CED

THE MAGAZINE OF BROADBAND TECHNOLOGY / SEPTEMBER 1991

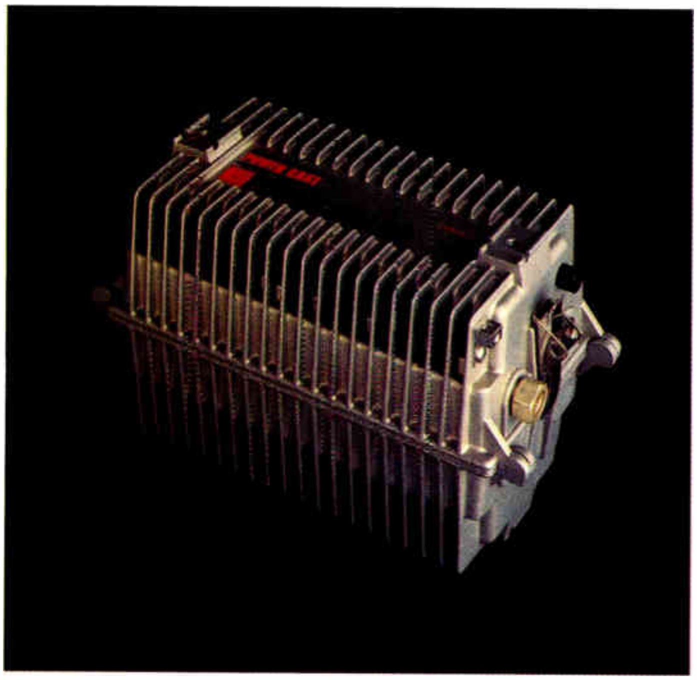
Inside: Network topologies chart

Fiber: Cable TV's connection to the future

A special supplement of CED magazine

Anixter introduces Power Cast™...

Are you designing optical networks or off-premise systems for the future?



Specify the power supply engineered for the technology demands of tomorrow.

Fiber optic systems and off-premises addressability demand a reliable, versatile power supply designed for the special applications of these systems. Power Cast is built for cool, quiet and efficient operation, with models which operate at 3, 6, 9, 12 or 15 amps.

Power Cast can be mounted virtually anywhere — on a pole, in a pedestal or on the strand. This lightweight power supply provides all the features you need along with incredible durability and performance. Backed by a five-year warranty, Power Cast is the power supply you can install today and continue using through tomorrow.

ANIXTER® CABLE TV + POWER GUARD

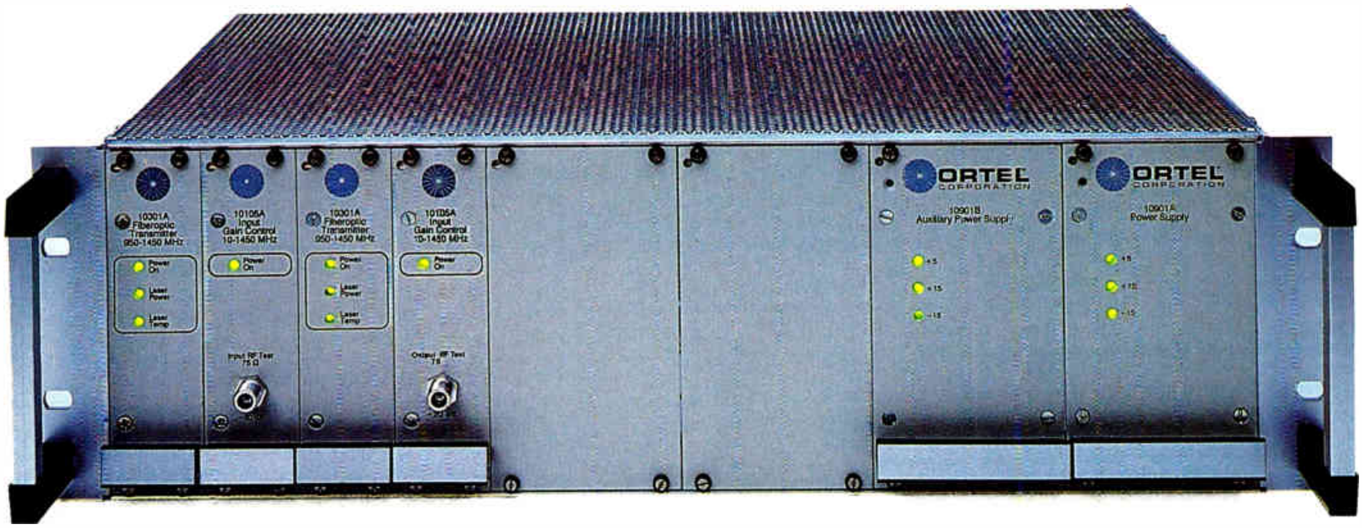
WEST-ANAHEIM: (714) 779-0500, (800) 854-0443; **DENVER:** (303) 740-8949, (800) 841-1531; **SEATTLE:** (206) 251-6760, (800) 426-7665; **MIDWEST-CHICAGO:** (708) 350-7788, (800) 544-5368; **CLEVELAND:** (216) 526-0919, (800) 321-8068; **DALLAS:** (214) 446-CATV, (800) 231-5006; **IRON MOUNTAIN, MI:** (906) 774-4111, (800) 624-8358; **SKOKIE, IL HDQTRS:** (708) 677-2600; **EAST-ATLANTA:** (404) 840-7901, (800) 242-1181; **NEW JERSEY:** (201) 328-0980, (800) 631-9603

In an emergency, weekends and holidays or after 5 P.M. call toll free 1 (800) 323-8166.
CORPORATE OFFICES, ANIXTER CABLE TV, 4711 Golf Road, Skokie, IL 60076, (708) 677-2600

Visit us in Booth #230 at the Great Lakes Cable Expo

Circle Reader Service No. 1

Freedom package.



Solve your antenna site location problems.

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.

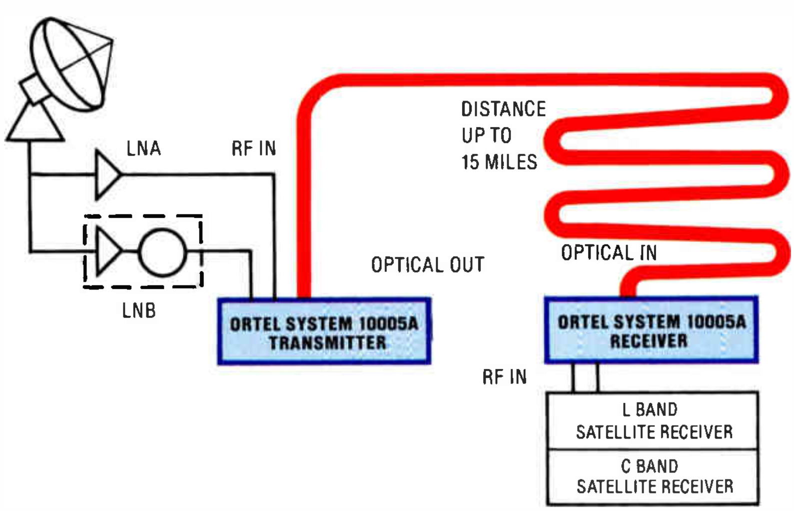
The modular design 10005A system uses a standard 19-inch rack mount incorporating dual, redundant power supplies for added reliability.

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 four polarizations.*

Ortel is the leader in analog laser design and manufacture. You can count on impeccable performance and a total commitment to service from Ortel.

To get the whole story, simply call your Ortel sales representative today.



ORTEL™ CORPORATION

2015 West Chestnut Street
Alhambra, CA 91803
(818) 281-3636

*Making light **work** for you.*

Circle Reader Service No. 2

September 1991

CED

Volume 17, Number 10

CAPITAL CITIES/ABC, INC.
DIVERSIFIED PUBLISHING GROUP
Office
600 S. Cherry Street, Suite 400, Denver, CO 80222 (303) 393-7449. Fax (303) 393-6654.

Subscriber Services
(215) 630-9326
Circulation Office
(212) 887-8568

AM fiber and digital compression for cable's future

AM fiber and digital compression are technologies unique to the cable industry. Both technologies have been developed by the cable industry in answer to its specific needs. The cable industry is already deploying fiber widely. However, recent interest in PCN and digital compression has partially diverted the attention of system operators from fiber optics issues.

But that does not mean that the industry deployment of fiber has slowed down. As someone (Dave Willis, Telecommunications Inc.) stated recently, "whether you're using superdistribution, starbursts, CANs, rings, service areas, six-packs, flamethrowers or whatever, the basic attributes of fiber are the important factors. Expanded bandwidth, high reliability, high quality of transmission, low maintenance and a future that will continue to expand make fiber deployment not only desirable, but necessary."

And both technology and business outlooks are rapidly changing. The new technologies are in deployment-reach range, but at the same time, the system needs are changing—requiring a review of applicability of those technologies, as well as a search for new solutions.

Cable needs both

With the advent of digital compression for cable systems, there is some uncertainty emerging about the amount of fiber that cable needs. For those who wonder about the recent rapid developments in digital compression of video signals, and are curious as to whether its transmission over cable systems will replace the need for fiber in cable, the answer is simple: Cable system operators need *both* technologies for today and tomorrow. While the answer is a straight one, its justification is much more complicated and depends on a point of view and initial assumptions.

By Aleksander Futro, Director of Technology Assessment, Cable Television Laboratories

Today's AM fiber technology both positions operators for the future and enables the industry to compete in any direction. Many MSOs are installing fiber that allows them to implement compression technology and offer opportunities in PCS and metro area networks for commercial business communications needs. Further, AM fiber costs keep coming down, which enhances the ability of operators to expand deployment.

Let's focus for a moment on the future. Let's assume that the ultimate cable system of the year 2000 will be part of highly granular, modular network with regional headends directly connected to fiber nodes. Depending on the architecture, each node will feed either small tree-and-branch networks or several short coaxial feeder lines providing service to 100 to 1,000 homes. And independent of architectural assumptions, the network will be characterized by:

- Very high picture quality, sufficient for subjectively excellent pictures with current NTSC technology and the proposed HDTV standards
- High channel capacity, with basic tiers of a minimum of 60 to 80 channels, and over 150 channels not being uncommon
- Very high reliability
- Two-way capability
- Tremendous reserve real and virtual bandwidth

It should be noted that the key factor to accomplishing those goals is to break the RF portion of the network into short cascades. This would eliminate the main deficiencies of RF distribution: Accumulation of system noise and distortion.

Role of AM fiber

The AM-VSB modulation format in coax and fiber CATV applications allows using home TVs without the requirement for additional costly conversion electronics. The main disadvantage of AM-VSB is the limited power budget arising from the high SNR requirement of 50 dB to 60 dB for future broadcast quality. Progress in technology and new and improved components and systems provide solutions to the technical problems and limitations faced by analog video transmission.

However, a fiber does not help directly to expand channel capacity on the cable system. While it has, in theory, an unlimited bandwidth capacity, practical applications are more limited today. A single AM fiber link carries 60 to 80 analog NTSC channels, with potential expansion to about 100 channels per 10 dB to 16 dB link. Multiple parallel fibers, or multiple wavelengths in the future, change the equation further. High count of channels can be delivered to a node with no cascading of signal noise and minimal distortion.

Video compression and bit rate reduction techniques have been researched for over 30 years. We are now at a point when technology permits hardware implementation of very sophisticated algorithms. One can expect, therefore, to be able to achieve very high compression of NTSC and HDTV signals in real time. However, the issues related to the transmission of those compressed video signals in analog or digital form are the other, often untold, story. So, the activities must focus on determining the best set of characteristics for distribution of digitally compressed video signals on cable systems.

It is necessary to emphasize different phases of video signal processing. The video analog source signal must be analyzed first. The digital data stream equivalent of one NTSC channel equals 120 Mbits/second, and one HDTV channel equals 600 Mbits/second to 1.2 Gbits/second, without any data compression.

Picture courtesy of Corning, Inc.

The next step is the compression of the informational content of this data stream. High speed video image processing algorithms are used to reduce redundant image components and any information which can be restored at the receiving end. The problem is that even with advanced algorithms, the data stream that is left is either too high for efficient transmission, or the quality of an image must be compromised.

A partial solution is implemented by a second step in signal compression for transmission purposes. In this process, a variety of modulation and coding schemes are used to increase the number of bits per hertz ratio for more efficient utilization of available bandwidth. A nominal number is one bit per one hertz.

"Perfect" digital

A perfect digital signal contains "zeros" and "ones." Or, from a signal perspective, it is a two-level system. Any value below a predetermined value means "0," and any value above the same reference means "1." This approach makes a perfect digital signal very robust to noise and distortions which may occur during transmission. The practical implementations of those levels can be two amplitudes (amplitude or intensity modulation), two values of phase (phase modulation) or two values of frequency (frequency modulation).

As a result, signal-to-noise ratio requirements can be reduced significantly for transmission systems. The systems which implement a "perfect digital" coding are used in data transmission. The highest achievable data rates are limited by applied electronics, and currently on fiber achieve up to 2.4 Gbits/second. However, this requires the equivalent of over 2 GHz of bandwidth. High speed real-time hardware is necessary, and the cost of this equipment depends on the complexity of coding algorithms and the type of multiplexing.

Cable's approach

Different schemes are used to increase bandwidth efficiency. All of them translate into efforts to increase bits-per-hertz counts. As a result, digitally coded information is imposed, or modulated, (amplitude, phase, frequency) onto an analog signal carrier. However, instead of a two-level system, a multiple level approach is implemented.

This process can be illustrated by introducing a fixed number of fractional sub-levels, equally distributed between ultimate "0" and "1." But, that gives a configuration of the predetermined discrete-analog values which a signal may have. It is also equivalent to a transition from an analog system, which is approximated by an infinite (or sampling rate determined) number of discrete values, to selective approximation by a limited number of discrete values.

The conclusion can be drawn that any level scheme used for signal coding, which deviates from "perfect digital" (two levels), more or less resembles analog (infinite number of levels). As a result, it is exposed to more distortions and transmission noise.

> 'Whether you use starbursts, CANs, rings, flamethrowers or six-packs—the basic attributes of fiber are important.'

Quality (or C/N) must be maintained for channel error rates of, say, 10^{-9} and kept acceptable up to, say, 10^{-4}. Error protection techniques are thus often required. Also, those signal coding schemes require a transmission pipe which can provide linearity and a noise-free environment similar to the needs of pure analog signals. Clearly, there is a lot of room for trade-offs and compromises.

CableLabs is confident that through technology and through the use of some clever methods, entertainment video compression scenarios will become ever more capable and will be deployed. The cable industry network architecture allows moving technology to the optimum point in cable systems and, therefore, it is likely cable will be an early adopter of data compression.

However, as bandwidth on cable systems becomes less expensive, data compression will be a less critical factor, and the ultimate quality of entertainment video imaging will not need to be compromised by processing.

Constraints on coding

Digitally compressed signals on cable systems will allow even more efficient utilization of available bandwidth. Thanks to image compression and carrier signal coding, more channels will be transmitted in the same available bandwidth, creating a perception of virtual-channel expansion.

However, two constraints on coding and transmission will exist. The first one is driven by a final image quality, as perceived by a viewer, and is based on video image processing and the amount of original information removed from the transmitted signal. The second one depends on the quality of a transmission system. The consequence is that cable systems, which are to carry "digitally compressed" signals, must be designed and built to performance requirements not much different from the requirements for pure analog AM signal transmission.

The leads cable system operators, equipment vendors and component manufacturers back to high performance designs and products. It also ultimately leads back to implementing as many AM fiber links as is affordable. Although the principle purpose of AM fiber in cable system designs is to increase picture quality and bandwidth economically, significant side benefits occur. Specifically, these side spiffs are reliability and simplified maintenance. AM fiber also enhances the system operators' ability to expand into other business arenas, especially enabling implementation of bandwidth efficient digital compression technology and opportunities in alternative services.

The next optical link?

The cable industry was responsible for embracing the original 1310 nm DFB laser and stimulated efforts in its developments and improvements to meet the needs and requirements of AM fiber optic links for multichannel video distribution over cable systems. The last word in 1310nm DFB lasers is not going to be said for a while, however thoughts about the next generation of AM fiber optic links are already pending.

There is a need to review the existing fiber optic technologies and available products, as well as changes in network architectures in light of new requirements for alternate services delivery (PCN, data, digital and compressed

THE OPTICAL ADVANTAGE ANYONE CAN SEE.

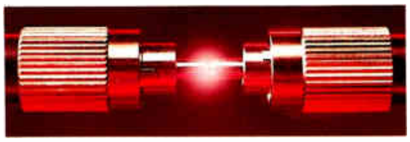
DEPTH OF F

Only Sumitomo designs, b everything you need

Sumitomo makes a full range of fiber optic cables. Choose from matched clad or depressed clad fiber in either loose tube or LitePipe™ cable construction.

As a result, you don't get a runaround: questions get answered, problems solved, deadlines met, network goals achieved. ■ We design, manufacture, install and support everything optical you need for video transmission. Including a full line of optical VSB-AM and digital video transmission equipment, matched clad VAD-type fiber pioneered by Sumitomo. Loose tube and economical LitePipe™ optical cables. Fully automated fusion splicers. Plus optical connectors and patch cords, all made by Sumitomo. ■ Hardware, though, is only half the story. Using our own in-house resources and expertise,

Our compact, lightweight T-35 fusion splicer is fully automated. You get advanced features because we pioneered fusion splicing



We manufacture a full line of multi-mode and single mode cable assemblies in standard or custom lengths.

Sumitomo VSB-AM video transmitters and receivers–rack, strand and pole mount–give you unmatched network design flexibility. Every unit meets uniformly high performance specs.

ESOURCES.

uilds, installs and supports for video fiber optics.

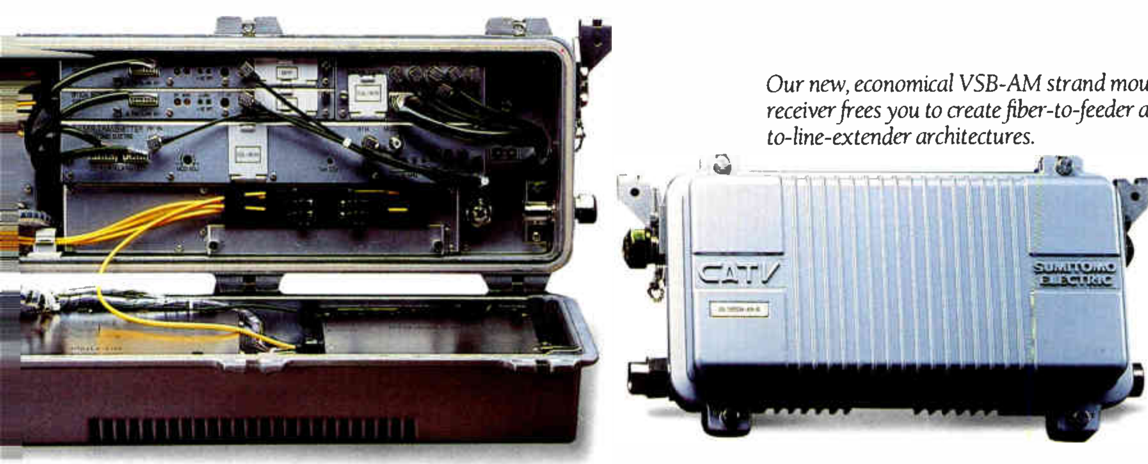
we offer engineering services and turnkey construction:

Sumitomo digital transmission equipment is cost competitive with FM. Get up to 24 video channels on a single fiber without compression or wave-division multiplexing.

single-source responsibility for your project, from initial design to turn-up. ■ Then there's training programs, ongoing support, maintenance/ repair with loaners–whatever you need. Whatever you want, all or any part. Including peace of mind–one reason we've been a leader in fiber optics *and* cable television for nearly 20 years. ■ Call us at (800) 358-7378. Discover the optical advantage anyone can see, but only Sumitomo can deliver.

We do it all, including engineering and construction–entire turnkey newbuilds and rebuilds, plus ongoing maintenance, repair and support.

