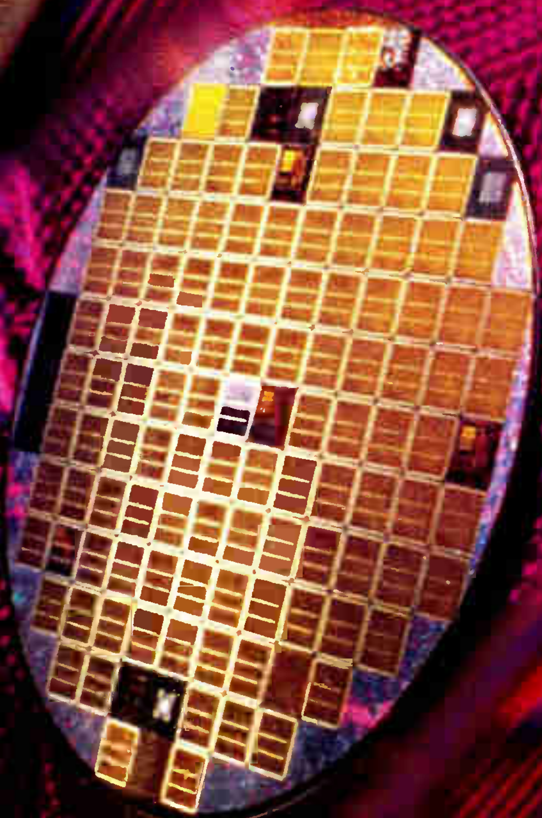
CED

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

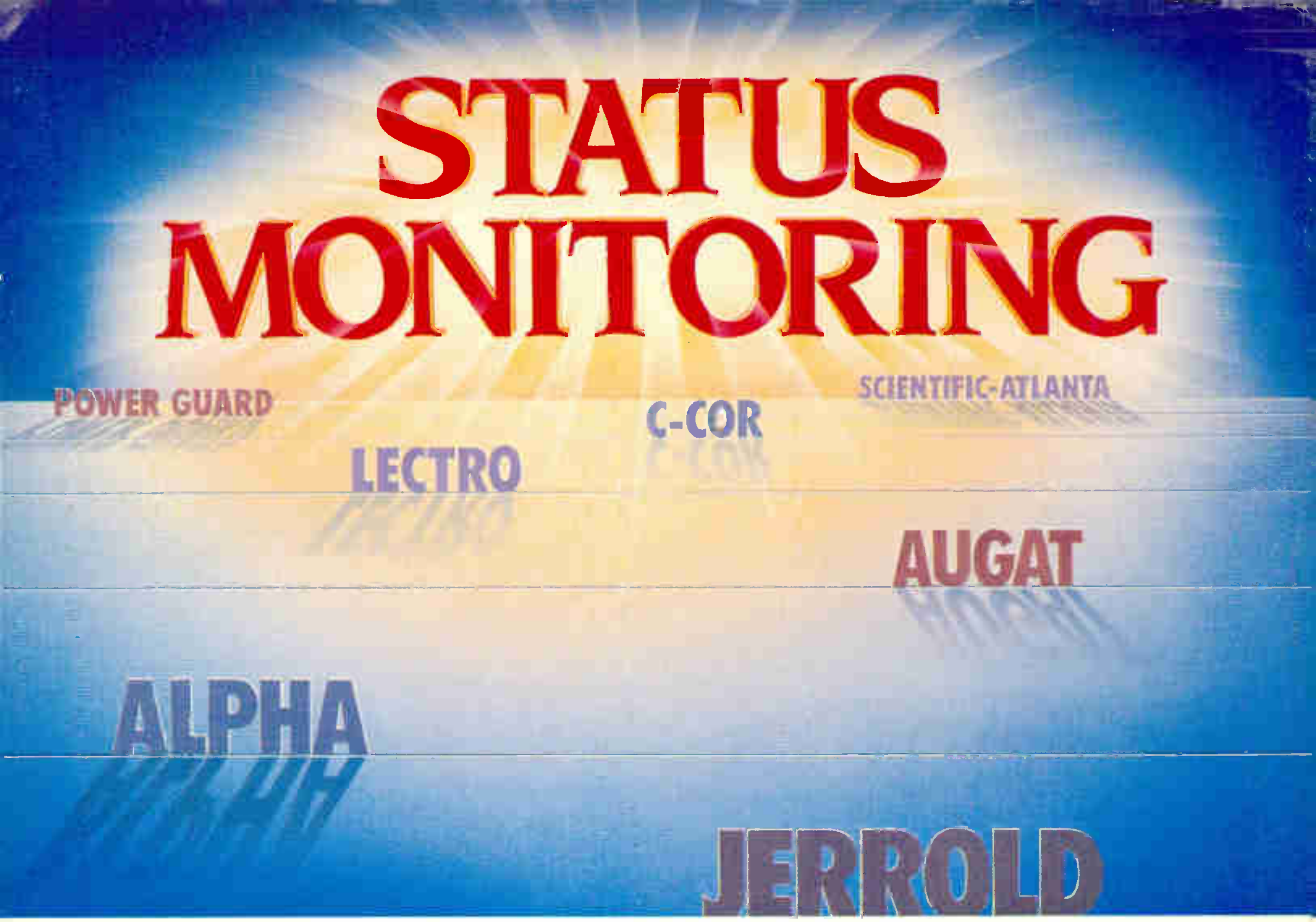
CED magazine is now recognized by the Society of Cable Television Engineers



Fiber optics: Coming into focus

Tech standards given OK by FCC

Inside: Exclusive coverage of OFC



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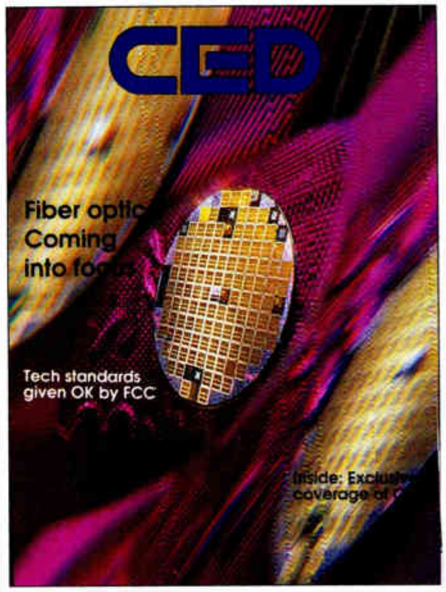

About the Cover:
Wafers similar to these "grow up" to be fiber-optic lasers. Photo by Dominique Sarrante-TIB.

DEPARTMENTS

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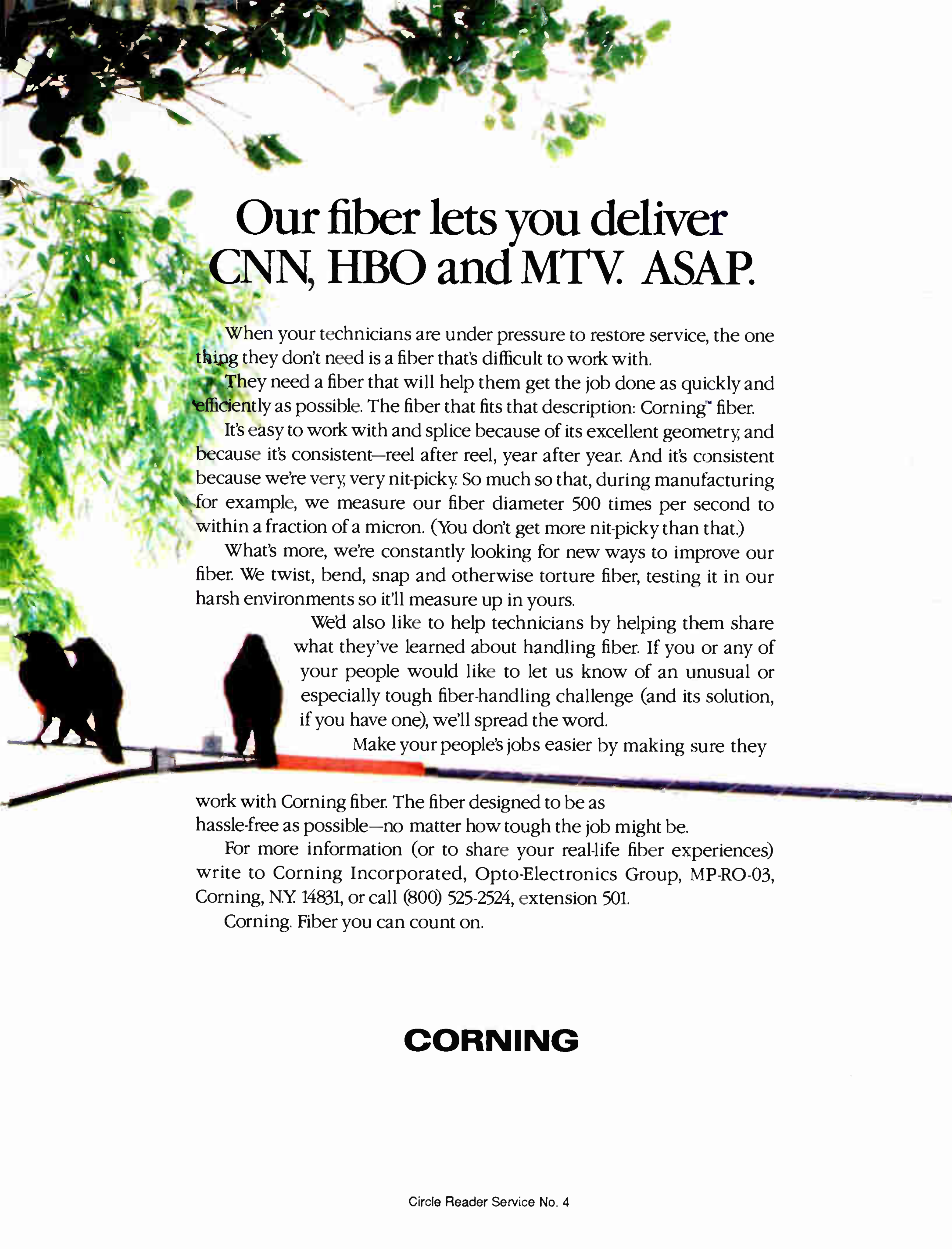

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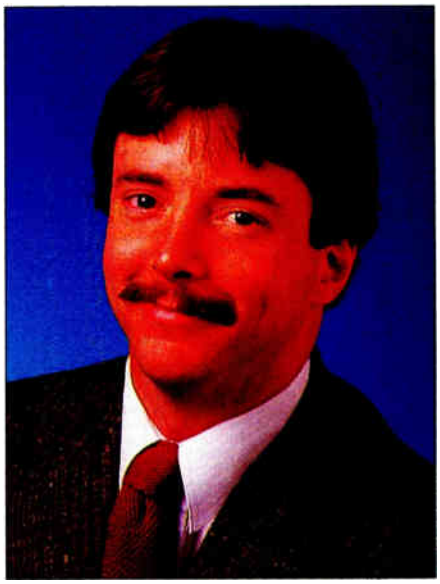
It's time to solve the interface problem

Ah, if only the engineers could run the business. . . .

It's doubtful that putting the engineers in charge would make life at a cable systems nirvana, but it might have prevented Sen. Pat Leahy's proposed legislation regarding video scrambling years ago.

Leahy's bill calls for an outright prohibition on scrambling the basic tier of cable channels and would encourage cable operators to cease use of convertors for signal security. In fact, Leahy proposes that cable systems and consumer electronic devices be outfitted with the MultiPort—the baseband interface that when implemented, descrambles cable signals yet allows full use of TV and VCR remote controls and offers no impedeiments to tape recording.



This particular piece of legislation faces an uncertain future. In fact, it's highly unlikely it will ever become law. But few people find fault with Leahy's motivation. Let's face it: Cable systems and "cable-ready" TVs and VCRs share little compatibility when set-top descrambling convertors are put in the mix.

Not everyone understands this, however. As consumers, many of us have had to think their way through the consumer electronics interface: First, you determine *what* it is you want to do (usually it's watch one channel while recording another), then you have to wire the system to make that possible. With an addressable descrambling convertor, it usually requires splitters, A/B switches and lots of coaxial jumpers. The result is a hideous mess of wires going all over.

Why is this necessary? Because cable operators aren't in the business of giving away their programming. They need some form of remotely accessible, secure signal denial. Traps are fine for some systems, but they're labor-intensive no matter how you look at them. Interdiction held promise, until compression came along and confused the issue.

The problem is with scrambling, but the solution won't be found in prohibiting its use. A new way must be found to control signal delivery to the subscriber. To date, the only truly friendly resolution that has ever been developed is MultiPort, which suffers from a serious "chicken-and-egg" birthing problem. It was a correction designed by engineers who have seen this problem coming for years, but support from the business office has been, well, less than overwhelming (I'm trying to be nice).

Nevertheless, consumers *must* be furnished with a seamless interface between cable and the TV and VCR. This issue simply must be resolved. The cable industry needs to renew its efforts to solve the standoff. It's time for CableLabs to convene a summit meeting between cable MSO chief executives and their counterparts from the consumer electronics manufacturers to decide on a fix.

I, for one, am tired of hearing people grouse about the problem. It isn't all cable's fault. But let's work together, spend some money if we have to, and get the interface problem cured.

Roger Brown
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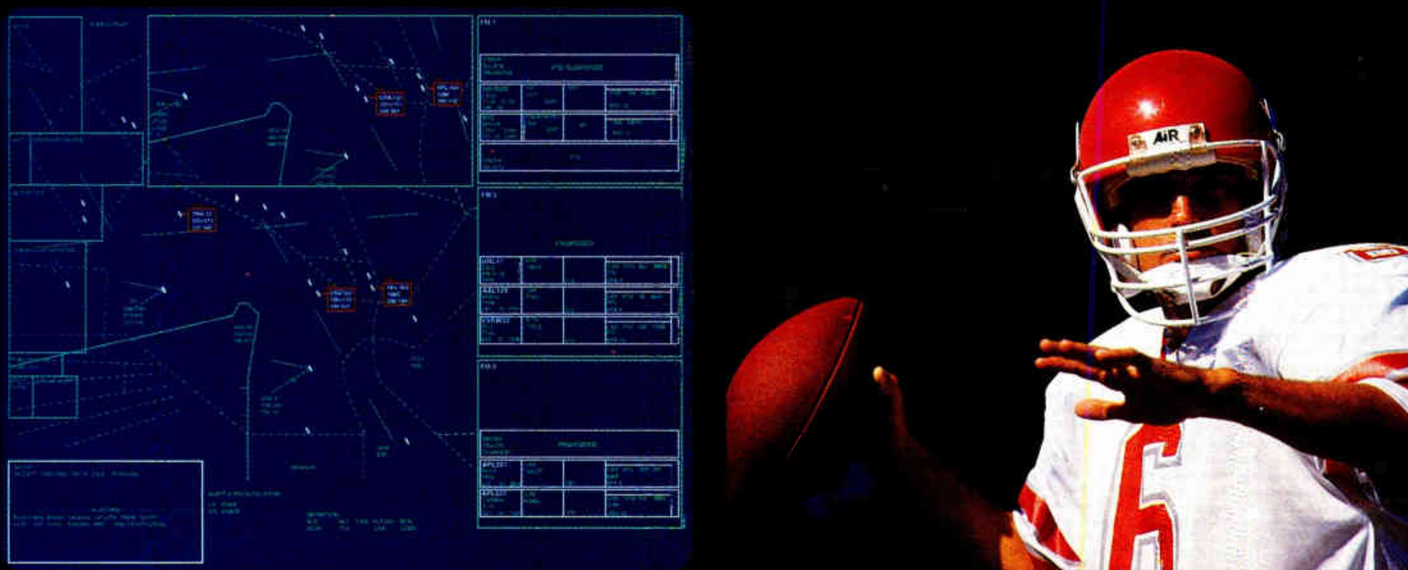


Cox Cable is first to use CATV plant for PCS call

The promise was made more than a year ago—and trade show demonstrations simulated the concept—but it took until February 12 for the first Personal Communications Services phone call to be placed and transmitted over a real cable system.

Cox Enterprises Chairman and CEO James Kennedy made a symbolic call to FCC Chairman Alfred Sikes from Cox's San Diego cable system to Sikes' Washington office, terming the event an "historic moment" in telecommunications.

PCS, a new wireless communications system presently under consideration for possible licensing by the FCC, consists of a series of microcells incorporating transceivers to allow users to make and receive telephone calls over small, handheld devices.

While there will be signal "handoffs" between microcells, PCS technology is intended primarily for pedestrians and persons located within office buildings, as opposed to rapidly moving users (such as persons in automobiles). This is in contrast to existing cellular service, which has larger (and therefore fewer) cell sites in a given area and therefore can install complex switching equipment more cost-effectively.

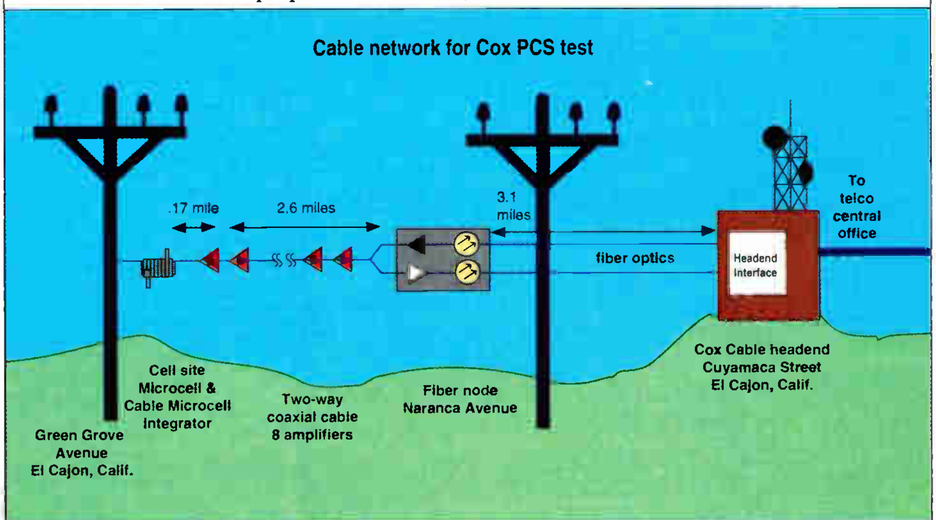
The Cox demonstration was undertaken as part of the company's experimental PCS license, which was granted about a year ago. Furthermore, the event proved that existing cable television systems can be used to send and receive voice traffic over both coaxial and fiber-optic cable. "The Federal Communications Commission could rely on cable TV operators to help speed this new communications service to the public in a cost-effective manner," said Cox officials in a press announcement.

The call from Kennedy was sent nearly one-fifth of a mile over the air to a microcell site in El Cajon, Calif. From there, the signal was routed upstream through the cable system to the headend and then connected to the public switched telephone network via the local telephone company's central office. From there it was carried over long distance lines to Washington.

Within the Cox cable system, the call was sent through 2.5 miles of coaxial cable and eight RF amplifiers to a fiber node location, where the signal was converted to optical energy. It was then sent three miles back to the headend, before being connected to the switched telephone network. (See Figure below.)

In addition to the symbolic value of the demonstration, the testing process is important in that signal propagation characteristics are being studied, as is the viability of spread spectrum techniques.

The key devices under test are the microcell electronics and the cable microcell integrator. The microcell consists of radio equipment which communicates through antennas with the hand-held portable phone. The integrator allows the microcell to be connected to the cable plant by combining digital voice signals from the radio equipment into a single high-speed digital signal.



In this case, the integrator was built by Scientific-Atlanta, which has so far installed two prototype devices in the system, according to David Fellows, president of S-A's transmission systems division. The integrator, or CMI, utilizes a standard trunk housing, but is conspicuously different, with two antennae sticking out.

S-A hopes to learn from the experiment, too. Specifically, S-A will test block conversion of the frequencies as well as delivery of 16-, 32- and 64-kilobit digital data streams modulated on the system, said Fellows.

This latest test utilized the 902 MHz to 928 MHz frequencies at TDMA coding with transmit and receive equipment manufactured by Omnipoint.

Later this month, Cox is scheduled to test SCS Mobilecom equipment that operates in the 1850 MHz to 1990 MHz frequency range. That test will also include handoff, switching and other intelligent functions in the headend.

FCC OKs tech standards

In contrast to public comments that led Western Cable Show listeners to believe it would be some time before the Federal Communications Commission took action on the proposed cable-TV technical standards, those accords were adopted by the FCC in the middle of February.

The Commission voted unanimously to adopt the standards, which have been modified slightly since they were filed jointly by the NCTA and NATOA back in October 1991. While some changes were made, they are minor. In fact, none of the critical system performance parameters were changed at all.

Despite the Commission's actions, it will be the beginning of March or later before cable operators will be able to scrutinize the Final Report and Order, which spells out the details of the standards. From the time they're made public, it will be at least 60 days before the new stan-

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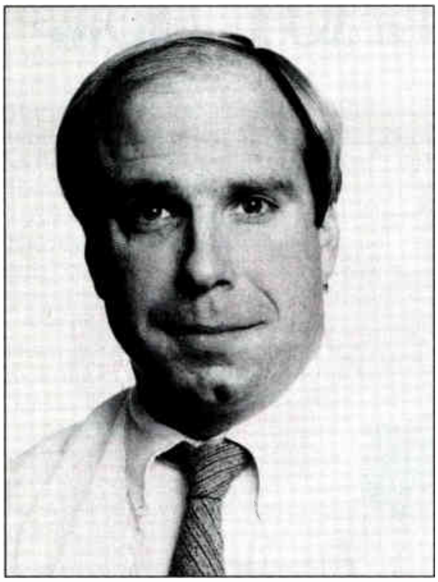


Geoff Roman

Cable's digital compression guru

In the early 1970s, Geoff Roman was schlepping books across the campus of Rensselaer Polytechnic Institute in New York, researching a National Science Foundation-funded project to use broadband technology for "blue sky" services—like transaction services, data transfer and video education.

Now, 20 years later, he's neck-deep in the same types of issues at Jerrold Communications, where he leads technology and new business development.

At RPI, Roman paved a somewhat unorthodox educational path. The five-year program not only earned him a masters degree in electrical engineering, but it marked his foray into cable television. That's because the curriculum had him "on loan" on a co-op basis to high-tech companies like New York Telephone, where he worked on a project to leaseback plant to cable television operators.

After college, Roman joined Mitre Corp., a non-profit federal contract research center based in Boston, Mass., where he performed system engineering work for the government. "The work at that time was in future communications," Roman recalls. "We were looking at taking broadband technology to automate a facility."

In fact, Roman has spent most of his career engineering things for the future. At Mitre, he worked on what he calls "fundamentally cable technology," building digital systems to carry voice, video and data over cable. "The work there was actually the forerunner of what became local area networks," Roman says.

And now, at Jerrold, Roman spends roughly 75 percent of his time on future-related projects like telephony over cable and digital compression. The rest of his time is split, he says, among all kinds of things—like running Jerrold's advanced development lab. There, he tinkers with "all kinds of strange things" like coherent detection fiber systems and optical tuners.

"Those things probably won't see the light of day in near-term products, but they're potential technologies that may apply in the future, particularly as cable becomes some kind of telecommunications provider," Roman explains.

Another humble engineer

Interestingly, Roman says he can't think of any personal major engineering accomplishments. (Why is it that engineers are so *modest*?) But while with Mitre, he engineered broadband networks for the U.S. House of Representatives, the Canadian House of Commons and the Walter Reed Army Medical Center.

Roman left Mitre to join General Instrument's RF systems division. He's been with G.I. ever since, but "really came into the mainstream cable business" in 1986, when he was named VP of marketing for the distribution division.

Then, when Jerrold reorganized and disbanded its separate distribution and subscriber divisions last year, Roman was moved into his current role—which is probably better for him, given his natural predilection toward future business thinking.

Thoughts on the future

Roman says cable television is definitely going through "another transition" right now. "It started out as a big antenna," Roman says, and is headed toward enhanced PPV programming, telecommunications and—Roman's baby—digital compression.

"One of the suppliers is going to make digital compression happen," Roman says (diplomatically). "It's just a matter of *who*. I certainly don't think there's any 'if' there."

The real challenge with compression, Roman says, is managing all the programming that will eventually surface. "If you think of a compressed digital video world, where you have literally thousands of different programs offered over the distribution system at any one time, you almost can't tune those channels simply by scrolling through the channel numbers—people just won't have patience looking for something on channel 949," Roman emphasizes.

To remedy that, Roman thinks the industry will be forced to use menus and integrate with electronic program guides. "It's a natural progression."

And how will interdiction fare in a world of digital compressed video?

"In the form that it's been defined to date, interdiction will become questionable as we move into compression," Roman says. "Because when that (digital compressed video) happens, you're going to probably need a box, too. And once you've got one box, why not have it do everything?"

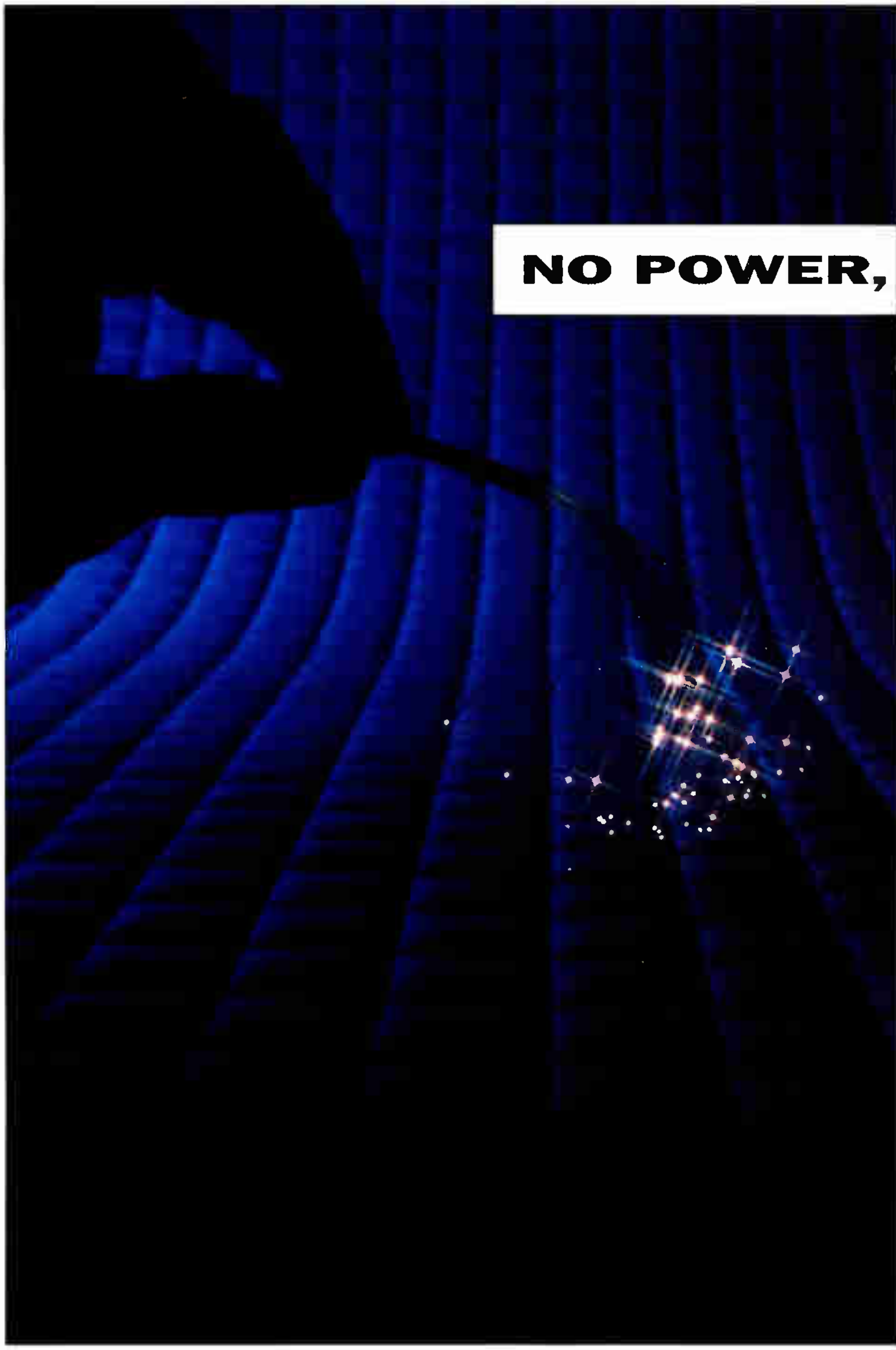
Speaking of boxes, Roman's view is to possibly redesign future televisions such that they accept a "simple video input"—and perform all functions in a separate, converter-like box. "So many subscribers are looking into home theater, where they have audio functions completely separate from the television anyhow," Roman explains, "So maybe the answer to consumer friendliness issues is to do everything externally. That would be an extreme way" to deal with consumer friendliness issues, Roman says.

It is these types of issues that Roman speaks out about in his varied and numerous public speaking engagements at industry group meetings across the U.S. Recently, in fact, Roman delivered four speeches in four different cities over four days. "I do that for the exercise," jokes the generally introverted Roman.

In fact, Roman is one of those guys who is almost impossible to track down easily. Over his career, he has logged more than 6 million actual airplane flight miles—"and that's before the airlines kept track," he says. He guesses that his total tracked and untracked flight mileage stands somewhere between 10 million or 11 million.

