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September 1993 CED

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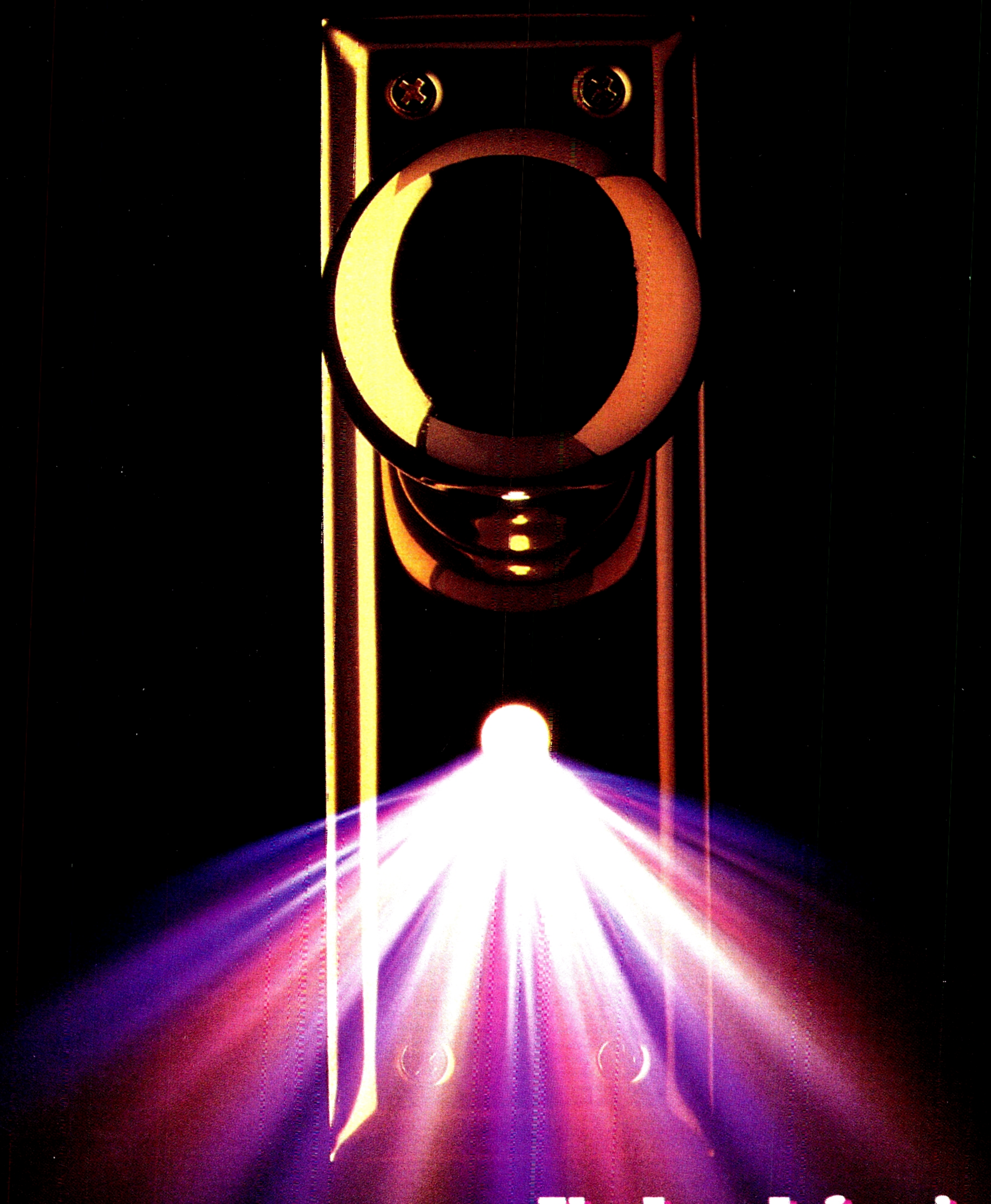

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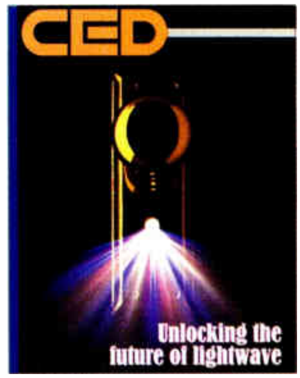

About the Cover

Lightwave technologies: Key to cable's future? Photo by Stock Market.

Departments

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Anatomy of a compromise

The issue of compatibility between cable set-top decoders and televisions is the subject of a Federal Communication Commission notice of inquiry that has had representatives of each side pulling their hair out ever since an advisory group was formed last January.

When Congress passed the Cable Act last year, an amendment was added that directed the FCC to issue a report to Congress on compatibility by early October. This was to be followed by new rules six months later that would address issues like recording one channel while viewing another and picture-in-picture.

Comments filed in response to the NOI were contentious, abrasive and did little to advance true workable solutions. The consumer electronics manufacturers wanted clear signals so consumers could throw away set-tops, while cable operators argued that TVs–even those touted as "cable ready"–simply weren't built with the cable environment in mind.

As recently as early June, the two sides were still miles apart. A panel discussion at the National Cable Show outlined the issues between the two sides, but did little to suggest there was common ground to be walked.

But by late July, the two sides issued a joint filing outlining a series of short- and long-term events that will take place to overcome most subscriber complaints. What happened during those six weeks that 10 years of work could never accomplish?

The answer lies in the question. It's an old axiom, that given an infinite amount of time to solve a problem, a problem will take an infinite amount of time to solve. But during a June 23 meeting of the full advisory group, an FCC representative said both sides had until July 1 to submit recommendations–or the FCC would do it for them. "That took and shook the whole room," recalls Dr. Walt Ciciora of Time Warner Cable, who was a leader in the discussions.

With both sides fearing a solution thrust upon them, the group sprang into action. It immediately asked for an extension (to July 15) and each side appointed negotiating committees consisting of just four persons.

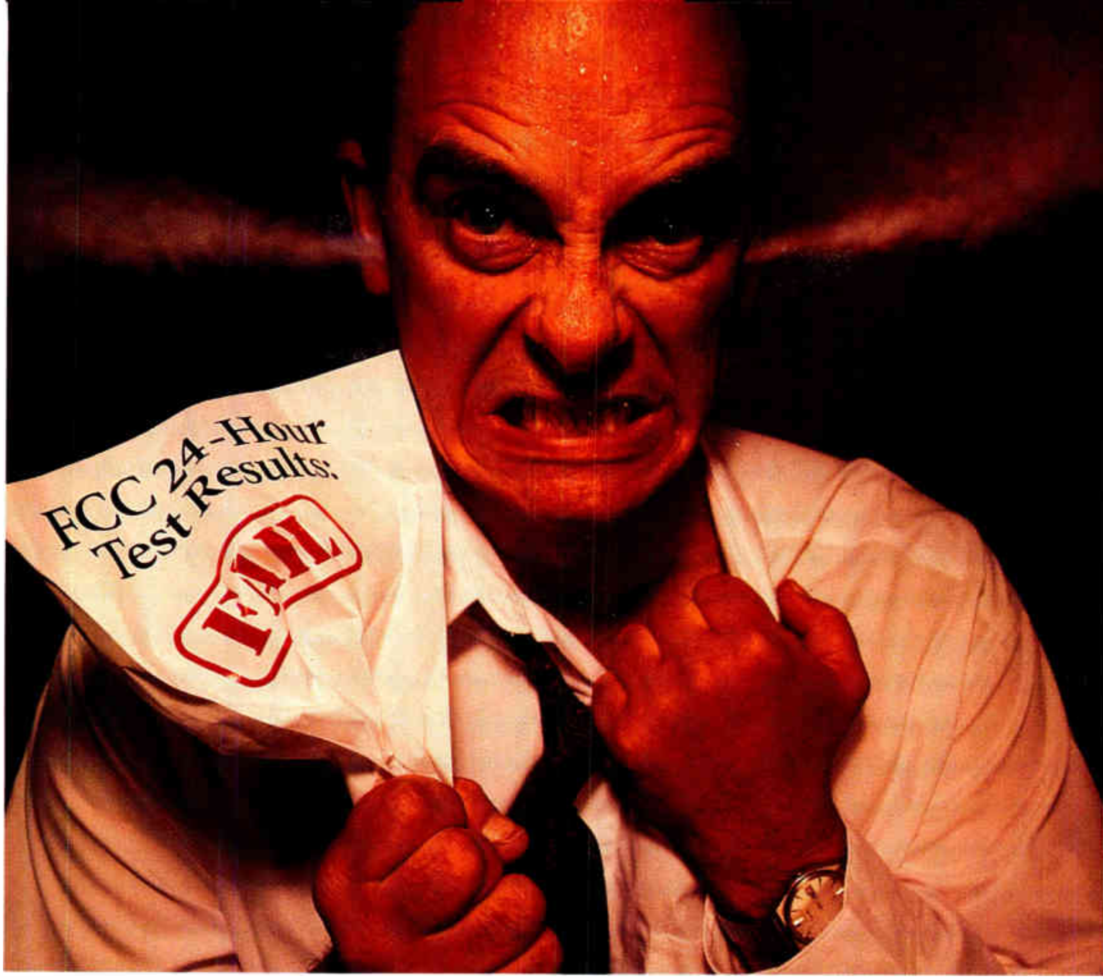
Then the real lobbying took place. Scores of telephone calls, one-on-one meetings and dinners were arranged. Cable engineers explained why interdiction and traps aren't a panacea and how scrambling protects their franchises; TV manufacturers explained why they don't want to make simple monitors. Much was given–and much was taken.

Toward the end, a draft agreement was drawn up, only to be rejected and replaced with a second one. Then the two drafts were merged. Then entire days were taken up haggling over individual words. "These were by far the most difficult negotiations I've ever been through," Ciciora says.

Even with a new deadline of July 21, negotiations continued until the final minutes, with Ciciora, Wendell Bailey of NCTA and Nick Worth of TeleCable facing at least a half dozen of their counterparts.

Neither side describes the result as a perfect resolution to their longstanding conundrum. Each side gave up many of their early demands. But each side got some of what it wanted and the burden is being shared. If that isn't a classic Washington compromise, I don't know what is.

Roger Brown
Editor



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WAVETEK

Cable, TV manufacturers reach accord on compatibility issues

In what could only be described as a classic compromise, representatives of the cable and consumer electronics industries have struck an agreement that would make set-tops and consumer devices more compatible with each other.

The agreement is the result of six months of intensive meetings of the Cable-Consumer Electronics Compatibility Advisory Group, which was formed after the 1992 Cable Act was passed. The Group has submitted a document to the Federal Communications Commission recommending a series of short- and long-term measures that should be undertaken to ease the problem of incompatibility. The FCC invited others to respond to the document by August 10. It must issue a report on compatibility to Congress in early October and issue rules six months later.

Significantly, the EIA capitulated from its earlier demands that cable operators be required to deliver their signals "in the clear" via traps, interdiction or broadband descrambling. Cable operators were apparently able to persuade electronics manufacturers that none of those approaches are suitable for universal deployment. "The Advisory Group recognizes that scrambling and encryption are an important part of providing cable service," the document said.

Furthermore, the EIA will work to improve television tuners (which have historically been poorly shielded, resulting in significant problems with direct pickup interference) and, in the long-term, will build plugs for an interface decoder that would externally descramble signals.

It is this last point that must have been difficult for the EIA to swallow, given the history of just such an interface. Most cable engineers will remember the Multi-Port debacle, a national standard that was hammered out by the EIA and the NCTA. After putting millions of plugs on TVs, manufacturers like Thomson were betrayed by cable operators who refused to buy the decoders for fear of losing revenue from remote control rentals.

Nevertheless, something similar to the MultiPort, but revamped to accommodate digital signals, will rise once again.

For its part, the cable industry will make available for rent or purchase RF bypass circuitry, set-tops with internal timers and dual decoding set-tops to overcome subscriber complaints that they cannot watch one channel while recording another or sequentially tape two programs unattended.

Also, the cable industry will work to better educate its subscribers on the methods of connection and supplementary hardware available to improve interoperability between set-tops and VCRs and TVs.

Over the long term, the Advisory Group will work to define the term "cable-ready" to mean a product that can be directly connected to a cable system without external hardware such as convertors. Aspects of that definition must include:

✔ Receiver designs that reflect differences in the broadcast and cable environments–direct pickup, in particular.

✔ Better dialogue between industries regarding channel capacity and channel mapping practices to ensure that a "cable ready" device remains cable ready for a reasonable period of time.

✔ The decoder interface, revamped to process digital signals. Proposed specifications for a hybrid analog/digital decoder will be submitted to the FCC in time for them to be included in the rules issued about six months from now.

To help manufacturers reduce costs and avoid further incompatibilities, the Advisory Group proposes to establish a timetable for the development of standards for digital decompression and a standard security interface system by 1995. "The Advisory Group believes these standards should be developed and prescribed as soon as practical while not limiting innovation and experimentation . . . " said the Group in its document to the FCC.

By putting off the issue of digital standards for about two years, it was felt that cable companies would be given sufficient time to test several different digital approaches. For example, a new MPEG standard might emerge or research into wavelets and fractals may pay off soon, said Dr. Walter Ciciora, VP of technology at Time Warner Cable.

However, in comments filed in response to the agreement, several telephone companies recommended that the Commission allow them and others to be part of the digital standards-setting procedures. Comments from Ameritech, BellSouth and others suggested that because they are actively involved in video dialtone efforts that they, along with representatives of creators of interactive multimedia systems, be allowed to provide input on a technology that will directly affect them.

"Clearly, video dialtone systems are being developed today for implementation in what appears to be the same time frame of implementation of the proposed long-term recommendations," wrote Ameritech. "It is critically important for the viability of video dialtone that the standards for compatibility not foreclose the development and growth of video dialtone. The issue of standards should not frustrate" this goal.

Similar comments were filed by BellSouth, which also called for wider representation. "The decoder interface proposed by the Advisory Group should be developed pursuant to an open industry forum in which engineering representatives of telephone companies, wireless CATV providers, the computer industry and the broadcast community can participate. . . ." Specifically, BellSouth is concerned that the propsed decoder interface accommodate baseband signals used by some emerging competitors.

Telco buys into cellular TV service

The wireless "cellular" video service presently operating near New York City has partnered with Bell Atlantic to speed the roll-out of the service to the remainder of the Big Apple.

CellularVision, which uses a super-high frequency to deliver video signals to small, flat receivers mounted on subscribers' windows, plans to license its technology worldwide. Under terms of the agreement with Bell Atlantic, the Bell operating company will operate the system under CellularVision's direction.

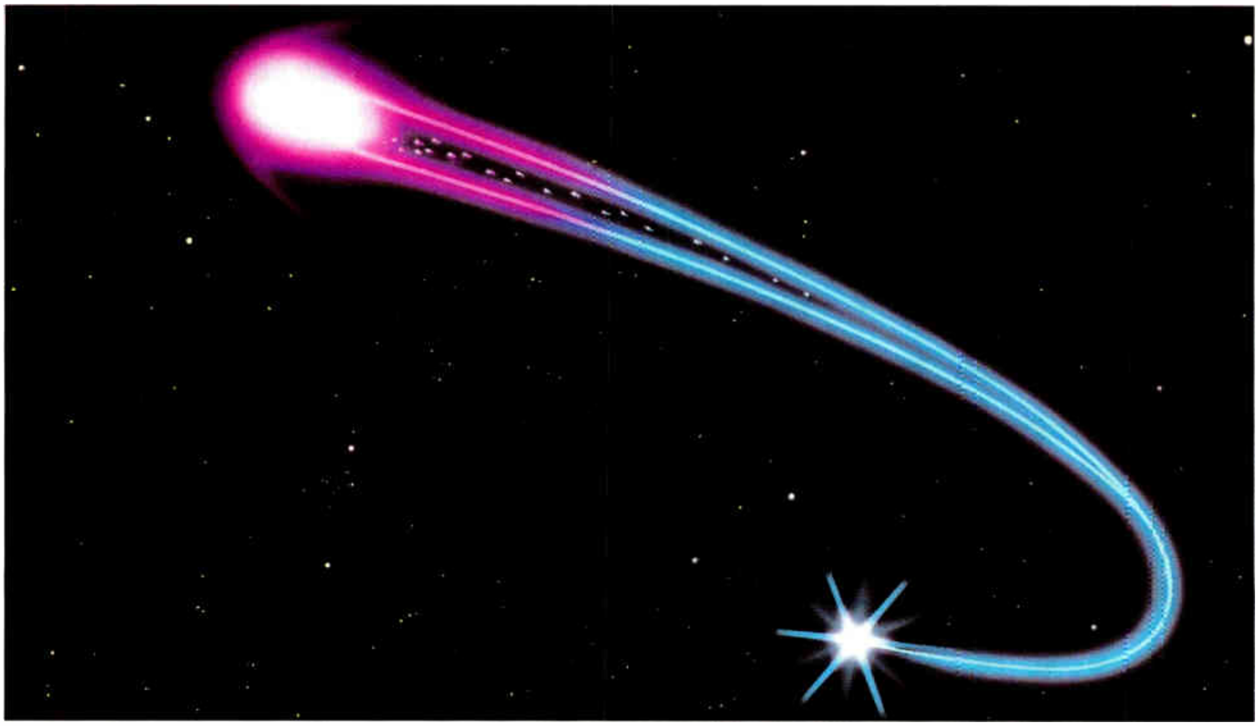
CellularVision presently provides 50 channels of television to Brighton Beach, Brooklyn via a wireless FM distribution system operating between 27.5 GHz and 29.5 GHz. According to Bernard Bossard, inventor of the technology, plans are underway to double the number of channels offered to 100. Plans also call for the system to build more cell sites and expand the service to include New York City's five boroughs and adjacent Westchester, Rockland and Putnam counties. Currently, the system utilizes just one cell site

The FCC is presently conducting a rulemaking aimed at allocating 2 GHz of spectrum for a national Local Multipoint Distribution Service with two licensees per region. There would be no restrictions on cable or telco operators as participants.

The Bell Atlantic/CellularVision partnership will test the ability of the technology to support commercial interactive video and data services.

Alliance formed to spur video dialtone

In order to help kickstart the video dialtone market, BroadBand Technologies has allied itself with Philips Consumer



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Electronics Company and Compression Labs Inc. to develop the technology deemed necessary to provide interactive video services via telephone companies.

The three companies are firmly behind the MPEG-2 standard for video compression and digital conversion. BBT plans to open the network interface of its Fiber Loop Access platform, making it possible for CLI and Philips to develop set-top decoders. CLI will also provide encoding technology to feed compressed digital video and other digital information into the BBT platform.

Fiber Loop Access is a fiber-to-the-curb system that delivers telephony services along with interactive switched digital video services, such as movies on demand, home shopping, educational programs and telemedicine.

BBT has furnished its systems to several telcos currently experimenting with video dialtone. The company plans to expand its platform system to access up to 1,500 channels of on-demand interactive switched digital video. By embracing the MPEG and other standards, the three companies hope to develop a system which will encourage other service providers to attach to the platform. "Industry standards are vital to the acceptance of a new technology on a broad basis," said Brian Smith, senior director of digital video business for Philips. The three companies will share technical resources and cooperate in marketing the system, which is scheduled for debut in the second half of 1994.

The keys to future survival

This space isn't often used to quote financial experts, but in this case it's probably justified.

The July issue of *The Daniels Letter* is devoted to a speech made by Gordon Crawford of Capital Research, a private investment management company. Capital is the largest institutional shareholder of nearly every significant cable MSO and programmer, according to Daniels officials.

In his speech, Crawford outlined the risks and opportunities awaiting the cable industry over the next several years. It will be an exciting era, but not one "for the faint of heart, the risk averse or those looking to reduce stress and anxiety in their lives."

Why? Because by the year 2000, cable and telcos will be operating in a "highly competitive, duopoly marketplace" where each offers both telephony and video services, says Crawford. He goes on to predict how this will occur and the strategies each side is putting in place to deal with this fact.

But the real key for technologists is where Crawford says cable operators will need six key attributes "to survive and prosper in the coming battle." Those attributes include:

✔ The commitment of resources to the construction of a robust, reliable fiber-rich digital network.

✔ An aggressive strategy to move into telephony services by ensuring the network can evolve into that service. In the interim, operators should be getting their feet wet in the alternate access market and in wireless. "Telephony will be the major theater in the coming wars," predicts Crawford.

✔ Size. To survive the battle, an operator will need 1 million subs today and a multiple of that later.

✔ Clustering, to consolidate ownership of ADIs through system swaps. The model used in the report is TCI's moves in Denver and Pittsburgh.

✔ A more politically active stance, to repair the damage that led to re-regulation and delay telco entry into cable "until you have your own network ready to compete."

✔ The attainment of a much higher level of customer service and marketing.

If you'd like a copy of the speech, call Daniels and Associates at 303-778-5555.

Primestar buys DigiCipher set-tops

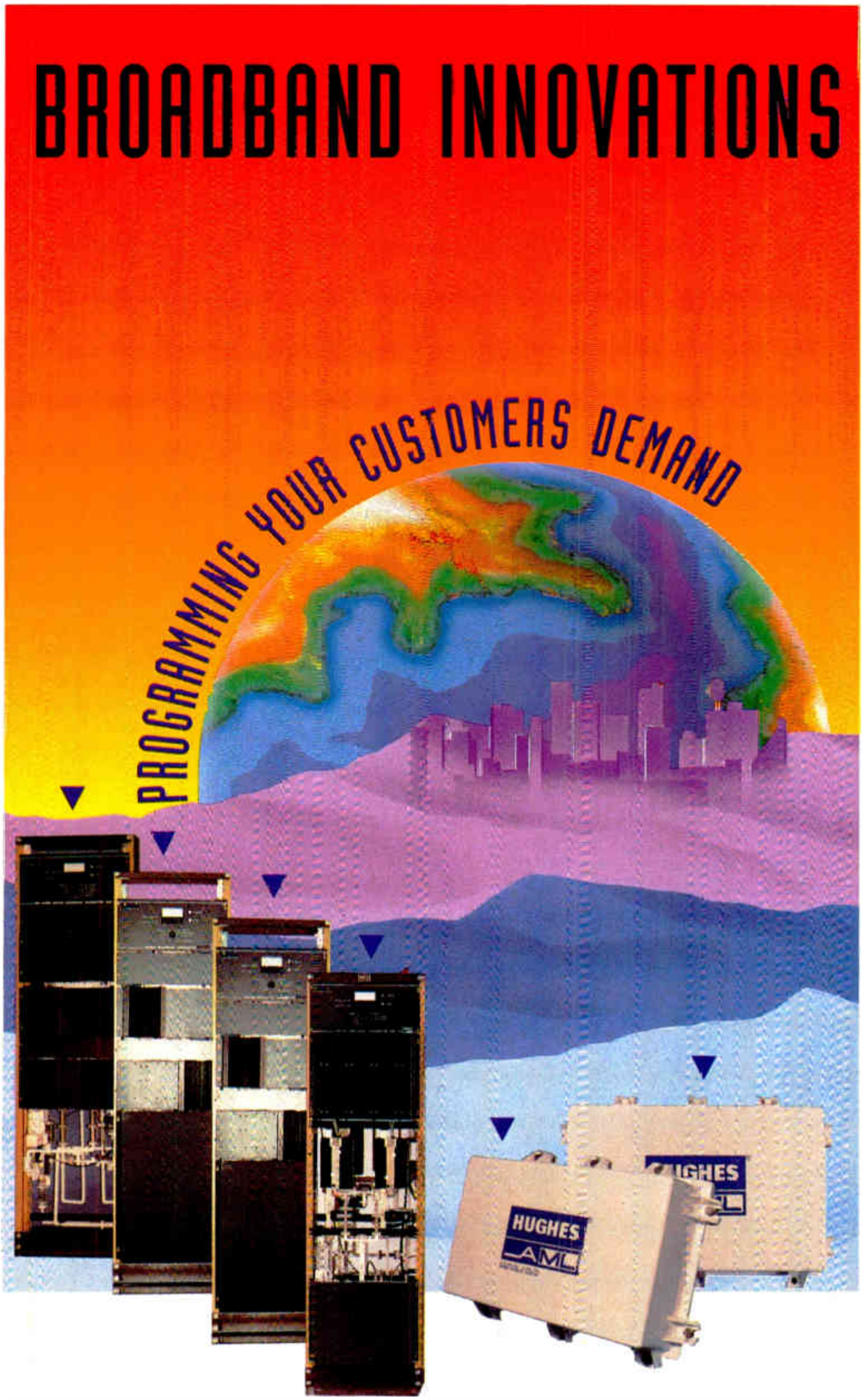
Direct broadcaster Primestar Partners has committed to purchase 500,000 DigiCipher decoders and other hardware from General Instrument as it upgrades its service from 11 analog channels to a digital service offering 70 to 80 services, including several pay-per-view channels.

Primestar presently is a medium-power DBS provider, using a Satcom Ku-band satellite to beam primarily conventional cable TV programming to an estimated 60,000 subscribers.

Primestar plans to offer the set-tops for lease or sale directly to homeowners. They are expected to be priced between $400 and $500 when the service rolls out beginning next January. The new terminals will replace the ones currently in place, which were supplied by Scientific-Atlanta.

Jottings

Golden Channels, the largest cable TV operator in Israel, recently activated what it believes to be the world's longest multichannel analog video link. The link runs nearly 51 miles over fiber optic cable and carries 41 PAL format signals (equal to 51 NTSC channels). The signals are repeated once at a central office located 24 miles from the headend. The optical path loss is 33 decibels, according to Josef Berger of **Harmonic Lightwaves**, supplier of the fiber hardware . . . **California Amplifier** demonstrated a proprietary encryption technology that utilizes broadband processing. The new MultiCipher technology allows for all received channels to be simultaneously processed and available at the output of the decoder, eliminating the need for a set-top . . . **Zenith Electronics** demonstrated a real-time interactive ordering system for use over wireless cable systems recently. Based on its Z-View system, the Wireless Interactive provides instant response to subscriber actions over the Instruction Television Fixed Service audio response channel instead of local telephone lines. A specially designed transconverter (combination down- and up-converter) was used to transmit info to the headend, where it is screened and authorization is sent . . . The **SCTE** has joined the American National Standards Institute in an effort to get its standards nationally recognized. To date, the SCTE has established a standard for the female F-connector and the 5/8-inch entry port . . . **AT&T Network Systems** and **ANTEC** say the CLC-500 integrated telephony/video system recently passed proof-of-concept testing at Bell Labs. The system will be evaluated by TeleWest in the United Kingdom later this year . . . **Request Television** is due to begin transmitting its first feature programs in a digitally compressed mode this month. Request had been testing GI's DigiCipher system by sending four compressed test signals over transponder 2 aboard Starcom C-4. The move to full-time digital transmission for Request channels 2 through 5 is scheduled to commence September 15, while Request 1 will remain an analog service sent over transponder 16 on C-4 The company recently hired engineering whiz **Dom Stasi** to lead the technological charge. . . **TCA Cable TV** has placed an initial order with **Scientific-Atlanta** for several thousand 8600x set-top terminals as part of an eventual order of up to 50,000 units. TCA executives said their experience with the first-generation 8600 boxes has been positive and they will use the new terminals to upgrade to digital compression . . .**Qualcomm** has signed an agreement with the Russian government and Russ Telecommunications Co. to initiate steps toward establishing code division multiple access (CDMA) as a new wireless standard in Russia. The agreement includes a plan to allocate spectrum and the rapid implementation of a network for 20,000 users . . . **FIND/SVP**, a consulting and research firm based in New York City, will conduct a new study of household demand for information. The intention is to learn what new types of information are desired and how much people will be willing to pay for such services . . . . CED



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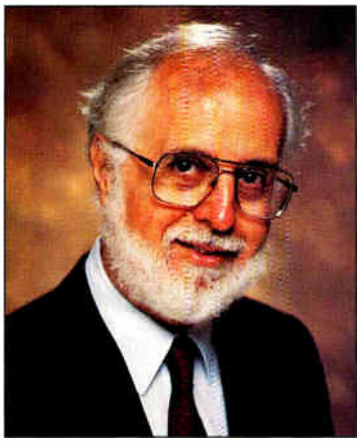

A lifetime of cable: In a literal sense

By Leslie Ellis

A worn, tweed jacket, leather satchel and a piece of chalk are all Jim Refi would need to excel as a professor. He already has everything else: he's erudite, having completed his E.E. at Villanova, followed by a master's in electrical engineering from the Polytechnical University of Brooklyn. He's an adept and careful listener, and a maestro at explaining things–from the nuances of polarization mode dispersion to basement enlargement. He's methodical, patient and simply a kind person.

Instead of education, however, Refi has dedicated his life's work to research and development for AT&T. For the past 27 years, he has toiled away at projects which would probably seem like minutiae to those outside his scientific circle. Indeed, intricate studies related to the improvement of coaxial cable, multipair copper and fiber have shaped Refi's working life. But it's not minutiae to him–and his discoveries have earned him both a prestigious award and recognition as a *distinguished* member of AT&T's technical staff.

Refi's many accomplishments, though, haven't evoked the least bit of arrogance. Instead, he is generous with his knowledge, and quelches the stuffiness attached to his title with this quip: "There's a joke among us who have been deemed distinguished members of technical staff–we call ourselves the FOFs, for 'faithful old farts,' " Refi chuckles.

The early days

Refi started at AT&T after attending an on-campus interview on the streets of Philadelphia. It was a mutual thing: they interviewed him, then he did his own careful research of the company, visiting sites and deciding whether the match was mutually beneficial.

It was. Refi joined AT&T Bell Labs' Baltimore offices in 1966. His first project, ironically, involved coaxial cable. The application was slightly different than cable's use of coax, however. In those days, telephone companies used coaxial cable and microwave for long-distance transmissions. Refi says there were some similarities between the coax AT&T used and the cable version (they were both 75 ohm), "But rather than working with a single coaxial cable in a tube, we would actually fabricate cables that could contain up to 22 coaxial cables in one cable sheath. As you might imagine, that's a humongous cable," Refi explains.

In the early 1970s, Refi says he got involved with a "more plebian" product analysis: twisted copper multipair, which Refi now describes as the nemesis of the telephone industry. "It's the major hurdle the telcos need to overcome in order to increase bandwidth."

Refi found three problems with the multipair transmission platform: loss, bandwidth and crosstalk. It was further research into the latter of these three woes that led to several exciting pinnacles for Refi.

"Crosstalk is not something we generally consider in coax or fiber, but with multipair twisted cable, it's a severe limitation," Refi says. "What happens is, signals can couple off one pair to another pair in the cable, introducing noise. That noise is called crosstalk."

Refi's research on crosstalk helped him to provide a hands-on, predictive model of expected crosstalk performance in multipair cables. His work on the subject won him an award at an International Wire and Cable Symposium in the late 1970s.

"There had been a lot of theoretical work done on crosstalk, but nothing that was useful and practical," Refi says. He says the crosstalk findings were the closest he's ever come to feeling like Thomas Edison (who literally tried thousands of times to manufacture a light source before coming up with the light bulb). "It was kind of exciting to discover something no one had ever heard before," Refi recalls. "You think, gee, I may be the only person in the world who knows this."

Also in the 1970s, the Refi family moved to the Atlanta area.It wasn't until 1982, however, that Refi began his work on fiber optic technologies. "Fiber was in its infancy; it wasn't until 1984 that single-mode fiber was starting to be used commercially," Refi explains. His early fiber work included predictive bandwidth modeling for multimode fiber.

When singlemode fiber hit the communications scene in a bigger way, Refi jumped in with both feet. "Along with the standard work on the 1310 nm operating wavelength, I did some exploratory work on the limitations of chromatic dispersion at the 1550 nm wavelength," Refi explains.

Refi says his work shifted toward applications in the late 1980s, when he started to investigate telco fiber-to-the-curb topologies. Apparently, he liked the shift, because in 1991, he joined a product management group within the company. "I decided to do that because I enjoy working with customers," Refi explains.

