CED

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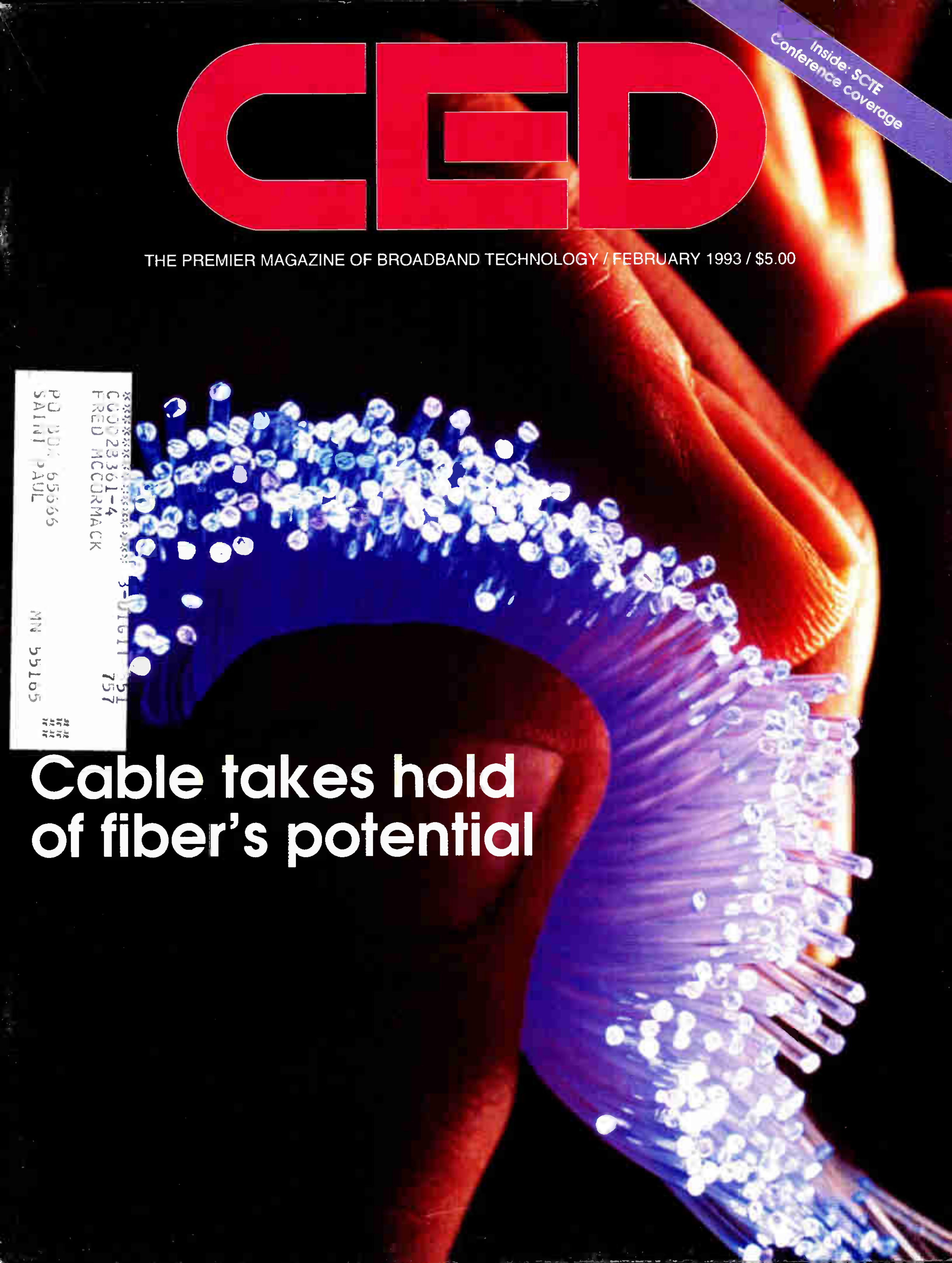
Inside: SCTE Conference coverage



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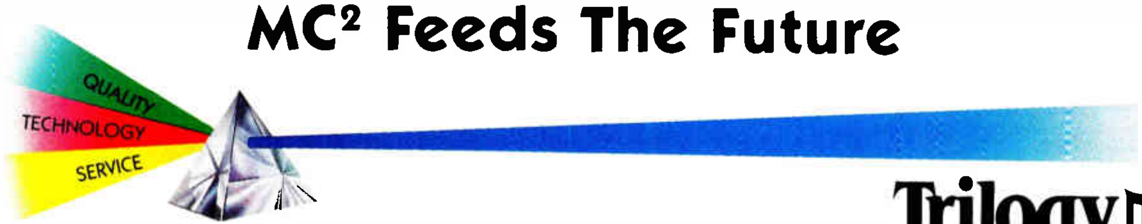

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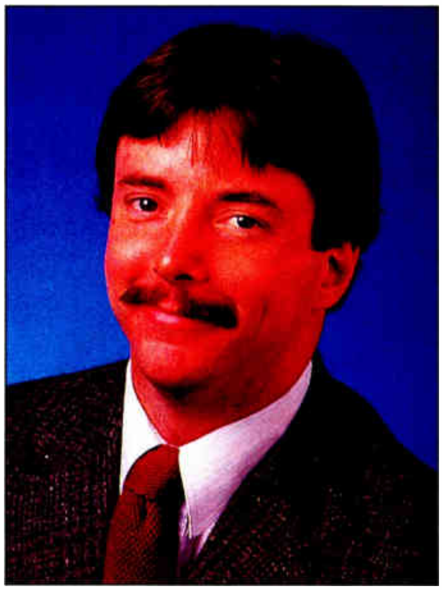
1993 will be a tumultuous year

Two events that occurred during the first week of the new year highlighted major themes cable operators will have to wrestle with during 1993: preparing for the implementation of digital transmission equipment and determining ways to make cable systems more compatible with consumer electronics hardware.

During the SCTE's Conference on Emerging Technologies in New Orleans last month, several speakers addressed the operational issues related to a future digital network. Bob Luff, Scientific-Atlanta's resident strategic thinker and a former operator, told the audience of 700 persons that chief engineers will be faced with a host of new concerns as they prepare to implement digital compression.



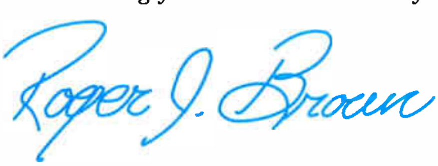
Specifically, Luff told those in attendance that a rebuild or upgrade to at least 750 MHz—and preferably to 1 GHz—will be necessary in order to deliver 550 MHz of standard analog channels and provide room for a tier of digital services. Furthermore, Luff said, engineers will have to re-consider several issues ....

For example, if your cable system presently has problems with satellite dish size and location, terrestrial interference, LNB frequency stability or reflections, they could be catastrophic in a digital environment. Furthermore, noise and distortions that accumulate through the plant could, if not diligently scrutinized regularly, make it impossible to deliver any digital signal at all. This threshold was the subject of a paper delivered by Bill Nash and Ben Summers of WTCI Engineering, who noted that new plant must meet rigid specifications for return loss, shield integrity, grounding and secure connections to make digital transmission viable.

Meanwhile, the Winter Consumer Electronics Show was being held in Las Vegas. It offered up new and/or improved electronic devices, including multimedia machines, widescreen televisions and other products cable networks may be attached to one day. All of which graphically illustrates what can go wrong when two industries don't communicate and end up building incompatible devices.

As mandated by last year's cable legislation, some of this industry's top engineers (Tom Elliot of TCI and Dr. Walter Ciciora of Time-Warner Cable) will be teamed with a group of industry CEOs and CableLabs personnel to try to find a solution to the cable/consumer electronics interface. It won't be easy—an effective solution has eluded the brightest minds for years. While consumer interests will be looking for a more "transparent" cable interface, cable interests will demand a definition of "cable-ready" and other terms freely tossed about today.

The coming year will indeed be busy.



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TCI plans massive upgrade program over next 4 years; fiber is key

Last month, as part of a larger program to provide its subscribers with more choice and control over television programming, Tele-Communications Inc. (TCI) officials announced a massive plant rebuild and upgrade program that could singlehandedly pull the industry's hardware manufacturers and suppliers out of a two-year funk.

According to company executives, TCI will offer premium and pay-per-view services to any customer, regardless of whether that person subscribes to basic services; furthermore, the company will offer a "broadcast basic" package that delivers just broadcast and PEG access channels.

The company's long-term vision is to provide cable system viewers more control and choice over the programs they view. During the Western Cable Show last December, TCI announced its intention to roll out digital video compression, beginning early next year. TCI says compression will provide consumers more choice and provide a method by which cable systems can be interconnected with multimedia and other information services as well as computer networks.

To help make that happen, TCI has tapped Mark Hess, formerly the New York state manager, to direct a management team to complete detailed planning for deployment of digital compression technology throughout all TCI systems. This team will also supervise initial deployment of compression and begin planning the operational systems that will be used as the company enters the next century.

TCI, which is the only cable operator with a centralized, national addressable control center, will also establish a national center to uplink, encrypt and authorize the reception of compressed digital signals in the Denver area. The center is expected to employ up to 100 people.

In a related announcement, TCI says it plans to implement fiber optics in all but its tiniest systems, using a fiber-to-the-serving-area topology to extend fiber to neighborhoods. The plan calls for the MSO to serve more than 90 percent of its customers via fiber optics within the next four years. The company's annual capital budget is expected to swell from $450 million to about $750 million to carry out that program.

CCTA issues DBS report

Some people may not think the start-up of high-powered direct broadcast satellite service poses much of a threat to the established cable-TV market, but the Canadian Cable Television Association (CCTA) is a believer.

The CCTA has released *The DBS Report*, a comprehensive analysis of DBS undertaken by the association. "The study focuses on the serious impact DBS poses to the future growth potential of the Canadian broadcasting system," said Ken Stein, president and CEO of CCTA, in a prepared statement.

The study examines key factors associated with the DBS service, including both low- and medium-power satellites that already exist and are regarded as interim approaches to direct-to-home satellite service.

High-power service, such as that advocated by Hughes Communications (DirecTv) and scheduled to begin in 1994, is considered a true competitor to cable service because it is targeting the same consumer entertainment market already served by conventional broadcasters, cable television and video rental outlets.

Hughes has indicated its intent to target Canada for a portion of its overall market because the satellite footprint will cover most of Canada's populated area. It is estimated that more than 80 percent of all Canadians will be able to receive Hughes' programming with an 18-inch dish.

The U.S. Federal Communications Commission has already awarded licenses to nine companies for the development of high-power DBS services. According to the CCTA study, the success of DBS will hinge on the ability of DBS providers to acquire attractive programming and the development of customer friendly and affordable satellite reception hardware.

If those two obstacles are overcome, the report says DBS will "establish itself successfully within two or three years of launch."

The Canadian association said that to compete, cable operators will have to develop innovative programming packages, be responsive to customer demand and be price competitive. "Cable can compete by offering choice and quality programming that is local, Canadian and best of the rest," said Stein.

Copies of the report can be obtained from the CCTA by calling (613) 232-2631.

CableLabs OKs $12.4M budget

Cable Television Laboratories (CableLabs) will spend $12.4 million in 1993, including $5.84 million to operate and $4.69 million in research and development, it was announced recently. The new budget represents a reduction in overall budget, down from $13 million in 1992. However, it represents increased operating and R&D spending of 3 percent to 4 percent, but the increase is offset by lower capital needs.

The CableLabs staff also identified several new projects that will be undertaken in 1993, including: the establishment of a demonstration center in Boulder for new technologies that could be delivered by cable television networks; a field trial of the regional hub concept and design in the Pacific Northwest; and further digital characterization testing. Potential participants in the tests include Chambers and Rogers Cablesystems in Canada and TCI and Viacom.

In addition to a new budget, the CableLabs board of directors will see a few new faces. Joining John Malone of TCI, James Doolittle of Time Warner Cable, Brian Roberts of Comcast, Richard Roberts of TeleCable, William Schleyer of Continental and Joseph Gans Sr. of Cable TV Co. are Trygve Myhren, president and COO of The Providence Journal Co., and Scott Chambers, executive vice president and COO of Chambers Communications Corp.

Alex Best, senior vice president of engineering at Cox Cable Communications, was appointed chairman of CableLabs' Technical Advisory Committee, succeeding Dr. Walter Ciciora of Time

Warner Cable, who had been TAC chairman since CableLabs' inception. Ciciora was recognized via a special resolution of the board for his past efforts and for "elevating it (TAC) to where it is now as a vital resource to the cable industry's technical community," said Dr. Richard Green, CableLabs president and CEO.

Best, who has been at Cox since 1986 following 20 years at Scientific-Atlanta, will play a major role in the technical efforts of the R&D consortium and will have a seat on the Labs' board of directors.

The CableLabs board also promoted several persons: Chief Operating Officer Baryn Futa was given the additional title of executive vice president; Stephen Dukes becomes vice president of Advanced Network Development; General Counsel Dorothy Raymond adds vice president and assistant secretary; and Scott Bachman becomes vice president of Operations Technologies Projects and will assume direction of consumer electronics systems and science and technology. The director of technology assessment will now report directly to the president.

Labs issues RFP on DPU tests

Cable operators may get beat up over interface compatibility issues, but CableLabs wants to make sure they don't get blamed for poor-quality pictures when its really the television's fault.

CableLabs in December issued a request for information and proposal to a dozen of the nation's leading test laboratories, universities and government agencies to determine methods to measure TV and VCR susceptibility to direct pick-up interference (DPU).

DPU interference is caused by signal ingress not through a cable, but directly through a television's or VCR's tuner that is connected to cable TV. Because of this, the source of the interference is often incorrectly blamed on a poor cable installation. Set-top converters, which are built with double conversion tuners that block out this interference, have typically been used by cable operators to eliminate the problem. But, of course, set-tops are perceived as unfriendly to consumer devices like TVs and VCR. Many attempts have been made to remove them from subscribers houses—to no avail because of DPU.

CableLabs staffers hope this RFP will lead to a definition of the test facilities, methods and procedures required to test consumer hardware for susceptibility to DPU.

Ortel demos 25 mW laser

Despite ever-increasing competition from a wide variety of sources, Ortel Corp., manufacturer of distributed feedback (DFB) lasers used by Jerrold Communications for cable television applications, has upped the performance ante once again.

The company announced that it has successfully tested a 25 milliwatt (mW) laser that meets full CATV performance specifications for 60 channel loading. With 18 dB of optical loss, the carrier-to-noise ratio was 55 dB, while composite second order and triple beat distortions were greater than 65 dB down.

Last year, in conjunction with the Optical Fiber Conference, Ortel officials described a laser that produced 18 mW of output power and projected that 25 mW production lasers were achievable within two years. "This test result is an important step toward that goal," said Larry Stark, vice president of new business development.

Ortel executives said they plan to begin shipping 16 mW DFB lasers later this year. This new generation laser provides 2 dB improvement in optical loss budget over current 10 mW designs. The higher power is important for supertrunking applications, long fiber links and broadcast architectures calling for several splits.

Stark said the new laser is consistent with past laser production trends that show a steady increase of 2 dB every year. "We believe we can maintain this trend for at least another two years, which can be expected to produce 25 mW lasers by mid-1994," said Stark.

S-A shakes up management

In a well-publicized story last December, Scientific-Atlanta's board of directors replaced William Johnson as the company's chief executive officer after it was determined it no longer approved of Johnson's management style. S-A did not name a replacement but installed James Napier as interim CEO. Jay Levergood, a former president of S-A was named senior vice president and president of the broadband communications group.

A week later, in an unrelated announcement, S-A announced that Robert McIntyre was named president of the transmission systems division in the broadband group, replacing David Fellows, who resigned from S-A to take the position of vice president of engineering and technology at Continental Cablevision. S-A officials and Fellows stressed that Fellows' departure was not related to Johnson's departure.

McIntyre, who joined S-A in 1991, had been president of the headend systems division. In his new post, he will now be responsible for digital video compression, B-MAC satellite encryption, and headend, distribution and fiber optic equipment. He will also supervise the acquisition of Nexus Engineering, which was announced at the Western Cable Show in December.

Fellows, who attended college at Harvard and Northeastern, returns to the Boston area in a post at Continental headquarters, where he will help the MSO chart its future business strategy. Fellows has a background in telephone laboratory research with GTE prior to joining S-A in 1987.

Finally, in January James Hart was named vice president of technology for S-A's broadband communications group. He will be responsible for tracking and analyzing emerging technologies and their potential applications; build relationships with MSOs and CableLabs; and interface with marketing people in international and domestic new product planning and development. Hart has been with S-A since 1966.

Jottings

The industry's technical crews should be breathing a sigh of relief, now that the deadline for the first FCC-mandated **proof of performance tests** has come and gone. Early word was that most operators, especially those who didn't wait until the last minute, were able to get the testing done on time, in spite of some last-minute changes to the procedural language . . . **Hughes Communications'** Galaxy VII, the company's first dual-payload HS 601 satellite, is operational and by the end of the month should be at 77 degrees west longitude. It replace SBS 4 and carries private data and broadcast television signals . . . **Zenith** and **Goldstar** have jointly developed a digital high definition videocassette recorder for home use. It records HDTV on standard Super-VHS tape and will also play back NTSC programming recorded on standard VHS tapes. The unit should hit the market in 1996 and will be priced at about $1,000. CED


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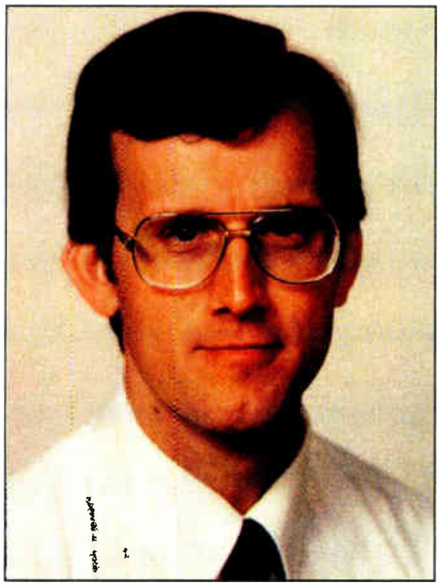

Multichannel Local Distribution Service

Recently, I wrote about primary competitive threats and briefly mentioned a new technology called Multichannel Local Distribution Service (MLDS) invented and operated by Suite 12, Hye Crest and Cellularvision. (Note that a recent press release from the FCC has rearranged the letters to LMDS for Local Multipoint Distribution Service, so you might see it written both ways for a while.) Because of the significant potential of this new competitive technology, I thought it would be a good idea to cover it in a little more technical detail.

Suite 12 has asked the FCC to set aside 2 GHz of spectrum, from 27.5 GHz to 29.5 GHz, in each market for the purpose of deploying this new technology. The 2 GHz of bandwidth would be split evenly between two licensees, thus leaving a full 1 GHz of bandwidth with which to market a plethora of two-way video, audio and data services. The technology, at least upon initial implementation, makes use of techniques similar to those in existing satellite delivery systems, including frequency modulation (FM) for video, orthogonal polarization (horizontal and vertical), spatial diversity and frequency reuse.

In the center of the cellular structure is the master "headend" facility where signals are collected for distribution. Here, using an omnidirectional antenna, a 100-watt (or so) transmitter, and either horizontal or vertical polarization, the signals are distributed to all customers within a radius of about 6 to 12 miles depending upon terrain and service density.

By Chris Bowick, Group Vice President / Technology, Jones Intercable

Using FM technology, the video carriers are spaced 20 MHz apart, and unlike satellite transmission technology, each video carrier within the cell is transmitted on the same polarization. Note also that the central headend facility also distributes many point-to-point bidirectional links to adjoining cells. Each adjoining cell receives and reprocesses these signals for omnidirectional distribution within its own cell.

Adjoining or adjacent cells rebroadcast the received information from the master headend facility on orthogonal (horizontal or vertical) polarizations. In addition to changing the polarization within each cell, each transmitter offsets its frequency spectrum by 10 MHz, or one-half the channel bandwidth. This type of frequency reuse, or frequency interleaving, when combined with the use of orthogonal polarizations and very narrow beamwidth antennas within each customer's home, provides for about 65 dB of isolation for users within each cell.

According to extensive analysis by the David Sarnoff Research Center[1], this 65 dB of isolation within each cell is the sum of the isolations that can be attributed to orthogonal polarization (25 dB), frequency interleaving (15 dB), and antenna sidelobe suppression (25 dB).

The use of 28 GHz brings up the obvious question of propagation through obstructions such as buildings, foliage, hills, rain, etc. These microwave frequencies are naturally severely attenuated by these obstructions. This is an obvious problem that must be dealt with. Rain must be dealt with by including a significant amount of fade margin in the link analysis for each cell. This might include 15 dB of margin, or more, depending upon the area of the country, in order to provide the 99.9 percent service availability the inventors purport.

Dealing with "shadows"

Obstructions which create "shadowed" areas, or areas that are not in direct line-of-sight to each cell's transmitter, are dealt with either by strategically placing a low-power (200-milliwatt) active repeater which operates on the opposite polarization to that normally being transmitted within the cell, or preferably by using a passive reflector such as the reflection off an adjoining building or other obstruction.

In this case, because of the use of FM technology and very narrow beamwidth (around 4 degrees) antennas within the customer premises, multipath, the bane of AM broadcast technology, can be used to their advantage. The distance covered by a passive repeater may be only a few thousand feet, while an active repeater might be capable of covering a shadowed area of up to a couple of miles.

The technology reportedly provides a clear weather video signal-to-noise ratio (S/N) of around 54 dB (studio quality) at the fringe of each cell, and with a rain-faded video S/N of around 42 dB! These kinds of numbers are possible using a 7- to 15-inch flat-plate antenna mounted in a window on the customer premises. Cellularvision currently has a 49-channel system in operation in Brighton Beach, Brooklyn, New York. Here, multipath and tree attenuation has been measured to be between 3 dB and 8 dB.