Wanna bet that Roman will most probably read this article on an airplane? (Hey Geoff, you just dropped a peanut!) CED

By Leslie Ellis



Getting down to details

I do a lot of traveling on airplanes. This is not news to those who know me, nor is it unique among engineers in any discipline I know of. I also have to admit that one of the things that I try hard to avoid is the inevitable discussion between me and the equally immobile fellow traveler. This is not to say I'm antisocial (those who know me sometimes say I'm "too social"), it's just that you can sometimes find yourself talking to a tape recorder that is stuck in "play" mode. I tend to follow that time-honored technique of frequent flyers, which is to say that I usually respond to the opening gambit with a polite (but unintelligible) grunt and a swift retreat into a book or magazine.

As many of you know, this doesn't always work. Sometimes, you find yourself next to one of those wonderful human beings who are completely incapable of getting any hint, no matter how obvious. The other possibility is that a wee part of your brain somehow registers the fact that the person just might be interesting. The latter happened to me recently and, I must tell you, I'm glad.

Targeting details

The young man sitting next to me on the plane from Denver, Colo. to Washington, D.C. was on his way to Germany to compete for the U.S. in a target shooting match. He was a resident at the Olympic Training Village in Colorado, and is one of the young people working and learning in hopes of competing in the world class sports arena. His mission is to make the U.S. Olympic team. In talking to this person, he got me thinking about how we in the cable industry handle *our* mission.

I was amazed to learn of the details that govern the sport of Olympic shooting and the amount of detail a competitor must pay attention to in order to be among the top rank. For instance, the very clothes a rifleman wears are subject to standards and rules that govern how stiffly and tightly they fit.

Since talking to this young man, I've been wondering: What would happen if we were to include the issue of "details" when we work to motivate and train our employees? I have long believed that in accomplishing any task in the service business (and what I'm about to say should also relate to manufacturing), the effort necessary to achieve perfection is the correct goal to set.

That is not to say that an unreasonable effort in terms of economics or time needs to be undertaken to accomplish every task, but it does seem to me that within the bounds of ordinary endeavors, extraordinary results can be achieved if one attempts to accomplish a level of perfection. That level of effort undoubtedly requires attention to detail.

Break it down

Attention to detail is a difficult concept to implement under every circumstance. I believe, however, that every task—no matter how mundane or how unique, no matter how simple or complex—can be examined in the light of its component parts. If one breaks a task down into components and seeks to achieve perfection in each and every part, then the overall task will be accomplished in a way that is much closer to perfection than if one just attempts to do what is necessary to finish the job.

The concept of working out details manifests itself quickly if a task is segmented and examined closely. And if we as an industry can teach this concept, perhaps we can learn how to accomplish those things that the Congress and the FCC are beginning to demand that we do.

After all, rules have been implemented concerning NCTA customer service standards. The FCC's version of our new technical standards is pending release. Congress is trying to reregulate our business so that we do things right and in a way that is satisfactory to the customer *the first time*. As such, we should do things that minimize—or completely eliminate—those recalls and reinstalls that are the direct result of failing to accomplish some small bit of our job correctly.

Getting it right

These factors will become increasingly important, not only to the economic viability of our cable systems, but for the retention of our jobs. It doesn't take a genius of a general manager to see that an engineer or technician who does the same job three times is less economically beneficial than the one who does it correct each and every time, even if he's on a higher pay scale.

The difference between these two individuals is quite simply that one pays attention to the details and the other, for whatever reason, does not. I recognize that it is possible that one of these two individuals is plainly incompetent. For the most part, though, I don't find much incompetence amongst the ranks of our engineers and technicians. I do, however, find a difference in the attitude toward the small bits and pieces that make up every task, with those I would put in the category of "detail-oriented" accomplishing more in a given period of time than those who don't.

While we worry about the perfection of putting on an F-connector and running house drops in such a way that they are concealed and unkinked, we should think about the young man I met on the plane whose job is to stand at a distance from a target, so that the center part of the target looks to the human eye roughly like the period at the end of this sentence, and attempt to put bullet after bullet through exactly the same hole.

That is the goal. But the details are what make that goal possible. Let's see if we can learn to use the details of our everyday jobs to reach a level of performance that earns us credit in the marketplace. **CED**

By Wendell Bailey, Vice President, Science and Technology, NCTA

ONI OPTICAL NETWORKS℠ INTERNATIONAL

Optical Network News

The following highlights are from Optical Networks International's quarterly newsletter.

■ External modulation extends fiber reach

Recent developments in external modulation techniques have yielded performance results unforeseen two years ago. With this new addition to the system operator's "toolbox," fiber can now be economically deployed over much longer distances with ever smaller node sizes.

(See related story on hybrid external modulator/DFB architectures in an upcoming issue of ONN.)

■ Now that you've got it, flaunt it!

The fiber upgrade process can be a community relations coup, if properly coordinated between engineering and general management. ONI has designed a comprehensive launch kit specifically to help operators get the greatest possible public relations mileage out of their fiber upgrades. The kit, "Getting The Most From Fiber Optics: A Cable Operator's Handbook For Community Awareness," includes print ads, bill stuffers, and numerous tools for promoting optical technology in the community. To order a copy, call ONI at 1•800•FIBER•ME.

(See related story in *Communications Technology*, January, 1992, pg. 32.)

■ Taking It to the Streets

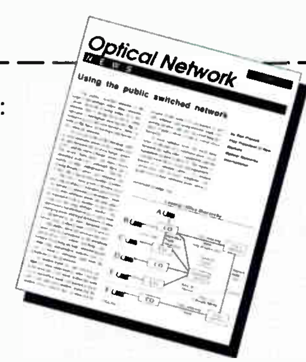
ONI has developed one and two-day training courses, "Taking It to the Streets", specifically for those contractors and installers who do not have the time to attend ONI's week-long "FIBERWORKS". Designed to be taught at the operator's location, Taking It to the Streets includes two separate courses on splicing and construction. The courses can be held independent of each other, or taught on consecutive days, depending on operator requirements.

(For more information call 1•800•FIBER•ME.)

■ Headend interconnects a new focus for technical community

Lately, a few operators are giving thought to streamlining business operations through a process called headend interconnects. This "master headend" concept will have tremendous implications for ad insertion, as well as reducing maintenance and real estate costs. Headend interconnects will be especially economical when digital compression technology is added, by consolidating expenditures for digital receiving equipment.

(See related story in the Summer issue of ONN.)



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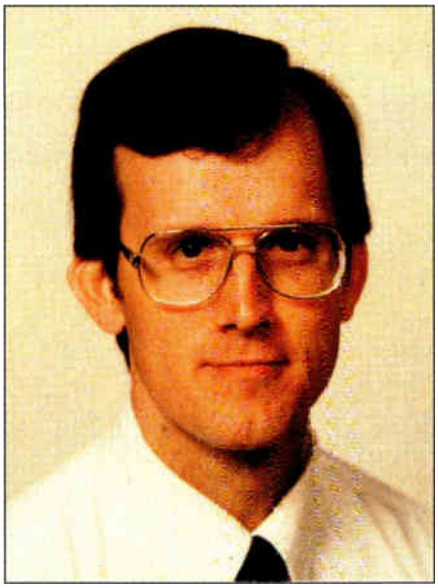

Vertical stacking of off-air antennas

This month will be the last of the series on the theory of operation and phasing of off-air antennas and arrays. So far, my previous two columns on the subject have taken a look at not only how individual antenna elements are phased in order to generate a specific antenna pattern, but also how two identical antennas can be mounted together, side-by-side, with a very specific phase relationship, in order to eliminate co-channel interference.

This type of multi-antenna structure or array, where the antennas are mounted side-by-side, is especially useful when the co-channel interference is coming from somewhere in front of the antenna array, several degrees on either side of the primary signal. But what happens when the co-channel signal is strong enough that it is still causing interference even when it is located directly behind the antenna (plus or minus a few degrees)?

In this case, we might need to further improve the antenna's front-to-back ratio by vertically stacking the antennas, and phasing them appropriately in order to eliminate the interfering signal.

The vertical stacking of two identical antennas for the purpose of eliminating co-channel (or other interference) from the rear of the antenna is most effective when the interfering signal is coming from a relative angle of 180 degrees, plus or minus about 8 degrees (172 to 188 degrees)—directly behind the antenna. As Biro Engineering points out[1], if you try vertically stagger-stacking a pair of antennas when the interfering signal falls outside of this criteria, you might do more harm than good!

As the name implies, with vertical stagger-stacking, the two antennas are mounted directly on top of one another, with one of the antennas mounted one-quarter wavelength (90 degrees) in front of the other. The antenna feedline interconnecting the two antennas in the array is cut to a length such that the feedline to the most forward antenna is electrically one-quarter wavelength (90 degrees) longer than the length of feedline that it takes to reach the antenna that is staggered to the rear.

> In the real world, perfect elimination of the co-channel signal is impossible.

Intuitively we can understand how this new array is effective in eliminating co-channel interference from directly behind the antenna as follows:

Our *primary* or wanted signal from in front of the array will arrive at the *forward mounted* antenna one-quarter wavelength or 90 degrees *sooner* than that same signal arrives at the rear-mounted antenna. However, the signal from the front-mounted antenna will then be *delayed* by one-quarter wavelength, relative to the signal arriving via the rear mounted antenna, since it must pass through the additional one-quarter wavelength of antenna feedline.

As a result, the signals from both the front-mounted and rear-mounted antennas, for our primary or wanted signal from in front of the array, will arrive at the headend in-phase and be additive. The net result will be a theoretical improvement of about 3 dB in signal strength for our primary signal.

What about the co-channel?

So, what happens to the *co-channel* signal arriving from the *back* of the antenna? Well, in this case, the co-channel signal will arrive at the *forward mounted* antenna one-quarter wavelength or 90 degrees *later* than the signal arriving at the rear-mounted antenna. In addition, the signal will be *further delayed* by 90 degrees relative to the signal arriving at the rear-mounted antenna because it must now travel through an additional one-quarter wavelength of antenna feedline in order to get to the headend.

Because it arrives at the front mounted antenna 90 degrees later, and travels 90 degrees further down the antenna's feedline, the co-channel signal arriving from the front-mounted antenna will arrive at the headend 180 degrees out of phase with the co-channel signal arriving from the rear-mounted antenna and will thus cancel, theoretically eliminating the co-channel interference.

Of course, nothing is perfect, and in the real world, perfect elimination of the co-channel signal is simply impossible. The antennas are not operating in free space, and the antenna tower, guy lines, and other reflectors, as well as the accuracy of the physical mounting of the array and precise length of feedline between the two antennas will have an enormous impact on the ultimate success of the array.

Vertical stagger-stacking, and horizontal stacking (see "From the Headend" December 1991) can be combined to produce a "quad" or four-antenna array, when co-channel interference is a problem from both in front and in back of the array. The horizontally stacked antennas could help in eliminating the co-channel interference arriving from in front of the array, and the vertically stagger-stacked antennas could be used to eliminate co-channel from the rear of the array. CED

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

References

1. "Garbage In, Garbage Out", The Biro Technical Bulletins, March 1991, Biro Engineering.
2. "Increasing Antenna Front-To-Back Ratio", SCALA Technical Bulletin, 1970.

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Perfect TV

Well, not exactly—not yet anyway.

CATV operators once adopted corporate names like "Perfect TV," "Clearview," and "Paragon" as a sort of promotional euphemism. In the 1950s and 1960s, video pictures of "Uncle Milty" Berle, "Lonesome George" Gobel, "Red" Buttons and Lucille Ball seldom achieved that noble goal.

Purple faces, flattened heads, raging snowstorms, and a conclave of ghosts were somehow not really what you would call "Perfect TV."

Still, a couple of million viewers fortunate enough to be "on the cable" in the hills of Pennsylvania, or the mountains of West Virginia and the Pacific Northwest were simply delighted. For the equivalent of about $15 a month in today's dollars, the Bobcat-Grizzly annual classic football game seemed "perfect," in spite of the multiple ghosts that shadowed each player around the field.

Things are better now

We have come a long way. TV sets are no longer plagued with the purple faces and flattened heads that never were caused by the cable anyway.

We no longer snowshoe to 7,000-foot mountain peaks to pick up weak, snowy TV signals. Now, we get signals from transponders in geostationary orbit at 22,300 miles above the equator; and they are good.

Well, maybe not quite perfect, but even the cable-bashers are not complaining about what we get from the satellites. Moreover, complaints about too few dBs and too many nanoseconds tend to be subordinate to other more vigorously pursued grievances.

So, what are they complaining about?

Not all of these problems can be fixed by engineers; but engineering will be an important component of the creative resolutions needed.

Here is what they tell the mayor and the senator:

- Prices. By all measures, the most persistent complaint is based on the universal perception that prices are going up faster even than doctor's bills. Who needs 150 channels anyway, they ask.
- Loss of service; outages; blown fuses; cut cable; whatever. Customers are no longer tolerant of cable outages.
- Those accursed set-tops that confound the connection to a VCR, obfuscate its already incomprehensible instruction, and thwart the picture-in-picture (PIP) and other convenience features.
- Remote controllers that won't turn the set back on, and TV sets that have to be retuned to channel 3 every time.
- Cable TV seems to be almost incompatible with the modern sophisticated TV set and VCR.
- Careless and incompetent service that at times is downright discourteous or arrogant.
- And those exasperating busy signals and recorded answers to service calls and customer complaints.

The cable TV "debate" on Capitol Hill has obviously focused on the bad apples. We all know they exist, much as we try to deny it.

Fixing the problem

The industry will probably continue to suffer cable-bashing, and is likely to lose customers to competitive technologies until effective, meaningful change has been demonstrated and publicly acknowledged in several critical areas, including:

- User friendly compatibility with all manner of TV sets and VCRs.
- Service reliability comparable with the residential telephone.
- Realistic *a la carte* program packaging that enables subscribers to create custom tiers without being forced to pay for too many unwanted programs.
- Rate structures that say: "We want your business."
- Accessible, courteous, competent customer service.

Not all of these problems can be fixed by engineers; but engineering will be an important component of the creative resolutions needed.

By the time this is published, it appears that the Congress will have acted on modifications to the Cable Act of 1984 in ways the cable industry does not like. However, neither legislation, regulation nor city ordinances can assure the public of "perfect TV."

We can do better

The infrastructure is in place. A million or so miles of coaxial cable plant with a rapidly expanding optical fiber base presently passes more than 95 percent of all TV households in the U.S. An additional million miles of flexible coaxial drop cable connects up to 70 diversified program sources plus over-the-air programs to more than 60 percent of the households passed.

No other technology can match it now, nor for a long time to come: not wireless cable; not DBS; not telephone companies. Over-the-air broadcasting is available to a few more TV households (98 percent), but the choice of program fare is much more limited, and the quality of broadcast program content is arguable.

The amended Cable Act could prove to be a blessing in disguise if it focuses industry attention more on overcoming than denying the conditions cable TV customers consider outrageous. **CED**

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

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furthest node.

For each of the four intermediate nodes, the 30-fiber cable is entered midspan, and a six-fiber cable is spliced to six dedicated fibers within the main cable. The six-fiber cables are each routed to one of the four intermediate nodes. There are four splice points, each with six splices, for a total of 24 splices for the system. Only the fibers needed for each node are accessed, which means that the attenuation resulting from splice loss is about the same for the four intermediate nodes, and the furthest node benefits by having no splice loss contribution to the overall attenuation margin.

While this method requires splicing and the link losses are higher than with the parallel cable option, the cable placement cost is lower. Also, the system is still easy to engineer.

The primary disadvantage of this method is the unused fiber which remains after each tap. After the fibers in a buffer tube are accessed at the first node, the remaining length of the fibers in that tube will not be used throughout the remainder of the total system route. The same is true at each of the remaining taps. This means that the cable cost for used fiber is higher. If the labor cost for splicing is higher than the cost of the unused fiber, this method will result in cost savings. However, this is seldom the case.

Keep in mind that the unused fibers are still functional. If the cable is damaged down the route, a working six-fiber group of unused fibers could be accessed, saving two splice points.

Tapered with splice option

In situations where the cost of unused fiber is higher than the splic-

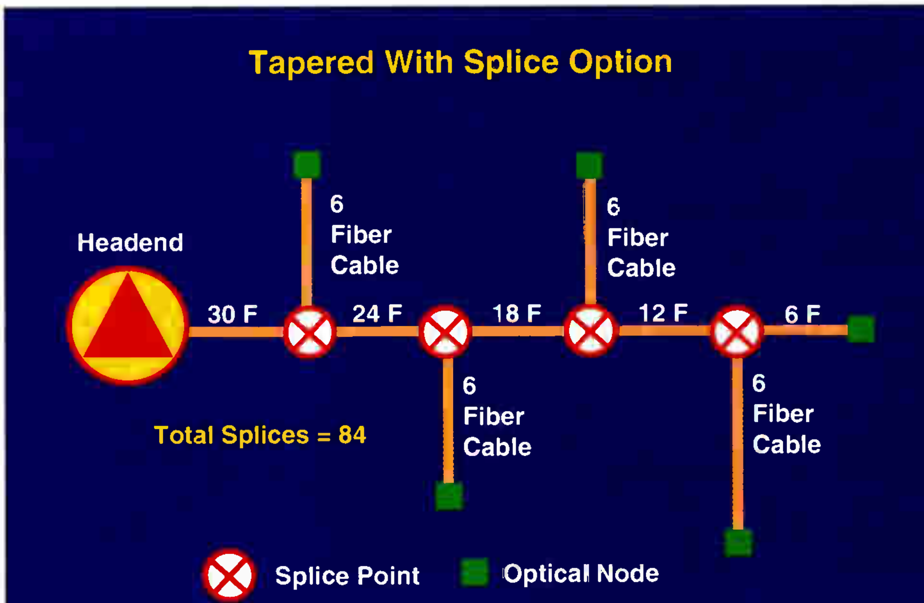


Figure 3

ing labor cost, then the cable tapering with splices option may be an appropriate solution (see Figure 3). Referencing the simulated system, a 30-fiber cable runs from the headend to the drop point for the first node. Here, a six-fiber cable and a 24-fiber cable are spliced to the 30-fiber cable. The six-fiber cable is routed to the node and the 24-fiber cable continues to the second drop point. At the second drop point, a six-fiber cable and an 18-fiber cable are spliced to the 24-fiber cable. At the third drop point, a six-fiber and 12-fiber cable are spliced to the 18-fiber cable. At the final drop point, two six-fiber cables are spliced to the 12-fiber cable, branching out to the final two nodes.

With this method, our example calls for a total of 84 splices at the four splice points, and the use of nine separate cables. The higher number of splices and cables increases the installation time. However, this method uses only the number of fibers needed for each node, so the cable is optimized for the application.

In addition to the increased installation time and increased installation cost, the splice loss contribution to the system attenuation increases by a factor of four by the time the final drop point is reached.

Tapered fiber cable option

A relatively new innovation in physical plant layout features a tapered fiber optic cable design that combines the advantages of minimal splice loss, reduced cable cost and lower cable placement and splice cost (see Figure 4).

The multiple loose tube cable construction is the building block for the tapered fiber cable. One or more buffer tubes are dedicated to a specific

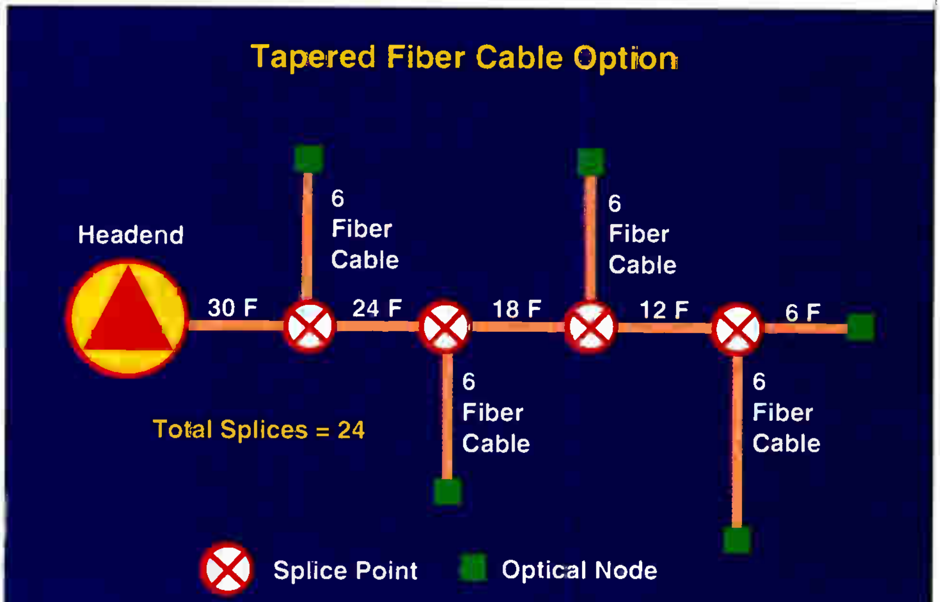


Figure 4

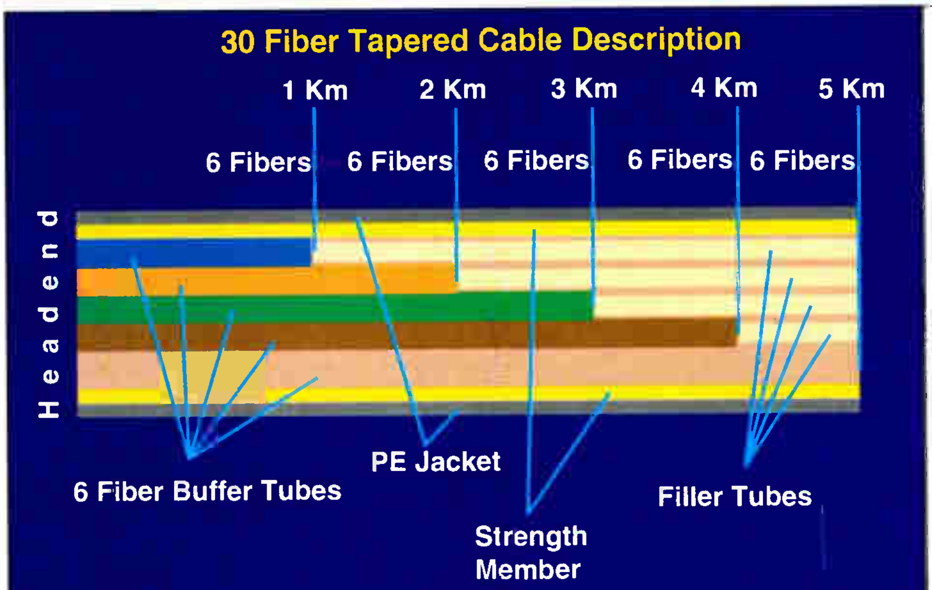


Figure 5

splice location. The remaining express tubes in the cable continue to the next splice points, leaving fibers within these express tubes undisturbed. Filler tubes replace the buffer tubes after fiber taper points, thus maintaining the uniform outside diameter of the cable (see Figure 5).

In the system example, the cable has 30 fibers leaving the headend. At the first drop point, a six-fiber cable from the first node is spliced to a six-fiber buffer tube in the 30-fiber cable. Beyond this drop point, a filler tube replaces the six-fiber tube and continues along the remaining length inside the 30-fiber cable.

There are no excess fibers as with the fully fibered cable option. At the second drop point, the cable now has 24 fibers and a filler tube. The six-fiber cable from the second node is spliced to a six-fiber buffer tube, and a filler tube replaces the six-fiber buffer tube past this point. At the third drop point, the cable has 18 fibers; 12 fibers at every fourth point. Six fibers are routed intact from the headend all the way to the final node.

A total of 24 splices are made in this system example. Documentation is provided for taper points, to ensure the fiber counts match the various drop points along the cable route.

A savings is achieved by reducing the total amount of fiber kilometers within the cable. The dollars saved are a function of the number of fibers in the cable and the distance at which the tubes are dropped off. A further savings is realized by avoiding the need to splice the express buffer tubes into a separate, low fiber count cable. Because only the outer sheath is opened to access the needed buffer tubes, the express fibers are simply routed through the splice hardware intact. The elimination of a splice also avoids unnecessary attenuation in the system.

The tapered fiber cable requires pre-planning for optimum labor and material savings. The cable is best suited for applications with splice points separated by 500 feet or more. Future growth potential must be considered up front to ensure the cable has enough fibers for the system upgrade.

A perceived disadvantage is the need for accurate measurements from the headend or hub to the various splice points. However, this is a standard requirement for any cable placement that will include splicing; not just for tapered cable designs.

Overall, the tapered cable design features minimal splicing, minimal cable placement and splicing costs and results in an optimized link loss budget for a spliced cable plant.

Conclusion

In the final analysis, the cable plant layout used should be determined based on the particular requirements of the application. System engineers must evaluate node location relative to the headend, the system's physical environment, fiber count, link loss budget, labor costs and engineering requirements to ensure the best option is selected. **CED**

Cable safety practices: Changing the hindsight riddle

Dimension Cable of Meridien, Conn. is an industry "superstar"—at least, that's what people at Times Mirror-California are calling it because of the system's "incredible" decline in workplace accidents.

In 1991, the 38,000-subscriber system with 44 employees (not counting sales staff and commissioned positions) was able to reduce its work-related accident and injury rate by more than 60 percent using "proactive" safety training methods.

It's one of six Times Mirror systems that showed tremendous improvements as part of the MSO's effort to minimize losses and improve workplace safety, says Gordon Baldwin, Times Mirror's national safety director.

The other superstar systems within Times Mirror were: Palos Verdes, Calif., with 27,000 subscribers and 36 employees, with a 60 percent reduction in accidents; Providence, R.I., 83,000 subs, 143 employees and a 60 percent reduction; Springfield, Ill., 49,000 subs, 69 employees and 30 percent fewer accidents; and Midland, Texas, 30,000 subscribers, 46 employees and 50 percent less accidents. Even the MSO's largest system in Phoenix, which has 318,000 subscribers and 745 employees, achieved a 30 percent reduction.

The latest buzzword

What's significant about the quantifiable improvements—besides the obvious individual system accomplishments—is that they're coming at a time when the entire cable industry seems to be abuzz about "safety." And, they were accomplished following a concerted and exhaustive effort by Times Mirror to track workplace accidents and reduce the drain on profitability.

Of the 10,400 work-related deaths that occurred in the U.S. in 1989, approximately 51 percent involved people between the ages of 25 and 44.

By Nina Bondarook-Belofsky,
Marketing Support Specialist,
National Cable Television Institute

More than one-third of the fatalities were the result of motor vehicle accidents. And falls accounted for the next highest category, or 13 percent of all deaths, according to National Safety Council statistics.

Roger Keith, director of the National Cable Television Institute's seminar department, says although cable is relatively safe compared to industries such as mining, chemical and fertilizer production, an estimated 5.6 of every 10,000 cable employees get hurt on the job annually.

"Now that the industry is maturing and paying more attention to safety instead of concentrating on getting systems up and running, it's realizing that safety pays," Keith says. Those benefits can be calculated not only in terms of lower insurance bills, fewer lost work days, smaller workers' compensation claims and other associated costs, but also in terms of improved morale.

Cable industry statistics are few and far between, but Keith says back injuries lead the way in types of industry accidents. "We find there's a lot of improper lifting techniques being used, and people also often get hurt climbing poles. At least 99.999 percent of cable's accidents are preventable with proper equipment and training."

When Times Mirror set out to analyze its workplace safety three years ago, it was able to recapture several years of data and ended up with a five-year database that was used in the development of a proactive safety program called Safe Work Observations, Baldwin explains. "SWO" focuses on sending supervisors into the field with a safety practices checklist to ensure employees are using "key safe behaviors."

"They look for and identify things that are being done right and wrong and they give a written record of that observation to the associate. It serves as a basis for offering immediate feedback and meeting training needs," Baldwin explains.

"What we wanted to do, initially, was get a handle on our most frequent and costly accidents," says Kathy Bardsley, Times Mirror's director of training and development. "I wish the heck more companies used tracking. There doesn't seem to be enough data out there for us to compare to other MSOs. It would be good to set a standard (for the industry). You can't do that without a benchmark."

Where the money is spent

Times Mirror identified four top loss categories, among other information, through its study. According to Baldwin, the highest loss category for the company is lifting and twisting accidents, which cost an average $3,900 each. Ladder-related injuries rank second and average $3,100 each. Pole-climbing accidents account for an average $5,200 each and are the third-highest overall loss category. Slips and trips are in fourth place and average $2,800 per accident. Even cuts and lacerations cost the company an average of $500 each, Baldwin adds.

"Those costs are according to what our insurance company assigns," Baldwin explains. "It's the direct costs. We don't factor hidden costs into anything because they're too difficult to quantify. Besides, the actual costs are bad enough."

Depending on whom you ask in the industry, hidden costs such as those related to hiring a temporary replacement, lost productivity and physical rehabilitation can average from three to seven times a system's actual cost.

Walter Curtner of Curtner Risk Management in Denver, Colo. says more and more systems are realizing, as Times Mirror has, that safety programs are good business. His firm provides safety-related consulting in three areas: risk financing, claims handling and loss control/loss prevention. "What we really try to do is set up a risk management program that considers all three areas," Curtner explains.

"I started working with cable in 1985 and when I first got into it, there wasn't a lot of formalized risk management," says Curtner. "Cable was still new and growing and had a lot more small companies that just handled it on an informal, intuitive basis."

But today, some of Curtner's clients are finding they can save as much as 40 percent in overall insurance costs alone by following his risk management suggestions. They haven't been overly concerned about increased federal safety regulations, he says. "OSHA is not a huge force in the cable industry yet. There's concerns there. But it's more the bottom line that's forcing cable's attention."

With an average workers' compensation claim cost (across all U.S. industries that insurance pays for) of about $4,500, it's no wonder business is paying more attention to safety.

"Workers' comp has gone up for all industries tremendously," Curtner says, "and for a growing industry like cable, it's gone up even more. That's because not only do you have national inflation, but as companies get bigger in size, the number of incidents are likely to increase and associated costs go up."

