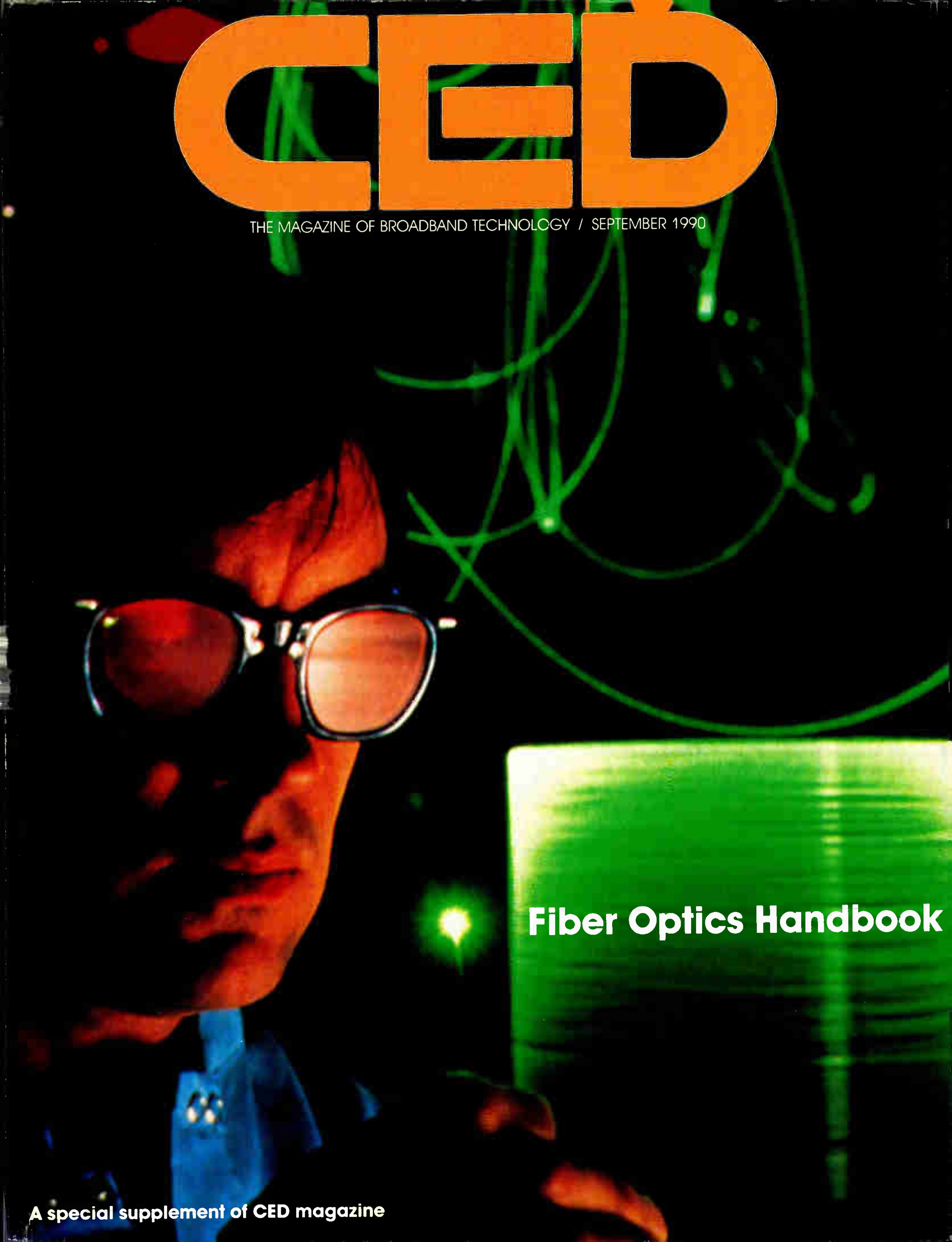
CED
THE MAGAZINE OF BROADBAND TECHNOLOGY / SEPTEMBER 1990



Fiber Optics Handbook

A special supplement of CED magazine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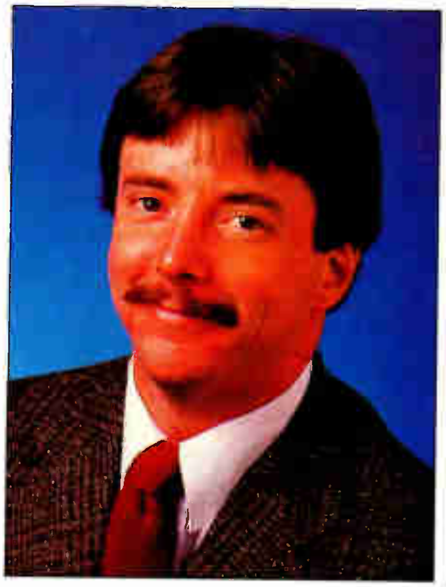
IN PERSPECTIVE

The politicalizing of fiber technology

In the three years that *CED* has been publishing special issues devoted to fiber optics, the technology—and marketplacehave come a long way.

Where our first effort concentrated on the theoretical and were authored by people and companies known only to a few familiar with the optical world, this latest issue focuses on a wide variety of topics, from advances made in fusion splicing and optical couplers, to the "vision of the future" offered by two of this country's largest cable operators.

In fact, optical technology has become a rallying point around which the cable industry bets its future. Cable's been forced to race to install fiber first because of a successful telco public relations campaign that gives fiber the same magic as the beans Jack traded his livestock for. Telephone companies have effectively lobbied a naive Congress and an unsuspecting populace into believing that, under their guidance, this nation can regain its global telecommunications dominance (as if it ever lost it) by installing fiber optics everywhere. These telcos have so far managed to convince a state legislature or two that it should be allowed to accelerate its depreciation schedule of old copper plant and be rewarded for upgrading to fiber.



In response, cable companies pointed out that the telco "Fiber City" was best built using *both* fiber and coax (or twisted pair), not an expensive, cumbersome all-fiber network. It took a while, but the telcos ended up agreeing with that assessment. Now it's beginning to look like CATV will probably install more fiber faster than anyone else. Why? Because the video business is where the growth is and the industry is unfettered by heavy regulation, which inhibits fiber implementation.

Although the number of cooperative ventures between cable and telephone companies continues to rise, it's a kneejerk reaction for cable companies to consider telcos as a huge, imposing competitor. In response, cable corporate engineers have been busy devising their own long-term strategies in an effort to convince anyone who'll listen that there's more than one way to skin a cat.

Two such strategies are presented here. ATC, long recognized as a leader in fiber, offers its view of the day when fiber, combined with switching technology, will bring viewers access to 1,000 different program sources. And for the first time, Continental Cablevision positions itself as a leader with a new strategy for fiber implementation.

Certainly, by the time we publish our fourth special issue devoted to fiber, cable could be well on its way to having more glass in the ground than anyone. And ever more MSOs will have devised long-term strategies that encompass the technology. Just how much of their justification is political remains to be seen.

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GENERAL INSTRUMENT

Reader Service Number 4

The evolution of cable television delivery systems

A strategic plan for Continental Cablevision of New England

As we enter the decade of the '90s, the cable television industry is entering a critical era of increased oversight and threat of competition. Cable's success during this pivotal time will largely revolve around its ability to respond to the complex array of issues that now confronts it. From a technological standpoint, the advent of fiber optics has provided the key to ensuring cable's position as the provider of broadband services to the home.

As the various applications for fiber in the CATV landscape are examined, one must first understand the limitations of the current system architectures and explore ways to strategically deploy fiber in a way that will counteract these limitations. Architectural limitations include the number of failure points between any one subscriber and the headend, and the ever escalating costs to maintain the cable plant.

The common denominator is electrical current. More than 50 percent of system outages can be directly correlated to power surges, outages, brownouts, etc. Figure 1 illustrates that power consumption in the cable plant increases dramatically as bandwidth increases. This not only impacts the reliability of the system, but places additional burden on operating expenses as well. As headends are consolidated and bandwidth expanded, the result will be longer cascades that may require feedforward technology in order to meet performance requirements.

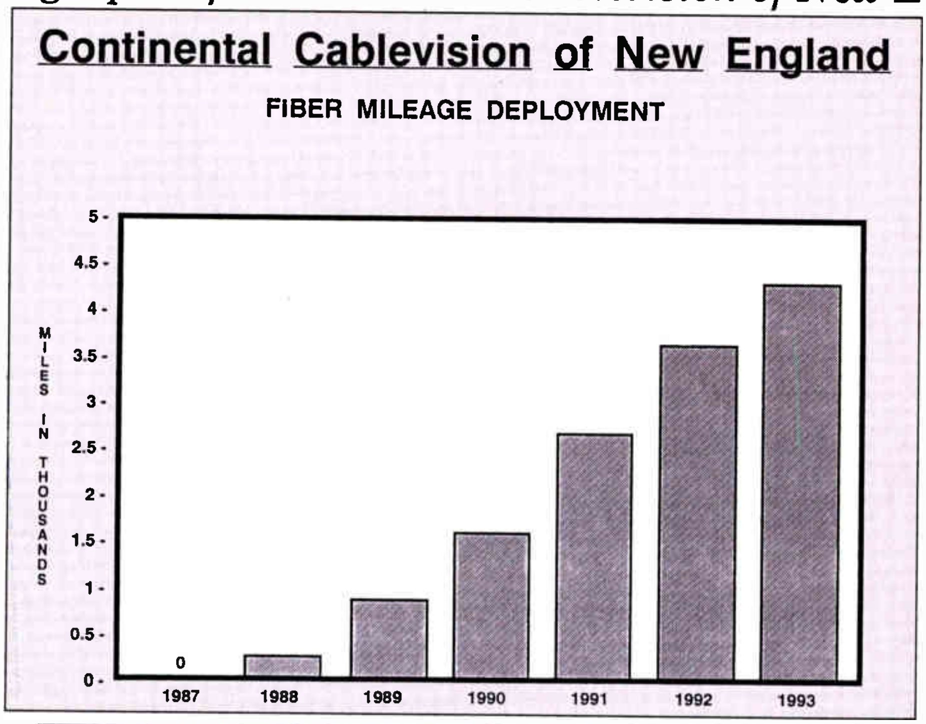
By Kevin M. Casey, director of engineering, Continental Cablevision of New England

Fiber usage a decade ago

The extent of fiber deployment in the cable system architecture of the '80s was largely restricted to supertrunking and limited trunking applications. This was attributed to the high cost and limited availability of fiber and optoelectronics. Prior to 1988, frequency modulation, which was the transmission medium used almost exclusively with fiber, did not require highly linear optical sources in order to meet EIA RS-250-B medium haul specifications for video transport. However, the economics of FM at $4,000 to $7,500 per channel limited the applications in which fiber was a viable alternative to microwave or supertrunking.

Notwithstanding the economic barriers, the key to widespread deployment of fiber is the reduction of signal processing components required under the FM scheme. For example, a 450 MHz 60-channel FM system would require more than 200 active headend components before final combining. To further complicate matters, group delay, inherent with video scrambling in the FM format, required signal scrambling to be performed at each hub site.

In 1988, the advent of the distributed feedback laser (DFB) for CATV applications provided direct modulation of AM broadband signals and the elimination of signal processing components required under the FM approach. Subsequently, several MSOs have deployed this technology with flawless operation to date. This has established vast



Power Consumption Costs Per Plant Mile

	300 MHz	400 MHz	450 MHz	550 MHz	550 MHz	550 MHz
P.S. Costs / Mile	$102.00	$114.00	$168.00	$366.00	$366.00	$193.00
P. Supplies / Mile	0.17	0.19	0.28	0.61	0.61	0.32
Homes / Mile	120	88	87	255	87	23
Cost / Passing	$0.85	$1.30	$1.93	$1.44	$4.21	$8.39

Figure 1

market potential for vendors and suppliers, who have accelerated research and development efforts to produce low cost, high performance AM optoelectronics. These recent developments have now altered the economic and technical outlook for widespread deployment in the CATV architecture. The opportunities that this technology now offers in improving the quality, reliability and capability of the cable plant are unequaled.

Three-phase fiber plan

The events of the past two years have helped shape our engineering strategy into the year 2000. Continental Cable of New England has established a three-phase plan that it believes will provide for increased fiber deployment into the distribution system, and ultimately to the tap, by the end of the century. The plan is evolutionary in that it maintains the technical and economic integrity that is essential to our long-term success.

Architectural development. Phase one of Continental's engineering strategy is the deployment of topology architectures designed to push fiber deeper into the system at an economically viable cost. The ATC "backbone" or Jones "CAN" systems are two such examples of the 1989-1990 generation of fiber deployment.

Under these architectures, fiber nodes would be strategically placed throughout the system, with trunk amplifiers limited in cascade from the headend. This type of deployment has worked well at Continental in cascade reduction, rebuild and upgrade applications. Figure 2 illustrates the traditional tree-and-branch architecture in 300 MHz system with a 20 amplifier cascade and a 13 amplifier remote TVRO interconnect, while Figure 3 shows the same system employing the backbone node approach in a 550 MHz rebuild application.

Cascade reduction of 70 percent combined with redundancy of the optical sources dramatically improves the integrity of the system. In analyzing the new design we discovered that in addition to the obvious reliability improvements, this type of fiber deployment allowed for the potential reduction of coaxial amplifier technology requirements in the system. As illustrated in the feedforward vs. push-pull cost comparison in Figure 4, deploying more fiber in the system made a measured impact on power consumption requirements, while reducing our

Coaxial Tree & Branch Architecture

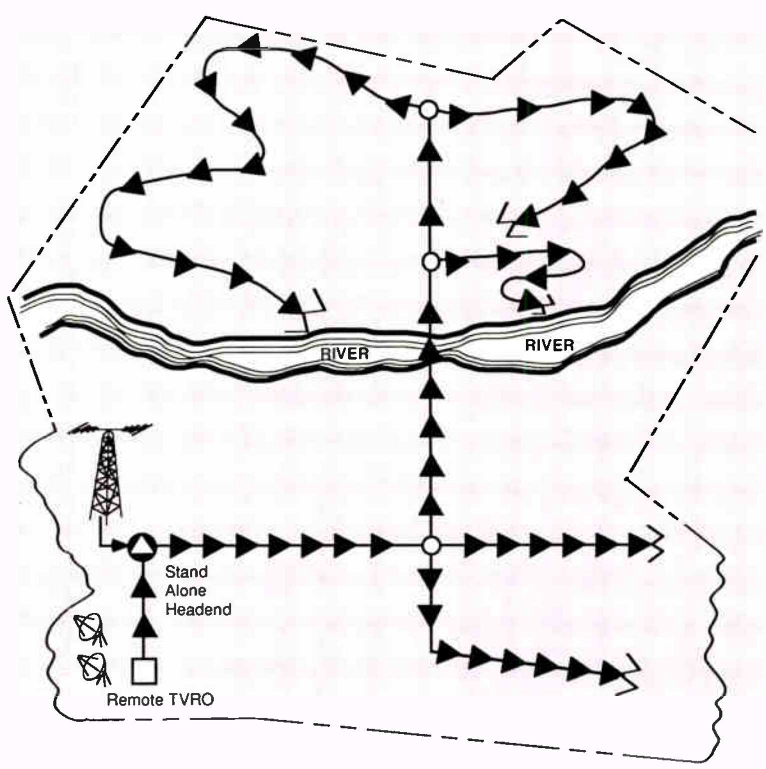


Figure 2

Fiber Optic Backbone Architecture

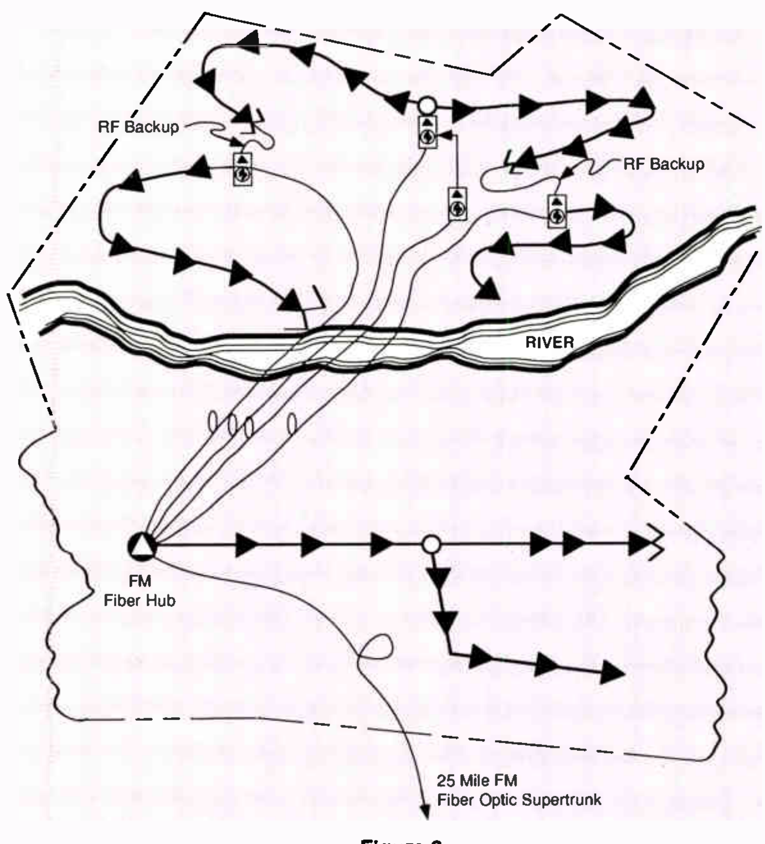


Figure 3

capital and operating expenditures by 18 percent over the 10-year period.

This type of architecture will improve the overall quality of the delivered broadband spectrum, while at the same time increase the reliability of the signal path. Virtually all electrical, equipment or plant failures in the immediate area of the headend would not have any greater impact at the extremities of the system, as is the case in the tree-and-branch architecture. While these approaches provide for significant improvements in signal delivery to the subscriber, the number of active components in the system actually increases, and the inherent limitations of broadband amplifiers is not eliminated.

Fiber's potential failure

The largest potential for failure in the fiber backbone approach is the fiber itself. Let us consider the ramifications of this type of delivery system. Because of link margins of typically less than 12 dB, and the material and labor costs of fiber optic plant ($9,000 to $12,000 per mile), alternate path routing is not technically nor economically viable in most CATV applications of this type.

Furthermore, our outage statistics (Figure 5) indicate that under the traditional architecture only 4 percent of service interruptions are the result of physical damage to the cable plant. This will improve as fiber maintains a 40 percent increase in tensile strength compared to .750 coax.

These dynamics, combined with the fact that we have little or no historical information on DFB laser performance, has led us to consider redundant signal transmit and receive sources in certain situations. This is important as entire systems with thousands of customers can be served from a single laser/receiver system.

