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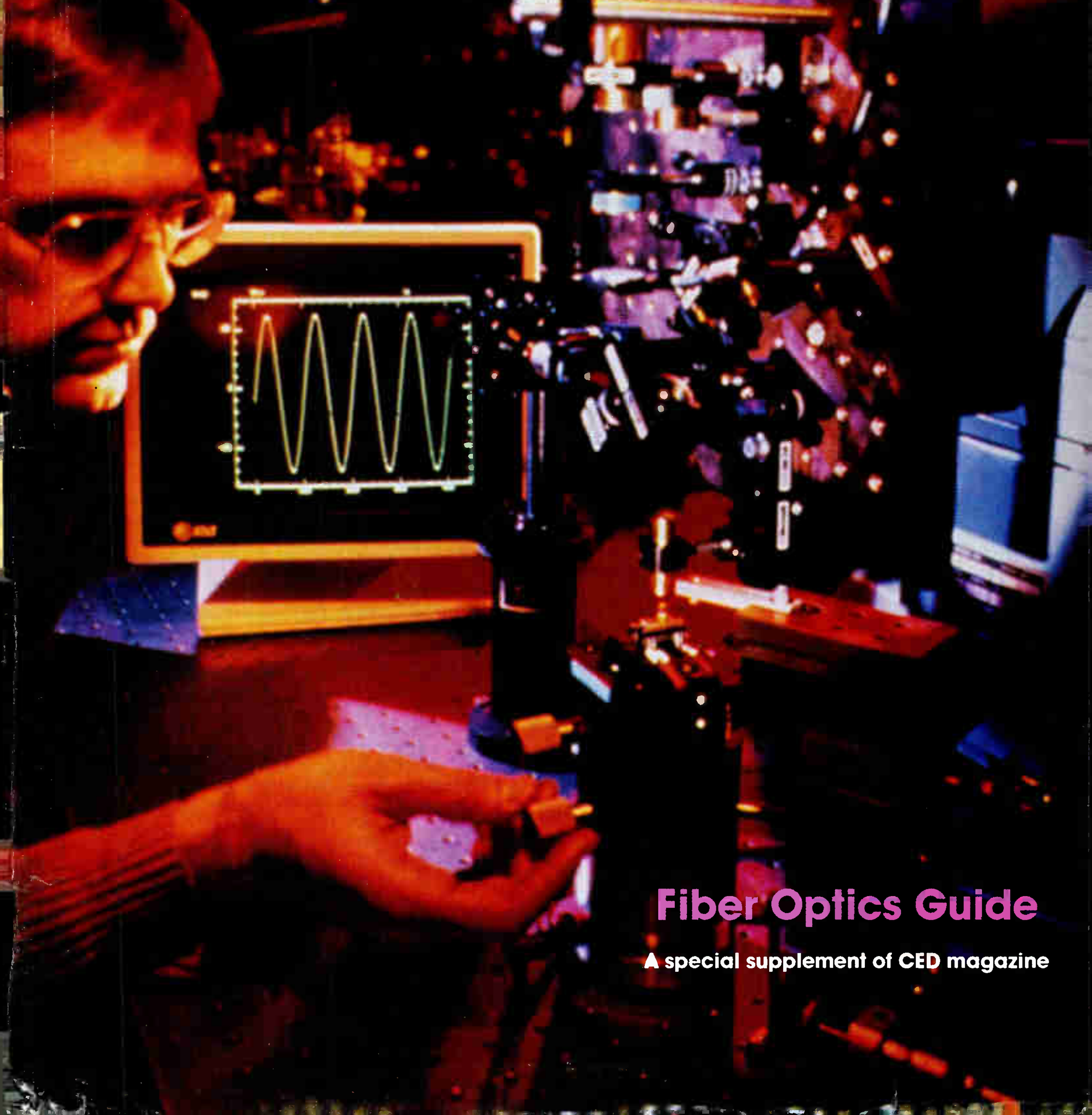
THE MAGAZINE OF BROADBAND TECHNOLOGY / MARCH 1991



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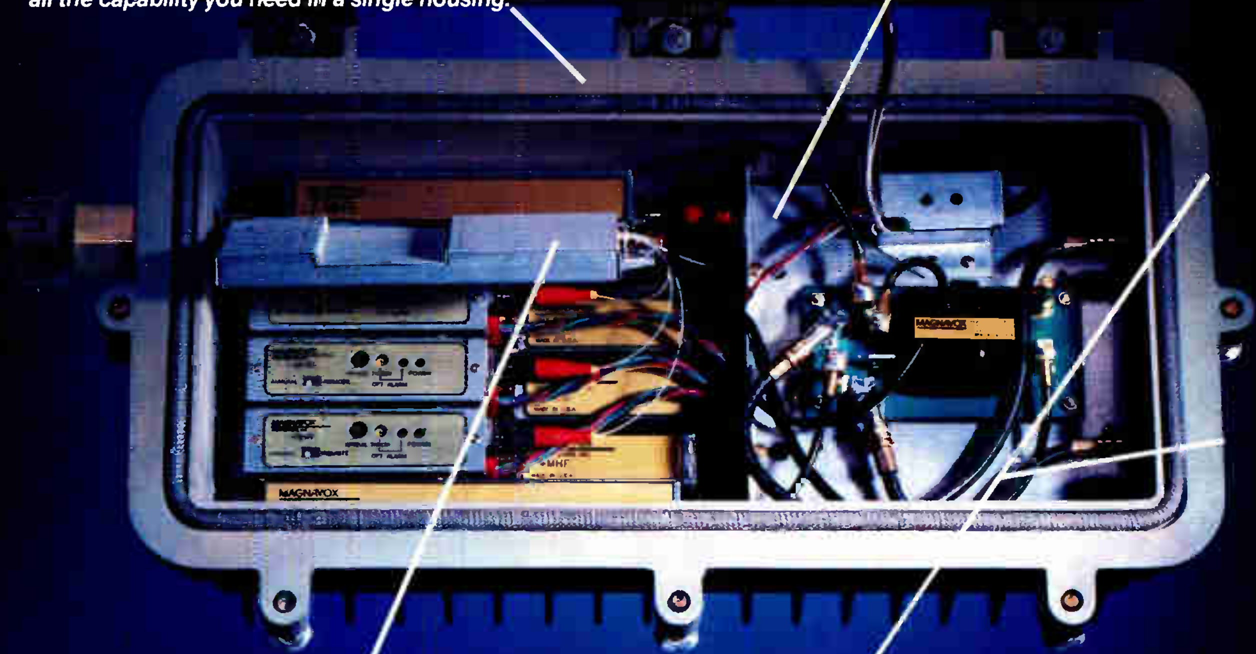

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Reader Service Number 2

CED

Cable's road to telephony 4

All the elements seem to be in line for cable operators to look seriously at its newest revenue opportunity—namely Personal Communications Networks (PCNs), or neighborhood microcell systems that enable cordless telephony delivery. *CED*'s George Sell examines cable's potential involvement in this arena, including transmission architectures and likely evolutionary trends.

Evolution of the broadband integrated network 13

GTE's Clif Holliday and Vern Junkmann address the future of the integrated broadband network and its potential ability to deliver voice, data and full-motion video. In this four-phase discussion, the authors examine legal and regulatory factors that may affect broadband network implementation, including the current cable/telephony status, the increased use of fiber, cooperation between cable and telephone operators, and the eventual replacement of distribution copper with all-fiber networks.

United Kingdom network architectures 16

Cable operators in the U.K. enjoy quite a different relationship with telephone companies, in that the two groups *jointly* deliver video, voice and data to business and residential communities. US West's Earl Langenberg describes current U.K. network architectures in this article based on his speech at the 1990 Western Cable Show.

Dealing with CATV system transparency 18

Several articles have been written regarding the impact of the Fiber Trunk and Feeder architecture. However, Ron Cotten of Engineering Technologies Group, has performed an exhaustive analysis of the fiber optic architecture and its impact on a cable system from the headend to the viewer's television. The set-top converter is the new weak link.

FTF coupler specifications 30

A variety of parameters must be considered when selecting optical couplers for use with fiber to the feeder (FTF) architectures, including coupler structure, optical and mechanical specifications and environmental tests. Herzel Laor, an independant consultant to American Television and Communications Corp., shares his research on the topic, including an illuminating fiber coupler specification table.

Cover photo courtesy of Optical Networks International

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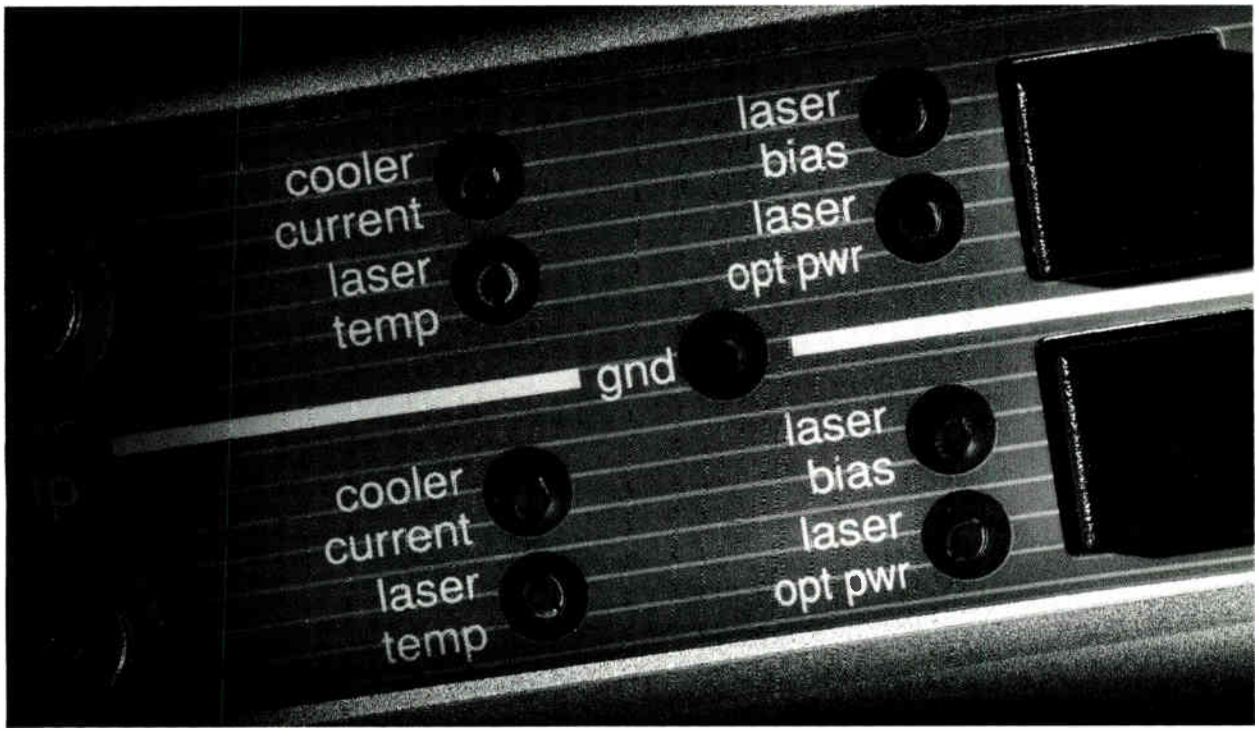

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Reader Service Number 4

'Hello, (cable) operator?'

Cable television's opportunities in the personal communications infrastructure

Telephony and data via the cable-television network. It's a concept many cable operators have privately considered, but until recently, refused to talk about openly. The evidence was there: "ring"-style and CAN fiber architectures that offer redundancy; and the natural evolution to new revenue streams. But the subject was "taboo" for press discussions.

But no more.

PCN arrives on the scene

The personal communications revolution is now upon us. As Archer Taylor, Senior VP of Engineering for Malarkey-Taylor Associates pointed out in a recent column ("My View," *CED* magazine, January 1991, p. 24), there are 5 million cellular telephones, 9 million pagers, a bunch of CBs, and 26 million cordless telephones. Sales of cordless telephones to dealers exceed 10 million annually. Pager growth in 1990 was 1.3 million subscribers. By the mid-1990s, there will be more than 15 million cellular users.

While these statistics seem to express a deeply rooted desire for highly mobile personal communications on the part of individuals and businesses, just how these newly established telecommunications industries fare in the future will depend greatly on the emergence and acceptance of new technologies and the network infrastructures they call for.

In fact, the development of Personal Communications Services (PCS) and Personal Communications Networks (PCN) seems to be spinning a telecommunications web that may result in a wholly new infrastructure rendering these growth industries as obsolete and extinct telecommunications dinosaurs soon after the turn of the century.

What infrastructure may emerge is neighborhood PCN microcell systems featuring full-function cordless phones slightly bigger than a pager, with similar wireless technology called "telepoint" systems replacing payphones. Perhaps eliminated from the mix may be today's answering machines and cordless phones.

By George Sell, Contributing Editor

And PCN may not stop there. These networks could significantly impact twisted-pair-based Plain Old Telephone Service (POTS), the telcos' most lucrative service. Concepts for PCN allow complete bypassing of local telephone networks by beaming calls directly from one transmitter through a switch to the next.

In May, the FCC awarded a preliminary license to Millicom Telecommunications, the first out of the gate, to conduct experiments with wireless microwave telephone systems. The network will consist of microcells as small as a single floor of an office building. However, the cell will be able to handle calls from 50 lightweight cordless phones communicating with a transmitter the size of a filing cabinet.

Millicom's handheld device would be pocket-sized, weigh 5 ounces and operate with a microprocessor-based smartcard. The transmission method would employ low-power (typically, one milliwatt, but it can range from 100 microwatts to 100 milliwatts), high-frequency (from 1.85 GHz to 1.99 GHz) spread spectrum (code-division multiple access) digital signaling technology. The tests will attempt to show that the signals will not interfere with existing microwave usages.

Each PCN user would have an individual phone number and available services such as voice mail and different types of rings to identify wanted and unwanted calls. With this low-cost system, users could receive calls anywhere regardless of location.

Needless to say, there have been a multitude of applications for PCN testing coming from telephone, cellular and paging industry companies, as well as a handful of cable companies. According to the FCC, as of mid-January there were 50 applications to experiment and 27 had been granted.

Also, the FCC is initiating a wide ranging study of spectrum allocation with an eye toward encouraging new services such as PCN. In a recent speech to the Los Angeles area business community, FCC Chairman Alfred Sikes wants to adopt a "pioneer preference" system that "will give a procedural leg up to those who propose a significant service innovation."

Cable's role

The question becomes, today and in the next few years, what role will cable television systems play in this brave new world of personal communications? And if CATV is to play a role, how must cable distribution systems adapt the technology to offer such services?

Some who have shown an interest in testing PCN include Cablevision Systems, Cox Enterprises, Continental Cablevision, Harron Communications, Cable USA and Time Warner's American Television and Communications. In January, Comcast Cable was the first to propose a system integrating a cable system with its cellular holdings. Tele-Communications Inc., the largest MSO, has also hinted at plans for experiments.

And Cable Television Laboratories has been quick to respond. At a December meeting of CableLabs' Board, PCN was high on the agenda. "Exploring the role of cable television systems in the provision of PCN" became an important item in CableLab's 1991 goals and budget.

Besides the basic technical spade work that needs to be done, work the cable/PCN experimental tests will accomplish, much will be determined by just how the FCC eventually allocates spectrum and licenses. Although all technical and business concepts for cable/PCN are preliminary and purely speculative, some elements are coming clearer.

PCN traffic on cable's highway

Cable operators may be able to participate in personal communications infrastructure services at various levels. The most fundamental is backhaul transport. If the local PCN licensee is not the cable operator and not the telephone company, and if PCN is seen as a competitor in the local loop, the licensee will not be likely to look to the telco for backhaul transport of traffic from the neighborhood microcells to the central switch that he owns, in which case the cable operator may be the only logical choice.

The licensee would place the microcell transmitters in the neighborhood. The cable operator could offer backhaul on the return path of the cable plant. The traffic would be either collected at a central point for bulk transmission to the switch or tapped off at several locations in the system.

A step up from a simple backhaul transport function for one PCN provider, a city-scale cable plant could act as an interconnection services wholesaler providing transport services for all local PCN comers. Certainly the cable plant in this case must be state-of-the-art and tight and probably consist of fiber optic trunking, at least.

Whether or not the cable operator is the PCN licensee, he may or may not want to own the switch. Just what hardware and software configuration the PCN switch would take is unknown but equivalent switches for cellular telephony, the Mobile Telephone Switching Office (MTSO), are large, complex and very expensive units. For a cable operator it would constitute a major capital commitment. But such a commitment may be necessary if he wants to operate as a full service retailer of personal communications services.

Just what needs to be in place before each of these levels of PCN infrastructure services could be offered is a matter of conjecture. But forward thinking strategic planning is underway

A role for coax?

There is some disagreement among planners as to whether PCN infrastructure services over cable can be accommodated by tree-and-branch coaxial plant or whether fiber optic star topologies are necessary.

Most who think that some PCN functions can be performed with coax systems believe it may be limited to simple backhaul transport. Bill Killen, vice president for planning and analysis for Cox Enterprises, the parent company of Cox Cable and an applicant for an experimental FCC license, is one. "Tree-and-branch is not all that bad a structure for carrying the signal from the microcell back to the headend where switching can occur, using the broadband capacity to carry the traffic," Killen says.

"We don't believe switched star is necessary at this point (for simple backhaul transport)," Richard Green, president and CEO of CableLabs, surmises. "What we're struck with is the present architecture that we have, basically a grid which spans neighborhoods, seems to have the right architecture to support a PCN (spacial) lattice. But that's an unevaluated finding."