The analysis by Sarnoff indicates that an in-home transmitter would be capable of providing a 30 kHz (48 kB/s) data or voice return channel with only 630 microwatts of power! A full T-1 (1.544 Mb/s) in its own 1 MHz return channel would only require 20 milliwatts of power! These return channels would be frequency interleaved (half-way in-between) among the video signals, using orthogonal polarization, in order to ensure effective isolation between the video and data services. Using this return capability, Suite 12 has been experimenting in its New York system with two-way video teleconferencing, mobile data communications, and "cellular" telephony.

Currently, Cellularvision is using modified satellite receiver technology combined with a 28 GHz down-converter for the in-home electronics. As the technology matures, we can expect dedicated in-home electronics, at a reasonable cost, housing both the receiver and the return transmitter.

With 1 GHz of bandwidth, a low-cost start-up and maintenance structure, the availability of an extremely efficient low-cost return path for video, voice and data, and with technologies such as video compression which will expand the number of available video channels using this technology to well in excess of 150, I'm convinced that MLDS may become one of the most intense battlegrounds of the future. CED

Reference

1. Suite 12 System Analysis for Video Distribution and Secondary Services, David Sarnoff Research Center, Princeton, NJ., September 17, 1991.

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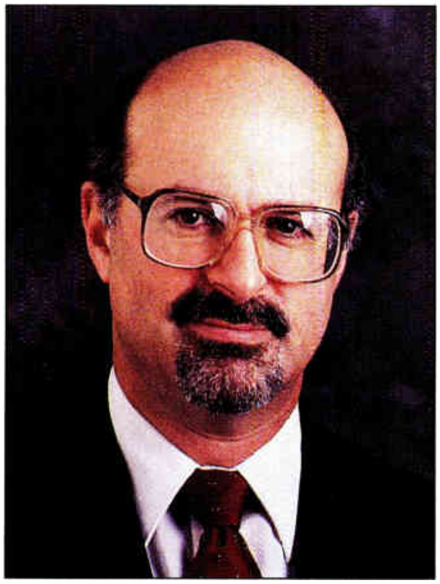

Dialing for dollars

The North American Numbering Plan for telephone numbers requires that you dial seven digits for a local call and 10 digits for a long distance call. But subscribers to Media General's Fairfax County, Va. cable system dial 103800—SIX digits—to order a pay-per-view movie. This is possible because the first five of the six digits represent a Carrier Identification Code. But here's a more complete answer.

Equal access

Starting with the introduction of MCI's Execunet service in the mid-1970s, telephone dialing became much more complicated. Rather than simply dialing the 10-digit number of the called party, you first had to dial a seven-digit local number to get access to the MCI service. This seven-digit number was different in every city. Then you had to dial your customer ID number, so that MCI would know where to send the bill.

In the late 1970s and early 1980s, there were several agreements reached between AT&T, other long distance carriers, and the local telephone companies on standardized interconnection practices. The telephone industry created a service called Feature Group B, which was an interconnection service offered by local telephone companies. A long distance company could give its customers the same seven-digit local phone number everywhere in the country. This phone number is 950-0XXX or 950-1XXX, where the XXX is a three-digit number called the Carrier Identification Code (CIC).

Each long distance carrier was assigned a three-digit CIC. AT&T, for example, was assigned 288, and if you look at your telephone dial you will see that 288 corresponds to the letters ATT.

A few years later, after the U.S. District Court ordered local telephone companies to provide "equal access," Feature Group D service was offered. Feature Group D created a dialing prefix of 10XXX for a subscriber to dial to get access to a long distance carrier. You reach AT&T by dialing 10288, for example.

There are technical differences between Feature Group B and D services. With Feature Group D, for example, the local telephone company passes along the telephone number of the calling party. This is called Automatic Number Identification, or ANI. It is needed by the long distance carrier for billing purposes.

Phone Base Systems and CICs

When the telephone industry started offering these new services, the FCC ruled that anyone could subscribe, not just long distance companies. As a result, some enterprising companies figured out how they could use this capability as part of a private service, even though they do not offer long distance telephone service.

Phone Base Systems of Vienna, Va. is an example. It runs the "back office" for a number of cable system pay-per-view services. Suppose you want to order the heavyweight championship fight. Throughout most of the country, you will dial an 800 telephone number, and you will reach the Phone Base operations room in Virginia. Before your call is answered, the attendant will see your phone number appear on the screen, and will know from your area code what cable system you subscribe to. This is because MCI and Sprint, for example, offer ANI information as part of their 800 service.

But to call Phone Base from within Media General's service area in Northern Virginia, it is a local call, and the C&P Telephone Company does not provide ANI as part of its regular local service. Or at least that was true two years ago, when Phone Base began its operations. So Phone Base's Senior Vice President, Mark Rosenfeld, figured out how to achieve the same result using Feature Group D service. Dialing the 10380 access code gives a subscriber access to the Phone Base "network" and the sixth digit dials the "operator."

There are quite a few other companies that subscribe to Feature Group D service yet they are not long distance carriers. The FCC publishes a periodic report. Many of these Feature Group D users are resellers of long distance service, some quite small. For example, the Chillicothe Long Distance Company (CIC 293) is a reseller that offers service only in Ohio. Discount Communications Services (CIC 601) operates only in Arkansas. Conquest Operator Services Corporation (CIC 319) operates in 19 different states.

But a review of the FCC list also shows companies with "telemarketing" in their name, such as TeleMarketing Communications (CIC 007). It also shows companies that may be operating private communications networks, such as Science Dynamics Corporation (CIC 609) and EDS (CIC 273). They use the 10XXX access code as an alternative to 800 services. This may be for pricing reasons or for technical reasons.

As of September 1992, 840 CIC codes had been assigned to a total of 654 firms. Some companies have more than one code because of mergers and acquisitions. Since there are only 999 CIC codes (the code 000 is not used), and the number of codes in use has gradually increased, they may soon be exhausted.

Of course, not only are we running out of CIC codes, we are running out of area codes as well. Bell Communications Research (Bellcore), which administers the North American Numbering Plan, issued a report last year on a plan to add 640 new area codes. These codes would have the format NXX where N is digits 2-9 and X is digits 0-9; currently, the format is N0/1X (the second digit must be a 0 or a 1).

These new area codes would be used to support new services as well as the growth of existing services. For example, some area codes might be assigned to nationwide database operators who keep track of mobile or personal communications (PCN) subscribers and forward calls to them as they travel around the country.

The FCC recently began a long range inquiry into these issues—the shortage of CICs, the shortage of area codes, how to accommodate PCN subscribers, and whether Bellcore should continue to administer the Numbering Plan. Comments were due on December 28, so it will be about a year before even a preliminary decision is made. CED

By Jeffrey Krauss, independent telecommunications policy consultant and President of Telecommunications and Technology Policy of Rockville, Md.

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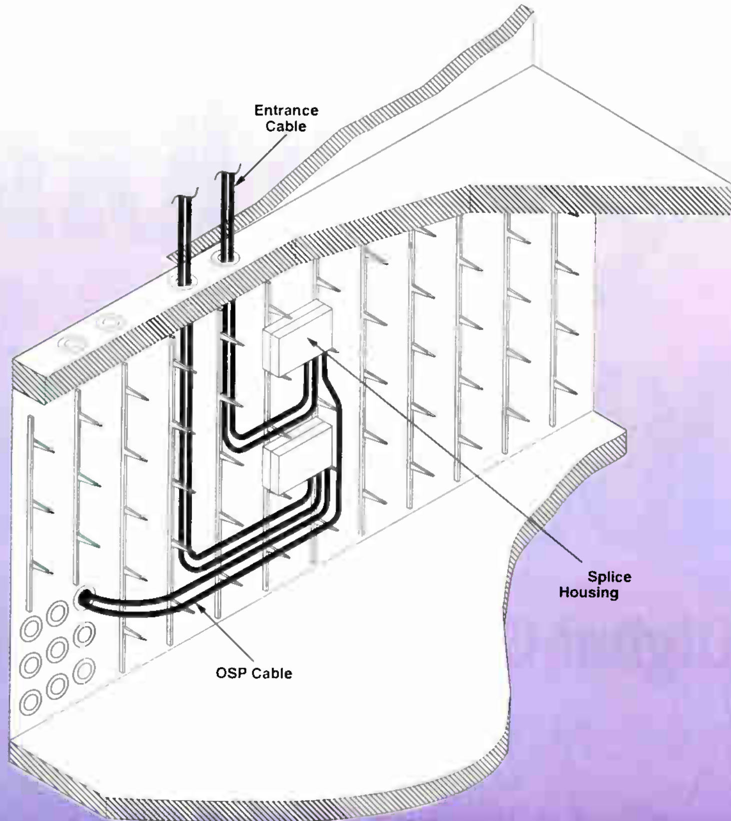


Figure 2

accommodate needed fibers and cable slack storage. Capacity needs include cable, fiber termination, splicing and routing mechanism capacities.

The following criteria should be considered when selecting patch panels:

- The panel should be able to accommodate multiple cables, depending on the configurations required by the system.
- In addition, the number of terminations a panel will house must be considered. The challenge, then, is to match the cable fiber count to the patch panel capacity while not exceeding the maximum number of cables the panel can handle.
- Panels must be modular, allowing units to be stacked or placed so that routing within or between panels is not impaired, and so new installations are simplified.
- The size should be adequate but not preclude placement in various locations. Patch panels are available to accommodate a range of fiber counts, from 12 to 72 fibers each. The ability to stack units in racks will permit up to 864 fibers per rack, allowing for high fiber-count systems to be managed efficiently.
- Panels should provide mechanical protection of connectors and splices not only during normal work operations but during construction as well. In some instances, protection from harsh environments is needed.
- Labels are essential to record cable and fiber termination information.
- Panels should have strength member retention capability to secure cables.
- In some instances, additional security is required. Locking mechanisms

> Operators must plan cable management into the headend system to introduce new services and increase reliability.

are available for this added protection.

- Storage of fiber and cable slack is needed within the unit.
- Panels should accommodate different connector types, depending on the electronics requirements. Today, the FC super-PC connector is often used for singlemode CATV systems. In addition, the singlemode SC super-PC is emerging as a preference for high density singlemode applications.

> The optical cable entrance portion of the headend design is often overlooked with an assumption that little will change.

In some headends, it is often advantageous to install a "stubbed" or prewired patch panel to terminate outside plant cable and manage the interconnection system. The stubbed patch panel consists of a factory-manufactured cable assembly of a predetermined length, unterminated on one end and terminated with optical connectors into a patch panel on the other end. Most often the cable is listed to meet NEC smoke and flame retardancy requirements.

With the stubbed patch panel's fibers directly connectorized at the factory and pre-installed into the panel for protection, the product package is ready for use—it is simply placed in the rack. The unterminated end is pulled to the proper location and spliced. The entire cabinet is inspected prior to shipment to ensure it meets performance expectations.

Electronics interconnection

It is usually advisable to place system electronics in a rack separate from the patch panel system. This allows for system expansion and a more organized network. With the electronics and patch panels in separate racks, fibers and cables must be guided within and between racks to provide protection of the optical fibers and to organize a high density of cables. Jumper storage and optical raceways can be used to store, protect and route fibers and cables within the headend's interconnection system. (See Figure 1.)

As with cable slack at the building entrance, jumper slack is useful in preparing for graceful future growth. Some slack is valuable so the system can be flexible. However, extreme overlength can cause cable congestion. Determining the right amount of slack required for current and future routings should be considered in planning stages.

Storage must be made available, either within the panel itself, or within a separate jumper storage housing within the same rack. With routing guides and storage areas, jumpers can be routed horizontally and vertically, between panels and racks, while avoiding a messy maze of cables.

Optical raceways are the routing mechanisms used to support, secure, manage, identify and protect jumpers and cables between housings and racks. They can include conduit, trays, encased raceways and ladder racks. Of course, the amount of raceway required and its placement must be considered as part of an upfront plan.

In addition, coupler housings should be planned into a CATV interconnection system to maximize the flexibility of the system. If a system includes couplers, it may be more difficult to test the system through the couplers. The use of a coupler housing allows the couplers to be disconnected and isolated to permit accurate testing.

Conclusion

Fiber optic cable plant management is becoming more critical as technology improvements are introduced and new applications are available. The number of optical cables and their fiber counts are on the rise, requiring new headend system designs.

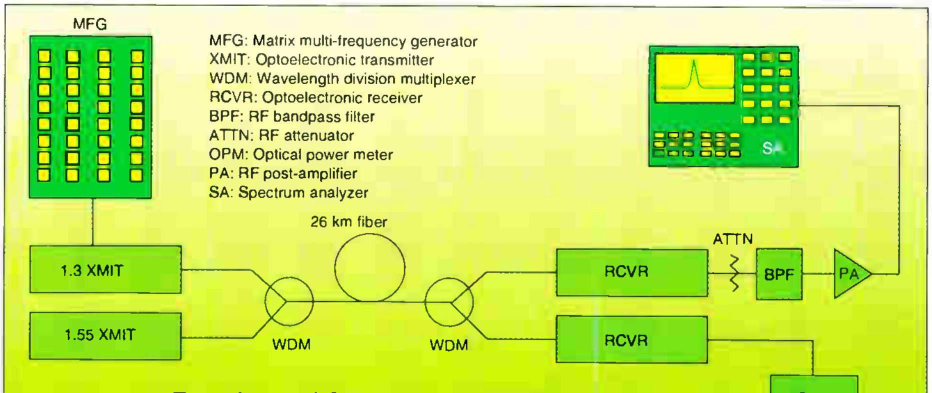
Operators must plan cable management into the headend system to effectively introduce new services and increase system reliability. The use of connectorized fibers in patch panels should be considered in headends to meet the flexibility and expansion requirements of the future. CED

Footnote

Specific grounding requirements may be governed by local regulations. All grounding should be done in accordance with your company's practices and in accordance with local/state/regional building and electric safety codes.

Advances in AM supertrunking

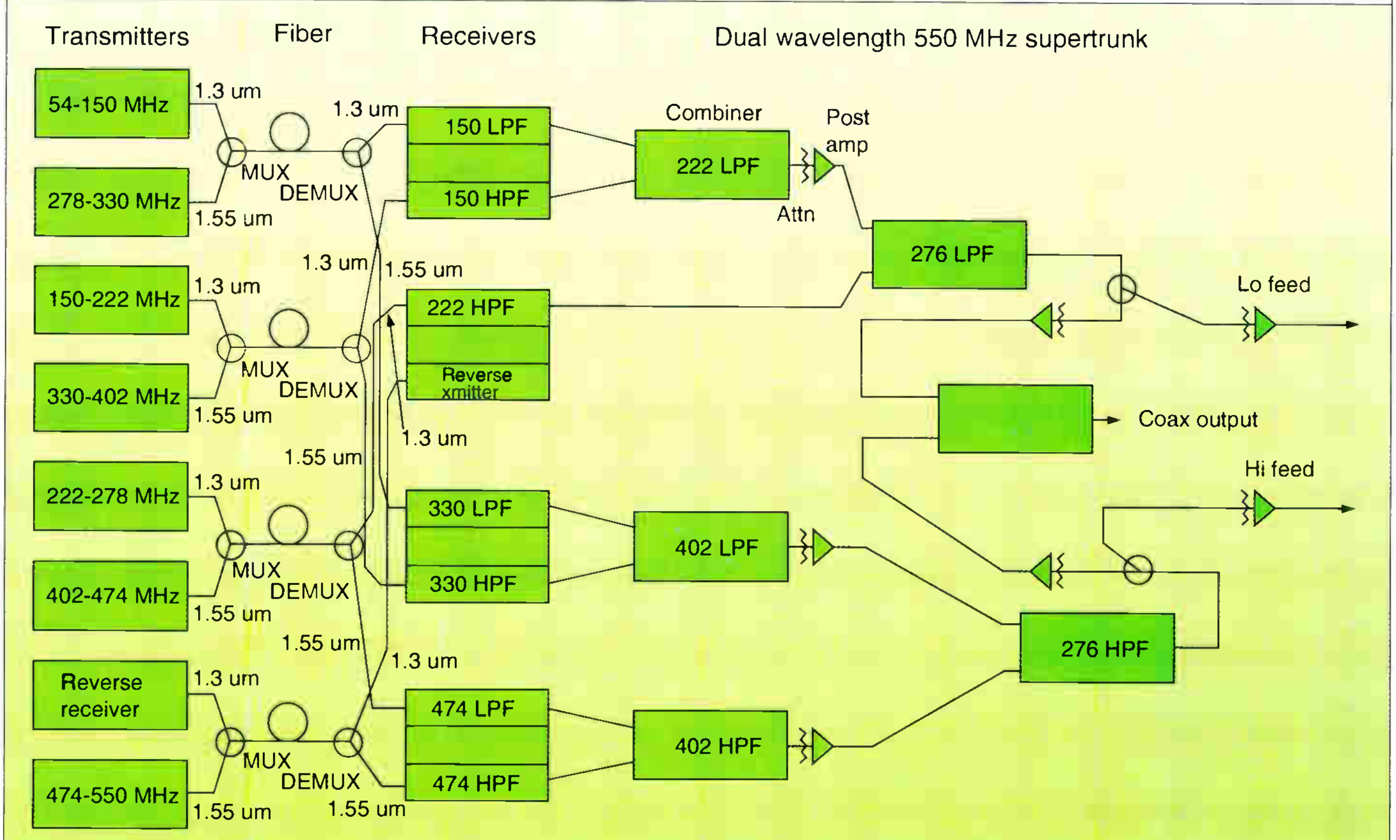
The application of standard singlemode fiber and AM fiber optic technology for CATV over the past several years has fostered dramatic improvements in both network performance and reliability. The continuing improvements to components and equipment used in the 1310 nm window will allow more widespread usage of fiber in network architectures well into the future. An area of interest to both equipment manufacturers and end users has been the prospective use of the 1550-nm window in singlemode fiber because of its lower loss vs. distance profile and the technical capability to use optical amplification at this wavelength.



Experimental AM supertrunk WDM single link

Figure 1

The standard singlemode fiber prevalently deployed today exhibits zero optical dispersion generally centered near 1310 nm.



Seven-tiered (54-550 MHz) AM supertrunk WDM system

Figure 2

By Don E. Frymyer, Senior Electrical Engineer, Rezin E. Pidgeon, Principal Engineer, and Frank R. Little, Engineering Department Manager, Scientific-Atlanta Inc.

However, at 1550 nm, the optical dispersion profile is significant (although the loss per unit length is lower). The application of direct-modulation AM laser technology for use in this window presents some difficulty because of the interaction of the chirp (spectral spreading) of the laser under direct modulation with the optical dispersion profile of the fiber. This leads to chromatic dispersion-induced signal "smearing" in time because the optical sideband energy travels with different time delays through the fiber.

The result of this phenomenon is a serious degradation in the composite second order (CSO) distortion performance and a less severe degradation in the composite triple beat (CTB) distortion performance of the system. Special fiber, such as dispersion-shifted fiber (where the zero dispersion profile point is moved to the 1550-nm area), can be used, but this does not address the use of 1550 nm over the installed base of standard singlemode fiber, and, in the small quantities in which dispersion shifted fiber is sold today, it remains more expensive than standard singlemode fiber. Solutions to these problems are being developed today. These include the application of external modulation technology, the use of lower chirp direct modulation lasers and application of dispersion compensation techniques.

One area in which direct modulation-based AM lasers operating at 1550 nm can be applied today is in AM supertrunking systems. In such a system, the 1550-nm distributed feedback (DFB) lasers can be applied in a frequency arrangement of less than an octave so that second-order distortion products fall out of the band being transmitted by the respective laser. As such, they can be filtered out in the recombination process of the various bands. Such a system is described below.

In this system, the application of 1550 nm lasers wavelength division multiplexed (WDM'd) to share fibers with corresponding 1310-nm lasers allows three major improvements to conventional supertrunking systems:

1. Because frequency bands are placed on both 1310-nm and 1550-nm lasers multiplexed onto the same fiber, a reduction in the number of fibers required for transport is possible;

2. The lower loss at 1550 nm allows the judicious application of channel counts to respective frequency bands to reduce the amount of frequency bands required to transport signals at a given quality level; and

3. The lower loss at 1550 nm allows

DFB laser diode parameters at 1310 and 1550 nm

Parameter	1310 nm	1550 nm
Output power (mW)	8	6
OMI (percent)	0.11	0.085
Spectral bandwidth (GHz)	3	4
Laser RIN (dB/Hz)	<-160	<-160
Intrinsic laser diode CTB (dBc)	<-70	<-75

Table 1

Measured system performance parameters by tier

Table 2

Tier (MHz)	No. of channels	OMI (%/ch.)	OMI@ clipping	rms OMI (%)	CNR (dB)	CSO (dBc)	CTB (dBc)
54-150	10	9.2	12.8	20.6	58.5	-70.6	-72.3
150-222	12	11.1	12.3	27.2	59.8	-80.0	-72.2
222-276	9	15.0	18.7	31.8	59.2	-80.0	-71.9
276-330	9	8.4	18.8	17.8	58.5	-80.0	-71.9
330-402	12	6.6	18.5	16.2	59.1	-80.0	-71.8
402-474	12	8.6	19.2	21.1	58.9	-80.0	-70.5
474-550	13	5.8	18.9	14.8	58.5	-80.0	-70.2

the judicious application of channel counts to respective frequency bands to improve the system performance at a given loss budget for a given amount of frequency bands.

The result of these improvements is to further enhance the capabilities of AM supertrunking systems, making them even more competitive with FM and digital delivery systems for high quality signal transport on the basis of cost. fiber count and encrypted signal carriage. The details of an actual system are described here.

Experimental set-up

The experimental set-up as shown in Figure 1 is a 77-channel, 55.25 MHz to 547.25 MHz supertrunk system that utilizes seven directly modulated DFB lasers to transmit the AM-VSB signals over four 1310/1550-nm multiplexed fiber links. The specific DFB laser parameter criteria, to meet the specified system performance of 58.5 dB carrier-to-noise ratio (CNR) and -70 dBc CSO and CTB, are given in Table 1.

