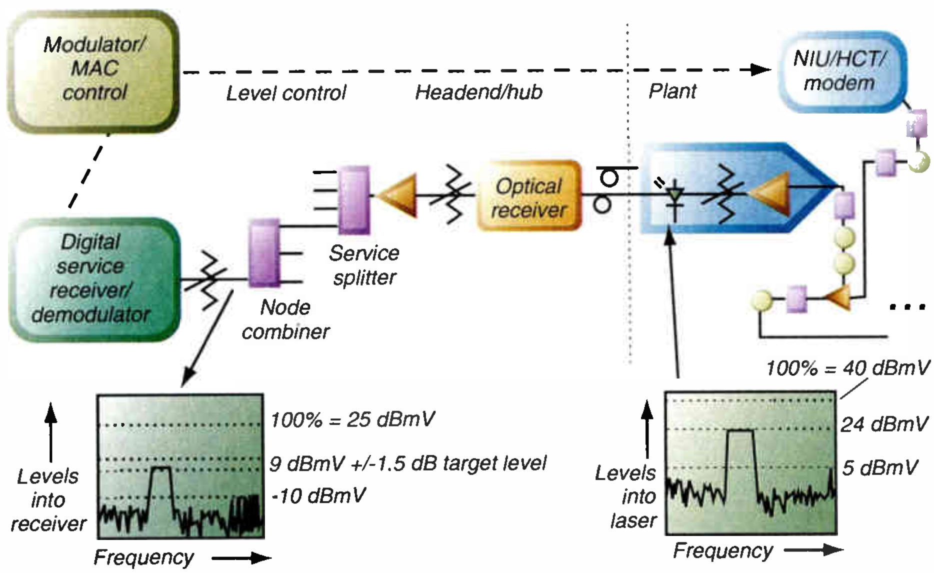


***Figure 2:** Closed-loop level control.*



Signal must be at target level into receiver . . . when signal is at correct level into laser. Otherwise, level control changes level into plant and laser.

Level design and alignment

The goal of alignment of the reverse path is to maximize the carrier-to-noise ratio and interference ratio at the service receiver, while avoiding errors resulting from overdrive of any of the components, most notably the laser. Interference and noise can come from many sources along the reverse path. Poorly-shielded equipment can permit ingress. Common-mode currents from home ground blocks can produce broadband voltage surges at reverse band frequencies. Amplifiers and optical links generate their own noise. Forward channels can beat in unintentional nonlinearities created by corrosion in connectors or other components in the common path. Node combiners in the headend will funnel all of the interference from many nodes to the receiver.

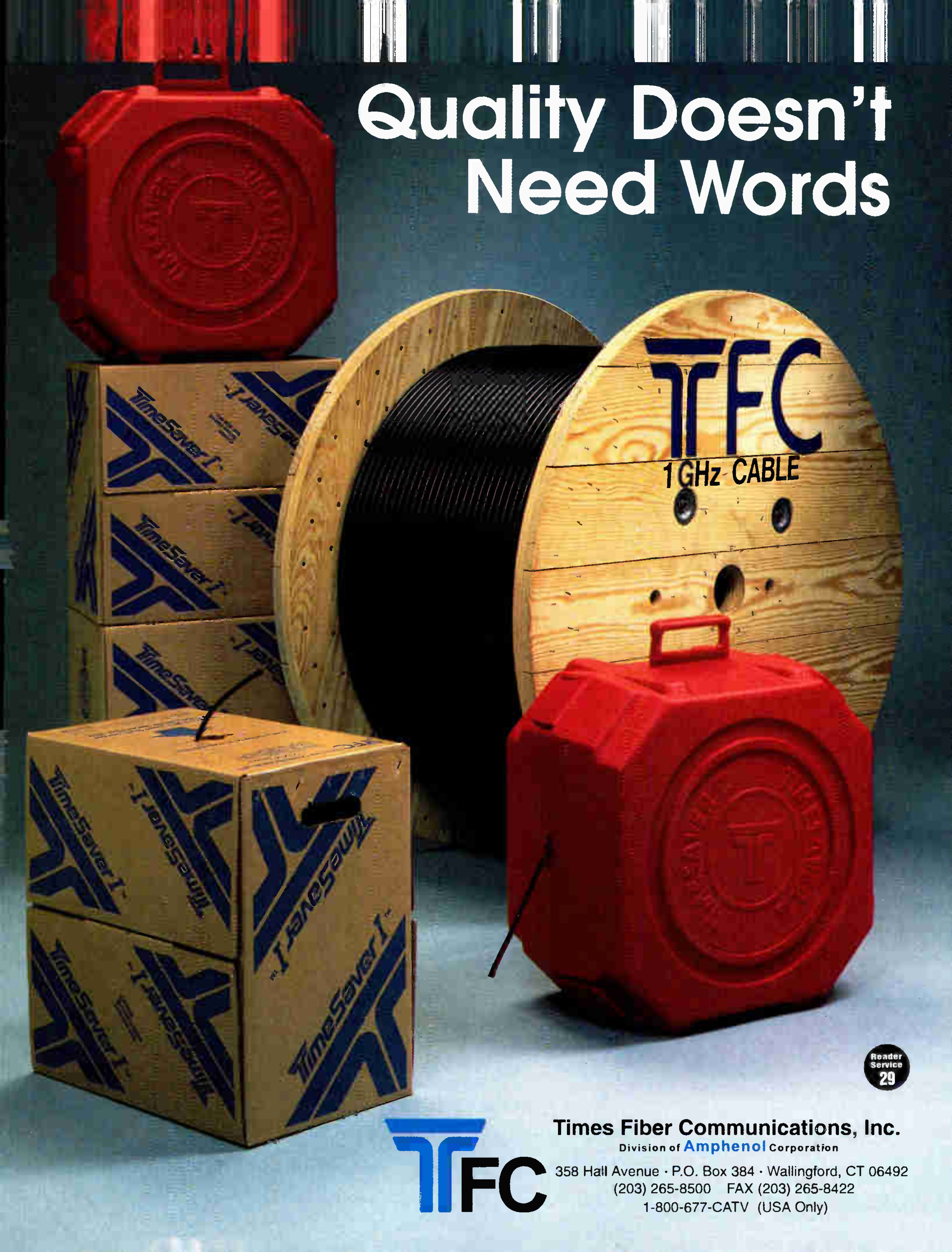
Unfortunately, the solution is not as simple as increasing the level until a sufficiently high signal-to-noise ratio is obtained. Consumer devices have limited output power. Overdrive of reverse amplifiers can cause discrete beats as well as composite intermodulation noise. The more abrupt nonlinearity of a reverse path laser can cause clipping and a consequent broadband increase in the noise floor from "clipping noise."[1] This increase sets an upper limit to the levels that can be carried on the reverse path.

As more signals are carried on the reverse path, the portion of the optical modulation index (OMI) available for each is reduced in order to minimize errors from laser clipping. This results in signal levels closer to the noise and ingress floor. This window of dynamic range narrows with increasing numbers of signals, and in some cases, may actually close before all of the reverse bandwidth is consumed. Such systems are referred to as being "power-limited" as opposed to "bandwidth-limited."

Thus, the true goal of reverse path system level design and alignment is to place and maintain the levels of each of the signals within an increasingly narrow dynamic range window.

Parts of the system

Typically, the upstream path is thought of in four parts, all of which are part of an interdependent feedback level control system. They include the headend/hub, the optical link, the coaxial plant and the subscriber/feeder network. Alignment adjustments, loss changes or gain changes in any part of the system affect the feedback loop and will alter levels in other parts of the system. Thus, alignment of the reverse path causes changes that are fed back through the forward path to the subscriber terminal and which alter the level of its transmissions. The system must be made to work together to optimize the network as a whole.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Headend or hub

As shown in Figure 1, the headend or hub houses the optical receivers for the links from the distribution plant optical nodes. The outputs of these optical receivers must be adjustable, or an external level adjustment must be provided. At the output of the optical receivers there are typically "service splitters" that split the signal among the various reverse path services on the system.

Depending on tolerable noise funneling or supportable quantities, some of the service receivers may support the signals from more than one optical node. "Node combiners" are present in the hub/headend for this function. Sometimes multiple receivers will be required to handle the traffic from one or a group of nodes. The "multiple receiver splitter" serves this function. In some cases, the addition of new services may increase the load to existing services to the extent that the receiver must be protected against overload. A bandpass filter (BPF) may be included to limit the input power to such receivers.

The headend/hub also houses the receivers/demodulators and their associated modulators for the various services. In modern systems using DAVIC or MCNS Media Access Control (MAC) protocols, these components form the level and delay "sensor" and "feedback provider" respectively in a closed-loop feedback system that controls the transmit level, as well as the delay of transmissions from subscriber terminals. The level control function of these components is critical to the subject of alignment and balance and will be revisited later.

The optical link is the next major part of the reverse. The optical receiver, which is housed in the headend/hub, was mentioned earlier. The fiber node has the laser transmitter at its output and RF circuitry to connect to the signals coming in from the coaxial plant. The node should provide an adjustment for laser drive independent of the levels in the coaxial part of the plant.

The coaxial plant is made up of the RF amplifier stations, the coaxial cable, and the through paths of taps. Finally, the subscriber and tapped feeder section consists of taps, drop cables, any in-home wiring and the interactive subscriber device, whether it is a set-top, modem, or telephony interface unit. The subscriber premise plant is substantially complicated if more than four splits or in-home amplifiers are present.

Level design considerations

✔Laser loading. A useful specification of an intensity modulated laser is the average power required for a single CW tone to modulate the laser to 100 percent of its optical modulation index (OMI). Getting from this number to the level of each of the multiple carriers is a complex process.[2] To simply divide the *power* of the single tone among all of the carriers will ensure laser clipping. To divide the *voltage* of the single tone among the carriers yields too low a level for each. The correct answer is somewhere in between the power division and voltage division extremes. This design should consider the different levels of carriers, individual modulation types used, the number of nodes to be combined into the receivers, the tolerance to bit errors, the value of the signal, and the amount of error correction. Software[3] is used to predict the bit error rate for a given carrier from a description of the maximum anticipated loading, and the parameters of the anticipated carriers. A "first guess" can be made using the above considerations, and then the results of the program can be used to iteratively optimize levels.

✔Headroom. Headroom below the laser cutoff


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threshold must be allocated to allow for variations in signal levels. All components in the coaxial plant will change attenuation with temperature. If temperature compensation is not built into the active components, the level control system will attempt to adjust the output levels of the boxes. However, the step size and accuracy of the level control scheme may be such that the levels of all boxes are allowed to change by several dB before any adjustment is made. Headroom should also be provided to prevent clipping caused by simultaneous transmissions (collisions) in contention-based protocols.

✔Subscriber terminal output power. Clearly, the upper and lower output power limits of subscriber terminals should be considered in plant design. Many plant designs are done only considering forward levels, without consideration for the maximum reverse transmit level from subscriber terminals.

✔Reverse path loss equalization. In the forward path, tap values are chosen in order to roughly equalize the losses to all subscribers. Thus, all subscribers receive forward signals at approximately the same level. In the reverse path, this has not traditionally been done. The range of losses coming back from subscriber terminals has been very high.

Recently, designers have become aware that it is desirable to narrow the required transmission level range between the lowest level and the highest level that any two terminals need to use in order to be received at the same level.[4] There are a number of tools[5] in the plant designer's arsenal to narrow this "window." These include everything from design guidelines to inline equalizers and tap equalizers or diplexed attenuators.

✔Carrier-to-ingress ratio (C/I). The C/I is improved with reverse loss equalization. If reverse path loss variations in the plant are designed to narrow this range and to keep it near the top of the terminals' output range, then C/I is improved. It has been shown that most ingress originates at the subscriber residences and drop cables and is assumed to reach all tap ports at essentially the same level. The absolute signal level at the tap port relative to this omnipresent interference effectively sets the C/I for the entire system. For this reason, the higher the signal levels are at the tap input ports, the more resistant the system is to ingress.

✔Excessive subscriber terminal transmit level. An additional benefit of requiring terminals to transmit near the top of their range is that the limited excess transmit level from boxes reduces the probability that a misbehaving terminal will cause laser clipping. Excessively high level transmissions can occur during the terminal calibration process, or during failure of terminal calibration.

Closed-loop level control

In the case of heavily-loaded reverse paths, the dynamic range window, within which signal levels into the laser must be maintained, can be quite small. Permissible level ranges at other points, though not as narrow, should also be observed. Given the cost constraints of subscriber transmitters, changes in home wiring and plant drift over time and temperature would seem a hopeless task. Fortunately, modern digital reverse path services use a closed-loop level control system to set the output levels of the subscriber terminals.

The system works by monitoring the signal power at the headend/hub receiver. If the received power falls outside a target window, the associated modulator/MAC controller sends a command to the subscriber terminal to change its output level. This leads to the single

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See Us At The Western Show, Booth # 1703 most important consideration in reverse path alignment: *The network must be aligned so that when the receiver sees its target level, the proper levels occur at the other critical level locations in the network.*

The example in Figure 2 illustrates this critical point. In this example, the goal is to align the plant such that a transmission within the dynamic range of the NIU/HCT/modem will reach the last amplifier at the design level and will reach the laser at a level of 24 dBmV. This level represents 16 dB below 100 percent OMI and was arrived at using theory and software. After passing through the optical link, the signal is affected by the gains and losses in the headend components.

Ultimately, the signal must arrive at the receiver at 9 dBmV ±1.5 dB in this example. If the signal is lower or higher than that level, then the modulator/MAC controller sends a message to the subscriber terminal with a correction for its output level. The next transmission from the terminal will then no longer be at the design level of 24 dBmV into the laser. The only way to maintain the signal into the laser at the design level of 24 dBmV is to get it to the receiver at 9 dBmV.

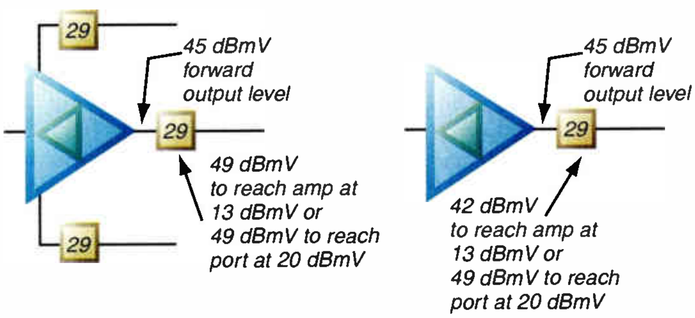
Once the network is correctly aligned, any changes must be carefully analyzed to make sure the results are as intended. Added attenuation will cause the signal levels to rise at all points before the extra loss. A receiver for a given service may be fed signals from many nodes, and the signal from a node may be split to several different services, each of which have independent level control systems. Loss inserted immediately in front of the receiver/demodulator will cause the devices for that service to increase power on all nodes fed in to the receiver.

Extra loss in one branch of the coaxial network will cause the output levels to rise for all services used by every subscriber on that branch. Adding attenuation at one reverse input port of a multiple-output amplifier station will raise the levels of all the subscriber devices feeding into that branch.

Note that adding splitters (loss) in the headend to support new services would require an equivalent increase in headend gain. It would be wise to initially provide enough headend splitters for all foreseen future service expansion.

In order for the closed-loop level control system to work, there must be enough dynamic range in the output power of the various subscriber devices to adapt to changes in the network. If no thermal compensation is used in the coaxial portion of the network, the loss between the tap port and the laser transmitter could vary by ±5 dB. While it is desirable to operate the subscriber devices as close to their maximum output power as possible, there does need to be some headroom allowed for variations in the network.

Figure 3: *Design for equal signal level at station port.*



Amplifier port level design

Signal levels in the coaxial plant are best defined at the amplifier station's reverse input port. The downstream losses from station port to subscriber residence are designed to be the same for all station ports of a given downstream output level; therefore, upstream signals coming in to those ports will also have the same total loss. In other words, amplifiers with one, two, or three output ports will have the same reverse input level at the station housing port, provided that the ports all operate at the same downstream output level.

Figure 3 shows how this is different from designing signal levels to be equal at the reverse gain stage, which is internal to the amplifier station and may follow combining networks for multiple-output amplifier stations. Note that this is different from past practice, where it was desirable to have the same signal level at the gain stage in order to avoid thermal noise degradation in long coaxial cascades. Because modern designs typically have fiber deep into the serving area, the chief concern is with interference from ingress.

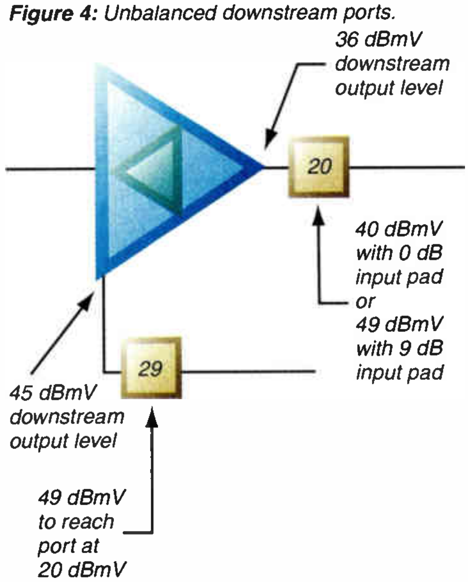
The spacing between amplifier stations is set by the gains and losses of the downstream cascade. In general, there will be less attenuation in the upstream direction because of the frequency dependent loss of the coaxial cable. There may also be taps and directional couplers that have nearly the same loss at all frequencies. The RF reverse amplifiers must have enough gain to cover the span with the most total loss. Because the loss between stations can vary greatly, attenuation will have to be added somewhere in the station to compensate. Without the interstage section found in forward amplifiers, the reverse path designer has to choose between padding the amplifier at the input, which degrades noise performance, and at the output, which will affect nonlinear distortion.

Multiple high-level signals coming through a reverse amplifier will generate second- and third-order beats and intermodulation noise that can interfere with demodulation. Fortunately, the RF amplifiers in the reverse path have several advantages over their downstream counterparts. In a downstream cascade, all of the signals generated at the headend are present on all amplifiers. Coming back toward the headend, only the RF gain stage in the fiber node carries all of the upstream signals. The remaining amplifiers carry less than the full upstream load, with some amplifiers carrying only a few signals at a time. To take advantage of this fact and avoid the problems of noise funneling, the amplifiers should be driven as hard as possible. This means adding as much attenuation as necessary at the output of the station.

There are a number of situations where amplifiers operate at different levels at their downstream output ports. Amplifiers can have an extra gain stage to drive high-level output ports. *Express* stations operate all ports at lower output levels to increase cascade reach. In some systems, a port or station is *derated;* that is, interstage attenuation is added to drive the output at a slightly lower level in order to improve distortion performance over a limited distance. Two-output amplifiers often use a splitter or directional coupler located between the diplex filter and one of the amplifier's ports to drive a third output. Each of these cases must be examined to determine the effects on the reverse path.

When an amplifier has low- and high-level downstream outputs because of extra gain stages on the high output legs, any taps that are fed by

Figure 4: *Unbalanced downstream ports.*



the low-level port will have much less loss than those off the high-level ports. Combining all of the ports equally in the station's reverse path will cause those subscriber devices fed from the low-level port to be driven at a lower level. To offset this, attenuation can be added in the reverse path of the low-level port equal to the level difference between the high and low downstream output levels. This is illustrated in Figure 4.

Figure 5: *Auxiliary output ports.*

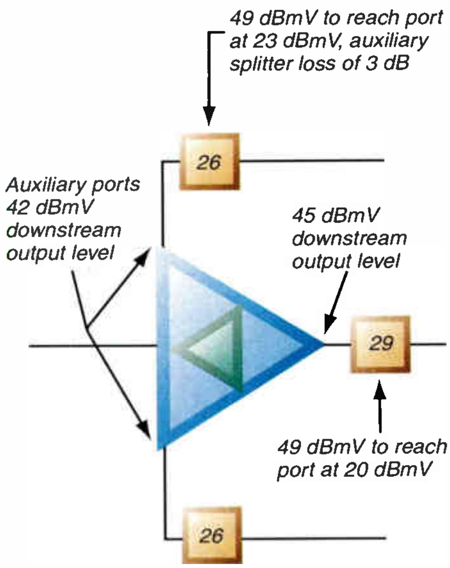
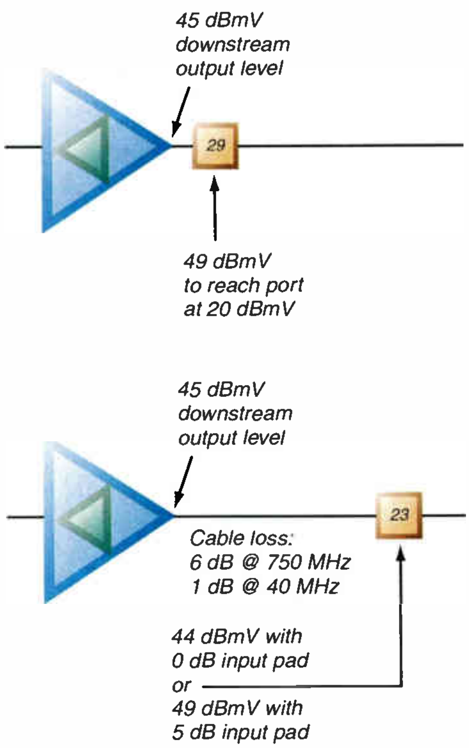


Figure 6: *Input pads with downstream taps.*



Express amplifiers and derated ports are similar to unbalanced amplifiers in that the loss in the taps will be lower than for high-level stations. Attenuation placed at the reverse input ports will narrow the range of upstream signal levels arriving at the tap ports throughout the RF plant.

Amplifiers with a splitter added immediately before the output port to drive a second auxiliary output are a special case of the unbalanced amplifier. The downstream signal level at the auxiliary outputs will be lower than at the main port, but the splitter loss is common to the forward and reverse paths. This means that a signal coming into an auxiliary port has to arrive at a higher level in order to leave the station at the same level as a signal at the main port. Thus, a signal from a subscriber location off the auxiliary leg will reach the tap port at a higher level, even though the tap has less loss, as shown in Figure 5.