Performance Analysis - Feedforward vs. Push Pull Technology

Parameter	Feed Forward	Per / Mile	Push Pull	Per / Mile	Variance	Per / Mile
Coaxial Elect.	$445,800	$4,328.16	$383,047	$3,718.90	($62,758)	($609.25)
Optoelectronics	92,000	893.20	129,000	1,252.42	37,000	359.22
Total Costs	$537,800	$5,221.36	$512,047	$4,971.32	($25,753)	($250.03)
Amplifiers	72	0.70	72	0.70	0	0.00%
Line Extenders	683	6.63	683	6.63	0	0.00%
Power Supplies	98	0.95	72	0.70	-26	-25.24%
Power Costs-10 Years	$588,000		$432,000		($181,753)	

Figure 4

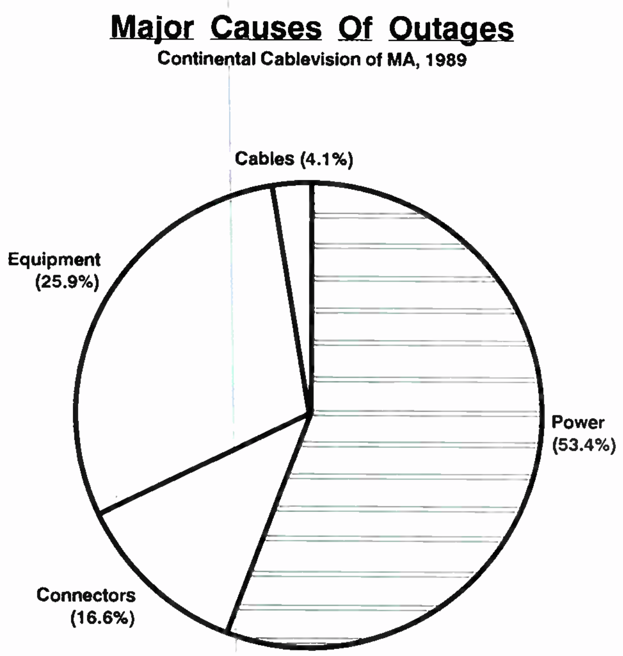


Figure 5

Phase two—all fiber trunk (AFT).

Recent developments in improving the link performance of DFB based AM systems and the advent of low loss optical couplers have accelerated the potential opportunities that are now available in configuring new delivery system landscapes in the 1991 timeframe. Our phase two strategy exploits these advances in meeting the ongoing need to improve quality, reliability and bandwidth expansion in an economically sound fashion.

This phase of the strategy, known as AFT, positions our network for new revenue opportunities that will become a component of our business plan in the second half of the decade.

The objectives of the All Fiber Trunk (AFT) network are:

- Deploy fiber deeper into the distribution system.
- Ensure that the network architecture is compatible with the next generation of delivery systems.
- Improve the reliability and quality of the broadband signals and path.
- Economically sound—competitive with coaxial amplification system.
- Position the passive network for future expense reduction and revenue opportunities.
- Affect system powering and maintenance costs of the network.

The all-fiber trunk architecture utilizes optical receivers as bridging networks between the fiber optic facilities and the distribution networks between fiber optic facilities and the distribution system. Dual DFB laser transmitters in the headend will feed multiple receivers in the optical trunking network that are strategically positioned inside individual neighborhoods as shown in Figure 6.

This architecture maximizes the reach of the laser transmitter with the use of optical couplers. Optical split ratios are determined for each optical trunk station based on link loss and desired system performance. The optical performance specifications in Figure 7 outline the AFT approach. In this example we have assumed optical path or link loss of 14 dB. The selection of the appropriate coupler will yield consistent performance within 1.5 dB throughout the system.

From each optical trunk station, line extenders or distribution amplifiers are cascaded three to four deep into the service area containing no more than 1,000 homes passed. From a technical standpoint, we can deliver excellent performance at every tap location in the area of 47 dB carrier-to-noise, 52 dB composite triple beat, composite second order and cross-modulation. In addition to these performance levels, we can consider the subjective enhancements that coherent headends provide to be an additional margin to the system.

Technical training

From an operational standpoint, our technicians would require a streamlined equipment inventory for routine service work, thereby impacting warehouse carrying costs as well. Training, however, becomes a vital component of bringing these improvements to frui-

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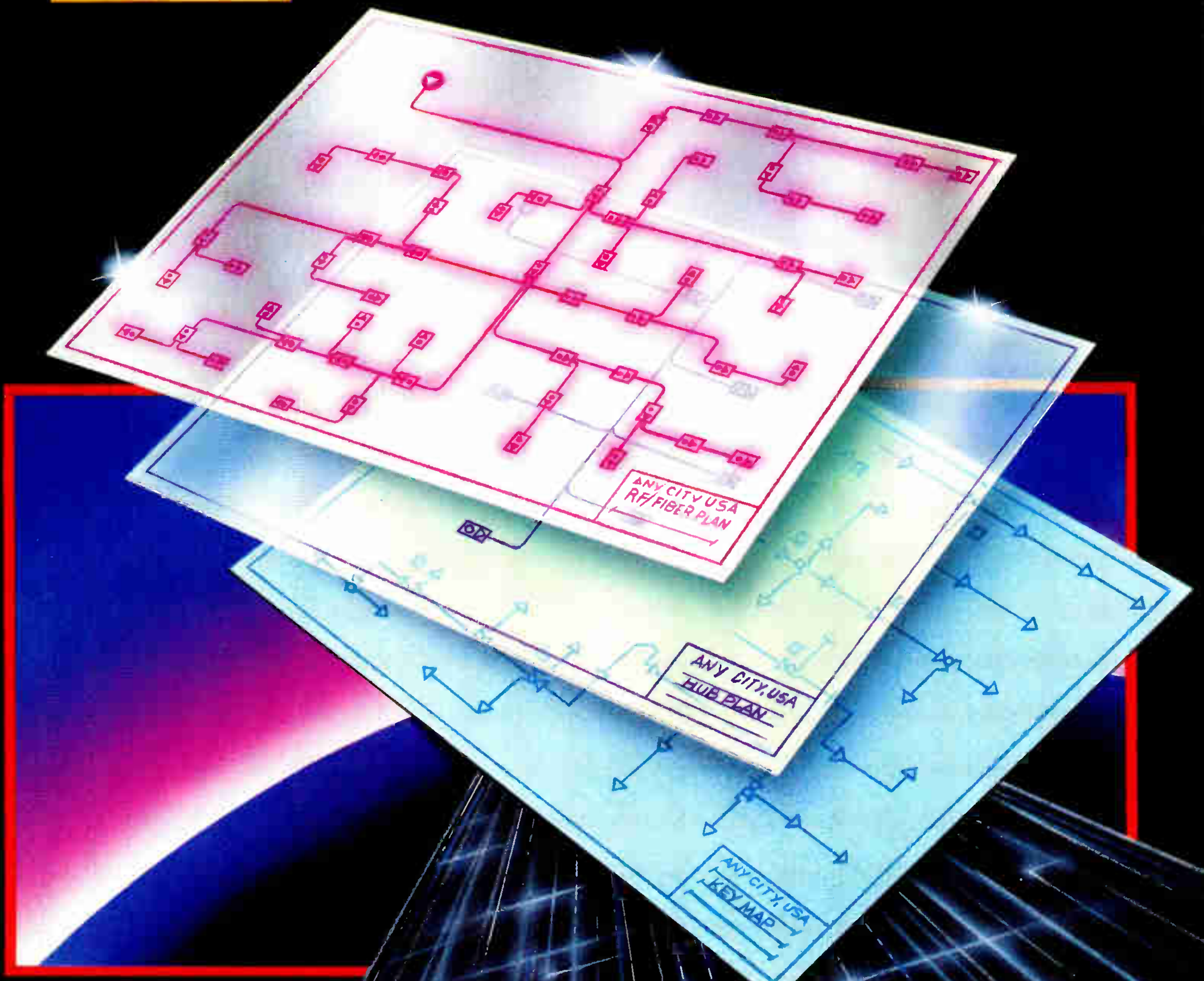

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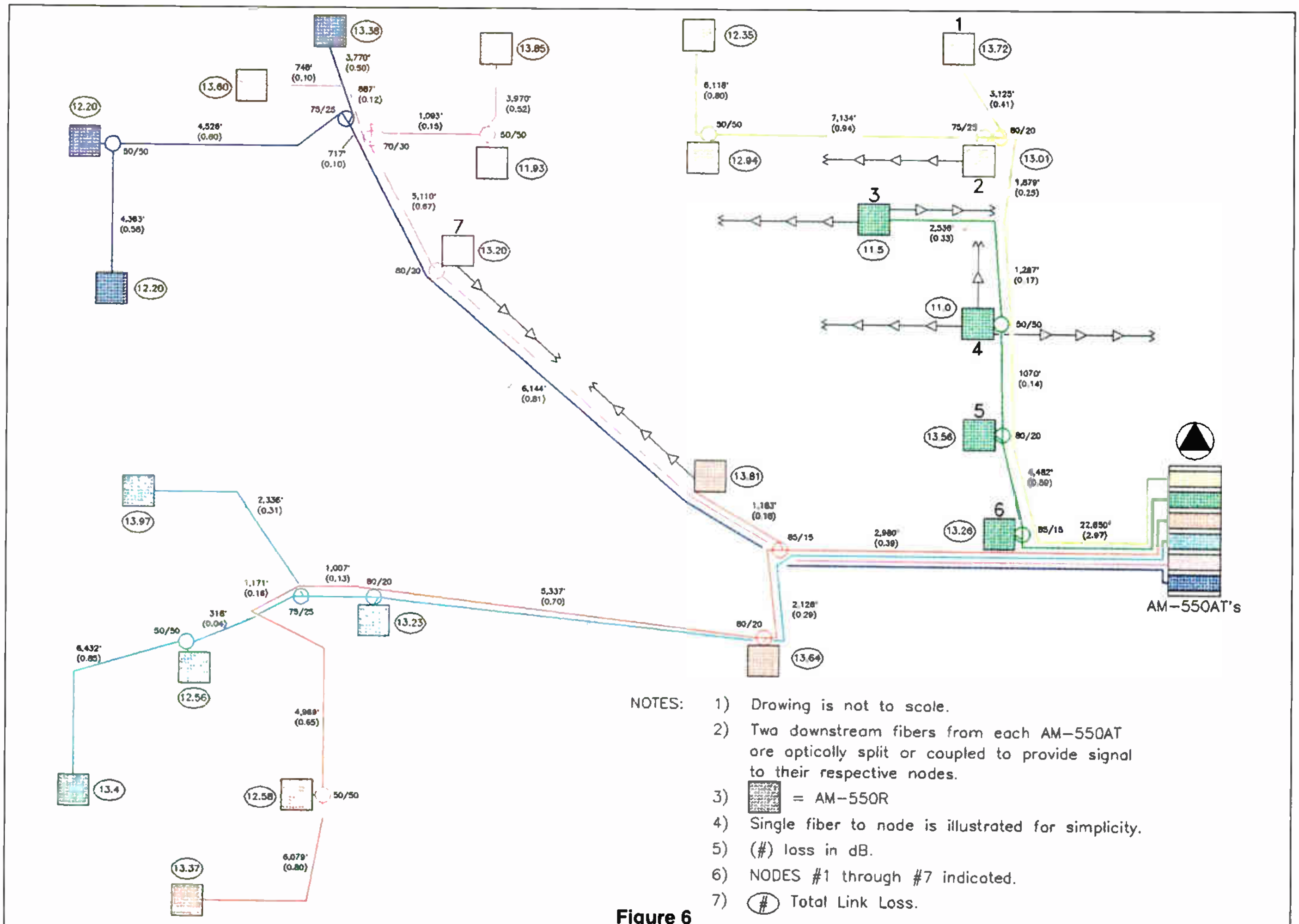


Figure 6

tion. The addition of fiber will add a new dimension to the system technician's scope of responsibility. As managers, we must ensure that our employees have the necessary skills to perform the new role of the system technician.

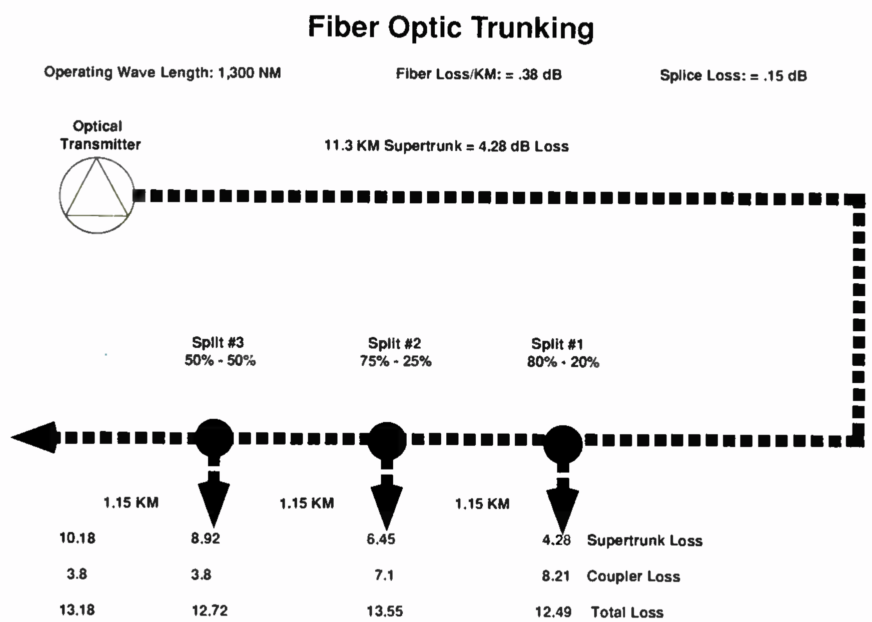


Figure 7

To that end, we have recently installed an AM system in our New England training center that will simulate system conditions and provide hands-on skill development for our employees. To further support these efforts, cable and optoelectronics vendors have begun to develop "craft friendly" products. Enhanced strength fibers, connectorized components and easy to prepare mechanical splices are but a few of the recent improvements.

In order to bring the AFT architecture to the implementation stage, the economics of the investment must meet established guidelines. In Figure 8 we have analyzed the costs for one 550 MHz system rebuild project in New England. In comparing the phase one approach to that of the AFT, we can see that there is a 7.5 percent investment premium required for phase two implementation in this particular project. What must be considered, however, are the tangible and intangible benefits that the AFT design provides both short and long term, including:

- Homes affected by any one cascade

went from 4,000 to less than 300.

- System performance was consistent within 1.5 dB throughout the entire system.
- Passive fiber architecture provides for future technology enhancements without major plant expense.
- Addition of 1.5 GHz bandwidth capability into neighborhoods.
- 28 percent reduction in active components in the cable plant.
- Inventory requirements for electronics are reduced.
- Long-term revenue opportunities in areas other than CATV transport.
- Investment in fiber plant can be expected to maintain five times the average life cycle of the coax plant.
- Power consumption costs are reduced by 21 percent which recoups 3.4 percent of the 7.5 percent investment premium over the 10-year franchise period.
- Strategic value of the network in offering advanced services to the commercial market.

Summary Of key Cost Components Of Total Investment

	Hybrid Conventional	All Fiber
Reception Facilities	242,047	242,047
Coaxial Facilities	3,176,110	2,563,428
Fiber Optic Facilities	223,457	1,034,298
Aerial $ Per Mile	$14,470	$15,243
U.G. $ Per Mile	$37,308	$39,272

Figure 8

This positions the cable network to provide for a passive fiber path back to the headend for every 300 to 1,000 subscribers. This quasi-star configuration positions the network for future business opportunities that are traffic limiting, or require extensive bandwidth requirements.

Why not video-on-demand on a per neighborhood basis? Or segmented programming to targeted demographic groups? With the infrastructure in place, systems, headends and offices can be interconnected to transport billing system data (MIS), voice and fax between offices. Additionally, remote commercial insertion becomes a distinct possibility. These are several network overlay options that are now available with fiber. Once accomplished in the 1991 to 1997 timeframe, we are positioned for phase three of our fiber deployment strategy.

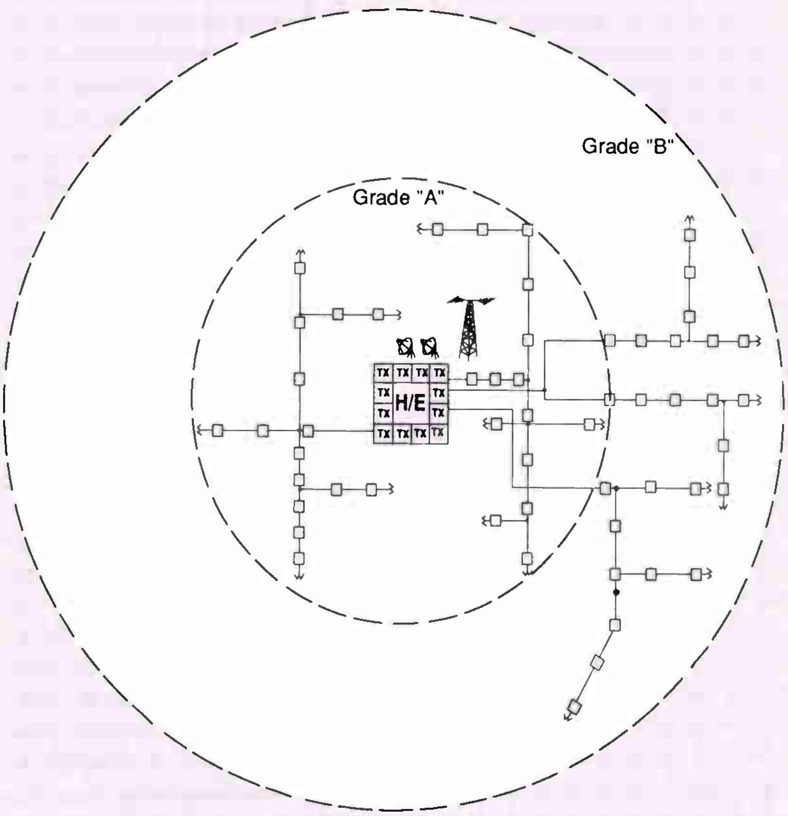
Phase three—fiber optic distribution. Phase three of our strategic plans looks beyond the configurations previously discussed, taking the fiber trunking one step further into the feed portion of the distribution system, specifically the tap.

Our "Fiber Optic Distribution Network" architecture will be designed to:

- Provide the capability of delivering advanced television signals to the subscriber's TV set.
- Improve the reliability of the system by eliminating the tree-and-branch architecture that limits the potential failure points or active components between the headend and the subscriber.
- Reduce controllable operating costs in the areas of plant maintenance and installation, while at the same time affect our dependance on power consumption.
- Deliver signals in a highly secure manner in such a way that enables the subscriber to utilize his video equipment, i.e. cable-ready sets or VCRs.
- Affect signal leakage and ingress potential that is inherent in today's coaxial systems.
- Provide for two-way transmission so as to anticipate future interactive revenue opportunities such as impulse pay-per-view, data transmission and voice.
- Incorporate flexibility in design so as to facilitate deployment of future technological developments.

The Fiber Optic Distribution concept utilizes several of the current tree-and-branch topology characteristics in that the broadband spectrum cascades from the headend out to the furthest point in the system. Unlike the tree-and-branch approach, however, the system is broken up into "grade contours,"

Fiber Feeder System Grade Contours



Grade contours represent a theoretical distance limit by which optical light sources may be split multiple times from a single source and deliver acceptable optical input signals to the receiver at each tap location. At each tap location, the light source is converted to RF energy to provide + 15 dBmv to +20 dBmv at the subscriber port.

Figure 9

Reader Service Number 7

bled mode for securing each outlet.