Also, these same laser characteristics and the experimental parameters cited below are used in constructing the curves shown in Figure 3. It should be noted that the 77-channel plan can be realized with four tiers that utilize only two fibers. The tradeoff here manifests itself as a 2 dB reduction in CNR.

The Matrix generator is split into seven tiers, as shown in Figure 2. This seven-tired system allows for a reverse transmitter at 1310 nm, but the reverse transmitter could be at 1550 nm—an equal number of 1310-nm and 1550-nm lasers are required in either case. Each link consists of two WDMs, indicated as a mux and a demux, and 26 kilometers of standard singlemode fiber. The system links contain a 2 dB optical passive loss attributed to the WDMs and connectors and fiber loss of 0.4 dB/km and 0.25 dB/km at 1310 nm and 1550 nm, respectively. The fiber loss includes the splice losses.

At the output WDM, each RF band is terminated into one of seven transimpedence receivers, each with a thermal noise current of:

$$7pA\sqrt{Hz}$$

and a detector responsivity of 0.9 A/W. Following the receivers, in Figure 2, are

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the RF combiners, the fixed RF attenuation pads, and then the post amplifiers.

These three items are repeated within the system's architecture in such a way as to minimize the CNR degradation and achieve the highest degree of overall system flatness once all the RF bands are combined.

The system's seven RF bands are optimized by establishing the optical modulation index (OMI) that satisfies or exceeds the CNR requirement of 58.5 dB. The CSO and CTB are then optimized to meet the -70 dBc specification. The chosen sub-octave RF channel plan for all bands except one eliminates the problem of CSO distortion.

In the lowest band where CSO will occur, a highly linear DFB 1310-nm laser is required. For all other bands, either a 1310-nm or 1550-nm DFB laser with excellent third-order intermodulation distortion products (IMDP) will be sufficient.

System performance

The entire system is theoretically modeled to account for signal shot noise, receiver thermal noise, fixed passive loss, CATV channel frequency, and laser and fiber parameters.

The laser parameters include relative intensity noise (RIN), OMI, output power and laser spectral bandwidth. The fiber parameters include induced RIN due to backscatter under randomly polarized conditions, attenuation per length, dispersion and Rayleigh scattering coefficients.

In 1550 nm systems, optimizing the overall system is more complex. The OMI must be high enough to achieve the desired CNR but not cause excessive spectral spreading or clipping of the negative peaks of the AM signal. Clipping sets a fundamental limit on system performance[1,2,3] while the spectral spreading creates a secondary limitation via the interaction of it with the fiber chromatic dispersion. Theses effects create IMDP and lead to a tradeoff between CNR and system distortion.

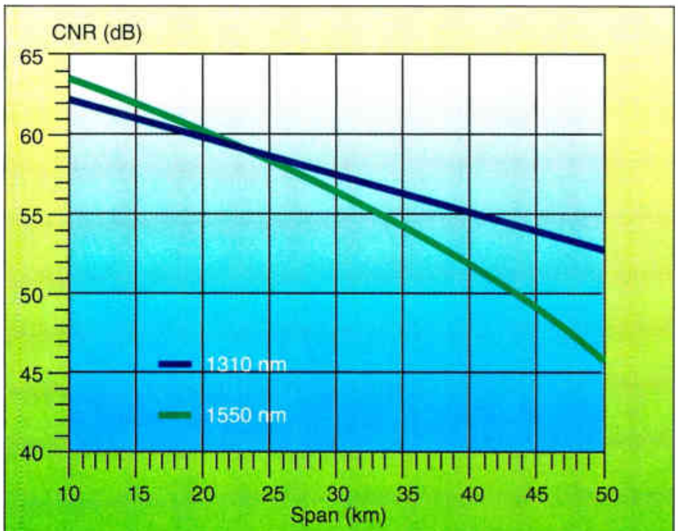
The data shown in Table 2 were taken at the output of the system after combining the RF bands. At each tier, the data reflect the worst case RF channel performance values. The root-mean-square (rms) OMI is equal to the per-channel:

$$\text{OMI} \times \sqrt{(N/2)}$$

where N is the number of channels. In the CSO column of Table 2, the value of -80 dBc is given to indicate that the CSO was at the system noise level. The measurement of CNR, CSO and CTB were made according to NCTA recommended practices.

Discussion

The results of Table 2 allow one to compare and contrast the 1310 and 1550 nm DFB laser diodes. For instance, the OMI at both wavelengths is close to their respective theoretical values shown in Table 1. The 1310 nm laser diodes were operated within a few percent of their OMI clipping point while the 1550 nm laser diodes were less than half of their clipping point. This difference is due to the dispersion-induced intermodulation distortion at 1550 nm. In this experiment, the rms OMI of the 1550 nm laser diodes is at or below the 0.2 value specified in reference 3 such that there is no significant clipping-induced nonlinear distortion.



Seven-tiered supertrunk CNR performance
Figure 3

In the seven-tier frequency plan shown herein, the RF channels are divided into sub-octave bands. However, the CSO that falls out of one RF band will fall into another RF band. To eliminate this problem, the RF filters within the receivers and combiners are designed for a high rejection of the unwanted CSO beats that fall into another RF band.

Figure 3 shows the type of performance one could expect from a typical system based on the parameters given in Table 1.

The system performance reported here indicates that AM WDM supertrunking is a technology that can be deployed in the current time frame. The ability to multiplex different wavelengths on the same fiber reduces the number of fibers required. WDM supertrunking in an AM CATV delivery system is one of the first clearly viable applications of the practical capabilities of 1550 nm technology. CED

> System performance data indicates that AM wave division multiplexing supertrunking is a technology that can be deployed in the current time frame.

Acknowledgment

The authors wish to thank Mr. Wayne Anderson for his assistance in constructing the experimental set-up.

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Directly and indirectly modulated lasers: A comparison

The use of fiber optics is attractive in CATV systems because high fidelity transmission over long distances without repeaters can be achieved. A key requirement of fiber optic transmission systems is a suitable light source which can be modulated with the RF signals. Laser-based transmitters are chosen because of their high optical output power and low noise characteristics.

There are two basic approaches to RF modulation of the laser output. The first is to directly modulate the electrical drive current of a diode laser. The second approach is to use an external integrated optic modulator (IOM) in conjunction with a continuous wave (CW) laser source.

The majority of fiber optic CATV systems utilize directly modulated distributed feedback (DFB) lasers which are widely available from a number of manufacturers. In 1990, the first externally modulated (EM) fiber optic transmission system specifically designed for CATV applications was introduced by Orchard Communications. Since this time, other externally modulated systems have been introduced by other manufacturers.

Because of the increasingly demanding performance requirements being imposed on fiber-based CATV transmission systems, it is useful to understand the tradeoffs between direct modulation (DM) and external modulation (EM) systems[1]. This article compares the DM and EM approaches, and reviews the issues related to the choice of laser sources and IOMs.

By Dr. Alex Rosiewicz, Director of Product Development, Micracor, and Ms. Leslie Giesler, Commercial Business Manager, United Technologies Photonics Inc.

A comparison of CATV linearization schemes

	DM DFB laser	EM feed-forward	EM predistortion	Optical techniques
CTB & CSO cancellation	Excellent	Excellent	Excellent	Good
Bandwidths available	600 MHz, 860 MHz	600 MHz	600 MHz, 860 MHz	600 MHz, 860 MHz
Operating wavelength	1300 nm or 1550 nm band	1313 nm	1300 nm or 1550 nm band	1300 nm or 1550 nm band
Stability over time	Good	Excellent	Excellent	Fair
Link length dependence	No	Yes	No	No
Optical link budget	Limited by DFB output power	Moderate optical insertion losses	Low optical insertion losses	High insertion loss reduces link budget
Other issues	Chirp, increased distortion at high frequencies	Requires multiple light sources	Allows system flexibility	Requires complicated IOM

Table A

Direct modulation

A standard diode laser is created by growing the semiconductor using conventional semiconductor techniques and then cleaving the wafer to make the mirrors. This is a very simple process, but it gives rise to several lasing modes which share the power in a random way, thereby increasing the intensity noise. This tendency can be suppressed by forming a "distributed feedback" element, creating a DFB laser[2].

These devices are available in the 1270 nm to 1350 nm and 1520 nm to 1570 nm wavelength ranges with typical output powers of 10 mW to 15 mW from the fiber— for a total electrical input of 500 mW to 1,000 mW into the package (including the thermoelectric cooler drive current) near room temperature. This results in a typical overall efficiency of one percent.

The output from a diode laser is modulated by imposing the RF signal directly onto the diode drive current. The diode laser package is small (typically about 1.5 inches x 0.5-inch x 0.4-inch) with an optically isolated fiber optic pigtail containing a diode laser, thermoelectric cooler, thermistor and rear-face monitor photodiode (to allow control of the output power of the laser).

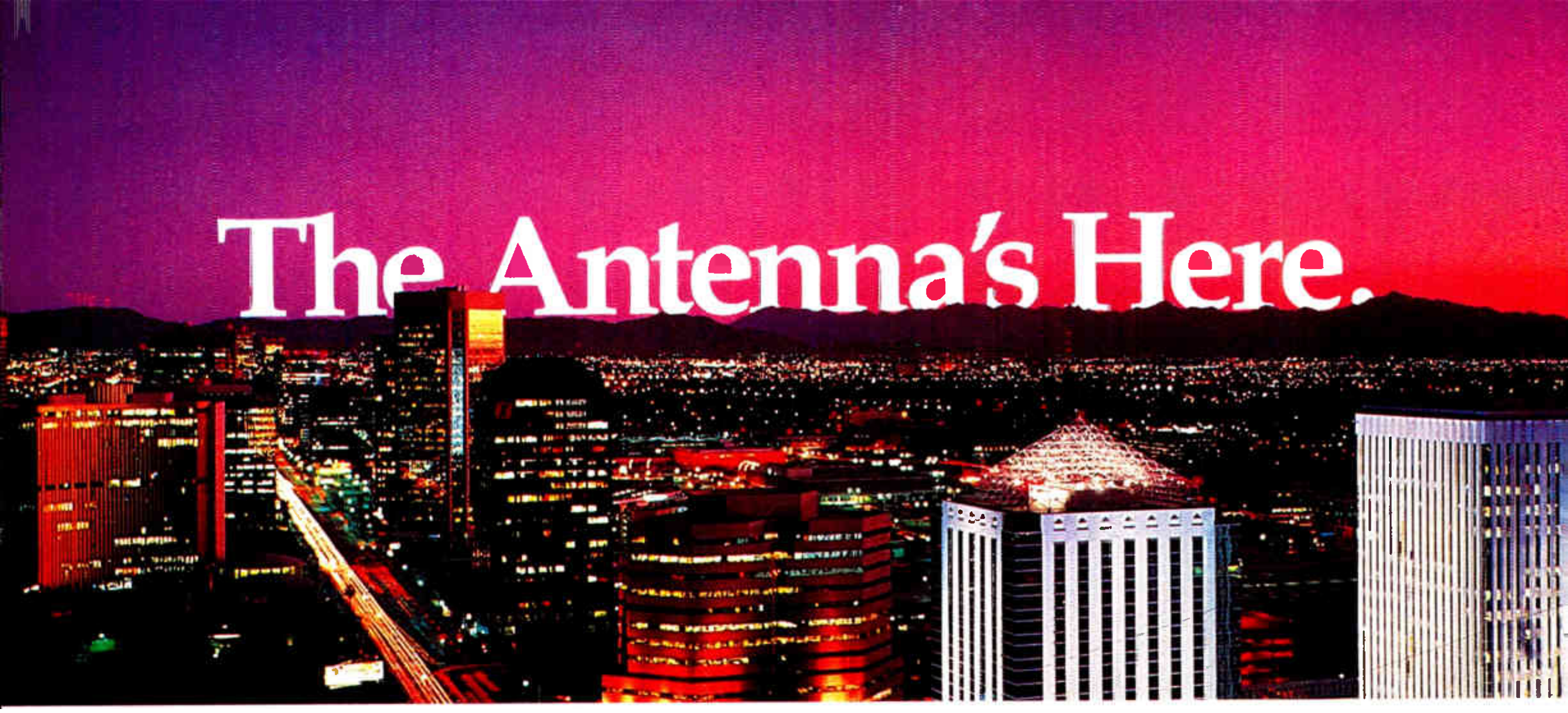
It is manufactured using semiconductor processing and hybrid packaging techniques, and therefore benefits from the economies of scale in the same way as other semiconductor components do. Also, because of the limited number of parts and one single critical alignment (diode output to fiber), good mechanical reliability can be achieved.

One problem that must be overcome when using diode lasers for CATV transmission systems is the non-linear modulation response. Considerable effort has been spent in recent years to solve this problem by redesigning the diode, but the majority of DFBs used in CATV systems have been actively linearized using either predistortion or feedforward techniques.

However, because the relaxation oscillation frequency of a typical DFB laser is in the range of 1- to 5-GHz, the associated non-linearities make it difficult to linearize these sources at frequencies approaching 1-GHz. Additionally, as these lasers age, the non-linear characteristics may change, resulting in a decrease in linearization performance.

External modulation

In an EM system, the CW light from either a solid-state or semiconductor



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laser is coupled into an IOM to form an optical transmitter. In general, external modulation of CW laser sources offers some advantages over directly modulated DFB laser systems including high optical power operation, stability and bandwidth.[1]

Solid-state lasers. Until quite recently (about 1987), solid-state lasers such as Nd:YAG were pumped using high intensity flash lamps. The overall efficiency of these lasers was very low, because the pump-band (i.e. the range of wavelengths the solid-state medium would absorb to excite its electrons) was very much narrower than the output spectrum of the flashlamp.

Now, diode-pumped solid-state (DPSS) lasers are available which match the tightly controlled output wavelength of a high power diode to the absorption band of the lasing medium, giving much higher efficiency.

A typical solid-state laser is made by taking a rod of laser gain medium a few centimeters long and polishing optical flats onto either end. Using carefully aligned semi-reflective focusing mirrors, feedback is allowed into the cavity to allow lasing to occur. Many modes are excited in this process so that additional optical elements are used to produce singlemode operation. These lasers cannot be directly modulated, and as such require an IOM to produce a modulated optical signal.

The output wavelengths of DPSS lasers are determined by the lasing transitions in the laser gain media used so that only discrete wavelengths are available. The most common for CATV and communications purposes are 1313-, 1319-, 1338- and 1545-nm. While most installed EM systems operate in the 1300 nm wavelength band, there is considerable interest in operating in the 1550 nm wavelength window because of the availability of erbium doped fiber amplifiers (EDFAs).

The typical DPSS is 6- x 2- x 2-inches. It produces approximately 50 mW to 150 mW of power from the fiber for 10 W electrical input power (including the thermoelectric cooler drive current), giving a typical overall efficiency of approximately one percent. DPSS lasers are quieter than solitary diode lasers, but have a relaxation oscillation peak in the 10 kHz to 1000 kHz range which must be suppressed in order not to interfere with the CATV signal. The suppression is commonly achieved using a straightforward electronic feedback technique.

With present assembly processes, the production of these devices is labor-intensive and, because of the relatively large number of discrete components, a high level of mechanical stability can be difficult to achieve.

A comparison of lasers for CATV systems

	DFB	DPSS	Microchip
Wavelength (nm)	1270-1350 1520-1570	1313,1319, 1338,1545	1313,1319, 1338,1545
Optical output power (mW)	10-15	50-150	20-100
Input electrical power (W)	1	10	10-25
Efficiency (%)	1	4	0.2-0.4
Size (inches)	1 x 0.75 x 0.5	6 x 2 x 2	1.75 x 1.25 x 0.75
RIN (dB/Hz) 10-1000 MHz	<-150	<-160	<-160
Relaxation peak reduction required	No	Yes	Yes
Direct modulation	Yes	No	No
Economies of scale	Good	Fair	Good

Table B

Microchip lasers

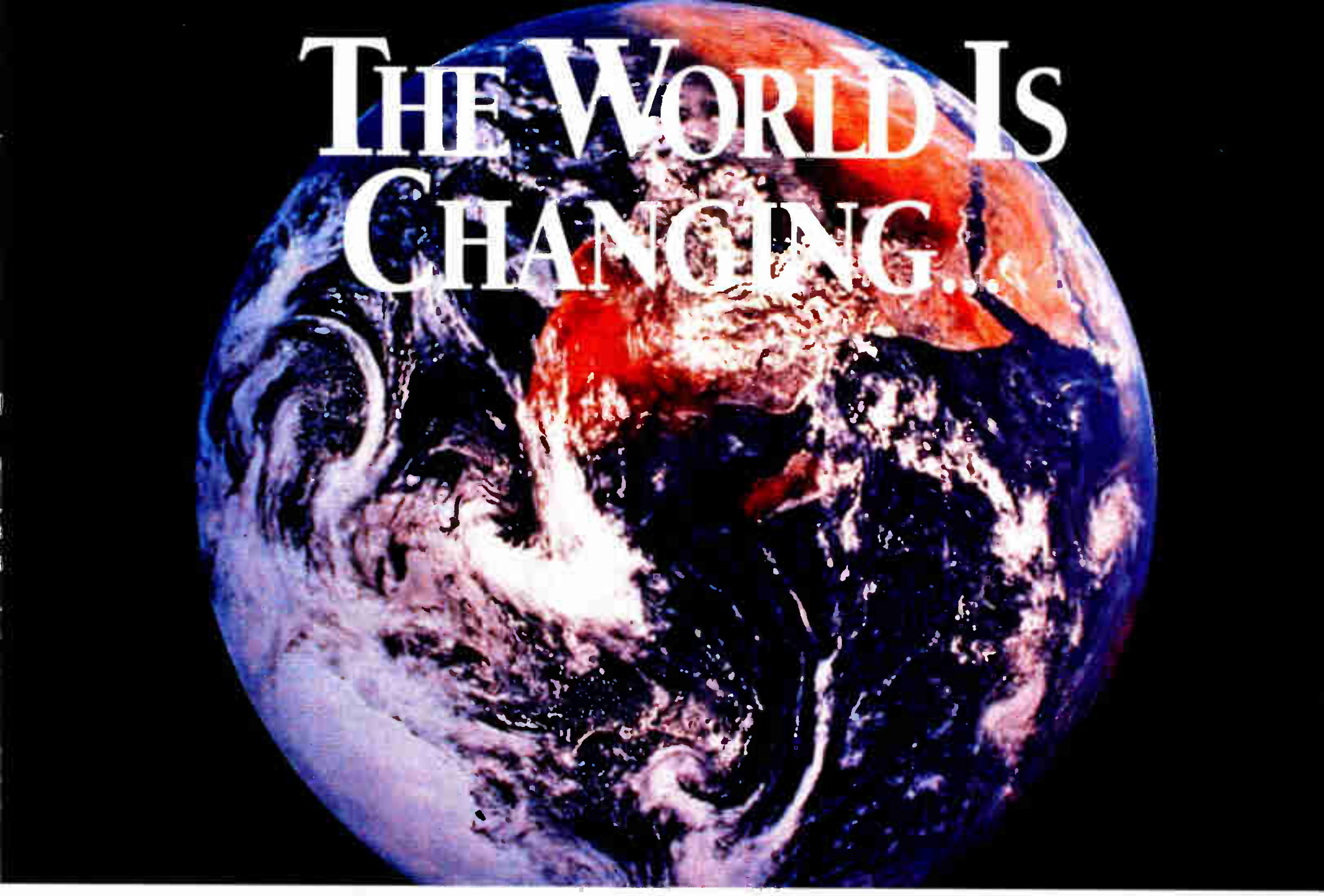
A special class of the standard DPSS is the microchip laser.[4] In this type of laser, the thickness of the lasing medium is specified such that the optical cavity formed by the laser medium is sufficiently small that only one lasing mode is possible inside the gain bandwidth of the material (see Figure 1). Typically the thickness is 300 µm to 1000 µm.

Dielectric mirrors are deposited directly onto the faces of the laser medium to give the feedback required for lasing action. A thermal lens is created inside the laser medium so that there is no need for focusing mirrors to create the lasing action. Therefore, many of the benefits of the DPSS (higher power, lower noise) can be combined with the advantages of the diode lasers (semiconductor hybrid manufacturing processes, economies of scale and reliability).

Devices are currently available that operate at 1319 nm with output powers of about 20 mW into the fiber for about 10 W electrical input (including thermoelectric cooler drive current), which results in a typical overall efficiency of 0.2 percent. Microchip lasers operating in the 1550 nm wavelength region are under development. A microchip laser package is 1.75- x 1.25- x 0.75-inch (about the same size as a diode laser package).

Like the standard DPSS, the microchip requires relaxation peak reduction circuitry and external modulation of the light in order for it to carry CATV signals. Also, because of the short length of the gain medium, the overall gain of the laser is lower than that of a conventional DPSS, thereby limiting the available optical output power.

In order to optimize the optical output power from the microchip, the wavelength of the pump diode must be matched carefully to the pump band of the lasing medium. This is done by control of the temperature of the diode. However, it is also desirable to control the temperature of the lasing medium to optimize its performance. Therefore, separate temperature controls of the two components is desirable.



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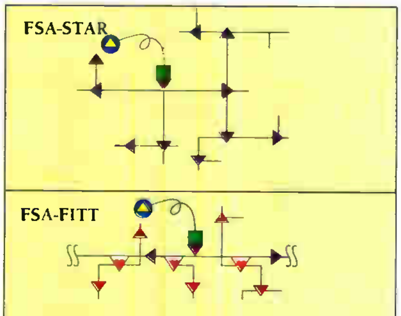

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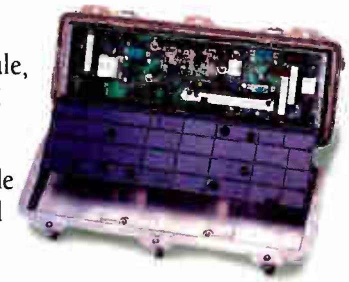

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Optical techniques

The primary integrated optical techniques that are being pursued involve combining Mach-Zehnder modulators in parallel and in series. Although these techniques have been demonstrated to provide adequate distortion cancellation, they usually do not provide stable performance over time and varying environmental conditions. Additionally, they require custom IOM designs and suffer from increased optical insertion loss.