Nick Hamilton-Piercy of Rogers Cablesystems urges caution. "The problem with the old tree system is that the accumulated interference and ingress would be so great by the time all these branches would be funneled into the trunk—it would swamp any bi-directional communications. The modern plant, the ones we see in the 1990s, is so small now in the amount of trunk and the number of branches that, even though there is interference, it can easily be coped with by the modulation schemes for upstream transmission."

Jim Chiddix, vice president for technology at American Television and Communications, and a prominent exponent of fiber optic architecture, agrees. "There is enormous capacity and enormous potential in short tree-and-branch systems. Coaxial cable is a terrific transmission medium for the last mile."

And backhauling can still be contained within the last mile if traffic is tapped off, perhaps at cellular cell sites where interconnection with the switch already exists.

One cable experiment may offer conclusive proof. Comcast Cable will be testing in two different cities. According to Mark Coblitz, vice president for strategic planning for Comcast. "One of the reasons we picked different cities was because each of the cable plants is very different. One of the systems has a lot of fiber and one is a state-of-the-art coax system."

In any case, if traditional tree-and-branch coaxial systems can offer basic backhaul transport functions in a PCN environment, smaller cable systems planning fiber upgrades may have an additional revenue stream that will help finance that investment.

Fiber star-bus

"That's not how we look at it," says John J. Sie, senior vice president of TCI. "We think the inherent problem in coax and copper is that the cost to make it real tight is just not worth the money for the reliability you need. To the extent that we are evolving to fiber in the trunking anyway, why fight a losing battle? That's been tried before and has failed catastrophically."

Sie urges pushing forward with the evolution to fiber optics because the numbers make sense. Sie believes the cable industry can build with fiber at a cost of $100 per household. "In total, it's about an $8.5 billion bill to retrofit the cable industry. If you do it over a seven-year period, which is a normal evolution, that's $1.1 billion a year. That's well within the normal cable discretionary capital budget. Cable spends about $1.6 or $1.7 billion (annually)," Sie says.

Sie also suggests cable systems could be interconnected nationally by satellite to provide a true personal communications network. "Therefore, you'd basically have an overlap of duplicate interexchange carriers as well as local exchange carriers. We do have satellite networks and, for data, all you would need from a VSAT point of view. It would be relatively inexpensive to interconnect the various headends." And true competition would exist in telephony.

"Regardless of political, business or regulatory considerations," Sie goes on, "what you should do is make sure two things happen. One is you have to design from the most complex and work backwards to make sure you don't create any black holes or insurmountable barriers as you start to move into the various options.

"Two, the industry must work together so there is a common standard and interface because to be able to compete or provide alternatives to others you must have the ability to be ubiquitous, universal interconnection (not necessarily universal service). The industry must develop a common consensus on a standard interface so that whatever infrastructure MSO 'A' builds should be the same as MSO 'B'."

Sie looks to CableLabs as providing the central guidance—and CableLabs is up to the challenge. "The truth is it's a very different ballgame with CableLabs and our mission is central to this kind of emergence of a new technology," says Green.

In the distribution network, for Sie, "The (fiber optic) star-bus is prudent as an optimum. You bring it to within 50 to 600 homes in the neighborhood. Once you hit the local node, it becomes a typical bus. It is individual lines, it is a star."

"I think everybody has the consensus of it evolving into a star-bus," says Sie. "The icing on the cake is if you have a really huge system then the star could be emanating from a loop to a star. That means you take a loop of digital, high capacity highway, that's for redundancy and the various nodes are sub-hubs, if you will, and from that point you generate a star-bus. That will give you the total flexibility of interactive, video and data on demand and segmentation."

According to Hamilton-Piercy, "The average cable upgrades that have happened in the last decade have put enough hubbing and segmentation that it becomes much easier. With the addition of fiber that started about two years ago, and is quite prevalent in a number of our companies, we are even closer to having a star-bus structure rather than a traditional tree-and-branch."

Parallel evolutions

But does PCN fall within the cable industry's mission? Clearly, the development of high definition (HDTV) and other advanced television systems do. Should cable television leave the personal communications future to other players in telephony and get on with developing improved television? Or is cable television technology already well enough adapted such that, with slight modifications to the fiber optic evolutions already underway, switched nodal architectures, and fully digital signal processing, cable can not only participate but predominate in this arena?

"What we are doing anyhow seems perfectly sensible in terms of supporting an infrastructure that links microcells," adds Chiddix. "Fundamentally, more fiber is better when you are faced with those kinds of choices because it not only serves you well today, it also leaves open more doors for tomorrow."

"For pure video purposes you will drive fiber to some point in the system based on today's prices," Killen of Cox Cable explains. "That point is pretty close to where the microcells are likely to be."

Fiber deployment for the industry's central mission of providing advanced video and the timeframes estimated for when PCN may be a viable business for cable operators seem to have parallel tracks. "That will be one of the focuses of CableLabs, to actually give the guidance to the cable operator to provide fiber in the most appropriate way, that it exactly dovetails," Hamilton-Piercy suggests.

"I see the cost-effectiveness of fiber becoming even more attractive even at a faster rate in the future," offers Green of CableLabs. "No matter where you project PCN as being possible in 1992 or '93 or '95, if you look at those two time curves, they track each other pretty well."

"What we would try to do is coordinate the capital investment cycle to make the differential upgrades track the kind of functionality you want to have in the network to be able to handle PCN. That's certainly part of the business planning here. If those cycles get too far out of whack, it's not a good business. If you have to make huge investments in fiber too soon in order to be able to participate, then it become less and less attractive as a business venture. But I think that is not the case. The (two curves) are within striking range of each other," Green observes.

The upshot of all this is that cable operators will continue to steer a steady course and install fiber for the video benefits it brings, yet remain watchful of new services such as PCN that may spring up in the future.

"The horse that runs before the cart is video," says Coblitz, "and the thing that makes PCN possible is being driven by video." ■

The integrated broadband network—how will it evolve?

There's been plenty of rhetoric and speculation on how and when the integrated broadband network of the future will evolve. However, it seems certain that the configuration of the envisioned integrated broadband network will depend largely on the degree of cooperation exhibited by the major network participants and the degree of flexibility and freedom those participants are allowed by the legal and regulatory environment.

The future

This article focuses on what could happen in an environment of cooperation, unencumbered by legal and regulatory restrictions. In such an environment, the integrated broadband network of the future could provide switched, two-way capabilities for voice, data and images—including full-motion video. The network would carry switched services, offering both residential and business customers access to a broad range of business products and services, educational programs, medical support and other conventional institutional services.

Migration to the network of the future could occur in several ways. It is clear, however, that the migration would be expedited by a common understanding among participants of how the network might evolve.

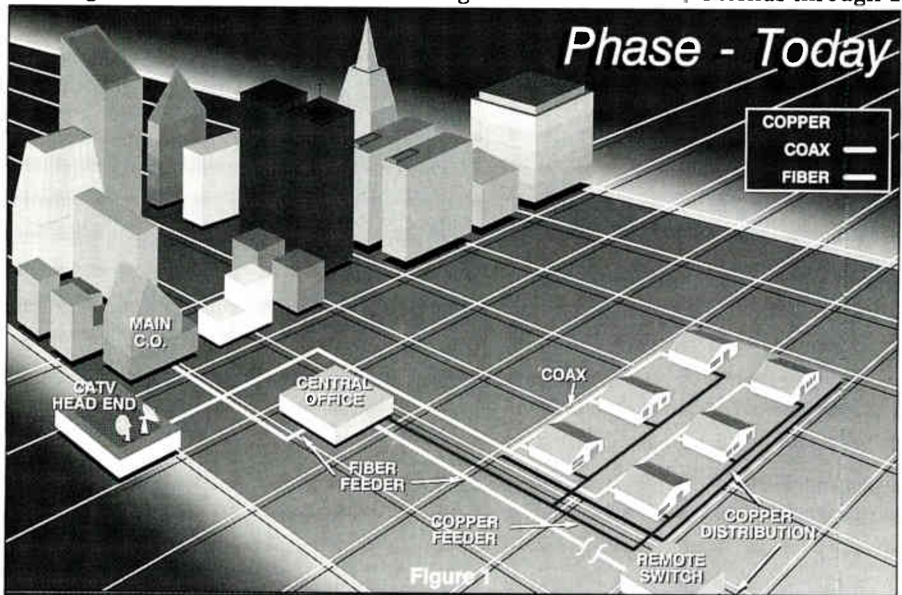

Figure 1

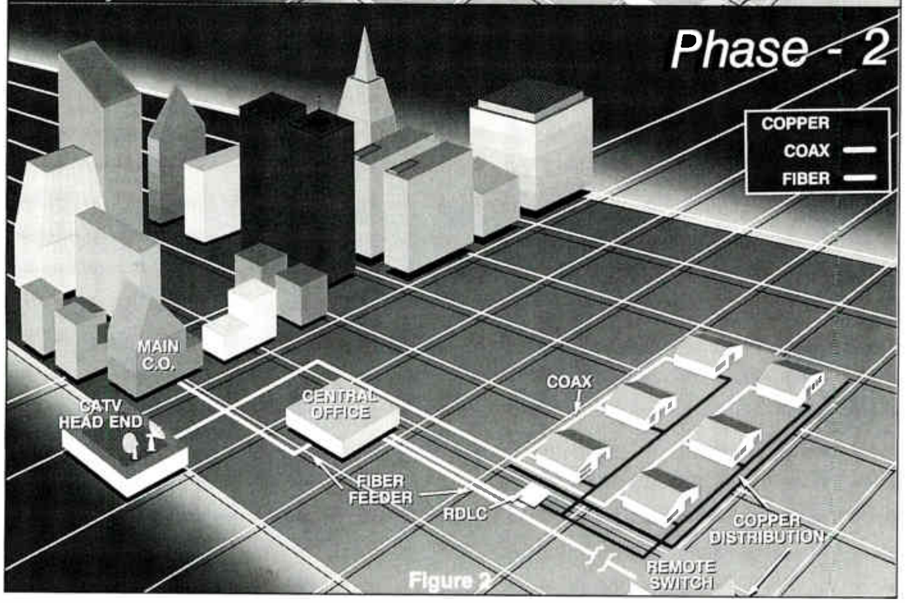

Figure 2

The first of four evolutionary phases of one possible migration scenario begins where we are today. The telephony and cable television networks are completely separate (see Figure 1.)

The telephony network is largely copper from the central office to the customer's home. The video network's coaxial feed from the headend to the home is also copper based (coax).

The second phase (Figure 2) begins where the networks are today and extends through 1992. Both the telephony and cable television industries will increase use of fiber during this period, particularly in feeder routes.

Fiber use in the telephony network will continue to grow as it is extended closer to the customer via those facilities connecting central offices to remote switching units and Remote Digital Loop Carriers (RDLCs). This transition to fiber is based largely on service quality and economic rationale.

It is the third phase of the network, 1992 to 1995, that represents the challenge for the major network providers to work together in the public interest. The nature of competition in the market and the legal and regulatory environment, at that time, will have significant influence on the physical network arrangement.

In some communities, the market conditions may inhibit cooperation and the cable and telephone networks may continue to remain separate. In others, one of the network providers may gain a significant portion of the market and dominate all other providers. Given the necessary legal and regulatory changes, the customers will most likely benefit the most, particularly in those

By Clif Holliday, Assistant VP of Operations and Technology Development and Vern Junkmann, Manager of Technology development for GTE Telephone Operatioins

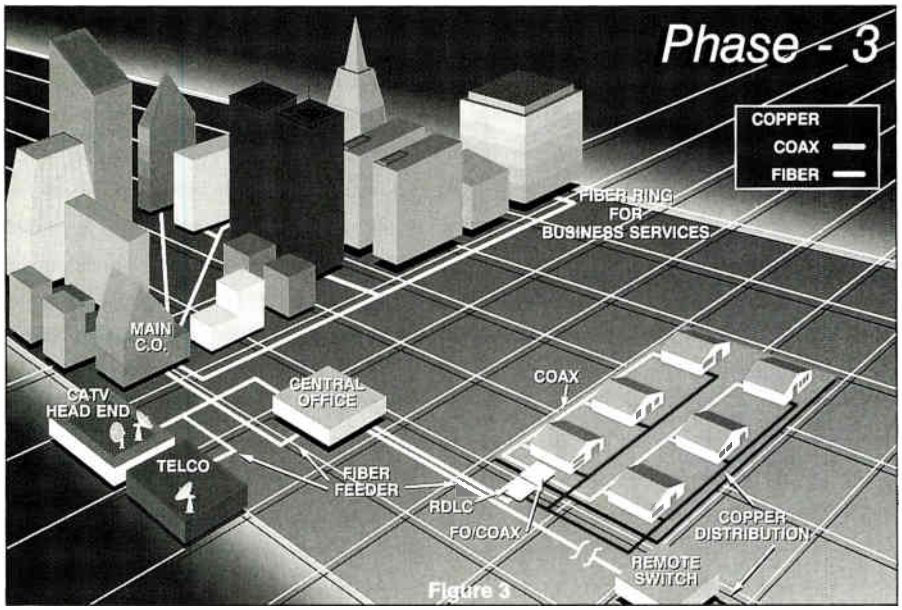

Figure 3

communities where market conditions and cooperation among network providers leads to an integrated network.

Customers in these communities will have access to a broader range of services and benefit from the economic advantages of cooperation. For example, rather than construct new fiber feeder facilities, cable television companies could lease fiber channel services provided by the local telephone company. The cable and telephone company could share fibers within a common sheath or share individual fibers on a time- or frequency-division basis.

Sharing the assets

This would reduce cable company construction costs and provide additional efficiencies in the public communications network while maintaining the basis for competition among service types and service providers. Further, where the channel service facilities pass through the telephone company's central office, the network would be positioned with the functionality and flexibility needed for the integrated, two-way network of the future (see Figure 3.)

In those communities where the cable and telephone networks are integrated, the cable company will likely remain as the major provider of programmed entertainment while the telephone company may want to provide some auxiliary programming. For example, GTE may want to provide near video on demand, or "Main Street." Main Street is a shop-at-home service that could make use of the full-motion media. These services, developed by GTE, are currently being trial tested and demonstrated in Boston, Mass. and Cerritos, Calif. These trials are important because they will encourage the telephone industry to participate actively in the development of the integrated broadband network.

Where the telephone company provides channel services through a central office, conversion from optics to coax for entertainment and to copper for telephony services would occur in a common location close to the customer. This achievement would be made possible by combining the fiber feed from the cable television headend with the telephony traffic at the central office. It would also be necessary to develop customer-friendly, easy-to-use home interfaces for a network with these added capabilities.

Migration to integration

Extension of fiber to a Remote Digital Loop Carrier (RDLC) to convert from fiber to copper in the telephone network will not depend on the cable company's decision on whether to use channel services provided by the telephone company. However, cooperative uses of fiber facilities between the central office and the remote coax converters and digital loop carriers would speed migration to the integrated broadband network. These nodes may also be used in this and later phases to integrate wireless services such as Personal Communications Systems (PCS) in the network.

Given the necessary relaxation of current legal and regulatory restrictions, Phase four in the evolution of the integrated broadband network will begin in the mid- to late 1990s (see Figure 4). This recognizes, of course, that service provider cooperation and market conditions within the community must be right for this level of network integration to occur.

Copper disappears

The most notable network change during this time period is the replacement of distribution copper with an all fiber network for the integrated distribution of voice, data and images, including full-motion video. The separate electronics in the distribution loop will begin to be replaced by a broadband switching capability (shown in

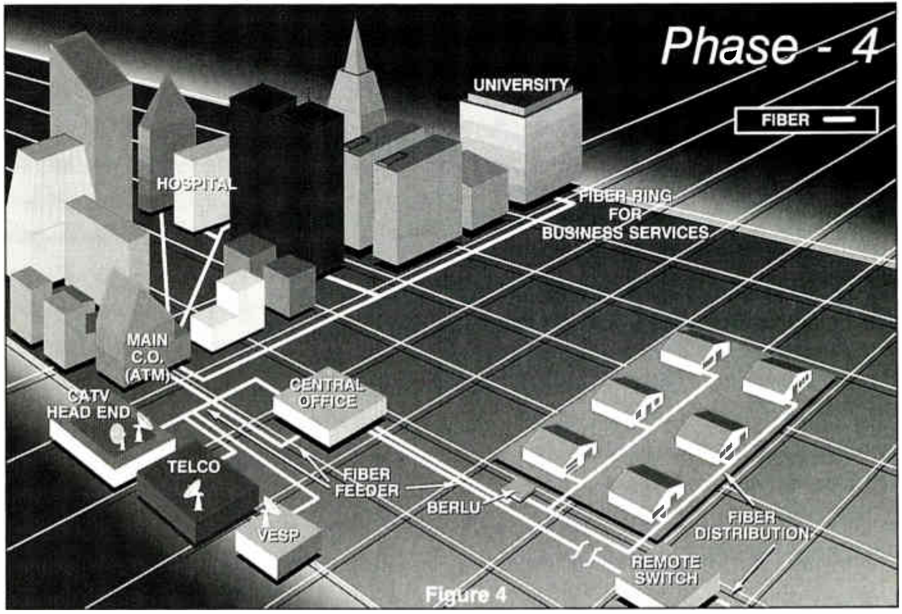

Figure 4

Figure 4 as a BERLU—or Broadband Enhanced Remote Line Unit).

This switching capability makes it possible for each customer to have access to literally thousands of information channels and the network will also be capable of providing two-way interactive services. This will encouraged Video Enhanced Service Providers (VESPs) to create and develop new services for the network.

