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THE PREMIER MAGAZINE OF BROADBAND COMMUNICATIONS

SEPTEMBER 1996 CED

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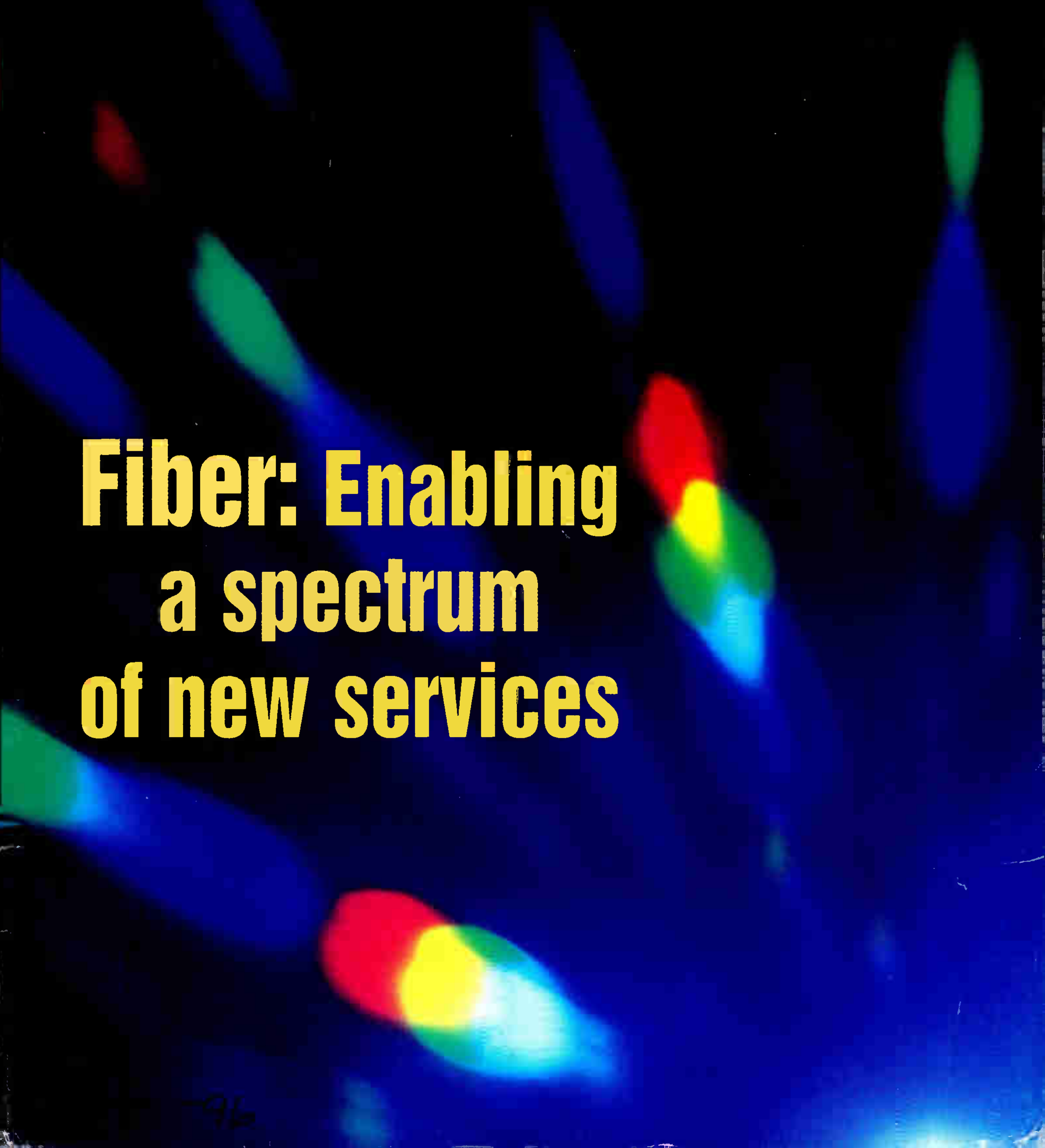

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Fax 44-1-494-773397
sales@texscan.co.uk

Texscan Pan Asia
35th Floor, Central Plaza
18 Harbour Road
Hong Kong
Tel. 852-2593-1158
Fax 852-2593-1134

Texscan do Brasil
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Tel. 55-11-259-1206
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Reader Service 1

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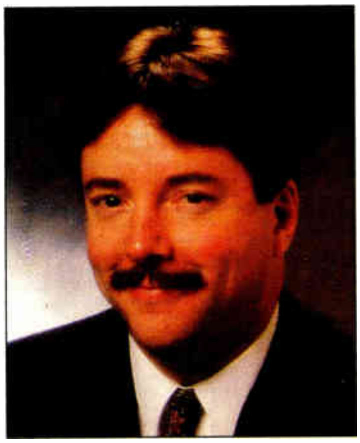
It has become one of life's little ironies that in this, the age of communication, we can't seem to really communicate with anyone anymore. Oh sure, we can pick up the phone and dial the numbers, but just how often do you get through to the person and have a "live" conversation? I'd bet it's probably less than 30 percent of the time.



"I'm sorry, but I'm not in right now..."

All kinds of new technologies have sprung up in an attempt to solve the issue. Facsimile machines made it easy to send documents and share information almost instantaneously, and were lots cheaper than using an overnight service. Voice mail was invented as a way to reduce the number of telephone volleys and allows the caller to ask questions, leave detailed info and communicate panic, when necessary.

The latest phenomenon, e-mail, is both a godsend and an abomination. When I first started using it, I thought it might bring back the lost art of written communication. Here was an opportunity to return to the professional business letter, where the nuances of the English language can be played out. Wrong. Instead, e-mail is a collection of quick thoughts, random non sequiturs and information that often leaves you more confused than you were at the start.

The amazing thing is, that to get someone's attention, you have to use ALL these things to motivate them to respond to you. It has become common practice to call someone, leave a voice mail, and follow up with a fax and now, an e-mail message. Before long, we'll be spending all our time retrieving messages and getting even less done.

But I am continually struck by the bad telephone habits we're all picking up. How often does the phone ring while you're at your desk, and you just ignore it, putting the caller into the voice mail maze? How long does it take you to return the call? On a percentage basis, how many calls do you actually return?

Sure, voice mail is a great way to screen out unwanted calls, especially at home during the peak telemarketing hours. But increasingly, people are getting frustrated with their inability to actually hold a conversation with someone.

I was amazed to hear a story told by an equipment distributor who was getting concerned because he couldn't get his manufacturer to call him back. "I've called him, faxed him and e-mailed him, and he won't call me back," he lamented to me. "And I'm trying to buy his damn equipment!"

Maybe we should all go back to school on this one. Resolve to return every message you get today. Answer the phone before it goes into voice mail. Write someone a letter. Let's act like the communication companies we say we are. I'll be the first to admit I don't do as good a job as I should. But recognition of the problem is the first step on the road to recovery, or so I'm told.

If you have any thoughts on this subject, write me. Send me e-mail. Or heck, give me a call. With luck, you won't end up in my voice mail . . . .

Roger J. Brown

Roger Brown
Editor

CED MAGAZINE

VP Group Publisher
William McGorry

Publisher
Robert C. Stuehrk, Rstuehrk@aol.com

Editor
Roger Brown, Rbrowner@aol.com

Managing Editor
Dana Cervenka

Associate Editor
Michael Lafferty, McLaffrt@aol.com

Contributing Editors
Leslie Ellis, Ellis299@aol.com
Fred Dawson

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Linda S. Sommer, Lssommer@aol.com

Classified Sales Manager
Tim Reeder; 800/866-0206

Assistant to the Publisher
Michelle Pazar

Production Manager
Johanna McGinnis

Art Director
Don Ruth

Assistant Art Director
Anney Grossberg

Address
600 S. Cherry St., Suite 400
Denver, CO 80222
303/393-7449; Fax 303/393-6654
Or visit our Web site at:
http://www.cedmagazine.com

Circulation Director
Maria Gottlieb; (212) 887-8565

Associate Circulation Manager
Shawn Green; (212) 887-8564

Subscriber services
CED
P.O. Box 10728
Riverton, NJ 08076-0728
Telephone: 609/786-0501; Fax: 212/887-8493

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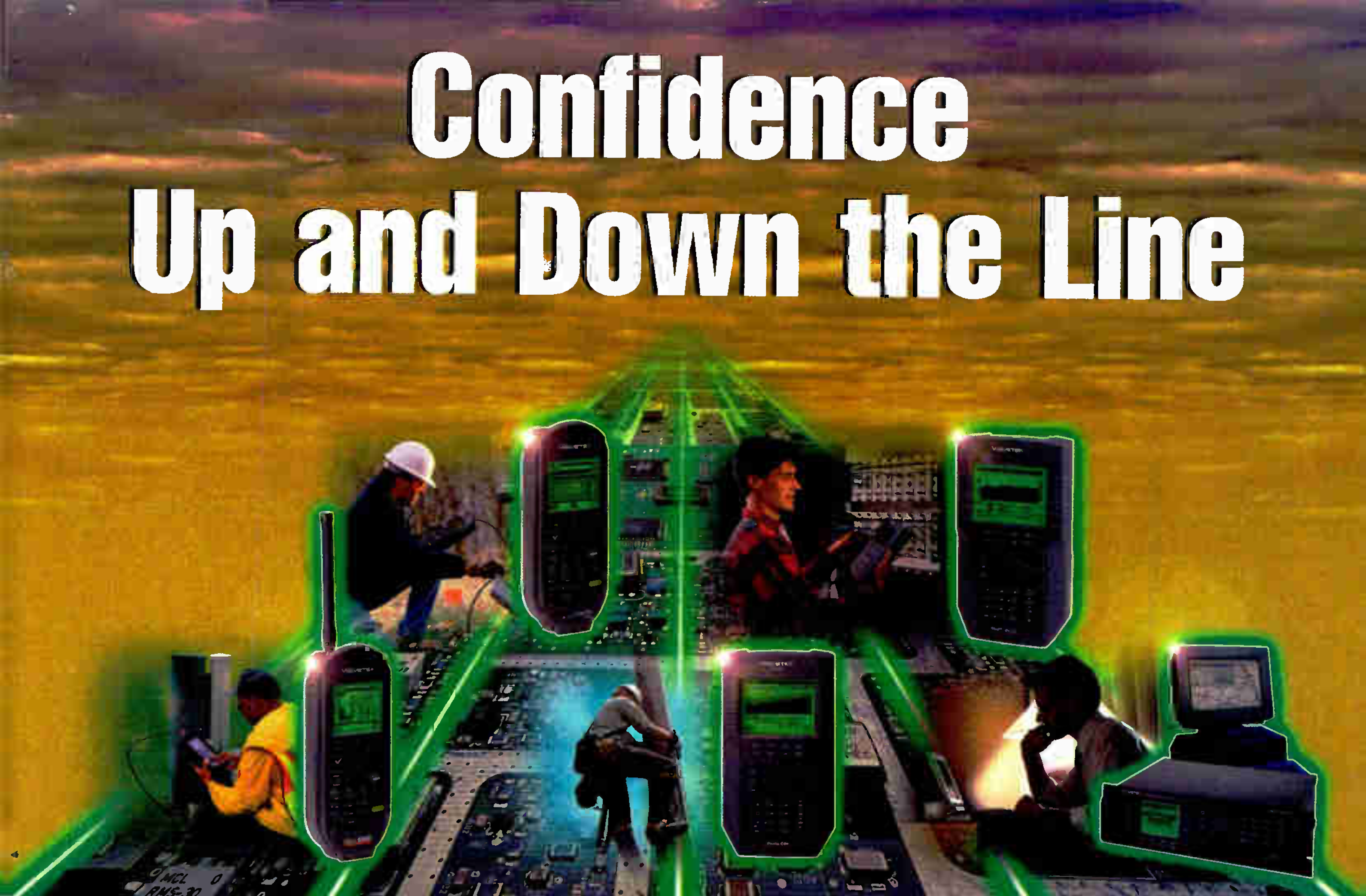
Confidence
Up and Down the Line

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Photo courtesy of Siecor Corporation

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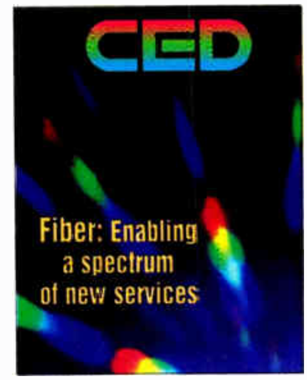

About the Cover

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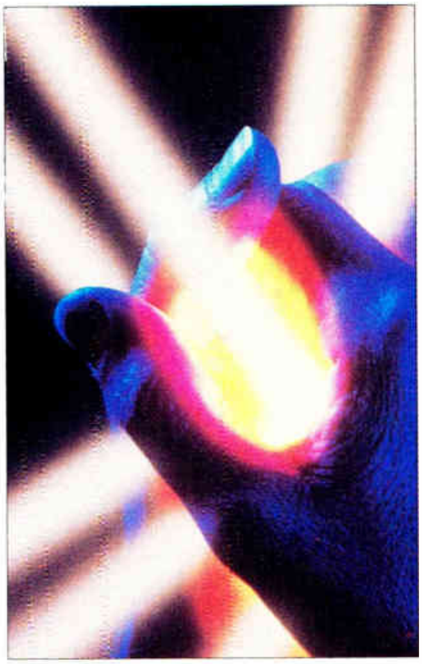

This month's Back to Basics section offers a primer on molding light via fiber attenuation. Photo by M. Tcherevkoff, The Image Bank.

Is ingress making your return path a road to nowhere?

Ingress is the major roadblock to getting your return path up and running. Fortunately, there's the new HP CaLan Sweep/Ingress Analyzer. It's the only test gear that allows you to quickly and accurately troubleshoot your system, regardless of the presence of ingress.

When ingress corrupts reverse-path communication, the headend unit (HP CaLan 3010H) senses the problem instantly, and transfers the display of the ingress problem to the field unit (HP CaLan 3010R). That means your technicians can begin troubleshooting immediately.

Now you can troubleshoot your system at all times. No matter how much ingress is present.

And of course, the HP CaLan Sweep/Ingress Analyzer offers DigiSweep, the industry's fastest, non-interfering, digital-services compatible forward and reverse sweep. In fact, reverse sweep measurements can be performed in real-time — even with multiple users.

So don't let ingress slow you down. To find out how HP CaLan's Sweep/Ingress Analyzer can help you identify, troubleshoot, and eliminate your ingress problems, call **1-800-452-4844, Ext. 1748**. Or visit us at: http://www.hp.com/go/catv

Reader Service 5

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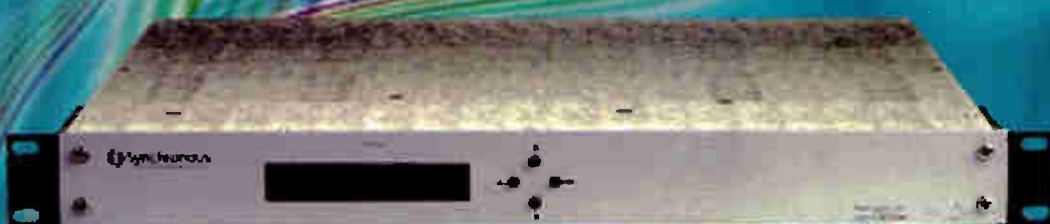

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GI adds 78 additional operators to its list of digital buyers

In spite of the fact that General Instrument has yet to commercially deploy digital set-tops en mass, the company in August signed up 78 more broadband network operators to non-binding letters of intent to purchase more than 480,000 of its MPEG-2 digital consumer terminals and related headend hardware.

The commitments are from operators who intend to deploy both wireless and conventional wireline set-tops, although GI officials declined to disclose how many of each were committed to.

These orders are in addition to the commitments already received from TCI, Comcast, Cox, Rogers and Shaw to purchase the DCT-1000 wireline set-top terminal. The addition of these new orders makes total commitments to purchase GI digital equipment exceed 3.5 million units, with approximately 2 million units currently under contract.

Even with the well-documented delays associated with the roll-out of digital technology, operators are still eager to deploy it because of competitive pressures from DBS and wireless video providers, notes David Robinson, vice president and general manager of GI's digital network systems.

"Many of the operators (who signed letters of intent) are not in major markets," he notes. "They have to compete with the likes of DBS or risk losing their very best customers."

The new commitments have expanded the representation of GI's digital network technology over a broad cross-section of communities in North America. These communities are serviced by various types of network operators, including cable operators, wireless cable operators and telephone companies that provide cable services.

Some of the latest operators that will purchase GI's digital set-top terminals include Helicon Corporation in New Jersey, Van Horne Cablevision in Iowa, Community Communications Company in Arkansas, Coast Communications Company in Washington, Atlantic Telephone in North Carolina and Syncom Media in Georgia.

The new set-tops offer enhanced picture and sound quality and expanded channel counts, as well as a host of other easy-to-use features, according to Robinson. With the expanded channel capacity, operators are expected to deploy new services, including enhanced pay-per-view, near-video-on-demand and various interactive options.

Robinson says GI is meeting the demand for digital equipment by incorporating open standards that gives system operators the flexibility to enhance their digital networks with interoperable equipment from multiple sources. To support true system interoperability, GI has also incorporated a broad licensing program at both the end-product and semiconductor components level. "We're driving away from the closed systems of the past," he notes.

Latest and greatest news on data modems

Seeing as how 30 days can't pass by without some cable modem news occurring, here's what transpired since mid-July:

✔ Continental Cablevision's Southeast Region has chosen to purchase 10,000 General Instrument SURFboard modems with a telephone return path to offer residents of the region high-speed access to the Internet and other data services. Continental has already performed field tests of the modems and the related network in Jacksonville, Fla., which serves 240,000 homes, and plans to deploy them in areas that are awaiting an upgrade to full, two-way interactivity.

Continental already operates as an Internet service provider in the area.

The announcement follows a previous one where Continental purchased 50,000 LANcity Personal cable modems over the next two years for deployment throughout systems in New England, Florida and Illinois.

✔ Meanwhile, Time Warner announced that its high-speed data-over-cable trial in Elmira, N.Y. has been expanded to Corning, N.Y. At the same time, the company announced a five-year agreement with Corning Inc. to use the service to develop a work-at-home program, called "Corning Connects."

The service will allow subscribers of Time Warner's LineRunner service who are also Corning employees to access Corning's databases so they can work from their homes, answer e-mail, access scheduling and perform other functions.

A small group of Corning employees has been testing the service; it will be expanded to about 300 employees by the end of the year.

✔ TV manufacturer Curtis Mathes has announced the Wireless SurfBoard, an optional data peripheral for a new, proprietary television technology called UniView. The UniView system provides access to the Internet, on-line services and television program listings; allows VCR programming and parental blocking of objectionable programming content; includes fax and e-mail capability; and includes a high-quality speaker phone. The UniView system is fully operational with its standard infrared-style remote control. The Wireless SurfBoard allows greater flexibility in "surfing" the Internet or sending e-mail by providing a full keyboard and mouse touchpad.

The RF Wireless SurfBoard allows operation of the system from up to 50 feet away without direct line-of-sight, which is required with infrared controls. It consists of a compact, 83-button keyboard and a mouse touchpad with dual mouse buttons.

The Wireless SurfBoard will be an optional accessory to its UniView system, priced at about $300. UniView set-top units can be connected to any brand or model of television to transform the ordinary viewing experience into a dynamic interactive experience, and are expected to be available in October at a suggested retail price of about $399.

✔ And finally, Norpak and the Sinclair Broadcast Group demonstrated a system that broadcasts Internet info to personal computers using the TV signal. Norpak's VBINET system utilizes a server and a data encoder at the headend and receiver (either a plug-in card for the PC or a stand-alone box) at the other end.

The info is distributed via the TV signal's vertical blanking interval and is stored and automatically updated on a user's PC hard drive. Users can browse and interact with the content, just as they do with PCs via any standard browser software. The system can send info at speeds of 100 kilobits per second or higher.

Separately, Sinclair announced its plans to deploy the system and offer an advertiser-supported subscription service called Supercast.

Own a tower? It's time to register it

The Federal Communications Commission has adopted new rules that require all FCC licensees who own antenna structures that are either higher than 200 feet, or located near an airport, to register those structures with the FCC.

Beginning July 1 of this year and continuing until June 30, 1998 (see the chart on page 14 for filing windows), owners of both existing and new antenna structures are responsible for registering the structures. In the case where the licensee doesn't actually own the tower, it is nevertheless required to inform the owner that the structure must be registered.

To register, licensees must verify the location and height of any existing structure and file FCC Form 854. Any proposed or altered antenna structures must be registered with he FAA as well as the FCC.

Information on special waivers and a complete listing of which structures must be registered (and those which don't have to be) are available directly from the FCC in PR5000 Number 15—Antenna Structure Registration

Filing window	States and territories
July 1 to Oct. 31, 1996	Alaska, Ariz., Hawaii, Mass., Mich., Mo., Mont.,N.C., N.M., N.Y.
Nov. 1-30, 1996	Ill., Wyo.
Dec. 1-31, 1996	Nevada, Okla., Puerto Rico
Jan. 1 to Feb. 28, 1997	Calif., Ohio
March 1-31, 1997	Iowa, Va.
April 1-30, 1997	Ga. and American territories
May 1-31, 1997	La., Maine, R.I.
June 1-30, 1997	Colo., Minn.
July 1-31, 1997	Neb., Penn.
Aug. 1 to Sept. 30, 1997	Fla., Ind.
Oct. 1-31, 1997	Del., Kan., Wash.
Nov. 1-30, 1997	N.H., Ore., Wis., W.Va.
Dec. 1-31, 1997	Ala, D.C., Md.
Jan. 1-31, 1998	Ark., N.D., Utah
Feb. 1-28, 1998	Idaho, Miss., S.D., Vt.
March 1-31, 1998	Ky., Tenn.
April 1-30, 1998	Conn., N.J., S.C.
May 1 to June 30, 1998	Texas

Fact Sheet. Copies can be obtained from the FCC's Forms Distribution Center at 800/418-3676, or through the Internet at http://www.fcc.gov/wtb/antstruc.html. Questions regarding the registration process can be answered through the Wireless Telecommunications Bureau Consumer Assistance Branch at 800/322-1117 or 717/338-2500.

Panel finds S-A violated EPG patent

A California arbitration panel has ordered Scientific-Atlanta Inc. to pay StarSight Telecast Inc. $15 million in damages, plus legal and arbitration expenses, and issued a three-year limited-term injunction on the future sale of Scientific-Atlanta's existing set-top electronic program guides as punishment for violating the terms of a 1992 license and technical assistance agreement between S-A and StarSight.

Under the terms of the injunction, S-A is permitted to fill current customer commitments with its existing electronic program guides. Also, S-A can ship any electronic program guide acquired from a third party or independently developed by itself after the date of the award.

Under an agreement between S-A and StarSight that was signed in late 1992, S-A was supposed to incorporate StarSight's guide into its 8600x set-top. Instead, the arbitration panel found, Scientific-Atlanta developed its own guide and released it in 1994. The only problem is that S-A apparently used StarSight's intellectual property.

Scientific-Atlanta senior vice president and general counsel William E. Eason Jr. said, "While the company is disappointed in the ruling because we believe that we did not violate our agreement with StarSight, we are pleased that the injunction has no effect on existing customer commitments. In addition, we will immediately begin a clean room operation to quickly develop a new and improved interactive guide in accordance with the panel's ruling. In the interim we will explore utilization of third party guides as permitted by the ruling."

The finding does not affect a patent infringement suit filed by S-A in February 1996 against StarSight and Philips Electronics North America. In that suit, Scientific-Atlanta alleges that the StarSight CB1500 receiver infringes at least three of the company's patents. The suit seeks damages and an injunction against continued infringement. Eason said the company intends to vigorously pursue that suit, but StarSight officials say those rights were licensed during the 1992 agreement. StarSight has filed for arbitration in the case.

Scientific-Atlanta will take a charge in its 1996 fiscal year fourth quarter to cover the total costs of the damages.

Ericsson taps Texscan for HFC fiber optic gear

TSX Corporation's Texscan subsidiary has entered into an agreement with Ericsson Inc. Fiber Access, a member of the Ericsson Group, for the development and the OEM supply of strand-mounted broadband optical nodes and high level broadband RF devices. The contract equipment will be utilized by companies within the Ericsson Group in the development and construction of hybrid fiber/coax (HFC) broadband networks worldwide.

This is a multi-year, multi-million dollar agreement against which Ericsson has already placed initial orders in the amount of $2.8 million with shipments to start by mid-summer. Texscan will be working closely with both Ericsson Fiber Access in the United States and Ericsson Public Telecommunications Product Supply Group in Norrkoping, Sweden, in the administration of the contract.

William H. Lambert, chairman and CEO, stated that, "We are absolutely delighted to be chosen to work with a company with the stature of Ericsson. This agreement is the culmination of many months of hard work between the two companies, and a clear indication of Texscan's abilities to develop and supply products serving both telephone and broadband telecommunications businesses worldwide. We believe that Texscan's reputation for innovative optical and RF products and the capacity of our world-class, ISO-9001 registered manufacturing facilities were keys in Ericsson's selection decision."

Headquartered in El Paso, Texas, TSX Corporation (http://www.tsx.com), through its Texscan subsidiary, is a leading manufacturer of cable TV fiber optic and RF distribution electronics and electronic advertising insertion equipment.

Competition wars heat up in Boston

It might be enough to make Paul Revere race through the streets shouting, "Competition is coming! Competition is coming!"

RCN Inc. has begun offering competitive local and long-distance telephone service, video programming and Internet access to residents in the greater metropolitan Boston area, in direct competition with Cablevision and Nynex.

RCN, which plans to merge with C-TEC Corporation, is utilizing MFS Communications' fiber-optic network as its primary distribution vehicle. The company plans to offer a wide array of telecommunications services in major metropolitan areas to residents of multiple dwelling units such as apartment, cooperative and condominium complexes, as well as hospitals, hotels and universities.

Previously, RCN announced a similar service offering in New York City and a national rollout of urban telecommunications systems, initially focused on northeastern metropolitan areas.

By the end of August, the company planned to be providing telephone, video and data services in approximately two dozen buildings in the downtown Boston area. In addition, approximately 250,000 additional subscribers

live within one mile of the MFS network utilized by RCN that extends from the downtown area to Cambridge and surrounding suburbs.

"The important alliance we're developing with RCN will be beneficial to both our companies as well as residential customers in major urban markets," said James Q. Crowe, chairman and CEO of MFS. "We're pleased that RCN will be able to use bandwidth on our advanced fiber network to provide a broad range of services to customers."

RCN is offering subscribers video programming at rates below those of Cablevision, local telephone rates that are below those of Nynex, and long-distance rates that are below those of the major long-distance carriers. In addition, the company will be offering substantial discounts, up to 33 percent, for those video customers who also subscribe to the local phone service.

The decision late last month by the U.S. District Court for Massachusetts concurs with RCN's position that the FCC has jurisdiction over RCN's video dialtone (VDT) service. The ruling resolves the uncertainty which Cablevision had raised as to RCN's authority to offer competitive video services in Boston.

The Court denied the Massachusetts Cable Television Commission jurisdiction over RCN's provision of video programming and rejected Cablevision's motion for leave to intervene in the case, stating that the state proceeding "threatens to hamper or destroy a technology which, if successfully implemented, offers consumers a viable and attractive alternative to the existing cable television system monopoly."

GI, Yuasa-Exide will develop FTTC power

General Instrument's Next Level Communications subsidiary has formed a partnership agreement with Yuasa-Exide to jointly develop "N3-Power," a remote power system (RPS) specifically designed for use with its NLevel3 Switched Digital Access System.

Under the agreement, Next Level and Yuasa-Exide will jointly develop the power interface and controller shelf to the NLevel3 system, that will optimize the battery and power system provided by Yuasa-Exide. In addition, Next Level will incorporate the Horizon Interlink software management system from Yuasa-Exide into its Element Manager System, providing customers with state-of-the-art operations and management capabilities for their remote power plant.

"Powering is a critical issue in loop electronics deployment," says Russ Tucker, director of outside plant deployment technology at Next Level. "Cost and reliability are major concerns to our customers. Next Level and Yuasa-Exide intend to develop a solution that satisfies both these concerns, and will be designed to optimize performance with our system."

The NLevel3 system is an integrated broadband platform that offers full service telephony, data, Internet and entertainment video over either coax or twisted pair drops to both residential and business consumers using ATM transport. Next Level's system is designed for low power consumption and high reliability, in order to greatly enhance performance and reliability in the end-to-end network.

Most existing RPS systems commercially available today have been designed for use with Digital Loop Carrier (DLC) or other existing loop electronics systems. Yuasa-Exide and Next Level will develop a -130V RPS system that is specifically intended for deployment with next generation broadband access using fiber-to-the curb and twisted pair loop access architectures.

Westell, Motorola team for ADSL gear

Westell and Motorola Semiconductor have forged an alliance for the development of modems that use asymmetrical digital subscriber line (ADSL) technology to speed the information superhighway into everyone's home or business.

By hooking up ADSL modems at its switching center and at its customers' sites, a phone company can use the standard, copper phone lines--not fiber–to enable access to new multimedia services on one phone line, along with simultaneous voice service. Currently, nearly 30 phone companies worldwide have announced plans for ADSL services in 1997.

Westell, which developed the first ADSL modem, will incorporate Motorola's standards-based DMT (Discrete Multi-Tone) transceiver chip, called CopperGold, in its modems and systems.

In addition, the two companies will collaborate on product design and development of future-generation, ADSL-based semiconductors, modems and systems. The highly integrated transceivers support both STM (synchronous transfer mode) and ATM (asynchronous transfer mode) transmission speeds up to 8 megabits-per-second (Mbps). The scalable DMT architecture supports a range of transmission speeds from 32,000 bps to 8 Mbps from the network provider to the customer, and 32,000 bps to 1 Mbps from the customer to the network provider.

Jottings

Zenith Electronics CEO Albin Moschner surprised many by resigning his post in late July. Zenith installed Peter Willmott, former president and COO of FedEx and a Zenith board member for the past six years, as interim president and CEO while a permanent replacement is sought. Moschner led Zenith through difficult financial times, during which Korean manufacturer LG Electronics purchased a majority stake in the company . . . Here's one for the "oops" department: Zenith had to retract a press release that was mistakenly sent out that said the americast consortium had selected its digital set-top for deployment. Zenith then had to confirm that discussions were ongoing, but that no deal had yet been formalized . . . The **SCTE** has formed the Digital Video Subcommittee to help develop standards to deliver digital TV and data services via cable networks. The group, which met during the 1996 Cable-Tec Expo in June, has five working groups: Video and Audio Services; Data and Transport Applications; Network Architecture and Management; Transmission and Distribution; and Encryption and Access Control. Anyone interested in participating on the committee should call Paul Hearty of General Instrument at 619/623-2935 . . . **Cox Communications** and **Pacific Bell** have hammered out an interconnect agreement for California that will allow Cox to connect to PacBell's switches. The three-year agreement has the following provisions: Residential ports will be $6.65 a month; measured residential ports will cost $4.15 per month, with a $1 credit for the use of Cox's network by long distance carriers, plus a penny per minute. Business measured ports will cost $4 per month, with the same credit and penny/minute charge. Interim number portability will be provided via remote call forwarding at $1.94 per month . . . **RELTEC** announced plans to build a new manufacturing facility for its outdoor electronic equipment cabinets and assemblies in LaGrange, Ga. The plant, which will eventually employ 300 persons, will fabricate metal and assemble electronics cabinets. LaGrange is located about an hour south of Atlanta . . . Real competition in Connecticut moved a step closer when the state's Department of Public Utility Control gave **Southern New England Telecommunications** an 11-year license to provide cable TV services statewide. The action came just a week after the same body certified Cablevision Corp. as a local telephone provider, and is expected to certify TCI as well. In spite of all that, expect the whole thing to land in court . . . . CED

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Clark: Learning to leverage photons

Given their relative high cost, how can lasers be used by industry to solve problems economically? That's the question which Dr. John Clark has spent his entire career trying to answer. Today, Clark's mission is clear: making laser photons so valuable, that they appeal to the cable industry's bargain-hunters.

When Scientific-Atlanta acquired ATx Telecom Systems this past July, the company also acquired the talents of Dr. Clark–chief operating officer of ATx, and by education, a chemist and a physicist–as well as his 24-karat touch with photons. So how did Clark, an academic from Berkeley, end up in the middle of the cable TV business?

Dr. John Clark

From algae to erbium

Executives at Amoco Corp. were visionary when they scouted out Clark in 1985 to help them diversify into high technology businesses, specifically targeting photonics lasers. By that time, Clark had already devoted years of research in trying to use photons in a "smarter" way than they had ever been used before, first as a grad student at the University of California, Berkeley in the early 1970s, and later, during post doctoral work at Los Alamos National Laboratory, where he held a prestigious J. Robert Oppenheimer fellowship.

While working at Los Alamos, one of the cost-effective commercial applications Clark discovered was using lasers for purification: by removing one impure molecule present in one part per million, effectively, a million molecules of product could be processed. That finding would turn out to be an important one for purifying semiconductor feedstock material.

Much of Clark's work in academia focused on picosecond spectroscopy—initiating chemical reactions with a very fast pulse of light and "watching what happens in real-time, at the molecular level." At Berkeley, where Clark would eventually become assistant professor in the Department of Chemistry, he worked on projects that seem far removed from the world of telecommunications, including observing how bluegreen algae use energy during photosynthesis to turn sunlight into food.

"It's seemingly a far cry from communications," says Clark, "but in fact, the fundamental building blocks are very much the same." Drawing on a variety of similar research projects, Clark, and a team he assembled to form Amoco Laser Co. (later to become ATx Telecom), would invent, develop and commercialize a unique incarnation of erbium-doped fiber amplifier technology (EDFA), optical amplifiers for the 1550 nm region.

And did the founders of Amoco Laser have any idea that they would one day end up making products for communications applications? "We thought we were going to make tiny, cheap green lasers for printing and reprographics," explains Clark. "To make a green laser, you have to make an infrared laser, and then frequency double it in a nonlinear optical crystal. And it turned out that we had lots of trouble making green lasers, but we could make one hell of an infrared laser. And one of the colors we could make was at 1300 nm," he notes. In fact, Clark holds a whopping 10 laser-related patents, including those related to a variety of sum-and-difference frequency techniques that could be used to optimize 1300 nm and 1550 nm light sources for various applications.

"There's a real problem right now with light sources for wavelength division multiplexing applications," says Clark. "You can't grab a laser, dial in its wavelength and plug it into the system. That's the sort of idealized laser source that we are working on, which is enabled by some of our patents. We have a view toward commercialization of the technology within a couple of years."

Clark found himself working with Scientific-Atlanta around 1988, back when Amoco Laser started marketing to the cable industry. By the time S-A began looking at the acquisition of ATx, Clark and his team were busy designing their high-powered, optical amp into S-A's System 70 product line, which marked the first time the two collaborated on a product for volume deployment.