Cost and reliability

With the commercial availability of both DM and EM systems, there are two key issues that must be addressed by users of this technology: Cost and reliability. As already stated, the diode lasers used in DM systems are fabricated using semiconductor manufacturing processes and therefore benefit from the ability to reduce cost using these techniques as volumes increase.

However, the manufacturing process used to produce high performance, high reliability DFB lasers for CATV systems is relatively low yield. This is because many steps, each with a finite yield, must be followed sequentially until the device is complete. Only when the laser has been completed can it be tested for performance and reliability. If any performance parameter is not met, the entire device fails and is almost impossible to modify.

By comparison, the standard DPSS laser is manufactured from a number of separate components each of which can be tested separately. The various performance and reliability parameters are controlled by separate components so that the probabilities are summed, rather than multiplied. In short, if the laser does not meet its specifications, simple and inexpensive modifications can be made to correct the problem which leads to a higher yield process. However, because of the labor-in-

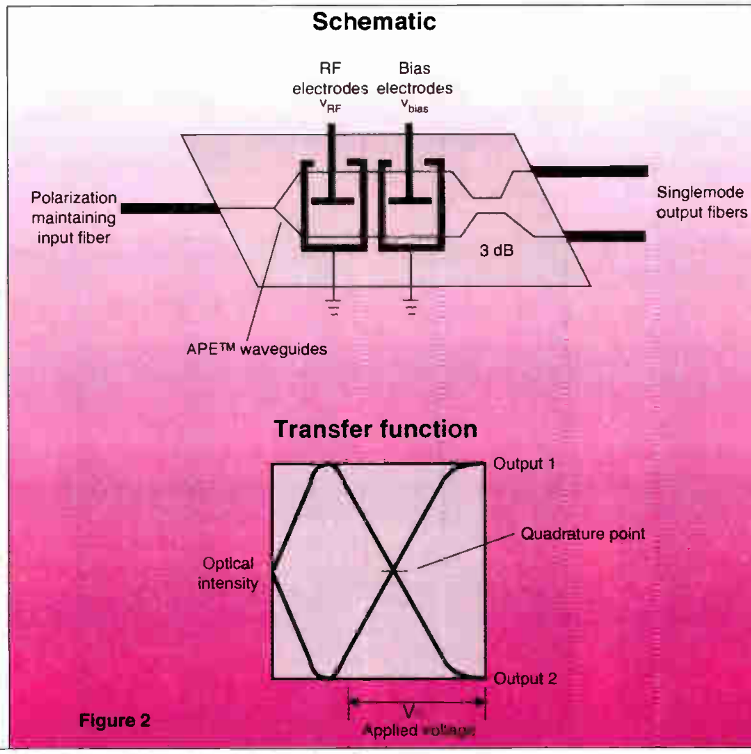

Figure 2

tensive manufacturing process and the cost of the constituent components, typical DPSS lasers are quite expensive.

The microchip DPSS laser manufacturing process utilizes the same separation of parameters as does the standard DPSS laser. However, because the fabrication processes are similar to those used in diode laser assembly, the economies of scale also apply. This results in the potential overall economies of scale being higher than those for either DFB or standard DPSS lasers. A comparison of the properties of diode lasers and DPSS lasers is presented in Table B.

Because linearized IOMs use standard semiconductor processing, economies of scale and automated manufacturing processes for fiber attachment and packaging are expected to lead to a substantial decrease in cost as the volumes continue to increase. Because of the use of this technology for other applications such as fiber optic gyros, antenna remoting, telecommunications and instrumentation, reliability data on these devices is rapidly increasing.

Summary

While DM systems have been commercially available for many years and account for the majority of the fiber optic CATV systems that have been installed, several EM transmission systems are currently in production and more are currently in development. EM systems promise continuing performance improvements that will meet the CATV industry's requirements for higher bandwidth and transmitted optical power as well as the cost and reliability considerations. CED

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Field testing of fiber optic cable systems

Cable operators need to perform certain field tests on their passive fiber optic cable systems in order to provide for the long term operation and maintenance of those cable systems. This paper discusses the field testing required to properly characterize the optical condition of that plant to ensure the reliability of day-to-day operations. Discussed are the relevancy and interrelationship of the data obtained from each of these different field tests normally conducted before, during and after the installation of the passive fiber optic cable system.

The process used to manufacture optical waveguides and subsequently to cable those fibers into a robust product suitable for installation in some of the harshest environments is incredibly complex, technically sophisticated and necessarily requires the strictest quality controls for both manufacturing and testing. The fiber optic cable that arrives at a warehouse door has been thoroughly tested and retested both as individual material components and as an assembled product. These rigorous testing procedures, now becoming standard for all fiber cable, ensure that the cable received meets the very highest standards established by regulatory bodies.

Nevertheless, the day the finished cable product arrives on the operator's loading dock is the time to begin field testing in order to continue maintaining these high standards of quality and to ensure the technical excellence of the finished product—the passive fiber optic cable system (see Figures 1 and 2). The largest investment of most operators is in their passive fiber transmission system. The amount of technical, logistical and financial resources required to build the passive cable plant mandate that extraordinary care be taken to verify the quality of the finished transmission system. Field testing by the operator or its contractor will provide verification of compliance with certain specifications required contractually of the manufacturer and contractor.

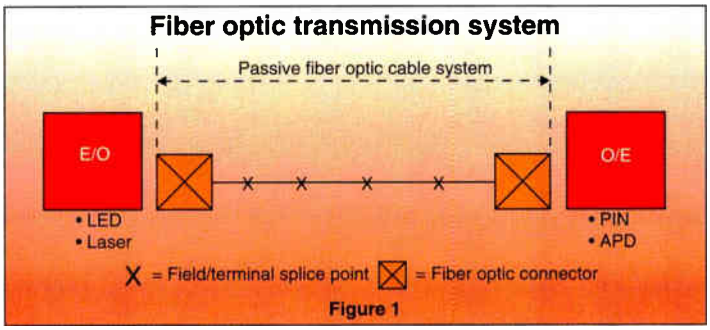


Figure 1

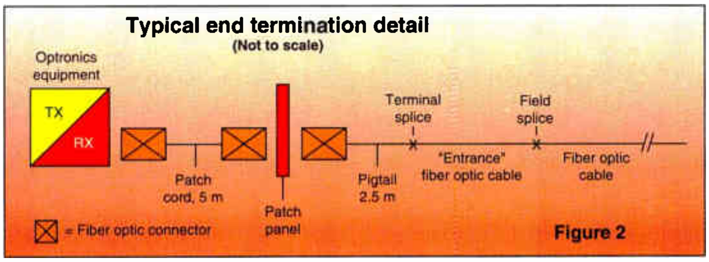


Figure 2

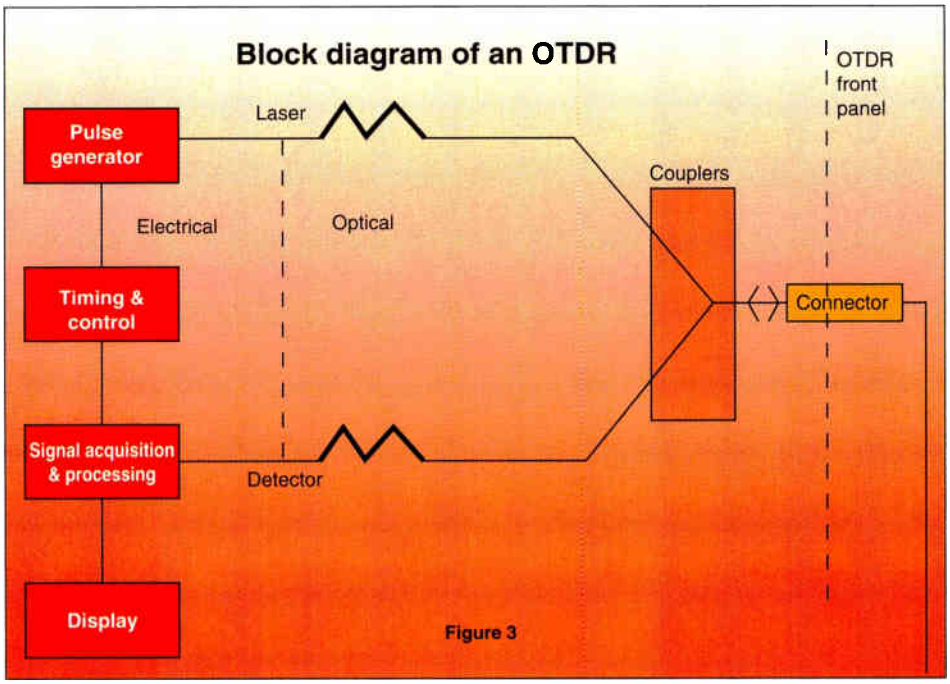


Figure 3

Reels should be unloaded in accordance with the manufacturer's recommendation. Normally, this means keeping the reel upright. Any lifting or movement of the reel should be done using appropriate materials handling equipment designed for the large reels typical of fiber cable. Any rotation of the reel should be done as recommended by the manufacturer. Most manufacturers place an arrow on the reel showing direction of rotation. The first field test to be done by the operator is simply a visual inspection of the reel to ensure that no obvious physical damage has occurred during shipment.

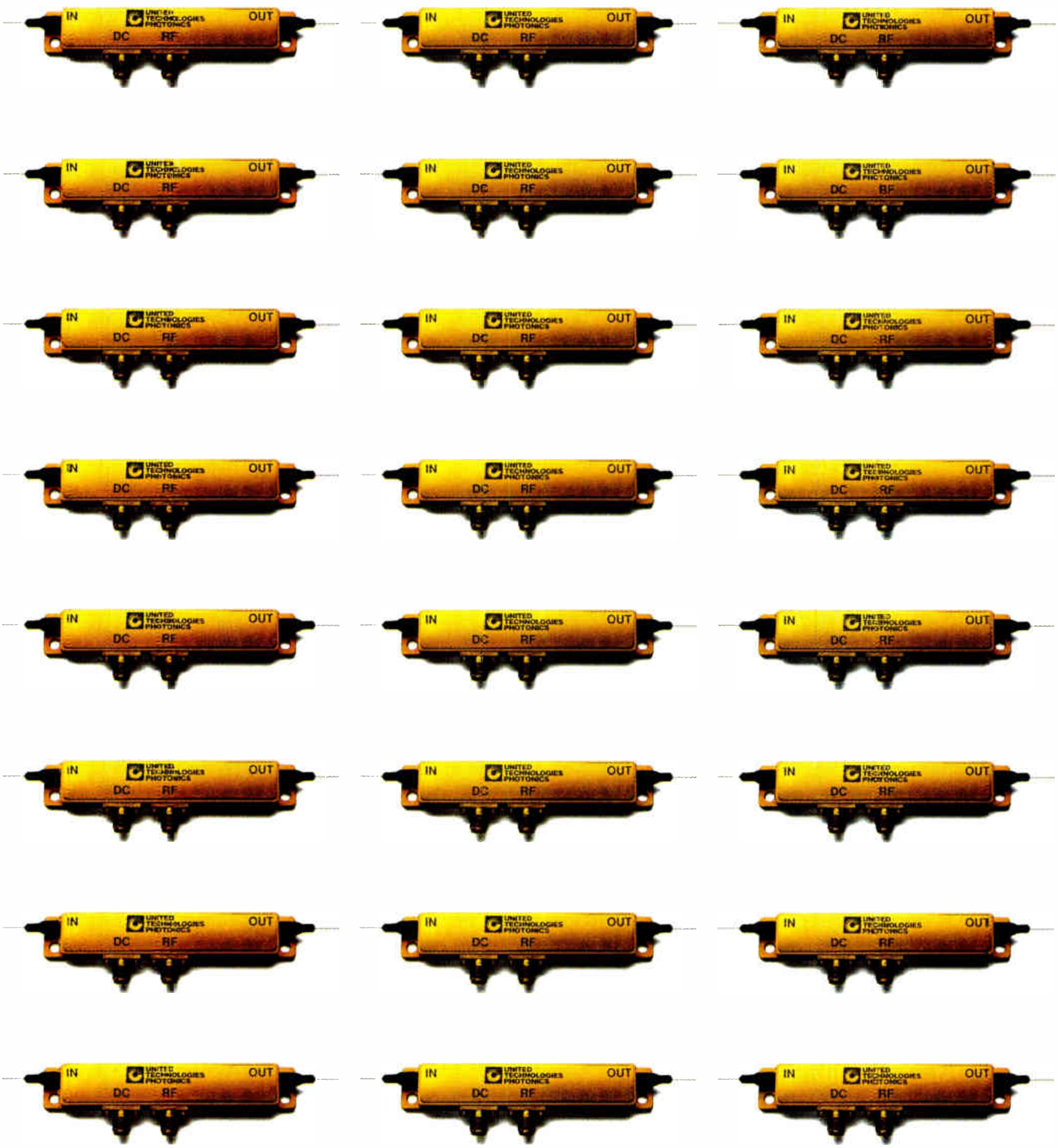
General testing

The operator is now ready to begin optical field testing of the fiber cable. Testing can be divided into three phases, as follows:

1. Pre-installation
2. Installation/splicing
3. Post-installation/final acceptance.

Optical characteristics that can be measured in the field include attenuation and dispersion. Dispersion characteristics are very closely controlled during the manufacturing of the optical waveguide and the

By K. Charles Mogray Jr.,
Applications Engineering Manager,
Comm / Scope Inc.



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Typical OTDR end-to-end trace (courtesy of ANRITSU)

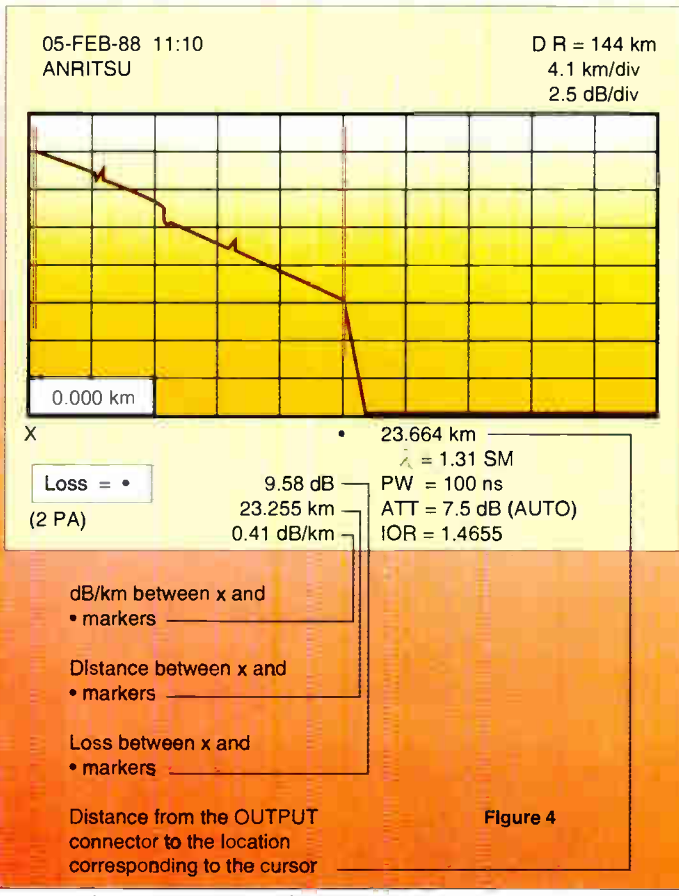


Figure 4

test equipment is extremely expensive; therefore, dispersion tests are rarely performed and generally not required in the field.

Two methods of measuring attenuation employed in the field are the backscattering and two-point methods. More common terms sometimes used to describe these methods are the use of an optical time domain reflectometer (OTDR) test and the insertion/cutback loss test, respectively. Additionally, the two-point method is often referred to as an optical power test. Both types of tests are required in order to completely and accurately characterize the overall optical condition of a fiber cable system.

Depending on cable and system specifications, these tests may be done at both the 1300 nm and 1550 nm wavelengths as well as from both directions. Normally, the optical power test is only performed as a part of the final acceptance testing. These test methods provide data which is complementary but may vary slightly as a result of equipment, technique and skill of the technician performing the test. The key to successful characterization of the fiber cable plant is following correct procedures consistently. This will improve the correlation between measured and calculated optical losses.

Test methods

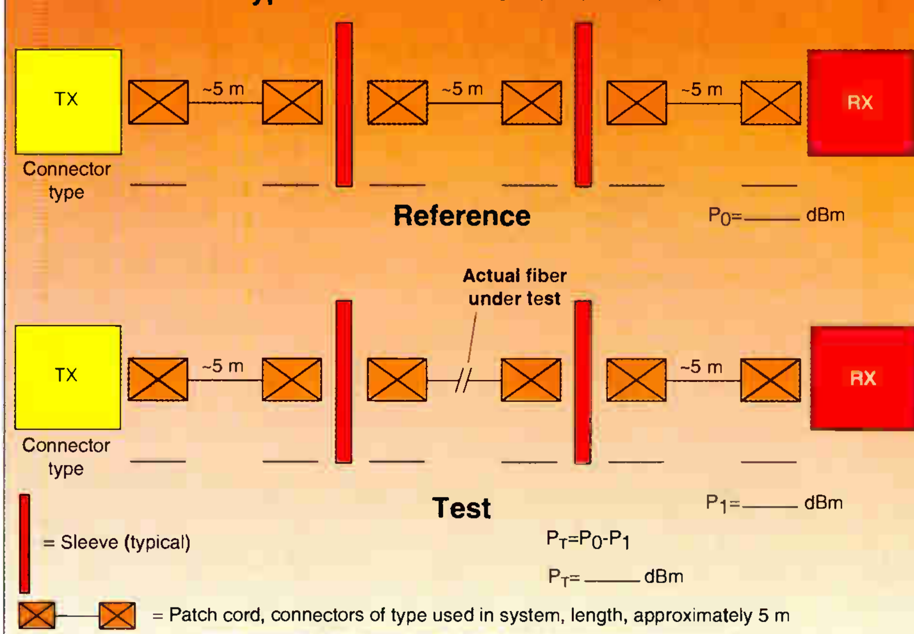
Backscattering. The first and most common method used is the backscattering method. This test is performed using an OTDR. The OTDR is primarily used for locating faults, discontinuities and anomalies, and general attenuation checks. The OTDR measures distance and loss in an optical fiber by transmitting an optical pulse through the fiber and measuring the optical power reflected back to a sensor in the OTDR instrument. A block diagram of an OTDR is shown in Figure 3.

The OTDR calculates distance along a fiber by measuring the interval between the pulse's launch and the time the reflected energy is detected at the sensor. Loss is calculated by comparing the received power to the transmitted power. As the pulse moves along the fiber, thousands of data points corresponding to distance and relative power are gathered and displayed on a CRT. The result is a linear trace of the fiber displayed as distance from the source (horizontal axis) vs. relative power (vertical axis).

The power reflected back from the fiber is caused mainly by Rayleigh scattering. This occurs when light traveling in a fiber strikes a non-uniform part of the core's molecular structure, or a non-silicon dioxide particle, and is scattered in a spherical pattern. The part of the scattered energy which travels back toward the optical source is called the "backscatter" and is the basis for the OTDR measurements.

Every fiber has a unique "backscatter coefficient." This is a measure of how well optical energy is reflected back to the source. The backscatter coefficient depends on the fiber's relative refractive index difference (the difference between the indices in core and cladding), the

Typical insertion loss test - field



Equipment data	Transmitter (TX)	Receiver (RX)
Manufacturer		
Serial number		
Type		
Wavelength		N/A
Output power		N/A

Figure 5

Typical OTDR splice loss measurement (courtesy of ANRITSU)

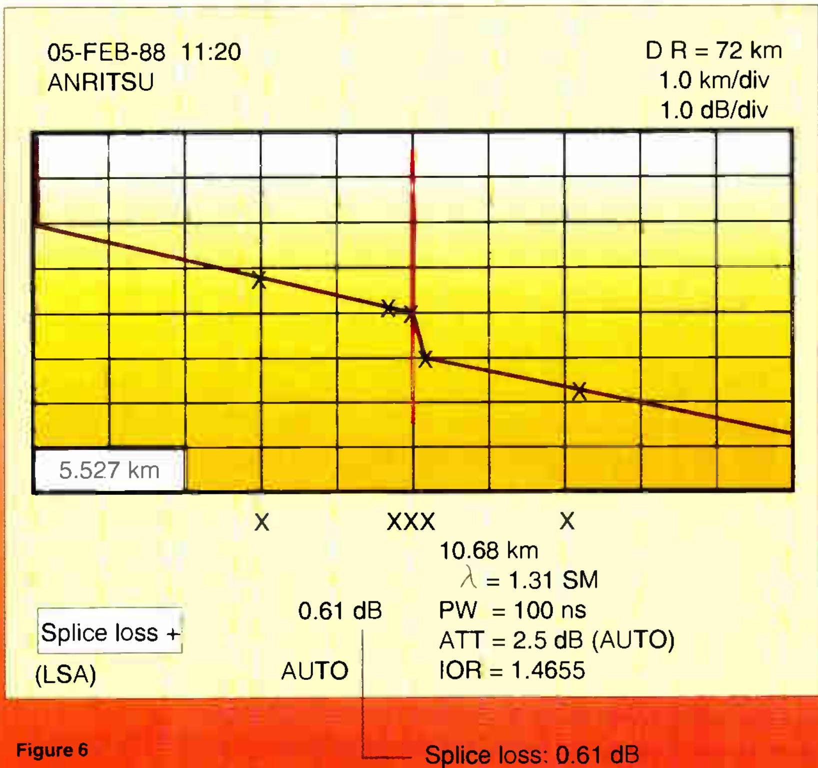


Figure 6

core refractive index and the core diameter.

