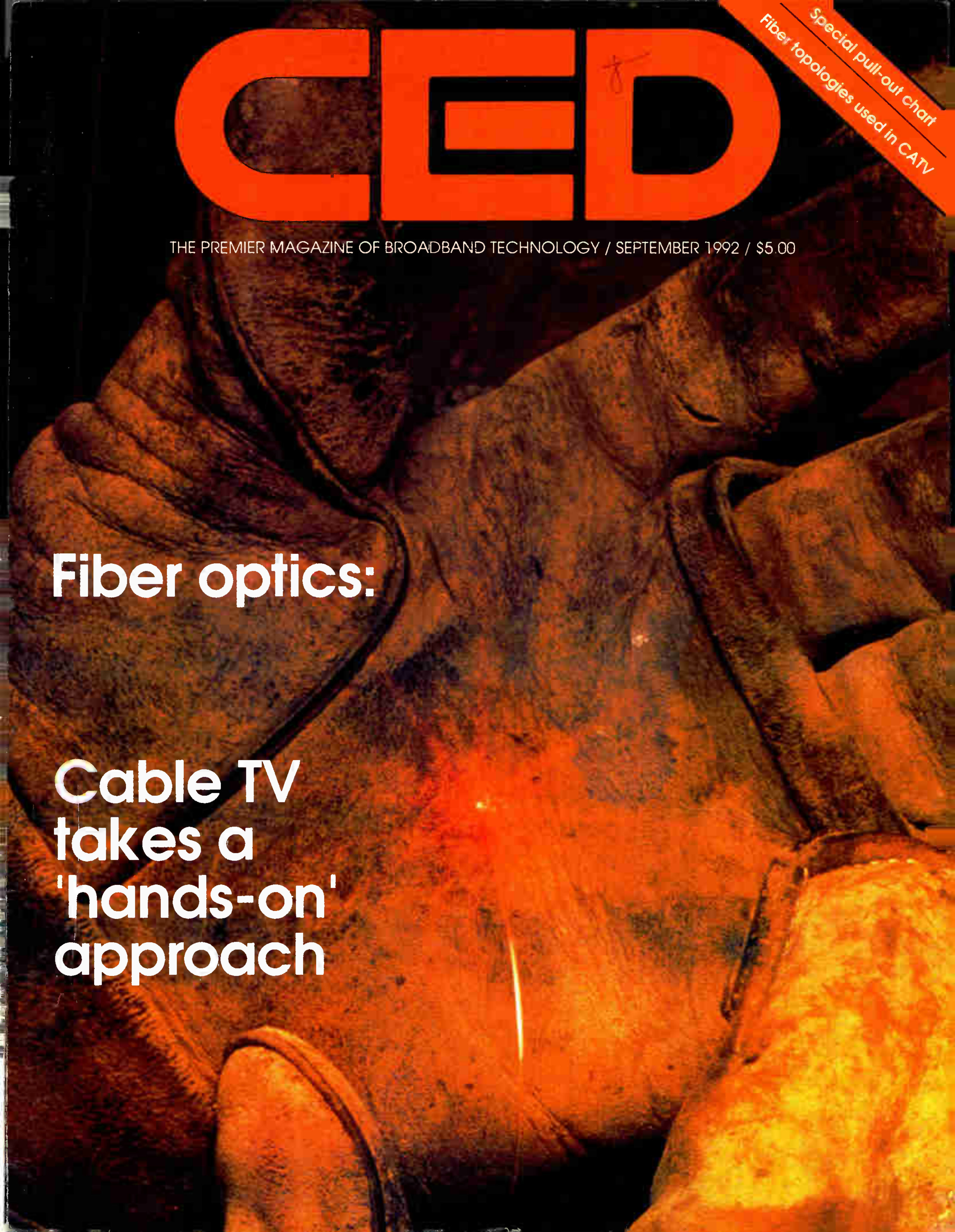
CED

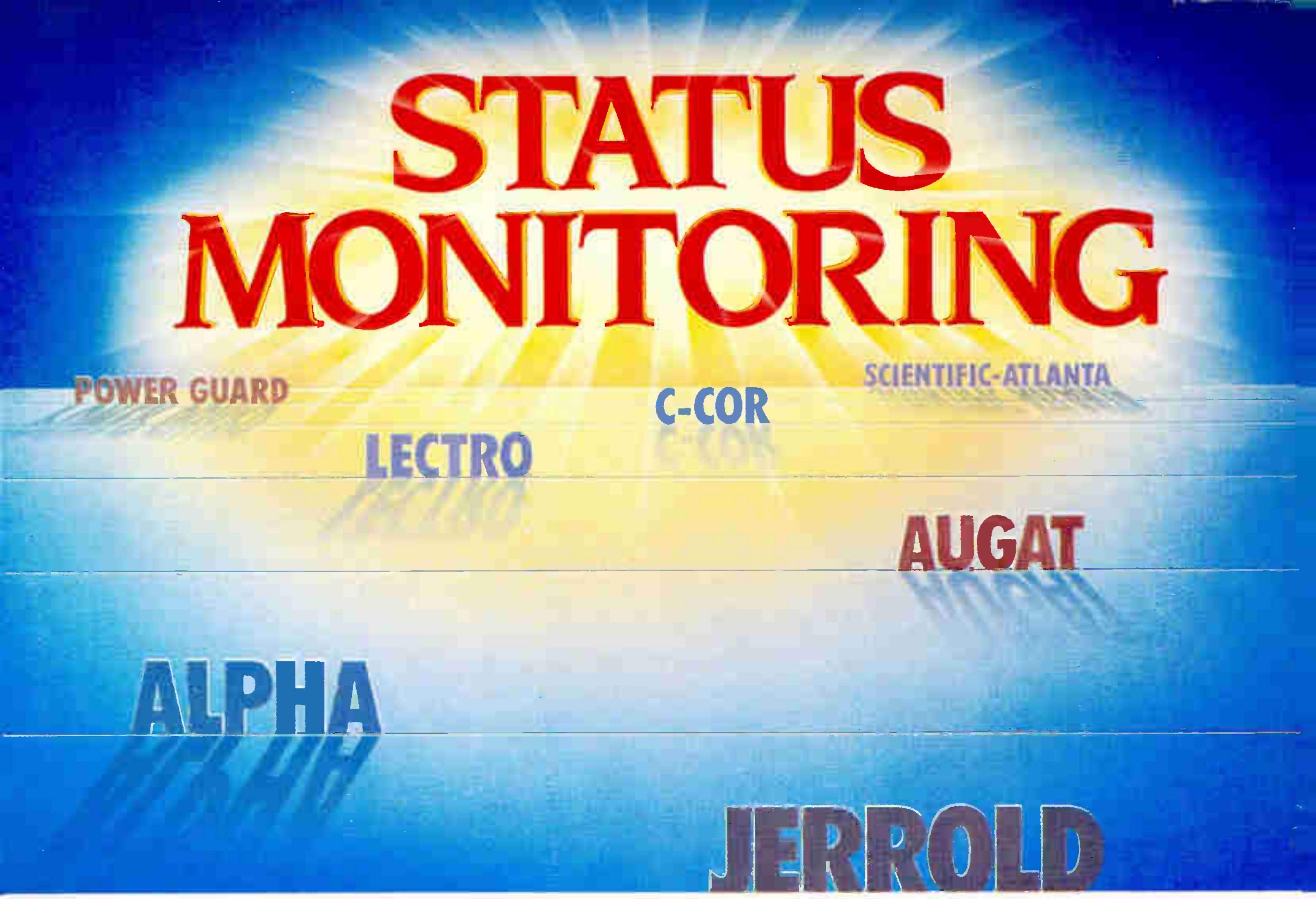
THE PREMIER MAGAZINE OF BROADBAND TECHNOLOGY / SEPTEMBER 1992 / $5.00

Special pull-out chart
Fiber topologies used in CATV



Fiber optics:

Cable TV takes a 'hands-on' approach



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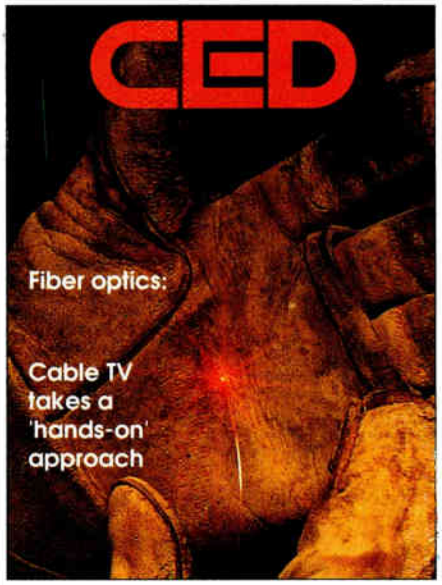
September 1992

CED

Volume 18, Number 10



About the Cover:
Fiber optics: Taking a hands-on approach. Photo courtesy of Corning Inc.

DEPARTMENTS

CED. (USPS 330-510) (ISSN 1044-2871) is published monthly except twice in May by Diversified Publishing Group, a Division of Capital Cities Media, Inc., 825 7th Ave., New York, NY 10019. ©September 1992, Volume 18, Number 10. U.S. domestic subscriptions are $48. Outside USA, subscriptions are $69 for surface delivery or $96 for air speed delivery, prepaid in U.S. funds drawn on a U.S. branch bank. Second-class postage paid at New York, NY 10019 and additional mailing offices. CED is published on behalf of the cable television and broadband communications industries. POSTMASTER: Please send address changes to CED Circulation, P.O. Box 3043, South Eastern PA 19398. MEMBERS OF THE BPA.

CED magazine is recognized by the Society of Cable Television Engineers.

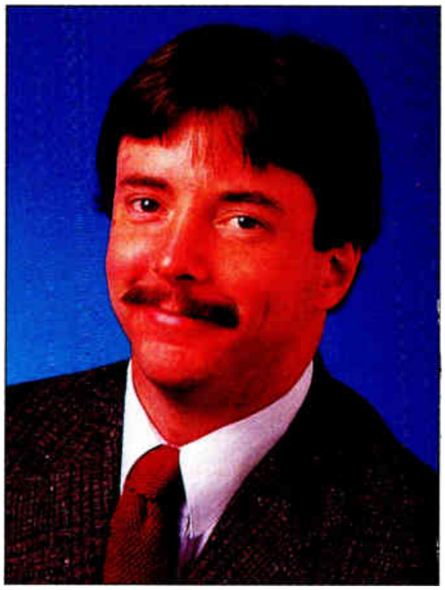
SCTE®

Good fences = good neighbors?

Like twin siblings separated at birth and then reunited years later, the cable television and consumer electronics industries are discovering they have plenty of common traits—but have grown up with their own way of doing things.

These two volatile industries discovered each other—and their incompatibilities—a few years ago when television manufacturers debuted the concept of "cable-ready" sets. These high-end receivers offered more channels and came with remote controls to make it easier to browse through a multiple-channel lineup. Indeed, these sets were compatible with most cable systems.

What they weren't "ready" to deal with, however, was addressable set-top convertors with single-channel outputs. Viewers who purchased these so-called "cable-ready" sets went home, hooked them up and then fumed at the local cable operator because his remote was useless and he couldn't tune more than one channel at a time (necessary in homes with VCRs that are used to record one channel while watching another).



Those events forced cable and consumer electronics engineers to come together to avoid similar occurrences. The vehicle created to share information was the joint Electronic Industries Association/NCTA engineering committee. This group managed to set aside personal feelings and worked toward a common goal: increased compatibility between the two groups.

By and large, the effort has been successful. Enough intelligence was traded to help both parties design better products and plan for the future. The committee even developed one interface solution, known as MultiPort, which unfortunately was never given the chance to work. Furthermore, EIA President Pete McClosky made a highly publicized trip to CableLabs in 1990 as a symbolic gesture of joint agreement and dedication toward ironing out the vexing problems.

What's disturbing is that this sense of cooperation appears to be unraveling. For example, the two camps are often at odds over political issues; an EIA staff engineer intimately familiar with CATV recently wondered in a public forum "why can't cable be TV-ready?"; TWICE, a weekly consumer electronics trade journal, recently blasted the cable industry's "price-gouging rampage" and practically begged the FCC to allow the phone companies into the video business.

If, as Robert Frost suggests, "good fences make good neighbors," some serious fence-mending has to be done here. It's quite possible the FCC will be commanded by Congress to *make* cable and television coexist more simply. By that time, however, it's doubtful the two industries could check their weapons at any meeting-room door. Consequently, the FCC would be forced to create rules that neither industry likes. Isn't it a better strategy to meet now and clear the air before any further damage is done?

Both industries need to realize their customers are the same people. It's time for a happy reunion.

Roger J. Brown

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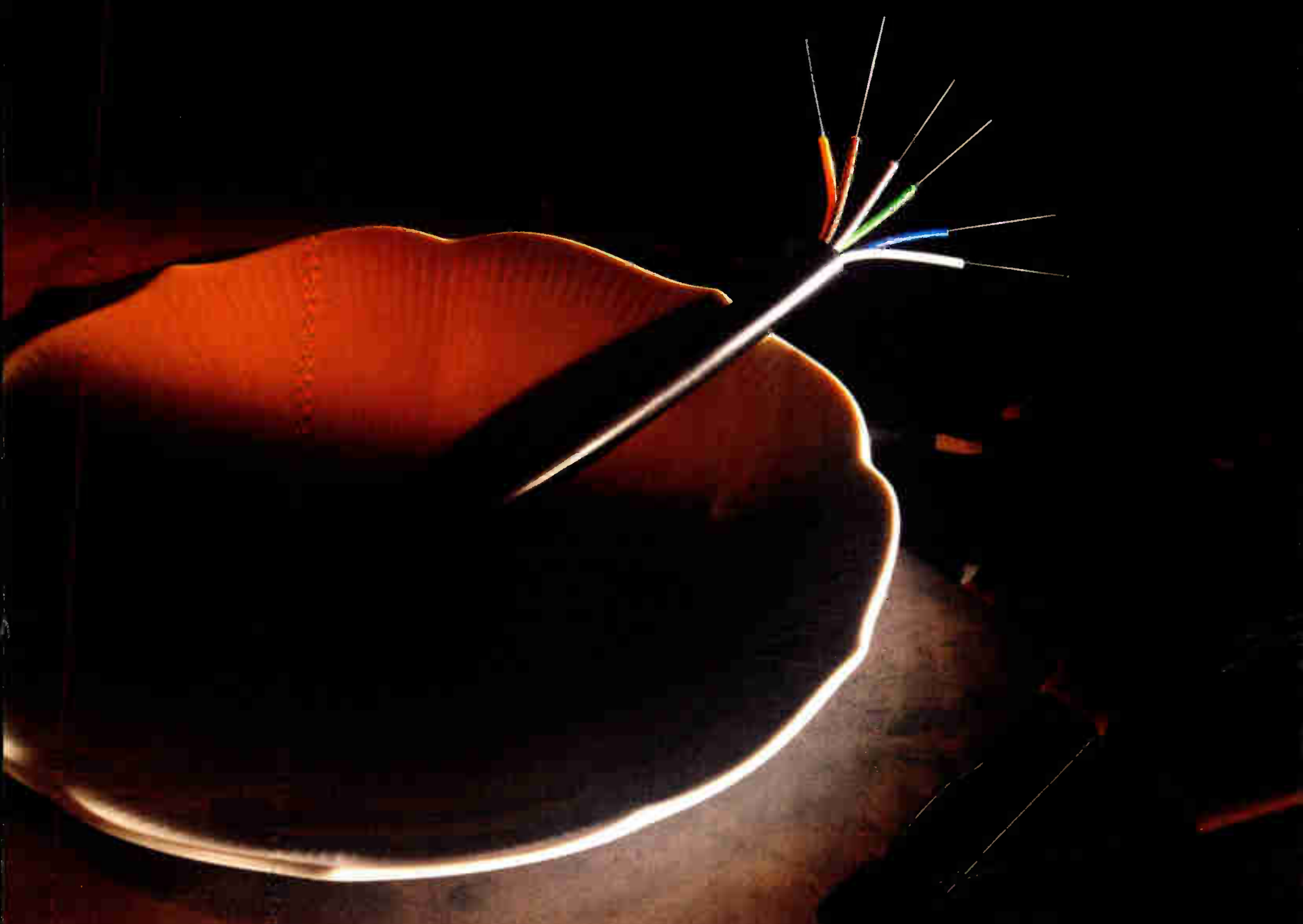

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WAVETEK

Cable has rosy future in 'Communicopia' report

It's not often that *CED* reports on policy reports from political or investment thinktanks, but when they focus specifically on emerging technology, it catches our attention.

Investment firm Goldman, Sachs & Co. has issued an exhaustive research report on this country's communication industries (it's titled *Communicopia: A Digital Communication Bounty*) as they wrestle with methods to establish a cohesive digital broadband communications platform. This 90-page document is encouraging reading for cable system operators and equipment vendors because it predicts a rosy future for the industry.

Why? Because with a broadband pipeline already in place, cable-TV has the easiest upgrade path to follow to provide a ubiquitous, real-time, two-way network to every home.

But the report goes way beyond parochial prognostications of who will "win" the cable/telco war. For example, the analysts forecast what might happen if the two industries decide to collaborate, they explain how developments in the computer and semiconductor industries will impact the question; regulatory and policy issues are thrown in the mix, as are programming and services.

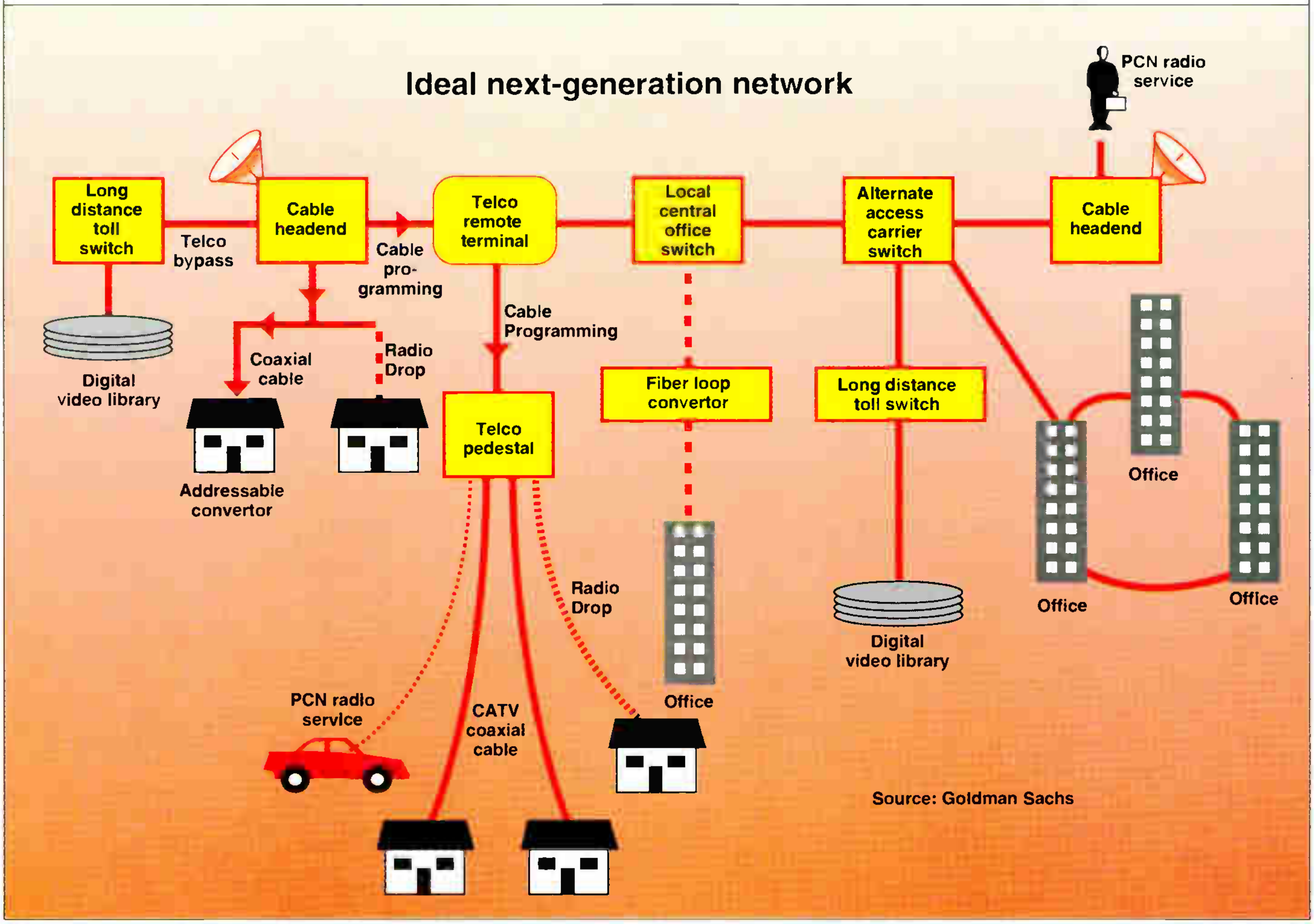
Along the way, the analysts peer into the future and determine how various divergent industries will eventually seek each other out to provide growth. Technology will change to reflect those new alliances, which cable TV will primarily spark.

"Cable converters should begin to resemble personal computers in both form and function," the report predicts. With 16- and 32-bit microprocessing power built-in, along with digital signal processors, increased memory and storage capability, those converters will allow "true interaction with the headend for functions like ordering movies, home shopping, voting, playing games and downloading databases." Furthermore, the converters may be used as "computers" to run video games, CD-I software, etc.

The report suggest that these converters will have to become modular, built to accommodate plug-in "cards" for decompression, extra processing power and storage. "As the box gets smarter, we expect IBM, Apple Computer, Microsoft and others to add technology to the converter.

But what will the local telcos do? Goldman, Sachs analysts suggest there are four paths they can follow:

1. Move ahead with current technology, hoping to garner some segment of the video marketplace while they construct fiber to the home.
2. Acquire cable systems outside their service areas.
3. Leapfrog today's technology and build networks to serve the multimedia networks of tomorrow.
4. Cooperate with the cable industry,



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perhaps sharing portions of each other's networks.

While the latter options makes the most economic sense, according to the analysts, there are competitive forces at work that cloud the issue. For example, AT&T, MCI and others want to see a second network develop at the local level because they are "frustrated by their lack of direct access to the customer and the high prices levied by the local telephone industry to gain access to those customers," the report states.

Could the "ideal network of the future" evolve as a hybrid telco/cable network as they are known today? Yes, say the analysts.

With the growing abundance of fiber optics in cable plants, the primary characteristics of such a network are present today. Regulation and legislation could be altered to encourage cooperation because the two networks "complement each other so well."