Another use for adding attenuation in front of the reverse amplifier is a feeder leg where the first tap is some distance down the coaxial cable. Because of the attenuation of the cable at the high end of the downstream band, the tap loss will be less than it would if it were adjacent to the amplifier port. At reverse frequencies, however, there is much less cable loss. Figure 6 shows how attenuation at the input to the reverse amplifier station forces the signal levels at the tap ports on this feeder leg to run higher.

The coaxial plant will be the most likely source of level variations from temperature. Although the change in cable loss and amplifier gain may be small compared to a downstream cascade, there is the danger of clipping at the upstream laser to contend with. Technicians aligning systems that do not have thermal compensation for the upstream components will need to be careful when balancing is performed during temperature extremes. If alignment is performed in summer, for example, some downtilt in the cascade response can be allowed so that levels do not increase too much in cold weather.

Headend

As the optical modulation index is divided among more and more signals, the output level of each signal at the headend optical receiver is reduced. Headend reverse amplifiers are often needed to compensate for this, and for the losses resulting from splitters and combiners. As shown in Figure 7, one set of splitters, called the "service splitters," are used to divide the optical receiver's output among the different interactive service receivers. The "node combiners" are used to combine the signals from one or more nodes into the headend receivers. The limiting factors to node combining are noise funneling and traffic volume.

Amplifiers placed immediately after the optical receiver can raise the signal levels to well above a spectrum analyzer's noise floor and so provide for good performance monitoring. Amplifiers placed after the service splitters improve isolation, but too many amplifiers are required. Note from Figure 7 that for a signal to make its way to the wrong receiver, the port-to-port isolation of two devices must be traversed.

After arriving at a topology considering the above factors, the headend designer must consider the longest optical link, the service receivers requiring the highest target input levels, and the signals with the lowest allocated fraction of the OMI. Taking these into account, the designer must ensure that there is sufficient headend gain to hit the service receivers with the target levels when the signals are at the correct levels into the lasers. The designer should further provide adjustments for calibration at both the output of the optical receiver and the service receiver input. These adjustments could be built into the amplifier and service receiver, respectively.

Equipment

The key to the alignment technique described here is the ability to inject a signal in the upstream path. Because there is not a balanced comb of analog video signals waiting to be measured, the technician performing the alignment must inject the necessary signals and measure the output at a point further upstream. In the coaxial plant, there is sometimes an injection point at the input to the reverse amplifier module. As mentioned earlier, the signal levels are fixed at the station ports, not the amplifier module. It is necessary, therefore, to know the injected level relative to the station port. Any combining network between the port and the injection point needs to be properly taken into account.

For example, suppose an injection point is 20 dB down from a reverse amplifier module input, and the reverse amplifier is built in to a three output station, as shown in Figure 8. A signal put in at the injection point will be 13 dB (= 20 dB - 7 dB) below a signal of equal level at the auxiliary station input ports and 16.5 dB below the main port.

Also required for this alignment procedure is an accurately known level on the source used to inject a signal. Relative measurements should be made as often as possible to avoid the need to know an absolute signal level. In cases where relative measurements can't be made, it is necessary to know the signal level accurately. The output level of the signal generator should be confirmed with a spectrum analyzer or signal level meter.

Amplifier test points should also be specified relative to the station ports. Any loss between the port and the test point from combiners, attenuator pads, or equalizers has to be accounted for when reading levels. Using the same example as with

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the signal injection point, suppose a test point is 20 dB down from a reverse amplifier module input, and the reverse amplifier is built in to a three-output station. The level measured at the test point will be 27 dB (= 20 dB + 7 dB) below the input level at the auxiliary station ports, and 23.5 dB below the input level at the main port.

Alignment method

For years, cable TV engineers and technicians have been accustomed to dealing with forward path signals that are always present and can readily be measured and compared to design levels. These signals act as their own level references at any point in the system. This is not the case in the reverse path. Signal sources will not be immediately deployed everywhere in the network. Even when in operation, the signals will be intermittent and broadband, making them extremely difficult to measure accurately.

The solution is to inject signals of known level at one point in the reverse path and measure them at another point upstream. Doing this will only provide the net loss or gain between two points in the network. Absolute levels of the signals used in the reverse path are set by the closed-loop level controls of the various services. As noted earlier, the network must be aligned so that when the receiver sees its target level, the proper levels occur at the other critical level locations in the network.

It is not necessary that a test tone used for alignment be at the same level as any of the signals in the system. If the system is in operation, a low-level signal would be appropriate in order to prevent overload from the combined power of the test tone and active signals.

For historical reasons, a source of five tones spaced 6 MHz apart is often available. Though this signal is not useful for accurate laser characterization, it can provide a convenient way to calibrate system flatness and provide a "benchmark" for proof of performance.

If there are no services using the reverse path when the alignment is performed, the five-tone signal source can be operated at nearly the laser clip point. To prevent clipping the laser with the five tones, the peak voltage at clipping should be divided by five. Thus, the levels of the individual tones at the laser transmitter input should be 14 dB (= $20°\log_{10}5$) below the level for a single tone at 100 percent OMI.

An alternative to the five-tone or discrete frequency signal injection is the swept frequency system. Figure 9 illustrates this system. A receiver at the headend monitors the injected signals and transmits the measured results on the downstream path. A technician can then pick off the data signals from a forward test point and display them on a field receiver. Using this closed-loop monitoring system, one person can align the coaxial plant. With discrete carrier injection, the injected signals are measured at a point upstream with a spectrum analyzer or a signal level meter, for example, then relayed back to the technician performing the alignment. Care should be taken to ensure that whatever test signals are used do not interfere with any services that may be in use.

In either case, it is desirable to reduce the uncertainties involved with making measurements by using relative measurements whenever possible. Frequency sweep systems often have a normalization function that sets the current measurement as a reference, and all future measurements are made relative to that reference. The same result can be achieved with discrete frequency injection by noting the measured levels at the injected frequencies, then measuring the change in level in subsequent measurements.

Figure 7: *Path for signal from optical receiver 1 to telephony receiver 2.*

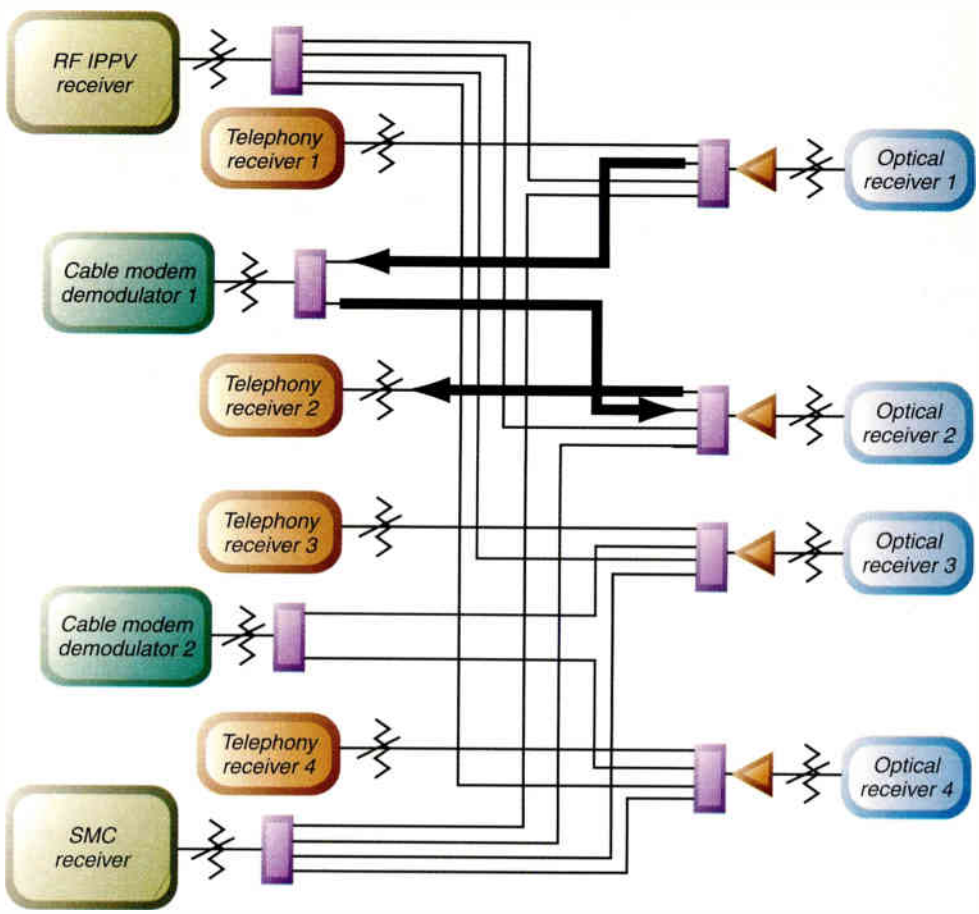
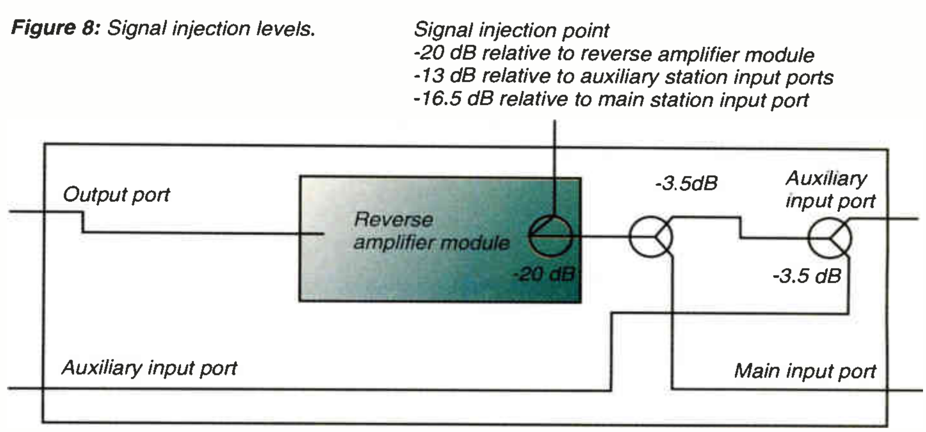


Figure 8: *Signal injection levels.*



The order for aligning the reverse path is from the optical transmitter out in both directions. By balancing from the optical transmitter to the headend receivers, we ensure that the closed-loop level control works to maintain correct laser loading. By balancing the plant from the optical transmitter toward the subscriber, technicians can work out from the nodes and align the forward and reverse paths at the same time.

Laser input sets the trend

There are several adjustments that need to be made to balance the fiber link. First, the level into the laser relative to the RF cascade must be set. Second, the optical power into the receiver must be checked. Finally, the net loss of the fiber link needs to be adjusted to match the requirements of the headend section.

The absolute transmitter input level and this level relative to the optoelectronic node's RF input port are set by the system designer. The technician performing the alignment must verify that the correct level has been set. In most cases, the 100 percent OMI level will be fixed or specified as a minimum level. The gain of the RF amplifier stage can vary from station to station. This will impact the selection of attenuation within the node. To set the laser drive level, inject a signal of known amplitude into the RF portion of the fiber node. Measure the level at the transmitter test point and adjust the attenuation at the output of the RF section so that a signal coming into the node's RF input ports at the correct level hits the laser at the proper level relative to 100 percent OMI for the transmitter. This is a critical measurement, so make sure all the losses in the injection point have been accounted for.

Measure the optical power into the receiver with an optical power meter or photodiode bias level test point, if available. If the received optical power exceeds the maximum recommended for the receiver, add the appropriate value optical attenuator at the transmitter. This will improve the noise performance of the optical link somewhat by reducing backscatter into the laser.

The next step is to measure the path loss from the node input to the RF output of the optical receiver and any gain stage that may be at the output. Again, inject a carrier into the node, noting the injected level relative to the 100 percent OMI point for the laser, as shown in Figure 10. Measure the level coming out of the optical receiver. Adjust gain or attenuation so that the correct level is coming into the service splitter.

Finally, normalize the injected signal through the optical link. This will be the reference against which the coaxial plant will be aligned.

The losses of service splitters and node combiners in the headend should be flat and close to their nominal values at the frequencies used by the reverse path. In many cases, amplification and variable attenuation will be required to correctly set the signal levels coming in to the receivers. Normalize the signal generator at a frequency in the reverse band. Inject the signal at the service splitter input and measure the normalized result at the demodulator input.

There are three points where adjustment to the loss between the optical receiver and the digital service demodulator can be made, as shown in Figure 11. Changing the loss at the output of the optical receiver to offset link loss variations will change the signal level from that node to all of the service receivers it feeds. Any change made at the input to the digital service receivers will affect the loss from all nodes coming into the receiver. The only location where an adjustment will change the loss from one node to one digital receiver is between the service splitter and the node combiner. If all levels at the inputs to the service splitters are the same, then the individual paths from the service splitters to the node combiners will not have to be adjusted, and the only loss that will have to be changed is at the input to the receivers.

Adjust the variable attenuation at the receiver so that the correct loss is measured from the service splitter to the digital service demodulator.

Using the signal injected at the node as a reference, inject a signal at the next amplifier in the cascade. Choose the correct reverse equalizer to flatten the cable span between the amplifier and the node. Select an attenuator pad at the station output for unity gain from the amplifier input port to node input port, as shown in Figure 12.

The input pad of the current station, if there is one available, should be ignored (0 dB) when selecting the output pad. Once the output pad has been selected, install the input pad according to the system design. Move on to the next amplifier in the cascade, keeping the same reference from the fiber node.

By ignoring the loss of the input pad when balancing the amplifier for the cable following it, the input pad is effectively "absorbed" into the cable ahead of the amplifier. The same is true of loss resulting from an auxiliary port splitter or directional coupler. The extra loss added by the input pad or splitter/coupler will be offset by reducing the attenuation at the output of the next amplifier. The upstream signal levels for all stations measured at the reverse station input port will be the same after the loss of the input pad or auxiliary combiner has been subtracted.

The proper system design will ensure that when subscriber devices are activated, they will operate near the highest output level possible. Some range has to be allowed for the closed-loop level control system to adjust the output level. If there is too much loss between the device and the nearest active port, the box will not be able to increase its level when requested by the system controller. Verifying that the design losses are correct will guarantee that the level control system will work correctly. When a new interactive device is installed, the loss should be checked by injecting a signal and measuring the level at the reverse input test point of the nearest upstream active.

Figure 9: Closed-loop frequency sweep.

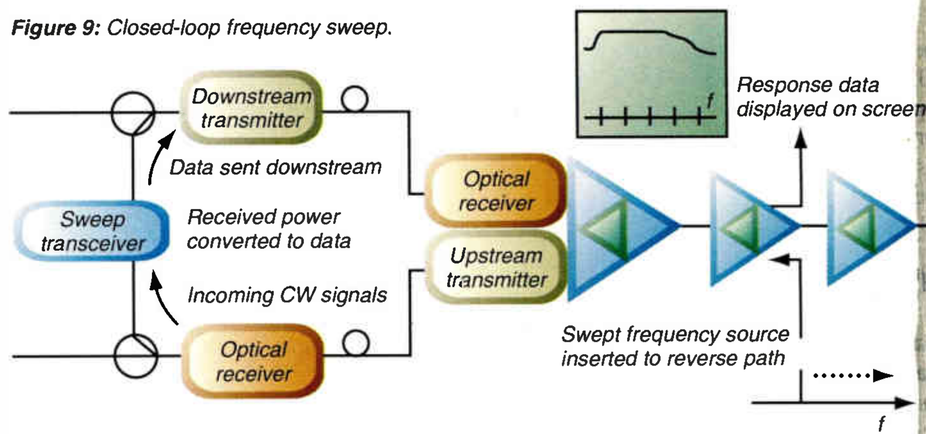


Figure 10: Link loss adjustment.

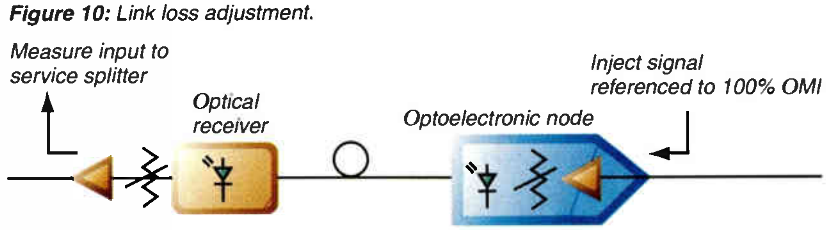
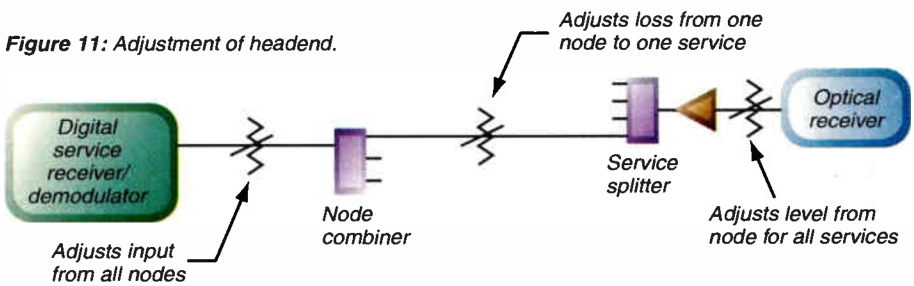


Figure 11: Adjustment of headend.



All outlets within the home should be terminated to prevent microreflections from splitter ports. If necessary, time-domain reflectometry (TDR) measurement equipment can be used to find missing outlets.

Systems that use inline equalizers with diplexed reverse attenuator pads or taps with equalized drops do have some room for adjustment in the feeder section. As with amplifier input pads, however, the amount of loss these devices add to the reverse path has an impact on the immunity to ingress of the entire HFC system. For this reason, design values should be used unless consistently poor performance indicates that the design needs to be re-examined.

Another area that may need to be investigated is in-home equipment. As more outlets are added to a residence, bi-directional amplifiers are required to make up for splitter and combiner losses. The upstream path of these amplifiers will need to be set up to overcome the losses as necessary, while not adding interference to either upstream or downstream signals. Because of the level differences between upstream and downstream traffic inside the home, it is possible that harmonics of reverse frequency signal can go from one splitter leg to the next and cause interference with analog TV channels. To avoid this, place drop amplifiers before any splitters in the downstream path. By amplifying the reverse traffic after the in-home combining network this way, the upstream levels within the home will not have to be as high and interference will be minimized.

Performance monitoring

Ingress and "noise" caused by clipping do not behave the same as thermal noise. Laser clipping is an impulsive phenomenon that results in a noise that may look like Gaussian noise on a spectrum analyzer, but will not be measured accurately by the analyzer, nor will it affect signals the same way as Gaussian noise.

It is difficult to measure the signal as well as the noise with existing test tools. The desired transmissions on the reverse path are bursty. Peak hold analyzer functions are useful in capturing burst signals, but they also exaggerate the noise. A single frequency, zero span sweep on a spectrum analyzer gives a useful view, but if the resolution bandwidth is set such that level measurements are accurate, adjacent channels will show up as lower level transmissions that appear on the same frequency.

While an estimate of signal-to-noise ratio from a spectrum analyzer will always be a good indicator of network health, this measurement will lose some of its quantitative value. A better metric is required.

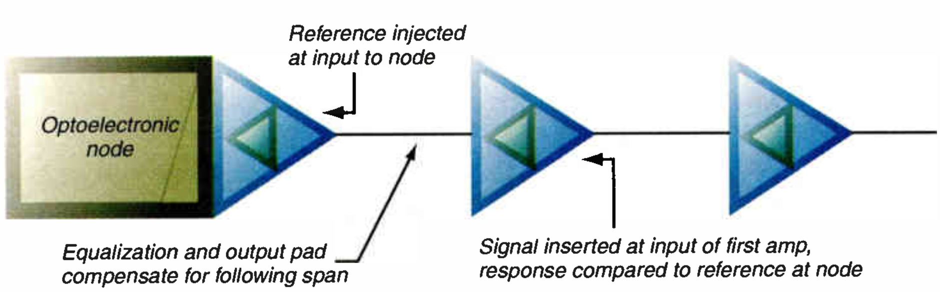
Almost all of the services being deployed on the reverse path use digital modulation techniques for the transmission of information. The key performance parameter for digital transmission is the bit error rate (BER), which is a measure of the number of bits which are received in error divided by the total number of bits transmitted. This is the "bottom line" and best measure of system performance.

It is important to consider the effects of error correction. Digital systems usually interleave the transmitted bit streams in order to spread or dilute the effects of burst errors from impulsive phenomena. Additionally, extra bits of redundant information are added using well-known error correcting codes. This is done to permit the complete correction of limited size bursts of errors. Thus, there are errors that are fully corrected, as well as errors that exceed the capacity of the error correction codes and therefore result in uncorrectable blocks of data.

Systems should be designed such that most of the errors are correctable. This has significant implications for system monitoring. An increase in correctable errors will indicate declining system health before performance is affected. This allows the operator to take action to correct the problem in anticipation of customer complaints–a "holy grail" of network operations. Note that it is difficult with standard test equipment to measure a precorrection BER. It is incumbent on digital equipment manufacturers to build these features into equipment, and to report these quantities to higher level network management computers.

When uncorrectable errors do occur, they will affect different services in different ways. Many services, such as status monitoring or TCP/IP (Internet), will simply request a retransmission of the desired information. This causes a slowdown in the overall throughput of the transmission system, but may not cause a problem that is noticeable to the end user. Services that operate in real time, like telephony or video conferencing, may have limited tolerance for data errors before a noticeable disruption of service occurs. In extreme cases, connections may be lost. Such considerations have to be weighed together with the revenue generated by a particular service when determining the bit error rate required. CED

Figure 12: Alignment of coaxial plant.



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A new approach toward off-premise security

Taking the security signal out of the home

By Gunther Diefes, Director of Engineering, D&P Manufacturing Inc.
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This article explains an alternative approach to addressable convertors and interdiction for securing services and offering pay-per-view. While the system described here is not yet a product, it has been prototyped and can easily become a production item. Because the system is flexible in terms of how it may be configured, there will be no attempt here to describe all of the possibilities.

Question: Which of the following features do you want in your addressable system?