General attenuation checks include cable reel acceptance, splice loss verification and final end-to-end measurements. Signature traces should be made of all fibers after connectors are installed, depicting the entire cable route (see Figure 4). These traces will be invaluable should trouble develop on the passive cable plant. Most importantly, the OTDR is essential for fault locating in the outside cable plant.

The OTDR has several significant advantages over other test methods. It is an extremely versatile instrument that can be operated by the technician with a minimal amount of training. It is the optical device normally used to locate fiber discontinuities in the cable plant. Through periodic comparison with the initial signature traces, the OTDR may provide early warning of a potential catastrophic failure by indicating points of stress in the cable. When the end configuration depicted in Figure 2 is used, the OTDR can be readily used to access the fiber system through the connectors.

Although the OTDR is a very accurate and important test instrument, several inherent factors make the OTDR the least accurate of the attenuation methods that may be employed in the field.

For very precise attenuation measurements, the cutback or insertion loss method should be used.

Cutback or insertion loss method

By definition, the cutback method is a destructive test and is not normally used for a fully concatenated fiber optic cable system. It is not commonly seen in the field, but because of its accuracy and precision, it is often specified and used in cable manufacturing for acceptance tests. Because this test is seldom used in the field, it will not be discussed in this paper. For additional information the reader is invited to review EIA standard 455-78, "Spectral Attenuation Cutback Measurement for Singlemode Optical Fibers."

The insertion loss test method is very similar to the cutback method. It is also called the "Attenuation by Substitution Method." This test method is defined in EIA standard 455-171, "Attenuation by Substitution Measurement for Short Length Multimode Graded Index and Singlemode Optical Fiber Cable Assemblies." The equipment required to perform this test will include a stabilized light source, normally a laser, an optical power meter or receiver and various patchcords or jumpers used to emulate and access the fiber cable system.

With this method, the first step is to establish a "reference" value to characterize the transmitter, receiver and connector assemblies. This consists of inserting a short reference cable between the transmitter and receiver of the attenuation measuring (optical power meter test) set and in measuring the transmitter output P_0 coupled into the fiber/jumper assembly. In the second step the reference cable is replaced by the cable link to be measured and (inserted) attenuation is obtained by comparing the level available at the output side of the cable link P1 with the reference level P_0. Figure 5 shows a depiction of the insertion loss test.

This method has the advantage in that it is simple to perform and it can be used for fully connectorized/concatenated cables. It has one disadvantage, in that the varying coupling conditions on the transmitter or receiver side may cause the reference level to deviate from the level coupled into the cable link, resulting in minor measuring errors.

All fibers must be checked in order for pre-installation field tests to be effective.

Field tests

Pre-installation tests. Pre-installation field testing consists of cable acceptance from the manufacturer by the operator. The operator conducts this test with an OTDR. The objective of pre-installation is to assure the operator that no damage has occurred during transit from the manufacturer to the user's dock. The technician should be verifying optical length, attenuation, anomalies and continuity. This data should be recorded either electronically or with a chart recorder.

The majority of cables now being specified are for dual wavelength operation. Because of the sensitivity of fiber to attenuation-related difficulties at the 1550 nm wavelength, it is recommended that this pre-installation test be conducted at that wavelength, assuming an OTDR with that wavelength is available.

All fibers must be checked in order for this test to be effective! Random testing can result in less than desirable assurances of delivered product. This is a result of one of the innovative and very positive features of most fiber cable designs. These designs will allow damage to occur to fibers within the cable in a

Calculated cable loss

Project:	Anytown, USA	Date:	2-Oct-89
Span:	Southport headend to node at Elm Street	Technicians:	
Optical Length:	18,579		
Sheath Length:	18,616		
Wavelength:	1300 nm		

Fiber number location length (km)	End splice headend Southport	Cable loss #890108 3.295	Splice loss Main Str. SP # 1	Cable loss #890206 5.569	Splice loss Oak Str. SP # 2	Cable loss #890207 4.351	Splice loss Hwy 428 SP # 3	Cable loss #890308 5.364	End splice node at Elm Str.	Concatenated summary loss (dB)
1	0.08	1.02	0.05	1.73	0.14	1.48	0.03	1.88	0.08	6.48
2	0.08	1.25	0.04	1.95	0.12	1.57	0.02	1.72	0.08	6.82
3	0.08	1.12	0.07	1.89	0.05	1.52	0.11	1.66	0.08	6.59
4	0.08	1.29	0.11	2.17	0.06	1.74	0.12	1.88	0.08	7.52
5	0.08	1.05	0.14	1.73	0.03	1.35	0.11	2.09	0.08	6.66
6	0.08	1.32	0.06	1.89	0.09	1.48	0.05	2.04	0.08	7.08
7	0.08	1.19	0.00	2.12	0.08	1.61	0.04	1.82	0.08	7.01
8	0.08	1.22	0.12	2.00	0.14	1.57	0.09	1.88	0.08	7.17
Average splice loss (dB):		0.08								
Average total loss (dB):		6.92								

Cable # 890108		Cable #890206		Cable #890207		Cable # 890308	
Fiber number	Loss dB/km	Fiber number	Loss dB/km	Fiber number	Loss dB/km	Fiber number	Loss dB/km
1	0.31	1	0.31	1	0.34	1	0.35
2	0.38	2	0.35	2	0.36	2	0.32
3	0.34	3	0.34	3	0.35	3	0.31
4	0.39	4	0.39	4	0.40	4	0.35
5	0.32	5	0.31	5	0.31	5	0.39
6	0.40	6	0.34	6	0.34	6	0.38
7	0.36	7	0.38	7	0.37	7	0.34
8	0.37	8	0.36	8	0.36	8	0.35

Figure 7

random and unpredictable manner. This means that it is possible to have an incident such as an air-driven nail inadvertently driven into a cable during the lagging process that may damage only a few fibers in a multiple count fiber cable.

At this point, our good friend Murphy steps in and the technician is guaranteed not to select the damaged fiber during random checks. It is only after that particular 30,000-foot reel is installed in a very troublesome area that the broken fiber is discovered and at the very least a splice is added—or worse, a reel of cable replaced. Therefore, if pre-installation tests are conducted, it is recommended that all fibers be tested.

This pre-installation check can provide assurances to the operator and to his construction group as to the quality of the fiber cable prior to installation. Many times these checks are conducted jointly by the contractor and the operator. This cooperation may preclude difficulties later, should a cable be damaged during the construction operation.

Installation/splicing. Installation or splicing field tests can be categorized into five main categories, including:

1. Optical time domain reflectometer (OTDR),
2. Optical power monitoring,
3. Local injection detection (LID),
4. Profile alignment systems (PAS), and
5. Some combination of the above.

There are several advantages and disadvantages to each of the fiber approaches. Detailed papers are available for each of the techniques the operator may use. The major points to consider are availability of skilled technicians, equipment and the logistics of communications during the splicing operation. In all cases, the resulting splice loss should be recorded so this value can be used when calculating the expected system loss (see Figure 6).

Post-installation/final acceptance. Post-installation and final acceptance testing should consist of end-to-end OTDR testing made from both directions at both operating wavelengths, if applicable. Additionally, an optical power test using the insertion loss method should be performed at both wavelengths from both directions, if connectors are used. By performing these tests, the operator is assured of having all the necessary data required to characterize the passive optical system.

Documentation

The minimum documentation required for a fiber optic cable system should include the following:

1. As-built drawings,
2. Splice loss,
3. End-to-end optical loss measurements,
4. End-to-end OTDR signature traces.

The purpose of this data is to provide historical references for maintenance and emergency restoration. By maintaining this data, the operator is assured the ability to quickly respond, identify, locate and repair any problem that may occur within the passive cable plant. Examples are a splice log, end-to-end loss measurement and summary of field data-attenuation loss.

Results

The data that has been acquired during the field testing of the fiber cable can then be analyzed. This measured field data is compared to the data obtained by summing cable loss, splice loss and pigtail splice loss (see Figure 7). It is not un-

Splice log

Project:				Date:		
Span:				Technicians:		
Optical length:				Weather condition:		
Sheath length:						
Splice point location:						
OTDR location:						
		Splice attempt (loss in dB)				
Identifier	Fiber number	1	2	3	4	Comments

Figure 8

Are you ready for a break?

A step-by-step guide to successful emergency restoration

With cable operators installing more and more fiber optic cable, technicians must be prepared for the inevitability of unexpected fiber cuts. The quick-fix that coaxial plant allowed will soon be a thing of the past. Each fiber in a bundle ultimately must be spliced by trained personnel who are familiar with the special tools and procedures fiber requires.

By Gene Bray, Fiber Optic Engineering Consultant, Antec Network Systems

Fiber technology is new, with little history of interruptions. When trying to get a fix on problems the fiber future holds, a rule of thumb is to consider what has happened to a system in the past with coax. These types of problems can and will happen again.

Although fiber cable truly is tough and generally more forgiving than coax, it is not indestructible. Common causes for fiber trouble include sheath pull-out, accidents caused by diesel-powered cable finders (a.k.a. backhoes and trenchers), storms, rodents and, where hunters roam, bullets.

Being prepared for such disasters is the essential ingredient of any effective restoration plan. Cable operators should develop and document a “game plan” that details what is to be done, who is to respond and where necessary tools can be found in the event of a fiber cut. A quick and effective response that can be executed confidently by any member of a restoration team depends on a comprehensive game plan.

A manual describing the game plan should include a list of home telephone

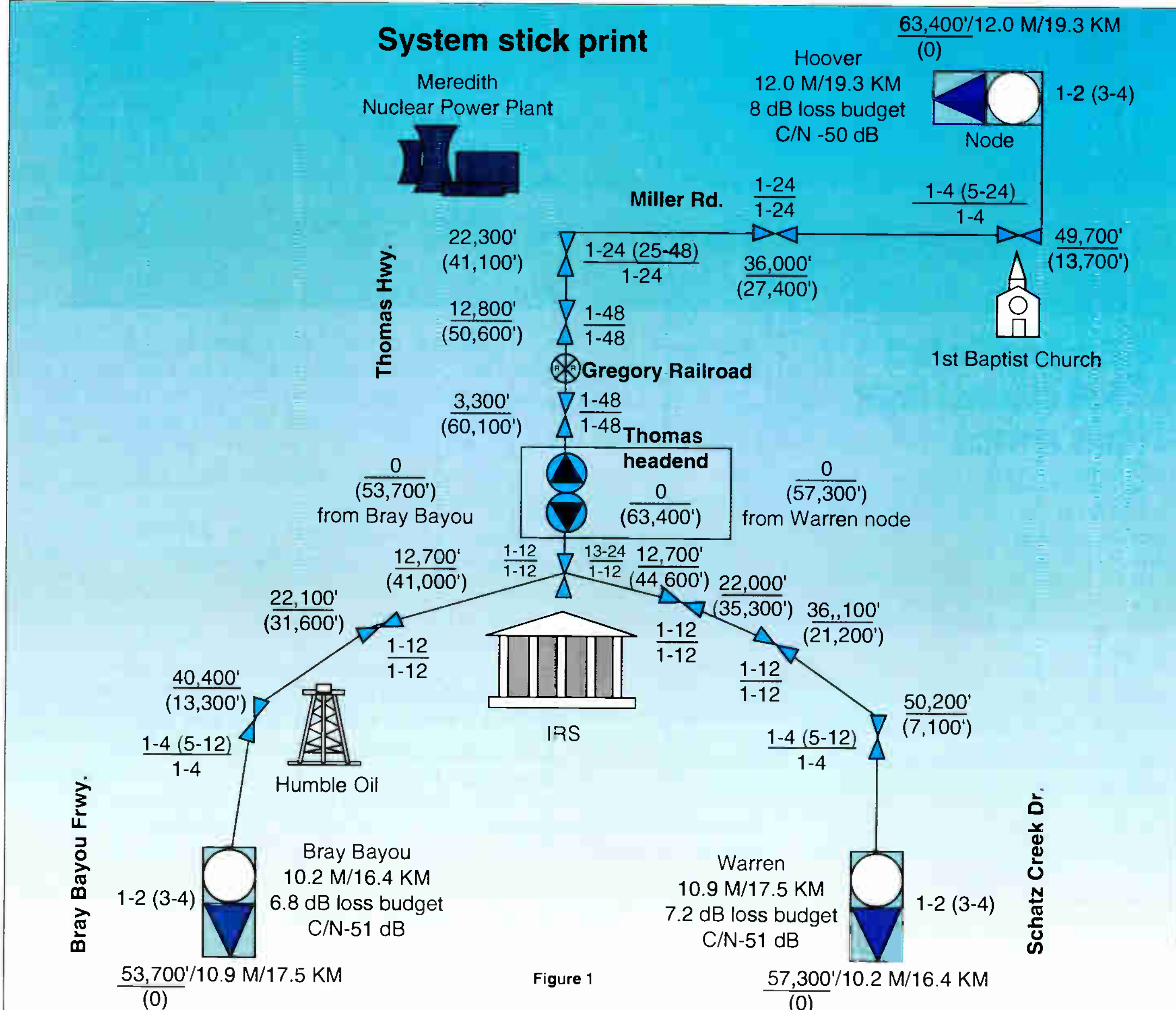


Figure 1

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numbers and beeper numbers of responsible parties, as well as the telephone numbers of applicable construction and vendor personnel. Another essential ingredient of the game plan manual is a stick print of the system (see Figure 1). The stick print is an informational map of the system that depicts splice locations in relation to familiar landmarks and provides their distance from one another. It also includes sheath and fiber counts, identifies working fibers and declares which fibers should be restored first, and denotes signal loss at each node. Information included in any game plan manual need not be exhaustive to the point of unmanageability, but it should provide a technician with all the pertinent details needed to restore service.

A system-specific manual should be distributed to all responsible parties, and included in restoration kits, headends and vehicles. Keeping the manual up to date is just as important as creating it in the first place. Regular maintenance ensures that the game plan reflects changes in personnel, procedures and fiber reassignments. Be sure you know where all copies of a restoration plan are located so that any changes in the plan are executed systemwide.

Practice makes perfect

Although developing a game plan is very important, it is not enough. The personnel responsible for carrying it out must perform dry run restorations periodically to gain confidence in their abilities and to detect flaws in the game plan. To keep current, a dry run should be executed every quarter. First select a location. Then lay a piece of cable down between poles, cut it in two, then report a break. Supervisors can stand back and observe the plan in action and document the time it takes to successfully restore service to active fibers.

Such drills are an excellent means of training new personnel and maintaining the skills of trained personnel. Dry runs can also scare up real problems, such as taking too much time to locate test sets, keeping batteries charged, or keeping a cool head when a key person is unavailable.

Another worthwhile exercise is to have members of a restoration team break out the test gear each month, test dark fibers and keep a record of the data. In addition to maintaining a trained workforce and collecting information, the testing of dark fibers can sometimes detect a fault a correct a potential problem before it occurs. This exercise can be done with a different technician each time.

What's the rush?

The primary objective of emergency service restoration is to get the system up and running first. Even though it might be easier to do something else, operators should use the game plan and avoid wasting time discussing alternatives.

Service reliability means a great deal to advertisers and subscribers. Fixing fiber cuts quickly will help cable operators improve their images and protect their franchises as well as the subscriber and ad insertion revenues they depend upon.

In emergency restoration, only active fibers are restored. A permanent fix that restores the entire cable can be applied later. The permanent fix should be carried out according to a carefully organized plan that can be executed during non-prime time hours using a method that will deliver the best performance possible.

A quick, cost-effective and safe re-

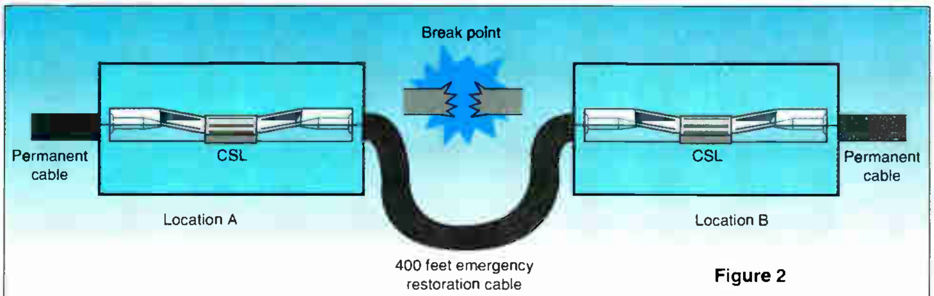


Figure 2

sponse to a fiber cut can be facilitated best by operators who have a complete fiber restoration kit at the ready. Kits that include all the tools needed to make an emergency repair keep the costs of a cable cut down because employees need not cannibalize supply shelves before heading into the field.

Keeping cost concerns out of the way during a break is difficult unless the operator has prepared in advance. It is best to create a budget for unexpected breaks at the beginning of the year, so that when they occur, precious time is not spent worrying about how much the repair is going to cost.

First things first

Technicians responding to a break must have immediate access to the proper tools. To makes they are located where they belong at the crucial moment, restoration kits and fault locators should be kept under lock and key in a central location. Once these tools are in hand, it's time to find out what's wrong.

First, determine the location of splicing points of the damaged cable. Then, identify splice points as locations A and B. The cable entry side of restoration case A should be placed close to the location A splice point in a level position. Open the case and reel out the enclosed fiber optic cable to Case B, which should be placed close to splice point location B (see Figure 3). Be sure to place the cable in a protected area away from traffic.

Position the cable in Case B, securing and protecting the fibers, and position tools in Case A and B in preparation for splicing. Depending on the severity of the break, process and logistics, a decision has to be made on how much cable sheath to cut off of the damaged cable before splicing starts, whenever possible, to 50 feet of sheath should be cut off, because fibers could be damaged under the sheath at the break point. No one wants to splice a fiber only to find out that it is also broken a couple of feet away under the sheath.

Once the cut is made, between two feet and five feet of sheath should be removed from the old cable, which should then be brought into both Case A and Case B. Determine which fibers must be spliced to restore service and proceed with the splicing. Establish communication with the maintenance group and arrange for system turn-up as fibers are made available. Finally, protect the cable and restoration kits from theft or damage for the duration of the temporary restoration by posting a guard if necessary. This procedure should be detailed in the game plan.

The permanent fix

Once service has been restored to active fibers, plans for a permanent fix of the entire cable can be developed. Before going back into the field, all of the necessary materials should be ordered, prepared and positioned for the procedure.

When making the permanent splices, new cable is placed and the temporary splices are accessed. The dark fibers in the old cable should be spliced to corresponding fibers in the new cable first. Once this has been accomplished, service on active fibers should be transferred to the inactive fibers to the previously active fibers can be permanently spliced to the new cable without a major service interruption. Once all fibers are spliced, service should be restored to the originally active fibers.

Service can be transitioned back and forth quickly during this process by technicians situated at the node and headend who are in communication with one another and the splicer via a fiber optic talk set.

The keys to success

When it comes to fiber breaks, confidence is the name of the game. To be truly prepared for these situations, an operator must first acknowledge their inevitability. Knowing they will occur, the operator should build the restoration costs into their operating budget each year. Developing a game plan is crucial, but putting it into practice ensures a solid and effective response. It also instills that confidence that will provide the restoration team with the peace of mind needed to focus on getting the job done when a break occurs. CED

SCTE conference an "emerging" success

Proving that there is great interest in the future directions of cable networks, more than 700 persons gathered in New Orleans for the Society of Cable Television Engineers' Conference on Emerging Technologies. The conference, which started back in 1988 as an educational event tied to the emergence of fiber optic technology, has widened its scope to include other technologies that may affect cable networks.

Though the majority of the program focused on digital and competing technologies, optical fiber was first on the agenda at the conference. Session moderator Alex Best, Cox Cable Communications senior vice president, responding to a news report that said fiber has become routine, quipped that "fiber is no afterthought."

When three aspects of optical fiber geometry are carefully controlled, splice loss and yields improve, thereby reducing testing needs, said Doug Wolfe, Corning Inc. senior applications engineer. Among the crucial parameters are cladding diameter, core/clad concentricity and fiber curl. Cladding diameter is a measure of the outside diameter of the cable, and is important when mechanical splice techniques are used, said Wolfe. That's because inconsistent diameters cause core offsets, increasing splice loss.

Core/clad concentricity is a measure of how well the core is centered in the middle of the cladding. It's important because the better the center alignment, the less light is lost whenever a splice is made, said Wolfe. Fiber curl is the amount of glass curvature over distance, an important parameter when mass fusion splicing techniques are used.

Use of tapered fiber cables, as advocated by NewChannels Corp., significantly reduces the amount, and cost, of splicing required when large fiber-count cable bundles are pulled out of headends, said Marvin Ashby, Siecor Corp. senior applications engineer. Among the advantages are faster installation time and lower splicing cost. On a sample run of 16.7 miles, for example, a tapered approach cost $14,663 in splice costs compared to $25,824 for an alternate approach requiring joining of separate spans of cable at each splice point.

Scientific-Atlanta engineers, meanwhile, argued that AM supertrunking using wave division multiplexing was a practical alternative to either digital or FM approaches. (See story, page 26.)

Jerrold Communications Cableoptics Director David Robinson argued that although DFB lasers capable of handling over 500 channels of analog and digital signals are available today, it is possible to develop lasers carrying more than 10,000 signals on a digital laser operating at 6 GHz. Where the typical DFB laser today offers 6 milliWatts to 10 mW of output power, and some hero devices can generate 13 mW, a 25 mW device should be available in a few years.

ONI President Andy Paff argued that regional fiber interconnects already can be built for between $3,500 to $4,000 a channel using standard pulse code modulation equipment. Compressed video systems using a synchronous optical network approach and OC-48 signaling represents a per-channel cost of about $2,063. CED

Staniec presented with first Polaris Award

From left, Bill Riker, Tom Staniec, Kathy Rauch and Roger Brown at the 1993 Polaris Award reception. Photo by Rob Stuehrk.