Figure 1 gives a glimpse into the analysts' proposed network of the future. It draws the best from both cable and telco plants. Switched digital video databases would allow viewers to call up a menu of programming items from which to choose. Because a switched network uses less bandwidth than simultaneous multichannel video delivery, bandwidth could then be used for true two-way interactivity, the report argues. Radio will be used as PCN becomes a reality.

If this scenario were adopted, the impact on spending would be enormous, the analysts predict. Both the telcos and cablecos would dramatically increase spending on transmission equipment as they vie for control of the portion of the plant between the switch and the home.

As it is, cable operators will "concentrate their investments" on addressable converters, digital compression, fiber, billing systems and programming during the 1993-1994 timeframe. This will increase channel capacity, giving them "room" for PCN and connections to switched video libraries.

Meanwhile, local telcos will probably ramp up their fiber-to-the-curb programs—testing video over coaxial cable and radio drops to the home.

By the middle of the decade, cable will roll out digital compression to the home, telcos will install photonic switches in big cities and transmission facility provision could become a competitive business. PCNs could expand. Data will be delivered via most cellular networks.

City dumps set-tops, buys interdiction

Never underestimate the popularity of convenience. The Morganton, N.C. city council didn't and it's going to be very popular with local cable subscribers.

Morganton plans to roll out Scientific-Atlanta's interdiction system in 100 miles of city-owned plant inside the city limits of Morganton to nearly 4,700 subscribers, according to Jay Coffey, public utilities director. The addition of interdiction will accompany S-A satellite receivers, headend and some fiber optic gear, as well.

The decision to purchase interdiction was prompted by a groundswell of opposition to set-top convertors and their inherent incompatibility with consumers' televisions and VCRs. Coffey said the outcry was so loud that his local city council ordered him to find a way around the problem.

The rebuild is presently undergoing final design and strand was scheduled to be installed around the end of August, said Coffey. The project is slated to be completed by next January, according to published reports. Morganton hired CCI, the same construction company that installed interdiction in Jones Intercable's Elgin, Ill. system, to do the build.

Morganton has made news by awarding itself a cable franchise after a long court battle with Tele-Communications Inc. The city also owns the local electric utility and plans to manage electrical loads with the cable-TV system. The cost of powering the interdiction system will be charged back to the cable system, said Coffey.

Zenith debuts new LAN products

Sensing renewed operator interest in two-way communication on cable plant, Zenith Electronics Corp. has developed a new data network that facilitates computer links over cable systems.

Developed jointly by Zenith's cable and communications product divisions, the new Z-LAN product now uses standard sub-split RF channel assignments, which will allow cable systems to extend both Ethernet and Token Ring data connectivity up to 30 miles for PCs, mainframes, terminals and printers to homes, campuses and businesses.

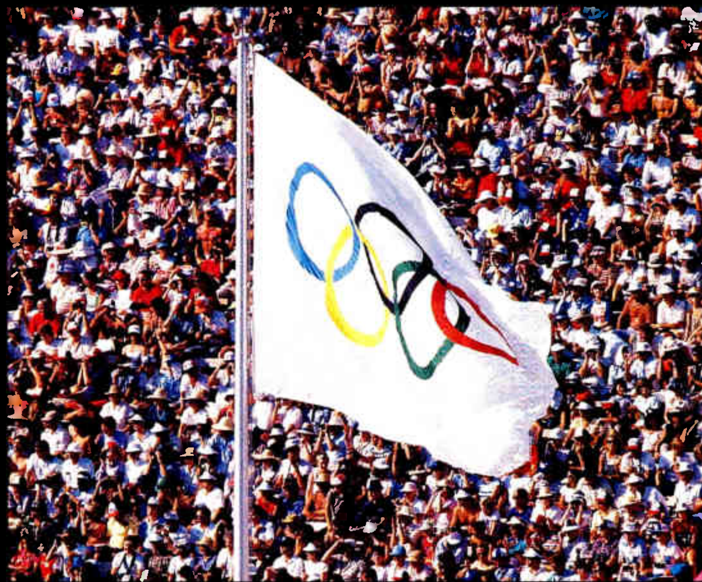
John Bowler, president of the Cable Products division at Zenith, said the product allows cable operators to use their existing networks as the backbone for a citywide metropolitan area network (MAN). The MAN could then be used for a variety of services, including point-to-point data, telephone bypass, video conferencing, security, multimedia and broadcast video. Those services could facilitate telecommuting, remote education, home computing and more.

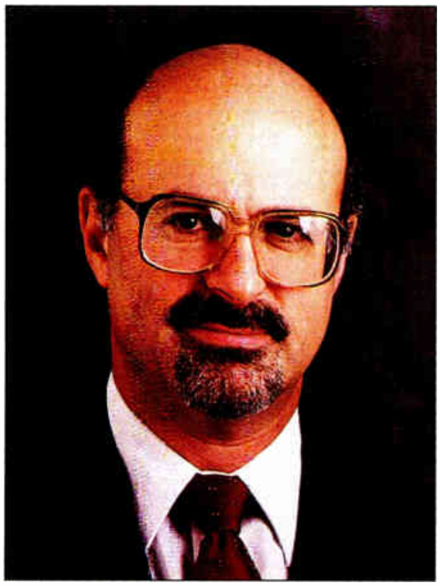
The product line consists of an Ethernet-on-broadband Medium Access Unit, network interface cards, asynchronous network communication units and a multiport router for Ethernet, Token Ring, WAN and broadband networks.

Jottings

For what it's worth . . . TCI Executive Officer **J.C. Sparkman** told a group of analysts at a recent Hanifen Imhoff investment conference that over the past two years TCI has become the single-largest user of fiber optics in the U.S. Sparkman also said bandwidth capacity on TCI's ring of fiber around metropolitan Denver is completely full. Finally, he told the analysts that TCI will utilize compression to viewers' homes by late 1993 . . . **Hughes Communications** second next-generation C-band cable satellite was scheduled for an August 20 launch. The new bird already has commitments from HBO, Cinemax, Comedy Central, ESPN, USA Network, The Disney Channel, Cartoon Network, TNT, Eternal Word Television, Univision, Nostalgia Channel, New Inspirational Network and Country Music Television. Galaxy I-R is scheduled to replace Galaxy I at 133 degrees west longitude . . . **Motorola** plans to increase manufacturing capacity of its hybrid components to support the "exploding requirements of the worldwide cable television market." It's doubtful anyone could be happier than **Texscan**, which blamed the shortage of hybrids for part of its 1992 order input woes in its latest financial report . . . The **FCC** clarified the rules surrounding its "interactive television" ruling (known formally as Interactive Video and Data Services). It also announced plans to accept applications for licenses in New York City, which were due August 20. The Big Apple will therefore be the first city to have wireless interactive TV.

Compiled by Roger Brown





Cable TV in Washington

The FCC has decided to allow telephone companies to lease channel capacity to video programmers. Video dial tone service will be permitted as a nondiscriminatory common carrier service offering by local telcos. This requires that telcos charge the same price to The Discovery Channel that they charge to Home Box Office.

Before a telco can offer the service, it must submit an application to the FCC, proposing the details of the video dial tone service. The FCC must grant approval before any video dial tone service can begin.

In the same decision, the FCC is recommending to Congress that the telco/cable crossownership prohibition in the 1984 Cable Act be eliminated. But in spite of this prohibition, the FCC decided to permit a telco to hold up to 5 percent ownership interest in a programmer. Commissioners Duggan and Quello dissented on allowing even a 5 percent ownership interest. They both felt this would encourage telcos to discriminate against programmers in which they do not own an interest.

Telcos are prohibited from purchasing the cable companies in the areas where they provide telephone service.

The FCC reaffirmed an earlier decision that telcos do not need a local franchise when offering video dial tone service. The FCC's theory is that video dial tone is not a cable TV service, and a programmer which leases video dial tone capacity is not a cable TV service and does not need a local franchise.

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

Personal Communications Services

The FCC adopted a Notice of Proposed Rulemaking on Personal Communications Services, but it put off all the hard decisions.

Probably three, but possibly as many as four or five, PCS licenses will be granted in the 2-GHz band in each geographical area. One decision that was deferred was the geographical scope of licenses. The FCC asked for comments on four geographical licensing plans:

- nationwide license
- separate licenses for each of 487 Rand McNally trading areas;
- separate licenses for each of 49 Rand McNally trading areas;
- separate licenses for each of 194 telco local transport areas (LATAs).

Commissioner Duggan opposed the idea of nationwide licenses.

Another decision that was put off was whether cellular operators and/or telcos should be eligible for PCS licenses. The cellular industry structure—only two operators per city—is not very competitive. Nonetheless, there is still a possibility that these two will get two of the PCS licenses in their cities.

The FCC also deferred any recommendation of pioneer preference awards until later this year when it acts on the docket that takes away 1850 MHz to 1990 MHz from the current microwave users. (I wonder if Rand McNally is in the running for a pioneer preference.)

The 1910 MHz to 1930 MHz band will be allocated for Part 15 unlicensed equipment such as cordless phones, wireless PBXs and wireless LANs. This will be within Part 15 but will have different technical standards than what is currently in Part 15.

At this point, the FCC has merely proposed these policies; a final decision is at least a year away. Then the FCC has to award licenses and decide on technical standards. In other words, don't hold your breath.

High definition television

The FCC has released a proposed channel plan for HDTV station assignments. Every existing TV broadcaster will get a second channel for HDTV broadcasting. In about 15 years, they will have to stop NTSC broadcasting and give back their existing channels to the FCC.

The new channel plan can accommodate HDTV using only the UHF spectrum (470 MHz to 806 MHz). This means that in about 15 years, the VHF TV channels (54 MHz to 88 MHz and 174 MHz to 216 MHz) can be used for some other service. Maybe a new broadcasting service. Maybe land mobile communications.

Meanwhile, five of the six proposed systems have been tested, testing of the final system has begun, and the test results for the first two systems have been released.

Narrow MUSE, an analog system, showed severe weaknesses: it has a slow channel acquisition time (5 seconds to acquire the channel after a channel change); the adaptive equalizer has a long convergence time (20 seconds to cancel a ghost); and poor adjacent channel interference rejection, which is a major concern for cable TV use.

The DigiCipher system came through without any serious problems or surprises. It exhibits a sharp threshold—noise first becomes visible at a carrier-to-interference ratio of 16.0 dB, and the picture is lost at a C/I of 16.5 dB. Channel acquisition time is less than one second, ghost cancellation is fast, and interference rejection is suitable for use on cable TV systems.

The schedule still calls for the Advisory Committee to make a recommendation on a standard in early 1993, the FCC to make a decision during the third quarter of 1993, and the first HDTV broadcasting to take place in the 1996-1997 timeframe.

Cable legislation

The House of Representatives passed H.R. 4850 on July 23, with a huge 340-73 majority that will probably make it "veto-proof." The House bill and the Senate bill (S. 12) contain differences that must be worked out in a Conference Committee that will include both congressmen and senators, but the substantive differences are small.

By the time you read this, the House and Senate may have reached agreement, and the bill may be on the President's desk...to sign or to veto. But with Bush behind in the polls and the likelihood that a veto will be overridden, things don't look so good for the cable industry.

Oh well...maybe this can all be fixed next year, by Vice President Gore. CED

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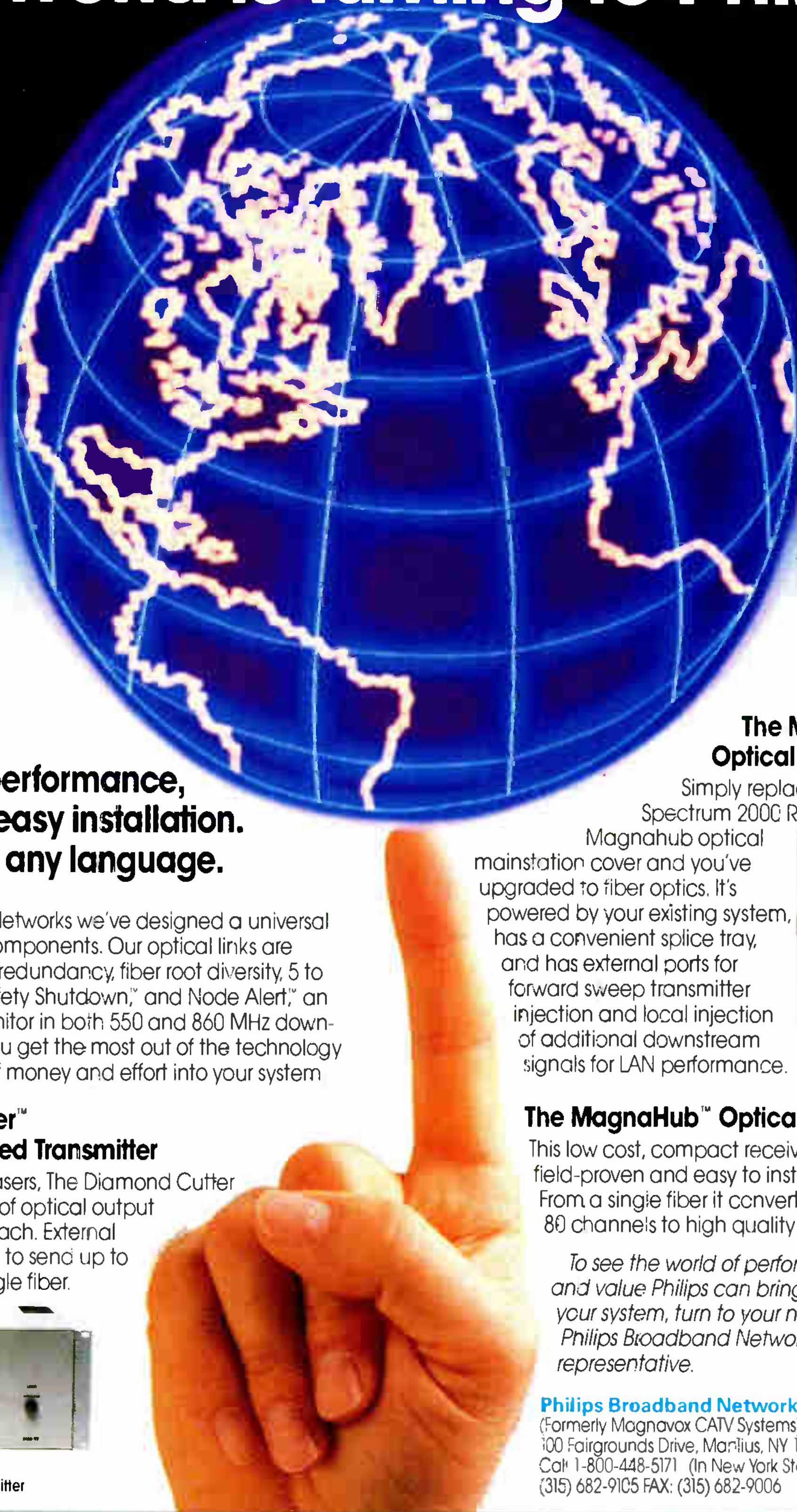

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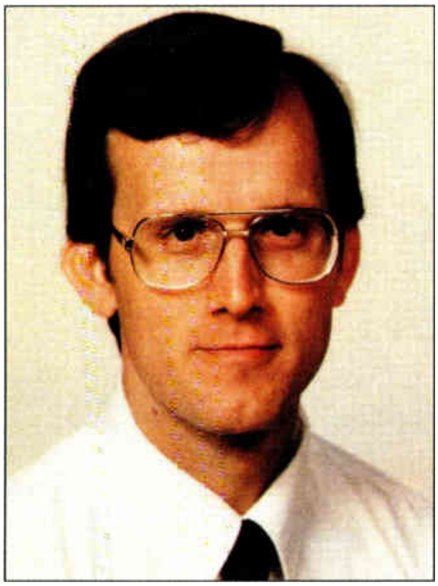

Future filled with competition

Recent advances in technology, especially on the digital front, have been absolutely incredible. Three years ago, the commercial use of digital video compression, for example, was thought to be many years into the future.

It is now anticipated that the technology will begin deployment late this year, and become commercial reality for satellite delivery of video, audio and data to headends, in full scale deployment, in early 1993. This same technology will certainly be available on a trial basis to the home by late 1993, and by early 1994. high volume production of in-home devices (set-tops) will be a reality.

Opens doors

But just as these technological advances promise to improve our network efficiencies, improve picture quality, relieve our "tapped-out" channel capacity and congested spectrum, so too will these and other technologies advance the capability of potential competition. Potential competitive services such as MMDS, MLDS (Multichannel Local Distribution Service), and telco video dialtone will become much more viable as these technological advancements are embraced.

MMDS, because of its limited channel capacity in most major markets, has never been considered much of a competitive threat by many MSOs. However, this strategy of blissful ignorance has been a serious mistake in some markets. This is especially true in areas in which the MSO has been providing poor customer service.

But if you believe the current channel line-up of an MMDS competitor, which consists of a measly 32 channels, simply can't compete, especially if you provide exceptional customer service, just wait until early 1994, when they are capable of 128 channels of programming!

This immense channel capacity is certainly feasible, and will allow for services such as near video-on-demand (NVOD). It is also estimated that robust digital modulation techniques, and error correction/concealment techniques will drastically extend the coverage area for the MMDS operator. Combine this with digital encryption techniques to remove theft of service as a barrier, and you've got a formidable foe.

In addition, the MMDS operator is typically hungry, and will be quick to embrace the technology. In fact, MMDS operators have already filed applications with the FCC for licenses to experiment with digital modulation techniques in several markets around the country.

MLDS

Multichannel Local Distribution Service (MLDS) is another potential competitor that may soon be in our markets. For those who have never heard of it, MLDS is a proposed two-way interactive service with enough bandwidth to provide video, audio, data and telephony applications. The transmission system would consist of about 1 GHz of bandwidth centered in the frequency spectrum around 28 GHz.

I often refer to MLDS as "cellular TV" because of its resemblance, from a network standpoint, to the cellular telephone network. In this network, a central high-power transmit/receive facility would broadcast programming out to smaller, low-power microcells which would then process and rebroadcast the signal over a much smaller coverage area, thus extending both the reach and performance of the network.

Because of the small size of these microcells, a low-power transmitter located in the home could provide telecommunications capability via these microcells to the primary facility and hence via the Public Switched Telephone Network (PSTN). The applications currently in-place at the FCC describe, in the initial phases of deployment, an analog FM approach providing 49 channels of programming in addition to telephony applications.

As digital technology comes to fruition in the very near future, the proposal also defines in great detail an evolution to compressed digital programming that would provide on the order of 150 channels of video entertainment along with full two-way telephony and data capability.

Telco moves

On the telco side, recent rulings by the FCC have given the CATV industry some cause for alarm relative to video dial tone. The "saving grace" for the CATV industry has always been that the telco industry's greatest financial asset, their copper plant, was also their biggest technological liability because of its narrowband nature. Recent technological advances in video compression, when combined with recent advances in digital transmission techniques over twisted-pair copper, have vastly changed this outlook.

Today, transmission techniques such as Asynchronous Digital Subscriber Line (ADSL), as well as Very High Digital Subscriber Line (VHDSL) are on the verge of making high-speed digital video in the telco local loop a reality.

ADSL technology provides for one 1.544 Mb/s channel, along with a 64 kb/s full-duplex voice channel (telephone service), and a 16 kb/s control channel over a copper pair in the local loop. These data rates will allow a single MPEG standard "VCR-quality" compressed video channel into the home, along with a control channel that can be used as a channel selector for video on demand applications.

VHDSL, on the other hand, promises the potential of 10 Mb/s to 40 Mb/s into the home over relatively short distances. If these data rates become a reality in the copper plant, we could begin to see more than six simultaneous VCR-quality, fully switched video services into the home—or, some combination of low-quality and high-quality services as well. This possibility might seem a little far-fetched based on what we know today of the cost of implementing these technologies, but when you consider the immense technical talent currently working on the solution, it certainly gives you pause to ponder the possibilities. CED

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

NCTA/CableLabs tackles audio level variations

The NCTA Engineering Committee and CableLabs are working to address the chronic industry problem of audio level variations across channels.

A month of testing earlier this year yielded massive data defining the problem. Proposed solutions, now being pursued, are:

- Working to encourage programmers to deliver signals at consistent audio levels, often by adding new audio signal processing equipment prior to transmission by satellite.
- Providing cable headend technicians with documentation of programmers' audio signal characteristics and recommended practices for level setting so that headend audio levels can be set with test equipment, not with human ears.

This article summarizes steps taken to date in this collaborative effort among engineers representing cable operators, equipment manufacturers and programmers.

First things first

Three years ago, the NCTA's Engineering Committee formed a Subcommittee on Quality Sound. Chaired by Ned Mountain of Wegener Communications, this group quickly decided that before addressing cable audio's more futuristic issues like Surround Sound, multichannel sound and digital audio, it should look at television sound quality and at the long-standing industry problem with maintaining consistent audio levels from channel to channel on the typical cable system.

This problem, Mountain observed, "gets worse with every passing year as the number of channels increases and the number of cable systems increases. I've been told that at city council meetings, it's usually the number-one or number-two problem that is mentioned."

Mountain ran some preliminary tests on Atlanta-area systems, confirming suspicions that audio level variations of 10 dB to 20 dB between lowest and highest signals were not uncommon. Cable operators tended to blame programmers for this problem, and vice versa.

Next, early in 1991, two of the NCTA audio subcommittee members who work for General Instrument Corp. measured the signals being transmitted by cable programmers.

They reported variations of at least 10 dB to 20 dB among both scrambled and unscrambled signals, Mountain recalled.

"The fact is that there is no technical standard for the delivery of audio over satellite," he added. Neither NCTA or CableLabs will set a standard, but rather will suggest a recommended practice.

In the absence of such standards, programmers had developed their own approaches. The committee found programmers were generally strongly committed to the approaches they had chosen.

Peak-modulation data sought

"So our approach was to go to each programmer and ask them to tell us what they are doing in a way that we can take their data and use it to set up a headend with test equipment," Mountain said.

Specifically, more than 30 programmers were asked to state their peak program levels—or levels for 100 percent modulation—as defined by the FCC rules that govern broadcasters (the actual questions posed are shown in Table 1).

The FCC defines 100 percent modulation for television audio as 25 kHz peak deviation. Of course, this standard was of little concern to cable programmers, who are not subject to this particular FCC rule since they are not engaged in over-the-air broadcasting. So explaining this FCC standard to the cable programmers took some effort. In the end, though, 26 cable programmers provided data and their answers ranged from 0 dBm to +16 dBm.

Broadcasters are obligated by FCC rules to set up their audio-delivery chain with reasonable precision; they have only one studio and one transmitter to deal with, greatly simplifying the process. By comparison, a major cable programmer has 10,000 transmitters in the form of the cable modulators at 10,000 headends, each with its own audio deviation control, and each adjusted by a different technician.