✔High level of security
✔Low cost
✔Compatibility with analog and digital signals
✔Backwards compatibility with your existing system
✔Configurable for one-way or two-way
✔IPPV via telephone or RF return
✔Ability to secure every channel
✔No degradation of program content
✔Installation that does not require existing system reconfiguration
✔Instantaneous program-viewership demographics
✔All of the above and more.

If your present system or the new one you are considering does not do all of the above, read on.

Overview

There are two reasons to employ an addressable device of some type in a cable system:

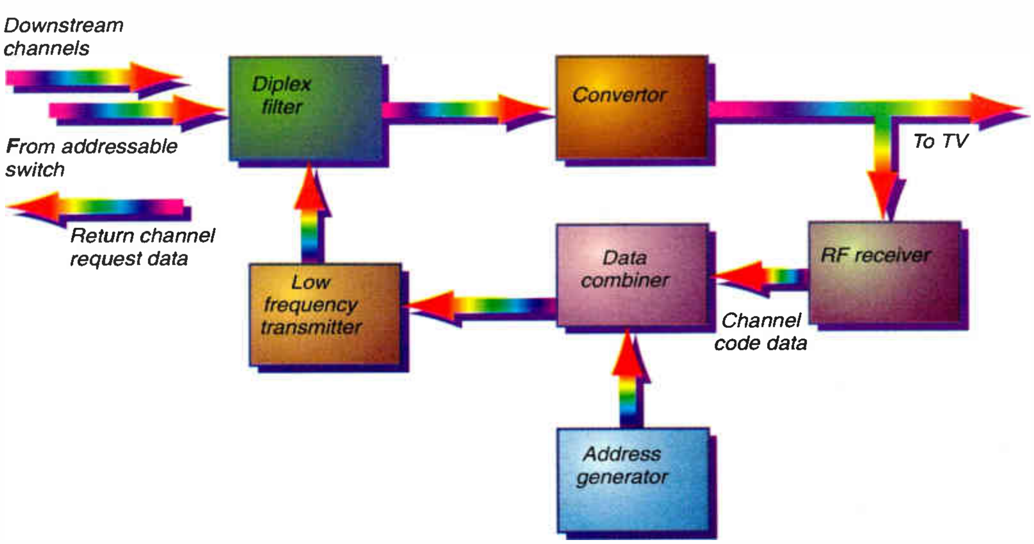
1. It allows the customer's level of service to be changed without a service call.

2. It adds a level of security to the premium services.

If these two goals are accomplished effectively by existing technology, then there may not be a need for a new product. But if the existing products are carefully evaluated as to how well they achieve their objective, it is reasonable to conclude there is room for improvement. Estimates are that the industry loses $5 billion to cable pirates every year. One reason for this loss of revenue results from the fact that, in the case of convertors, the security signal is brought into the home. OPSS, a new off-premise security system, does not compromise security by bringing the security information into the home, but like interdiction, leaves it outside.

Unlike interdiction, however, it does not limit the number of channels that can be secured, nor does it inject any new carriers into the system that could create more problems than they solve.

Figure 1: Channel identifier



Headend

How does OPSS work? While it is not necessary for OPSS to be configured as an addressable system, this article describes the operation as if it were. It will also assume that the system is configured as an active cable return plant, even though it is not necessary; the system will function in essentially the same manner when configured with a telephone return. There are four essential functions that take place in the headend: a means to identify a channel, a data transmitter, a data receiver and a controller.

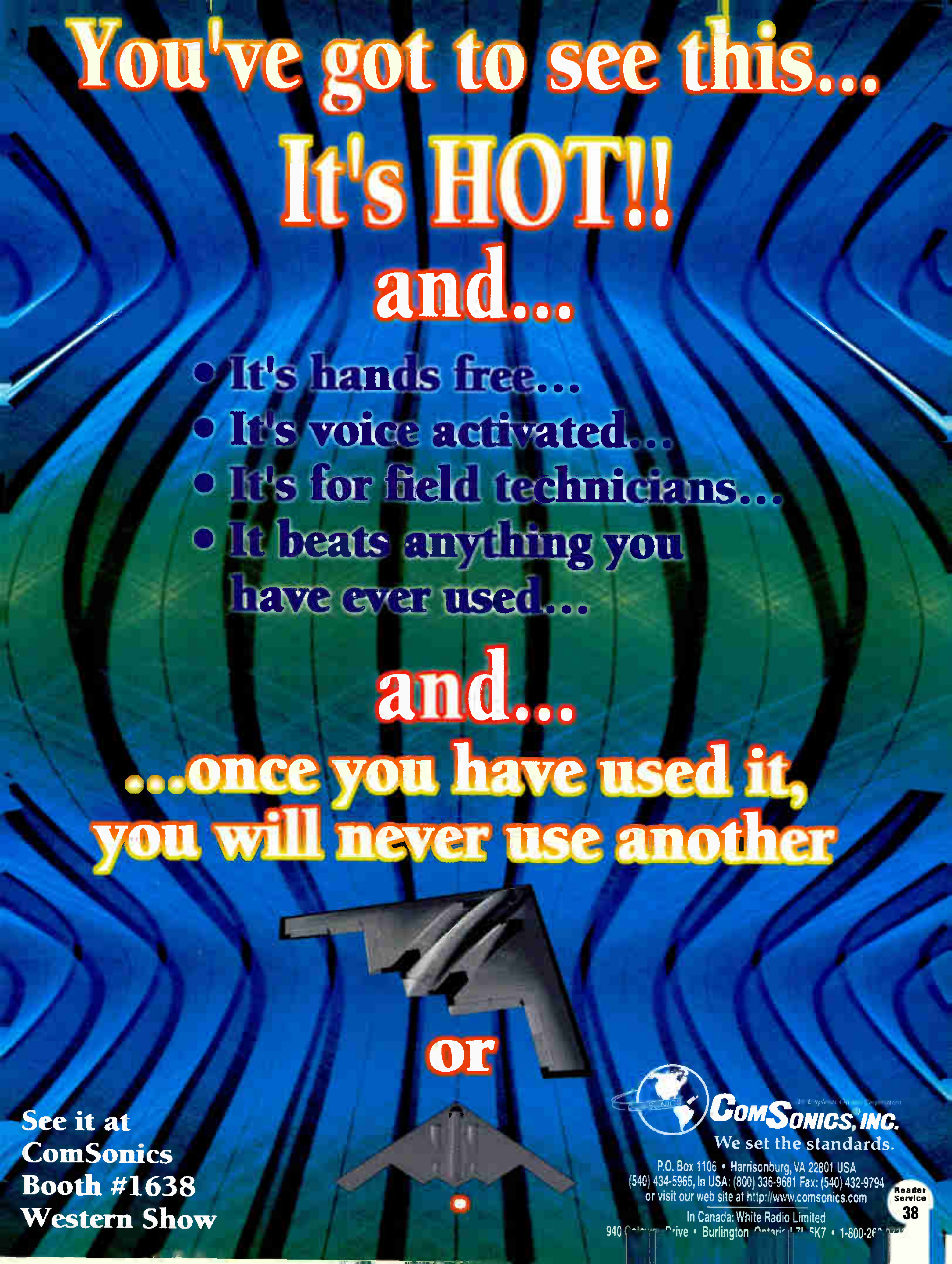
Each and every channel on the system must have an identification code. This code may be unique to a channel or can be shared by many channels to form a tier. The code can be inserted into the vertical interval or injected as a sub-carrier on the aural carrier. The exact placement of the code within the channel is not important. Nothing else needs to be done to the channel.

The controller is a computer that is used for billing, controlling subscriber authorization levels, and monitoring subscriber viewing requests. The data transmitter takes information from the controller and modulates it onto an RF carrier, and is referred to as the data channel. This carrier is combined with the other program channels for transmission to the subscribers. Control data from the computer is transmitted to the addressable switch, a subscriber device located outside the home. It is this data that determines which channels the subscriber is permitted to watch. The data receiver is tuned to receive information in the 5 to 40 MHz spectrum.

The data received is primarily requests from subscribers who order pay-per-view events. When the data is demodulated, it is sent to the controller, where the information is processed, and appropriate data regarding the request is prepared for transmission on the data transmitter.

Subscriber interface

When a subscriber is connected, two boxes are installed: the channel identifier in the home, and the addressable switch outside the home. The box outside the home can be part of the tap for new construction, or for existing plant, it is located between the tap port and the customer's home. The box in the home can be configured in



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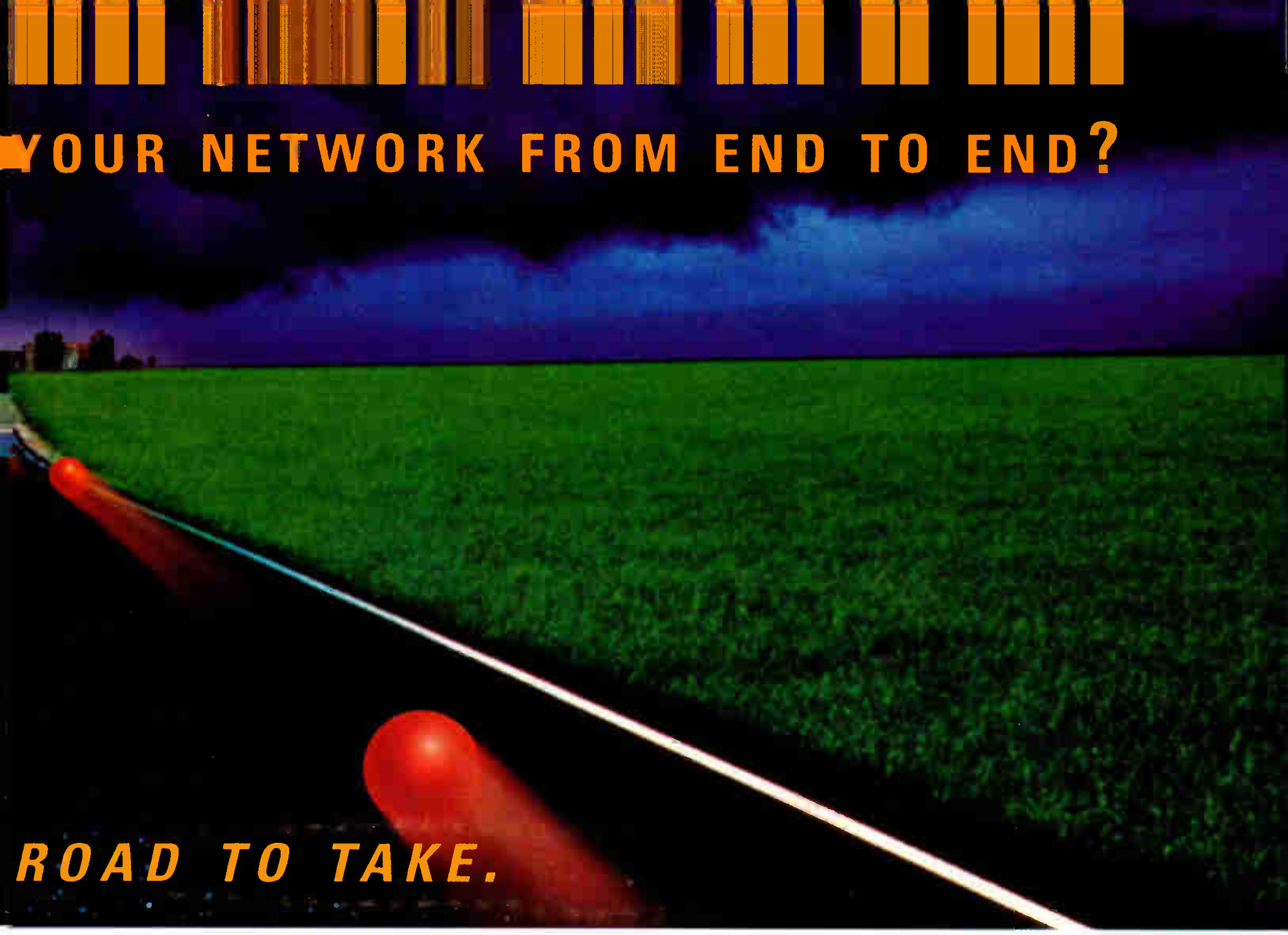

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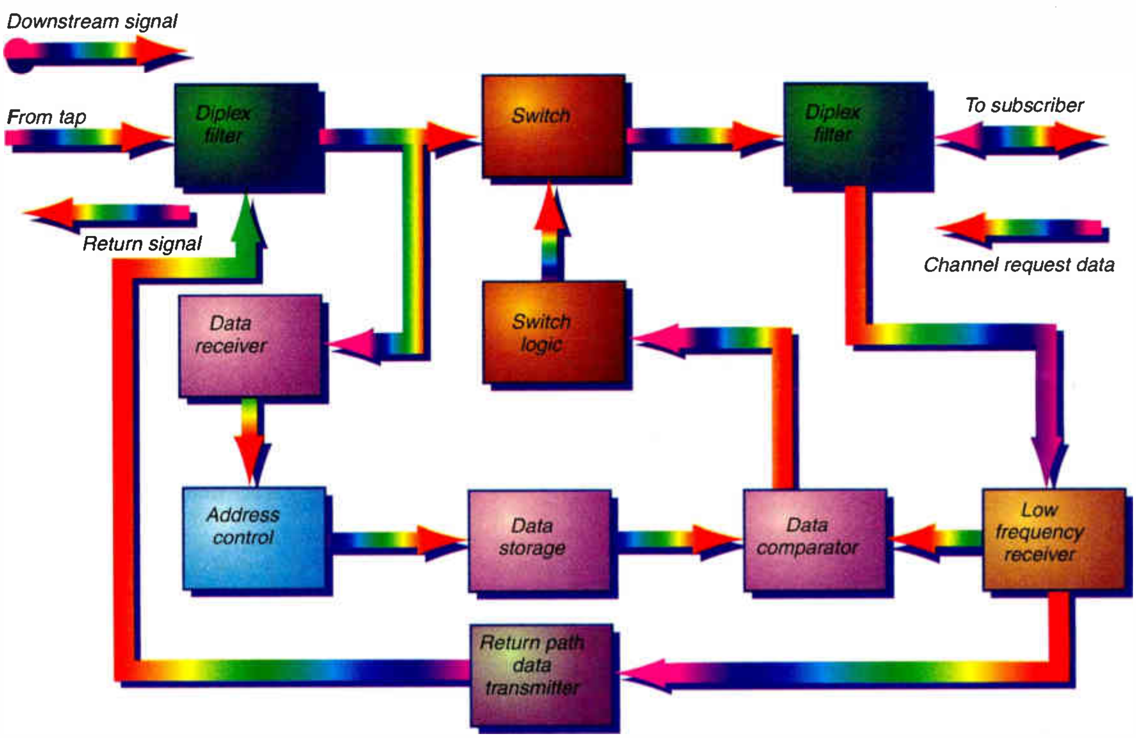
several ways, depending on the existence of convertors and the availability of baseband signals from the customer's television. To understand the operation of the system, first consider the in-house channel identifier (see Figure 1). This unit serves as a communications center, and its primary function is to receive data, combine it with its own address code and then transmit this data back to the outside box. Let's assume that there are convertors used in the system and consider Figure 1. All signals that are carried in the downstream direction on the system enter the diplex filter. The signals continue through the filter to the convertor. The convertor changes all of the incoming channels to a common output frequency. This output signal is then split into two paths: one connecting to the television set, the other to the channel identifier. The channel identifier demodulates this signal. The demodulated signal contains the channel code that was inserted at the headend. This channel identification data is combined with the channel identifier's unique address code and modulated onto a carrier for transmission through the diplex filter back up the drop cable to the addressable switch. While there are additional functions that take place in the channel identifier, they are not described here.

Several functions occur in the addressable switch, but its primary function is to pass or deny the signal to the subscriber. To understand its operation, see Figure 2. The addressable switch has two signals presented to it: one from the downstream and the other from the upstream.

Figure 2: Addressable switch



The downstream signal contains all of the system's programming, plus a data channel that is used to communicate with the box from the headend. The signal from the tap is fed into a diplex filter, while the signal from the filter is split into two paths. Part of the signal is presented to the switch, which when activated, passes all of the signals to another diplex filter. The signal passes through the filter into the subscriber's home. The second path for the input filter is directed into a data receiver that is tuned to the frequency of the data channel. The receiver demodulates the signal and sends the data to the address control section.

In this portion of the circuitry, a determination is made if the data sent applies to the particular address of that specific addressable switch. If the information is for the switch in question, then the data is forwarded to the data storage circuitry. The data storage circuits contain a table of channel address codes that the subscriber is permitted to receive. The data channel provides a means to change the level of service provided to the subscriber, connect and disconnect the subscriber or activate pay-per-view events.

The upstream signal from the subscriber enters the addressable switch through the diplex filter. This signal from the subscriber carries a request from the subscriber to view a particular program. The signal from the filter passes through the filter to a low frequency receiver. The receiver demodulates the return signal and splits the data into two separate paths. In the first path, the channel request data is sent to a data comparator where the data identifying the channel being requested is compared to the channel identifying data of those channels for which the subscriber is authorized.

Within the data storage is a lookup table that lists all of the channel codes that the subscriber is permitted to watch. If the subscriber tunes his convertor to an authorized channel, the switch remains closed, and the subscriber may view the program. If there is no match between the lookup table and the channel code, then the switch opens and the subscriber is denied service.

Because it is necessary for the addressable switch to see return data from the subscriber, there is a cycle timer that periodically closes the switch. Once the subscriber selects an authorized channel, the switch remains closed. The second path for the channel request data is to the return path data transmitter. The output from this transmitter, whose frequency should be in the 5 to 40 MHz band, then goes to the diplex filter for transmission back to the headend. When the subscriber requests a pay-per-view event, the data code associated with the event, along with the subscriber's identification code, is transmitted back to the headend computer. To change a subscriber's authorization level, a signal is generated on the data channel that contains the subscriber address and the updated authorization. While all subscribers receive the data channel, only the addressable switch that is being updated will respond.

Conclusion

While OPPS is rather simple in concept, it is very complex in the number of ways it can be configured to satisfy the needs of nearly any system. It is important to note that this article omitted many details, and does not give specifics regarding security, application or operation.

There is an additional benefit that OPSS has to offer that is not discussed in detail in this article. When properly implemented, OPSS can give almost instantaneous information regarding viewing habits of subscribers. This function could greatly enhance an operator's advertising/marketing efforts. CED

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Understanding the effects of noise on digital signals

Working in the lab

By John Ernandez, Manager, Digital Wireless System Integration, jernandez@nlvl.com; and Marc Ryba, Senior Project Engineer, NextLevel Systems Inc.'s Broadband Networks Group, mryba@nlvl.com

This article gives an overview of the various types of impairments encountered in a cable system, describes how they can affect a digital signal and provides a model for labs to generate and test these impairments. Future articles will fully explore each impairment and its effect on the digital signal.

Using this information ensures that digital end-to-end systems perform according to specifications and under conditions that are normally much worse than those found on actual cable systems. It assures system operators that when they implement digital technology, they will encounter no problems with digital signal transmission through their system (assuming the system meets FCC requirements).

The Cable Impairment System (CIS) Lab characterizes and develops digital modulation techniques for use on a cable system and measures the performance of digital modems, cable systems and RF support equipment. The lab's impairment simulator and medium-sized hybrid fiber/coax (HFC) trunk and coaxial distribution system enable engineers to add impairments found on a cable system in prescribed amounts and then measure the performance of tested units. The CIS Lab can then determine the system performance of digital cable TV products before they are placed in the field.

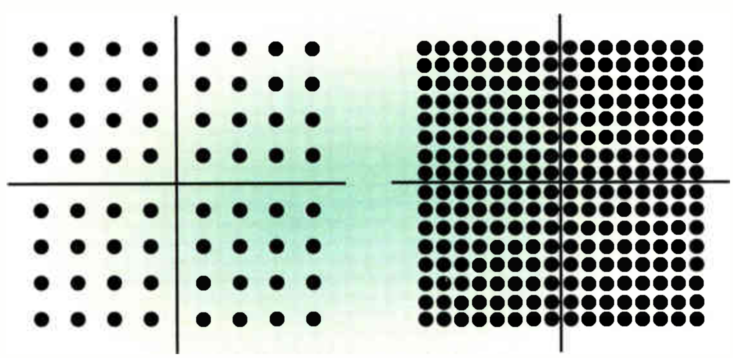
Information about the CIS Lab's test system is available to *all* interested parties to encourage standardized testing within the cable industry. Systems similar to the CIS Lab's test system are in use at several locations, including CableLabs and Motorola.

CIS lab overview

The CIS Lab's impairment test system and cable distribution system enable engineers to add impairments in precise amounts so that they can measure the amount added and the tested unit's performance. The CIS Lab can add the impairments directly to a digital signal for the research and development of a modem or other cable TV product such as a line amplifier or tuner. It can also add the impairments to a medium-size cable system to verify performance of production cable TV hardware.

The lab can test both the upstream and downstream paths either simultaneously or separately.

***Figure 1:** Constellation diagrams*



64 QAM   256 QAM

Quadrature amplitude modulation

Because the preferred form of modulation for cable television is quadrature amplitude modulation (QAM), most of the CIS Lab's efforts have concentrated on studies of the effects of transmission impairments on this form of modulation.

QAM is a form of modulation in which the digital information is carried in both the amplitude and the phase of the RF carrier. Current technology uses 64- and 256-QAM modulation schemes for cable and wireless television services. These modulation schemes permit the transmission of six bits and eight bits of information in each QAM symbol for 64- and 256-QAM, respectively. With a symbol defined as a distinct amplitude/phase state of the RF carrier, there are 64 distinct amplitude/phase states of the RF carrier, with each containing six bits of information in 64-QAM.

Figure 1 provides an example of 64- and 256-QAM constellation diagrams. A constellation is an X-Y representation of the symbols in a QAM signal. As the number of symbols in a constellation increases, the distance between each symbol decreases, making the signal more susceptible to impairments. Because different impairments have different effects on a digital signal, each impairment will have a distinct appearance on the constellation diagram. The CIS Lab uses constellation diagrams to display these different types of impairments and determine their effects on digital signals.

Types of impairments

A digital signal can encounter additive white Gaussian noise (AWGN), discrete RF interferers, impulse noise, composite second order/composite triple beat distortion products, and phase noise in a cable system. All of these impairments affect the performance of a digital signal to varying degrees.