Now, Clark is moving ATx from being solely a components supplier to becoming a supplier of complete optical links, including transmitters, amplifiers and receivers, at 1550 nm. As part of Scientific-Atlanta, ATx is experiencing a coming-out party of sorts: "S-A has the strong sales and marketing distribution presence with end users and MSOs that we don't have," notes Clark. For its part, S-A has gained vertical integration at 1550 from the relationship, with access to ATx's pump lasers and fiber.

The optics frontier

To do this interview, Clark actually called in from a break in scuba diving and body surfing during his vacation in Maui, part of an annual Hawaiian pilgrimage with his family (wife Ruth is a computer programmer by trade; daughter Cynthia is 13).

Back home in Wheaton, Ill., he and his daughter often hit the many bike paths which intertwine thick, green forest preserves throughout the Chicago suburb. "It's a pretty exceptional area," he notes. "Probably not quite like mountain biking, but for some place where 20 feet is a big elevation change, it's a nice thing." Clark is also doing a fair amount of business and financial-related reading these days as he continues to make the transition from the world of academia to the world of commerce.

Though everyone marvels at how far fiber optics has come in just a few years, Clark says that the telecom industry has barely scratched the surface: "With the whole emergence of 1550, optical amps and WDM, there will be some phenomenal changes in the kinds of bandwidth that one can move around, either in the analog or the digital world." And Clark will no doubt make sure that photons continue to do cable's bidding.

–Dana Cervenka

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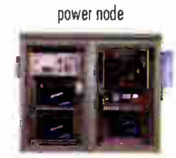

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Cable puts on gold-medal show at Olympics

By Wendell Bailey, VP of Science and Technology, NCTA

It may have produced some of the most popular sporting events ever to be watched on television. There were more moments of drama, joy, exertion, pain, exultation and emotion than could be counted. Luckily, there were only a few moments of terror, but those minutes, like the experience of the other emotions, will last in memory for a lifetime.

I'm talking about the Centennial Olympic Games of 1996, just concluded in Atlanta, Ga. I was lucky enough to attend the Games and be allowed behind-the-scenes to see how it was all put together. Compared to the Games in Barcelona, this effort had more of everything: more athletes, more visitors, more volunteers, more press, more sponsors and more complicated structures than have ever been assembled for an event of any kind.

The mere fact that the telecommunications and information systems could have been designed to do what was accomplished is remarkable in and of itself. The fact that it all worked would seem, to the outsider, like a miracle; but seen from the inside, it became clear that this, like all difficult, complicated endeavors, worked because of the talent and relentless attention to detail that was the hallmark of the people who designed and deployed this amazing system.

Up-to-the-minute results

Now for a few details. Signals originated at all of the venues and were distributed to a wide variety of locations. First and perhaps most importantly, the images from every event were delivered to the facilities of the world's broadcasters, for dissemination to countries around the globe. Perhaps just as important to the press in attendance at a particular event, the signals of that event, as well as the images of any other event that was ongoing at the same time, were delivered to a television and set-top at each seat.

In addition to the video programming that was available, there were dozens of virtual data channels that showed data about almost anything that you could want to know about, any sport or any athlete who was participating in the Games. You could also get up-to-the-minute results of ongoing events and tune in to the local cable system's regular line-up. All of these capabilities were available in stadiums, lounges, press rooms, volunteer rooms, private VIP lounges and just about anywhere you could find a place that a live person might be.

Scientific-Atlanta was a major sponsor of the Centennial Olympic Games and was the "official broadband supplier" to the 1996 Olympics. The company was literally at the heart of the network that handled all of the above-mentioned capabilities. It was impressive to see the thought and execution that went into the project which S-A mounted for this effort.

And while the equipment that the company made available for the Olympics was first-class and up-to-the-minute technology (mostly digital video), nothing that was built in its factories was as impressive as the people who installed, tested and then maintained this network for the course of the Games.

Star performers

While all of the employees of Scientific-Atlanta should be proud of the role that they played, I spent my time with a couple of stars who had the most influence on maintaining the reputation of the cable television industry.

Greg White spent endless hours both before and during the games managing the CATV Control Center. There were others who were in charge when Greg had time off (very little time off), but most of my contact was with him. It was great to see him in action. No problem was left alone, no request was too petty to take care of immediately, and when more things needed doing at one time than there were hands to do them, Greg was right on top of the priority list to make sure that everything got done, and done right. Operating in what had to be one of the most high-pressure centers of the whole system, Greg was calm and easy to work with.

There were others who were at the venues themselves to look after the things that came up there, and they all relied on Greg and the whole control center gang for help and advice.

In addition to the control center, there was a duty station for S-A that was the catch-all for all things technical and logistical. That station was manned by the two individuals who had the job of coordinating all of the people who put together the Scientific-Atlanta effort. Emmet O'Donnell was the overall leader, and he was available by phone, pager, cellular phone and hand-to-hand message relay for the whole duration. Emmet had plenty of help–most notably, Janet Dixon.

Janet had more facts and figures to deal with than one human could possibly handle, but handle she did. She kept track of where everyone was supposed to be, and who was doing what. The details of access, schedules, food, transportation and anything that had to be done or redone in any category were all handled by Janet–I only saw her once with fewer than two phones in hand.

All in all, this was an exceptional team, and a chance for one of the leading companies in the telecommunications industry to show the world what could be done with great technology and dedicated, hard-working people who built it, debugged it, turned it on and made it fly.

A truly world-class performance, with the whole world looking on. CED

Have a comment?
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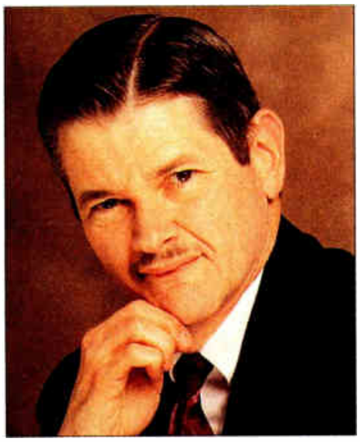

By Jim Farmer, Chief Technical Officer, Antec

The worst thing that the cable industry can do right now is to not stick to its knitting, and give up its video customers to another provider. However, that doesn't mean the industry can't knit gloves as well as sweaters, so long as it continues to raise sweater quality. There are some opportunities out there that make a lot of sense. After making sure its present house is in order, there are new things for the cable industry to pursue.

The industry is high on the idea of cable modems and the possibility of high-speed data into homes. Initial experiments have been very promising, both technically and in terms of customer acceptance. Early rollouts have shown this market to be perhaps 8-10 percent of today's subscribers.

However, more than 30 percent of cable subscribers have computers. Where are the others, and what will it take to reach them, too?

The expectations of "Reals"

When there is significant penetration of high-speed modems to the home, the Internet backbone will slow intolerably. As it is, often my frustration is not with my 28.8 Kbps modem, but with the time I sit there waiting for the "system" to service my request at all. People will become disenchanted if they get fast service to their homes, but are still slowed down by something farther back in the network. Some "commercials" help the problem by caching often-used information, such as local weather, at each point of presence. That should help, but it will require more computer storage in the headend. @Home seems to be following this model, even extending it to its own network that, to an extent, parallels the Internet.

The total job of delivering high-speed data is a lot more than just getting a few modems to work. If on-line service, be it the "commercials" or the Internet, is going to hold people's attention for the long run, and not be the '90s version of citizens band radio, then the industry is going to have to learn a lot more about putting useful information on people's screens. Not that all sites are bad, but there are enough bad ones to discourage "Reals," and complaints are starting to show up in the popular press. The cable industry seems to understand subscribers pretty well; that could be a big advantage over other providers.

Real people (a.k.a., "Reals") expect things to be simple to use and useful. They have no patience with something that it hard to use. How are they going to react when the site that promised so much isn't on-line, or doesn't really contain much?

Here's my ideal of how Podunk Cable's on-line service works. The headend server is a unique front-end to the 'Net, and a basic service. It identifies Podunk Cable as the service provider. The server provides local news and weather, school cafeteria menus (maybe under a "horror" heading), bus, train and plane schedules, and other useful local info. Hey, what about cable TV listings, including descriptions, previews and hot links to show or network sites? It also provides e-mail, both locally and via the Internet. It could provide access to Podunk's favorite Web sites, as the commercials are already doing. Those sites are selected for their relevant information content, accuracy and reliability. (Reliability: Hear that, you Web pages which keep hot linking me to URLs that don't exist?)

Advanced users could navigate to wherever their nerdy little hearts desired, but real people would have an easy to use, reliable, credible service. The Reals wouldn't know they were in the Internet, rather than Podunk's machine.

The front end to the 'Net would provide easy navigation to sites useful to Joe Six-pack (i.e., real people, who pay cable personnel's salaries). Navigation would all be menu- and *useful*-icon-based (another novel concept), and people would never have to meet a URL face-to-face if they didn't want to. Perhaps there is a future for the commercials in providing such headend interfaces to the Internet.

Podunk's home page, where the Reals start their cyber odyssey, is cartoon-based, with lots of color and catchy descriptions. It looks more like a game than anything else. A cartoon character featured on the home page is also featured on simple "how-to-use" videos that run on LO channels.

OK, if that's too big a turn-off to the nerds, who form the first wave of users, then establish a second access that is a normal, nerdy, Web home page. Give people the choice of which one they want to see when they first enter the service.

Fast modems alone won't cut it

Hooking up subscribers to the present Internet will draw in a number of computer savvy individuals who know how to surf the 'Net and who appreciate higher speed. This, and the work-at-home crowd, will provide a good initial market.

However, in order to reach the larger market, modem prices will have to drop further, interfaces will have to be simpler, and content must be better organized, more useful and more reliable. If we really are entering an information age–and we are–the problems will be solved.

But the industry shouldn't kid itself: a fast modem to the home, by itself, is not an automatic ticket to the next wave of per-sub valuation.

Thanks to my oldest daughter, Jeannie, for explaining the proper use of "nerd." She was last heard mumbling something about how I shouldn't have any trouble with that one. Hmm... CED

Have a comment?
Contact Jim via e-mail at:
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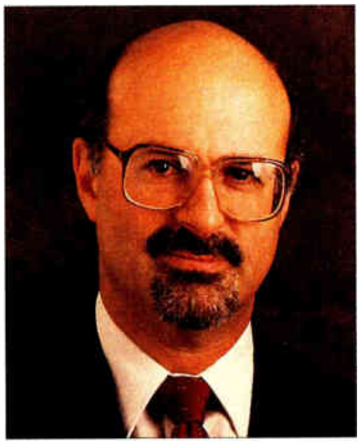
Is an FCC standard necessary for HDTV?



By Jeffrey Krauss, video standards bystander and President of Telecommunications and Technology Policy

Should the FCC adopt the Grand Alliance digital HDTV specification as a standard for broadcasters? Or will broadcasters use it even if it isn't a mandatory FCC standard? Will consumers take the risk of buying new digital TV receivers without an FCC standard? The cable industry argues that no FCC standard is needed. I disagree, but it's a close call. Whatever the decision here, the cable industry's arguments will have a lasting impact on FCC policy.

The FCC recently issued its Fifth Further Notice of Proposed Rulemaking in the proceeding on advanced television, asking whether the FCC should adopt the Grand Alliance digital HDTV system as a mandatory requirement for broadcasters. As I reported three months ago (see "Capital Currents," June 1996), three of the four FCC Commissioners like the idea of adopting the Grand Alliance standard, but FCC Chairman Hundt argued that broadcasters should be allowed to use their channel without any mandatory technical standards.

Now the comments have been submitted to the FCC, and we find that:

(1) The broadcasters and TV set manufacturers support the Grand Alliance standard (no surprise);

(2) The computer industry wants the FCC to prohibit the use of interlace scanning and permit only progressive scanning (no surprise);

(3) Some Hollywood directors oppose the 16 x 9 picture aspect ratio and prefer other ratios (no surprise); and

(4) The cable industry opposes a mandatory standard and supports Chairman Hundt's position (BIG surprise).

Everyone who has been participating in the development of digital HDTV, including most of the cable TV industry, has always assumed that the FCC would adopt technical standards for HDTV broadcasting. Now, that outcome is in doubt.

In its comments to the FCC, the NCTA and other cable industry parties have done the best job I've ever seen of making the argument that the costs of mandatory government standards outweigh the benefits. As I've argued before, technical standards have both costs and benefits. They can freeze the technology and stifle innovation, but they can reduce consumer uncertainty and promote market growth. In general, I would agree with the NCTA that FCC-mandated technical standards are the worst in terms of costs, because they are harder to change than voluntary industry standards.

I would have preferred the FCC to open a general inquiry into the costs and benefits of technical standards, rather than using advanced television as the vehicle for such a major policy assessment. Nevertheless, I am convinced that the FCC will never again propose to adopt mandatory technical standards, except perhaps to control radio interference, or to implement a law passed by Congress (like the V-Chip). The arguments made by the cable industry in this docket will forever stand as a hurdle that proponents of mandatory FCC standards will have to overcome.

I believe that hurdle can be overcome, for the special case of digital television broadcasting. Over-the-air broadcast television is a special service and has a special place in the nation's regulatory structure. It is a universal service, not a supplementary or elective service like DBS, cable TV or cellular telephone service. Consumers must have the assurance that they can tune from one channel to another and be able to receive all the broadcast stations in their service area. Adoption of a standard provides this assurance. I think that absence of a standard will create enough doubt in the minds of enough consumers that some will defer the purchase of new digital TV receivers. The result would be increased equipment costs, slower development of new equipment and new programming, and slower return of the analog TV channels. But it's a close call, because there is no uncertainty among broadcasters—they endorse the Grand Alliance system, and they intend to implement it.

New standards? Forget about it

But why did the cable industry take the lead in this fight? There are several plausible reasons. First is the "slippery slope" argument, namely, that a mandatory technical standard for broadcasters also becomes mandatory for cable. This becomes more evident if the FCC adopts "must carry" requirements that require cable companies to carry the digital signals being transmitted by the broadcasters. The cable industry has settled on QAM modulation rather than the VSB modulation that broadcasters will use, and cable systems will be able to stuff a higher data rate into a 6 MHz channel than broadcasters can. Cable companies should not be required to use VSB modulation, or to limit their channel capacity to correspond to broadcast channel capacity. But there is some risk that mandatory standards could require that.

Another possibility is pure politics. Supporting Chairman Hundt, when he is being opposed by the other three FCC commissioners, could pay off in the future. While a few years ago Hundt and the NCTA were at war, relations are more cordial today, and this NCTA position assures that they will stay cordial.

Finally, there is the argument that absence of an FCC standard will weaken the broadcast industry, and the cable industry favors anything that weakens the broadcasters. This scenario seems least likely to me.

Whatever the reason, the cable industry arguments in this docket have locked in the trend that began when the FCC declined to adopt specific technical standards for DBS and PCS. Don't expect the FCC to adopt standards in the future. But this is a double-edged sword. Forget about FCC technical standards that the cable industry might have wanted, like the Decoder Interface. Did the NCTA consider this aspect in preparing comments on HDTV? I doubt it. CED

Have a comment?
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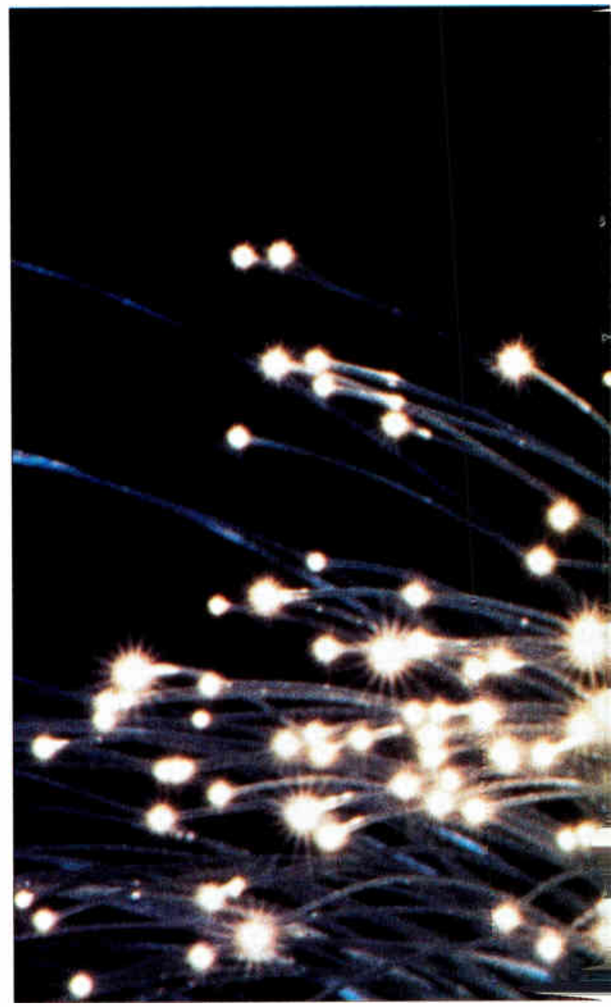
Wave of new products set to break

From 1550 to WDM, choices abound



By Roger Brown

Any video network designer who thought his life became infinitely more complicated a few years ago when fiber optics came on the scene will be astounded by the sheer number of options that are coming on-line today. No longer is it just a debate over 1310 nm vs. 1550 nm, or hybrid fiber/coax (HFC) as opposed to switched digital video: It's that plus a few others. For example, what about Sonet? Should you use DFBs or Fabry Perots in the return path? How big should your node sizes be? When does wavelength division multiplexing make sense? The options are almost mind-boggling.

Furthermore, given the pace of technological innovation, the industry's appetite for newer, better and more cost effective hardware, and the need to upgrade because of competitive reasons, the number of choices will likely only grow. It's no time for the faint of heart.

1550: It's back!

Perhaps the biggest bear to wrestle with is the 1550 nm issue. Whereas before it was a technology searching for a market, it's now enjoying a resurgence that has the likes of Scientific-Altanta, General Instrument, Harmonic Lightwaves, ADC Video Systems and a host of others planning new products to challenge Synchronous Communications, formerly the only game in town. (See story, page 32.)

S-A thinks it leap-frogged most if its competition and caught up to the likes of Synchronous when it purchased ATx Telecom Systems from Amoco Oil Company. For a scant $25 million, S-A gained access to more than 50 patents related to critical optical components, including erbium-doped fiber amplifiers, 1310 nm amplifiers and a wide variety of pump lasers. In addition, the company garnered about 75 people (many of whom are Ph.D.s) and access to ATx's customer list, including Bosch Telecom and at least two other well-know OEMs.

But video network operators will now have access to a suite of products that were actually designed with them in mind, but were simply hard to find. Through the S-A acquisition, "We finally have access to the market and a distribution channel," notes John Clark, chief operating officer at ATx, which will continue to operate as a subsidiary of S-A. "It's like springing forth, finally, into the market."

What ATx brings is a high-gain, high-output erbium-ytterbium doped fiber amplifier that utilizes 800 nm pump lasers that cost less than the 980 nm pumps used in typical EDFAs, says Clark. The ytterbium is energized by the 800 nm pump and then is used as a sort of translator to energize the erbium at levels much higher than those produced by 980 nm pumps. The result? An output measured in the hundreds of milliwatts, vs. 70 to 110 mW with 980 pumps. The co-doping method isn't actually new, but ATx was successful in patenting meth-

PHOTO COURTESY OF CORNING INC.

ods to make the process more efficient (see Figure 2).

Other innovations include ATx's power source, which consists of a solid state laser to send light through a crystal that takes the wide output beam and focuses it into the fiber, as well as converts the wavelength to about 1047 nm, which then pumps the ytterbium fiber.

In fairness, Clark admits that 980 pumps are getting better (he knows because ATx also builds 980 pumps), but says he has an inherent advantage. "While 980 pumps are creeping up in capability, until there's a fundamental change in technology, they won't be as powerful. There are ways to (make them more powerful), but they're a few years away, and they aren't cheap." In addition, because 800 nm pumps are used in a wide variety of applications, both professional and consumer, they'll likely enjoy a price advantage for a long time.

Subtle improvements

Ortel Corp., which owes its success to the popularity of the 1310 nm distributed feedback laser it helped make ubiquitous in cable TV networks, is also branching out into 1550 gear with an EDFA, a transmitter and a receiver. While the company doesn't make any claim to groundbreaking technology changes, executives say there are ways to differentiate their products.

"Looking inside, everybody's products are pretty much the same," notes Larry Stark, vice president of new business development at Ortel. "But as we have studied 1550, we have found areas where we think we can make improvements. For example, there are a number of subtle degradations, such as SBS and SPM (Stimulated Brillouin scattering and self phase modulation), and we're finding ways to control them and improve performance. We hope that our product will be viewed as the performance leader in carrier-to-noise and distortion."

While that remains to be seen, Ortel plans to debut an externally modulated transmitter that, when combined with a 40 mW EDFA, can launch 80 channels of video over 65 kilometers of fiber with a composite triple beat of -71 dB, composite second order of -68 dB and a carrier-to-noise spec of 52 dB. The same link can be configured with about 3 dB more carrier-to-noise with CSO and CTB of -65 dB. "You can view it as a product with two personalities" depending on the operator's preference, Stark says.

With all its in-house expertise, Ortel is also building its own CW and pump lasers. "We believe we can develop the same technology leadership in 1550 that we did with 1310," Stark says.

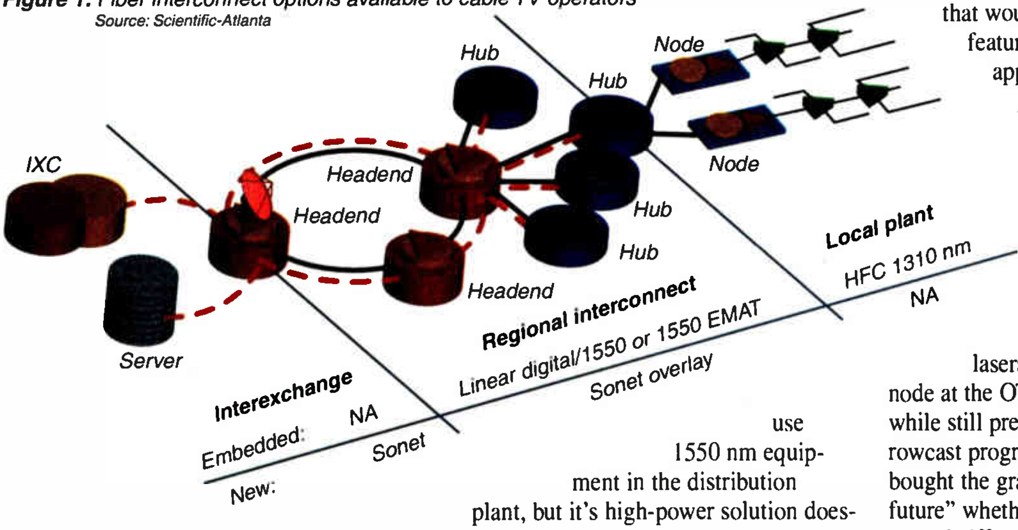
With all the work being done at 1550, how are operators reacting? There is no pat answer. Time Warner, for example, has been using the technology for nearly three years in its transport rings, according to Don Gall,

Time Warner has been using 1550 for nearly three years in its transport rings

senior staff engineer. He, for one, is glad to see other manufacturers get into the game (mostly for the pricing leverage it gets him).

Gall says Time Warner has some, limited plans to use 1550 nm equipment in the distribution plant, but it's high-power solution doesn't make it useful for narrowcasting.

Figure 1: *Fiber interconnect options available to cable TV operators*
Source: Scientific-Atlanta



"We're looking at it on a limited basis for small (systems) that are more rural and have less potential for some of the futuristic services we're talking about," he notes.

TCI, however, is doing very little with the technology, according to Tony Werner, director of technology. Instead, the country's largest operator appears focused on either proprietary digital approaches or Sonet, which is commonly twice as expensive as the digital approach offered by ADC Video Systems, C-Cor Electronics and others.

Coming back around

And some have even used it in the past, but are now reconsidering 1310 nm equipment because performance is improving and costs are dropping. One such operator is InterMedia: "We're swinging back toward 1310" for its interconnects, notes Ken Wright, director of technology and chief technical officer.

InterMedia's approach has been to use a two-level architecture where signals are launched to an optical transition node (OTN), which in turn serves several nodes. This approach reduced the number of fibers that would exit a headend versus an approach that features fibers in a home-run to each node. The approach also allows an MSO to serve high-growth housing areas more easily by dropping in a new node where it's needed.

"You can get there quicker and with less money, and many of the areas we serve are like that," says Wright.

To get the performance he needed, Wright was designing networks that used 1550 EDFAs. But with the advent of low-power 1310 DFB lasers, Wright says he can dedicate a laser per node at the OTN for about the same price as 1550 gear, while still preserving the option to offer targeted, narrowcast programming in the future. "That way, we've bought the granularity we'll need some day in the future" whether that be for targeted advertising or some sort of differentiated programming, Wright notes.

For Wright, the battle between 1550 and 1310 has been nothing but good for him. "The two technologies keep leapfrogging one another, and that's good for us," he points out. "There is no *one* answer."

The WDM solution

In fact, the time may soon be coming when both approaches become the answer–simultaneously. Although by most accounts it's a little early for cable operators, there are tremendous strides being made with wave division multiplexing equipment (which allows both operating windows to be used at the same time), and dense WDM gear that will offer up to 32 different "slots" between 1530 nm and 1560 nm.

Most of the Regional Bell Operating Companies plan to utilize WDM to help relieve congestion brought

New products address niches, too

While they get the bulk of the attention, not everything that's new centers around high-power, expensive and complex optics aimed at multichannel, entertainment video applications. Broadband Networks Inc., a small, State College, Pa. optics company, recently debuted a new product designed to upgrade legacy institutional networks that many cable systems were forced to install back during the franchising wars.

"Franchise renewals and competitive pressures are causing a new interest in I-nets," reports Bob Beaury, president and CEO of Broadband. For example, most of the top 15 MSOs have announced plans to provide schools with high-speed links to the Internet. But the problem is, these networks are typically all coax and are limited in bandwidth–often to just 330, or perhaps 450 MHz. Operators could upgrade them with fiber, but the costs usually far outweigh the business case, Beaury notes.

In response, Broadband developed a single wavelength fiber optic transceiver that can deliver up to three bidirectional services over a single fiber. These services can be either two video-audio and one data, or two data and one video-audio service. The "CyberFiber" transceiver is compatible with all cable modems and operates only in the 1310 nm window, leaving the 1550 nm window open for future services, according to Beaury. This is unlike other single-fiber solutions, which use wave division multiplexing for bidirectional service capabilities.

"This approach even allows one (service) to be given away, while giving the operator a chance to sell the other" and recoup his investment, says Beaury. "And it addresses something they have to do" because of franchise requirements or competitive pressures.

The applications for such a product vary from fast file transfer, high-speed Internet access, videoconferencing, video arraignment and other uses.

Beaury says reaction to the product has been overwhelming, with intense interest coming from Time Warner, Marcus and Comcast, in addition to TCI.

– R.B.

about by burgeoning new services like data transfer, videoconferencing and the sheer number of additional lines being requested.

To meet the need, just about every major telecom equipment manufacturer is getting into the game, although most are focusing on the 1550 nm window, where attenuation is lower and EDFAs can be used. Pirelli made major news at the most recent Supercomm show when it announced a 32-channel dense WDM system, giving telecom providers an amazing amount of new bandwidth without changing transport speeds or adding more fiber.

Clark predicts that a good, usable 1310 amp will be on the scene within a few years

Certainly, Pirelli's target market is the telcos, but the company is seeing interest from MSOs who are interested in offering telephony and data. "Our customer base for these digital applications is really growing," notes Fahri Diner, product line manager at Pirelli.

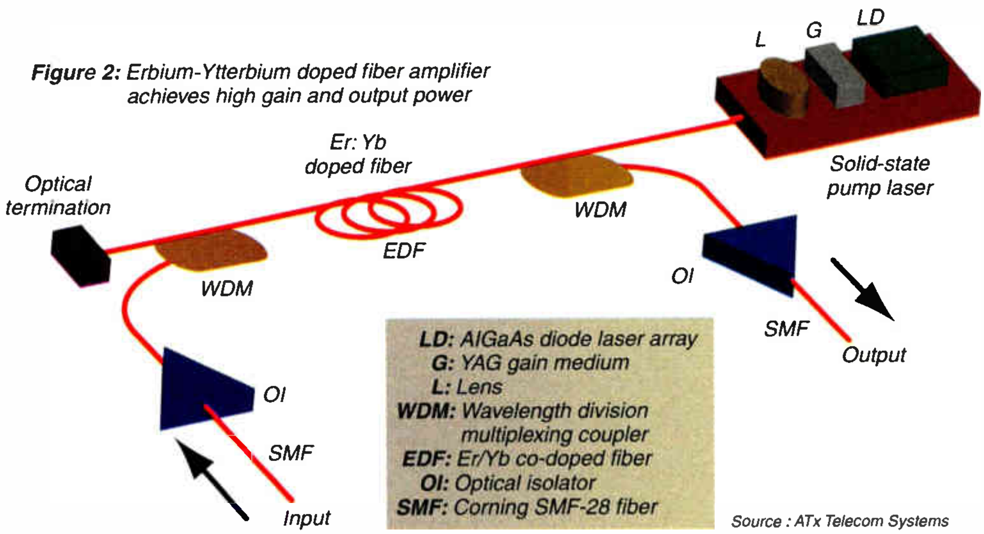
Similarly, Artel Video Systems recently announced a 12-bit digital video transport system that can handle up to 48 non-compressed channels (six channels in each of eight slots) over a single fiber.

"It is becoming more evident that dense WDM will be more cost-effective and quick to deploy than designing higher-speed products, especially in the digital domain," notes George Maier, vice president of marketing at Artel.

But do cable operators need it, yet? It's probably a bit early, but if an operator wants to supertrunk high-quality video, he could use up his usable fiber bandwidth rapidly. And, as Maier points out, consumers' tolerance for low-quality pictures is strained now that DSS and others are offering digital pictures.

Gall and Wright both think it's a bit early to deploy WDM solutions, but the possibility looms. "If, because of telephony or alternate access traffic, we start filling up fibers, we might do it," says Gall. "Right now, most of our rings have an average of 36 fibers, and to broadcast video, we only need two of them. But that's one of those things that's changing rapidly, so it's an option we'll use when we need to."

Figure 2: Erbium-Ytterbium doped fiber amplifier achieves high gain and output power



Source : ATx Telecom Systems

Naturally, a key question for cable TV providers is the isolation between densely-packed video channels, notes John Dahlquist, vice president of marketing at Harmonic Lightwaves. "But it's just a matter of time" before that technology matures, and performance becomes acceptable. "All these things will have their time in the sun," predicts Dahlquist.

Outside of new wavelengths and densely-packed streams, Stark sees a few other trends. "I'm going to go out on a limb and predict that pricing models will begin to follow the personal computer model," he said, "where prices stabilize or perhaps drop a bit, but the performance increases."

Stark says performance gains in lasers and receivers can be made in distortion, carrier-to-noise and channel count. "I still think the end-game with HFC networks is fiber to the last active," he stresses. "We'll eventually get to the point where the fiber link will define the performance between the headend and the home. Today, it's fiber and coax, but someday, the coax goes away."

Being the DFB champion that he is, Stark also says the time is ripe for an uncooled DFB in the return path, a product the company recently announced. "It gives at least 10 dB of headroom over a Fabry Perot, which ought to give operators more confidence in their networks," he notes. That might explain why Stark says he's been "overwhelmed" with interest in the product.

But, once again, there's a divergence of thoughts on the subject. "Everything we have done so far suggests that we can make Fabry Perots work for a digital return, as long as we don't have to do two-way video," says Gall. "If we do have a need for a really high-speed data path or a video return, such as an I-net for a school, then we'll put in a DFB. But that's a one percent solution."

Lab work

Finally, for those who like to look way out on the horizon, there's the 1310 nm, praseodymium-doped fiber amplifier. While some prototype and demonstration devices have been built, they aren't commercially viable yet because of the cost, according to ATx's Clark. "The problem is the fiber–it soaks up water and turns to dust."

One fiber that has been developed to overcome that problem has its own problem–it can't be fusion spliced. Nevertheless, Clark predicts that a good, usable 1310 amp will be on the scene within a few years, but it will take longer than some predict. "There are plenty of papers that say it will work," he says. "But that's just guys in the lab. They don't have to make customers happy or produce any real products."

With all the new and improved products coming over the horizon, a network designer's choices won't get any easier. But the tools should make the final product–the video network–stronger than it's ever been. CED

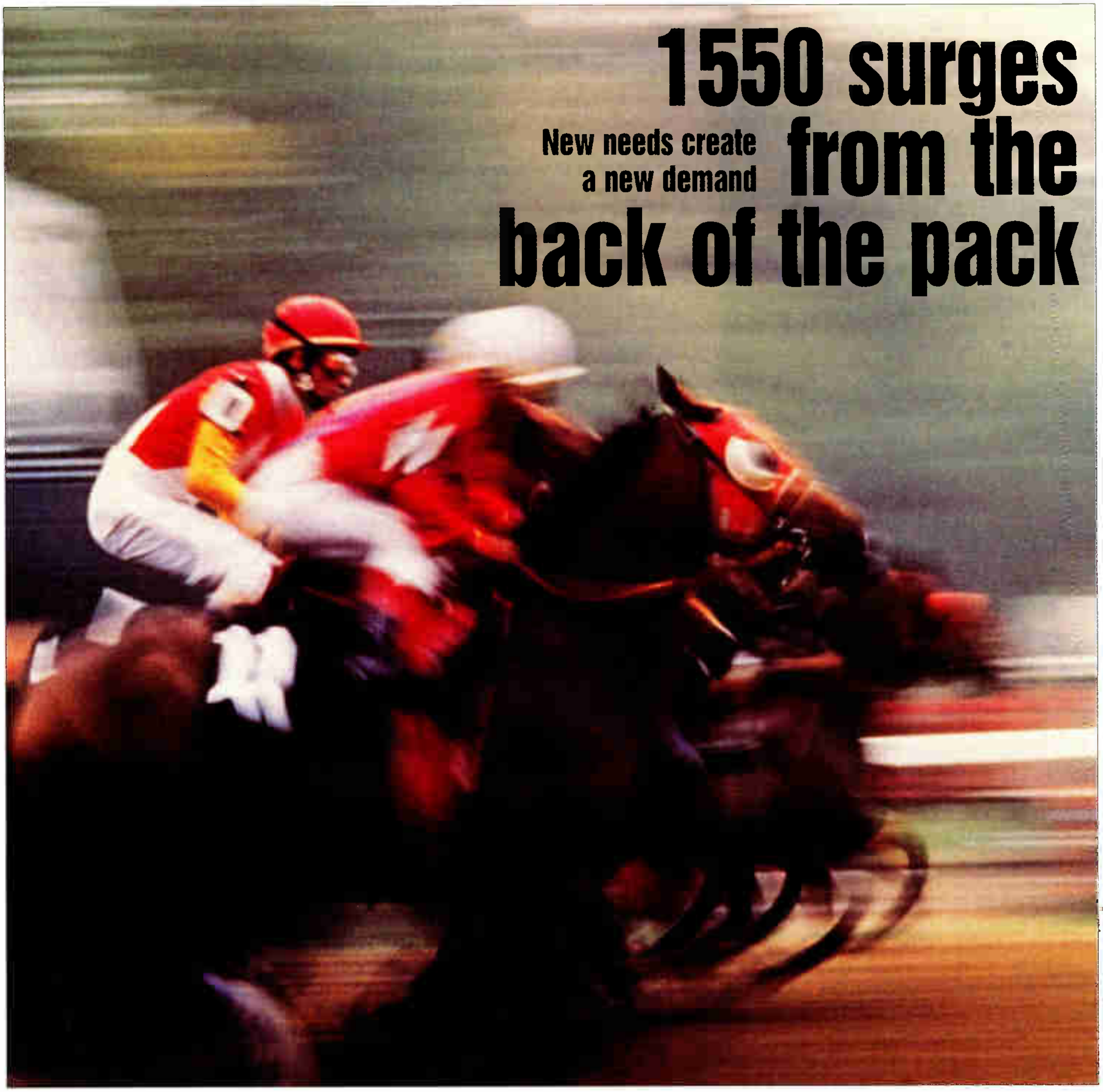


PHOTO BY FRANK WHITNEY, THE IMAGE BANK

By Roger Brown

You don't have to go too far back in the history books to find a time when, if you announced to the world that you planned to deploy 1550 nm fiber optic technology, you were considered odd, or unique. After all, 1550 was itself an oddity–a distraction to those who were lobbying cable operators to deploy fiber as fast as possible, but preferred that they use 1310 nm gear.