Measurements at CableLabs

The next step took place at CableLabs in Boulder in May 1992. There, Mountain assembled a working group from his subcommittee, comprised of Paul Resch, director of engineering for Disney Channel; Mike Aloisi, director of engineering services, Viacom Network Group; John Vartanian, director of engineering for Home Box Office; and Ken Cannon, senior application engineer, Transmission Systems Business Division, Scientific-Atlanta. Two others from

Audio Level Survey Questions

These are the questions about audio levels that the NCTA subcommittee posed to more than 30 cable programmers:

1. For scrambled transmissions, the output level of a VideoCipher transmission is ______ dBm of a 400-Hz tone provided by a factory-calibrated descrambler, monaural output, that when applied to a 600-Ohm resistive load represents 100 percent modulation for peaks of frequent recurrence as described by FCC Rule 73.1570 for a 75-microsecond preemphasized system.

2. For FM subcarrier transmission for those services that are not scrambled:
__ Yes, our FM subcarrier modulator is set for 185 kHz peak deviation
___ No, our peak deviation is ____ kHz.

3. Is some type of audio limiting in use (yes or no)?

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Chart on frequency?

Thanks for your new frequency allocation chart.

A couple of points: Channel 42 shows a frequency of 331.2625 MHz. The correct frequency for this channel, to comply with FCC offset requirements, is 331.2750 MHz.

The notes on the chart correctly indicate that channels 5 and 6 are moved in frequency in IRC systems. However, the EIA/NCTA chart continues to designate these as channels 5 and 6.

Finally, the footnotes indicate correctly that there is a potential problem with interference on channels 88 and 89, but indicate that the problem is interference **from** the convertor. The potential interference is **to** the convertor from signals occupying that channel on the cable system. It arises in the event that energy from the cable at those channels enters the first intermediate frequency stage of the convertor. It can then cause interference to all signals carried on the cable system when they are tuned with that convertor. The situation is the same as for channels 151-153 when used with a TV set employing a tuner using this EIA-J IF frequency.

Incidentally, at a joint committee meeting in July, there was some agreement (not yet official) to change the wording of the two footnotes in the table related to the EIA-J frequencies, as follows:

† (channel 145, local oscillator frequency) "Use of this channel for priority programming is not recommended. It is used as the second local oscillator frequency for some television sets. The possibility exists that local oscillator leakage from the set may cause interference to another TV viewing this channel. The interference may be independent of the channel to which the subject TV (i.e., the one containing the double conversion tuner) is tuned."

†† (channels 151-153, IF frequency) "Use of these channels for programming is not encouraged. They are used as the first intermediate frequency in some television sets. When such a set is tuned to any channel in this part of the spectrum, then it may experience interference from carriers on these channels. If this occurs, the only solution may be to provide a bandstop filter tuned to these channels. Such a filter will, of necessity, remove several additional channels either side of channels 151-153."

Those of us in the cable industry would encourage (television) set manufacturers to move away from using this intermediate frequency as quickly as possible. The cable industry may find it difficult to avoid these channels in the long run, and a manufacturer using this IF may then find himself at a competitive disadvantage.

Jim Farmer
Principal Engineer
Scientific-Atlanta

More on picture quality issues

It is quite probably true that television viewers are becoming more critical of noisy pictures, as suggested in Leslie Ellis' article in *CED*, July 1992. However, I fear she has relied on some significant misunderstandings of the 1959 TASO data.

First of all, none of the six categories by which TASO viewers judged pictures was named "slightly annoying." In 1950-53, the NTSC used a six-point scale in which a "somewhat objectionable" reception fault was to be rated Grade 4 and labeled "Not quite passable." TASO used the same categories, but labeled Grade 4 as "Marginal," and described it as: "The picture is poor in quality and you wish you could improve it. Interference is somewhat objectionable."

Half the TASO observers rated the stimulus pictures as "Marginal" at 24.5 dB C/N ratio (at 4.0 MHz noise power bandwidth), and "Passable" (Grade 3) at 29 dB. It is my opinion that the 30 dB C/N standard adopted by FCC for Grade B quality of service was probably based on this TASO finding.

The trouble is that 60 percent of the TASO viewers were seated at 10 times picture height; and 40 percent at seven times. The CCIR standard procedure for subjective viewing as at four to six times picture height, and recent data reported by Bronwen Jones were mostly at five times.

Obviously, the farther away the viewer sits, the less annoying the noise becomes. The typical viewing distance in homes is reported to be nine to 11 feet. This is 8.5 to 10.5 times the height of a 21-inch screen; six to seven times the height of a 30-inch screen.

People probably are more critical today, in part because most of them are viewing larger screens than 20 years ago. Perhaps they also expect more when they have to pay for what once seemed to be free.

The real challenge for cable TV operators is likely to be the squeeze between rising public expectations and the increasingly difficult ceilings imposed by analog technology. Expanded channel capacity tends to narrow the dynamic range of amplifiers, set-top convertors, and VSB/AM fiber optics. Even 45 dB signal-to-noise ratio may not be good enough to match uncompressed switched digital video dial tone.

The question still to be unanswered is: How critical will viewers be when confronted with pictures transmitted digitally after some of the information in the original scene has been discarded for compression? Laboratory tests indicate that people do not notice the missing information. What will field tests and actual operation show over a period of time?

Archer Taylor
Malarkey-Taylor Associates

Digital carriers aren't noiselike

The paper entitled "Composite Triple Beat: A new look and a new problem," (*CED*, August 1992, p.62) is an interesting study of an old problem. I take issue, however, with the statement:

"Digital carriers are expected to be noiselike and not to have a strong CW component in their spectrum."

When viewed on a spectrum analyzer, digital signals appear to be noiselike. That is, they have a flat frequency response (unless modified by RF or baseband filters), and it looks like noise. However, they do not have a random phase and Gaussian amplitude distribution. Depending on the modulation level, they have discrete phase states and amplitude levels. An analysis of IM assuming they are noiselike can be grossly in error.

My best guess is that they should be treated just like any analog carrier in IM analysis. Digital carriers may even exhibit lower levels of CTB because there will be less spectral spreading of the IM components than if they were treated as noise.

Norman Wienhouse
Norman Weinhouse Assoc.

the working group, Par Peterson, director of engineering for Western Communications, and Norman Weinhouse of Norman Weinhouse Associates, were unable to attend.

The CableLabs team supporting the effort included David Eng, manager of technical services; Max Morales, lab engineer; and Frank Wimler, senior electronics technician. Tom Jokerst, CableLabs vice president, office of science and technology, also participated.

First, the group spent a half-day calibrating the 25 to 30 satellite receivers and descramblers in the CableLabs headend so they could provide a fixed reference point for measurements.

Then, using the data provided by programmers, modulators for each cable channel were set up with a 400 Hz test tone to levels equaling the programmer's reported 100 percent modulation level. The satellite receivers and modulators were then connected. All the audio controls were secured with stickers, giving the group the option to go back and take additional data.

Then a month-long data-gathering process began. A key role fell to a device called Audio Rider®, which scans all the channels on a cable system, sampling each to gauge its peak deviation, retaining the data in computer memory. Data were gathered for cable channels and for Denver-area off-air channels.

Analyzing the data

In mid-summer, the group was analyzing the data to see: (1) how close the programmers were to their stated peak levels, and (2) how they compare with each other.

> The group hopes to publish information on each programmer's peak program levels and suggest procedures to set up audio levels.

The group, said Mountain, has already reached two initial conclusions:

- Several programmers obviously provided inaccurate numbers, not deliberately, but simply through incorrect measurements or calculations. They are being contacted and the data discussed with the intent of recalculating the numbers.
- "There are some programmers who do not control their audio levels that well on an hour-to-hour and day-to-day basis," said Mountain. In a dialogue with this group, the NCTA group is suggesting solutions, in particular the possible advantages of bringing in high-quality audio processing gear.

By mutual agreement with programmers, the test data are being kept confidential by the subcommittee.

The subcommittee is also organizing a seminar for programmers, probably to be held in September. There, the data would be shared, "without naming names," and some manufacturers of audio processing equipment would be present "to share their philosophies with programmers," Mountain said.

Ultimately, he added, the group hopes to publish, either in a separate book or as part of the *NCTA Recommended Practices for Measurements on Cable Television Systems*, information on each programmer's peak program levels and a suggested procedure by which headend technicians can set up audio levels with test equipment.

"I think the programmers will make more use of professional audio signal processing products that are generally available to the broadcast networks and their affiliates," said Mountain. "In terms of this problem, they need to think of themselves as broadcasters, not just programmers."

The biggest challenge in all this is "as much psychological as electronic," said Mountain. "It is convincing programmers that, even though they themselves are technically correct in what they are doing, we'll all benefit from collaboration so that cable operators can provide a quality product to their end customer, the subscriber."

CableLabs' Eng said, "I think programmers realize it's a benefit to them also, that it's not cable technicians and headend guys against the programmers. We're all in this together. We can help each other. The better the system sounds, the better it is for everyone." CED

Materials and cable design critical to optical cable

Aerial cable and messenger strands are exposed to harsh elements, with one of the most serious being lightning strikes. Usually, proper grounding and bonding prevent cable and electronics damage. Yet, despite these precautions, many systems have had lightning-induced damage, and CATV operators have experienced the associated downtime and resulting repair costs.

As increasing amounts of fiber optic cable are placed aerially, the performance of these cables in this harsh environment should be better understood in order to achieve the reliability that optical cables should provide.

Cable television system operators must make product decisions that will give their systems the best long-term, cost-effective performance. Specifically, operators must be aware of how fiber optic cables perform under all environmental conditions; attention should be focused on reliability and optical performance. This article will focus specifically on the lightning performance of fiber optic cables, the role of cable design and material selection.

Industry standard testing for fiber optic cable defines "survival" in a lightning environment to be fiber continuity only. In addition, operators must consider the cable plant's survivability. For a cable to survive an actual lightning strike, not only do the fibers need to remain continuous, but the cable must provide both mechanical and environmental protection for the fibers.

For years it was assumed that steel central member cables (that is, cables which strand multiple buffer tubes around a central support member constructed of steel) were more susceptible to lightning strikes. The concern was that the lightning would arc through the cable core to the steel central member and damage the fibers.

Recent tests were performed to investigate this assumption. Several cable designs currently used by cable TV operators were tested, including multiple loose tube cable, single tube cable with dielectric strength members, and single tube cables with metallic strength members embedded in the jacket.

The industry standard sandbox test, as well as a modified version to simulate an aerial environment, were used. The results of the test confirm, in many cases, that which is already known in the fiber optics industry: non-armored cables are preferred in lightning-prone regions. In another case, however, the testing produced results which refute conventional ideas regarding steel central member cables.

The test data clearly indicates there is no difference in the lightning performance of steel and dielectric central member cables. It was discovered, however, that the type of strength member used and its placement, as well as the materials used in the cable core, are far more important factors.

This article examines the lightning performance of fiber-optic cables as they relate to: (1) steel central member vs. dielectric central member or dielectric core cables; (2) armored vs. non-armored cables; and (3) metallic vs. dielectric strength members and their placement in the cable.

The study is based on several years of testing by an independent, industry-recognized laboratory. Testing was conducted in accordance with specifications outlined by the Telecommunications In-

By Kenneth L. Lindeman, Steven W. Karaffa, Ken D. Temple, Jr. Siecor Corp.

Sandbox test 105 kA

Cable	Continuous fibers	Comments
Multiple loose tube, steel CM, duct (non-armored)	Yes	No cable damage. Charge dispersed through sand.
Multiple loose tube, steel CM, armored	Yes	Outer jacket & armor melted at strike location, some outer layer buffer tube melting. Central member coating adhered to buffer tubes. Cable strength members intact.
Multiple loose tube, dielectric CM, duct (non-armored)	Yes	No cable damage. Charge dispersed through sand.
Multiple loose tube, dielectric CM, armored	Yes	Outer jacket & armor melted at strike location. Cable strength members intact.
Central tube, armored	Yes	Outer jacket & armor melted at strike location. Buffer tube deformed but intact. Cable strength members intact.
Central tube, armored, longitudinal steel wire strength members	Yes	Outer jacket melted and split along steel wires. Armor melted at strike location. Buffer tubes destroyed.

CM = Central member

Table 1

Fiber optic panel: A hands-on discussion

As fiber optic technology moves out of the ivory tower thinktanks and onto the to-do lists of cable engineers, a whole new set of questions arise. Instead of musing on the benefits of various topologies, today's field engineers are tackling other, day-to-day issues. In this fiber panel discussion, regional engineers across the nation discuss their needs, concerns and "I learned it the hard way" recommendations.

Panelists for the discussion include Andrew Shumway, a regional engineer for Kingwood Cablevision; Mike Smith, director of Adelphia's Virginia region; Carl Newberry, regional director of engineering for Cablevision Industries' Florida division; and Ron Cassel, an engineering supervisor for Suburban Cable.

> Mike Smith is a director of engineering for Adelphia's Virginia region. He has built over 200 miles of fiber.

What is the top implementation issue facing you regarding fiber optic rebuilds and upgrades of your plant?

Newberry: I would say pre-planning. The way we look at it, we don't put fiber in just to put fiber in. For us to put fiber in, it has to be cost-competitive to any RF build that we would do. And really, fiber is cost-competitive. In all our rebuilds so far, it's been as cost-effective or maybe a little more.

My biggest challenge now is to take fiber deeper into the system and still find ways of making it pay for itself.

Smith: My top concern is time. Fiber is very similar to coax, but by the same token it's very different. When you're putting in coax, you have one piece of cable, you make one splice, then you go down to the next location. Whereas with fiber, you can have as few as four of five fibers, or as many as 76 fibers.

At a location, each one of those fibers has to be either fused together or mechanically put together, so it's a lot more time-intensive at each one of those locations. By the time you prep the cable for a 60- to 76-count fiber, you're looking at an eight- to 12-hour day, just for that one location—whereas with a piece of coax, you can be through in 30 to 45 minutes.

Shumway: I'd say for us, it's route planning. We're mostly an underground system, in a PUD (planned urban development), so we're typically dealing with the county engineering department, or with the developers themselves. That's where we usually find out what's going to happen with growth.

Route planning

Speaking of route planning—what are your recommendations?

Cassel: I would make sure to check with the Department of Transportation for any road widening projects, even five to 10 years down the road.

Newberry: Again, the biggest thing is pre-planning. We check with the DOT, and we also check with the police department to make sure we have a complete accident report on a particular route. If there's a pole on a curve, you may want to stay away from it—especially if that pole has been hit a lot.

Smith: With fiber, access to the base of the pole comes very much into play, especially if you're using fusion splicing equipment. You have to be able to get the trailer or van in close proximity to the splice point. So when we plan a location, we physically drive the route to make sure we can get a vehicle off the road at that location.

But the biggest recommendation I have about routing is to pre-plan. It's not possible to overplan. You need to plan where the nodes are going to be located, where the splice points are going to be, where your backloops will be and where you put slack for emergencies.

Emergency restoration

What are your emergency restoration procedures?

Cassel: Usually, it's pretty easy to determine if a problem is related to fiber—if the fiber gets cut or damaged, everything goes out. So we have a 24-hour dispatch operation. If something goes wrong, they call the engineer in charge, and he rolls out the restoration truck. The truck has a shop in it, a cellular phone, two radios, a generator and plenty of lighting.

Newberry: You always have to be ready to repair. That's a major issue for us, so one day my chief tech and I did a trial run. We said, "If there was an outage right now, what would we do?"

Obviously, the first thing we did was try to find the restoration trailer. As it turned out, the exercise proved useful, because the restoration trailer was parked behind a bunch of other vehicles. We couldn't get it out. Had it been a real emergency, in the middle of the night, we would've been stuck—literally.

Shumway: The big thing with emergency restoration is fiber preparation. The actual splicing time is minimal compared to the time it takes to prep the fiber—if you have an end that's really mangled, you may have to cut back 10 or 20 feet and then prep the end, which means you might want to strip back about four feet of the sheath and then cut down.

> Andy Shumway is a regional engineer for Kingwood Cablevision. He is currently involved in a 225-mile rebuild using a fiber-to-the-feeder design.

Because most of our plant is underground, we have a different set of concerns than the aerial builds. We put in what I call a shadow pipe. It's just a

spare pipe in there in case I run out of fiber, or if we have a cut and I need to pull a temporary through.

It came in handy recently, too. A power company tried to set a pole and didn't realize we were buried there. They used an auger bit and went right through the cable. It was a real mess—they just obliterated a 24-fiber cable. My first slack pedestal was 600 feet away, and it had pulled the fiber in that pedestal to the point that it damaged it against some of the mounting plates in there.

I was able to take a smaller cable, repair the empty pipe, and pull a piece 800 feet. So you have to put down a procedure and know it well, because you don't really know what's going to face you until you get there.

Any other horror stories?

Cassel: We had a 60-fiber cut three blocks out of the headend. It happened during the wreckout of the old system—someone went up there with a hacksaw and cut the new cable instead of the old. Luckily, we were able to restore it quickly, because we didn't have to restore every fiber right then.

It took about six hours to restore it. That's where good documentation comes in handy. We have a book that tracks every fiber—you look at the different colored buffer tubes, find which ones are active, get them on and leave the rest for another day.

Slack

How much slack do you put in during fiber construction?

Shumway: Because we're underground, all of our optical designs have to include a buffer zone for future problems, like cuts and splices. Everything we do is in pipe, so we try to store 50 to 100 feet—or whatever is left on a reel.

Cassel: We don't put slack in just anywhere. We put it in just at splice points, but if there's an intersection we know is going to be under construction within the next five to 10 years, we'll put in 1,000 to 2,000 feet of slack.

Smith: It depends. Typically, if you take a hit or a cut, you're looking at possibly damaging 200 to 400 feet of cable. So what we do is have restoration kits already made up, sitting in warehouses, that consist of enough fibers to splice into our active fiber count at any location. So you've already got the enclosures made up, and half the work is already done—that 200 to 400 feet of cable's already there.

Training

How are you making sure your people are properly trained?

Shumway: Like I mentioned earlier, fiber preparation time is the hardest part of restoration—or at least, the most time consuming. So we have a program here where once a month, we hand each technician a piece of scrap fiber and tell them to prep a foot of it. That way we always have one or two guys who can go out and take care of things.

Other than that, most of our training has been from the equipment manufacturers. Usually, myself and the chief tech will get the training, and then we either train the rest of the crew or have someone else come in and train then.

> Carl Newberry is director of engineering in Cablevision's Florida division. He has installed more than 100 miles of fiber in the region.

Smith: For us, a good portion of it is hands-on. Fiber is very similar to coax, and I personally feel that there's nothing magical about it. That's been the hardest part for me to overcome (with my staff)—a lot of the articles generated by the phone companies put this mystical hype around fiber. I don't know if they're trying to psyche us out, or what. But it's like anything else, in that the more you work with it, the more comfortable you start to feel with it.

Cassel: We try to keep up with training. It's difficult to do, because you can't go out there and make fiber breaks. Every once in a while you should take a couple of pieces of scrap fiber and tear them apart, to make sure you can do it.

Newberry: We have a regional trainer, and he just finished writing a fiber optics course. The course will be used through all Cablevision Industries systems, and all of my guys have to go through it. The course gives some architectural fiber background, tells you how to splice, how it works, what it should look like, a little bit of AM and

THE OPTICAL ADVANTAGE ANYONE CAN SEE.

Building quality: Sammons innovates in fiber construction

Sticking your neck out can be smarter than burying your head in the sand.

Sammons Communications Inc., the Dallas-based owner of Sammons cable systems around the country, has enjoyed a reputation for cable construction innovation for many years. One source for this is the leadership at the top.

"There's first-rate information coming from our corporate office that keeps the people out here in the field abreast of all the new techniques," says Ellis McDaniel, system engineer at Sammons' Bensalem, Penn. system.

In the opinion of Dave Bell, construction coordinator for Sammons Communications in Turlock, Calif., "We've got two capable people in the corporate office who are doing construction and have been in the industry doing construction for a number of years. Bill Artz and Mac Zukoff, they really are sharp."

But being an innovator requires an ability to tolerate change and, occasionally, sticking your neck out. "If something looks reasonable," says Artz, Sammons' national construction coordinator, "we're not afraid of taking a chance and see if it works rather than just staying with something that has worked for a thousand years and everyone is doing it that way. If something is reasonable we say, 'Well, what the heck, let's give it a try.'"

Improving the quality of a cable system often cannot be accomplished by following a SOP (standard operating procedure). It requires keeping an open and reasonable mind, using creative thinking and planning, listening to ideas from the field, and trying new techniques and new products, according to the Sammons executives.

"Those two guys in construction and the whole engineering department look at new ways to do a better job more efficiently," says Bell. "They take everything into consideration: aesthetics, costs, etc. But cost is not the only thing that is important to them. It's whatever does the better job. If it's cheaper, that doesn't mean it's better. If it's expensive, that doesn't mean it's better. It's what does the job better that matters."

"Often we find methods that are easier and less expensive and just as effective," Artz offers. "Sometimes we will go the other way. We will do things that are more costly if we feel there are long-range benefits to be earned by it. It's not one way or the other. It's what makes sense in making a particular decision."

New messengered duct installs easily.

By George C. Sell, Contributing Editor

What works

Bell, who has been with Sammons for 11 years, says the corporate philosophy is to "buy practical stuff. You don't buy bells and whistles but what works and is going to last." The same philosophy is true when Sammons orders construction material. "We don't want you to go out and buy the very finest if there's something less expensive that will do that job as well," Bell explains.

The same is true for techniques. If it makes sense, try it. A case in point is an idea Bell had for burying cable and preventing dig-in damage. Bell spells it out: "We dug our fiber in 30 inches deep. I put black color in white sand and water and made a slurry. Then I filled it up to 15 inches in the trench. Then I put in fiber warning tape and back filled it with the original ground and compacted it."

The purpose was to make a backhoe operator, if he should ever dig up the warning tape and black dirt, stop and think. "That way he's not digging into my fiber," Bell concludes. "Our idea is prevention."

But, typical of Sammons' "reasonableness," it also avoids overzealous prevention. For example, "I don't know if any other companies double lash when they overlash, but we single lash," Artz explains. "We see the benefit of that being if it ever becomes necessary for our field personnel to delash the fiber in order to move slack around. With the weight and flexibility of fiber cable, I don't think double lashing buys them a whole lot."

Of course, it's different with coax. "We double lash our coax about 70 or 80 percent of the time. And that is for security among other things. And also because it's coax and much heavier," says Artz.

"Comparatively speaking, coax is very tender," notes Artz. Fiber is a lot more rugged than people originally thought it would be. "We were scared to death" at first, Artz admits. "We were afraid to touch it. We are finding now it is really easier to put up than coaxial cable."