Also in 1991, Refi wrote a book titled "Fiber Optic Cable–A Lightguide." Ever the teacher, Refi's explanatory style shines through in the 208-page text. "I enjoy explaining things," Refi admits.

Personal infrastructure

At home in Atlanta, Refi and his wife, Paula, will celebrate their 25th anniversary this month. They have two children: Karl, a 21-year-old architecture student at Clemson, and Katherine, a 17-year-old who starts art school this month. He's a devoted family man who built a soundproof room in his basement so as not to discourage Karl's high school interest in the drums.

Problem was, it was a half basement already filled to capacity by the furnace and other household objects. So Refi, an avid do it yourselfer, simply changed the infrastructure of his 50-year-old home by enlarging the basement. "I got a 25-ton hydraulic jack and actually jacked the house up to put in the support beams," Refi says. "What a feeling of power that is, to lift up your house." After two years of labor and lots of careful research at the local library, the Refis successfully soundproofed the room.

And now that Karl is a budding architect, the elder Refi has only one comment about his silent basement: "Anyone need a set of drums?" CED

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Fiber: We've come a long way

By Wendell Bailey, VP of Science and Technology, NCTA

Using light to communicate information across distances is a technique that is quite old. The use of flares or fires to alert one camp to another camp's information is a technique that we only see in history books and anthologies today, but the remnants of such light signals still remain.

If you go to any of the nation's East Coast beaches and watch the lifeguards signal from chair to chair with red flags, then you know what I mean. The flags are red for a variety of reasons, not the least of which is that historically, red symbolized fire. Signal flags are used in the same way burning torches were used in earlier times.

19th century photophone

In the 1880s, Alexander Graham Bell developed the photophone, a technique in which he proposed that voice signals could be sent by modulating light. It wasn't until the Englishman John Tyndall proposed a technique which might be of use, which was to guide light in a stream of water. Specifically, this principle is known as total internal reflection (which is how fiber optic cables work today, of course).

It took over 65 years before Norman French received a patent for an optical telephone system in which he used glass rods instead of streams of water to achieve total internal reflection.

The problem with Mr. French's optical transmission system was that it didn't work. It was simply a theoretical model on a proposed application. The primary obstacle faced by Mr. French (and all the other people with ideas about the use of light transmission)was that there was no good photon source for pushing light through solid glass rods for any useful distance.

It took until the late 1950s before Arthur Schawlow and Charles Towns developed the laser. After there was a light source that would drive signals through glass rods, they realized that glass rods were not the best medium with which to accomplish their goal of sending information over distance.

Back to the drawing board

In the mid 1960s, English scientist Charles Kae and George Hockham first suggested the use of glass fibers for light transmission. They also posited that the light fibers would have to show losses of no more than 20 dB per kilometer if they were to be useful. Alas, the fibers that were being developed in that same period had attenuations that were 500 times worse than this target parameter.

But even with that bad a record, glass fibers were useful for certain applications. In fact, these fibers were even used in scientific and medical pursuits, for the direct observation of certain hard-to-reach places, such as inside complicated equipment or human beings.

It wasn't until about 1970 that fibers manufactured using Corning's step index technique achieved the appropriate low level of loss that was needed to make practical transmission systems. And today, of course, our losses are 100 times less than even the modest suggestion of Kae and Hockham.

The first fibers were multiple mode fibers, and while they had their uses and continue to be useful today for certain applications, the needs of the telecommunications world were more difficult to meet. Today, we use singlemode fibers to achieve some extremely low transmission losses at the wavelengths of interest to us.

Other fiber users

I was surprised to learn (at a conference several years ago) how other industries use fiber optic cable and fiber optic components. The automobile manufacturing industry, for example, purchases a respectable amount of optical cable in a given year, primarily for remote observation of signal lights inside modern automobiles.

Not all fibers are made of glass. Many people are surprised to learn that there are fibers made of plastic. While they don't operate with the same transmission efficiency as glass fibers, plastic fibers still have their uses, nonetheless. Some of the most spectacular score boards used in sports stadiums around the country make use of bundles of plastic fiber to transmit images to the outdoor display.

The use that our industry has put fiber to probably best justifies the efforts that went into its development. I'm not saying the transmission of cable television signals is blessed in some way, but rather that we have a need for a large amount of bandwidth, all at once.

All of the uses others put the fiber to have been relative pikers when it comes to spectrum needs. Twisted copper pairs have the necessary capacity to transmit not only multiple voice signals, but a fair amount of data as well. With current ADSL and HDSL techniques, twisted pair copper can even handle video.

As ubiquitous as fiber is, there are still many things we don't understand about it.

No, these others have their right to claim credit for the development of the technology, but the ability to use its inherent capacity is what will allow us to truly open up its real usefulness. At the same time, we're opening up our own future. But our fascination with light is not anywhere its adulthood, as it were.

As marvelous as the fiber is and as ubiquitous as it is becoming in our everyday lives, there are still many things we don't understand or know about.

The recent articles about PMD, for example, illustrate the issues that can come up even after an industry has embraced a technology and used it in a day-to-day scenario. Caveat emptor. CED

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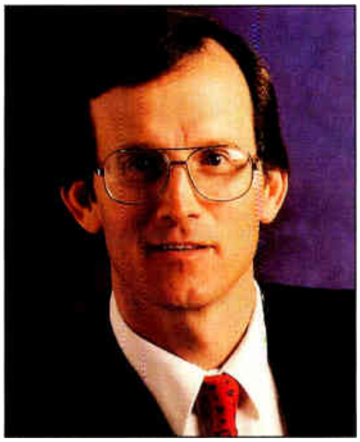

Resonant circuits, filters and traps: Part 3

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

This month we will examine a concept called "Loaded Q." The information presented here, and in the next several columns will be adapted from my book RF Circuit Design[1], and various data supplied by the "trap" vendor community.

The Q of a resonant circuit was defined in an earlier column to be equal to the ratio of the center frequency of the circuit to its 3-dB bandwidth. This "circuit Q", as it was called, is often dubbed *loaded* Q because it describes the passband characteristics of the resonant circuit under actual in-circuit or loaded conditions. The loaded Q of a resonant circuit is dependent upon three main factors:

1. The source resistance seen by the resonant circuit, R_S.
2. The load resistance seen by the resonant circuit, R_L
3. The Q of each individual component in the circuit.

Next month, we'll examine component Q in some detail, but this month, let's briefly discuss the role that source and load impedance play in determining the loaded Q of a resonant circuit. Last month, we printed a resonance curve for a circuit consisting of a 50 ohm source, a 0.05 µH lossless inductor, and a 25 pF lossless capacitor. The loaded Q of this circuit, as determined from the graph, is approximately 1.1. Obviously, this is not a very narrow-band or high-Q design.

But if you replace the 50 ohm source with a 1000 ohm source and again plot the results, you will get a much different picture. This contrast is shown in Figure 1. Note that with a 1000 ohm source, the Q , or selectivity of the resonant circuit, has been increased dramatically to about 22.

Note, however, that these plots assume that there is no load impedance affecting the performance of the resonant circuit. If, in addition to the source impedance, a load impedance were attached to the resonant circuit (as is normally the case), the effect would be to broaden or "de-Q" the response curve to a degree that depends on the value of the load resistance.

In this case, the equivalent circuit for resonance and Q calculations would be the combined equivalent parallel resistance of the source and load in shunt with the resonating inductor and capacitor. Therefore, the resonant circuit "sees" an equivalent resistance of R_S in parallel with R_L as its true load. This total external resistance must be, by definition, smaller in value than either R_S or R_L, and the loaded Q must therefore decrease.

If we put this observation in equation form, it becomes (assuming lossless components):

$$Q = R_P/X_P$$

where,

R_P = the equivalent parallel resistance of R_S and R_L

X_P = either the inductive or capacitive reactance (they are equal at resonance)

The above equation illustrates that a decrease in R_P will decrease the Q of the resonant circuit, while an increase in R_P will increase the circuit Q. It also illustrates another very important point. The same effect can be obtained by keeping RP constant and varying X_P. Thus, for a given source and load resistance, the optimum Q of a resonant circuit is obtained when the inductor is a small value (low value of inductance) and the capacitor is a large value (high inductance). Therefore, in either case, X_P is decreased.

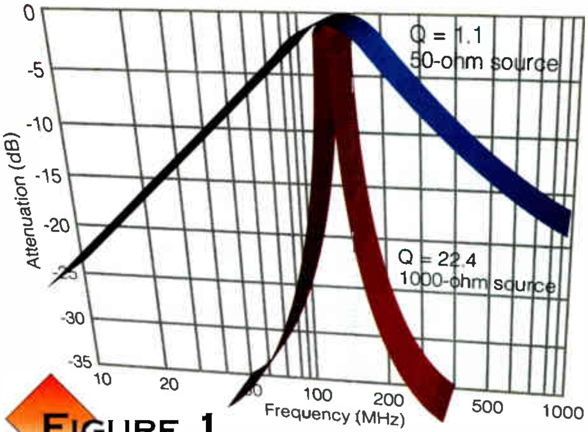

FIGURE 1

The circuit designer, therefore, has a couple of different approaches in designing a resonant circuit with a particular Q. Either select an optimum value of source and load resistance, or select component values for the inductor and capacitor which will optimize Q. In reality, however, there is likely no choice in the matter, because the source and load are usually defined and we have no control over them.

When this occurs, X_P is automatically defined for a given Q and we can quite often end up with component values that are very impractical. But circuit designers, being very resourceful types, have come up with numerous design methods (tapped C and tapped L transformers, for example) to minimize such problems. But these are outside the scope of this column.

What does it all mean?

So what? The point of all of this is that the performance of filters (traps) can be greatly affected by the characteristics of the circuit or system in which you insert them (R_S or R_L). In addition, so far this analysis has been greatly simplified by assuming the resonant circuit or filter sees nothing but a pure resistance as its source and load. In reality, this is rarely the case, and the source or load will likely consist of an impedance which has both pure resistance and either capacitive or inductive reactance and which may vary.

If this is the case, the circuit designer must incorporate the characteristics of the external network (capacitive or inductive reactance, if known) into the resonant circuit or filter design. Therefore, the network within which the filter resides actually becomes part of and therefore helps to shape the characteristics and performance of the filter. If the filter is removed from the network for which it was optimized, and placed in another network, or, if the characteristic impedance of the network changes, the performance of the filter is likely to change to some degree determined by the new source and load impedance that the filter sees. CED

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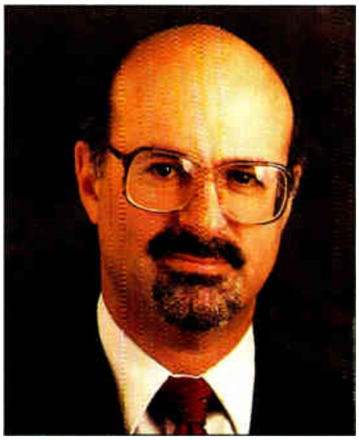
1. Bowick, Chris, RF Circuit Design, SAMS, (a division of Macmillan Computer Publishing,) Indiana, 1982-1991.



HDTV: The Grand Alliance

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

The FCC's process to select a standard for HDTV was redirected recently, when the proponents of the four digital HDTV formats created a "Grand Alliance" (GA) to produce a single system that incorporates the best features of the four. But this appears to mean a delay in the decision process, as the details of the single system are determined. Here's what we know so far.

Who is the Grand Alliance?

The GA has seven members: AT&T, General Instrument Corporation, David Sarnoff Research Labs, Massachusetts Institute of Technology, Philips Electronics, Thomson Consumer Electronics and Zenith Electronics. These were previously organized into three teams: AT&T and Zenith; GI and MIT; and Sarnoff, Philips and Thomson.

Picture formats. The GA system will support both progressive scan and interlace scan picture formats. The formats are:

✔ 960 x 1,728 pixels/2:1 interlace/60 Hz
✔ 720 x 1,280 pixels/1:1 progressive/60 Hz

The interlace format thus has 960 "active" lines of video, or about 1,050 total lines if the vertical blanking interval is included. The progressive format has 720 active lines, or 787 total lines. In addition, both 24 Hz and 30 Hz film formats are supported, in both the interlace and progressive scan formats.

There will be format converters available to convert (if needed) from the production format to the transmission format, and TV receivers will contain format converters to convert (if needed) from the transmission format to the "native" display format of that receiver. The GA system specifies a transmission format only.

TV receivers will use a single "native" display format and will employ format conversion to convert the transmission format to the display format. Displays used for entertainment video will probably use interlace format, at least during the early years of HDTV. But computer monitors will employ a progressive display format, to eliminate the inter-line flicker that interlace monitors can exhibit. The additional cost of format conversion in the receiver will be small.

The GA format decision is a compromise between the computer industry's support for progressive format and the broadcasters' support for interlace format. The compromise is possible only because of format conversion. For example, material shot with a camera can be produced and transmitted in interlace format, and converted to progressive in computer monitors, while films and computer animations, which are produced in progressive format, can be transmitted in progressive format and converted to interlace in home entertainment displays.

For the near term, there are HDTV cameras that employ interlace format with 1,125 lines (Japanese) and 1,250 lines (European). Pictures from these cameras can be converted to 960 lines for distribution in the United States. There are no progressive scan HDTV cameras on the market, but there is development work underway.

The eventual goal of the GA is a 960 x 1,728 pixels/1:1 progressive/60 Hz format for transmission, when the technology improves enough to support it. The broadcast industry has expressed a desire for an eventual HDTV production standard with a 1,080 x 1,920 pixel format. But the GA believes that a 1,080 x 1,920 transmission format is not feasible in a 6 MHz bandwidth. Moreover, a 960-line format allows easier up-conversion of NTSC program material, since 525-line NTSC pictures have 480 active scan lines.

MPEG compatibility. The GA system will use MPEG-2 syntax but a non-MPEG compression algorithm. It will include MPEG's I and P frames but not B frames. B frames will not be used because they add cost (memory) and complexity and increase channel acquisition time.

Audio. Three surround sound audio formats are being evaluated: Dolby AC-3 (composite channel coding), MIT AC (independent channel coding), and Musicam 5.1 (composite channel coding). The evaluation will consist of complexity analysis, subjective testing and testing of compatibility with other audio systems (e.g., Dolby Pro Logic and MPEG-1).

Transport. The GA system employs a packetized, prioritized data transport format. The MPEG-2 Systems Working Draft (June 12, 1993) will be used as a reference in reaching a final specification.

Transmission. The GA will select a modulation format from one of the following:

✔ 4 VSB
✔ 6 VSB (modification of 4 VSB with trellis coding)
✔ 32 QAM
✔ 32 Spectrum Shaped QAM (two carriers).

The GA will make this decision by the end of November, based on a theoretical analysis and (if needed) laboratory tests. The most important factor in the analysis will be the relative coverage areas of each modulation format, and the relative amount of interference caused into current NTSC service areas. Other factors in the decision will include robustness (immunity to multipath and phase noise) and receiver cost.

Implementation/development plan

The GA has promised to deliver a prototype system for testing in nine months, which would be May 1994. This testing will be done at the Advanced Television Test Center in Alexandria, Va. It will be followed by field testing in Charlotte, NC. The FCC's Advisory Committee could probably report its recommendation to the FCC by late 1994, and the FCC might then adopt a standard in mid-1995.

This seems like a delay of about a year–the FCC was planning to make its decision in 1994. But the HDTV selection process was actually heading for an impasse. The four formats were all going to be submitted for retesting because thay had all been improved. These improvements would have made it impossible to pick a winner. They would all have performed very, very well if they had been tested.

Thus, the formation of a Grand Alliance was not only a prudent business decision by the seven members, but it was also a good public policy decision because it substantially increased the likelihood that there will be a selection of a single HDTV standard for the United States. CED

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Circle Reader Service No. 11

Testing and troubleshooting techniques for the passive branching plant

By Marvin D. Ashby, Supervisor of Applications Engineering, and Stephen T. Ferguson, Applications Engineer, Siecor Corp.

The use of optical splitters is steadily increasing as systems migrate toward passive optical networks (PONs) to allow MSOs to share the vast bandwidth capability of an individual fiber among multiple subscribers. Additionally, the reduction of the number of active components in some system architectures improves system reliability to make the provision of increased bandwidth more cost effective.

A variety of PON architectures have been presented in literature for the provision of multimedia services. The commonality among the different network approaches is the use of a point-to-multipoint architecture regardless of whether the optical splitting occurs near the headend or at the far end of the system near the subscriber site. Some discussion and implementation is even being realized for integrated PONs which overlay video services with voice and data transmission in the form of a shared distribution channel.[1]

A study has been conducted to better understand the complexities and limitations involved when testing a branching network.

The architecture of the PON operating system introduces a number of new issues, beginning with the initial design through system operation and maintenance. The complexities of the system design have been addressed as well as techniques for optimizing the optical cable plant in these point-to-multipoint applications.[2] However, techniques for verifying system performance and fault location have only been approached in recent work.[3]

This paper focuses on the methodology and issues relating to the testing and troubleshooting of PONs used in cable TV systems, both during the initial system build phase as well as during operation. Recommendations will be presented for the most efficient techniques to properly verify system performance and for troubleshooting the system in the occurrence of an outage.

Building the path

A study has been conducted in order to better understand the complexities and limitations involved when testing a branching network with commonly employed test equipment such as the Optical Time Domain Reflectometer (OTDR) and optical test sets.

Three different systems were constructed and evaluated. The first system is based on a 50/50 multiple index technology splitter (see Figure 1). The second system is based on a 25/75 multiple index splitter (see Figure 2). The third system is a cascaded splitter configuration utilizing a 25/75 splitter in the front followed by a 50/50 splitter spliced to the 75 percent power output port (see Figure 3). The optical path lengths were chosen to be of sufficient length to preclude any measurement limitation issues.

For any system which incorporates optical splitters, care must be taken to characterize the system's performance before introducing these splitters into the net-

FIGURE 1

Branching system with 50/50 splitter

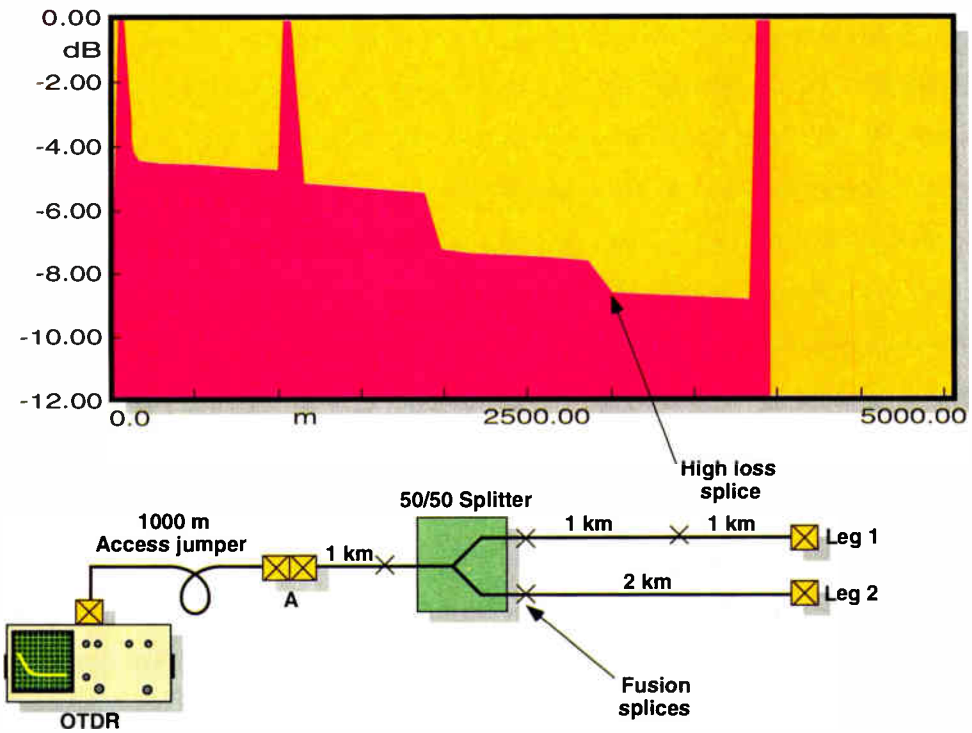

TABLE 1

OTDR bi-directional splice loss[A]

Splice loss w/o splitters (dB)			Splice loss w/ 50/50 splitter			Splice loss w/ 25/75 splitter			Splice loss w/ cascaded splitters		
Dir 1	Dir 2	Avg	A-Leg 1	Leg 1-A	Avg	A-Leg 1	Leg 1-A	Avg	A-Leg 1	Leg 1-A	Avg
2.13	2.07	2.10	0.96	2.07	1.52	1.82	2.07	1.95	1.22	2.07	1.65

Note: [A] These attenuation measurements were taken at 1310 nm.

work. As discussed in earlier work[3,4], OTDR measurements through optical splitters have been shown to yield apparent attenuation results much lower than the actual values found through conventional fiber systems. This "lower" attenuation is a result of the backscatter contribution from multiple legs on the splitter and is not always consistent.

A fusion splice of considerable loss was placed in one leg (Leg 1) of each of the three systems and measured to determine the apparent loss of this splice as compared to the bi-directional OTDR measurement taken before splicing the splitter(s) into the system.

System splices can also be concealed or lost due to the combined backscatter level being received by the OTDR through the branching component. This concealing of features is a result of the higher background backscatter level received from multiple legs on the splitter and is dependent on the reflection level from those legs.

(Note: As shown in Table 1, in order to verify each portion of an optical system for performance, any bi-directional splice loss, fiber attenuation and leg length measurements using the OTDR should be taken before inserting the branching component into the system.)

This procedure does not adversely affect completion of the cable system because the splitter locations must be accessed during the splicing process. Performance can be verified against system design requirements to ensure operation of the completed link. Any cable lengths or splice loss deviating from the design requirements can be easily detected and corrected.

Ultimately, this step will allow accurate splice loss measurements to be determined as well as more precise length measurements to these splice points and the leg lengths to be documented. However, OTDR bi-directional splice loss measurements may not need to be performed if fusion splices in the system legs can be completed with a splicer which incorporates local injection and detection techniques or profile alignment techniques to optimize fiber core alignment and provide accurate splice loss estimation.

Cable systems which include unterminated splitter legs present unique problems.

Splitter implementation

The splitter or other branching component can now be installed in the verified optical system. Because of manufacturing variability, most branching components manufactured today are 100 percent tested for performance characteristics by the splitter manufacturer. These performance values can be used for system design and implementation as field verification of these performance values is difficult. Once the splitter is installed in the system it is impractical to resolve the contribution of the adjoining splices or connectors from the actual splitter performance.

Fusion splicing of the splitter ports to the system can be completed with a splicer which utilizes profile alignment techniques to optimize fiber core alignment unless fiber coating diameter permits the use of local injection and detection techniques. Each system's estimated power loss was determined using these splitter performance values. The results are presented in Table 2.

After completion of the cable system incorporating the optical splitters, optical power loss measurements should be taken to qualify the cable plant's performance. Power loss measurements must be determined through each leg or port of the installed splitter.

A comparison of these test results to the end equipment specifications will assure the overall integrity and satisfactory performance of the cable plant. A comparison of the actual power loss measurements taken for each design system is presented in Table 3.

These test results show several key issues regarding splitter technology. First, 50/50 multiple index splitters do show some degree of port-to-port attenuation difference. The testing completed for this paper showed a maximum port-to-port difference of 0.4 dB.

> **The sharing of active sources leads to some unique occurences when a system fault occurs.**

Second, system design regarding splitter power loss should utilize the maximum insertion loss specified by the branching component manufacturer. These insertion loss values given by the manufacturer include the theoretical splitting ratio, excess loss, and uniformity over the specified passband or operating wavelengths.

Cable systems which include unterminated splitter legs present unique problems during testing and documentation. This unterminated leg may present a reflection at the splitter location that can be detrimental to the performance of AM video systems. Depending on the magnitude of the reflection, the apparent loss of the components in the system can be dramatically impacted.

A higher magnitude reflection will make the apparent loss of the splitter appear to be less. Accurate documentation on the cable plant and initial OTDR leg length measurements will ensure that this unterminated leg does not present a problem during restoration and upgrades. If this unterminated leg is spliced to another service area at a later date, OTDR signature traces and power loss measurements should be repeated to ensure complete system history documentation.

The sharing of active sources and optical distribution paths by multiple subscribers or service areas leads to some unique occurrences when a system fault occurs. When a fault occurs in the distribution sector prior to the optical split, all of the customers in that link may be affected. If a fault occurs downstream of the splitter, then only the users serviced by that particular leg of the splitter will be impacted. Report of a system fault can quickly lead to a determination of the portion of the system that will be affected.

A changing picture

An investigation of the capabilities for troubleshooting a system fault were examined by introducing a fiber break in one output leg of the 50/50 splitter in the cascaded system of Figure 3. The break was introduced near the original high loss splice point. The resulting OTDR trace of the interrupted system taken from the transmitting end is shown in Figure 4. Several changes of interest occur due to the broken span.

First, the fiber break coincides relatively close to the reflective termination of the 25 percent leg out of the 25/75 splitter. The pulse width of the OTDR was approximately 1,000 nanoseconds. The longer pulse width becomes necessary to support the dynamic range required for examining these types of passive systems. As a result, the reflection from the now broken fiber contributes to the apparent width and magnitude of the reflection introduced by the 25 percent leg.

This contribution to the magnitude was approximately 3.25 dB. Also, this change in reflection height resulted in the initial reflectance of -42 dB of the 25 percent leg to be altered to a reflectance including the broken fiber contribution of -36 dB. This reflectance contribution is dependent on the fiber break endface characteristics.

The second noticeable change is the last end-spike representing the system termination at the end of the 50/50 output legs is diminished. The reflection height is reduced from 4.8 dB to 4.0 dB.

These observations result in several important points. Accurate, detailed records are invaluable for the troubleshooting and restoration of an operating system. Without an original system trace for comparison, no baseline is available for which to compare the current system signature. Walking through a branching network "blind" without system layout documentation is virtually impossible.

The original OTDR signature traces should be pulled from the as-built system documentation as a point of reference for fault determination. If the affected service area appears to be upstream of the branching device, then conventional fault location procedures can be employed. Faults downstream of the branching component may be detected with an OTDR for simple networks.

In the example shown, a system problem has developed at approximately 3 km of fiber length out from the transmitter location. Based on the system layout, this event could be introduced by the 25 percent leg of the 25/75 splitter or by one of the outputs from the 50/50 splitter which extends beyond this distance.

Because the width of the reflective point is increased, the 25 percent leg can be eliminated assuming identical OTDR set-up parameters. Any fault on this span may alter the location or the magnitude of the observed reflection, but would not impact the width of the observed feature.

Power loss testing is the true final test of the optical link performance.

The OTDR trace may not pinpoint the exact location of the fiber fault, but can narrow the focus of the search area. Any further fault isolation now depends on the information received from the customer base which typically precedes the system troubleshooting. This information will focus repair crews on the suspect system link.

Resolving the exact location of the fault must now be done from the receive end or access must be gained to the system after the branch due to limitations introduced by the splitters. Access to the fiber under question may be difficult depending on system layout and construction techniques, but should be considered during the design phase for these very reasons.

Resolving fault location

After access has been gained to the suspect link (from Figure 4), an accurate distance to the fault location can be quickly determined with the OTDR. The OTDR trace taken from the receive end of the damaged path is shown in Figure 5.

A fiber overlength relative to cable sheath length value must be calculated to properly locate the distance to the fault. This is a result of the excess fiber length in fiber optic cables. A general procedure to locate the fault is given below.

Determining sheath distance to an optical fiber fault: a fault location procedure.

✔ Step 1: Calculate the fiber overlength

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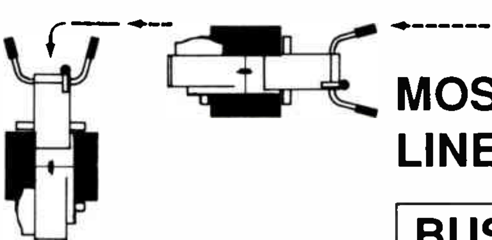

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correction factor.

a) System records should provide the fiber length to a splice point. If these records are not available, locate a splice point or other optical feature with the OTDR and record the fiber distance. This should be done while still at the transmitter site. A splitter can be selected as a known feature.

b) Measure the length to the splitter to obtain the fiber length.

c) System records or route diagrams should provide the cable meter mark at the splitter. Knowing this meter mark will allow the cable sheath distance to be determined.

d) Calculate the fiber overlength correction factor.

$$\text{Correction Factor} = \frac{\text{Cable Sheath Length}}{\text{Fiber Length}}$$

✔Step 2: Locate the fiber fault with the OTDR.

a) It is essential to establish landmarks when measuring fiber distance to a fault. Measure fiber distance to a fault from the nearest splice point, demarcation point, or other fiber anomaly. This allows for a more accurate distance measurement than measuring the fiber distance from the beginning of the OTDR trace. The access jumper from the OTDR serves to improve this resolution when testing from the receive end where no features occur before the break.

✔ Step 3: Calculate the cable sheath distance to the fiber fault.

Cable Sheath Length = Fiber Length x Correction Factor

✔ Step 4: Determine the cable sheath marking at the fault.

a) Calculate the cable sheath marking at the fault location by adding or subtracting (as appropriate) the distance to the fault by the sheath mark at the chosen landmark location. Locate this cable sheath mark in the field and inspect the cable carefully in this vicinity for any signs of damage.

When determining the cable sheath distance and cable sheath marking at the fault, remember to take into consideration any slack loops left during the initial cable installation. Forgetting to include these slack loops may cause your repair crew to start accessing the wrong cable location.