Just ask Wilt Hildenbrand, vice president of technology at Cablevision Systems. After all, it was he and Al Johnson (now president of Synchronous Communications) who designed and installed perhaps the most extensive 1550 nm cable system in this country. At the time, they were swayed by 1550's ability to be amplified, as well as its lower attenuation, and hence, longer reach into the network. Although he was comfortable with his decision, and it was one that made sense, Hildenbrand was often privately criticized for his actions.

"That's an old wound that has finally healed," Hildenbrand said during an interview earlier this year. Yet he remains mystified why his colleagues reacted the way they did. "There are very few things that have happened in this business that have caused a reaction like that, but this certainly caused a reaction. It caused quite a stir, and I never knew why. To this day, I don't know why. But it doesn't matter to me. To us, it wasn't a case of right or wrong. It worked for us."

But, as is often the case, market forces and product innovation came to 1550's rescue. Perhaps it should come as no surprise that as cable operators have become more familiar and comfortable with fiber optics, that they have also broadened their searches well beyond the obvious for network solutions. But what might surprise many is the rapidity of the resurgence and the number of companies that are now developing products for use at 1550 nm.

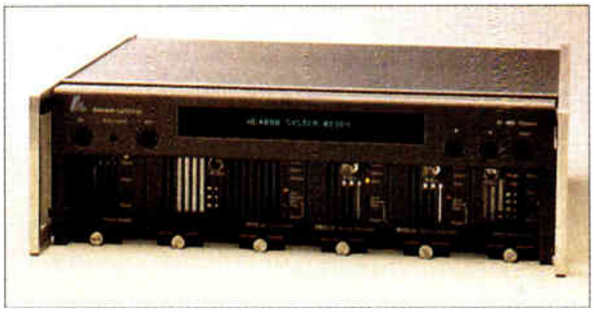
Even 1310 evangelist Larry Stark, vice president of new business development at Ortel Corp., has changed his tune. After pronouncing the 1550 approach "dead" in the pages of this magazine several years ago, Stark now says the diagnosis was slightly premature.

"When I made my famous statement, I think it was true at the time," says Stark now. "Our sense was that people were being distracted by too many technologies when 1310 (equipment) was exactly what they needed." Yet Stark understood why Hildenbrand and a few others were intrigued by 1550: "It was a technology that was ahead of its time. People were fascinated by it because it could be optically amplified, but they didn't know how to use it."

But now that many cable systems are actively "clustering" their systems in order to dominate major urban and suburban population areas, they're focused on interconnecting what were once disparate cable systems into a single, large, unified cable network. This approach allows them to collapse headends and share costs across a much wider subscriber base, ultimately saving them money.

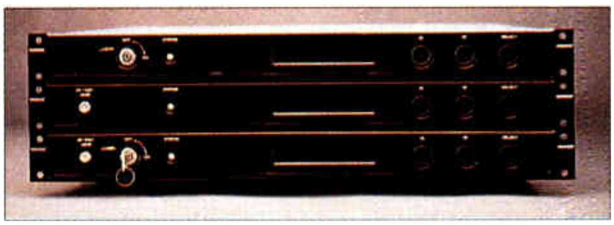
In scenarios such as this, 1550 gear plays nicely because of its inherent lower attenuation, its ability to easily amplify signals via the erbium-doped fiber amplifier, and the "broadcast" nature of sending the same signals to several hubsites. Plus, the technology has improved.

In the early days, some companies were using directly modulated distributed feedback



Harmonic Lightwaves' MAXLink 1550 nm transmission system.

lasers to drive 1550 transport systems, which introduced laser chirp and fiber dispersion. Today, most manufacturers have switched to transmitters that feature external modulators and continuous wave lasers to offer video net-



Ortel Corp.'s 1550 nm broadband transmission product.

work providers a reliable and cost-effective solution for the interconnect portion of their networks, notes Stark.

International applications are also driving the resurgence in 1550 technology. With limited reason to offer targeted advertising, interactive TV or differentiated programming, many HFC systems being built abroad are interested in one thing: getting video in front of as many eyeballs as possible for as little money as necessary.

Under that scenario, 1550 plays quite nicely, according to Gary Lyons, director of the optoelectronics business unit in Scientific-Atlanta's transmission systems division. "We've done a lot of economic modeling, and it does suggest that if you want the lowest cost method of getting video out, in most cases, it's the 1550 approach," Lyons says. "So if the operator is willing to defer the expenditure for interactivity for three to five years, then 1550 plays very nicely."

John Clark, chief operating officer at ATx, which was recently purchased by Scientific-Atlanta, sums it all up this way: "The model is changing: before, everybody said, 'Tell me THE answer for my optical network.' But today there's a richer toolkit that never existed before, so the answer depends on who you are, where you are, the money you have to spend and the services you want to offer."

"There's been a heck of a lot of 1550 gear put in over the last two years or so," notes John Dahlquist, vice president of marketing at Harmonic Lightwaves. And now that his company is about to begin shipping 1550 equipment, he hopes the trend continues.

He suspects it will, driven by operators who need to interconnect networks, collapse headends and want broad pipelines for high-speed Internet access, video-on-demand applications and similar new, bandwidth-hungry applications. "The digital (set-tops) should also be out soon, which will drive this need even more," Dahlquist argues. CED

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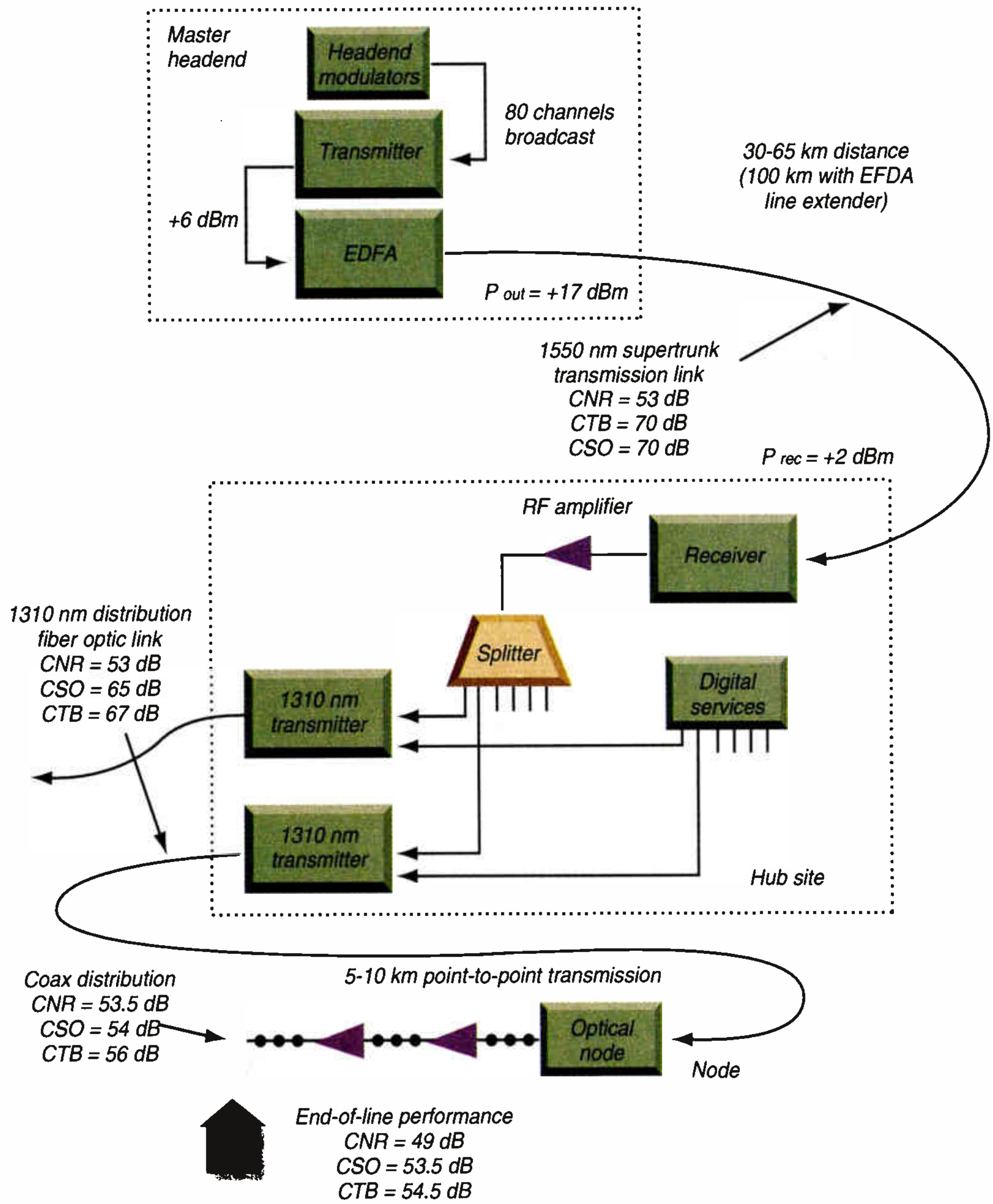
Enhancing long-haul performance with 1550 nm links

Adventures in supertrunking

Figure 1. Forward path transmission link example. In a dual ring, cascaded link design, the service to the home is delivered over cascaded fiber optic links and a coaxial network. Using high performance transmitters, EDFAs and receivers, operators can achieve high performance signal delivery to homes and businesses.



By Rudy Hofmeister, Staff Scientist, Ortel Corporation

Since 1990, linear fiber optic technology has transformed the design and performance of cable TV networks. Historically, the vast majority of fiber optic links installed in cable TV systems have operated at 1310 nm in the distribution path of the network. While 1310 nm properties remain prevailing for distribution, with the rising need of operators to connect headends and hubs over distances greater than those used in the distribution path, development of supertrunks became necessary.

Many cable TV network providers are taking advantage of the unique properties of 1550 nm for supertrunk links; namely, lower optical loss, and the availability of high power optical amplifiers. Taken together, these properties enable longer transmission distances than with 1310 nm links, thus enabling high performance supertrunk links for connecting headends together in large metropolitan areas. The resulting cascaded link architectures eliminate "home run" fiber links from the node to the master headend and provide the opportunity for local interactive digital signal origination at hubs serving 20,000-40,000 homes passed.

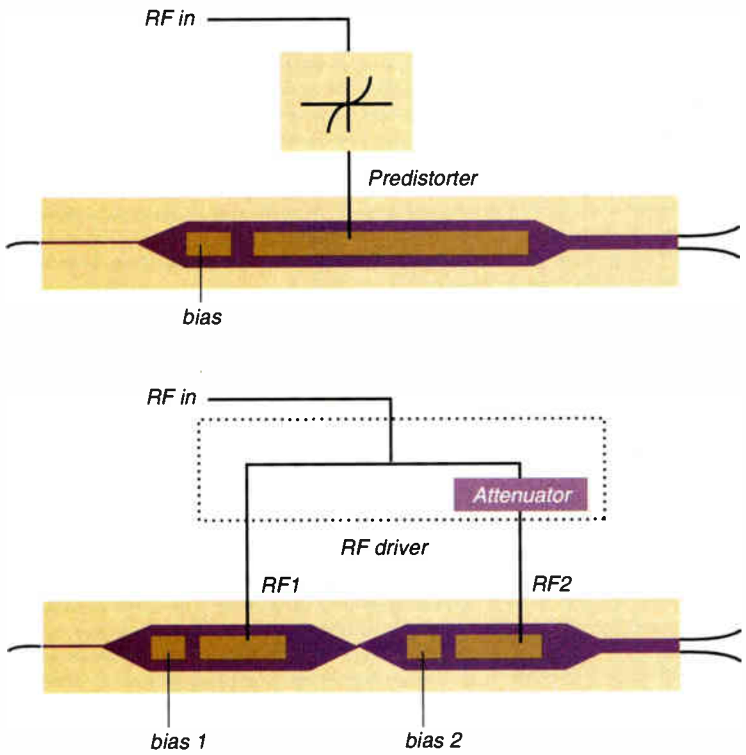
Links at 1550 nm differ in two important respects compared to 1310 nm links. First of all, because most installed fiber has its zero-dispersion wavelength at 1310 nm, the dispersion at 1550 nm is quite large—as much as 17ps/km/nm. This large dispersion prevents direct modulation of the laser as a viable option because of the attendant laser chirp. Instead, low chirp external modulation is used. Secondly, the presence of high-power optical signals at the output of optical amplifiers makes fiber nonlinearities a dominant concern. Stimulated Brillouin scattering (SBS) and self phase modulation (SPM), in conjunction with the high fiber dispersion, both contribute to noise and distortion products.

Specifying and operating a 1550

nm supertrunk transmission system requires knowledge of these issues. In addition, when a system designer uses 1550 nm, there are a number of system-level issues that must be addressed in order to achieve the desired performance.

This article will briefly discuss these issues, and then examine aspects of system design of 1550 nm links, including integration of components and how the component integration affects the performance of the link, measured in terms of the carrier-to-noise ratio (CNR), composite second order (CSO) and composite third order distortions (CTB) at the receiver.

Figure 2: Lithium niobate modulators come in two varieties: the Mach Zehnder modulator, and the optically linearized modulator. The top portion of the diagram shows the Mach Zehnder modulator with an electrical predistorter. The bottom portion shows an optically linearized modulator which provides optical predistortion when driven with the signal splitting drive circuitry shown.



1550 nm and 1310 nm

There are a number of tradeoffs between the technologies to transmit cable TV signals at 1550 nm or 1310 nm. First we discuss 1550 nm technology.

Transmission at 1550 nm benefits from the obvious advantage of lower optical loss than 1310 nm: 0.23 dB/km vs. 0.4 dB/km. Thus, for a given transmitted and received power, the ends of a link can be spaced nearly twice as far apart. The majority of the optical loss in silica fibers is due to Rayleigh scattering off of the atoms of the fiber core. This scattering process weakens as the inverse fourth power of the wavelength—hence the substantial difference in optical loss between these two wavelengths.

In addition, erbium-doped optical fiber amplifiers (EDFAs) are available in the 1540-1560 nm wavelength range. These amplifiers function by stimulated generation of signal photons in the 1550 nm range by conversion of photons from a pump wavelength, generally either 980 nm, 1060 nm, or 1480 nm. The pump beam excites erbium atoms in the fiber core to an excited state, from which they can undergo stimulated decay back to a ground state, emitting 1550 nm photons in the process. This amplification occurs with a low noise figure–typically on the order of 4-5 dB. For this reason, an optical signal maintains significantly higher CNR with optical amplification than with detection and optical regeneration at 1310 nm. Additionally, no further distortion is added in the optical amplification process. Finally, optical amplification is completely protocol transparent. That is, the EDFA is indifferent to the modulation scheme and signal bandwidth on the optical carrier.

Figure 1 is an example of a modern HFC architecture using point-to-point "super trunk" transport. Super trunks are used to connect multiple headends together over large distances, as high as 100 km. This obviates the need to duplicate expensive transmission equipment at each headend. One additional benefit of the long link range for 1550 nm supertrunks is that they provide the option of path diversity redundance, a factor that is extremely important in guaranteeing high network reliability.

The repeated HFC system in Figure 1 shows a supertrunk transmitting signals to the hub, and 1310 nm DFB transmitters distributing signals to the optical node. The supertrunk can use 1310 nm DFB lasers for link distances under 30 km or so. In the figure, the 1550 nm long-haul option is shown. Additional narrowcasted programming is inserted at the hub, and the composite signal spectrum is transmitted to the node over a single fiber. This "single fiber" architecture has become the preferred architecture for interactive HFC networks among many MSOs recently.

As with any technology, there are a number of performance limitations with 1550 nm links. The most obvious of these are the presence of fiber nonlinearities that cause excess noise and distortion in the link. These nonlinearities—SPM and SBS–are present in 1310 nm systems also, but they are insignificant at the low optical powers used in conventional 1310 nm HFC networks. These nonlinearities can be eliminated or compensated for with careful system design. This requires a solid understanding of the nonlinear mechanisms on the part of link equipment designers.

There are also deleterious effects on link performance because of linear fiber dispersion. Most singlemode fiber deployed to date has a zero-dispersion wavelength tuned to 1310 nm. Thus, 1310 nm links are at most a few nanometers off from the zero-dispersion point. At 1550 nm, on the other hand, the dispersion may be as large as 17 ps/km/nm. This dispersion will cause a frequency-dependent contribution to system-level CSO when present in conjunction with any type of link chirp.

Fiber effects on 1550 nm transmission

There are several fiber-induced effects that degrade performance of 1550 nm links. These are stimulated Brillouin scattering (SBS), interferometric intensity noise (IIN) and dispersion, in combination with modulator chirp or self phase modulation (SPM).

Stimulated Brillouin scattering

SBS is a nonlinear fiber effect that restricts the amount of optical power that can be trans-

mitted through optical fiber. At high intensities, an optical beam of light generates ultra-high frequency acoustic vibrations (acoustic phonons) in the fiber. These vibrations cause periodic changes in the optical refractive index of the fiber, off which the optical beam scatters. When the original optical beam is of sufficient intensity, the back scattered wave (the Stokes wave) is amplified. This leads to depletion of the forward propagating beam, as well as noise and distortion in the forward direction. In conventional singlemode fiber at 1550 nm, the SBS threshold normally occurs at 4-5 mW. The lifetime of the phonons is relatively long—50 ns. In order for the SBS effect to occur, the stimulated backscattering from all components of the optical beam must add in phase throughout the phonon's lifetime. This means that, by the tenets of wave theory, the optical spectrum of the beam must be narrower than approximately $\sim 1/t = 1/(50\times10^{-9}s) = 20$ MHz.

SBS is defeated by spreading out the optical spectrum into components that are separated by more than 20 MHz. That way, each individual component is unaffected by the others, and as long as no one component's power exceeds the SBS threshold, SBS will not occur. However, since optical signals with multiple frequency components cause frequency "beats" at the detector, it is important to space them far enough apart so that beat-products fall out of band. Typically, the spectrum is spread over multiples of at least twice the highest video subcarrier frequency so that the new optical carriers do not interfere to generate in-band distortion. Optical spectrum spreading is achieved by frequency chirping the source laser with a tone applied to the bias current, and/or by phase modulation directly on the modulator. Using these techniques, it is possible to achieve SBS suppression at launched powers of greater than 17 dBm.

SBS is defeated by spreading out the optical spectrum into components that are separated by more than 20 MHz

Interferometric intensity noise

Interferometric intensity noise (IIN) is already familiar to designers of 1310 nm directly modulated links. The mechanism here is that double-back-scattered light interferes with nonscattered light to create low frequency noise in the forward direction. The scattering centers can be distributed, as in Rayleigh scattering, or discrete, as in connectors or bad splices. The noise bandwidth is roughly twice the source laser linewidth, although the tails of the laser spectrum can easily generate noise out to many multiples of the laser linewidth. The solution to this problem is to make the laser linewidth narrow enough that the noise generated above 40 MHz is negligible. This requires the typical linewidth of the source to be less than approximately 2 MHz.

Dispersion

Dispersion is a linear effect whereby different frequencies of light travel with different group velocities through the fiber. For

1550 nm signals propagating through 1310 nm fiber, the typical dispersion is 17 ps/km/nm so that, for example, two beams spaced by 1 nm in frequency and propagating through a 1 km link would see a relative delay of 17 ps with respect to each other. Both modulator chirp and self phase modulation cause a shift in the optical frequency in response to the applied RF modulation. Thus different time segments of the optical signal travel through a dispersive link at different velocities. Thus, the peaks of the AM signal are delayed relative to the valleys of the signal. This process generates distortion when received with any square-law detector[1].

Self phase modulation (SPM)

SPM is caused by a change in the optical index of refraction with intensity* (see page 46). The intensity dependent nonlinear index causes a phase shift of the signal that is proportional to the instantaneous intensity and to the propagation distance in the fiber up to a maximum effective length of approximately 20 km at 1550 nm. Since the signal is AM modulated, the local phase shift corresponds to a local frequency shift which, via fiber dispersion, becomes a relative delay increasing linearly with propagation distance. This way, the AM modulated signal is progressively distorted as it travels down the fiber. SPM leads primarily to second-order distortion with power proportional to L^2f^4, where L is the link length, assuming L > 20 km, and f is the modulated frequency.

The use of chirp-free modulators is generally preferred in long distance analog links

It is important to clarify the distinction between the direct effects of SPM and that of dispersion after SPM. As stated, noticeable SPM occurs only near the launched end of the fiber where the intensity is high. In this region the phase shift increases linearly with fiber distance. As the intensity drops after 20 km or so, no further significant phase shift occurs. Meanwhile, the phase shift spreads the optical spectrum of the AM modulated signal, and these spectral components undergo dispersion which increases linearly with distance *ad infinitum.*

As an example of this, consider a link with cascaded EDFAs. Immediately after each EDFA where the intensity is high, SPM causes intensity modulated phase shift. But the associated spectral broadening will cause relative delay from then on. Assume the link is of length L, has an EDFA at the origin and a second one at an intermediate distance D, and that the launched power out of each EDFA is equal. In this case, the SPM from the first EDFA will have a much greater effect on the distortion of the link because it is affected by the dispersion due to the entire link L, while the SPM from the second EDFA is only dispersed by the distance L-D.

Modulator chirp

It is also important to consider the effects of modulator chirp on the link performance. Modulators with non-zero chirp will phase modulate a signal in addition to the desired amplitude modulation. It is well known that phase modulation can be converted into amplitude modulation via dispersion as the signal propagates through the fiber[2]. This process yields distortion—primarily CSO—in the received signal. Chirp-free modulators will not exhibit this effect, and it is for this reason that the use of chirp-free modulators is generally preferred in long distance analog links.

Externally modulated transmitter

General

The transmitter is at the heart of the 1550 nm link. Because of the large fiber dispersion at 1550 nm, the use of direct laser modulation is contraindicated. Instead, commercial links are currently externally modulated, either using Mach-Zehnder modulators (MZMs), or optically linearized modulators (OLMs). In both cases, the second order distortion is eliminated, to first order, by appropriately biasing the modulator. The performance of the link with respect to third order distortion depends strongly on the method of linearization of the modulators, and on the care taken in this process. Regardless of the method of third order linearization, corrections of 30-35 dB must be achieved over the CTB performance of a single stage modulator in order to meet the requirements of cable TV links. In addition, the source laser has characteristics that are critical to link performance.

Mach Zehnder modulators are almost universally chirp-free

Source laser

The source laser's primary characteristics are output power, wavelength and chirp; each of these can affect link performance.

The transmitter's output power is directly proportional to the source laser's optical output power. This fact is important because the effective relative intensity noise (RIN) introduced by an EDFA with a given noise figure is inversely proportional to the input optical power to the EDFA. (Relative intensity noise is defined as the ratio of intensity fluctuations in a 1 Hz bandwidth to the total optical power.) Thus it is important to make the laser as powerful as possible. For a link where the EDFA RIN contributes about half of the end-of-line noise, you will see 0.5 dB improvement in CNR for every 1.0 dB increase in laser power.

The source laser RIN also adds to the noise in the link. However, if the RIN is kept to less than -165 dB/Hz, then this noise contribution is minute, degrading the CNR of the link by only one or two tenths of a dB.

As stated above, the linewidth of the laser is also important. In order to reduce the effects of IIN at the lower frequency range of the cable TV band, the linewidth should be < 2 MHz.

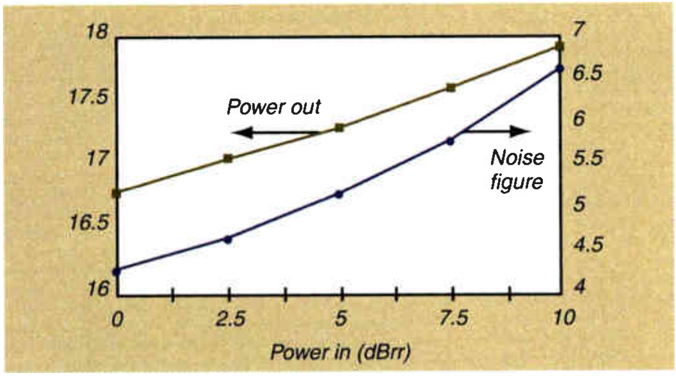
Modulator

The external modulator used generally falls into two categories: either the Mach Zehnder modulator, or the optically linearized modulator.

✔Mach Zehnder modulator. The Mach Zehnder modulator is linearized by the use of an electrical predistorter that precisely compensates the third-order sinusoidal nonlinearity of the modulator as shown in Figure 2. Up to 35 dB of correction must be achieved with this method, and this must be stable over the temperature range of operation. Mach Zehnder modulators are almost universally chirp-free.

✔Optically linearized modulator. An optically linearized modulator consists of two cascaded interferometers as shown in Figure 2. The RF signal is applied to each interferometer input, RF1 and RF2. The input to RF2 is identical in phase to RF1, but is attenuated by a fixed and

Figure 3: *Expected output power and noise figure vs. optical input power to a typical dual 980 nm pumped EDFA with total pump power of 150 mW. Noise figure includes a typical input isolator loss of 0.7 dB. Noise figure and output power both increase with increasing input power.*



predetermined amount. The cascaded interferometers perform both the modulation and distortion correction on the same lithium niobate substrate, hence the performance is quite stable over the operating temperature range. It must be noted that the chirp of the optically linearized modulator is not necessarily zero, so that the modulator can contribute to dispersion-induced CSO. It may be considered important to account for and deal with this effect in links of over 40 km.

Erbium doped fiber amplifier

General Design

Several parameters affect the overall performance of an erbium-doped fiber amplifier (EDFA). The main ones are the noise figure, the noise figure slope with input power, the output power, the gain and noise figure across the input spectrum, and the polarization mode dependence of the above.

There is generally a tradeoff between the output power, which relates to the efficiency with which the pump light is absorbed, and the noise figure of the amplifier. If most of the pump is absorbed, it means that the pump intensity is low at one end of the erbium fiber in the amplifier. Therefore, the inversion coefficient will be low at this point, and this will degrade the noise figure. To combat this problem, it is common to make two gain stages, one a low noise preamplifying stage with high inversion coefficient, and one a pump efficient power amplifying stage. In any multi-pump architecture, care must be taken to avoid pump laser interactions which can lead to laser instabilities.

Noise figure

The noise figure of an EDFA is calculated in a similar manner to that of an RF amplifier. It determines the excess noise introduced by the optical amplifier, where excess noise is defined as the total noise minus amplified noise from the input. If this excess noise is measured and is compared to the noise contributed by a shot-noise limited source with the same power as the input power to the EDFA, the difference between these two is the noise figure.

It is important to note that the noise figure increases with input optical power. Figure 3 shows expected noise figure vs. input power for a typical EDFA design. The noise figure increase happens because the erbium ion inversion becomes depleted as the input power increases and the gain is saturated. In addition, by the definition of noise figure given in the previous paragraph, any passive loss at the input of the EDFA adds directly to the resultant noise figure. For instance, because input isolators are almost always required, it is necessary to include their typical 0.8 dB loss as an addition to the noise figure.

Pump lasers

The absorption spectrum of erbium ions in silica has several broad absorption bands near 1 micron and 1.5 microns. The erbium ions are typically pumped with lasers in these bands. These may include lasers at 980 nm, 1480 nm, or solid state lasers in the 1.05 micron range. Figure 4 shows how the various wavelengths can be used to pump the erbium ions.

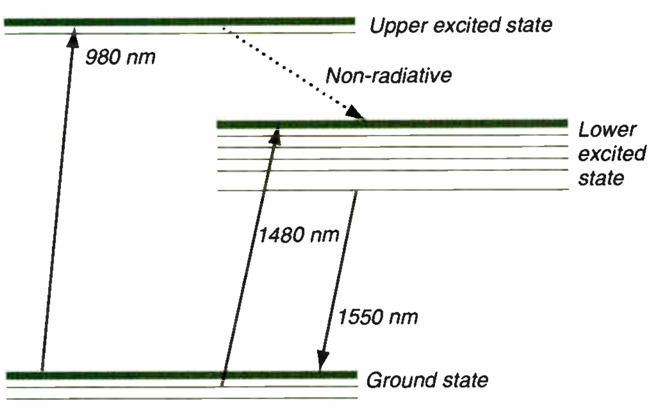
✔1480 nm pumps. 1480 nm pumps were traditionally considered more reliable than other types. However, reliability studies of 980 nm DFBs over the past few years have essentially eliminated this concern. 1480 nm pumping enjoys higher conversion efficiency, but gives a higher amplifier noise figure than pumping at the 1 micron band, even in Er:Yb codoped fibers. The higher noise figure can be attributed to the erbium system being pumped as a two-level system which leads to a lower inversion coefficient than three-level pumping (see Figure 4).

In some amplifier architectures where 1480 is used, it is placed in a power amplifying second stage, while the preamplifying stage is pumped at 980. This mitigates some of the noise figure penalty; nevertheless, there is always some penalty.

✔980 nm pumps. Pump lasers at 980 nm have come more into favor recently as it has been shown that they can be operated with e[illegible] reliability. EDFAs pumped with 980 nm [illegible] use the 1 micron band to excite the erbium ions in a three-level pumping scheme. This type of pumping allows much more compl[illegible] inversion of the erbium ion concentration th[illegible] 1480 nm pumping. As a result, the noise figure of 980 nm-pumped amplifiers is significantly better than 1480 nm-pumped amplifiers.

✔Solid-state pumps. Other schemes exist for pumping EDFAs, such as the use of diode-pumped solid state lasers. Here, 800 nm lasers, for instance, may be used to pump solid-state lasers near 1.06 microns. These solid state lasers then pump the erbium ions in the 1 micron band. While this method gives a low noise figure, it suffers from reliability issues inherent in using multiple pumping sources–more components can fail. This technique can be used to provide EDFAs with high output power, however.

Figure 4: *Schematic view of the electronic levels of erbium ions in optical fiber. 980 nm pumping populates the highest excited state, mimicking a three-level laser system. The population inversion obtained between the lower excited state and the ground state is higher than if the lower excited state is pumped directly, as it is with 1480 nm pumping.*



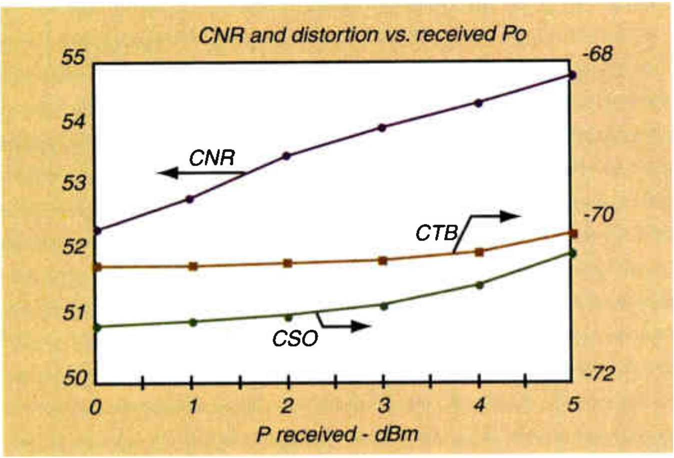


Figure 5: *CNR, CTB and CSO expected for a 65 km 1550 nm link driven with a 79 channel NTSC plan at 3.0% OMI/channel, as a function of received optical power. The CNR improves with higher received power because the contribution of shot noise at the receiver decreases. The distortion increase is entirely due to receiver distortion.*

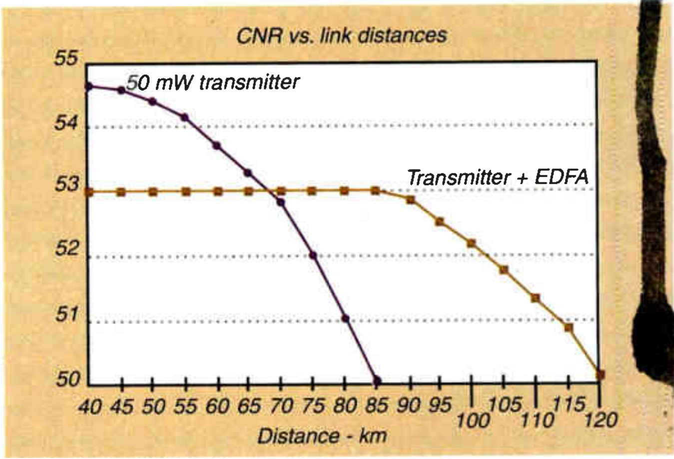


Figure 6: *CNR vs. link distance for a 1550 nm link with the 79 NTSC channel plan, assuming a maximum of +3 dBm received power. The upper curve is for a transmitter and 50 mW power boosting EDFA. The lower curve is for the same 50 mW transmitter along with a booster EDFA at 40 km.*

Receiver

General

The CNR of a link as a whole is degraded by noise contributions from all components of the link. Hence, the CNR at the receiver is as important to link performance as the transmitter CNR. The distortion products of the receiver may have a greater or lesser effect on the net distortion levels, depending on how the distortion adds. If the mechanism for distortion in the receiver and in the transmitter is the same, and has the same phase, then it is likely that the distortion adds in amplitude, obeying the "20 log" rule. If the distortion mechanisms are unrelated, then it is likely that the distortion adds by power, i.e., according to the "10 log" rule. If fortune smiles on the system designer, it may even be possible to achieve some cancellation of distortion products, so that the net link distortion is better than that of any of the individual components. This point should be kept in mind when evaluating link performance—it may depend somewhat on the receiver used.

Received power

The CNR of the receiver, more than anything else, is dictated by the received optical power, rising in direct proportion to received power. Thus there is an advantage to operating at as high a received power as is feasible, given the link optical loss budget, the receiver distortion, and the effects of SPM. In a well-designed link the noise contributions that determine CNR will be split fairly evenly between EDFA RIN and received shot noise. Hybrid amplifier noise and source laser RIN should be minor contributors. This means that an increase in the received power by 1 dB should lead to an increase in the link CNR by about 0.5 dB. Figure 6 shows the CNR and distortion expected in a link as a function of received optical power.