Fiber in the air

An innovation that has made fiber cable construction easier for Sammons is a new product, an aerial messengered conduit called Messenger-On-Duct (MOD) manufactured by Integral Corporation. In the field it is variously referred to as "MOD," "figure-eight duct" or "aerial duct."

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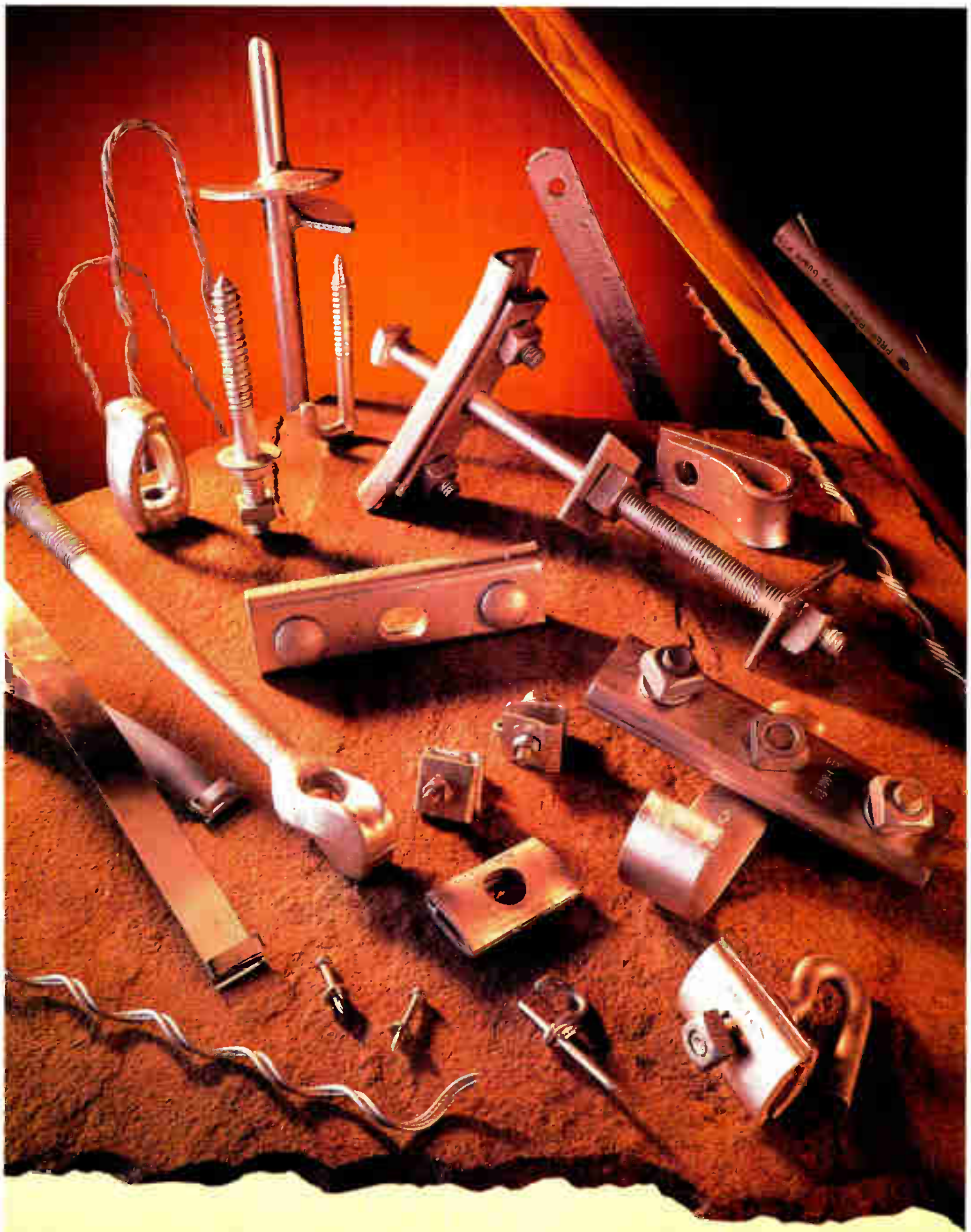

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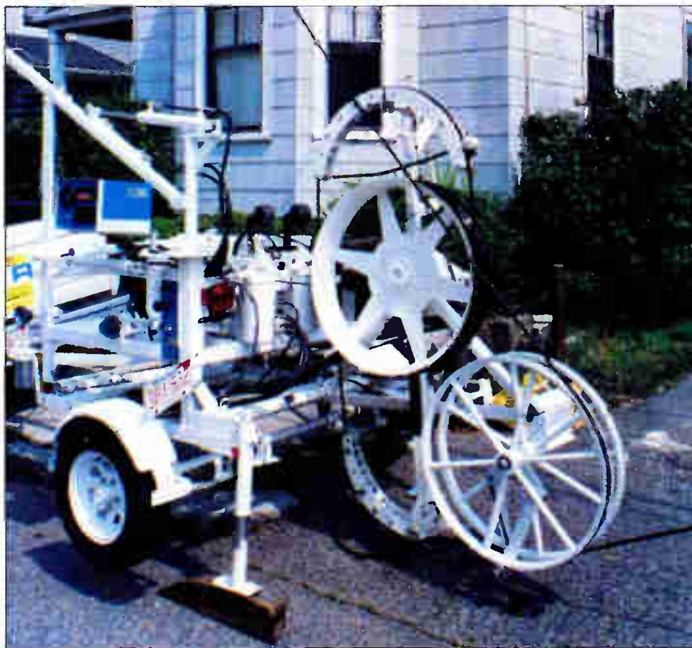

New capstan winch design reduces manpower needs.

ends offset the cost of the fiber. "The equipment that we recovered from discontinuing the other headends shortfell the cost of other systems using that material. So, the cost of the fiber was written off by the amount of reusable equipment that we shipped to the other systems."

The Bensalem project involves a 30-mile run of fiber, all but two miles of which are aerial. Large segments pass through areas not franchised to Sammons. To get from one Sammons' franchised area to another they had to cross an area franchised to ATC.

The original plan was to use MOD where Sammons was passing through a franchise where we didn't provide cable service, says McDaniel. "We wanted more security than just the glass hanging on the pole, and the MOD gave us that. Once we saw we could do that almost as inexpensively as strand and lashing, we used it in any virgin areas where we didn't have existing strand."

"We've viewed the aerial duct as (appropriate in) an application where, if we are going to go through virgin territory—an area where there is no other existing strand—then we think it's an opportune time to hang the aerial duct," advises Robert Saunders, assistant vice president of Engineering for Sammons. "It provides a somewhat easier construction practice. From a maintenance prospective, once the fiber's in the duct, if you have a breakage, it's much easier to move slack around and make splices than to delash and relash."

Artz says the MOD implementation project has moved beyond a testing phase. "The Bensalem project was an aggressive test," he notes. Sammons has made a commitment to it without having seen whether it will work anywhere else. "But it looked like an excellent idea. And we had a specific application up there that made it look even better."

McDaniel, the system engineer in Bensalem, describes the fiber project: "Our goal in Bensalem is to eliminate two remote headends and increase quality at the ends of our cascades, shorten cascades and give us the ability to add more channels. We were restricted with having three headends; not only financially but technically. Anything we did we had to do in triplicate."

According to McDaniel, "With the addition of fiber, we only had to buy one piece of equipment and we're still maintaining the same if not better quality at the end of our cascade."

Furthermore, the value of the equipment taken from the redundant head-

Hanging it up

And how did it go up? "If you can get the duct up there," says Artz, "you can pull fiber through the duct a lot easier than you can pull it on a messenger, which means you can reduce the times you have to figure-eight the cable. The major thing you can do away with is the lashing after you pull it out. Once you pull it out, you are done with it."

"For something that looked so big and cumbersome, the ease of operation, I think, astounded everybody," McDaniel advises. "Not only the people in the engineering office, but the people who had to put it up, because when it first rolled in here, you could see it in everyone's eyes: the 'Oh my God, what do they expect us to do with this thing?' look. And they got out there and started working with it, and they said, "This is a piece of cake!' "

MOD comes from the factory on large wooden reels that nevertheless fit a standard Telsta truck, according to McDaniel. However, it did not present any difficult handling situations, "other than the initial shock of seeing the big sons-of-a-gun on the truck," McDaniels recalls. "Installation was not a problem. The contractor said he was putting it up, start to finish, as quickly as he would have put up strand and lashed cable."

Bell from the Turlock system says he was surprised how well MOD was installed. "I didn't like the idea of it when we first started because the first thing I thought was it's going to be backlashing and flipping over on itself and doing weird stuff," he says "I was wrong. It went up nice and it pulled through real nice." In Turlock, Bell is also hanging MOD wherever aerial strand doesn't exist.

Pulling the fiber

"Pulling it was a lot easier than I thought it would be," Bell also reports. "This particular duct was lubricated. We pulled 6,000 feet of fiber cable through it at 149 pounds. Everybody was skeptical about pulling the 90's (90-degree turns) with it, but it went much better than anybody expected it would."

"Having a good internal lubricant and utilizing a low friction, high strength pull rope has a great deal to do with cable pulling success," explains Scott Lumley, director of field engineering for Integral. "We have found that aerial duct pulls easier than buried duct. Sidewall pressure is lower because the duct is straighter and more forgiving in the air."

Less personnel are needed compared with hanging cable on the strand, Bell claims, "because, when you're lashing, you've got a bucket truck driver and the guy pulling the lasher. Then, you've got to stop and bug it off at every pole, and you're always fiddling with the lasher, keeping it going, and you take a chance on wrecking the other cable that's up there."

Makes crossings easier

And, according to McDaniel in Bensalem, MOD can eliminate the need for splices at bridges, water crossings or highway crossings. "It's a continuous pull. I've got a couple of pulls out there that are a mile or mile and a half continuous. I've crossed water. I've crossed turnpikes without creating any interruptions."

Fiber routes can be in high traffic areas on main roads. At some times of the day it may not be practical to have a lane of traffic blocked off for long periods. Hanging conduit will reduce this time factor during the build and future maintenance. "What it does is you, physically, have the duct on a bucket truck and you're off-loading the duct right to the pole. So you don't have to pull out all the slack and then go back and pull out all the glass and then go back and pull in the fiber. You, physically, have made three passes through the same area," McDaniel observes. "What you do with the duct is pass through there once and hang it all up and then pick a point where there's limited traffic and set up your pull right there and it pulls right down through the whole congested area.

"Being in the metro-Philadelphia area," says McDaniel, "it's very mobile here and that was definitely taken into consideration."

According to Lumley, however, "These long continuous pulls may be good situations to order the duct with the cable pre-installed. The reels will be bigger," Lumley adds, "but if you can access a reel trailer temporarily, you could eliminate the need to pull cable completely."

Offering of protection

Of course, by being surrounded by duct, fiber cable gains significant environmental protection. But cable operators may benefit in other ways, according to McDaniel. "It does several things. It's a great maintenance advantage. It provides additional protection to your fiber. And we borrowed some test data from AT&T about the effects of expansion and contraction of fiber and it takes that away. It's there on its own and is not controlled by anything else."

In the short term, the costs of building fiber using aerial conduit is slightly more than strand mounting. One system manager reported that a single in-house person in a bucket truck can pull 10,000 feet of fiber in two hours through conduit at four points at an estimated cost of $90 with near zero risk of damage to fiber. And the amount of delashing and relashing of fiber is reduced or eliminated, thus reducing labor costs and excessive handling of fiber cable.

And cable is protected from damage caused by climbing equipment used on a daily basis by cable and utility personnel. "If you are going to have damage," McDaniel points out, "it's going to be at the poles where somebody is gaffing up the pole or throwing ladders up there. With the cable in the duct, you're protected against that."

Exposed fiber cable looks just like half-inch jacketed metal cable on the outside jacket. But aerial conduit is unmistakable and will possibly eliminate cutting by in-house personnel and contractors mistaking it for metal cable. There is also less chance of damage to cable from power lines which can burn through existing strand and cable.

Longer runs of fiber can be deployed with fewer splices per mile. This is true for new fiber and replacement fiber in a rebuild. With a rebuild, the old fiber can be removed with less damage and be reused elsewhere. Defective fiber or fiber damaged during shipment, which may not be apparent until after deployment, could be changed out with a minimum of downtime if aerial conduit was originally used in construction.

Later, other cable can be lashed externally to this conduit. That's something McDaniel already has in mind. "I'm laying out a project now where we are going to overlash the trunk right onto this figure-eight duct," he says.

Artz agrees that there are specific situations where he could use previously hung messenger-on-duct as strand. "In our Lanett, Alabama system, we have a particularly difficult intersection crossing to do with fiber. We've talked previously about using this product on interstate crossings, etc. for the obvious reason that if you have to pull the slack around, you can pull it through the duct and you don't have to worry about traffic control or timing or anything. So, we've decided to put up the duct and overlash the coax crossing to it—just treating the figure-eight as the messenger."

More than a winch

The winch used to hang the product and pull the cable through has been improved. In a number of builds (including Bensalem and Turlock), Sammons is deploying a newly designed capstan winch developed by John Pickrell of Duct Plus Industries (DPI).

The capstan winch was redesigned to automate a number of the functions that are traditionally performed manually. The use of the capstan winch dates back to the Egyptians. It's always involved a rotating drum around which a pull line is wound. But in order to make a capstan winch move that rope, some back tension has to be put on the pull line, Pickrell explains.

In the communications industry, using a winch is a labor-intensive operation. While one worker is keeping tension on the winch line, another is handling an accumulation of excess cable or rope and a third is pouring lubrication onto cable as it is fed into conduit.

DPI's winch design not only reduced its operation to a single person, but other benefits were discovered as well, says Pickrell. "One, we have a tool that can operate at 2,000 pounds force, so it's a more versatile tool than just being a fiber optic winch. It can be used for pulling multiple trunk coax cable or copper cable if somebody does crossover work.

Also, there's self-supporting fiber optic cable called 'free span' used up in the electric spaces of the pole where induced voltages are a problem. Those cables can see more than the standard 600-pound pulling force normal for fiber optic cable."

DPI also developed a unique method for sensing the tension in the cable or winch line. Instead of monitoring just the hydraulic pressure used to rotate the capstan and interpolate the pull force, the new method brings the cable around a pull sensing device that measures the tension in the line. That information is used to control the transmission output from the winch—it will override the speed setting and take the winch back to neutral in the event that the tension gets too high.

"The Bensalem project is a case where a self-supporting duct, which has high working strength, was able to be winched into place with our winch. So, the contractor was able to use our tool for winching in the aerial duct and then turn around and use the same product for winching the fiber optic cable," Pickrell points out.

It seems Sammons' corporate construction experts have found yet another technique and product to help do a big job right the first time, provide flexibility and benefits over the long haul at minimal incremental short-term expense.

Building quality

"The quality of the system you build is the quality of the system you develop for the customer," says McDaniel. "If you can create and keep building a better plant, you're just that much ahead of everybody else in the industry." CED

Harmonic Lightwaves

Laser transmitters

C-COR ELECTRONICS INC

By Emmanuel Vella,
Marketing Communications,
Harmonic Lightwaves

YAG: A better platform for cable TV

As cable networks grow in physical size, bandwidth and number of subscribers, operators constantly seek transmission systems with increased signal power, capacity and reliability. This search led to the industry's deployment of first-generation fiber systems, which adapted DFB (distributed feedback) lasers, designed originally for digital telecom applications, to the service of multichannel analog video.

In the subsequent years, as cable operators look to existing fiber technology for increased power, capacity and signal quality—and frankly, for better day-to-day operability—it is becoming increasingly evident that DFB lasers are nearing or have reached the upper limits of their power and linearity performance. Increasing the power beyond this point may compromise system reliability.

In contrast, we are at the beginning of the power and linearity curve with YAG technology. YAG systems are a "clean sheet of paper," a laser technology with a number of distinct advantages for cable operators, which eliminate many of the compromises inherent in first-generation systems.

In late 1991, Harmonic Lightwaves introduced a new generation of fiber technology, designed specifically for multichannel video transmission, based on externally modulated YAG (Yttrium Aluminum Garnet) solid state lasers. The YAGLink system (see Figure 1) consists of a transmitter, receiver and network management system.

The transmitter employs an ultra reliable YAG laser and a lithium niobate modulator. The modulator is linearized by predistorting the electrical RF input. These two significant developments work in conjunction with the benefits of the YAG

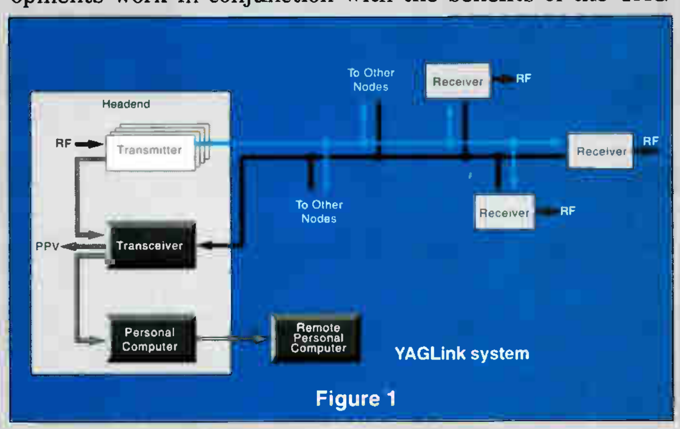

Figure 1

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

DFBs are laser of choice

Currently, cable operators are confronted with a wide variety of choices when considering either a rebuild or an upgrade of a CATV system. Within the field of AM fiber optics there are primarily two technologies which are being implemented in CATV applications: direct modulation using a standard distributed feedback laser and external modulation using a high-power, YAG laser and an external modulator.

This article examines the trade-offs between the DFB- and YAG-based fiber systems. Included are tables and charts in support of the argument in favor of a DFB-based system.

Analysis

With the introduction of AM fiber optic transmission systems, it is important to understand the various trade-offs between technologies and to identify the applications where a DFB- or YAG-based system would have an obvious relative advantage. Before discussing specific applications for the two types of AM fiber systems, it is helpful to review some of the basics of each technology.

Table 1 lists four principle features that cable operators typically consider when evaluating AM fiber links. The broad classification of features are: performance, the ability to segment a CATV system (narrowcasting), system reach and cost.

System reach refers to the ability of a given fiber system to

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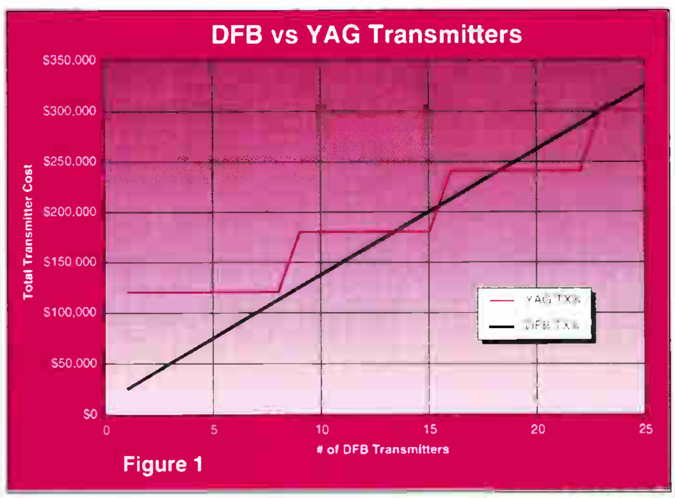

Figure 1

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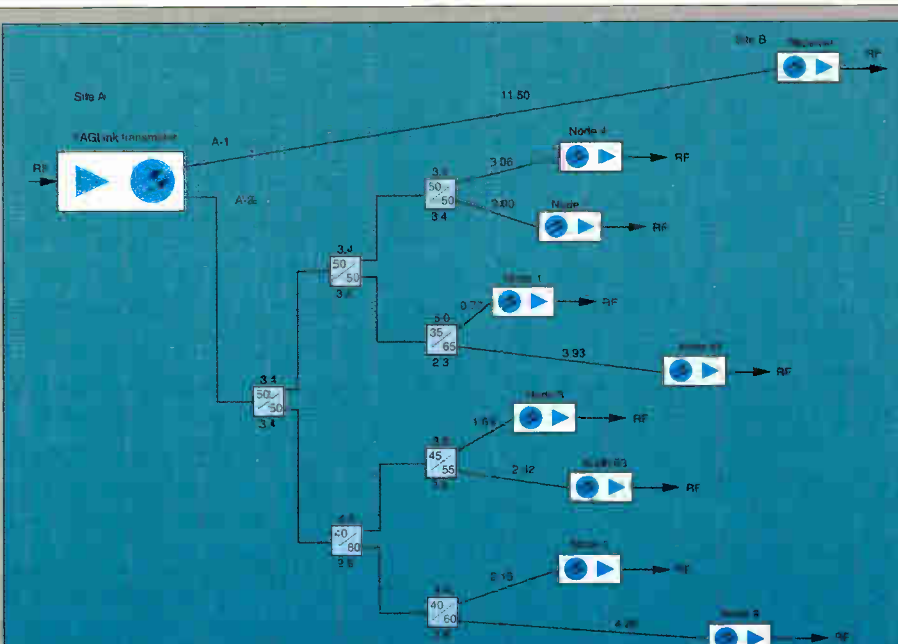

Architecture flexibility with YAGLink system

Figure 2

source, resulting in the highest quality fiber video system available today.

The main purpose of this discussion is to present a case for a generic YAG laser-based system. The reader will be notified where a YAGLink-specific benefit is used.

Power issues

The first YAGLink transmitters generated two outputs with 8 mW to 10 mW of power each. YAGLinks presently shipping provide two outputs with 13 mW each with CTB and CSO distortions of less than -67 dBc and -70 dBc respectively.

The YAGLink employs a YAG crystal (passive component) pumped by a broad area high power quantum well laser diode. The laser diode operates much below its maximum rated power. Therefore, output power can be increased without affecting performance, such as noise and distortion and without compromising reliability.

In contrast, DFB laser's emitting area is 50 to 100 times smaller than YAG pump lasers. Power density of a YAG pump laser is much lower than that of a DFB laser. The YAG provides significant reliability and operability benefits. These are important points to remember when making output power comparisons.

Another power-related benefit is Harmonic's narrow, yet multi-mode YAG laser. As a DFB laser's output power level increases, its single line spectral characteristic causes the onset of SBS (Stimulated Brillouin Scattering), or fiber-generated back refelection. These "back-reflections" degrade noise and distortion performance of DFB laser-based transmitters. A properly designed YAG system is optically isolated from back-reflections, and its multimode spectral characteristic makes the SBS threshold much higher than that of DFBs, thus affording operation at very high power levels.