As successful as Times Mirror's ongoing safety programs are, "we've also had to bite the bullet—we've had to spend some money to buy ladders, new equipment, and to provide more training," says Times Mirror's Bardsley. "But it's been a tremendous learning process. We've learned we need to look more critically at peoples' ability to perform certain functions."

Bardsley adds that the company's goal is "long-term improvements and we anticipate seeing accidents continue to decline."

SCTE's role in education

Ralph Haimowitz, director of training and safety for the Society of Cable Television Engineers, spends much of his time preaching the safety gospel at no charge at regional cable meetings. What the cable industry needs, Haimowitz says, is an insistence upon safety programs from the top down.

When the SCTE and NCTI began offering safety training and Occupational Safety and Health Administration-related seminars several years ago, Haimowitz says little else was being done within the industry to ensure the safety of cable employees.

"It (safety programs) virtually didn't exist," says Haimowitz. "I often say we suffer from a serious disease—anal optics—and that's what I call hindsight. And my other favorite phrase is that the cable industry suffers from the ostrich syndrome: We leave our butts sticking up in the air and hope OSHA doesn't see us.

"Both, many times in the past, have caught us off guard, just as deregulation/reregulation, signal leakage and customer service did," Haimowitz says. "And unless the industry does more soon, in terms of safety, we'll get caught again."

Haimowitz says increased enforcement by the Occupational Safety and Health Administration is opening some MSOs' eyes to the need for safety programs. But the potential fines and penalties aren't commonly known to those who stand to lose the most—system owners, operators and managers—who can be held personally liable for some infractions.

A management priority

"I'm still shocked by the fact these people in this industry have no idea what they're required to do," Haimowitz adds. "These people are bumbling through life. They're just rolling the dice."

One man who's not leaving anything to chance, however, is Glenn Jones. For the past decade or so, says Pam Nobles, senior staff engineer/technical training for Jones Intercable, the company has ardently advocated ongoing safety training and practices.

In a cover letter for the MSO's written safety manual, Jones, chairman and CEO, says "...no job being performed by any associate is so important, and no service so urgent, that time cannot be taken by all concerned to perform the job in the right way, the efficient way, which is the safe way."

Jones Intercable has a comprehensive plan that involves safety training, equipment checks, supervisory feedback and basic safety training reinforcement. Nobles says the most essential components to workplace safety are, "number one, to have management commitment from the top, and number two, to constantly reinforce the basics with ongoing training."

For about a year now, Jones has supplemented its ongoing safety program with an interactive video about general safety training. "It's designed to be used for new associates coming in, and also is used in monthly safety meetings by supervisors who want basic safety reinforcement," Nobles explains. "It's too new to be able to track results.

"We've also recently formed a corporate safety committee that includes people from all our systems who form groups and discuss safety issues one-on-one. They give monthly progress reports back to the systems. And in late spring, we're proposing to start regional safety meetings on an annual basis."

Perfection is the goal

Robert McRann, senior vice president and general manager of Cox's 323,000-subscriber, 800-employee San Diego system, believes insisting on a safe workplace is just plain good business.

"For the last 10 years, this system has been very heavily involved in safety," says McRann. "I truly believe a company, no matter what size, should concentrate on being absolutely accident free. We have spent an enormous amount of time and effort on safety."

And those efforts, once again, show not only in the system's annual safety assessment, but also in the weekly and monthly reports the system has been developing since it first began tracking workplace accidents and injuries in 1983.

"I can't speak for the entire cable industry, but I can tell you within the Cox Cable organization that ensuring safety is a number-one priority," McRann adds. "This is a maturing industry and any time you get into a maturing industry, those things that tended to be overlooked before tend to get priority attention."

Tom Brandon, the San Diego system's safety/security manager, says one outcome of his tracing and evaluation has been a change in drivers' training. "We've increased our fleet size over the years and increased the number of miles driven, so the volume of accidents did go up," Brandon explains. "So, we've instituted a 10-mile road course inspection with every driver."

In the road course, drivers must pass a series of tests to become certified, and are automatically enrolled in a "remedial" safety training program if they don't meet standards.

The highest category of injuries the Cox system incurs, he adds, is related to repetitive motion disorders involving the use of the hands.

On the technical side, the system has historically experienced a large number of ladder-related accidents and back injuries, Brandon says. "Some time ago, we went to a lighter ladder and our back injuries

Make sure your system is safe

No one is certain just how much work-related accidents and injuries cost the cable industry each year, but National Safety Council statistics show that nationwide, the statistics are staggering.

What cable does know, however, from the success stories of Times Mirror, Jones Intercable, Cox and other MSOs that have instituted and followed comprehensive safety programs (please see related article, p. 29) is that revenue loss is high enough that it's worth investing time and money to ensure the safety of workers on the job, as well as that of the public the cable industry serves.

That's why the National Cable Television Institute and *CED* magazine have joined forces to present **Safety '92: Your commitment to a safe workplace, April 9-10**, in Denver, Colo. The symposium, which takes place at the Sheraton Denver Technological Center, will emphasize safety regulations, safety training and safety program ideas from both management's and employees' standpoints.

"Safety is no longer an option," says the NCTI's Roger Keith, seminar department director. "A few years ago it was unusual to find a cable system with a full-time safety officer or an ongoing safety program in place. But with increased OSHA activity and the realization that workplace accidents impact the bottom line, we're seeing a new focus on safety."

In 1989, the National Safety Council estimates business and industry's costs related to occupational deaths and injuries was about $48.5 billion. That includes lost wages totaling $8.3 billion and insurance administration costs of $6.1 billion. Medical costs were another $8.1 billion.

Uninsured costs, which include items such as the monetary value of time lost by workers other than those who are injured, and the cost of time to investigate the incident, doing the required paperwork and reporting, and similar activities, came to another $22.5 billion. Then, there's fire damage-related costs of about $3.5 billion—excluding the property damage itself. And that, the Council says, is "conservative."

Safety '92 will include nine information sessions ranging in focus from the role of safety in the workplace and who should be responsible for it, how to develop a systemwide safety program, a look at risk/loss management, safety and the law, and working with heavy equipment. Other topics will show how to develop and implement safety training in both classroom and field settings, computer-assisted training and self-study programs.

The conference will conclude with a panel discussion that will culminate in the development of a "Code of Safe Practices" for the CATV industry.

The cost of the program is $325 for SCTE members and $365 for non-members who register before March 1. Registrations placed after March 1 will cost $345 per SCTE member and $385 per non-member.

A special post-conference Spring skiing package has also been arranged. The cost of the two-day event, which will take place at Winter Park ski resort and includes round trip transportation, lodging in a mountain condominium, ski lessons, equipment and lift tickets, is $109.50 per person.

For more information, contact NCTI at (303) 761-8554. **CED**

decreased. Our gaffing program is also one of the best in the industry. Our certification involves videotaping associates climbing poles and every certified gaffer goes through a one-week in-house training program. One January 31, for example, 128 gaffers were tested and all but three passed."

The trick to safety training, Brandon says, is keeping up with technology, sticking to the basics and ongoing reinforcement. "We're looking at laser technology associated with fiber optics now and thinking about that training. I think we're (the cable industry) becoming more safety conscious and we're adapting."

Ask Times Mirror's Gordon Baldwin whether he believes all the money and efforts spent on tracking and development is worth it and he'll give you a resounding "Yes!"

"Absolutely, incredibly, strikingly, unequivocally, yes," he adds. "All you have to do is ask your systems to do the minimum," Baldwin says, "and when they find they get great reductions, the system gets a life of its own and it all begins to work. It develops a kind of safety culture. You get people working more safely and it becomes an accepted thing to do." **CED**

Status monitoring in CATV optical networks

As a result of the new architectures used in fiber optic CATV networks, status monitoring is now much easier to implement than in conventional tree-and-branch coaxial networks. Status monitoring as an aid to improved network operation is more valuable than ever, because there is a genuine drive to improve CATV system performance and reliability. At the same time, status monitoring systems are becoming more sophisticated, providing system engineers with new tools to improve network operations.

In this paper, a brief outline of status monitoring in CATV systems is presented. The discussion includes the type of status monitoring and history of its use in CATV systems. Some of the new fiber architectures are shown and the relationship of architecture to the viability of status monitoring is also discussed. Finally, what status monitoring systems monitor and what information is available is discussed.

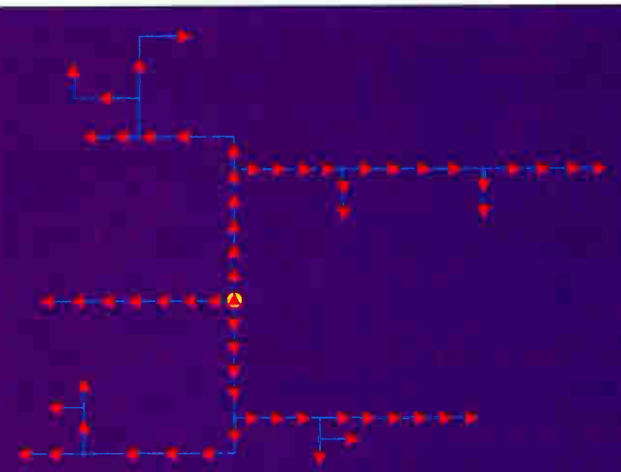
Types of status monitoring

Status monitoring has a number of possible implementations. The first and simplest is called *local status monitoring*. Local status monitoring equipment consists of a number of sensors installed within the trunk station that provide data to a local status monitoring module.

Those sensors monitor temperature of the output RF hybrids in each module, the 60 Hz current flowing into and out of the station on the trunk and feeder ports, the raw AC voltage at the power supply, the DC voltages generated within the station, the condition of certain redundancy switches, information about the status of the AGC amplifier as well as several other items.

All of this data is fed to a local status monitoring module which has an LCD readout. When the system engineer opens the housing, he or she can step through the monitored data to determine if the station is operating properly. Without the local status monitoring, it is impossible to know anything about the input and output currents or the temperatures of the RF devices.

However, while the local status monitor provides a great deal of information, it must be accessed by climbing the pole (or opening the pedestal in an underground system) and opening the amplifier in which the equipment is housed. It is truly local in nature.



Typical CATV System Tree and Branch Architecture

Figure 1

Telemetric monitoring

Another approach takes local status monitoring one step further. A connector provides access to the microprocessor in the unit, and therefore to the data. A plug-on module will be designed which contains a transceiver. With a stub antenna installed in the end of the amplifier housing, a system engineer with a handheld unit can download all of the data without ever climbing a pole. This scheme is called *telemetric* status monitoring.

Since most amplifiers are opened needlessly in a maintenance or outage situation, this status monitoring system promises to considerably reduce outage time over systems without telemetric status monitoring.

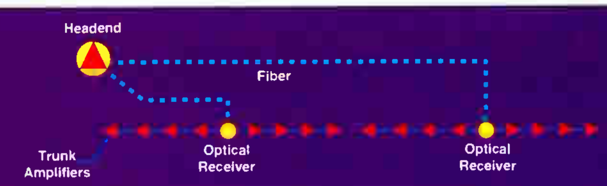
Remote monitor

While both of these status monitoring systems offer much information about the amplifier, it is still necessary for system engineering personnel to be at or in the vicinity of the amplifier to obtain data. Obviously, this is not the best way to achieve the kind of system reliability that is needed.

The only way to do that is with remote status monitoring. That means that amplifiers and other devices can be monitored from the system office on a real-time basis via a computer system.

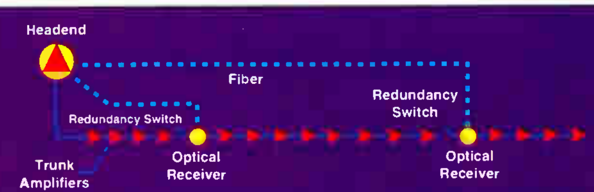
CATV monitoring

While status monitoring of standard tree-and-branch networks has been possible for at least 15 years, it



Fiber Backbone Architecture

Figure 2



Cable Area Network (CAN) Architecture

Figure 3

By William H. Ellis, Augat Communications Group, Inc.

has been met with little interest by the CATV community. There are several reasons for this lack of interest, including the complication of installing and maintaining the return path in a tree-and-branch network and the question by system engineers of a real need for status monitoring in a TV distribution network.

There are also historical reasons why these issues exist. The present cable industry, for example, grew up from an industry which had little real engineering capability. Most system chief engineers and technicians came from the ranks of TV repairmen and untrained individuals who came into the industry without any technical training. They had on-the-job training and were trained by others with little technical competence. It was sometimes a considerable struggle just to keep the older systems operating—much less being too concerned about the quality of pictures that were being fed to the subscribers.

We've come a long way

Fortunately, all that has changed in the past decade or so. As the industry grew from its "mom and pop" roots to system consolidation and the proliferation of multiple system operators (MSOs), the infusion of competent and trained engineers and technicians became a necessity. Further, many of those engineers and technicians who came up through the ranks even with little formal training, learned their craft well.

Now, system maintenance is taken seriously and quality of service is considered as important as merely keeping the system operating. Still, status monitoring is primarily done by subscribers who phone the system office when they have a signal outage or poor picture quality.

Maintenance a serious issue

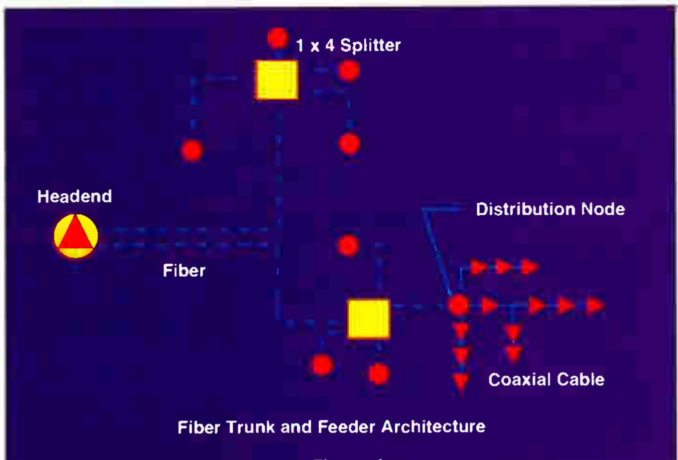
Moreover, in the typical CATV system, it may be uncomfortable but it isn't life threatening if the system goes down from time to time. Cable operators still don't want to install return path capability in tree-and-branch systems because it is not easy to see how the return path can generate revenue or sufficiently reduce cost to justify the maintenance required.

In tree-and-branch networks (see Figure 1), return path maintenance is difficult because of signal ingress and noise build-up. In the forward path, the noise is well defined. Calculations can be made which show the CNR at any location in the system. That is not the case in the return path. Because of the varying number of paths feeding into the return path, noise build-up is a fact of life. Signal ingress because of high powered signals in the return path also present problems.

Signal ingress is not the problem it once was, however, because the FCC has emphasized its rules limiting signal leakage. As a result, most CATV operators have an ongoing program to detect and repair leaks. Nevertheless, the noise build-up issues have not gone away in tree-and-branch networks.

Fiber system architecture

With the deployment of fiber links, the situation is quite different. There are many new topologies which are



Fiber Trunk and Feeder Architecture

Figure 4

not tree-and-branch. Further, even in those instances where a tree-and-branch architecture is still present, the use of fiber nodes has limited the amount of system that is connected to any given point as compared to all trunk lines beginning from one point in the classic tree-and-branch network.

There are a number of fiber architectures being used. Three of them that are well known are fiber backbone topology, cable area network topology (CAN) and fiber-to-the-feeder (FTF) topology.

Fiber backbone topology (see Figure 2) is similar to a conventional tree-and-branch network except that the connection from the headend to the distribution point is a fiber link. After the optical to RF conversion, there are a limited number of trunk stations that feed the RF signal to subscribers in the conventional way. However, because of the limited number of trunk stations, isolating a return path problem is much simpler in a system where all paths connect into a common trunk.

A CAN system (see Figure 3) is derived from a conventional tree-and-branch system. At specified points along the network, the trunk is broken and a trunk station is replaced with an optical-to-RF converter. Fiber feeds into these points which again limit the number of return path signals that collect at one point. The CAN system is unique in that a redundant switch at the optical-to-RF unit is automatically activated to supply signals over the existing RF path if the optical link is interrupted.

Fiber trunk and feeder topology (See Figure 4) is considerably different than that of the conventional system. Optical to RF converters are located throughout the area to be served. Instead of feeding into trunk lines, distribution begins at the optical to RF unit and feeds line extender or distribution amplifiers only.

It is easily seen that in all of the fiber architectures described, return path signals are now directly sent to the headend over many separate paths and noise is not combined into one return trunk path. Maintenance of return paths is now relatively easily accomplished because the number of locations where the problems can originate is much smaller.

The move to fiber brings about the opportunity for cable systems to take a quantum leap in reliability. Fiber lets operators put into place status monitoring systems that can help them to take preventive actions and not simply react to disaster when it occurs.

It is also clear that there are several compelling reasons why operators should take these steps to improve reliability and undertake preventive maintenance. These reasons include:

1. Competition and potential competition from other delivery services such as local video rental stores,
2. The potential of installing additional services such as personal communications services (PCS),
3. The potential of high definition television (HDTV), and
4. FCC rules and regulations.

Status monitoring capability

With fiber, it has been established that status monitoring is much easier to implement and there are valid reasons why it should be implemented. As noted early in this paper, status monitoring in a CATV system can do many useful things. Precisely what can be accomplished depends upon the particular status monitoring system being installed. Each system has its own capabilities. Each manufacturers' equipment has its own idiosyncrasies with some having considerably more capability than others.

In theory, remote status monitoring is relatively straightforward. Each amplifier or device that is to be monitored contains a transceiver. Each transceiver has an address and is polled by the controlling computer over the outbound path on an FSK modulated carrier. When it is polled, the transponder downloads its data to the computer on an FSK carrier on the return or inbound path.

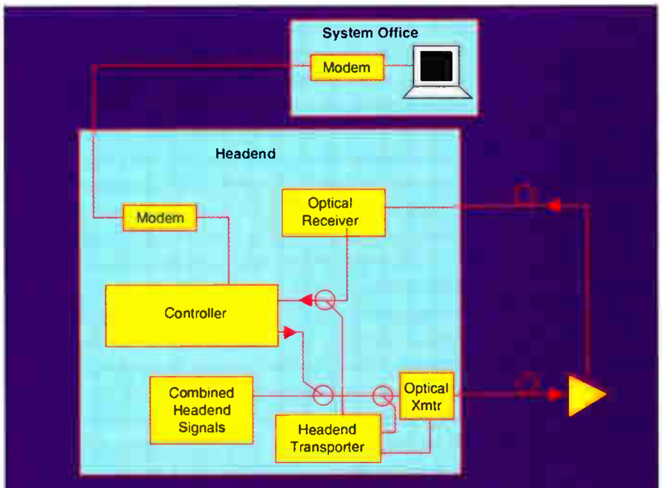
How it works

A controller or interface device of some type is located at the system headend. The controlling computer can also be located at the headend, but in many cases the system headend is not co-located with the system office. As a result, the controlling computer may be located in the office and communicate with the controller via a phone line using modems at each end.

The interface device typically has some limit to the number of transponders it can address, but that number is large. Further, more than one interface device can be used and therefore the number of devices that can be monitored is virtually unlimited.

Most remote status monitoring systems can monitor at least the following amplifier information:

1. AC and DC power supply voltages.
2. Amplifier station temperature at one or more locations.
3. Inbound and outbound data car-



Status Monitor System Block Diagram

Figure 5

rier levels.

4. Tamper or lid closure information.

More sophisticated systems can monitor trunk and feeder currents, status information within the station, individual RF hybrid temperatures, and other functions. In addition, status monitoring systems can remotely control or override some functions within the amplifier station. For example, redundancy switches may be controlled or overridden and return path bridger disconnect switches may be activated.

However, perhaps as important as monitoring amplifiers is monitoring standby power supplies. Transponders located in standby power supplies can monitor the condition of the batteries as well as the mode of operation.

The mode of operation is particularly important. If a supply goes into standby operation, it means that the AC power has failed. The cause of failure must be determined rapidly before the batteries are discharged so that the problem can be corrected prior to losing system power. Naturally, that is not always possible if the loss of AC power was caused by a local power utility outage.

However, in limited cases, a standby generator can be used to restore AC power before the batteries are discharged. The condition of batteries is also a vital piece of information, since standby supplies are used infrequently.

RF monitoring can also be accomplished with the installation of a transponder designed to report spectrum analysis data. With these transponders installed at the ends of lines, the sweep response of an entire system section can be monitored. System sweep information can tell a trained observer than an amplifier or splice or some other system component has a problem.

Other general purpose transponders with a variety of analog and digital inputs and digital outputs can be located anywhere in the cable system. For example, one or more of these devices located at the system headend can be used to monitor the condition of laser transmitters. Other analog inputs can monitor the headend primary or standby power. The digital inputs can be used to alarm the headend facility so that forced entry is immediately reported to the operator at the system office. Digital outputs can be used to switch satellite receivers or control other devices. The number of items to be monitored or controlled is open to the imagination of the system engineer.

Software

While much depends on the hardware, status monitoring software is certainly equally if not more important. With some status monitoring systems, an entire system can be programmed into the computer showing all of the trunk amplifiers, power supplies and end of line transponders. The software permits the operator to zoom in or out to select individual parts of the system. By selecting an amplifier of interest with a mouse and cursor, data can be displayed in a window which shows the operating condition of the location.

Virtually all monitored functions within the transponder can have

upper an lower limits set. If the monitored function gets out of the normal operating window, an alarm occurs. Depending how far the monitored function is out of range, a major or minor alarm condition can be specified.

And, some status monitoring software is designed to highlight the offending unit on a graphic display so that the operator can instantly identify the problem area and take action to correct the difficulty.

Other capability also exists within status monitoring systems. For example, the software can be directed to keep a record of certain information, such as signal level, over a period of time. This permits an operator to locate a potential problem that occurs at a particular time of day or at a particular temperature. The logging function also helps the operator meet certain FCC rules which require measurements to be made over specified time spans.

Keeping the system operating is obviously the first priority. After that, the system engineer wants to know how well the system is performing. Using the spectrum analysis capability of the end-of-line transponder, the engineer can determine the system carrier-to-noise ratio (CNR), the system signal-to-hum modulation ratio and the system distortions such as carrier-to-composite triple beat ratio (CTB) and carrier-to-composite second order beat ratio (CSO). Recording this information on a regular basis can show a deterioration in performance that can be watched and analyzed prior to causing a system problem that will be noticed by subscribers.

> Now, quality of service is considered as important as merely keeping a system operating.

In the final analysis, status monitoring can provide eyes and ears that heretofore were provided only by subscribers. Being aware of potential problems before they cause system outages or a reduction in quality of the supplied product is the purpose of status monitoring. When the subscriber sees a problem, it has already become a public relations issue. Status monitoring can help prevent those occurances.

With the implementation of fiber into the CATV distribution networks, an opportunity has arisen to simplify the utilization of status monitoring. Moreover, it is imperative that cable operators improve system performance quality and reduce to the absolute minimum outages in the system. Status monitoring provides a valuable tool to aid operators in reaching those goals.

Acknowledgments

The author wishes to thank Dave Delane and Joe Rocci of AM Communications, Quakertown, Pa. for helpful discussions and support in preparation of this paper. CED

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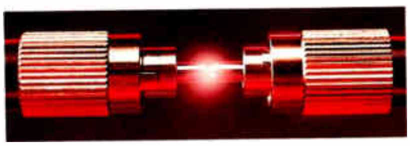

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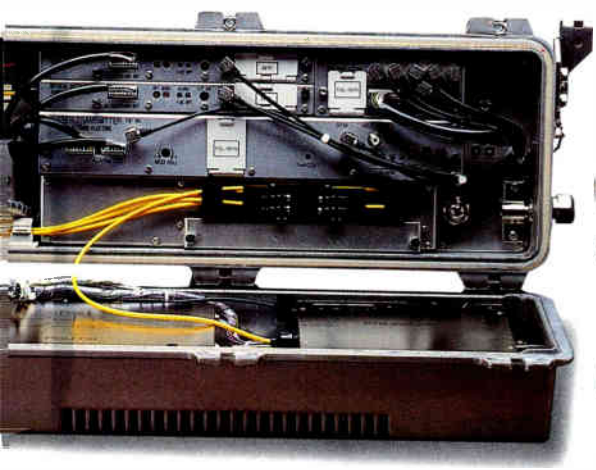

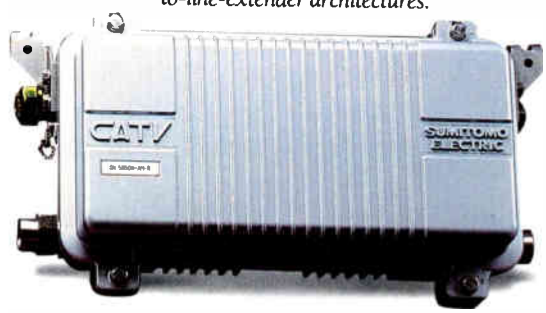

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Fiber optics in CATV: Fulfilling the promise

Fiber optic technology for cable television has come a very long way in a remarkably short period of time. In 1988, AM fiber was only a novelty, while today it is an accepted, standard "tool in the toolbox" of every cable operator. Yet despite these rapid gains, AM fiber technology stands at a dramatic watershed in its usage in the cable industry.

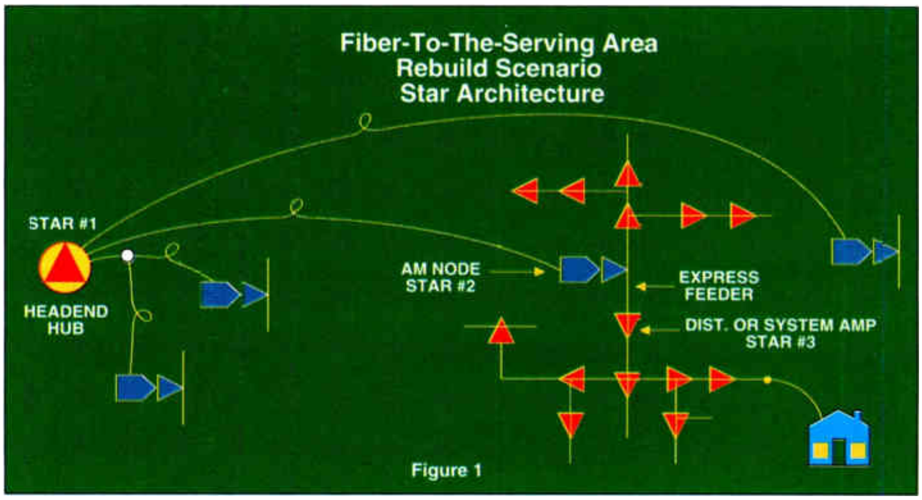

Figure 1

Up to this point, AM fiber has been used to deliver existing cable television service more effectively. Perhaps more importantly, AM fiber technology now provides the opportunity to deliver a host of new, revenue-generating services. Many such services are currently being tested, including video-on-demand, personal communications services (PCS), alternate access to long-distance carriers, and other voice, data and video communications services.

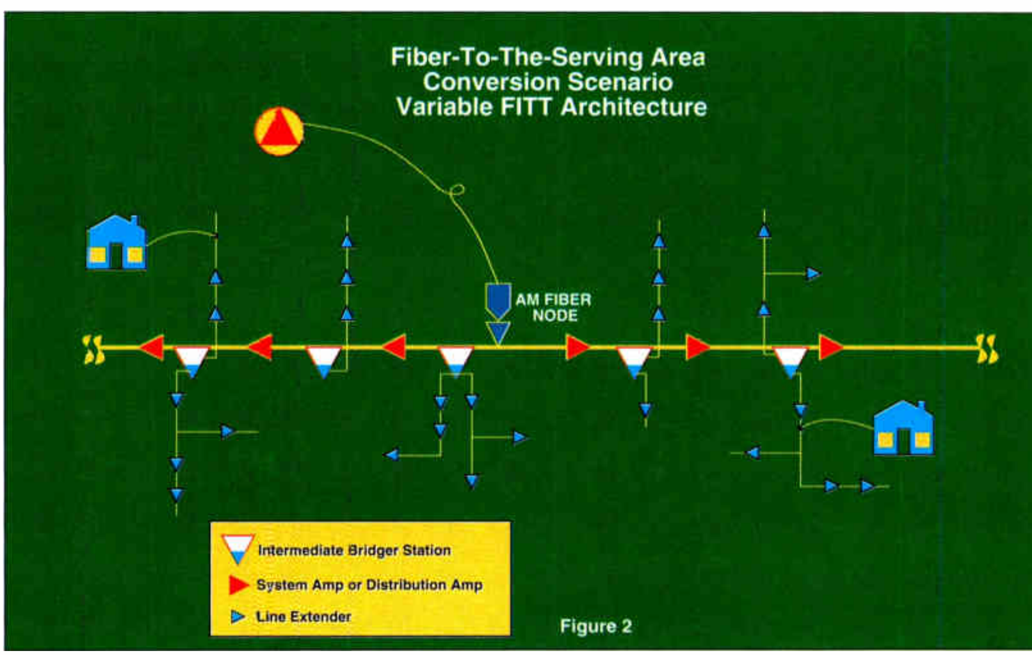

Figure 2

Delivery of new services such as those listed above will present the cable industry with a variety of challenges, both technical and operational. Before we examine these issues, however, it is essential to understand where we are today.

Both fiber technology and its applications have continually evolved, yet with all of the rapid changes that have occurred, the cable industry has proceeded with wide deployment of AM fiber. This commitment to the implementation of new technology was based on the promise of improving the existing cable plant in terms of picture quality, service reliability, bandwidth expansion and operational efficiency.

Promise delivered?