Figure 4 shows a university and a hospital connected to a business network fiber ring. Given the appropriate environment, the services in the business network can be made available to customers in the residential network. The integration of these networks is important to gain the potential societal advantages of a switched two-way broadband network for service applications such as interactive educational programs, remote medical monitoring and diagnosis, and other institutional services that are described later in this article.

Also shown in Figure 4 is an asynchronous transfer mode (ATM) switch. ATM is a new switching technology currently being developed that will facilitate the integrated switching of various types of services (voice, data and video) on a very flexible basis.

The integrated broadband network shown in Figure 4 provides the potential for a high level of service provision competition. New competition for broadband services will include competition among service types such as educational, medical and entertainment as well as among service providers, including the telephony industry. This increased competition will lead to a wide array of program choices. If the inhibiting legal and regulatory restrictions can be modified so that competition on a level playing field becomes possible, the nation's consumers will see a new high point in available broadband services.

Multiple advantages

There are many benefits to an all fiber, integrated public network that has switched, two-way capabilities. Interactive educational services, for example, would be possible. Students in their homes, as well as those in classrooms across the nation, would have access to some of our best teachers and would be able to interact with them in ways that promote effective learning. Switched educational services would add flexibility to scheduling, venues and programs. It would be much easier to access the program you want, when you want it and in the form you want it.

Remote medical monitoring and diagnosis would become a reality. Many medical services currently requiring a visit to the doctor's office or even a hospital visit may be provided in the patient's home through the use of video and fiber in an integrated broadband network. It may be possible to hold down the rising cost of medical services by sharing resources and reducing diagnostic time while improving quality of care.

The benefits of an integrated broadband network are clear. Just how the network will evolve, however, is not so clear. The network evolution described here represents a vision of what could be. It will take cooperation, relaxation of legal and regulatory restrictions and a level competitive playing field for the optimum network to become a reality. ■

Preferred network architecture for the United Kingdom

In the United Kingdom, cable and telephone operators have uniquely come together to build and operate telecommunication systems that deliver video, voice and data to business and residential customers. Other than to meet minimum British performance standards, operators are free to develop their own unique network architectures. Cost/performance trade-offs that are applicable in the United States are equally relevant in the United Kingdom.

This article describes in some detail the network architecture under construction today, as well as how it might evolve over the next few years. Much of the information contained in this article was presented verbally at the 1990 Western Cable Show in Anaheim as part of an SCTE seminar on international cable.

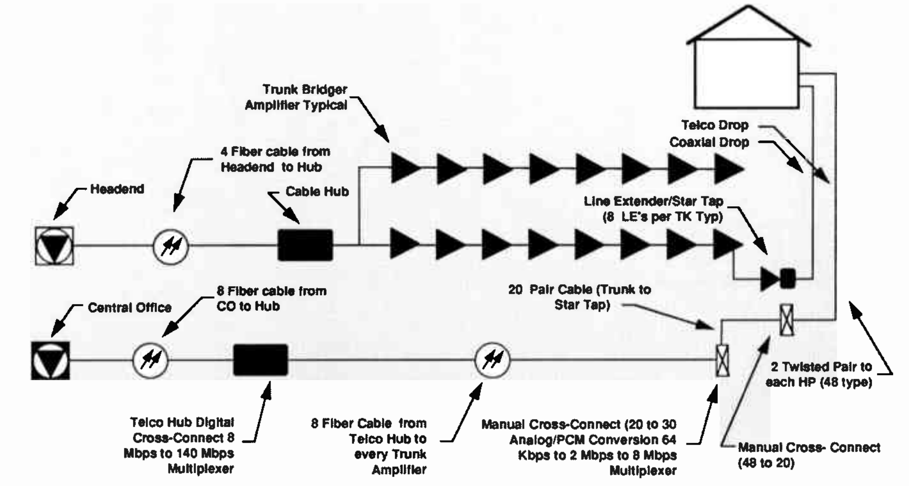

Figure 1

Current overlay architecture

The economics of provisioning switched voice in a cable television franchise has to date, mandated that; 1) it be confined to areas of new construction; and 2) that it be configured as a separate overlay network architecture.

The narrowband overlay network under construction today, as depicted in Figure 1, uses a combination of fiber optics and twisted pair in the outside plant. Integration of the two networks is, for the most part, limited to a sharing of the common conduit system, street cabinetry, and in some cases, a common fiber optic cable sheath. Within the two networks, two groups of equipment are co-located with one another, sharing a common street cabinet:

1) Manual cross connects are co-located at all star tap (off-premises converter for switched star network) locations.

2) A collection of equipment consisting of analog to digital PCM coder/decoders, multiplexers, and a manual cross-connect, are co-located at all trunk/bridge locations.

Cable television node locations are a constantly moving target. Because of this they are often not co-located with telco fiber nodes. As fiber optic costs lower, cable television nodes move deeper into the network.

Other distinguishing characteristics of the overlay network include:

- An eight-fiber non-metallic sheath cable connects, in a home run fashion, the telco fiber node to each trunk/bridge location.
- Eight fibers connect the central office to each telco hub site (two are in current use, with six held in reserve).
- A figure eight, or siamese, composite RG 6 coax with two copper pair drop wires connect customer premises equipment to a manual cross-connect co-located with each star tap. Under evaluation is a diplexer type of device that combines and separates the low frequency telco signal from the higher frequency cable television signal at both ends of the drop cable, allowing both telco and cable television signals to reside on the common customer drop.
- Headend and telco central office facilities need not be co-located.

This narrowband telco overlay network has proven to be the most cost effective way to add a voice circuit capability to the broadband cable television network. The incremental cost of constructing the overlay network to the boadband cable television network is between 10 and 15 percent.

Near-term integrated architecture

As fiber optic costs continue to decrease, the number of homes served off a given fiber hub also decreases. With fewer homes passed, the ability to integrate bi-directional narrowband switched services over the broadband cable television network, as depicted in Figure 2, becomes possible. Two technologies have been in development for some time to accommodate this integration.

One by Phasecom, an Israeli company, uses frequency division multiplexing (FDM) to assign each customer a 100 Kbps (64 Kbps clear channel) channel in both the forward and reverse direction. Using quaternary coding techniques this 100 Kbps data stream occupies 100 kHz of bandwidth; providing each customer a fixed or

Location & Time	Hub Size (Homes Passed)	Bandwidth (In Each Direction)
United Kingdom- 1990	12,000	120 MHz
United Kingdom - 1Q 1991	1,000 to 2,500	10 to 25 MHz
United Kingdom - 4Q 1991	500	5 MHz

A 10% concentration is deemed acceptable in the UK today and is incorporated in the above bandwidth requirements. Thus for every 10 modems in the field, one modem resides in the central office.

Table 1

By Earl Langenberg, VP Engineering and Technology, US West

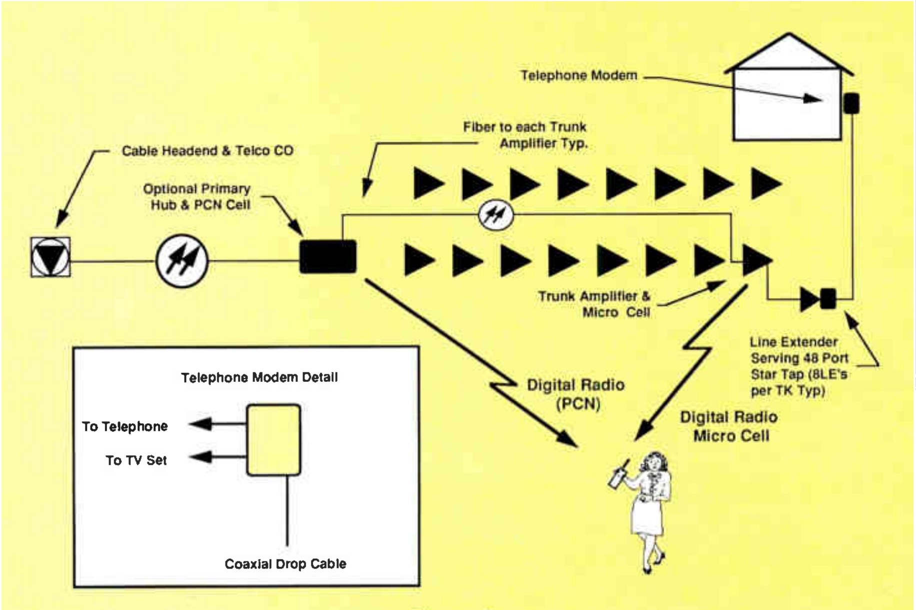

Figure 2

assignable 100 kHz channel in two directions over a cable system is only practical when fiber hub sizes are relatively small—2,500 homes passed per hub or less. Table 1 relates hub size to required bandwidth in various locations at different points in time.

A 10 percent concentration is deemed acceptable in the U.K. today and is incorporated in the bandwidth requirements shown in Table 1. Thus, for every 10 modems in the field, one modem resides in the central office.

From Table 1 it can be seen that a hub serving 12,000 homes passed requires 120 MHz in both the forward and reverse direction. This requires more bandwidth than is available in both a sub-split 5 MHz to 30 MHz/50 MHz to 550 MHz, or a mid-split 5 MHz to 112 MHz/150 MHz to 550 MHz system. While a high-split 5 MHz to 174 MHz/234 MHz to 550 MHz system could work, the loss of channel capacity and awkward treatment of FM radio services preclude it from serious consideration.

Expected telco penetration is an important factor. Table 1 provisions for 100 percent of homes passed to take a telephone service. If only 15 percent of a hub serving 12,000 homes passed were projected, the coaxial portion of the network would require 18 MHz of forward and reverse bandwidth. Recent developments in the manufacture of lower cost multi-channel VSB/AM single laser systems look promising, and cost effective fiber nodes serving approximately 500 homes passed may be realized by the end of this year.

A second supplier, First Pacific Networks (located in San Jose, California), has developed a product that uses time division multiplexing (TDM) to integrate narrowband telco services onto the broadband cable television network.

Advantages of integrating video, voice and data over a common network include:

- Improved reliability. No telco specific equipment is installed in the outside plant. Telco modems are located at the customer premises, and inside the headend facility.
- Lower capital/operating cost. The overlay network is replaced by a less expensive one made up of 1.1 modems per customer, and network management system.
- Existing network upgrade. Existing two-way cable television networks with adequately sized hubs are easily upgraded to add voice circuit capability. One-way systems and/or systems with hubs serving a large number of homes passed can be converted for considerably less expense than constructing an overlay network.

In addition to the provision of narrowband wire-line telco circuits, the integrated network is well suited to accommodate wireless telco services. In the United Kingdom, wireless services include: cellular, CT-2 (cordless telephone for outgoing call placement only), and PCN (personal communications network).

A great deal of progress is expected to take place over the coming year to integrate video, voice and data services over a single high performance fiber and coaxial based network. ■

Full fiber deployment: Transparency in CATV systems

The cable television industry has struggled since its infancy with customer service problems related to marginal signal quality and poor reliability. These seemingly intractable characteristics of cable systems are the bad news side of the "good news/bad news" nature of the tree-and-branch architecture that has been used virtually without exception since the early days of cable television.

Background

While the tree-and-branch architecture is perhaps ideally suited to point-to-multipoint broadband distribution networks from an economic point of view, from a signal quality and reliability point of view, the long chain of cable and components associated with the network has created difficulties. Aggravating this situation has been the willingness of operators to ignore the inherent limitations of tree-and-branch networks.

Picture quality in a cable system is primarily defined by noise content (carrier-to-noise ratio or CNR) and distortion content (composite triple beat and composite second order). Reliability is defined primarily by downtime. The typical cable system (if there is such a thing) delivers pictures with a CNR of perhaps 40 dB to 44 dB, CTB of perhaps -48 dB to -52 dB and a CSO of maybe -50 dB to -54 dB.

While some systems perform better than this and some perform worse, this range is realistic when one considers temperature effects, frequency response, level stability, and the myriad other factors that impact system performance. Further detracting from these numbers, and often ignored, is the converter. In general, today's cable television subscriber lives with and accepts visible noise and/or distortion in his picture.

With regard to reliability, cable television systems are complex electro-mechanical networks that consist of many thousands of individual parts. Reliability is impacted not only by failure of active devices, but also by mechanical failures of passive devices. Of equal concern is the length of the chain. A moderate trunk cascade and its associated distribution system may link sequentially together hundreds of individual parts in order to deliver the signal from the headend to any given subscriber. Failure of any one part will result in an interruption or degradation of service from that point. And then of course, there is the power grid and the weather.

In spite of its inherent limitations, the tree-and-branch architecture has served the industry well. With the advent of AM fiber optics however, it is now possible to build competitively priced systems that approach transparency with regard to signal quality and that significantly reduce both the volume of individual parts and the length of the chain between the headend and subscriber.

Much attention has been focused by

By Ronald Cotten, CEO, Engineering Technologies Group

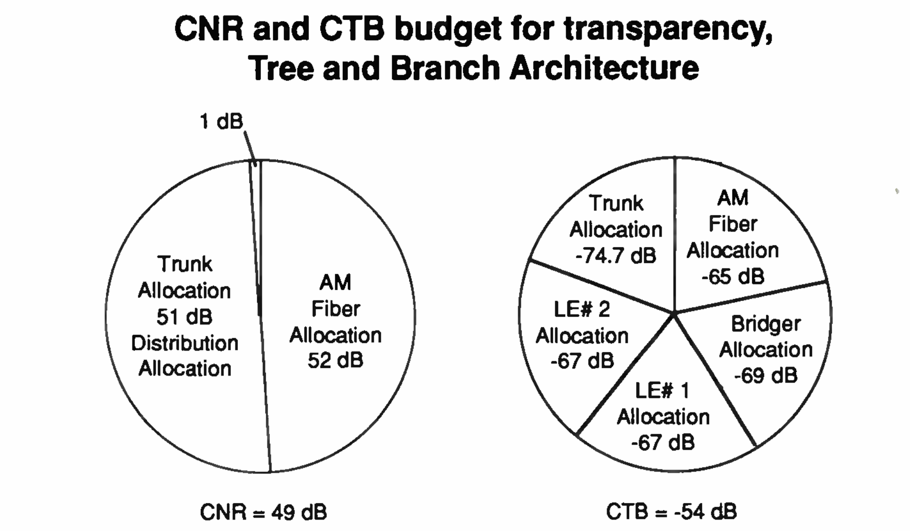

Figure 1

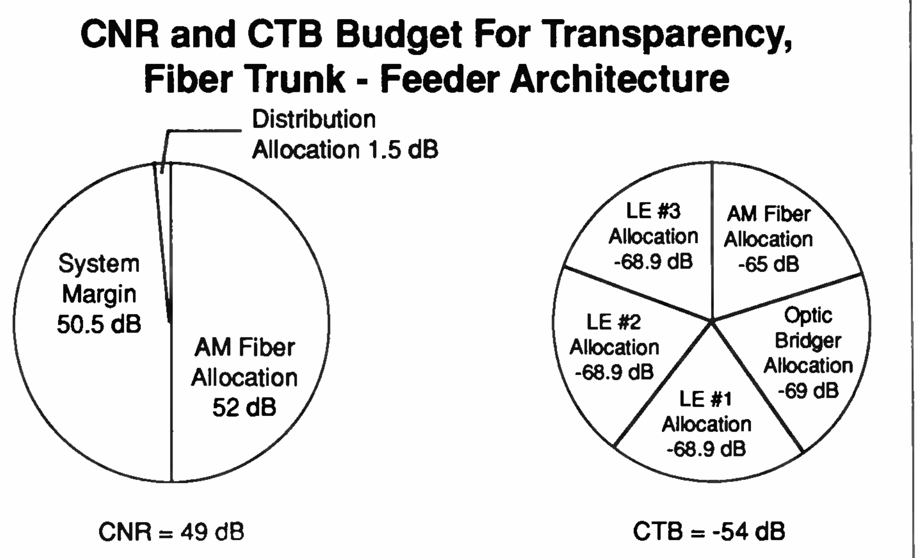

Figure 2

AM

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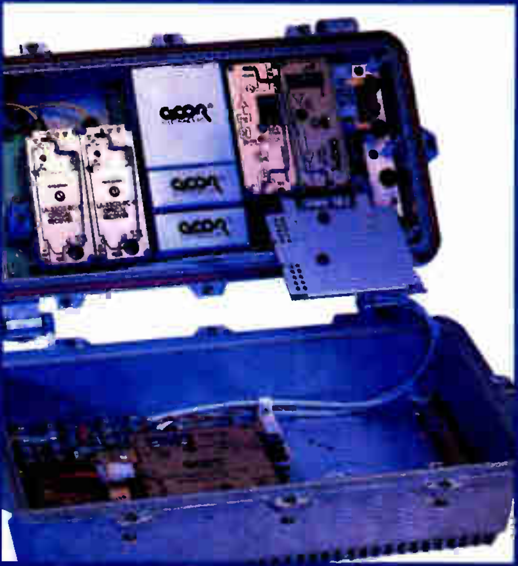

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the engineering community on the design aspects of the fiber optic portion of this new architecture. This paper focuses on the integrated system which includes the fiber optics network, the RF network and the housedrop.

The Fiber Trunk and Feeder network

AM fiber optic systems have been available for several years now. With steady improvements in technical performance being made over time, and with costs declining to the point where fiber trunking is economically comparable to conventional RF trunking, the time has arrived when widespread implementation is possible. At issue is how to deploy AM fiber optics to maximum advantage.