For two-way applications, an LED or laser operating in the reverse direction on the same fiber in the tap unit via wave division multiplexing (WDM) allows for interactivity of data, voice and video back to the headend. The fiber distribution network approach is unique in that it provides for each tap to have interaction directly with the headend as opposed to being connected through a series of active components. The only active components in the network are the optical transmitters in the headend, the tap at the pole, and in some cases, optical repeaters.

The advantages of the architecture include:

- System reliability is increased dramatically, as the number of failure points in the system are reduced between the headend and the subscriber.
- Reliance on electricity and its associated cost is virtually eliminated from the system.
- Capacity for advanced television delivery to the subscriber's set is maintained.
- Operating expenses are impacted by the lower installation, service and maintenance requirements that would be realized in the fiber system.
- Signal leakage would be eliminated in the distribution system and CLI would not be a consideration as the only RF signals transmitted in the system would be transmitted through the drop cable at levels below the 38.75 dBmV threshold for signal leakage.
- Disconnects and reconnects can be performed remotely from the office.
- Output level selectivity provides for the capability to anticipate and affect levels for long drops or span drops where less than four subscribers are fed from a single tap. This also enhances signal security on additional outlets.
- Bi-directional capability is built in to the system without additional plant costs.
- System architecture is conducive to delivering voice and data transmission in the future.
- The network is completely transparent; there is no need for tilted system operation or equalization of the spectrum at higher frequencies.

In addition to the technical advantages of this concept, there is potential for significant cost reductions in the area of manpower required to maintain such a system. Consider the following parameters that would be affected under the Fiber Optic Distribution concept:

Installation (average cable system).

Reconnects represent 25 percent of the total work performed. Should moves or non-pay disconnects be able to be reconnected without major rework at the pole, the manpower requirements for reconnects could drop that to seven percent of the total workload.

Disconnects represent 17 percent of the total work performed. Conservative estimates show that 80 percent of this work could be performed remotely. This would reduce the disconnect workload by 14 percent, or three percent of the total workload.

Changes of service represent 13 percent of the total work performed. The elimination of traps, converters and remotes could reduce the workload by two percent in this area to 11 percent.

Service.

Service related problems such as converters, customer education, power problems and distribution problems represent 78 percent of the total service department's activity. Under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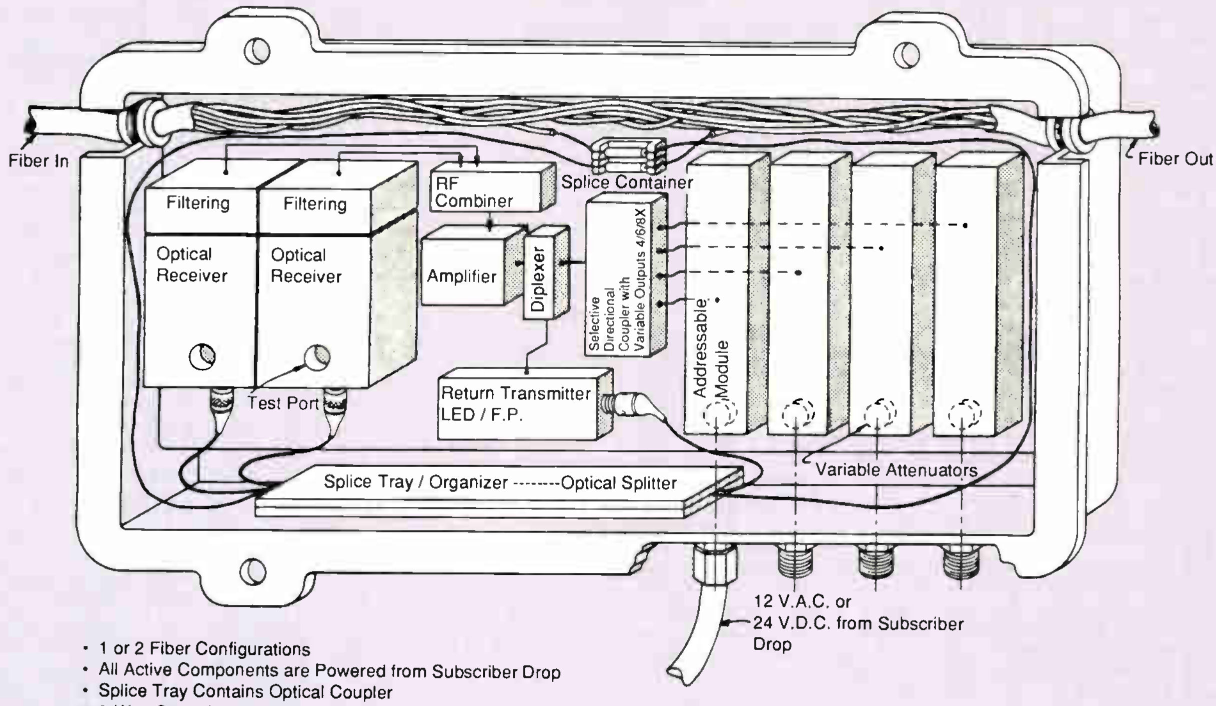
Fiber Optic Tap



- 1 or 2 Fiber Configurations
- All Active Components are Powered from Subscriber Drop
- Splice Tray Contains Optical Coupler
- 2-Way Capable
- Selective Port Output Signal Capability

Figure 12

the fiber to the tap concept, a minimum of 50 percent of these problems would be eliminated.

Not having a CLI or quarterly leakage rideout to contend with will also provide additional capability to the service staff. With a 39 percent overall reduction in service requirements, the technical staff could expand the geographic service area covered or enhance customer service applications of the technical department by offering timed appointments.

Plant maintenance.

Requirements would shift from that of equipment alignment and signal leakage protection to that of physical plant maintenance and splicing. Given these factors, the maintenance staff would be capable of maintaining upwards of 40 percent more plant in this type of architecture.

The manpower flexibility that this concept offers the technical operation of the future could allow for extended hours of coverage, seven days per week, and offer timed appointments with virtually no increase in expenses from those of today. Each technician would be trained in all facets of the system thereby increasing the capabilities of the operation. While this system provides for a number of improvements

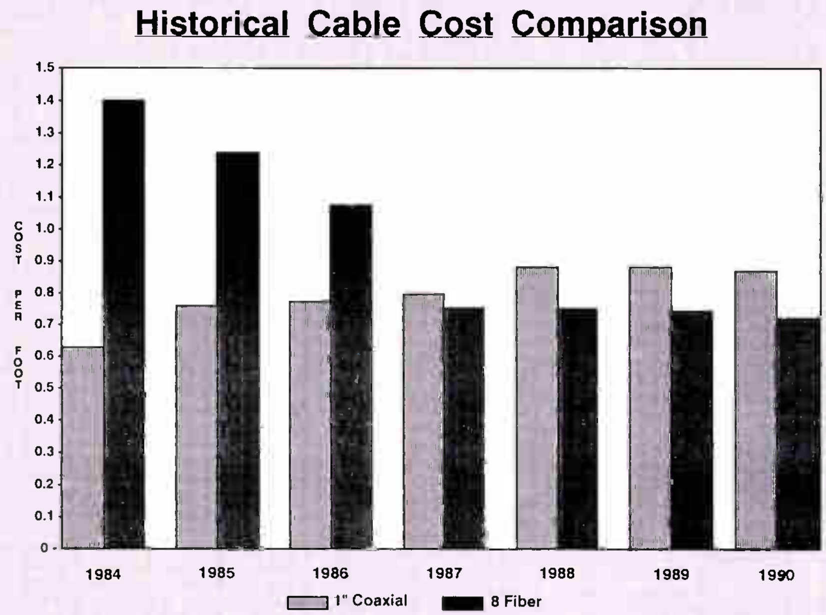


Figure 13

over current deployed technologies, there are several areas of this technology which should be considered:

- Maintenance and operation of the system requires more exacting information than in the coaxial architecture. This includes database information as well as the administration of the fibers within the network.
- Additional outlet revenues could be negatively impacted by moving the security controls to the tap as opposed to the outlet.
- Remote revenue is affected in the fiber to the tap concept as the consumer interface would no longer limit the use of cable-ready sets.
- Technical personnel will require broader types of training in the area of fiber optics. Test equipment would consist of a fusion splicer, optical power meter, signal level meter and test set.

The developments in fiber optics in just the past 12 months further heightened our expectations of fiber to the tap. Consider the performance improvements that suppliers have incorporated into their products. Doubling the link capability without affecting performance while reducing costs is a signficant improvement. For the future, we see a continued reduction in the cost of fiber optic components and cable as deployment increases through the 1990s.

In comparing fiber and coax cable costs in Figure 13, we can see the cost curve for fiber has dropped by over 50 percent, while the coaxial costs have increased by 42 percent during that same period. Note that coax relies heavily on raw materials, while fiber relies on an endless supply of sand. As shown in Figure 14, optical transmission systems have realized an even greater reduction in the cost per delivered channel from FM in 1988 to AM in 1989, and again using optical splitters in 1991.

Our plan relies heavily on optical couplers in advancing the widespread deployment of fiber. Figure 15 provides some insights into cost trending of these components. As evidenced by the history of these factors, the prospects for the economic viability of fiber to the tap is very bright. To that end, our intermediate deployment plans include a three-fold increase in the deployed fiber base in New England to more than 4,300 fiber miles by 1993.

The concepts discussed here outline an evolutionary approach to fiber technology that established long-term engineering objectives. The significant technological advances made duirng 1989 and 1990 provided the impetus for developing the phased approach to this techonology over the 10-year timeframe.

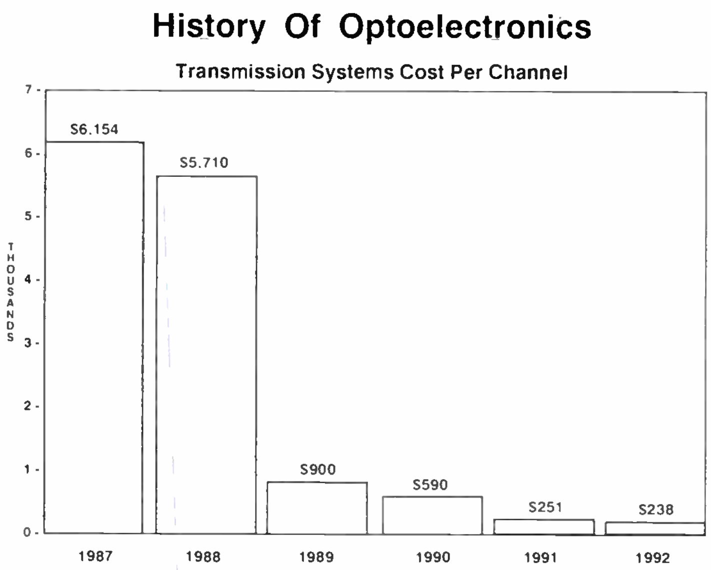


Figure 14

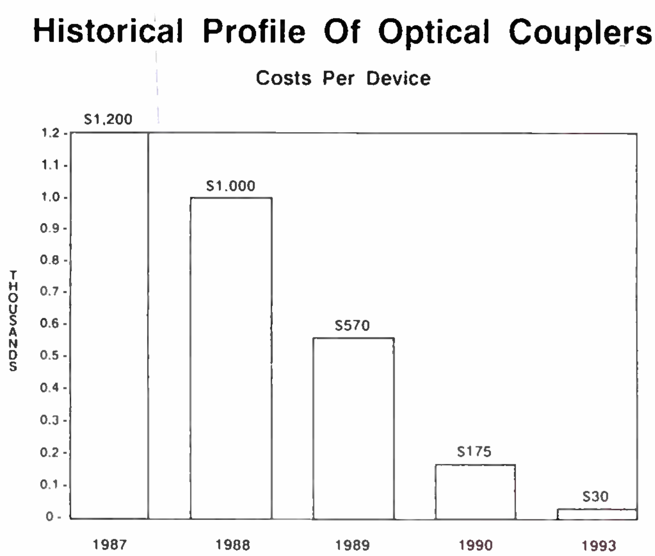


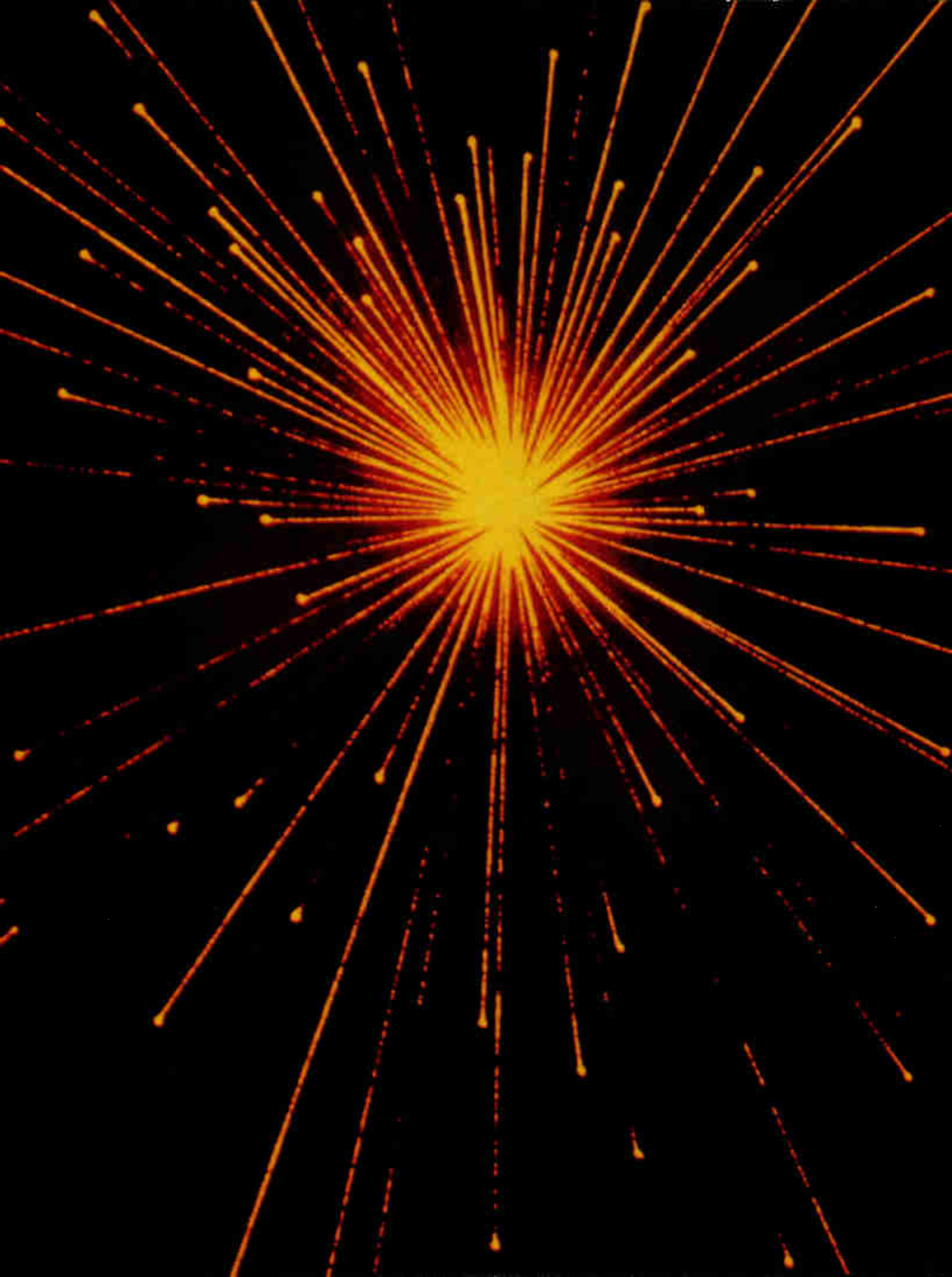
Figure 15

Key components for concept viability are:

- Optical splitting—low loss required to push lightwave out to system extremities.
- Splicing—again, low loss fusion or mechanical splicing with excellent reflection characteristics will be required.
- Transmitter—4 to 20 milliwatt transmitters yielding linear performance over 15 dB to 20 dB links in both the 1330 nm and 1550 nm region are necessary for deployment.
- Receiver—flexibility across a range of received optical power levels, with increased conversion tolerances in the -10 dBm to -13 dBm range.
- Equipment powering—current requirements for taps must be provided by the subscriber's premises.
- Environment—components must be able to withstand ambient temperature swings and variations in voltage.
- Packaging—components must be modular in design to facilitate ongoing maintenance of optical and RF electronics.
- Economics—system must meet investment rate of return guidelines.

Once fiber to the tap becomes a feasible, cost effective signal delivery method, the impact on operating expenses and system reliability will provide for significant new opportunities to provide a higher level of customer service to our subscribers. From a strategic standpoint, we would be in a position to deliver ancillary services to the customer via fiber. Should the regulatory environment change in the future, this architecture will incorporate the capacity to deliver diversified services from both an opportunistic or defensive position.

The type of technology discussed in this document provides for revenue enhancements, reliability improvements and cost reductions beyond those attainable in the current coaxial delivery systems, and positions cable to be poised for potential competition with providers of switched services. With the plan in place, we can begin implementation in the early '90s building the infrastructure that will position our system landscape for the next generation of fiber optics. As such, we are ensuring that the investments we make today in upgrading and rebuilding our plant in the short term will yield measurable benefits in the year 2000. ■



CATV's evolution to a switched network

ATC's vision of 1,000 channels starts with fiber in the trunks

	Headend	Supertrunks, Remote Earth Stations and Hub Sites	Trunk Network	Distribution Network	Drop and House Wiring
Plant Investment (%)	5	1	19	55	20
Plant Mileage (%)	-	1	14	40	45
Embedded Costs/Sub ($)	17	4	50	194	70
Signal-to-Noise Ratio Contribution (dB)	48	58	47	53	45

Table 1

Much has been written and speculated about what a cable system will look like 10 or 20 years from now. Outside of agreement that these networks will have to offer more channels of quality video and allow viewers to select events to be watched at their command, most visions of the future seem to lack a coherent, thoughtful methodology that should be followed to arrive at the goal.

Recently, Jim Chiddix, senior vice president of engineering and technology at American Television and Communications (ATC), started a lot of people thinking when he made mention of a 1,000-channel cable television system. The questions in people's minds could almost be heard: How could a headend offer 1,000 choices? Would viewers ever use that many channels? What about electronics—could there ever be enough capacity to pass that much spectrum? It seemed Chiddix's idea was mere wishful thinking.

The clear need for switching

But, indeed, Chiddix's thinking wasn't mere folly. But it does require an abandonment of today's coaxial tree-and-branch architecture in favor of one that consists of fiber throughout the trunks and switches in the headend to control a large number of video offerings.

Unlike the plans laid out by the nation's telephone companies, ATC's approach relies on an orderly evolution that requires capital outlay only when it makes good business sense—a key consideration in times of increasing competition.

> 'Strategically, we need to be able to evolve to a network where people can watch anything they want to watch.'

A review of a cable system's network architecture reveals that only a small fraction of the physical plant, in terms of mileage and capital investment, is dedicated to the trunk, yet it is this portion of the system which largely limits video performance and channel capacity. According to figures supplied by ATC, the trunk portion of the network accounts for roughly 19 percent of the investment made in the plant, and just 14 percent of its mileage (see Table 1). This compares to 55 percent and 40 percent, respectively, for the distribution plant.