FIGURE 2

Branching system with 25/75 splitter

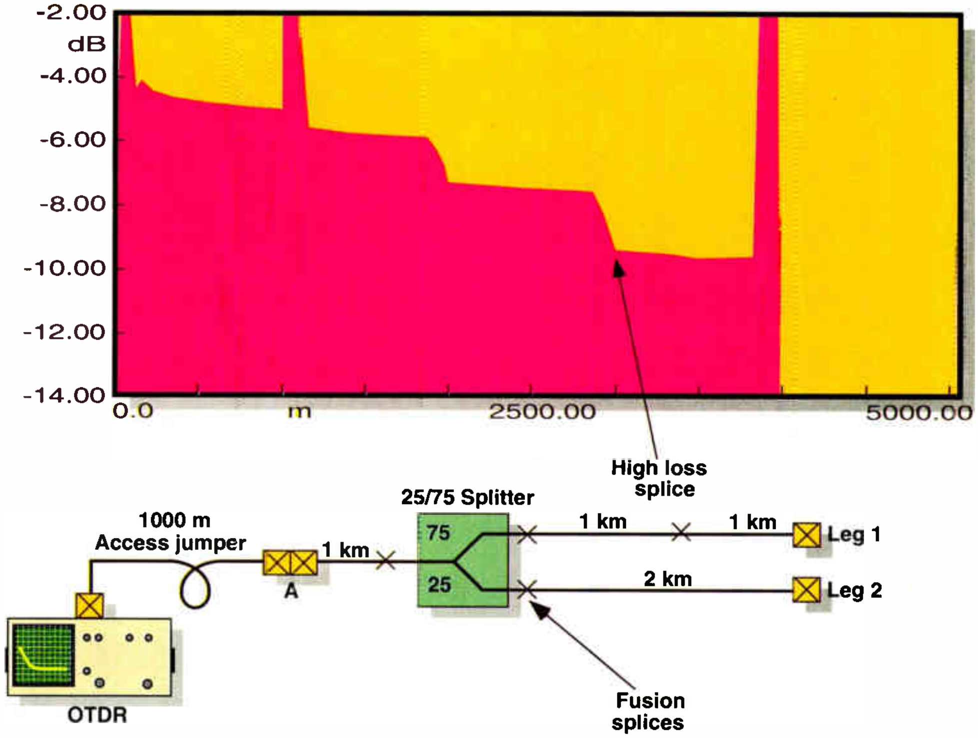


FIGURE 3

Branching system with cascaded splitters

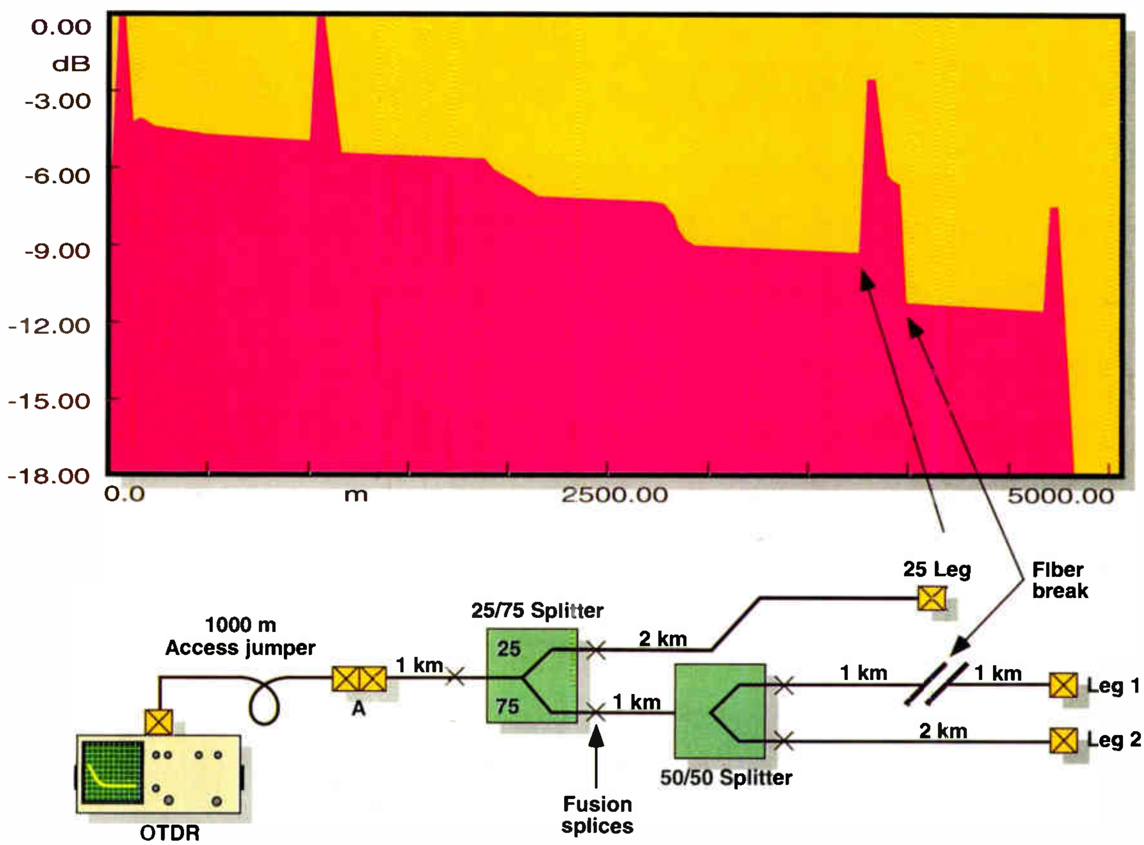


FIGURE 4

Branching system with cascaded splitters and fiber fault

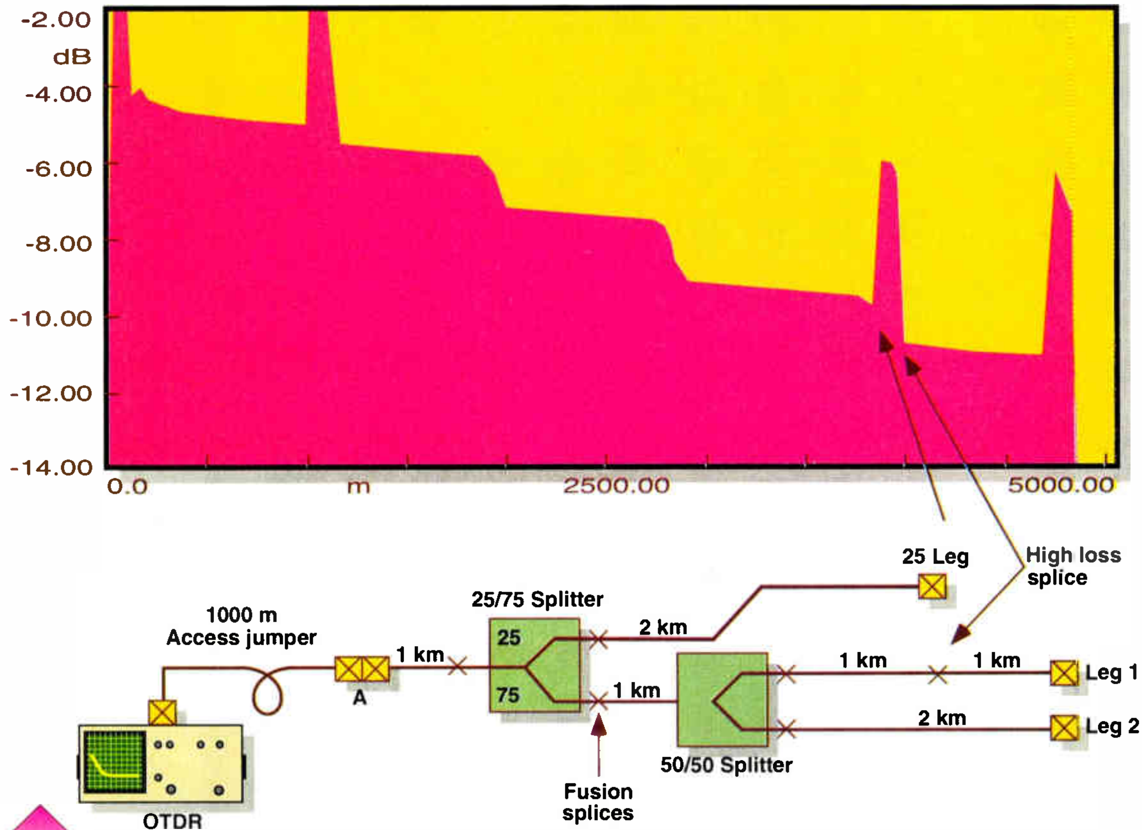
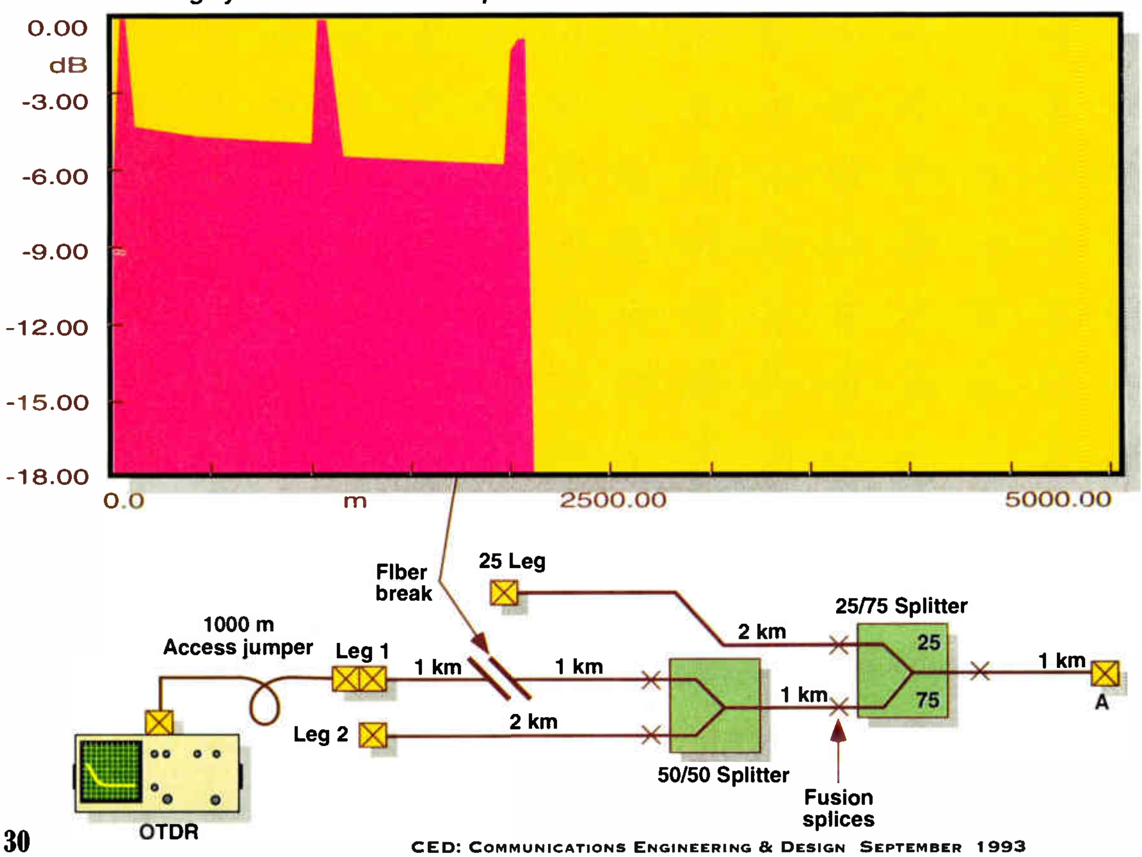


FIGURE 5

Branching system with cascaded splitters and fiber fault



Conclusion

The OTDR is a limited but useful tool in testing and troubleshooting passive optical networks. It can be used for determining true splice loss through bi-directional splice loss averaging, as well as to verify system links before system completion. Once the branching component is installed, true loss measurements of optical anomalies and system components can no longer be obtained with the OTDR.

Uni-directional loss measurements can be performed on a feature or component preceding the branching device, however, these values are only useful if the OTDR operator is aware of the variability associated with these types of measurements.

However, just as with conventional networks, power loss testing for each leg of the completed branching network is the true final test of the optical link performance.

The OTDR can still be used effectively for system troubleshooting provided accurate documentation is available; this documentation must include an accurate layout of the system architecture to include as-built lengths for each branch of the network along with the link component characteristics.

However, the OTDR may not pinpoint specific splitter leg faults, but can narrow the focus of the search area. The OTDR can be used to determine accurate length measurements to resolve the location of system features or distances to induced faults once the specific path leg(s) is determined through the inclusion of subscriber service information.

Access to the system beyond the branching

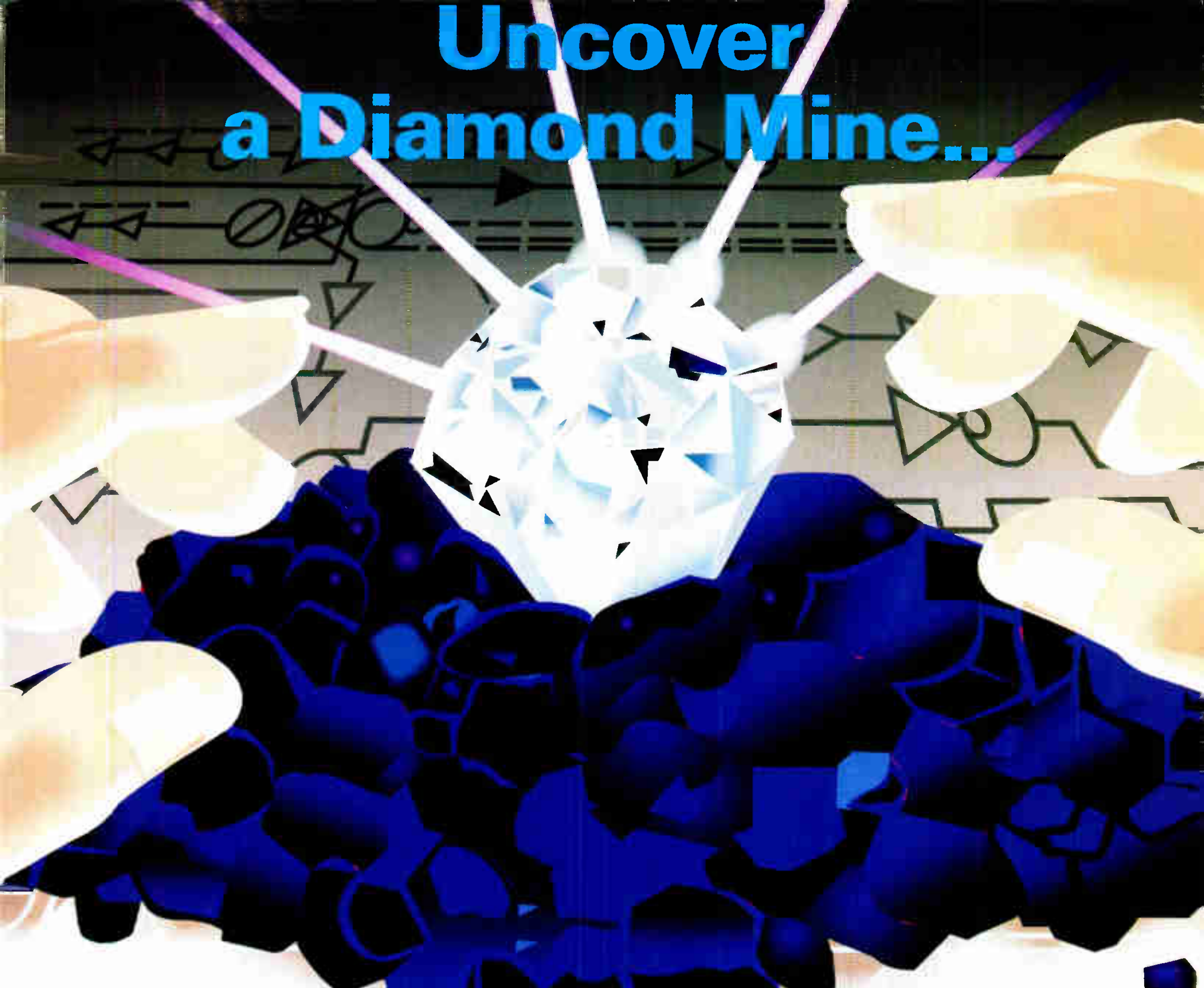


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TABLE 2
Estimated power loss calculations[A,B]

System link	50/50 Splitter system (dB)	25/75 Splitter system (dB)	Cascaded splitter system (dB)
A-Leg 1[C]	8.3	6.2	10.6
A-Leg 2	6.2	9.3[D]	8.6
A-25% Leg	-	-	9.3

Note: A The following maximum component attenuation values were used to determine this table:

Fiber attenuation -	0.4 dB/km
Fusion splice loss -	0.1 dB
50/50 splitter (both ports) -	3.8 dB
25/75 splitter (75% port) -	1.7 dB
25/75 splitter (25% port) -	6.8 dB
Connector pair loss (D4PC) -	0.5 dB

B These estimated power loss calculations were determined at 1310 nm.
C Leg 1 incorporates the 2.09 dB high loss splice.
D Leg 2 of this system was spliced to the 25% power port.

TABLE 3
Actual power loss measurements[A]

System link	50/50 Splitter system (dB)	25/75 Splitter system (dB)	Cascaded Splitter system (dB)
A-Leg 1[B]	7.6	6.0	10.4
A-Leg 2	5.9	9.1[C]	8.5
A-25% Leg	-	-	9.2

Note: A These attenuation measurements were taken at 1310 nm.
B Leg 1 incorporates the 2.09 dB high loss splice.
C Leg 2 of this system was spliced to the 25% power port.

component may be required to pinpoint a specific fault location. Once this optical fault location is determined, a fiber overlength relative to cable sheath length value can be calculated to properly locate the distance to the fault. CED

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Extending ring topology to hubs creates reliability breakthrough

By the CableLabs staff

Research commissioned by CableLabs has confirmed quantitatively the enormous benefits of incorporating ring topology not just at the regional hub level but inside individual cable systems.

Based on the work done by the three California Institute of Technology mathematicians, Stephen Dukes, former CableLabs vice president for advanced network development, (Dukes has joined 3DO) urged that such fiber hubs be reconfigured using a ring topology that includes two physically diverse points of interconnection to regional hub rings. The reason? The ring approach offers a huge boost in reliability.

A mathematical proof

CableLabs commissioned the exploration of cable design issues because of a need to quantify the reliability of redundant fiber rings linking cable systems regionally—a strategy that was championed by Dukes and which is being translated into many regional rings being built in the United States and Canada.

Designers previously had a good notion of the money to be saved by migrating functionality like antenna farms and modulators from individual systems onto shared regional rings. But they only had a general notion of the reliability boost offered by the redundant-ring topology.

Drawing on a branch of mathematics called graph theory, the researchers concluded that, in their words, "the ring, which is only marginally more expensive than the tree, is enormously more reliable."

Caltech professors Robert J. McEliece and the late Edward C. Posner directed the project, with much of the nitty-gritty analysis being done by graduate student Hongyu Piao. The three used a class of models for communications networks called finite undirected graphs. They made reference to, and built upon, several classic problems of graph theory.

In stark numerical terms, the modeling showed that for a 25-headend regional hub, the mean time to failure (MTTF) would be five months for a distributed-star network, compared to 61.6 *years* for a ring network. For a 50-headend ring, MTTF rises from 74.5 days to 30.2 years.

These gains, commented Dukes, are purchased "at the cost of just one additional link over what the star topology would look like."

Equally dramatic are the implications of this star-versus-ring comparison inside individual cable systems.

"You can take (the model) one step further and migrate the ring topology from the headend to fiber hubs serving, say, 2,000 homes passed," said Dukes. "There again, it's the cost of just one additional link. One has to look at this on a system-by-system basis, but, obviously, that cost falls as you incorporate more and more headends on one regional ring."

Dukes is recommending that a physically diverse fiber link be included in fiber running between headends and 2,000-home hubs. By thus adding what is functionally a second link between fiber hubs, he noted, "you add the ability to provide physically diverse routing in the event of a link failure between the headend and the fiber hub."

The MTTF leaps dramatically because the ring infrastructure is dual or bidirectional, and thus redundant, Dukes said, adding, "There are many protocols we're looking at, including IEEE 802.6, Distributed Queue, Dual Bus and SONET, that will provide this capability."

"This added step," he said, "provides the kind of reliability that is necessary for wireless and wired telecommunications and even for competitive access provisioning, i.e., providing business customers with access to cable's infrastructure."

This performance gain will be essential as cable seeks to position itself as a responsible transport provider in the eyes of businesses and state regulators, Dukes said.

Through these upgrades, said Dukes, cable companies will be able to offer inter-exchange carriers (IXCs) a new, alternative pathway to their business customers: a "virtual private ring" that is actually a separate physical ring within a shared fiber sheath. Thus, they can bypass local exchange carriers (LECs) and reach business customers—presumably at a lower price than what they pay LECs today, Dukes said.

"Of course," he added, "this is an architectural statement. Some will implement it, and some will not. But it's particularly important for those seeking to provide business access and transport."

To achieve these gains, Dukes added, "there's no need to migrate the ring topology below the fiber node level, except in specific cases involving business customers located well down in your infrastructure. In general, having the ring go to the fiber hub is sufficient."

Dukes said this approach provides more redundancy, or a better diverse-routing capability, than (that provided by) telcos, with their central office, remote switching and distributed-star topology. "They, in effect, have a single point into most of their remote switches."

This boosted reliability supports all aspects of cable's implementation of next-generation architecture, which is now being rolled out in Toronto, Orlando, Vermont, Seattle, Long Island, the San Francisco area and elsewhere, Dukes said.

'Life-line' reliability

It means, he added, that cable can provide the kind of "life-line" reliability that is needed for wired and wireless telephony and for transporting data between computers.

Dukes said the Caltech findings have been gaining increasing notice among cable and telco engineers ever since Dr. McEliece presented them at a meeting of the Network Development Subcommittee of CableLabs' Technical Advisory Committee (TAC) in Atlanta in February.

In continuing collaboration with Caltech, follow-up work is focusing on further defining benchmarks for estimating network reliability. CED

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Passive Cable Network Topology

Costs, benefits and drawbacks of passive design

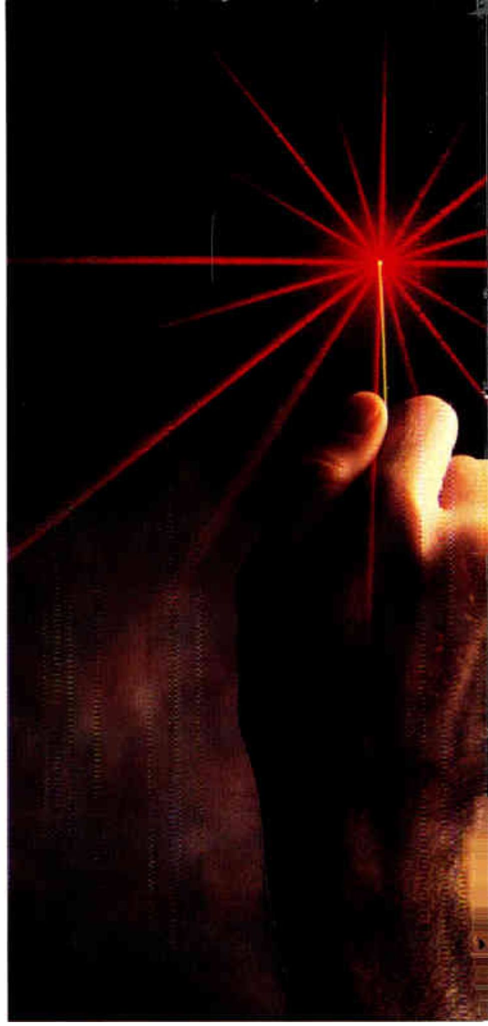


PHOTO COURTESY CORNING INC.

By Joe Selvage, Manager, Systems Engineering and Vel Kurjakovic, Corp. Technology Strategy, Adelphia Cable Communications

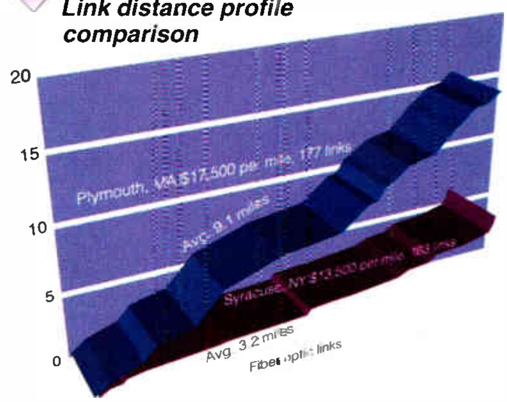
An interesting trend in cable TV network design is the industry's recent attempt to eliminate all amplifiers from its hybrid opto-coaxial network. The only amplification of the signal occurs at the fiber optic receiver. In a purely passive design, the signal is carried from the headend to a node by fiber optic cable, where it is converted, amplified, and sent by the tapped coaxial network to the end user. There, the signal may be amplified by a low noise amplifier (located on the premises), which enables clean delivery of desired video, audio, and data services.

By eliminating active components, several advantages over fiber-to-the-feeder (FTF) architectures are realized. Some of the benefits of the Passive Cable Network Architecture (PCNA) are high reliability, lower maintenance and operating costs, expanded bandwidth in downstream and upstream directions, greater amount of fiber backbone in the network, increased ability to perform network upgrades and "future proofing."

Adelphia Communications Corporation is currently implementing its plan to rebuild a 320 mile cable TV system in Syracuse, NY, with PCNA. This article will outline some of the key steps in the evolution of the design; indicate where and why our initial assumptions had to be changed; and demonstrate how these early redesign efforts led to a viable and cost effective version of PCNA.

First conceptual design for cable TV applications and model testing of the PCNA was carried out by

FIGURE 1
Link distance profile comparison



Cable Television Laboratories in 1992. The PCNA is essentially a fiber-to-the-feeder (FTF) architecture which has been modified at the optical detector and the coaxial feeder segment of the network, so that all RF amplifiers are eliminated from the design. (This elimination of active devices, or amplifiers, is the innovation which makes PCNA "passive.") The PCNA transmits analog AM-VSB signal via fiber optic cables from the headend to the fiber optic receivers, where the signal is converted from optical to electric form, amplified, and distributed by a tapped feeder coaxial cable to a service area of 0.5 miles, consisting of less than 300 homes. In contrast, the FTF service areas average 1,500-2,000 homes (see Figure 1).

The PCNA is a final stage in the transformation of

cable TV network from the conduit of analog signals via a relatively cumbersome, 40 amplifier cascade of trunk and feeder architectures–to a zero cascade, broadband network capable of digital datastream protocols, with the capability to provide a low or a high end video service. This is a key advantage of PCNA. Because the total RF chain of devices consists of only the detector, and of the pre/post amplifier stage of the receiver, the design empowers a cable TV operator with the flexibility to implement far reaching improvements of his network with relatively simple upgrades.

Unfortunately, the high percentage of fiber components within the network quickly inflates costs.

The downstream RF system

A point of reference for our PCNA design is based on the 44 dBmV (at 550 MHz) FTF/Neutral Network with a 9 dB tilt and an eight amplifier cascade. Because the serving area size in our purely passive network model was only 0.65 miles, the amount of fiber used in the network increased dramatically from comparable FTF designs. Consequently, the quantity of fiber cable and optical components is more than four times higher in PCNA than in FTF networks. This disparity is also a reason for the price differential between the two designs (see Table 1).

As we became more proficient in the design of the large scale PCNA, many of the anticipated advantages of the network surfaced. The number of active network elements (consisting primarily of the pre/post amplifier components at the node) per mile ranged from 1.2 to 1.5 . This was an improvement over 550 MHz FTF networks averaging five amplifiers per mile, but the small service area undermined the network reach and costs. The key PCNA parameters are itemized in Table 2.

Our decision to increase the tap output levels from 3 dB to 13 dB eliminated a need for a low noise amplifier at each home. This variation of PCNA, however, still commanded a hefty premium over the comparable FTF networks. A lower service area size increased the length of fiber optic links, expanded the amount of fiber used in the design, and pushed the overall cost of the network some 40 percent higher than comparable FTF architectures. Although we managed to cut the original cost estimates for building of the PCNA (from $20,000 to $30,000 per mile to $17,000 per mile), reducing costs to a target of $13,000 to $14,000 per mile proved more difficult. This objective–to equate the cost of PCNA and FTF networks–became a focal point of our redesign.

TABLE 1
PCNA vs. FTF cost comparison

	PCNA	FTF
Average area size:	*.65 miles/node*	*10-12 miles/node*
Amplifiers per mile:	*1.4*	*5*
Cost per mile subtotal		
FO:	*$ 8,300/47%*	*$ 2,180/17%*
RF:	*5,000/28%*	*6,700/52%*
Labor:	*4,300/25%*	*4,000/31%*
Total proj. cost per mile:	*$17,600/100%*	*$12,880/100%*

Cost issues

The cost cutting efforts focused on two critical areas of the network. These two considerations also impacted areas of network powering and reverse signal transport:

1. Increasing the size of the service area. As can be seen from Table 1, the elimination of amplifiers from the PCNA design did not offset a cost-per-mile increase in fiber optic components. We anticipated that the increase in service area size afforded the deepest cuts in fiber optic costs. This consideration drove our decision to modify our purely "passive" design of PCNA with the introduction of amplifiers beyond the node, in the coaxial segment of the network. The introduction of amplifiers–together with modifications in output ports of fiber receiver and the amplifier–allowed greater feeder network coverage. This increase in service area size was expected to result in a corresponding decrease in fiber costs.

2. Reducing the number of fiber optic components. Some 30 percent of the savings in fiber were a direct consequence of a larger service area. The attempts to reduce the quantities of fiber components also resulted in improvements in network powering and return signal transport.

In an effort to increase service area

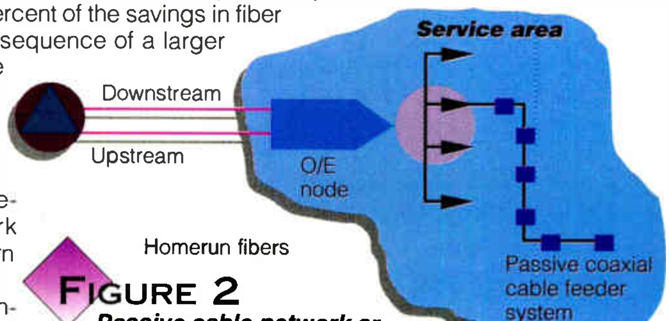
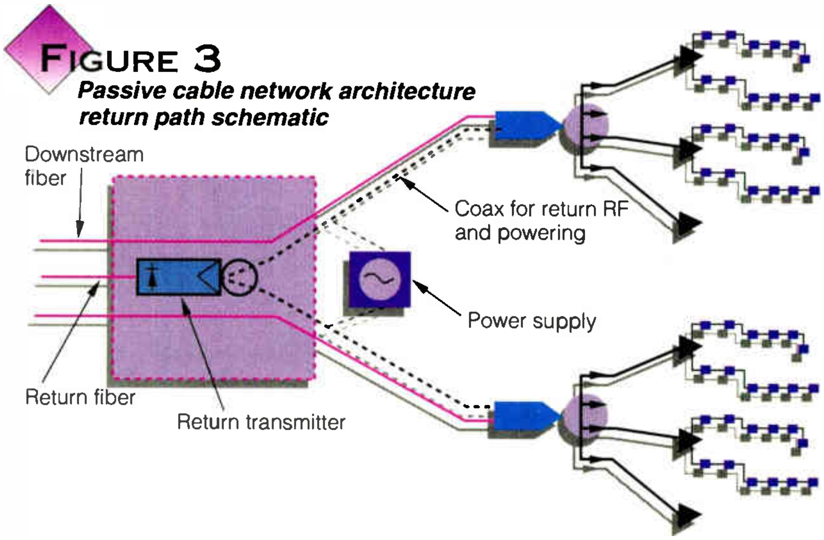


FIGURE 2
Passive cable network ar chitecture ideal schematic

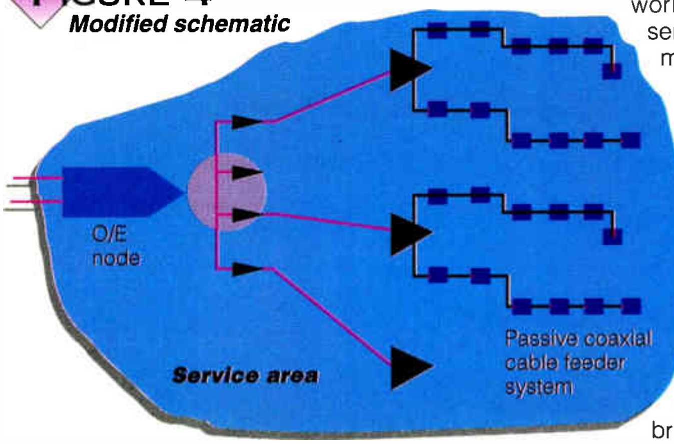
FIGURE 3
Passive cable network architecture return path schematic



size and reduce the number of optical components, several new approaches to PCNA design were considered. One line of thought led us to a less "passive" version of the design. In a truly "passive" design, the optic receiver unit consists of several active components which are used to first detect, then amplify, the signals to a high output level.

The strength of signal and the number of outputs determine the size of the service area. We found that the two outputs of 50 dBmV each appeared to be the optimum output for a node location. A third 50 dBmV output would produce only a marginal increase in the size of the service area. Higher tap outputs producing longer tapped feeder cable runs were required for a more substantive increase in service area (see Figure 2).