As the cable industry embarks on the wide-scale deployment phase of AM fiber in cable television, it is useful to examine how well the technology has delivered on its early promises. This analysis is particularly timely as the industry contemplates the prospects of a range of new services, which will probably necessitate even more extensive use of fiber to reach much closer to the customer's home. Before CATV rushes ahead based on expectation for AM fiber technology, we should understand how well reality has matched expectations up to this point.

Picture quality

There seems to be little doubt that AM fiber does in fact deliver superior picture quality when compared to all-

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

coax systems, although the difference is difficult to quantify. Anyone who has seen a comparison of the signal delivered over an AM fiber link versus a long coaxial trunk cascade can attest to fiber's clear visual advantage.

This type of evidence has been confirmed many times over in actual practice. There have been countless instances of subscribers calling in shortly after a fiber installation to find out why their picture was so much better! Of course, the amount of perceived improvement is highly dependent on the subscriber's proximity to the headend. In any event, one definite benefit of fiber is that the quality of the signal received has become much more uniform throughout the service area.

Target end-of-line specifications that operators are now planning for provide additional evidence. Prior to the advent of AM fiber, most systems were designed to deliver carrier-to-noise levels ranging from 43 dB to 45 dB at the last tap. During the first phase of AM fiber implementation, which was predominantly cascade reduction-type applications, the target range improved to 45 dB to 47 dB.

More recently, in the second phase of fiber implementation which has brought fiber into the feeder portion of the plant, the end-of-line performance has again improved to the 48 dB to 50 dB range.

> In systems that are using fiber, picture quality has reached unprecedented levels, and service reliability has improved.

Service reliability

It has been widely accepted from the beginning that fiber systems would be inherently more reliable than coax systems because so many fewer active devices were used. However, in the early stages, there were questions about the stability and lifetime of the optoelectronic equipment, in particular the lasers. Another question mark was the length of time that would be required to isolate and repair fiber-related outages.

Concerns such as these were major reasons for the widespread adoption of the Cable Area Network (CAN), in which the old coax trunk cascades were used as redundant paths to the new fiber links. In CAN systems, the reliability as perceived by the subscribers was vastly improved, since it would take both the fiber and coax systems failing simultaneously to cause a failure in the trunk portion of the plant.

Improvements in the cost and performance of optical systems have enabled AM fiber to play a much larger role in systemwide upgrades and rebuilds. The fiber-to-serving area (FSA) architecture, which is now in widespread use, brings fiber to the feeder plant and does not provide for redundant coax paths to fiber nodes. This design reflects a high level of confidence in the reliability of AM fiber systems. The available data indicates that the reliability performance of the current generation of AM fiber electronics has justified this confidence.

Kevin Casey of Continental Cablevision recently reported on a reliability analysis of Continental's fiber and coaxial systems in New England. His results showed that the fiber plant was 1,600 times more reliable than coaxial plant. In addition, cable systems with a mix of fiber and coaxial plant experienced 27 percent fewer outages than traditional coax tree-and-branch systems. Also, Casey's data confirmed the expectation that fiber would improve the reliability perceived by subscribers, by reducing the average number of subscribers affected by a given outage by 77 percent.

Bandwidth expansion

The combination of increasing end-of-line performance targets and higher bandwidth requirements has made fiber an essential element of upgrades and rebuilds. As the bandwidth increases for a given performance level, the maximum allowable cascade length decreases, and therefore the reach of the coax plant decreases as well. The gap that is created is filled by AM fiber.

In many cases, cable systems that would have to be rebuilt without fiber can be upgraded with AM fiber, which makes bandwidth expansion economical. In addition, higher bandwidths such as 550 MHz and beyond cannot be achieved cost-effectively without fiber.

In a rebuild situation, the most frequently used architecture is the Fiber-to-Serving-Area (FSA) Star design, which is shown in Figure 1. In the FSA-Star approach, traditional trunks, bridgers and line extenders are not used; each pocket of approximately 2,000 homes is served by an AM fiber node which feeds a cascade of distribution amplifiers. In a 550-MHz rebuild, an FSA-Star architecture utilizes AM fiber nodes feeding cascades ranging from five to eight amplifiers. At 750 MHz, the same FSA-Star design results in a maximum cascade of between three and five amplifiers.

In an upgrade situation, the FSA-Variable Forward Intermediate Terminating/Trunk (FITT) design, shown in Figure 2, permits upgrades to 550 MHz and beyond without respacing. Previously, systems operating at 270/300 MHz or less could not have been upgraded to 550 MHz unless the trunk/bridger stations were relocated.

The Variable FITT is a version of the FSA approach in which existing trunk/bridger locations are converted to Variable-FITT stations which serve as dual-output bridgers. Forward amplification is the provided by inserting distribution amplifiers between the Variable-FITT stations. In an upgrade to 550 MHz or 750 MHz, a Variable-FITT fiber design allows for cascades of up to eight amplifiers from each node site.

Operational efficiency

In terms of operating savings, the

early proponents of fiber believed that the improved reliability referred to earlier would translate into fewer truck rolls. In addition, the reduction in the number of active devices was expected to lower the overall plant power consumption, and thus the system's monthly power bill, as well. Of course, these assumptions do not hold in CAN designs, because in these cases, fiber is added to the existing coaxial plant.

In FSA designs, actual practice has fulfilled the original expectations. In every cable system that has implemented AM fiber and has measured data, both the number of truck rolls and the total plant power consumption have decreased. Continental Cablevision's Kevin Casey reported an 8 percent overall reduction in energy demand in the MSO's New England systems. Casey also cited a 13 percent reduction in subscriber service calls which was attributable to fiber, as well as 5.5 fewer outages per year per 100 miles of plant, which translated into operational savings from fewer truck rolls.

Where do we go from here?

As the preceding discussion indicates, experience in a large number of cable television systems has proven that AM fiber can and has delivered on its promise. In systems that are using fiber, picture quality has reached unprecedented levels, and service reliability has improved dramatically.

Channel capacity of 550 MHz, which until recently was considered overkill, has become the baseline bandwidth to shoot for, with a number of operators looking to go higher. Real dollar savings have been identified as a result of fiber-related operational improvements. All of these benefits have positioned the cable industry to provide a vastly improved level of overall service to its customers.

If the future of cable rested solely on providing 78 channels of broadcast television programming, the industry would be firmly established in a strong competitive position. But dramatic changes are taking place. High definition television and digital compression are changing the equation in terms of both bandwidth and picture quality. The capability of offering new revenue-generating services, such as video-on-demand, alternate access and data communications, also brings new challenges in terms of service reliability and operational efficiency.

In many cases, providing new services entails entering new markets with different competitive forces. In the past, cable operators have demonstrated the ability to successfully adapt to a changing competitive environment. The cable television market as we know it is now poised on the brink of merging into the much larger information services market. The cable industry's future depends on understanding what is required for success in that market and taking the steps to meet the challenge. **CED**

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Coherent technology for future cable systems — or not?

Within the cable industry, perceived opportunities for coherent lightwave techniques for futuristic cable systems are being discussed. However, factors motivating coherent detection, which include high receiver sensitivity and extremely high optical spectral efficiency, are offset by technical complexity and the recent emergence of less demanding alternatives.

Coherent detection is no longer required for exploiting the vast potential bandwidth offered by optical fiber. Rather, it is the most difficult of several dense wavelength-division multiplexing alternatives. These alternatives share the limitation of being incompatible with all current wired distribution architectures. Therefore, given the strength of the cable coaxial network, perceived coherent opportunities should be greeted with skepticism.

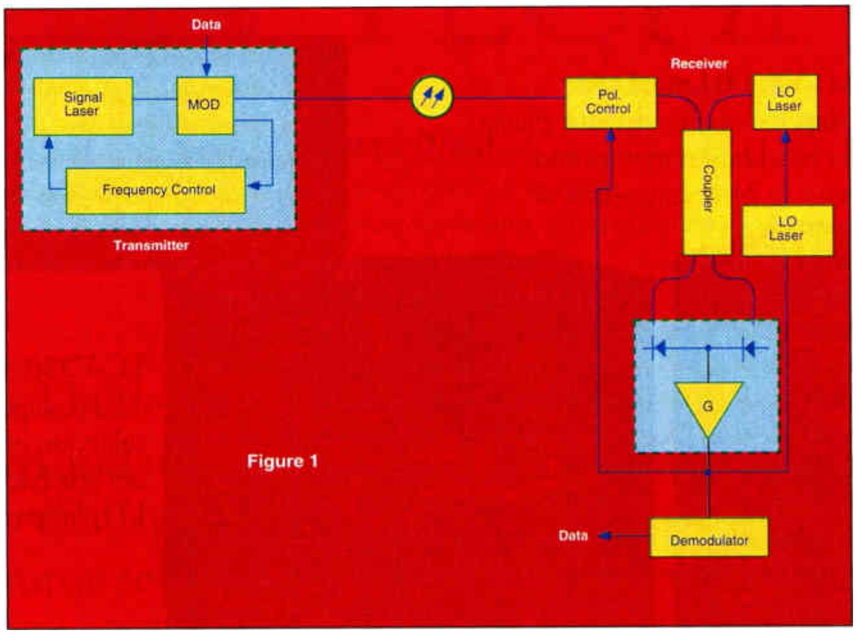

Figure 1

Understanding coherent

Coherent lightwave technology continues to capture the imaginations of research and systems development groups worldwide, yet defies practical implementation. Motivated by the obvious attractiveness of "photonic radio" and the exploitation of the "virtually unlimited fiber bandwidth," research efforts have, over the past 10 years, provided a firm technical basis of understanding for the possibilities and limitations of coherent techniques. Yet in spite of multimillion dollar initiatives and thousands of Ph.D. years of dedicated research, no commercial coherent system has been deployed.

National high-speed digital networks do not use coherent detection now, nor will they in the foreseeable future. Analog fiber-backbone cable systems and digital loop carrier systems have gained overwhelming economic acceptance, without consideration of coherent techniques. Plans for multi gigabit-per-second unrepeatered trans-Pacific systems appear real, but do not require coherent detection. Why then has this highly sought after and intensively researched technology not been applied? When and why might coherent detection be useful? More specifically, what opportunities do coherent techniques offer for future cable television applications?

These questions will be answered in detail, but first, put simply, coherent techniques have not been applied because they are not required for any present-generation system concept and they are difficult technically to implement. When? They might become useful only after the state-of-the-art of photonic integration has advanced to where the transmitter and receiver functionality is simplified to the level of today's lasers and detectors.

Why? The allure of the possibility of frequency-division multiplexing thousands of gigahertz (GHz) bandwidth channels over terahertz of fiber bandwidth, and selecting channels with a simple tuner, is irresistible. However, as will be seen, alternative technologies can offer this potential with greater ease.

What then, are the opportunities for cable television? As long as the coaxial distribution architecture remains a strength of the cable industry, and fiber-to-the-home (*all* the way to the home) remains economically unattractive, the opportunities for coherent are limited.

By Ted Darcie, AT&T Bell Laboratories

Basics of coherent detection

To take a closer look at the opportunities for coherent systems, let's first consider coherent transmission basics. A block diagram of a typical coherent link is shown in Figure 1. The underlying principles are identical to heterodyne radio, in which a modulated carrier is "mixed" with a local oscillator (LO). If the carrier and LO are, for example, at 10.0 GHz and 10.1 GHz, then this mixing, which is essentially a multiplication of the two signals in a mixer, results in a signal at the difference frequency, which in this case is 0.1 GHz.

The "downconversion" to the "beat frequency" between signal and LO also preserves the modulation on the signal exactly. Hence, the modulation on the 10.0 GHz carrier appears on the downconverted beat frequency. Relatively low-frequency electronics are then used to demodulate the downconverted channel.

Coherent lightwave systems operate on exactly the same principle, with the notable exception that typical carrier frequencies corresponding to 1.3 or 1.55 micron wavelength light are 20,000 GHz. Various modulation techniques are used to modulate the signal laser with up to several gigahertz bandwidth of information. The

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resulting laser spectrum, centered at 20,001 GHz, for example, then extends from 20,000 to 20,002 GHz. At the receiver, the signal is combined with another laser (LO) with a frequency of say 20,005 GHz, and the combined signals are detected on one or two photodiodes.

Each photodiode acts like a perfect square-law detector, meaning that the detected photocurrent is the square of the combined input optical fields, and this squaring produces the multiplication (mixing) required to generate the beat frequency. The detected photocurrent then contains frequency components identical to the modulation originally on the 20,001 GHz carrier, but at the more manageable frequency of 4 GHz. Using two photodiodes as a "balanced receiver" allows the use of all signal and LO power and cancels mosts intensity noise from the LO.

Technical difficulties arise from two main requirements. The first is frequency stability. As one familiar with microwave heterodyne techniques might guess, the frequency stability of the signal and LO must be high. Frequency or phase fluctuations of either are replicated as fluctuations of the downconverted signal. Unfortunately, although stable microwave oscillators with sub-kilohertz linewidths are common, currently available semiconductor lasers require complex external optical cavity stabilization to achieve linewidths less than 1 MHz. Several recently developed laser structures do have sufficiently narrow linewidths for many coherent applications, but only if care is taken to actively stabilize temperature or current fluctuations.

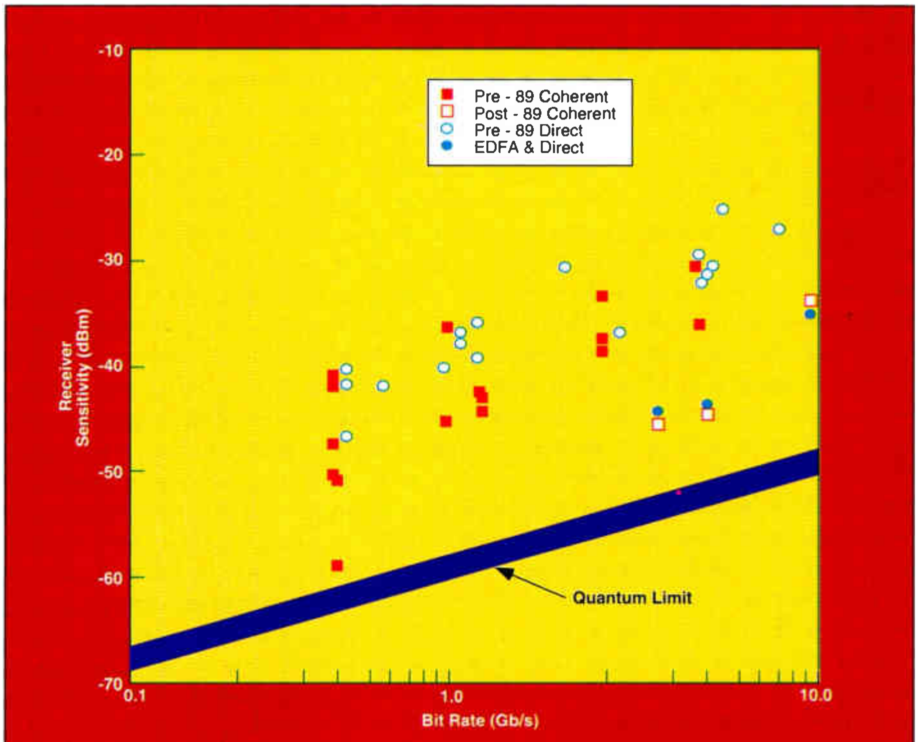

Figure 2

Polarization control options

The second source of difficulty is the requirement for polarization control. In order for the photodiode to mix the signal and LO and generate the beat frequency, the polarization of the LO must be matched to that of the incoming signal. However, the state of polarization of the signal at the end of a fiber system varies randomly with time, as mechanical and thermal variations change the physical stresses on the fiber cable. Thus, any coherent system must do one of three things:

First, special polarization preserving fiber can be used such that the state of polarization of the signal is known. This fiber is expensive, difficult to splice, and generally has more loss.

Second, an electro-mechanical polarization controller can be inserted prior to the coherent receiver to adjust the relative polarizations. These devices are large, complex and unlikely to become inexpensive.

Third, polarization diversity receivers can be used. These receivers operate by detecting each orthogonal polarization independently, in two separate detectors, and combining the outputs. As the polarization wanders, the beat frequency is generated in one detector or the other, or both. The equivalent of two receivers and extra optical and electronic components are required, and the ultimate receiver sensitivity is compromised by a few decibels. Since this diversity approach has the possibility of simplification by future photonic integration, it may be best suited for future use.

Vanishing motivation

Enthusiasm for coherent systems was fueled by two advantages over the direct-detection technology of the mid-1980s: spectral efficiency and receiver sensitivity. Each of these advantages has essentially vanished.

Various noise sources limit the performance of direct and coherent receivers. With direct detection, the primary concerns are with the receiver, or front-end noise (FEN) and shot noise (SN). FEN is strictly a function of the receiver design. Generally, wider receiver bandwidths result in higher FEN. Shot noise is the unavoidable noise generated by the detected current flowing in the photodiode. If SN were the dominant noise source, then the received optical power required for the desired signal quality would be the "quantum limit."

Unfortunately, even with state-of-the-art direct detection receivers, FEN is the limiting noise source. Direct-detection receivers are then limited to operating with approximately 15 dB more optical power than the quantum limit.

Where coherent comes in

Enter coherent detection. Noise sources for coherent receivers are the same as for direct, but with subtle differences. FEN remains unchanged (ideally). The detected beat signal is a product of the mixing between signal and LO. Hence, the microwave power in the detected beat signal is proportional to the optical powers of both the received signal and LO. If the LO is much larger than the received optical signal, the dominant SN comes from the LO. This SN, and the beat signal,

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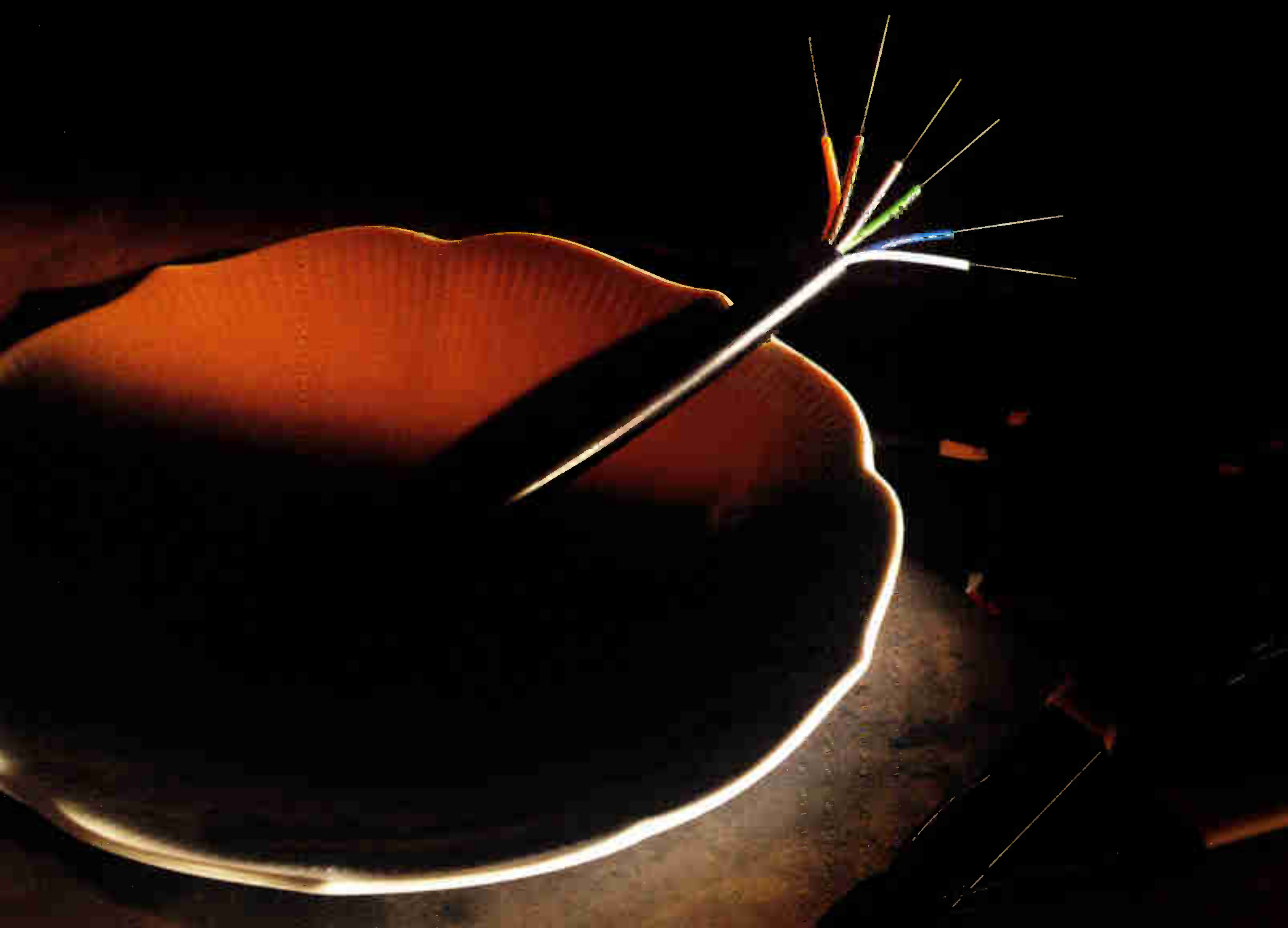

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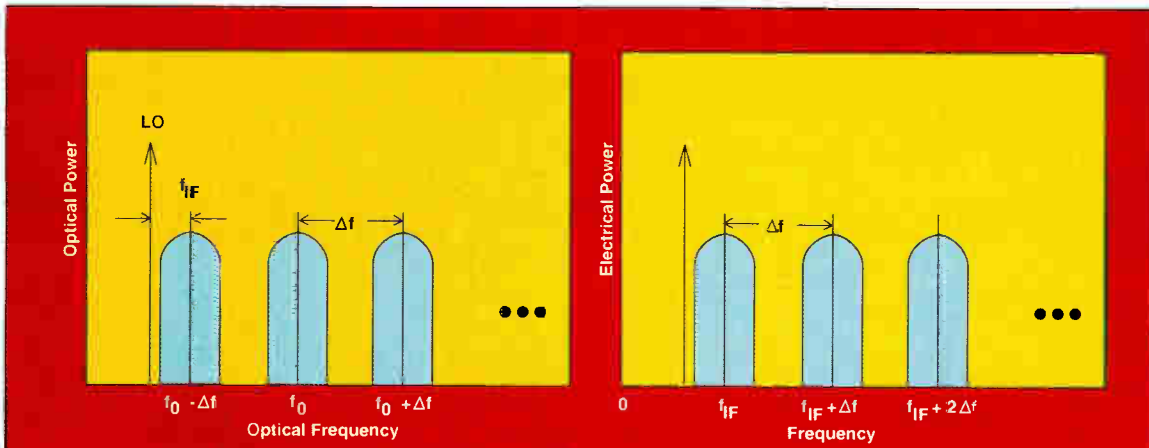

Figure 3

increase as the LO power increases.

The motivating feature of coherent detection is that as the LO power is increased, the downconverted signal power and the SN can become much larger than the FEN. Front end noise then is no longer the limiting noise and, if enough LO power is available, quantum limited sensitivities should be possible. The LO, in addition to downconverting the optical signal, effectively amplifies it with respect to the receiver noise.

Numerous coherent system demonstrations over the past decade have shown that this enhanced receiver sensitivity can be realized. Receivers that operate within 5 dB of the quantum limit have been designed. But then the significance of receiver sensitivity changed dramatically. Optical amplifiers, most notably erbium-doped fiber amplifiers, became practical and widely available system components. Thus the system designer could boost the signal power after the transmitter, in mid-span, or just prior to detection.

By amplifying just prior to detection (pre-amplifier), the FEN noise limitation of direct detection can be overcome. This is done by providing sufficient optical gain that the signal and its SN exceed the FEN. Additional noise is added by the amplifier, but almost theoretically-ideal noise figures have been demonstrated. As a result, the improved receiver sensitivity offered by coherent during the late 1980s has been matched within the last two years by direct detection with optical pre-amplifiers.

This trend is illustrated in Figure 2, which presents best the research results for various vintages of direct and coherent receivers. The most recent receiver sensitivity reported for direct detection at 10 gigabits per second exceeds coherent results by 2 dB.

Spectral efficiency

Without the advantage in receiver sensitivity, attention turns toward using the frequency selectivity of coherent detection to multiplex very closely spaced optical channels. Once again, the analogy with heterodyne radio is exact. Frequency division multiplexed (FDM) channels separated by a few gigahertz (Δf), with optical carrier frequencies near 20,000 GHz, can be selected by tuning the LO

Current cable industry lightwave applications differ from those for which coherent detection was investigated in two main respects.

laser, as shown in Figure 3. Desired channels are downconverted into an intermediate frequency f_{IF}. Tuning the LO in increments of Δf moves different channels into the microwave channel centered at f_{IF}. A microwave filter is used to reject the unwanted channels, and the IF channel is demodulated.

Until recently, coherent detection was necessary to realize this high optical frequency selectivity. However, recent advances in optical filter technology can also meet this objective. The filter technology, based on either tunable fiber Fabry-Perot filters or integrated silica on silicon waveguide filters, allows optical pass bands of less than 10 GHz. This is sufficiently narrow that individual intensity-modulated channels, spaced 10 GHz apart, can be optically selected and detected directly.

Tunable filters can also be used as optical frequency discriminators. If the laser is frequency modulated, rather than intensity modulated, the edge of the optical filter can be aligned such that the filter both selects the appropriate channel and demodulates the frequency modulation. These direct detection techniques enable one to realize very dense wavelength-division multiplexing (WDM), with relaxed requirements on the spectral properties of the lasers and without the need for polarization control.

Any dense WDM technique requires a method of allocating, maintaining and stabilizing the many optical channels. Techniques have been demonstrated whereby each laser is frequency locked to periodic resonances of a fiber Fabry-Perot filter, or to the comb of optical frequencies generated by a mode-locked laser. Absolute frequency references have been demonstrated by locking lasers to atomic absorption lines in one manner or another. Absolute frequency references have been used to stabilize a fiber Fabry-Perot filter, which is then used as a reference for several lasers. These systems get hideously complicated, but work, in the laboratory. Practical implementation, given the other complexities of coherent detection, is not in sight.

Specific considerations

Current cable industry lightwave applications differ from those for which coherent detection was investigated in two main respects: power and linearity. Received powers in AM-VSB

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fiber backbone architectures are typically 40 dB higher than those in long-haul digital. As a result, relative intensity noise (RIN) and shot noise are generally the dominant noise sources. Many high-performance links operate essentially at the shot noise or quantum limit. Coherent detection, which helped overcome receiver noise, cannot improve this.

Several formats supported

As for linearity, coherent techniques can use several modulation formats. Each has unique linearity limitations:

Amplitude modulation (AM): Coherent detection produces a signal (voltage) that is linear with respect to the optical electric field (square root of optical intensity). Direct detection produces a voltage that is proportional to optical intensity. If an ideal amplitude modulated source were detected coherently, then all would be fine. But practical AM techniques (e.g. direct laser modulation or external intensity modulation), really result in intensity modulation (IM), in that the output intensity (not electric field) is linear in voltage.

For digital applications the subtle distinction between AM and IM is irrelevant. But for analog applications, the coherent detection of IM, rather than AM, is highly nonlinear. Therefore, direct detection and IM have become the basis of the new cable television network, while coherent detection and IM cannot.

Frequency modulation (FM): It is conceivable that one could modulate the frequency of the transmitter laser, such that the frequency was linearly proportional to the applied voltage. This FM signal could be detected coherently, and the downconverted channel demodulated with a linear frequency discriminator. Unfortunately, at present there is no laser capable of sufficiently pure FM (without unwanted IM) over bandwidths approaching 500 MHz. Also, wideband FM discriminators, which generate a voltage that is proportional to the input frequency, are not intrinsically linear. Most importantly, if a suitable FM source were available, the FM channel could be selected and demodulated directly with an optical filter and direct detection, as discussed previously. Coherent detection would not be required.

Phase modulation (PM): Using existing lithium niobate ($LiNbO_3$) modulators, one could phase modulate an optical carrier such that the phase were linearly proportional to the applied voltage. Coherent detection of PM signals requires that a reference phase be available at the receiver. This reference phase is compared to the instantaneous phase of the received signal during the coherent detection process. The resulting phase difference is the original signal.

One cannot discount the possibility that a new trick might be uncovered that will lead to a spectacular linear cable TV system. But this is unlikely.

Obtaining this phase reference is perhaps the most challenging task in coherent systems research. Numerous publications have treated the optical phase-locked loops (PLL) required to detect PM signals. It is difficult, but feasible. However, even given a perfect phase reference, the generation of the phase difference, or the demodulated signal, is nonlinear. The nonlinearity is identical to that obtained from intensity modulation with an external modulator, and similar linearization techniques would be required.

One cannot discount the possibility that a new trick might be uncovered that will lead to a spectacular linear cable TV system. But this is unlikely. Of course, the capacity promised by coherent (and other) techniques must really be considered in context with digital services of the distant future, when linearity is perhaps no longer a compelling issue.

Looking ahead

The wide array of technologies being proposed for future distribution architectures make virtually any system concept appear within reach. Certainly, given the progress of the last decade, the enabling technologies will be within reach. Sadly, markets seldom support all contending technologies. If future services require a substantial fraction of the potential fiber bandwidth, then non-coherent dense WDM techniques appear more feasible than coherent.

We should not assume the future success of any dense WDM technique. Given continued advances in electronic processing speed, storage volume and software support, one cannot rule out virtual broadband networks, in which effective multi-gigabit access is provided over cheap, simple, low-tech, point-to-point data links. No sophisticated lightwave is required.