Coax in the trunk raises S/N

The presence of coaxial cable in the trunk is also a "weak link" in the chain of signal transmission. According to ATC's numbers, the trunk contributes 47 dB of signal-to-noise, compared to significantly higher numbers in the distribution plant.

However, as Chiddix points out, coax's strengths include its ability to

Elements of Cable Television Plant
Networks Elements

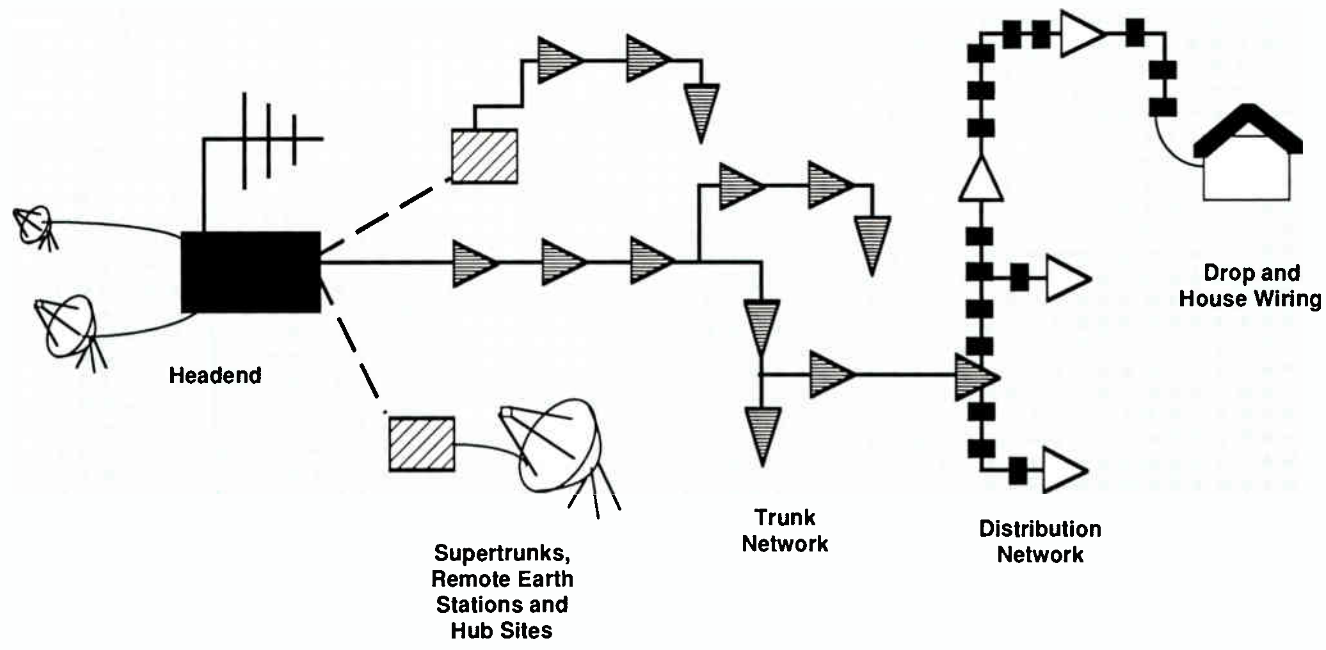


Figure 1

deliver signals in a form today's televisions recognize, without conversion. And the fact that cable-TV can deliver multichannel AM/VSB to the television "represents a key strategic advantage vis-a-vis potential competitors," which now includes DBS, MMDS and the telcos, says Chiddix.

However, coaxial cable's weakness—attenuation—is well documented and accounts for extremely long amplifier cascades, which in turn affects system performance. "That's the thing we've got to fix and fiber optics is the way to fix it," adds Chiddix. "Fiber's key characteristic, for the cable industry, is that it has low loss."

Elements of Cable Television Plant

Networks Elements With
Fiber Trunk & Feeder Architecture

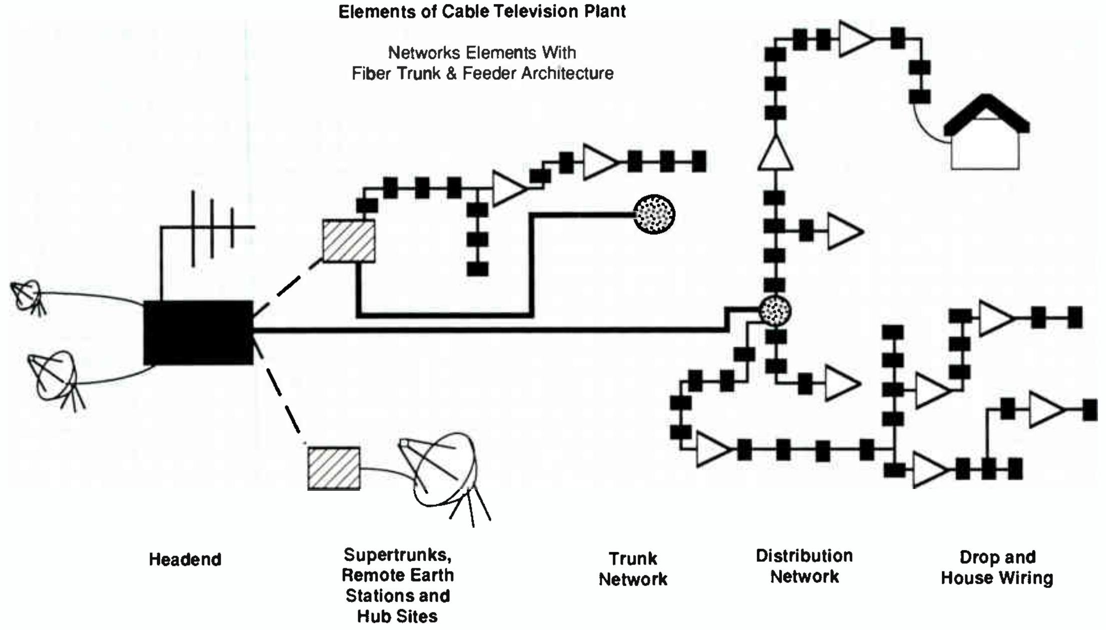


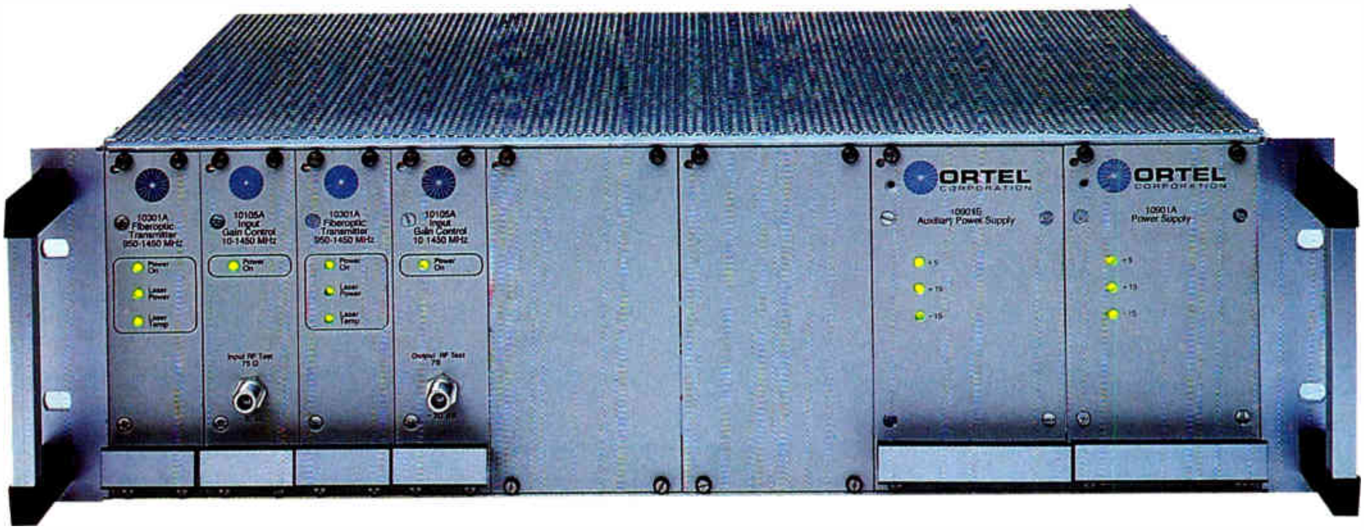
Figure 2

Coax stays in distribution

Conversely, coax works just fine in the distribution plant, whereas fiber would require expensive format conversion from lightwave to RF. "That's good news because distribution is a high percentage of the system and our investment," Chiddix adds.

Therefore, by putting fiber into the trunk networks, cable operators gain system performance, enhance reliability by

Freedom package.



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Ortel's new 10005A TVRO Fiberoptic Transmitter and Receiver give you the freedom to locate your satellite antenna where you want it without regard to the headend location…**anywhere up to 15 miles away!** The 10005A frees you from problems like terrestrial interference, line-of-sight obstructions and legal restrictions.

Installation is easy. The LNA or LNB output feeds directly into the transmitter, which delivers either one **or both** over a single optical fiber cable to the receiver, wherever you want it.

The modular design 10005A system uses a standard 19-inch rack mount incorporating dual, redundant power supplies for added reliability.

Modular design means you can expand the system to handle multiple polarizations. It also minimizes the cost of spares.

- *Passband: 950 — 1450 MHz*
  3.7 — 4.2 GHz
- *I/O gain adjustment range: 20dB*
- *Typical demodulated signal-to-noise ratio at 15 miles: 60dB*
- *Standard 19" rack mount x 5.25" high x 11.8" deep, houses two polarizations.*

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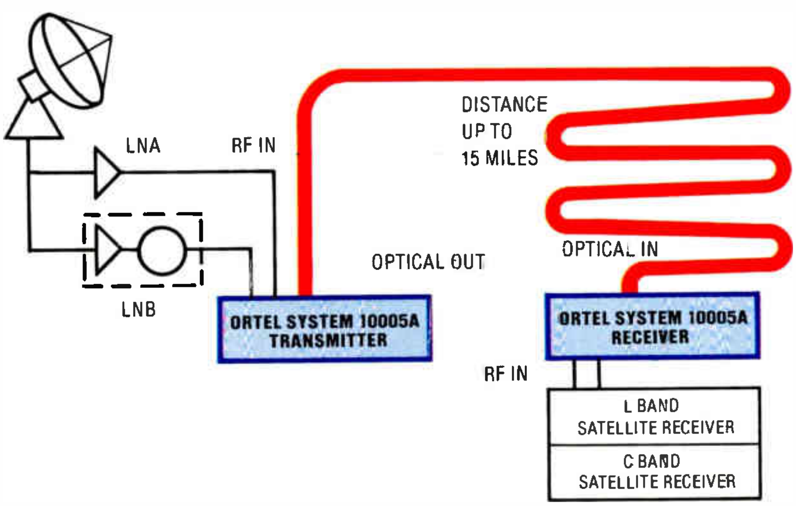

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reliable, long-term investment. If properly designed, manufactured and installed, a fiber optic cable will not couple strain to the optical fibers under the loading parameters normally encountered in a given region. This will enable the stable attenuation performance of the fiber over the 20 to 40 year expected cable life. The state-of-the-art of fiber optic cable is such that, once installed, system upgrades (for the foreseeable future) should only occur electronically. A stable single-mode fiber is capable of very low attenuation and carrying in excess of 1,000 channels based on current bandwidth requirements.

A substandard fiber optic cable can cause fiber strain which will degrade its life and can cause increased attenuation. Increased fiber attenuation may limit system performance and could create the need for early electronic upgrade by making the system operation substandard. Also, as the lasers begin to age and experience drift toward 1300 nm and below, or the more sensitive region of 1550 nm and above (if that wavelength is employed) the apparent degradation of the system will accelerate. Such a scenario is also capable of occurring on an intermittent basis if a substandard cable develops "hot spots" where attenuation fluctuates based on temperature cycling or increased loading conditions.

Over the past 10 to 15 years, volume users of fiber optics in industries outside cable television have written, revised and continue to update standards and test procedures for fiber optic cable. Their number one stated reason for the effort is to ensure a high degree of reliability. The basis for their expertise comes from the estimated 6 million homes of optical fiber deployed in the U.S. since 1981. Only about 60,000 to 65,000 thousand miles have been replaced.

The CATV industry has installed approximately 100,000 miles of optical fiber. The growth in the last three years has accounted for the vast majority of this cable and places the industry in a position of increased future dependence on the reliability of the technology. Cable systems can save considerable time and effort regarding the evaluation of fiber optic cable by drawing on the accumulated knowledge of prior users in other industries.

Some of the more well known documents addressing fiber optic cable standards area as follows:

- Bellcore TR-TSY-000020 Titled: Generic Requirements for Optical Fiber and Optical Fiber Cable
- REA PE-90 Titled: REA Specifications for Totally Filled Fiber Optic Cable
- EIA 472 Titled: Generic Specifications for Fiber Optic Cables.

The most widely referenced of the three is probably the series of fiber optic test procedures from the Electronic Industries Assocation (EIA). The EIA is in the process of updating and revising its specifications.

The basic standards and test procedures currently followed in the industry can be broken into two categories: optical fiber and optical fiber cable. The system engineer must first establish a baseline requirement for the optical fiber that will meet or exceed the application. Once that is determined, cable parameters must be established. It is important to note that the adage "fiber is fiber" is true only when comparing one manufacturer's fiber to itself and the fiber is of a specific grade. Once an optical fiber is incorporated into a cable design, material compatibility, mechanical efforts and environment may all impact the fiber's performance throughout its lifetime.

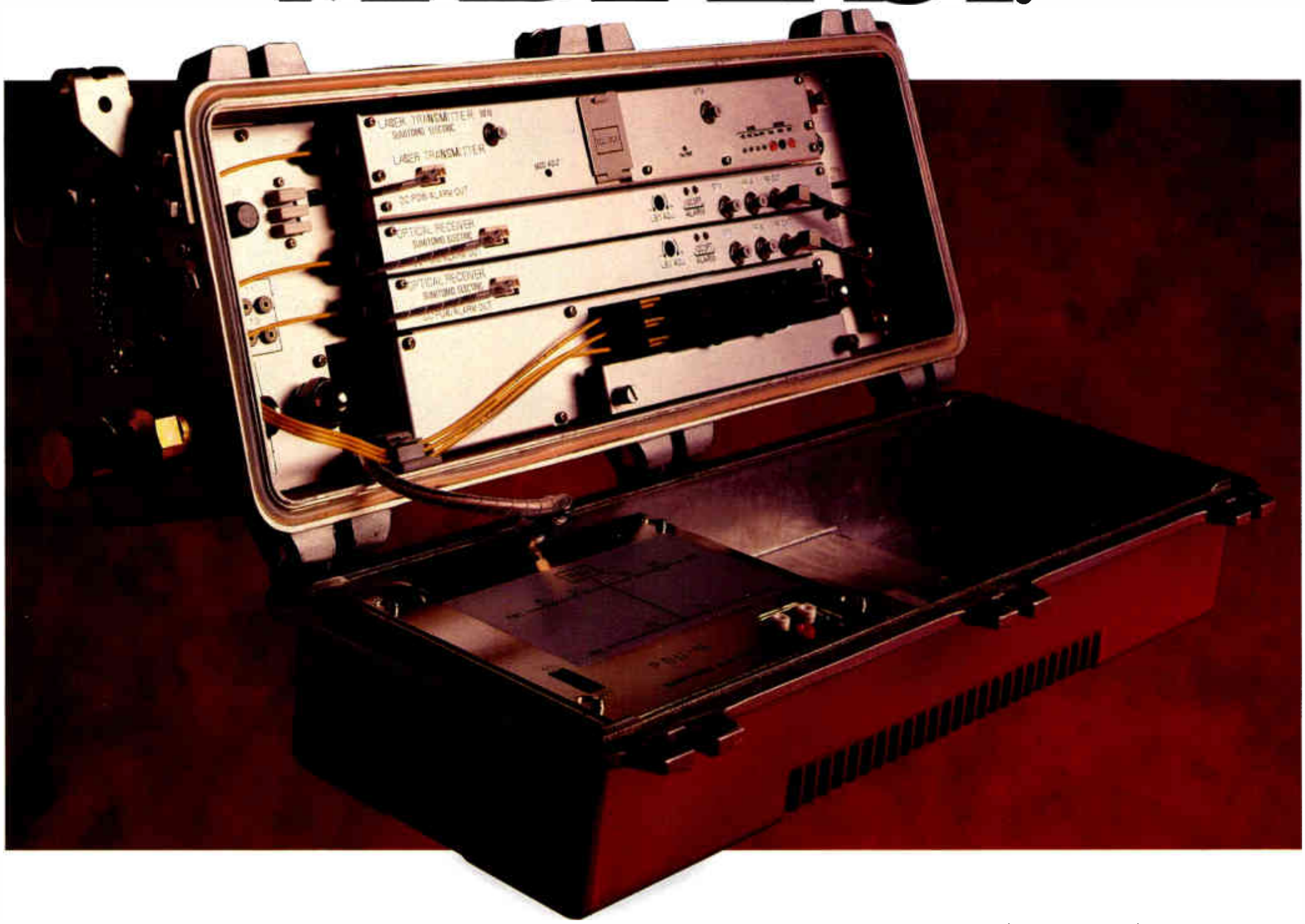
When evaluating optical fiber, certain routine optical and geometrical requirements can be evaluated and specified to qualify a product prior to cabling. Because of the effects of cable design and manufacturing, parameters such as maximum attenuation need to be specified for the end product.

A few examples of requirements and test procedures routinely encountered for optical fiber are as follows:

- Attenuation measurements will be made in accordance with EIA-455-61, OTDR Measurement or EIA-455-

	Optical Parameter	Test Procedures	Typical Requirement	Comments
7.	Mode Field Diameter (MFD)	EIA-455-164 EIA-455-165 EIA-455-166 EIA-455-167 EIA-455-174	8.7 µm ≤ MFD ≤ 9.5 µm ± 8% (Measured at 1300 nm)	In a single-mode fiber, light travels slightly into the cladding region. Controlling MFDs helps to provide compatibility between single-mode brands and minimizes splicing mismatch.
8.	Concentricity Error	EIA-455-45A EIA-455-176	Core to cladding offset ≤ 1.0 µm	Ensures light carrying portion of fiber is centered to allow proper splicing and connectorization.
9.	Cladding Diameter	EIA-455-45A EIA-455-176	125.0 µm ± 2.0 µm	Industry standard. Critical for low loss mechanical splicing and connectorization.
10.	Cladding Non-circularity	EIA-455-45A EIA-455-176	≤ 2%	Industry standard. Critical for low loss mechanical splicing and connectorization.
11.	Coating Diameter	EIA-455-55A EIA-455-173	250 µm nominal	Typical 250 ± 15 µm.
12.	Fiber Tensile Proof Test	EIA-455-31A	0.35 GN/m² (50 kpsi)	Test 100% of fibers to assure long term physical reliability.
13.	Coating Strippability	EIA-455-178 procedure.	Easily stripped with commercially available mechanical stripping tools. < 13.4 N of force to remove 30 mm of 250 µm diameter coating.	Important aspect for field installations.