FIGURE 4
Modified schematic



We began to explore the possibility of segregating functions of the receiver into its individual parts (mainly detection and pre/post amplification), thus creating separate network components. By separating the preamplifier from the post amplifier function of the receiver, and by moving a post amplifier component away from the node along the coaxial branch of the feeder network, the PCNA reach and service area size were dramatically increased. The service area expanded from 0.75 miles to 2 miles, reducing the quantities of fiber optic transmitters, receivers, and the amount of fiber cable used in the network. These savings cut the overall cost of PCNA by 55 percent and placed the network cost estimates in line with the comparable 750 MHz hybrid FTF designs (see Table 3).

Our studies revealed that 65 percent of the $4,600-per-mile savings (gained by the modified PCNA in the fiber optic component illustrated in Table 3) were incurred by the combination of fewer lasers and their reduced cost. The number of transmitters fell from 74 to 30, while their cost decreased by 40 percent. A decrease in laser costs resulted from our relaxing of network specifications from a 750 MHz, 110 channel analog system to an 80 channel analog/200MHz digital capacity.

These two factors combined to produce a $3,000 drop in the fiber optic costs per mile. Another $1,000 per mile was saved through reduction in optical receivers and $ 500 per mile was cut by using less fiber optic cable. The rest of the savings were attained through unique design modifications in powering and reverse transport, and will be detailed later. The jump in RF cost per mile stems primarily from the cost incurred by the introduction of four post amplifiers in the coaxial section of the network–a step which allowed an expansion of the service area to two miles and a 30 percent reduction in the use of optical components of the network.

By cutting the percentage of fiber optic cable and components in the network the PCNA becomes less dependent on the length of the fiber optic links within the design. A relatively low optical link radius in Syracuse, averaging only 3 miles, was one of the reasons that allowed us to maintain the cost effectiveness of PCNA. There is an obvious need to make the PCNA affordable over longer fiber distances. The fiber link effects on network cost per mile are diagrammed in Figure 3.

We realized that by introducing the post amplifier after the node, the PCNA becomes less "passive" than was originally envisioned and now resembles a one amplifier FTF design. However, our search for the best design continuously balanced issues of feasibility and affordability. The modified PCNA attempts to preserve the best features of a passive design without jeopardizing its cost effectiveness. We believe that

TABLE 2
PCNA design parameters

Network bandwidth:	
Electronics:	*750 MHz*
Passives:	*1 GHz*
Fiber/coaxial:	*1 GHz plus*
Channel capacity:	*80 NTSC, 200 MHz digital*
Amplifier housing platforms:	*1 GHz capable*
Remote post amp. output:	*50 dBmV (A modified version)*
Tap output levels:	*13 dBmV*
Tap output level, C/N:	*46 dBmV*
Tap output level, CTB:	*53 dBmV*

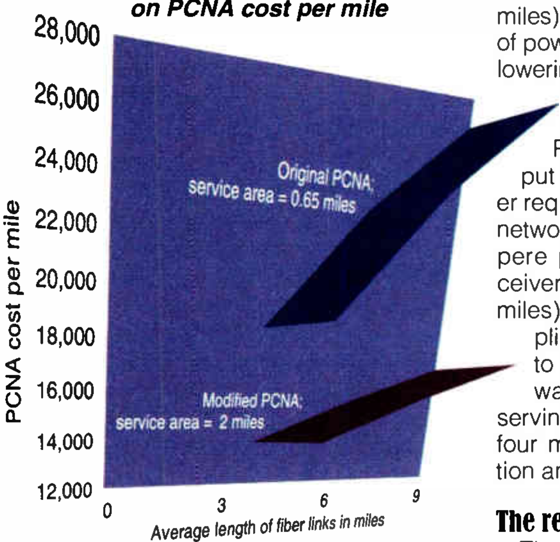
our PCNA succeeds in meeting key network reliability, engineering, and financial objectives while staying within the framework of a passive design.

We also recognize that our modification is but one of many evolutionary designs that will emerge as a consequence of passive network applications. Precisely because of the invaluable benefits of PCNA, further advances in forward and reverse signal transport, fiber count, network power distribution and operations support systems are inevitable.

The powering system

The architecture of the PCNA presented a challenge with regard to usage and location of the network power supplies. The original assumption–that each service area was independent from all others, requiring its own power supply–resulted in the PCNA power distribution of 1.5 to 2 units per mile, or a power supply per mile ratio which was some four times higher than the comparable FTF design.

FIGURE 5
Effects of Average fiber link length on PCNA cost per mile



The pure passive network presents a power system designer with an interesting proposition. Because the fiber optic receiver represents a last active device in the "ideal" PCNA, there is no requirement to transmit power through the coaxial distribution network.

Such a design would obviate a need for the present generation of 60 volt, square wave power sources used by the industry. In the "ideal" PCNA, one could envision replacing all power supplies with a simple 120 VAC outlet on a pole, or even using the alternative power sources (for example, solar power, gas generators, etc.) to supply the network. A great deal of time was spent on establishing new power equipment parameters for PCNA. If, on the other hand, off-the-shelf hardware was to be used, a different design approach was required.

By experimenting with power supply locations and power supply/node ratios, we found that several AM nodes could be connected by a dedicated coaxial cable to a common, centrally located power supply. Initially, this central 6 ampere power supply was designed to supply six to eight AM receivers (or a service area size of three to four miles). Such a solution reduced the number of power supplies by 75 to 85 percent, thus lowering the cost and complexity of the network.

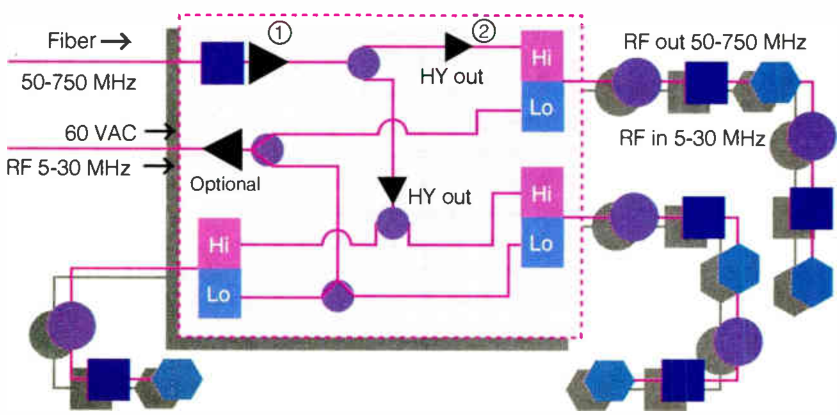
The final, modified version of the PCNA added one amplifier per output of the node, thus increasing the power requirement of the feeder segment of the network. In the modified PCNA, one 12 ampere power supply services two AM receivers (or a service area size of 3.5 to 4.5 miles). Although the number of power supplies per node ratio was raised from 1/6 to 1/2, the power supply per mile ratio was lowered from one power supply serving three miles to one supply serving four miles. (See the Modified PCNA section and Table 3.)

The reverse system

The reverse transport of signals faced similar difficulties previously encountered

Continued on page 53

FIGURE 6
Passive coaxial network node location



A fiber optic documentation system

Keeping your system organized

By Patrick Kelley,
Corporate Senior Project Engineer,
Tele-Communications Inc.

The requirement for accurate documentation of a fiber system begins with the designer and ends with the fiber service technician. Several forms of documentation exist for this purpose and can be obtained from fiber manufacturers and fiber distribution equipment manufacturers. Few of them, however, have been implemented from a CATV systems approach.

Since the fiber technician will be the person, in most cases, responsible for using and updating the documentation in the field, the documentation should be designed with the fiber technician in mind.

Whether your system is being designed in-house or by a subcontractor, it becomes paramount for them to define and document specific fibers and how they will be routed and spliced together. The documentation should define binder and fiber colors within each cable. It should show how fibers of one cable are spliced together with fibers of an adjoining cable (these will often be dissimilar colors).

By allowing the designer to make these decisions, it becomes an integral part of the construction process and relieves system personnel from the burden of deciding which colors go where in the field. It also begins to standardize the management of fiber documentation.

With ring architectures, multiple fibers and the new services being implemented today, fiber documentation must be accurate and easy to maintain and update. Now is the time to begin using computer-based documents for ease of use, storage and modification. To this extent, the following simulated computer based system will be discussed.

Like every "system," there is a minimum amount of equipment required for the designer, contractor and CATV operator. For this purpose, the users must have the following equipment and software:

✔ A 386 SX or DX computer with four megabytes of RAM (preferably portable)

FIGURE 1
Site laser array diagram

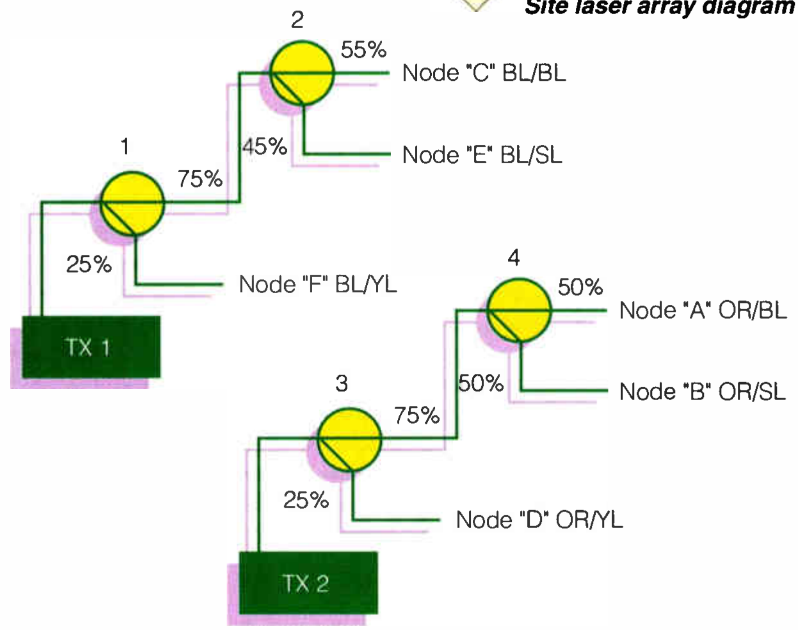


FIGURE 2
Fiber overview diagram

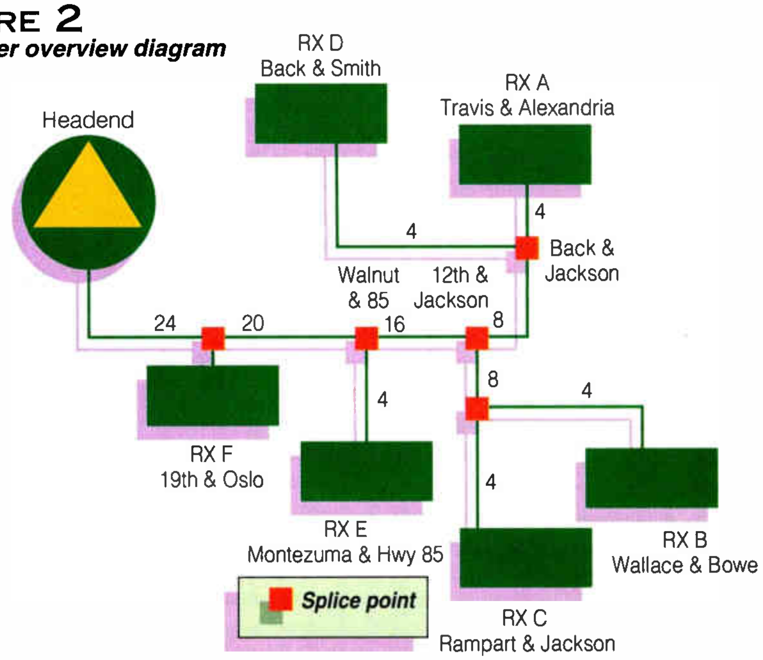


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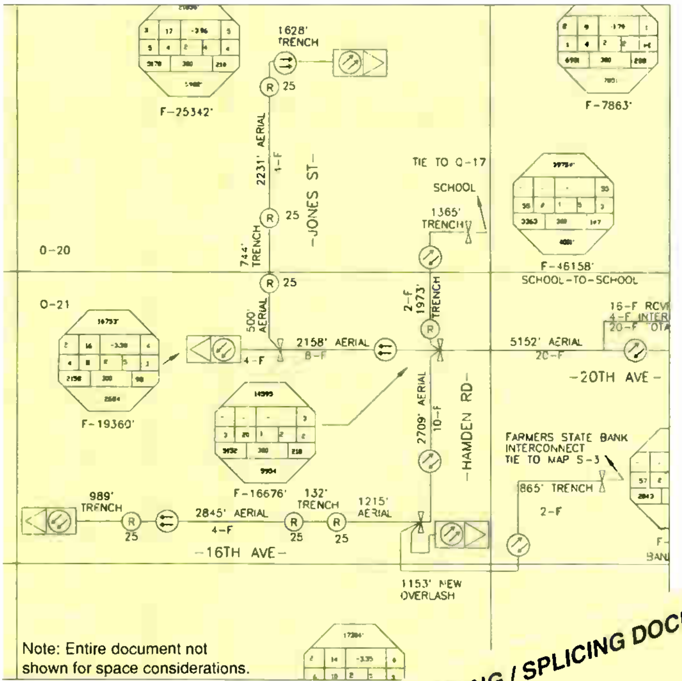
FIGURE 3
Fiber schematic diagram



✔ Current version of "Windows" software
✔ Current version of "Lotus for Windows" software.

For contractors and systems, the use of a portable computer would prove beneficial. Entries to files could be expedited by entering them directly into the file, as opposed to entering them onto a paper copy of the file and later to a computer file. Paper files can be updated to computer files.

Description

The documentation system consists of three diagrams and two computer based files called "forms." They are:

✔ A site laser array diagram of the head-end fiber components
✔ A fiber overdiagram or quick system reference of the distribution system
✔ A fiber schematic showing the true lay-out of the fiber trunks
✔ A routing/splicing form (Lotus-based) file
✔ A node/splice form (Lotus-based) file.

This article refers to two customized Lotus-based files TCI uses. Macros have been designed into each file. With a cou-ple of keystrokes, the macro built into the Routing file automatically calls up a menu

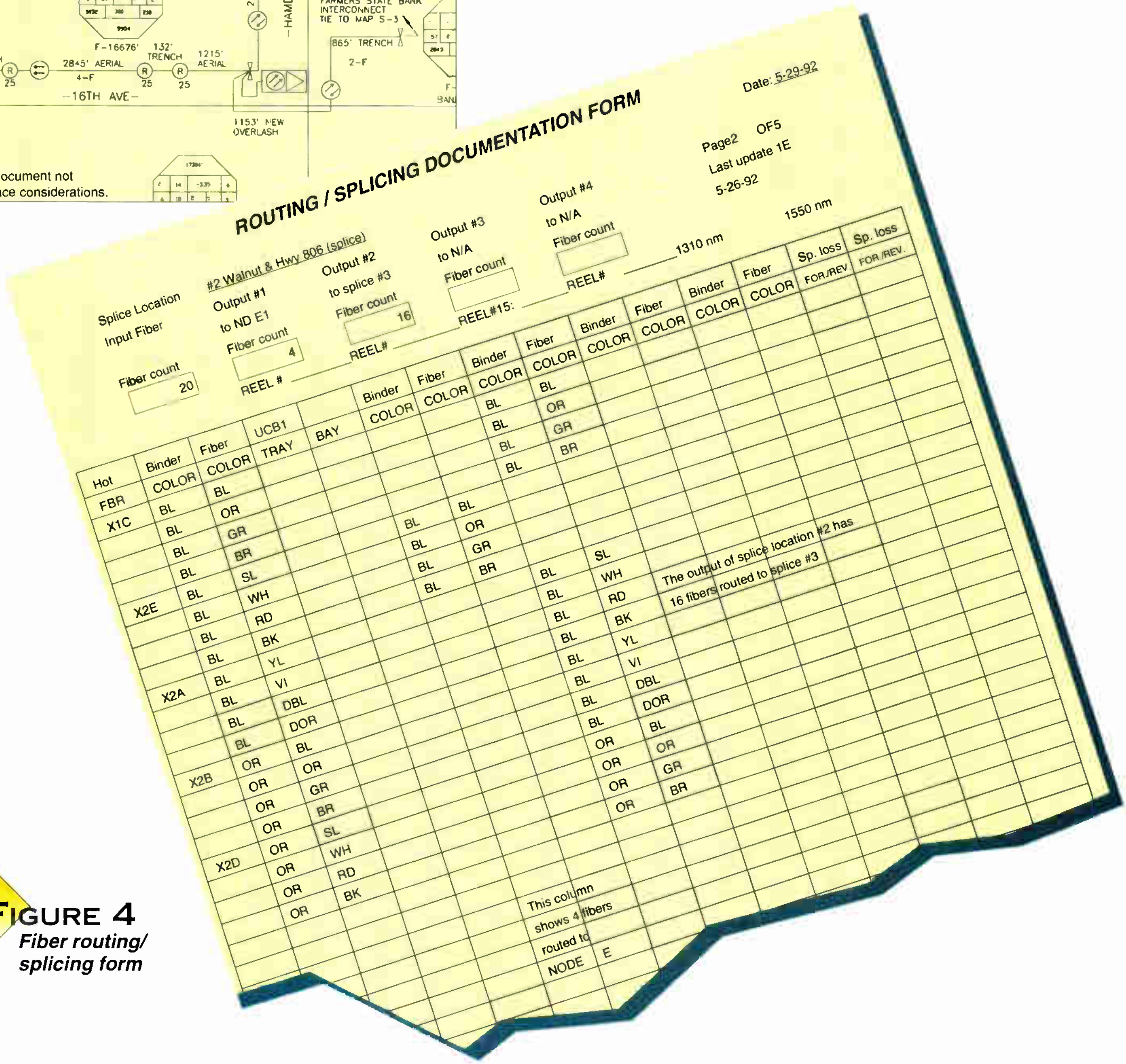


FIGURE 4
Fiber routing/ splicing form

of fiber counts. When the correct fiber count is selected, another macro automatically inserts into the spreadsheet the corresponding fiber count by binder/tube color and fiber color.

The following is an explanation of how these files are integrated into the documentation process.

The site laser array diagram shows details of how each fiber is routed from the headend (see Figure 1). It documents all lasers, directional couplers, and the associated binder color and fiber colors for each active fiber routed from the headend. The array diagram is provided by the contracted designer or in-house design department and serves as a quick reference for maintenance and restoration.

The fiber overview diagram is a quick reference that shows the routing of all fibers including active and future fiber nodes and splice points (see Figure 2). For each node and splice point, the nearest adjacent street crossings are called out. The number of incoming and outgoing fibers to each node and splice point are also defined. The overview diagram is compiled by the contract designer or in-house design department and serves as a quick reference for maintenance and restoration.

The fiber schematic diagram shows actual street layout of the CATV system with fiber trunks overlaid (see Figure 3). All node locations are defined. The fiber schematics are also provided by the designer and serve as a reference for drive out of a particular node during maintenance and restoration.

The fiber routing/splicing form is a Lotus-based file and is designed by anyone competent in Lotus programming. It is compiled by the designer. It defines, for the in-house or contracted splice crews, how each active incoming and outgoing fiber within a splice location should be spliced together. It also defines what incoming fibers are active and routed into a node (see Figure 4).

During construction and splicing, the node/splice form is completed. It, too, can be designed by a Lotus programmer. This form will become the bulk of the maintenance/restoration. A node form should be completed for each active fiber (see Figure 5).

Using the forms

Routing/splicing forms. Retrieve a file (for the sake of this article, we'll call the file "route.") The route/file form has one input and four possible outputs shown across the top of the form in a column. All incoming fibers are defined by binder color, fiber color and bay and tray number. The same applies to output fibers. The designer will determine how the fibers will be routed and spliced within each closure for all fiber trunks. Fiber to be activated in the future can be assigned in the field by the technician. The two columns on the right side of the form can be used to log the end-of-line losses at 1310 nm and 1550 nm operating wavelengths for each fiber, in both directions.

Now is the time to begin using computer-based documents for ease of use.

Data entry

1. Enter the splice location's cross street names on the line in the upper left corner, and date it in the upper right hand corner.

2. Enter the fiber count into the box labeled Input Fiber, Fiber Count. Move the cursor to the empty block directly

below "Binder Color" in the far left column.

3. Hit the "ALT" and "F#" keys simultaneously, and a menu of sequential fiber counts will pop up. Highlight the fiber count desired, and the program automatically inserts the correct binder and fiber colors vertically down the column. A fiber count greater than 48 fibers requires the use of two forms; the program can provide the additional form.

4. Under "Output #1, #2, #3," etc., enter the fiber locations to be routed to and directly below that enter the number of fibers being routed.

5. Move the cursor to the corresponding "Binder Color" blocks and enter the correct number of fibers. A portion of the fiber counts may be edited, once inserted into the column, to obtain the right count, color and position.

Anytime modifications to the system occurs, the forms must be updated.

6. Enter the page sequence and the last update. Below that, the fiber technician enters the forward and reverse losses for the 1310 nm and 1550 nm wavelengths.

After the designer has completed the system design, all route forms are sent to the system. The contracted installer or in-house construction staff should be given a copy of the paper forms or disk files. The routing/splicing forms then become a set of instructions for the construction crew on how the fiber should be routed and spliced together.

Node/splice form

The Node/splice form is completed by the fiber splice crew. It requires the use of two technicians, good communications between the two using talk sets, an OTDR, a fusion splicer and a portable computer (if available). One tech is located in the headend to read the OTDR and log entries to the form, while the second tech does the actual fusion splicing.

Once the designer has completed the form, it is sent to the system and used by the splicing crew to build the system. Again, this form can be printed out and presented in paper form or the file can be given to the splice crew on a disk. The splice crew has the option of making entries on the paper or to the computer file.

If paper forms are used, entries need only be made to the white areas of the form (see Figure 5). When splice data is logged to the computer file, the macro will automatically calculate fiber kilometers, cumulative footage, cumulative kilometers, cumulative fiber loss, average splice loss, cumulative splice loss, cumulative link loss and available power in dB.

One form is completed for each active fiber. If six fibers enter a node and four are active, four forms will be completed and entered into the manual. The node/splice form makes up the bulk of the maintenance/ restoration manual.

Data entry. Enter the node or splice location cross streets adjacent to node/splice location. Enter the cross streets in sequential order by coordinating an address with the node or splice. If fibers are routed through two splice points to the node, the lower left hand corner will have three cross streets listed with the node address on the last line. The user can quickly flip through the manual, using this section as a reference point, to quickly locate splice points or nodes.

As active fibers progress through each splice location to the node, the form can be used to track and document performance at each point.

TCI NODE & SPLICE FORM
(use 1 form per active fiber)

Frequency: 1310 nm

System: ______________________

Fiber Use: ______________________

Fiber Link Route:

		SPL#	SPL#	SPL#	SPL#						
Splice Location:	TRANS.	NODE#	NODE#	NODE#	NODE#						Final
Reel Number:											
Binder Color:											
Fiber Color:											
Tray/Bay:											
Fiber Loss(db/km):											
Fiber Footage:											
Fiber Kilometers:											
Cum. Footage:											
Cum. Kilometers:											
Fiber Loss @ Link:											
Cum. Fiber Loss:											
Splitter Loss:											
Rms. Splice Loss:											
For. Splice Loss:											
Rev. Splice Loss:											
Avg. Splice Loss:											
Cum. Splice Loss:											
Cum. Link Loss:											
Avail. Power (db):											

Trans Input (dBmV): ______ Rec. Input (Vdc) ______ Trans. Serial No: ______

Trans Output (dBm): ______ Rec. Output dBmV ______ Rec. Serial No: ______

Modulation (Nr): ______ Power Supply B+ ______ D.C. Serial No: ______

Node Location: ______ Node Location: ______

Splice ______ Splice ______

Figure 5
Node/splice form

Enter the fiber reel number, binder color, fiber color, the corresponding tray and bay number and the fiber loss in dB per kilometer. After making these entries, the previously assigned macro key will automatically calculate total fiber kilometers, cumulative footage and kilometers, and the cumulative fiber loss in dB.

Tray and bay locations must have a logical numbering scheme assigned to them. For example, bays could be sequentially numbered from top to bottom beginning in the upper left corner and continuing with the sequence at the upper right corner. The same numbering sequence applies to the UCB1 or any other splice tray used. Trays are numbered from the bottom up. The first tray installed in the bottom is numbered "one."

Enter any splitter losses and the corresponding mechanical or fusion splice loss. The program will calculate the average splice loss, cumulative splice loss, the cumulative link loss and the remaining available power in dBm.

The transmitter and receiver information are entered after the system has been optimized.

Creating the maintenance manual.

When the contracted or in-house installer is finished with the forms, they should be returned to the system operator. The system should copy the forms and compile them in three-ring binders along with the Site Laser Array Diagram, the Fiber Overview Diagram, The Fiber Schematic and the Routing/Splicing Forms. This will make up the fiber maintenance manual for each location. Make enough copies to provide manuals for every fiber technician. Place one copy in the emergency restoration kit, and keep one copy in the system office, preferably where easy access to the information can occur.

The fiber documentation becomes the responsibility of the system. Anytime additions, deletions or modifications to the system occurs, the forms must be updated. As stated previously, this process is easiest to maintain when performed on a portable computer. CED

Acknowledgments

The author would like to extend special thanks to Doug Combs and Dallas Richards of Tele-Communications Inc. for their assistance in preparing this article.

How to lower fiber install costs

The role of fiber geometry

By Douglas E. Wolfe, Sr. Applications Engineer, Corning Inc.

Optical fiber is traveling deeper into cable TV systems, serving nodes of fewer and fewer subscribers. With this deployment comes increased splicing and, with it, new considerations: splice loss, splice yield and increased installation expense. How can costs be kept under control without compromising system performance?

One answer is improved fiber geometry characteristics and the advanced splicing technologies they make possible. Together, tight geometry tolerances and more efficient splicing techniques can provide better results at lower costs.

The new realities of reregulation also have underlined the importance of managing fiber installation expenses for cable TV operators.

With today's fiber-rich cable TV architectures, fiber splicing accounts for more than one-third of cable installation costs.

For example, consider an actual installation in which Siecor Corp. performed the fiber splicing and testing for an upgrade of an existing coax-based cable TV system to a fiber backbone by NewChannels in Anniston, Ala. The route, an aerial span from a headend to a remote node, covered 88,173 feet, or 16.7 miles.

NewChannels was presented with three cabling/installation options. Based on a 0.1 dB maximum splice loss criteria, the cable route, design, choice of hardware and the chosen splicing method, the estimated cost per splice was $31.

The first two options called for a total of 473 splices; at an estimated cost of $31 per splice, the cost of splicing was $14,663. The remaining choice required 833 splices, at a cost of $25,824. With the first two options, splicing would account for 27 percent of the total labor cost of installation. Splicing for the third option, one commonly used in the cable TV industry, would make up 39 percent of the total labor installation cost.

NewChannels ultimately went with tapered cable, one of the first two options, in order to cut down on the number of splices and thus reduce its overall installation costs.

As further evidence, consider the fiber installation numbers for a typical fiber-to-the-feeder installation of 47,520 feet, assuming 10 nodes, six fibers and an average fiber count of 33:

Cable installation ($0.40/foot): $19,008

Splicing and testing 324 splices ($31/splice): $10,044

Total labor ($19,008 + $10,044): $29,052

Splice percentage of total: 34.6 percent

The conclusion is obvious: a substantial percentage of the overall installation budget is consumed by the cost of splicing. And with fiber moving closer to subscribers–with higher fiber-count cables and

FIGURE 1

Splicing fibers using fixed guides

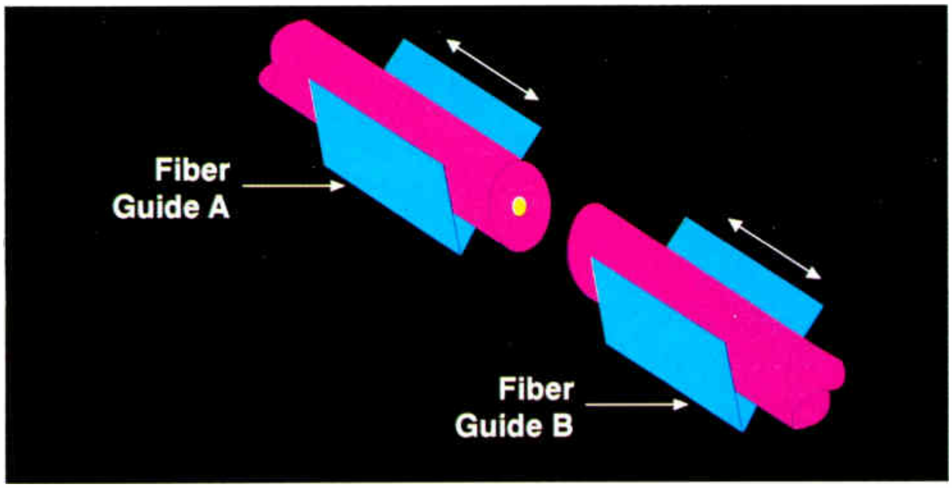
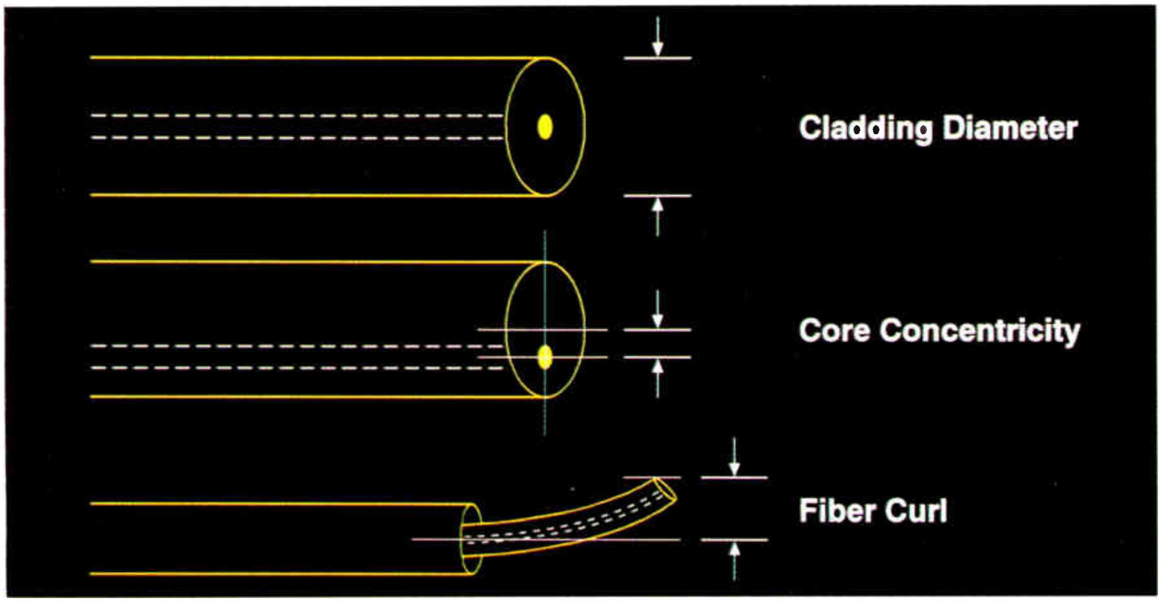
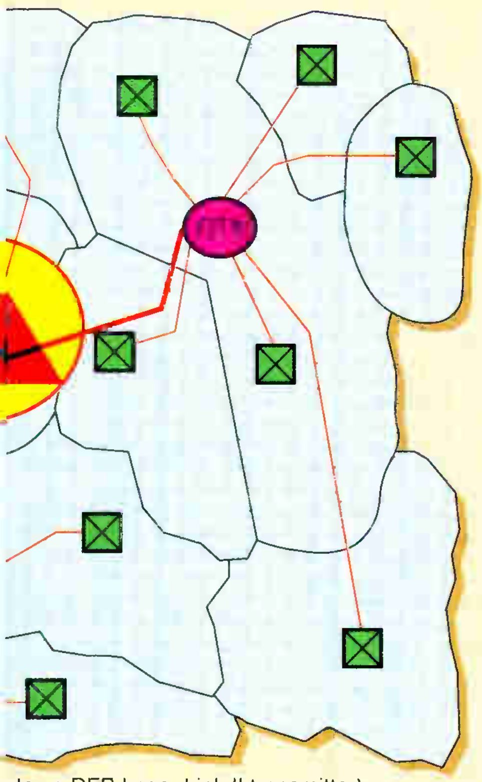