Performance criteria

Beyond sheer power, another key YAG benefit is the ultra low noise and spectral stability of light output. The physical characteristics of the YAG material itself "filter" the noise of the pump, making an excellent lightwave carrier for external modulation.

External modulation is a dramatic technological advance that brings significant signal quality and day-to-day operability benefits. External modulation allows the "decoupling" of light generation and modulation functions, which provides the flexibility to optimize both the qualities of the light source and the modulator's output for multichannel video applications.

The YAGLink system expands on the basic benefits of external modulation with a sophisticated set of closed-loop controls to handle CSO and CTB distortions. Advanced microprocessing techniques control the modulator bias point setting, virtually eliminating CSO. Other

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circuitry adjusts and predistorts the RF signal input to the modulator.

Predistortion assures that a clean and linear signal leaves the headend and eliminates the need for complex, labor-intensive installation procedures.

Installation and operation

YAG's power and signal quality are also more flexible in meeting real-world operating challenges, which should be considered when estimating the true cost of implementing and operating a fiber network.

With all system operating parameters under microprocessor control, a YAGLink system takes just minutes to install. Perhaps the best benefit is that transmitters do not have to be "hand-picked" to match the characteristics of a particular link or loss budget—they are interchangeable. A typical YAGLink system can also be shipped from the factory via standard delivery services, without an accompaniment of technicians carrying set-up and test equipment.

From an architectural standpoint, YAGLinks lend unequaled flexibility (see Figure 2). Adequate power and optical isolation permit the use of standard optical connectors. Predistortion eliminates sensitivity to link length, number of splits or receiver placement. Sophisticated AGC circuits in both the transmitter and the receiver also allow the operator to adjust the optical output levels and RF to exactly what is needed and assure consistently stable operation through the life of the system.

Application

For long fiber reaches, YAG systems are in a class of their own. Many of the first YAGLink systems have been used to consolidate headends, feed remote hubs and handle other supertrunking applications. Yet, it is hardly limited to these applications. In fact, we have found that as operators look at their system architectures and signal quality requirements, they have yet to find a situation that can't be—on a dol-

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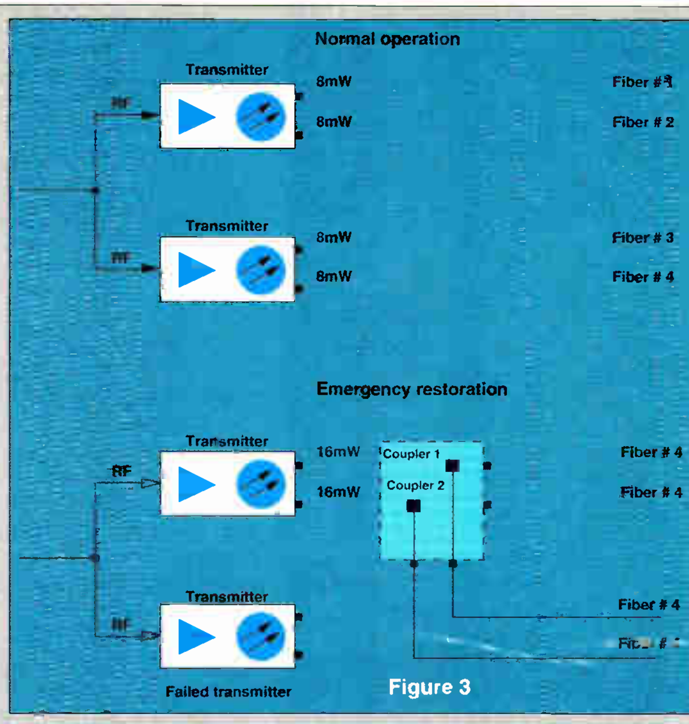
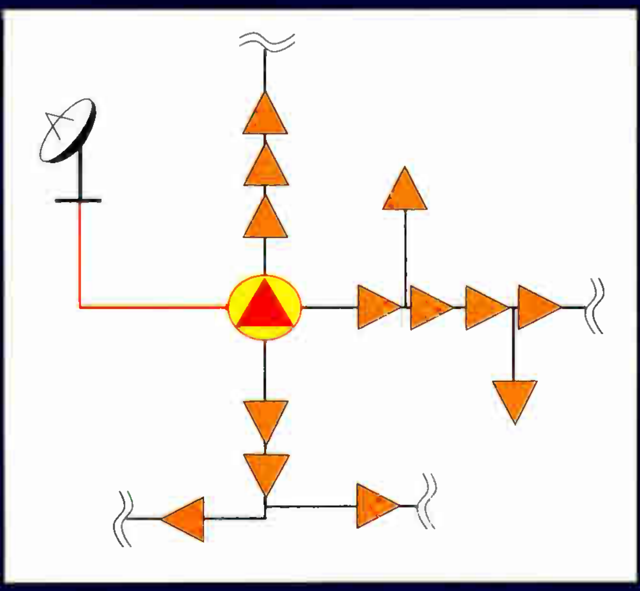


Figure 3

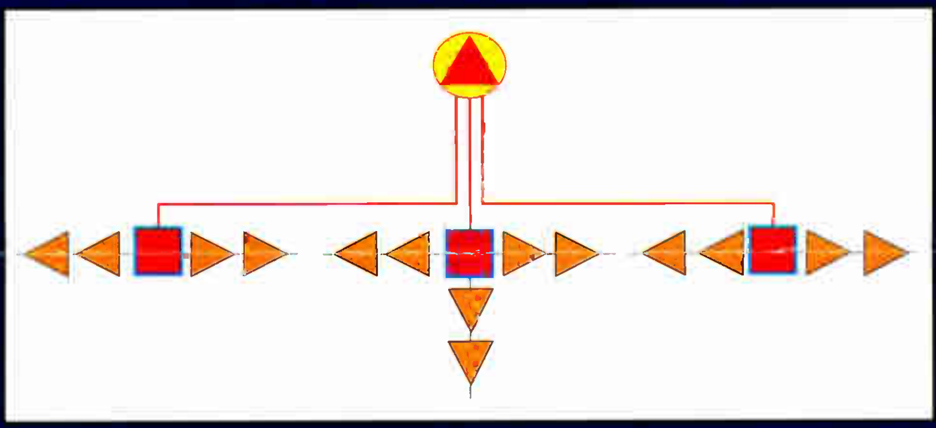
The Evo

Fundamental fiber optic topologies for CATV



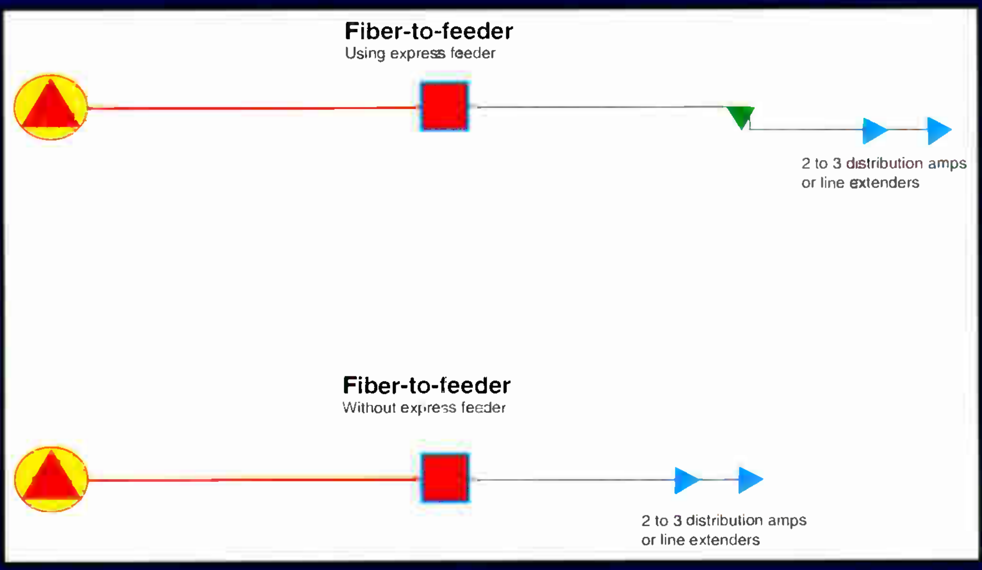
Supertrunks

Transport high-quality video signals on a point-to-point basis. Examples include interconnects between remote antennas and headends, headend interconnects for program sharing and multiple system interconnects for advertising insertion. Also could be used to provide route diversity for data delivery, personal communications, alternate access, etc.



Fiber backbone

Used primarily to reduce length of broadband amplifier cascades to improve carrier-to-noise ratio and distortion performance while reducing network maintenance. Designed for system upgrades and rebuilds to higher bandwidths. Defined by ATC as having fewer than four amplifiers in cascade on any trunk run.



Fiber to the Feeder

Originally designed for complete system rebuilds, now used increasingly in upgrades. Replaces nearly all coaxial trunk cable with fiber cable. Reduces amplifier cascades to no more than three active devices. Coaxial "express" feeder serves area immediately adjacent to headend and optical receivers. Concept originally termed Fiber Trunk and Feeder by ATC engineers. Also known as All Fiber Trunk and Fiber to the Bridger.

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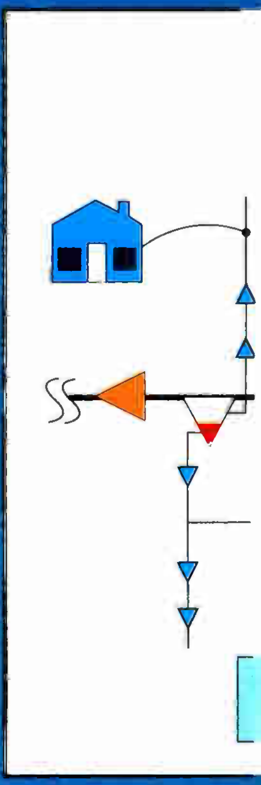

Scientific-Atla

The Forward Interm
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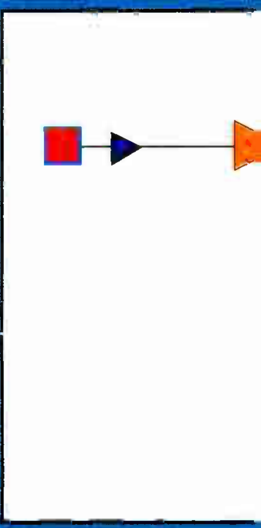

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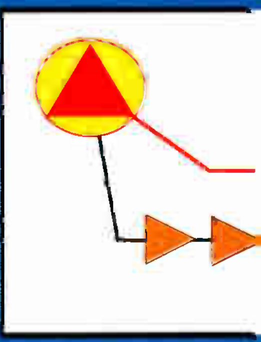

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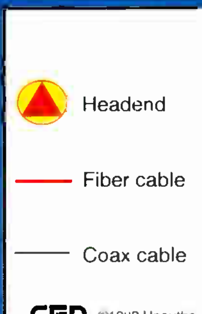

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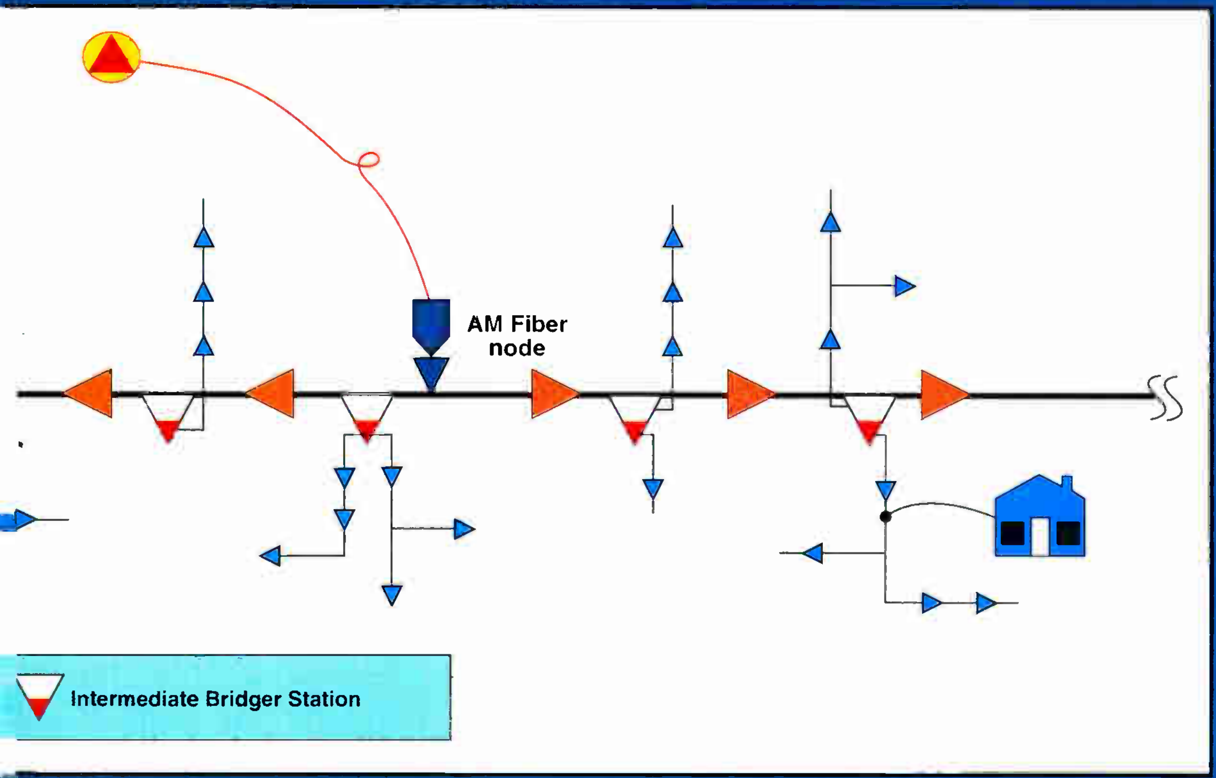
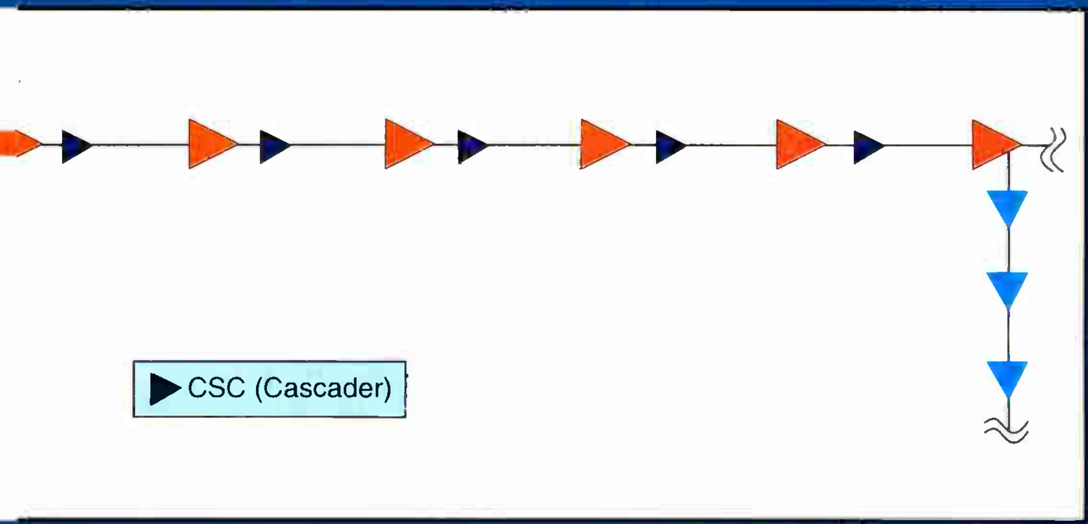


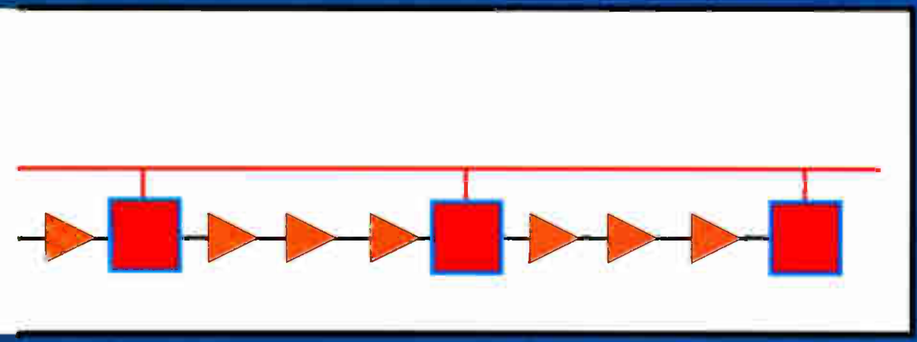
nta's FITT

diate/Terminating Trunk topology is similar to the fiber backbone concept. The approach provides 50 MHz capacity. Existing trunk locations are converted to FITT stations with dual output parallel tem or distribution amplifiers are placed between FITT/bridger stations to provide forward signal



unications' Distributed Gain Network

d of maintaining existing trunk/bridger locations in overspaced situations. The concept s the need to upgrade cable and the time needed to upgrade the system. The topology AN and FBB.



ble's Cable Area Network

ngineers to leave coaxial trunk in place as redundant signal path for new Coaxial route serves as back-up in the event of a fiber outage. A/B switch using senses loss of signal on fiber, switches to coax input and triggers arm.

Phil

Topol devic syste

Legend

- Fiber node
- Bridger
- Cluster tap (64 port)
- Secondary hub
- Line extender
- 8 port tap
- Trunk or distribution amp
- Splitter
- Standard tap

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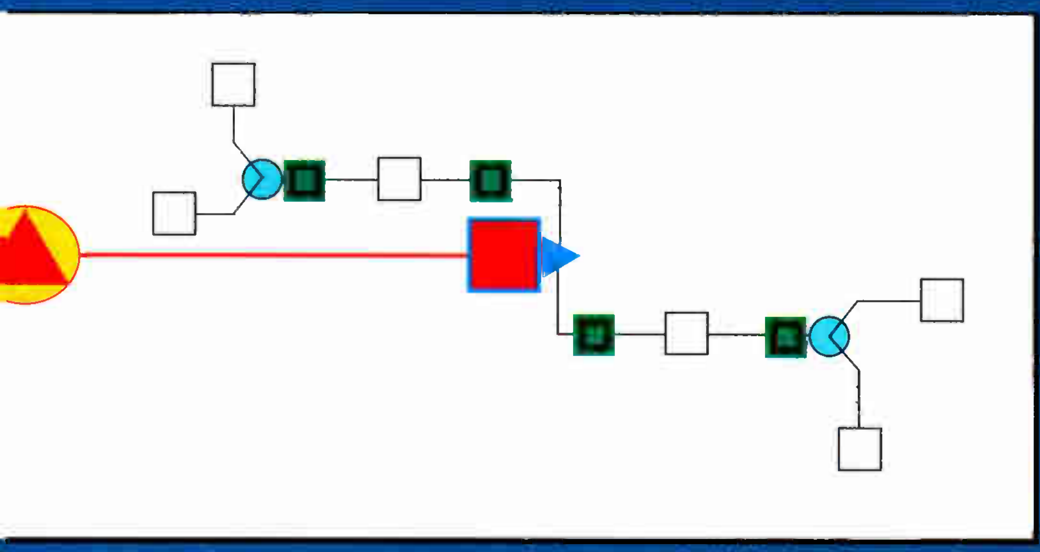
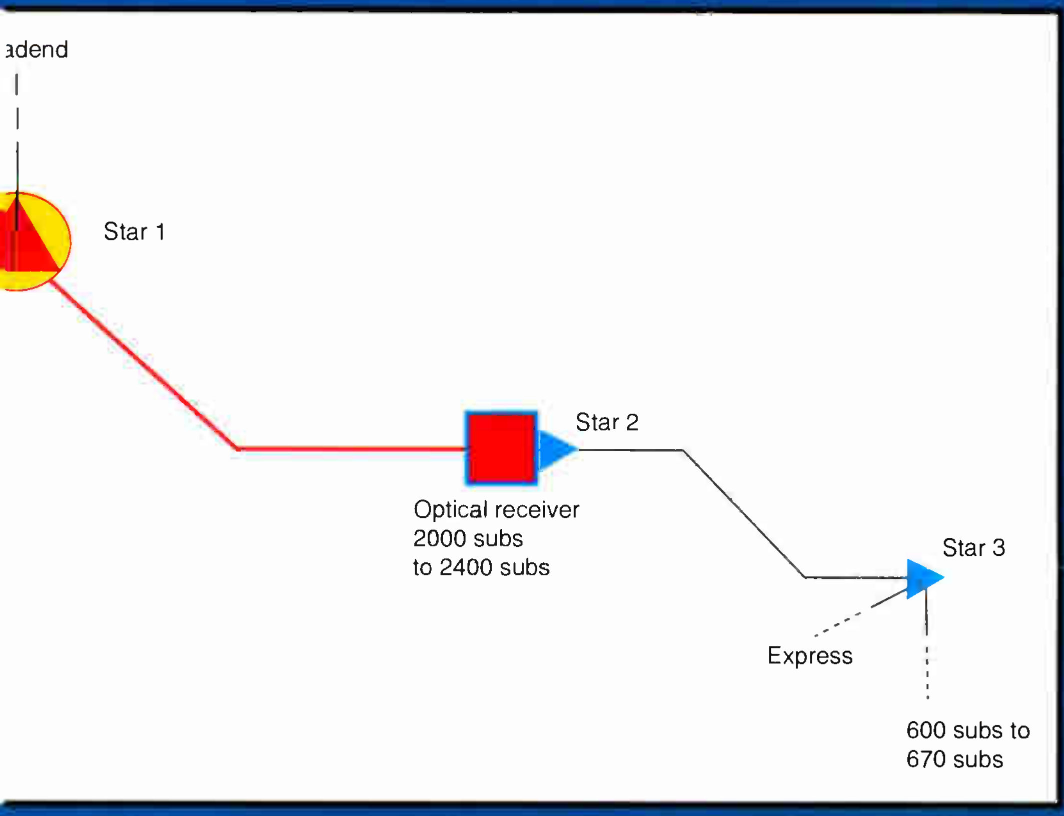


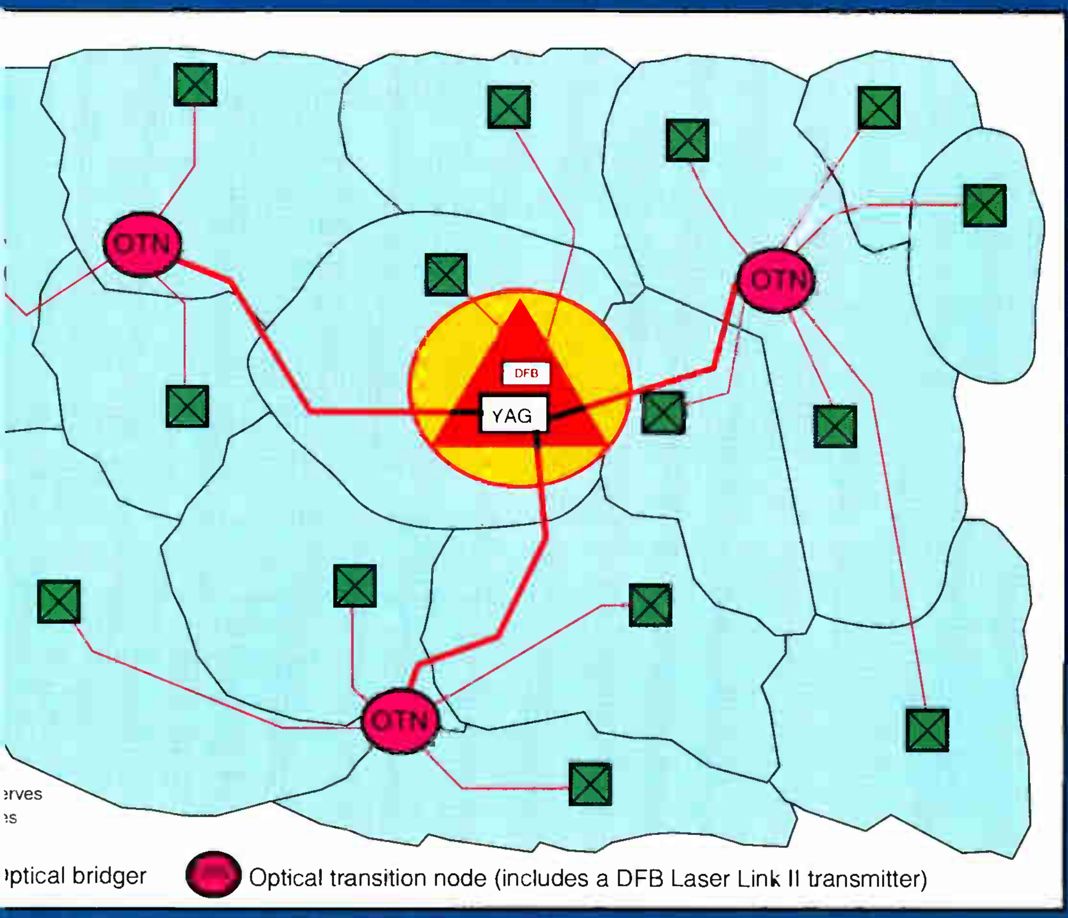
lps Broadband Networks' Diamond

ogy specifically designed for high density, urban areas. Utilizes just one active e between fiber receiver and subscriber. Optimized for expanding existing 550 MHz ms to 1 GHz. Also applicable for 750-MHz system expansions.