We think you have a big future with fiber optics, so we invested $100 million in our North Carolina research and manufacturing headquarters facility.



Our new, economical VSB-AM strand mount optical receiver frees you to create fiber-to-feeder and fiber-to-line-extender architectures.

Reader Service No. 110

Sumitomo Electric, your light-support system.

VIDEO TRANSMISSION EQUIPMENT

ANALOG

Choose from our full line of rack, strand and pole mount equipment. Optical transmitters and repeaters are available with 4 or 6 mw lasers at 1310 nm, rack or strand mount. The rack housing accommodates up to 2 transmitter or receiver units within 2 mounting spaces. One strand-mount trunk station provides 30 dBm V output and accommodates up to 4 receivers or 2 transmitters or 2 receivers and 1 transmitter with an A/B switch plus status monitoring. Our secondary-node receiver provides 48 dBm V for fiber to the feeder architectures.

DIGITAL

Simple to maintain, our equipment consumes far less space and power than FM — and requires fewer optical fibers. Sumitomo systems transmit, without compression, NTSC, PAL and BTSC baseband video/audio signals at 2.4 GBs, 24 channels on a single fiber; 1.2 GBs, 12 channels; or 400 Mbs, 4 channels. Up to 72 channels fit in a single 6-foot rack. Channel capacity can be doubled via Wave Division Multiplexing. Transmission distance: up to 80 km without a regenerator. Express and drop regenerators available. Systems meet RS250C medium haul specifications.

CONNECTION SYSTEMS

FUSION SPLICERS

Sumitomo pioneered fusion splicing, which produces economical, high-quality splices. Advanced features include high-speed imaging in two directions, self-diagnostic arc test and high-accuracy splice loss estimation, plus easy-to-use tools for fast stripping and cleaving. Sumitomo Type 35 is an industry standard, and our Type 51 splices up to 12 fibers at once. Our splice sleeves provide optimum protection.

CONNECTORS

We make a full line of optical multimode and single mode cable assemblies with connectors such as Biconic, ST, FC, D4, mini-BNC and SC. We provide custom lengths and can make Super PC Polish connectors, even FDDI.

DEPTH OF RESOURCES

We're part of $6-billion Sumitomo Electric Industries, Ltd. Group. Our $100-million, 350,000 sq. ft. manufacturing complex in Research Triangle Park, North Carolina employs more than 350 people dedicated to meeting all your optical network needs.

OUTSIDE PLANT

FIBER OPTICAL CABLES

We manufacture cable with your choice of matched clad or depressed clad fiber. We offer loose-tube cable in fiber counts of 4 to 216, plus our new, economical Lite-Pipe™ cable in counts of 2 to 24. Reel length: up to 12 km. Sumitomo pioneered vapor axial deposition (VAD), the matched clad fiber-making process that set the record for low loss. We offer optical cable sheath construction from all dielectric to double armoured suitable for all installations (lashed aerial, duct and direct buried) and environments.

CONSTRUCTION & ENGINEERING

We provide any level of service including entire turnkey newbuild or rebuilds. Our in-house experts work closely with your people to evaluate design alternatives, select methods of construction, perform installation, and do turn-up, testing, fusion splicing, repair and maintenance. We offer single-source responsibility, assuring your project gets done right.

SUMITOMO ELECTRIC
Fiber Optics Corp.
YOUR LIGHT SUPPORT SYSTEM

78 Alexander Drive ■ Research Triangle Park, NC 27709 ■ (800) 358-7378 or (919) 541-8100 ■ Fax (919) 541-8265
Member of the Sumitomo Electric Industries, Ltd. Group

video, etc.) on fiber. Of primary importance is the question about the next generation of fiber optic links for CATV, or what technologies can deliver an ultimate solution for the cable applications—the AM fiber optic link with 16 dB to 20 dB optical power budget and load of 50 to 60 channels per wavelength, priced at less than $10K per link, and available in less than an 18-month time frame.

Those parameters are required in view of increased needs for point-to-point (with no splitting) fiber links to support narrowcast program delivery to smaller but higher bandwidth nodes, and to support alternate services data transport.

A new concept

This brief status review clearly indicates that a new or improved light source can make the next fiber link possible. What about a laser with no chirp, narrow linewidth, output power in hundreds of milliwatts, available in multiple wavelengths useful for multiplexing in the 1300 nm window, and not only packaged in similar shape and volume as the familiar DFB, but also costing much less? It is not a dream! It exists and is available from at least two sources today.

It's name, depending on the source, is "cube," or microchip laser. Why has nobody used it so far? That's a very good question. We at CableLabs think that it is worth a try. Preliminary discussion and concept evaluation is positive. The manufacturers are planning a prototype design of a link based on a "cube" laser. How soon it will be available for testing depends largely on industry interest, but it could be relatively soon. It will take the cooperation of several parties, but all the needed components and circuitry exist. The key challenge is to match them together.

Microchip "cube" laser

"Cube" or microchip lasers are the new class of miniaturized lasers developed recently through "star wars" sponsored research. They have extremely desirable operating characteristics that are difficult to obtain with more conventional designs as well as with semiconductor diode lasers.

In brief, "cube"/microchip lasers are fabricated by polishing a wafer of a crystalline gain medium (e.g. Nd:YAG) so that two sides of the wafer are flat and parallel. The thickness of the wafer corresponds to the length of the laser cavity.

For a 1319nm Nd:YAG laser, wafer thickness is in the order of 1 mm (or about 1/32 inch). The polished surfaces are coated to form the mirrors of a laser cavity. The wafer is then diced into small pieces, typically 1 mm square. Each piece of a 1 mm cube is a complete microchip ("cube") laser. This simple and material-saving fabrication process offers the potential for low-cost mass production.

By selecting the proper cavity length, only a single longitudinal mode will oscillate when the laser operates in a single transverse mode. The laser is optically end-pumped by semiconductor diode. As an example, a Nd:YAG microchip laser operating at 1319 nm can be pumped by GaA1As diode laser (808 nm) with 60 percent absorbed power and a lasing threshold at about 75 mW of absorbed power.

> We at CableLabs think (the cube laser) is worth a try.

At the threshold power level, the maximum cw output power is 51 mW, and the slope of optical quantum efficiency is greater than 40 percent. The single-frequency output linewidth is less than 7 kHz. It must be noted that depending on device design and materials used, the numbers may vary.

The output power of the microchip laser is usually limited by the available pump power and for a special purpose, lasers achieved 500 mW. The central frequency (wavelength) of the output can be tuned over a large portion of its gain bandwidth by a small change in the cavity length induced by thermal, piezoelectric (transversal stress) or electrooptic effect.

Unfortunately, the direct modulation and pulsed operation of a microchip laser is limited to about 100 kHz for a 1319 nm Nd:YAG laser. As a result, an external modulator must be used. However, because of very small dimensions, the pump diode, microchip laser and modulator can fit inside a package similar in size and form to one used for DFB lasers.

Also, lithium niobate crystals have improved with time. The crystal's quality is better, and planar technologies are used to form electroacoustic high-frequency modulators. Enormous progress is being made in linearization of modulators by optical and electrical approaches. All those, together with more powerful and more reliable light sources, make the external modulation-based links an important alternative, when costs are acceptable.

Those lasers are monolithic devices. There are no optics that become misaligned. Nd:YAG is an extremely rugged material, and consequently the ambient environment in which a microchip laser can operate is determined by the other components in the package, and not by the cube itself.

Cube/microchip lasers also can be made using other elements. A quick review of the available crystalline materials, with optical gain in the 1280nm to 1360nm window, shows that there are several materials which can be used with present "cube" laser technology to provide spectrum coverage with outputs at approximately 7 nm intervals, and with an additional tunability of each output over an interval of roughly 1 nm. That translates into about eight to ten usable wavelengths for wavelength division multiplexing (WDM) on fiber in the currently used 1300 nm to 1360nm transmission window for telecommunications purposes.

Also, the output of a single laser diode can be used to optically pump two "cube" lasers which are arranged in series and produce output at two different wavelengths.

U.S. patent numbers 4,860,304 and 4,953,166 describe the original microchip laser concept. Also, several other patents cover the final functional devices. For a more detailed description, a review article titled "Microchip Lasers" in the *Lincoln Laboratory Journal*, volume three, number three is recommended.

CableLabs is bringing to the attention of the cable industry the concept of cube, or microchip laser technology as a high performance, low-cost light source for the next fiber link for cable. It is believed that this article is the first one which points to cube lasers for cable-specific applications. The early discussions about this concept have raised positive responses, and already some initial feasibility studies are being initiated by the manufacturers. ■

Alternative access and the cable operator

In recent years, the role of the cable operator in the local access business was primarily limited to low profile, individual projects. Concern about regulatory issues, diluting the focus on the core business, and problems with interactive coaxial cable were but a few of the reasons for slow development of alternative access networks by the cable industry.

However, with the deployment of fiber optic technology for core business applications, many of the initial economic barriers are reduced, creating a "window of opportunity" for cable operators. Because fiber optics, coupled with opto-electronics, offers unlimited bandwidth capability, cable and telephone operators both have the potential to offer voice, data and video services to the consumer. With the added advantage of economic and performance capabilities, cable operators are now in a unique position to take a closer look at the possible opportunities ahead for the alternative access business.

But what exactly is this market and who are the probable players? This article will attempt to review some of the *basic* considerations surrounding the alternative access market, paying particular attention to the cable television operator. During the course of the paper, various topics will be examined including the scope of opportunity, nature of the business, the product, various positions a cable operator can take, legal issues and specific recommended first steps.

(Unfortunately, the scope of many of these issues are extensive and cannot be explored in-depth within this article because of space constraints. Optical Networks International will continue to provide in-depth articles addressing specific issues in upcoming months.)

By Andy Paff, President, Optical Networks International

Market opportunity and size

The immediate market opportunity facing the cable industry for non-video revenue sources is to provide digital alternative access services (voice, data and video applications) within franchise areas. Alternate access, often referred to as "bypass," implies competition with the existing telephone company services. However, this competition is limited to a very narrow segment of the existing telco business.

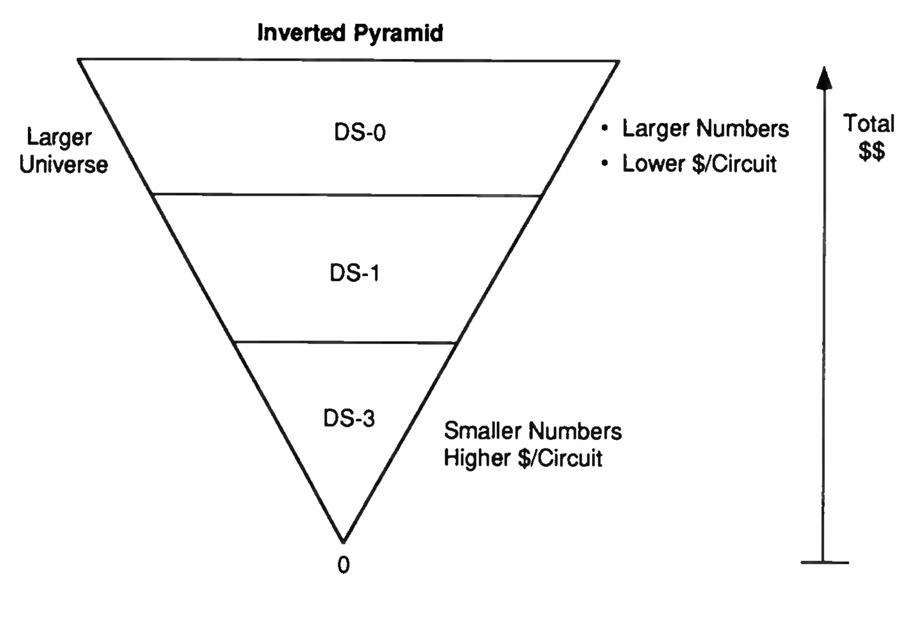


Figure 1

Revenue potential is keyed to the local tariffs, amount of DS-1 and DS-3 traffic, commercial growth, the number of interexchange carrier (IXC) (i.e. long distance provider) POPs (point of presence) and the existing facilities of the local exchange company (LEC). Tariffs are usually mileage sensitive, therefore the physical layout of a community is important as well.

The local exchange company is the primary competition, although there are also private microwave dealers and independent metropolitan area network (MAN) entrepreneurs to consider.

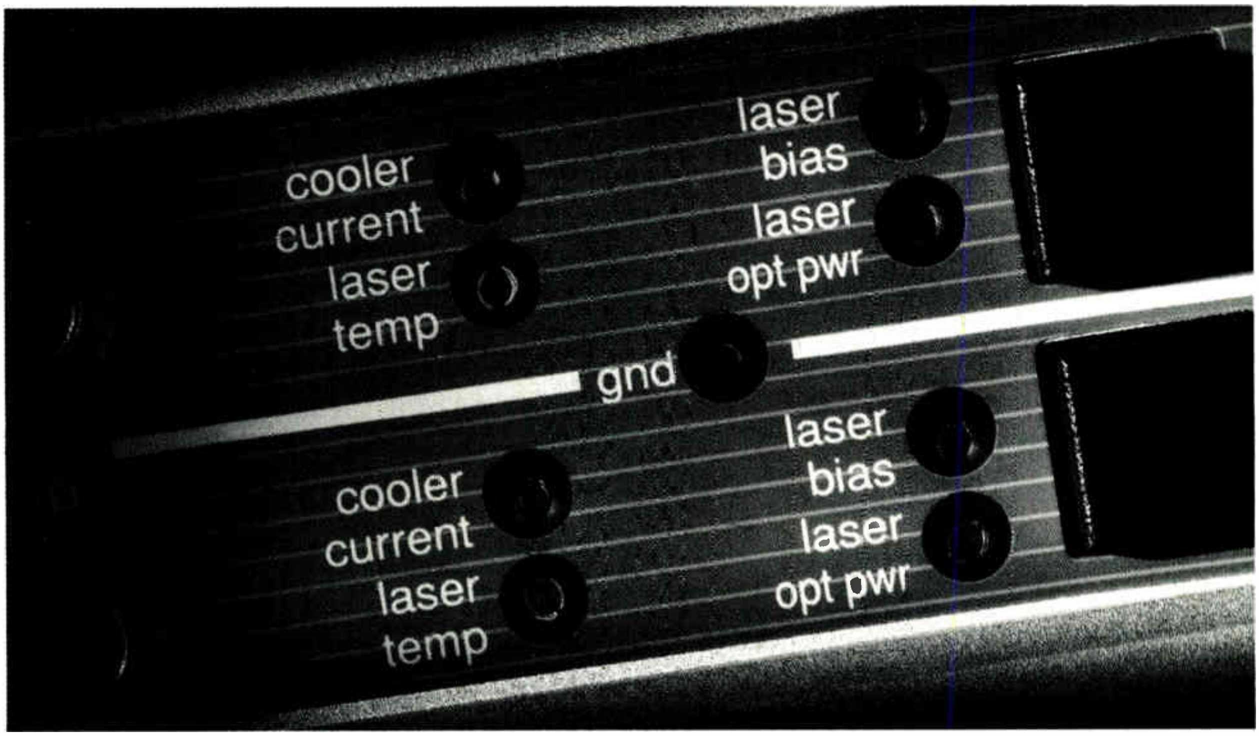
This market is in its infancy with independent MAN and cable companies just beginning to scratch the surface of this new and evolving market. The alternative local transport (ALT) industry estimates the access market at a $5 billion *dedicated* access market and a $20 billion *switched* access business. Currently, ALT companies represent less than $150 million in market share for the alternative access market.

Cable's opportunity is based on lower operating and capital costs as compared to the LEC or the MAN operator moving into a market where a cable operator is established. Capital costs can be leveraged to a degree, driven by market demand and rate of return. Independents generally have to build a near complete infrastructure in order to generate necessary cash flow to cover a much larger initial investment. Even where facilities do not exist, the cable operator knows the local construction variables and will have unique insight into third-party conduit (e.g. power companies, city utilities) and related resources.

The cable operator's cost advantages in the operations side of an alternative access business stems from the core business facilities and operational personnel in place. Depending upon the degree of commitment, technical support may be added or grown from the existing staff.

These capital and operational cost advantages simplify a product that has both price and technical attributes for the potential customer base, while meeting internal rate of return re-

Some call it the way of the future.
We're ready now.



Fiber optics. For years it's been discussed at the trade shows and written about in the journals. But when the time for talk came to an end and the call went out for it to finally become a reality, you knew that Jerrold would respond.

Designed, tested, and perfected at our Applied Media Lab, Jerrold's breakthrough Cableoptics™ products include the STARLITE™ AM-550AT Advanced Transmitter that contains the first and only laser developed exclusively for cable TV. Complemented by our full line of STARLITE Receiver products, Cableoptics is serving fiber-to-the-feeder backbone and super truck applications.

Jerrold has met the challenge. We can do it for you, too. Our Cableoptics engineers can provide a sample design and analysis to demonstrate the efficiency of fiber optics in your systems. To arrange an appointment, call 1 800 523-6678.

Responsive

JERROLD
COMMUNICATIONS

Circle Reader Service No. 4

quirements for the provider.

What is alternate access?

In its simplest and most basic form, alternate access is the connection of two telephones via facilities other than those provided by the LEC's central office (CO) switcher. This definition includes even those arrangements provided by the LEC but still "bypassing" its CO.

The term "alternate access" is most frequently used to describe the following four applications:

- POP to POP. This business consists of bringing an IXC from one POP to another, usually within the same city. The POP is merely the local access point of a particular IXC to its long distance network.
- End user to POP. This is a natural extension of "POP to POP" and involves bringing the large customers of an IXC directly to the IXC POP. Either the customer or the IXC can be the client of record for the access provider.

Customers—especially large ones—may be primarily interested in improved reliability. Many large customers will diversify their internal networks by using several long distance companies. However, if there is not redundancy locally, they are still subject to single points of failure.

- End user to end user. This involves providing telecommunications for a customer from one premises in the local access and transport area (LATA) to another premises in the same LATA. (A LATA defines Local Access and Transport Areas where provision of local [basic] telecommunications services could be a monolopy. Instead, the LATA network provider, often a BOC, must provide choice or access to all long distance carriers.) Applications may involve telephone off-premise extensions from a PBX, remote data terminals, alarm monitoring and data transfer.
- Private networks. The private network is virtually the same in application as the "end user to end user." The private network involves a dedicated facility for a client, not shared facilities between several clients. Thus, the market is limited to large applications such as hospital networks and other large locally integrated concerns.

The irony is that in many states the private network is the most isolated from regulatory issues while the shared end user to end user network is the most sensitive.

Figure 1 illustrates the concept of the "inverted pyramid." At the bottom are the DS-3 circuits with high incremental revenue although limited numbers. Further up are the DS-1 circuits where the revenue per circuit is lower but the universe and total revenue potential is much greater. At the top are the DS-0 circuits (single voice channel) where the revenue/circuit is the lowest but the total revenue is the greatest.

The business plan should involve moving as far up the inverted pyramid as possible to maximize the opportunity. The key to this goal is to plan an integrated network that will enable this ascent by keeping marginal costs to a minimum. More simply, start construction with secured business that provides acceptable return and look for additional opportunities within the operating network to build the business on.