Additive white Gaussian noise. This noise is produced by active components in the cable system, the biggest contributors being trunk amplifiers and line extenders. The tuner located in the digital set-top terminal can also cause this impairment. AWGN impairs the digital signal by effectively decreasing the distance between symbols in a constellation. This decrease can cause the demodulator to decode a symbol incorrectly.

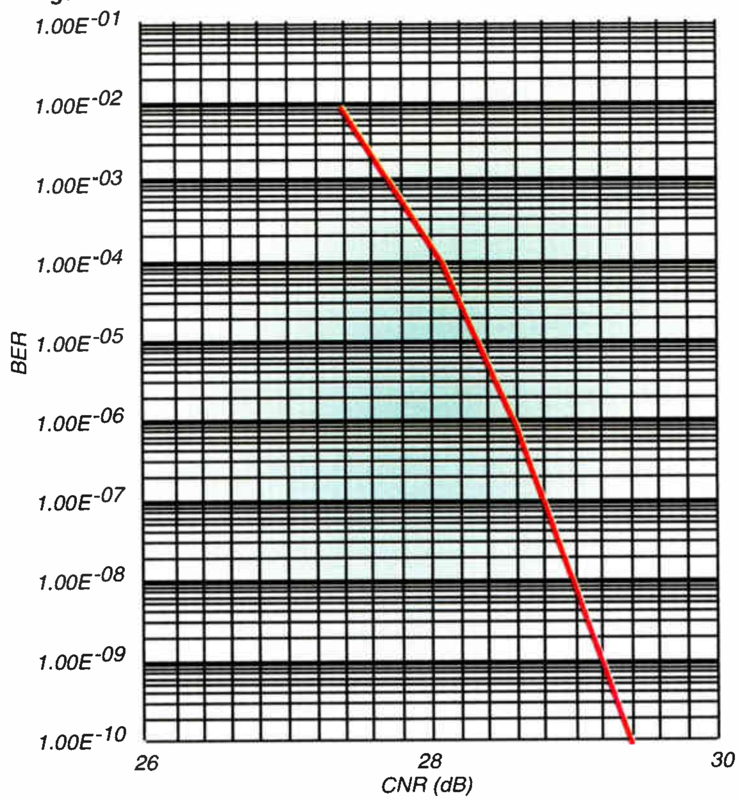
By definition, AWGN has a flat amplitude spectrum over a very broad frequency range. The CIS Lab can generate AWGN using a diode-biased noise source and a calibrated attenuator to set the level of the noise. The output of the noise source is combined with

the tested digital signal. The noise level is adjusted to produce a desired carrier-to-noise ratio (CNR). The CIS lab sets the CNR to different values and measures the bit error rate (BER) of the digital signal.

The forward error correction (FEC) system used in the digital modem can combat the AWGN impairment. The FEC inserts additional symbols into the transmitted data at the modulator and uses these symbols to correct a fixed number of errors. The system is designed to correct random errors in the data stream; it cannot correct all errors. However, it can convert a high error rate at the input of the FEC decoder into a lower error rate at the output of the FEC decoder.

The error rate derived at the output of the demodulator/FEC combination varies depending on the amount of noise present. This is why the CIS Lab tests the FEC system's capabilities by varying the CNR present at the input of the tested demodulator and then measuring the BER at each of the CNR points. The lab uses these points to generate a BER vs. CNR curve. Figure 2 provides an example of such a curve and shows that when the CNR increases, the BER decreases.

Figure 2: *BER vs. CNR for 256 QAM.*



Phase noise. This is a measure of the short-term stability of an oscillator. Random perturbations within the active device in the oscillator will cause minute amounts of phase modulation (or frequency modulation) of the oscillator. In a transmission system, oscillators are present at every upconvertor and downconvertor stage. Each of these oscillators adds a certain amount of phase noise to the system.

In a cable system, the major contributors of phase noise are the headend upconvertor and the tuner in the set-top terminal. If used, an AML system also contributes phase noise. Typically, phase noise is measured as spectral density (i.e., power in a 1 Hz bandwidth) relative to the carrier power at some frequency removed from the carrier. The data is presented as X dBc/Hz @ Y kHz.

The CIS Lab generates phase noise by using an AWGN source at the PM input of a synthesizer. This phase-modulated signal is mixed with the tested digital signal to add phase noise. A calibrated attenuator in the AWGN source controls the amount of phase noise added.

Because a QAM signal carries information in the RF carrier amplitude and phase, any disturbance of the received carrier's phase or amplitude will cause an increase in the BER. Phase noise will perturb the received RF signal's phase, making it more difficult for the demodulator to correctly demodulate symbols without an increase in the BER.

Multipath. The multipath impairment will produce time-delayed/amplitude-reduced replicas of the digital signal at the receiver location. Multipath is caused by the transmitted signal being reflected in the transmission path. Each time the signal is reflected, it experiences a time delay and amplitude reduction relative to the main signal. In a cable system, these reflections are because of an impedance mismatch at the junctions of the components in the cable plant such as the taps or trunk amplifiers.

The composite signal at the demodulator is a superposition of all the reflected signals and the main signal. This composite signal has both spectral peaks and valleys in the passband of the digital signal. These peaks and valleys vary in quantity and amplitude depending on the time delay and amplitude of the echoes present.

The CIS Lab can generate multipath with a Hewlett-Packard Ghost Simulator. This device enables the lab engineers to add up to five echoes to the digital signal. Software connected to the HP device can vary each echo's amplitude, phase and time delay.

The adaptive equalizer in the demodulator combats the multipath by adjusting itself continuously and automatically to the input signal. The output of the adaptive equalizer is the inverse frequency response of the channel through which the signal has passed; therefore, the adaptive equalizer will attempt to flatten the passband. While the structure of an adaptive equalizer can take many forms, it basically is a tapped delay line digital filter.

Burst noise. In theory, burst noise is impulsive, infinite amplitude, wide bandwidth Gaussian noise. Electric motors, lighting and other forms of ingress can generate burst noise in a cable system. This impairment can occur periodically or instantaneously.

There is some debate on the proper method of modeling burst noise. The CIS Lab has developed two methods for generating burst noise to accommodate both schools of thought. The first suggests that because burst noise is wide bandwidth and a Gaussian process, it should be modeled using pulsed AWGN. The second one believes that because burst noise is impulsive, a pulsed CW signal should be used to generate it.

The first method uses a PIN diode switch to switch AWGN on and off in the path of the digital signal. A pulse generator controls this switch, which can be varied in both pulse width and repetition frequency. Directly varying the amplitude of the noise source controls impulse noise amplitude. The second method uses the same PIN diode switch and pulse generator to pulse a CW signal on and off.

Burst noise will produce a contiguous block of errors in the data stream. Because the FEC is designed to correct random errors, this block of errors could be beyond its error

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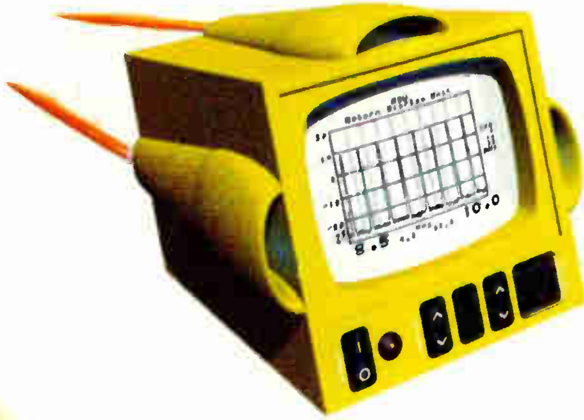

RDU patent pending
RDU © 1997 Cable Resources Inc

The RDU is a new piece of test equipment. It allows technicians to monitor the return system from any point in the cable system without the traditional and cumbersome HE spectrum analyzer / camera setup.

The RDU allows system installers and technicians to view on any TV screen, the RF Levels, Ingress and Noise present back at the HE from a subscriber's home, system amplifier, feeder tap or fiber node.

The RDU processes the X / Y output data generated by an internal spectrum analyzer and converts it to NTSC video for input to a standard CATV modulator. A data output allows the analyzer screen to be viewed on a computer, same as video. Software is Windows 95 networkable so office possibilites are endless.

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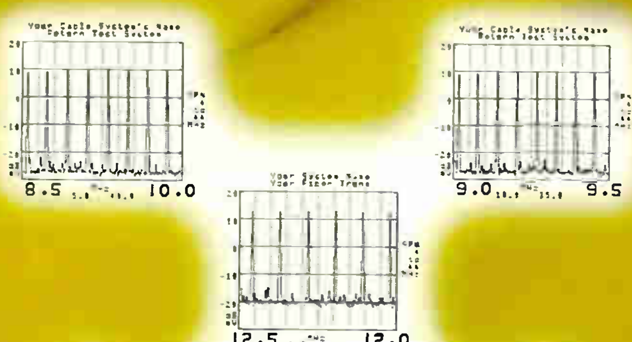

Above are samples of a TV screen that system installers or technicians would "see" in the field.

The RDU displays noise, ingress and RF carriers, the same as a spectrum analyzer with a video and computer screen refresh rate of just 350 milliseconds!

The RDU displays HE return levels on two user selectable test carrier frequencies in the 4-44 mhz. bandwidth. Test carriers and ingress / noise levels can be easily documented from every installation and service call. Simple and easy to implement.

RDU software monitors ingress / noise by recording RF energy, where you designate, in 200 khz. segments. The RDU averages the data and displays a ingress / noise number, real time. Response over time charts can be outputed for analysis and documentation.

The RDU is an efficient new tool to activate and maintain broadband networks creating benchmarks for return cable system operations.

The RDU allows you to start your system with a return video channel and migrate to a data stream as your people master the art of return operations. Keep it simple to succeed.

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correction capability. To combat the effects of burst noise, the digital demodulator uses an interleaver. The interleaver is designed to take the input data stream at the modulator and evenly disperse symbols in a prescribed manner. The interleaving process spreads out the blocks of errors, making them appear random to the FEC so that it can correct them.

Carrier wave interference. Carrier Wave (CW) interference represents itself as an unmodulated signal within the 6 MHz passband of the digital channel. However, if the interference is frequency-modulated with a low deviation like a two-way mobile radio signal, it can be treated as a CW signal. The primary sources of CW interference in cable systems are ingress, headend equipment spurious components and amplifier oscillations.

The CIS Lab generates CW interference by combining the output of a synthesized signal generator with the tested digital signal. The amplitude and frequency of the CW signal can be varied to generate a BER curve. Varying the frequency also reveals any sensitive areas within the digital system that could increase the BER for a given fixed amplitude level. The adaptive equalizer helps remove the effect of the CW signal from the digital signal.

Video degradation is not visible until the system reaches the threshold

Composite second order/composite triple beat. These distortion products are produced when a large number of signals drive an active component into its nonlinear operating range. Both of these impairments are labeled "composite," because each is a cluster of beats from all of the analog carriers in the system. In a cable system, the main contributors are the trunk amplifiers, line extenders and fiber optic equipment. The CSO is usually found 1.25 MHz above the NTSC video carrier frequency, while the CTB is found on the video carrier frequency.

The CIS Lab generates CSO and CTB by driving a cascade of amplifiers into saturation and bandlimiting the desired CSO/CTB distortions. The CSO or CTB distortion is combined with the digital signal for a given channel, and the amplitude is controlled by a precision attenuator.

CSO/CTB distortions generated by an all-digital plant have a different spectral form than distortions generated by an all-analog plant. Digital CSO/CTB appears like quasi-Gaussian noise on the cable plant. The FEC can handle these distortions, because they are Gaussian in nature, while the adaptive equalizer is better suited to handle the analog distortions which appear as a cluster of beats.

Effect of impairments

Whether testing an analog or a digital signal, the amount of picture degradation produced by the impairment is what matters. In an analog system, each impairment uniquely manifests itself in the video; and for every decibel increase in a particular impairment, the video quality degrades directly. Therefore, the video quality is directly affected by the transmission channel.

The digital system processes the video separately from the transmission processing. Therefore, the video is of a quality fixed by the encoding algorithm and not the transmission channel. The transmission system performance is fixed by the amount of FEC, interleaving and adaptive equalization that the modem has in order to combat impairments in the channel.

The threshold level of the system is the critical area that corresponds to the CNR where the total impairments present in the transmission channel increase the BER to the point where errors are seen in the video. This means that video degradation is not visible until the system reaches the threshold. At this CNR point, errors are typically seen as small monochrome blocks within the video. A change in CNR beyond threshold of a few tenths of a decibel will cause the data stream to have such a high error rate that the digital demodulator loses synchronization, and the picture becomes unrecoverable.

Summary

To judge the performance of the equipment under test, the CIS Lab generates BER curves for each impairment and notes a threshold of visibility (TOV) for each. The TOV is the point where block errors are first noted in the picture with impairments present in the transmission channel. The BER curves are useful to compare different test units and to characterize and measure performance for each of the units.

The TOV point enables the CIS Lab engineers to compare the performance of different digital transmission technologies and ensures that the digital cable TV equipment will meet or exceed all system design requirements. CED

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Swimming upstream: Making a modulation choice

Which one is right for you?

By Aravanan Gurusami, Senior Engineering Manager, Digital Transmission Systems; and Michael Nekhamkin, Senior Staff Engineer, Digital Transmission Systems, Philips Broadband Networks Inc.
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Deciding which return path (multipoint-to-point) modulation technology is right for your HFC network is a complex task. You must consider a number of criteria for a number of technologies, some of which are just beginning to be tested in the field. How do you make a sound decision?

First, of course, you learn all you can about your choices. Second, you try to figure out which trade-offs to make to arrive at the choice that best accommodates your system's needs.

This article is structured, accordingly, in two parts. Part one compares four of today's most promising modulation technologies:

✔Single-carrier QPSK/TDMA
✔Single-carrier 16 QAM/TDMA
✔MCM/FDMA
✔Spread spectrum/CDMA.

Part two provides an example of how decision-analysis software can be used to assess these four technologies against your own requirements.

Evaluating the technologies

This section of the article summarizes each technology's strengths and weaknesses.

✔Single-carrier QPSK/TDMA. Today's most widely-used upstream modulation technology for cable telephony and data is single-carrier QPSK modulation using TDMA as the media-access method. This technology is robust, low-risk and cost-effective. Its main drawback is low bandwidth efficiency.

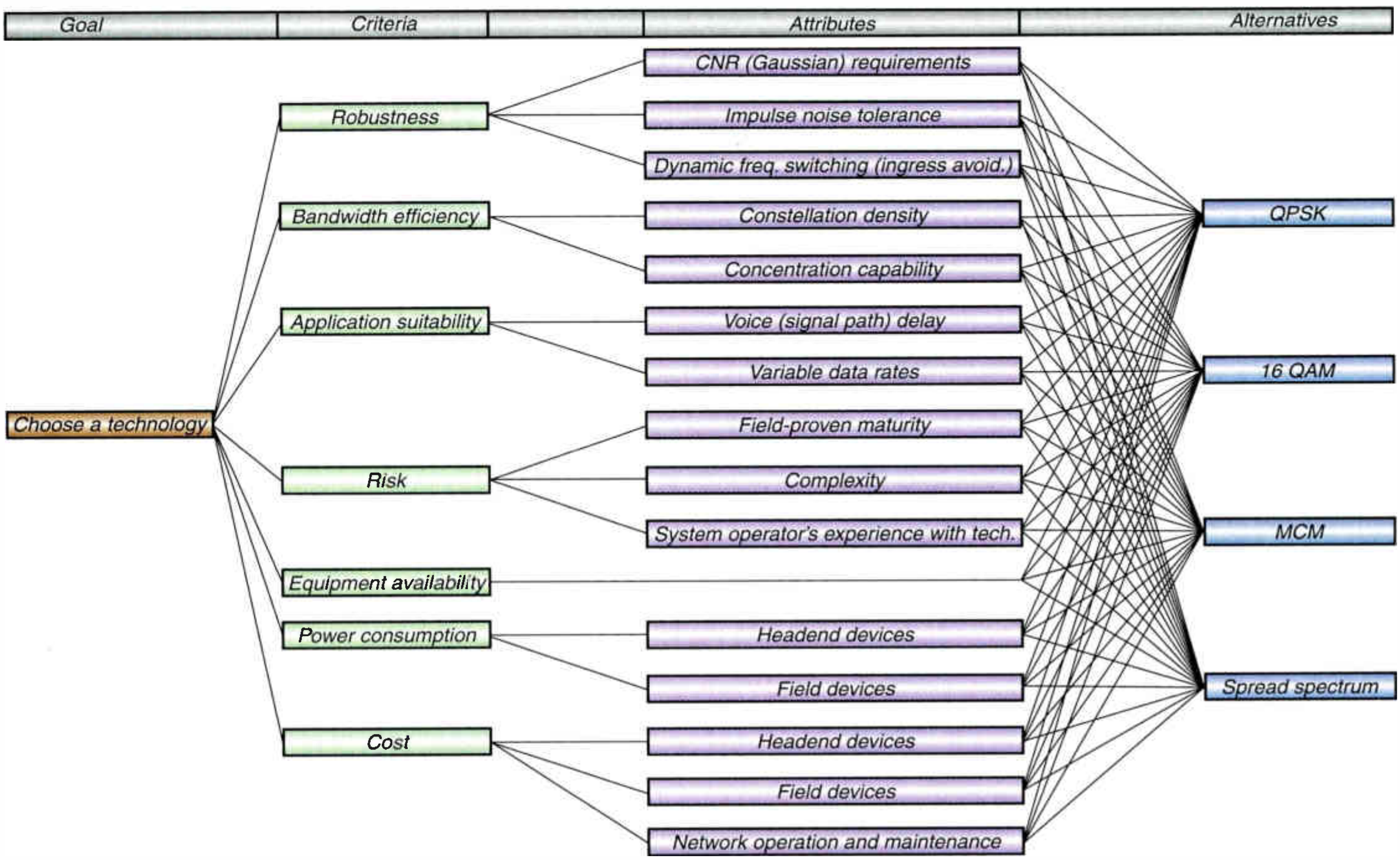
Robustness: QPSK is robust in the presence of noise and amplitude distortions. In systems using channel monitoring and dynamic frequency switching, QPSK also resists ingress and interfering frequencies.

Bandwidth efficiency: QPSK's practical bandwidth efficiency is low: around 1.6 b/Hz/s.

Application suitability: The use of short TDMA packets helps keep the signal-path delay low, but reduces the ratio of useful data to total transmitted data. Longer packets improve the efficiency for data transmission. For variable data rates, a system must be able to allocate additional time slots or vary packet lengths.

Risk: Because of its robustness and maturity, QPSK has worked well in field trials and

Figure 1: This value tree, or objective hierarchy, shows the links between all the decision-related factors identified.



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Consumers crave the Internet. Yet, multimedia-rich files squeak along on standard analog modems—leaving everyone starved for speed. Serve them what they want today with the first data-over-cable solution designed to MCNS standards. After all, someone will profit from high-speed Internet access—and it might as well be you.

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Moving to two-way is incredibly cost-effective, too. Start with telephony-return service and add two-way capabilities as you're ready. In fact, both run in the same Total Control chassis—even in the same channel—to simplify migration and preserve your headend investment. Food for thought if you're considering upgrading parts of your system.

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Figure 2: *These charts show the weights assigned to each criterion and each attribute on a scale of 0 to 100, with 100 being critically important to the system operator, and 0 being unimportant to the system operator. The program normalized weights, converting them into values ("priorities") that add up to 1 within each rating set.*

Goal	Weights	Priorities	Rating set (for criteria)
Choose a technology	100.00	0.222	Robustness
	75.00	0.167	Bandwidth efficiency
	50.00	0.111	Application suitability
	50.00	0.111	Risk
	50.00	0.111	Equipment availability
	50.00	0.111	Power consumption
	75.00	0.167	Cost

Criteria	Weights	Priorities	Rating set (for attributes)
Robustness	100.00	0.333	CNR (Gaussian) requirements
	100.00	0.333	Impulse noise tolerance
	100.00	0.333	Dynamic frequency switching (ingress avoidance)
Bandwidth efficiency	100.00	0.500	Constellation density
	100.00	0.500	Concentration capability
Application suitability	100.00	0.571	Voice (signal path) delay
	75.00	0.429	Variable data rates
Risk	75.00	0.375	Field proven maturity
	75.00	0.375	Complexity
	50.00	0.250	System operator's experience with technology
Equipment availability			Alternatives
Power consumption	50.00	0.333	Headend devices
	100.00	0.667	Field devices
Cost	25.00	0.125	Headend devices
	100.00	0.500	Field devices
	75.00	0.375	Network operation and maintenance

carries little risk.

Equipment availability: Single-chip QPSK burst modulators are readily available off-the-shelf. Headend burst demodulators are more difficult to find, especially when fast carrier and timing acquisition is required for short TDMA packets. Prospects for the long-term availability of QPSK equipment are encouraging, because QPSK is a mandatory constellation according to MCNS and IEEE 802.14 specifications.

Power consumption: QPSK modems typically consume less power and require less processing than other technologies' modems.

Cost: Of the four technologies, QPSK is the simplest, most familiar, and most widely available, making it the most cost-effective. Also, because of its modest carrier-to-noise requirements and tolerance of typical return system nonlinearities, QPSK requires minimal investment in network maintenance.

✔Single-carrier 16 QAM/TDMA. While it is more complex and less robust than QPSK, single-carrier 16 QAM is roughly twice as bandwidth-efficient.

Robustness: 16 QAM requires a higher carrier-to-noise ratio than QPSK, and it is more sensitive to amplitude distortions, so quality requirements for the return channel are tighter.

Bandwidth efficiency: 16 QAM's practical bandwidth efficiency is around 3 b/Hz/s.

Application suitability: Single-carrier 16 QAM could cause a minor increase in signal-path delay because of longer signal processing in the demodulator than QPSK. Otherwise, 16 QAM/TDMA's application suitability is comparable to that of QPSK.

Risk: Because 16 QAM is less robust than QPSK, it requires better channel maintenance to ensure that the system works reliably. A 16 QAM system that can back off to QPSK reduces the risk of unreliability.