Scientific-Atlanta's Fiber to the Serving Area

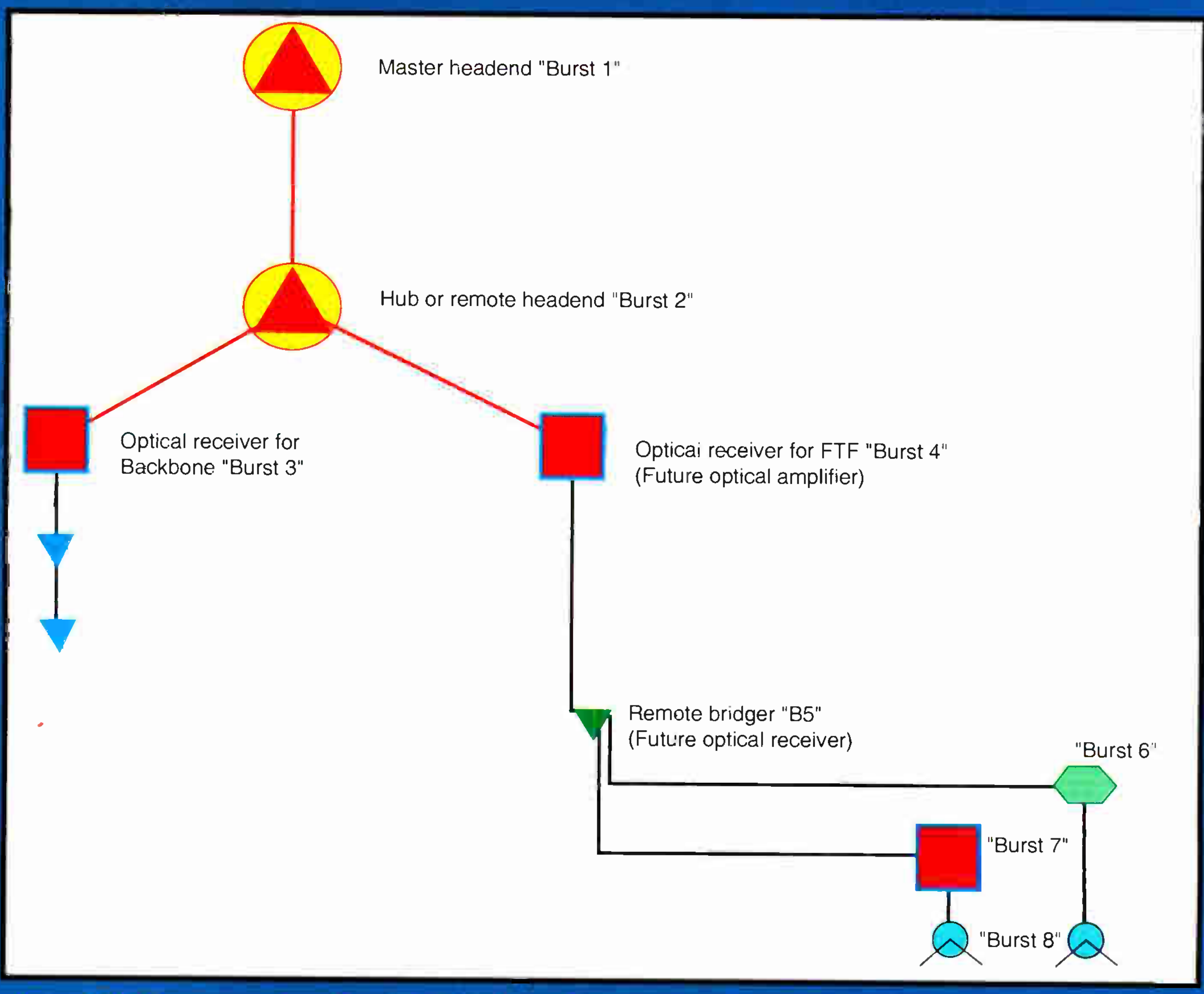
A design concept that enlarges the area serviced by fiber optics by utilizing "express" or untapped feeder lines. Encompasses both FTF and backbone basic topologies.



ONI's Star-Star-Bus 500

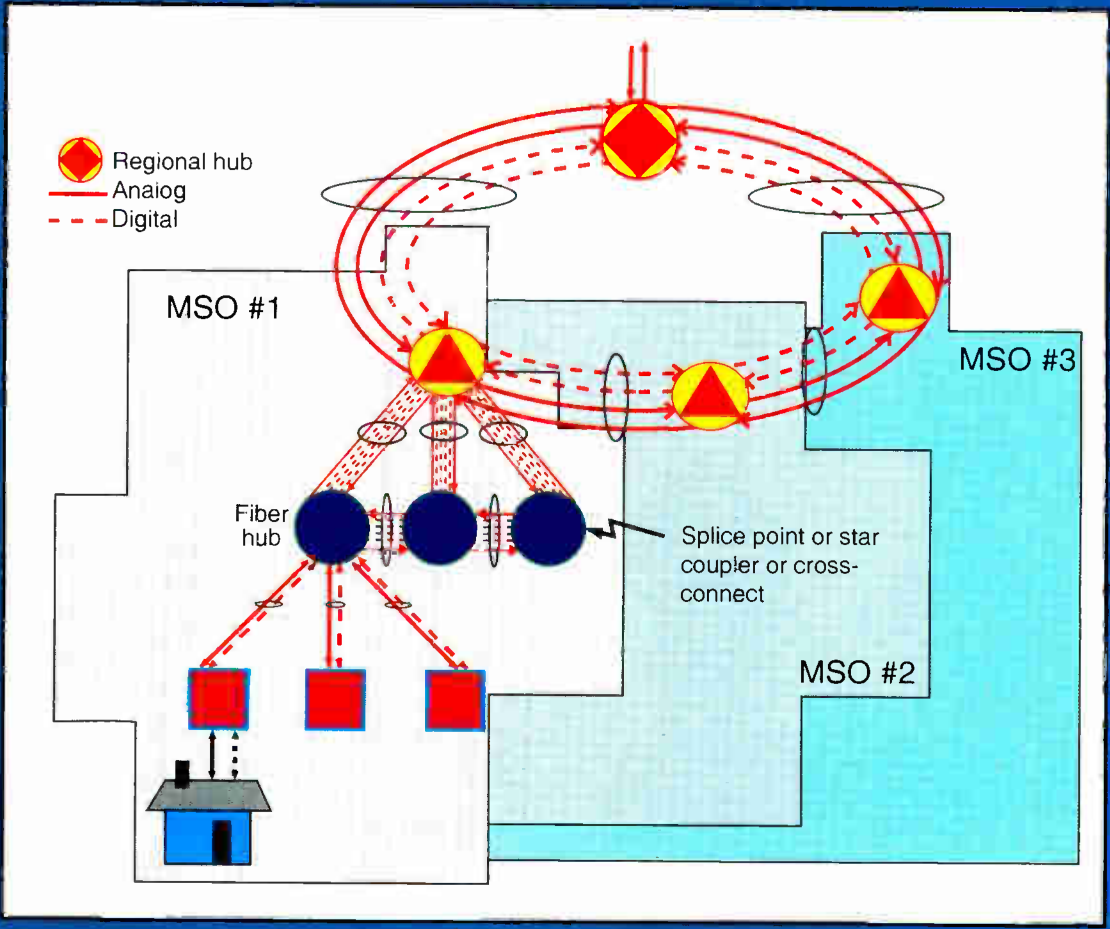
Developed by Optical Netw International as a way to co effectively serve nodes fee no more than 500 homes. M effective when utilized duri full rebuild or upgrades whe cable reclamation is the onl limitation. Combines the benefits of high-power Nd:Y and low-cost DFB transmitt to reduce number of subscribers served per nod Nd:YAG feeds Optical Transition Node, which feed DFB devices. Design calls f subscribers to be located n more than two active device from optical bridger.

ustomer



Jerrold Communications' Starburst

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



CableLabs' structured network architecture

Designed by Cable Television Laboratories to accommodate a variety of network concepts to avoid making any existing networks obsolete while providing incremental upgrade path. Topology includes centralized "regional hub" to share the cost of advanced television and communication equipment among several operators as well as secondary fiber hubs. Connections between central headend and fiber hubs, as well as hub-to-hub interconnects, provide "virtual" ring capability and route diversity. Passive coaxial distribution to the home (made possible with in-home amplification) improves reliability of network.

lar-per-milliwatt basis—cost-effectively met with a YAGLink system.

This is especially true as fiber carries larger numbers of channels deeper into the network. With the qualities of its YAG light source, complemented by the effectiveness of its modulation and linearization schemes and the sensitivity of its receivers, YAGLink systems have the unparalleled ability to place a high-quality signal at any point in the network, whether it is 30 km away or a pocket as small as 250 homes, or any combination of both.

This leads to one of the most significant theoretical objections to YAG systems—narrowcasting—or the ability to deliver different channel/service packages to small pockets of subscribers. There are several schools of thought regarding the best way to implement narrowcasting. However, Harmonic Lightwaves has found that operators are fairly consistent in their opinions: until issues regarding compression are clarified, no decisions regarding narrowcasting technology are being made.

As it stands, operators who have purchased YAGLink systems feel that the better strategic decision is one that assures a clean, quiet, powerful, flexible, high-capacity signal to support the delivery of custom-configured packages as the market demands.

Another common objection to YAG-based systems is the cost of spare transmitters. This is essentially a vendor-specific issue, so it will be addressed exclusively in terms of YAGLink system features and benefits.

Under the valid assumption that most, if not all, headends have more than one transmitter installed, the features of the YAGLink transmitter provides outstanding backup capabilities without the need for an idle spare.

The YAGLink transmitter provides microprocessor-based controls to allow the operator to adjust the optical power on the two outputs. In most YAGLink applications, operators will find that full system power is not required and will turn the output power down accordingly.

In a typical network with different transmitters feeding different portions of the network (see Figure 3), a failed transmitter can be backed up by connecting the output from another transmitter to a simple splitter arrangement and then to the fiber(s) served by the failed transmitter. By temporarily increasing the output power, a signal with adequate quality is available until a replacement transmitter can be installed. And since YAGLinks do not require hand-picking for specific architectures, a replacement can be shipped from the factory within hours and installed in a matter of minutes.

Cost

As with any capital equipment purchase, a valid cost analysis depends both on the specific application and a true accounting for all costs of ownership that are involved, not just the purchase price. Therefore, without a specific system architecture, it is not valid to generate a break-even analysis on a per-mile basis, on a laser-to-laser ratio or on any basis except for the one that fits the specific system.

What can be claimed is that, on a cost-per-milliwatt basis, YAG-based systems are less expensive than those that use DFBs. Yet that isn't the final word because factors such as the network's architecture and channel capacity have to be considered, as well as the operator's needs for end-of-line performance, the costs for installation, and the costs for ancillary equipment, maintenance and many others.

Customers who have purchased YAGLink systems seem to share a common perspective toward their decision. They say their main objective is to get their infrastructure "right," to be sure that the system they install today enables them to meet the multitude of competitive challenges in the future.

These operators have compared the switch to the YAGLink product to the switch from discrete to hybrid components in coax amplifiers. With YAGLink, they no longer have to rely on vendors to design and optimize their system.

Conclusion

In a snapshot view of time, with highly-specific details and qualifications, it is possible to work costs to make YAG-based systems look attractive only in larger systems, or only in large-volume point-to-point applications. Yet the fact remains that as output power and manufacturing volume ramp up, pricing, as well as total cost of ownership, is certain to become more competitive.

The true decision lies in the platform the cable industry wishes to build for the next 20 to 30 years. Do we want to base our business on a technology adapted to our application or one developed specifically for it? CED

Continued from page 48

deliver a given number of television channels, over a certain amount of fiber loss, with a particular end-of-line performance. When comparing the YAG system with its four 10-mW outputs with the present DFB system, capable of a single 5-mW to 6-mW output, it seems logical that the YAG-based system either provides better performance over the same loss budget or, the YAG system delivers equal end-of-line performance over longer fiber links. However, as with most technology options, the apparent advantages of the YAG based system are not "free."

Early DFB system were at a performance disadvantage relative to the theoretical limits of a YAG system using an external modulator. However, as AM fiber has matured as a product within the CATV industry, the performance of DFB systems has improved dramatically. When comparing a DFB system with an externally modulated AM system using identical loss budgets and channel loading, there is virtually no difference in performance between the two. A typical performance chart for both types of systems can be found below:

The second issue to consider when evaluating the trade-offs between a DFB and a YAG system is focused on future CATV programming capabilities. System segmentation refers to the ability to deliver specific channels or groups of channels to a specific segment of a CATV system. This is also known as "narrowcasting."

As CATV systems evolve, it is envisioned that operators will become niche providers of voice, video and data services. AM fiber optic transmitter/receiver pairs will initially serve 2,000 subscribers with a target serving area of 500 subscribers. In an attempt to make this vision a reality, operators are examining ways to economically reduce the number of subscribers being served from any one AM receive site.

By definition, YAG-based systems employ a very high power laser source which may be optically coupled to serve many different optical receivers. The principle of serving many receivers from a single transmitter runs counter to the objective of subdividing a CATV systems into many different "cells."

DFB technology allows for a more graceful transition for the cable operators from the reality today, which is essentially a one-way transmission system delivering video services, to the vision of tomorrow which is a two-way transmission system which is capable of delivering a wide range of integrated services.

The third product feature that operators consider is link loss, sometimes referred to as system "reach." Current DFB systems are capable of transmitting a group of signals over approximately 12 dB of fiber (roughly 18 miles) before reaching receiver sensitivity threshold. However, present YAG systems, because of their higher output power, can transmit an identical package of channels over 15 dB to 17 dB of fiber (roughly 25 miles) with slightly reduced C/N performance.

As indicated above, fiber is deployed in CATV systems to improve reliability and position cable operators for the future by segmenting their systems. The high power transmitters that the YAG systems utilize directly contradicts these objectives. The large power available with the YAG systems does allow for extended reach relative to DFB systems, however, this comes at the cost of serving more subscribers with a single transmitter and less system flexibility with respect to system segmentation.

Cost issues

The final product feature that operators consider when deciding on an AM

	6 mW DFB System	Externally Modulated System
Loss budget	10 dB	10 dB
# of channels	80	80
CNR (dB)	51	52
CSO (dB)	-62	-65
CTB (dB)	-66	-65

Figure 2

fiber system is system cost. Today, most DFB systems carry a list price of between $11,000 and $13,000. In DFB systems, fully 80 percent of a system link price is contained in the transmit electronics.

By comparison, most YAG-based systems have a list price of between $45,000 and $60,000. In most YAG systems, the transmit electronics account for close to 90 percent of the system link cost. In addition to an expensive, high-power laser transmitter, the YAG systems add an expensive external modulator. From purely an inventory perspective, it is much less costly to "spare" a DFB transmitter as opposed to a YAG transmitter.

A cost analysis comparing the difference between a YAG- and a DFB-based system is found in Table 2. Implicit in this analysis is a splitter efficiency of 90 percent. The DFB laser in this example is a 5-mW device with an end user price of $12,500. The YAG laser in this example is a 10-mW device with an end user price of $60,000. This analysis assumes that a particular system will need to purchase 10 DFB transmitters to achieve the desired performance and cascade reduction objectives.

As indicated in this table, one YAG device could match the optical power distribution of seven DFB devices. As you move down the table, adding DFB transmitters, you would also need to add YAG transmitters to achieve similar results. The relationship between the number of DFB transmitters and YAG transmitters follows a "step" function. The cost model in Table 2 assumes that the operator desired to maintain one spare transmitter regardless of system technology.

DFB vs. YAG Transmitters

Selection Criteria

Performance	DFB	YAG
System Segmentation	✓	
System Reach		✓
System Cost		

Figure 3

DFB vs. YAG Transmitters

Cost Analysis of Laser Types

DFB		YAG	
Cost	$12,500	Cost	$60,000
Power	5 mW	Power	10 mW
Number of Ports	1	Number of Ports	4
Splitter Efficiency	.90		

DFB 5.0 mW	Cost w/Spare	YAG 10.0 mW	Cost w/Spare	Delta
1	$ 25,000	1	$ 120,000	$ 95,000
2	$ 37,500	1	$ 120,000	$ 82,500
3	$ 50,000	1	$ 120,000	$ 70,000
4	$ 62,500	1	$ 120,000	$ 57,500
5	$ 75,000	1	$ 120,000	$ 45,000
6	$ 87,500	1	$ 120,000	$ 32,500
7	$ 100,000	1	$ 180,000	$ 20,000
8	$ 112,500	2	$ 180,000	$ 67,500
9	$ 125,000	2		$ 55,000

Figure 4

As indicated in this table, the DFB system cost is in all cases lower than the system cost of the YAG-based system.

Figure 1 expands the analysis to determine the break-even point. Assuming one spare transmitter of either technology, a cable operator would have to deploy more than 18 DFBs to realize a cost savings with a YAG-based system option. If we assume an average node coverage of 15 miles, and a transmitter to receiver ratio of 1-to-2.5, the net result is that YAG-based systems will generally be a viable option (in terms of cost effectiveness) only in systems which operate more than 675 miles of plant.

Conclusion

DFB lasers are field-proven devices that when packaged with the transmit electronics results in an end-user price of approximately $12,000. Current power capability of a DFB transmitter is an output of between 4 mW to 6 mW. Within the next 12 months, output power of DFB lasers are projected to exceed 10 mW. In contrast, YAG-based systems use a relatively expensive laser coupled with an unproven external modulator. The net result is a transmitter that cost as much as four to six times the price of a DFB transmitter, and long-term performance that is difficult to predict.

Barring a technological breakthrough in either direct or externally modulated fiber optic devices, it is obvious that in the near-term the YAG-based systems will primarily be deployed in point-to-point applications. If a cable operator desires to transport a large block of television channels over a long distance with reasonably high end-of-line performance, the optimum solution could be the YAG-based system. However, if a cable operator is deploying fiber to minimize amplifier cascades and build a network that can evolve in terms of future services and users, then in most cases, the optimum solution is a DFB-based system. CED

Are we asking the right question?

Whether to use a directly modulated laser or an externally modulated laser is not a particularly relevant issue here—both approaches have their own merits, and in many instances, combining an externally modulated laser with a DFB is an optimal solution. As a matter of fact, a fully flexible hybrid approach that incorporates the best in technological advances may use both types of lasers and offer the best efficiencies.

The combination of high output power and low distortion performance of an externally modulated laser facilitates cascades with the less costly DFB product. This has both performance and link cost advantages in some cases. The question we should address is "How do we best use the available technology to build optimal networks for cable television?"

Using both technologies

The recently developed Star-Star-Bus 500, which allows fiber to be driven deep into the cable plant, is one example of an application that may use both technologies. An externally modulated laser transmits to an intermediate point where the signal is then fed to a number of directly modulated lasers that continue the optical transmission to 500-home areas. This enables an operator to reduce node sizes, position cable plant for future opportunities and reduce link cost.

Another example is AM supertrunking. Suburban Cablevision in East Orange, N.J. recently used externally modulated lasers to eliminate a dual DFB laser configuration. By using the externally modulated laser, Suburban was able to improve noise performance. The DFBs were then placed in the field to shorten amplifier cascades. This type of network design improved the picture quality and reliability while using available equipment.

Although there are some applications (long distance AM supertrunking) where external modulation has strong advantages over DFBs, this does not displace the DFB as a key component in system design and engineering; nor is it optimal to always use external modulation in the network design.

Either/or comparisons of the two technologies are of questionable value. If the cable industry divides into two camps on laser technologies, we will limit ourselves in the way we deploy technology. Instead, we should use available technology to complement cable's objectives, thereby using all resources to build a cost-effective infrastructure that prepares us for competition in the future. CED

By Andy Paff, President, Optical Networks International

1550-nm systems promise reduced costs

Shared distribution architectures are key

New cable TV distribution architectures using 1550-nanometer (nm) technology can offer a cost per link potentially three times lower than traditional 1310-nm approaches.