FIGURE 2

Fiber parameters with greatest impact on splicing performance

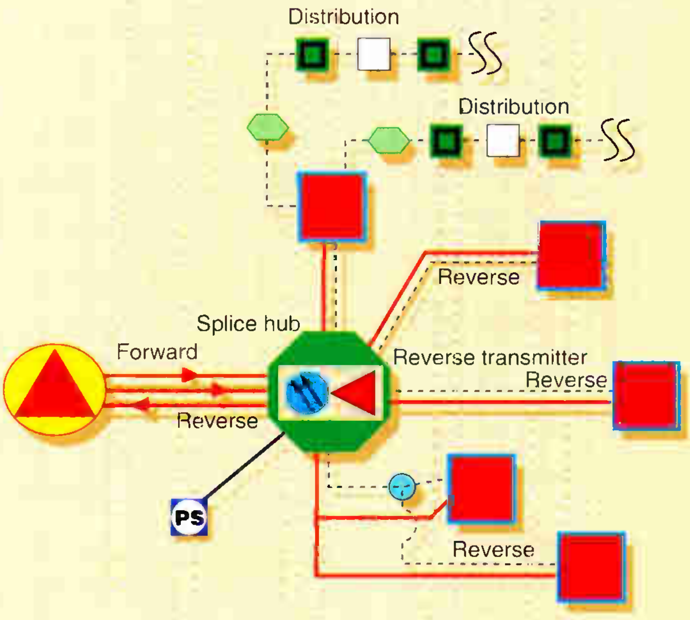


Comparison



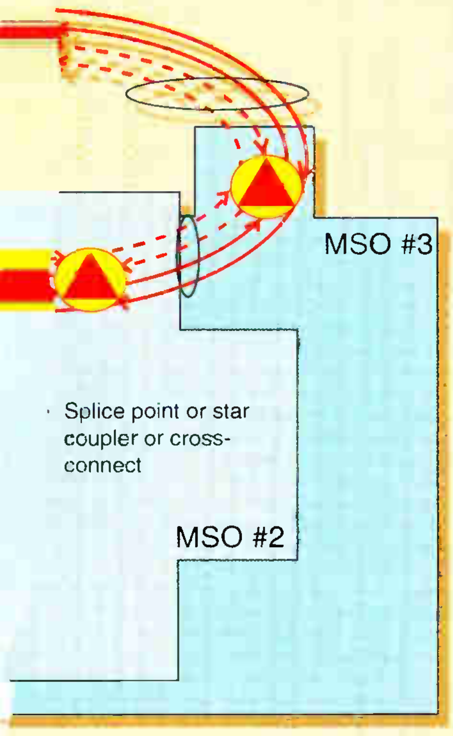
ıdes a DFB Laser Link II transmitter)

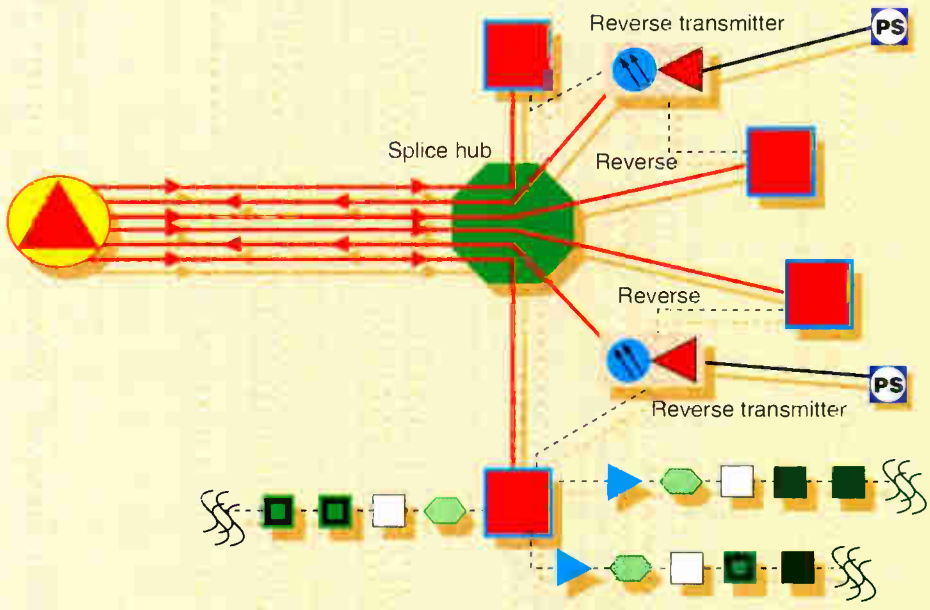
a way to cost-effectively serve nodes
when utilized during full rebuild or
nitation. Combines the benefits of high-
reduce number of subscribers served
, which feeds DFB devices. Design calls
ıctive devices from optical bridger.



Adelphia Cable's Passive Coaxial Network

Designed by Adelphia Cable Communications engineers to be a cost-effective method of eliminating all active components from the cable network, the true passive architecture places a node every half-mile or so, while the modified design, below, covers two miles of plant per node.



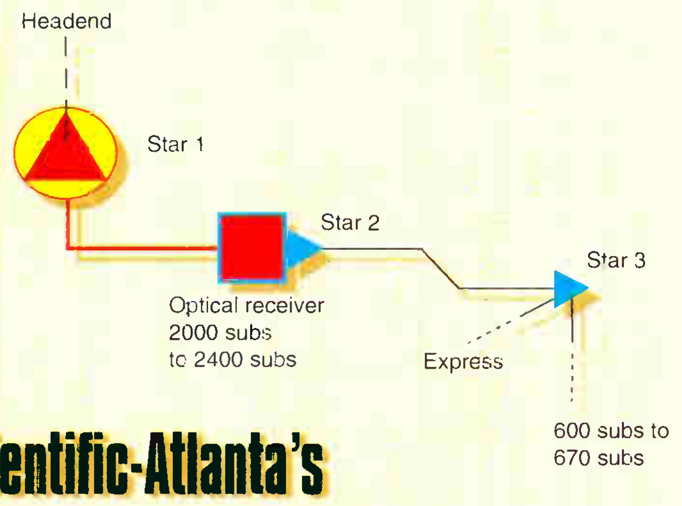


twork architecture

to accommodate a variety of network
vorks obsolete while providing
es centralized "regional hub" to
ommunication equipment among
r hubs. Connections between central
ıub interconnects, provide "virtual"
coaxial distribution to the home
improves reliability of network.

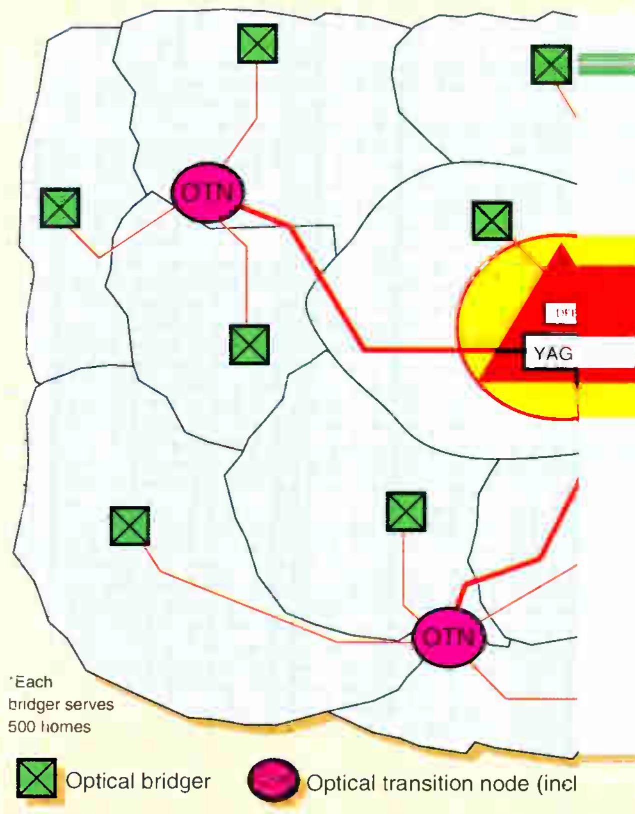
r Topologies

and platforms



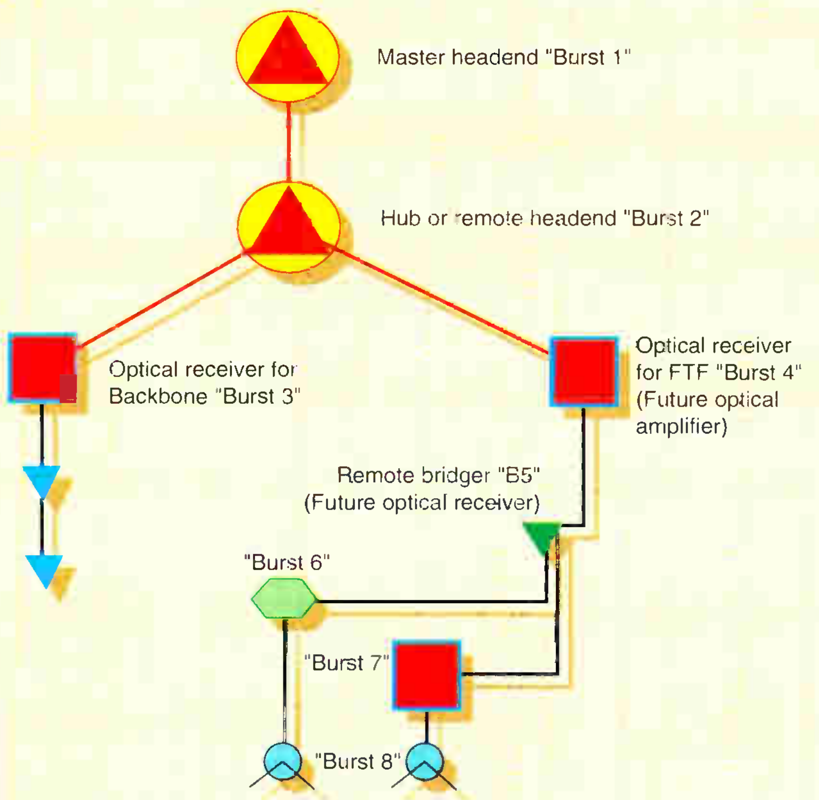
Scientific-Atlanta's Fiber to the Serving Area

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.



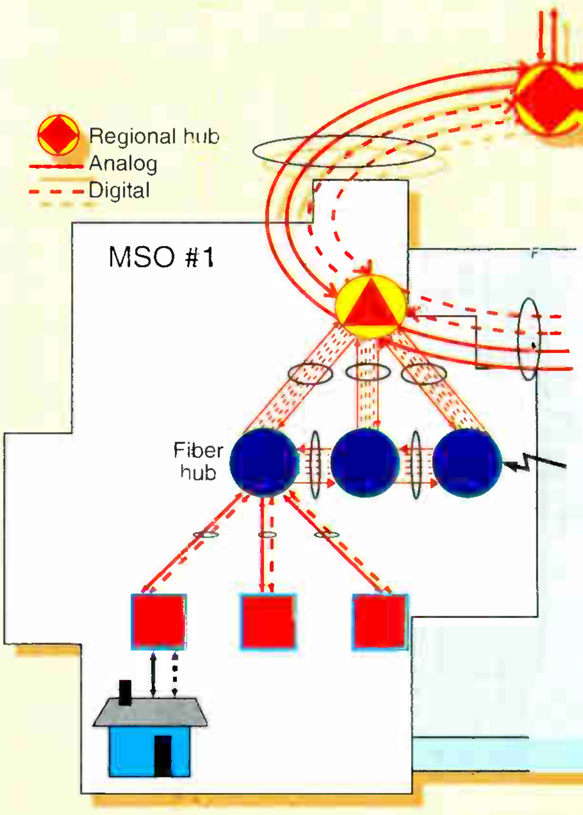
ONI's Star-Star-Bus 500

*Developed by Optical Networks International as
feeding no more than 500 homes. Most effective
upgrades where cable reclamation is the only li
power Nd:YAG and low-cost DFB transmitters t
per node. Nd:YAG feeds Optical Transition Nod
for subscribers to be located no more than two*



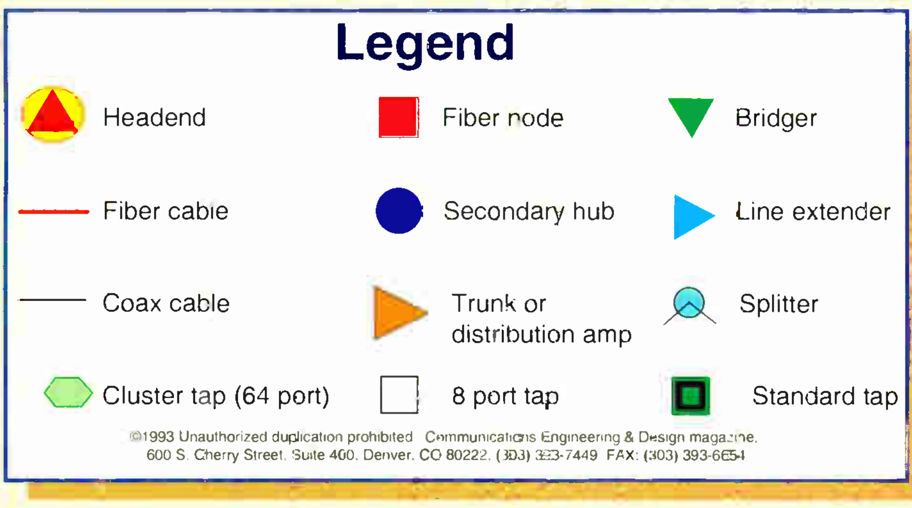
Jerrold Communications' Starburst

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."



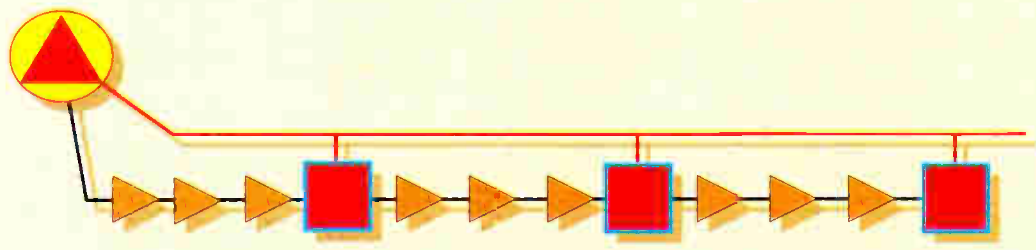
CableLabs' structured ne

*Designed by Cable Television Laboratories
concepts to avoid making any existing net
incremental upgrade path. Topology includ
share the cost of advanced television and
several operators as well as secondary fib
headend and fiber hubs, as well as hub-to-
ring capability and route diversity. Passive
(made possible with in-home amplification*



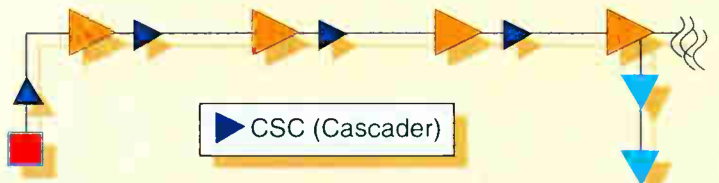
D Cable Fibe

Specialized topologies



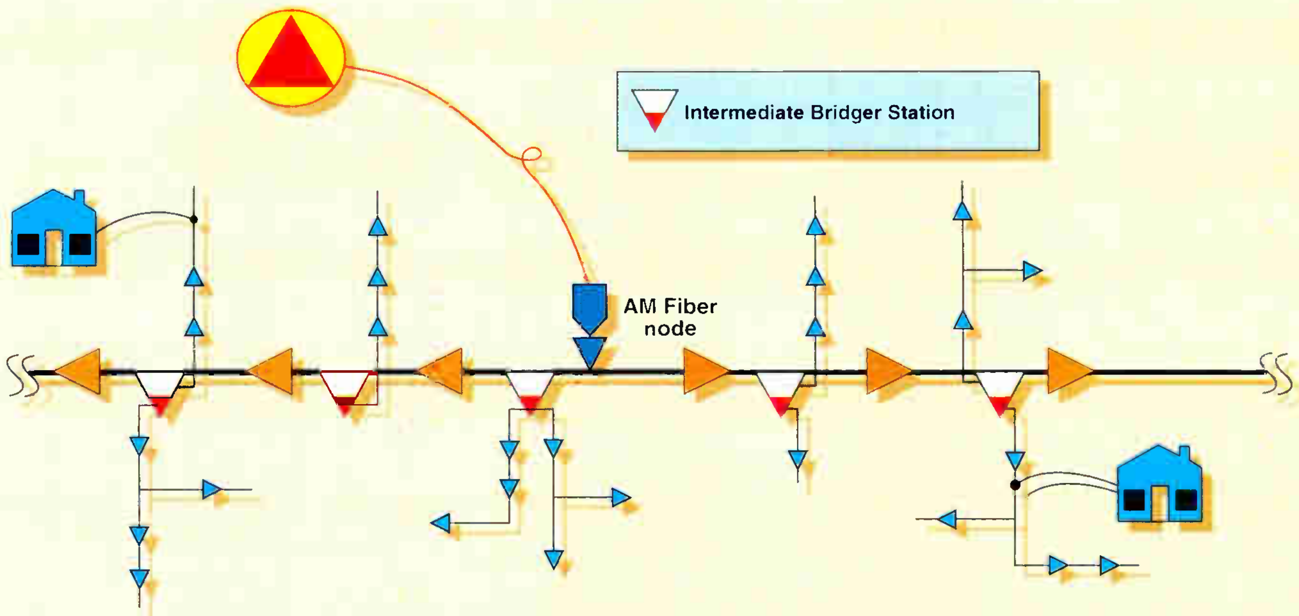
Jones Intercable's Cable Area Network

Designed by Jones engineers to leave coaxial trunk in place as redundant signal path for new fiber optic network. Coaxial route serves as back-up in the event of a fiber outage. A/B switch in optical receiver housing senses loss of signal on fiber, switches to coax input and triggers status monitoring alarm.



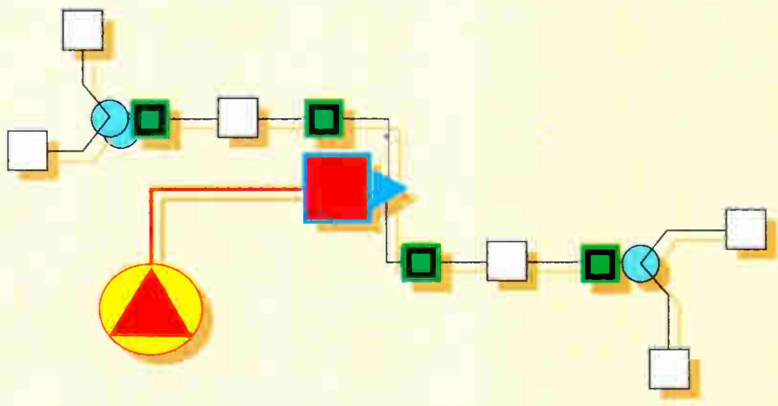
Jerrold Communications' Distributed Gain Network

Designed as a method of maintaining existing trunk/bridger locations in overspaced situations. The concept reduces or eliminates the need to upgrade cable and the time needed to upgrade the system. The topology is compatible with CAN and FBB.



Scientific-Atlanta's FITT

The Forward Intermediate/Terminating Trunk topology is similar to the fiber backbone concept. The approach provides an upgrade path to 550 MHz capacity. Existing trunk locations are converted to FITT stations with dual output parallel hybrid bridgers. System or distribution amplifiers are placed between FITT/bridger stations to provide forward signal amplification.

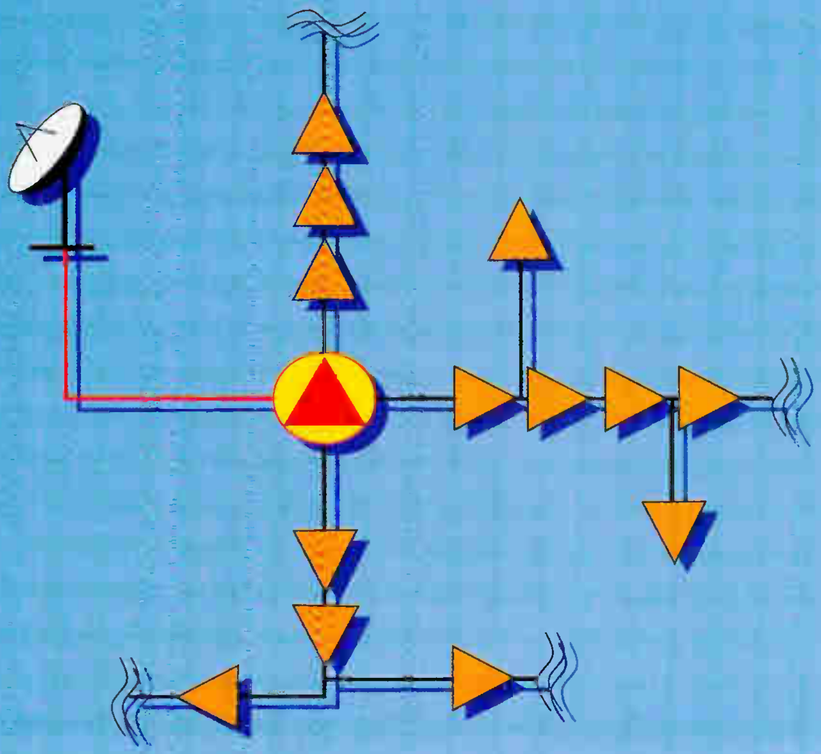


Philips Broadband Networks' Diamond

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

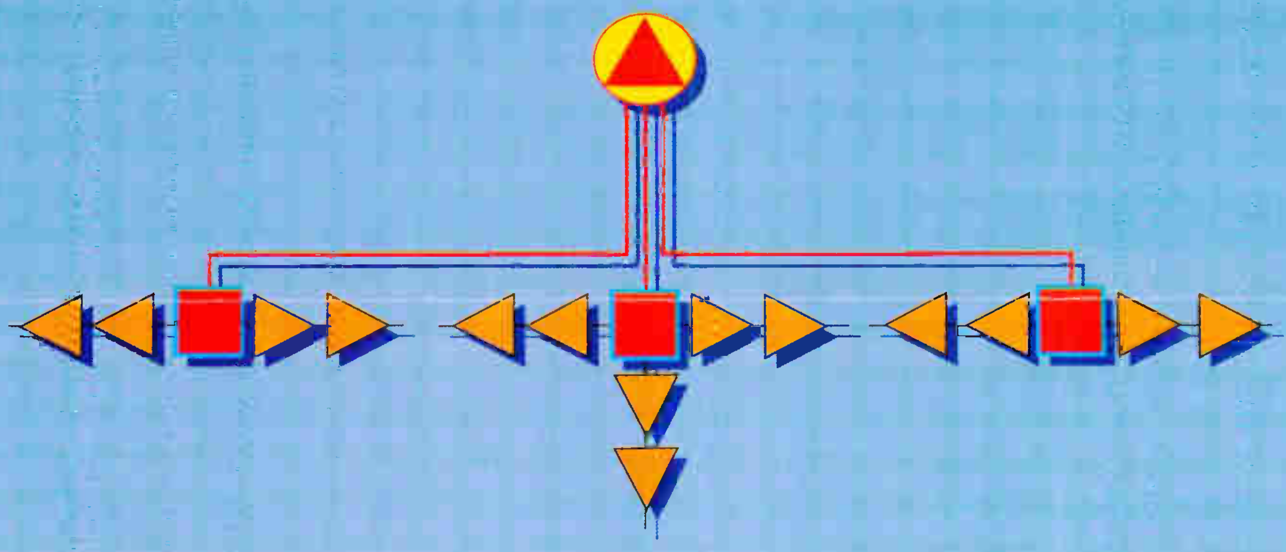
1993-94 CE

Fundamental fiber optic topologies for CATV



Supertrunks

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

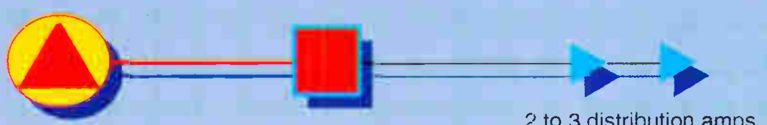


Fiber backbone

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-feeder
Using express feeder

Fiber-to-feeder
Without express feeder

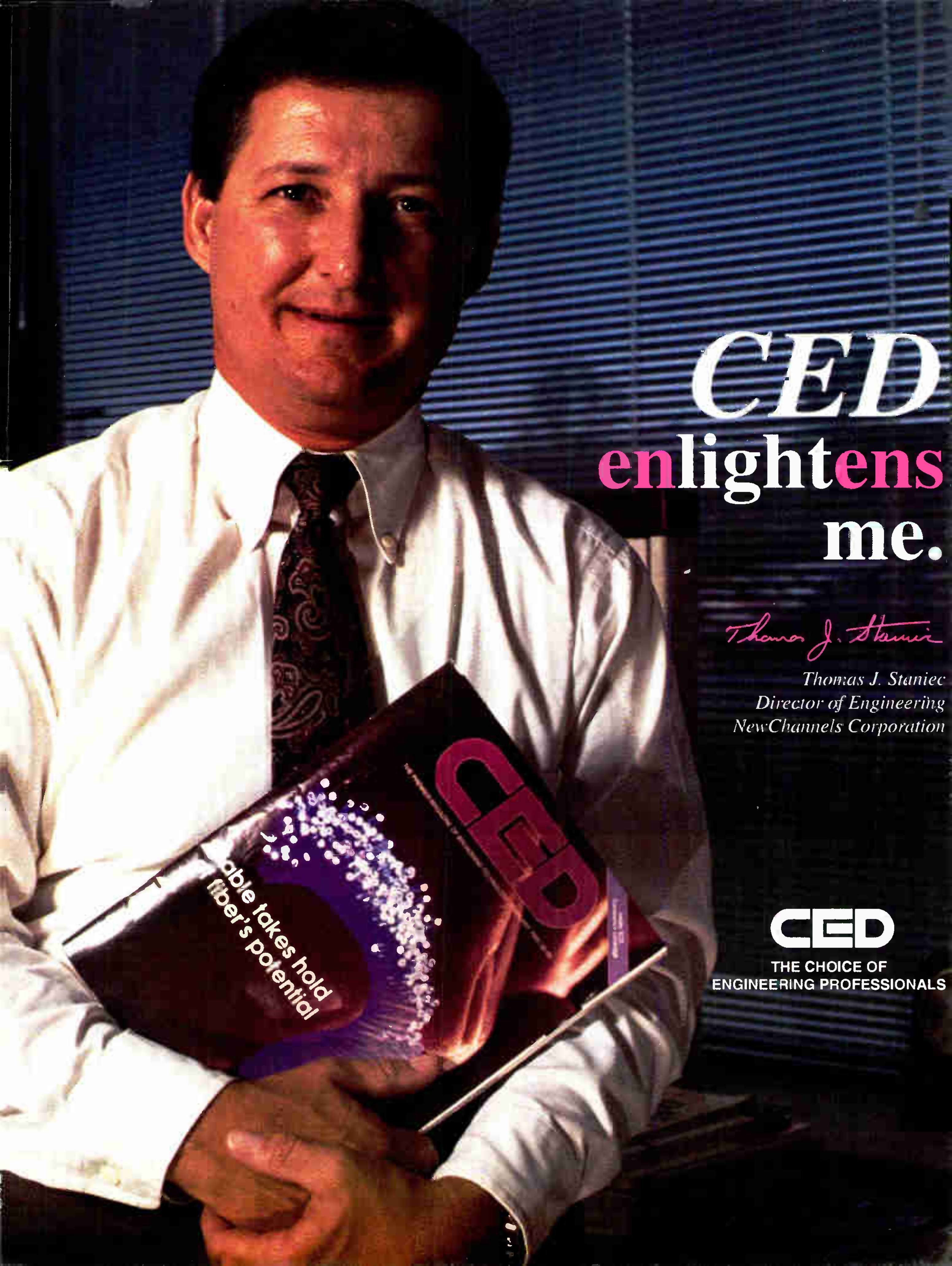


Fiber to the Feeder

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.

1993-94 CED CATV Fiber Topologies Comparison

The cable television industry first embraced fiber technology as a cost-effective upgrade to its traditional all-coaxial plant about five years ago. Since then, cable television has become the fastest-growing market segment for sales of fiber optic cable, growing by more than 100 percent last year, according to one study. Cable operators and equipment vendors have since developed new and innovative methods to integrate fiber deeper into cable networks, bringing the benefits of lightwave technology ever closer to the home. This chart graphically illustrates how fiber started as a method to tie headends together, then rapidly became the transport method of choice for virtually every cable operator.


CED
enlightens
me.
Thomas J. Staniec
Thomas J. Staniec
Director of Engineering
NewChannels Corporation
CED
able takes hold
fiber's potential
CED
THE CHOICE OF
ENGINEERING PROFESSIONALS

decreasing node sizes–that percentage is certain to increase.

Cable TV system designers, determined to keep system performance high and costs low, are on the lookout for any opportunity to shrink this percentage, bring down costs and at the same time achieve high quality, low-loss splices. One key way to bring these things about is to begin with excellent optical fiber with tight, consistent tolerance in glass geometry (the fiber's physical dimensions.) Tighter geometry tolerances improve the performance of fixed-guide splicing techniques (see Figure 1), such as fixed v-groove alignment (both single and mass fusion splicing) and mechanical splicing.

These technologies rely on the physical alignment of optical fibers to optimize the splice, rather than on more expensive computer-controlled, active core alignment methods.

Also, better geometry means more splices are done right the first time, resulting in fewer remakes and bigger savings.

Fiber geometry and splicing

Glass geometry–the physical characteristics of an optical fiber–is a primary contributor to splice loss and splice yield. This fact has been verified by industry studies, including collaborative efforts by Corning and two leading splicing equipment manufacturers, 3M, and Alcoa Fujikura Ltd.

These studies confirmed that improving the tolerances on fiber geometry can reduce splice loss significantly and improve splice yields when fixed v-groove alignment technologies are used for splicing. Moreover, fiber that exhibits tightly controlled geometry tolerances is easier and faster to splice, ensuring predictable, high-quality splice performance.