Equipment availability: Single-chip 16 QAM burst modulators are readily available off-the-shelf. Headend demodulators are not on the market yet. The need for coherent demodulation with fast acquisition, and the need for an equalizer in the demodulator, increase complexity. Prospects for the long-term availability of 16 QAM equipment are encouraging, because this technology is a mandatory constellation for a subscriber's modulator according to MCNS and IEEE 802.14 specs.

Power consumption: 16 QAM modulators and demodulators may consume more power than QPSK modulators and demodulators. However, for ASIC as well as some non-ASIC implementations, the difference is slight.

Cost: Because of higher carrier-to-noise requirements, 16 QAM systems require more expensive network maintenance than QPSK systems.

✔MCM/FDMA. MCM uses low-speed, fre-

Figure 3: *This chart shows the scores assigned to each technology on a scale of 0 to 100, with 100 being highly favorable and 0 being highly unfavorable. The program converted scores into comparable values ("priorities") on a scale of 0 to 1.*

	QPSK		16-QAM		MCM		Spread spectrum	
Attributes	Scores	Priorities	Scores	Priorities	Scores	Priorities	Scores	Priorities
CNR (Gaussian) requirements	100.00	1.000	75.00	0.750	50.00	0.500	100.00	1.000
Impulse noise tolerance	75.00	0.750	75.00	0.750	100.00	1.000	100.00	1.000
Dynamic frequency switching (ingress avoidance)	75.00	0.750	75.00	0.750	100.00	1.000	100.00	1.000
Constellation density	50.00	0.500	100.00	1.000	100.00	1.000	50.00	0.500
Concentration capability	100.00	1.000	100.00	1.000	100.00	1.000	100.00	1.000
Voice (signal path) delay	100.00	1.000	75.00	0.750	75.00	0.750	50.00	0.500
Variable data rates	75.00	0.750	75.00	0.750	100.00	1.000	100.00	1.000
Field proven maturity	100.00	1.000	75.00	0.750	75.00	0.750	50.00	0.500
Complexity	100.00	1.000	75.00	0.750	50.00	0.500	50.00	0.500
System operator's experience with technology	100.00	1.000	75.00	0.750	75.00	0.750	50.00	0.500
Equipment availability	100.00	1.000	75.00	0.750	75.00	0.750	50.00	0.500
Headend devices	100.00	1.000	100.00	1.000	75.00	0.750	25.00	0.250
Field devices	100.00	1.000	75.00	0.750	75.00	0.750	50.00	0.500
Headend devices	100.00	1.000	75.00	0.750	50.00	0.500	25.00	0.250
Field devices	100.00	1.000	100.00	1.000	50.00	0.500	75.00	0.750
Network operation and maintenance	100.00	1.000	75.00	0.750	100.00	1.000	100.00	1.000

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quency-multiplexed orthogonal subcarriers. A variable-constellation MCM may provide a good combination of robustness and bandwidth efficiency, but at the expense of cost, power consumption, and complexity.

Robustness: Sophisticated MCM implementations can vary the subcarrier constellation size based on channel conditions, alternating between QPSK, 16 QAM, etc. MCM can resist ingress and interfering CWs by reducing the constellation size or avoiding transmission on "bad" frequencies. MCM is also less susceptible to impulse noise and delay spread because it uses longer symbols than a single-carrier modulation of the same throughput. However, impulse noise of lower power has a greater impact because of reduced subcarrier power levels.

The MCM signal has a large ratio of peak signal power to average power because of the large number of subcarriers adding simultaneously. A fully-loaded single-carrier TDMA system may exhibit high peak power levels as well, but with a much lower probability, because the level addition happens only when carriers overlap in time. To keep peak levels below the return laser's clipping level, subcarrier levels must be kept lower than in a system using single-carrier modulation. As the subcarrier level is reduced, the subcarrier-to-noise ratio degrades, increasing the BER.

Bandwidth efficiency: If all subcarriers use the same modulation type, MCM provides the same bandwidth efficiency as that modulation type. However, a variable-constellation MCM can be made much more bandwidth-efficient than single-carrier technologies by assigning a higher-level constellation to subcarriers for which channel conditions are favorable.

Application suitability: MCM's effect on the signal-path delay depends on the transport protocol and on the amount of processing required to implement the orthogonal transform. Variable data rates can be achieved by varying constellation density and subcarrier allocation.

Risk: MCM's risk profile is higher because of its complexity. A variable-constellation MCM is yet to be proven in a real system, and peak-power compression issues could be significant.

Another risk factor is subcarrier synchronization. In an MCM signal, all subcarriers have a certain phase relationship, which should be preserved in the demodulator; otherwise, they lose a mutual orthogonality, which results in a BER degradation. In multipoint-to-point systems, different subcarriers will arrive at the demodulator from different network termination units. Their phase relationship should be as if they had originated from the same source, requiring a precise ranging of the network termination units.

Equipment availability: A number of companies are working on equipment to accommodate MCM technology, but solutions are not yet widely available. Implementing MCM is complicated, even for point-to-multipoint systems, where this technology is currently used. The IEEE 802.14 committee has formed a group to analyze MCM as a modulation choice for the next generation of cable modem products.

Power consumption: MCM modulators and demodulators consume a moderate amount of power. MCM modulators require complex, high-speed orthogonal-transform processors, which increase power consumption.

Cost: MCM modulators, which can generate a large number of subcarriers, are more complex and more expensive than simple QPSK or QAM modulators. Also, channel linearity requirements may be higher, increasing MCM system costs.

Finally, the management of a variable-constellation MCM can impose further costs.

✔Spread spectrum/CDMA. Direct-sequence spread spectrum/CDMA systems can offer superior resistance to impulse noise and interfering signals. Spread spectrum systems don't have to switch frequencies as MCM or TDMA systems do. However, this resistance may not be sustained for moderately loaded channels. Spread spectrum bandwidth efficiency is comparable to that of single-carrier TDMA systems, but complexity is significantly higher.

Robustness: The robustness of a spread spectrum system depends on the constellation size (QPSK, 16 QAM, etc.) and on the processing gain (a ratio of the chip rate to the data rate). Spread spectrum robustness is very good, but it may not be sustained for a moderately loaded channel because each additional user increases the total transmitted power. To keep the total power constant, each spread signal level has to be reduced.

Bandwidth efficiency: Because each individual spread spectrum signal's bandwidth efficiency is very low, bandwidth efficiency should be defined for the whole channel. Efficiency depends on the total number of users able to access the channel simultaneously, while maintaining a required level of robustness. It is comparable to the bandwidth efficiency of single-carrier TDMA systems employing the same modulation constellation.

Application suitability: Signal-path delay depends on the transport protocol. Using interleaving may be unacceptable for telephony. Variable data rates can be obtained by assigning to a subscriber a variable number of data streams, each of which uses its own spreading code.

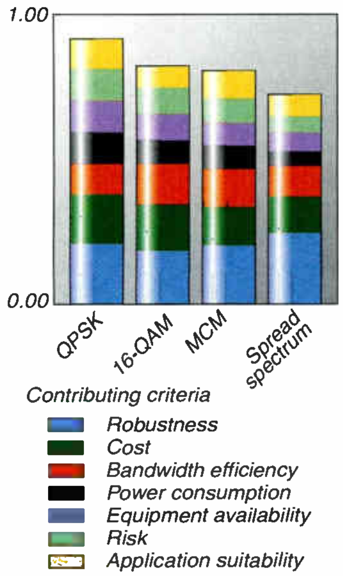
Risk: Spread spectrum systems are complex and are only beginning to be tested in the field. Like MCM systems, they are under consideration within IEEE 802.14.

Equipment availability: Not many spread spectrum systems are currently available for upstream communications.

Power consumption: Because of their complexity, spread spectrum modems consume more power than single-carrier modems. In addition, because each modulator requires its own demodulator, total power consumption is considerably higher.

Cost: Spread spectrum equipment costs are

Figure 4: *Given the weights and scores assigned, QPSK emerges as the preferred technology. This stacked bar graph shows how much each criterion contributed to the total decision scores.*



relatively high. Maintaining the orthogonality between the spreading codes requires a precise control of the power levels of spread signals. In addition, if a system uses synchronous spreading codes, it has to provide accurate ranging. Also, wideband equalizing is needed. And each modulator requires its own demodulator.

System maintenance costs vary with channel loading; as the number of simultaneous users increases, the CNR requirements–and the related system maintenance costs–also increase.

Choosing a technology

Once the modulation technologies have been evaluated, it's time to weigh particular system requirements against the advantages and disadvantages of each technology.

Faced with a complex decision, most of us rely on experience, advice, and intuition. Without necessarily being aware of it, we generally follow a predictable process, which researchers have studied for years and which software developers have incorporated into programs designed to help people formulate and analyze decisions. This decision process consists of a progression of logical activities like this:

✔Identify the criteria to be considered, and decide which are the most important.

✔Determine the alternatives you will choose from, and evaluate the strengths and weaknesses of each.

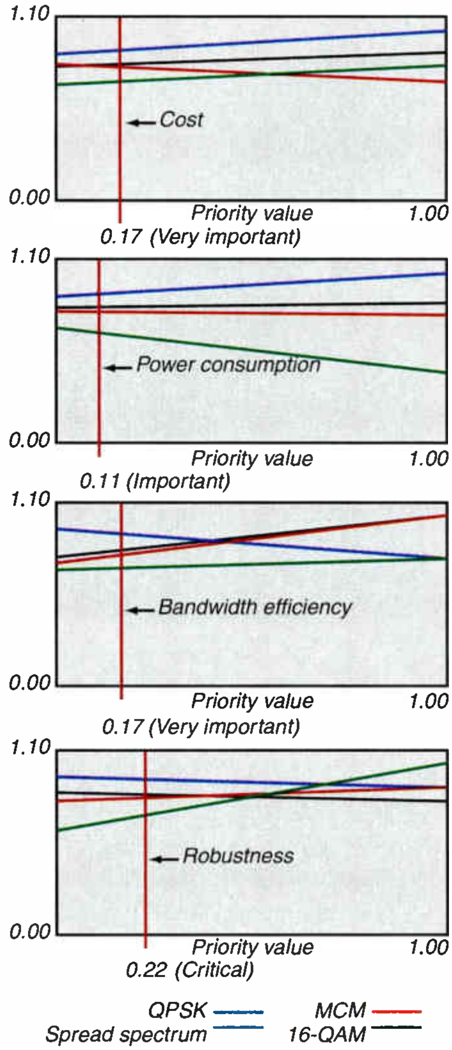
✔Synthesize all factors to see which choice makes the most sense.

It's perhaps in the synthesis of all the decision factors that computers contribute the most value, applying sophisticated, proven, mathematical techniques to take some of the guesswork and mystery out of the decision process. Because all decision-related factors are stored in memory, it's easy to alter any of the factors and see how the changes affect the results. In the end, of course, you control whether or not you accept the results.

For the purposes of this article, Criterium DecisionPlus software was used to show how software might help select a modulation technology.[1] Keep in mind that these illustrations are just based on an example. For one thing, scores assigned when rating the technologies are based on the authors' judgments of the technologies; these numbers are not "hard-and-fast." Also, the weights assigned when rating system-operator priorities are intended to be representative only; priorities will be unique to each operator.

Building the hierarchy: The first task in the software-assisted decision process is to build a hierarchy, a structured representation of all the factors to be considered. The type of hierarchy used in this example, called a "value tree" or "objective hierarchy," is built from left to right.

Figure 5: *These sensitivity graphs show what would happen to each technology's total decision score if we increased or decreased, one at a time, the weights assigned to robustness, bandwidth efficiency, power consumption and cost. In the case of cost or power consumption, QPSK remains the preferred technology regardless of the weight assigned to these criteria. In the case of bandwidth efficiency or robustness, all other criteria would have been deemed insignificant to increase the priority value enough that other technologies would be preferred over QPSK.*



It consists of a goal, decision criteria, attributes for those criteria, and alternatives (see Figure 1).

First, the goal was to choose a technology. Next the criteria to be considered were identified: bandwidth efficiency, application suitability, risk, equipment availability, power consumption and cost.

Then, each criterion was broken down if necessary into attributes that could be compared objectively.

Finally, the alternatives were listed; namely, the four technologies. The software then generated a "spider web" drawing showing the links between the decision-related factors, graphically revealing the true complexity of the decision at hand.

Rating the hierarchy: Once the hierarchy is built, the next step is rating the hierarchy. This step actually consists of two parts: (1) assigning weights to the criteria and their attributes based on the operator's priorities and (2) assigning scores to the alternatives (in this case, the technologies) based on their inherent advantages and disadvantages.

The longest chapter in the DecisionPlus user's guide is on rating the hierarchy. For now, the main thing to understand is that a *weight* refers to a value you assign to a given *criterion* or *attribute* with respect to its parent (the item it links back to in the hierarchy), reflecting that criterion's relative importance to the system operator. A score, on the other hand, refers to a value assigned to an *alternative* with respect to one of the attributes or lowest criteria (the items it links back to in the hierarchy) reflecting that alternative's relative strength or weakness in that area.

When weighting criteria and attributes, we chose a scale of 0 to 100, with 100 being critically important to the system operator, and 0 being unimportant to the system operator. Once these weights had been entered, the software normalized them, converting them into priorities on a scale of 0 to 1 (See Figure 2).

When assigning scores to the technologies, a scale of 0 to 100 was chosen, with 100 being highly favorable, and 0 being unfavorable. Once the scores had been entered, the software again normalized them (See Figure 3).

Reviewing the results: After rating the hierarchy, the next step is to review the results to see which alternative comes out ahead. First, the results were reviewed in bar graph form (see Figure 4), and QPSK emerged as the preferred technology. However, it remained to be seen whether QPSK would retain its lead if the assigned priorities were changed.

Next, the results were reviewed in the form of "sensitivity" graphs focusing on key criteria: robustness, bandwidth efficiency, power consumption and cost (see Figure 5). These graphs showed at what point, if at all, a technology other than QPSK would be preferred if that particular criterion's relative importance was increased or decreased. The cumulative effect of reviewing these sensitivity graphs was a resounding confirmation–for the particular weights and scores assigned–that QPSK was the technology of choice. CED

Footnotes

1. Criterium DecisionPlus is a trademark of InfoHarvest Inc

Why reinvent the deployment wheel?

CableLabs' new guide passes on deployment experience, expertise

By Michael Lafferty

It seems things are moving so fast in the broadband industry that it's sometimes hard to even catch your breath. That's especially true when it comes to upgrading systems in preparation for deploying enhanced services like high-speed data, digital TV and even telephony.

A group of dedicated professionals, representing their member companies at CableLabs, have taken it upon themselves to take the time to stop, look and listen to what they've all done and write down some of the hard lessons they've learned while deploying these new services. The result will be a new ring-bound reference source entitled "The Enhanced Services Deployment Guide."

The members of the Enhanced Services Deployment Group are leading the charge in developing new revenue streams for their respective companies. Tony Werner, senior vice president of engineering and technical operations for TCI and chair of the working group, thinks the Guide will serve a number of uses for a variety of operators, large and small.

"It's turned out," says Werner, "to be a pretty practical guide that goes through headends, network architectures, the services, customer premises and training, among other things. It will be really useful to the smaller member companies who are just getting their feet wet in some of these services. I think it will also promote some consistency in how people wire their headends, how they ground, how they do other things. That's a benefit to all of us."

The Guide will be published in two sections. The first section, which is targeted for an end-of-year mailing to approximately 3,000 member representatives, will include detailed chapters on physical plant issues, headends and network operations centers. It will also include an exhaustive resource appendix which lists and details cable modem suppliers, digital set-top suppliers, cable telephony suppliers, system integrators and training suppliers.

The second section, which is scheduled for a first quarter 1998 mailing, will include chapters on customer premises equipment (e.g., modems, set-tops, NIUs, etc.), training and the enhanced services themselves.

According to Doug Semon, director of network operations at CableLabs, the Guide is targeted at the heart of the MSO management structure. "First of all," says Semon, "none of this is theoretical stuff. It is all based on actual work experience, from those member companies that did trials and early deployments of these services. It's targeted to the plant manager, chief engineer in the headend, service manager, installation manager types and up, through and including the general manager.

"The point of the Guide is to provide a practical 'how to' for planning, launching and maintaining enhanced services. To help those system-level people avoid the same steep learning curve and costly mistakes others made doing the trials."

Mark Davis, director of engineering for telephony technology for Cox Communications, was one of the contributors on the headend chapter. Considering he's involved in a multi-million-dollar headend upgrade effort for Cox (70+ buildings nationwide), he and others are bringing a wealth of hands-on experience to the Guide.

"We contributed a very large chunk of that chapter," says Davis, "mainly because we've implemented a nationwide program to upgrade all of our headends and hubs for additional space, and to be 100 percent reliable and meet Network Equipment and Building Specifications (NEBS) from Bellcore.

"I think one of the most important paradigm shifts in cable," says Davis, "is going to be in the bonding and grounding systems that we have in headend buildings. We cover all that in very great detail, all the way down to which wire you put on the ground bar, and at what point, and the order in which you do that.

"Up to now, the grounding design has basically been a braid of wire underneath the raised floor that was just connected with a split bolt to every rack. And we've been doing just fine because the RF gear has been pretty robust.

"But now you have all the microprocessor-based gear, including the RF side, the phone and modems, and even the new lasers, receivers and modulators. And they've become very static and surge sensitive. So we spent a lot of money and time evaluating and developing a bonding and grounding design."

Because technology is moving so fast, especially in telephony, working group members have committed themselves to authoring a major revision of the Guide in about a year's time. With all the standardization efforts going on in the industry, it will be nice to see a major part of the industry reading and learning off of the same page. CED

PHOTOS BY BOB SULLIVAN

Regulatory goo buys more time for groups to craft LMDS plans

Delay in auctions could be blessing in disguise

ILLUSTRATIONS BY ROB PUDIM

By Fred Dawson

The movement of terrestrial wireless broadband technology into commercial deployment is shaking up thinking in the telecommunications arena just as the moment has arrived when decisions must be made regarding soon-to-be auctioned LMDS spectrum.

"We have about two weeks to go before we have to reach a decision on LMDS, so there's a lot of focus on the question," said one official at US West Communications, speaking on background last month just prior to a decision by the FCC to delay the auctions for local multipoint distribution services 60 days to February 10. With that delay, US West and anyone else trying to figure out what to do with the technology had a little more time to sort things through.

But, with WinStar Communications Inc. and Teligent Inc. already committing to deployments of broadband wireless networks on a wide scale, and many other firms well along in their examination of new interactive point-to-multipoint iterations of the technology, companies not prepared to act on the availability of 1.3 GHz of spectrum for LMDS networks have little time to come to grips with the full implications of these latest advances. By all indications, the implications are significant, extending not only to newcomers to the local access market, but to incumbents who might be seeking low-cost ways to expand the reach of broadband connectivity in their existing markets as well as new ones.

First displayed to a wide audience at this year's SuperComm convention last June, the new generation of interactive, point-to-multipoint wireless broadband technology uses gallium arsenide instead of silicon in microprocessors to support solid-state rather than traveling-wave-tube-amplified transmissions at the LMDS 28 and 31 GHz tiers, and at other high-level frequencies as well. Teligent has committed to spending $780 million over five years on solid-state broadband gear operating at 24 GHz, while WinStar was scheduled to have gotten underway this month with an initial installation as a prelude to company-wide rollout in mid '98.

In both cases, the supplier of the radio equipment for the initial rollout stages is Winnipeg-based Broadband Networks Inc., with Nortel serving as integrator and supplier of switching and backbone equipment for Teligent, and Siemens Telecom Networks Inc. playing that role for WinStar. BNI packages application-specific integrated circuits devoted to QAM (quadrature amplitude modulation), ATM (asynchronous transfer mode) and other capabilities into small solid-state transmitter/receivers that can be roof or window-sill mounted, providing a full two-way broadband connection for delivering any type of voice, video or data.

Nortel, acting ahead of a scheduled IPO by BNI, has tendered an offer for all the firm's shares, now privately held, in a deal valued at $416 million. "We've grown very confident in the reliability of wireless as a viable alternative to fiber," said Guy Gill, vice president and general manager of access networks at Nortel, which has been operating a demonstration network involving a single hub and multipoint connections to 10 buildings in Dallas.

"We expect Teligent to launch in 10 markets in '98 and to be in up to 30 by the end of '99, based on its filings with the Securities and Exchange Commission," Gill said.

"We see a huge market for fixed wireless access and are gearing up accordingly."

As with any new technology, cost is the key to success, assuming everything works as billed, and, in the case of gallium arsenide, the signs are positive, based on the track record so far, said Sanjay Moghe, director of advanced microwave technology at Northrop Grumman Corp. Users of the technology in wireless broadband can expect the type of cost decline seen in radar detectors, which use chips that once cost hundreds of dollars, he said.

Already the firm is supplying a single chip that performs all transceiver functions for LAN applications at the 24 GHz frequency range, and this design can be readily applied to 28 GHz or other frequencies in the wide area, Moghe noted. "This chip can be had for just a few dollars in very large quantities," he said, adding, "You will see costs come down drastically for LMDS as volume goes up."

The 60-day delay in the LMDS auctions, which will allocate blocks of 1,150 MHz and 150 MHz in each of 498

Reader Service 50

basic trading areas nationwide, is beneficial for everyone, including big players who are suddenly waking up to the potential of wireless broadband, noted David Mallof, president of WebCel Communications Inc. "Big companies can't move very quickly when they're looking at what could be a $500-million venture," he said.

> **'Big companies can't move quickly when they're looking at what could be a $500-million venture' –Mallof**

Just who is planning to use LMDS spectrum remains almost as uncertain as ever, despite the imminence of the auctions. So far, the known players consist of startups with intent to build networks and speculators who believe they can pick up spectrum cheaply before the market heats up.

US West, GTE Corp., SBC Communications, Bell Atlantic and BellSouth have had hands-on experience testing LMDS, but how avidly they pursue the technology largely depends on whether they can persuade a U.S. appeals court to overturn an FCC rule banning their use of the larger LMDS spectrum block within their operating territories for three years after initial licensing. "You don't have to be all that out-front at this point if you've gotten to where you understand the basics and are just waiting for the technological and cost pieces to come together," said an executive at one of the interested telcos, asking not to be named. "We've kept up with the technology and think there's plenty of time to prepare for auctions, because we think the court will decide in our favor."