In receiver design, there is a tradeoff between received optical power and distortion induced by the photodiode or receiving module, and also noise of the photodiode. It is nevertheless possible to design a receiver for +3 dBm received power, with noise of about 8pA/Hz$^{1/2}$ and cumulative distortion products typically in the mid- to high 70s for a 79 channel NTSC plan with 3 percent OMI per channel.

Putting it all together

Small degradations in every aspect of the system design add up quickly, and system performance can be adversely affected if any one of the components is not designed to synergize with the system as a whole.

We have shown that the performance of the laser, including its output power and RIN, is crucial to the CNR of the link. Other factors are the received photocurrent at the receiver, the responsivity of the photodiode and the noise figure of the EDFA. It is also important to take care to ensure that the amplifier noise contributions in the transmitter and receiver are minimized.

Finally, the response of the link must be equalized because CNR must be specified as a worst case number, i.e., the CNR actually measured in the link will be the CNR for a flat system minus half the peak-to-peak ripple in the frequency response.

When a link is carefully designed, and attention paid to all the system components, it is possible to achieve good performance over link distances exceeding 60 km. Typical measured performance for a well designed link using the 79 channel NTSC plan is CNR = 53 dB, CSO/CTB = -70 dB over 65 km. See Figure 6 for typical achievable CNR vs. link distance for a link operated both with and without an EDFA.

Conclusion

From the discussions in the previous paragraphs, it should now be apparent that there are numerous challenges inherent in the design of a 1550 nm link. Because the performance of the link is critically dependent on all aspects of system implementation, it is important to choose components that have been designed and selected to go together. Despite the difficulties in implementing 1550 nm, there are a number of compelling reasons to use it over 1310 nm for supertrunking. The final result is that when a link is carefully designed, it is possible to achieve long haul performance that cannot be matched with 1310 nm. CED

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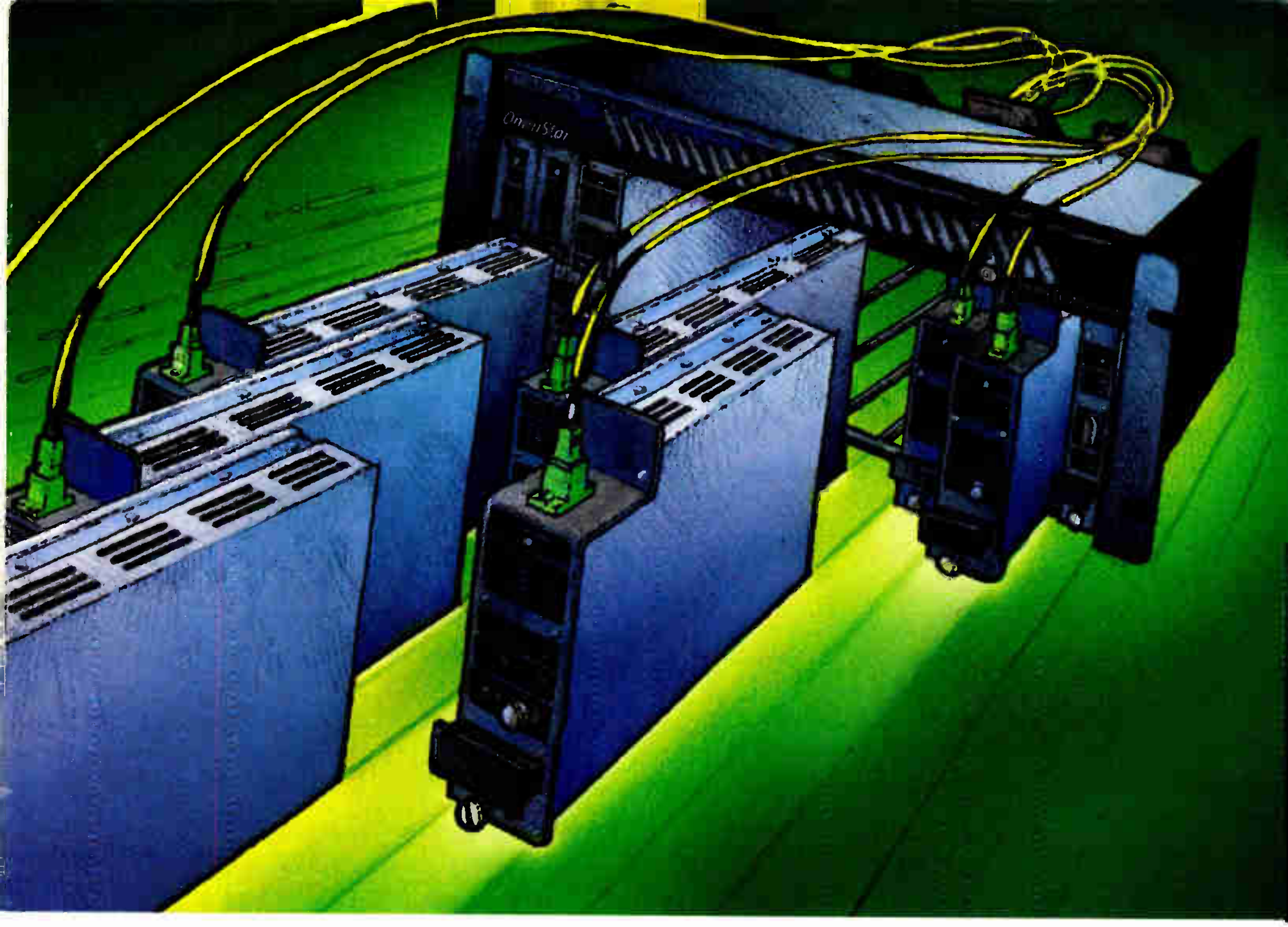
* In particular, the optical refractive index is given by $n = n_0 + n_2 I$, where $n_2 = 2.5 \times 10^{-16} cm^2/W$ in silica, and intensity (I) is calculated using an "effective area" of singlemode fiber that is approximately 80 μm^2.



New technology optimum for 1550 networks

Industry reaching the limits of 1310 nm transmission

By Dan O. Harris, Ph.D., Market Development Engineering Manager, Broadband Technology, Corning Inc.

Since 1990, optical fiber has been installed by cable TV operators at a brisk pace. The cable TV segment of the North American optical fiber market grew by almost 100 percent each year between 1990 and 1994, and continues to grow at a moderate but impressive rate. Operators are now taking dedicated fibers to smaller segments of the population, extending fiber deeper into their systems.

New architectural developments and services are spurring further installation of fiber in cable TV networks. These include consolidation and regional interconnection of headends and distribution hubs with highly reliable, bandwidth-rich, redundant optical fiber rings; the emergence of telecommunications, such as plain old telephone service (POTS) and personal communications services (PCS); and the burgeoning demand for high-speed data delivery, including video-on-demand (VOD) and Internet access.

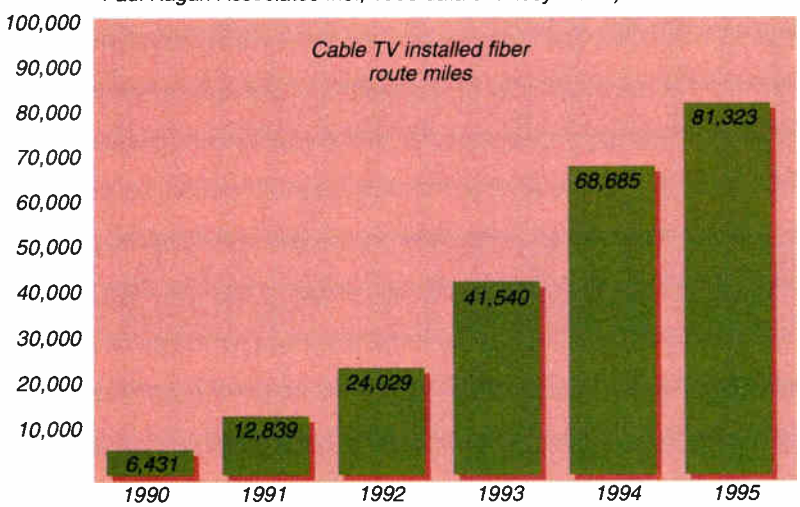
Improved signal quality and increased bandwidth to extend the usable RF spectrum are crucial to the success of these new architectures and services.

The fiber portion of today's cable TV networks is based primarily on standard single-mode fiber used in conjunction with 1310 nm directly modulated DFB transmitters. The industry is beginning to reach the limits of this technology, however, as new developments—particularly in long-distance analog transmission, high-speed digital transmission and dense wavelength-division multiplexing (DWDM)—become necessary to support expanding service portfolios.

Transmission at 1550 nm offers two distinct advantages as compared to conventional 1310 nm transmission: lower signal attenuation and the availability of optical fiber amplifiers.

These advantages, in conjunction with new optical fibers designed for transmission in the 1550 nm wavelength region, will help produce an optimum fiber link for emerging system requirements and technologies.

Figure 1: Installed fiber cable route miles by year (Sources: 1990-1994 data courtesy Paul Kagan Associates Inc., 1995 data courtesy NCTA).



Rapid growth of fiber in cable TV

The growth of optical fiber in cable TV networks has been phenomenal. In 1990, just 6,431 route miles of fiber were deployed in the United States by the cable TV industry, and many questioned the need for any fiber in those networks. Then, American Television and Communications Corporation (now Time Warner Cable) introduced the Fiber-to-the-Feeder architecture that touched off an explosion of fiber installation.

As shown in Figure 1, more than 200,000 route miles of fiber were installed over the next five years—in 1995 alone, 81,333 route miles of fiber were installed; that's 195 miles of fiber every hour, for a total of 1.7 million fiber miles. Also by 1995, cable TV demand represented approximately 30 percent of the North American optical fiber market.

Why the rapid growth? Because among its many advantages, fiber offers increased bandwidth, improved signal quality and enhanced reliability. As a result of these improvements, fiber provides an excellent platform from which to launch interactive, data-intensive services.

Developments driving fiber deployment

The primary drivers for optical fiber deployment in cable TV networks include the desire for improved signal quality, as well as a need for improved reliability and additional RF bandwidth to support new services such as telephony, VOD and Internet access.

In the spirit of continuous improvement, cable TV operators are always seeking to improve reliability and signal quality for the end user. The addition of telephony to the cable TV operator's portfolio of services has also piqued interest in network reliability. In addition to telephony, advanced services such as VOD, targeted regional programming, PCS, and Internet access are fueling a need for improved network performance. Cable modems, which allow PCs to communicate through the broadband cable network, are causing a considerable amount of excitement. This broadband platform is capable of carrying data 100 times faster than ISDN phone lines, and up to 1,000 times faster than conventional telephone modems. Because of this new technology, cable is positioned to become the access medium-of-choice to the Internet, the World Wide Web and other on-line services.

The aggregate of these new services increases demands on the reliability, RF bandwidth and signal quality in the cable TV network. To meet the needs of this new generation of services, cable TV network architectures currently being deployed consist of high-reliability redundant optical fiber rings to connect headends and hubs, with hybrid fiber/coax (HFC) in the distribution portion of the network, as depicted in Figure 2.

The fiber rings provide analog supertrunk and digital interconnection between headends

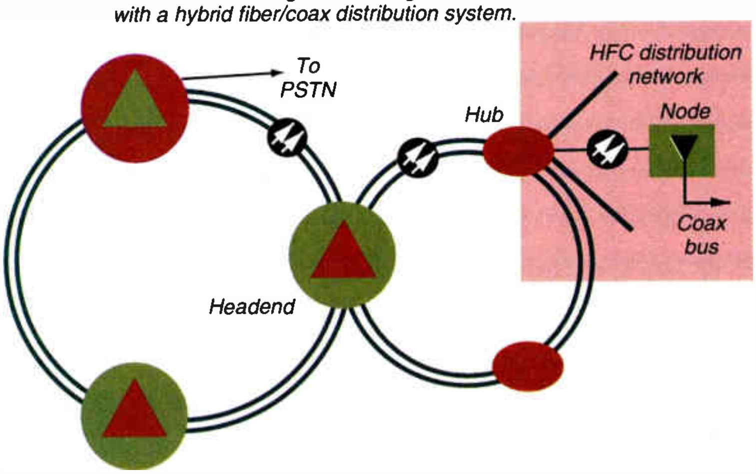


Figure 2: *Generic cable TV network architecture consisting of highly reliable redundant fiber rings connecting headends and hubs in conjunction with a hybrid fiber/coax distribution system.*

and hubs that often traverse long distances. Such a network of redundantly connected headends and hubs forms an extremely reliable, high capacity, seamless network within a region, enhancing opportunities for alternate telephone access, regional advertising and insertion of targeted local programming.

HFC is the distribution architecture of choice in cable TV networks today, delivering analog video and subcarrier modulated digital signals over the shorter distances to nodes located near the end user. Most new construction and rebuilds of cable TV systems are based on this architecture, which takes fiber to nodes typically serving as few as 500 homes. These HFC networks offer enhanced reliability, signal clarity, and extend the usable RF spectrum by replacing coax plant with higher bandwidth optical fiber and by greatly reducing the number of active RF devices the signal must pass through on its way to the end user.

Therefore, as fiber-rich architecture deployment continues to grow, three aspects of the network improve—reliability, signal quality and usable RF spectrum—thereby supporting an extended offering of services. By bringing optical fiber deeper into their networks, cable TV operators ultimately enable themselves to compete effectively in a broad range of communications service arenas.

Fiber performance issues

As in all communications systems, the crucial network performance issues in today's fiber-rich cable TV networks are noise and distortion. Both can affect signal quality, as well as information-carrying capacity.

Several fiber-related effects can reduce carrier-to-noise ratio (CNR):

✔Attenuation (power loss over distance) reduces carrier signal strength.

✔Multi-path interference (MPI—the recombining of light that is reflected back and forth

in the fiber) produces interferometric intensity noise.

✔Laser phase to intensity noise results from a random variation of source wavelength in conjunction with chromatic dispersion.

✔Stimulated Brillouin scattering (SBS) may result when too much optical power is launched into a fiber. In this non-linear effect, light is reflected by an acoustic wave, which depletes the signal and adds to MPI noise.

Fiber effects add to distortion, primarily in the form of composite second order (CSO). These effects include:

✔Chromatic dispersion—an effect resulting from different wavelengths of light traveling at different speeds through the fiber. Chromatic dispersion can create high distortion if the spectral width of the optical source is sufficiently broad.

✔Polarization mode dispersion (PMD)—occurs when the two components of a single fiber mode travel at different speeds.

✔Self-phase modulation (SPM)—in which very high optical power levels alter the index of refraction in the fiber, effectively broadening the optical spectral width.

✔Modulation instability (MI)—a non-linear interaction between the signal and noise.

Today: 1310 nm technology

What devices and component technologies make up today's optical fiber portion of the cable TV network, and how do they stand up against the effects described above? Most current systems use 1310 nm technology, primarily due to cost considerations. The most common design consists of 1310 nm directly modulated DFB transmitters and standard singlemode fiber. The workhorse of today's cable TV fiber plants, standard singlemode fiber is optimized for operation in the 1310 nm region.

Standard, singlemode fiber is optimized for operation in the 1310 nm region

In these commonly used 1310 nm systems, attenuation is low, typically 0.35 dB/km. Nevertheless, 10 dB loss budgets can limit link length to about 30 km. These distances are short enough that reflections do not accumulate significantly, and MPI noise levels remain low. SBS is not a problem either because of the large linewidth (> 1 GHz) of the directly modulated DFB transmitter. Also, the low chromatic dispersion at 1310 nm, in conjunction with low PMD for standard singlemode fiber transmission, mitigates all CSO effects.

Other 1310 nm systems employ externally modulated YAG lasers, which are more expensive than the DFB transmitters, but have 10 times the output power. This enables a signal to be split and launched simultaneously into several fibers for cost-effective signal distribution in HFC networks.

Performance of YAG systems is similar to that of DFB transmitters, except SBS can potentially limit YAG transmission distance due to the extremely narrow laser linewidths.

Emerging: 1550 nm transmission

Technology for 1310 nm transmission has performed well in cable TV networks; however, to achieve supertrunk transmission distances beyond 30 km, 1550 nm technology is essential. Why? First, attenuation is extremely low at 1550 nm, less than 0.25 dB/km—this is a fundamental efficiency in transporting signals that is only available in the 1550 nm wavelength region.

Second, erbium-doped fiber amplifiers (EDFAs) are the only commercially viable means of optically amplifying a signal, providing high output powers of 100 milliwatts or more for either boosting power directly from a DFB source or in-line amplification of the signal after it has been attenuated by several kilometers of fiber. EDFAs operate only in the 1550 nm region.

These two attributes of 1550 nm transmission can benefit conventional cable TV signal transmission in two applications, as illustrated in Figure 3. For longer distance applications like the analog supertrunk, transmission distances of 60 to 100 km are possible when 1550 nm externally modulated DFB sources are used with standard singlemode fiber. In the distribution arena, high EDFA output powers can be split for broadcasting to several HFC nodes simultaneously, much the same way the YAG laser is deployed at 1310 nm. Because attenuation is approximately 40 percent lower at 1550 nm, optical power is used more efficiently, allowing more nodes to be served by the same source.

In addition to the commonly used analog format, high-speed digital transmission at data rates of one gigabit per second (Gbps) or more is becoming more common in cable TV regional and backbone networks. Primary applications include carrying telephone and data traffic, while some MSOs are even replacing analog supertrunks with digital video transmission between headend and hub to improve signal quality. As in analog supertrunking applications, 1550 nm technology provides more efficient transmission of digital data, which ultimately extends the system's reach. The advantages in the 1550 nm region now are commonly exploited in long haul telecommunications applications, where data is routinely transported at several Gigabits-per-second over several hundred kilometers of fiber.

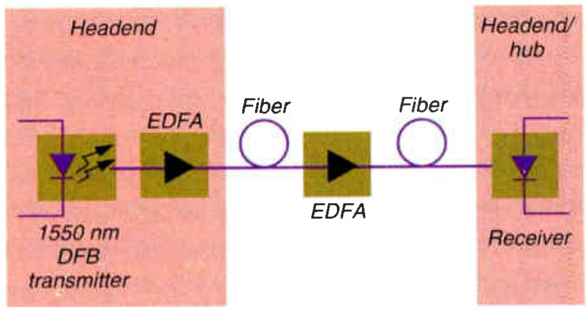
In the not too distant future, DWDM will be deployed to further increase the capacity and flexibility of cable TV networks. The use of DWDM at 1550 nm is particularly attractive in backbone and supertrunk applications because it not only increases the capacity of a single fiber, but EDFAs enable simultaneous amplification of all wavelength channels within the 1530-1560 nm window, meaning the analog or digital signals carried on the individual wavelengths do not have to be separated at repeater sites, resulting in a significant reduction in repeater cost. DWDM can also be used to route signals at hub sites using wavelength selective components such as couplers and filters. In such a network, a DWDM device directs light to individual ports based on optical wavelength, allowing for passive switched communication on a single fiber—a potential means of routing narrowcast information.

Optical fibers optimized for 1550 nm

As outlined above, transmission at 1550 nm is advantageous in several applications when compared to 1310 nm because of reduced attenuation and the availability of optical amplifiers. However, standard singlemode fiber is not optimized for operation at this wavelength. In particular, chromatic dispersion can be quite high on singlemode fiber, making complex transmitter designs a necessity in order to offset distortions that occur in the fiber.

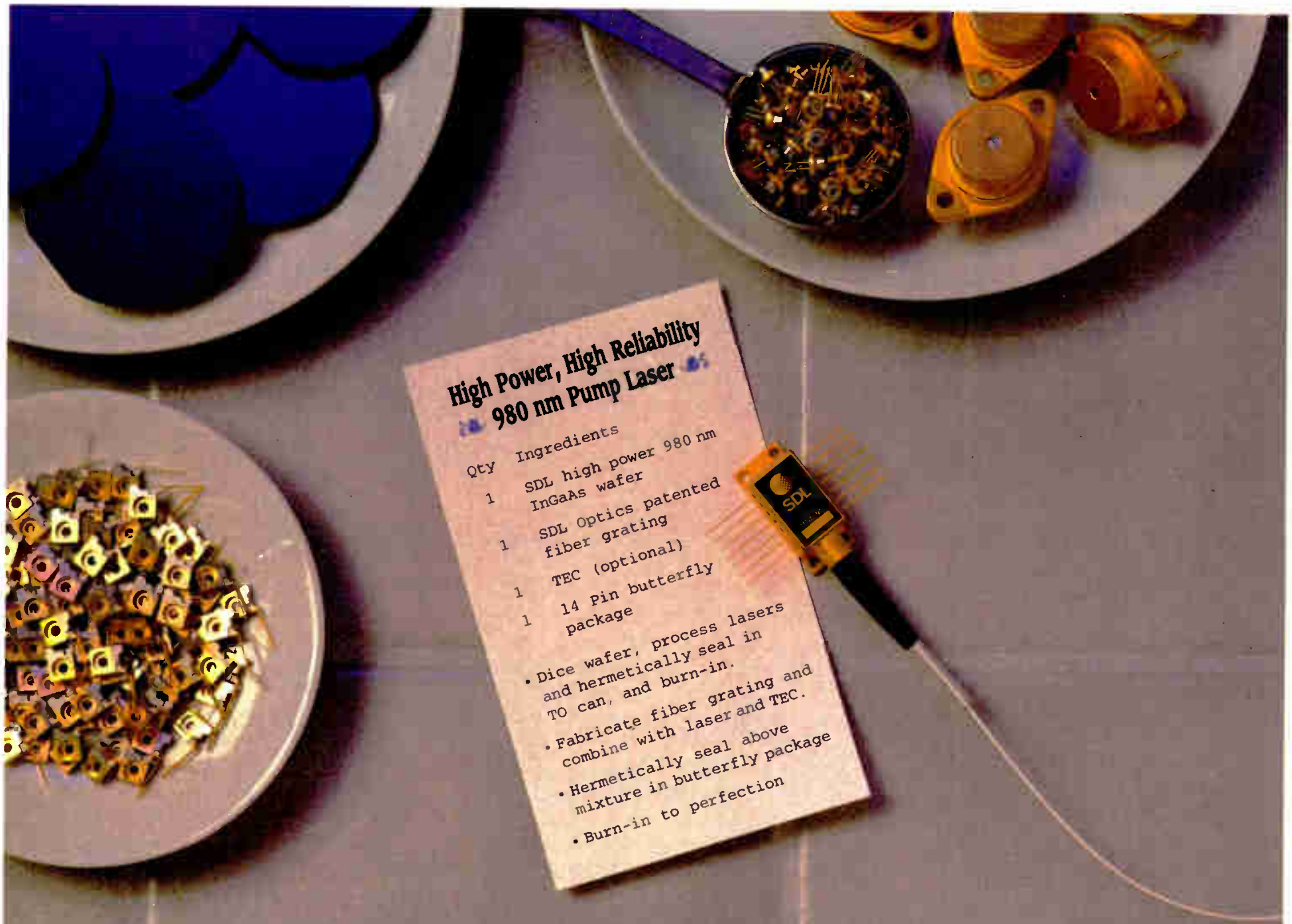
Today, the demand is growing for optical fibers that are optimized for 1550 nm technology; these include dispersion-shifted (DS) fiber and non-zero dispersion shifted (NZ-DS) fiber. Dispersion-shifted fiber is designed to have no chromatic dispersion at 1550 nm and to provide distortion performance comparable to that achieved at 1310 nm with standard singlemode fiber. NZ-DS fibers have a small amount of dispersion at 1550 nm, which is intended to offset some of the nonlinear effects that may occur in fibers at high input powers. NZ-DS fibers are designed to have either "positive" or "negative" dispersion (zero-dispersion wavelength slightly below or above 1550 nm, respectively).

Figure 3: Long distance transmission system consisting of a 1550 nm DFB source and EDFA power and in-line amplifiers. Lower attenuation at 1550 nm and EDFAs extend the reach of this system much farther than 1310 nm technology allows.



In a single wavelength analog supertrunk, both DS and NZ-DS can be advantageous. The greatly reduced dispersion of DS fiber at 1550 nm, in conjunction with its low PMD, practically eliminates the potential for CSO distortion in the fiber, including that created directly from chromatic dispersion as well as SPM; laser phase noise is also greatly reduced. Because dispersion is no longer a problem, directly modulated lasers or less complex externally modulated laser transmitters can be used which will either inherently eliminate or facilitate relatively simple means of eliminating SBS. Furthermore, since the transmitters are less complex than those required for standard singlemode fiber, this improved performance comes with a bonus of reduced transmitter cost.

Modulation instability could still potentially be a problem when using DS fiber. To guarantee that there will be no modulation instability, an NZ-DS fiber with a small amount of nega-



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SDL Optics, Inc., 6703 Rajpur Place, Saanichton, BC, Canada, V8M 1Z5 Fax: (604) 544-2225 tive dispersion at 1550 nm can be deployed. Therefore, nearly all troublesome effects—SPM, laser phase noise, SBS, MI—could be eliminated by using relatively inexpensive directly modulated or simplified externally modulated 1550 nm DFBs in conjunction with a negative dispersion NZ-DS.

A potential drawback to using inexpensive transmitters with NZ-DS fiber, however, is that for longer lengths, the total chromatic dispersion could be large enough to cause unacceptably high levels of CSO. A practical solution to this problem, called "dispersion management," is to install a short section of standard singlemode fiber somewhere in an NZ-DS link to compensate for chromatic dispersion effects (approximately five to 10 percent of the NZ-DS length placed at the end appears optimal). The small negative dispersion present at the beginning of the NZ-DS link reduces the effects of fiber nonlinearities, while the large positive chromatic dispersion of standard singlemode fiber at 1550 nm brings total dispersion of the link back to zero and corrects any dispersion-induced CSO in the NZ-DS portion of the link.

In addition to single wavelength systems, the use of NZ-DS fiber helps reduce other fiber nonlinear effects that occur when dense DWDM is used at high powers. NZ-DS fibers were developed primarily for DWDM applications, and the finite dispersion and slightly larger effective fiber cores help control fiber nonlinearities such as four-wave mixing and stimulated Raman scattering that surface in these applications.

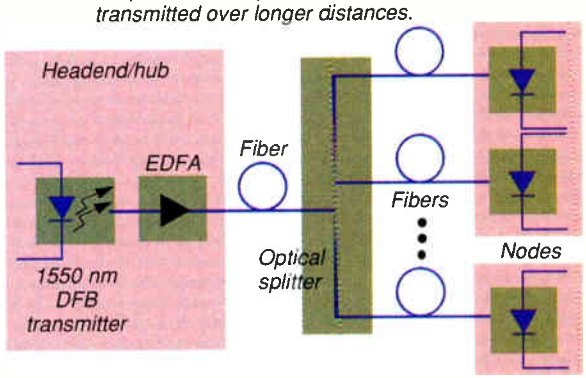
The success and practicality of NZ-DS fiber in reducing these effects has been reinforced by the ever-growing acceptance and deployment of the NZ-DS products for multi-Gigabit-per-second DWDM digital links in long distance terrestrial and undersea telephony applications.

Ultimately, the cable TV operator looking to improve transmission system reach and performance in the most cost-effective manner will implement 1550 nm transmission technologies with fiber that is optimized for the wavelength region.

Dispersion-shifted fiber eliminates the many problems associated with chromatic dispersion in standard singlemode fiber at 1550 nm. This enables improved performance compared to 1310 nm technology, but with much less complicated and, accordingly, less expensive transmitter configurations required for standard singlemode fiber. If future system upgrades call for DWDM of either analog or digital signals, non-zero dispersion-shifted fiber will provide the best performance.

To "future-proof" the network, a system operator can manage dispersion through deployment of NZ-DS fiber and in conjunction with a small percentage of standard singlemode fiber in the same link. In this configuration, one enjoys the benefits of local nonzero dispersion, but maintains the advantage of zero dispersion for the total fiber link; such a fiber link will perform optimally with today's single wavelength 1550 nm systems, as well as tomorrow's dense wavelength-division multiplexing technologies.

Figure 4: Broadcast system consisting of a 1550 nm DFB source and an EDFA power amplifier. The high output power of the EDFA can be split to cost-effectively broadcast information to several nodes. The reduced attenuation at 1550 nm provides more efficient use of optical power than at 1310 nm, allowing the power to be split over more nodes and/or transmitted over longer distances.



Glossary of abbreviations

CNR Carrier-to-noise ratio
CSO Composite second order (distortion)
DFB Distributed feedback (laser)
DWDM Dense wavelength-division multiplexing: carrying unique information on discrete wavelengths only a few nanometers apart in a single fiber.
DS Dispersion-shifted (fiber)
EDFA Erbium-doped fiber amplifier
HFC Hybrid fiber/coax
ISDN Integrated services digital network
MI Modulation instability: a non-linear interaction between signal and noise.
MPI Multi-path interference: the reflection of light back and forth in the fiber, interfering with the original signal and producing interferometric intensity noise.
NZ-DS Non-zero dispersion shifted (fiber)
PCS Personal communications services
PMD Polarization-mode dispersion: occurs when two components of the fiber mode propagate at different speeds.
POTS Plain old telephone service
PSTN Public switched telephone network
SBS Stimulated Brillouin scattering: effect in which an acoustic wave reflects light, depleting the signal and generating noise.
SPM Self-phase modulation: occurs when very high optical power levels increase the index of refraction and broaden the spectral width.
VOD Video-on-demand
YAG Yttrium aluminum garnet (laser)

Conclusion

The cable television industry has enjoyed the benefits of optical fiber for several years now. Since the beginning of the optical fiber boom that began in 1990, cable TV, as an industry, has become one of the largest consumers of optical fiber in the world. Through fiber deployment, the cable TV network of today is much more reliable, provides better signal quality and has more RF spectrum available than ever before.

Historically, 1310 nm optical fiber technology has served the industry well. However, the demand for new services and the economic need to interconnect headends and hubs into regional networks is beginning to push the limits of 1310 nm technology.

To improve performance and efficiency, system operators are beginning to turn to 1550 nm technology; when used in conjunction with fibers that are optimized for transmission in the wavelength region, 1550 nm technology provides the most capable, cost-effective fiber solution for many applications.

The bottom line: 1550 nm transmission is the future for cable TV networks because of lower attenuation and EDFAs.

To make that network a solid investment, MSOs need a fiber link that is optimum for today's system requirements as well as future technologies. The proper choice of dispersion-shifted fibers, non-zero dispersion-shifted fibers and dispersion management provide just that. CED

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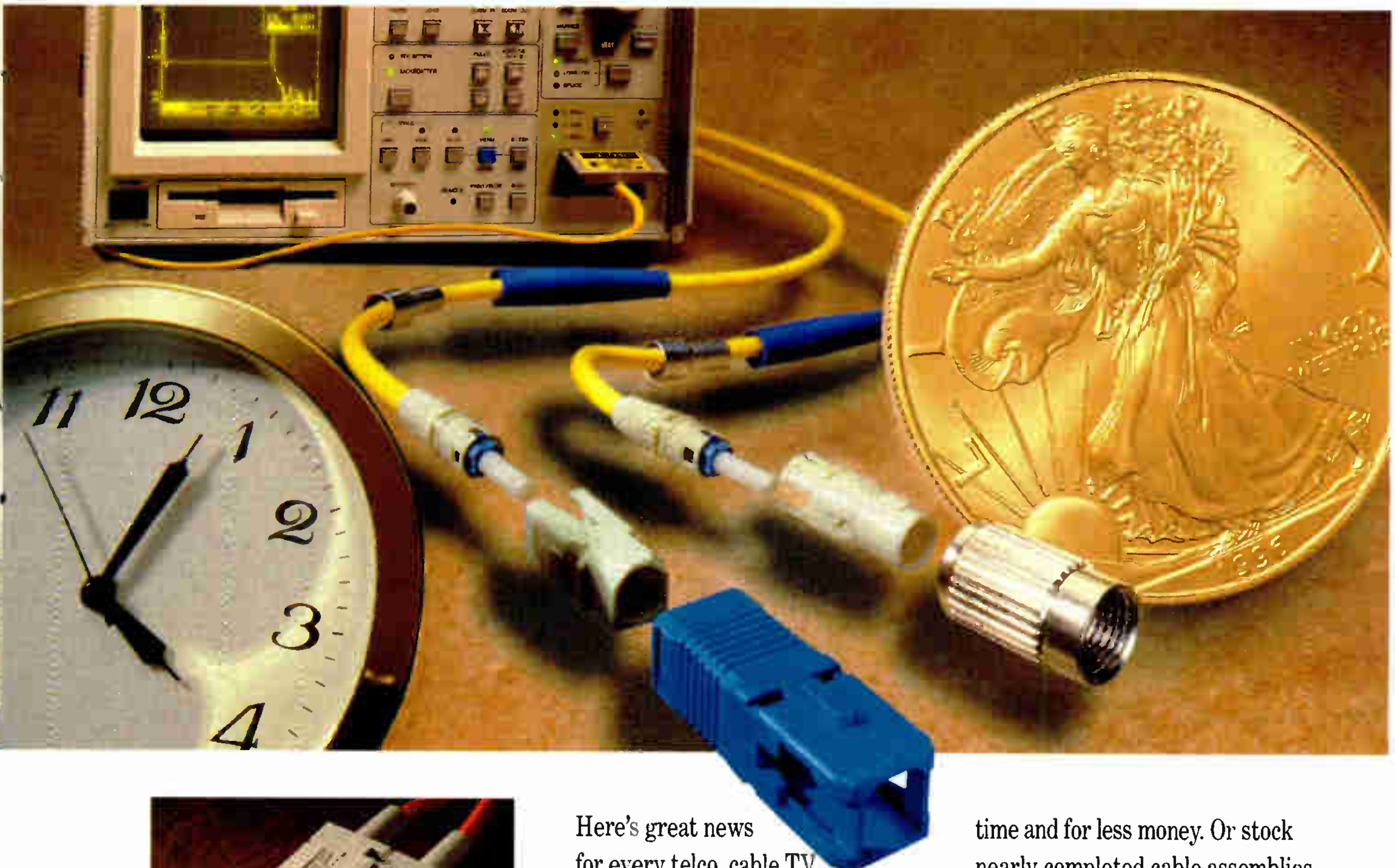

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Applying push-pull technology to optical networks

A new approach to high performance transmission

By Patrick Harshman, Ph.D., Product Manager, Transmitter Systems, Harmonic Lightwaves Inc.

The hybrid fiber/coax (HFC) network has emerged as the architecture of choice for broadband service providers who wish to upgrade their networks incrementally, in step with subscriber demands. A scalable HFC network requires allocation of sufficient bandwidth and an interconnected architecture which makes advanced switching, server and monitoring services available at any point in the network. In response to bandwidth allocation requirements, broadband service providers have converged on 750 MHz as sufficient bandwidth to provide a mixture of analog video and advanced digital communications services.