Early on, AM fiber was viewed as an interconnect mechanism, in a manner similar to AML microwave, only directed to smaller segments of plant. In this view, the fiber optics network could be overlaid onto an existing tree-and-branch architecture such that each fiber optic termination or node would be followed by a short but conventional tree-and-branch network consisting of several trunk amplifiers in cascade and their associated distribution networks.

This approach lends itself to upgrades with benefits of modest improvements in performance, improved reliability, and increased channel loading capability. In the performance category, systems could consistently achieve a CNR of 47 dB or so and limit CTB distortion to an honest -52 dB. While this is an improvement, it still falls short of the 49 dB CNR and -54 dB CTB necessary for transparency.

The fundamental reason for this shortfall is that today AM fiber optic systems typically deliver a CNR of approximately 52 dB to 53 dB and a CTB of -63 to -65 dB. Assuming then that a given fiber optic link can deliver a 52 dB CNR and -65 dB CTB, the noise and distortion remaining from the overall budget of 49 dB CNR and -54 dB CTB required for transparency is a 52 dB CNR and -56.9 dB CTB. This remaining noise and distortion must now be split between the trunk and distribution system that follows the node. See Figure 1.

Assuming that a typical single trunk amplifier has a 60 dB CNR with normal setup, a 51 dB trunk noise allocation would allow eight amplifiers to be cascaded following the node. And assuming that the same trunk amplifier has a -85 dB CTB, then a -74.7 CTB allocation would allow three amplifiers to be cascaded. Optimization of output power between CNR and CTB would then yield a maximum possible trunk cascade of four amplifiers following the optical receiver. When one considers the negative effects of temperature, the 49 dB CNR and -54 dB CTB achieved in this configuration will degrade to somewhere in the vicinity of 47 dB to 48 dB CNR and -52 dB to -53 dB CTB. The addition of a converter will cause a further degradation.

These assumed performance numbers are arbitrary in that they will vary depending on technology, vendor, operating levels, gain, etc. However, they illustrate the point with regard to the architecture that, given the slice of the CNR and CTB budget taken by the AM fiber optic interconnect, the ability to cascade trunk amplifiers in a traditional tree-and-branch system beyond the node, while simultaneously achieving transparency in signal quality, is limited.

Improving the numbers

The FTF (Fiber Trunk and Feeder) architecture improves on this situation by eliminating the conventional RF trunk portion of the network completely and reallocating its portion of the CNR and CTB budget to the distribution system. This allows the distribution portion of the system to be expanded on a per node basis and simultaneously improves system noise performance. This results in a system in which all trunks are fiber optic and where the number of node (i.e. bridger) locations are reduced and the distribution plant mileage per node is greatly increased.

Better noise performance is achieved because the low level component or RF trunk portion of the network has been eliminated. Noise performance is now dominated by the AM fiber optic interconnect and the converter while the expanded distribution network remains distortion limited. Expansion of the distribution network is possible because the portion of the distortion budget previously assigned to the trunk system is available to be used in the distribution network, thereby allowing longer distribution cascades and/or higher output levels. In this architecture, low distortion technologies such as power-doubling and feedforward are obviously desirable.

It can be seen in Figure 2 that on the CNR side of the picture, the distribution allocation has increased slightly because there are now three or more line extenders (or distribution amplifiers) rather than the customary two. With FTF architecture, the remaining 50.5 dB CNR allocation becomes system margin rather than being assigned to the trunk. This accounts for the improved noise performance of FTF system.

Thermal considerations

An additional benefit to the FTF architecture is that the 1-dB to 1.5-dB reduction in noise performance due to temperature in the tree-and-branch systems is avoided. This degradation in CNR is due primarily to the low level coaxial portion of the network; i.e. the trunk in conventional cable systems. The fiber optic link is inherently stable with regard to temperature, so eliminating the RF trunk also eliminates the majority of noise degradation due to thermal factors.

Noise performance with the FTF architecture is therefore improved by virtue of:

- converting all coaxial plant to high level (and therefore low noise) distribution, and
- eliminating most of the noise level increase associated with thermal effects.

With respect to distortion, for similar system performance objectives, additional distribution amplifiers or line extenders may be used, thus increasing the geographical coverage of the node. Their distortion contribution occupies that portion of the distortion budget previously occupied by the RF trunk. As noted above, a stable input to the RF portion of the plant is assured with regard to frequency response and level because of the improved stability of the fiber optic interconnect relative to a conventional RF repeater trunk. This means that levels and frequency response will remain much more consistent so less distortion margin is required as compared to a conventional system. Thermal effects related to distortion will still be apparent in the distribution portion of the plant however, so level control remains a priority.

Comparing geographical coverage, the typical bridger in a conventional tree-and-branch architecture will feed perhaps 2 to 4 miles of distribution plant. With FTF architecture, the node (analogous to the bridger), will feed typically 7 to 12 miles of distribution plant. Figures 3 and 4, which illustrate these differences, are flow charts of

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actual comparative designs.

(Note: It is important to realize that the numbers used in these descriptions, including the distribution cascade, while realistic, will vary depending on vendor, operating parameters, technologies, etc.)

Fiber trunking benefits

The benefits of fiber optic trunking have been thoroughly explored in other papers and publications. The primary advantages of the technology is low attenuation and a large bandwidth potential. In the context of the FTF network, these characteristics allow the repeatered RF trunk, a long series circuit consisting of many sequential active and passive components, to be replaced with parallel links between the headend and each node point, each of which consists of a transmitter, a passive fiber optic strand, and a receiver. This conversion results in improved performance (no trunking repeaters) and greater reliability (series active devices reduced to between four and six).

Optical transmission also renders ingress and egress of signals into and out of the trunking network a moot point. While direct pickup interference (DPI) and signal leakage related to the distribution system will remain as important maintenance activities, and Cumulative Leakage Index (CLI) will remain as a legal obligation, eliminating the trunk as a potential contributor will reduce workloads substantially.

This benefit does not accrue to system architectures that simply overlay the fiber network onto a conventional tree-and-branch RF system where RF trunking is retained in shorter cascades. Exposure to DPI and the potential for system leakage relate to the number of devices, connectors, etc. and footage of cable, not to their position in a cascade. Position in the cascade does, however, determine how many subscribers are affected by DPI.

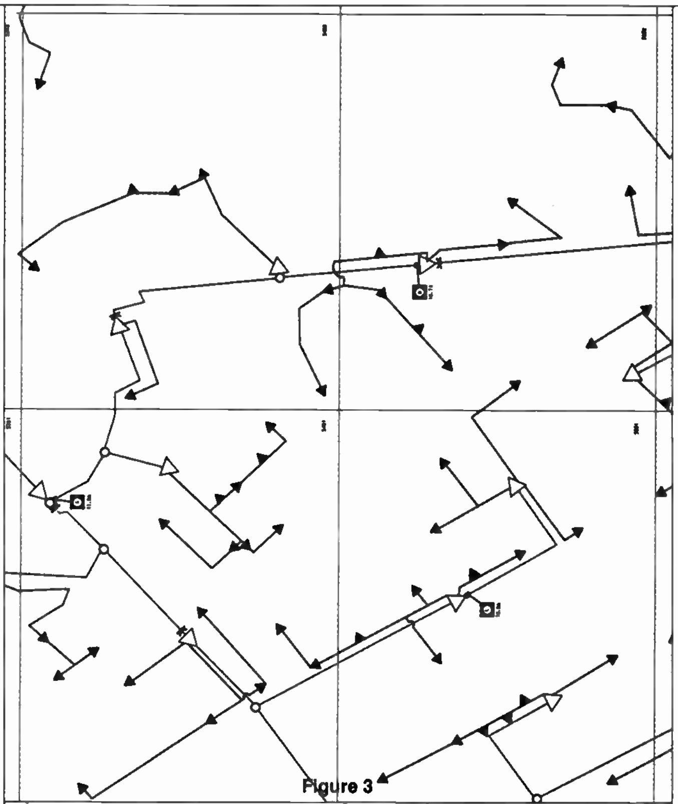
Figure 3

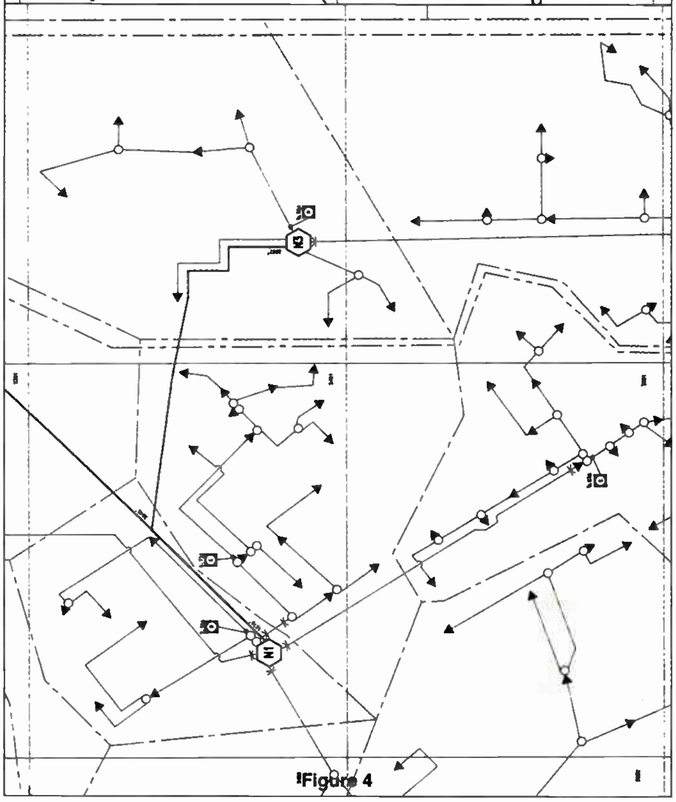
Figure 4

Another significant advantage with fiber trunking is that additional bandwidth is available when needed. Future upgrades can be accomplished by modifying or replacing the optical transmitter and receiver—the fiber itself need not be replaced.

FTF architecture is also friendlier to reverse transmission. A dedicated return fiber from each node eliminates the noise buildup inherent with reverse transmission in tree-and-branch systems, confines ingress to the distribution system, and simplifies maintenance and trouble-shooting related to the reverse path.

AM system limitations

As with all things, there are limits. The first limit with AM fiber optic systems has been discussed previously (noise and distortion performance). In FTF system architecture, the noise performance of the system is roughly equivalent to the noise performance of the fiber optic link. Current technology can consistently deliver a CNR of 52 dB or so. "Hero" lasers are sometimes available that can push this number to 54 dB or 55 dB. This additional margin is not significant in FTF architectures (with the exception of extraordinary reach requirements), but it can be significant in an overlay situation involving RF trunking.

From a distortion perspective, available optical links can reliably deliver a CTB of -63 dB to -65 dB and a CSO of -60 dB to -63 dB. The distortion performance is important because it directly subtracts from the available budget for the distribution system which is distortion limited.

Another factor is that AM fiber optic systems reintroduce second order distortion, in the form of composite second order (CSO), as a potential system limiting factor.

Using the previous example, an AM fiber optic link will generate a CNR of 52 dB and a CTB distortion of -65 dB. Assuming that the trunk amplifier with its normal setup is contributing a CNR of 60 dB and a CTB distortion of -85 dB, the fiber optic link, in terms of its equivalent in trunk amplifier cascade, is equal to 6.3 trunk amplifiers for CNR and 10 trunk amplifiers for CTB distortion. Optimizing levels for equal cascade gives an equivalent trunk cascade of 7.9 or roughly eight amplifiers. It can be assumed then that depending on the specifics of the equipment, technology, vendor etc., that the typical AM fiber optic link will be the approximate equivalent of 8 ± 2 RF trunk amplifiers in terms of its impact on the overall system CNR and CTB budgets.

The second fundamental limitation is reach. Current AM fiber optic technology is limited to an optical loss budget of 8 dB to 10 dB. Assuming a fiber attenuation of 0.45 dB/km (including splices at 1310 nm), this yields an average maximum reach of between 17.8 km and 22.2 km for a single link. It is important to recognize that while distortions are fairly independent of optical loss, CNR is somewhat of a function of optical loss. Any given link will be 3 dB to 4 dB better in CNR at a 2 dB or 3 dB optical loss than at a 10 dB optical loss. As a practical matter, however, loss budgets of 2 dB or 3 dB do not occur often.

For nodes located close in to a headend, optical splitting is used to fully utilize laser transmitter power and to minimize cost by feeding multiple nodes. Where longer distances are involved, less optical splitting or no optical splitting is used. As a result, the average cost per node for the fiber optic trunking increases with distance from the headend and maximum reach is usually limited to between 11 miles and 14 miles total with current technology. This reach will likely be extended with increased laser power and with the coming of optical amplifiers. However, it can be anticipated that the noise and distortion budgets will be affected accordingly.

For large systems where reach is a problem, some form of interconnect such as AML microwave or FM fiber may be required. Any interconnect used should be accounted for in the overall noise and distortion budgets. Clearly, the noise and distortion performance of any interconnect must be very good if transparency is to be maintained throughout the system.

Comparing FTF and conventional

The hypothetical comparison shown in Table 1 is given to illustrate the differences between FTF and conventional tree-and-branch architectures. Assumptions for the example are:

- 26 dB gain, power-doubling and feedforward trunk
- all distribution amplifiers are power-doubling
- trunk cable is .875-inch
- feeder cable is .625-inch
- 5 dB average flat loss per trunk span
- trunk distance = 12.5 miles
- system passband and channel loading = 450 MHz (62 channels)
- distribution and trunk operating levels and operating gain are consistent between models.

		Conv. P.D.	Conv. F.F.	AM Fiber Optic
1.	Cascade	32+1+2	32+1+2	1+1+3
2.	CNR	42.8 dB	46.7 dB	51.0 dB
3.	CTB	-52.8 dB	-52.3 dB	-54.6 dB
4.	CSO	-53.3 dB	-52.9 dB	-53.0 dB
5.	Response*	5.2 dB	5.2 dB	1.5 dB
6.	Total Passives & Taps**	75 ea (+208%)	75 ea	36 ea
7.	Total Connectors**	220 ea (+275%)	220 ea	80 ea
8.	Cable Sections**	110 ea (+333%)	110 ea	33 ea
9.	Power Supplies**	8 ea (+800%)	8 ea	1 ea
10.	Subscriber Signal Level	+6 dBmV	+6 dBmV	+6 dBmV
11.	Output Levels			
	Trunk	+34 dBmV	+39 dBmV	N/A
	Bridger	+47 dBmV	+47 dBmV	+47 dBmV
	LE	+44 dBmV	+44 dBmV	+44 dBmV
12.	Operating Gain			
	Trunk	26 dB	26 dB	N/A
	Bridger	32 dB	32 dB	32 dB
	LE	31 dB	31 dB	31 dB

*n/10 +1 for trunk, 1 dB for distribution

**sequential components from headend to last subscriber

Of particular interest here is the comparison of predicted CNR, CTB, system frequency response and sequential components. Also note that the predicted CNR's for the conventional architecture will be further reduced by 1 - 1.5 dB when thermal factors are considered.

Table 1. Technical comparison of FTF and conventional tree and branch architectures

The stability premium. The stability inherent in the FTF architecture is perhaps one of the most beneficial improvements from an operating standpoint. Conventional cable systems require constant maintenance in order to acquire and maintain predicted performance levels. System sweep alignment is a perpetual activity in most systems (and in those systems where it is not, it should be). The constant evolution of systems to higher passbands and greater channel loading has consumed system headroom at least as fast as the manufacturing segment has been able to improve equipment over the years. As a result, modern 450 MHz and 550 MHz systems generally have no more headroom with regard to noise and distortion than many lower capacity systems built years ago. More often than not, the rule is that most systems, new and old, have their backs to the wall with regard to maintaining quality service (i.e. predicted performance levels).

Other than outages and CLI, the single most troublesome technical problem in system operations is maintaining decent frequency response and level stability. In systems where little headroom or margin exists, even slight perturbations can generate additional noise and/or distortions. Cable systems can cover bandwidths of up to 500 MHz and do so over 3+ octaves. It is no wonder that these systems are as sensitive as they are to mechanical and electrical problems such as thermal expansion and contraction, corrosion, surge damage, alignment, etc.

Referring to Table 1, the numerical advantage in terms of reduced potential mechanical and electrical trouble spots with the FTF architecture is clear. There is great advantage in terms of system operations in replacing the mechanically and electrically fragile RF trunk with a rugged, passive counterpart. Frequency response remains stable, levels remain stable, performance variations caused by thermal effects on the coaxial cable are greatly reduced, and outages caused by lightning and power grid problems become more localized. The result is better quality pictures, greater reliability, and lower maintenance costs than is possible given conventional repeatered RF trunking.

Historically, the housedrop has often

been considered a stepchild to the system. The typical approach was to make some assumptions with regard to drop length, splitter losses, etc. in order to arrive at an appropriate tap output level. Also common was the practice of simply assigning a tap output level without considering the actual drop requirements. Usually this arbitrary approach was based on the perceived economics of the tap output level speci- fication (dollars per mile of distribution plant) with little or no regard to the technical consequences.

In cable systems that were capable of CNRs in the vicinity of 40 dB to 44 dB, this inattention to detail, while creating some problems, was tolerated because the impact in picture quality, while substantial, was not catastrophic. With the advent of transparent cable systems, this is no longer possible.

Effect on converters

Should the use of a converter be considered at all when the current trend is toward whole-house service and customer friendliness? Given the history of tiering, scrambling, and the many marketing strategies that have come and gone, it is risky business to assume that no terminal device of any kind will be used over the life of the system. A more prudent approach is to assume that some device will be marketed to or purchased by the subscriber base during the life of the system.