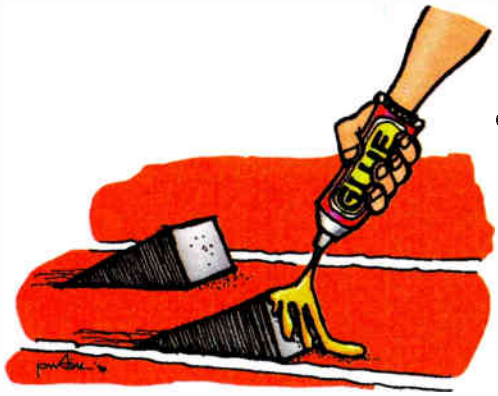
Equally unclear was the extent to which long distance carriers and CLECs (competitive local exchange carriers) would pursue LMDS spectrum. Officials at AT&T, which has made a commitment to proceeding with wireless access for local phone and data services using advanced fixed services technology over PCS and cellular spectrum it already holds, have signaled an interest in LMDS, but there was speculation that the carrier might attempt to acquire WinStar, rather than go after the new spectrum.

MCI, now agreeing to be joined with WorldCom Inc. in a firm to be called MCI WorldCom, has also looked at LMDS but has indicated it might sit out LMDS auctions in favor of buying or leasing the spectrum later. WorldCom was not known to have had any experience with testing LMDS but, like other carriers, was said to be awakening to the possibilities following the Teligent and WinStar purchase decisions.

As for cable operators, with the ban on access in-territory to the larger LMDS block, they would be limited to using only 150 MHz, unless the telcos win their case.

Nonetheless, sources said operators were beginning to pay attention to the technology, recognizing that even the limited B block of LMDS spectrum might be useful in getting high-speed data and/or voice services to business pockets that are not passed by cable plant.

The big prize most potential users of wireless broadband technology are targeting ahead of everything else is the same one Teligent and WinStar have their sights on–the small- and medium-size office market, where economies of



scale allow broadband services to be delivered to multiple smaller companies as well as fairly large companies in office complexes not connected to fiber links. WinStar, for example, has been aggressively amassing spectrum over the past three years with a goal of delivering point-to-multipoint wireless broadband services to a very large customer base in this market, just as soon as the technology was mature enough to deploy, said David Ackerman, executive vice president of WinStar.

'The most difficult aspect of making use of this technology is systems integration' –Ackerman

"Eventually we expect to be 100 percent point-to-multipoint in our network configuration with hubs positioned to serve the lion's share of our targeted market base in all our cities," Ackerman said. The FCC, in November, cleared the way for WinStar by authorizing point-to-multipoint and aggregation of bandwidth for such uses at 38 GHz.

The company has an average of five 100-MHz blocks at 38 GHz in each of its 160 markets, 21 of which are now operational with point-to-point services, and holds 600 to 700 MHz per market in the largest markets, including New York and Los Angeles. Ackerman said feedback from within the FCC suggests the agency plans to go forward with the long-anticipated auction of an additional 1.4 GHz of spectrum in the 38 and 39 GHz zones within the next year.

The new gear supplied by BNI and Siemens will deliver an OC-3 signal (155 Mbps) over each of the 100 MHz channels WinStar is licensed to operate in, offering bandwidth-on-demand to all users within reach of the signal. The system uses ATM to assign a dedicated data or voice stream to a particular user at whatever speed is necessary for the selected application within the OC-3 channel, leaving the rest of the channel for access by other users who are on that particular frequency block.

WinStar will enhance spectrum efficiency through use of sectorized antennas, dividing each service area into 90-degree segments so that any given frequency block can be used to serve four different clusters of users, Ackerman said. The company now has 5ESS high-capacity telecommunications switches operating in eight of its 160 markets and is acquiring 14 additional installed switches as part of a transaction with US One Communications Corp., he noted.

WinStar's move will soon be followed by several more commitments to deploying multipoint broadband wireless gear on the part of other operators in the 38 GHz spectrum block, said Doug Smith, vice president and general manager for BNI. "By December there will be quite a list of companies moving to this type of platform, which should provide convincing evidence that this technology is ready for commercial use," Smith said.

BNI's latest product advance involves fuller integration of end user functionalities into its terminals, which allows handoff of signals from the terminal to PCs, telephones and TV sets in native formats, thereby avoiding the need to equip each device with interfaces to the ATM signal. While BNI's system works with standardized ATM applications, it uses proprietary interfaces to accomplish the difficult feat of over-the-air transmission in the ATM mode.

Ackerman estimated that WinStar is two-and-a-half to three years ahead of its competitors in wireless broadband. "The most difficult aspect of making use of this technology, now that it is available, is systems integration, where you can interface billing, provisioning and network management systems to really take advantage of what the network technology can do," Ackerman said.

While WinStar has "some systems work" still to complete, Ackerman said the firm expects to have the OSS (operations support system) in place by the time it has satisfied its initial prove-in requirements with the first deployment. But LMDS operators are not without re-

sources in this regard as well, given the broad range of third-party systems integrators who are designing full service OSS for the broadband wireless environment.

"With wireless activity picking up in this area of fixed broadband connectivity, we believe there's going to be great demand for the types of services we provide," said Randall McComas, a manager within IBM"s telecommunications and media industries group. "We've worked with LMDS operators to develop a system that will be ready for use when they go into commercial operations."

The prospects of being able to deliver broadband services reliably enough to offer them as a viable alternative in the business market bodes well for early entry into the consumer market in some areas, Smith noted.

"Many of these (LMDS transmitter) cells where operators will be installing radios to meet commercial needs will also reach residential sectors," he said. "I think you'll see people taking advantage of that."

'LMDS can be all things to all people' –Allen

With use of sectorized antennas, which support reuse of the spectrum within multiple segments of the transmitter footprint, the 1,150 MHz of bandwidth in the A block of LMDS spectrum can deliver 5 gigabits per transmitter, according to specifications for service developed by WebCel Communications Inc., a Washington, D.C.-based potential bidder. But while most LMDS players readily acknowledge that these sorts of proportions will eventually position the technology as a major player in the mass market, they believe the best case for getting quick return on their investments is to go after high-end users, even if it means beginning with point-to-point implementations ahead of point-to-multipoint.

"There is a real question of whether LMDS operators will be best served by focusing on the large business market or targeting the residential and small business sectors," said Steven Warwick, CTO at WebCel. "We believe the opportunity to serve the SoHo (small office/home office) and telecommuter markets will come when costs for customer premises equipment get down to DBS-like levels. Until then, the residential sector is not the target."

While this cautious approach might make sense for startups looking to generate returns as quickly as possible, it should not be taken as the final word on the potential of LMDS, said Rosalind Allen, deputy chief of the Wireless Telecommunications Bureau. "LMDS is not going to be just another fancy CLEC (competitive local exchange carrier)," she said. "LMDS can be all things to all people. It is going to provide people with the type of instant one-stop shopping (for telecommunications and media services) that other competitors working through resale agreements, partnerships and other means are attempting to offer."

The only LMDS player so far voicing commitment to reaching the mass market with its services is the pioneer in the technology, CellularVision USA, now operating the only commercial LMDS system in the U.S. CVUS recently achieved a long-sought goal when the FCC turned its temporary waiver into a 10-year license covering a population base of 8.3 million people in the New York Primary Metropolitan Statistical Area.

CVUS CEO Shant Hovnanian said the license strengthens the company's bargaining position as it negotiates with potential partners that it might venture with in bidding for additional territories, including the remainder of the New York Basic Trading Area not covered by the PMSA. He noted that the Commission's newly-announced policy setting a 45 percent bidding discount credit for companies averaging $15 million or less in revenues over the past three years is also a boon to CVUS' position.

"Under the rules, we can have partners and still qualify for the credit as long as we're in voting control of the venture," Hovnanian said, noting that the rules only require that the small entity have a "substantial" rather than a majority equity stake in the enterprise.

CVUS offers 49 channels of television services in parts of New York City as well as a high-speed data service using telco return in Manhattan. The new license permits delivery of two-way, over-the-air services, which the company has said it will launch once the scale of national demand for LMDS services drives equipment costs to commercial levels.

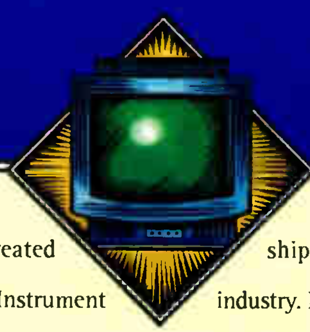
The firm now has 12 transmitters in operation, and by year's end, intends to have 19, providing coverage to much of Brooklyn, Queens and the Bronx as well as to 40 percent of the offices and homes below 72nd Street in Manhattan, Hovnanian said. The company is installing repeaters in high-rise areas as demand warrants to provide broader coverage, he added.

With the launch of 500 kilobit-per-second data service in Manhattan, using wireless downstream and telco return, the company hopes to demonstrate that this category of service can be a major force behind market acceptance of the technology. So far, response to the offering in the business community has been very strong, officials said, though they declined to break out data subscriber numbers from the total of 16,000 customers now reported to be taking CVUS' multichannel television services.

CellularVision co-founder and technology guru Bernard Bossard disputed assertions by some LMDS entrants that foliage blockage would limit usefulness of wireless broadband technology in the residential markets. "We have developed techniques that allow us to extend into the suburban neighborhoods, so that's not a big issue," he said.

CellularVision is preparing to implement a new, open technology licensing agreement with its technology affiliate CT&T which should allow broad access to CVUS solutions, such as repeaters and other means of extending into residential areas, Hovnanian noted. "Our patents and the patents we've applied for . . . are things people will need access to in order to operate LMDS economically," he said, naming Hewlett-Packard Co., Bosch Telecom Inc. and Stanford Telecom as some of the parties who appear interested in participating in an open licensing program.

With WinStar, Teligent and a host of other holders of spectrum outside the LMDS segment pushing ahead after the small- to mid-size business market, there's little reason to view LMDS as just another means of getting to this customer base, noted a senior vendor executive, asking not to be named. "The spectrum will be made available, and people will use it wherever they see an opportunity to offer services in under-served markets, and that means residential as well as business," he said. CED



WHAT'S AHEAD

DECEMBER

1 Introduction to Digital Video Systems, produced by Scientific-Atlanta Institute. Location: Atlanta. Call (800) 722-2009, press "3."

1-1/15 Return Path Test Seminar, presented by Hewlett-Packard. Call for dates and locations (800) 765-9200.

8-9 Fiber Optic Network Design, produced by Pearson Technologies Inc. Location: Washington, D.C. Call (800) 589-2549.

8-11 Hands-On Fiber Optic Installation for Outside Plant Applications, produced by Siecor Corp. Location: Hickory, N.C. Call (800) 743-2671, ext. 5539 or 5560.

15-18 Hands-On Fiber Optic Installation, Maintenance and Restoration for CATV Applications, produced by Siecor Corp. Location: Hickory, N.C. Call (800) 743-2671, ext. 5539 or 5560.

15-19 Advanced System Manager 10/20, produced by Scientific-Atlanta Institute. Location: Atlanta. Call (800) 722-2009, press "3."

JANUARY

6-8 Taiwan Broadcast and Communications '98. Location: Taipei, Taiwan. Call *Cable & Satellite Magazine* 011-886-2778-5818.

8-9 Telecommunications Fundamentals, produced by American Research Group. Location: Morristown, N.J. Call (919) 461-8600.

8-10 Caribbean Cable TV Association Annual Conference. Location: San Juan Marriott Resort, Puerto Rico. Call Margaret Dean, CCTA executive director (809) 776-3320.

21 Lincoln Land SCTE Chapter, Technical Seminar. Location: Bloomington, Ill. Call Kevin O'Neill (815) 433-1163 for more information.

26-27 Telecommunications Fundamentals, produced by American Research Group. Location: Chicago, Ill. Call (919) 461-8600.

26-29 ComNet '98. Location: Washington, D.C. Call MHA Event Management (800) 545-3976.

FEBRUARY

2-4 Wireless Cable International's Winter Show. Location: Singapore. Call the Wireless Cable Association (202) 452-7823 for additional information.

4 North Country SCTE Chapter, Technical Seminar. Location: Anoka and Wadena Technical Colleges, Minn. Topic: Transportation and distribution systems. Call Bill Davis (612) 445-8424.

8-11 CompTel '98. Location: Las Vegas, Nev. Call the Competitive Telecommunications Association (202) 296-6650 for more information.

8-12 1998 Western ComForum. Location: Dallas, Texas. Call the International Engineering Consortium (312) 559-4600.

10-12 Australasian Cable & Satellite Exhibition & Conference. Location: Sydney, Australia. Call AIC Conferences 011-61-2-9210-5700.

11 Delaware Valley SCTE Chapter, Technical Session. Location: Williamson's Restaurant, Horsham, Pa. Topic: Competitive access and business meeting. Call Chuck Tolton (215) 961-3882.

17-19 Philips Broadband Networks Mobile Training Center. Location: Albuquerque, N.M. Call (800) 448-5171, or (315) 682-9105.

22-27 OFC '98 (Optical Fiber Conference). Location: San Jose, Calif. Call the Optical Society of America (202) 416-1980 for additional information.

23-25 CTIA's Wireless '98. Location: Atlanta, Ga. Call the Cellular Telecommunications Industry Association (202) 785-0081.

24-26 Philips Broadband Networks Mobile Training Center. Location: San Antonio, Texas. Call (800) 448-5171, or (315) 682-9105 for additional information.

MARCH

2-5 Hands-On Fiber Optic Installation for Outside Plant Applications, produced by Siecor Corp. Location: Hickory, N.C. Call (800) 743-2671, ext. 5539 or 5560.

4-7 Seoul Cable & Satellite '98. Location: Korea Exhibition Center, Seoul, Korea. Call 011-82-2-551-1147.

11-13 Eighth Annual Northern California Vendors' Day. Location: Concord, Calif. Call Steve Allen of Roseville Telephone (916) 786-4353.

3/29-4/2 IN ComForum. Location: Orlando, Fla. Call the International Engineering Consortium (312) 559-4600.

APRIL

6-9 NAB '98. Location: Las Vegas, Nev. Call the National Association of Broadcasters (202) 775-4970 for more information.

Trade shows

December
10-12 The Western Cable Show. Location: Anaheim, Calif. Call the CCTA at (510) 428-2225.

January
8-11 Consumer Electronics Show (CES). Location: Las Vegas, Nev. Call (703) 907-7600.

28-30 SCTE Emerging Technologies Conference. Call the SCTE at (610) 363-6888.

February
25-27 The Texas Cable Show. Location: San Antonio, Texas. Call (512) 474-2082.

March
TBD SCTE Telecommunications Vendors Day. Location: Omaha, Neb. Call Riser Bond Instruments (402) 466-0933.

April
20-23 COMDEX Spring '98. Location: Chicago. Call Softbank (617) 433-1500.

May
3-6 National Show '98, produced by the National Cable Television Association. Location: Atlanta. Call the NCTA (202) 775-3669.

June
10-13 SCTE Cable-Tec Expo '98. Location: Denver, Colo. Call (610) 363-6888.

Cable TV surface mount diplexer

SALISBURY, Md.–K&L Microwave Inc. has announced a cable TV surface-mount diplexer, manufactured by its Kel-Com products division. Model number SD-631/700 has specifications including a 1 dB maximum

K&L Microwave's surface-mount diplexer

insertion loss from 5 to 631 MHz, and from 770 to 860 MHz. Return loss across each passband is a minimum of 20 dB. Stopband rejection is 45 dB minimum from 5 to 631 MHz and 770 to 860 MHz. Maximum group delay variation in any 15 MHz band from 554 to 631 MHz and 770 to 815 MHz is 4 nanoseconds. Minimum crossover isolation is 30 dB. Outline dimensions are 1.75 inches L x 0.70 inches W x 0.50 inches H in a leadless surface-mount configuration.

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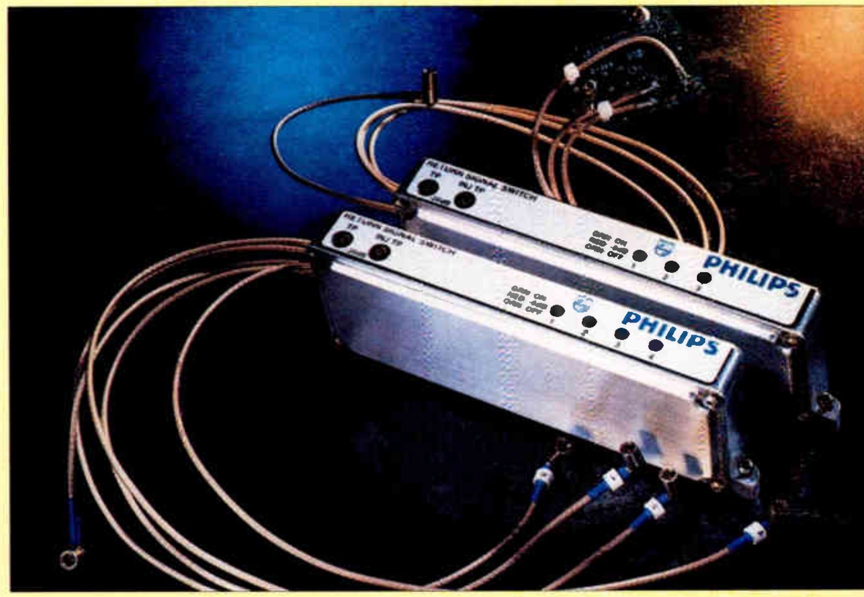


Return signal switch

MANLIUS, N.Y.–Philips Broadband Networks has introduced the flexible Return Signal Switch (RSS), which effectively manages and controls upstream traffic in the return path, for enhanced signal clarity and improved system integrity. Designed for use in optical stations or four-port optical node amplifiers, the RSS module accepts analog and digital signals from up to four individual return paths, and is a

Optical test system module

VANIER, Quebec–Exfo E.O. Engineering Inc. has introduced the IQ-3400 PDL/OL meter module as part of the IQ-200 Optical Test System. The new meter measures polarization dependent loss, insertion loss, optical return loss, coupling

Exfo's IQ-3400 PDL/OL meter module

ratio, and excess loss in passive components such as attenuators, isolators, couplers, Bragg components, connectors and switches.

The new IQ-3400 PDL/OL meter setup consists of a polarization controller and Fabry-Perot laser source at either single- or dual-wavelengths. Resolution is 0.001 dB in the 1200 nm to 1625 nm measurement range, and measurement speed is five seconds, with 4,000 samples per second. Test functions include PDL, PDCR, PDEL, ORL, insertion loss and source reference power measurements. Statistical tools such as standard deviation, averaging, and a graphical interface allow long-term statistical analysis of PDL behavior under changing conditions. Together with the GPIB-compatible IQ-200 Optical Test System, the IQ-3400 is an integrated turnkey solution within a user-friendly, Windows environment, complete with MAESTRO software applications adapted to a multitude of fiber testing needs.

Circle Reader Service number 102

Cable-in-conduit

HICKORY, N.C.–CommScope Inc. has announced the ConQuest "cable-in-conduit," a total package system which consists of factory pre-assembled CommScope cable in select grade high-density polyethylene conduit. Any of CommScope's outdoor cable products can be paired with a complete line of conduit sizes, ranging from 13 mm to two inches.

ConQuest "cable-in-conduit"

ConQuest offers the following features: chemical resistance; an internal lubricant to enhance cable removal and replacement; a lower coefficient of friction and moisture than traditional PVC stick pipe; it will not crack during storage or when used as a ground riser; it eliminates the need for field installation of cable, because the conduit comes pre-installed with CommScope cable; it installs faster than PVC; and it's easy to plow and needs no coupling or glue, according to the company.

Circle Reader Service number 103

Optical node

SUNNYVALE, Calif.–Harmonic Lightwaves Inc. has announced the PWRBlazer Mini Node, model HLR 3811, an optical node receiver for cable operators and telecommunications com-

Philips Broadband Networks' Return Signal Switch (RSS)

user-friendly tool for isolating noise ingress in upstream traffic. If noise is present in the return system, each individual return leg can be attenuated by 6 dB to determine if it is carrying the noise ingress. Then, the offending return leg can be shut down until the noise source is found, allowing the remaining legs to continue functioning.

The RSS works with a FOTO transponder and an element management system for remote monitoring and control of the return path. Automatically addressed and configured, the RSS simplifies installation and operation, and the unit's fast, solid-state switching accommodates both telephony and video applications.

For simplified monitoring, the front panel of the RSS features three LEDs, each corresponding to a return signal and its switch (green indicates "on," red indicates 6 dB down attenuation, and orange indicates "off"). A -20 dB test injection point for system diagnostic purposes, and a -20 dB output test point for measuring output signal level, are easily accessible on the module.

Circle Reader Service number 100

panies which are installing broadband overlays. The node features a single trunk level output and supports return path and network management through a return transmitter, a status transponder and an automatic gain control card (AGC). With a bandwidth which extends to 870 MHz and several forward/return frequency splits, the HLR 3811 can support cable and telecom networks worldwide.

The node has a flexible feature set that is easily integrated into new or existing network architectures, according to Harmonic. The node is suited for fiber-rich architectures, such as fiber-to-the-curb or fiber-to-the-building; for operators employing fiber overlay of trunk routes; and for networks in which an amplifier closely follows the receiver. The product will be available in the first quarter of 1998.

Circle Reader Service number 104

New software enhancement

SARASOTA, Fla.–Superior Electronics Group Inc. has released its new Spectrum 1000 software application to enhance operators' access to Cheetah spectrum analyzers throughout their broadband networks.

The Spectrum 1000 software is a standard feature of Superior's CheetahNet software application, and it is also available as a stand-alone application for use with Superior's Cheetah Director Software. As a stand-alone application, users can run Spectrum 1000 on a Windows 95 operating system.

With the Spectrum 1000 software as part of the Cheetah system, operators can view real-time spectral plots and take real-time interactive measurements from Cheetah spectrum analyzers anywhere in their hybrid fiber/coaxial plants. Spectrum 1000 communicates with Cheetah HE-1000 Headend Spectrum Analyzers and PC-1000 Strand Mount Spectrum Analyzers throughout the entire HFC domain–regardless of their physical location.