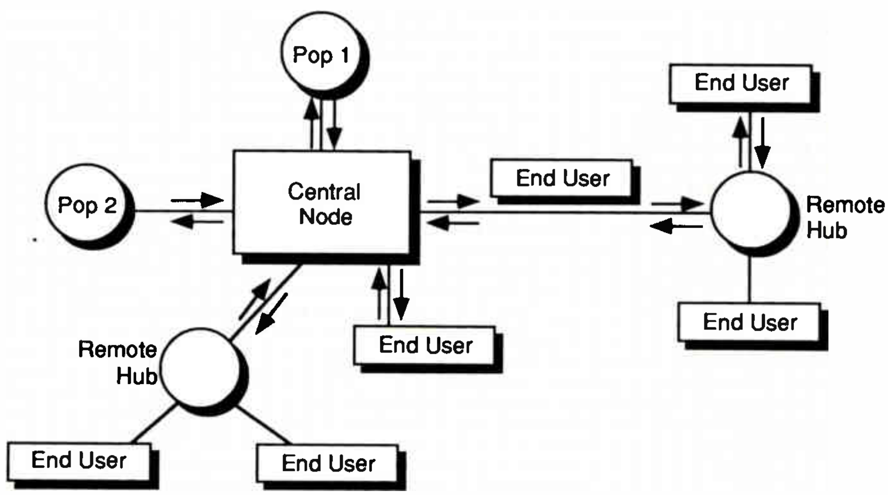
Dedicated and switched services

Alternate access companies may provide two types of network services—dedicated and switched. The four opportunities discussed above are dedicated access services. These are point-to-point connections, although the provider will typically use common facilidties for a number of different clients. Even if the provider enables access to a number of different carriers through a series of point-to-point connections, it is still considered "dedicated."

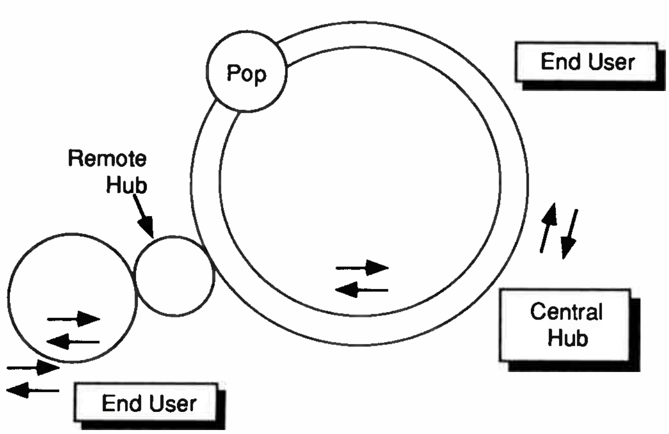
If the provider offers general long distance service to an end user client and installs a switch to route the customer to a particular destination, it would be considered a switched service. The provider in this case would be considered a "carrier." This creates greater regulatory visibility at the state and federal levels.

The switched service is more capital intensive as the switch is expensive and the margins on this form of IXC

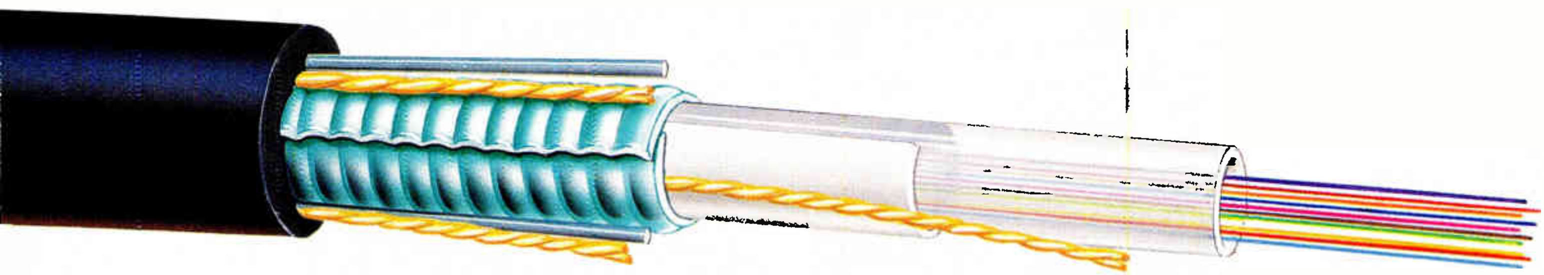
Ring-Star (Functional)



Ring-Star (Physical)



THE MORE YOU KNOW ABOUT FIBER OPTIC CABLE, THE BETTER WE LOOK.



You've heard the names Hybrid, Backbone, Fiber Trunk and Feeder. And, chances are, you've already looked into and learned quite a bit about fiber optic cable. Two more names you should also know. Comm/Scope and Optical Reach. CATV's fiber optic cable.

Optical Reach utilizes one central buffer tube, making it the smallest and lightest single fiber optic cable design available in fiber counts up to 144. Therefore, installations go faster and easier with less man-power. Our optical fiber has the best attenuation specifications offered in the market today and each individual fiber is measured and meets those specifications whether you need 2 fibers or 144.

Now, from what you've already learned here, don't those two names, Comm/Scope and Optical Reach, look even better to you? We thought so. That's why we've made it easy for you to reach us. Just call your nearest Comm/Scope representative or call us at (800) 982-1708. We think we'll get to looking even better.

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

Comm/Scope, P.O. Box 1729, Hickory, N.C. 28602.
Phone: (800) 982-1708. (704) 324-2200.
Fax: (704) 328-3400.

Circle Reader Service No. 5

business (often referred to as "reselling") are very slim. Typically, a switched carrier may average a few pennies per minute (10 percent to 15 percent) gross profit and be highly vulnerable to fluctuations in pricing by the major long distance carriers.

The advantage of a local access provider also operating as a switched carrier is the provider now takes a percentage of the long distance revenue in addition to the access revenue. It is also moving to a broader market (higher on the inverted pyramid). However, the regulatory exposure along with the increased capital risk provide reason for caution. It is recommended that such activity be market-driven from an existing dedicated access business.

Why bypass the local telco?

There are three common reasons for an end user to bypass the local telephone company. Each of these reasons provide the motivation and interest a customer will have when examining a local cable company for access provision.

- Technology: flexibility and reliability
- Cost savings
- Service

While the flexibility inherent in fiber optics is a critical point, many large customers are mainly interested in local loop reliability. This is most often translated into specifications called "availability" and "bit error rate." These concepts are important because this is how the product is defined and marketed. Availability is given in terms of a percentage of time the circuit is available for use by the customer. (For more information, see 'Measuring System Availability,' July 1991, CED, p.70.)

Bit error rate (BER) is the measure of errors in digital transmission. Alternate access providers must provide a BER specification of 10^{-9} or better (one error in one billion bits).

Cost savings are directly related to tariff issues. Because IXC's deal with a bewildering array of tariffs (primarily the interstate and intrastate access tariffs), the ability of these companies to provide profitable services is limited. Cable operators, on the other hand, face an incremental outlay of capital and operational costs allowing an operator to effectively price access provision lower than the market.

Initially, the alternate access provider should be prepared to offer a significant reduction in cost for comparable service. This may be a 20 to 25 percent reduction from the published DS-1 or DS-3 tariff. As the "new kid on the block," there has to be an incentive to make the change and price is a big incentive. Long-term viability, however, is more closely tied to the product quality as the telcos could fight a price war effectively if they experienced significant market erosion.

As for service, the installation and reconfiguration intervals provided by the LEC's can be a significant problem for the IXCs and the end users. Dedicated alternative access providers will simplify this process by focusing on the needs of a smaller client base with specialized needs.

Engineering and system design

The layout and design of the network is critical in order to provide a marketable product and to control costs. "Product" is defined in terms of technical performance. Large volume users particularly will look at technical performance in addition to price. A carefully designed network is imperative to providing availability and BER specifications worthy of consideration.

A "ring star" approach offers advantages in capacity, flexibility and redundancy. The terminal equipment provides both electronic redundancy and optical redundancy. Routing the backup optical system along a different physical route will provide the maximum in availability.

Capital and operating costs must also be considered. The ring star approach provides the maximum in usable capacity through a series of point-to-point links back to a central node. Primary links to the POPS can be used for "POP to POP" and "end user to POP' applications (See Figure 2). The goal is to use the central node and outlying nodes to concentrate traffic and thus minimize construction. With redundant electronics and routing diversity, along with inherent central alarm capability, personnel costs are also minimized.

When looking at system design, construction costs are the most significant consideration. Much of the local access business will be in the downtown area or in areas of expanding commercial development. Cable television facilities (conduit and strand) may not exist in these areas. Terminal equipment can be thought of as a variable expense because it need not be purchased until contracts are signed. However, this is more difficult during the construction phase as potential clients will want to see a network in place.

Potential structures

The structure of the cable operator's involvement in the local access market will incorporate all the elements previously discussed. There are also other, more common, business structures involving the cable television operator.

Third party operated network. Because of the problems obtaining cost-effective right of way, there may be third party access providers interested in leasing fiber capacity from the local cable operator. This might involve a flat rate for point-to-point service with a variable component to enable the cable operator to participate in the upside as the business grows.

Cable operator provides ad hoc service. This has historically been the norm. The cable operator will run a dedicated facility for a large local client and charge enough so it is worth the effort. With fiber optic deployment for cable television applications, this will probably become even more common. Little need be done except build and maintain the facility. While this activity does not maximize the local access opportunity, it does provide additional incremental revenue from an existing asset base.

Cable operator provides carrier service (carrier's carrier). In this scenario, the cable operator designs, constructs and operates a ring star network to connect IXCs to other POPs and bring large IXC clients to the POP. The advantage here is the IXCs provide the initial business from their internal network requirements, then provide the sales/marketing thrust to the end user group. The cable operator needs to service and interface directly only with a manageable number of IXC clients.

Cable operator provides full scope of permissible local access. This implies a dedicated marketing/sales staff to deal with both the IXCs and their end user clients. Care must be taken that sales activity does not conflict. The IXCs are interested in anything that involves their clients and local access will impact their business. *If* market driven, the business can grow into the wider base of smaller end users through one or more of the IXCs—even to the DS-0 level.

Cable operator provides own, internal service, between offices, both as carrier and as end user. Savings on operating expenses can pay for network (in some cases) without additional revenues.

These relationships are not necessarily mutually exclusive. Combinations and developmental market-driven growth between two or more of these business structures may be optimal.

Taking the first steps

Evaluation of a specific market should follow an organized approach. The following actions will aid in surveying particular markets for access services.

- Review franchise and pole attachment agreements. Specifically, does the cable franchise enable the operator to provide these services? Are the pole attachment agreements restrictive in this area? Other issues such as "video dial tone" and questions pertaining to the four areas of opportunities must also be explored.
- Review regulatory issues. A complete examination of both the FCC and state PUC guidelines and regulations is advised before any alternate access venture is undertaken. Particular attention needs to be paid to state regulatory issues. Each state is different in its interpretation of what is "permissable."
- Review local DS-1 and DS-3 tariffs.
- Meet with several potential large end users to discuss telecommunications needs.
- Identify the local IXCs and their POPs.
- Meet with the regional network managers for the IXCs present in the community.

These initial steps should provide the necessary background information to determine if a market exists for local access. The scope of business, structure and initial pro forma should develop from the preliminary evaluation. The project may require a more extensive marketing analysis involving more identification of potential customers, their location, routing and so forth.

Window open now

Fiber optic deployment is widening the window of opportunity for the alternative access market. How quick the window closes remains a question. For now, cable operators have a construction advantage in the access market, which experience has shown to be a *major* advantage. In order to benefit from this, operators need to understand the product, regulatory issues and the scope of the business.

In closing, it's important to emphasize a few key points. First, preliminary studies in specific markets will identify (and quantify) the market opportunity for those operators wishing to pursue the window of opportunity now.

Secondly, to properly facilitate participation in the access business, proper planning of system design engineering is essential. There are some vendors of optical equipment and independent consultants highly capable of helping with system integration.

And finally, perhaps most importantly, our experience indicates tremendous revenue gains in the alternative access business can be realized by only incremental investments. ■

Glossary

ALT: Alternative local transport
BER: Bit error rate
CO: Central office
IXC: Interexchange carrier
LATA: Local access and transport areas
LEC: Local exchange company
MAN: Metropolitan area network
POP: Point of presence
PUC: Public utilities commission

Using push-pull, PIN-FET fiber optic receivers

Significant progress has been made in analog fiber optic components and systems in recent years. Further reductions in the cost of devices such as DFB lasers will permit the extension of CATV fiber links beyond the present trunking applications. Increased use of fiber couplers and splitters will bring the fiber receivers closer to the subscriber. Optimization of receiver performance to maximize the reach and fan-out of an optical transmitter in a fiber system with low received optical power presents different design constraints from those of a fiber trunk line receiver.

This paper describes a new type of fiber optic receiver specifically designed for long distance links and with low received power levels (less than −3 dBm). There are four fundamental advantages associated with this receiver that will be discussed.

Design considerations

The new receiver design allows the cable operator to have longer reach with the same distortion characteristics displayed by conventional fiber optic receivers.

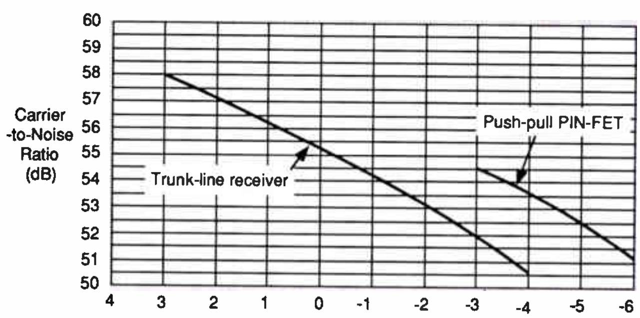
The reduced signal levels of the long reach fiber distribution systems permit the use of low-noise optical receiver front-end designs that would not be practical in fiber trunking applications. The larger signal levels of the trunk line would compress the low-noise receiver.

Conversely, much of the high-level dynamic range of a trunk line optical receiver would be wasted in a low received power application, because the high output level capability designed into the trunk line receiver would not be used, and this high output level capability is attained at the expense of noise figures.

In an extended reach link, the intensity noise of the laser is attenuated sufficiently in the fiber so the receiver noise limits the recovered carrier-to-noise ratio. The push-pull, PIN-FET receiver achieves a low thermal noise front-end by coupling the PIN photodetector to a pair of GaAs FETs in push-pull configuration.

Noise figure

This new design exploits the low-noise characteristics of GaAs FETs in providing pre-amplification, but it also provides a low thermal noise match to the photodetector. Noise figures of less than 1.5 dB are typical for GaAs FET amplifiers operating below 2 GHz. Design of a low-noise amplifier operating in a higher characteristic impedance than the standard 50 or 75 ohms minimizes the required impedance transformation. This is fundamental to the operation of this receiver, as there is a tradeoff between loss and bandwidth in matching between differing impedances.



Comparison of received carrier-to-noise ratio by push-pull, PIN FET receivers and trunk line receiver

Figure 1

Loss in the front-end translates to an increase in the effective noise figure of the pre-amplifier. The impedance for matching to the GaAs FET is provided by a simple low-loss matching circuit from the PIN photodiode because both of these are of reverse biased junctions and simple reactive tuning rather than impedance transformation is all that is required to tune the front-end circuit of this receiver.

Distortion in the push-pull, PIN-FET receiver is improved over single-ended PIN-FET receivers as the push-pull circuit reduces the RF power requirement of each FET by 3 dB; and, more significantly, the second order distortion of the FETs is canceled in the output combiner of the push-pull circuit. Many of the commercially available PIN-FET receivers available today are composite second order distortion (CSO) limited for this reason. The bandwidth capability of this receiver is beyond 1 GHz, which is the limit of present CATV applications.

Prototype push-pull PIN-FET receivers developed in the laboratory have demonstrated received C/N ratios of better than 50 dB with received optical power levels of less than −5 dBm for channel loading up to 550 MHz. This represents a significant improvement over the performance of trunk line receivers on this same link (see Figure 1).

The first of the advantages mentioned above pertains to the fact that the thermal noise of the photodetector is inversely proportional to the load impedance that it is driving. Both the PIN diode and the gate of the FET are high impedances of reverse-biased junctions, and broadband performance can be achieved with simple matching circuits that incorporate the gate biasing circuit for the FETs.

Since these impedances are similar, minimal impedance transformation is required in simultaneously providing a low noise match to both the photodetector and the FETs. It is this impedance characteristic of the GaAs FET at CATV frequencies as well as the low noise figure that make it attractive for this application.

Since the signals in the two branches of a push-pull amplifier are 180 degrees out of phase, they are negatives of each other. If one uses a Taylor series for the drain currents in the two FETs, with one drain current being the negative of the other, the series for one of the FETs is alternating in sign with all coefficients for the odd terms in the series being negative, while the coefficients in the series for the other FET are all positive.

The combiner circuit outputs a current proportional to the difference of these currents so all the positive (odd

By Nigel Watson, RF/fiber Optics Design Engineer, Magnavox CATV Systems Inc.

order) terms add while the even order terms cancel.

To explain the operational principles and specific advantages of this receiver, comparison is made to a conventional CATV optical receiver design in

The input matching network provides DC bias to the PIN photodiode and gates of the FETs, and it provides appropriate terminating impedances to the FETs and the photodiode over the desired bandwidth. The GaAs FETs

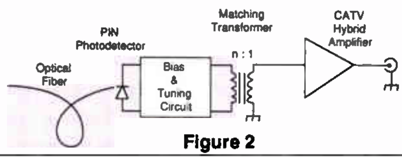


Figure 2

which the photodetector is coupled to a 75-ohm CATV amplifier (see Figure 2) using a passive tuning circuit and a transformer.

The transformer coupled front-end is typical of the type of receivers being used for fiber trunking. The thermal noise from the photodetector is directly proportional to the noise figure following it, and inversely to the load resistance it is driving. Losses in the input matching circuit add directly to the noise figure of the amplifier.

With only a transformer as the input matching circuit, the photodiode load resistance is the amplifier input impedance (75-ohms) multiplied by the square of the turns ratio of the transformer. Worst case noise figure for the CATV hybrid amplifier used in this trunk line receiver is typically about 6 dB. For discrete component receivers, the maximum turns ratio that is suitable up to 550 MHz is 2:1, which yields an impedance transformation of 4:1 (the impedance goes as the square of the turns ratio) resulting in load impedance of 300 ohms for the photodetector.

With an appropriate PIN-FET de-

in the diagram are grounded source and require a split supply for a negative gate bias and positive drain bias; however, single positive supply operation can be accommodated while still using the common source configuration with the addition of bypassed source resistors.

With this approach, DC causes a positive voltage at the source of the FET while remaining RF ground because of the bypass capacitors. The gate is grounded and therefore is negative with respect to the source voltage. An adjustment potentiometer balances the gain of the two amplifier branches.

The output circuit consists of a balun transformer to combine the two amplifier outputs, flatten the gain over the desired bandwidth and to introduce the drain bias to the FETs. The output circuit design is less critical than the input circuit, as it is the input circuit that determines the noise performance of the receiver.

When the input circuit is properly designed, it provides a balanced feed to the FETs with appropriate impedances for a low-noise match.

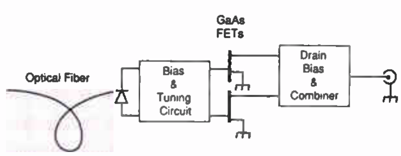


Figure 3

sign, photodiode load impedances of greater than 1200 ohms can be obtained over the 50 to 550 MHz bandwidth. Equally important to the operation of this receiver is the noise figure of the FETs and input circuit losses. Computer simulations of prototype versions of the push-pull PIN-FET receiver confirm that the noise figure, plus losses of the front end (the effective noise figure), is less than 3 dB.

A conceptual block diagram of a push-pull PIN-FET receiver is shown in Figure 3.

Output matching of the receiver flattens the gain, provides a low VSWR and stabilizes the out-of-band response. The major constraint in operating this receiver is the output third order intercept point of the FETs. Based on data from FET manufacturers and on experimentally characterized amplifiers, an output of 15 dBmV per channel is the maximum level at the output of the FETs. Additional CATV hybrid amplifiers can, of course, be added after this receiver if additional level is desired. ■

Improving reliability in CATV systems with optical switching

Improving the reliability of cable television systems has become increasingly more important over the past few years. A number of events have contributed to this trend. Competition with DBS, MMDS and videotape rentals, plus the prospect of direct competition with the telephone companies have been key drivers in forcing cable operators to re-evaluate their reliability objectives. The advent of AM fiber technology has created the opportunity to re-examine the architecture of the cable system, while simultaneously requiring the installation of new optical plant.