These savings are achieved through reduced requirements for equipment made possible by optical fiber's better attenuation performance in the 1550-nm region combined with erbium-doped fiber optic amplifiers. As a result, these systems produce enough optical power to allow laser output to be divided among multiple nodes, reducing the hardware investment per link or node.

Transmission at 1550 nm also can be used to increase both reach and flexibility in fiber supertrunking applications. Because of lower attenuation, unregenerated optical signals travel almost twice as far in this longer-wavelength region. And with the addition of optical amplifiers, 1550-nm systems can offer very long trunk lengths with negligible loss of quality.

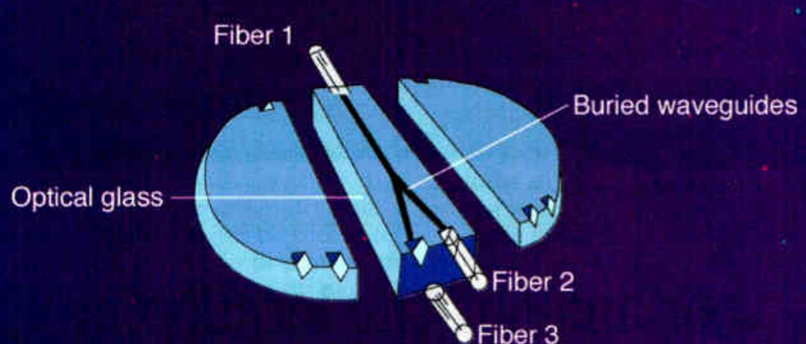
Recent developments in 1550-nm transmission technology that support these approaches are overcoming many of the limitations that previously restricted fiber's use in cable TV applications.

As equipment and components designed to operate in this region become available and proven under field conditions, cable TV operators can look forward to taking far greater advantage of the technical benefits of optical fiber transmission.

This article examines realistic scenarios for the deployment of 1550-nm systems using advanced passive components, optical amplifiers and high-performance fiber. It also will provide a cost analysis to contrast 1550-nm shared distribution architectures with traditional 1310-nm tree-and-branch systems.

By Curt Weinstein, Senior Sales Engineer, Opto-Electronics Group, Corning Incorporated

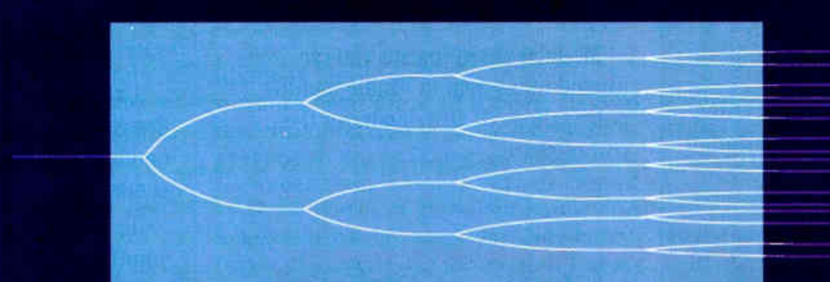
Planar coupler manufacturing process



In planar processing, the glass substrate containing optical waveguides is diced, equipped with fiber leads and packaged.

Figure 1

Planar monolithic 1x16 optical circuit pattern



High-port-count planar couplers are produced through passive integration of identical Y-junctions on a small glass chip

Figure 2

Progress in 1550-nm design

Fiber optic networks based on 1550-nm technology are viable today because of recent breakthroughs in engineering and manufacturing. As a result of the availability of new 1550-nm hardware, an evolution is occurring from traditional coax-based configurations—with fiber used primarily for supertrunking—to new fiber-intensive distribution architectures that allow much deeper penetration of fiber closer to the home.

Fiber's superior optical transmission in the 1550 nm region, with attenuation nearly 40 percent less than 1310 nm, supplies the basic operating advantage that is fueling the development of 1550 nm AM cable television systems. The recent breakthroughs in competitively priced linear distributed feedback (DFB) lasers and receivers with increased responsivity at 1550 nm have made the deployment of these systems a highly attractive option.

Supporting the growth of 1550-nm technology, erbium-doped fiber optic amplifiers (EDFAs) could virtually eliminate concerns about optical budgeting. High-performance couplers in multiple-

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port-count configurations provide significant system cost reductions by optimizing the value of expensive laser transmitters.

In addition to dispersion-shifted fiber, with minimum dispersion at 1550 nm, a variety of compensation techniques now are available to minimize the effects of dispersion on AM video signals.

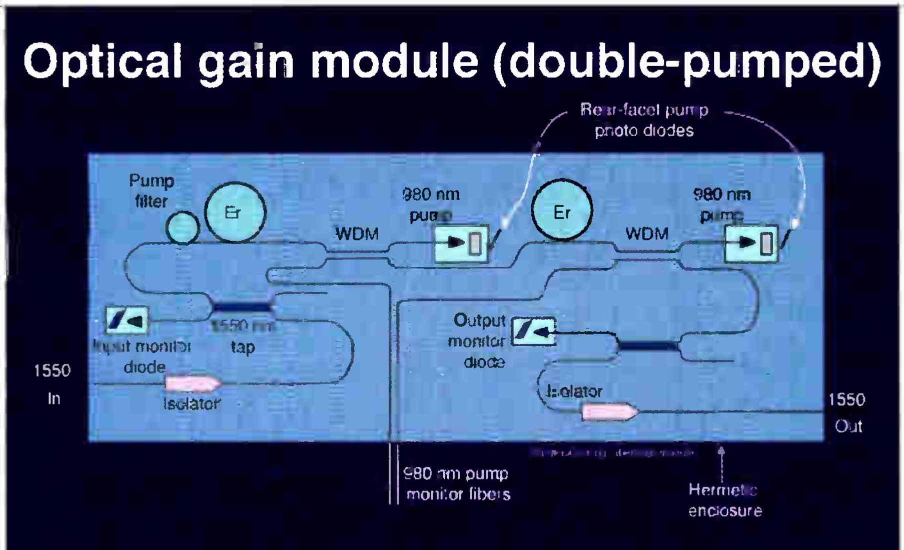
High-performance splitting

High-port-count couplers are a key element of new 1550 nm cable TV systems that reduce costs through power distribution. Ion-exchange planar technology was developed to manufacture these components with extremely consistent optical performance from device to device. It is a radical departure from conventional coupler fabrication techniques that depend on heat fusion of two adjacent optical fibers.

The precise circuit design of planar couplers offers optical characteristics that permit high-level signal splitting with low insertion loss and uniform power distribution among output ports. Their reliable performance over wide passbands supports accurate power splitting required in shared distribution architectures.

Planar processing uses a photolithographic technique similar to semiconductor manufacturing to embed optical circuits in a glass substrate. The processed substrate wafer, which contains numerous identical waveguide structures, is diced into discrete chips (see Figure 1), mechanically equipped with input and output fibers and mounted in protective packaging.

Consistent optical performance and reduced size is achieved through the passive integration of multiple Y-junctions, required for higher port-count devices (see Figure 2). Planar technol-



An optical gain module combines an input signal with a pump laser output to amplify light signals in erbium-doped fiber.

Figure 3

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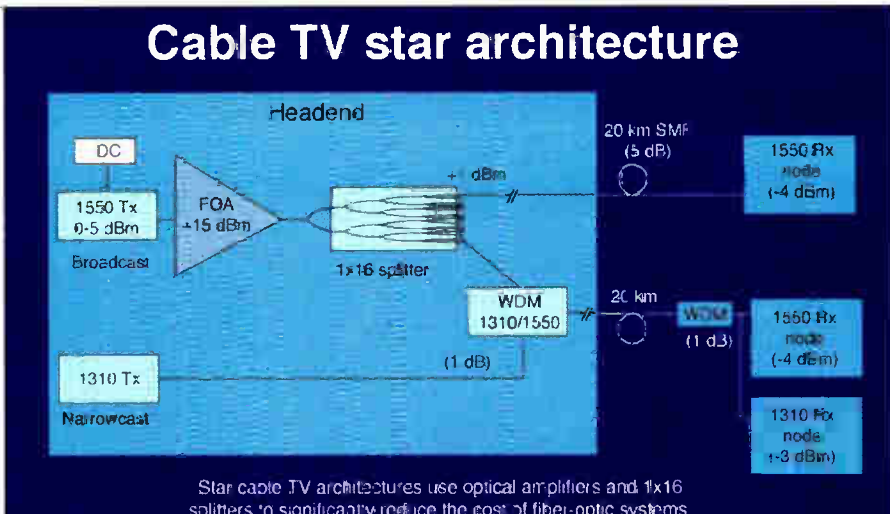
ogy is ideal for the volume production of low-loss splitters with multiple operating windows.

Continual improvements in circuit design and fabrication techniques have resulted in high-port-count planar couplers with wideband achromatic performance. Double-window devices in 1x2, 1x4, 1x8 and 1x16 configurations have been achieved with very low insertion loss.

Since all optical circuits are contained on a single glass chip, planar couplers are extremely small compared to cascaded devices made from multiple fused couplers. A planar 1x8 coupler, for example, is approximately 1/250 the volume of an equivalent cascaded fused device.



Star cable TV architectures use optical amplifiers and 1x16 splitters to significantly reduce the cost of fiber-optic systems

Figure 4

EDFAs conquer optical budgeting

Combined with the high-performance splitting capabilities of advanced planar couplers, optical amplification is a compelling incentive to consider 1550-nm optical systems.

These devices, which are available only for operation at 1550 nm, offer enormous opportunities for cost savings and system upgradability.

Optical amplifiers overcome power budget limitations and, consequently, facilitate longer trunk spans and additional signal-splitting in shared distribution architectures. Prior to the development of 1550-nm optical amplifier technology, transmission sources for cable TV systems were restricted to expensive DFB lasers with limited output power. With the emergence of EDFAs, however, low-cost, distortion-free power gains now are available that offer tremendous opportunities for system expansion.

EDFAs provide up to 30 dB signal gain with virtually no increase in distortion. The amplifying function is provided by an optical gain assembly containing pump lasers, wavelength division multiplexers (WDMs) and about 20 meters of erbium-doped single-mode fiber (see Figure 3).

Amplification is achieved by coupling the incoming 1550-nm signal with the

output from the 980-nm pump lasers through a WDM and passing the combined lightwaves through erbium-doped fiber. Erbium absorbs 980-nm pump light. The 1550-nm signal stimulates the erbium to emit more photons at 1550 nm. As a result of this conversion of pump power light to amplified signal, output power levels as high as 12 to 15 dBm are possible.

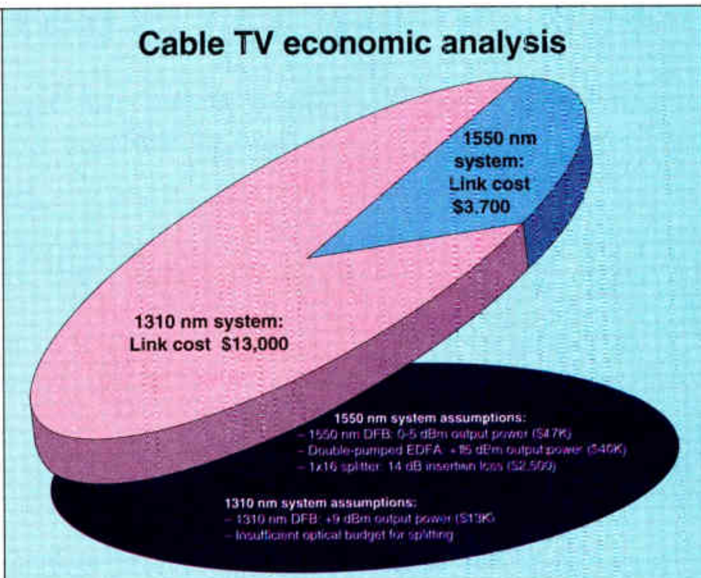


Figure 5

Extending trunk length

In addition to these advances in equipment and components, the growth of 1550-nm transmission systems is enhancing the viability of dispersion-shifted fiber, which is optimized to provide near zero dispersion and low attenuation in the 1550-nm window.

Dispersion-shifted fiber has gained recognition in the last few years in submarine cable applications due to its ability to maximize link lengths in long-distance installations with fewer in-line amplifiers. With the anticipated availability of optical amplifiers, this fiber could become a major asset for cable TV systems, as well.

Deploying dispersion-shifted fiber in conjunction with 1550 nm transmission systems can reduce the current 25- to 30-kilometer limitation on span lengths in cable television trunking applications. In fact, it will extend the maximum transmission distance of a trunk system up to 40 or 50 kilometers without amplification.

Even more important than extending supertrunking routes, the fundamental reason for considering 1550 nm technology for cable TV systems is the savings that can be achieved as a result of sharing expensive transmitters. This advance will permit operators to reduce the initial cost of their optical links and also extend fiber's reach deeper into their systems.

New architectures

New architectures that vary widely from the traditional tree-and-branch design are being considered to take maximum advantage of fiber and advanced 1550 nm components. One of the most interesting of these approaches is the cable television star architecture, which uses high-level splitting at the headend to allow operators to maintain home run fibers to and from their receive nodes (see

Figure 4).
An additional advantage of the star architecture is its potential for upgrading to double-window operation. This ... maintains the 1550 nm win-

based on a DFB laser with an output of 0 dBm combined with a fiber optic amplifier providing a 15 dBm signal gain. This implementation offers sufficient power for 16-way splitting using a high-... with a total inser-

link lengths of 15 to 20 kilometers.

System cost benefits

An economic analysis of the 1550-nm star architecture shows that it is sig-

Digital techniques—Part II

DS-1 and higher multiplex levels

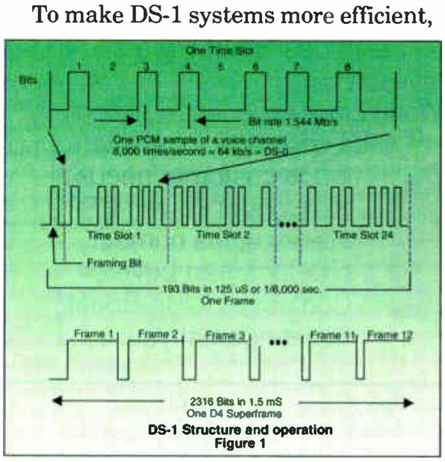
Last month, part one of this series discussed the process of digitizing a single voice channel. Although the process is straightforward, it is cost-restrictive to transmit a single voice channel. Because the smallest transmission path is a DS-1, or 24 voice channels, it is impractical to transmit a fraction (1/24th) of the available bandwidth.

Thus multiplexing, a process of transmitting two or more signals over a single channel, is a cost-effective, logical method of transmission. The basic technique of multiplexing combines a group of voice channels (DS-0s) and then time-division-multiplexes (TDM) the individual channels into a DS-1. The following article discusses in-depth this process.

DS-1 structure and operation

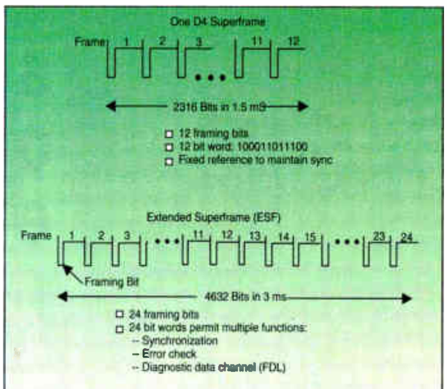
The first basic (practical) level of TDM is a DS-1 (Digital Signal level 1). A DS-1 consists of 24 DS-0s (64 kb/s digital channels), combined into a frame (See Figure 1). This frame is repeated every 125 µS or 8,000 times per second, resulting in a bit rate containing usable information of 1.536 Mb/s (24 x 64 Kb/s). In order to maintain synchronization, there are additional "framing bits" added to each frame. The framing bits add one bit each 8,000 times per second, resulting in the total DS-1 speed of 1.544 Mb/s.

To make DS-1 systems more efficient,

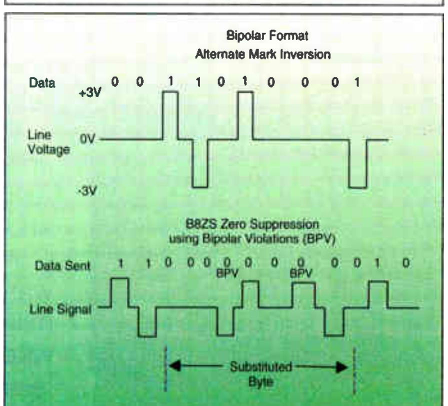


DS-1 Structure and operation
Figure 1

By Randy Reynard, Director of Training, Optical Networks International



Superframing
Figure 2



DS-1 Transmission
Figure 3

the frames are further combined into "superframes." Superframing is accomplished through the channel bank which does the initial analog-to-digital conversion. The original channel banks to use superframing were the AT&T D4s. Because of this, superframing is referred to as "D4 Superframe" consisting of 12 basic DS-1 frames. This allows 12 framing bits in each superframe to maintain synchronization (See Figure 2).

With the advent of more sophisticated timing circuits, not all 12 framing bits are required, and efficiency is increased by making the superframe larger. The next step in making systems even more efficient is to use "extended superframe" (ESF) which places 24 frames in the superframe, producing 24 framing bits. Since only one out of every four framing bits are actually needed, the remainder are available for other purposes. Those purposes include:

- Synchronization (using six of the 24 framing bits);
- Error checking (known as CRC6—uses six bits);
- Facility Data Link (FDL) (uses 12 bits).

The FDL is a sub-communication channel which allows properly equipped terminal equipment to communicate without using the payload bandwidth of the DS-1 circuit.

Transmitting DS-1s

The electrical transmission of DS-1 signals uses a format known as Alternate Mark Inversion (AMI). The principle behind AMI is that every other "1" has inverted polarity (see Figure 3). By inverting succeeding ones, the total average voltage on the line over a period of time is zero.

In order to maintain proper clocking, in addition to the framing bits which occur once every 192 bits, there needs to be predictable activity on the line. The FCC (Part 68) and Bellcore (Pub 62411) have established a standard which states that there must be at least one bit in eight representing a "1".

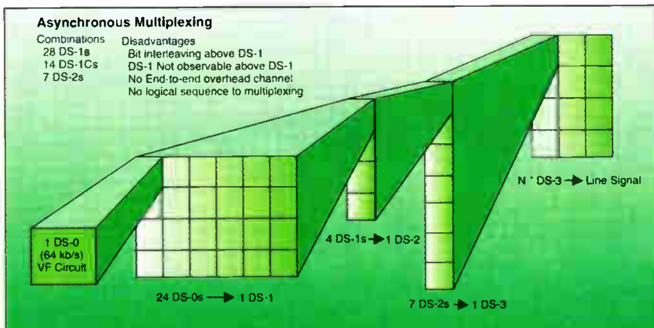
This results in a "ones density" of 12.5 percent, and ensures that clocking can occur. In normal voice traffic (on active circuits) this is not a problem. However, on circuits carrying data (especially encrypted data) and low usage voice channels, it is possible that a lengthy string of zeros could pass down the line. Thus, to enforce the 12.5 percent ones density requirement, ones have to be inserted. To accomplish this, a technique called Binary 8 Zero Suppression (B8ZS) is used.

B8ZS uses a method whereby a pattern is inserted which is recognized by the terminal equipment as a replacement for a string of eight zeros. By inserting Bipolar Violations (BPV) as seen in the bottom half of Figure 3, a string of zeros is replaced with consecutive sets of pulses that violate the AMI for-

Level	Transmission speed	Telephone channels
DS-0	64 kb/s	1
DS-1	1.544 Mb/s	24
DS-1C	3.152 Mb/s	48
DS-2	6.312 Mb/s	96
DS-3	44.736 Mb/s	672
DS-4	274 Mb/s	3,920

North American Hierarchy
Figure 4

Circle Reader Service No. 45



SONET (Synchronous Optical Network)

Figure 5

mat. These pulses maintain the ones density while providing a method of indicating a long string of zeros.

The most common multiplexing systems currently in use in North America are asynchronous. That is, synchronization between elements of the network is maintained by signals embedded in the traffic. Framing pulses and ones density requirements are examples of embedded information. In order to maintain synchronization between elements, there are several additional considerations that must be observed.

The first consideration is that the bit rate must be maintained within a ±75 bit-per-second tolerance, thus the bit rate is between 1,543,925 and 1,544,075 per second. Second, to maintain that bit rate, some form of stable clocking must occur. In a private point-to-point network, clocking can be achieved through the internal clock of the channel banks—assuming they have a relatively stable clock. In this situation, one end of the network is declared the "master," with the other points being the slave.

However, in the Public Switched Telephone Network (PSTN), there must be a higher level of stability. For the PSTN, clocking can originate from a local telephone carrier using a station clock. The stability of the station clock can be based on high accuracy clocks such as: a certified cesium standard (such as the National Bureau of Standards and Technology); a Loran C receiver with a phase locked clock attached; or a Global Positioning System (GPS) receiver with a phase locked clock attached. There are pulse generators and clocking sources available for each of these to interface with the carrier's system.

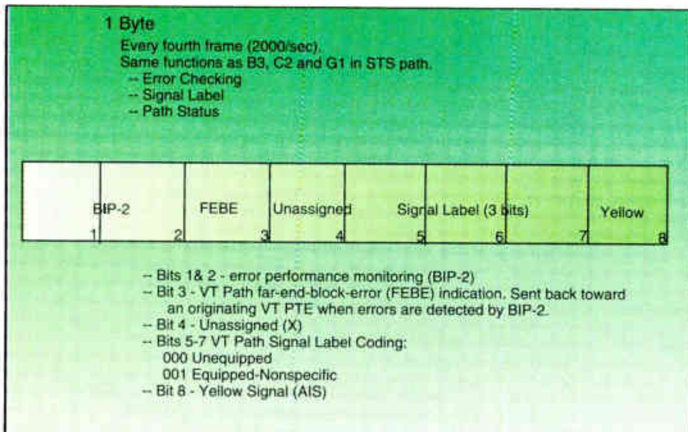
Digital hierarchies

The North American digital hierarchy (DSn) is seen in Figure 4. The basic rate (individual voice channel) is a DS0 at 64 kb/s. Twenty-four DS-0s are combined into a DS-1 as discussed above. In a similar manner, by using bit-interleaving and assigned positions within the frameworks, higher levels of multiplexing are attained.

In the process of multiplexing, bit interleaving causes the identity of specific DS-1s to be lost until the higher level signal is de-multiplexed. This means DS-1s are not observable at higher levels. In multiplexing, two DS-1s become a DS-1C, although this is not commonly used now. Four DS-1s become a DS-2, also rarely used as a direct transmission method. One of the most widely used levels, DS-3, consists of 28 DS-1s or seven DS-2s (Figure 5).