An elated Tom Staniec, director of engineering for NewChannels, accepted the first annual Polaris Award during a reception at the Society of Cable Television's Conference on Emerging Technologies last month in New Orleans.

The gregarious Staniec says that when Corning officials first contacted him and told him he had won the new award, he thought it was a joke. "I asked them, "are you sure you dialed the right phone number?" Staniec laughs. "I was dumbfounded. In fact, I was speechless," which is an adjective that doesn't often work to describe Staniec.

Just doing his job

Staniec says that after spending a few days "walking into things," the fact that he had won cable' s highest lightwave-related award finally sunk in. Even then, though, he says he still didn't quite understand. "I'm just out there doing a job," Staniec submits.

But obviously, the three-person selection committee representing the SCTE, Corning Inc. and *CED* magazine (the three award sponsors) thought otherwise. Staniec was chosen because he

Continued on page 60

Cable wrestles with PMD effects

Perhaps the loudest whisper weaving in and out of Conference conversations was that of PMD, or polarization mode dispersion. Simply put, PMD is a quirky and complicated fiber snafu that rears its ugly head in the form of time-varying second order distortions. The phenomenon, which industry observers, including several high-level engineers at MSOs, speculate could affect more than half of all U.S. fiber installations deployed prior to 1990, is caused by a combination of factors, including fiber core non-circularity, polarization dependent losses, high laser chirp and rapid environmental temperature changes.

Discreet rumblings about PMD surfaced over a year ago, around the time of the 1991 Western Cable Show. Since then, the subject has been well-guarded in an attempt to shield both a growing market segment and nationwide "cable as a technological leader" lobbying efforts.

But in New Orleans last month, the subject of PMD started to creep into conversations between operators and equipment manufacturers. Doug Wolfe, a senior applications engineer for Corning Inc., discussed PMD at length during his speech on fiber geometry.

"Fiber geometry is an important issue, because the better it is, the better a cable system's overall performance will be," Wolfe said. Fiber non-circularity (the roundness of the fiber's core glass region) is the biggest contributor to polarization mode dispersion, Wolfe said. Specifically, as the actual glass within the fiber sheath strays away from a perfect circle toward an oval shape, the fiber's refraction indices are adversely affected.

"The light ravels through the fiber at different speeds," Wolfe explained, "and results in time-varying composite second order distortions."

Wolfe wasn't the only speaker to openly discuss PMD at the Conference. At the tutorial sessions preceding the two-day event, CableLabs' Director of Technology Assessment Aleksander Futro talked at length about the phenomenon and its causes.

"We must be concerned about it (PMD)," said Futro, who acknowledged that many people know of the malady but don't want to talk about it. In fact, Futro suggested that many operators have been affected by PMD but corrected it by swapping out lasers or connectors to improve picture quality. "Some of you might have PMD on your systems, but you go out and fix it," Futro told the audience.

Futro said PMD is caused by numerous factors, including lasers, temperature swings, connectors, stretched fiber pigtails, etc. But, like Wolfe, Futro said the largest contributing factor is fiber construction. But he stopped short of saying one manufacturing process holds an advantage over another: "Today, I'm not sure that one manufacturing method is better than another," he said.

During his closing comments, Wolfe cited an ongoing need for further industrywide research into the causes and effects of PMD. "This is a very complex issue," Wolfe said. "There are other factors involved, besides fiber concentricity and circularity. The industry still has a lot of work to do on PMD."

However, executives from fiber manufacturer AT&T and its CATV distributor Optical Networks International stressed after the Conference that a lot of work has indeed been done on the PMD phenomenon. "We were very public about the cases (of PMD) we saw," says ONI President Andy Paff, citing an article authored by AT&T's Ted Darcie in May 1991 (please see "Polarization-induced performance variables," *CED*, May 1991, p.50).

Futro said the industry must come to an agreed-upon standard for core circularity, but said he was not sure what the "right number" would be. CED

By Leslie Ellis and Roger Brown

NewChannels, Time Warner discuss network platforms

NewChannels Corp. has developed, as part of its upgrade of the Syracuse, N.Y. system, a "Network Compatible" topology that cost effectively delivers 750-MHz worth of bandwidth to customers in urban, suburban and rural areas, said Tom Staniec, company engineering director last month at the SCTE Emerging Technologies conference.

Wolfe on T-W's plans

At the same session, Time Warner Cable Group Manager Ron Wolfe provided a glimpse of that MSO's future network architecture, featuring a ring-of-rings design and using digital transmission based on the Synchronous Optical Network (SONET) standard.

The Time-Warner network features signal redundancy at three levels: headend-to-headend, headend-to-hub and hub-to-feeder. The copper feeder plant is designed around a 500-home optical serving area.

The NewChannels "Network Compatible" design features an urban design using a standard fiber-to-feeder design, initially using a 1,200-home optical serving area and designed for an upgrade to a 600-home serving area, Staniec said. The FTF uses five active devices after the optical receiver and is activated at 750 MHz.

Suburban areas use a "flexible Cable Area Network" design with 13 active devices after the receiver and is activated at 550 MHz. The feeder plant, though, is activated at 750 MHz to start with. The copper trunk plant is replaced by optical media when the network is activated at 750 MHz.

Rural areas use a repeatered AM supertrunk design, and although some carrier-to-noise performance is sacrificed, NewChannels can provide 750 MHz service to rural customers as a result, said Staniec.

The Time-Warner "Full Service Communications Network" of the future features an "applications ring" that connects headends, local exchange carrier central offices, long-distance telephone carrier points of presence, video-on-demand and multimedia playback centers, said Wolfe.

Trunking rings

The "trunking ring" interconnects a single cable TV system's headend and hubs. A "distribution ring" connects optical receivers that are part of today's fiber-to-feeder optical trunks. The network presupposes a coaxial cable feeder plant and an optical serving area of 500 homes.

The ring network is designed as a digital network using synchronous optical network (SONET) for high-speed digital transport, Wolfe said. CED

By Gary Kim

IBM, cable could benefit from partnerships

The cable industry and the computer industry should work cooperatively to utilize cable TV's braodband pipes to deliver high-speed full-motion video to businesses and homes, said Dr. Alan Baratz, group director of higher performance computing and communications for IBM's multimedia division. Baratz was a keynote luncheon speaker during the SCTE Conference on Emerging Technologies last month.

Because the cable industry has begun an inevitable evolution into a digital network delivering a wide variety of entertainment and information services, IBM is a perfect partner to help in that process, Baratz suggested. "When it comes to digital, we've been doing digits for decades," he said, including the creation, delivery and storage of digits.

To get its feet wet in cable, IBM is currently field testing its "Planet" project (formerly known as PARIS), a high-speed transmission system, in Rogers Cablesystems cable network in Toronto. The Planet system also offers switching speeds two orders of magnitude faster than conventional digital transmission systems, according to Baratz.

Projects similar to Planet, which employ data transmission speeds of gigabits per second, will be necessary to allow desktop video, personalized desktop video, multimedia, movies on demand and shared movies on demand (where two or more persons can watch the same movie simultaneously), to be employed in the home, Baratz said.

The cable industry is uniquely positioned to bring these services to the home because they offer high bandwidth and high quality pictures. This is in contrast to telco networks, which are highly personalized (switched), but offer low quality video because of low transmission speeds, and satellite links, which offer high quality video, but virtually no interaction between users, Baratz added.

For information providers, the greatest challenge is the development of an adequate storage architecture. Any server will have to be dense (because a one-hour segment of video will require gigabytes of storage space) and will require fast access if thousands of viewers require simultaneous viewing of the same video.

Real-time interactive services will also require changes in consumer electronic hardware and cable set-tops. Convertors will have to be built to a set of open standards so that service providers sending different types of data (bursty packets or real-time, high speed) can be sent without interruption. Likewise, computers will have to undergo some changes, as processors struggle to keep up with the capacity offered by broadband pipes. "Computing, rather than communications, is becoming the bottleneck," Baratz said.

What will it take for the cable industry to evolve from an entertainment medium to one offering multimedia? According to Baratz, user interfaces will have to be improved, linkware (the sharing of software between users) will have to be developed and the distribution channel must be available. All three pieces will have to be effectively integrated, something Baratz believes can be done in six to nine months. CED

By Roger Brown

Continued from page 58

has shown innovation in his appproach to implementing fiber optics while basing his decisions on marketplace realities. Specifically, Staniec has designed and implemented fiber network designs for alternate access, distance learning and to serve rural cable television networks.

The award was given the name "Polaris" because it serves as a symbolic reference for lightwave transmission. The star Polaris, more commonly known as the North Star, is both a navigational standard as well as the brightest star in the night sky.

Staniec, who describes himself as someone who not only looks at things as how they are today, but how to get from today to tomorrow, credits three sources for his cable achievements. One is his ongoing desire to investigate "oddball technologies" by reading the optics and telephony trade publications and absorbing other research sources.

Big consulting firm

But Staniec says his biggest "encyclopedia" of knowledge is a large group of cable people who steer him in the right direction and assist him in learning the nuances of optical technologies. "It's almost like having one hell of a consulting firm," Staniec says of the group, which consists largely of vendors and other operators.

The third element of Staniec's success, he says, is the latitude and direction given to him by his employer, NewChannels Corp. "NewChannels has given me the support, backing and capability to find out the 'hows,'" Staniec explains.

In addition to presenting Staniec with a piece of Steuben crystal entitled "Rising Star," Corning Inc. representatives donated $2,000 to the SCTE to fund fiber educational programs. CED

NewChannels' Director of Engineering Tom Staniec, recipient of the 1993 Polaris Award, displays the "Rising Star".

Ad Index

The path to passive optical networks

Fiber vs. coax? After four years of first-generation fiber technology and the emergence of second-generation technology with its higher power, increased capacity and better signal quality, fiber is a forgone conclusion. Fiber is the correct choice for the cable delivery infrastructure of the future.

The next question is how to put fiber today so that operators—and the cable industry—will be ideally positioned to provide the services of tomorrow. One thing is for certain: the more fiber an operator can afford to install now, the better off the system will be in the future.

In a definitive article published by Cable Television Laboratories Inc. (CableLabs),[1] Stephen Dukes outlines a vision for migration to the network architecture of the future. This architecture is achieved through an evolution from the trunk-and-branch topology of today's plant to one of a seamless, passive network with a hierarchy of fiber hubs, rings and passive optical and coaxial distribution plant all the way to subscribers' homes.

The benefits of a passive optical network are many, especially for those with a hierarchical infrastructure covering large regions. They include the ability to share advanced television and telecommunication resources between operators, distribute multimedia services, perform ad insertion, provide advanced programming guides, and a host of others.

There are many considerations to make in defining how a fiber system installed today might work within this infrastructure as it evolves. Fortunately, hierarchical networks offer the flexibility to accommodate diversity. It is important to note, however, that many of the key benefits to passive optical networks can be realized today if the appropriate steps are taken when implementing a fiber system.

By Israel Levi, Vice President of Sales and Marketing, Harmonic Lightwaves

Benefits of a passive optical network

The first benefit is capacity. Given that the bulk of the cost of installing fiber is construction, it makes sense to put in as many fibers as as deep into the network as can be cost-justified when building or upgrading plant. It is important to realize that with the nearly limitless bandwidth provided by fiber, it is entirely feasible that a passive optical network an operator puts in now can be functional for the next 100 years.

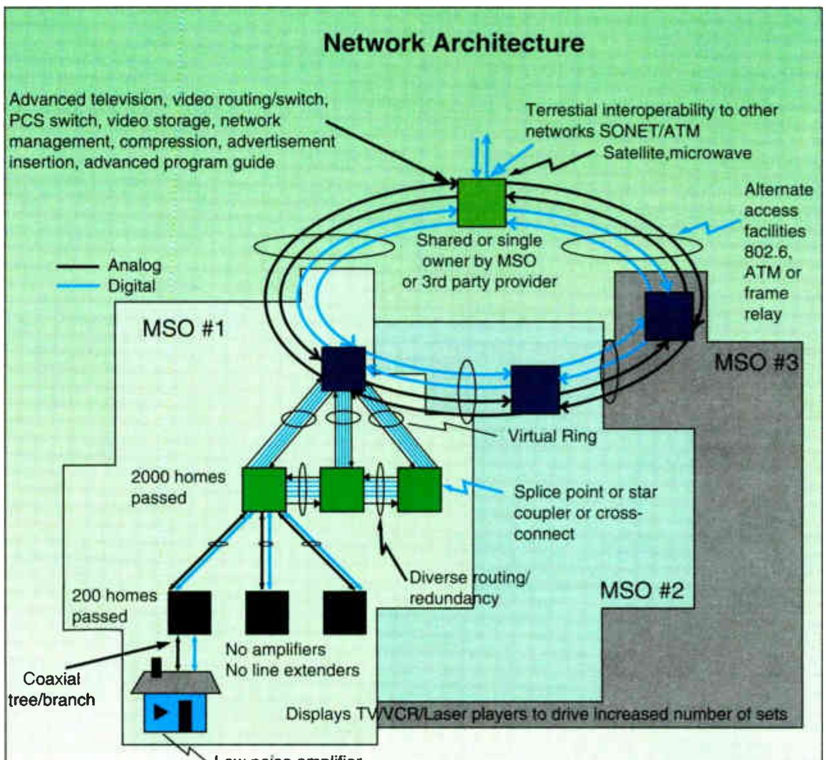
The second benefit is reach. Again relating to construction costs, it makes sense to implement fiber as deeply as possible into the plant. This assures a smooth path to a passive optical network as technology evolves to enable it. The successful cable systems of the future will be the ones that can place the most bandwidth as close to the subscriber as possible.

A third benefit is network simplification. By eliminating as many active devices as possible when planning a fiber upgrade or rebuild, operators can count on avoiding the bulk of the costs—ranging from powering to maintenance—associated with active coaxial plant.

Another benefit is architectural flexibility. With the advent of second-generation optical transmission technology, operators have significantly more flexibility in configuring network architectures.

New products such as solid-state lasers and external modulation technologies offer significant increases in networking flexibility compared to first generation systems.[2]

A hierarchical network vision was developed to take advantage of the passive optical network with the purpose of increasing network functionality, performance and reliability while reducing operating costs. The intent is to provide an operating platform where it takes far less time to deploy new technology and introduce new services, where capital investment is spread across a wider base of operators, and to enable interoperability with other networks.[3]



The passive optical network as outlined by Cable Television Laboratories. Illustration used by permission of CableLabs.

Transmission technology

Optical transmission technology is critical to realizing these benefits. In order to smoothly evolve to the capabilities of a passive optical network, operators must make some careful considerations regarding equipment purchases made today.

One of the most important considerations is optical power. Whether the objective is to achieve extremely long links between optical hubs, or handle the extensive signal splitting required to serve small pockets of homes in a distribution area, the output power of the transmitter will be the primary concern.

As first generation fiber technology nears its practical power limits, it becomes less likely to be suitable for applications beyond dedicated links in a local distribution network. Second generation technology already has the power to consolidate headends or economically reach serving areas as small as several homes with a high-quality signal.

A second consideration is capacity per fiber. For operators to receive the most return on their investment in a fiber build, it is essential that the transmission system be capable of carrying a minimum of 80 analog channels (550 MHz).

Of course, as digital compression technology emerges, and as the demand for carrying digital multimedia services evolves, it will be increasingly important to have additional capacity above 550 MHz available in the transmission system. This has implications for signal noise as well as the linearity of the modulation system employed by the transmitter.

Another important consideration is laser construction. To be workable in the real world, a passive optical network should be connectorized. If the laser source used by the network's transmitter is not optically isolated, back reflections caused by open connectors can cause unfavorable signal degradation.

Migrating to a passive optical network

There are many opinions on how the cable industry can evolve to a passive optical network, however, it is evident that the vision outlined by CableLabs will be able to accommodate the largest degree of diversity.

Significantly, this perspective looks far beyond the single system, toward a hierarchical infrastructure that helps different operators work together for the benefits of their own business as well that of the cable industry as a whole.

In essence, this migration as motivated by the need to provide a more uniform service offering for large and small cable operators, share functionality, minimize operating costs and improve signal quality and reliability. The first step in this migration is underway, with headends being interconnected to form virtual rings within one or several cable franchise areas. Also, a significant number of headend consolidations are underway.

The next step in this migration will undoubtedly be the interconnection of these super headends via route-diverse fiber rings, turning each into a regional hub capable of providing a wide range of advanced services to the area that it serves.

Near term, these rings will be analog, but will certainly incorporate digital signals that either overlay the analog on the same fiber, or are carried on separate fibers. At this stage, the cable network will take on many of the characteristics of the telephony network, and will offer many of its advantages in terms of high network availability, full two-way capabilities, and automated network management. Additionally, these hubs will be the internetwork bridge to the telephony network, bringing a wealth of competitive advantage to the cable industry. CED

Conclusion

With compression, PCNs, multimedia, two-way interactive video, ad insertion, program guides, regulatory issues . . . all of the nearly endless issues in front of cable operators today, it is not difficult to conclude that now is the time is to focus on the service delivery infrastructure.

By putting in as much fiber as feasible, and installing advanced fiber transmission technology, the right first steps will be made toward a passive optical network with maximum capacity, quality and reliability.

There will be many radical advancements in digital technology yet to come—and many changes in the business environment. A passive optical network offers a number of advantages, but perhaps the best is that it will help the cable industry be prepared for practically any eventuality.

References

1. Stephen Dukes, "Photonics for cable television system design," *Communications Engineering and Design*; May 1992, p.34.

2. Dr. Moshe Nazarathy, et al; "Predistortion linearization," *Communications Engineering and Design*, March 1992, p.60.

3. Stephen Dukes, "Photonics for cable television system design," *Communications Engineering and Design*; May 1992, p.36.

RETURN PATH

System outages

The good news is that cable operators know they have a problem with outages. The bad news is that the problems aren't going away.

According to a Return Path survey printed in the November 1992 issue, cable operators suffer an average of 11 outages per month (most respondents said an "outage" is a loss of two or more signals to two or more customers). One operator even said he had as many as 45 outages per month. No wonder cable networks are perceived by the public as unreliable.

The most common causes of outages are, in descending order, power failures, cut cables, power surges/blown fuses. electronic failures and poor network design/maintenance.

Eighty-four percent of those responding said their systems have taken steps to reduce outages, including installation of surge protection devices, standby power supplies, improved preventive maintenance and fiber optics. But even more revealing was the fact that every single person responding said their systems could do even more.

For example, only 5 percent said their systems currently use status monitoring, but nearly half said their systems were contemplating the wisdom of purchasing such technology.

Few systems fault the local power company for their woes, however. Sixty-three percent say the local power utility is generally reliable and nearly half of all respondents say they have worked with the power company to reduce outages.

Finally, more than half of those answering said they were familiar with CableLabs' efforts to reduce outages, but most are taking a wait-and-see attitude about following CableLabs' recommendations.

Answers are shown in percentages		Yes	No	Don't know
1. Would your system term a loss of signal for five minutes or less an "outage"?		89	11	–
2. If not, what is the definition of an "outage" at your system? (Define)				
3. How many outages would you guess your system typically suffers in a month's time?	**Avg-11**			
	High-45			
	Low-<1			
4. Has your system taken steps to reduce the number of outages it experiences?		84	16	–
5. If so, what steps has it taken? (Answers listed in order of frequency): Surge protection, standby power, preventive maintenance, addition of fiber optics, more test equipment, grounding and bonding.				
6. Do you think your system could do more to reduce outages?		100	–	–
7. Does your system currently use status monitoring devices?		5	95	–
8. If not, has your system considered purchasing equipment to monitor the outside plant?		42	42	5
9. What is the source of most of your system's outages? (Answers listed in order of frequency): Power failures, cut cables, power surges, electronic failures, poor network design/maintenance.				
10. Does your system use devices to protect current and voltages?		79	16	5
11. Has your system performed surveys to determine subscriber attitudes about outages?		53	47	–
12. Does your system adequately track the location and cause of outages?		58	37	5
13. Has your system worked with the local power company to reduce outages?		47	47	5
14. Would you consider your local power company to be reliable?		63	32	5
15. Are you familiar with CableLabs' Outage Reduction Task Force?		58	42	–
16. Do you plan to follow CableLabs' recommendations to reduce outages?		26	–	63

The CABLE POLL

Midwest CATV • CED • Cablevision

The @#!%# thing broke—now what?

"If it ain't broke, don't fix it"—or at least, that's how the saying goes. But what if it *is* broke? That was the subject of a recent Cable Poll survey, in which 200 cable system general managers were questioned about equipment repair practices. In a nutshell, the findings are as follows:

• Most operators (64 percent) leave equipment repair to the experts, farming out projects to repair facilities when necessary.

• If it needs to be replaced, it's being replaced, and not repaired. To a large degree (69 percent), capital shortages have not caused ops to repair equipment that would normally be replaced.

• A quarter of the GMs polled use reconditioned equipment, and a shade more than a quarter (26 percent) do not. One-third (33 percent) don't use reconditioned equipment at all.

• Two-thirds of those polled replace remote control transmitters for set-top convertors, instead of having them repaired. Generally, they purchase the same type of remote control that was originally supplied with the set-top device (at 54 percent)—although 43 percent ultimately opt for different remote control units, mostly because of price. Indeed, 33 percent of the GMs polled say the most important factor when purchasing remote control units is price.

But that's not to say that no cable equipment is repaired in-house. The Poll found that signal acquisition gear and headend products top the list, at 36 percent, of items that get fixed on-site. Signal distribution equipment/physical plant products and subscriber/drop equipment were equally split (27 percent each) to make up just over one-half of the GM's in-house equipment repair functions.