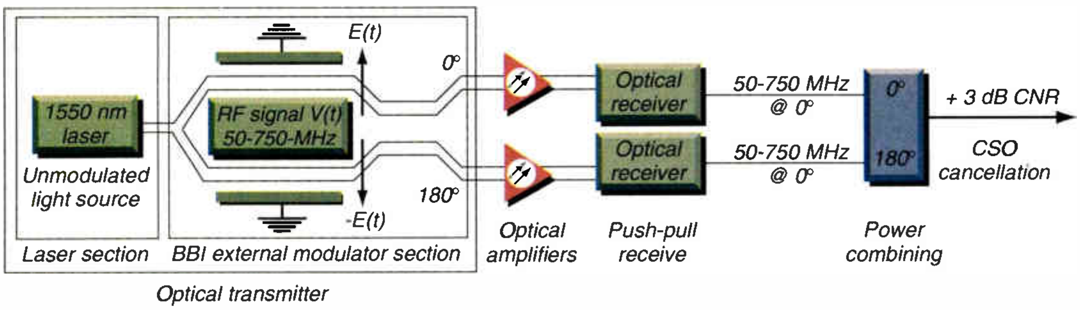
In response to the requirement for interconnected networks, a dominant trend in HFC architectures is the consolidation and interconnection of headends and hubs. Headend interconnects present two key challenges to the HFC network designer. First, distances between headends to be interconnected can be very long; distances of 50 km or longer are frequently encountered. Second, the optical transmission technology employed for the interconnection must be capable of delivering exceptional signal performance; for analog video channels, a typical interconnect performance requirement is carrier-to-noise ratio (CNR) of 55 dBc or greater.

Historically, one approach to these HFC transmission trends has been to digitize the analog channels and to use a digital transmission system for headend interconnects. While this approach can provide excellent performance, it has a definite cost disadvantage. Specifically, the costs associated with the analog-to-digital (A/D) conversion at the transmit location and the subsequent digital-to-analog (D/A) conversion at the receive location make the digital transmission approach much more costly than the analog-ready transmission systems usually employed in HFC networks.

A second approach to high-performance headend interconnects is the so-called "split-band" approach. In a "split-band" system, the 750 MHz is divided up, through band-pass filtering, into two or more smaller bandwidth signals which are transmitted separately on parallel optical paths. As an example, over a 50 km headend interconnect optical link, a 1550 nm optical transmitter may be able to deliver only CNR = 51 dBc when transmitting 80 analog video channels. However, if the 80 channels are split up so that two optical transmitters are used, each transporting 40 analog video channels, then the performance for each video channel can be improved to CNR = 54 dBc.

A cost disadvantage of the split-band approach is immediately obvious: splitting the 750 MHz band in two requires doubling the number of optical transmitters. A less obvious disadvantage of the split-band approach is uncovered when considering how the split band is re-assembled at the destination headend. To eliminate excess broadband noise when re-combining a split frequency band, carefully tuned band-pass filters are employed. While these filters can successfully eliminate unwanted noise, they also degrade the performance of the video channels located near the frequency roll-off edges of the filter. Performance stability can also be a problem because filter characteristics can drift with environmental changes such as temperature.

Figure 1: *Optical push-pull and power combining fiber link*



Push-pull concept and technology

Given the challenges presented by the HFC headend interconnect problem and the limitations of digital and split-band transport, there is a clear need for alternative optical transmission approaches which maximize cost, performance and stability over time and temperature. The approach considered in this paper involves applying the push-pull technique to both 1550 nm and 1310 nm optical transmission systems.

In the context of broadband RF amplifiers, the CNR improvement and distortion cancellation advantages of the push-pull concept are well known. An RF push-pull amplifier works by amplitude splitting the broadband signal and adding a 180-degree phase shift to one half of the signal. The two out-of-phase 750 MHz signals are then separately amplified. An additional 180-degree phase shift and signal recombination yields composite second-order (CSO) distortion cancellation and a 3 dB increase in CNR.

Figure 1 depicts how an externally modulated optical transmission system can be implemented in a push-pull configuration. Analogous to the RF amplifier configuration, the advantages of this optical push-pull and power combining configuration are a 3 dB improvement in CNR and cancellation of CSO distortion. Unlike the RF amplifier configuration, whose dimensions are measured by centimeters, the optical push-pull transmission system has been demonstrated on links of over 100 km. Despite differences in physical dimensions, the basic principles of operation of the push-pull optical transmission system are the same as those of the push-pull RF amplifier: a broadband RF signal is split onto two paths, with one path undergoing 180-degree phase shifts at both the beginning and end of the signal path.

A detailed description of this optical transmission system requires a closer look at the optical transmitter and external modulator system. Implementation of a push-pull optical link requires a specially-designed, externally modulated optical transmitter (see Figure 1). Within the optical transmitter, a strong, unmodulated beam of light is emitted from a 1550 nm or

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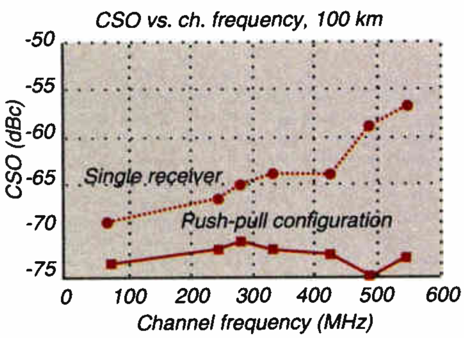
Figure 2: *Optical push-pull technology cancels both optical receiver and dispersion generated CSO distortion*



1310 nm laser source. The light then passes into the external modulator where it is split and travels along two waveguides patterned into a lithium niobate ($LiNbO_3$) substrate. The 750 MHz broadband RF signal is applied to an electrode, generating electric fields (E(t) in Figure 1) within the light-carrying waveguides. The interaction of the light and the RF-generated electric fields leads to phase modulation of the laser light.

After passing by the RF signal electrode, the two $LiNbO_3$ waveguides are brought close together, causing mixing of the two optical waves so that the phase modulation is converted to intensity modulation. In an intensity modulated optical signal, intensity fluctuations in the transmitted light mimic the electrical fluctuations of the original RF signal. Finally, the two light paths are separated and routed to separate transmitter outputs. This type of external modulator is known as the dual-output Balanced Bridge Interferometer (BBI).

At the termination of the fiber link, the two optical signals are detected by two optical receivers which convert the two signals, still 180 degrees out of phase, back to the RF domain. Finally, just as with the push-pull RF amplifier, an additional 180-degree phase shift and signal recombination yields CSO cancellation and a 3 dB increase in CNR.

In the context of HFC headend and hub interconnects, these CSO cancellation and 3 dB CNR improvements provide performance and cost advantages. In terms of analog video CNR performance, push-pull technology improves conventional 750 MHz optical technology, which delivers, for example, CNR = 52 dBc, into power-combined technology which delivers a full 750 MHz with analog video CNR = 55 dBc.

Because of modulation index and distortion limitations, conventional 750 MHz 1310 nm DFB and 1550 nm analog-ready optical transmitters usually employed in HFC networks typically deliver CNR performance of 50 dBc to 53 dBc on short to medium distance (< 30 km) fiber links. Over longer links (> 40 km), CNR performance is degraded by at least 1 dB from noise contributed by optical amplifiers, which are required to boost the optical signal level.

Thus, for headend interconnect distances of 50 km or greater, conventional optical transmitter technology delivers 750 MHz with a maximum analog video CNR of 52 dBc. It is this fact that has forced HFC network planners to utilize "split-band" transmission schemes and multiple transmitters to achieve the required 55 dBc CNR for long-distance, headend interconnect applications. The push-pull approach of Figure 1b provides a means of achieving 55 dBc CNR without the extra expense of multiple transmitters and without the performance degradation and instabilities associated with band-recombining RF filters.

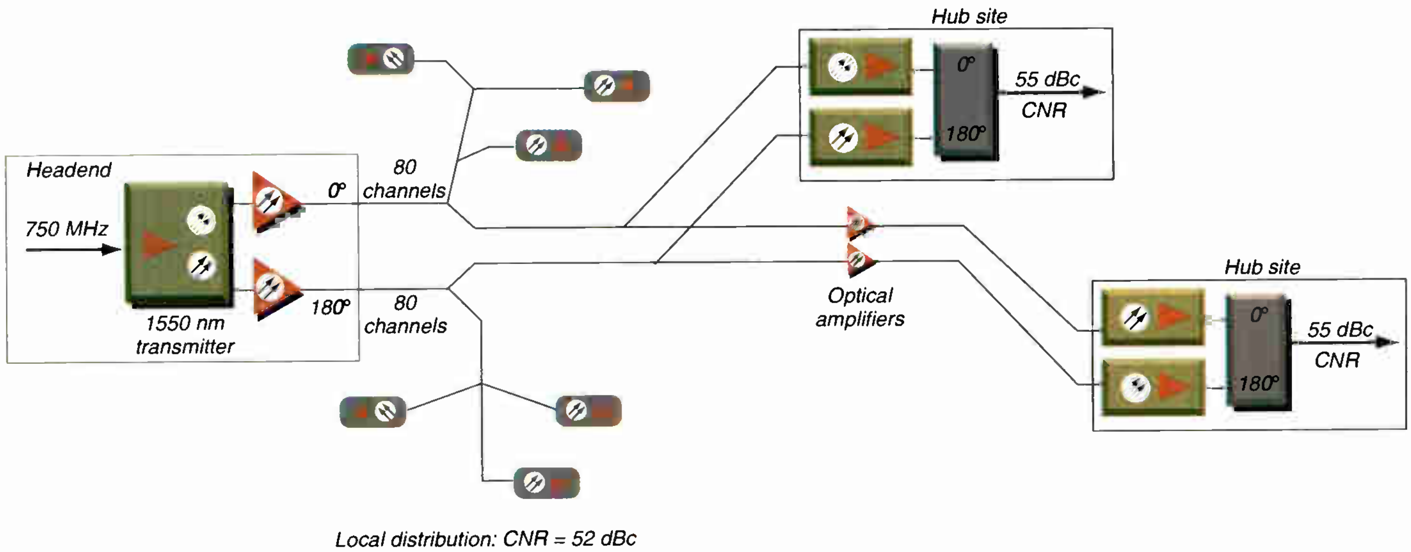
In addition to transmitter cost savings and

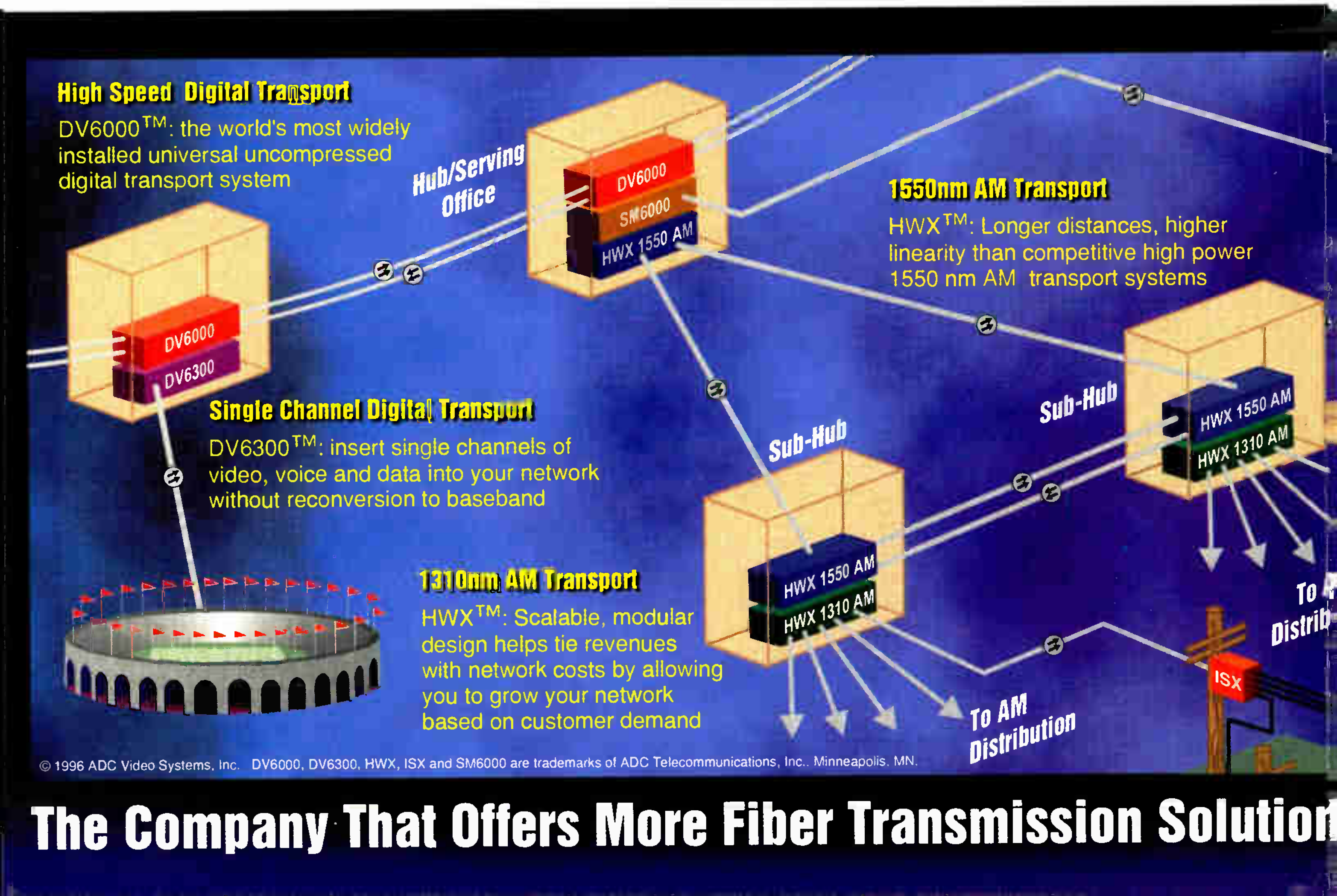
◆ Push-Pull Technology

CNR improvement, the push-pull approach offers advantages in terms of CSO distortion, as shown in Figure 2. An essential feature of the original RF amplifier push-pull design is the 180-degree phase shift and subsequent cancellation of CSO generated in the parallel RF gain blocks. Similarly, the phase shift offered by the BBI external modulator ensures cancellation of CSO generated in the parallel optical receivers of the push-pull optical transport configuration, Figure 1. As with a push-pull RF amplifier, cancellation of optical receiver CSO yields an improvement in optical link CSO of approximately 6 dB.

Perhaps more important than elimination of optical receiver CSO, push-pull technology can also be exploited to cancel problematic CSO distortion arising from dispersion and

Figure 3: *A single 1550 nm push-pull optical transmitter is employed for both local distribution and high performance hub interconnection.*





nonlinear optical interactions within the fiber itself. As is well known to HFC system engineers who have worked with 1550 nm optical transmitter technology to address long-distance headend interconnect applications, launching high optical powers over long fiber distances opens the door to a whole class of fiber-related problems which are not encountered on shorter optical links. These problems can include stimulated Brillouin scattering (SBS), optical phase noise, and distortions due to chromatic dispersion and self phase modulation.

As an example, the top curve of Figure 2 shows CSO distortion degradation as a function of channel frequency at the end of a 100 km link. SBS has been completely suppressed on this 100 km link so that the high-frequency CSO problem can be traced back to chromatic dispersion. As shown by the bottom curve of Figure 2, the push-pull configuration can be used to cancel both the CSO generated in the optical receiver (evident at low channel frequencies) and the high-frequency chromatic dispersion CSO. As demonstrated in Figure 2, push-pull technology leads to CSO < -70 dBc over a 100 km optical fiber link (reference 1).

From an HFC architecture point-of-view, one benefit of push-pull optical transport technology is network design flexibility. First, the push-pull power combining scheme can be implemented with either 1310 nm or 1550 nm laser technology. Second, a 750 MHz optical transmitter designed with 180-degree phase-shifted dual fiber outputs can be used for either headend interconnect or local distribution applications. Third, when integrated with 1550 nm laser technology, a push-pull optical transport system is completely compatible with erbium-doped fiber amplifier technology. Thus, the optical transmission set-up depicted in Figure 1 can be used on optical links of up to 100 km and beyond.

As depicted in Figure 3, the 1550 nm transmitter in this application is used to simultaneously perform two distinct optical network distribution functions. First, the transmitter is used for 750 MHz local distribution directly to optical nodes. Second, high-performance interconnect transmission of a full 750 MHz is provided to two remote hub locations.

This architecture provides a good example of how the design flexibility offered by push-pull technology can be translated into equipment cost savings. Without a push-pull optical transmission system, two separate optical transmission systems would be required: a full 750 MHz system for the local distribution and a separate split-band trunking or digital transport system for transmission to the optical hubs.

Network consolidation trends in HFC architectures present the dual challenges of spanning longer fiber distances and delivering a higher level of network performance. Innovations in push-pull optical transport technology meet these emerging architecture demands by providing 3 dB of carrier-to-noise improvement, distortion cancellation and network design flexibility.

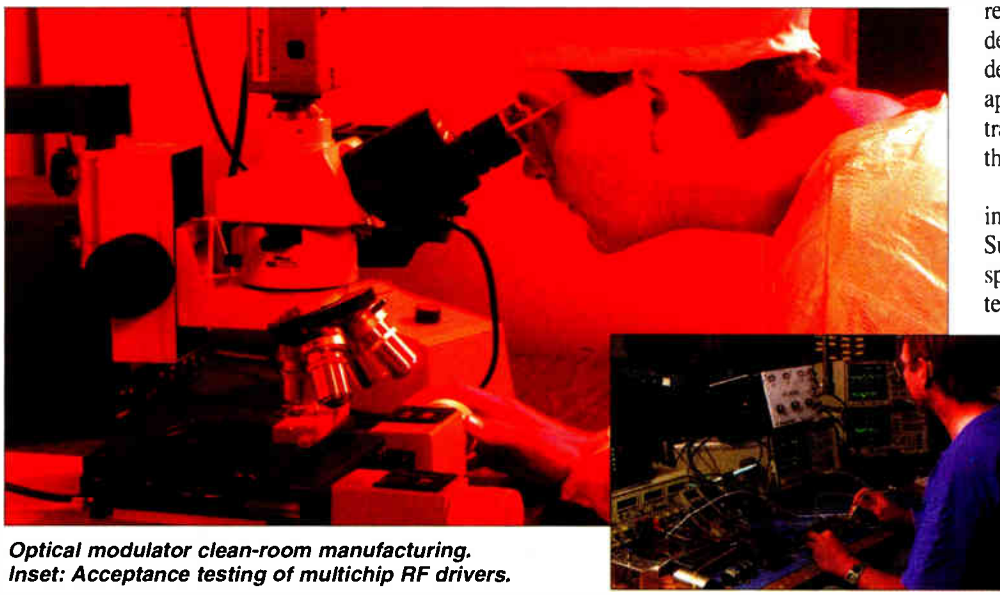
When used effectively, the performance advantage of the push-pull optical transport system can be translated into a flexible and cost-effective tool for meeting the challenges of tomorrow's HFC network. CED

Reference

1. C.Y. Kuo, D. Piehler, C. Gall, J. Kleefeld, A. Nilsson, and L. Middleton, "High performance optically amplified 1550 nm lightwave AM-VSB CATV transport system," Optical Fiber Conference (OFC), 1996.

Future-proofing without overengineering

A scalable solution from broadcast to narrowcast



Optical modulator clean-room manufacturing.
Inset: Acceptance testing of multichip RF drivers.

By Michael J. Noonan, President and CEO, FONS Corp.

As competition widens in the wake of deregulation, cable TV and telco providers are naturally planning or undertaking major plant upgrades to maintain or capture market share. The difficulty, however, in creating the ultimate network that offers reliability, narrowcasting, and therefore, new services, is cost. While cable TV providers must be aggressive in their upgrades in order to remain competitive, they are being forced to exercise caution when it comes to capital expenditures. Such expenditures must be justified by an acceptable rate of return on investment.

Although the potential revenues from new services such as Internet access, video-on-demand, etc., are phenomenal, the costs of delivering such services are high, and the technology is still evolving. In the meantime, what should cable TV providers do? They are still faced with improving performance and preparing networks that will reliably deliver new services as soon as they are cost-effective and viable. The providers who wait to upgrade may find themselves too far behind to be competitive, and the providers who upgrade now may have to spend millions again in a few years and see their return on investment plummet.

Despite the precarious position in which many cable TV providers find themselves, viable solutions that protect initial investments and create cost-effective growth exist.

Network modernization background

As MSOs begin to modernize their physical infrastructures by deploying 750 MHz hybrid fiber/coax (HFC) networks with interactive capabilities, they generally can choose from a variety of transmission approaches. The most common approach is based on capital investment cost conservation. The philosophy behind this approach is to minimize initial capital outlays. Long-term effects on system operation and the delivery of future services become secondary. Every attempt is made to maximize preservation of the embedded coaxial plant assets by enhancing the metallic network's broadcast platform (see Figure 5, page 68).

The next common transmission upgrade approach, which modifies the broadcast platform to accommodate new services, enhances the network by overlaying additional services on a separate fiber. For example, services like video entertainment with broadcast-like qualities are carried on one optical fiber; and services which are more circuit-like in orientation, such as pay-per-view, Internet access, etc., are transported on a separate fiber to the node. These separate optical signals are combined in the field into one electrical signal and simultaneously transmitted through the coaxial cable plant to the home (see Figure 1).

Priority is placed on reliability and availability of interactive services. Special lower cost, redundant optical transmitters and receivers are deployed side-by-side with existing optronics to deliver video entertainment services. With this approach, additional fiber optic capacity and transmission equipment are needed, increasing the cost of future upgrades.

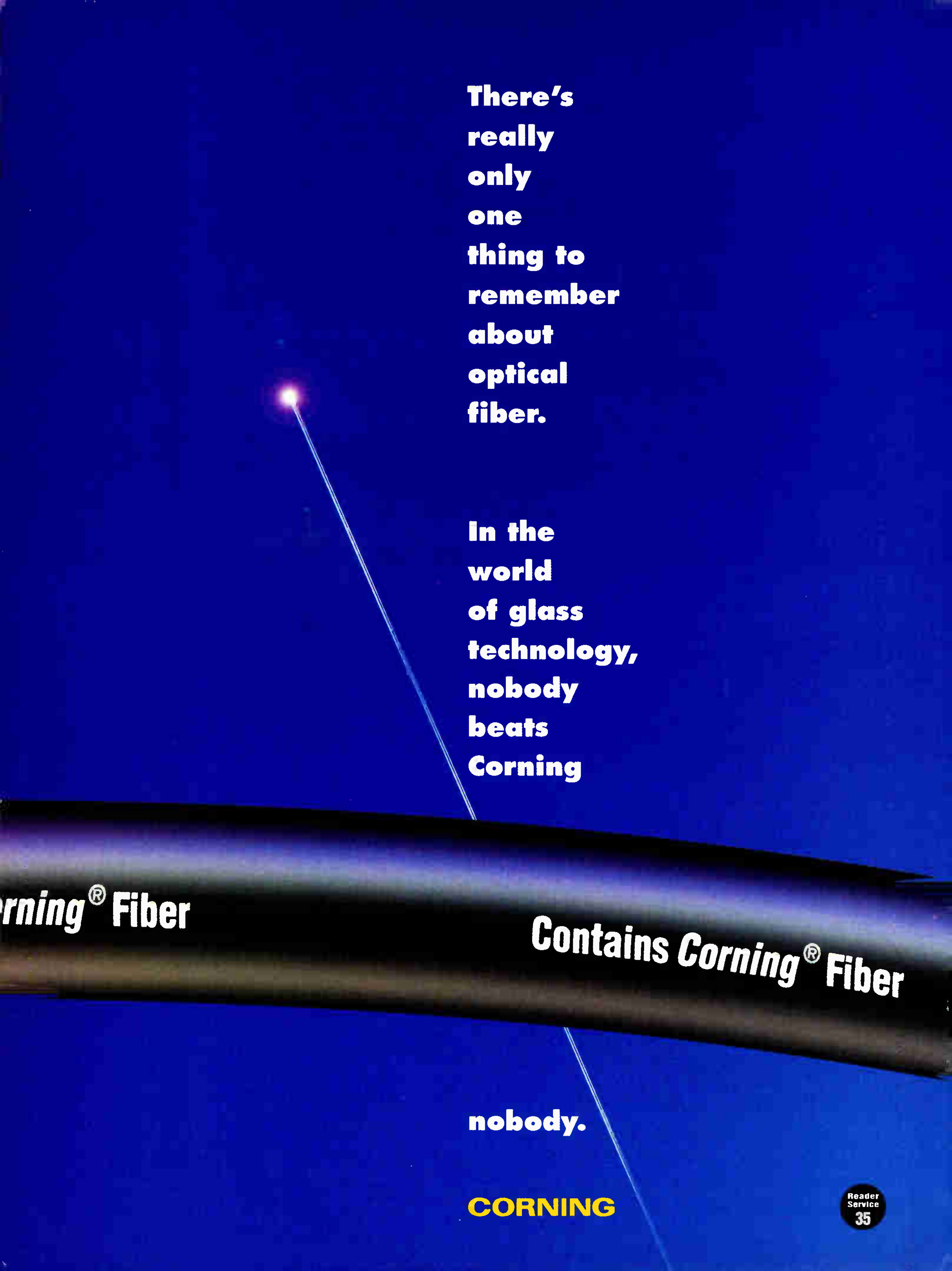
Furthermore, the integration of RF signals into these networks occurs at the field level. Such an approach relies heavily on separate, specialized field personnel for preventive maintenance and requires outside plant maintenance, which contribute to operating expenses.

A third, more long-term, focused transmission approach is based on narrowcasting with product redundancy and route diversification. In other words, one laser is dedicated to one node with redundancy built into active components and into the plant (route diversification).

This may be the ultimate solution to providing standard video entertainment services as well as all the potential revenue generating services such as RF modems, Internet, video-on-demand, phone services, etc. However, cable TV operators' financial parameters must be justified in terms of return on investment over a certain time frame. Given the high cost of low-powered DFB output transmitters that enable narrowcasting, most cable providers can't justify the investment.

Return on investment becomes problematic under all three approaches. The first two offer high-powered DFB optical output required for broadcasting, but waste optical power if reconfigured for narrowcasting. Essentially, multiple nodes are supported from one laser for broadcasting, providing only one RF "pipeline" to all nodes in the field. With a true narrowcasting transmission approach, one laser would be utilized for every node, providing a separate RF "pipeline" to each node. The return on investment from the transmission equipment is lost when the market demands a conversion from broadcasting to narrowcasting.

While the third approach utilizes low-power DFB lasers for narrowcasting, their cost of approximately $5,000 a piece makes the initial investment prohibitive. The cable operator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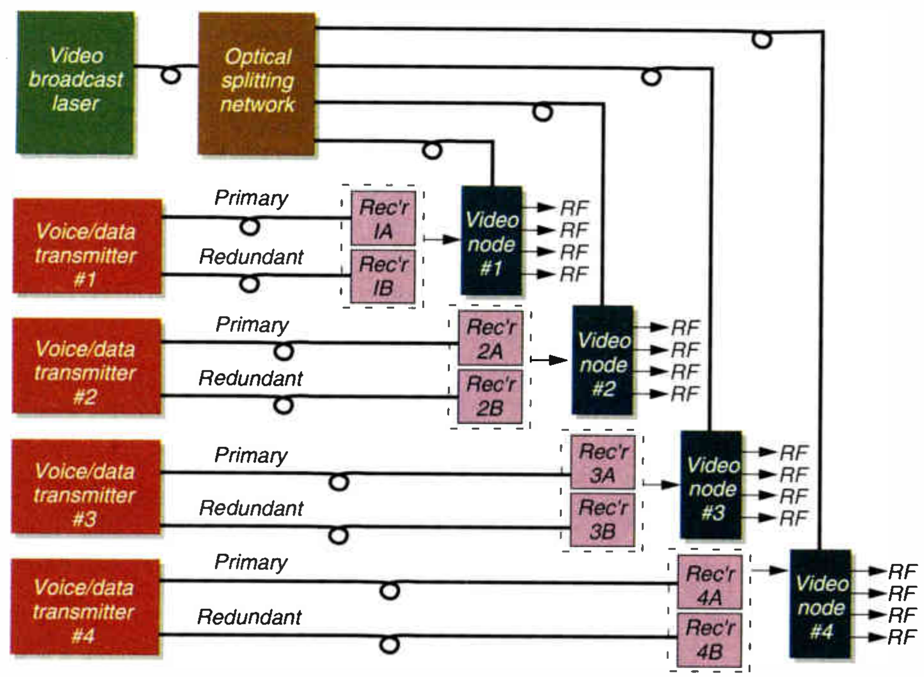
must wait until the initial broadcast investment is recovered before reinvesting in new services, which may take two to three years. Unfortunately, the market, especially an unregulated one, doesn't always allow such luxuries.

(Not exactly) new transmission solutions

If providers are to "future proof" their networks so they can recoup their return on investment with new services, they must employ a transmission platform that is flexible, scalable, reliable and affordable. The platform must be suitable for broadcasting, but easily and affordably upgradable to narrowcasting. It must also address reliability and redundancy concerns.

Ironically, transmission technologies that

Figure 1: *Fiber overlay approach*



have been around for the past 10 years in government applications are providing solutions. While the technology is not new, the manufacturing and engineering of such transmission technologies is where the innovation lies.

Proven technologies, such as lithium niobate, which has been used in high-speed digital transmission and government applications, and the microchip laser, which is a derivative of the YAG laser that was invented 10 years ago, can be combined with innovative manufacturing and packaging to offer dramatic, cost-effective, scalable transmission solutions.

Newly-developed transmission solutions that allow providers to take advantage of fiber optics today by providing broadcast capabilities are currently available (see Figure 6, page 68). As selected bandwidth becomes necessary to provide distinct services to smaller groups of homes, these transmission platforms can be upgraded from broadcasting to narrowcasting with minor field adjustments at a low cost. To understand the growth path from broadcast to narrowcast, the building blocks of this new transmission approach should be examined.

By utilizing different transmission technology—essentially a new transmission platform—cable operators can preserve their embedded HFC networks and still provide a simplified migration path for adding new revenue producing services later, without disrupting existing customer service delivery.

An important component of this new transmission platform approach is a very low noise, high-powered microchip laser. Microchip lasers are compact, robust, high performance, diode-pumped solid-state lasers. Unlike the semi-conductor DFB lasers traditionally utilized, which combine the carrier and signal electronically (continuously turning the laser on and off), the microchip laser is configured with an optical modulator, enabling it to distribute voice, video and data.

The laser operates in continuous wave (CW) mode and is not electrically modulated—the laser runs continuously and is not turned on and off. With the laser acting as the carrier, the signal is combined with the laser through optical modulation. Because of the physics of running a laser CW, carrier-to-noise ratios and distortion numbers are lower than those achieved with electronically modulated lasers. Furthermore, optical modulation offers greater capacity range up to 10 Gbps.

Figure 2: Lithium Niobate optical modulator

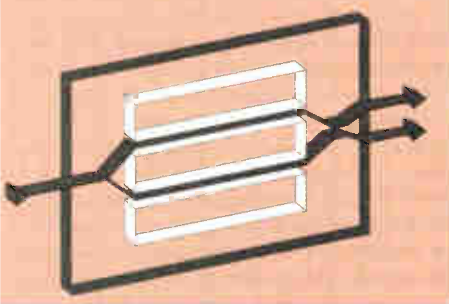
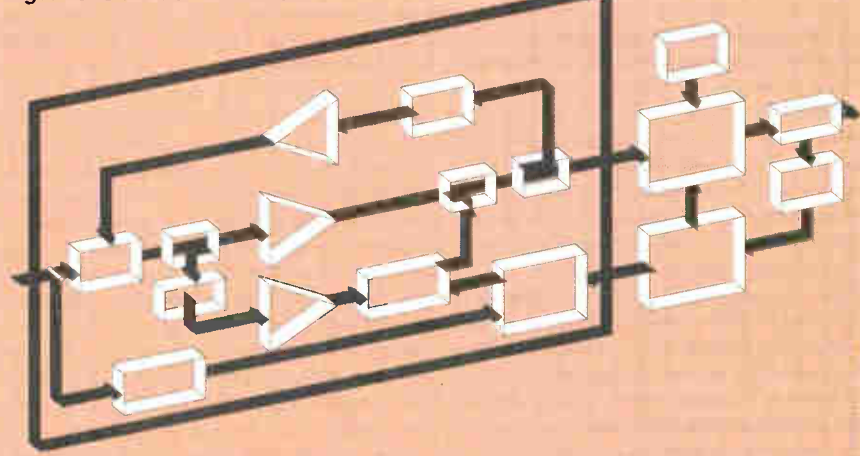


Figure 3: Ultra linear RF driver



A second important component of this platform is a planar wave device used to optically split the raw optical power of the laser. Since each of the optical outputs is individually modulated, the number of transmission paths is determined by the planar wave guide divider. The device can be configured to provide between two to 16 divisions of the optical source, which will vary the optical output between levels. Each division is then modulated.

This device can be produced by using planar optical wave guides fabricated with a technique that uses a flame hydrolysis process to consolidate a glass layer. The optical circuits can then be patterned in the planar waveguide using photolithography and reactive ion etching. This technique provides a very reliable, high performance and repeatable process with low loss requirements and exacting division. The optical circuits can later be diced from the substrate, tested, attached to fibers and packaged.

The next building block is the dual output optical modulator (also called a Mach Zender interferometer). It can be manufactured on lithium niobate substrate using a photolithography process in connection with reactive ion etching. This provides a repetitive low loss integrated optical modulator for the modulation of the optical source. The RF modulation can then be applied to the electrodes on the substrate, producing a modulating effect on the optical carrier as it passes through the device. By using an optical modulator with a dual output, the incoming electrical signals received by the transmitter can be split, allowing providers to configure the transmission platform for plant redundancy/route diversification (see Figure 2).

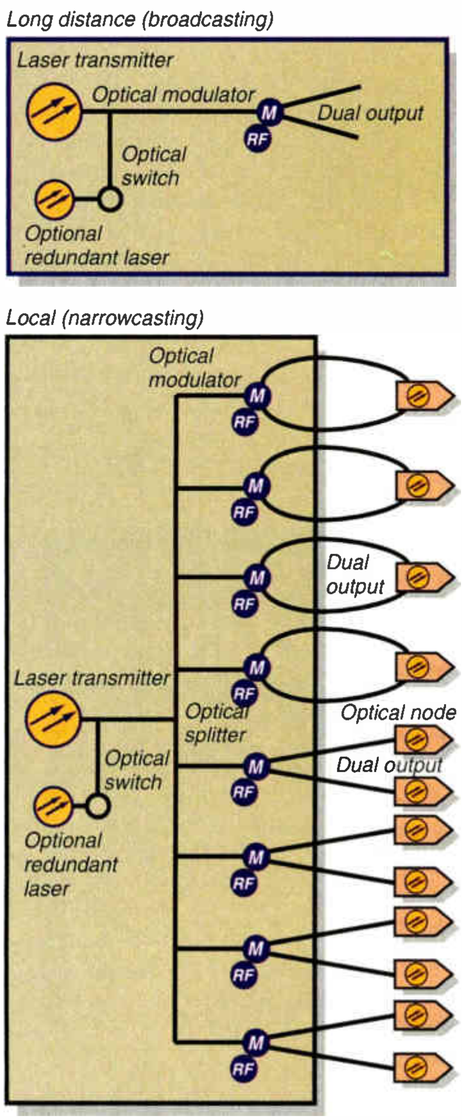
Coexisting with the optical modulator is an RF driver. This driver is an ultralinear circuit with wide bandwidth and a large dynamic operating range with minimal distortion. The driver itself is a multi-chip design that can be made from a substrate material that is compatible with the frequency bandwidth of interest. The critical parameter of linearity over bandwidth is automatically compensated in the module. The circuit utilized provides both compensation for the optical second- and third-order non-linearities produced by the optical modulator. The optical modulator is automatically biased at the half voltage symmetry point by the RF driver, minimizing the distortion created by the non-linear element (see Figure 3).