SONET summary

In Europe, the hierarchy is different



VT Path Overhead

Figure 6

from the North American DSn structure. The Europeans use the same basic rate of 64 kb/s but call it an E-0. An E-0, equivalent to a DS-0, is combined into an E-1, which contains 30 voice channels as opposed to the DS-1 rate of 24 DS-0s. A area of similarity is the asynchronous nature of both the DSn and E-n standards. Unfortunately, one of the significant disadvantages of asynchronous networks is that overhead (framing and signaling) increases with each successive level of multiplexing.

The excessive requirements for overhead, combined with a trend toward global telecommunications, has resulted in the creation of a universal standard known as Synchronous Optical Network (SONET). The SONET standard includes:

1. Defined levels of potential transport and signal levels, with specific rules on converting light to electrical and vice versa.

2. Overhead capacity for operations, administration and maintenance (OA&M), along with additional capacity for the future.

3. The same digital and phase compensation rules.

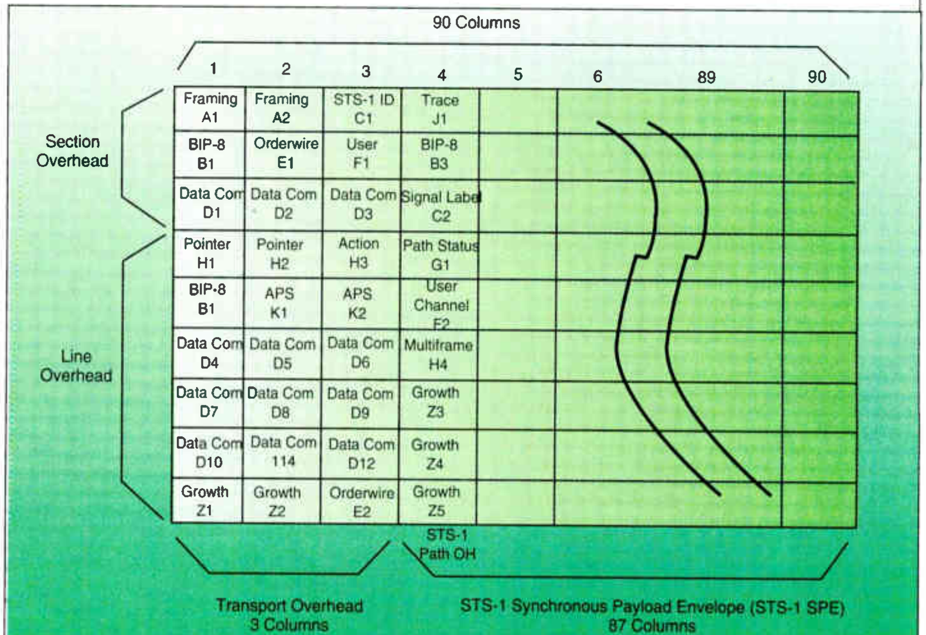
4. Multi-vendor compatibility (mid-span meet), allowing one manufacturer's equipment to work with another manufacturer's equipment.

5. High speed connections ranging in levels from a DS-1, 1.544 Mb/s signal up to a 2 Gb/s (gigabit-per-second) signal.

The SONET hierarchy begins with a "VT-1.5". This is known as a virtual tributary at a speed of 1.544 Mb/s—a DS-1 which has been "SONETized"—the DS-1 has the SONET overhead added to it so that it totals 1.72 Mb/s (see Figure 6).

Four VT-1.5s are combined into a virtual tributary group (VT-G), with seven VT-Gs combined into an STS-1. This is roughly equivalent to a DS-3 (See Figure 7). There are numerous advantages to this: the VTs use byte interleaving above a DS-1 rate; the DS-1s are observable above a DS-1 rate; and there is a standard end-to-end overhead channel.

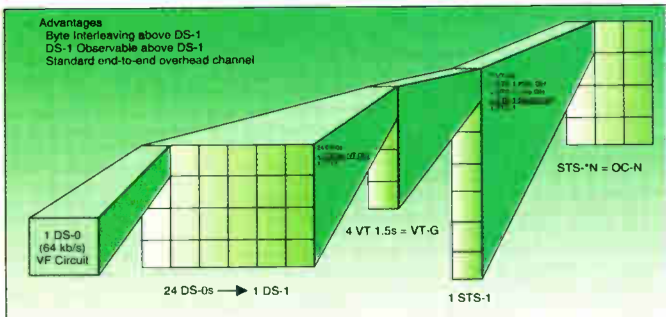
The SONET hierarchy works on



STS-1 Frame Format

Figure 8

	Reader Service #	Page #
AM Communications	1	2
ATC	36	78
Alpha Technologies	7	13
Anixter Cable TV	54	116
Antec		Chart
Applied Instruments	51	99
Aurora Instruments	52	100
BT&D Technologies		27-28
Budco	19	41
C-COR	48	93
Cable Prep/Ben Hughes	26	50
Cable Services Co.	20	43
Champion Products Inc.	30	70
Channell Commercial Corp.	16	33
Contec International	53	115
Cooper Industries, Belden	34	77
Corning		Chart
Eagle Comtronics		27-28
EXFO Electro-Optical Engi.	43	84
Epitaxx	46	88
Fibertron	28	52
Fotec	29	69
Gould Fiber Optics	22	45
Hughes Microwave	6	11
Isowave	45	87
Jerrold Communications	27	51
Jerry Conn Associates	37	9
Kennedy Cable Construction	21	44
Laser Precision	17	35
Lectro Products	11	21
Matrex Industries	14	26
Matrix	39	81
Midwest CATV	31,32	71,73
Monroe Electronics	18	36
NCTI	47	92
Nacom	23	46
Nexus Engineering	3	5
ONI	8,13	Chart,15,24-25
Optical Society of America	38	80
Ortel	33	75
Philips Broadband	9	17
Power Technologies Inc.	50	98
Power & Telephone	44	85
Regal Technologies	24	47
Riser-Bond	35	78
Scientific-Atlanta		Chart
Sencore	42	83
Siecor Corp.	25	49
Standard Communications	10	19
Sumitomo	15	31, 37-40
Tailgater, Inc.	40	82
Tech Electronics, Inc.	41	82
Trilogy	2,49	3,79
Wavetek	4	7
Wegener	12	23
White Sands		27-28



Synchronous Multiplexing

Figure 7

"building blocks," with the basic STS-1 the format that is used throughout the hierarchy. The STS-1 frame consists of: 90 columns of 8-bit bytes, 9 rows of 810 bytes (9 times 90), and 8,000 frames/second. There are a total of 51.84 Mb/s (6,480 bits/frame times 8,000 frames/sec) in the STS-1 frame.

Without going into the various subtleties of the individual overhead blocks (see Figure 8), there are a few notable blocks in the overhead that should be examined. These blocks demonstrate a significant difference between SONET and asynchronous systems.

First, there are several data communication blocks which allow SONET terminal equipment to communicate (mid-span meet), share configuration information, control commands and operational functions. This function enables a system to do add/drop[1] functions, a capability that makes SONET a superior system to asynchronous.

A second communications block is a dedicated orderwire (similar to a party line) which allows voice communication between elements of the network without impacting traffic. Essentially, it gives computers an overhead voice channel, accessible via a phone line.

Another advantage of SONET-based equipment is its ability to do a Time Slot Interchange (TSI). This feature allows the user to use the terminal equipment as a sort of mini-DACS (digital access cross connection) which enables the system to selectively switch and route circuits between major elements of the network. The TSI also permits the system to execute add-drop functions.

SONET appears to be the wave of the future for high capacity transmission. For anyone entering the alternate access business, starting with SONET on the main backbone of the digital network makes a great deal of sense because of the flexibility and ease of expansion that is afforded. Additionally, SONET's ability to interface with other entities at an optical level and for one manufacturer's equipment to interface with another's is a tremendous asset.

Reference

1. In today's digital market, it is necessary to demultiplex and then multiplex the entire signal in order to get to the single DS-1 level. With SONET, the capability exists through VTs to add or drop a DS signal anywhere along the transmission path without the costly demultiplexing/multiplexing steps required by asynchronous methods. This is referred to as add/drop functions.

Next time . . .

In the final part of the digital primer, digital transmission equipment and systems will be discussed. Loss budgets for telephony and cable television networks will also be examined. CED

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Following is a list of SCTE technical seminars with contact name. If available, location and seminar topic are also listed.

September 4 *Heart of America Chapter* BCT/E exams to be administered at all levels. Contact Don Gall, (816) 358-5360.

September 8-9 *Central Indiana Chapter* BCT/E exams to be administered at all levels. Contact Greg Nydegger, (219) 583-6467.

September 9 *Great Lakes Chapter* "FCC Technical Standards" with speaker Jim Bridgewater of the FCC. BCT/E exams to be administered. To be held at the Holiday Inn, Livonia, Mich. Contact Jim Kuhns, (313) 541-4513.

September 9 *Magnolia Chapter* To be held at the Ramada Inn Coliseum, Jackson, Miss. Contact Steven Christopher, (601) 824-0200.

September 9 *Oklahoma Chapter* "Microwave System Design, Installation and Maintenance" and "BCT/E Category III" with Dane Walker of Hughes Aircraft Co. To be held at the Fifth Season Hotel in Oklahoma City, Okla. Contact Arturo Amaton, (405) 353-2250.

September 9 *Hawaii Meeting Group* "CATV Power Supplies, Batteries and Grounding" to be presented by Alpha Power Supply. Contact Michael Goodish, (808) 836-2888.

September 10 *Hawaii Meeting Group* "FCC Technical Standards" to be presented by Wendell Bailey of NCTA. To be held at the Ritz Carlton, Kailua-Kona, Hawaii. Contact Michael Goodish, (808) 836-2888.

September 10 *Mid-South Chapter* To be held at Howard Johnson's, Senatobia, Miss. Contact Scott Young, (901) 365-1770, ext. 4150.

September 10 *Penn-Ohio Chapter* "Broadcasting Forum" and "Working Together." To be held at the Sheraton Hotel, Warrendale, Pa. BCT/E and installer exams to be administered in all categories. Contact Marianne McClain, (412) 531-5710.

September 10 *Satellite Tele-Seminar Program* "Video and Audio Measurements, Part Four produced by the SCTE's Wheat State Chapter. To air from 2:30 p.m. to 3:30 p.m. Eastern time on Transponder 6 of Galaxy I. **Please note new time.**

September 12 *Chaparral Chapter* "CATV Math Fundamentals and Calculations" with Richard Covell of Texscan. BCT/E and installer exams to be administered at all levels. Contact Rita Erickson, (505) 761-6206.

September 14 *Central New York Meeting Group* "FCC Rules and Test Procedures" with Tom Staniec. To be held at the Ramada Inn in Syracuse, N.Y. Contact Vincent Cupples, (315) 652-4698.

September 15 *Central Illinois Chapter* "OSHA Safety." To be held at the Holiday Inn, Brandywine, Ill. Contact Chuck Prosser, (309) 347-7071.

September 15 *N.Y. City Chapter* "Signal Level and Automated Testing" with Bill Mackenzie and "FCC Specifications" with John Vartanian of HBO. Contact Rich Fevola, (516) 678-7200.

September 15 *Delmarva Meeting Group* "Leakage Theory and Analysis" with Terry Bush of Trilithic and "Terminal Devices" with Paul Harr of Scientific-Atlanta. BCT/E exams to be administered. Contact Linc Reed-Nickerson, (215) 825-6400.

September 16 *Appalachian Mid-Atlantic Chapter* "RF Transportation Systems." To be held at the Holiday Inn, Chambersburg, Pa. Contact Richard Ginter, (814) 672-5393.

September 16 *Florida Chapter* "FCC Technical Standards." To be held at the Holiday Inn, Ft. Lauderdale, Fla. Contact John Tinberg, (800) 327-9767.

September 16 *Golden Gate Chapter* "Video and Audio." Contact Mark Harrigan, (415) 358-6950.

September 16 *Snake River Chapter* "Transportation Systems." To be held at the Weston Plaza in Twin Falls, Idaho. Annual election of officers to be held. Contact Paul Elgethun, (208) 377-2491.

September 18 *Palmetto Chapter* BCT/E and installer exams to be administered. To be held at the University of South Carolina, Columbia, S.C. Contact John Frierson, (803) 777-5846.

TRADE SHOWS

September 8-11 *OE/Fibers '92* hosted by the International Society for Optical Engineering. To be held in Boston, Mass. Call (206) 676-3290 for details.

September 9-11 *Eastern Show '92* To be held at the Inforum, Atlanta, Ga. Call SCTA headquarters at (404) 255-1608 for more info.

September 15-17 *Great Lakes Expo* To be held in Cleveland, Ohio. Call (517) 482-9350 for details.

September 23-25 *International Conference on Data Transmission* hosted by IEE, the Association for Computing Machinery and special interest groups COMM and OIS. To be held in London, England. Call (212) 869-7440 for more information.

October 6-8 *Mid-America Show* To be held in Kansas City, Mo. Call (913) 841-9241 for more information.

October 13-14 *Atlantic City Show* To be held in Atlantic City, N.J. Call (609) 848-1000 for more information.

October 20-22 *BCTA Show* British Cable Television Association's annual convention. To be held in London, England. Call 071-22-2900 for details.

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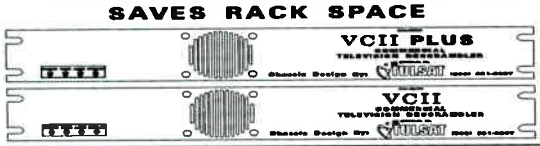

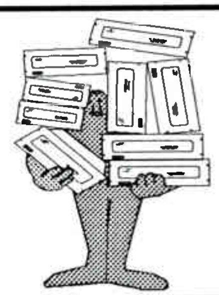

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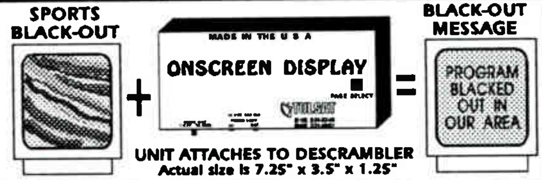

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Who invented television?

"John Logie Baird was destined to become the pioneer of one of the greatest innovations of our time - television."

So they say in the United Kingdom, based on Baird's 1925 demonstration at Selfridge's department store in London using a Nipkow disk generating eight scanning lines.

But, hold on a minute. Three months later, in Washington, D.C., Charles Francis Jenkins demonstrated the transmission of moving pictures using a different, but still mechanical system, with 48 scanning lines.

Both Baird's and Jenkins' devices were crude, initially producing little more than silhouettes. Although their mechanical systems were quickly improved so as to produce half-tones, the concept of all-electronic scanning would soon overtake the perforated spiral disk patented in 1884 by Paul Nipkow.

Campbell-Swinton and Zworykin

As a matter of fact, in 1908, many years before either Baird or Jenkins, Alan A. Campbell-Swinton proposed a television system that accurately predicted the iconoscope for generating the electrical signal, and CRT (cathode ray tube) for displaying the received image. No one knew then how to create a photomosaic of rubidium crystals.

By Archer S. Taylor, Senior Vice President, Engineering, Malarkey-Taylor Associates Inc.

But it was not technology that kept Campbell-Swinton from recognition as a television pioneer. In 1924, he told the Radio Society of Great Britain that his idea could be developed with one or two years research. But, he said, the real difficulty in regard to this subject is that it is probably scarcely worth anybody's while to pursue it. That was the year after Vladimir Zworykin of RCA had applied for a patent on the iconoscope.

Farnsworth and EMI

In 1927, Philo T. Farnsworth applied for a patent on the image dissector. The ensuing litigation effectively blocked Zworykin and David Sarnoff, the driving force at RCA, from commercial exploitation of television until 1939 when they capitulated and signed a licensing agreement with Farnsworth. The State of Utah has placed a likeness of Farnsworth in Statuary Hall on Capitol Hill, as inventor of electronic television.

Back in London, in 1936, the BBC conducted a crucial test by alternately transmitting programs using Baird's mechanical system, now at 240 lines, with the electronic system developed by Marconi and EMI (Electric and Music Industries) at 405 lines.

Baird lost, and the 405-line system survived in the U.K. until about 1987.

NTSC and PAL

While the BBC was deciding in favor of 405 lines, an RMA committee (Radio Manufacturer's Association) in the U.S. was recommending adoption by the FCC of a 441-line standard used in Germany by Telefunken. The first NTSC (National Television Systems Committee) appointed by the FCC in 1940 rejected Philco's 605-line, 24-frame proposal as well as Dumont's 625 lines and 15 frames. In 1941, the FCC adopted the upgraded NTSC 525-line, 30-frame standard.

U.S. television gained a clear lead over Europe for more than a decade after WWII. The FCC adopted NTSC compatible color standards in 1952, 10 years before the U.K. adopted its 625-line phase alternating line (PAL) standard.

While the British tend to flaunt the superiority of their color standard, its vertical resolution is only incrementally greater than NTSC, and the occasional NTSC transmission errors which the phase alternating line technique was skillfully designed to correct have largely been overcome in other ways.

If European television pictures look better than American (after you get used to the 50-Hz flicker), it is most likely because of the meticulous attention to detail that is characteristic of technical operations throughout most government-supported television facilities.

HD-MAC and DigiCipher

In 1986, Joe Flaherty and CBS persuaded the U.S. State Department to press the World Administrative Radio Conference (WARC) meeting in Yugoslavia, at historic Dubrovnik, to adopt the Japanese MUSE (Multiple sub-Nyquist sampling encoder) as a worldwide standard for HDTV. Europe was having none of it, and went on to enhance the C-MAC (multiplexed analog components) standard developed by the British Independent Broadcasting Authority (ITA) for satellite transmissions. Most of Europe has gone along with the resulting D2-MAC and HD-MAC standards, coaxing the U.S. to do likewise.

In the meantime, Jerrold tossed its DigiCipher like a hand grenade into the contest for HDTV standards. The shrapnel are still falling, but MUSE, D2-MAC, and HD-MAC are beginning to look like casualties.

Pioneers are rarely authentic innovators. Invention is inevitably rooted in the vision of predecessors. "First" and "best" often represent only the mercurial judgments of provincialism.

Nevertheless, parochial though it may sound, isn't it gratifying that cable TV engineering has brought forth not only the cutting edge of HDTV, but also the unmistakable digital future of television all over the world? CED

References

1. Geoff Hutchinson; "Baird: The Story of John Logie Baird" ISBN 0-9510651-3-0. Copyright 1985 London. Written and published by G. Hutchinson. (0424) 882192.

2. Alan A. Campbell-Swinton's remarks to the Radio Society of Great Britain were printed by A.F. Inglis in "Behind the Tube," in which he referenced the quotation to George H. Brown, *"and part of which I was."* (Princeton, N.J.; Angus Cupar, 1982)

3. Much of the history presented was drawn from A.F. Inglis' book "Behind the Tube" ISBN 0-240-80043-5; Butterworth Publishers, Stoneham, Mass. 02180; also, from "Engineers and Electrons" by John D. Ryder and Donald G. Fink, published 1984 by IEEE Press. ISBN 0-87942-172-X

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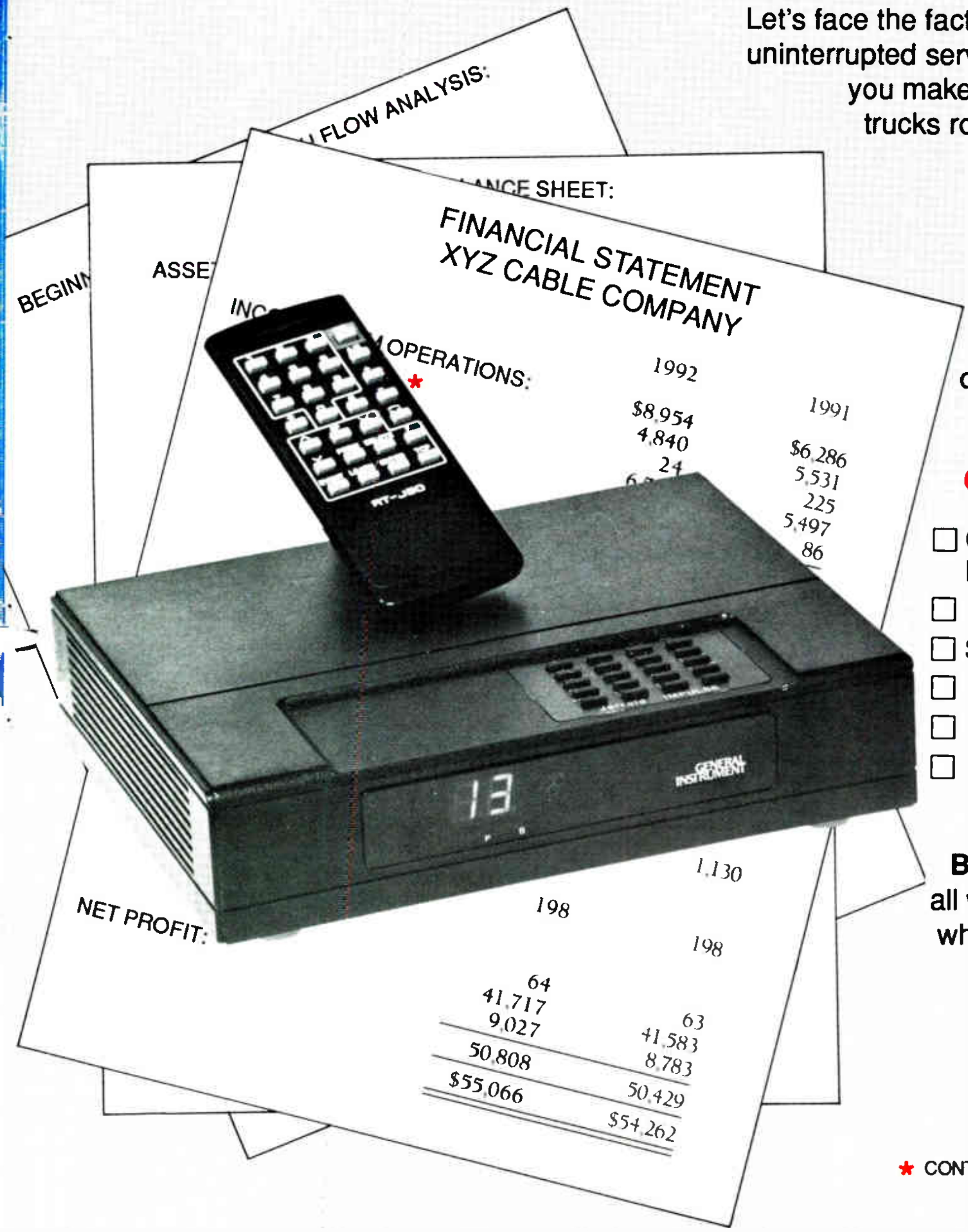

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