How these technologies will impact future cable operations is anyone's guess. However, any sensible path must begin with today. The dense WDM systems described herein would be useful over fiber. Any such installation must have an information bottleneck at the fiber termination. These WDM techniques are then incompatible with current wired distribution architectures. For applications, we are restricted to trunk or interoffice systems where no bottleneck exists, or we must wait for fiber-to-the-home (FTTH).

The telephony bottleneck

Telephony futurists, encumbered with a twisted pair-distribution network, must embrace such system concepts, and the associated FTTH architectures, regardless of economic or practical viability. Although fiber-to-the-curb or pedestal systems may be close to economic feasibility, fiber all the way to the home is required if this bottleneck is to be avoided. This will not happen in the foreseeable future.

In contrast, the strength of the cable industry lies in its broadband coaxial cable distribution architectures. It would be inappropriate, even folly, for cable futurists to follow the telephony lead. Evolving system concepts that are not synergistic with industry strengths may best be left to academic research. **CED**

For further reading

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Optical feedforward in AM fiber optic transmission

Longer link reach and better noise and distortion requirements have provided opportunities for fiber optic equipment to be deployed deeper into the CATV network. One of the more recent developments in CATV fiber optic technologies is distortion cancellation in conjunction with the use of DFB laser direct modulation, erbium-doped fiber amplifiers and diode pumped Nd:YAG laser external modulation.

The transfer function of these devices exhibits nonlinear characteristics over the fully loaded 550 MHz CATV bandwidth. There are two possible solutions: First, produce a light source with a high degree of linearity by improving device fabrication processes. This means having a better device structure as well as better packaging techniques. However, the limited success in these areas is indicated by the low production yield.

A second solution is to compensate or to cancel the distortions produced by these nonlinear devices. There are several approaches to distortion cancellation. Two are discussed in this paper: Predistortion and feedforward.

Predistortion

Predistortion techniques generate distortion products equal in amplitude and opposite in phase from nonlinear devices, such as diodes, to cancel unwanted distortions. There are series and parallel predistortion schemes. In series predistortion, as shown in Figure 1, the RF signal passes through a series of nonlinear devices before driving the light source. By choosing an appropriate number of these nonlinear devices and providing them with the right bias, arbitrary distortions can be generated to cancel the unwanted distortions of the light source.

Figure 2 illustrates parallel predistortion. The RF signal is phase-shifted into two arms with respect to each other by pi/n. Any nth-order distortion can be canceled when the phase angle between the arms is equal to pi/n.

By Eric Mak, Manager of Engineering, Fiber Optic Products, Magnavox CATV Systems Inc.

With an additional pair of light sources, second- and third-order distortion products can be canceled simultaneously, providing that the phase angle within each combining pair is pi/2 and pi/3, respectively.

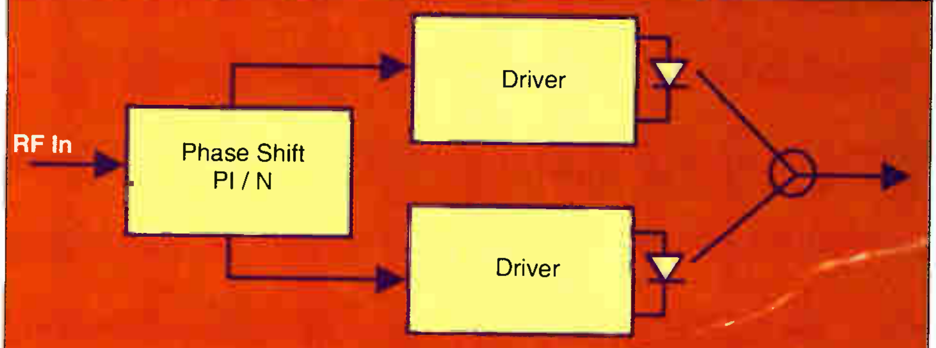
The improvement in linearity is, however, at the expense of the 3 dB amplitude penalty paid every time two light sources are combined. An additional constraint to this technique is the need to select light sources with identical transfer functions over temperature and frequency range. In general, predistortions are a form of open loop distortion cancellation which will be limited by operating conditions such as ambient temperature, operating frequency range and variation of device characteristics over time.

Feedforward

There are two types of optical feedforward schemes for distortion cancellation: quasi-feedforward and feedforward. The quasi-feedforward scheme is illustrated in Figure 3. It is really a

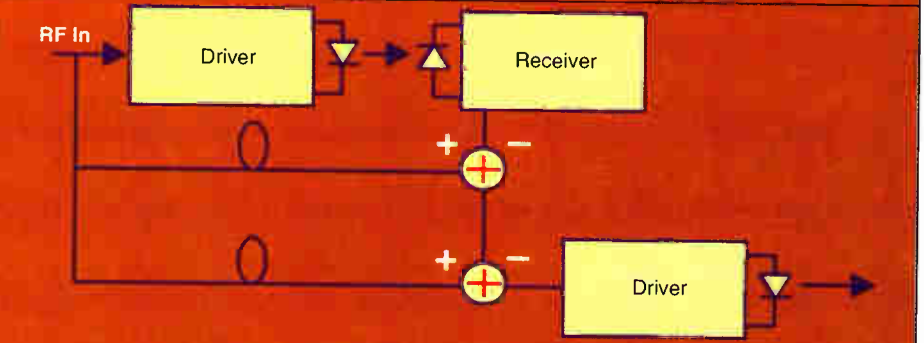
Series Predistortion

Figure 1



Parallel Predistortion

Figure 2



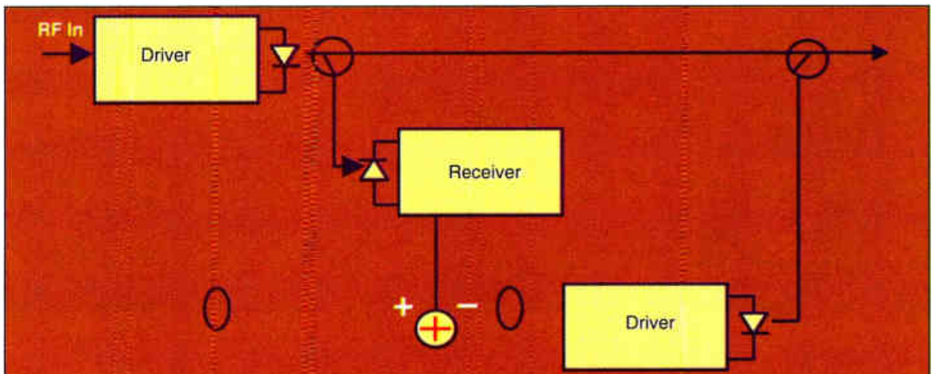
Quasi-Feedforward

Figure 3

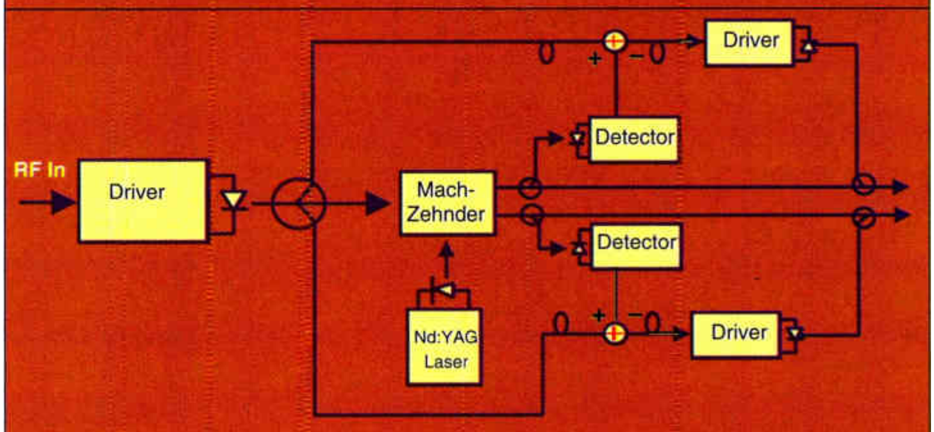
combination of feedforward and predistortion to achieve a linear system. The RF signal drives both the nonlinear light sources. Error information isolated from one light source is used to predistort the other with equal amplitude and phase angle of pi. The problem here again is the need to match the transfer functions of the two light sources over temperature and frequency range.

The feedforward scheme is illustrated in Figure 4. Isolation of nonlinear components of the main light source is performed by a linear detector, which is identical to the quasi-feedforward. However, only the nonlinear component is used to drive a second light source and the distortion cancellation is accomplished by subsequent optical combination of this error signal.

Unlike the predistortion, feedforward generates no distortion. The closed loop control between the two optical couplers shown in Figure 4 greatly enhances the system's stability over variations of operating conditions. This feedforward technique is incorporated into a multichannel AM optical transmitter as shown in Figure 5, which consists of a diode-pumped Nd:YAG laser and Mach-Zehnder modulator.



Feedforward
Figure 4



Magnavox AM Transmitter
Figure 5

Performance characteristics

Extremely low distortions and high output power are obtained. The external modulator alone exhibits a CTB distortion of approximately -40 dBc due to the raised cosine transfer function of the device. Feedforward on both arms can achieve more than 30 dBc of distortion cancellation over 77 NTSC channels from 55 MHz to 550 MHz, which, when combined with the -40 dBc CTB from the modulator, reduces the transmitter CTB to below -70 dBc. The output power at each port is rated at a minimum of 15 milliwatts (mW). Composite second order is rated at -65 dBc and can be further reduced to -70 dBc by careful control of DC bias to the modulator. Another benefit from the external modulator is that it is not susceptible to external optical reflections.

As shown in Figure 4, the error light source uses a distributed feedback (DFB) laser which does not have to be highly linear because relatively low output power and small modulation depth is required. However, this error signal is at a wavelength of 1310 nm, which is not optically coherent with the 1319 nm Nd:YAG laser used for the main signal.

Fiber dispersion effect

As a result, distortion cancellation does not occur at the transmitter, but at the receiver node after both wavelengths are detected and combined by the photodetector.

An electrical delay compensation is usually required during the link set-up to maintain the relative phase angle between the main signal and the error signal. Knowing the fiber dispersion, the difference of the wavelenths and the distance of the fiber link, the precise length of the electrical delay line can be calculated.

In some cases, optical interfaces such as couplers, connectors or macrobends along the fiber link may be wavelength dependent. An amplitude compensation is then required at the transmitter to maintain the relative amplitude between the error signal and the main signal.

To compensate for different distances among multiple receiver nodes fed by the same feedforward arm, dispersion-shifted fiber can be installed to slow the error signal, which has a shorter wavelength. In most cases, however, this is not needed. It is interesting to note that a reduction in wavelength difference between the error signal and the main signal can reduce, if not eliminate, the fiber dispersion effect.

Conclusion

An external modulator utilizing the optical feedforward technique can achieve extremely low second- and third-order distortion products and high output power in CATV systems. The feedforward approach achieves much better performance than the predistortion approach in error cancellation and system stability. The fiber dispersion effect can be compensated for or eliminated by using phase delay. CED

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Predistortion linearization

A new technique for externally modulated fiber AM video transmission systems

Fiber has the potential to dramatically transform the CATV industry. By upgrading distribution trunks with AM fiber links, CATV operators can increase profitability by providing customers higher quality pictures, an increased number of channels and more reliable service.

This increased capacity and signal quality will enable operators to add high definition television (HDTV) signals and offer programming flexibility in response to evolving market conditions. From the operational side, fiber newbuilds will be more cost-effective and current installations will cost less to maintain.

In recent years, several thousand fiber optic AM CATV links have been deployed using distributed feedback laser (DFB) transmitters. Some progress has been made in improving the performance of direct modulation AM fiber CATV systems, which are based on 1300-nm DFB laser technology. Although some additional advances can be expected, it is difficult to overcome practical limitations on output power, linearity, channel loading and Relative Intensity Noise (RIN).

In addition to the difficulties in increasing optical power and the inherent problems of laser linearity and noise which limit link performance and affect device fabrication yield, several other phenomena can impair transmission quality. Most notable are several types of undesirable interactions between the laser transmitter and optical reflections from the splices and connectors in the fiber distribution system, leading to enhanced noise and distortion.

External modulation

High continuous wave (CW) power diode-pumped solid state lasers such as Nd:YAG and Nd:YLF lasers, in conjunction with $LiNbO_3$ (lithium niobate) intensity modulators, are a feasible alternative to overcoming the difficulties associated with direct laser modulation.

With external modulation, the functions of light generation and modulation are separated, providing the flexibility to optimize both laser and modulator for specific applications. This flexibility is particularly important in AM fiber CATV applications, which impose strict requirements on the transmitter.

By Moshe Nazarathy, Charles H. Gall, Somnath Mukherjee and Yishai Kagan, Harmonic Lightwaves Inc.

Architecture

The general architectures of a DFB laser-based transmitter vs. an external modulation system using a solid state diode pumped Nd:YAG laser are depicted in Figure 1. In a direct detection system, the DFB laser is directly modulated by the video electrical signal. In external modulation systems, the light output of a high power CW-pumped 1.3 Nd:YAG laser is coupled to an external modulator.

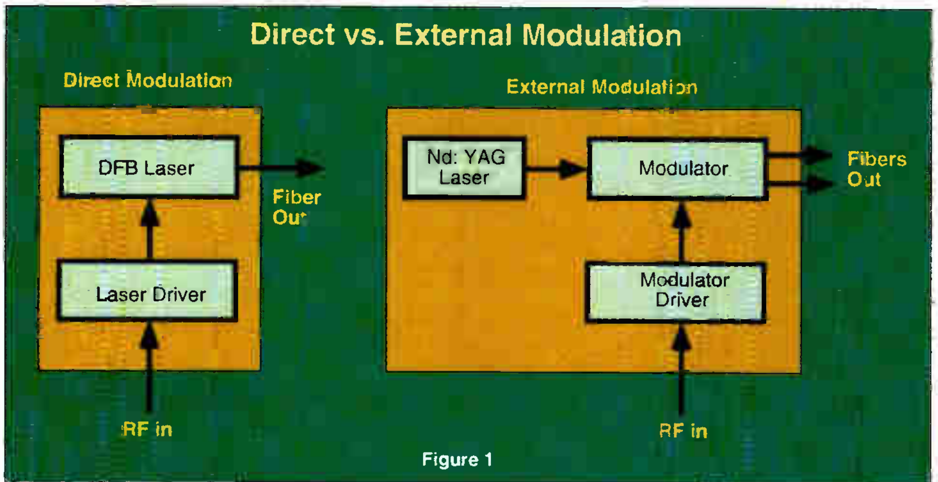

Figure 1

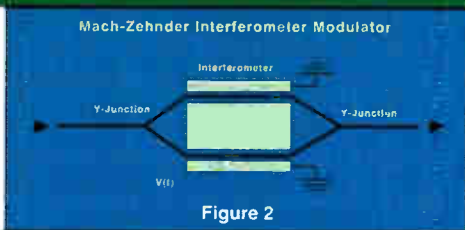

Figure 2

Mach-Zehnders

The structure of a $LiNbO_3$ integrated optics Mach-Zehnder modulator is depicted in Figure 2. Integrated optic modulators are generally constructed by patterning optical waveguides into a $LiNbO_3$ substrate by means of microlithographic techniques and depositing electrodes on top of the waveguides.

The light from the Nd:YAG laser enters the input waveguide and is split equally at a Y-junction feeding the two arms of the interferometer region wherein push-pull phase modulation is applied by means of the interaction between the electrical and optical fields. A Y-junction combiner converts the phase modulation to light intensity modulation at the optical output.

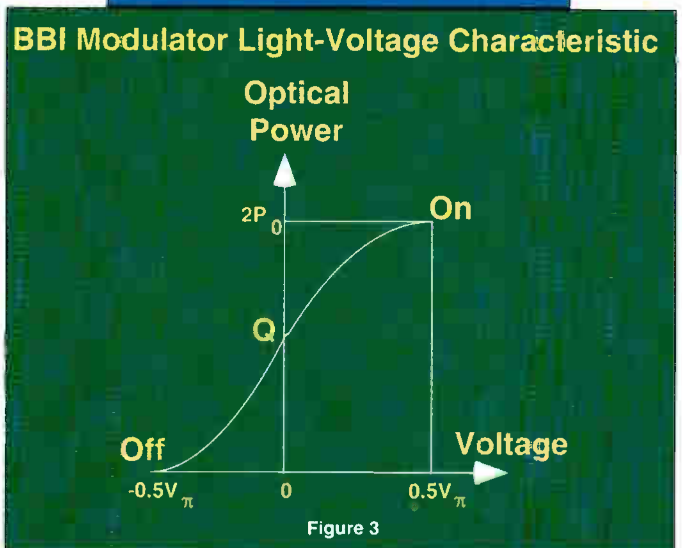

Figure 3

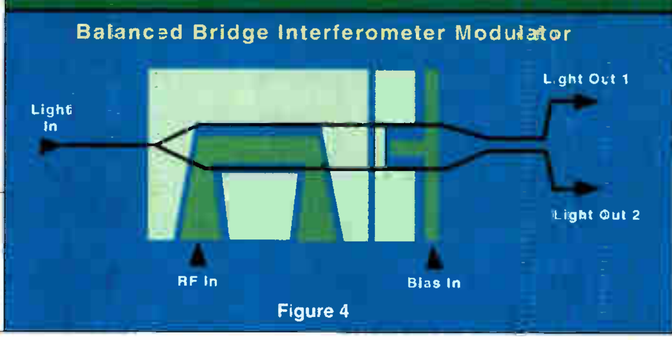

Figure 4

Trade-offs

As one initially approaches the concept of using external modulators, some distinct advantages become apparent—along with some limiting factors. On one hand, the L-V (light power vs. voltage) modulator characteristic is nonlinear, and the insertion loss of the $LiNbO_3$ Mach-Zehnder modulators seems large (approximately 6 dB).

On the other hand, the optical power deliverable by a Nd:YAG laser into a single mode waveguide is very high (50 mW to 200 mW) and the RIN is as low as -165 dBc/Hz.

Continued on page 67

Predistortion linearization test

The following describes a test based on a state-of-the-art predistortion linearized transmitter and optical receiver. The block diagram of the transmitter is shown in Figure 8. The transmitter incorporates a high power Nd:YAG laser with a baseband RIN reduction feedback loop, a dual output BBI modulator device, linearizing circuits and parametric feedback control loops as described in the accompanying article.

Transmission over two fibers of 30 km each, where each fiber carries 80 NTSC channels, is now routinely achieved with a CNR greater than 50 dBc and a CTB less than -65 dBc and CSO typically -70 dBc.

As the number of channels broadcast over each fiber is reduced from 80 to 60, CNR increases to 52 dBc, CTB is less than -65 dBc and CSO typically -70 dBc. The fiber links served by the system under test each have 12-dB link budget, and include four connectors per fiber, with no degradation observed in one link when the connectors were opened on the other link.

The experimental setup is described in Figure 9. Fiber output #1 of the transmitter is connected via a patch cord to a 30-km fiber spool, followed by a variable optical attenuator that feeds into the input of an optical receiver.

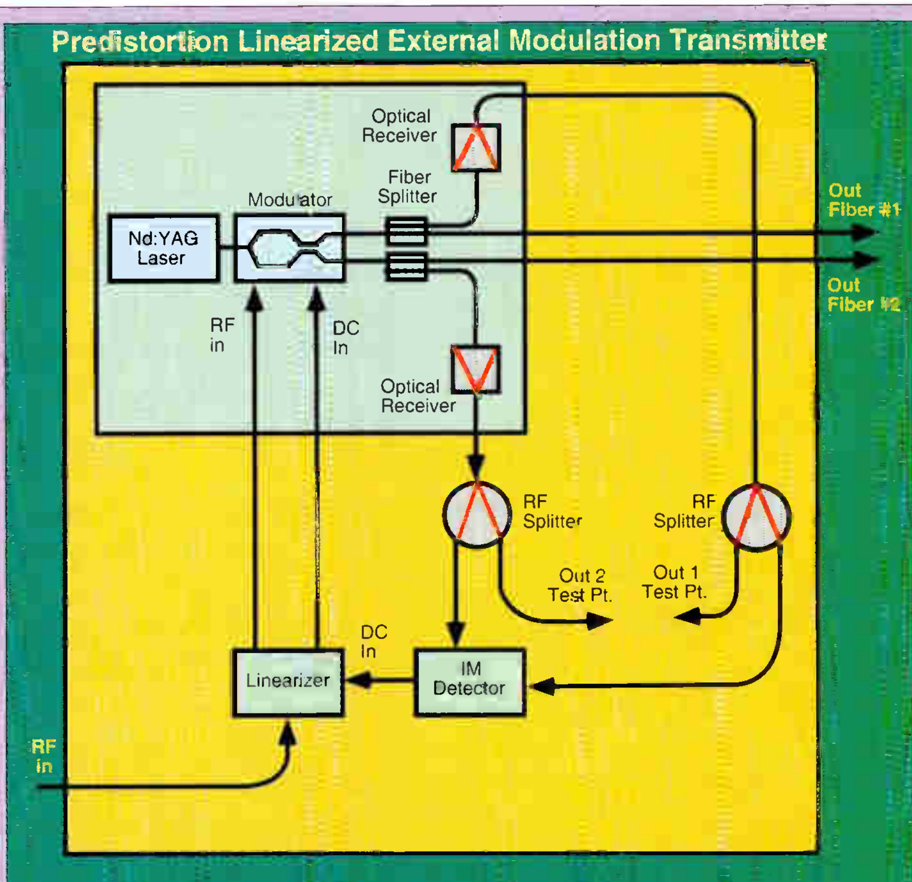

Figure 8

Fiber output #2 of the transmitter is split three ways by means of 3-dB optical couplers to feed three fiber spools with the lengths of 5 km, 10 km, and 20 km. Three optical receivers are connected to the ends of these three fiber links.

The RF outputs of these receivers are displayed on three TV monitors. The output of receiver #1 is bandpass filtered using a tunable filter, preamplified and displayed on a spectrum

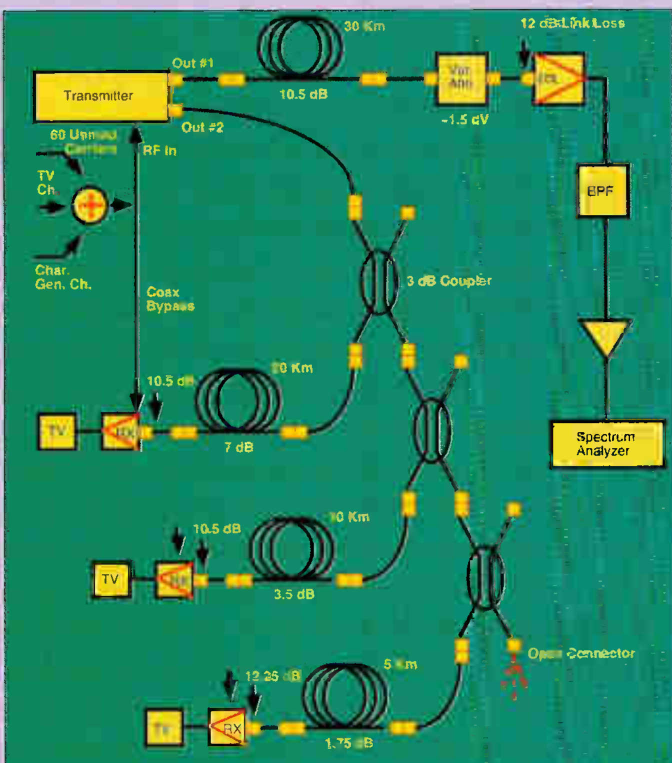

Figure 9

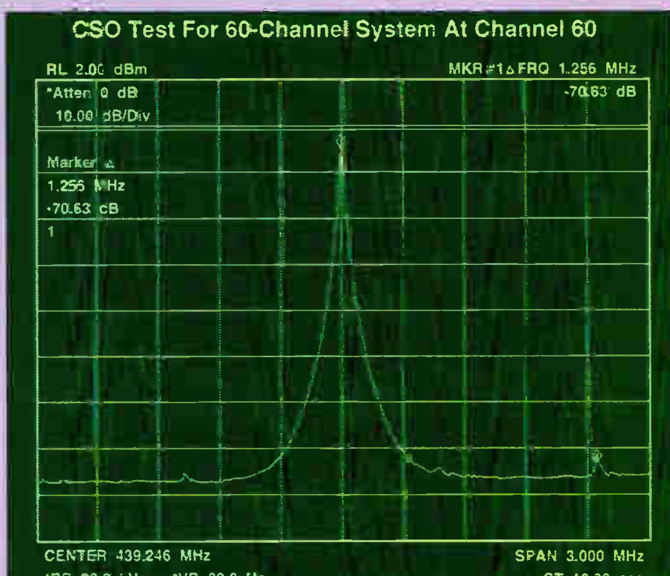

Figure 10

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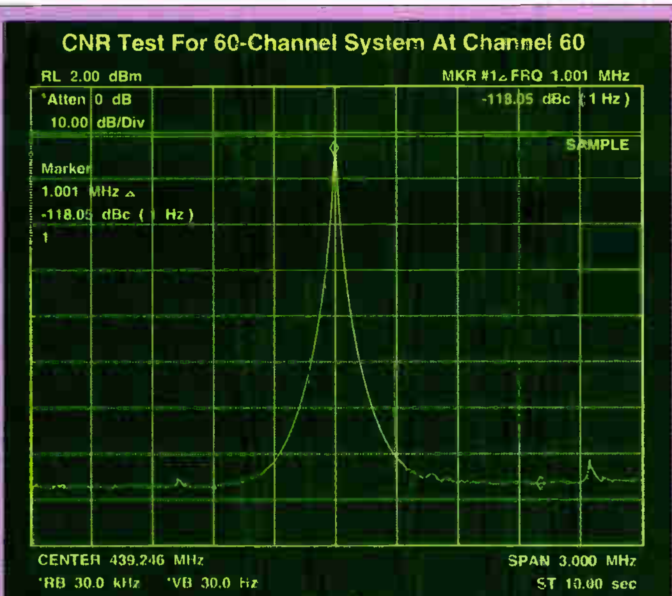

Figure 11

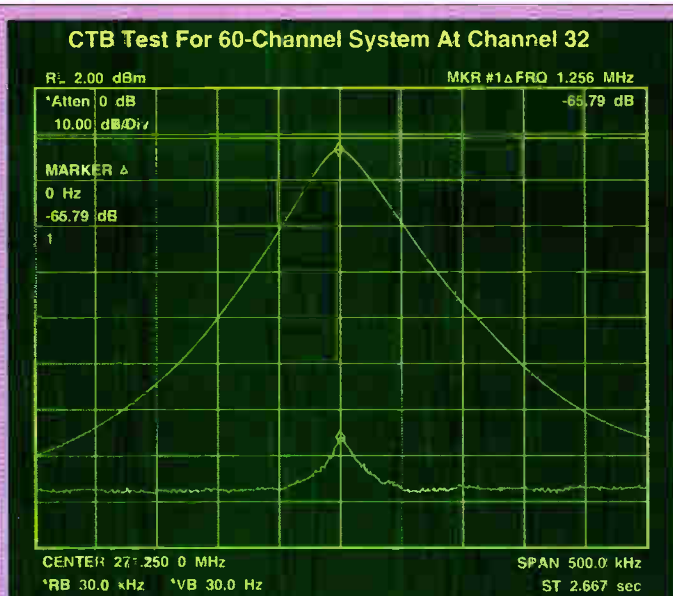

Figure 12

analyzer.

The transmitter RF input is connected to a matrix multichannel generator in order to perform an unmodulated carriers test on the spectrum analyzer. Alternatively, two of the 60 unmodulated carriers are replaced by two channels of modulated video (character generator and laser disc player) in order to assess picture quality by switching between the fiber input and a coax bypass provided with each one of the receivers (see Figure 9).

The receiver is based on a PIN photodiode. The CSO and CTB contributions of the receiver are negligible for detected optical power less than 0 dBm. The variable optical attenuator was set to achieve a total loss of 12 dB for link #1. The optical power on transmitter output fiber #1 was 9.8 mW and the received optical power was 0.63 mW. The laser optical spec-

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Optical power

In terms of optical power, both linearization methods benefit from advances in the design of Nd:YAG high power lasers and the usage of dual output balanced bridge interferometer modulators, which results in doubling the total optical power delivered to the distribution network with respect to the usage of Mach-Zehnder modulators.

In terms of system performance stability, both methods can benefit from the use of parametric feedback control loops, although to date such loops have only been demonstrated using predistortion, wherein the CSO is stabilized by an RLL (retardation locked loop) and another loop may be used to control the linearizer bias condition.

The long-term CSO and CTB performance of a predistortion linearized transmitter is maintained by closed loop parametric control systems (see Figure 7). Such loops are called parametric since the feedback quantity is a slowly varying quasi-DC signal obtained by processing intermodulation beats detected in the optical output.