The initial applications for AM fiber technology have primarily been in cascade reduction applications. Cable operators have taken advantage of the opportunity to improve the reliability of the service they deliver to subscribers by overlaying AM fiber links on their existing coaxial plants. This architecture, which has been dubbed the Cable Area Network (CAN) and is illustrated in Figure 1, involves inserting AM fiber receive nodes at specific points in the existing trunk amplifier cascade, depending on the new cascade length desired.

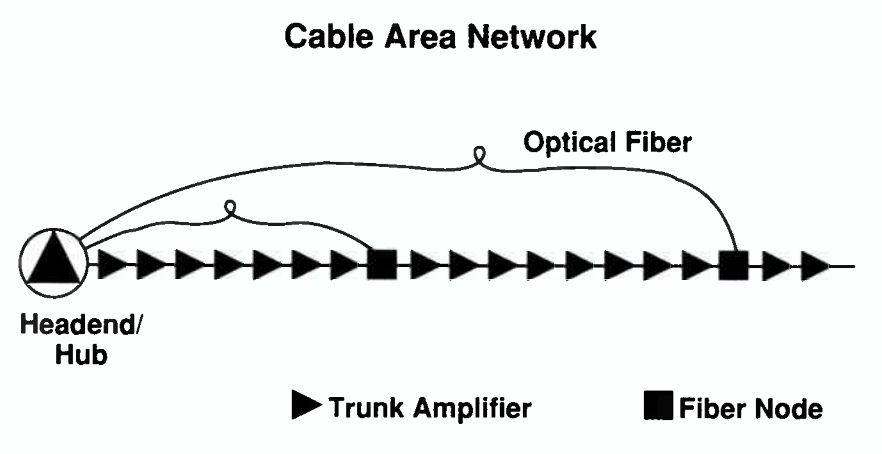


Figure 1

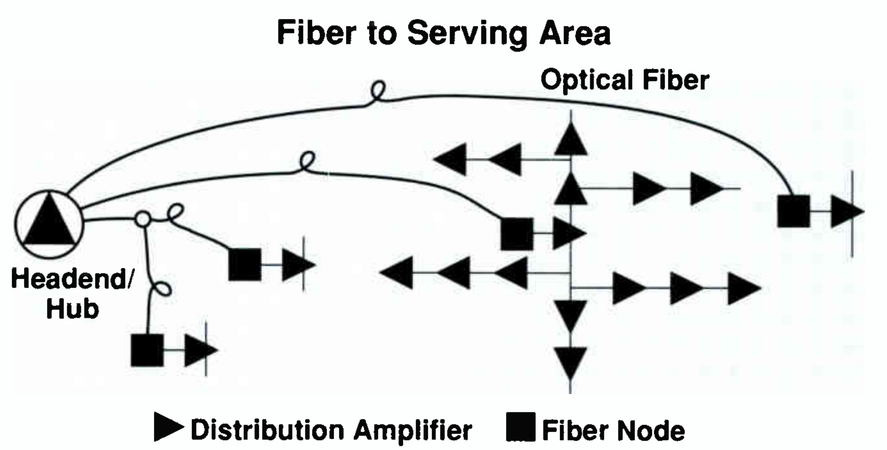


Figure 2

The optical cable is routed via a separate path from the coaxial trunk cable. Both the existing trunk cable and the optical cable enter the fiber receive node. Inside the receive node, the optical signal is converted to RF, and a relay selects between the two RF input signals. Normally, the fiber input is considered the primary path, and the relay is actuated to the coaxial input in the event of a problem with the fiber signal.

As AM fiber and distribution plant architectures are discussed, new approaches have been developed which call for a different solution. Increasingly, cable operators are implementing Fiber to the Serving Area (FSA) type architectures, in which no coaxial trunk cable is utilized, as illustrated in Figure 2.

In addition, the quantity of AM fiber transmitters and receivers used in a given cable system has increased dramatically. With the elimination of the coaxial trunk as a potential backup path and the increase in optical plant and electronics, cable operators have begun to consider alternative means to add redundant elements to their systems and thus enhance reliability.

In order to investigate the ques-

By John A. Mattson, Director of Marketing, Scientific-Atlanta

What Does a Lost Subscriber Cost?

Cost to Add a Subscriber:	Low	$ 50
	Medium	$125
	High	$250

Average Revenue per Month = $25

Annual Cost Per Lost Subscriber

Months to recapture:	0	1	3	6	9	12
Low	$ 50	$ 75	$125	$200	$275	$350
Medium	$125	$150	$200	$275	$350	$425
High	$250	$275	$325	$400	$475	$550

Table 1

tion of improving reliability in cable systems, it is necessary to do three things:

- Define the meaning of reliability.
- Determine the relative value of improved reliability.
- Explore alternative methods for improving reliability.

What is reliability?

The term "reliability" means different things to different people. In the context of a cable television plant, reliability can be approached from two directions: That of the individual subscriber and that of the cable system as a whole.

From the subscriber's standpoint, reliability is determined by the amount of time during which the cable service is unavailable or severely degraded, when it should normally be available. By including the restriction that the service should normally be available, we are excluding general power outages, during which time the subscriber's set will not work anyway. Cable operators can monitor reliability from the subscriber's point of view by measuring the amount of downtime during a regular interval, such as a month. An increasing number of operators have established customer service standards which measure "subscriber reliability" based on the number of outage minutes per month.

The second way cable operators define reliability is from their own point of view, in terms of the effect of a failure on the entire system, and the resources needed to correct the problem. A system failure will not always cause any subscribers to experience a problem. For example, in the case of a CAN architecture, a failure may occur in the fiber path, but the signal will still reach the subscriber via the redundant trunk cascade.

Of course, the subscriber may notice a degradation in the quality of the signal, but that is preferable to no signal at all. In any event, any failure will still need to be repaired, and thus the operator will want to minimize all system-affecting failures, not just the subscriber-affecting ones. Cable operators measure "system reliability" in terms of the total outage minutes per month, the number of outages per month and the number of truck rolls to repair system failures.

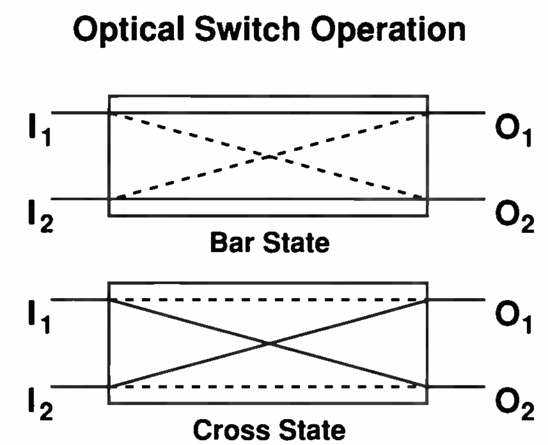


Figure 3

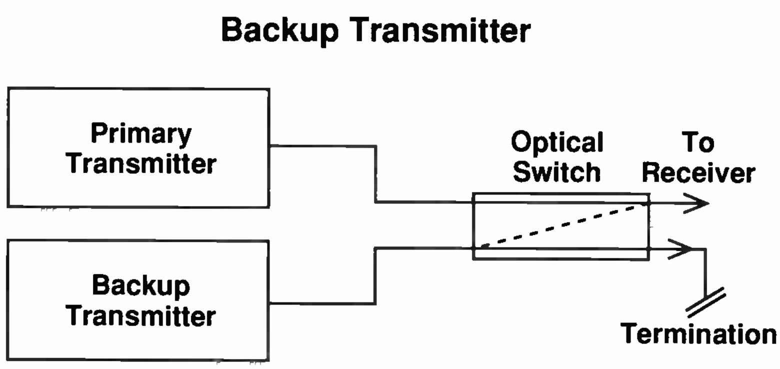


Figure 4

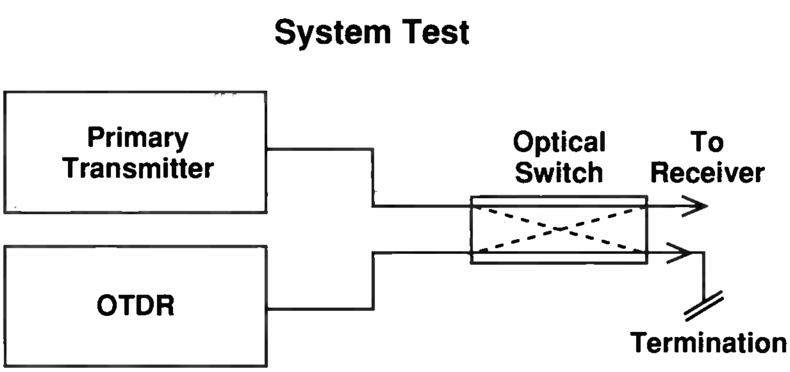


Figure 5

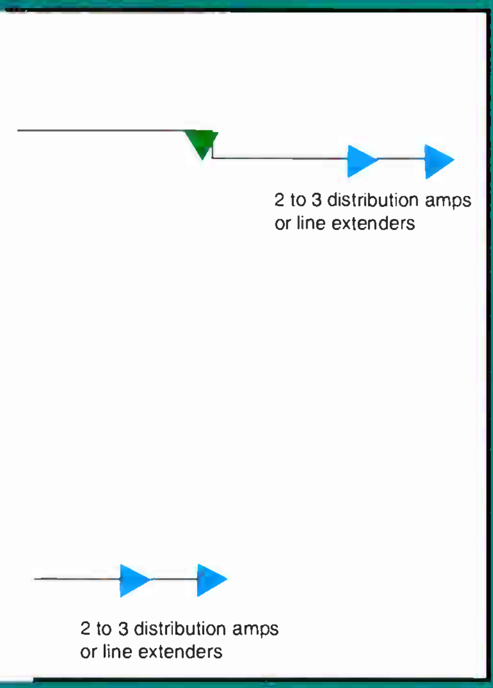
Reliability in CAN architecture

The impact on both system and subscriber reliability resulting from the introduction of AM fiber nodes into an existing cable plant has been studied in terms of a CAN architecture. In this context, it is clear that the outage time per month will be reduced for the subscribers located beyond the first fiber node locations.

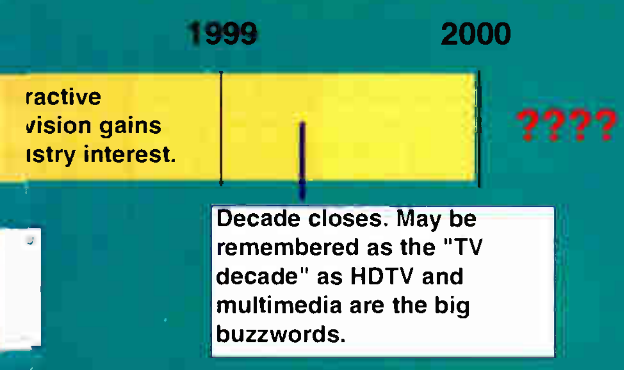
The total percentage of subscribers who fall into that category will depend on the number of trunk amplifiers in cascade prior to the first node, but it is normally a sizable portion of the total

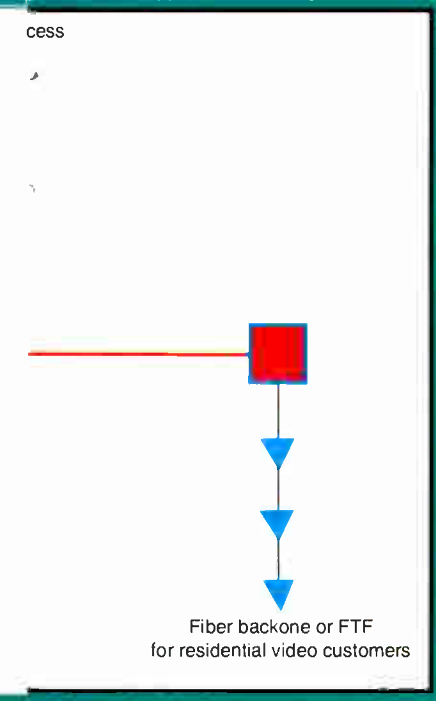
Continued on page 44

ustomer



in upgrades. Replaces
leduces amplifier cascades to
ress" feeder serves area
ceivers. Was originally called
known as All Fiber Trunk and





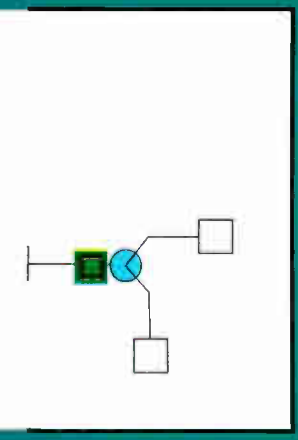
Legend

- Headend
- Fiber cable
- Coax cable
- Optical receiver
- Secondary hub
- Trunk amp
- Bridger
- Distribution amp or line extender
- Splitter
- Cluster tap (64 port)
- 8 port tap
- Standard tap

CED Magazine
600 S. Cherry Street, Suite 400
Denver, CO 80222
(303) 393-7449 FAX: (303) 393-6654

ONI communications infrastructure

An ONI network platform, or "open architecture," that takes into account video, voice and data delivery to a wide range of customers, including residential subscribers of cable television.



Diamond

Magnavox CATV Systems topology specifically designed for high density, urban areas. Utilizes just one active RF device between fiber receiver and subscriber. Optimized for expanding 550 MHz systems to 1 GHz. Also applicable for 750 MHz system expansions.

Get nearly 10 times the optical output of one DFB for under $6,000* a node with

The Diamond Cutter™
Externally Modulated Transmitter.

Multifaceted.
Flawless.
Brilliant.

No other technology can match the power of external modulation to drive fiber deeper into your system. And no one but Magnavox can offer you the Diamond Cutter's precise performance and flawless reliability at such an economically attractive price.

Driven by powerful YAG lasers, The Diamond Cutter gives you up to 40 mW of optical output so you can now cover much longer distances -- over 20 miles. And with the Diamond Cutter, you no longer have to band-split your channels over dual fibers. The low distortion, high dispersion immunity and narrow line width inherent in external modulation allows you to send up to 80 channels over a single fiber. The result is the purest optical signal transmission and brilliant picture clarity -- all for less than $6,000. per node.

To see how the Diamond Cutter can reduce optical transmission costs in your system call your Magnavox representative today.

* In combination with our *new* low cost receiver

Circle Reader Service No. 9

MAGNAVOX
CATV SYSTEMS, INC.

100 Fairgrounds Drive, Manlius, NY 13104
Call 1-800-448-5171 (In NY State 1-800-522-7464)
(315) 682-9105   Fax: (315) 682-9006

Continued from page 26

subscriber population. From a system standpoint, however, the total system outage time will increase, because the fiber portion of the plant is simply overlaid on top of the existing coaxial plant. The cable operator is now faced with maintaining both the coaxial and fiber plants simultaneously.

FSA reliability

The situation is dramatically different in an FSA architecture. The fiber plant replaces the coaxial system in the trunk portion of the plant. Thus, from a system standpoint, the reliability of the trunk is now solely a function of the fiber system, which is presumed to be more reliable than the coax system because of the reduction in the number of active devices. In the feeder portion of the plant, the use of fewer amplifiers in cascade after the fiber node translates to improved system reliability in the feeder. On the whole, therefore, it is apparent that system reliability will be improved in an FSA design relative to a CAN approach.

From the viewpoint of the subscriber, the perceived reliability of an FSA system compared to a CAN architecture is more difficult to assess. In the trunk portion alone, the outage performance will be worse in the FSA system unless a redundant path is added to the FSA plant design. As a result, subscribers located in close proximity to a node location will perceive the reliability to be worse than in a CAN system. The farther away from the fiber node a subscriber is located, the more the feeder reliability will determine the outage performance seen, and the perceived reliability will be better in the FSA system.

From this discussion, it is clear that is important to understand the differences in the methods used to define and measure reliability. The key measurements are the number of outages per month and the total outage minutes per month. These parameters must be determined with reference to both the subscriber base and the cable system itself. The reliability for the subscriber and for the cable system are not necessarily correlated, and an improvement in one may lead to a degradation in the other.

For example, using AM fiber in a CAN architecture, the subscriber reliability will be improved relative to the coax-only plant, but the system reliability will be degraded. On the other hand, in an FSA architecture without redundancy, the system reliability will be improved relative to the CAN system, but the reliability as perceived by the subscriber may be worse on average, although this will vary depending on the subscriber's location.

As a result, an operator will want to consider adding redundant elements to an FSA plant design. The decision will depend on a comparison of the cost of redundancy to the value of improved reliability.

Reliability's worth

There are two components to con-

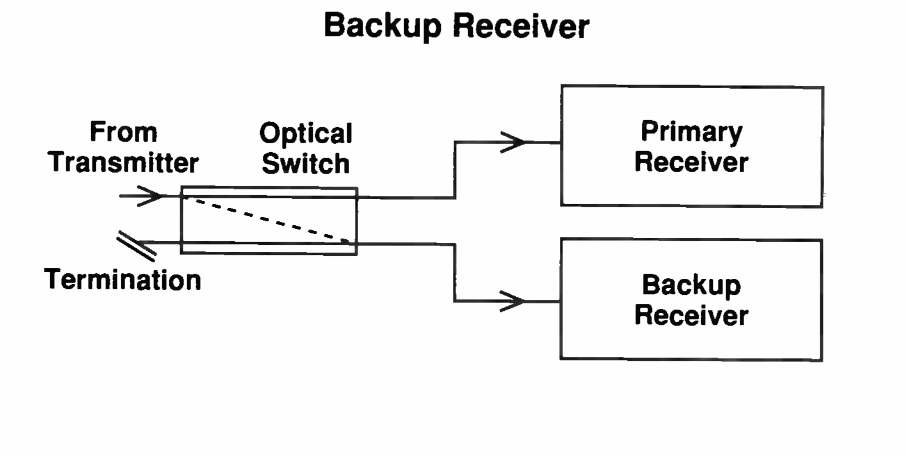


Figure 6

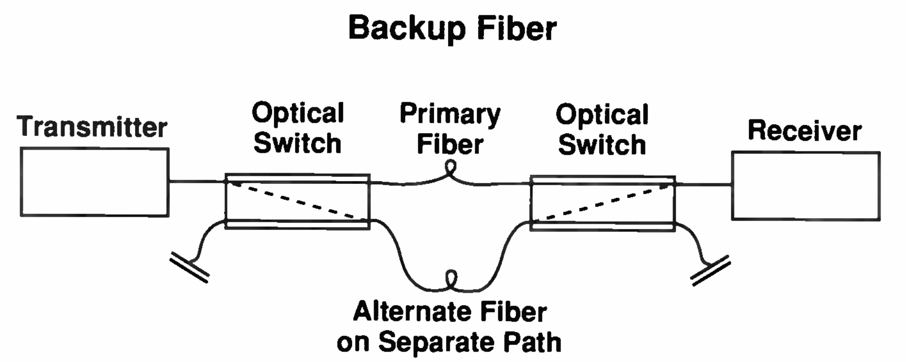


Figure 7

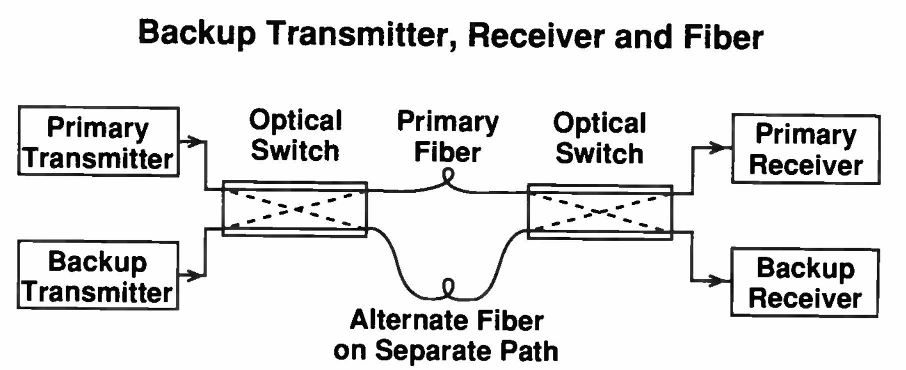
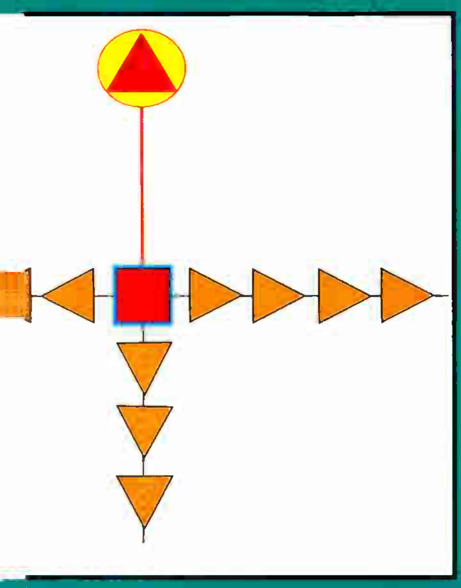


Figure 8

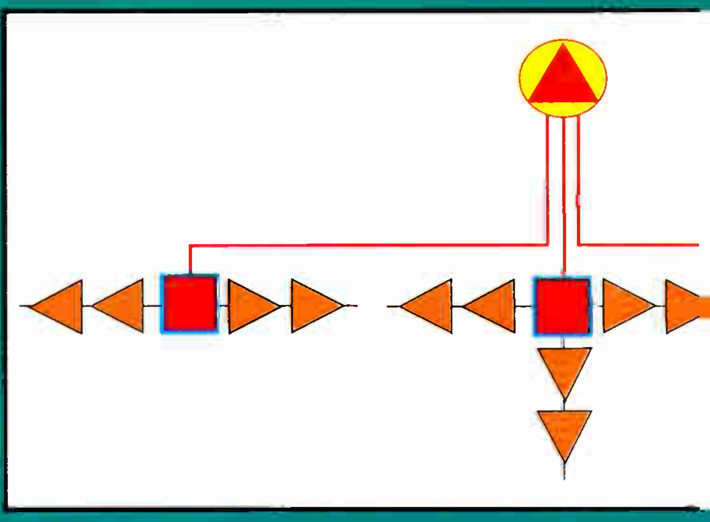
olution of Fib

Fundamental fiber opti



pertrunk

axial cable with fiber optic t transportation run. Often als from antenna farm to ovides improvement in se ratio and distortion over erpart. Defined by ATC as runs of more than four cascade.