Although other, extrinsic factors, such as dust, climate, operator training and machine settings greatly impact splicing performance, three intrinsic fiber parameters can have a large impact as well, when fixed v-groove alignment technologies are used:

✔ cladding diameter, the outside diameter of the cladding glass region (see Figure 2)

✔ core/clad concentricity (also known as core-to-cladding offset), how well the core is centered in the cladding glass region (see Figure 2)

✔ fiber curl, the amount of curvature over a fixed length of fiber (see Figure 2)

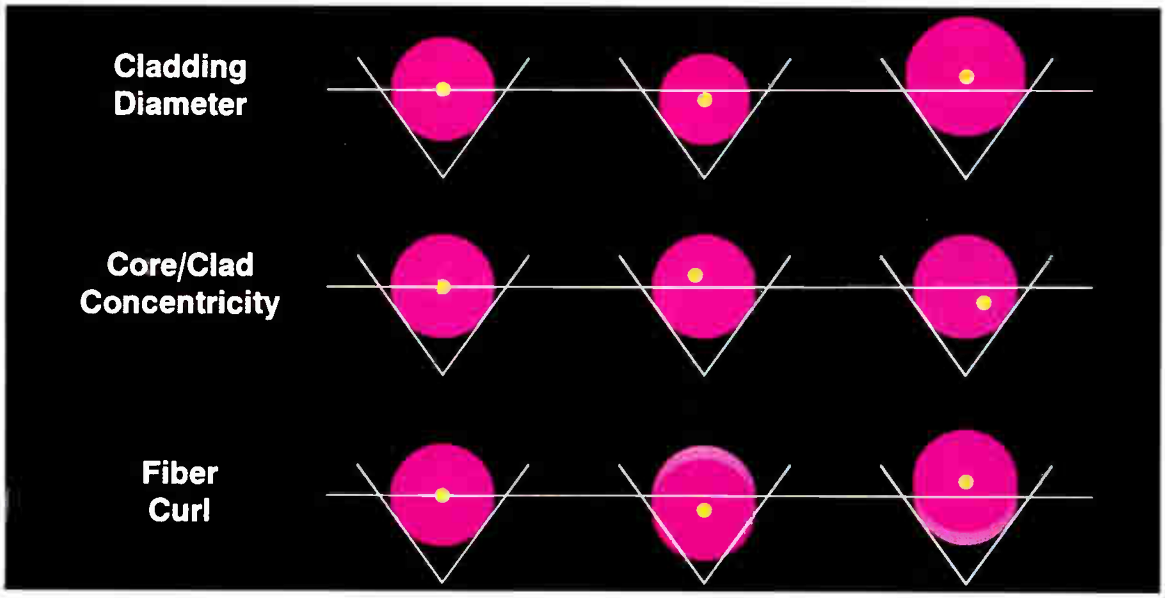
Each of these parameters is controlled during the fiber manufacturing process, and must be ensured throughout the entire length of fiber through the use of quality control systems and state-of-the-art process technology. They cannot be selected reliably after processing, because end measurements alone will not guarantee performance to a specification. Other industries recognize the benefits of tighter fiber geometry and are now moving to tighten requirements. In the telephone industry, for example, Bellcore has set requirements for tightening cladding diameter and core/clad concentricity tolerances. Fiber curl is receiving growing attention as well with the increased application of mass fusion splicing technologies.

Many things can lead to time-consuming installation practices and poor splice yields. Some of these are in the hands of the installer: equipment selection, splicing practices and handling procedures. But geometry-related core offset, a major contributor to splice loss, is under the control of the fiber manufacturer.

When two fibers are joined, core offset can be caused by large differences in cladding diameters, core/clad concentricity errors or fiber curl. Any of these can prevent the fiber cores from aligning properly during splicing. So, tight tolerances are critical, especially when splicers use technologies that rely on the physical dimensions of the fiber for alignment: fixed v-groove alignment for single and mass fusion splices, and ferrule-type

FIGURE 3

How fiber geometry parameters impact splicing



alignment for connectors and mechanical splices.

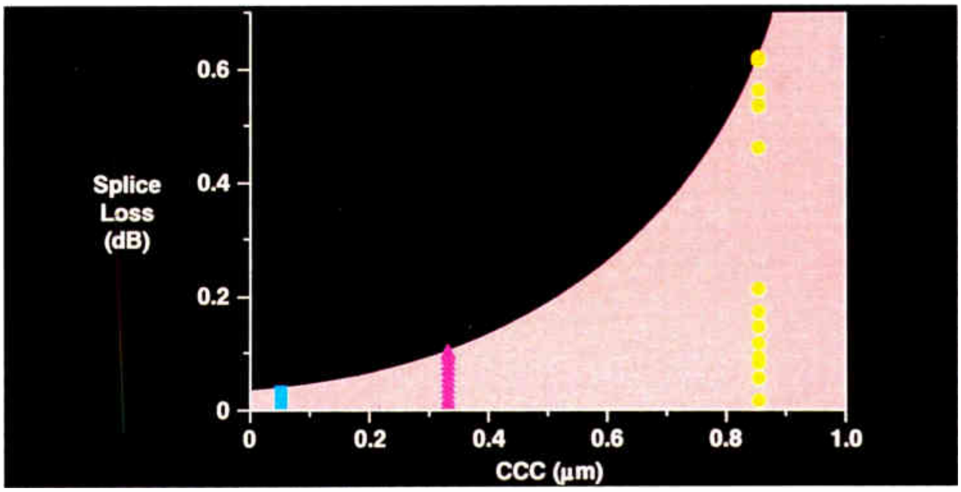
Figure 3 illustrates how cladding diameter, core/clad concentricity and fiber curl affect fiber core offset during splicing. For installers, tight tolerances result in low-loss splices a greater percentage of the time.

Tight cladding diameter tolerances ensure that fibers are nearly exactly the same size, helping to avoid core offset in mechanical joining. These tolerances are controlled during manufacture by draw rate (how fast a fiber is made) and temperature. On-line, in-process computer controls measure the fiber's diameter hundreds of times per second, as a closed-loop system continuously monitors and adjusts the fiber draw process.

Once exacting diameter tolerances are assured, core/clad concentricity becomes the single largest geometry-related contributor to splice loss. Tight core/clad concentricity tolerances help ensure the fiber core is centered in the cladding glass. When this is so, the chance of core misalignment during splicing is greatly reduced, yielding a better,

FIGURE 4

Role of core/clad concentricity



lower-loss splice.

Core/clad concentricity is established during the first stages of the manufacturing process, where fiber design and characteristics are created. During these "laydown" and "consolidation" processes, the dopant chemicals that make up the fiber are deposited with precise control and symmetry in order to maintain consistent core/clad concentricity along the entire length of the fiber.

Fiber curl

The inherent curvature along a specific length of optical fiber, exhibited to some degree by all fibers, is called fiber curl. It is a result of thermal stresses that occur during the manufacturing process. Therefore, these factors must be rigorously monitored and controlled during fiber manufacture. Controlling fiber curl is a relatively new concern for fiber manufacturers, brought about by the increasing use of mass fusion splicing technologies, which also typically employ fixed v-grooves for simultaneous multiple fiber alignment. Fiber curl tends to have a greater effect on splice loss when splicing multiple rather than single fibers. Cable TV MSOs will benefit from improvements in fiber curl should they decide to employ mass fusion splicing in the future.

Tight tolerances for cladding diameter, core/clad concentricity and fiber curl also affect splicing efficiency. Because tighter geometry tolerances translate to a good match between fibers, more splices meet splice loss requirements the first time. In the field, tighter fiber geometry tolerances mean faster splicing, fewer remakes and reduced labor costs–keep in mind the percentage of costs devoted to splicing.

Moreover, with better dimensional matches, fixed v-groove splicing techniques should be easier to learn, requiring less training, another add-on to the total installation budget.

The industry standard for cladding diameter is 125.0 ±1.0 microns. A tolerance this exacting is not only difficult to attain; it's hard to imagine, and impossible to see with the naked eye. To get some idea of the sliver this dimension represents, consider that a sheet of paper is about 25 microns thick.

After cladding diameter, the main parameter of concern is core/clad concentricity. To examine the impact of core/clad concentricity on splice loss and yields, an experiment was conducted at Corning. In this test, fibers with three different core/clad concentricity tolerances were spliced and measured for loss.

Figure 4 illustrates how fibers spliced together with enhanced core/clad concentricities (that is, smaller core offset) exhibit lower splice losses and significantly reduce splice loss variability.

The results of this experiment indicate that as core/clad concentricity and other geometry tolerances continue to improve, splice losses and the variability of loss will decrease. This could mean that, ultimately, there may be less need to verify splice loss.

Fiber with improved geometry characteristics can help cable TV operators reduce their capital investment by enabling the use of lower cost, single fiber and mass fusion splicing, or even mechanical splicing technologies. These passive alignment methods, such as fixed v-groove alignment, discussed earlier, give cable TV operators more equipment choices. CED

Continued from page 39

in the power distribution–namely, too many fiber optic components. Initial designs of PCNA had allocated one reverse transmitter at each node. Such an architecture translates to 1.5 reverse lasers per mile.

If the home run fibers and individual receivers are used within the 400 mile PCNA design, then an operator would face nightmarish prospects of managing the headend and the performance of the network consisting of some 600 reverse receivers and 2,000 miles of fiber. The cost implications were staggering and led to redesign efforts which improved the architecture.

The initial PCNA design attempted to cut costs of reverse signal transport by using the standard 0.500-inch coaxial power cable as a conduit of reverse signal from several nodes to the central power supply location, where, after an electro-optic conversion they would be passed to the headend by a single reverse transmitter.

As with power supplies, this preliminary design was later modified in order to increase the size of the service area. In the modified PCNA version, the coaxial cable performs dual roles of:

1. conducting current between the power supply and two nodes
2. acting as a returning RF signal transport from two nodes to a single reverse transmitter.

The new designs managed to maintain the network performance standards while improving on the original fiber count and reverse-path opto-electronic estimates for a 300 mile PCNA plant (see Figure 4).

Reverse equipment considerations

All of our PCNA design models attempted to preserve compatibility with existing, off-the-shelf equipment. Occasionally, the new architectural design required modifications to the equipment and the adjustment of its specifications.

In one such instance, a slight modification to the existing optical receiver evolved to a design of a new device. Typical AM fiber receivers are designed to accommodate an installation of a reverse transmitter in its housing. Reverse RF signals are internally routed to the reverse laser for a transmission back to the headend. Since most receivers use standard CATV amplifier housing, the input port (sub-band output) to the housing is either unoccupied or fitted for fiber cable entry. Many of the newer 750 MHz receivers route fiber cable entry to the lid of the unit.

Our PCNA node requirements called for a receiver that would route and amplify reverse signals from the output ports to the unused input port. In addition, we needed the unit to accept its AC power supply from this port (see Figure 5).

By allocating a dedicated coaxial cable for power and reverse signal transmission, a cost per mile savings in the order of five to 10 percent was realized, placing PCNA costs within a range of comparable FTF designs.

New considerations for PCNA

The widespread use of fiber and the proliferation of optical splitting in order to feed multiple receivers places extra emphasis on issues of fiber management, optical component quality, and reliability. The management, redundancy and reliability issues raised by the operation of multiple transmitters in a headend of a wide reaching system become more acute. The limitations of optical link budgets and a sheer number of splitters, connectors, and splicing locations highlight a need for high quality passive optical components, beyond the usual concerns with transmitters and receivers. Finally, the physical size of optical network magnifies the requirement for a shorter fiber repair times.

While PCNA modeling and design modifications continue, preliminary technical and financial considerations are encouraging. Under the current fiber optic pricing structure, the PCNA is dependent on system topography and the size of its optical link profiles.

By exercising judicious amplifier per-mile ratios and by using hub architectures, cable operators should be able to achieve further advances in the design of PCNA or similar topologies. Improvements in fiber optic and digital technology, manufacturing, and pricing are bound to increase the PCNA deployment within the cable TV industry. Such a trend will likely add an extra impetus to a growing effort by the industry to enlarge a role of the cable TV networks from the local provider of entertainment services to the nationwide supplier of information and data. CED

TABLE 3
PCNA cost comparison, original and modified

Homes per mile: 224
System mileage: 324

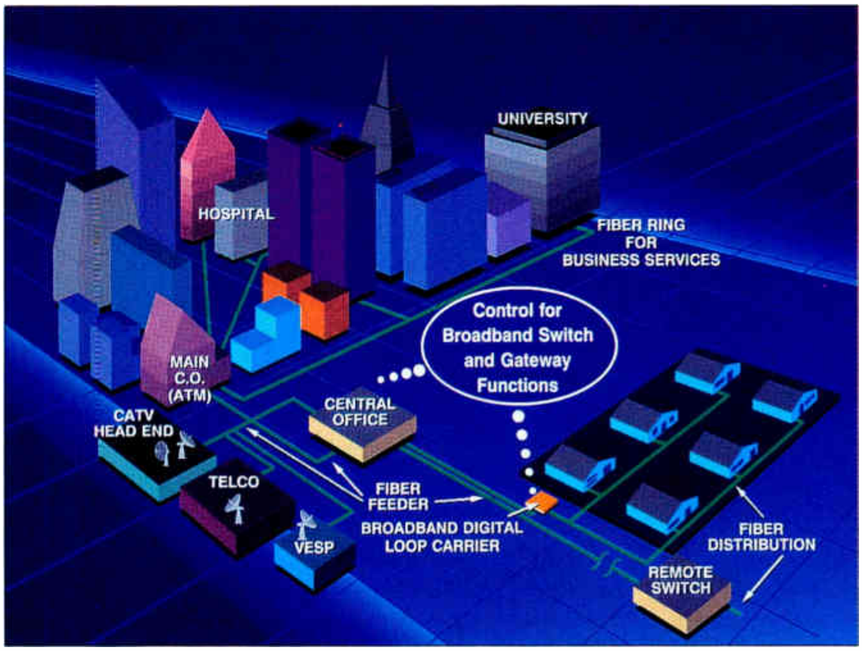
	Original	Modified
Avg. serv. area size:	.65 miles/node	1.97 miles/node
Cost per mile, subtotal:		
FO:	$ 8,300/47%	$ 3,700/28%
RF:	$ 5,000/28%	$ 5,700/43%
Labor:	$ 4,300/25%	$ 4,000/30%
Total project cost per mile:	$17,600/100%	$13,400/100%
Cost per household:	$79.	$60.

GTE's broadband field trial results

Lessons learned at Cerritos, Calif.

FIGURE 1

Switched broadband network topology



By Clif Holliday, Assistant Vice President-Operations & Technology Development, and Vern Junkmann, Manager-Technology Development, GTE Telephone Operations Headquarters

The evolving integrated broadband telecommunications network of the future will serve business and residential customers with equal effectiveness.

The business and residential markets will use the same basic technologies for an array of applications, including:

✔ Enjoying video-on-demand entertainment services
✔ Conducting business video conferences
✔ Reviewing manufacturing and performance data
✔ Scanning market reports
✔ Delivering and sharing video resources among classrooms
✔ Diagnosing and consulting on medical conditions of patients
✔ Shopping or working at home
✔ Participating in TV game shows from home
✔ Sharing "video phone calls" with friends and relatives across the country.

These and other innovative capabilities will evolve by layering new services on a broadband telecommunications infrastructure. Network evolution will gather momentum as remaining regulatory restrictions are relaxed, legislative barriers are removed, near-term technological advances are deployed, and technological field trials and market tests prove technical feasibility and customer acceptance.

Considering the impact of legislative restrictions and technology advances, this article focuses on field trial results of an evolving integrated broadband network with the flexibility to support new broadband business and residential services.

Regulatory and legislative environment

On the regulatory front, the Federal Communications Commission has set the stage to unleash the power of the integrated broadband telecommunications network. First, the FCC modified its rules to permit telcos to compete in the video marketplace through video dialtone. Second, it recommended that Congress reverse the statutory telco-cable cross-ownership restrictions. And third, it proposed expanding the rural area exemption to permit telcos to provide video programming directly to subscribers within franchise areas of fewer than 10,000 persons.

The Cerritos field trial has provided a platform for service layering.

These new rules can promote an environment for non-traditional partnerships as well as individual enhanced service providers to develop and market new interactive services that go beyond what is offered to either phone or cable customers today.

However, the telcos are shackled with two inhibitors. First, telcos have program packaging restrictions, which place a cloud of uncertainty on infrastructure investment and may limit the telcos' ability to attract high-value programming. Second, the statutory restrictions of the telco-cable cross-ownership act of 1984 remain a disincentive for the deployment of this network.

If these regulatory and legislative limitations were lifted or reduced, deployment of a network similar to Figure 1 would be accelerated. The network shown in Figure 1 is a switched broadband network, with gateway control, capable of providing both residential and business customers access to business products and services, educational programs, medical support and other conventional services.

Technological advances

Recent technological advancements and those expected during the next few years will provide network elements with the flexibility to support new broadband services at lower cost. For instance, development advances in the production of high-speed lasers will drive down the costs of those devices and will promote expanded use of fiber in the distribution loop.

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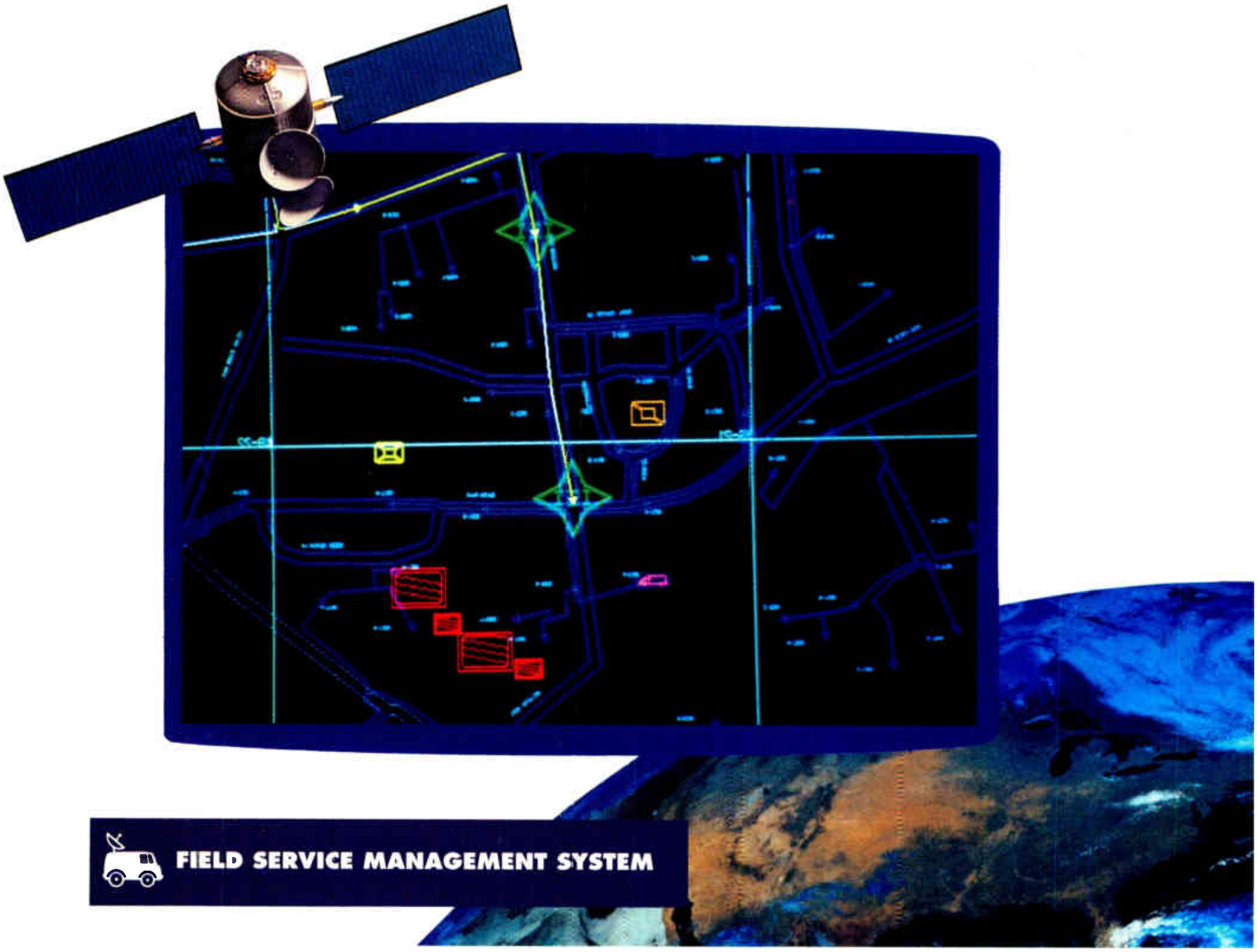

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In areas where fiber deployment may not prove economical in the near term, other technologies that use digital compression may make it possible to deliver new services that rival those delivered by fiber.

Technical advancements in switching will continue to hasten deployment of remote broadband switches and high-speed Asynchronous Transfer Mode (ATM) switches. Recent developments in optical transmitters and receivers will drive down costs, reduce size, and dramatically lower power requirements. The communications and information industries are developing switching and distribution capabilities that will provide residential and business customers with broadband services throughout the public switched network.

Field trials and market tests

Since the first of this year, we've been bombarded with news announcing "breakthroughs" in advanced broadband video services. These announcements come on the heels of a large field trial experiment in broadband video services–the GTE Cerritos project. Now in its fourth year, the trial has allowed field testing of many innovative services.

The Cerritos trial supports both technical and market tests for residential and educational services. The technical tests are aimed at gathering important construction and service provisioning information.

Service layering

The Cerritos field trial also has provided a platform for demonstrating a concept of "layering of services"–adding new services to an existing broadband infrastructure. Figure 2 is a graphic depiction of how educational programs, medical support, and business services can be layered on a broadband telecommunications infrastructure.

High-speed broadband switching combined with SONET- based fiber optic facilities creates a high capacity, two-way pipe for carrying multiple and layered services to both business and residential customers.

Technological advancements in switching will hasten deployment of remote broadband and high speed ATM switches.

The layering concept further ensures that the broadband infrastructure can be efficiently used.

First layer

As the first layer of the Cerritos broadband infrastructure, let's examine the residential tests that have served as the cornerstone of the project. Residents are using:

✔ Video-on-demand–This is a technology test that gives residents complete control over when and how they view a movie. The homes are connected through fiber optics to GTE's broadband switch, so that residents are able to watch regular television, premium television and special events as well as a wide selection of movies over which they have full, VCR-like control.

✔ Main Street–This information video service delivers two-way interactive TV by using the telephone network for "upstream" data (from the customer to Main Street) and a standard cable channel for "downstream" delivery (from Main Street to customer) of audio programming, still-photography and graphics.

Menu options

The viewers have 50 different menu options including bill paying, airline reservations, municipal services and electronic encyclopedias and dictionaries.

✔ ImagiTrek "New TV"–Some 60 homes are using this video service which allows simultaneous interaction with television programs and information and images presented from a compact disc.

> **The magic behind all these tests is the public switched telephone network.**

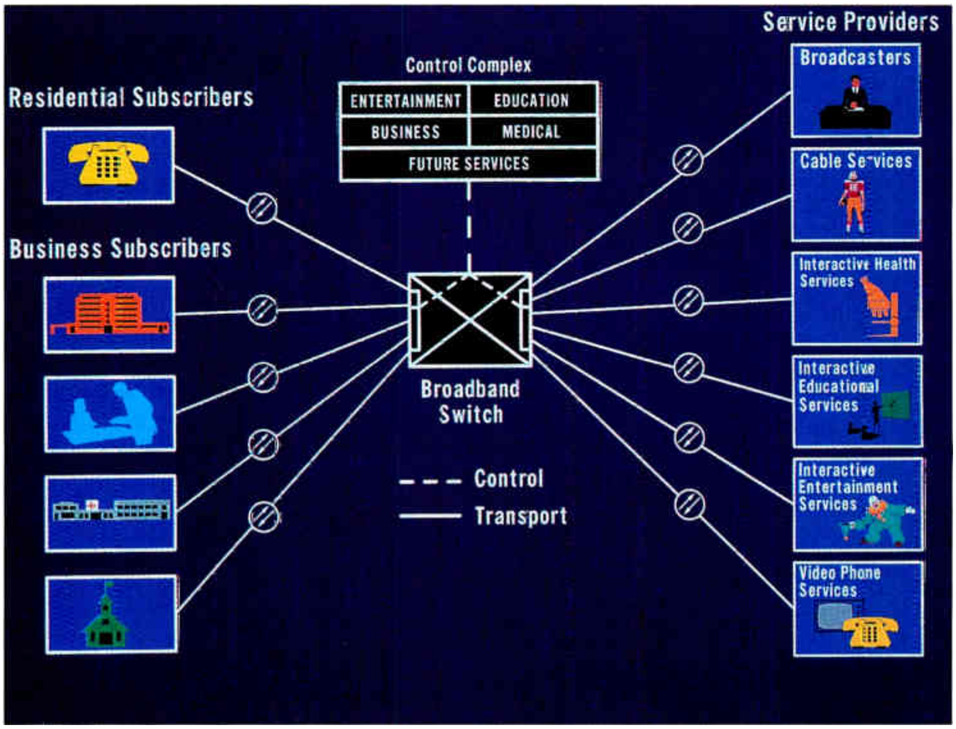
Second layer

As a second layer, let's look at the educational tests that have been added to this Cerritos broadband infrastructure.

The cooperative educational test includes two schools in the ABC Unified School District, the Los Angeles County Office of Education, and the Regional Education Television Advisory Council. The test involves grades three and six, with three classes in each of the two

FIGURE 2

Service layering with control for switch and gateway



schools. The six teachers and their 180 students use the following services as part of their everyday activities:

✔ Full-motion video conferencing–The six classrooms, each equipped with television sets and video cameras, allow a teacher who is a specialist in one subject to teach several classes simultaneously. Children in different classes also can interact with each other via video.

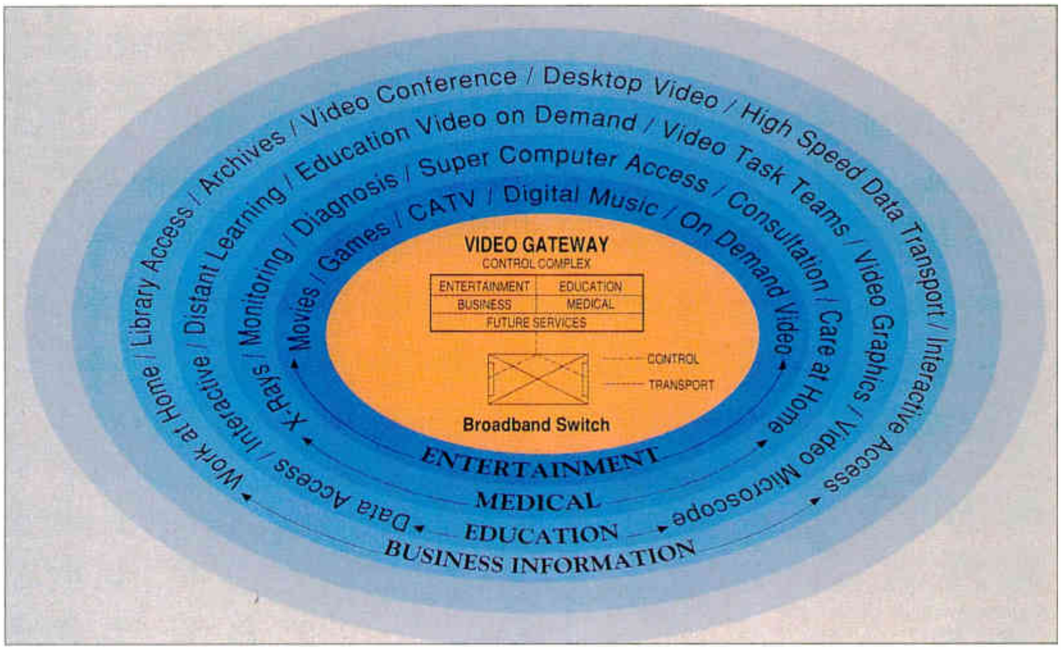
✔ Video-on-demand–Each teacher has access to a video-on-demand library of 200 educational titles.

Traditionally, teachers would have to order a videotape and then wait days or sometimes weeks before delivery. Today, they simply select the desired video from titles they view on their television set. Using a remote control, they view the video using VCR-like features such as pause, fast-forward and rewind.

✔ Video microscope–A teacher can position a specimen on a microscope and display it on a television monitor. The teacher then can discuss what is on the screen with the class and with other classrooms, rather than taking time for each student to view the specimen on a standard microscope.

FIGURE 3

Switched broadband and gateway-controlled info infrastructure



✔ Electronic tablet–Teachers can highlight material on the television monitor by writing comments or drawing diagrams over video images. This technology is similar to that used by sports announcers when reviewing TV replays.

Video dialtone

A new video services platform, recently introduced in Cerritos, will allow the exploration of technical parameters associated with video dialtone.

This platform, developed by GTE Laboratories, provides an electronic gateway with user-friendly menu control to accommodate multiple providers of video services.

GTE is planning to offer a commercial version of its educational system to other schools.

The new video service platform used in the field trial is capable of providing different services to four separate TV sets in each home.

The residential user will have access to as many as 200 channels of broadcast-like entertainment video, video-on-demand for more than 3,000 programs, and point-to-point connections for video telephone or video conferencing.

What's the magic behind all of these tests?

It's the public switched telephone network that makes it possible to deliver these and future services efficiently to both residential and business customers.

With the Cerritos pilot serving as a proving ground, GTE is preparing to offer a commercial version of the education system to other schools throughout the country. The Main Street service already has evolved to a commercial offering. This premium cable TV channel now is being offered to 50,000 cable TV subscribers in Carlsbad, Calif.–with sights on further deployment in other major U.S. markets during the next couple of years.

The switched broadband network will provide a new world of consumer products.

Another field trial, called VISTAnet, provides a fiber-based, high-speed communications network between the University of North Carolina Medical Center in Chapel Hill and MCNC at Research Triangle Park in North Carolina. This is an example of the future network integration envisioned for the business sector. VISTAnet partners include GTE, BellSouth, The University of North Carolina, the MCNC, and the Corporation for National Research Initiatives.

VISTAnet solves the challenge of transmitting medical images–anatomical maps–to guide physicians in their treatment planning.

Medical imaging

For example, doctors at the University of North Carolina Medical Center can transmit data images of cancer patients from a CAT scan at the hospital to a supercomputer some 18 miles away. The computer can produce three-dimensional images and simulate the effect of various possible treatments to determine, for example, the most effective radiation doses.

All of this will be accomplished in real time, with the computer providing immediate responses, thanks to the speed of the broadband fiber network.

The information transmitted between doctors and computers can result in more effective treatment and more efficient use of the medical equipment. Although it is still in the planning stages, this same network is a prime candidate for the layering of educational services to share resources among the educational institutions in the communities around the Research Triangle Park.

VISTAnet is a first step toward realizing an ambitious vision of a fiber-optic, broadband network that ties together academic and medical research facilities nationwide. The scope of the project includes research in communications, graphics and medical applications and features a gigabit testbed network. The VISTAnet testbed network is designed to feature ATM and high-speed circuit switching as well as multi-gigabit fiber optic facilities. This testbed is an example of the kind of capability envisioned for state and national information highways.

The VISTAnet field trial experience further verifies the feasibility and benefits of a switched, two-way integrated broadband information network. At the same time, it proves that such a network can be expanded to provide a wide range of broadband services.

The education and medical applications being market tested and field trialed are innovative adaptations layered on a broadband infrastructure of high-speed, broadband switching and fiber optic, two-way distribution facilities. This concept of layering broadband services is shown graphically in Figure 3.

The switched broadband network with gateway control will provide a new world of consumer products and services. Items such as home banking, shopping, video-on-demand, remote medical monitoring and diagnosis will become necessities rather than luxuries.

Teachers will have resources at their disposal to stimulate students to new levels of learning. Doctors and other health service providers will be able to remotely diagnose and monitor patients and potentially provide selected health care at reduced cost.

Work at home

Working at home will also be possible with a switched broadband network that links the business and residential segments of our communities. Network users could simply communicate via modems.

Such a lifestyle shift would release resources now used for the transportation infrastructure by substituting electronics and optical cable for highways and bridges–not to mention the reduction of traffic jams, smog and stress.

The integrated broadband network of the future is evolving–the regulatory and legal environments have begun to change to permit it, technology is available or is being developed to support it, and our experience with business and residential customers tells us they want it.. CED

Developing high-power fiber networks

How to get passive ...and like it

By Tom Williams, Project Manager, Ventura County Cablevision; Joe Selvage, Manager of Systems Engineering, Adelphia; and Moshe Nazarathy, Vice President, Research & Development, Harmonic Lightwaves, Inc.