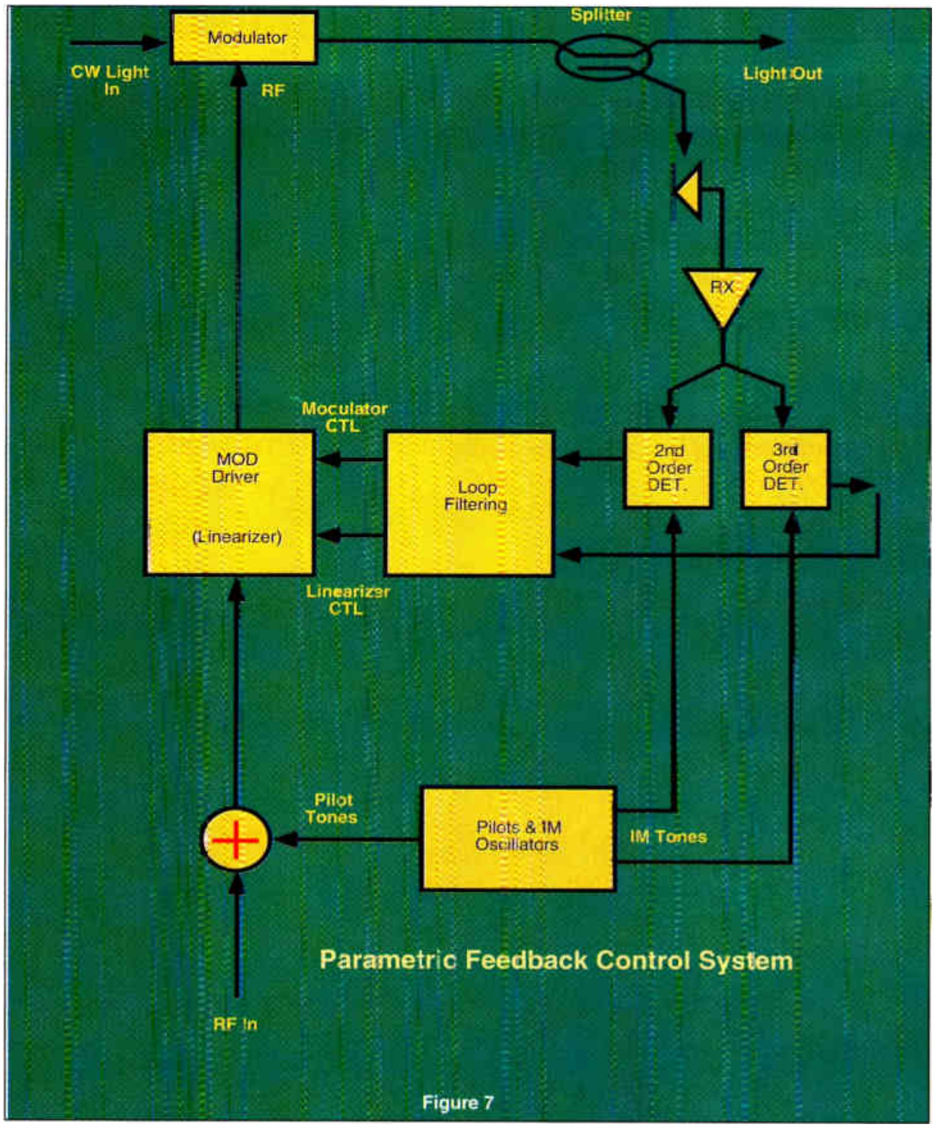

Figure 7

The objective of the CSO parametric control loop is to maintain the modulator at a fixed phase retardation. Retardation is the optical term for the modulator internal phase-shift which determines the bias point. Therefore the terminology "retardation locked loop (RLL)" is introduced in analogy with the term "PLL," or phased lock loop, in the sense that much as a PLL maintains the phase of a voltage controlled oscillator at a fixed value, the RLL maintains the phase retardation of the modulator at a fixed value.

To this end, an error signal proportional to the phase deviation is detected and processed to generate a bias correction voltage to the modulator. The operation of this parametric control loop results in the modulator always being biased around Q point (see Figure 3) such that the CSO is within specifications, say less than -70 dBc.

A separate closed loop can be used to control and maintain CTB performance within a specification of, say, less than -65 dBc. This is done by controlling the relationship between the gain and the linearizer's nonlinearity.

Conclusion

The reliability and stability of the external modulation system is now comparable to that of DFB laser-based systems. Furthermore, external modulation-based systems exhibit enhanced performance specifications for the CSO, CTB, CNR and range and are less affected by the impairments related to interactions with optical reflections in the fiber link. CED

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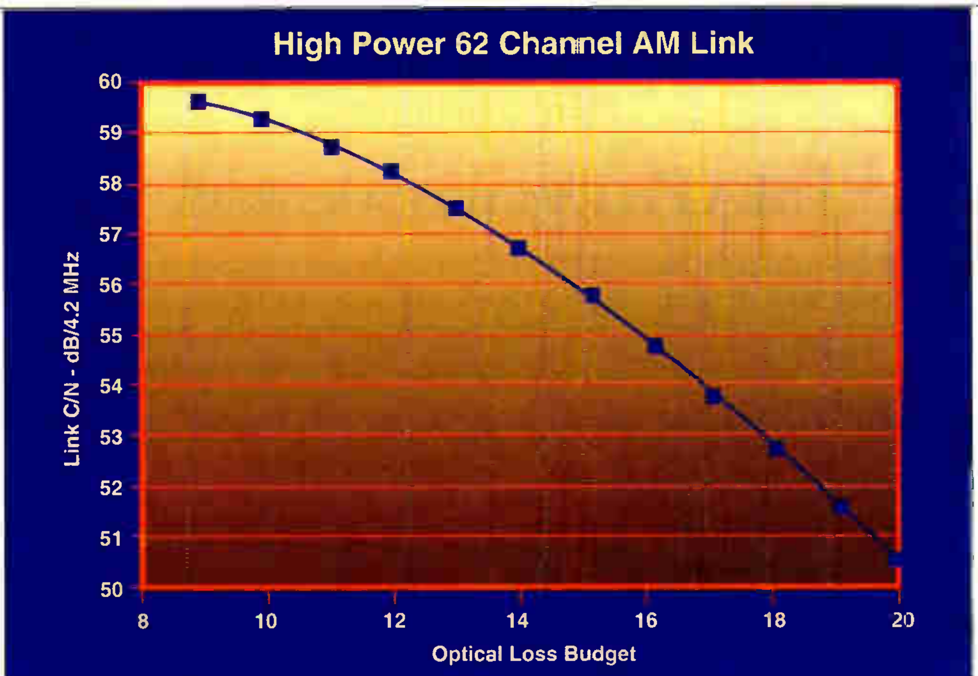

Figure 2

years, let us ask what we can expect for "ultimate performance" from DFB lasers. Also, what practical obstacles stand in our way?

First, let us consider some practical issues:

Distortion

We have found that all semiconductor lasers produce unacceptable levels of second-order distortion at high bias currents. While we can optimize certain design parameters to increase the linear operating current, there will always be an upper limit. Typically, the upper limit is seen at 80 mA to 100 mA of bias current, but we have also seen some devices that remain linear up to 130 mA. Improvements to the laser chip design could increase the yield for such "high current" lasers.

RF drive amplifiers

The RF power needed to modulate the laser to a given modulation depth increases as the square of the bias current. Feedforward amplifiers can provide +46 dBmV per channel with 60-channel loading. With a DFB input impedance of 25 ohms, and using a 25:75 ohm impedance transformer at the input to the laser, 6.5 mA/channel is available to modulate the laser. This is enough to provide optimum performance at bias currents up to 100 mA above threshold, but would be inadequate at 150 mA above threshold.

DFB laser reliability

Lasers cannot be operated at currents that result in unacceptable degradation of long-term performance. It is not clear today what is the maximum reliable DC current for a CATV-quality DFB laser. Existing data would indicate that 100 mA is an acceptable bias level, with no adverse effect on long-term reliability. Further work is needed to determine the upper limit to reliable CW operation.

How much average power can be expected from production 1300-nm DFB lasers in the future? The optical output power from a packaged laser is the product of three quantities:

$$P_o = (LE) \times (CE) \times (I_o - I_{th})$$

where LE = laser chip efficiency, CE = fiber coupling efficiency, I_o = operating current, and I_{th} = threshold current.

Realistically, what are the highest numerical values that we can expect for these parameters in production lasers? A good approach is to look at today's best results as an indication of what to expect in the future. The following list shows the best performance achieved to date for each of these parameters (not all were achieved on the same laser):

Laser chip efficiency = 0.51 mW/mA

Fiber coupling efficiency = 67%

Linear bias current = 130 mA (I_{th} = 20 mA)

If a single laser could achieve all three values simultaneously, the optical power would be:

$$P_o = (0.51 \text{ mW/mA})(0.67)(130-20) = 37.6 \text{ mW}.$$

When we compare this with the 18-mW "best laser" result achieved to date, we can clearly expect further advances in the output power performance of 1300-nm DFB lasers.

> Transmit power from single lasers of 25 mW is a realistic expectation within the next two years.

Conclusion

While routine production of 38 mW DFB lasers for CATV applications may still be a distant goal, the available evidence is that transmit powers from single lasers of 25 mW is a realistic expectation within the next two years.

Other advances in DFB performance will also be seen, such as increased bandwidth and channel capacity. It is quite realistic to expect single lasers to carry a full spectrum from 50 MHz to 1 GHz before long, with a combination of traditional AM signals and digitally compressed signals.

The next generation of 1300 nm DFB lasers, with 7 dB higher power and twice the bandwidth, will be the cornerstone of network designs that serve the traditional CATV market, plus enhanced services that are on the drawing boards today. CED

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Video-on-demand: The cable advantage

Most telephone companies (telcos) have given up on stringing fiber to the home during this decade. It would be too expensive. But they have not necessarily given up in competing with traditional cable TV operators in providing residential video services.

Telcos have switches and cable operators don't. So, telcos will focus on switched video services like video-on-demand or "video dial tone," the reasoning goes. They'll use highly compressed digital video technology to get through the twisted copper pair bottleneck into the home. And they'll add a heavy dose of fiber optics, perhaps to the curb, to ease future expansion. Certain regulators and academics are among those promoting the concept.

As this subject is explored, it will be determined that it is the cable operator who is actually technically advantaged in pursuing the video-on-demand opportunity.

Cable's broadband pipe

Cable operators have active coaxial cable into approximately 55 million households in the U.S. alone. These cables can simultaneously carry well over 150 video channels, each 6 MHz wide (using North American standards), even without compression.

In contrast to cable's broadband pipe, telcos are trying to make do with their narrowband twisted copper pair wire into the home. The telco drop wire has traditionally carried less than 50 kilohertz (kHz) of voice and/or data, which is 1/20,000th the capacity of cable's 1-gigahertz (GHz) drop.

By David E. Robinson, Director, Cableoptics, Wireless and Headend, Jerrold Communications

Now, researchers are attempting to compress a video channel into roughly 1.5 megabits of information per second (Mb/s) and to squeeze that "VCR quality" channel through a twisted copper pair. High bit rate digital subscriber line (HDSL) and asymmetric digital subscriber line (ADSL) are terms for the proposed techniques.

Let's ignore potential problems getting 1.5 Mb/s signals through field-installed twisted copper pairs. For the sake of argument, accept that a single "VCR quality" video channel could make it into the home. But then the video quality is inferior to what cable operators already offer, and only one of the household's many TVs and VCRs is served at a time. Video dial tone at 1.5 Mb/s would offer inferior quality and less choice than a video-on-demand service over broadband cable.

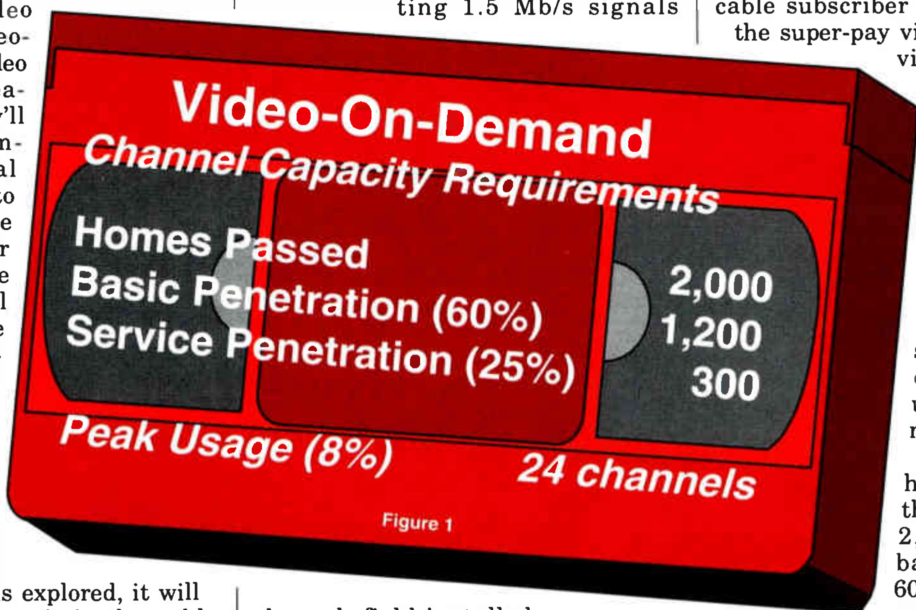


Figure 1

Cable's video-on-demand

Jerrold Communications studies indicate that video-on-demand services can be started under certain conditions with coaxial cable tree-and-branch or fiber backbone/coax hybrids. Clearly better choices in the long run are more robust fiber-to-the-feeder (FTF) type architectures. Two good examples of future-ready system designs that would facilitate video-on-demand are Adelphia's neutral network and Time-Warner's FTF superdistribution used in Queens and Rochester, N.Y.

With an FTF system, fiber cable is run to an optoelectronic node typically serving between 500 and 1,300 homes. That node becomes a potential distinct narrowcasting service area for the cable operator. Not every home subscribing to cable and not every cable subscriber would want to use the super-pay video-on-demand service during its early days. Also, not everyone would use the service simultaneously. So we use probability percentages to plan the appropriate network configuration ("contention" is the term used in similar probability exercises commonly used to plan telco networks).

Figure 1 highlights how this works. If the FTF node serves 2,000 homes and basic penetration is 60 percent, then 1,200 subscribers are eligible to sign up for video-on-demand. If 25 percent of those subscribers wanted this super pay service, the total penetration would be 300 homes. But only a small percentage of subscribers simultaneously watch impulse pay-per-view services according to data from Cable Video Store (Saturday prime time is the peak). If peak viewing was eight percent of all video-on-demand subscribers, then 24 channels would be needed for video-on-demand.

With a 550-MHz system, approximately 80 channels are available. The example of Figure 1 would allow over 55 channels of basic and subscription pay services. Cable's true strength in video-on-demand is its ability to provide for increased service needs in an evolutionary manner. By incorporating digital video compression and/or evolving toward smaller node service areas, video-on-demand capacity can be increased to satisfy virtually any demand success scenario.

If we maintain a constant allocation of 55 channels for basic and subscription pay services, then 25 channels, each 6-MHz wide, are available for video-on-demand. Within 550 MHz, we could go from a 2,000-home node size to 500 homes and essentially quadruple capacity. Or, we could keep the 2,000-home node size constant, use digital compression and significantly increase capacity. If 5-to-1 compression was used, then 125 video-on-demand channels would be available.

> The ultimate solution involves digital storage and retrieval technologies

At 8-to-1 compression, 200 channels could be provided (enough to handle 67 percent peak viewing in the example used in Figure 1).

Digital signals provide another evolutionary expansion option. Because they require a lower carrier-to-noise ratio than analog signals, they can be carried at lower power levels, reducing overall system loading. Jerrold studies indicate that a modest cost premium of less than 10 percent can be achieved for cable plant rebuilds allowing full analog channel loading up to 550 MHz and spaced for digital channel loading up to 750 MHz (an additional cost would be required later to activate 750 MHz through a "drop-in" electronics upgrade).

With a 2,000-home node, 55 analog channels of basic and subscription pay, and an average digital compression ratio of 5-to-1, approximately 290 channels would be available for video-on-demand. Almost 15 percent of all homes passed could simultaneously watch video-on-demand (peak usage). Shrink the node size to 500 homes and almost 60 percent peak usage (of all homes passed) capacity is provided.

Headend technologies

Options showing the mix of node size, bandwidth and digital compression (using an 8-1 ratio) are illustrated in Figure 2. Under these assumptions, 100 percent peak usage capacity is provided with plant spaced for 550 MHz analog/750 MHz digital and a 500-home node service area size.

Cable operators and telcos both face a considerable challenge in developing a suitable headend (or central office) video library and switch. The brute force method of stacking video tape players at the headend and manually inserting tapes is adequate only for field trials. The ultimate solution is likely to involve advances in digital storage and retrieval technologies with no mechanically moving parts (i.e. computer chip video).

Fiber optic technology implications

Unlike the old tree-and-branch broadcasting days, cable TV plant designers can no longer simply minimize capital costs for a given end-of-line signal performance goal. The

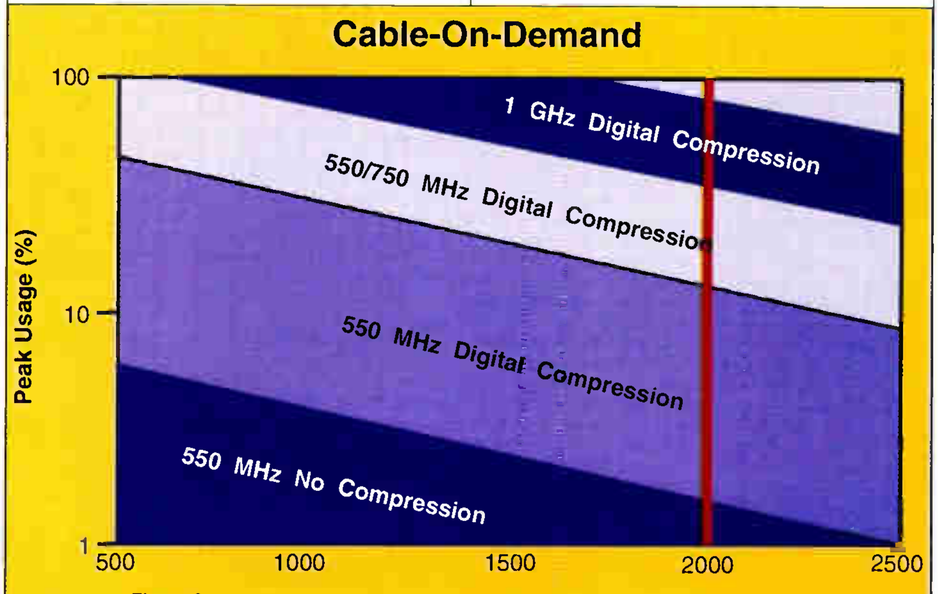


Figure 2

advent of video-on-demand and other narrowcasting services requires some strategic decisions.

Expandable FTF designs best facilitate such services. The optoelectronic nodes are placed to optimize end-of-line picture quality without exceeding a given service area, 2,000 homes or so. Some operators are choosing to place optoelectronic nodes such that they serve only 500 homes, with extra fibers ready to expand further when market demand warrants.

Expensive externally-modulated fiber optic transmitters are a poor fit for such services. The higher power of yttrium-aluminum-garnet (YAG) lasers is wasted on anything but broadcast services and long distance trunking. Excessive splitting eliminates the narrowcasting advantages that fiber optics otherwise provide. The workhorse of cable TV's fiber optic trunking to date, the distributed feedback laser (DFB), should continue to serve our needs well as CATV evolves toward video-on-demand.

Likewise, the high power available from optical amplifiers may be more than our industry needs today for many applications. Optical amplifiers do hold advantages over YAG lasers, though. The amplifier's high power is not limited to the headend; it can be distributed throughout the trunk and distribution plant. Today's optoelectronic node location may turn into an optical amplifier location several years from now.

None of this is meant to imply that there is no role today for optical amplifiers and/or high power lasers. Cablevision Systems Corp. is pioneering the field use of erbium doped fiber amplifiers (EDFAs) for cost-effective broadcast service applications. Continental Cablevision uses a mix of YAG lasers and DFB lasers in Ohio for broadcast services, finding one laser type more economical for certain applications and the other for other applications.

Advantage over DBS and MMDS

The cable operator's broadband pipe provides a major advantage relative to telcos in providing video-on-demand services. Because such services require a purchase order signal to be delivered *from* the home as well as video *to* the home, they are inherently two-way. Direct broadcast satellite (DBS) and multichannel microwave distribution systems (MMDS) have no pipe returning from the home to their uplink or headend facilities. They also have *much* larger service areas than cable's optoelectronic node.

The market will decide

The technology is available today to provide video-on-demand services, and the cable operator is in the best position to provide such services. Relevant market trials have already begun with more to start during 1992 by leading cable MSOs like Time Warner, TCI and Comcast.

Ultimately, it is the market that will decide whether available programming, technology and economics will lead to video-on-demand success. The market-driven nature of the opportunity suggests advantage to the cable operator (relative programming and marketing expertise) in addition to the technical advantage outlined above. Cable TV subscribers soon may truly get *what* they want, *when* they want it. CED

Upgrading system specs and bandwidth in a tight budget

Editor's note: *The following article was recently presented at a SCTE chapter meeting in Hawaii.*

Is your system 400 MHz now? Do you need another 450 MHz? Could it use another 2 dB to 3 dB of carrier-to-noise improvement? How about 3 dB to 13 dB of composite triple beat reduction? Would another 50 MHz of usable bandwidth—six channels—be of any help? If the answer to any of these questions is "yes," then good news exists.

Most standard CATV push-pull amplifiers presently in operation can have their specifications improved.

System performance will often parallel amplifier specifications within the plant. Just like personal computers, most standard CATV push-pull amplifiers presently in operation can have their specifications improved. And CATV hybrid technology advances have been especially fast and furious for the past nine months.

By Fred Rogers, President, Quality RF Services Inc.

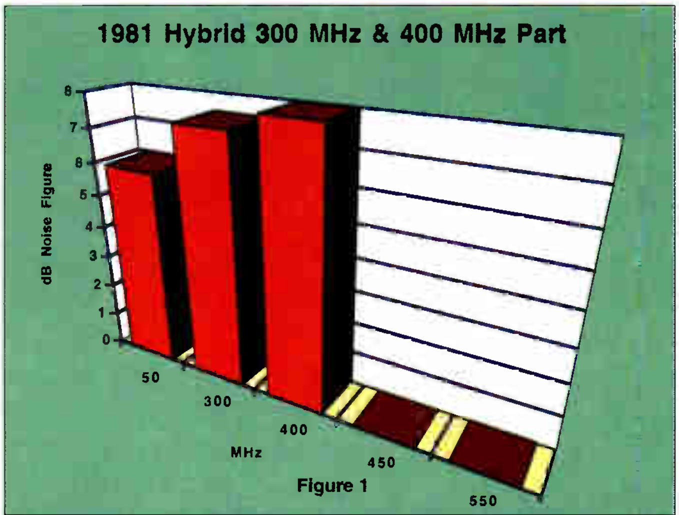


Figure 1

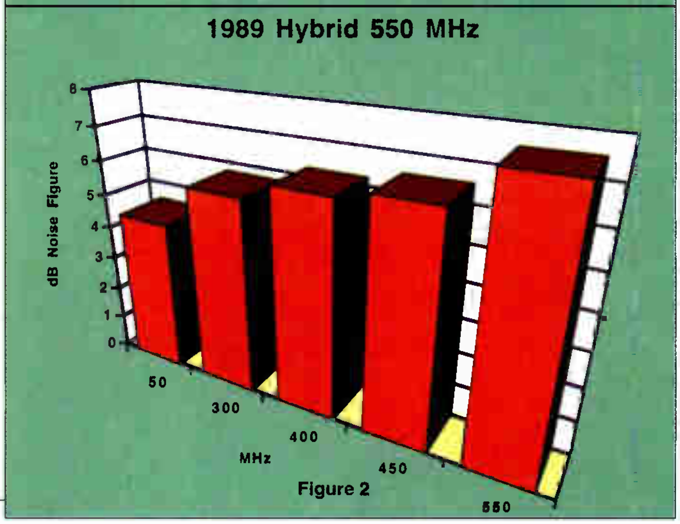


Figure 2

The good news

Now for the good news. Translated, those technological advances in hybrid technology mean that the internal "hardware" of most modern CATV amplifiers can be dramatically improved by changing the hybrid integrated circuit (IC) chips. Several so-called "super chips" are now available, as follows (see Figures 5,6 and 7 for actual examples of modules upgraded and the improved specifications achieved):

1. An 18-dB gain hybrid with 5-dB noise figure at 550

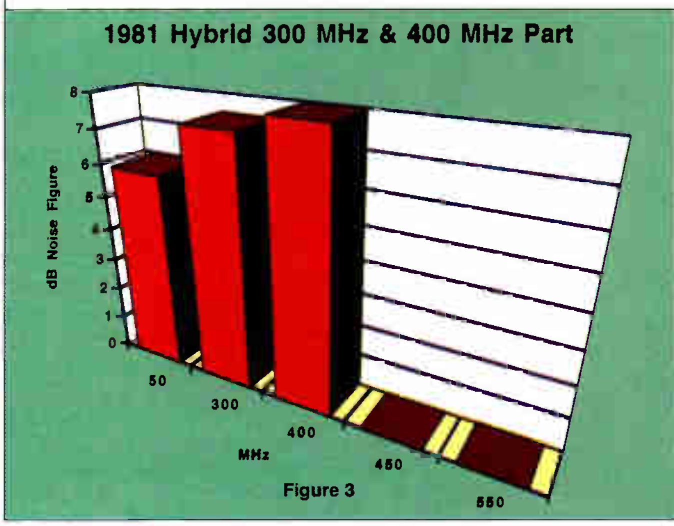


Figure 3

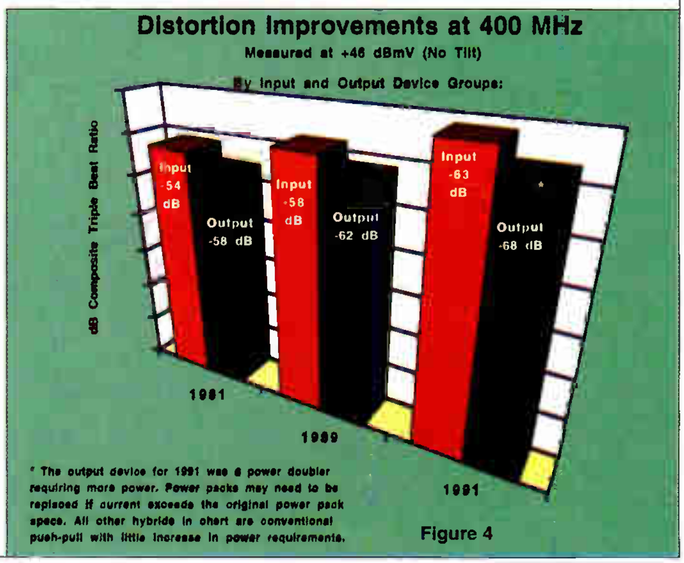


Figure 4

MHz (4.5-dB noise figure at 450 MHz) for trunk input applications. This hybrid also has excellent output distortions.

> The engine of a modern CATV amplifier is the hybrid integrated circuit.

2. A power doubler hybrid with 18-dB, 20-dB or 22-dB gain for use on trunk outputs and dual hybrid line extenders and bridger final stages. A 6-dB composite triple beat improvement over the best push-pull hybrid and up to 10-dB over first generation 400 MHz conventional push-pull hybrids.

3. A 36-dB gain power doubler for single hybrid bridgers and line extenders. This hybrid just began production within the past six months and fills a void that had stopped many potential upgrades before it was available.

4. Printed circuit boards that allow the replacement of "quads" with modern hybrids. In this scenario, just the gain sections are replaced; plug-in flatness boards and control boards are retained.

In amplifiers using standard 18-dB gain push-pull hybrids, the input hybrid can be replaced with a "super chip" to obtain 1.5-dB to 3-dB improvement in the trunk amplifier's noise figure. This is accomplished by replacing every trunk amplifier's input hybrid in a cascade while maintaining original levels and a 1.5-dB to 3-dB carrier-to-noise improvement. Remember, a 3-dB reduction in noise is half the power—or the same as cutting a trunk cascade in half when calculating carrier-to-noise.

Apples to oranges

To liken first generation 400-MHz hybrids to today's 550-MHz super chips is truly an "apples to oranges" comparison. In an attempt to rate distortion measurements, 52-channel CTB is used throughout Figure 4. Both the input and output hybrids need to be considered as each add together in a voltage addition to determine amplifier output.