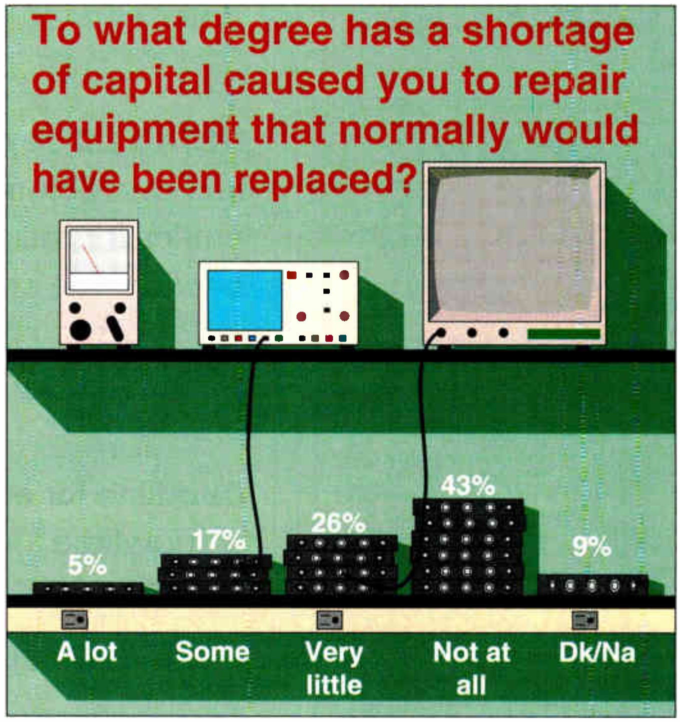
Most of the GMs (52 percent) submit that although they have the capability to repair equipment on the premises, they don't have what they'd call a full-service center.

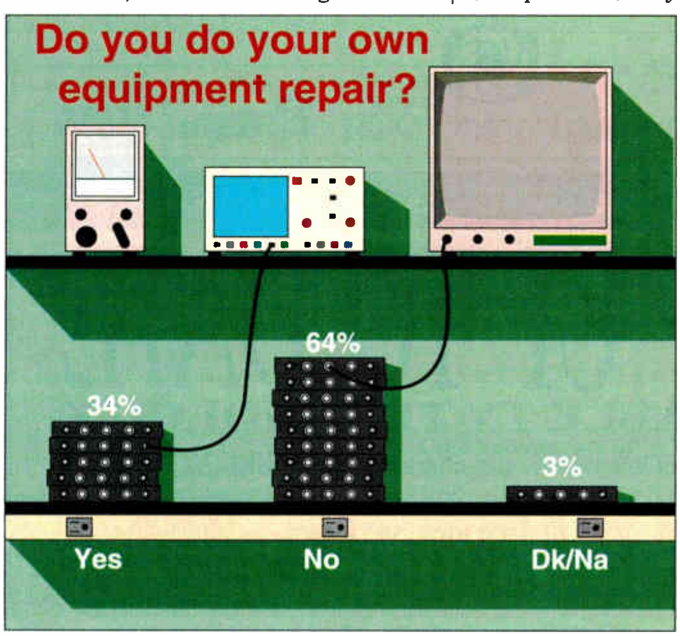
How much of an operator's budget is allocated for equipment repair? Predictably, the answers vary. Most (36 percent) say they allocate less than five percent for repair expenses. Almost the same amount, at 31 percent, say they don't know.

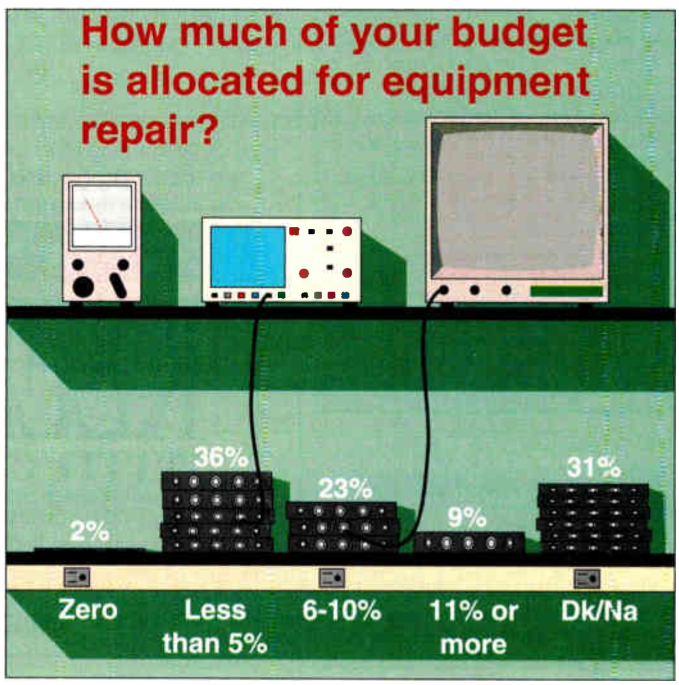
Nine percent say they set aside 11 percent or more for repairs, while 23 percent say they allocate between six and 10 percent for equipment repair.

Two percent say they don't allocate any money for broken equipment . . . which sounds to us like an easy target for the omnipresent "Murphy." CED

By Leslie Ellis







New products

Mechanical optical splice

Advanced Custom Applications has announced its new Ultrasplice, which it submits is a low-cost mechanical fiber optic device which utilizes a glass capillary alignment member preloaded with index matching gel. Molded-in springs hold the buffer during installation and/or tuning, which eliminates the need for extra tools, officials say. To permanently secure the fibers, users would twist an end cap to lock the internal fixtures onto the buffer—similar to using a pin vise. The ultrasplice is available for both singlemode and multimode fibers, and is re-usable. Splice loss, officials say, is less than 0.2 dB; return loss (back reflections) is roughly -50 dB. For more information, call ACA officials at (908) 281-0353.

Cable expanding tool

Ripley's Cable Expanding Tool Kit

New from the **Cablematic Division** of **Ripley Co.** is its CXT cable expanding tool kit, developed to simplify changeovers to different connector types. The kit includes a "T"-type handle and six interchangeable inserts sized from 0.412- to 1.0-inches. Use of the proper tool, officials say, assures a proper inside diameter for hardline cable.

A carrying case is included so that the inserts and handle are kept together for use on-site or otherwise. For more information or pricing, call (800) 528-8665 or fax inquiries to (203) 635-3631.

FDDI tester

Fotec's new LCT100 link confidence tester

Fotec Inc. has introduced an enhanced version of its LCT100 FDDI link confidence tester, designed to test singlemode FDDI networks. The unit performs link tests and helps in installing networks, where it diagnoses problems of initial connections to the network. Also, Fotec officials say, the fact that the device is priced at about one-tenth of that of a network analyzer doesn't hurt—it sells for $5,900. For more information, call Bill Piercy at (800) 537-8254.

Fiber storage vaults

New from **Moore Diversified Products** is its MOV-1 and MOV-2 buried fiber optic cable storage vaults, designed to serve as slack storage chambers or cable pull boxes for below-grade installations. Constructed of high density polyethylene, the units can support H-20 live loads and up to 400 feet of cable. Further, officials say, technicians can work safely inside without violating OSHA underground work standards. For more information, call Moore officials at (800) 769-1441 or fax inquiries to (606) 299-6653.

LAN-grade fiber cables

New from **Optical Cable Corp.** is its FDDI commercial grade fiber optic cable products, designed for local area network applications. B-series breakout and D-series distribution versions are available and are manufactured with a PVC outer jacket—which means the cables can be used both indoors and outside. Both versions of the new fiber can be manufactured with from two to 156 fibers, and officials say prices start at roughly 20 percent less than "premium" grade fiber optic cable products. For more information, call Optical Cable Corp. at (703) 265-0690 or fax inquiries to (703) 265-0724.

Off-site addressability

New from **PageTap Inc.** is an off-site addressability system designed for apartment complex applications. The system, also called PageTap, enables operators to use an IBM or compatible personal computer to conduct real-time hook-ups or disconnects with full accounting capability. Company officials say the system can be retro-fitted into any existing trap-tiered systems without adding power supplies or headend equipment. A total of eight tiers and 32 ports are available. For more information, call (800) 735-3650 or fax inquiries to (303) 337-3084.

Low cost laser source

Siecor Corp. has introduced a new hand-held singlemode laser source, called the OS-210. It offers an output power of more than -8dBm for 48 hours, on four AA alkaline batteries (an AC adapter is also provided). The laser source can be paired with a power meter to perform end-to-end attenuation testing in the CW mode. Or, a 2 kHz mode can be used in conjunction with fiber identifiers. The units operate at the 1310nm or 1310/1550nm wavelength windows.

Siecor's low-cost OS-210 laser source

For more information, call Siecor at (704) 327-5000.

Modulator for smaller ops

Standard Communications has announced its new TVM450L CATV frequency agile modulator, which company officials say is priced to attract smaller distribution system operators.

PLL tuning in the new device ensures FCC stability requirements, Standard officials say. Other features include six levels of filtering, enhanced mixing techniques and high quality low noise am-

Duly noted

To the Editor:

I note with concern the diagram references in the article I authored entitled "DFBs are laser of choice," (*CED*, September 1992, p.48). Following are the correct references:

- Table 1, in the second paragraph, should be Figure 3.
- The last sentence of the fourth paragraph should read, "A typical performance chart for both types of systems can be found in Figure 2."
- In the third paragraph under **Cost issues**, the Table 2 reference should be Figure 4.
- In the last paragraph under **Cost issues**, the Table 2 reference should be Figure 4.

I have had several readers express confusion over these incorrect references and would appreciate your cooperation in communicating the proper information.

Thank you.

J. Timothy Mooney
Senior Sales Engineer
C-Cor Electronics, Inc.

Standard's new TVM 450L modulator

plifiers to provide improved spurious response and broadband noise performance. The unit includes factory-calibrated front panel controls with full metering. Both visual and aural IF loop-throughs are included for compatibility with all scrambling formats.

Also new from Standard is its Agile IRD-I, an agile IRD modelled after the company's existing IRD-II integrated receiver and VideoCipher II Plus descrambler—but priced such that it is affordable to smaller CATV system operators.

The IRD-I features 100 kHz PLL synthesized tuning, dual converted 70 MHz final IF and other features including a

Standard's new Agile IRD-I is a scaled-down version of its IRD-II

signal quality alarm, active loop-through and +20 VDC LNBC power output.

The new IRD takes up one rack unit of space, which represents a space savings of 50 percent. Further, several functions can be performed without service interruption—such as changing the batteries, sliding in the VC-II Plus into the rear panel or monitoring at the 70 MHz test point.

Both the TVM450L and the Agile IRD-I are backed by a seven-year guarantee and a lifetime loaner program. For more information, call Standard at (800) 745-2445 or fax inquiries to (800) 722-2329.

Voice-activated remote control

Voice Powered Technology's new universal remote could change all those VCRs blinking "12:00"

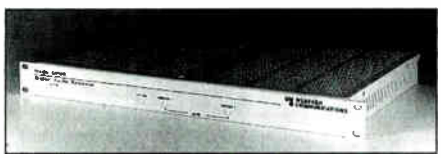
New from **Voice Powered Technology Inc.** is a hand-held, universal remote control that executes VCR timing commands by human voice. The device, called the VCR Voice Programmer, works with "virtually every" VCR, television and cable convertor, officials say, and performs play, rewind, pause, stop and fast-forward commands. It also changes TV channels by voice or performs volume adjustments with one-button touch.

The remote can program 15 separate "events", regardless of the former capability of the VCR. Further, a single programmer can control two video systems—or two combinations of VCRs, TV sets and convertors. It can learn up to four voices, which can be confirmed via an LCD display.

The remote is priced at $169 and is available directly from the manufacturer. For more information, call (800) 788-0800.

Digital SCPC line

Wegener Communications has announced production of a new product line of single channel per carrier (SCPC) products which use MPEG-II compression technology. Among the first of the new products is Wegener's Model DR96



Wegener's DR96 digital audio receiver

Digital Audio Receiver, which derives mono or stereo audio channels from a digital data stream. Here's how it works: When the DR96 receives an MPEG-II compressed data channel, it uses its demodulation, error correction and MPEG decoding algorithm to restore the audio to high quality mono or stereo.

Also new from Wegener is its 1834 digital audio subcarrier, designed for use with the company's existing series 1800 FM^2 subcarrier receiver. It uses MPEG compression technology to give users the choice between a single stereo channel or two mono channels, yielding near CD-quality audio reception via a single subcarrier 128 kilobit data channel.

For more information, call Wegener officials at (404) 623-0096 or fax inquiries to (404) 623-0698.

Deals

Technology exchange agreement

Advanced Micro Devices, the fifth-largest U.S. manufacturer of integrated circuits, and **C-Cube Microsystems** have announced an alliance that will "ring digital video compression technology to mass markets including multimedia for PCs, office applications, consumer electronics and digital TV broadcasting.

In the agreement, AMD will design, manufacture and market integrated circuits that combine C-Cube's MPEG, JPEG and Px64 compression technology. In turn, C-Cube will be licensed to use "certain AMD intellectual property" to produce products. The agreement also provides for AMD to make an equity investment in C-Cube.

Cox Cleveland rebuilding to 750 MHz

Cox Cable will rebuild 750 miles of its Cleveland, Ohio area cable system from a current capacity of 330 MHz to 750 MHz, **Jerrold** officials have announced. In the rebuild, which will affect the southwest suburbs of the system, Cox will use Jerrold Starline SX power-doubling amplifiers, mini-bridgers and 1-GHz taps.

C-Tec upgrades convertors

C-Tec Cable Systems of Somerville, N.J. will replace outdated convertors in its N.J. and N.Y. systems with Jerrold's CFT-2000 addressable devices, **Jerrold Communications** has announced. The franchises, located in the "affluent suburbs" around New York City, have one of the highest per-subscriber incomes in the industry, Jerrold officials say. C-Tec provides 56 channels of programming.

Corning to provide couplers

Corning Inc. has announced it has been chosen by telecommunications supplier **Siemens** to provide the optical couplers for its installation of "thousands of telephone cable television lines" in the eastern states of Germany. Siemen's contract calls for 68,000 lines, to be installed this year using a fiber-in-the-loop architecture as part of the Deutsche Telekom OPAL 93 project.

DMX service moving to Satcom C-3

Digital Music Express (DMX) has announced the signing of an agreement with **GE American Communications** to join the Satcom C-3 cable satellite. Currently located on Satcom 4R, DMX will move to Satcom C-3, transponder 24, early this year. Satcom C-3 is one of two new-generation satellites dedicated to cable industry programming. CED

Compiled by Leslie Ellis

The following companies have paid a fee to have their listing appear in the Fiber callbook.

Adaptors

STORM™
PRODUCTS CO. ■ DESIGN & MANUFACTURING ■

Storm Products,Advanced Technology Group ....**(708) 323-9121**
WATS ....**(800) 247-8676**
FAX.......................................**(708) 323-9121**
116 Shore Drive
Hinsdale Industrial Park
Hinsdale, IL 60521
PERSONNEL: Mark Kotilinek, Manufacturing Manager; Brian Holland, Sales Manager
DESCRIPTION: Storm's Adaptors are available in single and multimode with any combination of connectors: Biconic, FC, D4, ST, Mini BNC, SMA, FDDI and SC. (PC polish upon request.) SERIES 62 Adaptors allow quick termination with insertion loss less than 1dB and return loss of -42dB typically. SERIES 68 Hybrid Adaptors - female to female receptacle adaptors provide precision ferrule alignment between different connectors. Available in various flange styles and receptacle combinations: ST_RSC, FC-SC, FC-ST, ST_RSMA 905, ST_R-SMA 906, FC-SMA 906. SERIES 71 Short Length Adaptors (1.3"). Protect the ports of expensive equipment. Multimode adaptors exhibit insertion loss of less than 1dB. Singlemode adaptors have an insertion loss of less than .5dB and return loss of -42dB typically. OTHER PRODUCTS: Low Back Reflection Attenuators, Fiber Optic Line Simulator, Pulse Suppressor. Custom assemblies built to specification. Engineering, design and manufacturing to specifications.

Attenuated Products

STORM™
PRODUCTS CO. ■ DESIGN & MANUFACTURING ■

Storm Products, Advanced Technology Group ....**(708) 323-9121**
WATS ....**(800) 247-8676**
FAX.......................................**(708) 323-9121**
116 Shore Drive
Hinsdale Industrial Park
Hinsdale, IL 60521
PERSONNEL: Mark Kotilinek, Manufacturing Manager; Brian Holland, Sales Manager
DESCRIPTION: Storm's low back reflection, PC polished, multimode and singlemode attenuators are available in a wide variety of connector combinations and fiber types. SERIES 62 fixed in-line attenuated adaptors and cable assemblies exhibit a return loss of -42dB typically, and are available from 2dB to 20dB with a tolerance of ±1dB for 10dB and ±2dB for 20dB. SERIES 72 single mode attenuators utilize a proprietary filter method of attenuation exhibiting a minimum return loss of -35dB. The short 1.3" body is stable through 250 mating, displays a polarization dependent loss (PDL) of ≈.04 and will work equally well with standard as well as dispersion shifted fiber. They are ideal for balancing line power, preventing detector overdrive, test equipment and laboratory applications. Standard attenuation levels 5dB, 10dB, 15dB, and 20dB. OTHER PRODUCTS: adaptors, fiber optic line simulator, pulse suppressor. Custom assemblies built to specification. Engineering, design and manufacturing to specifications.

Cable

ARNCO

ARNCO Corp.......................**(216) 322-1000**
WATS ....**(800) 321-7914**
FAX.......................................**(216) 323-7111**
860 Garden St.
Elyria, OH 44035
PERSONNEL: Robert F. Smith, President
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.

COOPER
Belden

Belden Division ....**(800) 235-3362**
FAX.......................................**(317) 983-5609**
2200 US Highway 27 South
Richmond, IN 47375
PERSONNEL: Jim Hughes, National CATV Sales Manager; Craig Snyder, Product Manager; Doris Nichols, CATV Sales Administrator
DESCRIPTION: Belden offers a complete line of armored and all dielectric fiber optic trunk cable. Belden's fiber optic line includes a full range of fiber counts in a multi-fiber per tube design for cable television applications.

Comm/Scope, Inc.
THE Fiber Cable in Cable TV.

Comm/Scope.....................**(704) 324-2200**
WATS (National)..................**(800) 982-1708**
FAX.......................................**(704) 327-7878**
1375 Lenoir-Rhyne Blvd.
PO Box 1729
Hickory, NC 28602
PERSONNEL: Lynn Sigmon, John Chamberlain, K. Charles Mogray
DESCRIPTION: Supplier of Optical Reach® fiber optic cables designed especially for AM video transmission and the CATV industry. Optical Reach is available in a variety of constructions and fiber counts from 1 to 144.

SIECOR

Siecor Corporation.............**(704) 327-5895**
FAX.......................................**(704) 327-5488**
PO Box 489
Hickory, NC 28603-0489
PERSONNEL: J. David Johnson (704) 327-5895; Pattie M. Wolford, (704) 327-5109
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.

Cable Assemblies

Radiant Communications Corporation

Radiant Communications Corporation.........................**(908) 757-7444**
WATS ....**(800) 969-3427**
FAX.......................................**(908) 757-8666**
PO Box 867
South Plainfield, NJ 07080
PERSONNEL: Mike Thaw, President; Gary Mikula, General Manager
DESCRIPTION: Radiant manufacturers the industry's most reliable Fiber Optic Cable Assemblies; including APC and Super PC Singlemode Assemblies with low backreflection. Also manufactures a line of Fiber Optic Splice and Patch Centers, Attenuator Products, and Multimode Video and Data systems.

Storm Products, Advanced Technology Group ....(708) 323-9121
WATS ....(800) 247-8676
FAX.......................................(708) 323-9121
116 Shore Drive
Hinsdale Industrial Park
Hinsdale, IL 60521
PERSONNEL: Mark Kotilinek, Manufacturing Manager; Brian Holland, Sales Manager
DESCRIPTION: For your specific application needs Storm Products offers single channel, multichannel, multifiber, crush resistant, and semi-rigid cable assemblies. All assemblies are 100% optically tested and available in any quantity. Super PC and PC Cable Assemblies are available with SC, FC, ST, D4, SMA, MINI BNC and Biconic terminations. Multi-fiber cables/assemblies are available buffered or unbuffered. Up to 50 fibers can be bundeled in one small diameter rugged loose tube cable. Breakouts of simplex or multiple channel jacketed cables can be terminated or unterminated. Semi-Rigid assemblies are optimum for situations where extreme optical stability is necessary for maintaining uniform power levels because they minimize variations in optical output which occur when polarization dependant losses are induced by motion, and can be manufactured into 90 degree angle terminations or other custom configurations. Available in a variety of connector combinations. OTHER PRODUCTS: Low Back Reflection Attenuators, Fiber Optic Line Simulator, Pulse Suppressor. Custom assemblies built to specification. Engineering, design and manufacturing to specifications.

CAD

Mapping Technologies, Inc. (MTI).............................(301) 309-3810
FAX.......................................(301) 309-3815
9430 Key West Ave., Suite 210
Rockville, MD 20850
PERSONNEL: Heidi L. Sorg, Marketing Representative; Kent Garvis, Manager CATV Division
DESCRIPTION: MTI combines experience in the CATV industry with advanced technology in digital mapping to provide comprehensive services in CATV Field Engineering, Digitizing of Existing Maps, Conversion to any Standard Format, Complete Design Services, Digital Terrain Mapping (DTM) and Propagation Studies for PCNs. Most advanced CATV Mapping Services in the U.S.

Contractors

Cable Services Co., Inc......(800) 326-9444
FAX.......................................(717) 322-5373
2113 Marydale Ave.
Williamsport, PA 17701
PERSONNEL: John M. Roskowski, President; Neal W. Kimberling, V.P.-Turnkey Accounts
DESCRIPTION: Full service fiber optic and coaxial turnkey construction, built to order to the customer's specifications. Services include strand walking, manual and CAD design, equipment supply, fiber and coaxial splicing, aerial and underground construction and full engineering services.

Cablemasters Corp............(800) 242-2522
FAX.......................................(814) 838-8713
5663 Swanville Rd.
Erie, PA 16506
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.