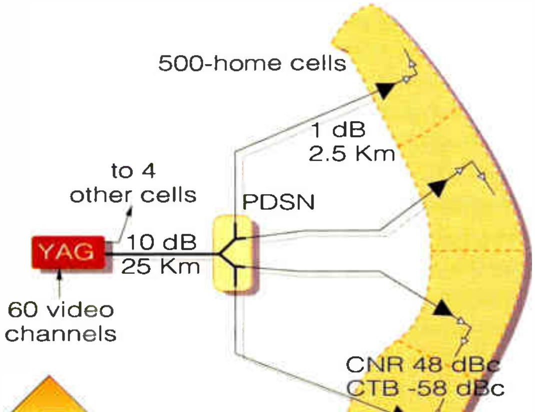


FIGURE 1
The passive-distributed-star-network architecture

Though high-power optical transmission systems based on Nd:YAG lasers clearly are capable of spanning immense distances, even replacing digital supertrunks, the more significant applications may come as cable TV operators push optical fiber closer to customers.

Indeed, as cable operators build passive networks, create compact serving areas and offer new types of services–such as interactive multimedia, video-on-demand and telecommunications services–the role of high-power transmission networks will increase. Though it is sometimes mistakenly believed that high-power transmission networks are suitable only for broadcast–not narrowcast–services, Nd:YAG/externally-modulated transmission equipment is well-suited for targeted, niche service delivery, not just high penetration basic, premium or pay-per-view fare. This article aims to explain how high-power transmission networks are suitable for such narrowcasting, as evidenced by the specific and recent actions taken by cable operators Ventury County Cablevision and Adelphia Cable Communications.

Ventura County Cablevision, for example, installed its first YAG transmission system in August last year, retrofitting 30 of 110 miles of plant with optical fiber trunk. The installation created 19 optical serving areas of about 500 homes, each connected on a home-run basis with one of three transmitters.

Each of the three transmitters features dual 10-mW output ports, and each of the outputs is split on about a 3:1 ratio to feed receivers over optical paths featuring between 2.5 dB and 11 dB worth of optical loss. There's no need to "tweak" each of the receivers for received optical power that varies because of path loss. Instead, each receiver compensates automatically for received optical power, using both optical automatic gain control circuitry and radio frequency AGC.

Ventura County Cablevision installed the YAG network as part of a planned upgrade from 300 MHz to 550 MHz. Prior to its decision to use the YAG network, Ventura County engineers carefully weighed the use of both DFB-based transmission equipment and YAG gear.

During Ventura's decision-making process, which happened last fall, the trade-off came down to a choice between an 8-mW output DFB transmitter and a YAG solution featuring a transmitter with two 10-mW outputs.

However, since Ventura County Cablevision needed 80-channel-active capability, it would have needed to install two DFB transmitters for each of the 19 receive nodes, using a split-band approach to load 40 channels on each of two separate fibers and recombining the signals at the node.

Using the YAG approach, all 80 channels are carried on a single forward path fiber to each receiver. All things considered, Ventura Cablevision found the initial, first-installed cost of either the DFB or YAG network to be comparable.

Perhaps just as significant, Ventura Cablevision didn't sacrifice its ability to provide more targeted services later. For starters, each of the three communities served by the network (Calabasas, Agoura Hills, Oak Park) is fed by a different transmitter.

That means targeted programming can be provided on a community-specific basis. Also, the 3:1 transmitter-receiver split ratio is similar to that typically found on DFB-based systems. Should bandwidth-intensive video-on-demand or telecommunications opportunities later require it, in-place dark fibers would support additional, dedicated transmitters for those purposes. Alternatively, wave division multiplexing techniques could be used.

Passive networks

Separately, Adelphia Communications engineers have been building passive, or nearly passive, networks that feature only one or two active devices in the entire distribution network.

As originally conceived for the 750-MHz rebuild of its Syracuse, N.Y. network, the Adelphia passive network imposed only a single active element–the optoelectronic receiver–between the headend and any single customer location (see related story, pg. 36).

Such a design completely eliminated the use of active RF devices on the feeder network. The objective: remove as many points of failure in the network as possible. As design work proceeded, however, Adelphia engineering Vice President Dan Liberatore and Manager of Systems Engineering Joe Selvage found that adding one active device back into the design had enormous cost implications.

High-power optical systems gain significance as ops push fiber closer to customers.

"We started out with half-mile service areas, using the passive approach," said Selvage. "When we added one active element to the cascade, our service area coverage stretched out to two miles, just by adding the first active."

Two actives per mile

Such a design results in a plant that features only two actives per mile, compared to the five to seven devices typical of a "fiber-to-feeder" design. In Syracuse, the active counts have come in at about 2.25 actives per mile.

"I'd be real happy if we can lock in at under two per mile," says Selvage. As a

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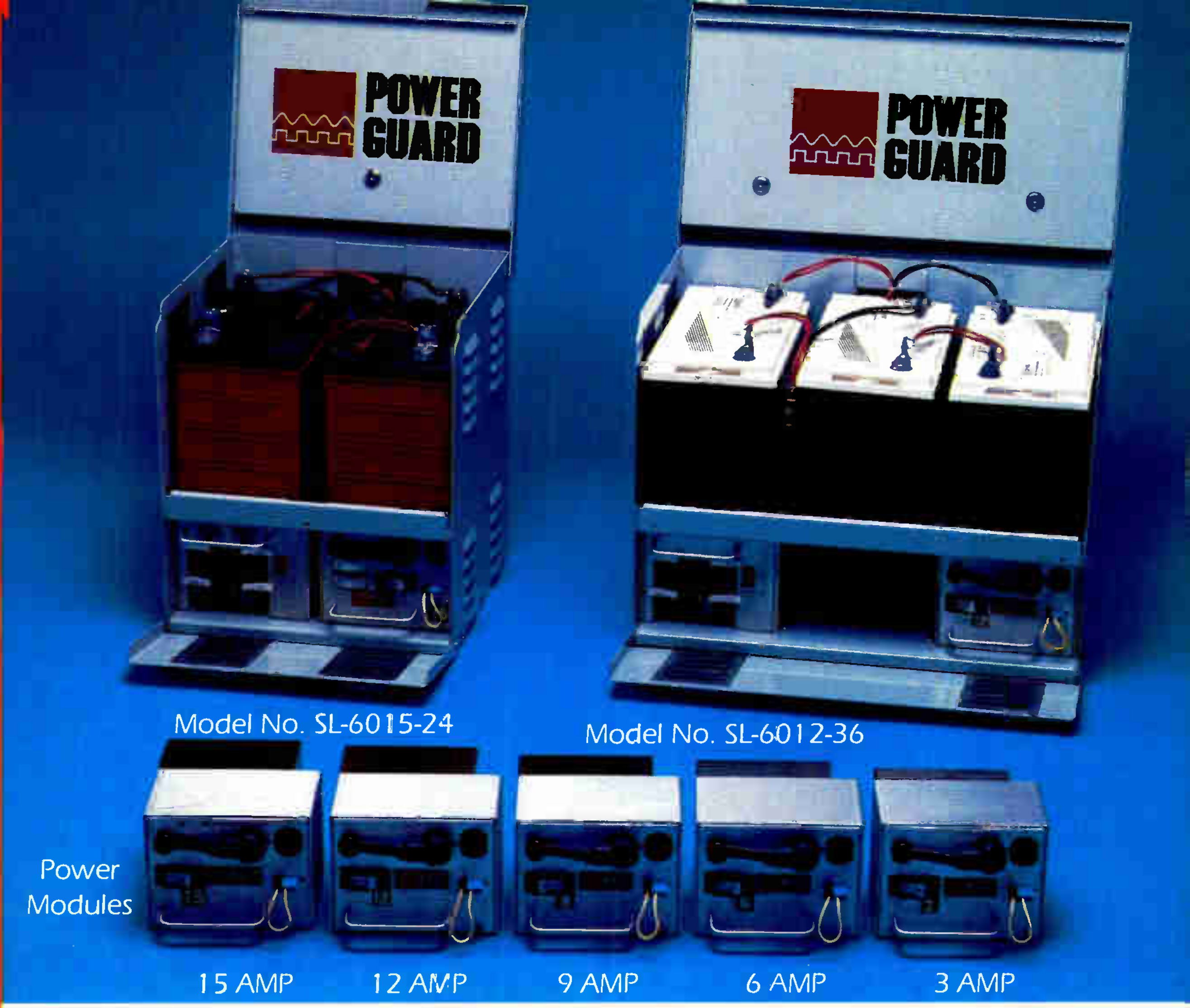

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plus, the power supply coverage area, using the nearly-passive design, is "up to four miles coverage each." When Adelphia engineers looked at the standard FTF design, power supply counts were running 0.3 to 0.4 per mile, says Selvage. Indeed, it seems that "passive is a whole new animal."

Wave division multiplexing or dedicated fiber should accommodate any conceivable service.

According to Selvage, high-power YAG technology becomes increasingly attractive as large, sprawling urban and suburban systems are looked at with such nearly-passive networks in mind. "We've begun to look at using repeat stations for such large networks, where five to six miles of fiber need to be put into place just to reach a neighborhood," says Selvage.

Urban advantages

"Transmitters in the 20 milliwatt range do seem to play a role when you have hundreds of nodes to feed," Selvage continues. " We've found that we get a more efficient design, when working with 200 to 400 nodes, using high power transmitters."

Narrowcasting?

Adelphia doesn't think the need for active signal repeating, as may be required in many 750-MHz urban and suburban networks, necessarily implies that narrowcasting capability is lost or otherwise diminished as a result.

In fact, argues Adelphia's Selvage, there will always be some inherent limitation to physical narrowcasting. This is true, Selvage explains, even when using the conventional fiber-to-the-feeder (FTF) design and a high transmitter-receiver split ratio.

"Even in FTF, the number of nodes fed by any single transmitter bounds you. If you have a 1:6 ratio, then there's an inherent limitation on narrowcasting, in any case," Selvage explains.

Still, the way Adelphia sees it, either wave division multiplexing or use of dedicated fiber should accommodate any conceivable service provided on a highly-individualized basis.

"We see using one broadcast transmitter for the 5 MHz to 550 MHz bandwidth, then an inexpensive laser and a second detector to provide narrowcast material," Selvage notes.

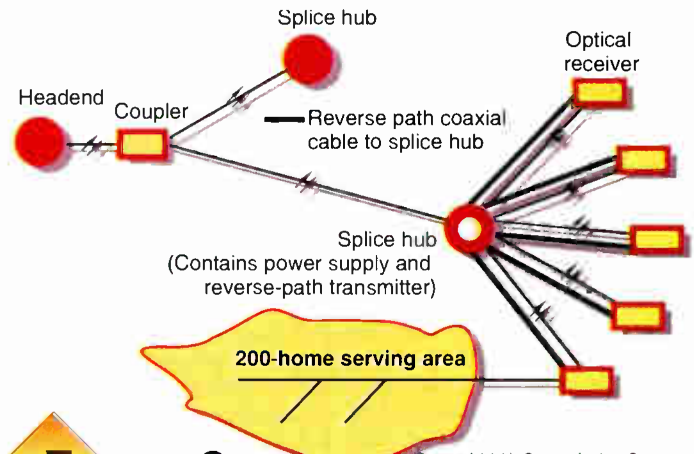

FIGURE 2
Adelphia Communications passive network design

In its Syracuse system, Adelphia allocated one fiber for broadcast services, one fiber for return communications and one fiber for narrowcast services.

> **The sheer challenge of managing large fiber counts inside headends and hubs must be addressed.**

Harmonic Lightwaves officials use the term "logical narrowcasting" to describe much the same thinking. The issue is discretionary bandwidth. How much do you need?

In a typical application, which might require use of the 550 MHz to 750 MHz bandwidth for compressed digital services, it makes sense to allocate about 2,000 to 4,000 subscribers per transmitter.

Also, because a high bandwidth and reliable network suggests the use of as much passive design as possible, a 200-home serving area design therefore requires something on the order of 10 to 20 receivers for each transmitter.

That, in turn, suggests a high-power transmitter featuring 20 mW of output. The point: operators don't sacrifice narrowcasting capability, at least when a compressed digital services tier is to be carried alongside an analog tier. This is true for the simple reason that high-power transmitters are used as part of the network design.

All that is requiredto adequately facilitate narrowcsting is some reasonable estimates of traffic and contention, and a network design which accommodates the expected level of contention for narrowcast services.

Fiber management

Though it hasn't been a huge headache up to this point, the sheer challenge of managing large fiber counts inside headends and hubs also must be met as passive and near-passive networks become commonplace. In many systems, this could amount to hundreds of fibers going into and coming back from the distribution network.

"It's a substantial task," says Selvage. At issue, of course, is the simple fact that terminating this many fibers inside a headend or hub makes optical splicing a less effective solution than using optical connectors, especially when the network

Ventura County Cablevision at a glance

- ✔ 10,500 customers
- ✔ 110 miles of plant
- ✔ 80 percent underground plant
- ✔ 19 optical receiver nodes
- ✔ 500-home optical serving areas
- ✔ Maximum 5 distribution amps in cascade
- ✔ 50 dB or better C/N at the fifth amp
- ✔ 550 MHz bandwidth
- ✔ Optical paths range from 2.5 to 11 dB
- ✔ 12 homerun fibers to each node
- ✔ Since August 1992, not a single optical network failure
- ✔ Remote network management

needs to be reconfigured.

To manage a headend with large fiber counts, operators will need a structured fiber management system resembling a patch cord matrix, or cross-connect panel, such as those typically found in telephone networks. That way, all necessary splicing and connectorization can be done at the factory and before it arrives on site. All that must be done in headends and hubs, then, is a fairly simple attachment of input and output jumpers.

Signal repeat stations or high-power transmitters do not necessarily sacrifice narrowcasting capabilities.

There could be noise penalties with such a strategy, however. This depends largely on the type of laser used in the transmitter. Optical connectors, for example, can cause backreflections of light within the fiber, which can ultimately degrade the signal quality to unacceptable levels.

Fortunately, the optical output power of a YAG transmitter addresses this problem. Because of its construction, YAG lasers are virtually immune to backreflections, so that splits and connectors, even when they are made within the headend, do not affect signal quality going out to the distribution plant.

There are advantages in the testing arena as well. As an example, consider a situation in which an optical time domain reflectometer (OTDR) measurement is necessary. With the connectorized hubs in place, all a technician must do is remove a jumper cable and attach the OTDR.

Also, because the connectors and couplers are located so close to the transmitter, tests of link launch power are inherently simplified.

High-power distribution

It's a fairly safe bet that tomorrow's high-bandwidth, reliable networks will deliver narrowcast applications, such as video-on-demand or telecommunications. In order to accomodate those narrowcast functions, those networks will almost certainly feature the use of passive or near-passive distribution plant and extremely compact serving areas.

Taken as a whole, those requirements suggest the need for the deployment of hundreds of optical receivers in the field, as well as a supporting backbone network. This network will likely be structured as a physical and logical ring.

In light of these considerations, high-power YAG transmission techniques, combined with a ring backbone architecture and simple, connectorized hubs for physical management of the cabling infrastructure, are one way of building such a transmission platform.

No sacrifice

Though conventional wisdom suggests that signal repeat stations or use of high-power transmitters necessarily sacrifices narrowcast capability, it is our opinion that this is simply incorrect.

Prudent analysis of anticipated traffic and contention for network bandwidth suggests that high-power transmitters and moderately-high transmitter-receiver splitting ratios are not detrimental to the goal of maintaining narrowcast programming capability. In fact, the combined use of compressed digital signals in the 550 MHz to 750 MHz bandwidth, wave division multiplexing techniques and dark fibers are tools to provide a cost-effective mix of broadcast and narrowcast services. CED

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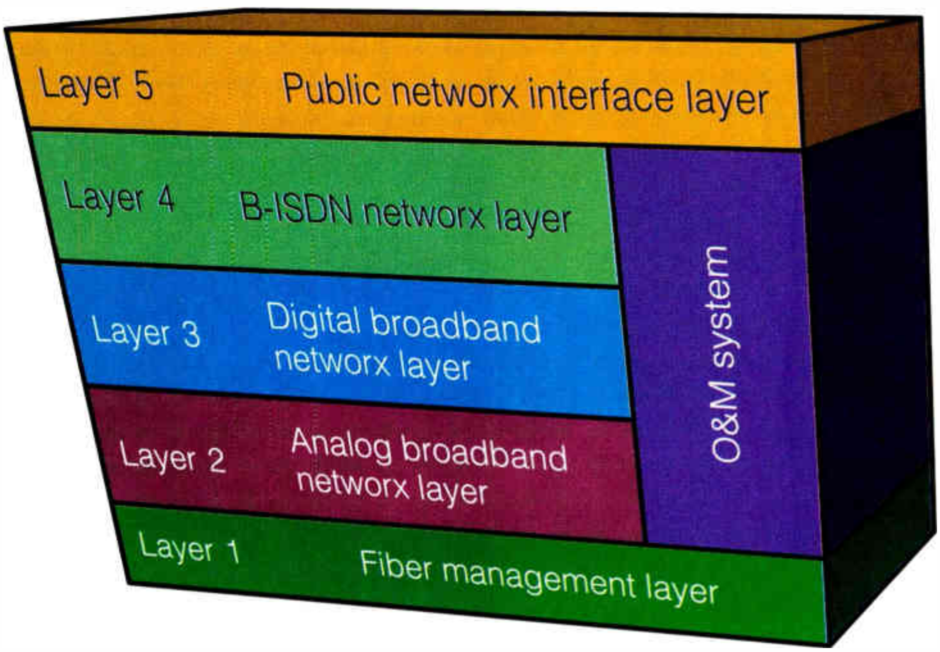
FIGURE 1
Universal Broadband network hierarchy



By Steve A. Day, Vice President, CATV Business Group, American Lightwave Systems

Universal Broadband Networx (UBN) is a concept that has been developed to assist CATV companies with plans to evolve into multimedia. Simply put, UBN places primary emphasis on the network's ability to evolve vertically to support an increasingly wide variety of information services.

One of the most important demands being placed on MSO engineering resources is to invest in the network today. When future multimedia opportunities arise; the CATV system will not have to be burdened with second time investments. Figure 1 represents an overview of the UBN model.

"Universal" reflects that the UBN model will fit any system, no matter how big or small. "Broadband" is "a service or system requiring transmission channels capable of supporting rates greater than the primary rate" (CCITT SG XVIII Draft I.113, January 1990). This is significant because CATV represents a huge broadband pipeline that can be utilized for a variety of services. "Networx" reflects the ability to integrate all services represented by transmission capacity from broadcast video to packet switched services.

The UBN five-layer hierarchy represents the core planning tool for CATV operators. These layers are:

1. Fiber management
2. Analog broadband networx
3. Digital broadband networx
4. B-ISDN networx
5. Public interface.

If a CATV system is small and can only justify small fiber optic investments, then current capital investment should only deal with layers 1 and 2.

However, layers 3, 4 and 5 should also be planned for. If a CATV system serves a major urban area, then current capital investment should deal with all the layers of UBN.

Univeral broadband networx hierarchy

Figure 2 represents a more expanded view of each layer. Upon viewing the detail of each layer, note that there is also a growth pattern within each layer from left to right. The far left partition represents the nearest term, fundamental UBN element. To the right of the hierarchy, the partition represents a longer term, secondary UBN element. However, the farthest right partitions cannot be properly implemented if the far left elements have not been addressed.

Fiber management layer

Fiber management has been largely neglected in CATV networks because fiber optic cables have served the single purpose of video transmission. In the future, good fiber management will become essential as broadband services are added. Also, as switched traffic is added, fiber management becomes essential. Without fiber management, the CATV system will experience lost productivity, unnecessary service interruptions, limited plant access and other contributors to high network maintenance cost.

Fiber management begins with OSP (outside plant) cable and splice management. This is followed by cable storage, connectorization, and the ability to reassign fiber cables to different headend equipment at will. It is important to maximize the utilization of each fiber and the opto-electronics when capacity becomes scarce.

As the percentage of fiber optic utilization increases, an integrated optical passive management system for optical coupling, optical WDM, variable optical attenuation and other fiber maximization techniques becomes important.

Analog broadband networx layer

Layer 2 represents the traditional AM fiber optic network. All CATV systems should establish network migration plans to accomplish fiber optic propagation from 2,000-home cells to 100-home cells. Much has been written about this, so it will not be described within this paper. However, the important fundamentals of UBN layer 2 are:

✔ UBN requires a status monitoring system that not only serves to deal with the electronic components on layer 2, but also on layers 3 and 4. Reliability and outage prevention become increasingly important as telephony and transaction-based services are added to the network.

Switched networks require status monitoring because a component failure can affect only one individual. This is dissimilar to today's CATV broadcast network where an outage always affects many customers. Individual customer outages

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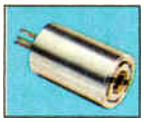

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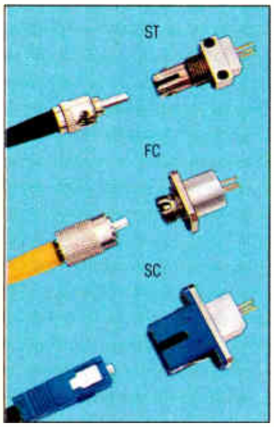

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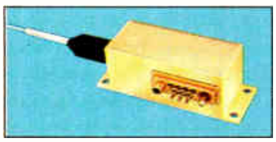

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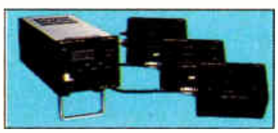

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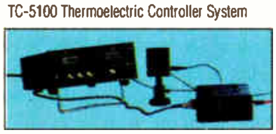

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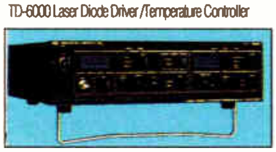

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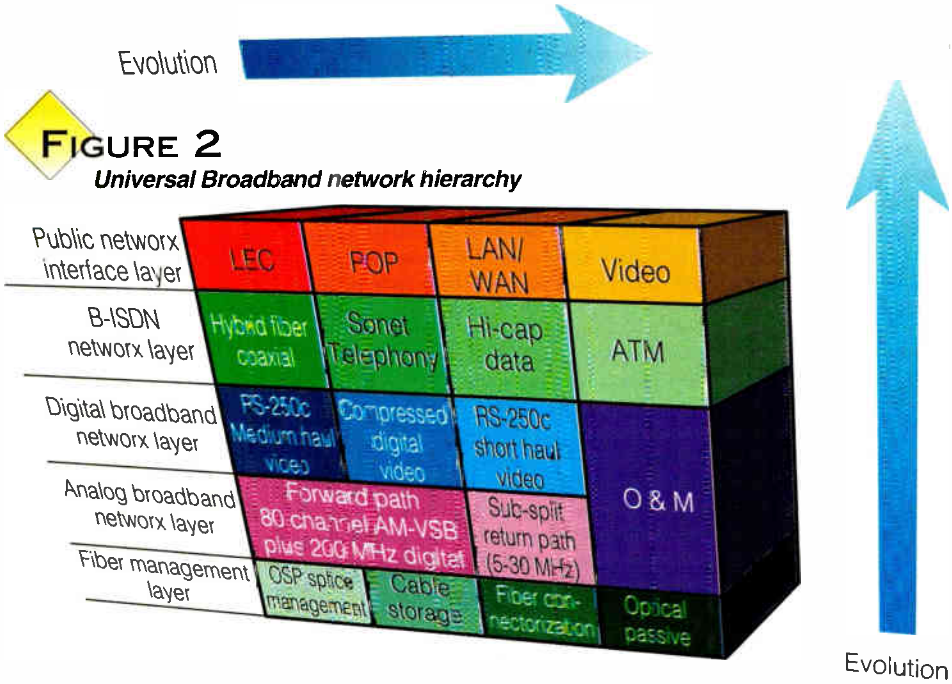

FIGURE 2

Universal Broadband network hierarchy

are much harder to isolate.

✔ UBN does not require exotic return schemes. Using only the 5 MHz to 30 MHz return path, 224 DS-0s can be allocated to the homes within each cell. The UBN utilizes traditional diplex filtering and economical Fabry Perot return lasers. Other network architectures require non-conventional return paths (operating near 1 GHz). This requires expensive diplex filter sets and, most importantly, high-cost DFB lasers. Because networks will have hundreds of cells, this has a major economic impact on network costs.

Digital broadband networx layer

Layer 3 defines three key network elements. First, it represents a remote hub with substantial physical presence (i.e. building, cabinet, vault). Second, it represents the traditional point for power supply, optical node and splice access point. Third, it represents the extension of the digital network (later the cost justification is given).

The key network elements include:

✔ Provision of 60 dB CNR headend quality video (medium haul).

✔ Provision of a remote location that can offer hundreds of broadcast video channels and distribute a selected channel lineup at each hub (narrowcasting).

✔ An access point for compressed video processing.

✔ A 70 dB SNR for studio quality video transmission (short haul).

✔ A the termination point for UBN layer 4 (B-ISDN).

Finally, the UBN layer 3 hub will provide the necessary site for MAN (metropolitan area network) access. The key MAN elements include:

✔ An add/drop/multiplex site for telephony ring networks.

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- ☐ 2. Cable TV Contractor
- ☐ 3. Cable TV Program Network
- ☐ 4. SMATV or DBS Operator
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❺ What is the approximate dollar value of the annual budget you are responsible for?
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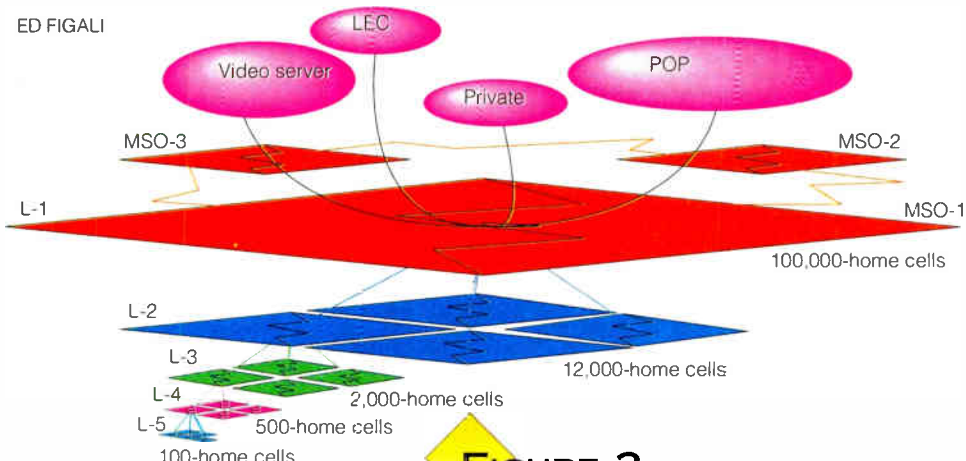


FIGURE 3
Universal Broadband network topology

✔ A point of concentration for telephony services.
✔ A future ATM hub location.
✔ A routing point for digital video services.

B-ISDN networx layer

Layers 1 through 3 are essential for CATV video transmission. Upon adding the B-ISDN layer 4 to the network, the CATV system becomes a fully functional multimedia network.

Competitive access (CAP) vis-à-vis digital telephony networks represents the second partition of UBN Layer 4. To deliver CAP services, the CATV system must invest in fiber plant within commercial enterprise zones (CAP business will not typically utilize the coaxial plant).

Upon adding DS-0 through DS-3 services to the CATV CAP network, the CATV system can then evolve to include many specific high-capacity transmission circuits; such as SMDS and FDDI. By adding high capacity (Hi-cap) data circuits, the CATV system can substantially increase revenue off of CAPs.

Finally, as ATM technology develops and its cost comes down. the CATV system will incorporate ATM technology within the residential HFC and the commercial CAP areas. This will provide for interactive video and multimedia services.

Public network interface layer

By the time a CATV operator reaches the need and revenue justification for the Public Networx Interface Layer, the need for network connectivity will become overwhelming. Co-location, switched access, intra-LATA toll and number portability will all be regulatory stimuli for LEC (telephone local exchange) connection.

Growth in CAP business should result in connection to all POPs (common carrier points of presence). The growing business of LAN (local area network) connectivity should stimulate LAN/private network connection. Lastly, the cost of switched video and the CATV economy of scale should drive MSOs to interconnect CATV systems within the same geographic area.

Given any one or all of the above events, the CATV system must consider the physical interface for each of these access points. The following elements of the network should be considered:

✔ The CATV system must develop an access frame which isolates its equipment from that of the customer or signal provider. These physical frames must provide cross-connect functionality, the ability to fault locate and restore failed circuits, and change traffic patterns at the origination point.

One of the most important demands being placed on MSO engineers today is prudent network investment.

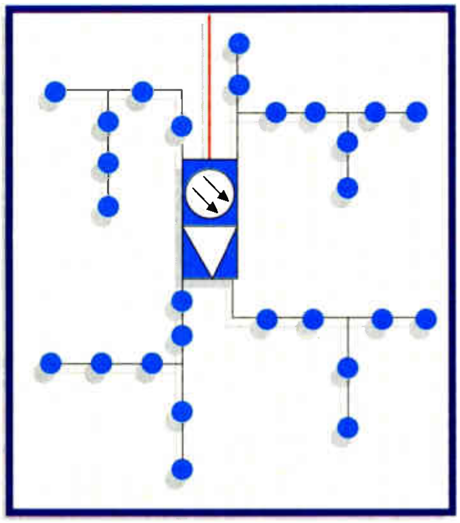
✔ The CATV system must develop an access frame that provides the opportunity to multiplex or de-multiplex the signal hand-offs to the appropriate formats (de-multiplex a DS-3 into many DS-1 circuits).

✔ The CATV system must define a plan of physical frame access or digital cross-connect system functionality to adequately meet the needs of connectivity to other communications systems.

UBN topology

Figure 3 reflects how the five layers of UBN interrelate. The network development goal is to migrate economically to 100-home cell sizes. With 100-home cells, a CATV system will have the sufficient capacity to support future services, as

FIGURE 4A
100-home fiber cell



defined in the higher layers. The key question is why do 12,000, 2,000, 500 and 100 homes represent critical sizes for the network serving areas?

Figure 4a reflects a 100-home cell. This is the cell size goal for providing true multimedia service. Engineering studies have established 100-home cells (at 750 MHz) as the point of elimination of all RF amplifiers. This becomes extremely important because:

✔ Cascades of electronics are eliminated, thereby improving system reliability.

✔ One set of diplex filters (at the cell receiver) can be used to dynamically change the return bandwidth for future ATM channels or other higher capacity switched services.

✔ System reliability for any telephony services requires the ability to transmit high-speed data streams. Each stage of modulation and amplification in the network represents a point of data corruption.

A cell size of 500 homes (Figure 4b) represents all of the elements contained in the 100-home cell, with two differences:

✔ RF amplifiers are required, in cascade. This locks the return path to 5 MHz to 30 MHz. This is acceptable until higher capacity circuits in UBN Layer 4 are added to the network. Then, the requirement of a dynamically increasing return path becomes a problem multiplied by the number of amplifiers in the system.

✔ At 500-home cells, only 20 percent customer telephony service penetration is supported. To provide a basic rate ISDN circuit to customer #101 will require two decisions: Increase the return path bandwidth or reduce the cell size.

This leads the CATV network to the 100-home cell.

In a small system, UBN also accommodates the 2,000-home cell (Figure 4c). This cell size does not have a functional definition in UBN because it does not allow for telephony services, at any significant penetration level. Yet, it is viewed as an interim economical goal for later migration to fiber cells. A 2,000-home cell can migrate to four 500-home cells or ultimately to 20 100-home cells.

The cost of switched video should drive MSOs to interconnect CATV systems within the same area.