Note: Each series of amplifiers needs to be individually tested for output distortions to ensure PIN diodes or other active diodes are not nullifying the hybrid improvements. Each 6-dB improvement in CTB results in half the voltage addition. A 400-MHz amplifier of the early 1980s vintage upgraded with a super chip, a low

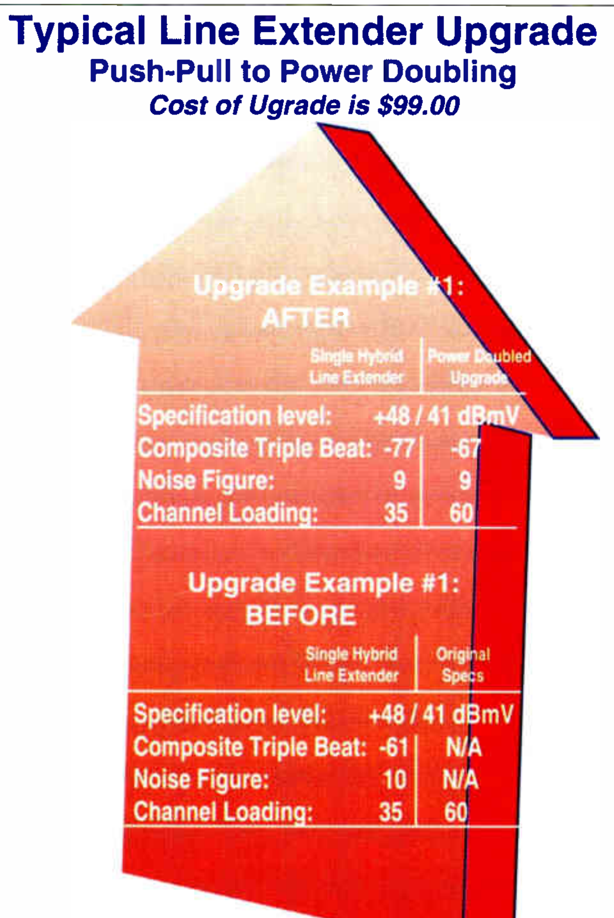
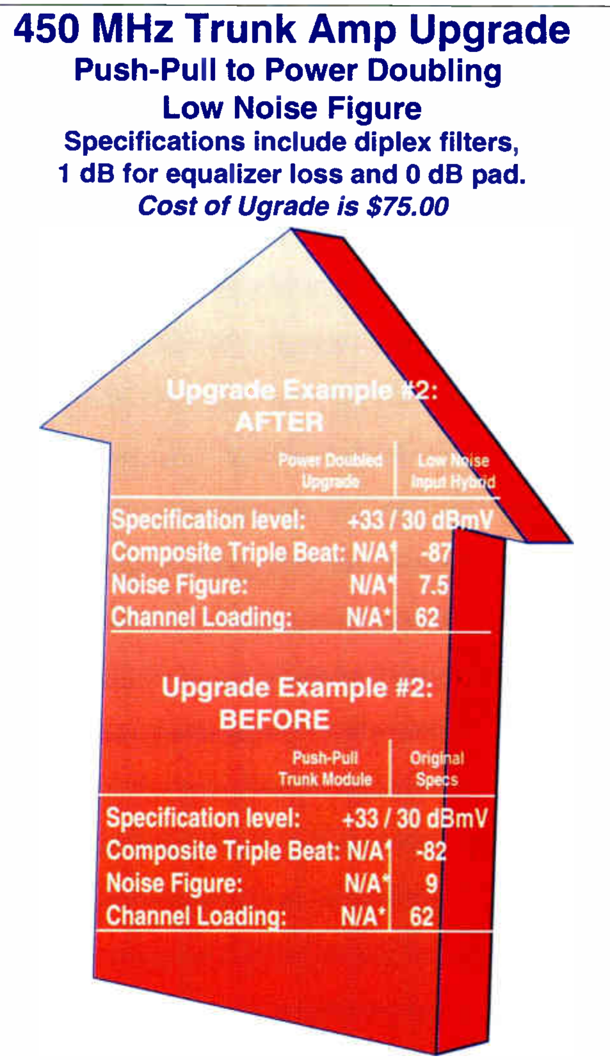


Figure 5



* Note: 300 MHz trunk modules have been sucessfully upgraded to the same 450 MHz specifications. More labor is required for this upgrade.

Figure 6

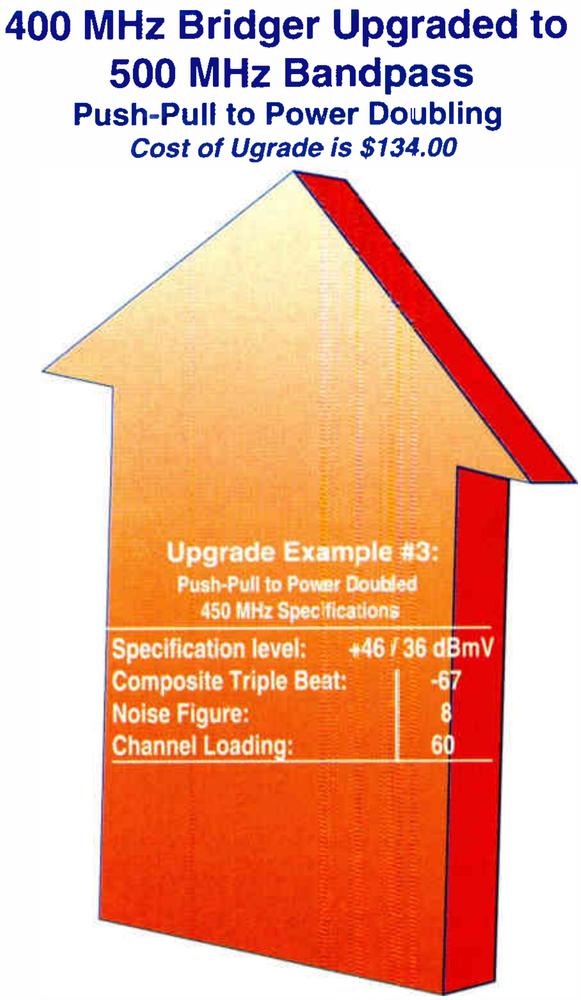


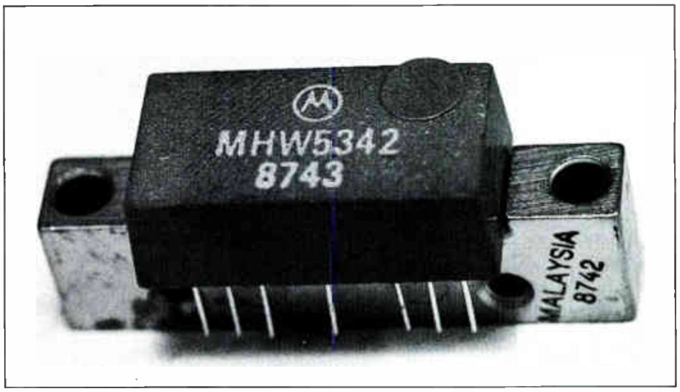
Figure 7

noise input and power doubler output, had a measured improvement of 13 dB CTB and a noise figure that became better by 3 dB.

A look at the engine

The engine of a modern CATV amplifier is its hybrid integrated circuit. Just as the power and efficiency of an automobile is determined by its motor, hybrid ICs play the same role in cable amplifiers. Improve the benefits of the hybrid IC, and amplifier specifications benefit accordingly.

Cable TV's desire to obtain 1 GHz bandwidth has forced hybrid manufacturers to obtain not only higher frequency but drastically improved distortion numbers at 450 MHz and 550 MHz operation. New tools in the form of super chips are available now that did not exist even as recently as last year.



A standard hybrid

In summary, replacing original hybrids with super chips while amplifiers are being repaired will add to your system's headroom. The "re-chipped" amplifier will be better than new, at a fraction of the cost of purchasing a new amplifier. **CED**

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DESCRIPTION: Supplier of Optical Reach® fiber optic cables designed especially for AM video transmission and the CATV industry. Optical Reach is available in a variety of constructions and fiber counts from 1 to 144.

CORNING

Corning Incorporated ....(800) 525-2524
Opto-electronics Group
MP-RO-03
Corning, NY 14831
PERSONNEL: Jon K. Chester, Market Development Manager, Cable TV; Amy L. Kennedy, Senior Applications Engineer, Components; Curt Weinstein, Senior Sales Engineer, Components; Douglas E. Wolfe, Senior Applications Engineer
DESCRIPTION: Corning Incorporated manfactures a full line of optical fiber and components to meet today's demanding cable TV applications. Optical fiber products include: Corning™ single-mode fiber, and Corning™ dispersion-shifted fiber. Fiber-optic components include: Corning couplers and the Corning FiberGain™ module.

ONI OPTICAL NETWORKS INTERNATIONAL

ONI ....(303) 694-9220
WATS ....(800) 342-3763
FAX ....(303) 694-0127
8101 E. Prentice Ave., Suite 210
Englewood, CO 80111
PERSONNEL: Andy Paff, President; Mike Sparkman, Vice President Sales & Marketing
REGIONAL OFFICES: 4905 E. Hunter Ave., Anaheim, CA 92807, (714) 779-0500, FAX (714) 777-1527; 2100-A Nancy Hanks Dr., Norcross, GA 30071, (404) 840-0121, FAX (404) 840-7902; 1620 Crosby Road, Suite 115, Carrollton, TX 75006, (214) 446-2288, FAX (214) 242-8421; Century Plaza, 100 Prospect St., Stamford, CT 06901, (203) 325-0390, FAX (203) 325-0388
DESCRIPTION: Optical Networks International is a system integrator of complete fiber optic networks for video, voice, and data. ONI develops innovative products with manufacturing partners worldwide. ONI provides a wide range of services to meet the specific needs of each customer including system design, project management, contract splicing, training courses, and 24 hour technical support and emergency restoration.

SIECOR

Siecor Corp. ....(704) 327-5895
FAX ....(704) 327-5488
PO Box 489 (CS)
Hickory, NC 28603-0489
PERSONNEL: J. David Johnson, (704) 327-5895; Pattie M. Wolford, (704) 327-5109
DESCRIPTION: Siecor manufactures a variety of fiber optic cable designs for aerial, direct buried, duct installations. Loose tube design is rugged, easy to handle and provides superior environmental protection. Modularity simplifies fiber drop-off and mid-span access. Also supplies splicers, testers, training, services.

Pre-Assembled Duct

Integral Corporation

Integral Corp. ....(214) 826-0590
WATS ....(800) 527-2168
FAX ....(214) 823-4845
1424 Barry Ave.
PO Box 11269
Dallas, TX 75223-0269
PERSONNEL: James L. Gray, President; Dwight Berry, Exec. V.P.
DESCRIPTION: Cablecon® is Integral Corp.'s registered tradename for a unique cable-in duct system used in underground applications. Cablecon is coax-cable—any make and type specified—preinstalled in rugged flexible high density polyethylene conduit, so it can be replaced by "pull through" instead of costly redigging. Cablecon is delivered on reels and installs as easily as direct burial. Cablecon protects your coax from accidental or environmental damage, and your budget for punishing replacement costs.

Fusion Splicers

ORIONICS
AURORA INSTRUMENTS, INC.

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

SUMITOMO ELECTRIC
Fiber Optics Corp.

Sumitomo Electric ....(919) 541-8100
Fiber Optics Corp.
WATS ....(800) 358-7378
78 Alexander Dr.
Research Triangle Park, NC 27709
PERSONNEL: Larry Corsello, VP Marketing and Sales; Fred McDuffee, Director-Product Management, Optic Cable
DESCRIPTION: Manufacturer of optical fiber cables and related products. Supplier of fusion splicing instruments, optical connectors, cable assemblies for connecting fibers, opto-electronic products for data transmission, analog and digital optical video transmission equipment and full engineering and construction services for optical communications systems.

Powering

alpha
ALPHA TECHNOLOGIES

Alpha Technologies ....(206) 647-2360
FAX ....(206) 671-4936
3767 Alpha Way
Bellingham, WA 98225
PERSONNEL: Bob Bridge, National Sales Manager
REGIONAL SALES OFFICES: Northeast, 800-678-2122; Mid-Atlantic, 804-745-8517; Southeast, 800-438-0812; North Central, 800-451-9032; Central, 800-367-1450; South Central, 214-686-5800; Southwest, 818-887-3114; Northwest, 206-647-2360;

Western Canada, 604-430-1476; Eastern Canada, 416-516-9575
DESCRIPTION: Alpha Technologies designers and manufacturers of innovative, reliable cable power products since 1974. Offering a complete line of 60Vac standby and non-standby power for pole, ground, shelf, wall and rack mount applications. Alpha also offers a full line of uninterruptible power sources from 600VA to 15KVA in 120Vac, 208Vac and 240Vac input/output variations. Developers of the pioneering Amp Clamp surge protection devices for outside plant lightning/surge protection. Distributors of Johnson Controls, Dynasty series, gelled batteries. All products available in international voltages and frequencies.

Lectro

Lectro Products .... **(800) 551-3790**
FAX .... **(706) 548-5493**
420 Athena Dr.
Athens, GA 30601
PERSONNEL: Michael R. Filkins, President; Mike Kearns, National Sales Manager

Connecticut	(203) 875-8805
California	(805) 251-8054
Georgia	(404) 513-1984
Kansas	(913) 782-4309
Virginia	(703) 273-5322

DESCRIPTION: Lectro manufactures a complete line of single ferro and dual redundant standby power systems and a full range of ferroresonant power supplies with outputs of 2 to 18 amps for both fiber optic and non-fiber powering. A wide range of high quality products for the U.S.A. and International markets are available including dual output units for combined CATV and telephone nodes.

Surge Protection

alpha ALPHA TECHNOLOGIES

Alpha Technologies .... **(206) 647-2360**
FAX .... **(206) 671-4936**
3767 Alpha Way
Bellingham, WA 98225
Bob Bridge, National Sales Manager
REGIONAL SALES OFFICES: Northeast, 800-678-2122; Mid-Atlantic, 804-745-8517; Southeast, 800-438-0812; North Central, 800-451-9032; Central, 800-367-1450; South Central, 214-686-5800; Southwest, 818-887-3114; Northwest, 206-647-2360; Western Canada, 604-430-1476; Eastern Canada, 416-516-9575
DESCRIPTION: Developers of the pioneering Amp Clamp surge protection device for various host-hardware. The Alpha designed SCR crowbar device has virtually unlimited life, is very fast and very robust. The twin SCRs short-out longitudinal sheath currents (LSC) and other induced transients directing them harmlessly to ground. The Amp Clamp has withstood repeated ANSI/IEEE standard C62.41-1980 unipolar pulses of 6,000 volts and 3,000 amps without deterioration, other commonly used devices failed one or both tests. (Reference CableLabs Outage Reduction Task Force report for further details.)

Cable Assemblies

Radiant Communications Corporation

Radiant Comm. Corp. .... **(908) 757-7444**
WATS .... **(800) 969-3427**
FAX .... **(908) 757-8666**
PO Box 867
South Plainfield, NJ 07080
PERSONNEL: Mike Thaw, President; Gary Mikula, General Manager
DESCRIPTION: Manufactures the industry's most reliable fiber optic cable assemblies; including low back reflection singlemode assemblies, coil cords, in-line attenuators, ribbon cable assemblies. Also manufactures a comprehensive line of patch panels and multimode transmission systems. They are each listed separately.

Tools

cable prep®
BEN HUGHES COMMUNICATION PRODUCTS CO

Cable Prep® .... **(203) 526-4337**
Ben Hughes Communication Products Co.
FAX .... **(203) 526-2291**
207 Middlesex Ave.
PO Box 373
Chester, CT 06412-0373
PERSONNEL: Deborah Morrow, President; David Morrow, Vice President; Eric Smith, Sales Manager; Patricia Anderson, Inside Sales
DESCRIPTION: Manufacturer of CABLE PREP tools. Product line includes hex crimp tools for CATV, MATV, STV and standard RF connector applications; coring and stripping/coring tools for all major cables (Times Fiber, Comm/Scope and Quantum Reach); the CPT series tools for stripping 59 & 6 series cables; EZ Squeeze tools for Raychem connectors; ratchet handles for all coring and stripping/coring tools; jacket stripper tools and other accessory tool items. Special tools made to order. Products are sold through major distributors. Call or write for information.

Test Equipment

CALAN

CALAN, Inc. .... **(717) 828-2356**
WATS .... **(800) 544-3392**
FAX .... **(717) 828-2472**
1776 Independence Drive
Dingmans Ferry, PA 18328
PERSONNEL: Syd Fluck, President
DESCRIPTION: CALAN provides fiber-ready test and measurement systems that perform sweep, spectrum analysis, signal level metering and remote line monitoring. In addition, fiber optic light source, test sets and accessories are available for complete support of CATV and LAN systems.

EXFO
Electro-Optical Engineering

EXFO E.O. .... **(418) 683-EXFO**
Engineering Inc.
FAX .... **(418) 683-0211**
465 Godin
Vanier, Quebec, G1M 3G7
PERSONNEL: Andrew Benn,Sales Support, Christine Fournier, Sales Support
DESCRIPTION: Full range of fiberoptic test equipment for CATV, laboratory, telecom and LANs: optical power meters for high power range (up to +23 dBm), fiber talk sets, return loss test sets, visual fault locators, optical variable attenuators with low refelection (-45 dB), LED/laser light sources, variable back reflectors, dual wavelength attenuation test sets. EXFO is widely recognized for the high quality level of its products (manufactured to ISO-9002 standard), its highly innovative designs. EXFO is strongly committed to support its customers. East Coast: 603-424-8211, West Coast: 818-500-0466, Distributor: Optical Networks International (ONI) 800-FIBERME (Tom Schatz).

laser precision

Laser Precision .... **(315) 797-4449**
FAX .... **(315) 798-4038**

109 North Genesee St.
Utica, NY 13502
James Nerschook, Product Mgr. (OTDR Products); Mark Jensen, Product Mgr. (Hand Held Products)
DESCRIPTION: Laser Precision manufactures a wide variety of portable fiber optic test equipment. Products range from the industry leading TD-2000 optical time domain reflectometer (OTDR) and craftsman style FF-1000 series Feature Finders to our rugged, hand held LP-5000 series optic power meters and LED and laser light sources.

MATRIX TEST EQUIPMENT INCORPORATED

Matrix Test Equip. Inc. ....(908) 469-9510
FAX ....(908) 469-0418
200 Wood Ave.
Middlesex, NJ 08846
PERSONNEL: Jack Kouzoujian, President; Nancy Ketseas, Sales Manager
DESCRIPTION: Manufacturer of test equipment primarily cross modulation and inter-modulation. All equipment is available either manual or full automated.

SIECOR

Siecor Corp. ....(704) 327-5040
FAX ....(704) 327-5042
PO Box 49 (TE)
Hickory, NC 28603-0489
PERSONNEL: Judy Lavin, Test Equipment Marketing Manager; Todd Hudson, Test Equipment Product Specialist
DESCRIPTION: Siecor's line of fiber optic test equipment includes attenuation test sets, hand-held test kits, return loss test option, talk sets, dispersion test set, and test fiber boxes. Siecor test equipment meets all your testing needs from pre-installation on-the-reel testing to post-installation acceptance testing, maintenance, troubleshooting.

WAVETEK

Wavetek RF Prods., Inc. ....(317) 788-5965
WATS (National) ....(800) 622-5515
WATS (Cust. Svce.) ....(800) 851-1198
FAX ....(317) 782-4607
5808 Churchman Bypass
Indianapolis, IN 46203-6109
PERSONNEL: Jack Webb, Product Marketing Manager; Mike Richardson, Western Regional Sales Manager; Tony Shortt, Eastern Regional Sales Manager
DESCRIPTION: A full line manufacturer of CATV and LAN test equipment for use on coaxial and fiber optic cable. Products include optical signal level meters, system analyzers, system sweep equipment, frequency agile leakage detection and bench sweep gear.

Enclosures

HENNESSY PRODUCTS

Hennessy Products Inc. ....(717) 264-7146
FAX ....(717) 264-1634
910 Progress Rd.
PO Box 509
Chambersburg, PA 17201
PERSONNEL: Patrick Hennessy, Sales Manager; Bruce Ritchey, Vice President, Sales
DESCRIPTION: Hennessy designs and manufacturers quality aluminum and stainless outdoor enclosures/cabinets ideal for fiber equipment such as nodes, lasers, repeaters, amplifiers and other electronic equipment that requires protection. Wide range of sizes available. Options include: air conditioning, insulation, heaters, receptacles, breakers, lights etc. Equipment can be 19" or 23" rack, shelf, panel or custom mounted. Catalog, application photos and product demo available.

MOORE

Moore Diversified Prods. Inc. ....(606) 299-6288
FAX ....(606) 299-6653
1441 Sunshine Lane
Lexington, KY 40505
PERSONNEL: Dario Santana, Vice President; Gia Phelps, Sales Service Manager
DESCRIPTION: Metal cabinets designed specifically for CATV. Sizes from 24"x24"x12" to 54"x54"x24". Options include shelving, weather stripping, reshielding, cooling units and more. Metal optic black boxes—pedestal, pole mounted and vault type. Unique figure eight rack. First aid optic trunk—contains, protects and organizes. The tools, equipment, and materials needed to perform emergency splice.

Radiant Communications Corporation

Radiant Comm. Corp. ....(908) 757-7444
WATS ....(800) 969-3427
FAX ....(908) 757-8666
PO Box 867
South Plainfield, NJ 07080
PERSONNEL: Mike Thaw, President; Gary Mikula, General Manager
DESCRIPTION: RADIANT manufactures a comprehensive line of fiber optic patch panels and splice centers. These are available for both rack mount and wall mount applications. All our enclosures are rugged, heavy duty units with superior cable management features; yet very low in cost compared to our competitin. Also our enclosures are rugged, heavy duty units with superior cable management features; yet very low in cost compared to our competition. Also manufactures cable assemblies and transmission systems.

RELIANCE COMM/TEC

Reliance Comm/Tec
Reliable Electric/Utility Prod. Div. (708) 455-8010
FAX ....(708) 451-5516
11333 Addison St.
Franklin Park, IL 60131
PERSONNEL: Tom Coyne, Product Manager, CATV Products; Paul Zoba, Product Manager, Fiber Optics
DESCRIPTION: Reliance Comm/Tec, a manufacturer of CATV products for three decades, offers the industry the widest range of outdoor enclosures, including amplifier housings, pedestals, and MDUs. Our new access 360 pedestals feature complete access to internal components and are available in PVC and metal.

Accessories

MOORE

Moore Diversified Products, Inc. ..(606) 299-6288
FAX ....(606) 299-6653
441 Sunshine Lane
Lexington, KY 40505
PERSONNEL: Dario Santana, Vice

President; Gia Phelps, Sales Service Manager
DESCRIPTION: Optic cable slack rack—Optirack® is used when storing loops of cable on the strand. Protects fiber by insuring that cable is not bent beyond minimum recommended bend radius. Optic cable tag—prevents costly mistakes and solicits phone call in case of an accident. Each tag is stamped with company name and phone number.

Contractors

Cable Constructors, Inc. ......(906) 774-6621
WATS (National) ....(800) 338-9299
FAX ....(906) 774-9120
Corporate Office:
105 Kent St., PO Box 190
Iron Mountain, MI 49801
PERSONNEL: John P. Jamar, Vice President of Marketing; David C. Sanders, Vice President of Engineering
DESCRIPTION: Aerial and underground. Fiber and coaxial system construction including mapping, design, material supply and management, fusion splicing, splicing, activation, sweep, balance and documentation. Complete turnkey CATV project management. Southeast Region: Contact Les Smith, V.P. Southeast Operations (813) 965-2847, 1903 Success Road, Suite 301, Auburndale, Florida 33823.

Cable Engineering, Inc........(502) 589-2848
WATS (National) ....(800) 626-2715
WATS (National) ....(800) 334-9684
1615 Mellwood Ave.
Louisville, KY 40206
PERSONNEL: Phillip Lacy, President; Terry Johnson, Vice President
DESCRIPTION: Test of CATV, LAN, and Fiber Systems. CATV includes activation, sweep, proof, CLI, and performance evaluation. Fiber includes attenuation, OTDR, and design evaluation for performance. Map functions include broadband/fiber design for CATV or LAN, digitizing, strand mapping, as-build, make ready and permitting. Enhanced 911 map and implementation. Audit, prewire, postwire, and all phases of installation. LAN certification, upgrade, design, maintenance, and remote status monitoring. Vendor of CATV and LAN products such as actives, passives, and chipcom eithernet broadband/fiber modems.

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

Cablemasters Corp. ....(800) 242-2522
FAX ....(814) 838-8713
PO Box 219
Lake City, PA 16423
PERSONNEL: Bernie Czarnecki, President; Gary Morris, Operations Manager
DESCRIPTION: Cablemasters Corporation provides complete aerial and underground construction services, specializing in fiber optics. The company has been involved in fiber optics construction and testing for many years, resulting in the experience required to meet the needs of today's modern CATV system.

Communications Construction Group Inc. ....(215) 696-1800
235 E. Gay St.
PO Box 561
West Chester, PA 19380
PERSONNEL: George Tamasi, President; Thomas Polis, Executive Vice President
DESCRIPTION: Providing high quality construction services for cable television, fiber optics, and twisted pair communications networks. Services include field strand surveys, manual and CAD based drafting, system, design, field engineering and all aspects of rebuild of new build construction. Service packages include full or modified turnkeys and unique management turnkeys customized for the operators' needs.

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

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

Metronet Inc. ....(404) 475-9956
FAX ....(404) 475-9944
1111 Alderman Dr., Ste. 210
Alpharetta, GA 30202
PERSONNEL: James P. Worthen, President; Frank Walkers, Director of Sales
DESCRIPTION: CAD fiber optic and coaxial system design (Lode Data). On site

project management; turnkey services; mapping services—strand and as-builts; drafting services—base, strand and electronics; AutoCAD conversion to lynx; Auto LISP programming-client specific; CAD training and set up; marketing services (dark fiber).

Proof of Performance

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

Distributors/Suppliers/Reps

Cable Services Company Inc.

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

FIBERTRON
Your Link with Fiberoptics

Fibertron Corp...........(714) 871-3344
FAX..........(714) 871-5616
1405 E. Orangethorpe Ave.
Fullerton, CA 92631
PERSONNEL: Marlene Spiegel, President; Henry Cohen, Vice President; Marc Spiegel, Vice President, Sales & Marketing
REGIONAL OFFICES: 733 Ridgedale Ave., E. Hanover, NJ 07936, (201) 515-9200, FAX (201) 515-9269; 4056 Wetherburn Way, Norcross, GA 30092, (404) 409-1700, FAX (404) 409-1702
DESCRIPTION: A full service stocking distributor of quality fiber optic cable, connectors, couplers, closures, innerduct, modems, multiplexers, distribution equipment, splices, test equipment, LAN, FDDI, tools, tool kits, wall outlets and supplies. Value added services include: standard and custom cable assemblies, technical applications assistance, and customer training.

JCA

Jerry Conn Assoc., Inc.
WATS (National)..........(800) 233-7600
WATS (in PA)..........(800) 692-7370
FAX..........(717) 263-1547
Corporate Office:
130 Industrial Dr.
PO Box 444
Chambersburg, PA 17201-0444
Satellite offices: Bob Sollenberger, 6109 55th Ave., Circle E., Bradenton, FL 34203, (813) 739-1856, FAX (813) 753-5127; D.J. Bos, Rte. 1, Box 264A, Waverly, AL 36879, (205) 826-2809, FAX (205) 826-2818
PERSONNEL: Trav Neumann, Director of Sales and Marketing; Dave Showalter, Vice President/General Manager
DESCRIPTION: Jerry Conn Associates, Inc. is an East coast based manufacturers' representative and distributor. Among the wide array of CATV products available is Fitel General's fiber optic cable, Tektronix test equipment, Moore Diversified's new OptiRACK, and LRC connectors. Our sales efforts are directed to application selling and providing first class customer service through a combination of outside and inside sales teams.

FIBER OPTICS

The Light Brigade, Inc...........(206) 277-1240
FAX..........(206) 228-8388
PO Box 390
Renton, WA 98057
PERSONNEL: Larry Johnson, President; Valerie Johnsen, Customer Service
DESCRIPTION: Specialists in fiber optic training, providing various courses for technicians (hands-on), engineers, consultants, and users. Also produce a full line of training videos. Products Division stocks fiber optic materials for outside plant, patch panels, closures, test equipment and connectors. Service Division provides installation, restoration and maintenance services.

The CABLE POLL™

Midwest CATV • CED • CableVision

Cable operators support in-house training efforts

It seems that the constant barrage against cable about poorly trained customer service reps, installers and technicians has finally caused operators to sit up and take notice, according a recent Cable Poll survey of 405 cable general managers.

Indeed, last year's Poll (published in the January 1991 edition of CED) revealed that 65 percent of operators offered in-house training for their employees. This year's survey, in turn, shows 87 percent of operators doing the same—that's a 22 point increase.

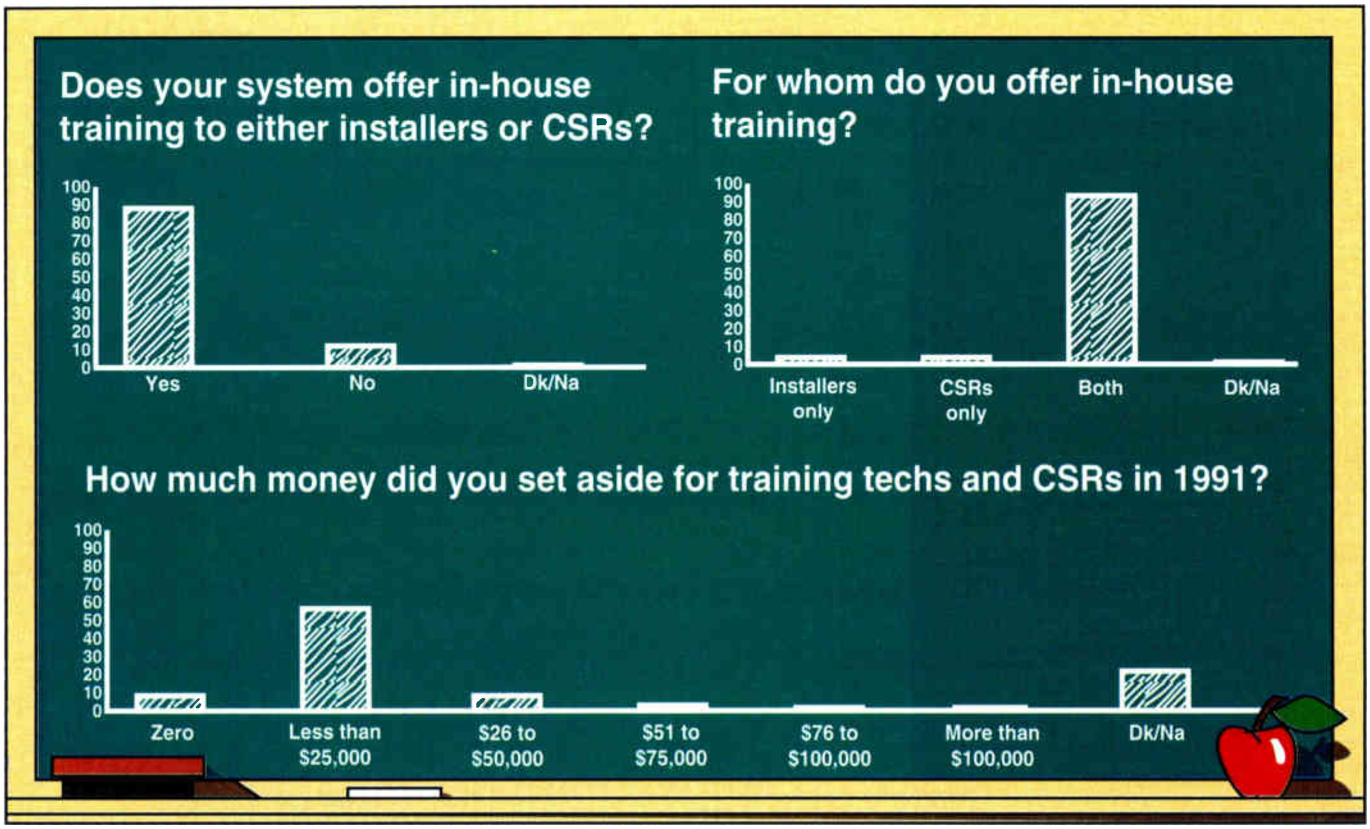
Of that 87 percent, a whopping 92 percent offer the training for both installers and customer service reps (last year, just over 75 percent of CSRs received formal training).