The nature of the device (i.e. converter, preamp, VCR, descrambler, etc.) is relatively immaterial with regard to picture quality as long as it's noise and distortion contribution is accounted for initially in the system engineering. If a given system has converters in it, the noise figure and distortion performance of that converter can be assumed. If a system does not contemplate converters (very rare), then an appropriate noise figure and distortion performance can be assumed as an allowance for a terminal device of some sort, whether furnished by the system or installed by the subscriber.

Table 2 shows the CNR delivered to a subscriber's receiver as a function of system CNR, terminal device noise figure, and terminal device input signal level. This describes the impact of a given terminal device on CNR. Table 3 rearranges the data so that the impact of the device on subscriber CNR can be seen as a function of terminal device noise figure.

It can be seen that if one defines "maintaining system picture quality" as no more than a 1 dB degradation in system CNR, then input levels must rise or noise figures must decrease as the system CNR increases. As an example, at a 44 dB system CNR, a 9 dB NF converter requires an input signal level of 0 dBmV to yield a 43 dB (1 dB degradation) CNR. The same converter requires a +6 dBmV input level when the system CNR is 50 dB in order to yield a 49 dB (1 dB degradation) CNR.

performance systems are converters or other terminal devices that have noise figures in the 12 dB to 14 dB range—the typical RF converter.

It can be seen in Table 3 that converters in this category are between the proverbial rock and a hard place in that if input levels are high enough to deliver good noise performance, distortion becomes a problem. (The economic impact of the system tap output level is also of concern).

		Terminal Device Input Signal Level (dBmV)				
System CNR	Terminal Device NF	-6	-5	-4	-3	-2
43 dB	7 dB	41.2 dB	41.5 dB	41.8 dB	42.0 dB	42.2 dB
	9 dB	40.5 dB	40.9 dB	41.2 dB	41.5 dB	41.8 dB
	12 dB	38.9 dB	39.5 dB	40.0 dB	40.5 dB	40.9 dB
	14 dB	37.5 dB	38.2 dB	38.9 dB	39.5 dB	40.0 dB
44 dB	7 dB	41.9 dB	42.2 dB	42.5 dB	42.8 dB	43.0 dB
	9 dB	41.0 dB	41.5 dB	41.9 dB	42.2 dB	42.5 dB
	12 dB	39.2 dB	39.9 dB	40.5 dB	41.0 dB	41.5 dB
	14 dB	37.8 dB	38.5 dB	39.2 dB	39.9 dB	40.5 dB
45 dB	7 dB	42.5 dB	42.9 dB	43.2 dB	43.5 dB	43.8 dB
	9 dB	41.6 dB	42.0 dB	42.5 dB	42.9 dB	43.2 dB
	12 dB	39.5 dB	40.2 dB	40.9 dB	41.6 dB	42.0 dB
	14 dB	38.0 dB	38.8 dB	39.5 dB	40.2 dB	40.9 dB
46 dB	7 dB	43.0 dB	43.5 dB	43.9 dB	44.2 dB	44.5 dB
	9 dB	41.9 dB	42.5 dB	43.0 dB	43.5 dB	43.9 dB
	12 dB	39.8 dB	40.5 dB	41.2 dB	41.9 dB	42.5 dB
	14 dB	38.2 dB	39.0 dB	39.8 dB	40.5 dB	41.2 dB
47 dB	7 dB	43.5 dB	44.0 dB	44.5 dB	44.9 dB	45.2 dB
	9 dB	42.2 dB	42.9 dB	43.5 dB	44.0 dB	44.5 dB
	12 dB	40.0 dB	40.8 dB	41.5 dB	42.2 dB	42.9 dB
	14 dB	38.4 dB	39.2 dB	40.0 dB	40.8 dB	41.5 dB
48 dB	7 dB	43.9 dB	44.5 dB	45.0 dB	45.5 dB	45.9 dB
	9 dB	42.5 dB	43.2 dB	43.9 dB	44.5 dB	45.0 dB
	12 dB	40.2 dB	41.0 dB	41.8 dB	42.5 dB	43.2 dB
	14 dB	38.5 dB	39.4 dB	40.2 dB	41.0 dB	41.8 dB
49 dB	7 dB	44.2 dB	44.9 dB	45.5 dB	46.0 dB	46.5 dB
	9 dB	42.8 dB	43.5 dB	44.2 dB	44.9 dB	45.5 dB
	12 dB	40.4 dB	41.2 dB	42.0 dB	42.8 dB	43.5 dB
	14 dB	38.6 dB	39.5 dB	40.4 dB	41.2 dB	42.0 dB
50 dB	7 dB	44.5 dB	45.2 dB	45.9 dB	46.5 dB	47.0 dB
	9 dB	43.0 dB	43.8 dB	44.5 dB	45.2 dB	45.9 dB
	12 dB	40.5 dB	41.4 dB	42.2 dB	43.0 dB	43.8 dB
	14 dB	38.7 dB	39.6 dB	40.5 dB	41.4 dB	42.2 dB

Referring to Table 2, if the system CNR was increased to 50 dB, but the converter input level remained at 0 dBmV (a common situation in upgrades) the effective CNR would be reduced from 50 dB (system CNR) to 47.0 dB, or a 3 dB drop in CNR caused by insufficient input signal level to the converter. This means that the converter is contributing as much noise as the entire system preceding it. Of particular concern with regard to high

As the system CNR increases to transparency, the noise contribution of all terminal devices (i.e. converters, VCRs, preamps, descramblers, etc.) becomes a limiting factor in system performance and must be carefully considered in the system design process as well as in the installation and maintenance processes. In transparent systems, the terminal device input signal window is squeezed on the lower end by noise performance factors, and simultaneously squeezed on the upper end by the distortion limitations inherent to high system channel loading.

As a result, the input signal window, if it can be called that anymore, is very narrow when compared to traditional lower performance and lower channel capacity systems. In high performance systems the housedrops must be considered as an integrated part of the system and as such will require much more attention in system planning and in system operations than has been the case in the past. Recent improvements in converters, specifically the availability of low noise preamplifiers and AGC control of levels, are highly beneficial in high performance systems.

It can be seen in Tables 2 and 3 that converter noise figures must be in the 7 dB to 9 dB range if tap output levels are to be controlled. Tap output levels can become a major problem because they are driven up not only because of the higher cable and passive attenuation created by bandwidth increases, but also simultaneously by noise performance requirements of the converter.

AGC recommended

AGC control of converter input levels is recommended if distortion in the converter is to be effectively controlled in the face of the higher input levels required to achieve noise performance. (Converter AGC that derives gain control at the converter output provides no such benefit).

The blocked areas of Table 3 indicate input levels that are potentially problematic with regard to distortion. AGC control at the converter input allows the converter input level to be set for optimum noise and distortion performance and then maintains that relationship. It is important to remember that the internal losses (cable length, passive loss, etc.) of housedrops vary greatly from subscriber to subscriber, so input levels are hard to predict with much accuracy. Signal levels will also vary to some degree with temperature. AGC at the converter input acts as a shock absorber with regard to signal level. Even with AGC however, installation personnel will be required to have better technical skills than in the past to assure that each housedrop is properly engineered, installed and maintained.

Aside from the qualitative advances possible with FTF system architecture, perhaps equally important is the quantitative aspect of fiber optic trunking. With no RF trunk to contend with, wider bandwidths and higher channel loading are much easier to achieve. One may anticipate that the deployment of an FTF system architecture will likely include a substantial increase in bandwidths and channel loading. Once again, the housedrop becomes a major player in that transition.

There are many different combinations of drop length, cable size, etc. The example chosen for Table 4 is a reasonable representation of the drop architecture likely to be in place in an older 300-MHz system. It can be seen that the combination of higher losses inherent with wider bandwidths, and the higher input levels required to maintain improved system noise performance, result in much higher tap output level requirements.

Referring to Example 5 in Table 4 and to Table 2, if the 300 MHz configuration had a CNR of 44 dB, the converter, assuming a 12 dB NF, would yield a 43.0 dB noise figure with an input level of +3 dBmV. If the system were upgraded to a 50 dB CNR with FTF, but the tap output level, drop configuration and converter were left as is (+17 dBmV TOL, 16.93 dB drop loss), the converter would degrade the 50 dB system CNR to 45.2 dB; a 5-dB loss in CNR as a result of a 0 dBmV input level.

This example illustrates the importance of the drop in high performance systems. In transparent systems, the drop and terminal device are limiting factors with regard to signal quality and they must be considered if transparency is to be achieved. Issues that have been largely ignored in the past, such as noise figure and distortion performance of converters, input levels, equalization of signals, drop length and

-1	0	+1	+2	+3	+4	+5	+6
42.4 dB	42.5 dB	42.6 dB	42.7 dB	42.7 dB	42.8 dB	42.8 dB	42.9 dB
42.0 dB	42.2 dB	42.4 dB	42.5 dB	42.6 dB	42.7 dB	42.7 dB	42.8 dB
41.2 dB	41.5 dB	41.8 dB	42.0 dB	42.2 dB	42.4 dB	42.5 dB	42.6 dB
40.5 dB	40.9 dB	41.2 dB	41.5 dB	41.8 dB	42.0 dB	42.2 dB	42.4 dB
43.2 dB	43.4 dB	43.5 dB	43.6 dB	43.7 dB	43.7 dB	43.8 dB	43.8 dB
42.8 dB	43.0 dB	43.2 dB	43.4 dB	43.5 dB	43.6 dB	43.7 dB	43.7 dB
41.9 dB	42.2 dB	42.5 dB	42.8 dB	43.0 dB	43.2 dB	43.4 dB	43.5 dB
41.0 dB	41.5 dB	41.9 dB	42.2 dB	42.5 dB	42.8 dB	43.0 dB	43.2 dB
44.0 dB	44.2 dB	44.4 dB	44.5 dB	44.6 dB	44.7 dB	44.7 dB	44.8 dB
43.5 dB	43.8 dB	44.0 dB	44.2 dB	44.4 dB	44.5 dB	44.6 dB	44.7 dB
42.5 dB	42.9 dB	43.2 dB	43.5 dB	43.8 dB	44.0 dB	44.2 dB	44.4 dB
41.6 dB	42.0 dB	42.5 dB	42.9 dB	43.2 dB	43.5 dB	43.8 dB	44.0 dB
44.8 dB	45.0 dB	45.2 dB	45.4 dB	45.5 dB	45.6 dB	45.7 dB	45.7 dB
44.2 dB	44.5 dB	44.8 dB	45.0 dB	45.2 dB	45.4 dB	45.5 dB	45.6 dB
43.0 dB	43.5 dB	43.9 dB	44.2 dB	44.5 dB	44.8 dB	45.0 dB	45.2 dB
41.9 dB	42.5 dB	43.0 dB	43.5 dB	43.9 dB	44.2 dB	44.5 dB	44.8 dB
45.5 dB	45.8 dB	46.0 dB	46.2 dB	46.4 dB	46.5 dB	46.6 dB	46.7 dB
44.9 dB	45.2 dB	45.5 dB	45.8 dB	46.0 dB	46.2 dB	46.4 dB	46.5 dB
43.5 dB	44.0 dB	44.5 dB	44.9 dB	45.2 dB	45.5 dB	45.8 dB	46.0 dB
42.2 dB	42.9 dB	43.5 dB	44.0 dB	44.5 dB	44.9 dB	45.2 dB	45.5 dB
46.2 dB	46.5 dB	46.8 dB	47.0 dB	47.2 dB	47.4 dB	47.5 dB	47.6 dB
45.5 dB	45.9 dB	46.2 dB	46.5 dB	46.8 dB	47.0 dB	47.2 dB	47.4 dB
43.9 dB	44.5 dB	45.0 dB	45.5 dB	45.9 dB	46.2 dB	46.5 dB	46.8 dB
42.5 dB	43.2 dB	43.9 dB	44.5 dB	45.0 dB	45.5 dB	45.9 dB	46.2 dB
46.9 dB	47.2 dB	47.5 dB	47.8 dB	48.0 dB	48.2 dB	48.4 dB	48.5 dB
46.0 dB	46.5 dB	46.9 dB	47.2 dB	47.5 dB	47.8 dB	48.0 dB	48.2 dB
44.2 dB	44.9 dB	45.5 dB	46.0 dB	46.5 dB	46.9 dB	47.2 dB	47.5 dB
42.8 dB	43.5 dB	44.2 dB	44.9 dB	45.5 dB	46.0 dB	46.5 dB	46.9 dB
47.5 dB	47.9 dB	48.2 dB	48.5 dB	48.8 dB	49.0 dB	49.2 dB	49.4 dB
46.5 dB	47.0 dB	47.5 dB	47.9 dB	48.2 dB	48.5 dB	48.8 dB	49.0 dB
44.5 dB	45.2 dB	45.9 dB	46.5 dB	47.0 dB	47.5 dB	47.9 dB	48.2 dB
43.0 dB	43.8 dB	44.5 dB	45.2 dB	45.9 dB	46.5 dB	47.0 dB	47.5 dB

so on, will have to be accounted for at all stages of system operation. It makes little sense to build transparent systems all the way to the tap and then lose it behind the subscriber's receiver.

Tradeoffs are involved in balancing the conflicting demands of converter input level and excessive tap output levels. Referring once again to Example 5, with regard to tap output level, it can be seen in Table 2 that a reduction in the converter noise figure to 7 dB (a 5 dB reduction) would yield a net CNR of 47.9 dB with a 0 dBmV input level. Further improvement could be achieved by replacing the drop with larger cable, thereby increasing input level. If the RG 59 drop were replaced with RG 6 for example, the net drop loss would be reduced by 1.6 dB to 15.4 dB.

Referring to Table 2, a +4 dBmV input level would be required to net at 49 dB CNR (1 dB degradation, 7 dB NF). Therefore, if the drop were replaced with RG 6, and the converter was replaced with a less noisy converter (7 dB NF), the tap output level would have to be raised from +17 dBmV to +19 dBmV in order for the subscriber to receive a 49 dB CNR signal. These kind of tradeoffs need to be evaluated on a case-by-case basis to determine their economic and operational impacts, but they cannot be ignored if success is to be achieved.

Terminal Device NF	System CNR	Required Input Level, -2 dB in CNR	Required Input Level, -1 dB in CNR
7 dB	43 dB	-6 dBmV	- 3 dBmV
	44 dB	-5 dBmV	- 2 dBmV
	45 dB	-4 dBmV	- 1 dBmV
	46 dB	-3 dBmV	0 dBmV
	47 dB	-2 dBmV	+ 1 dBmV
	48 dB	-1 dBmV	+ 2 dBmV
	49 dB	0 dBmV	+ 3 dBmV
	50 dB	+1 dBmV	+ 4 dBmV
9 dB	43 dB	-4 dBmV	- 1 dBmV
	44 dB	-3 dBmV	0 dBmV
	45 dB	-2 dBmV	+ 1 dBmV
	46 dB	-1 dBmV	+ 2 dBmV
	47 dB	0 dBmV	+ 3 dBmV
	48 dB	+1 dBmV	+ 4 dBmV
	49 dB	+2 dBmV	+ 5 dBmV
	50 dB	+3 dBmV	+ 6 dBmV
12 dB	43 dB	-1 dBmV	+ 2 dBmV
	44 dB	0 dBmV	+ 3 dBmV
	45 dB	+1 dBmV	+ 4 dBmV
	46 dB	+2 dBmV	+ 5 dBmV
	47 dB	+3 dBmV	+ 6 dBmV
	48 dB	+4 dBmV	+ 7 dBmV*
	49 dB	+5 dBmV	+ 8 dBmV
	50 dB	+6 dBmV	+ 9 dBmV
14 dB	43 dB	+1 dBmV	+ 4 dBmV
	44 dB	+2 dBmV	+ 5 dBmV
	45 dB	+3 dBmV	+ 6 dBmV
	46 dB	+4 dBmV	+ 7 dBmV
	47 dB	+5 dBmV	+ 8 dBmV
	48 dB	+6 dBmV	+ 9 dBmV
	49 dB	+7 dBmV*	+10 dBmV
	50 dB	+8 dBmV	+11 dBmV

*Potentially Limited by Distortion and/or Tap Output Level Considerations

Table 3: Required input level for 1 dB and 2 dB gradation in CNR as a function of terminal device Noise figure

FTF distribution architecture

The distribution architecture of FTF networks differs from that of conventional tree-and-branch systems in several ways. Perhaps the most fundamental is that in tree-and-branch systems, the distribution system architecture is secondary to the trunk requirements. Issues such as trunk routing, cascade, reach, etc. that dominate the performance of tree-and-branch systems are largely eliminated in FTF systems. The distribution system can be optimized without regard (or perhaps with less regard) to the dictates of the trunking system.

Secondly, the distribution system area in FTF architectures is physically larger than that found in conventional systems. As illustrated in Figures 1 and 2, a major portion of the noise budget that is normally allocated to the trunk in tree-and-branch systems is now available for improved performance in the FTF architecture. Likewise, the distortion allocation normally used by the trunk is available for use in the FTF system by additional distribution amplifiers and/or line extenders. Where tree-and-branch distribution systems typically consist of a bridger and two line extenders, FTF networks typically consist of an optical bridger and three or more line extenders or distribution amplifiers.

The distribution network in an FTF system is characterized by high levels and low noise. As such it is distortion limited. The economics of FTF networks depend on maximizing the amount of RF plant associated with any individual node. Therefore, power-doubling and feedforward technologies are most often used to provide the highest possible operating levels relative to the distortion generated. FTF networks, like tree-and-branch networks, are affected by temperature in the coaxial cable portion of the plant. Gain control and thermal compensation should be used as in tree-and-branch systems. In FTF networks, however, the thermal changes mostly affect the distortion performance, not noise performance. In conventional systems both are affected. And as previously discussed, level stability is also important with regard to terminal devices.