The 12,000-home hub represents the boundary between UBN layers 2 and 3. In the short term, this represents a serving area that justifies digital video versus AM video. In the long term, it represents a threshold wherein distributed broadband services (such as ATM circuits) can be injected into the residential pipeline.

The economics

The following define the economic assumptions for the 12,000-home hub model:

A layered network approach enables cost-effective network planning and implementation.

1. A digital video hub currently costs $3,200 per channel ($256,000 for 80 channels) and provides a 60 dB CNR video performance .

2. Each milliwatt of optical power budget in an AM fiber optic system costs $1,125.

3. A 12,000-home hub with homerun fiber optics (to individual cells) serves 24 cells (500-home cells) or 120 cells (100-home cells).

If the CATV system architecture utilizes a (60 dB CNR) digital backbone to link 12,000-home serving areas, it would cost $256,000. By dropping 60 dB studio quality via the digital system, the operator can relax the demand on the AM fiber optics from 53 dB CNR (10 mW laser transmitter) to a 51 dB CNR (6 mW). At 500-home cells this represents a savings of $243,000, and at 100-home cells a savings of $540,000.

When considering telephony switched services, it is important to remember that each physical transmission medium (i.e. the hybrid fiber/coaxial cell) must be terminated uniquely and individually (homerun fiber links) onto the telephony switching fabric. Therefore, it is more economical to provide digital service to the 12,000-home serving area than to over-extend AM fiber optics.

One final note on this layering concept. It is not as important today to implement digital video down to the 12,000-home serving area as it is important to create the migration opportunity from UBN layer 2 to UBN layer 3. AM fiber can be used at 12,000-, 2,000-, and/or 500-home cell sites for providing video services. Digital

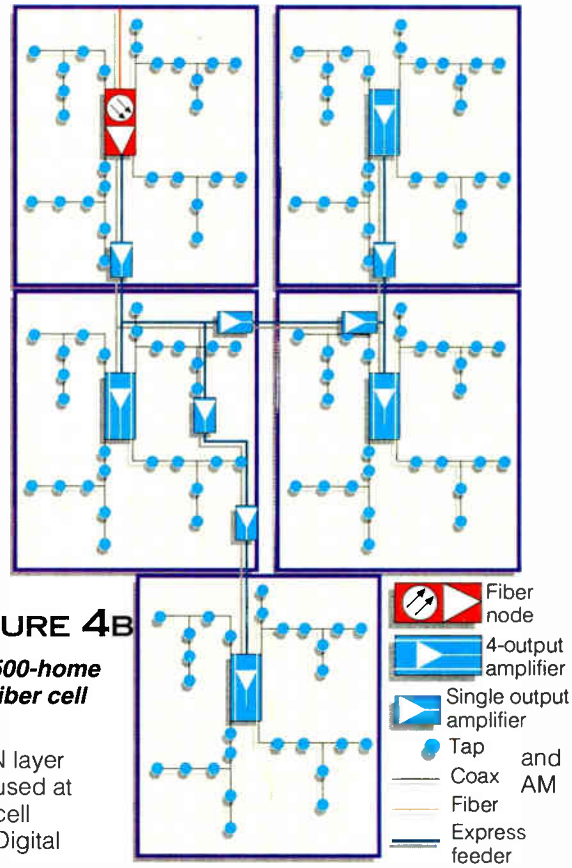
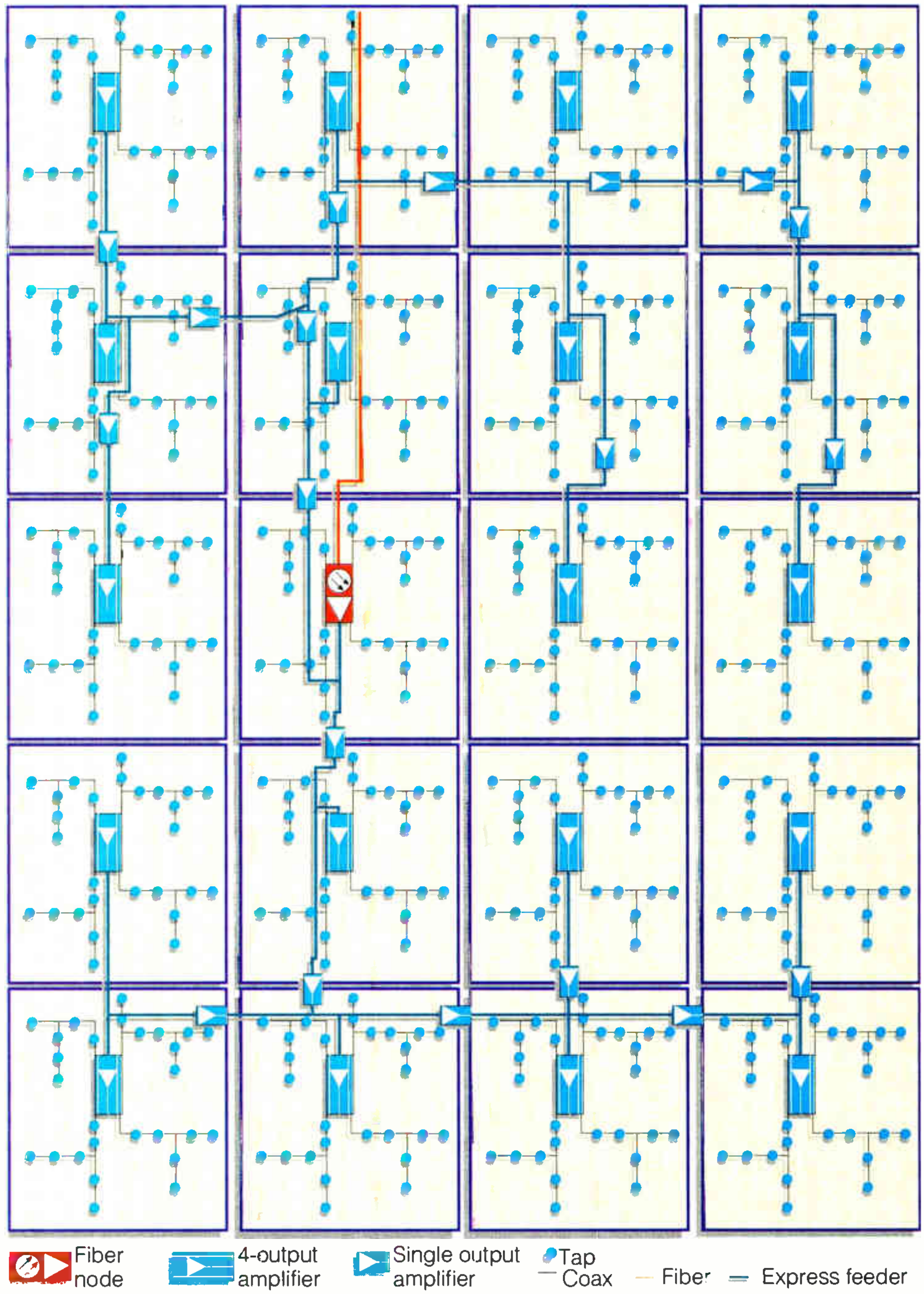


FIGURE 4B
500-home fiber cell

FIGURE 4C

2,000-home fiber cell



may be extended, closer to the subscriber, as revenue opportunities arise.

This ability to migrate, based on revenue opportunities, is what the UBN layering concept and design philosophy is focused on.

Conclusion

The Universal Broadband Networx is a philosophy that attempts to focus on important elements of the future CATV network development. UBN views the network in terms of future requirements of multimedia and switched services.

At layers 1 and 2, for example, the CATV engineer can plan, budget and build a modest AM fiber network positioned to grow in the future.

At layer 3, the CATV engineer can develop a physical presence, a digital demarcation point and a switched services access point. At layers 4 and 5, the CATV engineer can begin adding entire new business platforms including physical connection to other communication networks. CED

The issue: Emergency alerting

Another FCC rulemaking currently underway that stands to have a major impact on the cable industry is one related to the old Emergency Broadcasting System. The FCC would like to modernize the system and bring more cable operators into the program as active participants. Operators want to be good citizens, but the industry has said it cannot afford expensive hardware because of the number of channels a system distributes. How do you feel about the issue?

The questions:

1. Is your system active in the current EBS locally?

❑ Yes ❑ No ❑ Don't know

2. Is your system interested in becoming more active in a modern emergency alerting program?

❑ Yes ❑ No ❑ Don't know

3. Is your local geographic area prone to numerous emergencies on an annual basis?

❑ Yes ❑ No ❑ Don't know

4. Are you aware of the FCC proceedings to include cable in the new national alerting system.?

❑ Yes ❑ No ❑ Don't know

5. Does your franchise agreement require emergency alerting capability?

❑ Yes ❑ No ❑ Don't know

6. Do you have plans to add emergency alerting equipment to your headend in the next year?

❑ Yes ❑ No ❑ Don't know

7. If a new alerting system cost $500 per channel, would your system buy it?

❑ Yes ❑ No ❑ Don't know

8. If a new alerting system cost $1,000 per channel would your system buy it?

❑ Yes ❑ No ❑ Don't know

9. Does your system presently have programming override equipment in place in the headend?

❑ Yes ❑ No ❑ Don't know

10. If so, does it override audio only, or audio and video signals?

❑ Yes ❑ No ❑ Don't know

11. If your system has such equipment, does it override all channels, including broadcast?

❑ Yes ❑ No ❑ Don't know

12. If you have emergency alerting equipment, how often has it been activated and/or tested?

❑ Yes ❑ No ❑ Don't know

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RESULTS

Cable operators think the industry should do more than it already has to become more compatible with TVs and VCRs located in subscribers' homes, according to our survey.

A large number of those responding said they often hear complaints from consumers regarding the incompatibility, so much so that they've at least investigated the use of traps and interdiction to overcome the problems.

While a slight majority favor placing decoding circuitry inside the TV or VCR, even more think "smart card" type renewable security makes more sense, because operators won't be "giving away" their decoders.

Unanimously, survey respondents said the cable industry and the consumer electronics industry need to act in concert to overcome the conundrum. Nearly half of those who answered the survey thought the government will end up forcing the two interests to work together.

Finally, the move toward a digital world was hardly seen as a panacea for the problem: respondents were almost evenly split over the issue improving with the advent of digital set-tops.

Note: This is an unscientific survey that may or may not reflect the feelings of the industry as a whole.

The issue: compatibility

The issue of compatibility between cable set-tops and consumer electronic devices has gained wide attention because it's the subject of a current FCC rulemaking. We wanted to find out operators' thoughts regarding the issue.

The results:

1. Does your system use set-top addressable descramblers?

Yes	No	Don't know
85	15	0

2. Does your system often hear complaints about incompatibility between set-tops and TVs and VCRs?

Yes	No	Don't know
80	20	0

3. Do you personally often hear these complaints?

Yes	No	Don't know
75	25	0

4. Has your system made any effort to purchase convertors that are more compatible with new TVs and VCRs?

Yes	No	Don't know
30	70	0

5. If so, have those efforts been successful in reducing the number of complaints?

Yes	No	Don't know
83	17	0

6. Has your system considered using traps or interdiction to improve the compatibility issue?

Yes	No	Don't know
65	30	5

7. Has the compatibility issue gained the attention of your local city council, newspaper or franchising authority?

Yes	No	Don't know
20	55	25

8. Have subscribers disconnected because of your system's use of set-top descramblers?

Yes	No	Don't know
25	55	20

9. Do you favor an industry shift toward putting decoding circuitry directly inside TVs and VCRs?

Yes	No	Don't know
55	30	15

10. Do you favor adoption of smart card-type renewable security for set-top descramblers?

Yes	No	Don't know
75	15	10

11. Do you believe the cable industry should do more than it is already to become more compatible with consumer electronics?

Yes	No	Don't know
65	35	0

12. Do you think the two industries should act together to solve the incompatibility problem?

Yes	No	Don't know
100	0	0

13. Do you think the government will force the two industries to work together?

Yes	No	Don't know
45	25	30

14. Do you think that as the industry moves toward digital technology, the compatibility problems will improve?

Yes	No	Don't know
50	40	10

15. Is direct pick-up interference a major problem in your system?

Yes	No	Don't know
25	70	5

Selected comments:

All industries involved need to put the end user at the top of the list and get on with solving this problem.

–John Drake, TCI, Red Lion, Pa.

We have started using convertors with a built-in A/B switch. This has cut complaints a lot.

–Jim Dineen, TCI, Olympia, Wash.

The problem with decoders built into TVs and VCRs is that cable operators could not affect repairs. Subscribers with TVs in repair shops would go without service for an unacceptable amount of time.

–Mike Snow, Cablevision, Corry, Pa.

September

2 Badger State SCTE Chapter Technical Seminar. "New Competitive Technologies" with David Devereaux-Weber of DDW Services; "Business Opportunities in a Digitally Compressed Format" with Chuck Koplar of Scientific-Atlanta. Location: Chula Vista Resort, Wisconsin Dello, Wisc. Call Gary Wesa, (414) 496-2040.

9 SCTE Satellite Tele-Seminar. "Fiber Optics: A Practical Approach, Part II" featuring Tom Staniec of Newchannels Corp. Transmitted on Galaxy I, Transponder 14. Call SCTE headquarters, (215) 363-6888.

9 Chesapeake SCTE Chapter Meeting, Testing Session. Installer and BCT/E exams to be administered in all categories at both levels. Location: Arlington, Va. Call Scott Shelley, (703) 358-2766.

9 Magnolia SCTE Chapter Technical Seminar. "Proof of Performance and CLI Testing" with Terry Bush of Trilithic. Location: Ramada Coliseum, Jackson, Miss. Call Chris Cooper, (618) 982-9700.

9 Penn-Ohio SCTE Chapter Technical Seminar and Testing. "Video and Audio Measurements." Installer and BCT/E exams to be administered in all categories at both levels. Location: Sheraton Hotel, Warrendale, Pa. Call Marianne McClain, (412) 531-5710.

12-13 Old Dominion SCTE Chapter Technical Seminar and Testing. "Digital Compression;" "Data Networking" with Wes Burton of Continental Cable. Installer and BCT/E exams to be administered in all categories at both levels. Location: Holiday Inn, Richmond, Va. Call Margaret Davison, (703) 248-3400.

13 Cable TV Measurement Seminar. Hosted by Tektronix. Location: New Orleans, La.

Conferences/Shows

September 13-14 Convergence II: Interactive Services. Produced by Multichannel CommPerspectives. Focus: The next generation of cable services, including multimedia, electronic program guides, interactive advertising, video game distribution, advanced home shopping and more. Location: Santa Clara, Calif. Call Jayne Conant, (303) 393-7449.

September 15-17 Taipei Satellite and Cable '93. Location: Taipei, Taiwan. Call Cable and Satellite TV Guide, 011-886-2-778-5818.

September 27-29 National Communications Forum. Hosted by National Engineering Consortium. Location: Hyatt Regency O'Hare, Chicago, Ill. Call (312) 938-3500.

September 29-30 Defining the Electronic Consumer II. Hosted by Jupiter Communications. Location: Grand Hyatt, New York City. Call (212) 941-9252.

October 5-6 Atlantic City Show. Location: Atlantic City, N.J. Call (609) 848-1000.

14 New York City SCTE Chapter Technical Seminar. "Digital Compression" with Carl McGrath of AT&T; "Video Servers" with Ed Szurkowsi and "Personal Communications" with Bob Tvohy. Location: AT&T Bell Labs, Murray Hill, N.J. Call Rich Fevola, (516) 678-7200.

15 Bluegrass SCTE Chapter Technical Seminar, Testing. "Video Testing," "Waveform Monitors," "Vectorscopes" and "Demod or Calibrated Demod" with Jim Edwards of Tektronix. BCT/E exams to be administered in all categories at both levels. Location: Howard Johnson's, Lexington, Ky. Call Alan Reed, (502) 389-1818.

15 Piedmont SCTE Chapter Technical Seminar and Testing. "Alternate Technologies." Installer and BCT/E exams to be administered. Location: Greensboro, N.C. Call Mark Eagle, (919) 477-3599.

15 South Jersey SCTE Chapter Technical Seminar. "VideoCiphers and Interactive Convertors." Location: Ramada Inn, Vineland, N.J. Call Mike Pieson, (609) 967-3011.

15-17 Fiber Optic Training. A three-day course hosted by the Light Brigade. Focus: design, installation and maintenance of fiber optic communications systems for voice, video and data applications. Classroom and hands-on activities included. Location: Beaverton, Ore. (206) 251-1240.

16 Gateway SCTE Chapter Technical Seminar. "Antennas, Earth Stations and Headends." Location: Overland Community Center, Overland, Mo. Call Bill Mullin, (314) 272-2020.

16 Greater Chicago SCTE Chapter Technical Seminar. "Troubleshooting." Location: Quality Inn, Palatine, Ill. Call Bill Whicher, (708) 362-6110.

16 Lake Michigan SCTE Chapter Technical Seminar. "Basics." Call Karen Briggs, (616) 941-3783.

16 Mount Rainier SCTE Chapter Technical Seminar. Location: Martha Lake, Wash. Call Gene Fry, (206) 747-4600, ext. 107.

16 Rocky Mountain SCTE Chapter Technical Seminar. "Plant Equipment." Call Ron Upchurch, (303) 790-0385, ext. 403.

18 Rocky Mountain SCTE Chapter Technical Seminar. "Equipment Calibration and Set-up." Location: Glenwood Springs, Colo. Call Patrick Kelley, (303) 267-4839.

22 Palmetto SCTE Chapter Technical Seminar. "Headend Standards and Compliance Testing." Location: Columbia, S.C. Call John Frierson, (803) 777-5846.

27 Cable TV Measurement Seminar. Hosted by Tektronix. Location: Cincinnati, Ohio. Call (503) 627-1555.

27-29 SCTE Technology for Technicians II Seminar. Hands-on technical training for broadband industry technicians and system engineers. Location: Las Vegas, Nev. Call SCTE headquarters, (215) 363-6888.

An economical cable TV analyzer

SANTA ROSA, Calif.–New from Hewlett-Packard is its HP 8591C cable television analyzer, designed for cable operators to make economical, portable RF and video measurements. The unit, H-P officials say, conducts measurements in accordance with both FCC regulations and IEC standards. It supports NTSC, PAL and SECAM formats.

The analyzer performs the required FCC proof-of-performance RF measurements, and with an additional option, will perform the video measurements (which will become mandatory in 1995). What makes the unit different, H-P officials say, is its non-interfering RF and video measurement capabilities within a portable, single-box analyzer. Non-intrusive measurements enable uninterrupted service to the subscriber.

A selection of 14 built-in channel plans are included in the analyzer. For any channel plan, measurements can be made either manually or automatically. For example, the analyzer can perform automatic and unattended measurements and data collection for system monitoring and the FCC-required 24-hour tests.

Also, with an added accessory, the 8591C can double as a TV receiver, so that both audio and video can be displayed. The feature enables cable technicians to quickly identify picture quality problems, such as hum, noise, distortion and ingress.

The analyzer performs a wide variety of dedicated cable television measurements, including automatic tuning of visual, aural and FM broadcast carriers; visual and aural carrier levels and frequencies; depth of modulation; aural and FM broadcast carrier deviation; carrier-to-noise ratio; in-channel frequency response, in-service hum/low frequency disturbances; system frequency response, and distortion–among others.

Circle Reader Service No. 53

Stuck in a cornfield and need to phone home?

TORRANCE, Calif.–Here's some good news for those rugged, in-the-field types. New from Magnavox Electronic Systems Co. is a portable satellite telephone system, called the Magnaphone, for use in areas beyond the reach of telephone lines and cellular zones. Heads up, *Get Smart* fans–the phone looks "just like a modern briefcase," Magnavox officials say (see photo, this page). But inside, there's an integrated system of specially designed electronics, including a voice codec which converts human speech into digital data for satellite transmission.

The device weighs 27 pounds, including an internal power supply and replaceable battery pack. It can be hand-carried as passenger airline luggage.The new satellite phone was developed to provide mobile telecommunications in remote locations where reliable telephone landlines, cellular networks or electrical power connections are not available. The phone is

Networked ARUs

ROSWELL, Ga.–Telecorp Systems has introduced its transaction management system (TMS), a LAN-based automatic response unit for use in large, regional call centers. TMS allows large call centers to manage multiple ARUs as a single, unified system.

The system works by providing central administration and supervision of multiple Telecorp System 6000 ARUs. From a control center, a supervisor can monitor any ARU in the network and perform any administrative/supervisory function that can be performed individually from a single ARU. Consolidated reports are included, based on data collected from the connected units. "In the past, if a call center was utilizing multiple ARUs, reports would have to be generated from each unit and then consolidated manually. Now, reporting for multiple ARUs is simplified," says Roger Reece, VP of marketing for Telecorp.

The TMS database resides on the data server and contains all call transaction data collected from individual ARUs, and the report definition records used to generated consolidated reports. As calls are processed by ARUs, transaction records are automatically written to the TMS database. In the event of a server failure, transaction records are written to the local hard disk drive resident in individual networked ARUs.

Circle Reader Service No. 54

Optical power meter

BINGHAMTON, N.Y.–New from Meson Fiber Optics is its XL2000 series of optical power meters. The meters are rugged and hand-held, Meson officials submit, and measure the optical power of light traveling in an optical fiber in dBm, dB and watts. The units can be selectively calibrated at 850 nm, 1300 nm and 1550 nm. Two units are available: the XL2000, designed for telecommunications and data communication testing, and the XL2000C, designed for higher power applications including cable television. Both units can be powered via an AC adapter, rechargeable NiCd batteries or alkaline batteries.

Also new from Meson is its BR1550/Ls optical return loss light source, developed to provide a low-cost means for field technicians to perform return loss tests. Using their own power meters, Meson offiused by raising the lid of the briefcase and pointing it toward the appropriate satellite using its built-in compass, elevation angle indicator and signal strength meter. "You don't have to deploy an external satellite antenna array or fold out additional antenna panels, because the high gain antenna is integrated into the top of the unit," explains Mario Cid Fernadez, a spokesperson for Magnavox. The briefcase phone works in conjunction with the Inmarsat M satellite system.

All command and control functions are carried out through the Magnaphone handset, which is contained in a pull-out drawer and includes a standard LCD display showing system status, signal strength, operating mode and menu prompts. A "friendly, synthesized voice" leads the user through the operating procedures. The system includes several automated features, such as preprogrammable call routing, speed dialing, automatic satellite acquisition and call logging. Interfaces include two RJ-11 telephone ports for extra extensions, and an RS-232D serial data port for connection to a modem or printer. Production deliveries for the Magnaphone M are expected to begin this month, Magnavox officials say. No word yet on how much this portable phone booth will cost, but chances are it's more than a quarter.

Circle Reader Service No. 52

cials explain, technicians can connect the BR1550/Ls to the system under test, read their meter and subtract the two numbers to arrive at a system evaluation The source also includes a stabilized 1550 nm laser light source, which enables single-mode loss testing.

Circle Reader Service No. 55

Fiber optic attenuator

BOSTON, Mass.–New from Fotec is a variable fiber attenuator which is compatible with "SC" style fiber optic connectors. The SC connector has been chosen as a standard for several fiber optic networks as well as many telephone companies, Fotec officials explain.

Variable attenuator

The Fotec A434 variable attenuator allows insertion of up to 30 dB loss in any fiber optic cable system, Fotec officials say. It can be used to simulate long cables in a laboratory for testing systems, where its maximum loss of 30 dB is equivalent to 50 km to 60 km of cable. It can also be used to reduce receiver power levels in actual networks where cables are too short to provide enough loss and the receiver is overloaded.

Circle Reader Service No. 56

External current supply

BLUE BELL, Pa.–Aurora Instruments Inc. has introduced a new external source current supply for its FW-310 automatic fiber optic fusion splicers. The supply can drive any external light source with a DC current from zero to 150 mA.

The supply can be used when optical power launched into the fiber from the instrument's LID injector is not optimal for proper splicing, such as when aligning polarization-maintaining optical fibers on their rotational axes prior to splicing. For this kind of application, an external light source (such as a laser diode) could be used to inject light directly into the fiber.

FW-310 automatic fiber splicer

In addition to facilitating the use of polarized light, the new splicer modification incorporates a unique detector to enhance its operating wavelength range, which permits its use with 1550 nm external light source. The current supply can also drive any LED or laser up to 150 mA, permitting the use of virtually any light source desired to increase the operating flexibility oft he FW-310, Aurora officials say.

Circle Reader Service No. 57

Intrabuilding video adapter

MURRAY HILL, NJ–New from AT&T is its Systimax Structured Cabling System 381A video adapter, which AT&T officials say does the work of three coaxial cables in the distribution of analog video signals within a building.

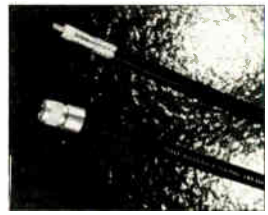
The adapter provides intrabuilding connectivity for transmission of analog baseband video signals for users of RGB video equipment, such as subscribers to news or financial information services.

The adapter uses existing building wiring, information outlets and modular cords, thereby reducing wiring costs and simplifying installation, moves and rearrangements. It supports monitors with resolutions up to 640 x 480 pixels and refresh rates up to 72 Hz.

Circle Reader Service No. 58

High performance coax

WALLINGFORD, Conn.–New from Times Microwave Systems is a high performance coaxial communications cable which company officials say is well suited for use as an antenna feeder in outdoor cellular and land mobile communications applications.



LMR-600

Dubbed the LMR-600 flexible communications cable, it features a foam polyethylene dielectric to provide 2.5 dB per 100 feet at 900 MHz attenuation.

The cable offers better than 90 dB shielding efficiency and can be supplied in bulk or preterminated with N-type connectors. The coax is 0.59-inches in diameter; it is also available in 0.50-inch and 0.405-inch diameter sizes.

Circle Reader Service No. 59

LAN, telephone enclosures

ATLANTA–GC Technologies has introduced its first line of fiber splice and termination cabinets for telephony and local area network (LAN) applications. Splice, terminate or preterm options for up to 144 fibers can be accommodated; a series of standard size rack or wall mounted cabinets are available. Customization is also possible.

The company's telephony cabinets are designed to handle a variety of termination needs, ranging from a six-fiber termination-only unit up to a 72 fiber splice/72 fiber termination shelves and preterminated cabinets with 144 fiber terminations. Cables can enter the cabinets from the front or rear of the unit and are easily routed, clamped and stored through a unique series of slots, clips and trays, company officials say. A sliding splice tray platform provides access during splicing.

The LAN cabinets can accommodate direct termination of two to 95 cable fibers or splicing of pigtails. A 45-degree tilt feature on the connector panel allows access to the termination point without disturbing the stored cable in the cabinet. Cable entry is possible from the front or rear of the unit. A rack-mountable patch panel with up to 72 fiber capacity is also available, along with two wall-mounted versions which accept up to 48 fiber terminations.

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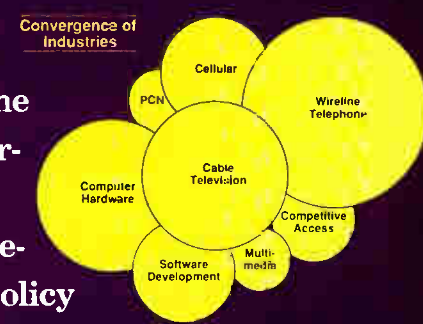

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TV signal quality: Why not the best?

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

If British television is technically better than American, as many believe, it is not entirely because of 625 lines. After all, 625 lines at 25 frames per second amounts to 15,625 lines per second, which is almost the same as 525 lines at 29.97 frames per second, or 15,734 lines per second. The alternating line phase reversal has little effect on normal reception. PAL provides slightly more resolution by virtue of 1 MHz wider video bandwidth and 100 more lines per frame. But this is offset by the noticeably increased flicker at 25 frames per second.

However, the real difference between British and American television picture quality is primarily in the continuous, conscientious and precise attention dedicated by the BBC to correct technical operations. This is TLC–tender, loving care. Moreover, until recently, European television receivers were not required to operate in an adjacent channel environment, permitting more gradual filter roll-off and less phase shift.

Set it and forget it

American broadcast station (and network) operators are more likely to install the finest available equipment and never touch it again. Transmitter amplitude and phase performance is infrequently tested and seldom refined. Minimum FCC "broadcast standards" do not represent the highest possible performance quality, yet are universally held to be "good enough."

Cable TV operators are concerned mostly with carrier-to-noise and composite triple beat ratios. Many are not even aware of the picture degradation caused by relatively minor phase errors in the chrominance band as well as in the vestigial side bands.

FIGURE 1

Reflections and chroma delay

Vestigial sideband group delay error

Much has been written and studied about degradation because of noise and intermodulation. Little attention has been given to the degradation resulting from group delay errors. Viewed at 2 to 3 times picture height, I have only rarely seen a cable TV picture that did not display either color shift ("comic book effect"), or the "edge effect" due to improper group delay in the VSB. Yet, some cable TV technicians either claim never to have seen the "edge effect," or blame it entirely on the TV set.

Next time you look at TV pictures, move up close and look critically at the screen. Watch for sharp, high contrast edges, such as the edge of a dark suit or dress. Compare it with what you would expect of a Kodacolor snapshot print.

Probably, you will see some color "bleeding," generally to the right, but sometimes to the left. Color bleeding may be only a fringe, or it may extend up to 1/8-inch or 1/4-inch. This is chroma delay.

Perhaps you will also see a faint copy of the sharp edge, clearly separated from the true edge. This is attributable to phase and amplitude (group delay) error at and just beyond the inflection points of the vestigial sidebands at 0.5 to 1.0 MHz above and below the visual carrier. Figure 1 is an attempt to show that reflections (ghosts) and chroma bleeding are continuously displaced, while only the edge itself is displaced by VSB group delay.

VSB phase errors (group delay) may be produced in any band-limiting or shaping filters, including sound diplexers and VSB filters in the broadcasting facility, the IF shaping filters in cable TV modulators and demodulators, band edge filters in heterodyne processors and AML microwave transmitters, set-top convertors (especially baseband types), TV receivers, and bandpass filters generally. Unfortunately, this makes it easy to overlook the effect by blaming it entirely on the monitoring equipment or the source.

In every single one of hundreds of cable TV headends I have seen, picture and signal quality have been monitored exclusively by means of conventional TV sets, mostly Sony, connected through set-top convertors, usually baseband.

No headend I have ever witnessed has been equipped and set-up so as to permit continuous monitoring of its technical performance separately from any defects at the source or the monitoring equipment.

High quality vertical interval test signals (VITS) inserted in the signal received off-air or by satellite is one way to exclude source defects. The VITS can be evaluated on a waveform monitor and vectorscope, or other forms of analyzer. Both test signals and pictures must be processed through the highest quality demodulator obtainable, such as Rohde & Schwartz, Tektronix or Marconi.

Pictures should be viewed on a studio quality video monitor without a set-top convertor. Considerable technical ingenuity, along with professional grade patch panels or routing switches, will be needed to provide convenient but permanent arrangements for evaluating the performance of each channel, exclusive of defects in either the source or the monitoring facilities, and without disrupting service.

This is expensive, almost certainly approaching or exceeding $200,000. While prohibitive for small systems, it is but a small fraction of the hundreds of millions of dollars of fair market value of metropolitan systems. The headend is the very heart of the cable TV entity. It ought to be perfectly transparent; otherwise, damaged goods are delivered to subscribers. DBS and MMDS can do better.

The challenges to technical personnel are indeed daunting. Much more attention needs to be paid to analog video, even while trying to grasp the intricacies of digital compression technology. Both must be mastered lest we be overwhelmed by the competition.

For further discussion of VSB group delay, see:

1. A.S. Taylor; "The Vestigial Sideband and Other Tribulations"; 1988 NCTA Technical Papers

2. A.S. Taylor; "HDTV & the Vestigial Sideband Syndrome"; IEEE Trans. on Broadcasting; March 1990. CED