OPTICAL NETWORK DESIGN MADE EASY.



Now enjoy the freedom of a true outdoor repeater, for unmatched flexibility on the strand. ■ You can quickly configure the new Sumitomo Electric Series II VSB-AM optical strand mount unit as two transmitters; a transmitter and two receivers; or up to four receivers. Fiber in, fiber out. ■ The unit comes complete with a built-in, three-tray splice center. Plus optional status monitoring and coax RF switching. ■ Placing this much capability on the strand will change the way you think about network design. And that's just the beginning of what you'll find in our new Series II product line.

SUMITOMO ELECTRIC
Fiber Optics Corp.

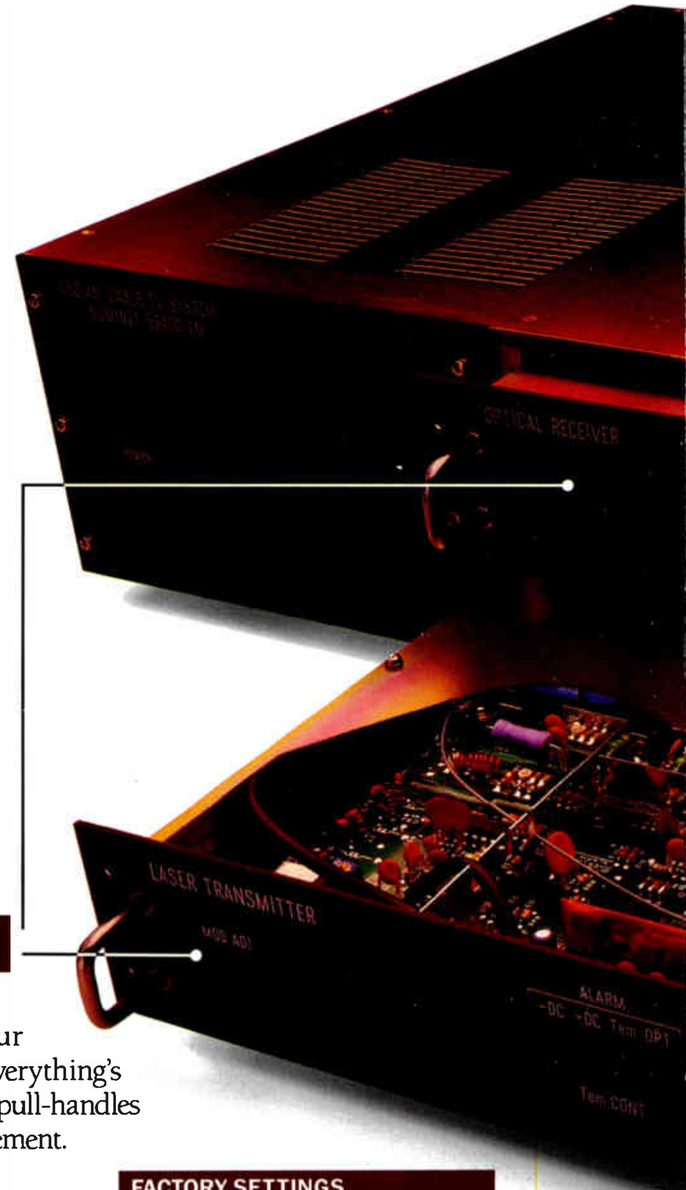
CONTINUED►

Rack Up Major Advantages From Sumitomo Electric.

Optical transmitters and receivers are not created equal. Sumitomo Electric has long been a leading designer and manufacturer of VSB-AM optical transmission equipment. One result is our new-generation Series II. It's transparently compatible with coax cable TV systems of up to 550 MHz, with built-in advantages like those shown here.

Uniform Specs Save Management Headaches

Anyone can give you best-of-the-bunch "hero" lasers that squeeze out an extra dB or so. But what happens when you face real-world maintenance, repair and replacement needs? Sumitomo Electric offers a saner approach: *lasers that meet uniformly high performance specifications in every unit we make.* Result: you get consistent high performance, plus components that are interchangeable throughout the network. Which makes for low-cost spare stocking — and makes managing the entire system a lot easier.



QUICK-CHANGE MODULES CUT DOWNTIME

If the need ever arises, you can swap out a subsystem to put your unit back on line in seconds. Everything's plugged or connectorized. The pull-handles help speed removal and replacement.

FACTORY SETTINGS MINIMIZE ADJUSTMENTS

All test points are accessed on the clearly labelled front panel. Inside, you set only the transmitter's depth of modulation and the receiver's RF level. Everything else is factory-set for optimum performance.

TOUGH STEEL COVERS PROTECT EVEN THE SUBSYSTEMS

Our philosophy: everything matters. Such as steel housings for added rack-unit durability. The assemblies have a carefully finished look about them, inside and out. It reflects good workmanship: the care and thought we put into every detail.

LASER ISOLATOR BOOSTS PERFORMANCE, STABILITY

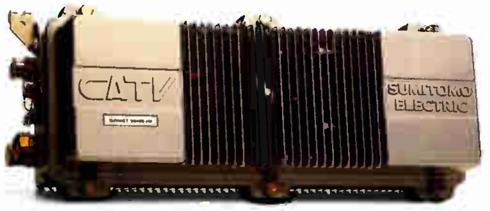
Not everyone's optical transmitter has an isolator, a reflection-cancelling device which helps optimize laser performance. Ours does.

SURFACE-MOUNT ELECTRONICS ADD NETWORK RELIABILITY

Look for neat, orderly packaging: no jumpers, no jerry-rigs, no confusion. Our advanced surface-mount electronics, all on one board, are measurably more reliable than conventional wiring and mounting. All of which minimizes downtime, simplifies network management.

VSB-AM Optical Transmitters And Receivers

More Packages, More Options
Permit More Flexible
Network Engineering

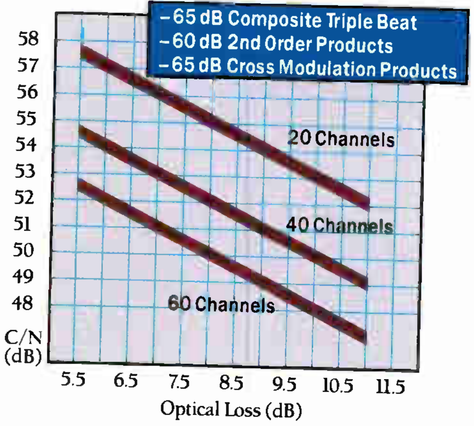


STRAND MOUNT. Install any combination of transmitters and/or receivers. Local alarms help quickly pinpoint system status.

RACK MOUNT. Two half-height transmitter and/or receiver units are supported by a single 2RU chassis/power supply.

POLE MOUNT. Rugged pole mount for optical transmitters and receivers.

Design Performance vs. Attenuation



SPECIFICATIONS — SUMINET 5840 SERIES II

RACK UNIT

	COAX RF		OPTICAL	
Transmitter	**IN**		**OUT**	
	Bandwidth	50-550 MHz	Source	DFB-LD
	Level	25±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Isolator	Yes
	Return Loss	14 dB Min	Avg Power	4 mW (set)
	Connector	F-Female	Output	Pigtail (5 m)
Receiver	**OUT**		**IN**	
	Bandwidth	50-550 MHz	Detector	PIN-PD
	Level	25±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Performance	SEE GRAPH
	Return Loss	14 dB Min	Input	Pigtail (5m)
	Connector	F-Female		

NOTE: Rack Mount Chassis Accommodates Two Units — Either Transmitters or Receivers or one of each.

STRAND UNIT

	COAX RF		OPTICAL	
Transmitter Forward	**IN**		**OUT**	
	Bandwidth	50-550 MHz	Source	DFB-LD
	Level	30±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Isolator	Yes
	Return Loss	14 dB Min	Avg Power	4 mW (set)
	Connector	Standard 5/8 x 24	Output	Pigtail (2 m)
Receiver Forward	**OUT**		**IN**	
	Bandwidth	50-550 MHz	Detector	PIN-PD
	Level	25±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Performance	SEE GRAPH
	Return Loss	14 dB Min	Input	Pigtail (2 m)
	Connector	Standard 5/8 x 24		
Transmitter Return	**IN**		**OUT**	
	Bandwidth	5-30 MHz	Source	DFB-LD or FP
	Level	30±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Isolator	Yes
	Return Loss	14 dB Min	Avg Power	4 mW (set)
	Connector	Standard 5/8 x 24	Output	Pigtail (2 m)
Receiver Return	**OUT**		**IN**	
	Bandwidth	5-30 MHz	Detector	PIN-PD
	Level	25±5 dBmV	Wavelength	1310 nm
	Impedence	75 ohms	Performance	SEE GRAPH
	Return Loss	14 dB Min	Input	Pigtail (2 m)
	Connector	Standard 5/8 x 24		

NOTE: Strand Housing accommodations: Up to 4 receivers or one transmitter (Forward or Return) and two receivers or two transmitters. Also, it can be configured as a repeater with one receiver and transmitter.

GENERAL	RACK UNIT	STRAND UNIT
Power	110/220 VAC 50/60 Hz 30 W/unit	30/60 VAC 50/60 Hz 30 W/unit
Operating Temperature	0° C to 40° C	−20° C to 50° C
Operating Humidity	Max 85% RH	Max 100% RH
Dimensions	EIA 19″ Rack Mount 3 9/10″ High (2 RU)	18¾″ L x 8″ H x 7″ D
Weight	25 lbs Max	25 lbs Max
Splice Ctr	—	3 Tray (12 Fibers)

Specifications are subject to change without notice.

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78, Spectral Attenuation Cutback.

- Single-mode attenuation change between 1285 nm and 1330 nm will be no greater than 0.1 dB/km versus the attenuation value at 1310 nm.
- Single-mode attenuation at the "water peak" will not exceed 3 dB/km. The central wavelength for the test procedure will be 1383 nm ±3 nm.
- The zero-dispersion wavelength shall be between 1300 nm and 1322 nm, and the maximum value of the disperion slope at the zero-dispersion wavelength shall be no greater than 0.095 ps/(km•nm^2). Measurement shall be made in accordance with either EIA-455-168, EIA-455-169 or EIA-455-175.
- The cutoff wavelength of cable single-mode fiber shall be less than 1250 nm. The cutoff wavelength of cable fiber shall be measured on a routine basis according to EIA-455-170.
- For conventional fiber at 1310 nm, the nominal mode field diameter shall be no less than 8.7 μm and no greater than 9.5 μm. The range for the specified nominal shall not exceed ±8 percent.
- Core concentricity for single-mode fiber shall be less than or equal to 1.0 μm.
- Outside cladding diameter shall be 125.0 μm ±2.0 μm.

These examples are some of the more common. A comprehensive list would be quite extensive and in some cases go beyond the level of detail needed.

To emphasize why the establishment of the standards is important and why the test procedures should be followed, two examples will be viewed more closely.

Water peak: The term refers to the increased spectral attenuation attributed to hydroxl contamination in optical fiber. It occurs in all silica based single-mode fiber peaking in the vicinity of 1380 nm. It limits the width of the 1310 nm transmission window. The spectral width affected by this phenomenon depends on the method of fiber manufacture. Generally, the higher the peak, the broader the base effect or the narrower the 1310 nm transmission window.

The problem with increased attenuation in the 1380 nm range is that it restricts the future utilization of wave-division multiplexing. Another problem is that lasers can inadvertently drift into these wavelengths, causing higher system attenuation.

Some customers tighten this requirement in their specification. The best

CHART II

OPTICAL CABLE SPECIFICATIONS

Measurement Techniques

	Cable Parameter	Test Procedure	Typical Requirement	Comments
1.	Low and High Temperature Bend Test.	EIA-455-37	Ave. fiber attenuation increase ≤ 0.20 dB. No mechanical damage under 10X magnification.	Important parameter for installed cable performance.
2.	Compressive Strength	EIA-455-41	Min. load of 440 N/cm (armored) or 220 N/cm (non-armored) with no increase in attenuation > 0.10 dB.	Force applied uniformly over sample length for 10 minutes.
3.	Tensile Strength of Cable	EIA-455-33A	≤ 0.10 dB ave. attenuation increase at rated tensile load. No measurable attenuation increase at long-term tensile rating. No jacket cracking or splitting.	Typical ratings are 2700 N short-term and 600 N long-term.
4.	Cable Twist	EIA-455-85	≤ 0.10 dB ave. attenuation increase. No jacket cracking or splitting under 10X magnification.	Insures mechanical integrity when cable is twisted.
5.	Cable Cycle Flexing	EIA-455-104	≤ 0.10 dB ave. attenuation increase. No jacket cracking or splitting under 10X magnification.	Predicts cable reliability under multiple flexing.
6.	Cable Freezing	EIA-455-98A	≤ 0.10 dB ave. attenuation increase. No jacket cracking or splitting under 10X magnification.	Indication of cable performance in frozen water.

	Cable Parameter	Test Procedure	Typical Requirement	Comments
7.	Resistance to Water Penetration	EIA-455-82A	One meter static head applied at one end of one meter of cable for one hour, no water to leak out other end.	Indication of effectiveness of filling/flooding compounds within the cable.
8.	Filling and Flooding Compound Flow	EIA-455-81 (Method A)	Compounds shall not drip or flow from a filled cable at 65°.	Upper end sealed to simulate actual installation conditions.
9.	Temperature Cycling	EIA-455-3A	≤ 0.20 dB/km change in attenuation (measured at 1550 nm) at extreme operational temperatures (-40°C to +70°C).	Temperatures should be maintained at extremes for 24 hours during cycling to allow for thermal equalization.

procedures. The duration of the test is such that it can be passed by incorporating various materials such as swellable tape or powders into the cable. This allows the cable to pass the test but is a short term block which will allow the compound to flow after saturation. This is where the "spirit" of the test rather than the letter becomes important. In general, you can assume manufacturers that recommend cable blocking kits for open ends have problems with cable flow.

Lightning damage susceptibility. Damage from lightning is always an issue when the cable contains metallic components. The obvious problem is fiber damage from electrical arcs. Specifications have typically addressed buried applications because the vast majority of aerial fiber optic cable deployed outside the CATV industry has been non-armored and primarily dielectric. The concern in the CATV industry regarding rodent damage to aerial cables has prompted a number of operators to specify armored cables for their systems. In these cases, a lightning specification is very applicable.

To ensure high reliability, it is recommended the system operators specify a 205 kA rating for cable lightning resistance. This is based on the fact that 95 percent of lightning strikes are 105 kA or less. Some companies specify higher values for their own reliability requirements. The limit of the Bellcore test is 200 kA. There are manufacturers that have standard product capable of meeting the 200 kA limit.

This snapshot of reasons for, and examples of, standards and procedures should provide a broad enough picture to generate interest regarding the incorporation of currently available projects. At the same time, the task of reviewing, comparing, adding to, and deleting from the currently available documents would be a tedious one. Some system engineers may have the time and desire to undertake such a study. For most, it would probably be easer for the basic groundwork to be provided and to allow for revisions as deemed necessary by experience and improved technology.

In an attempt to meet the requirements of most systems for fiber optic cable, two charts accompany this text. The first addresses optical fiber. The second addresses optical fiber cable. Following the charts is a "ready to use" Optical Cable Specification. Several manufacturers may exceed the requirements in some categories with standard product, and customers may opt to tighten specific requirements as they see fit. The purpose of the charts is not to set the highest possible standards (which may eliminate manufacturers with satisfactory product), but to establish a minimum for the protection of the cable operators and the reputable manufacturers that serve the CATV industry. The Cable Specification reflects actual requirements for high grade applications (e.g. AM systems). Again, some manufacturers may exceed this specification.

A final point in support of standards they help to reduce cost by allowing manufacturers to perfect basic processes and become more efficient. Also, standards ensure compatibility between different manufacturers' products, providing the system operator with competitive bidding and reduced inventory. Cable operators have already benefited in this way from the standards established in other industries.

The need for minimum standards and common test procedures for fiber optics has been validated over the past 10 to 15 years in other industries. The same need holds true for cable television. By incorporating the information provided by previous specifications and the basic specifications offered in this paper, system operators should save themselves valuable time and energy associated with climbing the learning curve of a "new" technology. ■

Optical Cable Specification

Optical Performance Specification

Attenuation @ 1310 nm	0.35 dB/km max/fiber
Attenuation @ 1550 nm	0.25 dB/km max/fiber
Attenuation Discontinuity Max @ 1310/1550 nm	0.1 dB
Attenuation @ Water Peak (1383 ± 3 nm)	<2.1 dB/km
Mode Field Diameter (matched clad)	9.5 ± 0.5 μm
Mode Field Diameter (depressed clad)	8.8 ± 0.5 μm
Dispersion Zero Crossing	1311.5 ± 10 nm
Dispersion Max @ 1310 ± 20 nm	2.6 ps/(nm x km)
Dispersion Max @ 1550 nm	17.5 ps/(nm x km)
Bending Loss @ 1550 nm	EIA RS-455-62
Fiber Proof Test	50 kpsi
Cladding Diameter	125.0 ± 2.0 μm
Concentricity Error (core/cladding offset)	1.0 μm
Cladding Non-Circularity	2.0%
Coating Diameter	250 ± 15 μm
Fiber Coating Color Code	Bellcore or REA Standard

Cable Performance Specification

Temperature Range	-40 to +70 C
Cutoff Wavelength	1250 nm
Min. Bending Radius (dynamic)	15 x Outside Diameter
Min. Bending Radius (static)	10 x Outside Diameter
Pulling Tension	600 lbs.
Polymetric Sheath Material	Black Medium or High Density Polyethlyene
Sheath Thickness (nominal)	1.4 mm
Continuous Length (no factory splices)	Up to 12 km
Length Markings	Every Meter
Resistance to Lightning	Bellcore TR-TSY-000020 Issue #4 EIA FOTP 181 Draft (Task Group FO-6-7-8) 15 μS Rise Time 40-60 μS Decay Time. Peak Current Resistance 105kA.

References

Bellcore TR-20: "General Requirements for Optical Fibers and Optical Fiber Cable", Bellcore Customer Service, 60 New England Ave., Room 1B252, Piscataway, NJ 08854-4196

REA PE-90: "REA Sepecifications for Totally Filled Fiber Optic Cable," Telecommunications Staff Division, Rural Electrification Administration, Washington D.C. 20250

EIA-472: "General Specifications for Fiber Optic Cables," Telecommunication Industries Association, Engineering Dept., 2001 Eye St. N.W., Washington, D.C, 20006


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Specifying AM fiber system performance

This paper discusses the methodology for specifying noise and distortion performance of AM fiber optic links. The relative merits of live video vs. unmodulated carrier measurement techniques are compared, and both theoretical and experimental data are presented to correlate the two methods. Also, the relationship between AM fiber system specifications, amplifier specifications and end-of-line performance is considered. Various performance tradeoffs are examined, and extensive analysis is presented to demonstrate the range of specifications that is appropriate for AM fiber systems.

Determining the reference frame

Over the past year, there has been a great deal of discussion with regard to the performance of AM fiber optic systems. Great effort has been undertaken to maximize the performance of DFB laser-based systems, and several alternative approaches have been and continue to be investigated. In order to compare the relative merits of the various options which are available, it is first necessary to establish a common frame of reference on which to base the comparison.