In FTF networks, extensive use is usually made of "express feeders" to extend the reach of the distribution system. Express feeders are essentially untapped, high-level, dedicated cables that function as pseudo-trunks to expand reach from the node. With an expanded distortion budget and the accompanying potential for longer distribution cascades, express feeders help maximize the geographical reach of each node.

Cascades

In the context of cascade considerations, the FTF distribution architecture somewhat resembles conventional tree-and-branch networks, except that the "trunk" is a high-level, low-noise extension of the distribution system and the total cascade is usually distortion limited to five or six amplifiers. As the cascade number increases, the operating levels of each amplifier in the cascade must be reduced (derated) in order to meet distortion performance objectives. This results in a larger node in terms of total mileage that is less efficient in terms of actives per mile of plant. This is because the reduced amplifier output level is taken from the high level portion of the distribution span, the most efficient in terms of signal power usage. Higher operating levels associated with shorter cascades are also more efficient in systems with high tap output level requirements. Longer distribution cascades clearly require high performance, low distortion amplifiers.

A second concern with respect to cascade limitations in FTF systems relates to microreflections and fre-

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Fiber couplers for FTF CATV systems

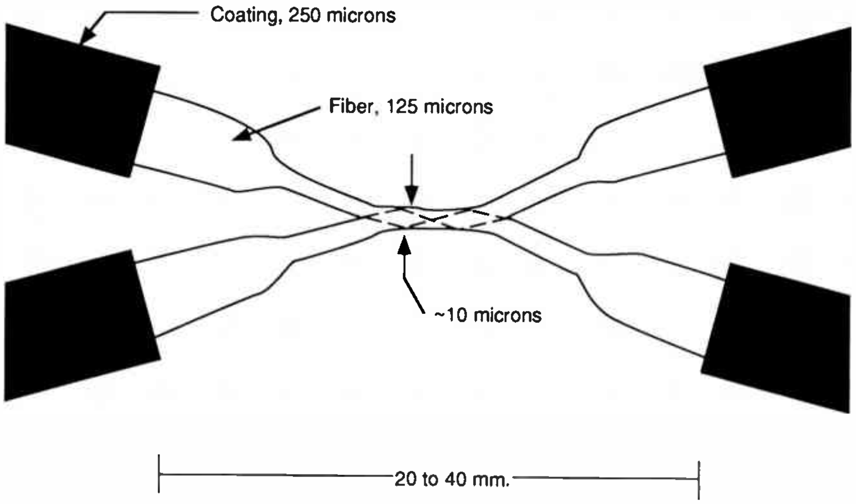
By Herzel Laor, Independent Consultant to American Television and Communications Corp.

Optical fiber couplers are the optical analogue of RF directional couplers. Light arriving on the input fiber is being split among two or more output fibers.

Fiber couplers are very important components of the Fiber to the Feeder (FTF) architecture. The average use of 3.5 receiver nodes per laser is anticipated, and an average of 2.5 couplers are needed to couple a laser to these nodes. The average node will serve approximately 500 to 700 subscribers, so the average installed coupler will serve 700 to 1,000 subscribers.

There are several manufacturers of couplers, and each has an extremely diverse line of products. It is very difficult to compare couplers quoted by different suppliers. ATC is now developing standard specifications for fiber couplers. Since these couplers are installed within splice enclosures supplied by several manufacturers, it is important to have mechanical compatibility between the couplers and enclosures.

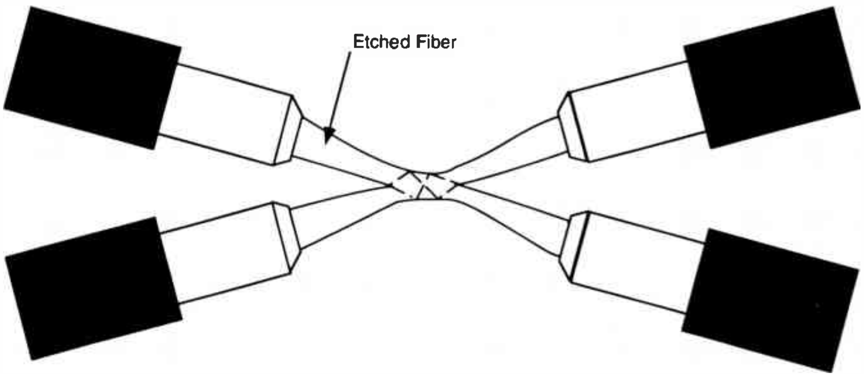
The use of a limited set of coupling ratios is important to ease the design and maintenance of FTF systems. The useful coupling ratios for 1x2 units are displayed in Table 1. If one accepts some inefficiency in the system design, only 3 different couplers are required, those marked with an asterisk (*) in Table 1. These couplers are the majority of couplers we use today.



Tapered Fused Couplers

Note: drawing not to scale

Figure 1



Tapered Fused Couplers, Depressed Cladding Fiber
Note: drawing not to scale

Tapered Fused Couplers

Note: drawing not to scale

Figure 2

Coupler structure

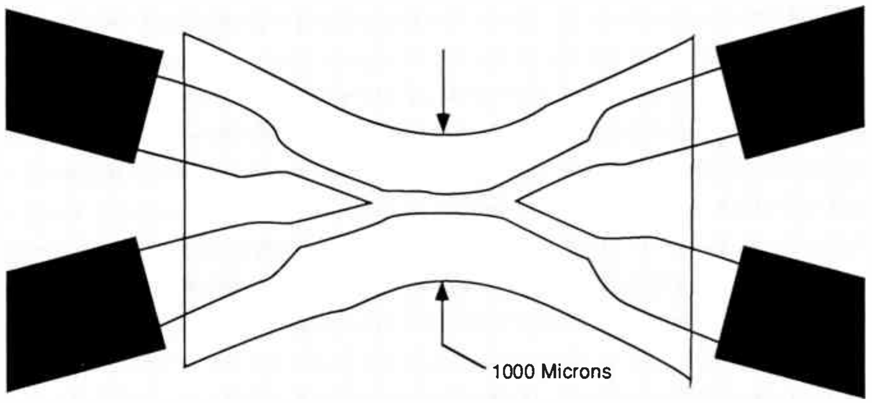
Several different technologies are used to make fiber couplers. Each has pros and cons, which are described below.

Tapered fused fibers. (Figure 1) Two pieces of fiber are cut to the required length. A few centimeters of the center of each fiber is stripped of its protective coating. The fibers are twisted together, at the stripped location, and heated until the glass softens and the two fibers are fused. The fibers are pulled to extend in length and create a narrow neck at the heated area. The operation is monitored for the coupler performance by injecting light into one of the fibers and measuring the amount of light coupled between the fibers. The pulling is stopped in time to achieve the required coupling. Coupling is achieved when pulling the fibers, because the size of core and cladding is reduced, and light starts to propagate in the cladding. Part of this light finds its way to the other fiber's core and propagates in it. The two fibers are drawn together to roughly 10 microns (0.4 mil) diame-

ter. Because of the small diameter and because exposing bare fiber to humidity will cause it to become brittle, it is important to embed the coupler in some mechanical assembly.

Tapered fused fibers—depressed cladding variety (Figure 2). If the fibers used for making the coupler are of the depressed cladding type, it is necessary to etch the exposed fiber and to remove the outer cladding material before the fusion operation. The drawn coupler is somewhat smaller in diameter compared to matched clad fiber couplers.

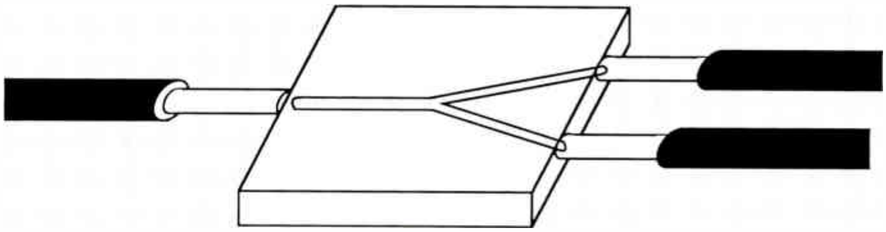
Tapered fused fibers—with glass tube (Figure 3). The two fibers are inserted in a glass tube, prior to the drawing. The fibers and the tube are heated and drawn together. The diameter of the neck is now roughly 1,000 microns (40 mil). Potting is used to protect the fibers on the two sides of the tube.



Tapered Fused Coupler With Glass Tube
Note: drawing not to scale

Figure 3

Planar waveguide couplers (Figure 4). Y-shaped waveguides may be constructed on a variety of substrates. Fibers are then butt-coupled to the waveguide, usually glued in position. On the other hand, this type of coupler is less sensitive to wavelength variations. This type of coupler will prove very useful if splitting of light from an input fiber to more than two output fibers is required.



Planar Waveguide Coupler
Note: drawing not to scale

Figure 4

Coupler configuration

An exclusive use of 1x2 structure is suggested. The rationale is that 1x3 and larger splitting count generate too many combinatorial possibilities for the splitting ratios. Our experience is that the need for 1x3 splitting in one location is rare, and we could use two 1x2 splitters to accommodate such cases. 2x2 splitters may be used, but care should be taken to be terminate the unused fiber properly, to minimize reflection problems. (It may seem that this reflection will not create a problem since it does not reach the laser, but interference between this reflection and the fiber backscatter may create some optical noise.)

Optical specifications

Fiber type. Single mode fibers are used, with a mode field diameter to match the transmission fibers. A 1.0 micron mismatch between the mode field diameters of the coupler fibers and the transmission fibers will generate approximately 0.05 dB loss. The use of depressed cladding fiber will result in the need to have extra long pigtails, so the separation between splices is larger than recommended by the fiber manufacturer (usually 20 meters.) In a system constructed of depressed cladding fibers, it may be acceptable to use matched cladding fibers for the couplers and suffer the excess loss. Splice of fibers with 1 micron difference in mode field diameter will not create too high of reflection to be a problem. (The problem of mode field diameter mismatch exists when using different types of fibers in different portions of the system, as well as for the coupling between the laser or detector and the transmission fiber.)

Wavelength span. It is recommended to request a wavelength span of 1290 to 1330 nm, since most lasers are specified for this span. Tightening of this specification dramatically increases the performance of the coupler, but will require the selection of lasers that actually transmit in the reduced band.

Insertion loss. Some coupler manufacturers will define separately the variation in splitting ratio, the wavelength dependence of splitting ratio and an excess loss. This creates some confusion to the system designer. We define a total insertion loss figure for each output fiber, to include the wavelength dependence, the splitting ratio error and the excess loss (see Table 1.) The numbers in Table 1 are the worst case measured input to output loss over all wavelengths. The measurements will be performed at 25 C.

Polarization. Couplers may be used near the laser, in which case the light may be polarized. It is important that the coupling ratio not be dependent on the polarization. (There are fiber couplers that will preserve the polarization upon splitting of the light. Polarization preservation, however, is not required for our application.)

Back reflection. Reflections are always an unwanted phenomenon in optical communications. The lasers are usually protected against reflection from the system, but this does not mean that the issue can be ignored. If light is reflected twice in the system, it will create optical noise because of the

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		Total Insertion Loss		Maximum Allowable Degradation	
Coupling Ratio - %	Coupling Ratio - dB	First Output - dB	Second Output - dB	First Output - dB	Second Output - dB
50/50 *	3.0/3.0	3.5	3.5	0.1	0.1
55/45	2.6/3.5	3.3	4.2	0.1	0.11
60/40 *	2.2/4.0	2.8	4.7	0.1	0.12
65/35	1.9/4.6	2.4	5.3	0.1	0.13
70/30 *	1.5/5.2	2.0	6.0	0.1	0.14
75/25	1.2/6.0	1.7	6.8	0.1	0.15
80/20	1.0/7.0	1.4	7.9	0.1	0.16
85/15	0.7/8.2	1.1	9.3	0.1	0.18
90/10	0.5/10.0	0.9	11.3	0.1	0.20

Table 1: Couplers Performance

Note: The couplers marked with * are the most commonly used in FTF systems

interference between the directly transmitted light and the reflected light. Since the fiber itself reflects light at approximately −31 dB per Km, any source of other reflection may cause problems, and the coupler is not an exception. It is recommended to specify −55 dB as the maximum allowable for all reflections in the coupler.

Mechanical specifications

Temperature. The temperature span that couplers can be subjected to, in a pole-mounted splice enclosure, is −40 degrees Celsius to +85 degrees Celsius. The insertion loss will usually change with temperature, and the maximum allowable degradation is shown in Table 1.

> It is recommended to specify −55 dB as the maximum allowable for all reflections in the coupler.

Mechanical structure. Couplers are usually installed in splice enclosures. Because of the different shape of trays in different splice enclosures, it is not practical to set up a size standard that will enable the coupler to be instalied in a splice tray. It is recommended, however, to put the coupler in the back of the enclosure and to use cable fibers

Appendix: Fiber coupler specifications

Optical

Splitting structure	1x2.
Mode field diameter:	8.5 to 9.5 Micron. The actual mode diameter should be specified by the manufacturer.
Wavelength:	1290 nm to 1330 nm.
Total insertion loss:	Worst case input to output loss over the wavelength range of 1290 nm to 1330 nm, including coupling ratio variations, measured at 25 degrees Celsius, is specified in Table 1.
Polarization:	No preservation of polarization is required. However, with any polarization of the input radiation, insertion loss will not degrade more than the allowable degradation in Table 1.
Back reflection:	Better than −55 dB. (On all three fibers)
Directivity:	Better than −55 dB. (On all three fibers)
Temperature:	−40 degrees Celsius to +85 degrees Celsius.

Mechanical

Pigtails:	Two meter minimum (six feet). Minimum one meter of two mm to three mm loose tube cable, and the balance of 125 μm coating.
Diameter/square:	20 mm maximum (0.8 inches)
Length:	150 mm maximum (six inches)
Fiber marking:	The input fiber and the fiber with lower insertion loss will have natural color. The higher insertion loss fiber will be color coded, with the color extending to at least 90 percent of its length. For three dB couplers, one of the output fibers should be color coded, regardless of the loss.
Coupler marking:	The coupler dB loss or percent splitting ratio should be marked on the coupler body. It may be embedded in the part number, if it is readily discernable.

Environmental tests

Temperature:	Cycling from −40 degrees Celsius to +80 degrees Celsius. Total insertion loss will not degrade more than the allowed in Table 1.
Humidity:	Condensing and subsequent freezing per IEC 68-1, climatic sequence (chapter 7), where the dry heat is at 85 degrees Celsius and cold is at +40 degrees Celsius. Insertion loss will not degrade more than the allowed in Table 1.
Vibrations:	20 g. from 10 Hz to 2000 Hz. Insertion loss will not degrade more than the allowed in Table 1.
Fiber pull:	5-N pull on fiber and 40 N pull on cable will not result in permanent increase of insertion loss of more than 0.02 dB.
Aging:	Simulation of field aging performance will be done by conducting a series of tests as follows: ● Climatic sequence per IEC 68-1, as in the humidity test, ● Thermal aging per EIA FOTP-4, condition 3-D, ● Damp heat exposure per IEC 68-2-3 for 21 days, ● Cold test "Ab" per IEC 69-2-1, at 40 degrees Celsius for 96 hours, ● Repeating of the climatic process. Permanent loss performance will not degrade more than the allowed in Table 1. Transient loss during tests may be 0.1 dB more than the allowed in Table 1.

Life	Couplers are expected to serve 15 years in a pole mounted or underground splice enclosure, without significant degradation of performance.

to reach the trays. It is suggested to requires two meter pigtails, and a minimum length of one meter of each fiber to be protected by two mm to three mm diameter loose tube cable. The fibers should have 250 micron coating to match the housing used for bare fibers. A maximum of 150 mm length and 20 mm diameter or square is suggested.

Markings. To enable the assembly of couplers in a system without power measuring tools, the higher insertion loss fiber should be color coded. The color should extend to at least 90 percent of its length, so it will not disappear if the fiber is chewed away be repeated splicings. For three dB couplers, one output fiber should be color coded, regardless of the loss, for ease of documentation of the system structure. The input fiber and the fiber with lower insertion loss may be left unmarked. Because all couplers look alike, the coupler dB loss or percent splitting ratio should be marked on the coupler body.

Handling. It is important that the coupler will not be sensitive to normal forces applied while installing it. A moderate requirement is that 5 N pull on fiber and 40 N pull on cable will not result in permanent increase of insertion loss of more than 0.02 dB.

Environmental tests. A sample of couplers should pass some environmental tests to prove the integrity of the mechanical structure. During and after each test, the performance should not degrade more than that allowed in Table 1. The suggested tests are listed in the Appendix. This is a very tough test procedure, and couplers that allow for water ingress are sure to fail at the freezing temperature of the climatic sequence test procedure. Couplers with large differences in coefficient of expansion of different materials used in the assembly will have strong deterioration of loss performance or will break altogether at the temperature extremes. Couplers that have undergone environmental tests are not to be installed in systems.

> A sample of couplers should pass some environmental tests to prove the integrity of the mechanical structure.

Couplers are expected to serve 15 years in a pole-mounted or underground splice enclosure. The environmental tests provide some assurance that the couplers made in the same procures and from the same materials as the couplers that undergo the tests will have long life in field installations.