By utilizing these transmission building blocks in various configurations, a broad range of products can be produced that satisfy local and long-distance requirements (Figure 4).

Building on existing networks

The benefit of this transmission technology for cable providers is that these building blocks coincide with how the industry wants to employ and take advantage of the benefits of fiber optics. By externally modulating a high powered laser and splitting the optical power

Figure 4: *Minor modifications to platform configuration yield local or long distance distribution.*



several times in the headend, several nodes can be fed where networks are converted from coax to fiber. Configuring the transmission platform in this manner allows providers to cost-effectively utilize fiber (HFC network), realize quick returns on investment and improve reliability and performance.

When additional, interactive services are demanded, providers will no longer want to take that RF broadband signal on an input and divide it to send the same signal to several different nodes. Instead, providers want the capability to narrowcast, or in other words, to have channel or bandwidth allocation so that each RF broadband signal can be changed for every group or node to which they are transmitting.

Figure 5: *Cost conservation approach*

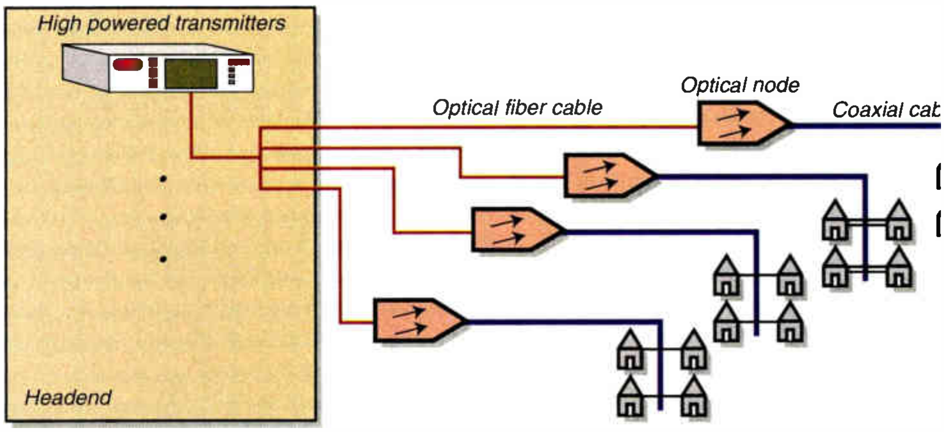
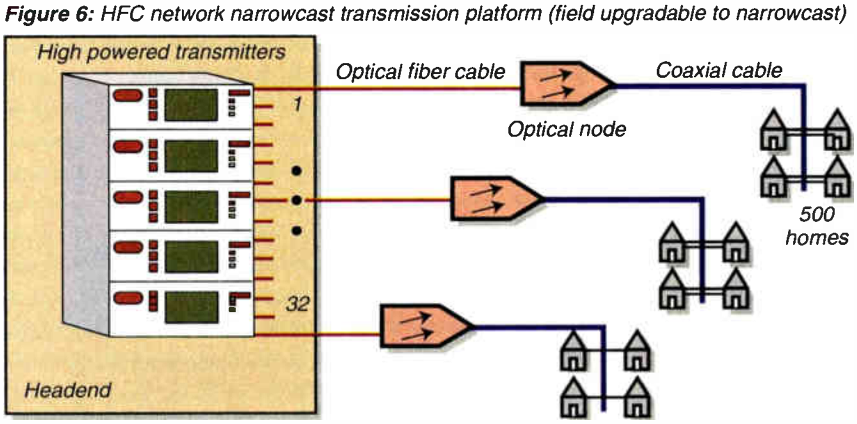


Figure 6: *HFC network narrowcast transmission platform (field upgradable to narrowcast)*



The next step for cable providers is to upgrade to true narrowcasting by sending that dedicated or selective bandwidth of information to the node in two different paths for route diversification/redundancy. As a result, providers would not only have a large portion of dedicated bandwidth for each node, but also, improved network reliability with redundancy.

This type of transmission platform is also field upgradable to allow cable providers to follow an optimal development path, because it offers the versatility to grow with the network. The high power broadcast platform can be modified to incorporate additional banks of optical modulators and drivers, so that it can grow from a single broadcast, high power or transport system to a narrowcast system with minor modifications, while preserving the original transmission equipment (laser).

Because of the platform's field upgradability, the upgrade process is both simple and inexpensive. Additionally, a field upgradable design allows for easy and affordable maintenance.

By developing a transmission approach that offers cable TV providers the ability to "future-proof" their networks, initial capital investments in upgrades are minimized and recovered through broadcasting revenues. When the market demands true narrowcasting, the network is prepared for simple, affordable upgrades. As a result, cable providers can make cost-effective network decisions today, and be positioned to offer advanced services tomorrow. CED

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Maximizing the return path in HFC plant

How OFDM makes effective use of upstream bandwidth

By Todd Schieffert, Program Manager, and Greg Hutterer, Senior Product Manager, Homeworx Access Platform, ADC Telecommunications Inc.

As service providers accelerate their development and deployment of two-way services over hybrid fiber/coax (HFC) cable plant, the return path becomes critical. But bandwidth in the return or upstream path is limited, typically to 5 to 30 MHz, or 5 to 42 MHz. And of that, the lower portion, 5 to 18 MHz, has not been considered reliable for data communications such as Internet access. These limitations raise several questions. How many telephony, data and interactive video applications can be supported? What kind of bandwidth is actually required? And how can different kinds of noise ingress be avoided or controlled? One key to answering these questions is the modulation scheme used. A second-generation modulation technology, orthogonal frequency division multiplexing, or OFDM, offers significant advantages in making the most effective use of available upstream bandwidth.

OFDM has its roots in frequency division multiplexing (FDM), the technology used in analog telephony carrier systems, which were first deployed some 75 years ago. One version of FDM enabled 24 voice frequency channels, each about 3100 Hertz, to be carried simultaneously on the 300 kHz spectrum of twisted pair cabling—a tremendous increase in bandwidth efficiency at the time. OFDM delivers similar advantages for two-way HFC cable plant today.

How OFDM works

OFDM is a frequency-based, multi-carrier modulation scheme, whereas other modulation technologies use a time-based, single-carrier approach. With time division multiplexing (TDM), signals are transmitted alternately in time, taking turns on a single 2 MHz slice of spectrum.

In addition, TDM systems enable separate input signals to be carried on different components of the same carrier wave, so more than one signal can actually be carried at the same time. This degree of spectral efficiency is possible with a technique called quadrature amplitude modulation, or QAM.

One version of QAM uses binary-level modulation of the carrier wave components, generating an output signal space with four message points. This is known as 4-level QAM, or QPSK, for quad phase shift keying. By using two components of the carrier wave, QPSK can carry twice the information possible with simpler bipolar modulation schemes such as bipolar shift keying (BPSK).

With OFDM, on the other hand, digital signals are modulated onto many narrow RF carriers or subcarriers for simultaneous transmission. In fact, each 64 Kbps voice channel, or DS-0, may be allocated its own RF carrier. An implementation of OFDM by one company takes this a step further, dividing each DS-0 payload byte into two parts. Each of the two parts is carried on a different tone in the RF channel, one DS-0 being made up of two tones. Using such small slices of spectrum allows individual signals to be remapped to frequencies with a higher signal-to-noise ratio (SNR) within the same 6 MHz band, rather than wasting a lot of spectrum by reserving spare frequency. This resiliency, in turn, permits the use of much higher-level QAM, which adds up to significantly greater spectral efficiency. With 480 usable tones, 240 DS-0s can be packed into a single 6 MHz channel, including the guardband—at least twice as many DS-0s as TDM systems allow.

Figure 1: *OFDM modulation scheme.*
The core technology in an OFDM modulation scheme, shown in this simplified diagram, is the FFT/IFFT engines, which create and receive the multiple tones that form an OFDM signal.

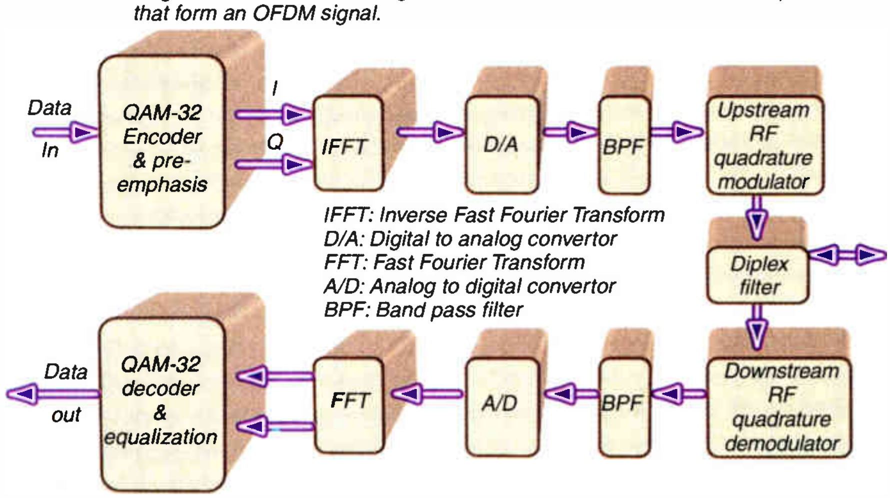


Figure 2: *Modulation Efficiency and ingress protection.*
With each DS-0 assigned to its own RF carrier, OFDM offers superior immunity to narrowband noise. When narrowband interferers disrupt a few tones, the affected signals are remapped to other tones, and the granularity is only 18 kHz, or one DS-0. As a result, the amount of bandwidth lost to an interferer is kept to a minimum, and the chances of dropping a call are substantially reduced since the DS-0 can be reassigned to another frequency.

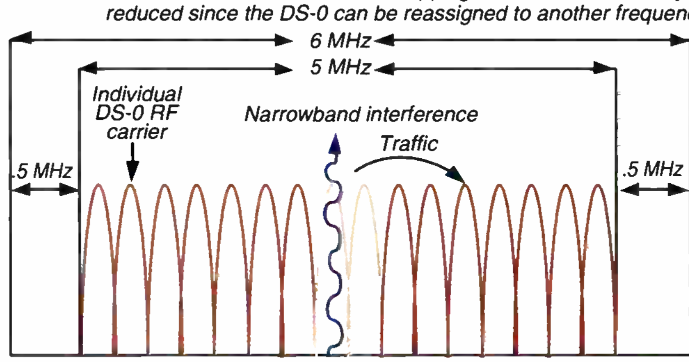
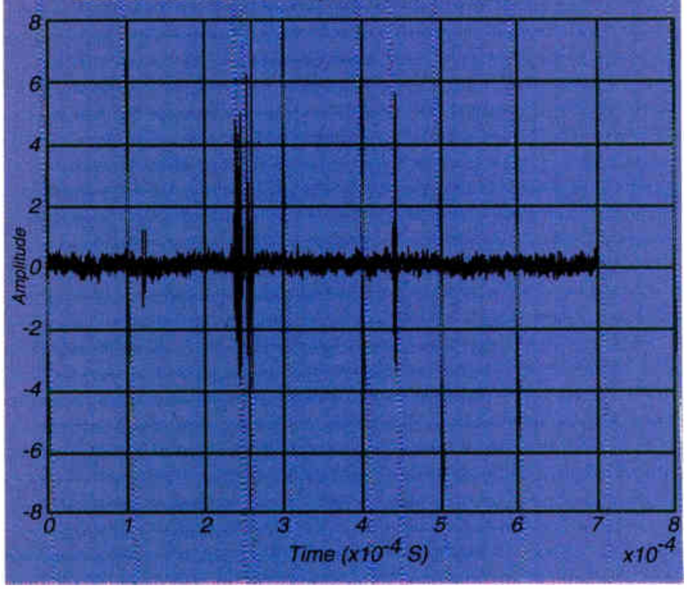


Figure 3: *Time domain of impulse. OFDM is especially resilient when it comes to impulse noise. This example measures the time domain of a typical impulse taken from the return path of an operational hybrid fiber/coax system. A spectrum analyzer and storage oscilloscope were used for the measurement, with a receive bandwidth of 3 MHz.*



The modulation and demodulation are accomplished with application-specific integrated circuits (ASICs). At the sending end, the OFDM is generated with an ASIC running an inverse Fast Fourier Transform (IFFT) algorithm. At the receiving end, another ASIC runs a Fast Fourier Transform (FFT) algorithm on the input signal continuously and converts the received FFT data vectors into five bits per subcarrier. The receiver also performs carrier frequency phase tracking and symbol centering tracking.

These functions, along with the use of BPSK synchronization channels, allow the modems to maintain synchronization between the headend and the remote ends, even in harsh cable TV environments. See Figure 1.

Let's look at both of the key features enabled by OFDM in more detail: resiliency and efficiency.

Resiliency against noise

Noise in the return path is a nemesis for two-way services, because it can come from every subscriber and be funneled back to the headend. Noise from outside the system comes in two forms: narrowband and impulse. Narrowband noise can originate with ham radio or CB traffic whose frequencies fall within the 5 to 42 MHz band used for return-path signals. Impulse noise, on the other hand, occupies a broad bandwidth for a very short time. Cable plant discontinuities, lightning, household appliances and power tools can cause impulse noise.

OFDM offers superior immunity to narrowband noise, because each DS-0 is assigned to its own RF carrier. When narrowband interferers disrupt a few tones, the affected signals are remapped to other tones, and the granularity is only 18 kHz, or one DS-0.

As a result, the amount of bandwidth lost to an interferer is kept to a minimum, and the chances of dropping a call are reduced because the DS-0 can be reassigned to another frequency. See Figure 2.

With a TDM system, on the other hand, a large narrowband interferer that falls anywhere within the 2 MHz bandwidth carrying the upstream signals can render the whole 2 MHz slice unfit for transmission.

The usual way to deal with this situation is to hold other 2 MHz slots in reserve, but this technique cuts bandwidth efficiency even further, because those slots are not otherwise available. That means a major revenue source is lost.

OFDM is especially resilient when it comes to impulse noise. Because frequency-multiplexed signals are not divided in time, they have substantially longer symbol periods than do time-multiplexed signals. With a slower symbol rate, the OFDM system has a lower receive bandwidth, so only a fraction of the pulse makes it through the receive filter, giving a much higher signal-to-noise ratio (SNR) and a lower bit error rate (BER) than with a time-multiplexed system. Incidentally, the BER, which is generally around $1x10^{-7}$ to $1x10^{-9}$ with RF modems, can be reduced even further with forward error correction.

> **Modulation efficiencies possible with OFDM go hand-in-hand with its noise resilience**

Some implementations of this forward error correction allow users to adjust the error corrections to provider either greater robustness or lower latency. See Figures 3 and 4.

Efficiency

The spectral and modulation efficiencies possible with OFDM go hand-in-hand with its noise resilience. Higher-level QAM is able to optimize bandwidth by modulating the carrier frequency to a higher number of discrete levels.

For example, 32-QAM generates a signal space of 32 message points, or symbols, using six discrete levels of the carrier wave. Each symbol can carry five bits of information, and two symbols make up one 10-bit word, plus overhead and error correction.

With each DS-0 allocated its own 18 kHz spectrum, a DS-0 corrupted by narrowband interference is easily reassigned to another available in-band frequency, regaining the SNR necessary for high modulation effi-

Figure 4: *FFT vs. time of impulse. The impulse data measured in Figure 3 has been plotted in both time and frequency after the Fast Fourier Transform (FFT) is performed on segments of the time domain data.*

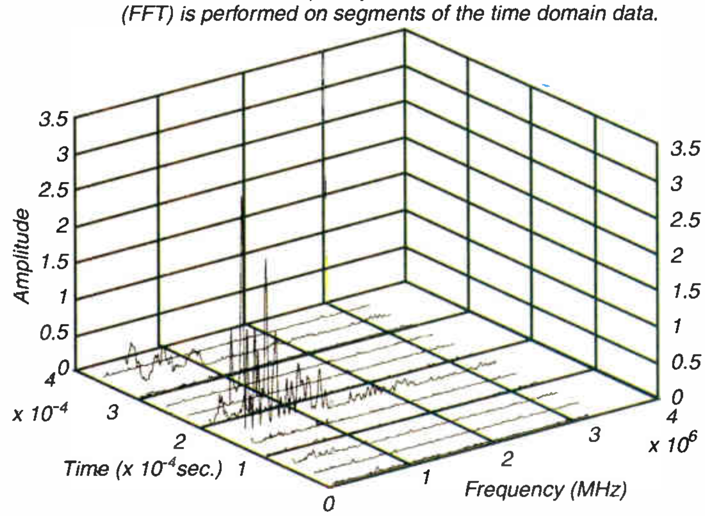


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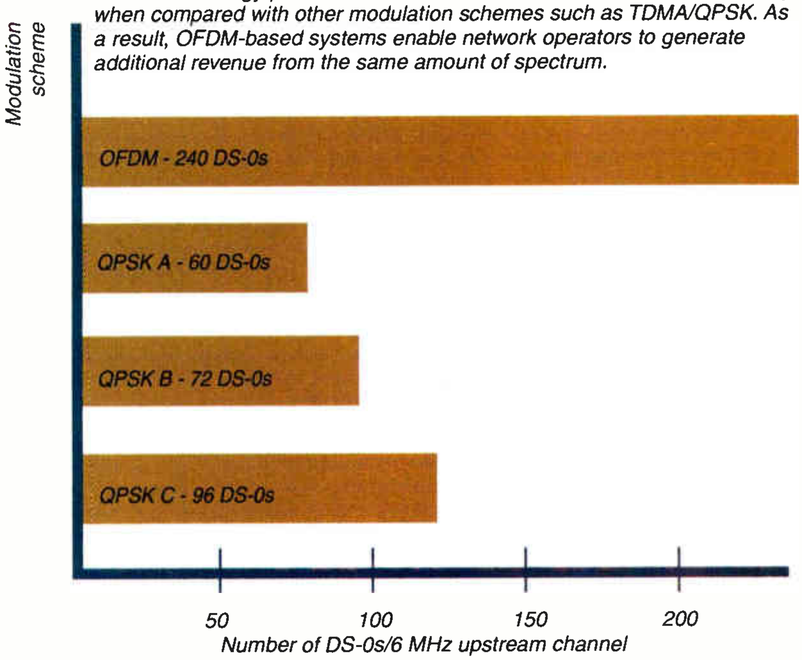
Figure 5: *Modulation scheme comparison.*
OFDM technology provides from two to four times the bandwidth efficiency when compared with other modulation schemes such as TDMA/QPSK. As a result, OFDM-based systems enable network operators to generate additional revenue from the same amount of spectrum.



ciency. Studies have shown that typical interferers are in the range of 5 to 29 kHz wide, which would disrupt only one or two DS-0 channels, each 18 kHz wide. So this ability to move channels to different frequencies is a significant advantage.

As a corollary, large amounts of spectrum do not have to be held in reserve, because of the small granularity.

And the large number of OFDM data carrier waves are frequency-spaced quite close together for optimal spectral efficiency. See Figure 5.

Real-world tests

OFDM has undergone extensive field testing using real systems, both small (200-500 homes passed) and large (30,000 homes passed), as shown in Figure 6. One international trial combined Ethernet file transfers, voice traffic and video.

During load testing in preparation for the trial, more than two million calls were run, with a 99.9 percent call completion rate. In the actual four-day test period, hundreds of data and voice calls were made, without a single call failure. The OFDM systems also passed noise immunity tests with flying colors, handling carrier-to-noise ratios even below the specification of 35 dB.

> **OFDM is under consideration around the world for broadcast HDTV, DAB and ADSL services**

This international trial also tested a variety of equipment and services. The equipment included fax modems, 28.8 modems, and high-speed data modems running 512 Kbps in each direction.

In addition, the systems proved compatible with Caller ID and a wide range of answering machines. Nor were there any

What's an extra 6 MHz worth?

Using OFDM rather than QPSK as a modulation scheme yields an additional 6 MHz of upstream bandwidth. So how does a service provider get the extra 6 MHz, and what does that mean? Let's look at an application based on telephony, data and special services that assumes the following:

- ✔ 5 to 42 MHz in the return path with a usable upstream bandwidth of 18 to 42 MHz for these higher-end services.
- ✔A pre-allocated data spectrum of 18 to 30 MHz in the upstream.
- ✔30 to 42 MHz remains for telephony, specials and incremental services, such as additional data.
- ✔A 500-home node.

In this scenario, the total requirement for POTS (1.2 lines/home) and special services (10 percent of POTS lines) is 660 DS-0s per node. OFDM has an efficiency of 224 DS-0s in 6 MHz upstream and 6 MHz downstream, and QPSK has an efficiency of 20 DS-0s in 1.8 MHz upstream and 96 DS-0s in 6 MHz downstream. Based on that, the total requirement for POTS and specials with OFDM is one 6-MHz carrier in the upstream, and the total requirement for QPSK, assuming 20 DS-0s, is 12 1.8-MHz carriers, or 21.6 MHz.

The bottom line: OFDM plays within the 18 to 42 MHz upstream spectrum with an additional 6 MHz to spare, while QPSK uses up the upstream spectrum for just POTS and specials; there is no allocation left for data.

So what's the extra 6 MHz worth?

First, for a POTS service, let's assume 500 homes to a node and three-to-one concentration. Let's further assume 672 subscribers for the service and a $20 monthly fee. The extra 6 MHz is worth $13,440 per month per node.

Or take a data service for telecommuters and other power users, with a guaranteed 512 Kbps bandwidth. Again, let's assume 500 homes per node, and a 20 percent take rate, or 100 homes signed up. The peak rate is 28 percent, or 28 users at a time, and the monthly charge is $99.95. In this case, that extra 6 MHz is worth $9,995 per month per node in incremental revenue.

A third example deals with casual Internet users. With 500 homes per node, let's assume a 100 percent take rate, or 500 subs, with a 45 percent peak rate, or 224 users at one time. With a monthly charge of $19.95, that 6 MHz works out to $9,975 per month per node.

Now let's take the $9,995 in incremental revenue per node and extrapolate that benefit for an entire area, with 100,000, 150,000, and 200,000 households (See table). *–TS & GH*

Incremental revenue information

Households	Number of nodes	Monthly extra revenue per node	Total extra monthly revenue	Annual extra revenue
100,000	200	$9,995	$1,999,000	$23,998,000
150,000	300	$9,995	$2,998,500	$35,982,000
200,000	400	$9,995	$3,998,000	$47,976,000

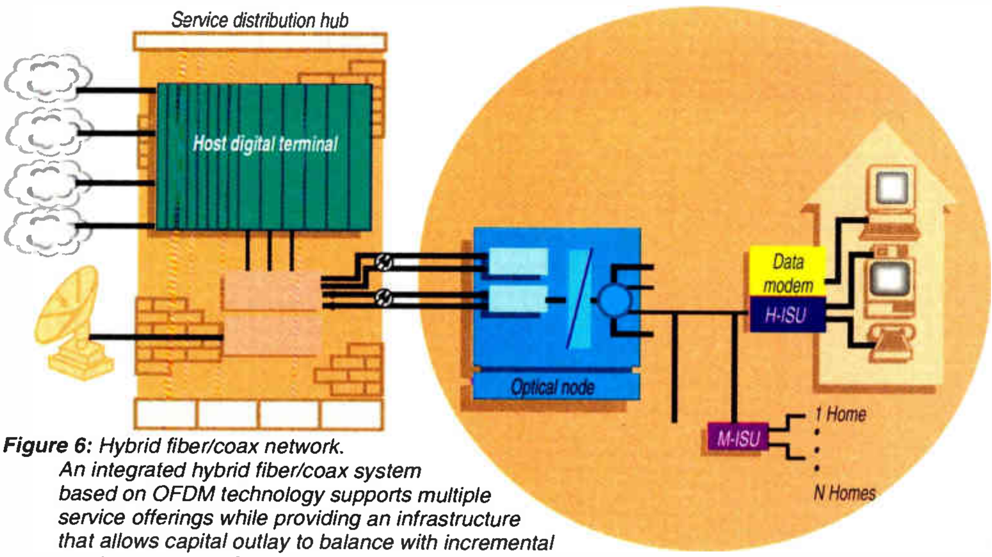


Figure 6: *Hybrid fiber/coax network.*
An integrated hybrid fiber/coax system based on OFDM technology supports multiple service offerings while providing an infrastructure that allows capital outlay to balance with incremental service revenues. Both residential and business services are supported with multiple lines of telephony, data and broadcast video.

problems with a 24-hour call test, where a circuit was kept up for a full day.

After this successful field trial showing the robustness of OFDM, live services are now running on the system. That proven resiliency and efficiency are two reasons why OFDM and related multi-carrier technologies are also under consideration around the world for broadcast HDTV transmission, Digital Audio Broadcasting (DAB), and Asymmetrical Digital Subscriber Line (ADSL) services.

Conclusion

MSOs desiring to turn bitstreams into revenue streams from telephony, data and other two-way services are taking a hard look at the return path, which can be a choke point in their networks. Several strategies can be employed to overcome noise and capacity problems in the return path, including plant hardening and high pass filters.

But one of the keys to getting the most out of the return path is the modulation scheme used.

Current chip technology makes it feasible to use OFDM, a state-of-the-art modulation technology that offers greater spectral efficiency, more resilience against narrowband and impulse noise, and better overall reliability than alternative TDM schemes. CED

Cost and capability analysis of self-healing video

Universal uncompressed systems vs. Sonet

By John Thoma, Senior Product Line Manager, ADC Video Systems

The superiority of digital over analog technology in transporting video signals is well recognized. Only digital transport systems can provide a fail-safe backbone that will carry voice, high-speed data and video over long distances without signal degradation.

In designing a broadband digital network, the designer has to choose between two kinds of systems: Sonet or universal uncompressed. Although both will deliver superior capacity, each is based on a different architecture. For network engineers designing for maximum performance with minimal life-cycle costs, several factors should be considered in the design process. These are:

- ✔ Application flexibility and universality
- ✔ Signal fidelity (measured with signal-to-noise ratio, or SNR)
- ✔ Platform capacity and reliability
- ✔ Cost to implement and maintain.

An understanding of these factors will help designers of video networks understand tradeoffs and achieve optimal cost/performance characteristics.

Figure 1: Example network architecture: Sonet

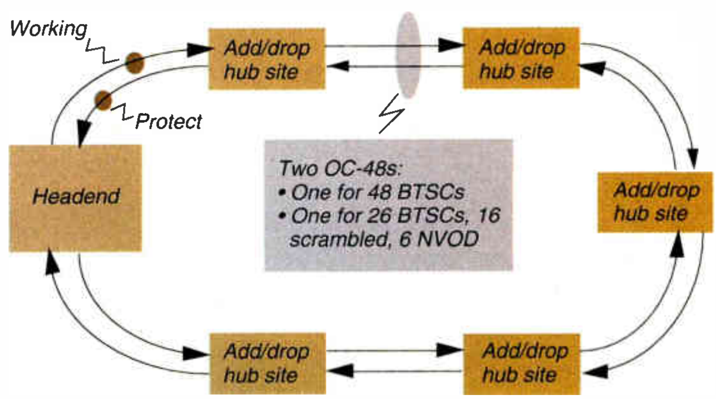
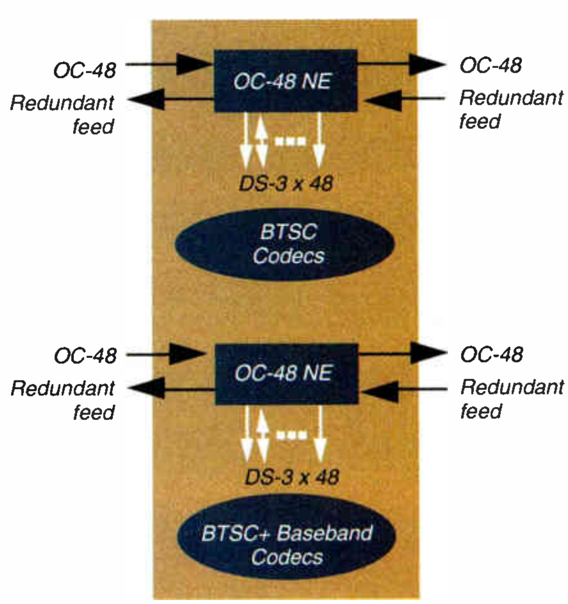


Figure 2: Example Sonet network equipment detail



The platforms

Sonet. Sonet (Synchronous Optical Network) is an evolving network interface standard that describes synchronous fiber optic transmission systems. The standard established a set of rates, e.g., OC-48 (2.46-Gigabit per second) and formats so that telephone companies could synchronize telephone networks and interconnect fiber optic transmission lines. Sonet video systems typically carry compressed video signals at an OC-3 rate (155.52 Mbps), using proprietary video codecs.

Universal Uncompressed Digital. These systems transmit a wide variety of signal types (e.g. any video signal, broadband plus IF) using a high-speed, uncompressed digital format in the supertrunking of broadcast and interactive video networks. Because signals are uncompressed, they are of higher quality–they do not suffer the signal fidelity loss accompanying compression.

Application flexibility and universality

Sonet was established as a standard for carrying digital data for multiple services. There is strong network management support for Sonet systems, and equipment is available from multiple vendors. Its primary users are telecommunication carriers and telephone companies that use the platform for their corporate needs or for public network resale. The ability to build self-healing networks is an integral part of the Sonet standard.

Sonet systems feature a drop/add/pass capability. Sonet uses "payload pointers" to mark the position of each subrate channel, making them available for dropping/adding without demultiplexing the whole high-speed stream. This means that signals can be dropped or added into a higher speed digital stream (e.g. dropping or adding DS-1 signals from a DS-3) without demultiplexing.

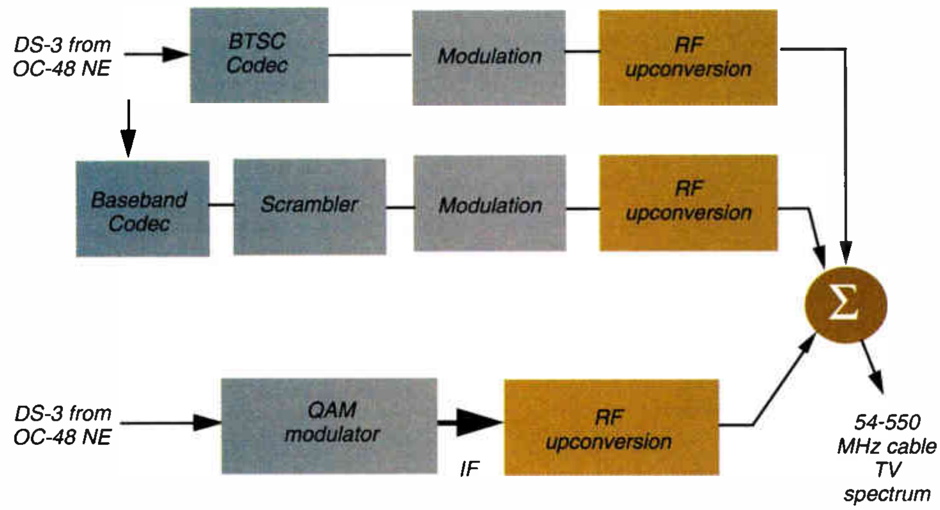
While Sonet can be used for video transport (typically with compressed DS-3 video signals), it has disadvantages–it's still inherently focused on vendor-dictated, proprietary standards. For example, video codecs from different vendors cannot be used interchangeably–an operator is "locked" into one supplier. And, even at the "mid-span meet," network management systems from different vendors cannot talk, and interact, with each other.

Additionally, Sonet has a limited ability to carry many common video signal types. For example, it cannot carry DS-3 and E-3 signals together, in native format. Nor can Sonet carry the IF signal (41-44 MHz) to video system components such as satellite video receivers, scrambling equipment and QAM modulators. Sonet systems are unlikely to be able to carry SMPTE-259 (D-1) 270 Mbps stereo anytime soon.

Universal uncompressed digital video networks, in contrast to Sonet networks, offer more flexibility and openness. They have been available from multiple vendors for several years. The wide range of interfaces available for universal uncompressed digital video transport systems also means that studio and broadcast quality video can be carried, as well as scrambled and digitally modulated (QAM, VSB) signals at IF. Data and telephony networks can be built using DS-3 interfaces. SMPTE 259 interfaces will be available by September 1996.

Flexible drop/add/pass capabilities are available for universal uncompressed digital

Figure 3: *Example Sonet network - hub site equipment detail*



video networks–electronically switched, remotely controllable, and optimized for video. Compared with Sonet, they offer far more drop/add/pass capabilities. They offer more flexibility, allowing, for example, the direct switching of video signals. They supply more payload information, and more information about the video channels, including channel identification, so that reinsertions are avoided.

Universal uncompressed digital systems carry scrambled signals and vertical blanking interval (VBI) information with high fidelity, intact. This offers large cost savings by centralizing processing equipment, instead of distributing it at each hub site, as is required in a Sonet video transport system.

Flexibility and centralized processing means that universal digital transport systems can be cost-effective for low capacity networks and then scaled up as capacity demands increase. Scrambled signals can be added without adding equipment at each headend. Single-channel extensions can easily be added to the backbone.

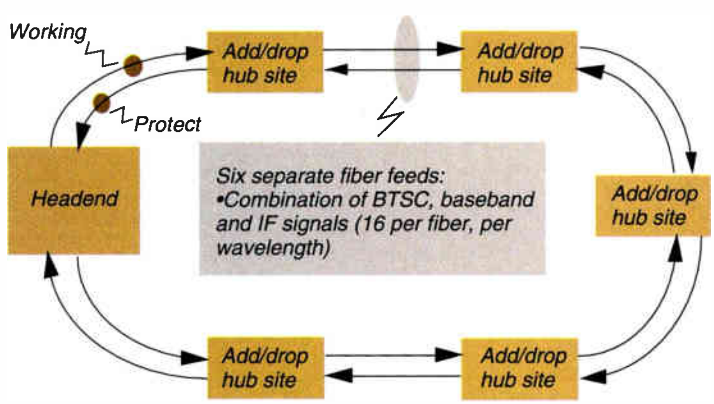
Digital video networks feature the capability to build multiple types of self-healing networks (electronically and optically switched), and standards-based network management systems (currently TL-1, with more capabilities to come).