Geographically, there's not much differentiation in who's offering training programs to customer service reps and installers—they're all doing it. Operators polled in the Northeast, Midwest, South and West regions weighed in at an impressive 89 percent, 88 percent, 89 percent and 84 percent, respectively.

In fact, the small percentage that aren't hot on training are those operators with less than 10,000 subscribers, at 19 percent, and those operators holding an "over 100" MSO ranking, at 33 percent.

Certification requirements

It also seems that operators are



becoming more interested in how well their training dollars are being spent. In fact, 55 percent responded that they require certification testing of technicians and installers. The top 25 MSOs are particularly keen on certification, at 70 percent.

Time off not a factor

And while the smaller operators (those with fewer than 10,000 subscribers) aren't shelling out the big bucks for technician and installer training, they're certainly generous when it comes to time off and other assistance. In fact, the smaller operators maxed out in this category, with 81 percent of those polled saying they are lenient with time away from the job. So it appears that when the money *is* freed up for training, those smaller operators want the best for their employees.

Overall, 76 percent of the GMs polled say they provide time off and other assistance.

How much *did* operators spend on training last year? Most of the GMs polled—58 percent—say it was around $25,000 in 1991. A handful, at eight percent, spent up to $50,000 to train their employees.

Not many at all (one percent) spent more than that. And, nine percent spent nothing at all; again, these were operators with fewer than 10,000 subs.

Training spending in 1992

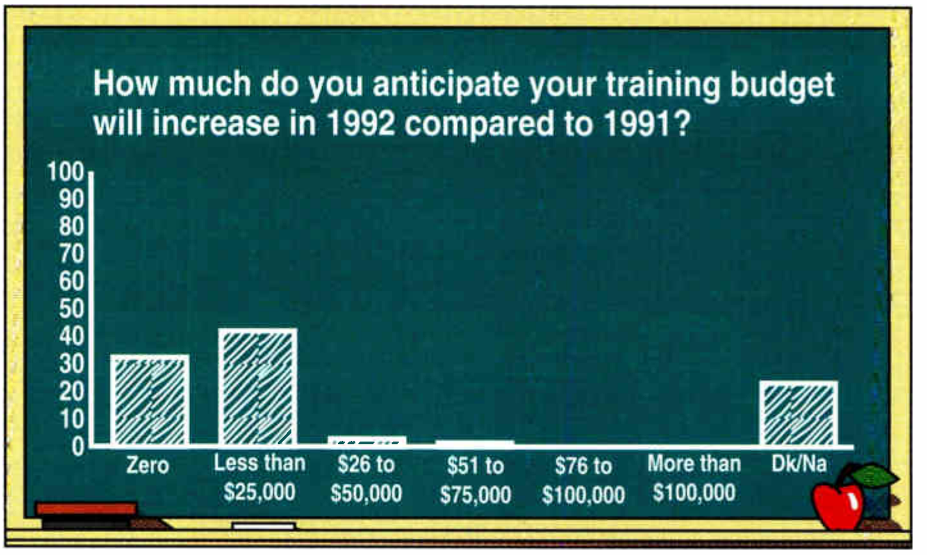
As for training spending in 1992, the outlook appears to be cautiously optimistic. One MSO with a "top 25" ranking said it would spend more than $100,000 in 1992, but that kind of spending is obviously an exception rather than a rule.

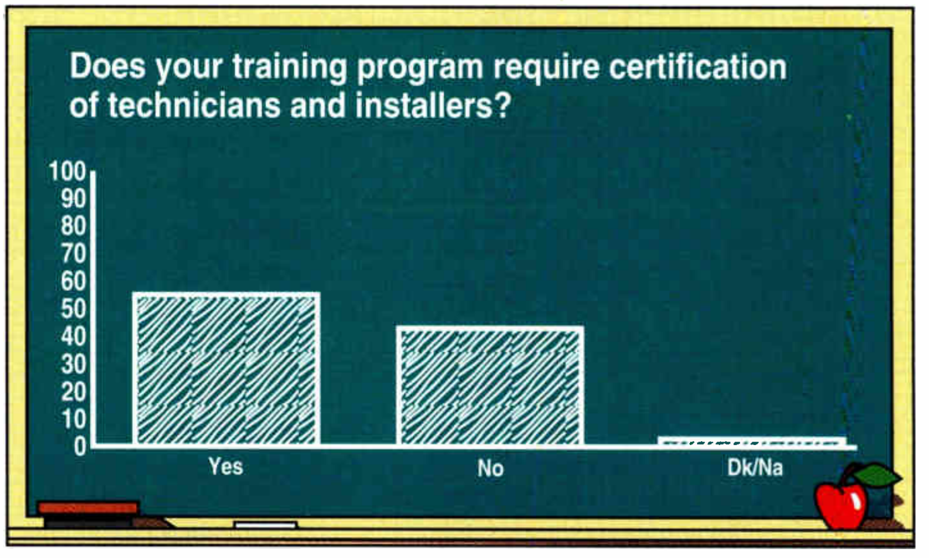
More realistic is the numbers cited by 41 percent of the surveyed GMs, who said they will increase training budgets up to $25,000 over 1991.

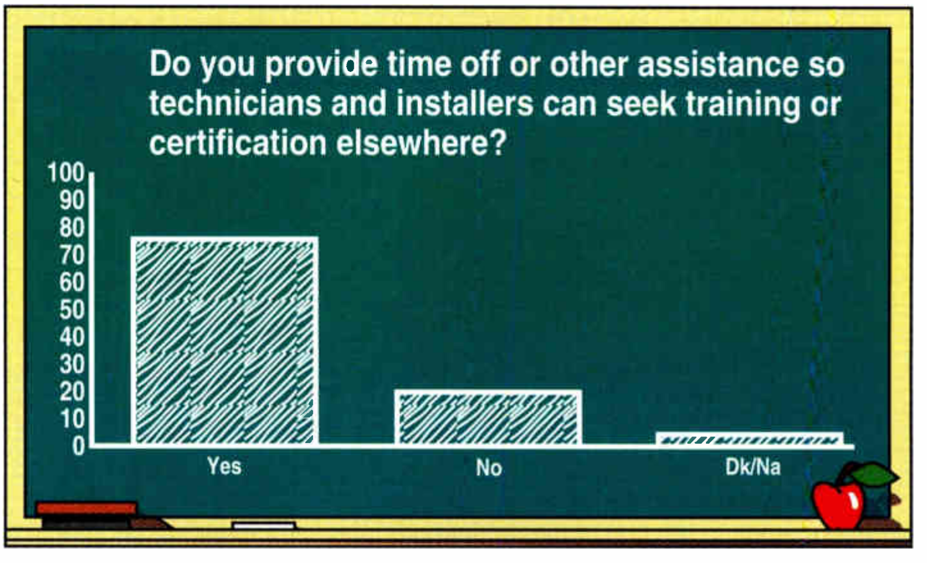
No increases

However, one third of the GMs (32 percent) foresee no increase at all. Most of the budgetary increases will come from those MSOs with more than 50,000 subscribers, at 45 percent, and those MSOs ranked "26 to 100," at 47 percent.

Of course, if certain people in Washington have their way, these figures all may change... CED







SCTE

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

March 6-7 *West Virginia Mountaineer Meeting Group* Consecutive testing sessions to be held; installer exams to be administered March 6. BCT/E testing in all categories March 7. To be held at the ATC Training Center, Charleston, W.Va. Contact Ken Gabehart,(304) 965-7026.

March 10 *Cascade Range Chapter* Contact Cynthia Stokes, (503) 230-2099.

March 10 *Central Illinois Chapter* "FCC-CLI." To be held at the Brandywine Holiday Inn. Contact John Heck, (309) 353-8777.

March 10 *Desert Chapter* BCT/E exams to be administered. Contact Chris Middleton, (619) 340-1312, ext. 258.

March 10 *New York Chapter* "Alternate Access." To be held at Time-Warner offices, Flushing, N.Y. Contact Rich Fevola, (516) 678-7200.

March 11 *Oklahoma Chapter* Contact Arturo Amaton, (405) 353-2250.

March 11 *Oahu Meeting Group* "Electronic Upgrades, Amplifier Designs and Distortions" with Fred Rogers of Quality RF Services. Contact Michael Goodish, (800) 836-2888.

March 12 *Penn-Ohio Chapter* "Maintenance and Construction Standards." To be held at the Sheraton Hotel, Warrendale, Pa. Contact Bernie Czarnecki, (814) 838-1466.

March 12 *Wheat State Chapter* "FCC Rules and Regulations" and "System Standards." To be held at the Holiday Inn, Salina, Kan. Contact Mark Wilson, (316) 262-4270.

March 12-13 *Dakota Territories Chapter* "FCC Technical Performance and Testing" presented by Tony Gauer and Wes Schick of TSB. Consecutive meetings to be held March 12 at the Ramada Inn in Pierre, S.D. and March 13 at the Radisson Inn in Bismarck, N.D. Contact Kent Binkerd, (605) 339-3339.

March 14 *Chaparral Chapter* "Fiber Optic Fundamentals" and BCT/E Category III, "Transportation Systems" presented by Anixter. BCT/E exams to be administered in all categories at both levels. To be held in Albuquerque, N.M. Contact Joe Roney, (505) 761-6224.

March 14 *Wyoming Chapter* To be held in Casper, Wyoming. Contact Stan Olson Sr., (307) 347-3244.

March 15-16 *Old Dominion Chapter* Second annual vendor show. To be held at the Holiday Inn, Richmond, Va. Chapter board meeting to be held. Contact Margaret Davison, (703) 248-3400.

ONI OPTICAL NETWORKS INTERNATIONAL

Optical Networks International (ONI) has announced its 1992 series of "Fiberworks '92" seminars, developed for system personnel and contracts. Topics covered include construction techniques, splicing, path testing, transmission path electronics, system test and alignment and maintenance/troubleshooting. All seminars will be held at ONI's Denver training and product development center on the following dates:

March 16-20
March 30 to April 3
April 6-10
April 20-24

For more information, call Rand Reynard at 1-800-FIBER-ME.

Scientific Atlanta

Scientific-Atlanta will hold a series of seminars in the Pittsburgh, Pa. area on March 10-12. The seminars are open to any local cable operators and those who install, maintain and troubleshoot cable TV equipment. Cost is $215 per person for each session. The sessions will be held at the Airport Holiday Inn. Contact Dan Pruitt at (800) 722-2009 to make reservations or for more information. The seminar schedule is as follows:

March 10 *Headend and Earth Station Systems*
March 11 *Distribution Systems*
March 12 *Fiber Optic Systems*

Trade Shows

April 9-10 *Safety '92: Your commitment to a Safe Workplace*, Sheraton Denver Technological Center, Denver, Colo. Contact NCTI at (303) 761-8554.

May 3-6 *National Show* Convention Center, Dallas, Texas. Contact (202) 775-3669.

May 30-June 3 *Canadian Cable Television Association* To be held in Vancouver, B.C. Call (613) 232-2631.

June 3-5 *International Conference on Consumer Electronics*, Chicago, Ill. Call Diane Williams, (716) 392-3862.

June 14-16 *SCTE Show* San Antonio Convention Center, San Antonio, Texas. Contact (215) 363-6888.

1550-nm wavelength 'dead' for CATV?

Despite its heavy concentration on component-level fiber optic research, the Conference on Optical Fiber Communication '92, held in San Jose, Calif., in early February, delivered a few reassuring messages to cable-television operators.

OFC '92, co-sponsored by the Optical Society of America, IEEE/Communications Society and IEEE/Lasers and Electro-Optics Society, featured discussions regarding optical wavelengths, wavelength division multiplexing CATV signals at both the 1300-nm and 1550-nm windows and the prospects for optical amplifiers for systems utilizing 1300-nm optoelectronics.

Meanwhile, the 1550 nm optical wavelength was pronounced "dead" for cable-television use during the conference by Ortel Corp. officials, manufacturers of high-power DFB lasers that operate at about 1310 nm.

1310-nm device improving

Larry Stark, director of marketing at Ortel, said recent performance gains made with 1310-nm lasers eliminate any motivation to switch to 1550-nm devices. Devices operating at the longer 1550-nm wavelength takes advantage of optical fiber's intrinsic lower loss characteristics at that wavelength to extend the reach of a fiber network or to provide more splitting, which lowers the per-link costs of fiber optics. Furthermore, 1550-nm signals can easily be amplified with readily available erbium doped fiber amplifiers (EDFAs).

However, Stark said DFB lasers operating at 1550 nm have excessively high chirp (unwanted modulation), resulting in second-order distortions not easily compensated for on standard singlemode fiber cable. Even with dispersion-shifted fiber, the chirp produces distortion in EDFAs, reducing their effectiveness for CATV systems.

Although Ortel officials admit the company plans to develop and market a 1550-nm DFB laser later this year, they insist that 1310-nm devices will continue to be the workhorse in CATV. To ram home that point, the company reported transmit powers exceeding 15 milliwatts in the laboratory (typical DFBs installed by cable operators today offer transmit powers of about 6 or 7 milliwatts) and predicted that even greater output power would soon be common.

In fact, during a workshop on fiber's role in video delivery, Henry Blauvelt of Ortel said DFB lasers with output powers of 25 milliwatts and higher could be in production in as little as two to three years. This will be made possible by improvements in coupling efficiency, current and laser efficiency, he said.

1310-nm amps coming soon?

Although 1550-nm signals can be amplified via EDFAs, even that advantage could be short-lived, according to a researcher from British Telecom Laboratories who presented a paper during OFC. Despite widespread industry opinion to the contrary, BT scientists believe a practical 1310-nm amplifier utilizing a fluoride glass fiber and the rare-earth dopant Praseodymium will be developed soon.

Recent tests of such devices have reported encouraging results, including a 38.2-dB gain for a 300-mW pumped device and greater than 20-dB gain for a module employing a 150 mW pump laser. These test results suggest that performance of such devices in a system would be comparable to EDFAs. This "progress gives confidence that practical devices will be developed," wrote the BT scientists.

112 channels on a fiber

While the debate over 1310 and 1550-nm options may rage in some corners, others have shown that both "windows" can be effectively used to transport more than 100 cable channels. A group of researchers at AT&T Bell Laboratories reported that they were able to send 112 channels of video a distance of 10 kilometers (6.2 miles) over one standard singlemode fiber by wave division multiplexing the signals between the two windows.

Fifty-two channels between 445 MHz and 755 MHz were sent over the fiber by a directly modulated 1310-nm DFB laser while 60 channels between 55 MHz and 440 MHz were transmitted via an externally modulated 1550-nm laser. The signals emerging from the 1550-nm device were then amplified with an EDFA, which allowed the signals to be split eight times.

The test determined that the EDFA has no effect on second- or third-order distortions, but does effect system carrier-to-noise by degrading it between 3 dB and 5 dB. However, results also showed that signals within both wavelengths can reside on the same fiber without appreciable degradation.

CATV leads the growth

The market for cabled optical fiber in cable television is forecast to grow 30 percent per annum over "the next few years," making it one of the fastest-growing segments of the overall fiber market, according to Jon Chester, CATV market development manager for Corning Inc.

The growth is being driven by operators who are installing fiber optics at a furious pace to ever-greater numbers of node locations in order to prepare themselves to offer a greater number of strategic services, including alternate access to long-distance networks, Metropolitan Area Networks and Personal Communications Networks, Chester said.

In total, cable television accounts for about a 5 percent slice of the annual North American cabled fiber market. That represents about 110,000 fiber miles sold for CATV purposes in 1991, according to Corning's figures. Overall, the North American market for optical cable across all application segments grew to 2.2 million miles in 1991. Those numbers were released by Larry Aiello, VP of business development and planning for Corning.

Chester said Corning is "seeing incredible growth" within the cable-TV market. Despite the growth that has already occurred, Chester said CATV will account for a larger piece of the overall market over time because less than 10 percent of the CATV wired infrastructure consists of fiber optic cable.

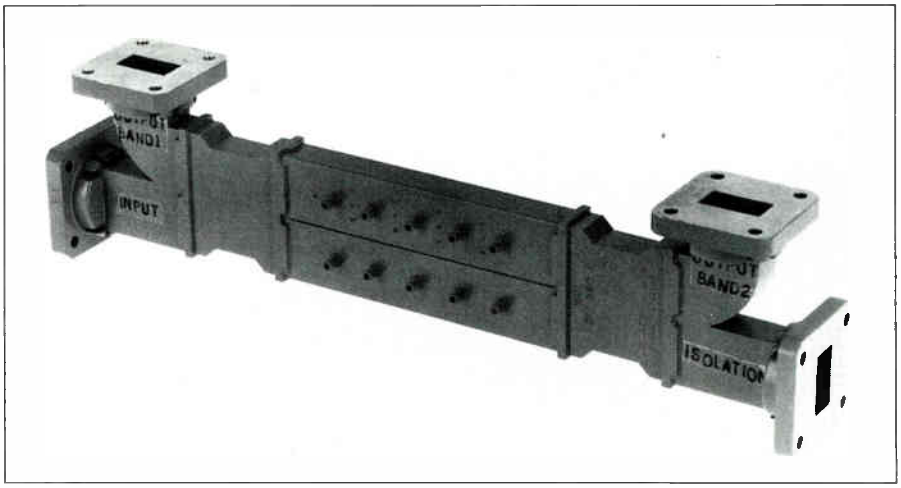
New products

Four-piece, 3.7-meter antenna

New from **Antennas for Communications** is a four-piece, 3.7-meter satellite dish antenna, the PR-12/4. It is designed for "general cable services" and has been selected by the **Hughes Communications, Home Box Office** and **Turner Broadcasting** consortium to provide 3.7 meter and larger antennas for the Galaxy V cable affiliate program.

The antenna is designed to provide both C- and Ku-band frequencies. It mounts directly to a 5.5 inch OD pipe. Primary features of the four-piece antenna include a high gain, dual linear receive system; fewer sections, which offers less opportunity for antenna assembly errors; and an economical common carrier transported in a single crate. The antenna, backframe and mount assembly can be assembled by two people in less than two hours, company officials say.

In addition, AFC has unveiled a Multiple Satellite Feed System for two-degree satellite spacing. With the new system, cable operators can simultaneously receive signals from up to five adjacent satellites, without replacing existing antennas. Isolation between beams is reportedly better than 20 dB. For more information, call (904) 687-4121.



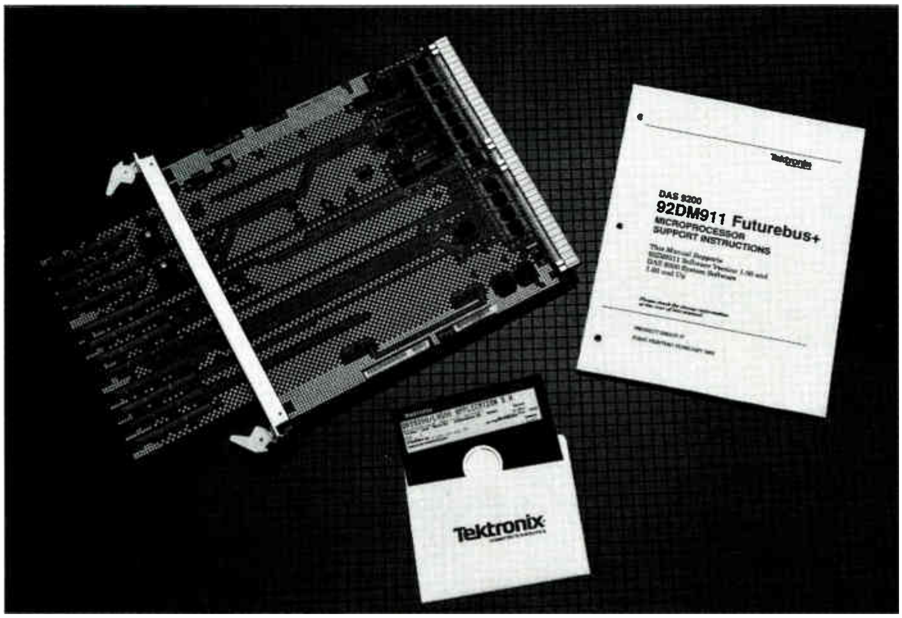
Microwave Filter's diplexer

Analyzer interface

Tektronix has introduced a logic analyzer interface package for its DAS9282 Logic Analyzer, which allows users to measure and optimize system performance using a single package. The package, called the 92DM911 Futurebus+ Interface, provides full acquisition, display and analysis capability for Futurebus+ applications.

The package works with a DAS9200 system equipped with two Centurion logic analyzer cards and consists of a probe adapter card, setup/display software and a user's manual. For bus-based timing analysis, the logic analyzer system offers up to 192 channels running at 100 MHz. The board performs real-time state acquisition of all three phases of each Futurebus+ transaction at a data width of up to 128 bits, and state acquisition can also support narrower data widths.

The package will be available from Tektronix this month and costs $9,950. For more information, call (800) 426-2200.



Tektronix's 92DM911 Futurebus+ Interface

Portable antenna

Rhode & Schwarz's portable antenna

New from **Rhode and Schwarz** is the model AC 008 portable broadband microwave antenna, covering a 1 GHz to 18 GHz frequency range. The antenna is particularly useful for detecting RF signals and for field strength measurements, company officials say.

The small size and light weight of the antenna permit easy transport and troublefree installation in open terrain, in shelters or as part of a remote-controlled radio monitoring system.

The antenna consists of a 90 cm reflector with a broadband feed assembly at its focus (which collapses for transport) and a manually operated biaxial positioning device. An unlimited positioning adjustment range allows the antenna to line up on terrestrial targets and on geostationary satellites. Three different log-periodic antennas are available as feeds.

A transverse support is included as a mounting platform. Optional accessories include a tripod, sighting telescope, and control unit with microwave cables. The latter selects the desired sense of polarization if the AC008 is equipped with a dual linear feed and a polarization switching network.

The unit sells for $10,826 (plus shipping and handling) and is available 90 days ARO. For more information call (301) 459-2810.

Power inverter

Exceltech Corp. introduced the SI-500 Power Inverter, which produces a true sine wave output (as opposed to a square or quasi-sine wave output), says company president Gary Chemelewski. Explaining that virtually every electronic device operates on a sine wave output and using the common television as an example, Chemelewski says that when forced to run on a square or quasi-sine wave, the (television) picture may not fill the screen and "significant" interference will occur in the form of herringbone patterns and hum bars.

To that end, the SI-500 has a peak current capability of 12 amps, which gives it the ability to power non-linear, electronic or highly reactive loads. Possible applications include electric motors, computers, test equipment, stereos, televisions and VCRs.

Also, the power inverter includes protection circuitry and line/load regulation, so that it is protected from damage caused by overloads, short circuits, over-temperature or input polarity reversal. It "guarantees" that the electronic devise will receive a pure sine wave equal to or better than 115V household current.

For more information call (817) 595-4969.

Ku-band uplink/downlink diplexer

New from **Microwave Filter** is the Model 9169 diplexer which separates two bands to allow transmission and reception at the same Ku-band antenna.

Downlink (11.7 GHz to 12.2 GHz) and uplink (14.0 GHz to 14.5 GHz) insertion loss is less than 0.5 dB, officials say, and VSWR is less than 1.25:1. Mutual isolation is greater than 35 dB, and the unit is rated for 500 watts uplink and 1 watt downlink.

Price for the diplexer is $2,667 with delivery in two weeks. For more information call Martin Smith, (800) 448-1666 or collect at (315) 437-3953 from the states of N.Y., Hawaii and Alaska. Fax inquiries can be submitted at (315) 463-1467.

High speed dispatch info system

GTE Labs has introduced a high-speed information system for vehicle navigation, fleet management and emergency dispatch applications. Using computer graphics and information from large databases, GTE's Geographic Information System (GIS) can compute (in less than four seconds, officials say), the shortest route between one point and over 100,000 other points in a typical street network.

The system is similar to those used by telephone companies in routing

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CSR MGR–NE, $42.5K, union & sales experience a must.
SALES SUPPORT ENG–CATV products background preferred, S, salary open.
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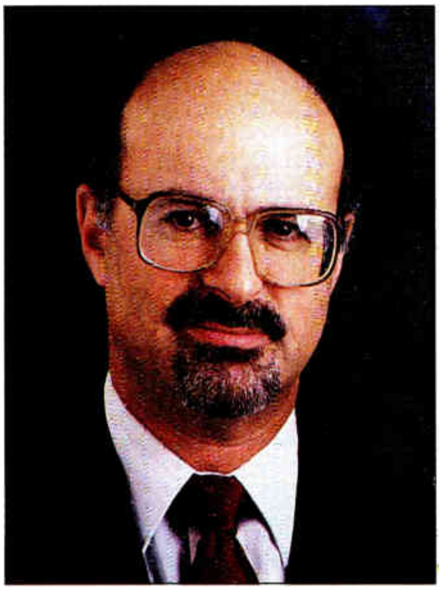

HDTV simulcasting and must-carry

In my July 1991 column, I wrote about the FCC's choice of the "simulcast" approach, where a broadcaster would continue to transmit an NTSC picture on one 6-MHz channel and would simultaneously transmit an HDTV (or "ATV" for Advanced Television) picture on a separate 6-MHz channel. The FCC decision defined "simulcast" to mean the broadcast of the same program over two channels to the same area at the same time.

I raised a number of questions. For example, must the NTSC and HDTV stations carry the same programming *all* the time? Or is 90 percent of the time sufficient? What about 70 percent? Or 20 percent?

These questions haven't been decided yet, but the broadcast industry has expressed its opinion: "The extent of simulcasting should be left to the marketplace, to give each broadcaster the incentive to tailor its NTSC/ATV simulcasting to meet its market's needs and minimize non-revenue producing costs...."

In other words, the broadcasters want flexibility in deciding how to program the ATV channel. If a program is available in both NTSC and HDTV formats, then they would broadcast those two formats at the same time.

If a program is available only in NTSC format, they want the flexibility to either run that same program on the ATV channel (perhaps by using some line-doubling technique to make it appear to have better resolution than NTSC) or to substitute an entirely different program that was created in HDTV format.

During the startup days of HDTV, there might be a shortage of HDTV programming. That's when broadcasters will want the flexibility to use line-doubling on much, perhaps most, of their programming.

All this would seem reasonable, if it were not for cable carriage requirements.

Must-carry

The United States Senate passed S.12 on January 31, 1992. The full gory details of that bill have been reported elsewhere. The House of Representatives has not yet passed a companion bill, but that is expected within a few months. S.12 is unacceptable to the cable industry, and the White House has suggested that the President would veto it if it is passed by both chambers. Others have said that the White House would be afraid to veto a pro-consumer law in an election year. I tend to agree with the latter view.

If S.12 is enacted into law, the key feature for this discussion is that a TV station will be able to demand that its signal be carried by the local cable operator. This presumably applies both to the NTSC signal and the ATV signal.

Broadcasters face a startup problem with HDTV. They can't begin to derive additional revenues from their second channel until there are a significant number of viewers.

But if the majority of potential viewers are cable subscribers, it is reasonable to expect broadcasters to demand that cable companies carry their ATV channel. This will be particularly true in the early days of HDTV, even if there is little HDTV programming and few viewers actually own HDTV receivers.

(Yes, I have heard the argument that these cable subscribers could use A/B switches with their existing TV antennas to receive HDTV broadcasts. But the quality of current TV antennas may not be sufficient for HDTV reception.)

The FCC has proposed that existing TV stations be given 5 years to get their new ATV stations up and operating. If this proposal is adopted, then the first ATV stations will begin operation in 1995 or 1996, and most will be on the air by 1999.

Impact on cable systems

This discussion can be short. For every local broadcast TV channel you now carry, you must assume that you will have to carry a second channel in the HDTV format. Do you have the spare capacity? Most cable systems do not. Can you increase your capacity by 1999? If not, what existing programming services will you have to eliminate, in order to make room for the broadcasters?

At the same time that TV stations are putting up ATV signals, the cable programming services will be doing the same thing. Since 35 mm film has a resolution that is quite compatible with HDTV, there are vast libraries of movies that can be converted to HDTV programming. The premium programming services may be the first to deliver HDTV movies and other programming, perhaps sooner than most TV stations.

They, too, will want a second channel, so that they can continue to deliver NTSC programming to subscribers with NTSC TV sets while they start up their HDTV program channels. The difference here, of course, is that the second channel becomes the subject of contract negotiations between the cable operator and the programmer, instead of being mandated by "must-carry" legislation.

Big fight ahead

I think that cable legislation will pass, and it will give broadcasters the right to demand cable carriage. If given that right, they will assert it.

What I don't know is whether the law will deal directly with carriage of the Advanced Television channel. S.12, as it was passed by the Senate, does not. If not, the FCC will probably have to make the decision. The fight may come this year in the Congress, or next year at the FCC. But it is a fight that is certain to occur, because it has immense financial implications both for broadcasters and cable systems. **CED**

By Jeffrey Krauss, Independent Telecommunications Policy Consultant and President of Telecommunications and Technology Policy of Rockville, Md.