Fiber backbone

Reduces broadband amplifier cascades, impro and distortion performance while reducing ma system upgrades and rebuilds to higher band having less than four amplifiers in cascade on

1987

ATC actively shops around the idea of analog AM CATV signals over fiber. "Backbone" topology proposed.

1988

Field tests of AM fiber backbone begin in earnest.

1989

Hybrid FM/AM systems appear. System reliability improves with advent of fiber.

1990

Fiber to the feeder topology designed. Systems carry between 35 and 77 channels. Systems begin rebuilding for 47 dB to 49 dB carrier-to-noise ratio.

1991

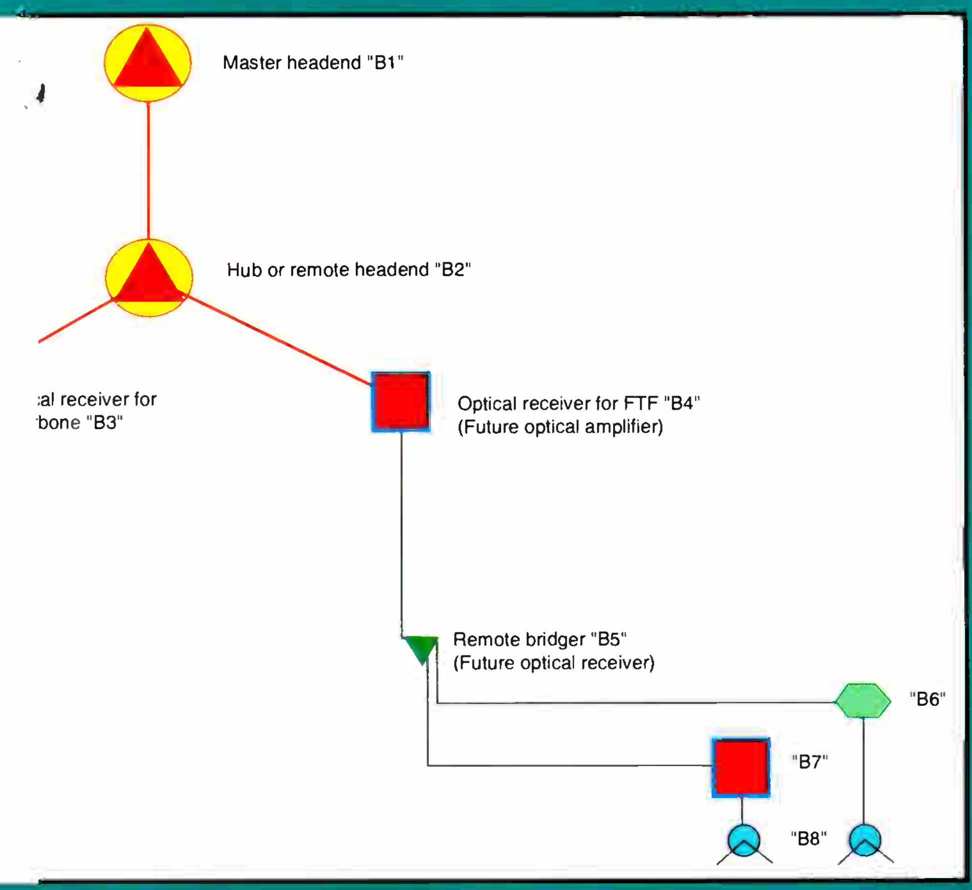
Recession hits industry, but fi implementation continues. De audio and data is big issue. Pe communications networks cap industry's attention.

1992

Digital signal comp satellite feeds beg compressed signa headend start.

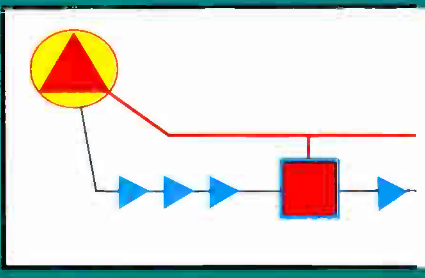
e

pecialized topologies and



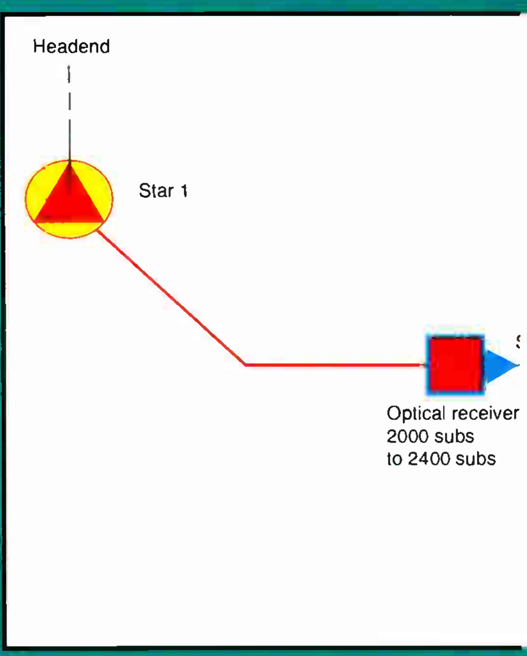
irst

fiber-to-the-tap topology designed by Jerrold ications. Provides for video, voice and data delivery. es star architecture but doesn't carry the cost burdens of star network. Star points are referred to as "bursts."



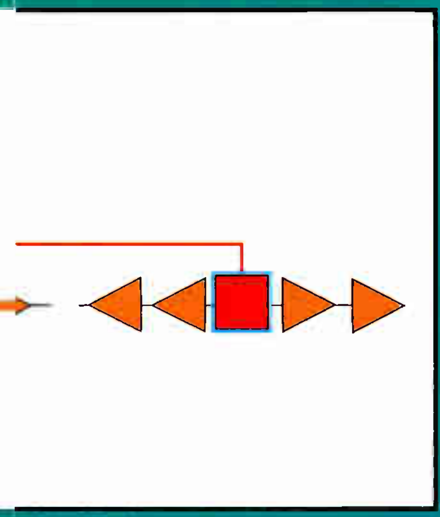
Cable Area Networ

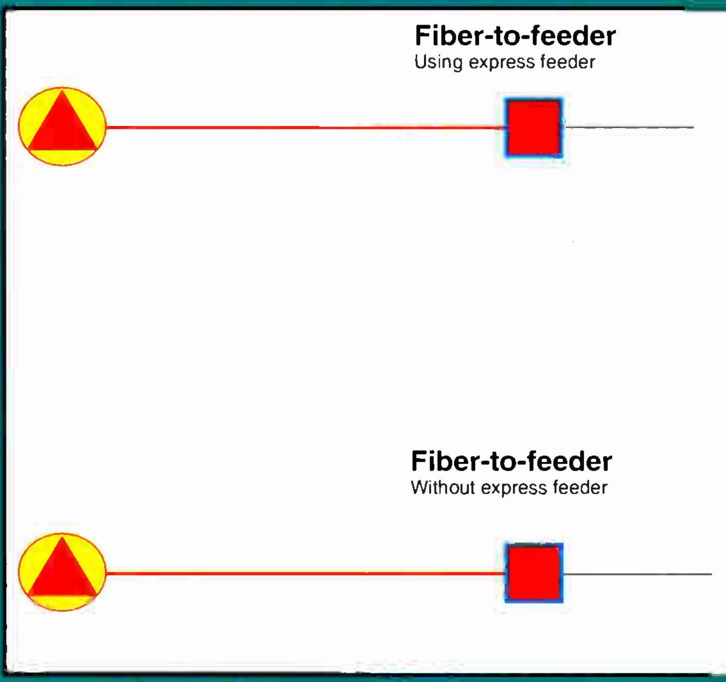
Designed by Jones Intercab primary fiber path. Coaxial A/B switch in optical receiv coax input and triggers stat and coax) increases the reli



ber-to-the-Cu

ic topologies for CATV





ves carrier-to-noise ratio
intenance needs. Used in
widths. Defined by ATC as
any trunk run.

Fiber to the feeder

Designed for system rebuilds, and increasingly
nearly all coaxial trunk cable with fiber optics. I
no more than three active devices. Coaxial "ex
immediately adjacent to headend and optical r
Fiber Trunk and Feeder by ATC engineers. Also
Fiber to the Bridger.

ber
livery of digital
ersonal
pture

pression of
ns. Tests of
ls in

Compression terminals available for use by subscribers. Digital signal transmission to the home is tested. Studio-quality video gets closer to the house.

HDTV receivers go on sale. HD programming (mostly sports and films) available in limited areas.

Some systems use switches in the network to provide video-on-demand. Revenue per sub leaps.

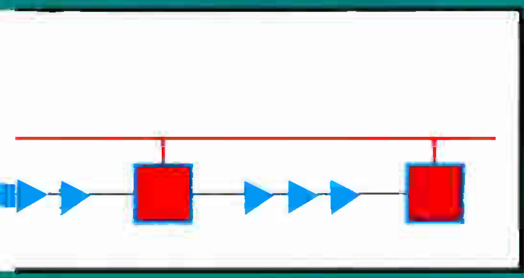
1993 | 1994 | 1995 | 1996 | 1997 | 1998

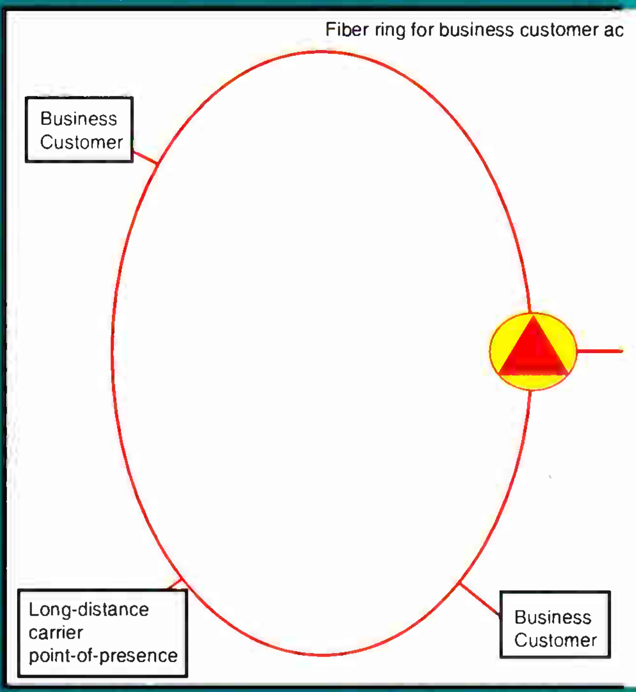
Full competition between cable operators and telcos allowed

Inte
tele
indu

Systems carry between 130 and 150 channels. Voice and data delivery via cable more common. Outages cease to be an issue in most large systems

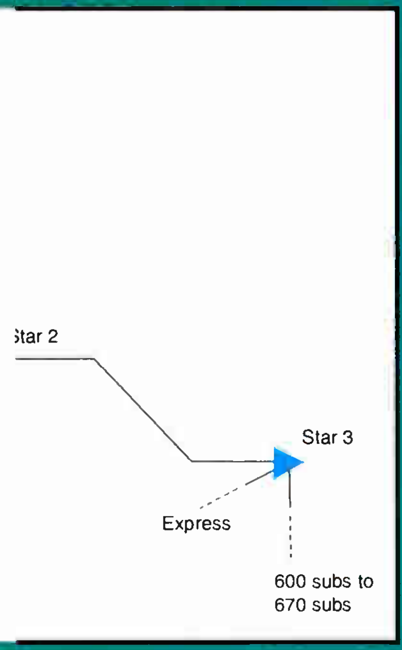
platforms





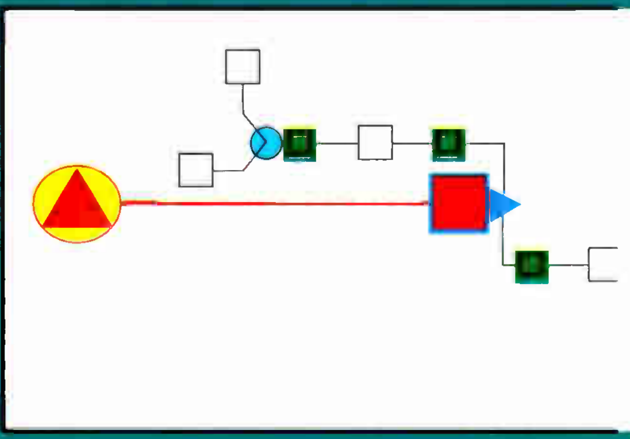
k

le engineers to provide redundant coaxial route to
oute serves as a back-up in the event of a fiber outage.
r housing senses loss of signal on fiber, switches to
us monitoring alarm. Route diversity (between fiber
ability advantage which this topology offers.



Fiber to the serving area

A Scientific-Atlanta design concept that enlarges the area serviced by fiber optics by utilizing "express" or untapped feeder lines. Encompasses FTF and backbone topologies.



sider in order to determine the value of improved cable system reliability. The first is the maintenance cost savings to the cable operator resulting from lowering the system failure rate, which is tied to system reliability. The second is the indirect savings resulting from reduced churn in the subscriber base, which is tied to subscriber reliability. In evaluating the need for redundancy in an FSA system, the key factor to consider is the potential benefit from increased subscriber reliability.

Because of the lack of detailed data, it is not possible to determine with precision the exact relationship between reliability and subscriber retention. It is possible, however, to arrive at some general conclusions. It is fair to assume that as reliability increases, the number of subscriber disconnects will decrease, thus improving retention.

The value of improved retention can be derived by calculating the cost penalty for each subscriber lost. The cost of a lost subscriber consists of two components: The opportunity cost of the lost revenue, and the cost of replacing or recapturing the lost subscriber.

Lost subscriber cost

The opportunity cost of lost revenue can be calculated by taking the monthly revenue per subscriber and multiplying by a specified number of months. The number of months used will depend on how long it is expected to take to regain the lost subscriber.

The cost of adding a new subscriber can vary over a wide range, depending on the existing penetration and the type of marketing used to add subscribers. The specific costs involved will vary from one cable operation and location to another. For the purposes of this discussion, a range of values has been used which should be representative of the industry as a whole. An individual operator can insert his own numbers and perform the same calculations. The range of possibilities is illustrated in Table 1 from which it can be determined that the total annual cost of each lost subscriber ranges from $50 to $550.

The total dollar value of improved reliability will depend on the cost of a lost subscriber, the number of subscribers in the system, the current disconnect rate and the percentage change in the disconnect rate. The reduction in the annual number of lost subscribers in a 50,000 subscriber system is demonstrated in Table 2, with various assumptions for the disconnect rate and the potential reduction in that rate. The number of reduced disconnects can then be multiplied by the appropriate cost per lost subscriber from Table 1 to arrive at the expected annual savings from improved reliability.

Table 3 summarizes the average savings that might be expected, based on a typical cost per lost subscriber. For example, in a 50,000 subscriber system with a two percent per month disconnect rate, a five percent reduction in the disconnect rate will result in 50 fewer disconnects per month, or 600 per year, which translates to an average annual savings of $165,000.