Kennedy Cable Construction, Inc. ....(912) 557-4751
WATS ....(800) 673-7322
FAX.......................................(912) 557-6545
Hwy. 280 W
PO Box 760
Reidsville, GA 30453
PERSONNEL: Roger Kennedy Jr., President; Deno Jones, Operations Manager
DESCRIPTION: Aerial and underground line construction of CATV, LANs, telecommunications and fiber optic systems. Splicing, upgrades, rebuild, new extensions of system, balance, sweep and proof system. Over 20 years of experience.

NaCom................................(800) 669-8765
1900 E. Dublin-Granville Rd.
Suite 100A
Columbus, OH 43229
PERSONNEL: Larry Linhart, President; Joe Govern, Vice President Operations; Randy Carpenter, Sales Director; Bob Pierce, Engineering Director
DESCRIPTION: Full service communications contractor specializing in the following fiber services:
Fiber pre-testing, end-to-end testing
Fiber to feeder design/drafting
Fiber route engineering
Fiber construction
Fiber activation
Fiber splicing.

Schenk Construction..........(206) 668-1300
FAX.......................................(206) 668-1400
8602 Maltby Rd.
PO Box 1530
Woodinville, WA 98072
PERSONNEL: Edward A. Schenck, President; Bud Longnecker, VP/Aerial; Imel L. Wheat, Jr., VP/Underground
DESCRIPTION: Aerial and underground cable TV construction; turnkey, fiber optic construction.

TCS Cable, Inc. ....(813) 789-6826
WATS ....(800) 999-8270
FAX.......................................(813) 787-5077
PO Box 909
Palm Harbor, FL 34682
PERSONNEL: Bobby J. Payne, Chairman; Scott A. Stevens, President
DESCRIPTION: Full-service telecommunications contracting company, including as-builts, upgrades, rebuild/new build construction (aerial and underground), fiber optic cable installation, fusion splicing and testing, subscriber installations, existing cable (system) engineering evaluations, FCC compliance testing, complete sweep/repair services, on-line project management.

Couplers

Gould ....(410) 787-8300
Fiber Optics Division
WATS ....(800)-544-6853
FAX ....(410) 787-2831
6740 Baymeadow Dr.
Glen Burnie, MD 21060
PERSONNEL: Jeff Bugenhagen, Eastern Region Sales Engineer; Craig Whitson, product manager
DESCRIPTION: Gould offers a complete line of high performance, highly reliable passive fiber optic components including wavelength independent splitters and couplers in the 1300nm to 1550nm wavelength range, singlemode and multimode couplers, singlemode and multimode WDMs, singlemode trees and stars, optical isolators, and FC and SC connectors. Devices are available with specialty fibers, custom packaging and connectorization.

Dist./Suppliers/Reps

Cable Services Co., Inc. .....(800) 326-9444
FAX ....(717) 322-5373
2113 Marydale Ave.
Williamsport, PA 17701
PERSONNEL: Gene Welliver, Vice President
DESCRIPTION: A full service stocking distributor of all major manufacturers. Full line of fiber optic and coaxial products servicing the CATV industry.

FIBERTRON CORP. ....(714) 871-3344
FAX ....(714) 871-5616
1405 E. Orangethorpe Ave.
Fullerton, CA 92631
PERSONNEL:
Marlene Spiegel, President
Henry Cohen, Vice President
Marc Spiegel, Vice President Sales/Mktg.
REGIONAL OFFICES:
East Hanover, NJ (201) 515-9200
FAX ....(201) 515-9269
Norcross, GA ....(404) 409-1700
FAX ....(404) 409-1702
DESCRIPTION:
A full service stocking distributor of fiber optic cable, cable assemblies, connectors, couplers, closures, distribution equipment, innerduct, modems, multiplexers, splices, test equipment, tools, tool kits, outlets, and supplies. Value-added services include: standard and custom cable assemblies, applications assistance, and customer training.

Jerry Conn Assoc., Inc.
WATS (National) ....(800) 233-7600
WATS (in PA) ....(800) 692-7370
FAX ....(717) 263-1547
Corporate Office:
130 Industrial Dr.
PO Box 444
Chambersburg, PA 17201-0444
Satellite offices: Bob Sollenberger, 6177 55th Terrace East, Bradenton, FL 34203, (813) 739-1856, FAX (813) 753-5127; Bob Glass, 1380 Greenwood Rd., Lincolnton, NC 28092, (704) 732-7637, FAX (704) 732-9595
PERSONNEL: Trav Neumann, Director of Sales and Marketing; Dave Showalter, Vice President/General Manager
DESCRIPTION: Jerry Conn Associates, Inc. is an East coast-based manufacturers' representative and distributor. Among the wide array of CATV products available is Fitel General's fiber optic cable, Tektronix test equipment, Moore Diversified's new OptiRACK, LRC connectors, and Fiberlign microfusion splicer. Our sales efforts are directed to application selling and providing first class customer service through a combination of outside and inside sales teams.

Power & Telephone
Supply Co. ....(901) 324-6116
FAX ....(901) 320-3082
2701 Union Extended, Ste. 300
Memphis, TN 38112
PERSONNEL: Michael Phillips, Customer Service Supervisor; Larry Landaal, CATV Specialist
DESCRIPTION: Wholesale distributor of fiber optic cable and related products for complete optical communications systems. Major lines represented: Sumitomo, AT&T, Siecor, Alcatel, Northern Telecom, Laser Precision, Chromatic Technologies.

Enclosures

Cable Security ....(205) 742-0050
WATS (National) ....(800) 288-1506
FAX ....(205) 742-0058
801 Fox Trail
PO Box 2796
Opelika, AL 36803-2796
PERSONNEL: Mike W. Springer, Vice President of Sales; John Demos, National/International Accounts.
REGIONAL SALES OFFICES: Northeast: Richard Simile (302) 832-1190; Midwest: Don Imbody (513) 878-9300; Southeast: Ernie Cope (800) 288-1506; West Coast: Matt Arnoldus (805) 379-0034.
DESCRIPTION: The industry's number one manufacturer of high security, low maintenance apartment boxes and custom CATV enclosures. Our Beast™ lines of boxes will climinate theft of service and the additional liabilities that illegal hookups create. Theft of service through cheap apartment boxes is a billion dollar problem. Don't sell your system short—invest in the best—The Beast™.

Champion Products ....(417) 736-2135
FAX ....(417) 736-2662
Route 1, Box 422
Strafford, MO 65757
PERSONNEL: Peggy Lane, Customer Support; Carl Tiedt, VP Operations
DESCRIPTION: Products for OSP buried distribution and building entrance. Products include steel pedestals, apartment boxes, stakes, signs, and miscellaneous hardware. A complete line of fiber distribution products are also available as well as custom design and fabrication of products to meet specific customer needs.

Hennessy Products ....(800) 950-7146
FAX ....(717) 264-1634
910 Progress Rd.
PO Box 509
Chambersburg, PA 17201
PERSONNEL: Bruce Ritchey, VP Sales; Patrick J. Hennessy, Director of Sales
DESCRIPTION: Hennessy designs and manufactures quality aluminum and stainless outdoor enclosures/cabinets ideal

for fiber equipment such as nodes, lasers, repeaters, amplifiers and other electronic equipment that requires protection. Wide range of sizes available. Options include: air conditioning, insulation, heaters, receptacles, breakers, lights, etc. Equipment can be 19" or 23" rack, shelf, panel or custom mounted. Catalog, application photos and product demo available.

RELIANCE COMM/TEC

Reliance Comm/Tec
Reliable Electric Co. Div. ....(708) 455-8010
FAX......................................(708) 451-5516
11333 Addison St.
Franklin Park, IL 60131
PERSONNEL: Tom Coyne, Product Manager, CATV Products; Paul Zoba, Product Manager, Fiber Optics
DESCRIPTION: Reliance Comm/Tec, a manufacturer of CATV products for three decades, offers the industry's widest range of high quality, high performance outdoor enclosures for CATV/Fiber optic equipment such as nodes, lasers, repeaters, amplifiers, and other electronic equipment requiring protection. Enclosures are available in both plastic and metal versions. Additionally, the Access 360 degree pedestals permit complete access to internal components.

Fusion Splicers

ORIONICS
AURORA INSTRUMENTS, INC.

Aurora Instruments, Inc......(215) 646-4636
FAX......................................(215) 646-4721
Dublin Hall, Ste. 402
1777 Sentry Parkway West
Blue Bell, PA 19422
PERSONNEL: Laurence N. Wesson, President; Nellie L. Cabato, Vice President; Sean O'Neill, Sales Manager
DESCRIPTION: In just 40 seconds, the FW-310 automatically aligns, gaps, cleans and fuses prepared fibers. Splice losses of 0.028 dB are typical, with losses of 0.0 dB quite common. The FW-310 has the capability to store twenty fiber profiles. Factory set profiles are designed to accommodate commonly used single mode, multi-mode and depressed cladding fibers. The menu-driven process assists the operator in selecting the desired splicing mode and correct fiber profile. Three splicing modes are available—automatic, manual, and edit. A proprietary pigtail port allows the operator to splice both single mode and multi-mode pigtails efficiently and easily.

Networks

Harmonic Lightwaves

Harmonic Lightwaves ....(408) 970-9880
FAX......................................(408) 492-0766
3005 Bunker Hill Lane
Santa Clara, CA 95054
PERSONNEL: Paul Schaller, VP Sales & Marketing
DESCRIPTION: Harmonic Lightwaves designs and manufactures fiber optic transmission systems for CATV and telecommunications applications. The systems consist of transmitters, receivers and optional status monitoring. The products are based on proprietary technologies including Nd: YAG lasers, Lithium Niobate electro-optical modulators and broadband predistortion linearization.

PHILIPS

Philips Broadband
Networks ....(800) 445-5171
WATS (State)........................(800) 822-7464
FAX......................................(315) 682-9006
100 Fairgrounds Drive
Manlius, NY 13104
PERSONNEL: John Caezza, Product Manager, Larry Brown, Product Manager; Al Kernes, Vice President Sales
DESCRIPTION: A leader in the manufacture of MagnaHub AM fiber optics systems, including optical mainstations, compact optical receivers, DFB and externally modulated transmitters; complementary network RF amplifiers optimized for FTF architectures; and MagnaReach FM video long distance fiber optics systems.

Raynet

Raynet Corp.........................(415) 324-6400
Brussels...........................011-32-16-271700
FAX......................................(415) 324-6666
155 Constitution Dr.
Menlo Park, CA 94025
PERSONNEL: Gilles Vrignaud, Director-Video Marketing; Ken Pyle, Manager-Video Marketing; Michael Triboulet, Director, International Video Marketing
DESCRIPTION: The Raynet Video System (RVS) from Raynet Corporation is a fiber bandwidth transport and distribution system for AM, FM, or digital n. QAM signals in FTTC and FTTLA applications. RVS is designed to offer state-of-the-art performance for compressed digital video channels or up to 80 AM video channels and is compatible with all conditional access systems and all transmission standards such as NTSC, PAL, SECAM, D2MAC and HDTV.

Optoelectronics

ALS
AMERICAN LIGHTWAVE SYSTEMS, INC.

American Lightwave
Systems, Inc. ....(203) 630-5770
A subsidiary of ADC
Telecommunications, Inc.
FAX......................................(203) 630-5701
999 Research Parkway
Meriden, CT 06450-8323
PERSONNEL: Dr. M.F. Mesiya, President; Zee Shams, VP Sales & Customer Service; John Holobinko, VP Marketing & Strategic Planning
SALES OFFICES: California, (510) 847-9151; Colorado, (303) 850-7016; Georgia, (706) 563-9859; Illinois, (708) 810-1295; Massachusetts, (508) 339-9311; Texas, (214) 580-1153; International, (612) 946-3036
DESCRIPTION: ALS is a single source of complete fiber optic system solutions for all CATV entertainment video, data and telephone applications. ALS products are available for VSB/AM, uncompressed digital, FM, and DS1-DS3 loop carrier applications, plus a complete line of fiber optic organizers, cabinets, patch cords and other fiber accessories.

AMOCO
Amoco Laser Company

Amoco Laser Co..................(708) 961-8400
FAX......................................(708) 369-4299
1251 Frontenac Rd.
Napervilloe, IL 60563
PERSONNEL: Juan Cerda
DESCRIPTION: Amoco Laser Company is the leading producer of diode-pumped, solid-state laser products for the fiber optic communications industry. Amoco's microlasers are targeted for use in high-power-budget, externally modulated CATV applications for either headend or distribution links. Standard single frequency products operate at 1.3 µ or 1.5 µ with output powers up to 175 mW. Amoco's 1.5 micron optical fiber amplifier features output power up to 24 dBm (250 mW) and gain up to 50 dB for repeaterless transmission across 400 kilometers.

BT&D Technologies............(800) 545-4306
500 N. Walnut Road
Kennett Square, PA 19348
PERSONNEL: Ken Miller, Sales Engineer; Ray Taylor, Passive Business Mgr.
DESCRIPTION: BT&Ds new 1x6 broadband monolithic coupler offers a small footprint, lowcost, second sourcing. Enhanced single mode multiport coupler arrays for multichannel splitting and combining, single window 1x2/2x2 fused couplers, broadband 1x2/2x2 fused couplers, feature a wider industry standard temperature range and excellent temperature stability.

C-COR Electronics, Inc. .....(814) 238-2461
WATS...................................(800) 233-2267
FAX......................................(813) 238-4065
60 Decibel Rd.
State College, PA 16801
PERSONNEL: John Hastings, Director of Sales; Dick Taylor, Eastern Sales Director; Dan Trayler, Western Sales Director
DESCRIPTION: C-COR is the leading manufacturer of digital video/audio/data fiber optic transmission systems, including 8- and 9-bit video and 16-bit audio codecs. Digital systems offer medium and short haul specs with both 1310 and 1550 nm optical terminals, 32 chs/fiber optical budget, and a 100 km range. DFB-based AM systems offer 80 channels per fiber and are designed for FTF, CAN and Backbone architectures. C-COR also provides full status monitoring, a wide range of broadband RF amplifiers, as well as support services including system design, training courses, 24-hour technical assistance.

EPITAXX ....(609) 538-1800
FAX......................................(609) 538-1684
7 Graphics Drive
West Trenton, NJ 08628
PERSONNEL: Brian VanOrsdel, National Sales Manager; Jay Liebowitz, Manager, Fiber Optic Group
DESCRIPTION: EPITAXX manufactures sources and detectors for 1300 and 1550 nm optical communications. For fiber optic CATV, the company produces receiver components specifically designed for AM and FM transmission. AM receiver products include the EPM700, a line of low distortion photodiode modules, and the ERM721/2, a series of high linearity detector modules that incorporate an impedance-matching network. The EPM700 has second order intermodulation distortion to -80 dBC; the ERM721/2 series is available with bandwidths of 600 and 900 MHz. The FM receiver line entails the ETX 75FJ-SLR, a high bandwidth photodiode module that provides -55 dB back reflection. EPITAXX CATV receiver components are already widely installed in the U.S. and Europe.

ONI.......................................(303) 694-9220
WATS...................................(800) 342-3763
FAX.......................................(303) 740-9420
8101 E. Prentice Ave., Suite 210
Englewood, CO 80111
PERSONNEL: Mike Sparkman, Vice President Sales; Jack Bryant, Vice President Marketing
REGIONAL OFFICES: 4905 E. Hunter Ave., Anaheim, CA 92807, (714) 779-0550, FAX (714) 777-1527; 2100-A Nancy Hanks Dr., Norcross, GA 30071, (404) 840-0121, FAX (404) 840-7902; 888 Thomas Dr., Bensenville, IL 60106, (708) 350-7788, FAX (708) 350-7840; 321 Richard Mine Rd., Wharton, NJ 07885, (201) 328-0980, FAX (201) 328-1267; 1620 Crosby Road, Suite 115, Carrollton, TX 75006, (214) 446-2288, FAX (214) 242-8421
DESCRIPTION: Optical Networks International is a system integrator of complete fiber optic networks for video, voice, and data. ONI develops innovative products with manufacturing partners worldwide. ONI provides a wide range of services to meet the specific needs of each customer including system design, project management, contract splicing, training courses, and 24 hour technical support and emergency restoration.

Ortel Corp. ....((818) 281-3636
FAX......................................(818) 281-3231
2015 W. Chestnut St.
Alhambra, CA 91803
PERSONNEL: Bill Moore, Vice President of Sales
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PERSONNEL: Rick Jaworski, Product Marketing Manager
DESCRIPTION: Tektronix is the world's largest manufacturer of video test and measurement equipment. Products for the cable industry include sweep systems, spectrum analyzers, video measurement sets, waveform monitors and vectorscopes, sync and test signal generators, fiber optic cable testers, precision demodulators, tunable down converters, and other equipment.

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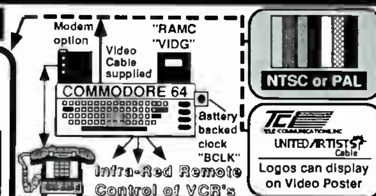

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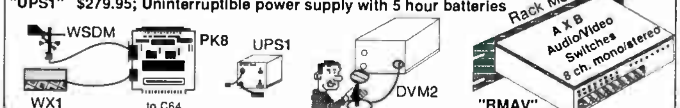

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Competition at 28 GHz

Seventy years ago, a distinguished scientist at the National Bureau of Standards stated conclusively that radio wavelengths shorter than about 200 meters (i.e. frequencies greater than 1500 kHz) would never be commercially useful. Fifty years ago, 75 MHz was called "ultra-high frequency."

Thirty years ago, Hub Schlafly and the folks at Hughes needed to find spectrum space for a multi-channel microwave service for cable TV (now known as CARS). Fearing that cable TV lacked the clout to challenge established users, they picked what they thought was unused spectrum at 18 GHz, only to be rebuffed by undisclosed telephone company plans. The compromise at 13 GHz has turned out fairly well. One wonders if there is an upper limit to the useable spectrum. It keeps growing—and growing—and growing.

Given the smashing success cable TV has enjoyed worldwide, entrepreneurial competition was probably inevitable. MMDS has never quite fulfilled its promise as a "wireless cable" system, partly because of channel capacity restrictions while sharing the 2.5 GHz spectrum, but also,

in many places, because of line-of-sight problems created by foliage, terrain and structural obstacles in the path. DBS also has a line-of-sight problem with reception at 12 GHz in MDUs and mountain valleys.

LMDS

Local Multipoint Distribution Service (LMDS), at 28 GHz, is the latest entry in the competition-for-cable sweepstakes. Offering capacity for 100 TV channels, no wires in the streets, no franchises, no amplifiers, no backyard dishes and no unsightly antennas, it seems quite attractive.

A New Jersey-based firm, Cellularvision/Suite 12 Group, has been licensed by the FCC to begin transmission tests in the Brighton Beach area of Brooklyn, using 1 GHz of spectrum to distribute 50 frequency modulated video channels at 28 GHz. Cellularvision has petitioned the FCC to establish the service for general use. Some 300 applications have already been filed—even before the FCC issued its Notice of Proposed Rulemaking.

Cellularvision claims that the allocation of frequencies to LMDS in the 27.5 GHz to 29.5 GHz Domestic Public Fixed Radio Service band could provide up to 100 channels in each community, to be shared by two licensees. Cross-polarized cells would be arranged to cover the desired service area, much like cellular telephones. The idea has the backing of former FCC Chairman Alfred Sikes as another viable competitor for cable TV.

Line-of-sight

Cellularvision claims that engineers have devised means to overcome "line-of-sight" problems. Small passive reflectors could be placed on the parapet of a multi-story building so as to reflect the LMDS signals to small horns or parabolic antennas mounted in the windows below. At 28 GHz (1.07 cm wavelength), reflectors and antennas could be quite small, not more than two or three inches in size. Moreover, small narrow beam, high gain antennas could be effective in rejecting unwanted multipath reflections.

MMDS operators typically find the service range at 2.5 GHz (12 cm wavelength) to be about 15 miles to 25 miles. Using the same radiated power (2000 watt EIRP), antenna gain and receiver noise figure, the comparable LMDS service range at 28 GHz would be only 1.2 miles to 2.2 miles. FM improvement, higher gain antennas and low noise figures would probably extend the range, perhaps to the six miles or more projected by Cellularvision.

However, the useful range will be realized only where clear lines-of-sight exist on both the incident and reflected paths. Passive reflectors are not likely to be effective in overcoming attenuation due to foliage or terrain obstacles, and may be of only limited value in overcoming blockage by other buildings.

Rain

The specific attenuation (dB/mile) at 28 GHz attributable to heavy rain storms is about four times as great as in the CARS band at 13 GHz. With 28 GHz path lengths less than about two miles, some fading would occur but complete outages would be rare. However, for the six- to 12-mile paths suggested in press reports, considerable outage time should be anticipated.

In view of the intrinsic characteristics of 28 GHz transmission, LMDS cells probably would have to be too small to serve single-family suburbia. However, if the trials at Brighton Beach are favorable, LMDS might succeed in distributing multi-channel service to individual residences in MDUs, or even to groups of existing MATV or SMATV internal networks. If passive reflector (beam-bender) technology proves to be practicable, LMDS could serve the useful purpose of providing an alternative for disgruntled cable TV customers.

ADML

The telephone industry is also investigating wireless technology in the 28 GHz range and above as an alternative to fiber access lines for broadband services. The inevitable acronym assigned for this is ADML, asymmetric digital microcell link. Each such microcell would provide service to a group of households. The useful range would presumably be short enough to avoid obstructions and minimize rainfall outages.

Obviously, the telephone industry is wrestling mightily with the difficulty of delivering broadband video services to residential customers on existing copper wires. First, it was FTTH (fiber to the home). Then, it was ADSL (asymmetric digital subscriber loop). Now, they are looking at ADML (asymmetric digital microcell link). The low cost and wide bandwidth of 150 feet or so of flexible coaxial cable is hard to beat.

LMDS does not appear likely to threaten the existence or economic health of the cable industry generally. As to the telcos, we have a moving target. Only time will tell. CED

By Archer S. Taylor, Director and Senior Engineering Consultant, Malarkey-Taylor Associates, Inc.