This reference frame consists of the methodology for measuring the video performance of a given system, and a common data set with which to express and compare that performance. The standard data set, which has been in use for a number of years in the cable industry and is defined in the "NCTA Measurements on Cable Television Systems," is the carrier-to-noise ratio, the composite triple beat and the composite second order. Each of these measurements describes the relative quality of a transmitted video signal in terms of a standard reference point.

While there is general agreement regarding the data to be measured and the procedure to follow, there are two contrasting views as to the correct signal source to be used for measurement: modulated video or unmodulated CW carriers. Both alternatives are included in the *NCTA Recommended Practices*, and each has its proponents.

The modulated video carrier method involves the measurement of the modulated output of a headend. The advantage of this method is that it is relatively simple to set up and execute the measurements, without requiring any additional equipment other than a spectrum analyzer, a variable attenuator and bandpass filters. Also, the measurements are made on the same signal that is transmitted to the cable system subscribers.

The disadvantage of using modulated video carriers is that the peak level of the carrier varies continuously over time. This is particularly significant because the composite triple beat and composite second order measurements are taken at the peak carrier level. In addition, the modulated carrier level peaks at approximately 75 percent of the maximum carrier level, except for the brief sync pulse intervals on each carrier when the level reaches 100 percent. As the number of carriers used in the composite signal increases, the likelihood of the sync pulses occurring simultaneously decreases, and thus the probability of ever reaching the 100 percent composite level also decreases.

Using unmodulated carriers as the signal source eliminates this problem, because the carriers are operated at 100 percent levels continuously. Thus, the advantage of the unmodulated carrier method is that it yields a consistent, repeatable measurement.

The disadvantage of the unmodulated carrier method is that it requires either the use of a matrix multichannel generator, or the removal of video modulation in a headend. The first alternative necessitates having an expensive piece of test equipment, and the second means turning service off for a period of time.

For specifying AM fiber system performance, the unmodulated carrier method is preferred. It has the distinct advantage of being both accurate and repeatable, which are the critical attributes for a measurement standard. It is also the standard method for specifying amplifiers, since ultimately fiber and amplifier performance must be considered together. The impractical nature of using unmodulated carriers in field testing situations is of no concern in this context. Rather, what is important for field usage is to establish correlation factors which will allow modulated video measurements to be referenced to the unmodulated carrier standard.

CW-to-modulation correlation

Recently published theoretical and experimental results indicate that correlation factors for CTB and CSO can be established with some certainty. A theoretical model employing computer simulation indicates a CW-to-modulation improvement factor of 12.3 dB for CTB and 8.2 dB for CSO. Reported experimental data ranges from 10.0 dB to 12.8 dB for CTB, and from 6.0 dB to 7.8 dB for CSO. As expected, carrier-to-noise ratios remain constant using either method. Thus, even using the minimum improvement we can infer CTB and CSO correlation factors of 10 dB and 6 dB, respectively.

The implications of these factors can be significant in evaluating AM fiber system performance. A system specified using CW carriers for a CNR of 51 dB, CTB of 65 dB and CSO of 62 dB would, if measured using modulated carriers, yield performance specifications of 51 dB CNR, 75 dB CTB and 68 dB CSO. This would afford the opportunity to increase the laser drive level in order to maximize measured carrier-to-noise performance, by trading off CNR vs. CTB in a 2:1 ratio, and trading CNR for CSO in a 1:1 ratio. Thus, the same system could be measured, using modulated carriers, with 56 dB CNR, 65 dB CTB, and 63 CSO. In other words, by varying the laser drive level to equalize measured distortions, a 5 dB CNR CW-to-modulation improvement factor can be derived.

Required AM fiber performance

For the purpose of this analysis, the performance needed at the end of the last tap will be assumed to be 45 dB

By John A. Mattson, marketing manger, transmission systems division, Scientific-Atlanta

CNR and 53 dB CTB and CSO. Because amplifiers are specified for discrete second order (DSO), a 7 dB correction factor will be used to convert CSO to DSO. For example, a fiber system's CSO specification of 62 dB was converted to 69 dB DSO, and an end-of-line DSO of 63 dB was converted to 56 dB CSO.

Throughout the analysis, a 450 MHz bandwidth has been used. In order to investigate the effect of various AM fiber performance levels on end-of-line performance, the length of the post-fiber trunk cascade and the trunk, bridger and line extender amplifier technology have been varied. In all cases one bridger and two line extenders were used. Trunk, bridger and line extender output levels were held constant at 36, 48 and 45 dBmV, respectively. Trunk cascades of 8, 15 and 20 were tested.

The reference case for amplifier technologies was established as feedforward trunks and parallel hybrid bridgers and line extenders. The analysis was also conducted using "PT" bridgers (advanced parallel hybrid) and push-pull line extenders. Every possible combination of these five amplifier technologies was tried at each of the three trunk cascade lengths. (Amplifier specifications are given in the Appendix.)

Figure 1

Required AM Fiber Performance Specifications

End-of-line objective: 45 dB CNR, 53 dB CTB, 53 dB CSO

Feed Forward Trunk Cascade	Bridger Technology	Line Extender Technology	CNR	CTB	CSO
8	PHD	PP	47.0	----	55.0
8	PHD	PHD	47.0	65.0	54.5
8	PT	PP	47.0	67.0	54.5
8	PT	PHD	47.0	60.0	54.0
15	PHD	PP	50.0	----	55.0
15	PHD	PHD	50.0	68.0	54.5
15	PT	PP	50.0	70.0	54.5
15	PT	PHD	50.0	62.0	54.0
20	PHD	PP	53.0	----	55.0
20	PHD	PHD	53.0	71.0	54.5
20	PT	PP	53.0	75.0	54.5
20	PT	PHD	53.0	63.0	54.0

Legend
PP = Push-Pull
PHD = Parallel Hybrid
PT = Advanced Parallel Hybrid

Fiber vs. end-of-line performance

The data in Figure 1 shows the trade-offs that are possible between fiber and amplifier performance. Depending on the amplifier technology used and the length of the trunk cascade, required fiber CNR to achieve 45 dB end-of-line CNR may vary from 47 dB to 53 dB. Required fiber CTB varies from 60 dB to 68 dB, with the exception that it is not possible to achieve the end-of-line objective of 53 dB CTB using parallel hybrid bridgers and push-pull line extenders. The required fiber CSO falls in a narrow range from 54 dB to 55 dB.

This data indicates that CTB is by far the more critical of the distortion specifications. This is not surprising, because CTB dominates in amplifier distortion analysis as well. In the range of performance normally expected for composite second order distortions in cable systems, CSO is not a factor in the end-of-line calculations.

As might be expected, improvement in the CTB performance of the amplifier cascade leads to signficant reductions in the required fiber CTB performance. The amplifier CTB can be upgraded both by reducing the length of the trunk cascade, and by upgrading the technology used for the bridger and line extenders. The biggest gain in CTB performance is achieved by upgrading from push-pull to parallel hybrid line extenders. Using PT bridgers leads to significant improvement as well, particularly as the cascade is lengthened.

Testing performance specs

As a result of this analysis, the

Figure 2

End-of-Line Impact of AM Fiber Performance Improvements

CNR Variation

Fiber System CNR:	49.0	50.0	51.0	52.0	53.0	54.0	55.0	56.0	57.0
End-of-Line CNR									
8 amp cascade:	46.1	46.6	47.0	47.4	47.7	48.0	48.2	48.4	48.6
15 amp cascade:	44.8	45.2	45.5	45.7	46.0	46.1	46.3	46.4	46.5
20 amp cascade:	44.1	44.4	44.7	44.9	45.0	45.2	45.3	45.4	45.5

CTV Variation

Fiber System CTB:	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0	71.0
End-of-Line CTB									
8 amp cascade:	52.4	52.7	53.0	53.2	53.4	53.6	53.8	54.0	54.1
15 amp cascade:	51.9	52.1	52.4	52.6	52.8	53.0	53.2	53.3	53.5
20 amp cascade:	51.5	51.8	52.0	52.2	52.4	52.6	52.7	52.9	53.0

CSO Variation

Fiber System CSO:	54.0	55.0	56.0	57.0	58.0	59.0	60.0	61.0	62.0
End-of-Line CSO									
8 amp cascade:	52.8	53.6	54.3	54.9	55.5	56.0	56.5	56.9	57.3
15 amp cascade:	52.8	53.5	54.2	54.8	55.4	55.9	56.4	56.8	57.2
20 amp cascade:	52.8	53.5	54.2	54.8	55.4	55.9	56.3	56.7	57.1

Note: Feedforward trunks, 1 parallel hybrid bridger, and 2 parallel hybrid line extenders used in all cases.

appropriate range of performance required of AM fiber systems to achieve the stated end-of-line performance objectives has been established. Next, the effect of increasing the performance specifications of the AM fiber system was investigated.

For this portion of the analysis, the reference specifications were set at 49 dB carrier-to-noise, 63 dB CTB and 54 dB CSO. Each was increased upward in 1 dB increments. The results are shown in Figure 2. It is apparent from the data in Figure 2 that in the range of performance being investigated, each decibel of improvement in fiber system CNR yields a corresponding end-of-line improvement of 0.2 dB to 0.3 dB. Likewise, for each decibel of CTB improvement in the fiber system, 0.2 dB was realized at the last tap, and the corresponding CSO increase was 0.4 dB to 0.5 dB.

The data in Figure 2 also indicates the effect of changing the length of the cascade. Reducing the cascade from 20 to 15 accounts for about a 0.7 to 1.0 improvement in CNR, with an additional 1.3 dB to 2.1 dB improvement by reducing the cascade from 15 to eight. The CTB performance is improved by about 0.5 dB in each reduction in the cascade, and the CSO performance is essentially unchanged.

Conclusions

The appropriate specifications for measurement of the performance of AM fiber systems are carrier-to-noise ratio, composite triple beat and composite second order. In order to make these measurements, either modulated or unmodulated CW carriers may be used as the signal source. The unmodulated carrier is preferred because it is consistent and repeatable.

Nevertheless, the modulated carrier method is in widespread use, and it is much more practical to carry out in a cable system. Therefore, correlation factors to convert from one method to the other are needed. While theoretical calculations suggest factors of 12 dB for CTB and 8 dB for CSO, experimental results tend to indicate that the somewhat smaller figures of 10 dB for CTB and 6 dB for CSO are appropriate. If the system is optimized for CNR, a 5 dB conversion factor should be used.

In all cases, the CSO required was well within the range of available AM fiber technology; the required CNR was also within the range of existing AM fiber technology. The required CTB performance varied over a wide range, and in some cases it exceeded the limit of generally available AM fiber equipment. However, by carefully selecting the amplifier technology and the trunk cascade length, the CTB performance needed from the fiber system can be set at easily achievable levels.

Increasing the performance of an AM fiber system has limited effect on the end-of-line performance, particularly as the trunk cascade length increases. With a cascade of 15 trunk amplifiers, it would take anywhere from 4 dB to 6 dB improvement in fiber CNR or CTB to realize a 1 dB improvement at the last tap. On the other hand, much larger improvements are attainable by upgrading the bridger and/or line extender technology, as well as by reducing the trunk cascade.

The results of this analysis indicate that the range of performance required to meet reasonable end-of-line objectives is attainable with existing AM fiber technology. Achieving the desired cost and performance targets for a given system design depends on the

Appendix

Amplifier Specifications

Equipment:	Feed Forward Trunk	Parallel Hybrid Bridger	PT Bridger	Push-Pull Line Extender	Parallel Hybrid Line Extender
Noise Figure (dB):	10.0	7.5	9.0	9.0	9.0
Distortion Reference:	33.0	46.0	46.0	46.0	46.0
CTB Rating (dB):	-99.0	-66.0	-73.0	-62.0	-67.0
DSO Rating (dB):	-92.0	-70.0	-73.0	-70.0	-73.0
Operational Tilt:	3.0	7.0	7.0	7.0	7.0
Level Control:	AGC	N/A	N/A	thermal	thermal
Channel Capacity:	62	62	62	62	62
Amplifier Input (dBmV):	10.0	16.0	16.0	13.0	14.0
Operational Gain:	26.0	32.0	32.0	32.0	31.0
Amplifier Output (dBmV):	36.0	48.0	48.0	45.0	45.0

specific requirements and operating parameters, but the existing AM and amplifier technology provides the tools to reach the goal. ■

References

McEwen, Doug; Slater, Norm; Strauss, Tom; and Pidgeon, Rezin. "Distortion Characteristics of Integrated Fiber, AML and Cable Amplifier Systems," CCTA Convention Papers, 1990.

Williamson, Louis. "Laboratory vs. Field Measurement of AM Optical Links—Reconciling the Differences," SCTE Fiber Optics Papers, 1990.

Slater, Norm; McEwen, Doug. "Limited Non-Linear Distortions in 400+ MHz Systems," CCTA Convention Papers, 1984.

Arnold, Bert. "Composite Triple Beat Measurements," NCTA Convention Papers, 1975.

Pike, Dan. "The Measure and Perceptibility of Composite Triple Beat," NCTA Convention Papers, 1979.

NCTA Recommended Practices for Measurements on Cable Television Systems, National Cable Television Association, First Edition, 1983.

AM fiber trunking field performance guide

The deployment of fiber optic trunking systems out of the lab and into the field is now so widespread that a basic industry primer is needed to identify and answer the key questions of maintaining this new system technology application and keep it operating and peak efficiency.

Now is the time to start thinking about the care and maintenance of fiber links in AM fiber video distribution systems—whose technical requirements are markedly different than their FM broadband and digital counterparts.

The introduction of fiber plant in CATV distribution systems is expected to improve the performance, reliability and cost of cable video signal distribution. However, the fiber link or connection to fiber optic transmitters and receivers can be the site of more than a few trouble spots in the fiber link.

This article will review specific approaches and tools necessary to install and maintain AM fiber optic video distribution systems. It will suggest procedures to prepare for the installation of a fiber link, as well as actual installation of transmitter, receiver and other equiment. Finally, it will review some of the typical failures likely to crop up in higher performance fiber trunking systems and examine how to troubleshoot effectively to harness the full power and benefit of this exciting new technology.

Getting started: The right tools

Every system technician or engineer is familiar with the standard CATV tool box that contains test equipment and tools for quick troubleshooting or on-the-spot repairs. Usually these include a signal level meter, a volt-ohm meter, spectrum analyzer and a selection of hand tools, including wrenches, screwdrivers and alignment tools.

In the AM fiber video distribution system, however, specialized tools and test equipment are required to keep the system in tune. This list of essentials for fiber installation and maintenance will get you through just about any situation or crisis:

- an optical power meter
- an optical time domain reflectometer (OTDR)
- an optical power source
- a fusion spicer
- a splice preparation kit

A technician checks a fiber link.

- tools for splice enclosures.

Not every system needs its own fusion spice, which can run in the neighborhood of $30,000 each. Units can be shared among systems, or systems with significant fiber installation can obtain access to one through their fiber contractor.

While the above list outlines the basic kit for installation, a maintenance kit is expanded and the essentials should normally include:

- alcohol
- lint-free cleaning wipes
- spare connectorized pigtails
- emergency splices.

Many problems, including video picture distortion and low optical power at the receiver, are the result of dirty mechanical connectors. So keep enough alcohol and wipes around to troubleshoot this common irritant.

Planning ahead for the installation of a fiber link can save your system a lot of headaches. A systematic approach will ensure that all the bases are covered—from signal levels, powering requirements, and the fiber itself to the interface between the fiber plant to the fiber optic transmitting, receiving and amplifying equipment.

Don't be lulled into thinking there's nothing much to do while you wait for the optical transmitters and receivers to arrive. When the fiber link is already in place, there is in fact plenty to do before the equipment shows up.

Check signal levels. Prepare for a smooth and trouble-free installation by checking the type and level of signal being supplied. The number of transmitters will determine the required signal levels.

Band splitting. With today's higher power AM lasers, there's little need for solely point-to-point fiber links. There are many economical options available with two-, four- and even eight-way splitters.

Optical splitters can separate a single laser transmitter's signal into multiple paths, feeding multiple optoelectronic receivers. When preparing for the fiber link, check all equipment configurations to make sure the channels are split and combined correctly to feed into the right transmitters.

Also consider all powering requirements for both the transmit and receive locations before installation of the fiber link.

If a full-fledged system with multi-bundle fibers is slated for installation, it will also be important to know how each fiber is going to be used.

Know thy fiber

Any preparation for installation of the fiber link requires a quick and thorough tour of the fiber plant. As a manufacturer of optical components, we recommend the following procedures:

- Identify selected fibers for their specific use, including whether they're to be spliced or connected. External plant can be miles long and if a problem arises, clearly identified fiber plant

By Chuck Moore, Cableoptics applications engineer, Jerrold Communications

will help facilitate problem solving.

- Know and verify the continuity and loss measurement of all identified fiber. Use an OTDR to measure any light loss along the fiber. Most systems involved in rolling out fiber plant should have access to this diagnostic device. The OTDR reads the amount of light being reflected back through the fiber and allows evaluation of the state of the fiber based on this light reading, especially measurement of signal loss across the fiber.
- Use power meters to measure loss at connector sites and at the bare fiber adaptor.

Fiber to equipment interface

The equipment has arrived: What's next? Prepare the environment for a seamless interface of fiber plant to all fiber optic equipment.

Identify the location for all transmit and receive equipment—whether indoor or outdoor. Know which splicing techniques you'll use and where you'll employ them, giving weight more toward return loss than insertion loss. Placement and type of mechanical connectors should also be considered.

The risks in using mechanical splices, even in the case of good splices in terms of insertion loss, point to excessive reflection. While data seems to indicate that the new generation of mechnical splices offer performance close to fusion splicing, environmental factors from temperature and weather loss could result in deteriorated splice return loss from the time of original installation.

Recommended is the use of fusion splicing, primarily because of excellent return loss and insertion loss of typically 0.05 dB per splice or better.

An all fusion-spliced fiber link is ideal for AM CATV performance, but this isn't always possible. The real challenge is achievement of acceptable insertion loss and minimization of reflection risk.

In terms of connectors, proper cleaning of the fiber ends for each connect or re-connect is essential for a number of reasons, but primarily because dirt and fingerprints cause reflections and dampen AM fiber performance, particularly at the transmitter connection.

Ready, set, install

Ensuring proper installation of all the equipment that will interface to the fiber plant is a several step process. For installation of transmitters, power them up and test all vital signs and outputs to make sure they are fully functional.

Check voltage test points. If there are test points for the transmitter unit, use measurement equipment to test them. Check for:

- laser bias
- laser temperature
- cooler current
- optical power
- any indication of laser fault.

Apply signals to the transmitter. The next step in the process of installing the optical transmitter is to apply signal to the unit. You'll need to attach both RF and fiber optic cables to check and measure:

- RF test points
- RF drive-level indicators
- make any adjustments to the proper levels.

Check transmitter power output. Here, simply use a power meter to examine the power outputs of the unit.

All output levels should be recorded for later reference.

The installation of receiver units follows much the same procedure as the transmittter, except that testing is directed to measuring the quality of the light transmitted to the receiver.

- Check the voltage supply
- Check the optical power at the end of the fiber by using a connector on the power meter and using a bare fiber adapter on the power meter if the receiver is to undergo fusion splicing.