Annual Reduction in Lost Subscribers

50,000 Subscriber System

Monthly Disconnect Rate	Reduction in Disconnect Rate 1%	3%	5%	10%	15%
1.0%	60	180	300	600	900
2.0%	120	360	600	1200	1800
3.0%	180	540	900	1800	2700

Table 2

Multiple Transmitter Backup: Step Down Configuration

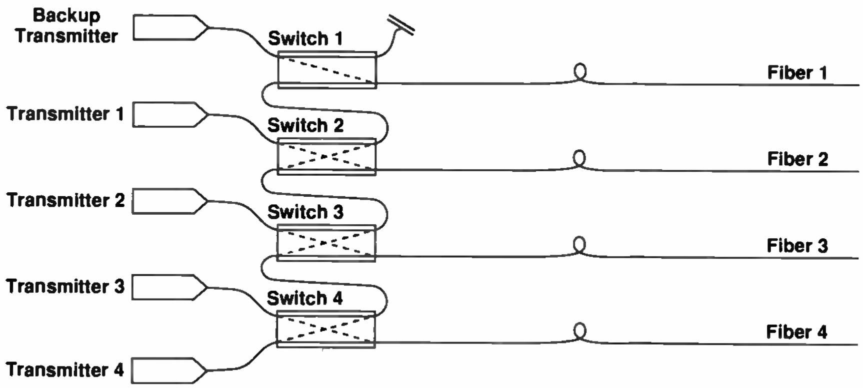


Figure 9

Value of Improved Reliability

50,000 Subscriber System

Average Savings (assumes 6 months to recapture)

Monthly Disconnect Rate	Reduction in Disconnect Rate 1%	3%	5%	10%	15%
1.0%	$16,500	$ 49,500	$ 82,500	$165,000	$247,500
2.0%	$33,000	$ 99,000	$165,000	$330,000	$495,000
3.0%	$49,500	$148,500	$247,500	$495,000	$742,500

Table 3

Improving reliability

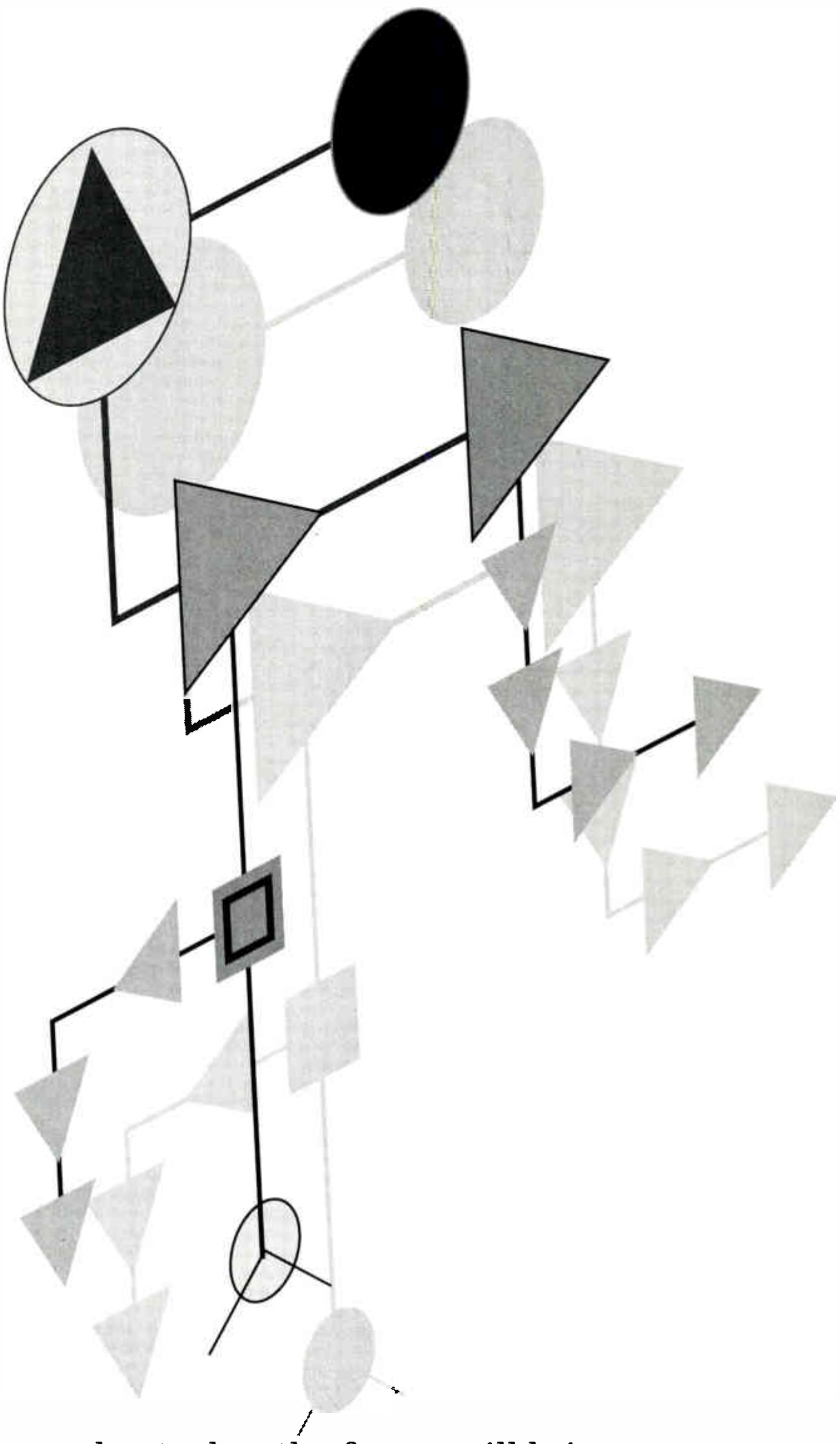
There are a number of ways to improve the reliability of the coaxial portion of a cable television plant. However, this discussion is limited to the optical portion of the CATV plant, which contains three basic elements: A transmitter, a receiver and the optical cable and connections which tie the transmitters and receivers together.

There are a number of essential steps which can be taken to ensure that failures are minimized. When selecting the transmitters, receivers, splices and/or connectors and cable to be used in a fiber project, the vendor's product reliability record and support capability should be considered carefully.

Likewise, potential contractors should be held to the highest standards for quality workmanship, and all equipment should be installed in accordance with manufacturer's recommendations.

The Evolution of Fiber-to-the-Customer

A pull-out wall chart

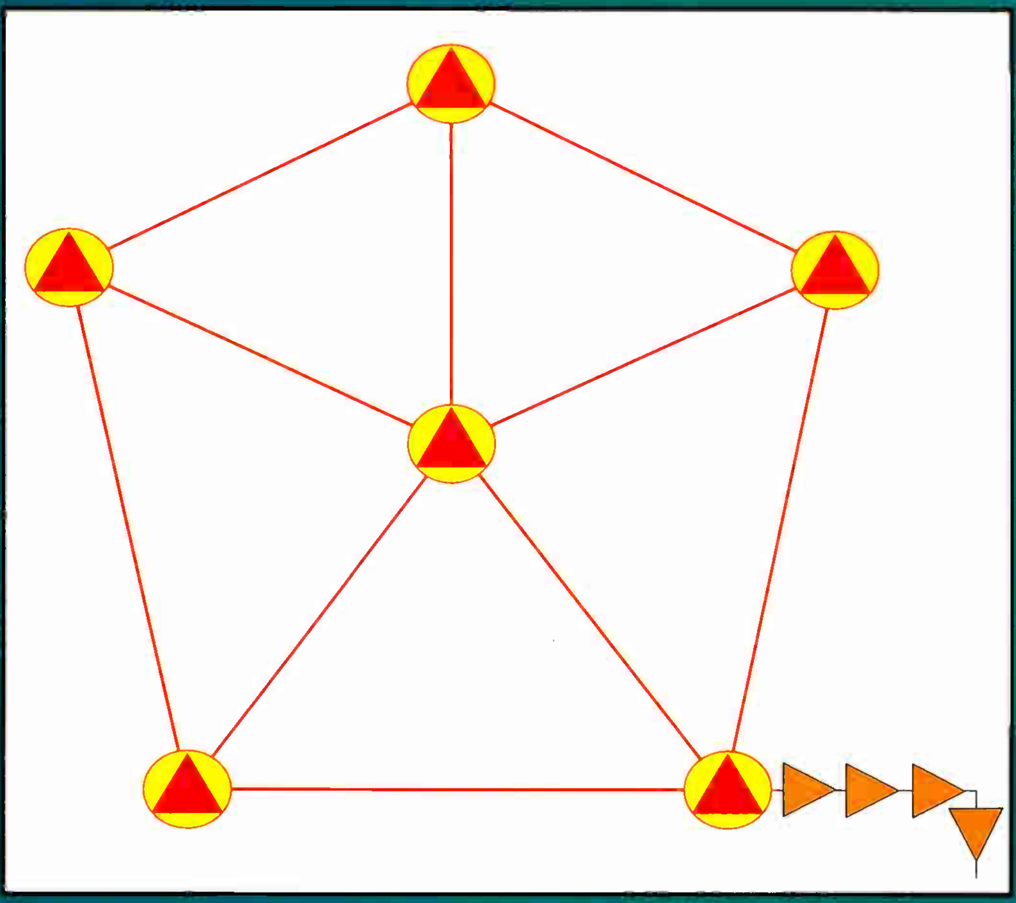


As recently as five years ago, no one would have believed fiber would be so universally embraced by cable television. But in a few short years, applications have moved from simple FM point-to-point supertrunks to a complete replacement of the coaxial trunk, and the electronics associated with it. Some are already preparing for a passive optical network that delivers a nearly unlimited amount of bandwidth to subscribers located miles away.

To help keep track of the developments and the options available to system designers, CED has published this wall chart. It displays the four fundamental fiber optic topologies as well as a host of other designs created either for special applications or with more than video delivery in mind.

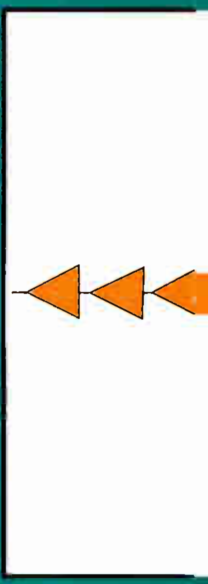
As an added bonus, a timeline full of prognostications is included. The information there is taken from a variety of sources and represents some guesses about what the future will bring.

The Evo



Supertrunk interconnects

Interconnects multiple headends (and perhaps multiple systems) on regional basis. Provides signal path redundancy in case of local outage. Allows interconnection and sharing of programming on regional basis as well as route diversity for data, personal communications, alternate access, etc.

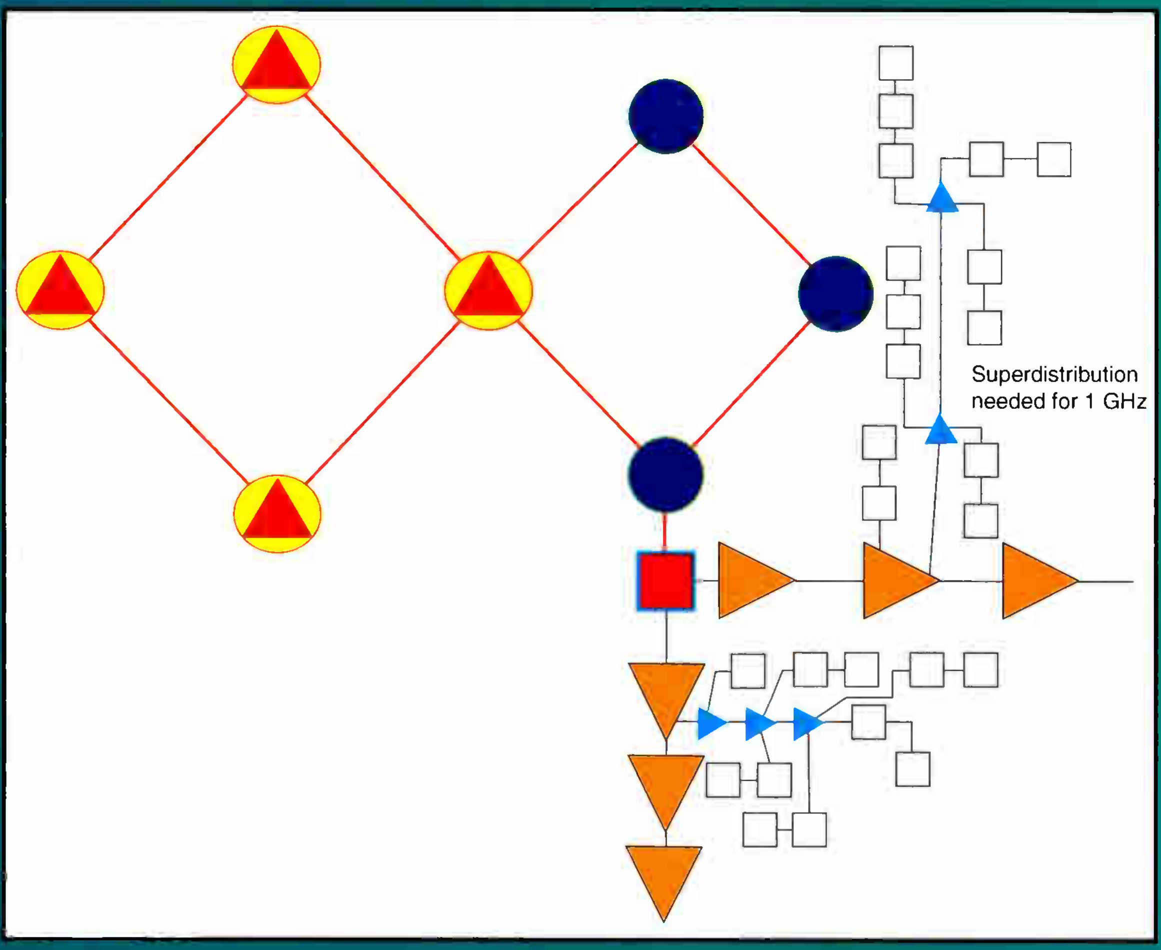


Fiber su

Supplants co
point-to-poin
delivers sign
headend. Pro
carrier-to-no
coaxial coun
having trunk
amplifiers in

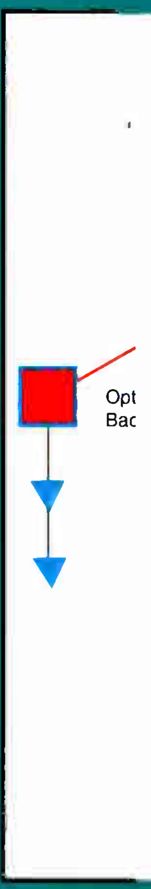
Network Evolution Timelin

S



Rogers Cablesystems architecture

Multi-service platform relying heavily on route diversity for provision of video, voice and data. Consists of FM or digital primary hubs (serving 100,000 subs) served by fiber backbone network with "ring" path routing for redundancy. These serve AM secondary hubs (which in turn deliver signals to 10,000 homes each). Designed to deliver up to 150 channels of video with use of superdistribution. Long-term objective is to replace trunk stations with optical bridgers.



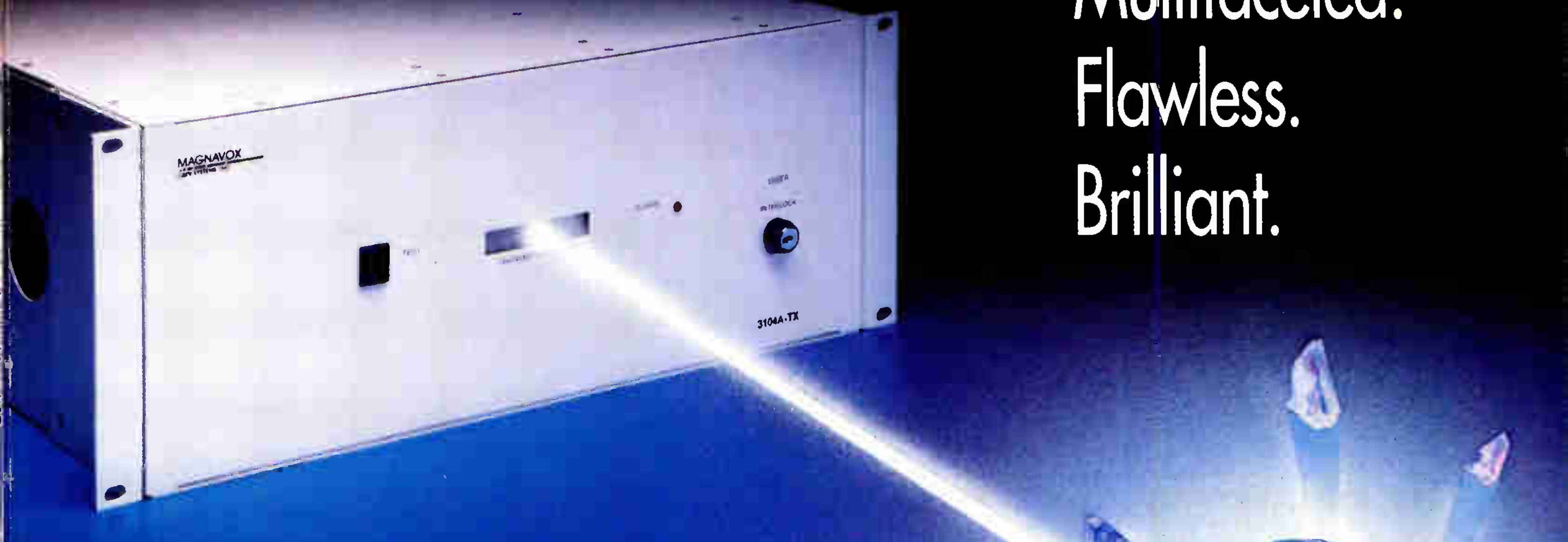
Starbu

A layered
Commun
Resembl
switched

Get nearly 10 times the optical output of one DFB for under $6,000* a node with

The Diamond Cutter™

Externally Modulated Transmitter.



Multifaceted.
Flawless.
Brilliant.

No other technology can match the power of external modulation to drive fiber deeper into your system. And no one but Magnavox can offer you the Diamond Cutter's precise performance and flawless reliability at such an economically attractive price.

Driven by powerful YAG lasers, The Diamond Cutter gives you up to 40 mW of optical output so you can now cover much longer distances -- over 20 miles. And with the Diamond Cutter, you no longer have to band-split your channels over dual fibers. The low distortion, high dispersion immunity and narrow line width inherent in external modulation allows you to send up to 80 channels over a single fiber. The result is the purest optical signal transmission and brilliant picture clarity -- all for less than $6,000. per node.

To see how the Diamond Cutter can reduce optical transmission costs in your system call your Magnavox representative today.

* In combination with our *new* low cost receiver

Circle Reader Service No. 9

MAGNAVOX
CATV SYSTEMS, INC.

100 Fairgrounds Drive, Manlius, NY 13104
Call 1-800-448-5171 (In NY State 1-800-522-7464)
(315) 682-9105 Fax: (315) 682-9006

Continued from page 26

subscriber population. From a system standpoint, however, the total system outage time will increase, because the fiber portion of the plant is simply overlaid on top of the existing coaxial plant. The cable operator is now faced with maintaining both the coaxial and fiber plants simultaneously.

FSA reliability

The situation is dramatically different in an FSA architecture. The fiber plant replaces the coaxial system in the trunk portion of the plant. Thus, from a system standpoint, the reliability of the trunk is now solely a function of the fiber system, which is presumed to be more reliable than the coax system because of the reduction in the number of active devices. In the feeder portion of the plant, the use of fewer amplifiers in cascade after the fiber node translates to improved system reliability in the feeder. On the whole, therefore, it is apparent that system reliability will be improved in an FSA design relative to a CAN approach.

From the viewpoint of the subscriber, the perceived reliability of an FSA system compared to a CAN architecture is more difficult to assess. In the trunk portion alone, the outage performance will be worse in the FSA system unless a redundant path is added to the FSA plant design. As a result, subscribers located in close proximity to a node location will perceive the reliability to be worse than in a CAN system. The farther away from the fiber node a subscriber is located, the more the feeder reliability will determine the outage performance seen, and the perceived reliability will be better in the FSA system.

From this discussion, it is clear that is important to understand the differences in the methods used to define and measure reliability. The key measurements are the number of outages per month and the total outage minutes per month. These parameters must be determined with reference to both the subscriber base and the cable system itself. The reliability for the subscriber and for the cable system are not necessarily correlated, and an improvement in one may lead to a degradation in the other.

For example, using AM fiber in a CAN architecture, the subscriber reliability will be improved relative to the coax-only plant, but the system reliability will be degraded. On the other hand, in an FSA architecture without redundancy, the system reliability will be improved relative to the CAN system, but the reliability as perceived by the subscriber may be worse on average, although this will vary depending on the subscriber's location.

As a result, an operator will want to consider adding redundant elements to an FSA plant design. The decision will depend on a comparison of the cost of redundancy to the value of improved reliability.