Platform capacity

Both Sonet and digital transport platforms are capable of 10-Gbps capacity. In ,this is the OC-192 rate, achieved with wavelength division multiplexing (WDM) or higher bit rate time division multiplexing (TDM) technologies. Some universal uncompressed digital transport platforms achieve this same capacity with dense wavelength division multiplexing technology (DWDM). It does not suffer any of the optical dispersion limitations, and resulting distance limitations, of high rate TDM systems.

Capacities of 20-Gbps and higher have been demonstrated for both Sonet and uncompressed digital systems.

Figure 4: *Example network architecture: universal uncompressed*



Reliability

Reducing downtime will maximize advertising and service revenue and lower repair and maintenance costs. But there is another reason to be concerned about the reliability and availability that a self-healing network provides. If a video service provider is to compete as an "all" service provider (cable TV, telephone interconnect, Internet provider), it will need to demonstrate the same uptime values that customers now expect and receive from telephone networks.

Household expectations for video services, and future interactive broadband service, are based upon their telephone experiences. Customers expect close to 100 percent reliability and availability, and they get it: average telephone network availability is 99.99 percent[1], with 50 to 60 minutes of downtime per year.

Self-healing network costs

In order to evaluate the performance/cost of the two platforms, a video distribution network based on Sonet, and one based on universal uncompressed digital, will be assumed. These are compared for self-healing capabilities and costs.

Customers expect close to 100 percent reliability and availability, and they get it from telephony

This network example will be designed with:

✔ A headend and five served hub sites
✔ Average of 20 miles between sites
✔ Local drop/add/pass is needed for up to 32 of the video channels
✔ Redundant protection must be provided against any one fiber break
✔ Channel types: 16 scrambled premium channels
✔ 6 Quadrature Amplitude Modulated (QAM) channels for near video-on-demand (NVOD)
✔ 74 baseband signals with BTSC audio. See Figures 1 through 3.

In this example, the Sonet network uses two OC-48 signals to transport the 96 video channels. It was designed with counter-rotating rings, to provide complete protection against any one fiber failure.

There are two main types of Sonet self-healing capabilities: Unidirectional Path-Switched Ring (UPSR) and Bidirectional Line Switched Ring (BLSR). In the UPSR case, signals are duplicated at the master headend and fed around the ring in opposite directions. Working, or service, circuits typically flow clockwise, and protection circuits, counter-clockwise. If a failure occurs, service hubs switch to the protection fiber.

For the BLSR case, fibers are typically shared, with one fiber carrying working circuits on one-half of the capacity (e.g. slots 1-24 of an OC-48), with protection on the other half (slots 25-48). If a failure occurs, the equipment next to the failure alerts neighboring equipment of the problem (by a loopback).

While BLSRs have advantages in efficiently distributing inter-node traffic, the UPSR architecture is typically used for video transport applications because it offers path protection. UPSRs are considered in the Sonet version of this network example.

Sonet network cost assumptions

These assumptions, considered by the author to be conservative, were used for the Sonet cost models:

✔ OC-48 network element: $75K/site per OC-48

Table 1: Example network costs for Sonet network

Fiber	$135,000
Network equipment	$960,000
Codecs, scramblers, modems	$2,791,000
Total:	$3,886,000

With WDM, save about $50K in fiber costs (in this example)

✔ BTSC, baseband DS-3 codecs: $3,500/channel/end

✔ Add $1,300/channel for modulation/upconversion

✔ Add $2,000/channel for premium scrambled channels

✔ QAM modulators @ $4,500/channel

✔ Add $700/channel for upconversion

✔ Aerial fiber cost (4 links at 20 miles/link): $22,500 in materials and installations

This example excludes network management costs because these are assumed to be similar

Figure 5: Example network equipment detail-universal uncompressed

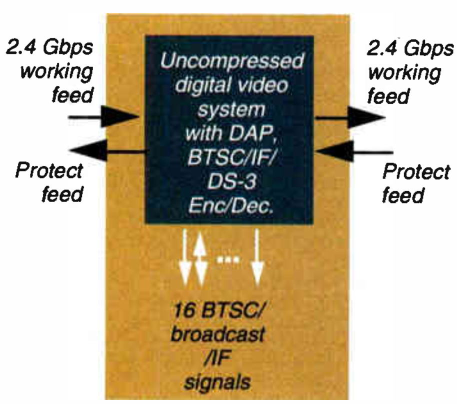


Figure 6: Example network hub-site equipment detail-universal uncompressed network

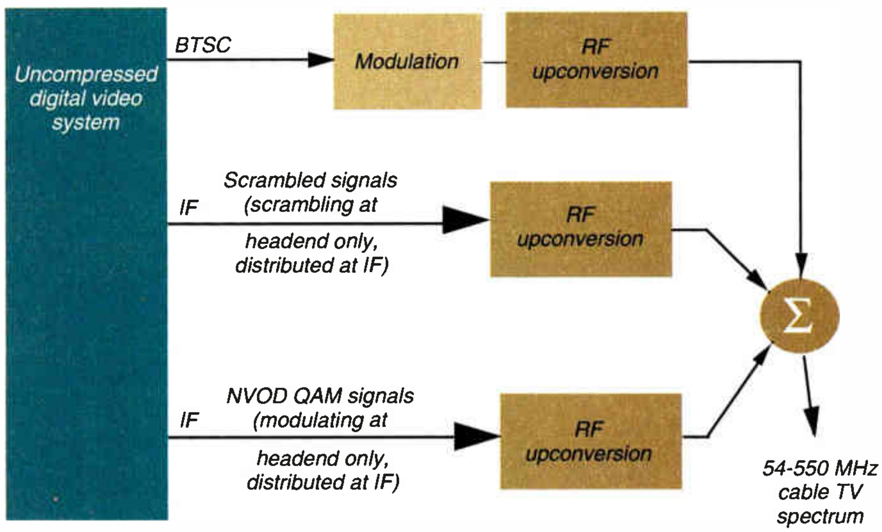


Figure 7: Universal uncompressed network with electronic protective switching

At each shelf, each hub site:

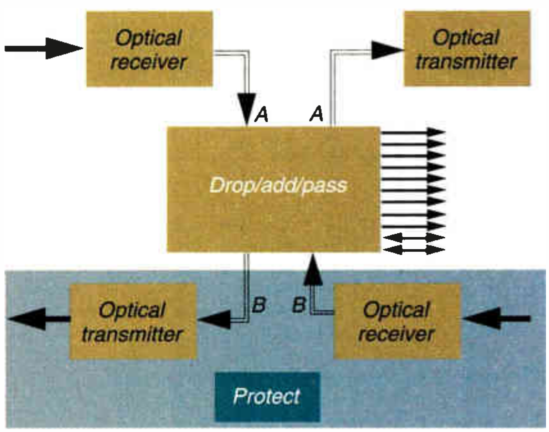
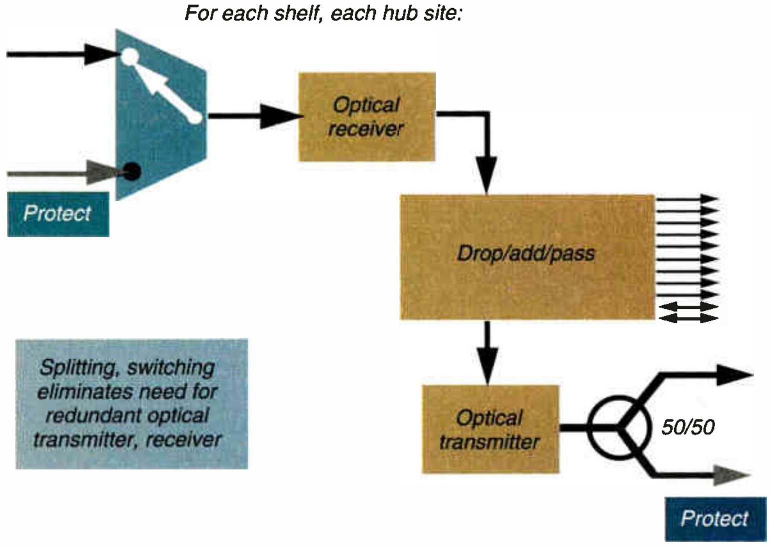


Figure 8: Universal uncompressed network with optical protective switching

For each shelf, each hub site:



for both the Sonet and universal uncompressed cases.

The working and protect paths can be done with either two separate sets of fibers, or wavelength division multiplexing (WDM) to put signals at different wavelengths (1310 nm and 1550 nm) in opposite directions on the same fiber.

Not included in this cost analysis is the cost of transporting and locally inserting subscriber control information. This must be done at each of the served hub sites.

Universal digital example

The universal uncompressed system studied is a 2.4 Gbps, 16-channel system. It features two types of automatic protective switching for self-healing networks: Electronic (redundant optics) and optical. The system works with two types of network managers, including a TL-1 compatible system.

In contrast to the Sonet network, which requires scrambling equipment and QAM modulators at each of the served hubsites, the universal digital system can transport signals directly at intermediate frequency (IF): 41 MHz to 46.5 MHz. This gives the opportunity to save costs by consolidating scramblers and QAM modems at the headend, and distributing these signals at IF. Then, only a carrier frequency upconversion at each hub site is needed[4]. See Figures 4 through 6.

The cost savings comes from the elimination of the duplicate optical transmitters and receivers

This network offers two choices for switching in backup redundant fiber paths: electronic and optical. Figure 7 shows a detail of the electronically-switched configuration.

With electronic switching, the optical transmit and receive components are duplicated. The switching is done electronically by the drop/add/pass card.

The optical protective switching architecture (see Figure 8), uses a single pole, double throw optical switch to restore lost signal by switching to a backup fiber feed. For this case, a processor constantly queries the drop/add/pass card, and commands the switch if a failure is reported.

The cost savings for the optically-switched universal uncompressed case, versus electronically, comes from elimination of the duplicate optical transmitters and receivers. See Table 2.

Figure 9 shows failure by cause, for outages recorded by the Network Reliability Steering Committee (NRSC), 1992-1995[5].

As shown, the majority of network outages are fiber faults (75 percent). Both Sonet's redundant protection and the electronic and optical switching in the universal uncompressed case will fully protect against any single fiber failure. However, as Table 3 shows, self-protecting universal uncompressed digital networks enjoy a large cost advantage versus Sonet networks with similar capabilities.

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Wavelength division multiplexing (WDM) offers slight cost savings versus use of separate fiber paths for working and protect feeds. This cost savings will increase as fiber path lengths increase. The initial network could be built using separate paths, and converted to WDM as future needs for network expansion dictate.

WDM has the disadvantage of stopping traffic in both directions if a fiber fault occurs. However, all hub sites will still have a good working feed in the event of one single failure, and the network will be unaffected. This will be a problem if multiple fiber failures occur (if WDM is not used, the network is less susceptible to multiple fiber failures).

Summary

Universal uncompressed digital networks offer advantages over Sonet networks for the transport of wideband video services.

To be specific, universal digital:

✔ Offers more versatility, carrying more types of common video signals, and offering more interfaces than Sonet. Universal digital's increased drop/add/pass functionality, greater flexibility, and centralized processing (versus Sonet's distributed) make it easier to operate and scale.

✔ Offers capital investment protection because the system is not tied to one supplier's standards. Flexibility and scalability mean it can be added to, or upgraded, as needed.

✔ Operates at the same capacity as Sonet and provides equal protection against outages.

✔ Is less costly to install and, because less equipment is involved, will be easier and less expensive to maintain. Centralized equipment reduces inventory, personnel requirements, and space and overhead costs.

Of the network configurations reviewed, the optically-switched universal uncompressed network offers the lowest cost of all alternatives considered, and fully protects against fiber failures.

Video service providers should consider it for the best combination of protection performance and cost-effectiveness. CED

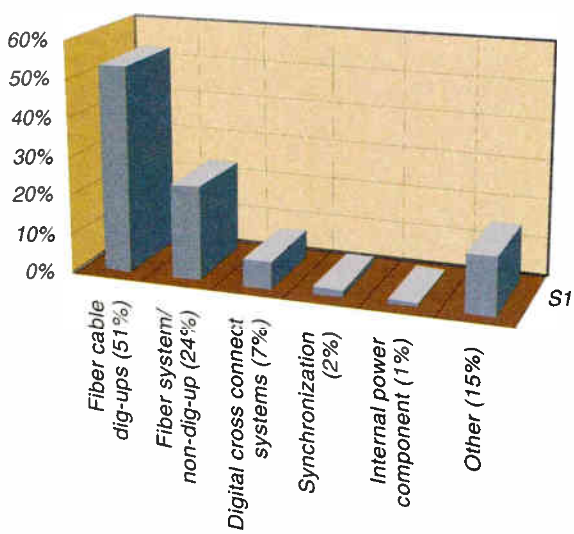
***Table 2:** Example network costs for universal uncompressed network*

	Electronic backup switching	Optical backup switching
Fiber	$407,295	$431,227
Uncompressed digital video system equipment	$1,568,976	$1,280,040
Scramblers, modems upconvertors	$617,000	$617,000
Total:	$2,593,270	$2,328,267

***Table 3:** Sonet versus universal uncompressed example network cost comparison*

Network type	Network cost:					
	Total	Per site	Per channel, per site	Per channel, per site with WDM	Cost savings versus Sonet	% cost savings versus Sonet
Sonet network with line-switched path, distributed scramblers	$3,886,000	$647,667	$6,747	$6,616	-	-
Universal uncompressed network with electronic switching	$2,593,270	$432,212	$4,502	$4,300	$1,292,730	33%
Universal uncompressed network with optical switching	$2,328,267	$388,044	$4,042	$3,840	$1,557,733	40%

***Figure 9:** Causes of service affecting fiber outages, 1992 - 1995*



From: The Network Reliability Steering Committee (NRSC), 1992-95 outages, as reported in "Concern over Fiber Cuts Prompts Call for New Rules," by Deborah Eby, America's Network, *January 15, 1996, page 14.*

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About the author

John Thoma is a senior product line manager with ADC Video Systems and is based in Meriden, Conn.

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CED

THE PREMIER MAGAZINE OF BROADBAND COMMUNICATIONS

Cable pros:

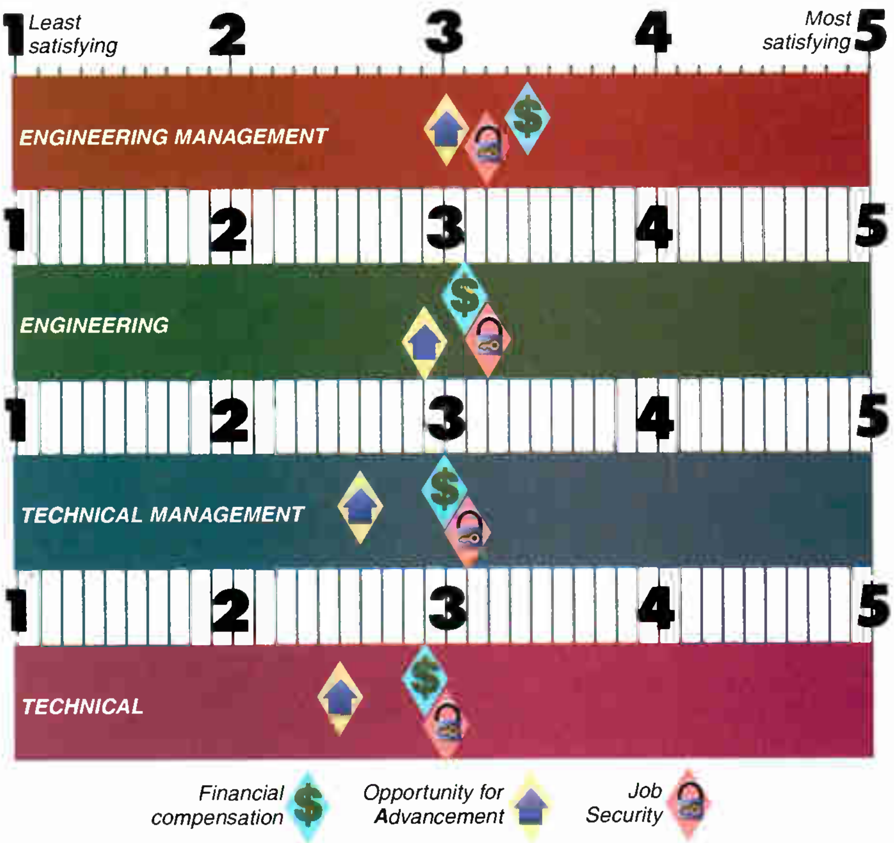
By Michael Lafferty

While the newspapers analyze the latest merger, lawsuit or technical advance in the converging telecommunications industries, the workers in the trenches are left wondering how each event is going to ultimately affect them. The corporate convolutions often leave these dedicated professionals concerned and terribly confused about their future in an industry that many openly love and sometimes hate at the same time.

CED's 1996 Salary and Job Satisfaction Survey, which generated more than 280 replies, also shows another alarming trend that bodes ill for both the industry and its committed workforce. Technical professionals are reporting increased levels of on-the-job stress that's threatening not only job performance, but personal lives as well. And for many, there's no relief in sight.

One 42-year-old technical manager from Washington state seems to summarize the feeling of many when he commented, "I'm not willing to die for cable TV. If stress levels continue to rise, I will leave the industry." Unfortunately, some won't or can't seem to acknowledge the ultimate harm such high levels of stress can cause, often with tragic results for all concerned. (See story, "Stress takes its toll," on page 92.)

***Figure 1:** Satisfaction index of financial compensation, opportunity for advancement and job security by job classification*



*Respondents ranked their satisfaction levels 1 through 5 in each category; 1 being the least satisfying and 5 being the most satisfying. **Note:** Job classification examples-see Figure 3.*

Genuine concerns

Respondents to this year's survey were, at times, blunt ("My immediate supervisor is an _ _ _hole!"), confident ("For the most part, no one questions what I do. I am very good at what I do, and management knows it."), and doubtful ("I really wonder if the industry is as ready for competition as they claim to be. I hope we are."). Yet, the concerns that came through were deeply felt and often very perceptive.

While many MSOs have pooh-poohed the impact that competitive services are having on cable, many front-line workers seem less sanguine. One 42-year-old technical manager from California seemed to sum up the industry's situation succinctly, while taking on the competitive challenge personally, when he stated, "Although I encourage it (competition), it has been a lot of years since I have worked in a real competitive environment. With DBS,

Satisfaction guaranteed?
Most 1996 salary and job satisfaction survey respondents were somewhat less than enthusiastic when it came to their satisfac-

stretched to the limit

DSS and MMDS, I will need to get my sales cap back on to keep my industry ahead."

Another worker from a small West Virginia system notes that, "DSS has started to erode my subs like a waterfall." He predicted that because of competition of the telcos and DSS, "If the cable industry doesn't open their eyes, they will lose 30 percent of their subs to competition by the year 2000. They need to start spending money on rebuilds and upgrades before revenue declines so much that they can't."

The deep pockets of the rival telcos had more than one respondent worried. A technical manager from a mid-sized system in Missouri speculated, "Their capital and extensive experience makes me think it's only a matter of time before they overwhelm us." A 46-year-old engineering manager from a mid-sized system in Florida put the ultimate question even more bluntly when he asked, "When will it all belong to AT&T?"

The road to success

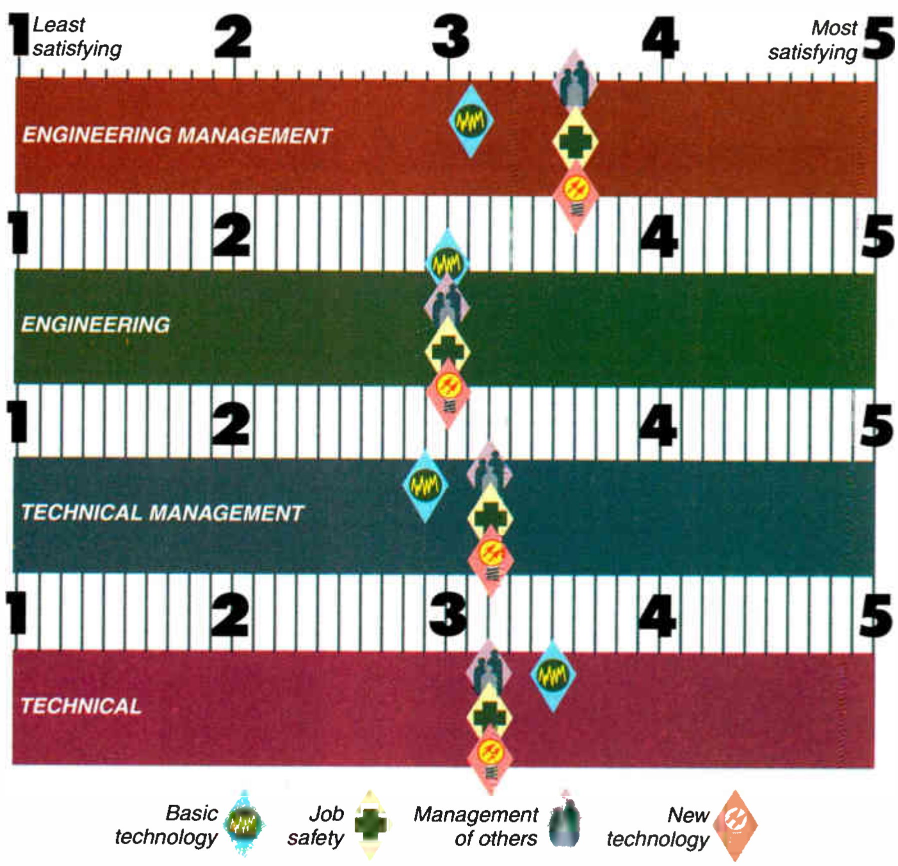
Yet many of this year's survey respondents, through experience and plain old common sense (POCS), go straight to heart of the solution when it came to discussing cable's strategy for success in the increasingly competitive marketplace. As one manager from a smaller system in Alabama notes, "The major product for a cable company should be service, not programming."

tion in a number of areas, including job advancement and pay (left) and training received in basic technology and personnel management (right).

A manager for a cluster of small systems in West Virginia sums up the situation better than most high-priced marketing executives could when he wrote, "Customers should be the biggest concern with everyone. We can deal with the rest, no matter what that may be. But without customers, there will be no job or industry. As we grow, we're losing sight of each and every customer. We need that personal contact, that familiar face. We need our customer's trust."

Another manager, from a mid-sized operation in Illinois, believes customer service will be the deciding factor when consumers have to make a competitive decision. "We have to do whatever it takes to win the customer over," he

Figure 2: *Satisfaction index of training received in various areas by job classification*



Respondents ranked their satisfaction levels 1 through 5 in each category; 1 being the least satisfying and 5 being the most satisfying. ***Note:*** *job classification examples-see Figure 3.*

Figure 3: Average salary of survey respondents by job classification and age

	Engineering management	Engineering	Technical management	Technical
Under 35	$45,240	$34,901	$37,018	$33,105
35 to 45	$63,936	$46,099	$43,084	$39,500
Over 45	$67,633	$48,527	$42,722	$37,000

Notes: **Engineering management** - includes V.P. Engineering, Chief Engineer, etc.; **Engineering** - includes Staff Engineer, District Engineer, Plant Engineer, etc.; **Technical management** - includes Plant Manager, System Manager, Administration, etc.; **Technical** - includes Installer, Technician, etc. Due to limited response in some job classifications, salary figures may not reflect realistic industry averages.

stated. "As technology evens out with the RBOCs, our people will be the reason customers choose to do business with us or our competitors. We have to take customer service to the next level just to survive."

Feeling the pinch

The industry's ability to deal with customers and the new technologies elicits considerable concern and criticism from survey respondents. A technical manager for a large MSO in Tennessee states, "Our industry seems to be more technology driven, rather than service driven. We are not meeting customer needs now! Yet, we want to provide even more technical services."

More than a few respondents decry corporate belt tightening, which has resulted in reduced funding of training, maintenance and staffing. One of the few women to respond to the survey described a situation that appears to be all too common. A technical manager for a large MSO in the Midwest, she states: "I am in a technical department with supervisory responsibilities. Yet, I've never received more than minimal basic technical training and no supervisory training. My department is pretty much ignored as long as our major duties are done."

A manager in a mid-sized system in Illinois believes his company is not anticipating the need for new technology training. "It seems," he said, "like the new technologies are emerging more and more each day, and we don't seem to be learning much about them until they're on top of us." Another manager from a large MSO in Texas bemoans staff cutbacks as a self-defeating measure that has immediate implications for cable customers. "Cutting back doesn't serve our customers better," he states. "It causes more missed appointments, more promises and commitments to be broken."

A 36-year-old manager from Oregon describes his harried situation this way: "Our corporate offices expect each man to do the work of two men everyday. We all run around like chickens with our heads cut off putting out fires." He went on to describe how preventive maintenance has fallen victim to finances as well. It has, he states, become nothing more than, "Run it until it breaks. Jury-rig it back together and run it some more. Headends, plant, trucks, it doesn't matter what we're talking about." He and others believe the fault lies with "corporate suits" he describes as "Greedy, moron accountants, who do not have a clue about what it takes to run a system, (and who) are running (and ruining) our industry."

Money talks, people walk

Again and again, survey respondents bemoan the fact, as they see it, that cable personnel, especially when compared to the competition, are underpaid. As a result, they say this compensation gap is depleting cable ranks of trained talent. As one mid-sized manager from Massachusetts stated, "It's the same old story. Cable employees (and their superiors) have been underpaid for years."

According to a manager from a smaller system in California, "tech-napping" is occurring from both inside and outside the industry. "We have had a major employee turnover during the past four years due to higher wages offered at other area cable companies and the phone company!" Another California manager believes pay scales punish his company's best techs. He notes line maintenance techs with 25 years experience earn $14.75 an hour, while those with half the experience (i.e., 12 years) earn $13 an hour. As a result, he believes "We punish our best techs for staying and doing what they enjoy. The industry forces them to move on."

A technical manager from a large MSO in New Jersey wondered why technical personnel never receive credit nor additional compensation for keeping their systems going. He finds this particularly galling when CSRs receive sales incentives, telemarketing people get sales bonuses, sales managers are rewarded with customer bonuses and general managers receive system bonuses.

Consolidation woes

Many respondents also worry about the growing clustering movement in the industry. Their concerns are expressed on several different levels. Middle management types fear mergers with large MSOs could mean their jobs would be deemed redundant by the new management. As one manager from a mid-sized Ohio system states, "Where will I stand three to five years from now? Will middle management be cut like they did in the telcos?"

A 33-year-old engineer from a mid-sized system in Texas says his years of experience may not now bode well for him. "I've been through three sales, and every time, the corporate office was dissolved. I was system level then, and I was not cut. I am corporate level now."

A number of technical pros from smaller systems are concerned about being swallowed up and forgotten by larger systems. One manager likens his small system to a "cash cow" for a larger operator.

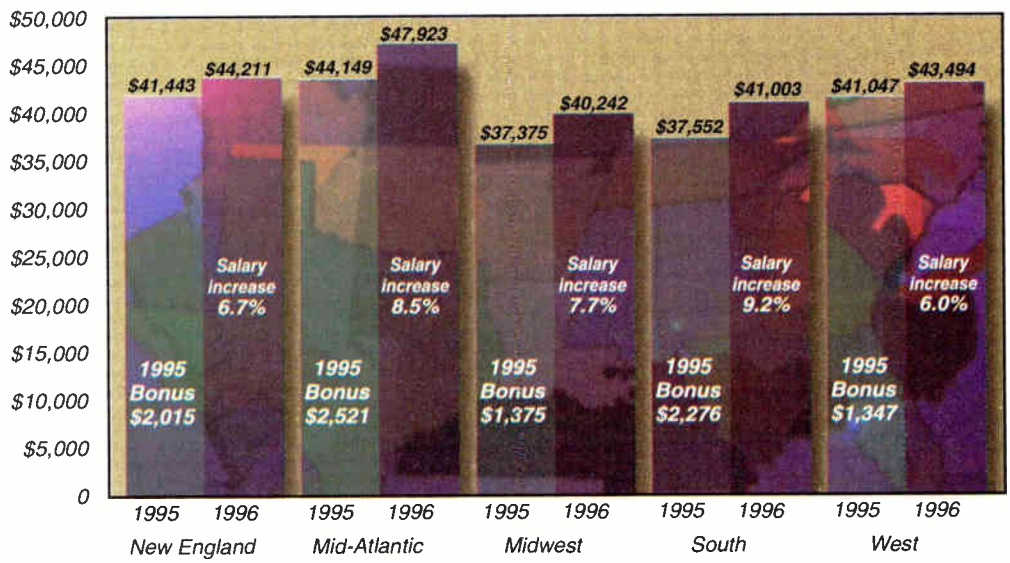
Another manager from a small system in West Virginia states, "Small systems like mine are being sucked dry of revenues. But not one dime is being put back in. Large MSOs seem to put these systems on the back burner, instead of looking at ways to make use of the resources available to them."

Figure 4: Job classification profiles of survey respondents

	Engineering Management	Engineering	Technical Management	Technical
Average age	42.7	41.7	39.9	29.5
Tenure in industry	12-15 yrs.	12-15 yrs.	12-15 yrs.	10-12 yrs.
Tenure at employer	7-10 yrs.	7-10 yrs.	7-10 yrs.	7-10 yrs.
Average salary - 1996	$62,241	$44,213	$42,056	$34,595
Average # of subs in system	40,000-79,999	40,000-79,999	20,000-39,999	20,000-39,999
Average # of vacation days	16.4	18.8	17	15
Average # of personal days	6.1	6.9	7.1	9.2

*Notes: **Engineering Management** - includes V.P. Engineering, Chief Engineer, etc.; **Engineering** - includes Staff Engineer, District Engineer, Plant Engineer, etc.; **Technical Management** - includes Plant Manager, System Manager, Administration, etc.; **Technical** - includes Installer, Technician, etc. Due to limited response in some job classifications, salary figures may not reflect realistic industry averages.*

Figure 5: Average salaries / % of salary increase / 1995 bonuses of survey respondents by region



*Notes: **New England:** Maine, New Hampshire, Vermont, Massachusetts, Rhode Island; **Middle Atlantic:** New York, New Jersey, Pennsylvania; **Midwest:** Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North and South Dakota, Nebraska, Kansas; **South:** Delaware, Maryland, Dist. of Columbia, Virginia, West Virginia, North and South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas; **West:** Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii. All salary and bonus figures rounded to the nearest dollar.*

Figure 6: Average salaries of survey respondents by job classification and region

	Engineering management	Engineering	Technical management	Technical
New England	$78,000	$40,000	$43,114	$30,000
Middle Atlantic	$52,750	$45,400	$48,856	$33,250
Midwest	$38,500	$43,924	$40,429	$35,447
South	$44,007	$42,625	$40,567	$30,336
West	$68,400	$47,167	$40,886	$37,375

*Notes: **New England:** Maine, New Hampshire, Vermont, Massachusetts, Rhode Island; **Middle Atlantic:** New York, New Jersey, Pennsylvania; **Midwest:** Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North and South Dakota, Nebraska, Kansas; **South:** Delaware, Maryland, Dist. of Columbia, Virginia, West Virginia, North and South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas; **West:** Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii. All salary figures rounded off to the nearest dollar. Due to limited response in some job classifications, salary figures may not reflect realistic industry averages.*

Despite it all...

Survey respondents were never shy about sharing their concerns and criticisms of the industry they work in, yet they weren't hesitant to express their joy and satisfaction with their work, either. And, while one manager from a mid-sized system in Kansas expresses happiness that his system "was no longer TCI," most others took pleasure from their work situations on several levels.

A district manager from Indiana, like many others, puts it on a human level by stating simply, "It is so nice to turn a grouch into a smiling face." Another manager says his co-workers were like "a second family."

While many say they don't like having their hands tied by corporate policies, these same people revel in their own freedom of action in other areas. A young worker in Florida expresses joy about his "freedom to make decisions. The opportunity to succeed and accomplish limitless tasks."

A 48-year-old engineering manager for a large Colorado MSO takes great pleasure in the fact that the cable industry provides him a level of satisfaction he never realized in his previous job. He says that his "personal ownership and responsibility for 'my piece of the pie' is most gratifying, since I didn't have this luxury in my last job at the telephone company!"

And, while worries and concerns about the future run throughout the responses, that very same future was also generating a lot of excitement as well. One middle-aged manager from Indiana exclaims, "We are part of a staggering evolution of technology that has put 'fun' back into cable TV."

A 40-year-old Maryland manager remarks that his company is "still very aggressive, and I feel the cable TV industry, as a whole, is on the verge of a technical revolution. It's the same excitement the industry went through in the late ''70s and early '80s."

One of the industry's veterans, an engineering manager from a large Pennsylvania system, put it best. "The field of cable TV," he states, "has and remains to be an exciting career to pursue. And though frustrating some days, it has never been boring in my 30 years in this field." CED

Stress takes its toll

By Michael Lafferty

In early July 1995, things were looking pretty good for David and Kitty Meszes and their two children, Joshua, 12, and Racheal, 10. David, an almost 10-year veteran with Cablevision Systems Corp., had recently returned to his home outside Cleveland, Ohio from the 1995 SCTE Cable-Tec Expo in Las Vegas with a second place medal for his efforts in the Cable-Tec games.

On July 10, 1995, David made the big switch from being an hourly wage earner to a salaried position when he was promoted to field service technician supervisor. According to his wife Kitty, 35-year-old David had worked toward the promotion for a couple of years and "when he got it, he was all excited."

The excitement was short-lived.

"For the last six months of his life, I watched the man I love fall apart under the stress of a job. I reached out and couldn't help, and I shall forever live with the pain."

Kitty Meszes
August 1, 1996

Soon, the stress associated with the job seemed to consume David. "It took like three months," says Kitty, 34. "At home, it fell apart immediately. He was bothered by everything. We just couldn't do anything right. I had seen such a turnaround in his personality. I mean he was angry all the time. He was yelling. He kept telling me, 'Give me time to adjust.' And, I'm like, 'David, we are.' But in his mind, he started treating us like we were his enemy. And it was sad. I was seeing something happening, and I didn't know what it was until it was too late."

David's preoccupation with his new job got worse, says Kitty. The long hours started piling up. "It was like he doubled his hours," she says. "I tried to talk to him. I said, 'Dave, it's not really worth it. You're putting in twice as many hours and coming home with not much more pay than you were making before'."

The on-call nature of the job began to interfere in what little time they did have together. "You know," says Kitty, "they had to be on 24 hours a day. The minute he'd walk in, he'd get paged. And it would be like an hour on the phone. And that even took more from us."

She begged him to take time off, pointing out that he had more than 200 hours of vacation, sick and personal days accumulated. "The whole thing," says Kitty, "was unbelievable. He kept telling me, 'I can't right now,' because he had to adjust to the position."

Sometime near the end of January, something between the two, who had known each other since childhood, broke. "David," says Kitty, "had decided he no longer could deal with his family. He shut us out completely. He told me, 'I can't deal with everything, and right now, all I can worry about is my job'." He told Kitty and the kids to leave.