Conclusions

Fiber optic coupler specifications may be defined so that it would be easy to select couplers for system installation. A small number of splitting ratios and a fixed set of requirements that will apply to all manufacturers are key issues. Several coupler manufacturers that we have spoken to have helped in the preparation of the performance parameters described in this article, and have indicated their willingness to offer couplers withstanding these specifications. ■

FIBER OPTIC CALLBOOK

SIECOR

Siecor Corp. . . . .(704) 327-5943
FAX . . . .(704) 327-5973
489 Siecor Park
Hickory, NC 28603-0489
PERSONNEL: Everett McNair, 704-327-5943; David Johnson, 704-327-5895
DESCRIPTION: Siecor manufactures a variety of fiber optic cable designs for aerial, direct buried, duct installations. Loose tube design is rugged, easy to handle and provides superior environmental protection. Modularity simplifies fiber drop-off and mid-span access. Also supplies splicers, testers, training, services.

Opto-electronics

ALS
AMERICAN LIGHTWAVE SYSTEMS, INC.

American Lightwave . . . .(203) 265-8802
Systems, Inc.
FAX . . . .(203) 265-8801
358 Hall Ave.
Wallingford, CT 06492-1149
PERSONNEL: John Holobinko, VP/ Marketing & Sales; Rod Andersen, Regional CATV Sales Manager
DESCRIPTION: ALS LiteAMp™ AM fiber optic and FN6000™ FM fiber optic systems are designed for easy installation by normal CATV personnel without special optical training, yet they feature high performance and no periodic maintenance adjustments. ALS systems are completely modular. LiteAMp™ is available in strand, pole, pedestal and rack mounts. FN6000 and LiteAMp™ offer advanced features not found on competitive systems, based on ALS' 12 years of CATV fiber experience, more than twice any other vendor.

AMOCO
Amoco Laser Company

Amoco Laser Co. . . . . . .(708) 961-8400
FAX . . . .(708) 369-4299
1251 Frontenac Rd.
Naperville, IL 60563
PERSONNEL: Juan M. Cerda; Scott L. Miller
DESCRIPTION: Leading manufacturer of diode-pumped, solid-state Microlaser for fiber optic communications industry. These Microlasers are intended for use in high-power-budget, externally modulated CATV applications for either headend or distribution links. Amoco Laser offers standard products at 1.3 µm and 1.5 µm up to 175 mW with isolators and fiber optic pigtails.

BT&D
TECHNOLOGIES

BT&D Technologies . . . .(302) 479-0300
FAX . . . .(302) 479-9560
2 Righter Pkwy. #200
Wilmington, DE 19803
PERSONNEL: Wm. Grif Morrel, Product Mgr. Passive Components; Ken Miller, Sales Engineer
DESCRIPTION: BT&D Technologies offers a full line of passive fiber optic components including optical splitters, directional couplers, and multiport splitters. BT&D's broadband (wavelength-flattened) couplers are offered with equal splits as well as with asymmetric split ratios (DCs) and are designed to be used in dual wavelength 1300/1550nm networks. Multiport couplers such as 1x4 and 4x4 splitters are also available in wavelength-specific and broadband models. BT&D's couplers have an operating temperature range of -40 to +70°C and have been used extensively in both CATV installations in both headend and UCB1 enclosures. Contact BT&D Technologies at (800) 545-4306 for more information about these and other products.

C-COR®
ELECTRONICS INC

C-COR Electronics, Inc.. .(814) 238-2461
WATS . . . .(800) 233-2267
FAX . . . .(814) 238-4065
60 Decibel Rd.
State College, PA 16801
PERSONNEL: John Hastings, Director of Sales; Dick Taylor, National Sales Manager-CATV
DESCRIPTION: C-COR's products include digital and AM fiber optics, a variety of amplifiers, status monitoring, modems, passives, and power supplies. Our professional services include System Design, Field Engineering Assistance, Technical Training, Equipment Repair, a 48-hour Emergency Repair Service and a 24-hour hotline.

CORNING

Corning Inc. . . . .(607) 974-4214
Telecomm. Products Div.
FAX . . . .(607) 974-7522
MP-RO-03
Corning, NY 14831
PERSONNEL: Jon Chester, Cable TV Market Development Manager; Bill Willson, Sales Manager, Coupler Products
DESCRIPTION: Corning Incorporated manufactures a full line of optical fiber and components to meet today's demanding cable TV applications. Products include: Corning Titan™ single-mode fiber and Corning™ couplers, both multimode and single-mode tree, star, tap and WDM couplers.

EPITAXX

EPITAXX . . . .(609) 452-1188
FAX . . . .(609) 452-0824
3490 U.S. Route 1
Princeton, NJ 08540
PERSONNEL: Brian VanOrsdel, National Sales Manager; Rick Larin, Sales Engineer
DESCRIPTION: EPITAXX is a manufacturer of detectors and sources for optical communications. For fiber optic CATV, we produce InGaAs PIN photodiodes with high responsivity at 1300nm and 1550nm. Our CATV line includes the EPM700 series, photodetectors designed for the low intermodulation distortion requirement of AM transmission. In addition, we have designed our entire line of CATV photodiodes to have low optical back reflection.

JERROLD
COMMUNICATIONS
where innovation is a tradition

Jerrold Communications
Cableoptics . . . .(215) 674-4800
WATS . . . .(800) 523-6678
2200 Byberry Rd.
Hatboro, PA 19040
PERSONNEL: David Robinson, Director, Cableoptics; Daniel Sutorius, Project Manager, Cableoptics
DESCRIPTION: Designer/manufacturer of the industry's most comprehensive line of electronic and fiber optic broadband communications equipment. Jerrold STARLITE™ Cableoptics™ equipment supports both FM supertrunk and AM trunking (fiber-to-the-feeder, backbone and

more) applications. The company's RF distribution and headend gear provide a complete optoelectronic product line for cable TV.

MAGNAVOX
CATV SYSTEMS CO.

Magnavox CATV Systems	**(800) 448-5171**
WATS (State)	**(800) 522-7464**
FAX	**(315) 682-9006**

100 Fairgrounds Drive
Manlius, NY 13104

PERSONNEL: John Caezza, Product Manager; Larry Brown, Product Manager
DESCRIPTION: Manufacturer of video and data transmission systems. FM video transmission systems include MagnaReach FM modulators/demodulators, laser diode transmitters, and optical receivers. MagnaHub AM fiber optic transmission systems include rack mounted transmitters and rack or strand mounted receivers. Al Kernes, Vice President Sales

ORCHARD®
COMMUNICATIONS

Orchard Comm., Inc.	**(203) 284-1680**
WATS (National)	**(800) 523-7893**
FAX	**(203) 269-2964**

101 N. Plains Industrial Rd.
Wallingford, CT 06492

PERSONNEL: Dean Bogert, Director of Systems Engineering; Ronald Jones, VP of Sales, NJ office 609-596-9222
DESCRIPTION: Orchard manufactures a full range of fiberoptic AM-VSB, FM, and digital video transmission systems. AM systems use DFB lasers, or external modulation for high output power. Interfaces for FM and digital systems include baseband video/audio, monaural or BTSC audio, 45.75 MHz IF, or composite video with 4.5 MHz audio.

Making Light *Work* For You
ORTEL™
CORPORATION

Ortel Corp.	**(818) 281-3636**
FAX	**(818) 281-8231**

2015 W. Chestnut St.
Alhambra, CA 91803

PERSONNEL: Larry Stark, Director of Marketing; Bill Moore, Vice President of Sales
DESCRIPTION: Ortel manufactures fiber optic components for AM CATV transmission and for satellite TVRO antenna remoting.

Accessories/Passives

AUGAT
AUGAT COMMUNICATIONS GROUP INC.

Augat Comm. Group	**(206) 932-8428**
FAX	**(206) 938-8850**

2414 SW Andover St.
Seattle, WA 98106

PERSONNEL: Bill Jensen Dir. of Sales Fiberoptics; Amy Amrhein, Fiberoptic Product Manager
DESCRIPTION: The fiberoptics product line of the Augat Communications Group offers the following: SMT, SMA and biconic connectors; SMT, SMA and termination kits. Gauging tools; heat curing ovens; tools and accessories; modems and mux interfaces; cable assemblies; fiberoptic patch panels; Augat/Cinch fiber optic wiring system.

BT&D
TECHNOLOGIES

BT&D Technologies	**(302) 479-0300**
FAX	**(302) 479-9560**

2 Righter Pkwy. #200
Wilmington, DE 19803

PERSONNEL: Wm. Grif Morrel, Product Mgr. Passive Components; Ken Miller, Sales Engineer
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FAX	**(814) 238-4065**

60 Decibel Rd.
State College, PA 16801

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DESCRIPTION: C-COR's products include digital and AM fiber optics, a variety of amplifiers, status monitoring, modems, passives, and power supplies. Our professional services include System Design, Field Engineering Assistance, Technical Training, Equipment Repair, a 48-hour Emergency Repair Service and a 24-hour Hotline.

CORNING

Corning Inc.	**(607) 974-4214**
Telecomm. Products Div.	
FAX	**(607) 974-7522**

MP-RO-03
Corning, NY 14831

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Test Equipment

ADVANTEST®

Advantest America, Inc.	**(708) 634-2552**
FAX	**(708) 634-2610**

300 Knightsbridge Parkway
Lincolnshire, IL 60069

PERSONNEL: Atlee Jacobson, Sales Support Eng.-Midwest; Joe Diamond, Regional Sales Manager-East
DESCRIPTION: Q8460A High resolution OTDR: Automatic splice loss and location, optical return loss measurement, optical floppy disk drive stores up to 100 traces, and the modular construction supports multimode and singlemode fibers. R3361 series spectrum analyzers come with either 2.6 or 3.6 GHz capability and with an internal tracking generator. Its 120dB display dynamic range puts high and low signals on screen simultaneously. R4131 is a 3.5 GHz spectrum analyzer with numerous advanced digital functions at a low cost.

FIBER OPTIC CALLBOOK

CALAN

CALAN, Inc.	**(717) 828-2356**
WATS (National)	**(800) 554-3392**
FAX	**(717) 828-2472**

1776 Independence Dr.
Dingman's Ferry, PA 18328

PERSONNEL: Sydney Fluck, President; Edward McDonald, New Business
DESCRIPTION: CALAN, Inc. manufactures top of the line CATV test equipment including Integrated Sweep/Spectrum Analyzer Systems. The equipment combines the function of a Non-Interfering System Sweep and Spectrum Analyzer in one portable battery operated unit. The CALAN Sweep System has been successfully field tested on several fiber systems. Sweeping over fiber is a proven reality with the CALAN System. CALAN also offers the STAR 2010 SLMS Signal Level Measurement System which integrates field measurement and data management in the same device. The meter is a portable signal level meter with built-in data storage and PC communication. Both product lines are compatible with CATV and Broadband Data Networks. Phyllis Thompson, Major Accounts; Ian Jones, Product Manager

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hp HEWLETT PACKARD

Hewlett-Packard Co. **Signal Analysis Div.**	**(707) 794-2484**
FAX	**(707) 794-4620**

1212 Valley House Dr., 2LR-J
Rohnert Park, CA 94928

PERSONNEL: Pat Thompson, Marketing Communication
DESCRIPTION: Quality Analyzers Dedicated to Cable Television: Keep your CATV system operating and customers satisfied with HP CATV test equipment. For headend and trunk RF measurements, the HP 8590B/91A operate from 9kHz to 1.8 GHz. For microwave-link testing, the HP 8592B/93A extend coverage to 22 GHz. And for lightwave, the HP 83810A signal analyzer covers wavelengths from 1,200 to 1,600 nm and bandwidths from 9 kHz to 22 GHz. Consult your local telephone directory for the HP sales office nearest you.

SIECOR

Siecor Corp.	**(704) 327-5943**
FAX	**(704) 327-5973**

489 Siecor Park
Hickory, NC 28603-0489

PERSONNEL: Everett McNair, 704-327-5943; David Johnson, 704-327-5895
DESCRIPTION: Siecor manufactures a variety of fiber optic cable designs for aerial, direct buried, duct installations. Loose tube design is rugged, easy to handle and provides superior environmental protection. Modularity simplifies fiber drop-off and mid-span access. Also supplies splicers, testers, training, services.

WAVETEK

Wavetek RF Products, Inc.	**(317) 788-5965**
WATS (National)	**(800) 622-5515**
FAX	**(317) 782-4607**

5808 Churchman Bypass
Indianapolis, IN 46203-6109

PERSONNEL:David Waddington, Business Unit Manager, Broadband Communications; Jack Webb, Product Marketing Manager
DESCRIPTION: A full line manufacturer of CATV and LAN test equipment for use on coaxial and fiber optic cable. Products include optical signal level meters, system analyzers, system sweep equipment, frequency agile leakage detection and bench sweep gear. Mike Richardson, Western Regional Sales Manager; Tony Shortt, Eastern Regional Sales Manager

Powering

alpha
ALPHA TECHNOLOGIES

Alpha Technologies Inc.	**(206) 647-2360**
FAX	**(206) 671-4936**

3767 Alpha Way
Bellingham, WA 98225

PERSONNEL: Fred Kaiser, President; Bob Bridge, Sales Manager
DESCRIPTION: Alpha Technologies designs, manufactures and markets standby power systems, uninterruptable power sources, status monitoring systems, software and modems, batteries and CATV surge protection products for CATV systems domestically and internationally. Alpha is the world's largest manufacturer of 60 VAC products for CATV and broadband applications, producing AC power products in both 50 Hz and 60 Hz versions in Canada and the U.S.A. The company also owns and operates Argus Technologies, a specialized manaufacturer of 48 VDC rectifier equipment for telephone central office power plant, and Flight Trac, Inc., providing flyover signal metering for cable TV operators. Jeff Geer, Product Manager; Larry Roper, Product Manager

Lectro

Lectro Products	**(800) 551-3790**
Connecticut	**(203) 875-8805**
California	**(805) 251-8054**
Kansas	**(913) 782-4309**
Virginia	**(703) 273-5322**
FAX	**(404) 548-5493**

420 Athena Dr.
Athens, GA 30601

PERSONNEL: Michael R. Filkins, President; Mike Kearns, National Sales Manager
DESCRIPTION: Lectro manufactures a complete line of single ferro and dual redundant standby power systems and a full range of ferroresonant power supplies with outputs of 2 to 18 amps. A wide range of high quality products for U.S. and international markets are available including dual output for CATV and telephone system powering.

Surge Protection

CABLE INNOVATIONS INC.

Cable Innovations Inc.	**(404) 962-6133**

288 King Arthur Drive
Lawrenceville, GA 30245

PERSONNEL: Larry Filson, President
DESCRIPTION: Dirty Power Solution: the new CLPS-35 amp. Cable Line Power Suppressor, the only device made to go directly in RF line, will crow-bar over voltages directly from center conductor to ground in 60 ns, up to 1000 volts for 8.3 ms with less than .25dB insertion loss. Recommended use: All fiber stations, plus 3 per mile in trunk and feeder cable for total system protection. Patent pending. For information: 1-404-962-6133.

Enclosures

MOORE

Moore Diversified Products, Inc.	**(606) 299-6288**
FAX	**(606) 299-6653**

1441 Sunshine Lane
Lexington, KY 40505-2918

PERSONNEL: Dario L. Santana, Vice

President, Sales Manager; Gia Phelps, Sales Service
DESCRIPTION: Fiber optic slack boxes—Pedestal and pole mounted designs. Unique racking forfigure-eight storage of fiber optic cable. Durable aluminized steel construction and stainless steel welds. Scratch resistant powder applied polyester finish. Secure interlocking lids.

Construction

ARNCO

ARNCO Corp. . . . . **(216) 322-1000**
FAX . . . . **(216) 323-7111**
860 Garden St.
Elyria, OH 44035
PERSONNEL: Robert F. Smith, President; Thomas J. Stewart, National Sales Manager
DESCRIPTION: Arnco manufactures an integrated system of products for placing fiber optic cable. Our Starburst innerduct has internal and external ribs to reduce friction and cable sheath damage. Other products include Dandy-Line lubricated stiff tape, Hydra-Lube cable lubricant and cable cleaners, and Tension-Master pulling equipment.

Cable Services Company Inc.

Cable Services Co. Inc. . . **(717) 323-8518**
FAX . . . . **(717) 322-5373**
2113 Marydale Ave.
Williamsport, PA 17701
PERSONNEL: George A. Ferguson, VP, Sales; John M. Roskowski, VP, Construction
DESCRIPTION: Aerial and underground cable TV construction turnkey and fiber optic installation.

Cablemasters Corp.
Our Name Says It All

Cablemasters Corp. . . . . **(800) 242-2522**
FAX . . . . **(814) 838-8713**
PO Box 219
Lake City, PA 16423
PERSONNEL: Bernie Czarnecki, President; Gary Morris, Operations Manager
DESCRIPTION: Cablemasters Corporation provides complete aerial and underground construction services, specializing in fiber optics. The company has been involved in fiber optics construction and testing for many years, resulting in the experience required to meet the needs of today's modern CATV system.

Channel Communications
We Build The Best

Channel Comm. . . . . **(414) 565-3378**
(414) 565-2911
FAX . . . . **(414) 565-2106**
5430 Highway 42
Sheboygan, WI 53083
PERSONNEL: Jeff Ebersole, President; David Huff, Engineering Manager
DESCRIPTION: Complete engineering and construction services offered, including strand mapping, as builts, design, CAD or manual drafting, construction, fiber installation, activation, sweep and balance, engineering assessments, residential and multi-dwelling unit installations.