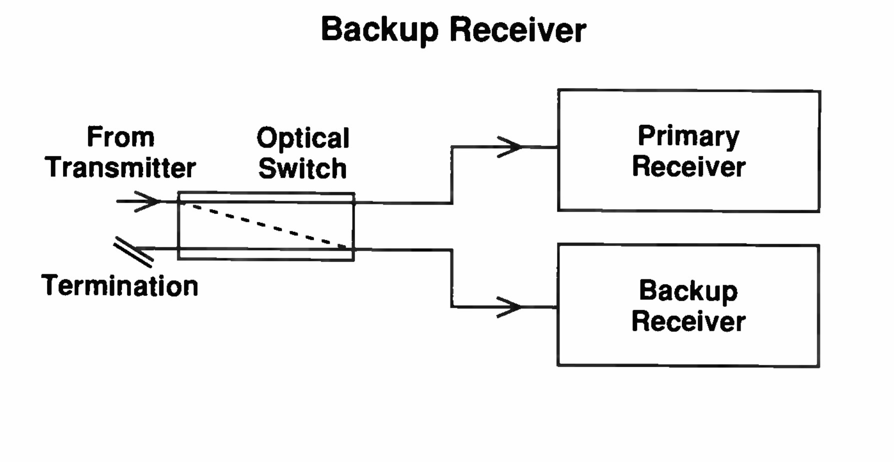


Figure 6

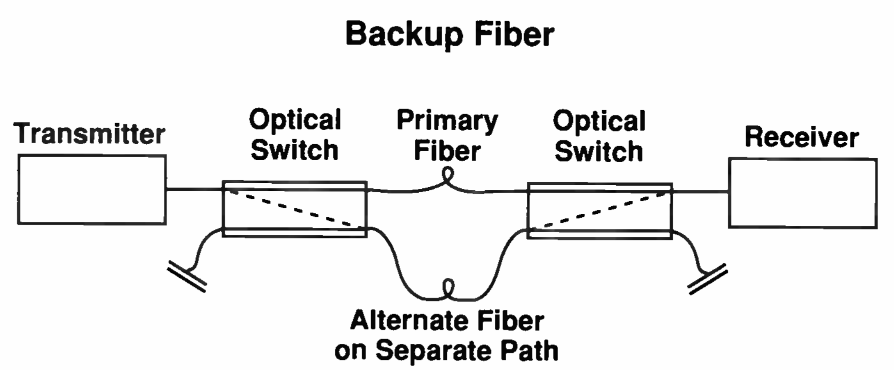


Figure 7

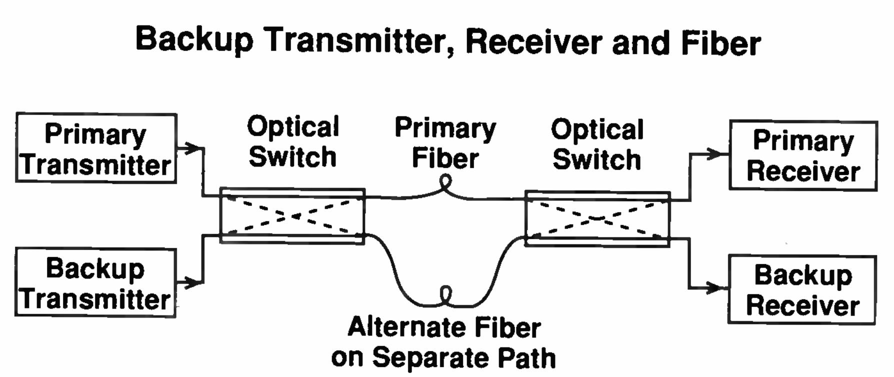


Figure 8

Reliability's worth

There are two components to con-

Once the equipment is installed, it should be maintained and operated within its specified ranges and tolerances. Access to the system should be restricted, and adjustments should be minimized to prevent exposure to tampering, misuse or to the elements.

If optical connectors are used, special care should be taken to avoid scratches or dirt, which can degrade the quality of the signal severely. Finally, optical time domain reflectometer (OTDR) readings should be taken periodically to ensure the integrity of the optical path.

Redundancy and optical switching

In addition to these preventive steps, it is possible to dramatically improve the reliability of optical links and thus the entire CATV plant by adding redundant elements to the system. This can be accomplished with the use of optical switching. Optical switches allow the incorporation of a redundant transmitter, receiver or optical path into the system. Each of these redundant components can be set up to operate in a "hot standby" mode such that if the primary unit fails, the backup unit can be switched in automatically and instantly.

A cable operator may choose to back up only those elements of the system which were deemed most likely to fail, or those which might cause the most damage if they fail. Alternatively, by backing up all of the system components, a virtually failure-proof, "self-healing" network can be established.

The basic operation of a two-by-two optical switch is illustrated in Figure 3. Each of two inputs on the left side, I1 and I2, feeds the corresponding outputs on the right side, O1 and O2. When switching occurs, the two paths move from the bar to the cross state, and now I1 feeds O2 and visa versa.

In order to be effectively used in an AM fiber system, the optical switch must not introduce reflections or crosstalk, and should have a low insertion loss. In general, insertion loss of 0.5 dB or less is acceptable, although a loss of 0.2 dB is preferred.

In the relatively simple scenario shown in Figure 4, an optical switch is used to incorporate a backup transmitter. This configuration also enables the use of an OTDR from the backup input, as shown in Figure 5, which eliminates the necessity of breaking a connection to test the optical path. Optical switches can also be used to provide a backup receiver as shown in Figure 6, or an alternate fiber path, shown in Figure 7.

Finally, all three elements can be combined for a completely redundant system, as illustrated in Figure 8.

Minimizing cost

Of course, in considering the benefits of the improved reliability provided by using redundant components and optical switches, a cable operator must also evaluate the incremental cost involved. While the cost of the optical switch itself is but a fraction of the cost of a typical transmitter, most operators would not even consider installing a backup transmitter for each of their primary transmitters.

Fortunately, it is possible to configure the switches in such a way that only one backup transmitter can support a large number of primary transmitters. In fact, depending on the technique used, it is possible for one "hot standby" transmitter to back up all of the primary transmitters, as depicted in Figure 9.

In this approach, called the "step down" configuration, if a transmitter fails, every transmitter prior to the failed unit will be switched to the next adjacent fiber, and the backup will be switched onto the first fiber. One advantage to this technique is that each transmitter is always routed through a maximum of two optical switches.

If an operator plans to do any narrowcasting of alternate programming to different points in the system, the step-down approach may not be appropriate. An alternative would be to set up a series of smaller step-down networks, each served by its own backup transmitter. As shown in Figure 10, it is also possible to set up optical switches in a "daisy chain" configuration.

Using this method, the output of the backup transmitter is routed through a chain of optical switches until the failed transmitter is reached. Because of the accumulation of insertion loss through the chain of switches, a "hot standby" transmitter can back up a limited number of primary transmitters, depending on the optical loss budget of the system. Regardless of which configuration is chosen, it is clear that a full complement of transmitters can be backed up with a small number of redundant transmitters.

Multiple Transmitter Backup: Daisy Chain Configuration

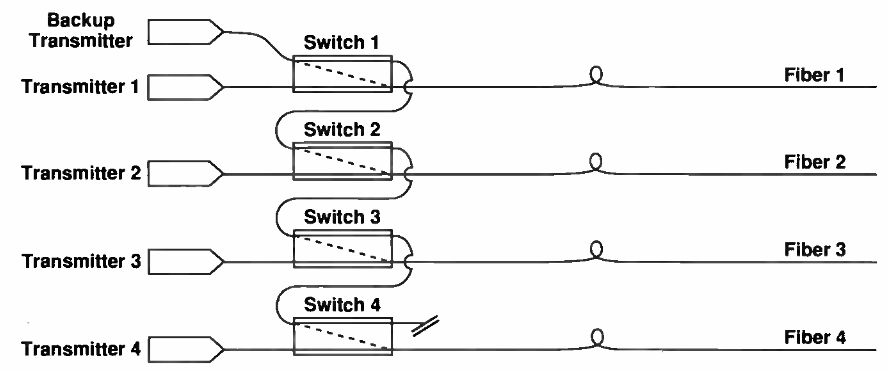


Figure 10

The bottom line

In the final analysis, the cable operator must consider whether the benefits of improved reliability are worth the incremental cost of optical switches and backup components. If we consider the example used in Table 3, the annual savings from improved reliability would pay for the optical switches and redundant components several times over.

In addition, cable operators who plan to broaden their business beyond broadcast television may need to elevate their standards of reliability. The types of services that are being envisioned today, including video-on-demand, alternate access to long distance carriers and personal communications networks, will probably require a much more robust network than most cable operators are accustomed to providing.

As a result, now is the time for the cable industry to reassess the value of improved reliability and to establish a new vision of a cable system as not just a broadband video pipeline, but as an integrated voice, data and video communications network. ■

Reducing power related outages in fiber optic systems

Most cable system operators have identified outage reduction as an important issue. The emphasis placed on higher system performance and reliability has developed steadily over the last few years due to several well-known issues facing the cable television industry. Potential competition from fiber-based telcos, government scrutiny of cable system rate structures and customer service, and ever increasing customer demand for higher performance and network reliability have resulted in system operator identification of reliability as a high priority.

System reliability is not only important to retain existing customers, but it is an absolute necessity to obtain new customers and maintain growth in the face of competition and government regulation.

Recently, Cable Television Laboratories (CableLabs) has sponsored an Outage Reduction Task Force. The outage reduction working groups have divided the responsibilities for research into the different areas of focus for providing "hands on" suggestions to the industry for improvement in the performance and reliability of the network.

ID outage history

Most systems perform some sort of tracking of system outages to help identify trends of reliability in certain areas as well as serve as an indicator of improvement when steps are taken to increase the reliability of the system. Most operators have arrived at their own definition of an outage and how outages are tracked over time. Comparison of system to system data and monthly reports of each system helps to quantify progress in increasing plant reliability.

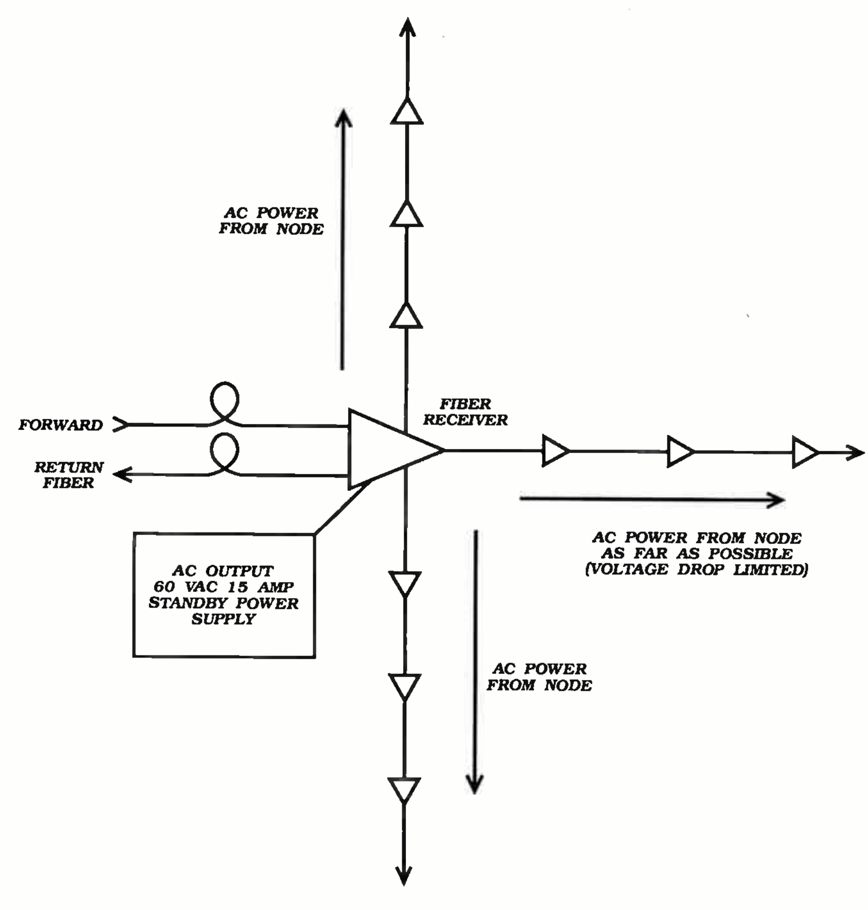
Outage reduction will increase in priority in the future as the cable industry continues to diversify its revenue sources. PCNs, data networking, alarm monitoring, local origination and other non-entertainment services require a reliable network in order to compete.

By Tom Osterman, Director of Research and Development, Alpha Technologies

Fiber optics

With the rapid deployment of fiber in cable systems over the last several years, there has been a substantial gain in the performance and reliability of the signal delivery system. Long trunk cascades have been reduced or eliminated, microwave links have been replaced, headends have been consolidated and power supplies have been reduced in number. In spite of all these improvements, the system is still vulnerable to outages due to a number of causes.

Power fluctuations and outages, transients, surges and premature equipment failure all continue to plague even the higher reliability, fiber-based systems. Power reliability in the United States is decreasing in a number of regions. CATV system reliability is directly affected by the characteristics of the local power grid. It is imperative that system designers and operators understand the local utility power



"WIDE AREA POWERING"

Use large AC standby supply to power the node and as much of the service area as possible. Note that the distance fed from the node will usually be determined by the end of line voltage limitations, not output current limitations of the AC power supply.

Figure 1

distribution network and plan the system powering based upon this information.

Traditionally, the powering locations were determined by cascade voltage drop calculations. Power supplies were somewhat haphazardly located in the system over time with expansion of the plant. For maximum powering reliability, follow the traditional design approach for power supply locations, but in addition, "overlay" the CATV system map over the utility grid to identify powering locations that may be unreliable in the future.

Plant powering changes

With the implementation of fiber optics, the powering requirements have changed in a number of ways. There has been a reduction in the power requirements for the fiber trunk in comparison to the coaxial predecessor due to the reduction or elimination of the power-hungry trunk amplifiers. Power is required at the fiber receiver locations (nodes), and, of course, is required for the distribution actives as usual. What has changed is the configuration of the powering of the distribution area; with fiber signal delivery getting closer and closer to the subscriber service area, the requirements of power supplies have evolved and are still being re-thought by a number of system operators. (See Figure 1.)

What has changed?

In the coaxial trunk architecture, the total power requirements were defined by the power consumption of the actives, the loop resistance of the cable (I^2R drop transmission losses), the end-of-line voltage for the last active in the cascade and a certain amount of headroom left to allow for temperature related changes in loop resistance, future expansion and the effects of transient events such as longitudinal sheath currents, etc.

With fiber signal delivery to the distribution area, the power requirements have been reduced in most cases for the trunk function, but it can be argued that there is an increased requirement for more powering locations in the distribution area. Depending on the architecture implemented (FTF, fiber backbone, fiber to the service area or any similar hybrid), the powering configuration is being reconsidered to optimize reliability and economy of operation.

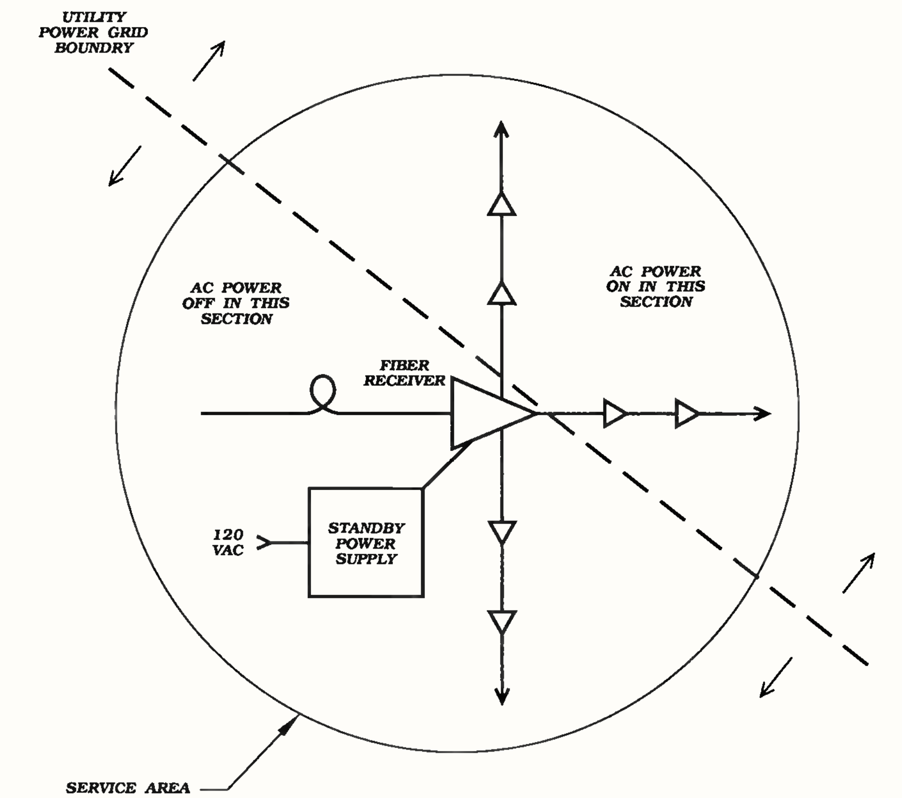


Figure 2

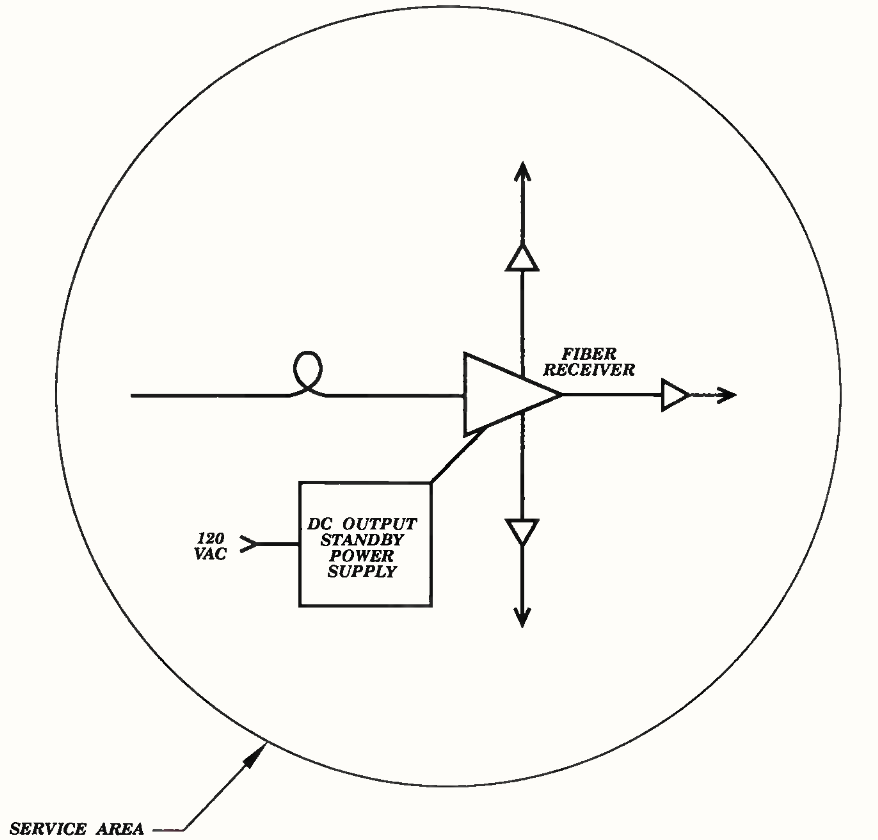


Figure 3

FTF node power

In this architecture the fiber node is a critical point for power reliability; if utility power where to fail in this area, all of the distribution fed by the node would be without signal. It is often argued that this is academic; the subscribers would most likely be fed from the same utility grid as the node, and thus would not have AC power to operate their televisions anyway, so standby power is not justified at this location.

In this example it would make sense to install non-standby power supplies at the node and in the distribution area. While this theory of the service area contained in the same utility grid may hold true for high density urban builds, it may not be the case in the typical system. The utility grid network is segmented; the utility companies have a fairly sophisticated system for overvoltage and overcurrent protection in their power distribution system.

There are automatic circuit breakers intended to isolate power feeds when an overcurrent condition exists, such as a tree over the lines or a line down. They have the similar objective of the cable operator in isolating a fault to an area that affects the least number of customers. The utility companies also have the ability to remotely shut down all or segments of the grid when an overcurrent condition is detected. The importance of awareness of the utility grid configuration and how it will affect the reliability of the powering of the cable system cannot be overstated.

In the previous example of the power outage affecting the fiber node, it is more likely that the outage only will affect sections of the service area fed by the node. In this case it would make sense to install a standby power supply to power the node and even the first actives fed by the node. If a power outage occurred in a small section of the service area including the node, the standby supply would keep the node operational and provide signal to the remainder of the service area that still has utility power. In this example a small standby supply would provide power for the fiber node, and non-standby power supplies would power the remainder of the distribution equipment in the service area.

The use on non-standby supplies for powering the feeder legs is cost effective; standby powering into the neighborhood areas is not necessary because of the previous discussion about local power outages affecting the subscriber home (small section of the node service area). (See Figure 2.)

In the fiber backbone architecture, the use of a small size standby power supply works well. The fiber receiver, distribution amps and line extenders can be powered from the node and as far out in either direction as allowed by voltage drop limitations. In a fiber backbone retrofit installation, a small physical size standby supply providing up to 8 amps output current can be pole mounted at the node. In many cases, because of its compact physical size, the power supply can be pole mounted even if the utility company has prohibited any new installations.