If the power is low or nonexistent, refer to the common troubleshooting techniques mentioned shortly. If the power is correct, adjust the unit to its proper output level. Consider adjusting the padding as necessary and making adjustments to the level control as needed.

Fiber test facility.

Fiber troubleshooting

There are a number of common recurring failures in the fiber link that require troubleshooting. Generally, most problems are external to the equipment itself and point to things that went wrong in the installation and testing process, such as broken fibers, poorly adjusted or dirty connectors or laser/receiver problems.

In order to avoid Murphy's Law—where anything than can go wrong, will go wrong—it is worthwhile to be prepared to handle any and all of the common problems that arise. After all, forewarned is forearmed.

No optical power at the receiver location. Problems in this area point to a number of things that can go wrong, including:

- broken fibers
- defective connectors
- transmitters that are defective or not powered.

Low optical power at the receiver. It's important to measure optical power at the receiver to ensure an adequate level of output from the receiver. As a general rule, keep in mind that a 1 dB increase in optical loss is likely to decrease the receiver output by 2 dB.

While the causes of low power at the receive site are numerous, they typically include one or more of the following:

- defective or dirty connectors
- pinched fiber
- inaccurate measurement of the fiber link
- inaccurate measurement with OTDR
- improper configuration of optical splitters, such as the legs interchanged.

Connectors can be a real problem if not dealt with consistently. Any time a connector is opened up, clean it. Dirty or defective connectors cause excessive loss in the fiber path and physical impairment of the picture quality.

Inadequate signal level at the receiver location. As more and more

Preventative maintenance is a growing concern in fiber optic technology.

optical transmitters are loaded into the headend, the signal level requirements will become more and more of a concern. Consult the equipment specifications to make sure that the correct level of the signal is being provided to the operating units. When there are insufficient signal levels, there also won't be enough power to generate adequate signal to the receive location. This is typically caused by:

- improperly adjusted transmitter/receiver
- excessive fiber loss
- defective transmitter/receiver.

Once the transmitter is supplied with correct operating levels, make all necessary adjustments. Transmitters must be adjusted to their normal operating point, an important factor in driving the laser to achieve its desired performance.

Unit adjustment can be preset by the manufacturer or is done by the users. Only when ideal transmitter operating levels are verified can you go on to adjust the receiver for its desired output performance.

Distortion in the video picture. Distortion is normally caused by:

- distortion in signals applied to the transmitter
- poorly adjusted transmitter or receiver
- fiber that is defective, broken or barely touching
- mechanical connectors that are loose or dirty
- excessive channel load on the fiber.

In one system, field engineers found that mechanical connectors caused a significant amount of reflection, detectable using an OTDR. The recommended solution is to replace mechanical connectors with fusion splicing.

In the best of all possible worlds, nothing goes wrong with the installation of the fiber link. But in the real world, you need to keep a high-technology, high-performance AM fiber video distribution system running. The emerging world of fiber optics means that new tools and techniques must be added to the system technician and engineer's care and maintenance repertoire.

By following some of the procedures discussed here, and understanding how to apply common sense troubleshooting to problems in the fiber link, the true elegance, power, efficiency and compatibility of AM fiber optic distribution systems will continue to shine through for years to come. ■

Ad Index

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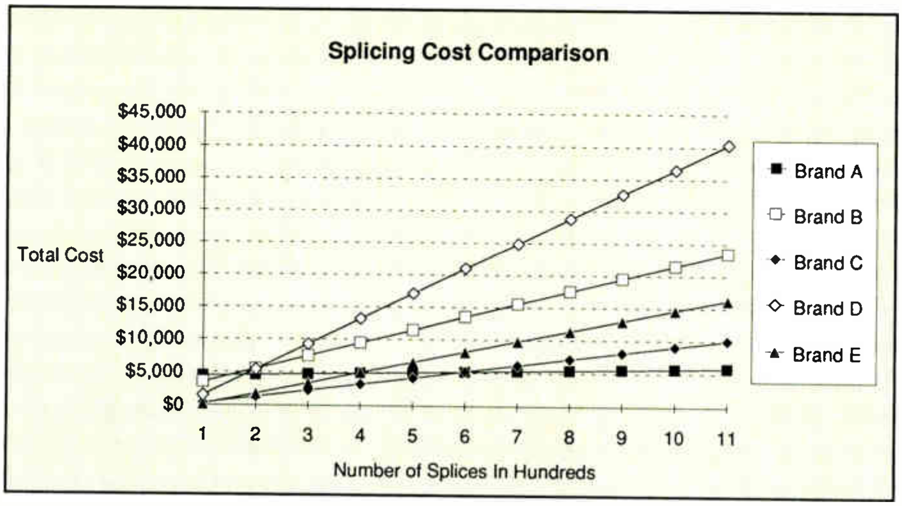
Fusion splicing technologies

As cable systems install and utilize larger quantities of fiber optic cable and laser equipment, the need to perform reliable splices has become a necessity. Craft sensitivity, training, complexity, cost and reliability are the topics of concern with every fiber splice made today.

Fusion splicing advantages

Fusion splicing has been used over the years and has evolved from the original condition of needing very special handling—such as a splicing van dedicated to protecting the environment—to today's automated equipment, can be utilized virtually anywhere. Fusion splicing provides unquestionable integrity over time, and eliminates worry associated with adhesive or mechanical splices that can relax due to vibrations and aging.



Total Cost

Splices	Brand A	Brand B	Brand C	Brand D	Brand E
0	$4,500	$3,500	$350	$1,516	$200
100	$4,631	$5,500	$1,318	$5,406	$1,800
200	$4,762	$7,500	$2,286	$9,296	$3,400
300	$4,893	$9,500	$3,254	$13,186	$5,000
400	$5,024	$11,500	$4,222	$17,076	$6,600
500	$5,155	$13,500	$5,190	$20,966	$8,200
600	$5,286	$15,500	$6,158	$24,856	$9,800
700	$5,417	$17,500	$7,126	$28,746	$11,400
800	$5,548	$19,500	$8,094	$32,636	$13,000
900	$5,679	$21,500	$9,062	$36,526	$14,600
1000	$5,810	$23,500	$10,030	$40,416	$16,200

Reflections, which are inherent in all mechanical splices and can adversely affect the transmission of high speed signals and video, are eliminated with fusion splicing. Reflections are even more critical as splices are performed closer to the output of laser transmitters. Because the short length of the pigtails on the outputs of laser equipment, it may be difficult to find a bad mechanical splice with an optical time domain reflectometer (OTDR).

Splices performed using fusion techniques take less time to complete. The curing process is eliminated with fusion, and hand polishing is not required. Other than preparing and stripping the cable, which is the same for either a mechanical or fusion process, the only glass preparation necessary with fusion techniques is a cleaning with isopropyl alcohol or acetone, and a cleaving tool.

Fusion splicers provide the technician with a clear, magnified view or views of the fiber ends, which is needed to assess the quality of the fiber end preparation (cleaving). A clear view of the completed splice is also provided with the fusion splicers, which allows the technician to assess the visual quality of the splice.

Low cost fusion splicing equipment is available that will allow a relatively small project requiring 250 splices to be completed at half the cost per splice of mechanical types. The benefit of purchasing a fusion splicer even for small jobs is that you still own a splicer when the system is completed, instead of an empty box that once contained mechanical splices.

Current splicing technologies

The splicers available today are of compact size and rugged construction for use almost anywhere—even within a splice enclosure. They are simple to operate and quickly restore service in emergency situations. Lower cost units provide typical splice loss of 0.2 dB or below on singlemode fibers and 0.1 dB or below on multimode fibers.

The higher end products are actually splicing systems, which are menu-driven, automated devices. These machines position the fibers, inspect the prepared ends, clean them and align the fiber cores in the vertical and horizontal directions. When the cores are perfectly aligned, an electric arc is turned on to melt the glass while the ends are fed together. Then the resulting splice is inspected and evaluated with the final loss estimate displayed on the screen. The entire automatic process takes less than a minute and produces quality splices even for inexperienced splicers.

As the price ranges for fusion splicers can run from $5,000 to $40,000 it is advisable to shop the functions, features and benefits of the units available today. The attached chart has been plotted based on the number of splices versus total cost. The graph shows flat and increasing cost plots. The flatter plots are for fusion type splicers, and the increasing plots are for mechanical splices. Any reference to specific manufacturers has been omitted to avoid bias.

The use of fiber optic cables for communications has been around for many years. The need to splice fiber has been around just as long. In the CATV systems of today, it makes sense to take the lead from other industries. Application of mature technology does not require that we reinvent the wheel. Talk with the engineering communities of other industries about the advantages and disadvantages of splicing systems. Your application of technology can make the difference between a maintenance free network and one that requires constant baby sitting. ■

By Scott Henry, applications engineer, Midwest CATV

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The following companies have paid a fee to have their listing appear in the Fiber Optic Callbook

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Englewood, CO 80111
PERSONNEL: Tim Gropp, National Sales Manager: CATV; Ron Causey, Account Executive: CATV
DESCRIPTION: AT&T is a manufacturer of optical fiber, optical fiber cable, and lightwave transmission systems for cable TV. AT&T also supplies turnkey installation services. Anixter Cable TV is the sole supplier of AT&T products.

Belden Wire and Cable . .(317) 983-5200
FAX . . . .(317) 93-5294
2200 US 27 South
Richmond, IN 47374
PERSONNEL: Phil Dunn, CATV Sales Manager; Phil Pennington, Regional CATV Manager
DESCRIPTION: Belden offers a complete line of armored and non-armored fiber optic SuperTrunk™ cables in two styles. Belden offers multi-fiber per tube and a bundled fiber optic cable. Both styles are offered in fiber counts from 6-72 fibers. Belden also offers a turnkey package from design to installation from a network of authorized systems integrators.

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

Comm/Scope, Inc. . . . . . .(704) 324-2200
WATS (National) . . . . . .(800) 982-1708
WATS (State) . . . .(800) 222-6808
FAX . . . .(704) 328-3400
1375 Lenoir Rhyne Blvd., P.O. Box 1729
Hickory, NC 28603
PERSONNEL: Paul Wilson, Lynn Sigmon
DESCRIPTION: Supplier of high quality Optical Reach™ fiber optic cables employing depressed clad fibers in buffered tubes. Optical Reach is available in many constructions and fiber counts.

Corning Incorporated . . .(607) 974-4411
Telecomm. Prods. Div.
FAX . . . .(607) 974-7522
MP-RO-03
Corning, NY 14831
PERSONNEL: Scott Esty, Cable TV Market Development Manager; Bill Willson, Sales Manager, Coupler Products
DESCRIPTION: Corning Incorporated manufactures a full line of optical fiber and components to meet today's demanding cable TV applications. Products include: Corning™ Fiber—Titan™ single-mode fiber, SMF/DS™ single-mode dispersion-shifted fiber—and Corning™ Couplers, both multimode and single-mode tree, star, tap and WDM couplers.

Siecor Corp. . . . .(704) 327-5554
FAX . . . .(704) 327-5973
489 Siecor Park
Hickory, NC 28603-0489
PERSONNEL: Sandy Lyons, 704-327-5806; David Johnson, 704-327-5895
DESCRIPTION: Siecor manufactures a variety of fiber optic cable designs for aerial, direct buried, duct installations. Loose tube design is rugged, easy to handle and provides superior environmental protection. Modularity simplifies fiber drop-off and mid-span access. Also supplies splicers, testers, training, services.

Electro Optics

AT&T . . . .(303) 740-6102
FAX . . . .(303) 694-3977
8101 E. Prentice Ave., Suite 210
Englewood, CO 80111
PERSONNEL: Tim Gropp, National Sales Manager: CATV; Ron Causey, Account Executive: CATV.
DESCRIPTION: AT&T is a manufacturer of optical fiber, optical fiber cable, and lightwave transmission systems for cable TV. AT&T also supplies turnkey installation services. Anixter Cable TV is the sole supplier of AT&T products.

AMERICAN LIGHTWAVE SYSTEMS, INC.

American Lightwave . . . .(203) 265-8802
Systems, Inc.
FAX . . . .(203) 265-8746
358 Hall Ave.
Wallingford, CT 06492-1149
PERSONNEL: John Holobinko, VP/Marketing & Sales; Rod Andersen, Regional CATV Sales Manager
DESCRIPTION: ALS LiteAMp™ AM fiber optic and FN6000™ FM fiber optic systems are designed for easy installation by normal CATV personnel without special optical training, yet they feature high performance and no periodic maintenance adjustments. ALS systems are completely modular. LiteAMp is available in strand, pole, pedestal and rack mounts. FN6000 and LiteAMp offer advanced features not found on competitive systems, based on ALS' 12 years of CATV fiber experience, more than twice any other vendor.

Amoco Laser Company

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

BT&D TECHNOLOGIES

BT&D Technologies . . . .(302) 479-0300
FAX . . . .(800) 545-4306
2 Righter Pkwy.
Delaware Corporate Center, Ste. 200
Wilmington, DE 19803
PERSONNEL: William G. Morrel, Prod. Mkt. Mgr. Passive Components; Kenneth Miller, Sales Engineer
DESCRIPTION: BT&D is a volume manufacturer of fiberoptic components for use in SONET/SDH, FDDI, CATV, and

Local Loop applications. Products range from ELEDS, lasers and PIN detectors to integrated function modules, passive couplers, splitters, switches and advanced products. BT&D's Subscriber Loop Coupler can be used in a variety of applications.

C-COR®
ELECTRONICS INC

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

CORNING

Corning Incorporated . . .(607) 974-4411
Telecomm. Prods. Div.
FAX . . . .(607) 974-7522
MP-RO-03
Corning, NY 14831
PERSONNEL: Scott Esty, Cable TV Market Development Manager; Bill Willson, Sales Manager, Coupler Products
DESCRIPTION: Corning Incorporated manufactures a full line of optical fiber and components to meet today's demanding cable TV applications. Products include: Corning™ Fiber—Titan™ single-mode fiber, SMF/DS™ single-mode dispersion-shifted fiber—and Corning™ Couplers, both multimode and single-mode tree, star, tap and WDM couplers.

CABLEOPTICS

Jerrold Communications .(215) 674-4800
General Instrument
WATS (National) . . . . . .(800) 523-6678
WATS (State) . . . .(800) 562-6965
FAX . . . .(215) 672-5130
2200 Byberry Rd.
Hatboro, PA 19040
PERSONNEL: David Robinson, Director of Cableoptics; Geoff Roman, VP of Marketing
DESCRIPTION: Designer/Manufacturer of the industry's most comprehensive line of electronic and fiber optic broadband communications equipment. Jerrold Starlite Cableoptics™ equipment supports both FM supertrunk and AM backbone distribution applications. The company's RF distribution and headend gear provide a complete opto-electronic product line for cable TV and LAN systems.

MAGNAVOX
CATV SYSTEMS CO.

Magnavox CATV Systems .(800) 448-5171
WATS (State) . . . .(800) 522-7464
FAX . . . .(315) 682-9006
100 Fairgrounds Drive
Manlius, NY 13104
PERSONNEL: John Caezza, Product Manager; Rick Haube, Fiber Optic Product Specialist
DESCRIPTION: Manufacturer of video and data transmission systems, FM video transmission systems to include FM modulators/demodulators, laser diode transmitters, and optical receivers. AM fiber optic transmission systems to include rack mounted transmitters and rack or strand mounted receivers. Also a supplier of Amplitude modulated headend equipment.

NORTHERN
TELECOM

Northern Telecom . . . . .(404) 661-5000
FAX . . . .(404) 395-5000
One Ravinia Drive
Atlanta, GA 30346
PERSONNEL: Tim Grimsley, Area Sales Manager; John Park, Area Sales Manager
DESCRIPTION: Northern Telecom Limited is a leading global supplier of fully digital telecommunications switching systems. The Optical Cable Division develops, manufactures and markets a complete line of fiber optic products including splicing and jointing, test products and optical connectors. Our line of optical cable and outside plant products is fully complementary to Northern Telecom's FiberWorld family. (A supplier to CATV.)

OPTICAL CABLE CORPORATION

Optical Cable Corp. . . . .(800) 622-7711
FAX . . . .(703) 265-0724
PO Box 11967
Roanoke, VA 24022-1967
PERSONNEL: Luke J. Huybrechts, VP, Sales; Robert Kopstein, President
DESCRIPTION: Optical Cable Corporation manufactures a complete line of fiber optic cable products for video, voice, data communications and local area networks applications. The tight buffered cable design is easily terminated and suitable for inside building and outside plant environments as well as aerial, burial and duct environments. A-series jumper cables, B-series breakout cables, D-series trunking cables, military tactical field, plenum and riser cables. All cables are manufactured with communication grade fibers. Sales are made to end-users, OEMs, installers, contractors and through distribution.

ORCHARD®
COMMUNICATIONS

Orchard Comm., Inc. . . .(203) 284-1680
WATS (National) . . . . . .(800) 523-7893
FAX . . . .(203) 269-2964
101 N. Plains Industrial Rd.
Wallingford, CT 06492
PERSONNEL: Dean Bogert, Director of Systems Engineering; Ronald Jones, VP of Sales, NJ office 609-596-9222
DESCRIPTION: Orchard manufactures a full range of fiberoptic AM-VSB, FM, and digital video transmission systems. AM systems use DFB lasers, or external modulation for high output power. Interfaces for FM and digital systems include baseband video/audio, monaural or BTSC audio, 45.75 MHz IF, or composite video with 4.5 MHz audio.

ORTEL™
CORPORATION

Ortel Corp. . . . .(818) 281-3636
FAX . . . .(818) 281-8231
2015 W. Chestnut St.
Alhambra, CA 91803
PERSONNEL: Larry Stark, Director of Marketing; Bill Moore, Director of Sales
DESCRIPTION: Ortel manufactures fiber optic components for AM CATV transmission and for satellite TVRO antenna remoting.

POWER GUARD

Power Guard Inc. . . . . .(800) 288-1507
FAX . . . .(205) 742-0058
506 Walker St., PO Box 2796
Opelika, AL 36801
PERSONNEL: Jerry Schultz, Presidet; Mike Springer, VP of Sales

DESCRIPTION: Power Guard manufactures the revolutionary and versatile new Power Cast™ which is the first power supply designed for strand, pole, or pedestal mounting. The Power Cast™ is available in 3, 6, 9, 12, and 15 amp models; for optimum powering of fiber/coaxial plant. Power Guard also manufactures a complete line of standby and non-standby power supplies to meet virtually any CATV requirement.

Scientific Atlanta

Scientific-Atlanta . . . . .(800) 722-2009
FAX . . . .(404) 925-5445
PO Box 105027
Atlanta, GA 30348
PERSONNEL: John Mattson; Godfrey Pinto
DESCRIPTION: Scientific-Atlanta's FOCUS AM Fiber Optic System provides unmatched perormance combined with maximum reliability. The system consists of the model 6450 Optoelectronic Transmitter and the model 6901 Optoelectronic Bridging Amplifier, each of which can be custom-configured for optimal performance in a variety of applications.