Circle Reader Service number 105

Multi-function combiners

CORAL SPRINGS, Fla.–VisionTeq has introduced two new multi-function headend combiner units. The RCD 1001 is designed for return path signal processing and has 16 discrete inputs and outputs. Additional features include

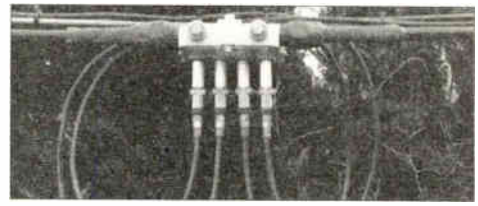
VisionTeq's headend combiner unit

group (eight) and sub-group (four) outputs, front panel monitoring and test signal insertion facilities. The FCD 1001 provides high isolation and is an active unit for use in the forward path of HFC networks. It has eight outputs and has been designed to allow for flexible signal insertion/deletion and narrowcasting facilities.

Circle Reader Service number 106

Fitting protection

LAKEWOOD, Colo.–Telecrafter Products has redesigned its Fitting Saver–now, the unit not only saves the cost and hassle of a fitting replacement, but it also helps eliminate noise ingress through drops that are temporarily disconnected in the field, according to the company. With its pre-positioned rubber washer, the Fitting Saver protects exposed fittings and drop cable from adverse weather conditions and accidental damage while drops are disconnected. Because there is no need to cut off and replace fittings with each disconnect, the Saver saves



Telecrafter's Fitting Saver

time and money in the field by reducing waste and shortening service time, says Telecrafter.

Circle Reader Service number 107

Swing gate rack

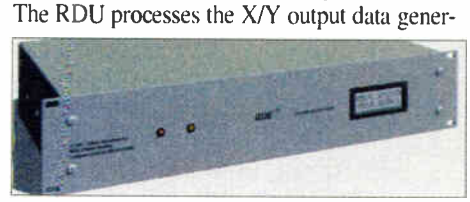
RIVERDALE, N.J.–DataTel Corp., a division of Middle Atlantic Products Inc., has introduced a new series of swing gate racks which utilize an open wall-mount design that allows equipment to be easily swung out into the open. Equipped with an abundant number of tie points and velcro loops to neatly control and route even challenging cable bundles, each rack is capable of holding up to 150 pounds of components. Because of a sturdy positive stop, punching down is no problem, even in a fully open position. Models are offered in 12- and 18-inch depths, with heights of two or three feet.

DataTel's SGR-20-18 swing gate rack

Circle Reader Service number 108

Test equipment

ISLANDIA, N.Y.–Cable Resources Inc. has introduced its Return Display Unit (RDU), a new piece of headend test equipment that allows system installers and technicians to view (on any TV screen) the RF levels, ingress and noise present back at the headend from a subscriber's home, system amplifier, feeder tap or fiber node. The RDU processes the X/Y output data gener-



Cable Resources' RDU

ated by an internal spectrum analyzer and converts it to NTSC video for input to a standard cable TV modulator. A data output allows the analyzer screen to be viewed on a computer, the same as the video, in real time.

Circle Reader Service number 109

Advanced Networking

C-COR Electronics, Inc. Circle # 15, 72
C-COR's RF amplifiers. AM headend equipment, digital fiber optics, and customized service and maintenance provide global solutions for your network. p. 29, 11A

NextLevel Systems, Inc./Broadband Networks Group Circle # 31
GI/NextLevel Broadband Networks Group is a worldwide market leader in digital and analog set-top systems for wired and wireless cable television networks. p. 55

NextLevel Systems, Inc. (Corp. HQ) Circle # 54
GI/NextLevel Broadband Networks Group is a worldwide market leader in digital and analog set-top systems for wired and wireless cable television networks. p. 101

Passive Devices Inc. Circle # 27 p. 51

Construction Equipment

Cable Prep ®/ Ben Hughes Comm. Products Co. Circle # 32
CABLE PREP®, a Ben Hughes Communication Products Co., is a leading designer and manufacturer of hand tools for the broadband industry. p. 60

CommScope, Inc. Circle # 7
CommScope: ISO 9001 registered manufacturer of a comprehensive line of coaxial and fiber optic cables for all telecommunications applications. p. 12-13

Telecrafter Products Circle # 5
Supplies drop installation products for CATV, DBS, and wireless operators, single and dual cable fastening products, identification tags, residential enclosures. p. 10

Datacom Equipment

Terayon Communication Systems Circle # 4
Terayon Communication Systems delivers high-speed, two-way cable modem systems — based on S-CMDA technology — that operate over *any* cable plant and support both business and residential services. p. 9

Distribution Equipment

Alpha Technologies Inc. Circle # 3
World leading manufacturer of power conversion products, widely used in cable television, telecommunications, and data networks around the world. Offer a complete line of AC and DC UPS systems. p. 7

Exide Electronics, Emerging Technologies Group Circle # 59
Our Lectro brand is the industry's first true uninterruptible power supply, provides innovative decentralized and centralized power solutions for CATV and high-speed data networks. p. 66-67, 47A

Lindsay Electronics Circle # 25, 26, 57
Focused on the last mile, our revolutionary new technology creates 1 GHz communication amplifiers, passives, taps, and subscriber materials to solve system problems before they become subscriber problems. p. 48, 49, 111

Philips Broadband Networks Circle # 24, 60
A global supplier of broadband RF and fiber optic transport equipment, is also a leading provider of advanced systems used to access broadband telephony and data services. p. 46-47, 48A

Times Fiber Communications, Inc. Circle # 29
TFC is an ISO 9001 registered manufacturer of coaxial cable for the telecommunications industry. Committed to quality, service and technology. p. 59

Trilogy Communications, Inc. Circle # 10
ISO-9001 manufacturer of low-loss coaxial cable. Full line including air dielectric trunk and feeder, UL listed and corrosion protected drop, radiating and 50 ohm for wireless. p. 19

Distributors

ITOCHU Cable Services Circle # 9
iCS, Inc. is a leading full service stocking distributor. iCS operates ten sales offices and nine warehouses conveniently located in North and South America. p. 17

Power & Telephone Supply Co. Circle # 17
Power & Telephone Supply serves the power and communications material distribution needs of the U. S. through 18 strategically placed stocking warehouses, including a specialized export facility in Miami, Florida. p. 32

Teledyne Battery Circle # 47 p. 89

TeleWire Supply Company Circle # 12, 73
TeleWire Supply is a leading nationwide distributor of products needed to build and service a broadband communications network. p. 23, 15A

Fiber Optic Equipment

Corning Incorporated Circle # 16, 20
The Corning Optical Fiber Information Center gives you FREE access to the most extensive fiber-optic library in the industry. p. 31, 36-37

Synchronous Group, Inc. Circle # 22
The Actair and Antares 1550 nm external modulation transmitters offer outstanding performance and the best specifications in the industry. Perfect for super trunks and direct distribution. p. 43

Pirelli Cable Corp. Circle # 11
Leading manufacturer of fiber optic loose tube, ribbon, interconnect, and distribution cables. Supplier of connectivity systems including connectorized cable assemblies, drop cable, distribution panels, adapters, and optical fiber access tools. p. 21

Qualop Circle # 41
Silicon Valley Communications Group: Full two-way optical transmission products including 1550 and 1310 nm transmitters, EDFAs and receivers with Network Management System. p. 79

Headend Equipment

ADC Telecommunications, Inc. Circle # 1, 71
Leading global supplier of transmission and networking systems. The company holds a pre-eminent market position in physical connectivity products for fiber optic, twisted pair, coaxial and wireless networks worldwide. p. 2-3, 7A

Barco, Inc. Circle # 30
BARCO's Gemini Upconverter is an ideal alternative to conventional modulators for hub site headends, accepts digital or analog IF inputs and saves cost and space. p. 57

Blonder Tongue Circle # 23
Quality manufacturer of headend equipment (including pre-fabricated headends), reception, distribution, MDU interdiction products and test equipment. p. 45

Dawn Satellite Circle # 69
Dawn Satellite offers technical information and competitive prices on products such as: satellite "dish" antennas, satellite receivers, digital ready LNBs, modulators, processors and a wide variety of related products. p. 111

FrontLine Communications Circle # 33
FrontLine Communications manufactures patented, field proven, Emergency Alert and PC-based Character Generator products to fulfill the needs of cable and other multichannel system operators. p. 61

Harmonic Lightwaves, Inc. Circle # 8, 66
Worldwide supplier of highly integrated fiber optic transmission, digital headend and element management systems for the delivery of interactive services over broadband networks. p. 15, 2A

Microwave Filter Co., Inc. Circle # 58, 74
Passive electronic filters, traps and filter networks for interference elimination and signal processing at the TVRO, headend and distribution equipment. p. 111, 19A

Pico Macom Inc. Circle # 34
Pico Macom offers a full line of quality headend components including satellite receivers, agile modulators and demodulators, signal processors, amplifiers, and completely assembled headends. p. 63

Quintec Circle # 70 p. 113

Scientific-Atlanta Circle # 62
Scientific-Atlanta's new Continuum™ Headend System for analog and digital applications. This features a vertical packaging design which allows for up to forty front-loaded modules to fit into a standard 70" rack. p. 132

SkyConnect Circle # 37
SkyConnect meets the demands of the growing cable advertising industry by offering the most complete digital advertising solutions available. p. 122

Trompeter Electronics, Inc. Circle # 49, 63

Trompeter is the premier US manufacturer and supplier of innovative, robust design RF interconnect products to the telecommunications and broadcast markets. p. 93

Spectrum Circle # 65

The Sub-Alert utilizes the advanced features of the Sage Endec for total automation and will interface with your headend by IF, baseband video or comb generator. p. 34-35, 82

Interactive Media

Communications Information Software (CIS) Circle # 21

Communication & Energy Corp. specializes in channel deletion filters. These delete an incoming channel for reuse by other programming in headends, schools, apartment complexes or motels. p. 41

Services

Cadix International Inc. Circle # 19

Cadix develops Fiber and RF Design and Management Software. Cadix's unique "Single Pass Design Process" significantly reduces design costs. p. 35

IMMCO Inc. Circle # 56

IMMCO provides competitively priced, quality HFC and fiber design, drafting and file conversions for CATV and telecommunications companies. p. 111

National Cable Television Institute (NCTI) Circle # 67

National Cable Television Institute (NCTI) is the world's largest independent provider of broadband industry training; both technical and non-technical. p. 62

TCS Communications, Inc. Circle # 52 p. 98

Subscriber Equipment

Stanford Telecom Circle # 55

Stanford Telecom designs and manufactures integrated circuits and board level assemblies for interactive HFC cable headend equipment and subscriber modems. p. 103

Telecom Equipment

Argus Technologies Circle # 48

Argus Technologies manufactures DC power systems, switchmode rectifiers, DC-DC converters (12, 24, 48, 130r) and various DC power components for telecommunications applications. p. 91

Channell Commercial Corporation Circle # 62

Channell Commercial Corporation is a leading designer and manufacturer of precision-molded, thermoplastic and metal enclosures for telecommunication applications. NASDQ: CHNL. p. 96

Test Equipment

AM Communications, Inc. Circle # 61

OmniStat by AM is the worldwide choice for monitoring HFC telecommunications networks. It is the standard for ADC, NextLevel, Philips and Scientific-Atlanta. p. 131

Avantron Technologies, Inc. Circle # 18

Battery operated portable spectrum analyzers, forward and reverse, and ingress monitoring test equipment for the Cable TV Industry. p. 33

Cable Leakage Technologies Circle # 28, 40

With the FCC imposing stiff fines for leakage, CLT presents operators with the only sure, comprehensive method of locating and documenting the nearest street address of system faults/signal leakage. p. 53, 77

Cable Resources, Inc. Circle # 42

Cable Resources offers test equipment to maintain 5-40 MHz return networks. The RDU displays ingress, noise and carrier levels. p. 81

ComSonics, Inc. Circle # 38

The leader in providing quality signal level meters and leakage detection systems, as well as superior CATV repair services. p. 73

Hewlett-Packard Company Circle # 6, 39, 43

Hewlett-Packard offers a comprehensive range of test equipment to keep your entire broadband system at peak performance - from headend to subscriber drop. p. 11, 74-75, 83

Riser-Bond Instruments Circle # 35

Manufacturer of TDRs with unique and exclusive features to locate and identify faults and conditions in metallic two conductor cable. p. 65

Sadelco, Inc. Circle # 46

Sadelco, Inc. manufactures SLMs for CATV. Minimax meters can now provide accurate readings of the average power of all digital channels. p. 88

Sencore Circle # 13

Sencore designs and manufactures a full line of CATV, Wireless CATV, QAM and MPEG-2 test instruments. Each instrument is designed to meet your system analyzing and troubleshooting needs with exclusive tests and measurements. p. 25

Trilithic, Inc. Circle # 14, 53, 75

Trilithic manufactures test equipment for the CATV and LAN industries and components for aerospace and satellite communications. Key products are SLMs, leakage detectors, and a comprehensive line of return test equipment. p. 26-27, 98-99, 43A

Wavetek Corporation Circle # 2

Manufactures equipment for CATV, telecommunications, wireless, and general purpose test. CATV equipment includes signal level, analysis, and leakage meters, sweep and monitoring equipment. p. 4-5

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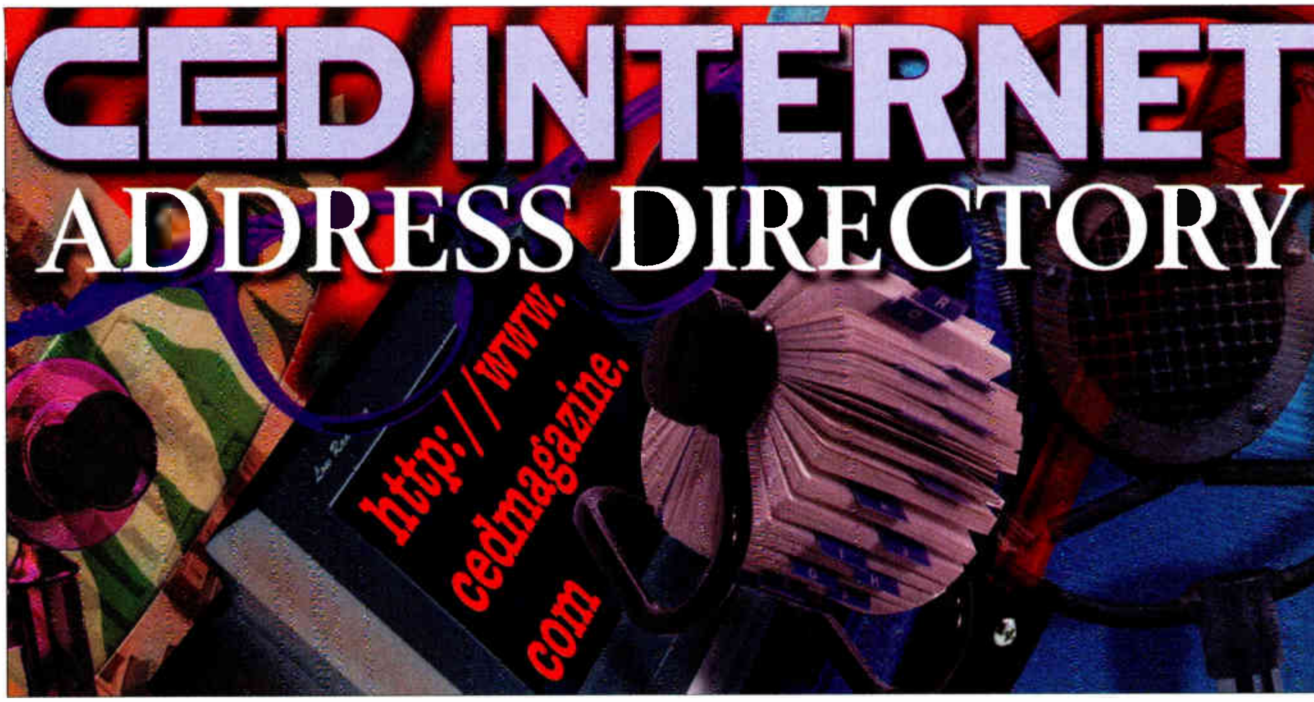

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http://www.ras.com/mwfilter/mwfilter.htm

National Cable Television Institute (NCTI)
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Companies in this issue

The following companies are cited in articles and features in the current issue. Page numbers refer to where the initial mention takes place in a particular story. Listings do not include some departments.

More consumer confusion ahead?

By Walter S. Ciciora, Ph.D.

The cable industry has been struggling with the issues put forth by consumer electronics portions of the 1992 Cable Act. Frankly, they were much more difficult than anyone had expected. The technical issues were horrendous because of the wide variety of implementations of consumer electronics products and the scope of possible cable services.

Of course, the two sides have strong, but very different, economic drives. The consumer electronics side (I worked for a major consumer electronics manufacturer for 17 years before seeing the light and moving over to the cable side) suffers from incredible economic pressures caused by the fact that the technology of their products is something almost any developing country can adopt and produce in larger quantities than the world can absorb.

Consider that there are about 100 million households in the United States which have access to television signals, and about 25 million color television sets are sold each year. Clearly, there are more television receivers available for sale than are needed. The natural consequence of all of that is terrible price pressure. Bottom-of-the-line receivers–which produce excellent pictures–sell for around $10 an inch. This situation causes a simultaneous reluctance to add even a few cents of cost and the need to have marketable features such as the ability to use the term "cable-ready" on a product.

Once burned . . .

Now consider the cable side. Cable has been burned by all sorts of criticism about everything from prices to the difficulty of accessing services. Consumers who bought products labeled "cable-ready" assumed that this meant no more set-top boxes and the extra charges that came with them (no more bundling–the law requires that these charges be pushed up front and stuck in the consumer's face). Note that the cable industry did not define "cable-ready." That label was put on without permission or consultation. This has caused cable to be anxious to avoid a future situation where the FCC authorizes a product to be labeled "cable-ready," which then fails to give access to services and requires a set-top box.

Cable has another concern. Cable is worried about the consumer who purchases a set-top box, only to find that a new service being offered shortly thereafter cannot be accessed by the newly-acquired set-top. That consumer will likely not be a potential customer for the new service. Yet one more marketing hurdle has been introduced. And finally, the FCC's Notice of Proposed Rule Making on this subject put forth several issues in a threatening format. Carefully reading that NPRM makes it clear that there are no requirements placed on the consumer electronics side if they simply don't use the term "cable-ready." However, the cable side may be obligated to provide decoder interface units even "at no separate charge" and for any "cable-ready" product sold. So cable is sensitive to this still ticking time bomb which has not yet been resolved.

Where is the decoder interface?

After many years of meetings which started with simple-minded approaches such as (1) "Why don't they just sell monitors?," and (2) "Why don't they just not scramble?," the two industries have come up with just one viable solution: the decoder interface. While others have proposed self-serving, magical approaches, none has stood the test of practicality. The decoder interface is the only solution found by a relatively large number of workers over a long period of time. The FCC has adopted it as part of its NPRM.

The decoder interface is a set of connections on the back of televisions and VCRs which interface with descramblers and other after-market devices that add functionality to the consumer's previously-purchased products. In order to solve the above-mentioned fundamental differences between the two industries, the decoder interface standard has been divided into two "levels." Level one includes the absolute minimum capability to satisfy the 1992 Cable Act. This author strongly encouraged that level one be called "basic cable-ready" to distinguish it from level two ("advanced cable-ready") which is to be much more capable. Unfortunately, in my opinion, level one is just called "cable-ready." I believe this will lead to more consumer confusion. Both levels are divided into two parts, a hardware part and a protocol part. The hardware part is complete for level one and essentially complete for level two. The protocol part is essentially complete for level one, but has a lot more work to go for level two. Then, as any good engineering project requires, there should be extensive testing of prototypes.

The 1996 Telecommunications Act precludes the FCC from setting protocol standards for any features or functions above the absolute minimum required for the goal. The big difficulty now is over what constitutes "absolute minimum." The majority of the committee believes that the level one protocol it defined is the minimum necessary to comply with the 1992 Cable Act. There is a minority opinion that it is not. The FCC has to decide. Until the FCC decides–and there is a chance it may not decide–neither consumer electronics manufacturers nor cable equipment manufacturers can justify the substantial costs involved in building prototypes for testing. So the committee cannot finish its work. Essentially, after the committee submits the paper protocols to the FCC, the work will have to wait until the FCC decides if it will set standards. CED

Have a comment?
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ADC will be featuring EtherRing™, the new champion for high-speed data and IP video transport over CATV backbones, offering all the benefits of Fast Ethernet transport at 80X faster rates. Also on display will be the Homeworx™ access platform, Homeworx™ cable data modems, RF Worx™ distribution and management products, Broadband Connectivity products, and Systems Integration services.