The smaller unit has a minimal interference with climbing space requirements in comparison to the large 15 amp standby power supply enclosures currently used. It is possible to negotiate a waiver of the pole mount-

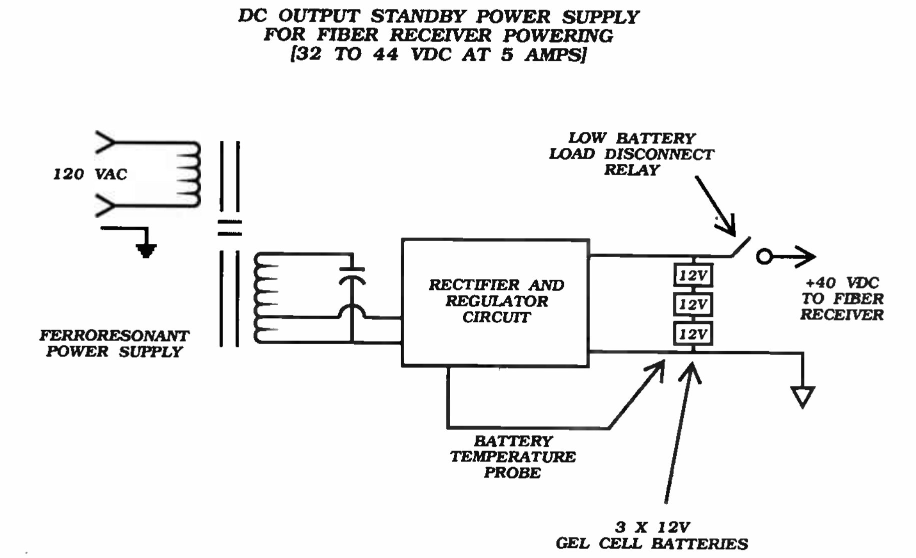


Figure 4

ing restriction because the enclosure is as small as the existing non-standby power supplies.

The smaller standby supply utilizes small, low capacity batteries, which can provide over an hour of standby time at 8 amps load. This is a reduction of standby capacity in comparison to the existing 15 amp units, which can operate over two hours at full load. It can be argued that standby capacity can be safely reduced if status monitoring is implemented via the return fiber. In long outage events, generator trucks can be dispatched to the appropriate nodes for extended operation prior to complete discharge of the standby power supply batteries.

DC powering

Another new option for fiber powering that has recently been introduced is direct DC powering of the fiber receiver by a DC output standby power supply. If, in the system design process, it has been decided to provide standby powering at all node locations only and to use non-standby supplies for everything else, the DC powering option offers several advantages. (See Figure 3.)

Use of DC powering of cable TV equipment has been investigated in years past, but has not been implemented because of several technical limitations. First is the electrolysis problem. With moisture present and direct current flow through dissimilar metals, such as coax connectors, passives, amp chassis, etc., galvanic corrosion will occur and will eventually deteriorate all of the electrical connection points.

Second is the safety issue; 20higher voltage, direct current is more dangerous to personnel because contact with DC causes muscle contraction—there is no zero voltage point, as there is in the traditional 60 volts AC system, to allow the technician to let go when shocked. The application for DC powering that avoids these pitfalls is the dedicated powering of the fiber node only with a compact, low cost and efficient DC standby supply. The powering interconnection is separated from coax; all electrical connections are isolated and protected from moisture ingress.

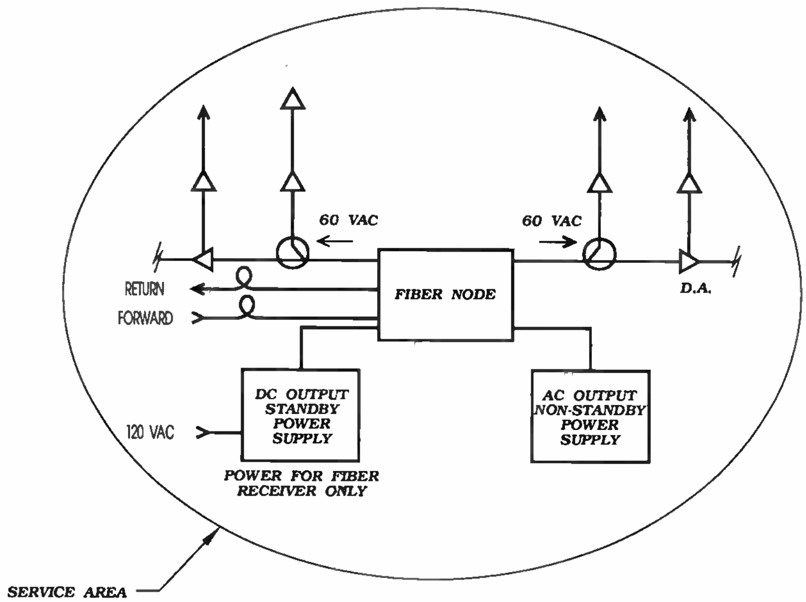
Increase powering efficiency

If a system designer chose to standby-power the node only to ensure operation during power outages, especially to protect return data (status monitoring), PCN interconnection, PPV, and to provide signal to the service area, a dedicated AC output standby supply for each node only would be costly and inefficient.

In a typical AC standby supply, to provide AC voltage during a power outage, an inverter is needed to convert the battery DC voltage to 60 volts AC. Inside the fiber receiver power pack the 60 volts AC is rectified back to DC and then converted to regulated 24 VDC as well as other voltages required by the amplifier and receiver circuitry. All of these conversion steps are inefficient, and the extra components utilized contribute to lower reliability.

The DC standby supply provides a nominal 40 volts DC to the input of the fiber receiver power supply, where it is regulated down to the required internal voltages by an efficient DC to DC converter; no rectification, preregulation or other failure prone components are required.

The DC standby supply is essentially a battery charger that provides the correct float voltage to maintain charge of the internal batteries and to provide



DC UPS POWER FOR FIBER NODE
AC POWER OUT FEEDER LEGS

Figure 5

FIBER IS GOOD FOR YOUR SYSTEM.

Any cable system committed to providing good service knows fiber optics will play an important role in delivering a quality signal to its subscriber base.

At Midwest CATV, we're equally committed to providing good service by being your full line supplier of fiber optic products. Our inventory contains products for complete systems as well as fiber accessories. Headend equipment from Sumitomo and Jerrold. Fiber optic cable from BICC and Sumitomo, including Sumitomo's new LitePipe™ fiber optic cable. Test equipment from Noyes. Fusion splicers from Preformed. And price levels that only Midwest CATV can provide.

Our full line of accessory items includes splice trays and organizing systems from AMP, BICC and Preformed. We also stock a full line of tools for stripping and cleaving from Klein and Thomas and Betts.

Our technical services group offers complete system engineering including walk-outs, loss budget calculation, system architecture and *light-ups*.

Most products are in inventory and ready for immediate shipment. So for fast response, phone 1 800 MID-CATV.

MIDWEST CATV

a UNR Company

More than supplies. Solutions.

1 800 MID-CATV

Denver, CO • Clarksburg, WV • Dallas, TX • Lafayette, IN
Ocala, FL • Phoenix, AZ • Pottstown, PA

up to 5 amps of output current to operate the fiber receiver. The DC voltage must be well regulated and adjusted for changes in battery temperature to always provide the correct charge voltage for maximum battery service life.

When a brownout or complete blackout of utility power occurs, there is immediate "transfer" to standby. Because the batteries are in parallel with the load, there is no transfer relay or inverter circuitry required and the output is truly uninterrupted. (See Figure 4.)

Because of the high efficiency and low output current draw (less than 5 amps) even with small 15 ampere hour batteries, the standby time can be as much as 12 hours! Depending on the current draw of the fiber receiver, with this amount of standby time possible at least 99 percent of all utility outages would not result in a service outage at the node.

Another advantage with this concept is that the batteries can be directly connected to the power supply output during maintenance or complete removal of the power module for service. This eliminates outages caused by maintenance or repair; no auxiliary power supply or generator is necessary for service.

DC supply technical features

The output of the DC standby supply is two-conductor jacketed cable that is connected to a terminal block inside of the supply to eliminate the galvanic corrosion problem. The other end of the cable is fed through a water-tight strain relief fitting that installs in the standard 5/8-inch threaded entry in the receiver housing. No coax is used for the DC power and no external connectors that are exposed to moisture are used.

Inside of the fiber receiver is a quick connect terminal block for connection of the two conductors to the internal power pack. With DC powering, the efficiency of the receiver power supply is increased; it no longer has to regulate over a wide range of AC voltage and its losses are decreased, resulting in less heat dissipation inside the receiver chassis. This translates into longer life of the electronic equipment.

The amplifier manufacturers are considering the auxiliary DC input connection in addition to the existing coax 60 VAC input and output power distribution capability. The DC standby supply operates the fiber receiver and amplifier internal circuitry only; 60 volts AC from a local or remote non-standby supply can still be fed into the node and out through the feeder ports to power line extenders, etc. on the coax distribution side.

The objective of the DC powering concept is to provide a small, reliable and cost effective standby power to the critical fiber node as used in any fiber architecture. With the return fiber installed to most nodes, status monitor-

The objective of the DC powering concept is to provide a small, reliable and cost effective standby power to the critical fiber node.

Advertiser's Index

ing of the power supply (and status of utility power at each node and service area) can be reliably provided back to the headend for real-time status of the entire system. If the return transmitter is installed for local origination, PPV, data networking, PCNs or any other revenue source, the power supply status monitoring is now essentially "free."

The problem with past status monitoring systems is that they were costly to maintain and were less reliable than the cable system they were designed to monitor. With the vast improvement in reliability offered by return fiber, status monitoring will be used much more often and more effectively in the future.

For full benefits, though, there must be standby power at each of the nodes to continue to operate the return data during utility power outages. (See Figure 5.)

The DC standby concept is currently being reviewed by the amplifier manufacturers and several MSOs for feasibility and system trials. As with all new technology, there will be issues to resolve in order to effectively implement the concept in future systems.

Conclusion

Power related outages can be significantly reduced by implementing standby power in critical locations. In fiber based cable systems, the fiber node is a critical point for signal delivery to the distribution service area as well as the critical point for return data, video, PCN interconnect and status monitoring data.

In fiber backbone, FTF and other architectures, the fiber optic receiver is the most important device to maintain during utility power outages. With these new system architectures it is important to provide standby power to the node whether it be existing technology 60 VAC or the direct DC powering concept. The distribution devices can be powered by small, low cost non-standby supplies if the utility grid contains both the distribution feeder and most or all of the subscribers fed by that feeder so that a localized power outage does not contribute to a signal outage to subscribers that continue to have utility power.

For longer runs that may cross several utility powering sectors, AC standby supplies should be considered for the amplifiers in cascade to the service area if it has enough subscribers to justify the added cost and long term maintenance liability, or if future expansion of the subscriber area is anticipated.

Fiber provides a significant improvement in overall system reliability. However, utility power outages can negate the reliability gained by fiber implementation. By installing standby power at each node and at selected distribution areas, the overall system reliability can be maintained at a high level. Attention to this issue will go a long way toward increasing and maintaining customer satisfaction and to provide a competitive advantage to the system operator. ■

The author wishes to acknowledge the following people for their contribution to this article: Del Heller, vice president of engineering, Viacom Cable; Mark Bowers, president, CableSoft Engineering Services; and Roy Ehman, director of engineering, Jones Intercable.

FIBER OPTIC CALLBOOK

Kennedy Cable Construction, Inc. . . . . . .(912) 557-4751
WATS (National) . . . . . .(800) 673-7322
Highway 280 W
PO Box 760
Reidsville, GA 30453
PERSONNEL: Roger Kennedy Jr., President; Bob Skelton, Vice President, Operations; Thomas Heath, Marketing Manager
REGIONAL OFFICES: Florida, (800) 344-0976
DESCRIPTION: Aerial and underground line construction of CATV, LANs, telecommunications and fiber optic systems. Strand mapping, design, splicing, upgrades, rebuild, new extensions of system, balance, sweep and proof system. 18 years of experience.

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; Imel L. Wheat, Jr., VP/Underground
DESCRIPTION: Aerial and underground cable TV construction; turnkey.

CAD

Dumbauld & Associates . .(602) 870-4977
FAX . . . .(602) 870-4820
9034 N. 23rd Ave., Ste. 6
Phoenix, AZ 85021
PERSONNEL: Robert Forney, President; Tom Dumbauld, Vice President
DESCRIPTION: Our knowledge of the CATV industry and ability to enhance AutoCAD to be the production tool it was meant to be, makes us a very valuable addition to your engineering department. We can provide complete mapping/fielding/design functions or assist you with programming that will enhance and automate your system.

METRONET, INC.

Metronet, Inc. . . . .(404) 475-9956
FAX . . . .(404) 475-9944
1111 Alderman Dr., Ste. 210
Alpharetta, GA 30202
PERSONNEL: James P. Worthen, President; Frank Walker, Director of Sales
DESCRIPTION: CAD Fiber Optic and Coaxial System Design (Lode Data). On Site Project Management; Turnkey Services; Mapping Services—Strand and As-Builts; Drafting Services—Base, Strand and Electronics; AutoCAD Conversion to Lynx; Auto LISP Programming-Client Specific; CAD Training and Set Up; Marketing Services (Dark Fiber).

TSB, Inc.

TSB, Inc. CATV Engineering . . . .(605) 665-1393
FAX . . . .(605) 665-1708
221 West 3rd
PO Box 244
Yankton, SD 57078
PERSONNEL: Tony Gauer, President; Wes Schick, Vice President
DESCRIPTION: Consulting and technical services firm specializing in fiber optic system design and activation, FCC compliance certification, headend rewiring and relocation, CAD drafting and design, strand mapping and as builts with complete system auditing.

Proof of Performance

Systems Performance Engineering, Inc. . . .(904) 262-8269
FAX . . . .(904) 260-0383
PO Box 24927
Jacksonville, FL 32217
PERSONNEL: Peter J. Otten, President; Sherrie Otten, Secretary/Treasurer
DESCRIPTION: Systems Performance Engineering is fully equipped for the following; Testing of CATV, fiber and LAN, Upgrade, retro-fit, cumulative leakage and repair, technical evaluations and state of the art proof of performance. We have 24 years of experience in the CATV industry, covering the Continental United States and the world.

Distributors/Suppliers/Reps

Cable Services Company Inc.

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

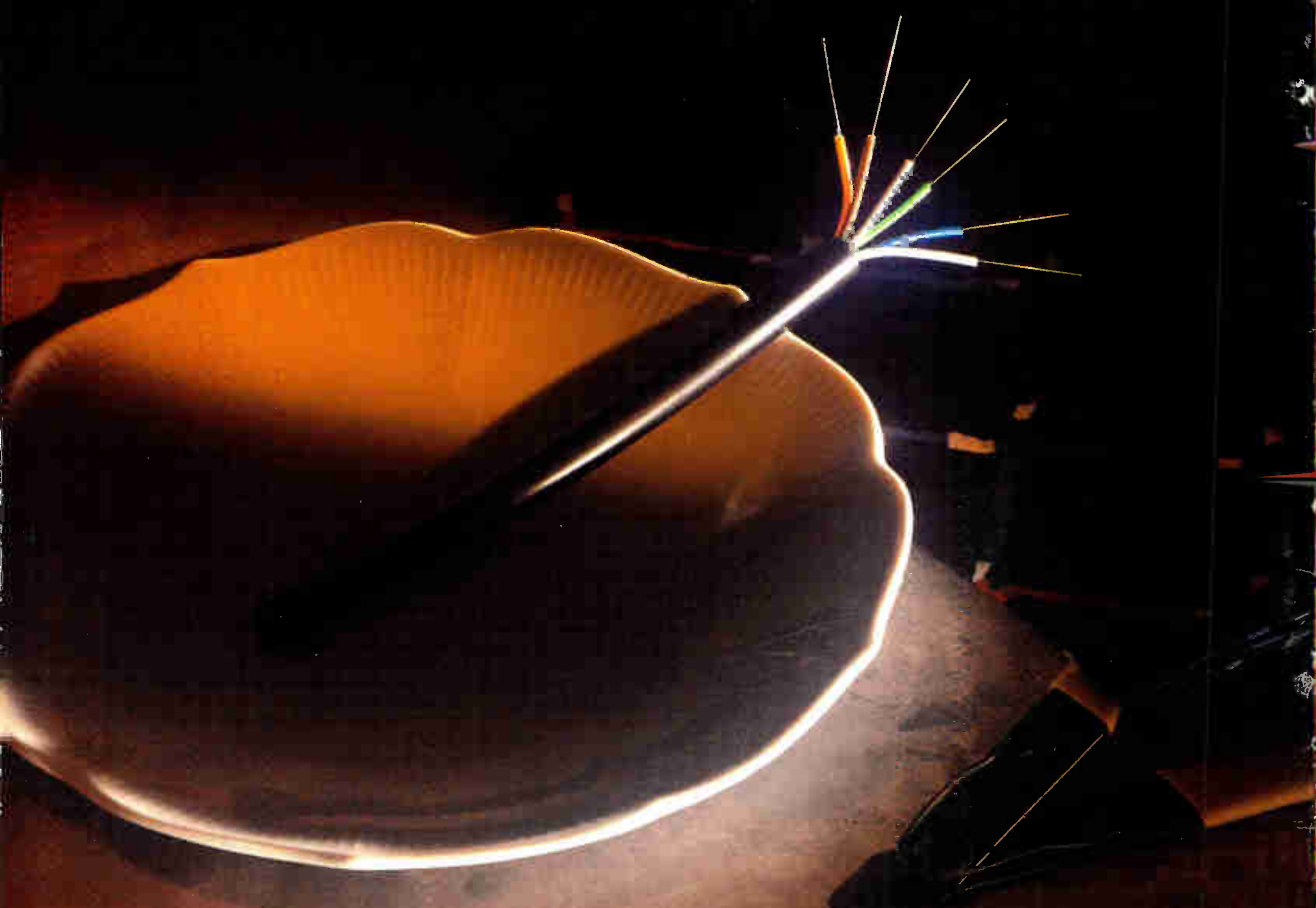
FIBERTRON
Your Link with Fiberoptics

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 AMP, Amphenol, AT&T, Augat, Belden, BICC, Chromatic Technologies, Fibermux, GTE, Noyes, Pyramid, Reliance, Siecor, 3M, Tektronix, and more. Choose from the widest assortment of standard and custom cable assemblies, connectors, closures, enclosures, innerduct, LAN, modems, muxes, splices, supplies, test equipment, tools and wall outlets available. We also offer specialized customer support, training and consultation.

MIDWEST CATV
More than supplies. Solutions.

Midwest CATV A Div. of U.N.R. Ind. Inc. . . . .(303) 799-4343
FAX . . . .(303) 643-4797
PO Box 4543 (Zip 80155)
Fairways II at Inverness
94 Inverness Terr. E. Suite 310
Englewood, CO 80112
PERSONNEL: Chuck Krone; Scott Henry
DESCRIPTION: Midwest C.A.T.V. is a full line supplier of fiber optic equipment from several manufacturers. Products include head-end laser transmitters, fiber optic cable, receiver detectors, fusion splicing equipment, splice trays and organizing systems, fiber stripping and cleaving tools. A complete line of test equipment to include laser sources, power meters, and O.T.D.R.s are available for immediate delivery. In addition to being an equipment supplier, Midwest offers engineering resources to assist in loss budget calculations, system design, and performance verification.

Now SAM has added fiber.



Introducing Fiber SAM®

The first signal level meter that measures fiber optic power.

New Fiber SAM meets *all* your day-to-day requirements for testing and maintaining the trunk or headend of today's high-technology CATV systems. Including troubleshooting fiber optic cable!

The built-in, easy-to-use fiber optic power meter means convenience, accuracy and efficiency. No more supplemental meters to tote around. And no more guesswork on the fitness of your fiber optic network.

Fiber SAM. The first signal level meter and fiber power meter in one. If you've added fiber to your cable system, add Fiber SAM to your maintenance program.

Call Wavetek at 1-800-622-5515; in Indiana, 317-788-5965.

WAVETEK

Circle Reader Service No. 16