Communications Construction Group Inc ®

Communications Construction Group . . . . . **(215) 696-1800**
FAX . . . . **(215) 696-2371**
235 E. Gay St.
West Chester, PA 19380
PERSONNEL: George Tamasi; Tom Polis
DESCRIPTION: Providing high quality construction services for cable television, fiber optics, and twisted pair communications networks. Services include field strand surveys, manual and CAD based drafting, system design, field engineering and all aspects of rebuild and new build construction. Service packages include full or modified turnkeys and unique anagement turnkeys customized for the operators' needs.

Kennedy Cable

Kennedy Cable Construction Inc. . . . . . . **(912) 557-4751**
WATS . . . . **(800) 673-7322**
Hwy. 280 W.
PO Box 760
Reidsville, GA 30453
PERSONNEL: Roger Kennedy, Jr., President; Bob Skelton, Vice President Operations
DESCRIPTION: Aerial and underground line construction of CATV, LAN's, telecommunicatiions and fiber optic system construction. Strand mapping, design, splicing, upgrades, rebuild, new extensions of system, balance, sweep ad proof system. 18 years of experience. Call our Florida branch office, too, at (813) 439-3621. Thomas Heath, Marketing Manager

NaCom

NaCom . . . . **(614) 895-1313**
WATS (National) . . . . . . **(800) 669-8765**
WATS (California) . . . . . **(800) 767-6772**
1900 E. Dublin-Granville Rd. #100A
Columbus, OH 43229
PERSONNEL: Leslie H. Lotte, VP-Operations, Western Region; Stan Johnson, VP-Operations, National Region
DESCRIPTION: Full service communications contractor providing drafting (AutoCAD, Lynx) & RF design (Lode Data, Lynx, CADSUM II); make ready engineering; sweep and balance; activation; aerial & underground plant construction; fiber optic installation & splicing; residential installations; CLI detection & correction; pre and post-wire MDU's; traps; audits; converter exchanges; DBS; SMATV; and LANs throughout the continental United States.

Schenck construction

Schenck Construction . . . **(206) 867-9694**
15042 NE 95th, PO Box 3159
Redmond, WA 98073-3159
PERSONNEL: Edward A. Schenck, President; Bud Longnecker, VP/Aerial
DESCRIPTION: Aerial and underground cable TV construction: turnkey, and fiber optic installation.

CAD

CABLE ENGINEERING, INC.

Cable Engineering, Inc. . . **(502) 589-2848**
WATS (National) . . . . . . **(800) 626-2715**
WATS (National) . . . . . . **(800) 334-9684**
1615 Mellwood Ave.
Louisville, KY 40206
PERSONNEL: Phillip Lacy, President; Terry Johnson, Vice President
DESCRIPTION: Test of CATV, LAN, and Fiber Systems. CATV includes activation, sweep, proof, CLI, and performance evaluation. Fiber includes attenuation, OTDR, and design evaluation for

performance. Map functions include broadband/fiber design for CATV or LAN, digitizing, strand mapping, as-build, make-ready and permitting. Audit, prewire, postwire, and all phases of installation. LAN certification, upgrade, design, maintenance, and remote status monitoring. Vendor of CATV and LAN products such as actives, passives, and chipcom eithernet broadband/fiber modems.

NaCom

NaCom	(614) 895-1313
WATS (National)	(800) 669-8765
WATS (California)	(800) 767-6772

1900 E. Dublin-Granville Rd. #100A
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TEA

Transamerica Energy Associates, Inc. (TEA)	(404) 992-7003
FAX	(404) 992-8432

1301 Hightower Trail, Ste. 300
Atlanta, GA 30350

PERSONNEL: Frank Walker; Ed English

DESCRIPTION: Specializing in field engineering, fiber optic and RF broadband design, and computerized drafting.

Proof of Performance

CABLE ENGINEERING, INC.

Cable Engineering, Inc.	(502) 589-2848
WATS (National)	(800) 626-2715
WATS (National)	(800) 334-9684

1615 Mellwood Ave.
Louisville, KY 40206

PERSONNEL: Phillip Lacy, President; Terry Johnson, Vice President

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Systems Performance Engineering Inc.	(904) 262-8269
FAX	(904) 260-0383

PO Box 24927
Jacksonville, FL 32217

PERSONNEL: Peter J. Otten, President; Sherrie Otten, Secretary/Treasurer

DESCRIPTION: Electronic testing of cable systems and LANs: sweep, balance, proof of performance, cumulative leakage testing and repair. Electronic upgrades, retro-fits, technical evaluations. The company is fully equipped to perform all services for CATV and LAN operators related to electronics.

Distributors/Suppliers/Reps

Cable Services Company Inc.

Cable Services Co., Inc.	(800) 233-8452
WATS (State)	(800) 332-8545
FAX	(717) 322-5373

2113 Marydale Ave.
Williamsport, PA 17701

PERSONNEL: Sales Department

DESCRIPTION: Suppliers of cable, distribution, splicing, tools and hardware for CATV fiber optic systems.

FIBERTRON
Your Link with Fiberoptics

Fibertron Corp.	(213) 690-0670
FAX	(213) 697-5360

450 E. Commercial Way
La Habra, CA 90631

PERSONNEL: Marlene Spiegel, President; Henry Cohen, Vice President

DESCRIPTION: Fibertron, a leading value-added, fiber optics distributor, offers the widest array of quality oriented products from leading manufacturers like AT&T, AMP, 3M, Amphenol, Augat, Belden, BICC, Chromatic Technologies, Clauss, Fibermux, Leica, Lunzer, Noyes, PSI, Pyramid, Reliance, Siecor, Tektronix, and more. Fibertron also offers both standard and custom cable assemblies, including: pigtail, tactical, hybrid and multi-fiber; patchcords and custom cable putups; plus, specialized customer support, consultation and training.

MIDWEST CATV
More than supplies. Solutions.

Midwest CATV	(303) 799-4343
A Div. of U.N.R. Ind. Inc.	
FAX	(303) 643-4797

PO Box 4543 (Zip 80155)
Fairways II at Inverness
94 Inverness Terr. E. Suite 310
Englewood, CO 80112

PERSONNEL: Chuck Krone; Scott Henry

DESCRIPTION: Midwest C.A.T.V. is a full line supplier of Fiber Optic equipment from several manufacturers. Products include head-end laser transmitters, fiber optic cable, receiver detectors, fusion splicing equipment, splice trays and organizing systems, fiber stripping and cleaving tools. A complete line of test equipment to include laser sources, power meters, and O.T.D.R.'s are available for immediate delivery. In addition to being an equipment supplier, Midwest offers engineering resources to assist in loss budget calculations, system design, and performance verification.

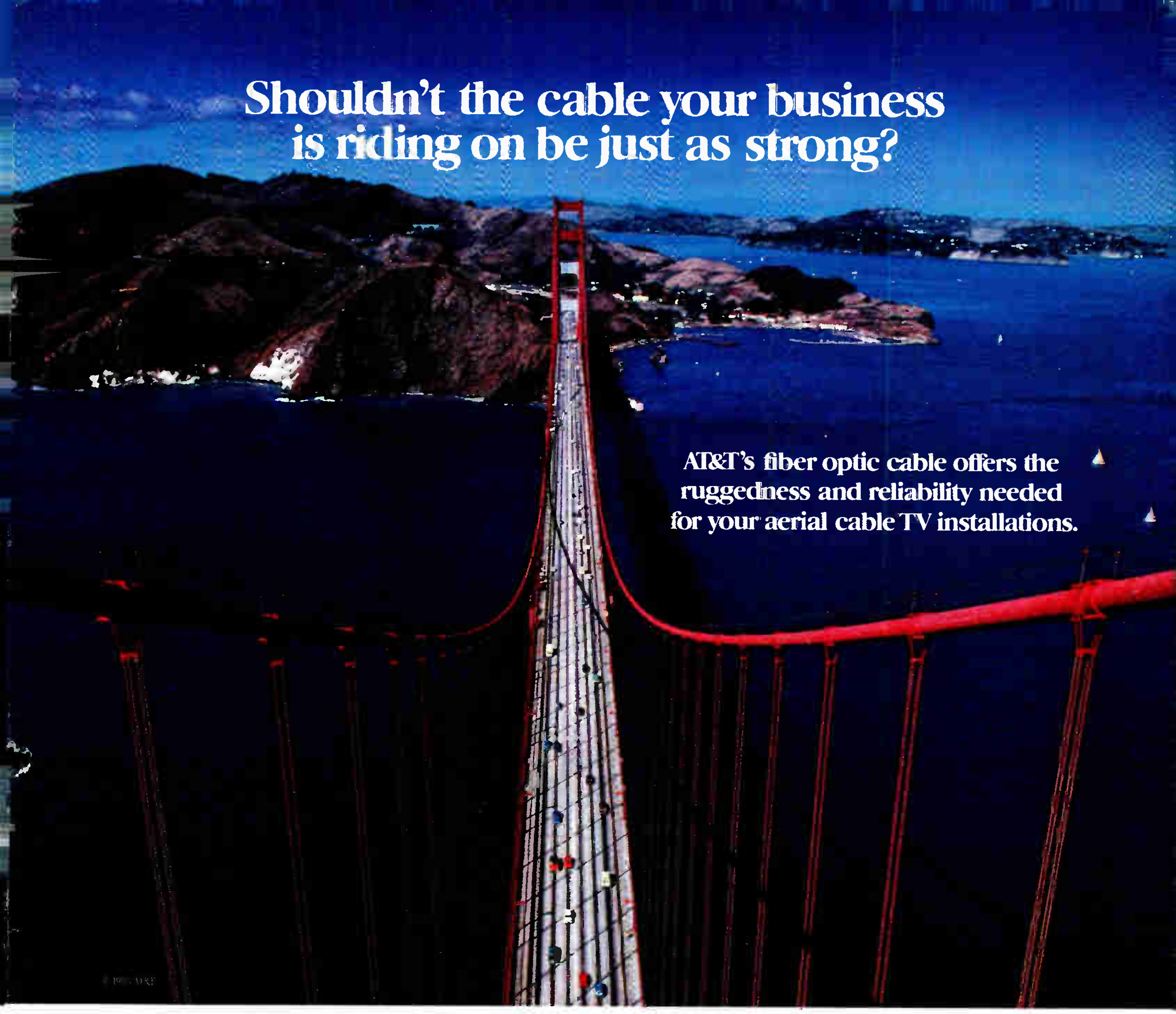
SUMITOMO ELECTRIC
Fiber Optics Corp.

Sumitomo Electric Fiber Optics Corp.	(919) 541-8100
WATS	(800) 358-7378

78 Alexander Dr.
Research Triangle Park, NC 27709

PERSONNEL: Larry Corsello, VP Marketing and Sales; Fred McDuffee, Director -Product Management, Optic Cable

DESCRIPTION: Manufacturer of optical fiber cables and related products. Supplier of fusion splicing instruments, optical connectors, cable assemblies for connecting fibers, opto-electronic products for data transmissiion, analog and digital optical video transmission equipment and full engineering and construction services for optical communications systems.



The cable you're installing now may seem great today, but how's it going to hold up against tomorrow's heat? And the ever present gnawing by nature's pests? Install AT&T's fiber optic cable and you won't have to worry.

That's because all AT&T fiber optic cable is designed to withstand harsh temperatures, rodents, lightning, and a host of other environmental stresses.

Take a look at our LXE family of lightguide cable. Available in multiple sheath designs, each is made with a high-density polyethylene jacket to resist abrasions—making it easy to pull and inexpensive to install, too.

The LXE also allows for easy end-prep and midsheath entry. Rip cords lie beneath the jacket and armor, to allow for entry without damaging the fibers.

AT&T's fiber has the smallest mode field diameter of any standard single mode fiber available. Light stays more tightly confined to the fiber core, providing outstanding transmission performance—at both 1310 and 1550 nm.

And our D-LUX™ 100 coating offers excellent stripability, static fatigue performance, and aging characteristics, for superb splicing capabilities.

You'll find, too, that all our fiber optic cable is backed by the design expertise and technology of AT&T Bell Laboratories.

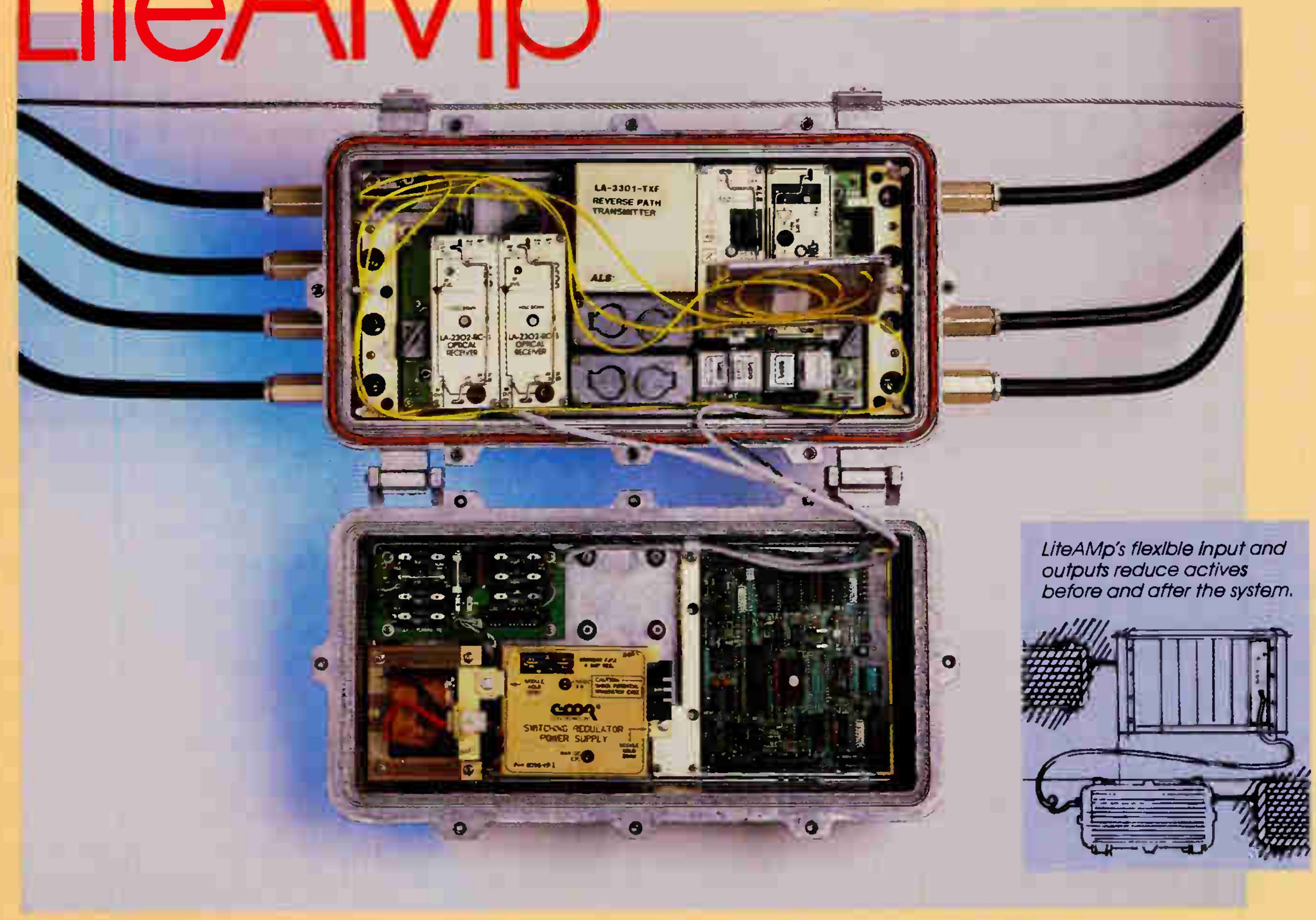
For more on cable that's at its best when the elements are at their worst, call AT&T at **1 800 344-0223, ext. 223.**

AT&T
Network Systems

Reader Service Number 14

LiteAMp™

INNOVATIVE DESIGN, PROVEN AM TECHNOLOGY from the company that specializes in fiber transmission systems



LiteAMp's flexible input and outputs reduce actives before and after the system.

FOUR REASONS TO SWITCH FROM COAX TRUNK AMPLIFIERS TO LiteAMp™ AM FIBER SYSTEMS TODAY

Group W Satellite looks to ALS for critical reliability fiber video links.

① LiteAMp AM FIBER SYSTEMS NOW BEAT COAXIAL TRUNK AMPS IN PRICE AND PERFORMANCE

For rebuild and system extension applications, LiteAMp costs less than coaxial trunk amplifier runs. Fewer actives translates to better performance and reliability at the tap where it counts.

② LiteAMp ELIMINATES THE COMPLEXITIES OF OTHER AM FIBER OPTIC SYSTEMS

LiteAMp looks and feels like a standard trunk amplifier, eliminating the need for retraining of field personnel. No special optical test equipment or optical matching is required. LiteAMp's modular architecture is designed for "plug and play" installation and maintenance.

③ LiteAMp SAVES AMPLIFIERS COMPARED TO OTHER AM FIBER SYSTEMS

LiteAMp requires as little as + 10dBmV input for 80 channel operation, which is 15–25 dB lower than other systems. At the node, output levels from trunk to multiple high level (+ 50 dBmV) bridgers are available, insuring you maximum reach with minimum electronics cost.

④ LiteAMp PRODUCT EXCELLENCE IS BACKED BY ALS CUSTOMER SUPPORT

In addition to CATV applications, ALS fiber systems are used extensively for critical reliability applications such as missile launch control, and network broadcasting. No CATV fiber systems supplier understands reliability and customer support better than ALS.

ALS

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