Texscan

Texscan Corp. . . . .(915) 594-3555
WATS . . . .(800) 351-2345
FAX . . . .(915) 591-6984
10841 Pellicano Dr.
El Paso, TX 79935
PERSONNEL: William H. Lambert, Chairman, President, CEO; George L. Fletcher, Senior V.P. Corporate Marketing
DESCRIPTION: Manufacturer of a broad line of distribution electonics, fiber optic systems, character generators, commercial insertion equipment. Texscan's Flamethrower Systems, offer new architecture for CATV's future. Flamethrower Optical Bridging Systems feature unique bridger architecture allowing lower RF active counts (and cost) with greater reliability and performance, less mechanical system interfaces with 2 or 4 output versions. Unequalled RF output performance for additional savings in RF and optical active devices for lower construction, maintenance and operational costs. The right RF technology to do the job.

Test Equipment

ADVANTEST®

Advantest America, Inc. . .(708) 634-2552
FAX . . . .(708) 634-2610
300 Knightsbridge Parkway
Lincolnshire, IL 60069
PERSONNEL: Atlee Jacobson, Sales Support Eng.-Midwest; Joe Diamond, Regional Sales Manager-East
DESCRIPTION: Q8460-High resolution OTDR. Provides accurate fault detection at distance ranges of 15, 50, and 100Km.The unique reflective mode locates reflected faults. R3361 series spectrum analyzers come with either 2.6 or 3.6 GHz capability and with an internal tracking generator. Its dB display dynamic range puts high and low signals on screen simultaneously. R4131 is a 3.5 GHz spectrum analyzer with numerous advanced digital functions at a low cost.

Anritsu

Anritsu America, Inc. . . . .(201) 337-1111
WATS (National) . . . . . .(800) 255-7234
FAX . . . .(201) 337-1033
15 Thornton Rd.
Oakland, NJ 07436
PERSONNEL: Chuck Smith, Director of Sales & Marketing; Hugh Felger, Marketing Manager
DESCRIPTION: Fiber optic instrumentation including OTDR's, light sources and power meters. RF and microwave products including spectrum analyzers, EMI receivers, synthesizers, power meters and network analyzers.

CALAN

CALAN, Inc.. . . . .(717) 828-2356
WATS (National) . . . . . .(800) 544-3392
FAX . . . .(717) 828-2472
1776 Independence Drive
Route 739
Dingmans Ferry, PA 18328
PERSONNEL: Edward McDonald, Major Accounts; Ian Jones, Product Manager
DESCRIPTION: CALAN, Inc. manufacturers top of the line Integrated Sweep/Spectrum Analyzer Systems. The System combines the function of a Non-Interfering System Sweep and Spectrum Analyzer in one portable, battery operated unit. The CALAN Sweep System has been successfully field tested on several fiber systems. **Sweeping over fiber is a proven reality with the CALAN System.** The System is fully compatible with both CATV and Broadband Data Networks. CALAN also offers rugged Fiber Optic Power Meters and Sources for measuring optical power and component or system loss.

EXFO
Electro-Optical Engineering

EXFO E.O. Eng. Inc. . . . .(418) 683-0211
FAX . . . .(418) 683-2170
352 St-Sacrement Ave.
Quebec City, QC G1N 3Y2
PERSONNEL: Andrew Benn; Vedrana Stojahac
DESCRIPTION: EXFO manufactures a complete range of fiberoptic test equipment for CATV, LAN, or long haul testing and is the best known for Quality, Innovation and Customer Support. These products include optical power meters, attenuation test sets at 1 or 2 wavelengths, LED/LASER light sources, talk sets, variable attenuators, visual fault locators, variable back reflectors, back reflection test sets, etc. Product range include low-cost hand-held to top performance laboratory units which are available in over 30 countries around the world.

hp HEWLETT PACKARD

Hewlett-Packard Co. . . . .(707) 794-3569
Signal Analysis Div.
FAX . . . .(707) 794-4620
1212 Valley House Dr., 2LR-J
Rohnert Park, CA 94928
PERSONNEL: Julie Bickford, Division Marcom Manager
DESCRIPTION: Quality Analyzers Dedicated to Cable Television: Keep your CATV system operating and customers satisfied with HP CATV test equipment. For headend and trunk RF measurements, the HP 8590B/91A operate from 9kHz to 1.8 GHz. For microwave-link testing, the HP 8592B/93A extend coverage to 22 GHz. And for lightwave, the HP 83810A signal analyzer covers from 1,200 to 1,600 nm and bandwidths from 9 kHz to 22 GHz. Consult your local telephone directory for the HP sales office nearest you.

YORK
YORK TECHNOLOGY, INC.

York Technology Inc. . . . .(818) 955-8927
FAX . . . .(818) 955-9728
210 N. Glenoaks Blvd., Suite C
Burbank, CA 91502
PERSONNEL: Brent Ware, VP; Paul Walker, Sales Mgr.
DESCRIPTION: S18 **Chromatic Dispersion:** Fast-typical scan of 120 nm in 10 nm increments accomplished in less than

15 seconds, including curve fit (500 m to 75 km). Direct measurement of fiber length, with millimeter resolution. Direct measurement of chromatic dispersion, lambda-zero, and slope. Direct measurement of group delay characteristic. Strain measurements to cabled fibers. Up to 5 sources. **S25 Spectral Attenuation:** Fast measurement-2 minutes; Excellent repeatability-0.003dB RMS; Wavelength range 350 to 5500 nm; Singlemode and multimode; Easy fiber handling; Auto-sequencing; HP/IBM PC controlled; Cutback or stored technique; Mode Field Diameter using the VAFF technique measures from 750 nm-175 nm, 0.5 NA optics.

Accessories

AT&T

AT&T . . . . **(303) 740-6102**
FAX . . . . **(303) 694-3977**
8101 E. Prentice Ave., Suite 210
Englewood, CO 80111
PERSONNEL: Tim Gropp, National Sales Manager: CATV; Ron Causey, Account Executive: CATV
DESCRIPTION: AT&T is a manufacturer of optical fiber, optical fiber cable, and lightwave transmission systems for cable TV. AT&T also supplies turnkey installation services. Anixter Cable TV is the sole supplier of AT&T products.

AUGAT
AUGAT COMMUNICATIONS GROUP INC.

Augat Comm. Group . . . **(206) 932-8428**
FAX . . . . **(206) 938-8850**
2414 SW Andover St.
Seattle, WA 98106
PERSONNEL: Bill Jensen, Dir. of Sales Fiberoptics; Amy Amrhein, Fiberoptic Product Manager
DESCRIPTION: The fiberoptics product line of the Augat Communications Group offers the following: SMT, SMA and biconic connectors; SMT, SMA and termination kits. Gauging tools; heat curing ovens; tools and accessories; modems and mux interfaces; cable assemblies; fiberoptic patch panels; Augat/Cinch fiber optic wiring system.

C-COR®
ELECTRONICS INC

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

CORNING

Corning Incorporated . . . **(607) 974-4411**
Telecomm. Prods. Div.
FAX . . . . **(607) 974-7522**
MP-RO-03
Corning, NY 14831
PERSONNEL: Scott Esty, Cable TV Market Development Manager; Bill Willson, Sales Manager, Coupler Products
DESCRIPTION: Corning Incorporated manufactures a full line of optical fiber and components to meet today's demanding cable TV applications. Products include: Corning™ Fiber—Titan™ single-mode fiber, SMF/DS™ single-mode dispersion-shifted fiber—and Corning™ Couplers, both multimode and single-mode tree, star, tap and WDM couplers.

Enclosures

HENNESSY PRODUCTS

Hennessy Products, Inc. . . **(800) 950-7146**
FAX . . . . **(717) 264-1634**
910 Progress Rd., PO Box 509
Chambersburg, PA 17201
PERSONNEL: Patrick Hennessy, Sales Manager; Bruce Ritchey, Vice President, Sales
DESCRIPTION: Hennessy designs and manufactures quality aluminum and stainless enclosures/cabinets ideal for fiber optic equipment and other electronics and electrical equipment that requires protection. Catalog available.

RELIANCE COMM/TEC

Reliance Comm/Tec . . . . **(708) 455-8010**
Reliable Electric
FAX . . . . **(708) 451-5516**
11333 Addison
Franklin Park, IL 60131
PERSONNEL: Cloyd Poll, Fiber Optics Products; Frank Priebe, CATV Products
DESCRIPTION: Fiber optic accessory items, connectors, cables splice organizers, distribution enclosures for indoor and outdoor applications, buried and aerial terminal and splice enclosures, headend distribution equipment, fiber optic pedestals.

Construction

AT&T

AT&T . . . . **(303) 740-6102**
FAX . . . . **(303) 694-3977**
8101 E. Prentice Ave., Suite 210
Englewood, CO 80111
PERSONNEL: Tim Gropp, National Sales Manager: CATV; Ron Causey, Account Executive: CATV
DESCRIPTION: AT&T is a manufacturer of optical fiber, optical fiber cable, and lightwave transmission systems for cable TV. AT&T also supplies turnkey installation services. Anixter Cable TV is the sole supplier of AT&T products.

Cable Services Company Inc.

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

Cablemasters Corp.
Our Name Says It All

Cablemasters Corp. . . . . **(814) 838-8713**
FAX . . . . **(814) 838-8713**
PO Box 219
Lake City, PA 16423
PERSONNEL: Bernie Czarnecki; Gary Morris
DESCRIPTION: Cablemasters Corp. provides high quality aerial and underground coax and fiber optic construction services.

FIBER OPTIC CALLBOOK

We Build The Best

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

DITEL®

Ditel, Inc. . . . . (704) 328-5640
FAX . . . . (704) 324-4738
PO Box 3386
Hickory, NC 28603
PERSONNEL: Tom Isaacs, Operations; Dare Johnston, Administration
DESCRIPTION: Serving the northeast and sunbelt, Ditel provides quality installation of fiberoptic systems, both buried and aerial. Systems may be surveyed and designed on either a turnkey or labor only basis. Ditel also provides professional seminar training for your personnel. A complete line of accessory products for fiber is available.

NaCom

NaCom . . . . (614) 895-1313
WATS (National) . . . . . . (800) 669-8765
WATS (California) . . . . . (800) 767-6772
1900 E. Dublin-Granville Rd., #100A
Columbus, OH 43229
PERSONNEL: Leslie Lotte, VP-Operations, Western Region; Bob Gemignani, VP-Mktg. & Corporate Develop.
DESCRIPTION: Full service communication contractor experienced in all aspects of fiber optic cable constructioin for CATV and LAN industries. We also provide strand mapping etc.

Schenck construction

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

TEA

Transamerica Energy Associates, Inc. (TEA) . . . (404) 992-7003
FAX . . . . (404) 992-8432
1301 Hightower Trail, Ste. 300
Atlanta, GA 30350
PERSONNEL: Edwin A. English, Operations Manager;James P. Worthen, Director of Marketing
DESCRIPTION: Specializing in field engineering, fiber optic and RF broadband design, and computerized drafting, a principal part of TEA's business is cable layout for cable TV and telephone companies. Keeping in mind the ever growing demand for TV and phone services at the personal and business level, it becomes obvious that speed, quality, and competitive prices can quickly determine the level of success.

Suppliers/Dist./Reps

C-COR® ELECTRONICS INC

C-COR Electronics, Inc. . . (814) 238-2461
WATS . . . . (800) 233-2267
FAX . . . . (814) 238-4065
60 Decibel Rd.
State College, PA 16801
PERSONNEL: John Hastings, Director of Sales; Dick Taylor, National Sales Manager-CATV
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Cable Services Company Inc.

Cable Services Co., Inc. . . (800) 233-8452
WATS (State) . . . . (800) 332-8545
FAX . . . . (717) 322-5373
2113 Marydale Ave.
Williamsport, PA 17701
PERSONNEL: Sales Department
DESCRIPTION: Suppliers of cable, distribution, splicing, tools and hardware for CATV fiber optic systems.

FIBERTRON
Your Link with Fiberoptics

Fibertron Corp. . . . . . . (213) 690-0670
FAX . . . . (213) 697-5360
450 E. Commercial Way
La Habra, CA 90631
PERSONNEL: Marlene Spiegel, President; Henry Cohen, Vice President
DESCRIPTION: As a leading fiber optics distributor, Fibertron offers the widest array of quality oriented products from leading manufacturers like AT&T, AMP, 3M, Amphenol, Augat, Belden, BICC, Chromatic Technologies, Clauss, PSI, Pyramid, Reliance, Siecor, Tektronix, and more. In addition, we offer custom cable assemblies, including: pigtail, tactical, hybrid and multi fiber; patchcords and custom cable putups; plus, specialized customer support, consultation and training.

JCA

Jerry Conn Assoc., Inc. . . (717) 263-8258
WATS (National) . . . . . . (800) 233-7600
WATS (State) . . . . (800) 692-7370
FAX . . . . (717) 263-1547
130 Industrial Dr., PO Box 444
Chambersburg, PA 17201
PERSONNEL: Mike Harpster; John Miller
DESCRIPTION: Manufacturers' Representative for Catel, manufacturer of FM and AM fiber optic transmission equipment including Transhub FM VSB/AM and the high performance Transhub III VSB/AM fiber optic systems. Also representative for Fitel General, manufacturer of single mode and multimode cable. Product line includes loose tube, PowerGuide and tight buffer constructions.

MIDWEST CATV
More than supplies. Solutions.

Midwest CATV . . . . . . (303) 799-4343
WATS (National) . . . . . . (800) 232-9378
FAX . . . . (303) 643-4797
94 Inverness Terrace East, Suite 310
Englewood, CO 80112.
PERSONNEL: Christopher Sophinos, President; Bill Dancy, Sales Engineer
DESCRIPTION: Midwest CATV is a full-line fiber optics supplier. Fiber is available to your needs from Belden, Comm/Scope or Times Fiber. Electronics are available from Olson Electronics and the Jerrold Division of General Instrument. Accessories for installation are also available from numerous manufacturers, including our own fiber optic splice pedestal. Call our offices for fast service.

It's such a simple idea: construct a power supply with fewer internal parts so there's less to go wrong. Heat sink its transformer into a cast aluminum housing for maximum heat dissipation. Make it adaptable to power configurations around the world. Protect the electronics with a weather-proof seal. And engineer the entire unit so that it mounts easily on a pole, a pedestal, and even the strand.

But the simplest ideas are often the most revolutionary. And that's the idea behind the new Power Cast™ power supply.

Make Your System Right From The Start.

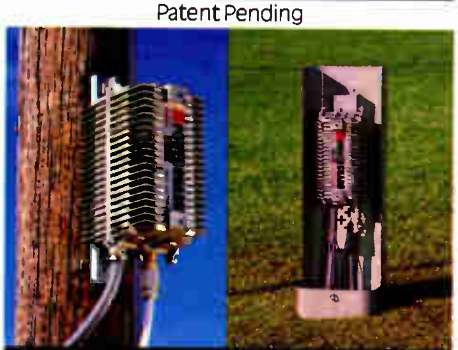
Jerry Schultz and our Power Guard engineers spent five years designing, planning, and testing the Power Cast. They wanted to make sure it had all the features you demand—no matter where in the world your system may be.

For instance, the placement of your power supply is very important because of local costs, regulations, controls, and specifications.

Anticipating these problems, we made the Power Cast so you can mount it anywhere. Whether that's on a pole. In a pedestal. And even on the strand itself. So it's the ideal power supply solution for off-premise addressability. And the

POWER CAST

Patent Pending



The Power Cast™ mounts on the pole, the pedestal, even on the stand.

Power Cast is light enough so that it weighs less than most trunk amps. Plus it's the first power supply specifically designed with fiber optics in mind.

The Sky's The Limit Once You Have The Power Cast.™

The Power Cast is available in various power configurations to meet your country's specifications.

All models feature:
- strand/pole/pedestal mounting
- cool, quiet operation
- fiber optic compatibility
- input/output surge protection
- 90% - 93% efficiency rating
- time delay

We also offer an anodized model for underground and coastal environments.

So order your Power Cast evaluation unit today. You'll see how the Power Cast power supply keeps on hanging in there—giving you performance you can count on anywhere in the world.

International Distributors, Let's Talk.

Power Guard is the fastest growing manufacturer of power supplies for CATV.

To help us grow internationally, we are seeking foreign distributors. If you are interested in representing an aggressive, quality manufacturer, please contact us.

POWER GUARD

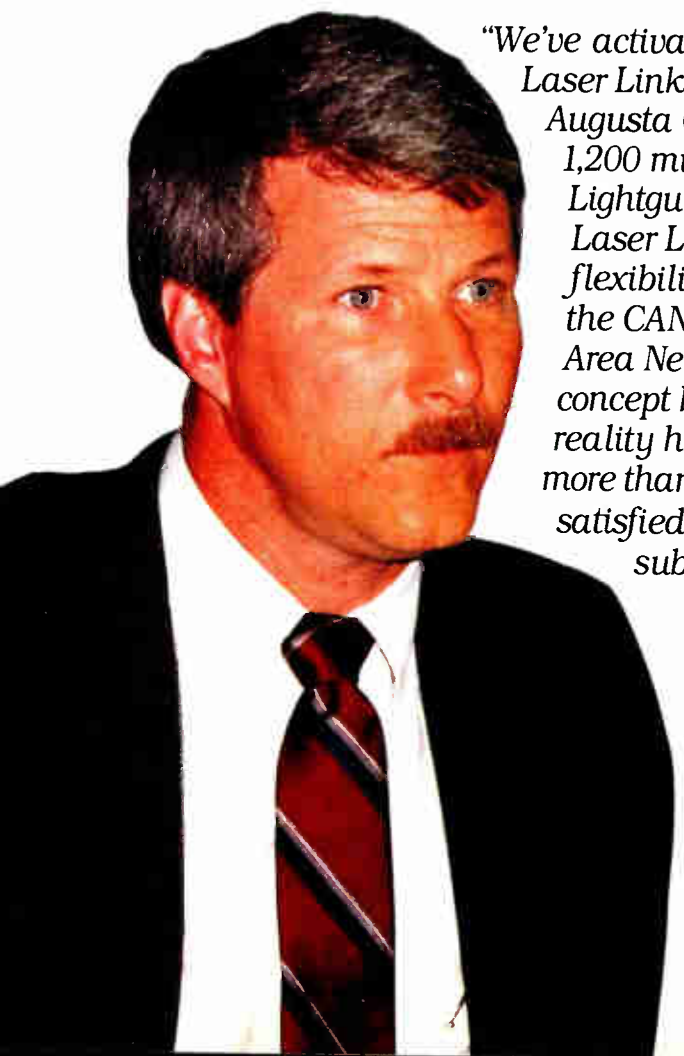
801 Fox Trail
P.O. Box 2796
Opelika, AL 36801
USA

Ph: 800-288-1507
205-742-0050

FAX: 205-742-0058

"Outstanding performance with no surprises—

Anixter's Laser Link was the best choice for Augusta."



"We've activated 24 Laser Links in Augusta GA, with 1,200 miles of LXE Lightguide cable. Laser Link's design flexibility helped the CAN (Cable Area Network) concept become a reality here for more than 40,000 satisfied Jones subscribers.

Anixter gave us outstanding performance throughout the entire project, with no surprises. Their engineering support and project management expertise were invaluable, and each phase of the upgrade has proceeded like clockwork.

Laser Link was definitely the right choice for Augusta, and we plan to use it in more fiber upgrades."

Bob Luff
Group Vice President, Technology
Jones Intercable

ANIXTER CABLE TV

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