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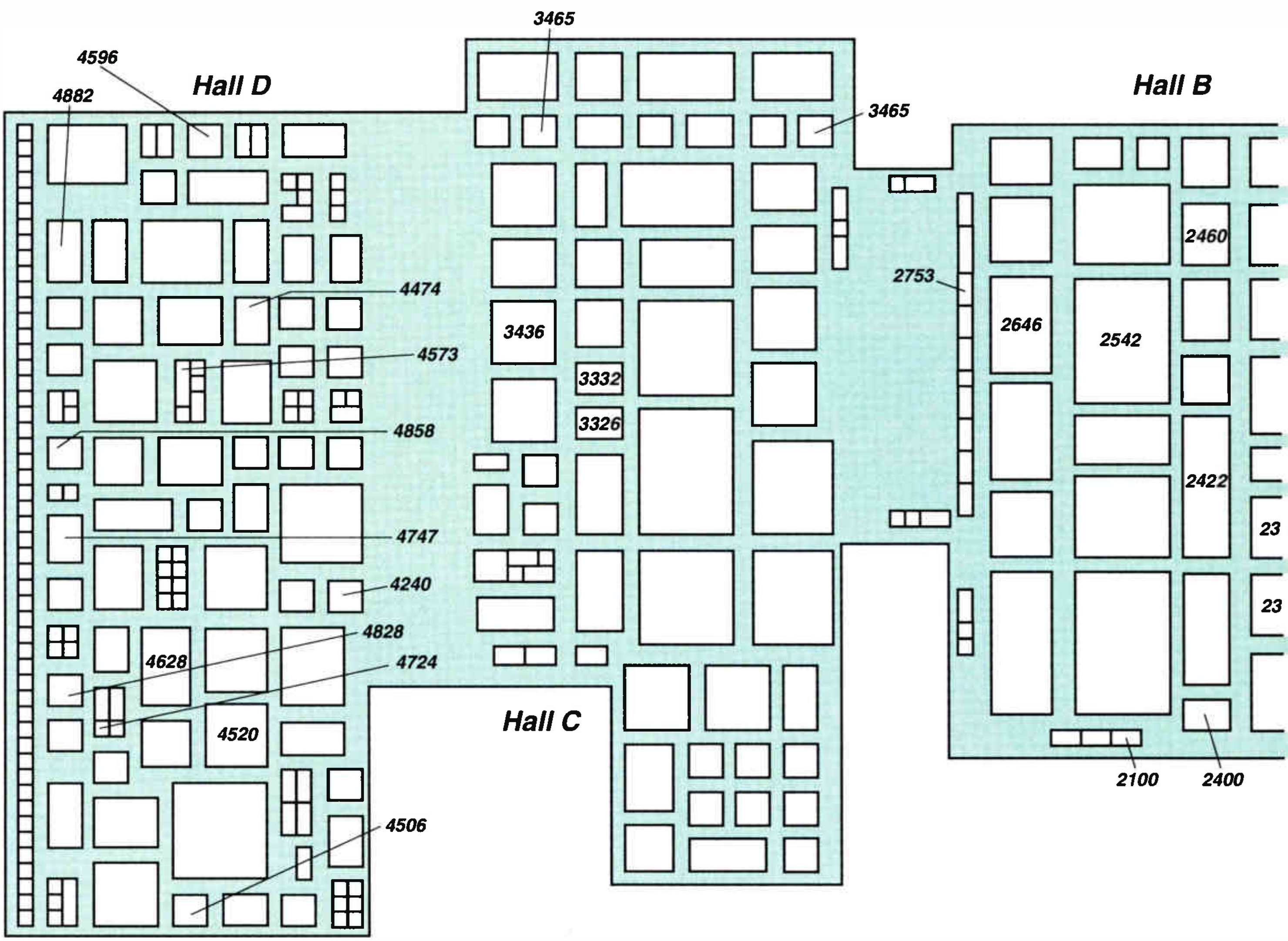

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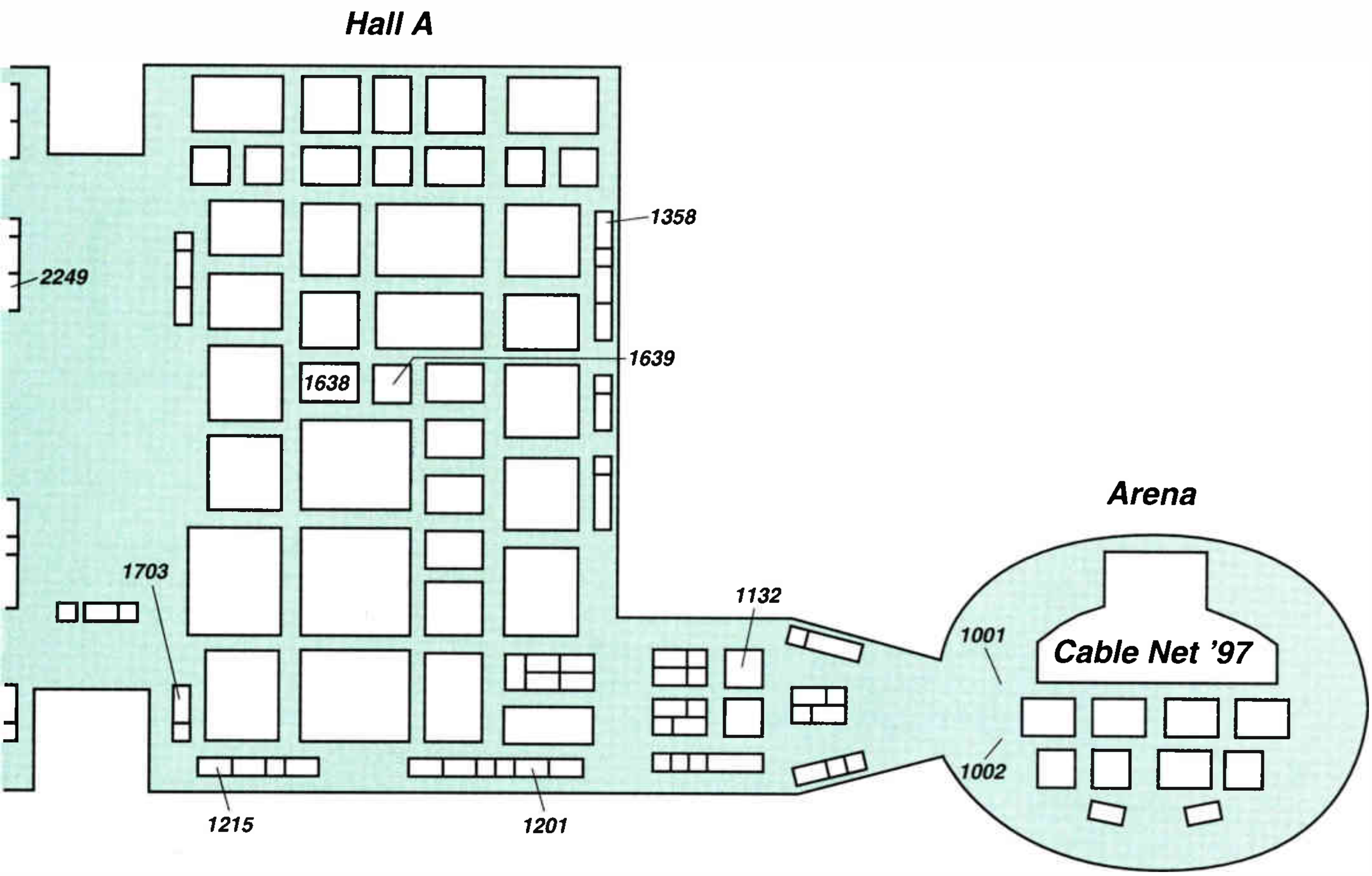

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Cable Link, Inc. 4366

CABLE RESOURCES INC.

Cable Resources 4724
800-537-9995

Cable Resources offers simple solutions for day-to-day operations, including a variety of containers for converters, foam shelves for line equipment and plastic bags for converters. Cable Resources has introduced the RDU, a new piece of test equipment providing a simple solution for maintaining return systems. The RDU displays noise, ingress and carrier level in a video and data format.

CableData 1700
CableServ Electronics, Ltd. 3000
Cabletron Systems 4696

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CADIX International develops Fiber and RF cable plant Design and Management Software. CADIX's unique "Single Pass Design Process," combined with a superior graphical user interface, allows cable plant design speeds up to 12 miles/day utilizing a scanned base map. The management software uses the plant design itself as the graphical interface into a database containing inventory, network and subscriber information.

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Eagle introduces its spectacular new Elite Series of traps and decoding filters. Shortness is a major concentration, along with reduced notch width and performance beyond 1 GHz. Included are model EMN single channel trap less than 2", EHP-50 high pass filter less than 1.5", short step attenuators, and tier traps. Sealing techniques are emphasized, providing long, stable performance. 800-448-7474 or fax 315-622-3800.

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Exide Electronics manufactures the Lectro brand of Zero Transfer Time (ZTT) uninterruptible power supplies for advanced broadband networks. Zero transfer time, field upgradability and modular construction. Centralized Powernode configurations are available for multiple ZTT installations and HFC optical transition nodes (OTNs). Other standby and non-standby power supplies available.

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Harmonic Lightwaves is a worldwide supplier of highly integrated fiber optic transmission, digital video, high-speed data and element management systems for the delivery of interactive services over broadband networks. New products to be demonstrated include: PWRBlazer™ Scaleable Node, MCNS cable modem termination system (CMTS) and New Media broadband headend data management and subscriber interface cards.

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Hewlett-Packard Company 4882
800-452-4844 xHPTV

Hewlett-Packard Company offers a comprehensive range of test equipment to keep your broadband system at peak performance. In our booth, you will find the HP 8591C cable TV analyzer as well as the HP L1500A low-cost spectrum analyzer for return path and ingress maintenance. Also on display will be our Sweep/Ingress Analyzer, mini-OTDR, bench sweep, management tools for BIDS and digital video test equipment for network operators.

IMEDIA

Imedia Corporation 4520
415-975-8000

See the first commercial release of the Imedia StatMux Server, geared for NVOD and PPV, and the only file server that can perform direct playout of both VBR *and* CBR encoded video by separating the decoding and re-encoding process, ensuring no loss in picture quality. The Imedia CherryPicker will demonstrate real time grooming, CBR and VBR statistical Re-multiplexing and seamless digital ad insertion.

Inacom 4755
Integrated Photonic Technology
(IPITEK) .3421
Integration Technologies 2769
Intel Corporation 4774
IRIS Technologies 1021
Jones Broadband International 1756
Jones Cyber Solutions 3254
KGP Telecommunications, Inc. 4545
Lavender Cable TV Services 1708
Leaming Industries 2259
Lemco Tool Corporation 4165

Lindsay Electronics 3332
705-324-2196

Focused on the last mile, revolutionary new technology creates 1 GHz communications equipment to solve system problems before they become subscriber problems - achieved through applied ISO continuous improvement disciplines and strict attention to details. A quarter century of proven reliability and superior performance under the most severe climactic conditions result in fewer service interruptions, less maintenance, and thus, better service at lower operating cost.

Litton Amecom 4690
Lode Data Corporation 3002
LRC, A Business Unit of
Thomas & Betts Corporation 2470
LSI Logic Corporation 1011
Lucent Technologies 4483
Main Line Equipment 2731
MDSI Mobile Data Solutions 1409
Microsoft Corporation 4712
Molex Fiber Optics, Inc. 2223
Monroe Electronics, Inc. 4541
Motorola 3618
Multilink, Inc. 1463
NaCom 2219
NextLevel Systems, Inc. 2502
Nortel 4628

Ortel Corporation 3364
626-281-3636

Ortel Corporation is a world leader in the design and manufacture of signal transmission products, specializing in optoelectronics and RF electronic technologies, including wafer fab and hybrid microelectronic packaging facilities. Ortel was founded as an optoelectronics technology company. The Company has evolved into a leader in products for both wired and wireless communications.

Ortronics, Inc. 1358
860-599-1760

Ortronics, a leader in flexible network solutions, introduces FiberMo™ at the Western Cable Show booth #1358. FiberMo™ Cable Management Rack, a total system approach to high density fiber management, effectively manages, routes, protects and distributes optical fiber. Ortronics also provides fiber optic wall or rack mount cabinets, adapters, patch cords and pigtails for datacom, telecom and CATV applications.

Panasonic Industrial Co., ECG 1356
Panasonic Video Communications
Company 1669
PCI Technologies, Inc. 4771
Phasecom, Inc. 1048
Philips Broadband Networks 2300

Pico Macom, Inc. 1703
800-421-6511 or 818-897-0028

Pico Macom offers a full line of quality headend components including satellite receivers, agile modulators and demodulators, signal processors, amplifiers and completely assembled headends. Pico also manufactures the complete line of Tru-Spec 1 GHz drop and installation passives, splitters, couplers, switches and connectors for CATV/MMDS/SMATV and DBS installation.

Pioneer New Media Technologies., Inc. . .3128
Polotec/Eastern Electronics 1334
Power & Telephone Supply Company 1208

PPC 3165
315-431-7248

PPC is located in Syracuse, N.Y. and manufactures a full line of Hardline and Drop Connectors, a full range of Traps/Filters, and an emerging Fiber Optic connector line. We now have contracts with major telecommunications companies in the United States, plus many throughout the world. Our customers include such names as Time Warner, MediaOne, TCI, Comcast, Cable & Wireless, Telecom Italia and Telecom Australia.

Preformed Line Products 4839
Progressive Electronics, Inc. 2711
Qintar, Inc. 1354
Quality RF Services, Inc. 1204
Qualop Systems Corp. 3512
Quintech Electronics
& Communications 1128
R.L. Drake Company 4542
Radiant Communications Corp. 2735
RELTEC 1114
Ripley Company 2709
Riser-Bond Instruments 1210
Rockwell Semiconductor Systems ...4200
RR Enterprises 3404
Sachs Communications, Inc., A Business
Unit of Thomas & Betts Corporation ..2470
Sadelco, Inc. 4167
Sargent Quality Tools 1125
SAT Corporation 4882
Satellite Engineering Group, Inc. 4854

Scientific-Atlanta, Inc. 2542
800-433-6222

Scientific-Atlanta can take you there with subscriber and terrestrial network products to give you a complete system solution. See our full range of products including: • Explorer 2000™ digital set-top terminal and its built-in cable modem • 8600X™ advanced analog set-tops with interactive viewing guides and Virtual Channel Express • Prisma™ family of opto-electronic products • Continuum™ headend system to also support analog and digital.

Scott Cable Communications, Inc. ...1354
SCTE 1206
SeaChange International 4756

Siecor Corp. 2753
800-743-2675

For years, the Siecor name has been synonymous with quality optical fiber cable, interconnect hardware, termination and splice equipment, test equipment and training for the CATV industry. Today, we offer even more of the products and services you need to build a broadband network - contact us at 1-800-743-2675 or visit us at booth #2753 at Western CATV.

Signal Vision, Inc. 3332
Smallworld Systems, Inc. 3407
Sony Electronics, Inc. 2370
South River Metal Products, Inc.,
A Business Unit of
Thomas & Betts Corporation 2470
South World Enterprise Co., Ltd. 1759
Sprint North Supply 1130
Standard Communications Corp. 1568
Stanford Telecom 4282
Sumitomo Electric Lightwave Corp. ..1346
Superior Electronics Group, Inc. 1668
Synchronous Group, Inc. 1500
Syntellect, Inc. 2713
Tadiran Scopus 1200
Tektronix, Inc. 4358
Telecrafter Products 4540
Telect 1404
Telewire Supply, An ANTEC Company 2452

Tellabs 3436
800-445-6501

Tellabs is a leading supplier of access, transport and service enhancement solutions to communications service providers around the world. The CABLESPAN® 2300 universal telephony distribution system allows cable operators and other competitive service providers to provision voice and data services over hybrid fiber/coax (HFC). Tellabs' transport solutions include TITAN® digital cross-connects, the Tellabs MartisDXX™ system and various element management systems.

Terayon Corporation 4217
TFT, Inc. 1139
Thomas & Betts Corporation 2470
Time Warner Cable's Road Runner ..4334

Times Fiber Communications, Inc. ..2322
203-265-8500 or 800-677-2288

Times Fiber Communications, Inc. is an ISO 9001 registered manufacturer of coaxial cables for the telecommunications industry. Standardized on 1 GHz bandwidth for trunk, feeder and drop cables, featuring T10 Semi-flex, TX10 Low-Loss and T10 Drop cables with lifeTime. TFC is proud to be a part of bringing information and entertainment into the homes of your customers in the United States and in over 30 countries around the world.

Toner Cable Equipment, Inc. 2203
Toshiba 1044

Trilithic 3465
800-344-2412
http://www.trilithic.com

For over 25 years, Trilithic has been a trusted supplier of Cable TV and RFLAN test equipment. At this year's Show, Trilithic is featuring the EASy EAS Compliance System, the Guardian Return Path Maintenance System and a full line of leakage and SLM products, all in active displays. CLT will be displaying their Wavetracker GPS leakage location system in the Trilithic booth.

Trilogy Communications, Inc. 1002
800-TRILOGY

Manufacturer of low-loss, air dielectric MC2 trunk and feeder cable. Ideal for all CATV architectures. Also offering a full line of quality drop cables. For radiating and non-radiating transmission line cables for wireless and RF communications, Trilogy offers the latest 50-ohm AirCell product line. Trilogy is ISO-9001 registered at all facilities. Fax 601-939-6637.

Triple Crown Electronics, Inc. 1116
TVC Inc. 1662
TW Comcorp 1107
U.S. Electronics 1663
U.S. Robotics 4464
Ubiquinet 1350
Underground Service Alert 1705
Universal Electronics, Inc. 3164
Vela Research, Inc. 3156
Video Data Systems 4550

A Newbridge Affiliate

Vienna Systems Corporation 1201
613-591-3219

Interested in adding voice to your service offering? Vienna Systems Corporation delivers scalable, integrated IP Telephony solutions for service providers, carriers and corporations with award-winning *Vienna.way*. With this proven technology, voice, video and data (including real-time fax) are transported seamlessly across IP networks to public telephone networks. Come and "hear" our leading-edge voice quality via cable for yourself!

Viewsonics, Inc. 1110
Vikimatic Sales, Inc. 2725
VLSI Technology, Inc. 4726
Wavecom Electronics, Inc. 1402

Wavetek Corporation 2400
317-788-9351

The revolution in HFC maintenance starts here! Wavetek will introduce its new PathTrak™ Return Path Performance Monitoring and Management System. PathTrak™ is an open architecture, advanced monitoring system designed to optimize, troubleshoot, and maintain the return path. Wavetek's popular Stealth Sweep System, with improved reverse sweep and spectrum display speed, self-calibration, and new reverse noise and ingress troubleshooting features will be displayed.

Wegener Communications 4828
770-814-4000

Visit Wegener Communications and see the receiver and control system chosen by Fox for digital conversion of FX and Fox Sports Nets. Wegener's COMPEL™ Control System and UNITY™ Digital Broadcast Platform are the industry's most advanced program distribution and network control solution available. Ask about regionalized programming and targeted advertising solutions.

Western CATV, Inc. 2217
Wiztec Solutions 3414
Worldbridge Broadband Services, Inc.1000
Worldgate Communications, Inc. 4370

Zenith Electronics Corp. 4506
800-239-0900

Zenith Electronics Corporation is a leading developer, manufacturer and marketer of Network Systems products, including digital and analog set-tops for wired and wireless networks, and cable modems. With strategic partners C-Cube/DiviCom and News Corp./NDS, Zenith is showcasing its leadership in digital technology. Highlighted are Zenith's cost-effective analog addressable converters and cable modem systems. Stop by our booth for a chance to win a Zenith DVD player!

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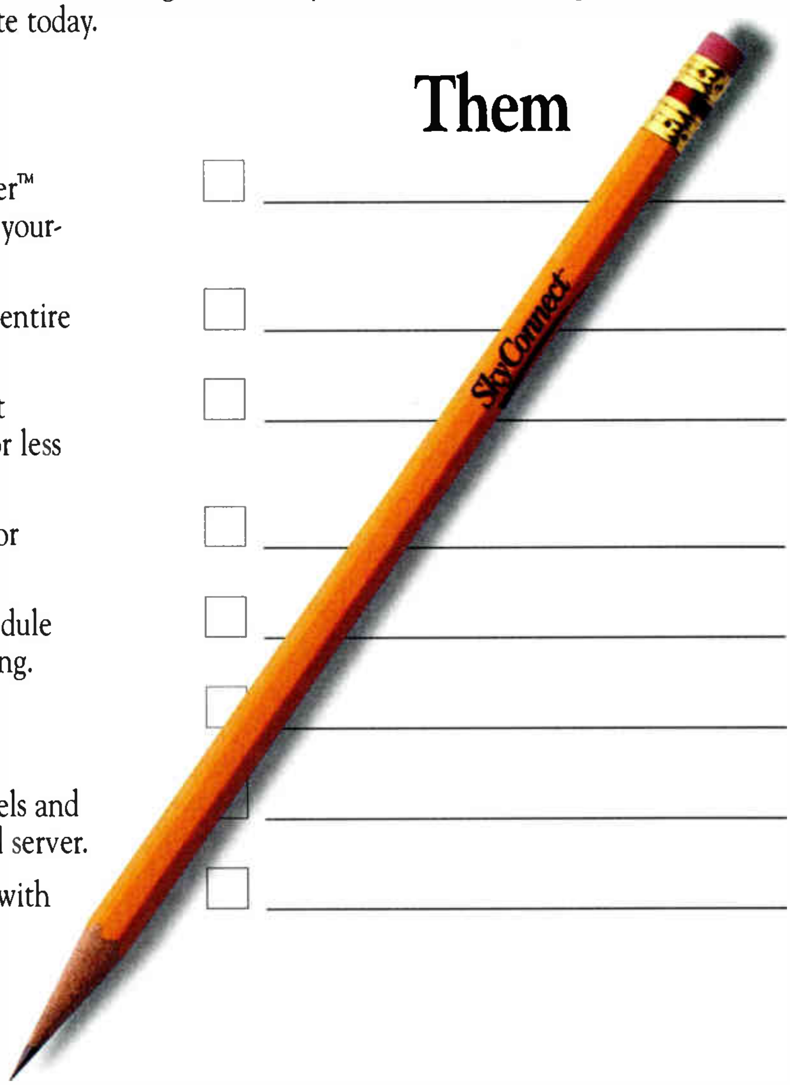
Take the SkyConnect Headend-to-Headend Challenge.

Compare us to our competition, and we're sure that point-for-point, feature-for-feature, nobody beats SkyConnect. Whether you're replacing obsolete MPEG-1.5 gear or planning a new digital install, we have the products and services for you.

Take the SkyConnect Headend-to-Headend Challenge and take your ad sales to the top. Call us for more information and a quote today.

Us	Them
☐ Digital's proven 64-bit AlphaServer™ technology used worldwide in bet-your-business applications.	☐ ________
☐ Full compatibility throughout the entire SkyConnect product line.	☐ ________
☐ Round-the-clock customer support help desk center with 15 minute or less call back guarantee.	☐ ________
☐ Digital UNIX™ operating system for mission-critical reliability.	☐ ________
☐ Powerful Oracle® database for schedule management and system monitoring.	☐ ________
☐ Flexible encoding bit rates from 1.5 Mbps to 15 Mbps.	☐ ________
☐ Capable of handling 4 to 40 channels and multiple zones in a single headend server.	☐ ________
☐ Value-added business partnership with Digital Equipment Corporation - a world leader in computer design and manufacture.	☐ ________



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