"That was so unlike Dave that I called his work," explains Kitty. "That's when I had started calling and asking them to have him take a vacation. They barred me from calling. He had started acting so irrationally. It wasn't like him. He was despondent. There were major problems there. And I wanted them to give him a vacation or a stress test."

Things got even worse. David visited his doctor in early February complaining of chest pains, pains in the back of his neck and down his left arm. Kitty continued calling David and his supervisors at work but couldn't get through to anyone. She couldn't leave voice mail messages for him. She threatened legal action. David's voice mail became accessible again.

"You know," says Kitty, "all I wanted to do was tell him that the kids and I loved him and that whatever he was going through, we were family and we would deal with it together. And I asked him to go get help. I left messages on his voice mail everyday until...".

On Monday night, March 11, Kitty called David, and he picked up the phone himself, the first time he had done so in two or three weeks. "I thought, Oh God, a ray of hope," said Kitty. "Maybe something I had said had registered.

"I just needed to talk to him. And he had answered the phone and he said, 'Kit, I'm in pain. I'm in pain.' And, I'm trying to figure, what kind of pain?

"I don't think he was even hearing me talk to him. He just wanted to tell me what he had to tell me. He wanted me to have compassion for him, to forgive him. He was in pain. And he wanted to tell me good-bye. And he killed himself on the phone.

"It was the longest good-bye in my life. But see, I was the only person in his life, and I think he needed me there when he left."

Since David's death, Kitty has been working with Ohio State Senator Alan Zeleski to fashion legislation that would require companies of a certain size to offer employees some type of Employee Assistance Plan (EAP) to head off downward spirals like David's. According to Isabelle Arace, vice president of human resources for TKR Cable Company, EAPs offer short-term counseling for people who are having any number of problems.

"The purpose behind the EAP," says Arace, "is to get workers who might be demonstrating performance, alcohol or drug problems. It's usually totally company supported (i.e., no cost) and highly confidential." Once the EAP counseling and/or evaluation is done, says Arace, an employee's medical coverage usually kicks in if further counseling is required.

Barry Lawrence, spokesperson for the Society for Human Resources Management, says it's important that EAPs become common knowledge and easily accessible. "Companies," says Lawrence, "have to do a good job of communicating their EAP programs without embarrassing people. They have to post that information and send out flyers often so that contact numbers are easily available. That's because many people are still shy or reticent about asking about counseling, although I think the stigma is slowly fading."

The past five months have been difficult for Kitty and her children. "You know what? I still have his work shoes waiting at the door," she says. "There are days I really have bad, bad days. And then there are other days when I can rationalize and understand." Her work to spread the word about the dangers of high-level stress and EAPs gives her hope, and ultimately, a sense of purpose.

"I don't blame him," says Kitty, "like some people, for the fact that he did it over the phone. I think I would have been mad if he had just done it and never contacted me. That's how close we were. I mean, we were best friends since he was 13. It's like a whole chunk of my life is just gone. But, if something can help someone else, I'll feel as though his life wasn't, you know...". CED

Harnessing light through fiber optic attenuation

Real-world performance

By John V. Romeo, President, Fiber Wave Technologies Corp.

The following is an overview of what fiber optic attenuation is, why it is needed, and how it is currently being implemented in cable TV and other data communication systems. It is intended for those who are not engineering specialists, but who need or would like to have a good general understanding of the subject. With that objective in mind, let's start with some fundamentals.

In a general sense, the verb "to attenuate" means "to weaken or lessen." As applied to the light signals involved in fiber optic communications systems, the term has two basic meanings. One meaning relates to the strength or intensity of the light signal–in layman's terms, how bright the light is. The other meaning relates to the "dynamic range" of the light signal, or the range between the lowest and highest input frequencies. Both types of attenuation are needed in fiber optic communications systems.

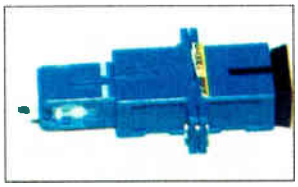
When "less" is better

One reason underlying the need to attenuate the light signals in fiber optic communications systems will be familiar to everyone under the sun: bright, intense light can be hot–and damaging. An intensely bright, sharply focused light can literally vaporize human tissue, which is essentially what happens in laser surgery.

Of course, the laser diodes used in fiber optic communications systems produce power levels measured in mere milliwatts, and only a small portion of that power winds up as a useful signal in the core of a fiber optic cable. But everything is relative, and even a signal that's extremely weak in absolute terms can cause heat damage in delicate I/O components when it exceeds the power-handling capability of a receiver.

It's like feeding a high wattage audio signal to

PHOTO BY M. TCHEREVKOFF, THE IMAGE BANK



This fixed attenuator (SC compatible) is a compact unit used to balance signal levels on networks.

Air gap attenuators are stable in static, predictable environments

speakers that are not designed to handle high-power input: the speakers will burn out.

Another reason why attenuation is often needed can be understood in principle (to extend the audio analogy) by anyone who has heard speakers with a limited frequency response try to cope with an audio signal with a wide dynamic range. The frequencies the speakers were not built to handle are distorted. Like speakers, the receivers used in fiber optic data communication systems vary in their "power-handling/frequency response" capabilities. Although modern receivers are robust, and can accept variable power levels, care must nevertheless be taken to match the signal to the receiver in specific applications to avoid distortion (nonlinear response) at the upper end, and signal loss and distortion due to "noise" at the lower end. The dynamic range of the pin diodes at the receiver end allows the user to pad or attenuate within an "operating window," which is typically ±3 dB.

Of course, a light signal, whether analog or digital, can also be too weak. The objective in fiber optic communications systems is to have the strongest signal possible that does not result in signal distortion, transmission errors and losses or heat damage to expensive equipment. Achieving that objective in cable TV and telecommunications applications is complicated by a number of real-world practicabilities and considerations.

Why signals start out strong

The question naturally arises: if very strong signals pose a problem, why not start out with signals that are "just the right strength?" The short answer is that light intensity is lost over distance–the longer the distance, the greater the loss. Transmitters have to compensate for that "built in" attenuation by starting out with a signal stronger than the optimum signal strength required at the receiver. Also, despite the focus in this article on the need for signal attenuation, the overriding need in fiber optic communications systems is to generate signals that are strong enough to "get the job done" accurately and efficiently.

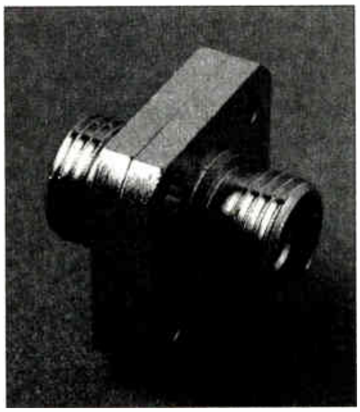
Standard procedure in most fiber optic communications systems is to design transmitters and receivers that are optimized for 10 kilometer distances. In urban cable TV and telecommunications applications, however, the distance between the transmitter and receiver is often 3 km, and in fact varies over a wide range of distances shorter than the standard 10 km. Another "power" variable is that different communications networks often have a varying number of fiber junctions, as well as "legs" of varying lengths and power requirements. Clearly, it would be absurdly expensive and wildly impractical to have transmitters and/or receivers custom-built and optimized for every "local circumstance" and every leg of a communications system.

One solution, which is in fact implemented in perhaps 25 percent of all installations, is to handle signal attenuation at the receiver through automatic gain-control circuitry that either compresses the signal to get it within an acceptable range or "cuts off" the signal outside of the acceptable range. One drawback to such receiver-based solutions is, of course, that such receivers are expensive. For that reason, among others, it is currently more economical and efficient, in the majority of cases, to use fiber optic attenuators–often at the patch panel, where access is easy and convenient.

Fiber optic attenuators enable all terminals in a network to use the same transmitters and receivers, even though the terminals are at varying distances from the transmitters and receivers. They also allow the use of the same terminal equipment in all parts of a local area network by making power levels uniform on the different-length legs of the network. In fact, fiber optic attenuators have proven to be so flexible, effective and reliable that they are used not only to "adjust" power requirements within existing applications, but also are used "up front" in the design and configuration of cost-effective new fiber optic communications systems.

Choices

There are two basic types of fiber optic attenuators–fixed and variable, both available in "inline" or "bulkhead" configurations. As might be expected, fixed attenuators are used when a fixed and unvarying amount of attenuation (usually measured in decibels per kilometer) is desired. They commonly provide fixed attenuation levels in the amount of 5, 10, 15 or 20 dB. Variable attenuators include a mechanism that enables the user to manually adjust the amount of attenuation–any amount between 5 and 35 dB, for example. Variable attenuators are used in testing applications, and in systems with variables that have to be accommodated or adjusted to on an ongoing or periodic basis.



A bulkhead fixed "coupling" attenuator (FC compatible) is easily installed between two patchcords to provide (typically) 5, 10, 15 or 20 dB of attenuation. Also available in SC or ST styles.

Attenuation in both fixed and variable fiber optic attenuators is achieved by absorbing light energy. There are two principal ways this absorption is accomplished: air gap and filtering device. The air gap method–considered "old technology" by some–uses hollow rings for the ferrules at the fiber ends, and it is those hollow rings that create the light-absorbing air gap. In air gap variable attenuators, adjustment of the level of attenuation is achieved by manually turning a threaded mechanism to increase or decrease the size of the air gap. Air gap attenuators are low cost, produce uniform attenuation across wavelengths, and are stable in static, predictable environments. The primary drawback, serious enough to prevent their universal use and acceptance, is high reflectance. Air gap attenuators are also sensitive to environmental conditions and changes and are incompatible with some connector designs.

In the basic filtering-device type attenuator, a light-absorbing material is placed between the ferrule endfaces. Attenuators are also available in the form of adaptors with a light-absorbing filter built in. The primary benefit of such filter attenuators is low cost and relatively low back reflection (typically -50 dB). The primary drawback is that attenuation is not uniform across wavelengths.

Another variation on the filtering-device type attenuator features a high-loss fiber (instead of a filter) between two polished ferrules. On the plus side, high-loss fiber attenuators have low back reflection and produce uniform attenuation over wavelengths. However, they are more expensive than air gap or filter attenuators, and are too long for some hardware configurations.

Summing up

Today, fixed and variable fiber optic attenuators are available for singlemode and multimode, and with a wide variety of connector and fiber configurations to meet virtually any application need. The most common field use involves SC (cable TV applications) and FC (telecommunications applications) types, but Biconic, ST and other types are also common and readily available.

Although variable attenuators are being used throughout the industry, the fixed style is the most widely used. There are also configurations with special adaptors to make bulkhead installation easy, as well as "snap-in" patch panel units requiring a separate bulkhead adaptor.

It appears at this time that manufacturers and end users alike are moving quickly to the fixed, inline type as the industry "attenuator of choice." However, the field of fiber optic attenuation seems far from mature. New types of fiber optic attenuators will almost certainly continue to be introduced, so there is a need to keep on the lookout for innovative breakthroughs. In the meantime, there are a multitude of uses for these versatile, useful and increasingly essential "power-adjusting" devices, and a multitude of excellent choices among the attenuators themselves.

It is important to remember that fiber optic attenuators are not laws unto themselves. They are used in real-world applications that call for specific performance characteristics. Therefore, in addition to being specified on the basis of their "attenuation" characteristics, fiber optic attenuators also have to be evaluated and selected in a general sense, using the same criteria that are applied to other fiber optic components in each specific case. Those criteria include operating range, operating temperature, vibration, return loss, PDL (polarization dependent loss), repeatability, thermal stability, etc. It doesn't make sense to achieve desired signal attenuation at the expense of overall system performance. CED

About the author

John Romeo is president and founder of Fiber Wave Technologies Corp., which is based in Brooklyn, N.Y. Fiber Wave was established in 1992.

Cellular TV adds new wrinkle to war

Telcos and MSOs face new headache

By Fred Dawson

The FCC, with the unveiling of a final order and new proposed rules for LMDS, has presented cable and telephone network strategists with a major new headache.

In a nutshell, the agency has left planners with the task of deciding almost immediately on whether to bid for a huge swath of spectrum over which to deploy a technology they have had little opportunity to investigate, while leaving it unclear as to what extent, if any, they'll be eligible to bid at all. If the FCC meets its intended schedule, it will allocate up to 1.3 GHz of spectrum for local multipoint distribution services in auctions beginning before the year is out. Amazingly, that amount of spectrum will go to a single licensee in each of 493 basic trading areas blanketing the U.S. and its territories.

A measure of the cable industry's lack of preparation for any participation in the forthcoming auction can be found in the fact that, at Cable Television Laboratories' summer meeting in Keystone, Colo., the subject never came up during a session on competing technologies. "No one has asked us to take a look at it, so we haven't," says CableLabs Communications VP Michael Schwartz.

Some companies, choosing to stick with their well-honed wireline strategies, have already decided to take their chances without going after the spectrum.

"We do pay attention to LMDS," says Michael Luftman, vice president for public affairs at Time Warner Cable. "But we're in the wireline business and, in our affiliation with PrimeStar Partners, the DBS business, and I know of no plans to expand into this area."

But for others, where the old unspoken proscriptions against invading each other's territory may no longer make sense, LMDS could present an inviting way to expand their customer bases. "There's been no strategic discussions (about use of LMDS) that I'm aware of," says Jim Carlson, public affairs vice president at Jones Intercable. But, he adds, that doesn't rule out future interest, given Jones' consideration of ways to expand beyond its current operating territories.

Under the band plan adopted as a final FCC order on July 18, 1 GHz of spectrum is allocated to LMDS: 850 MHz at 27.5-28.35 GHz and 150 MHz at 29.1-29.25 GHz, with a prohibition against LMDS use of the 150 MHz slot for return transmissions from subscribers. To compensate for this limitation, which results from spectrum demands of satellite interests, the Commission, in a fourth notice of proposed rulemaking, said it wants to add another 300 MHz to the LMDS pot at the 31 GHz tier with no strings attached.

This allocation will put a single LMDS operator on a par with wireline broadband service operators, officials say. Using digital technology in conjunction with prototype systems now moving into production, a single operator would be able to deliver upwards of 200 video channels and a full slate of dedicated interactive voice and high-speed data services at newbuild costs that are comparable to the upgrade costs of cable and telephone networks.

While the Commission is officially neutral on the cable and telco eligibility question, pending further industry comment that was due to be filed by August 22, insiders say it is clear the agency wants to prevent wireline operators from using the spectrum within current franchise boundaries.

"The telcos wanted two licensees per market, because they knew they wouldn't be given a chance to capture the whole LMDS block for themselves," says one LMDS executive, asking not to be named.

"This was one issue where the record was not fully developed, which is why they're asking for more comment," says Michael Gardner, a Washington attorney representing LMDS interests. "But they have to get it resolved quickly if they're going to get auctions underway this year."

Rock and a hard place

The issue presents the Commission with an excruciating dilemma, insofar as LMDS has long been seen as a low-cost

Figure 1: General Instrument LMDS - analog pricing

- MVP-II (analog scrambler) $3,200/channel; available now
- ACC4000 (access control computer) $36,000; available now
- LMDS-A (analog convertor) $160; available October 1996

Figure 2: General Instrument LMDS - digital pricing

- MPEG-2 Encoder system (digital encoder) $100,000/program: October 1996
- UCS control system (universal access control computer system) $950,000; available October 1996
- LMDS-D (digital convertor) $450; available October 1996

Figure 3: MulTIpoint sector capacity

Bandwidth in MHz	500	850	1,000
One-way video service only			
Digital channels available	144	240	288
Two-way telephony/data only			
T-1s available	288	672	768
DS-0s available (non-concentrated)	6,912	16,128	18,432
Combined video channels and DS-0s			
Digital video channels @ 3.2 Mbps		DS-0s	
24	4,608	13,824	16,128
60	2,304	11,520	13,824
96	0	6,912	11,520
132	0	4,608	9,216

Source: Texas Instruments Inc.

means to realizing the Commission's goal of stimulating competition to cable operators from the telephone companies. Moreover, with AT&T and other telecom giants likely to enter the bidding, barring telcos might only make it easier for other big players to grab the bandwidth, gaining the government nothing in terms of auction revenues, and smaller entrepreneurial firms nothing in terms of their ability to compete.

"The issue isn't keeping out big companies, it's making sure there's a level playing field," says David Mallof, CEO of WebCel Communications Inc., a start-up firm that has been instrumental in generating support for a barrier to telco and MSO entry. "My concern is with letting folks in who have an inordinate interest in bidding high just to protect their monopoly positions."

Mallof says he is confident smaller companies will be given sufficient dispensation as "designated entities" along the lines of the PCS auction rules to ensure their ability to compete for spectrum, if the monopoly interest factor is kept out of the bidding equation. But there's little doubt among parties to the deliberations that LMDS spectrum will cost a lot.

Limits on spectral efficiency

Commissioner Rachelle Chong, acknowledging the eligibility issue is a sticking point in the Commission's struggle to conclude its deliberations, says, "I believe there is no more important policy objective than increasing competition."

Noting that cable and telephone companies still largely dominate their markets without offering much competition to each other, she adds, "Although the legal obstacles (to competition) are gone, these incumbent wired providers still face significant obstacles to enter each other's market."

While 1.3 GHz sounds like it should be enough bandwidth to support two or more licensees, the properties of millimeter waves in the 28 GHz region and above impose limitations on spectral efficiency not seen at lower frequency levels, notes Shant Hovnanian, CEO of CellularVision USA, the pioneer in LMDS technology. "If you were to split the allocation, even if it's 1,300 MHz, between two providers, you'd run the risk of neither one having enough spectrum to make a go of it against the entrenched wireline companies," he says.

Indeed, given CellularVision's use of FM modulation, or other developers' use of QPSK (quadrature phase shift key) techniques, LMDS transmitters can deliver only 50 analog or 200-plus digital TV channels over 1 GHz of spectrum, versus 110 analog or 500-plus digital channels over the 750 MHz hybrid fiber/coax network. But CellularVision has long espoused use of reverse polarization as a technique to double bandwidth efficiency, and developers are pursuing solid state versions of the transmitters using quadrature amplitude modulation, which will also greatly enhance bandwidth efficiency.

Hovnanian says CellularVision isn't planning to use the reverse polarization technique at this point. And, others note, QAM-based LMDS is at least a year away. Thus, if the FCC wants to see a third competitive force emerge in broadband communications sooner than later, allocating the 1.3 GHz is the way to go, they say.

Among a handful of companies who have gained access to early prototype equipment, decision makers are well positioned to begin planning auction strategies, with enough information at hand to determine how much they're willing to bid in the context of what it will cost to build these new networks. But there are many other potential players who don't have anything approaching the field experience they would need to make an informed decision.

Perhaps the most persuasive case for LMDS as an interactive service has been made in Canada

In part, this is because most players were barred from close scrutiny out of refusal to sign stringent nondisclosure and non-compete agreements with the technology arm of CellularVision USA Inc. And, in part, it is because many engineers have refused to take the technology seriously. "Our technical people are pretty skeptical, especially when it comes to providing interactive services over LMDS systems," says Spencer Kaitz, president of the California Cable Television Association.

However, with Texas Instruments Corp., Hewlett-Packard Co., General Instrument Corp., Lockheed-Martin, M/A-Com and several other manufacturers preparing to offer competing means of delivering LMDS, engineers are starting to pay it more attention.

"We're seeing every type of company represented in the visits to our facilities," says Carlton O'Neal, director of business development, marketing and product management for TI, which is demonstrating a prototype of its emerging product line near Dallas. "Most are seeing the technology in operation for the first time."

"We had a lot of reservations (about LMDS) early on," says Hewlett-Packard wireless systems manager Douglas Gray, whose team is working with Stanford Telecommunications Inc. to bring a system to market next year. "But we did a lot of testing and convinced ourselves the technology offers adequate link margins to compete quite favorably with other network technologies, including HFC (hybrid fiber/coax) and ADSL (asymmetrical digital subscriber line)."

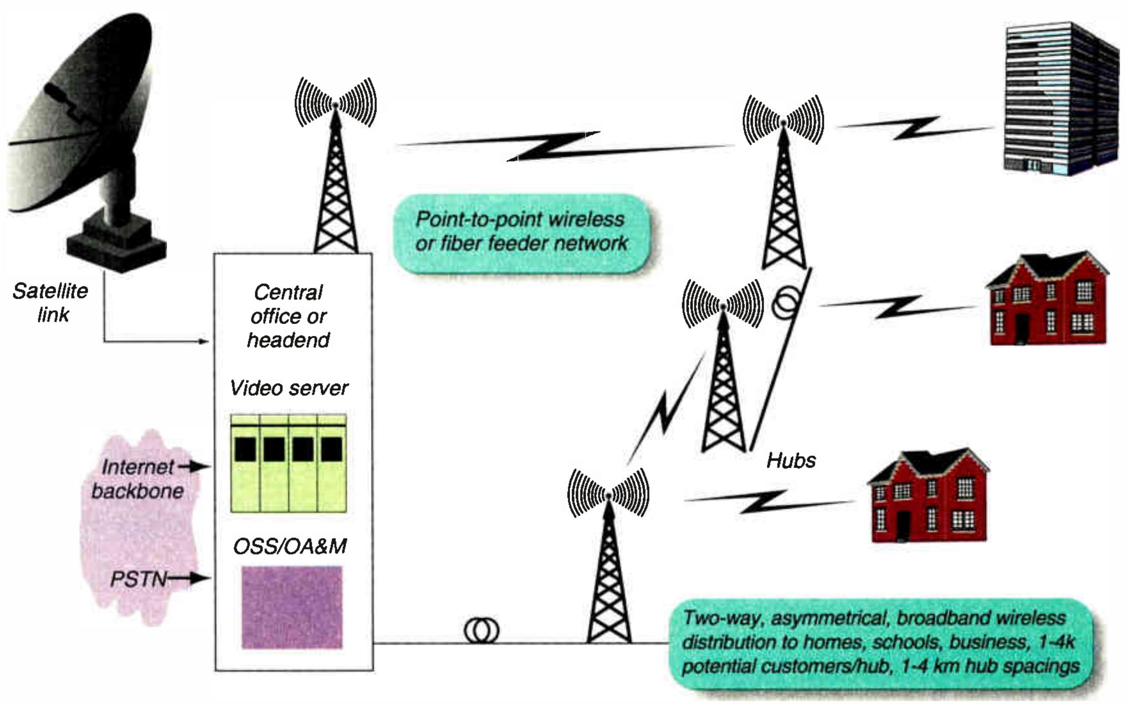
Look north

Perhaps the most persuasive case for LMDS as an interactive service so far has been made in Canada, where Vancouver-based Western International Communications Ltd., a leading terrestrial and satellite broadcast concern, has convinced the Canadian government that a new industry can be built on the two-way capabilities of CellularVision's technology. The country was preparing to license 1 GHz of what it calls "LMCS" (local multipoint communications systems) nationwide by summer's end, with plans to allocate an additional 2 GHz to the category over the next two years.

WIC's strategy, reflecting the common carriage requirements of the government's LMCS policy, is to build its business on the interactive digital communications potential of 28 GHz technology, says John Quigley, vice president of WIC's CellularVision operation. WIC has been working with Lockheed-Martin Canada, which has developed a transmitter/receiver that supports a two-way, point-to-point T-1 data stream, as well as 200 channels of digital TV, he says.

"We've found this to be an extremely robust technology for supporting every type of interactive service, which is why the Canadian government has moved so

Figure 4: Local multipoint distribution service (LMDS)



Source: Hewlett-Packard

quickly to license the technology," Quigley notes. He adds that experimentation with reverse polarization has demonstrated the technique works well when applied under the right operating conditions.

H-P's Gray notes that while the technique works fine in line-of-sight connections, multiple reflections result in shifts of polarization that begin to blur the distinctions between signal streams. Given the importance of "bounce" to avoiding a line-of-sight requirement for reception of LMDS signals, where millimeter waves hold their shape much better than reflected signals at lower frequencies, such as those used in MMDS (multichannel multipoint distribution services), H-P recommends against using reverse polarization, Gray says.

However, given Gray's findings, it might turn out that 1.3 GHz of frequency can be made the equivalent of 2.6 GHz with reverse polarization if operators shorten the signal paths by deploying a higher concentration of transmitters in future expansions. Basically, it's a tradeoff between gaining the benefits of multiple bounces to achieve saturation coverage over a large area from a single transmitter or giving up some of the bounce coverage in order to gain frequency reuse.

Whatever becomes of the reverse polarization application, it is clear that the coherency of millimeter wave signals will support a significant penetration of antenna receivers that don't have a direct line-of-sight to the transmitter. This makes it easier to deploy the service using small windowsill-mounted antennas versus the rooftop variety, which are harder to install and require more wiring.

CellularVision co-founder and LMDS inventor Bernard Bossard notes that the closer receivers are to the transmitter, the higher the number of bounces a signal can go through before getting to the end user at required performance levels. "Some people have said they're getting as many as eight bounces in core coverage areas," he adds.

By year's end, CellularVision will install 15 more transmitters to accompany four that are already operating in Brooklyn and lower Manhattan, expanding coverage to 80 percent of the 3.2-million-household New York market encompassed in its special license, says John Walber, president and CEO of CellularVision New York. "With bounce and use of repeaters we will be able to provide coverage to all homes in our territory," he says.

The performance of the technology has prompted General Instrument to begin product development using QPSK modulation, says senior product manager Lindsay Allen. "We're working with several people in developing an end-to-end system," he notes, adding that equipment will include a 28 GHz wireless version of the firm's SURFboard cable modem.

GI's LMDS digital convertor will be on the market at $450 per unit by October, Allen says. "We hope to get the price to $350 fairly quickly and, ultimately, to $300 or less," he adds.

Given the sudden surge in manufacturing support for LMDS, it appears the industry will have plenty of suppliers, but it may do cable and telco newcomers to the concept little good in light of the Commission's determination to clear the way for auctions this year.

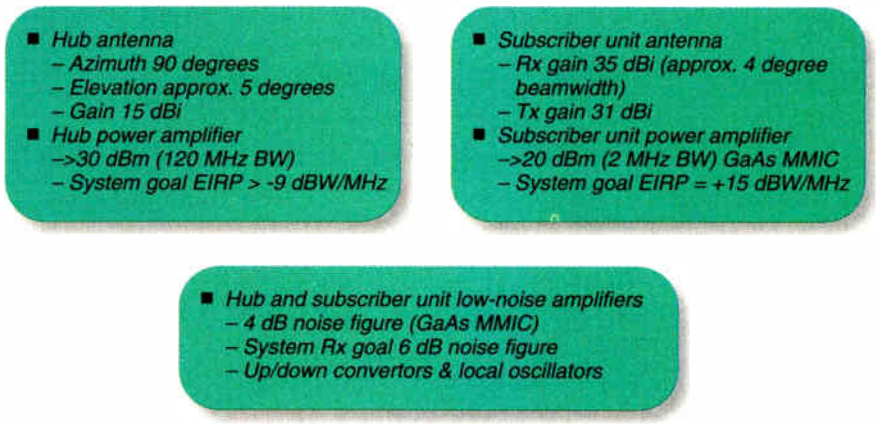
The upshot is that those not already in the know could soon find themselves under siege from not only the LMDS startups but, more significantly, the handful of carriers who have been paying attention.

"Telcos are the sleeping giants in this arena, keeping a low profile but staying very close to developments," says a source in Washington who has long been involved in deliberations over LMDS policy.

"This is where the companies who have kept abreast of the technology have an advantage," comments another knowledgeable insider, asking not to be named. "BellSouth, US West, Bell Atlantic–they're not going to go away just because they can't use the spectrum in territory."

While telco executives reiterate long-standing opposition to any barriers to their access to technology, observers suggest the industry is not ready to go to the mat on the issue, which is one reason the Commission may be optimistic that it can rule on eligibility soon enough to get auctions underway this year.

Figure 5: *MM-Wave component requirements-residential applications*



Source: Hewlett-Packard

"I believe that, for most of the telcos who have been following this technology, LMDS has been an out-of-territory strategy from the beginning," says O'Neal.

Bell Atlantic, a 4.2 percent stakeholder in CellularVision, will oppose restrictions "as a matter of principle," says Larry Plumb, communications director for Bell Atlantic Video Services. "I'm not in a position to speculate about any plans we might have for the technology," he added.

BellSouth, which has participated in two field trials of LMDS, is also reticient about future plans, though spokesman Al Schweitzer stresses the telco's strategic emphasis on in-territory growth opportunities over out-of-territory expansion. "We want to promote competition in the industry, but we would hope to have the same options to compete as any other service provider," Schweitzer says.

Concerns over cost of entry

If LMDS manufacturer claims hold in market deployment, the 28 GHz approach to broadband networks might be the cheapest way for newcomers to take on established telephone and cable providers. Assuming incumbents are barred from in-territory entry, the economics come down to what the margin of difference is between upgrade of wireline versus new construction of LMDS.

By the estimate of H-P's Gray, the capital cost of providing a 7 megabit-per-second downstream, 1.5 Mbps upstream dedicated digital service over LMDS facilities is about $1,000 per-customer, from the ground up, including customer equipment. By contrast, according to Chong, the FCC estimates the per-sub upgrade cost to full-service capability for cable is $800, and for telcos, $1,000.

With auctions looming in a matter of months, there is likely to be a significant amount of coalition forming in preparations for bidding, especially among smaller firms.

"As we saw in the PCS C-block auctions, I think there will be some really creative strategic alliances taking shape in the months ahead," Gardner said.

But they'll need financial support from Wall Street, and how far Wall Street is willing to go to back aggressive spectrum bids could well hinge on the fortunes of the C-block players, says Bear Stearns analyst Jack Roberts.

"The amounts bid in the C-block auction have caused some nervousness in the financial community," he notes. "If we see some bad experiences in PCS, it could cast a shadow over the LMDS process."

One startup player scouting Wall Street for backing confirmed the fears generated by the C-block feeding frenzy.

"Our biggest problem seems to be explaining why LMDS has nothing to do with what happens in PCS," he says, asking not to be named. "Here, we're talking about one licensee getting 1.3 GHz of spectrum, as opposed to someone getting 30 MHz to compete against five or six other licensees."

Still, even LMDS advocates are concerned over the financial risks an auction is likely to impose. "I think we'll wind up seeing (bidding) numbers higher than any reasonable person estimates," says Paul Sinderbrand, a partner in the Washington law firm of Wilkinson, Barker, Knauer & Quinn. "I'm afraid we're going to see some defaults afterward, maybe greater than the percentage of defaults we've seen in the C-block (PCS) auctions."

Maybe so. But, one thing is certain: the major carriers who are ready to go after the spectrum won't be among the defaulting players. CED

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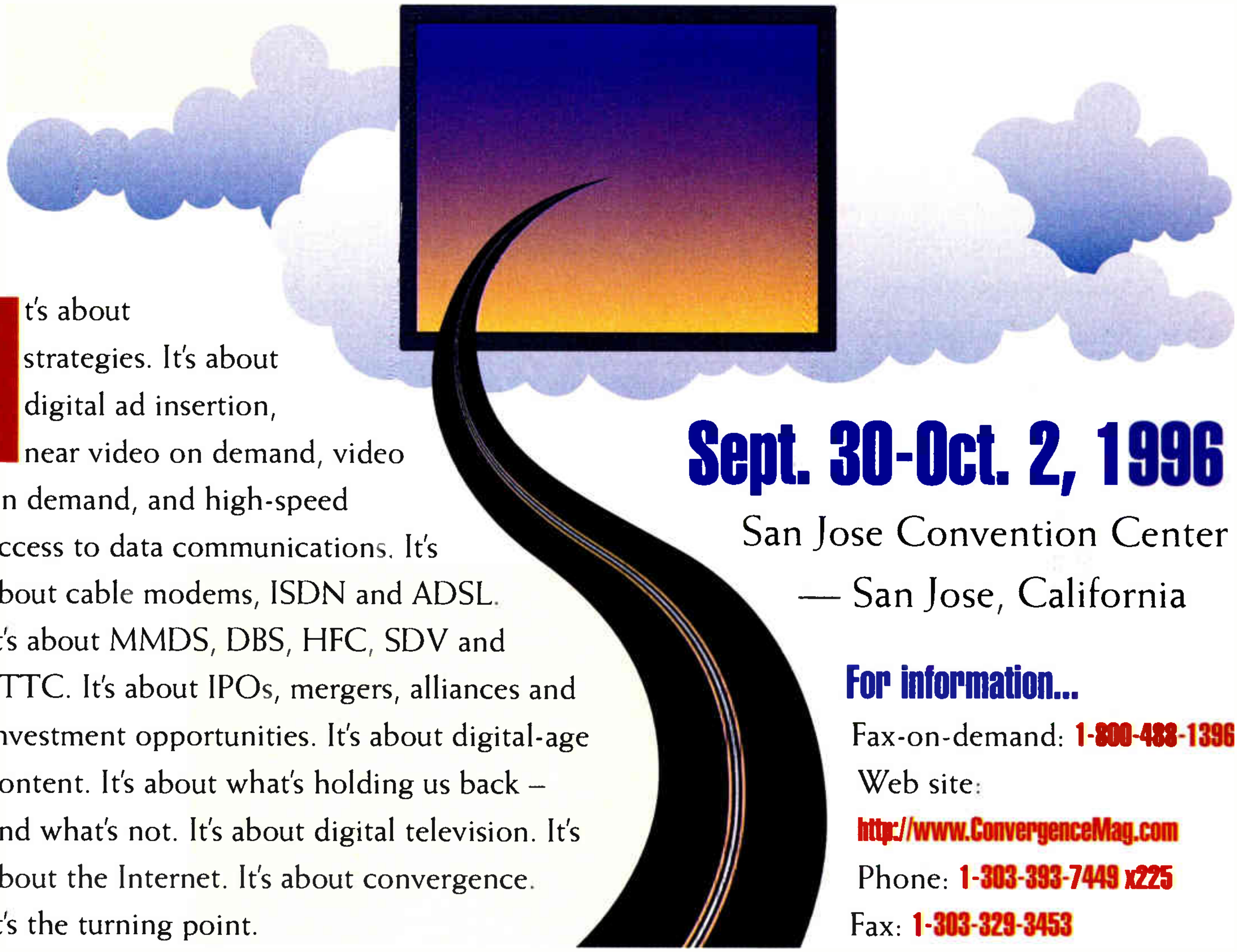

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Quality Cable now Belden distributor

NASHVILLE, Tenn.–Quality Cable & Electronics Inc. has been named as a full stocking distributor for Belden Wire & Cable Company's Broadband division. The original transaction, negotiated at the SCTE's Cable-Tec Expo, is in effect for the U.S. and puts more than 1 million feet of drop cable in Quality's Pompano Beach, Fla. location.

AM to provide monitoring for GTE

QUAKERTOWN, Pa.–AM Communications Inc. has signed a supply agreement with GTE Telephone Operations to provide its OmniStat network monitoring system for GTE video services networks under construction in the Tampa Bay, Fla. and Ventura County, Calif. markets. The value of the agreement is expected to exceed $2 million, according to information released by AM Communications. Several of AM's OEM partners will also be providing products to GTE, according to Keith Schneck, president of AM.

S-A supplies set-tops to TITUS

ATLANTA–Scientific-Atlanta Inc. is providing set-tops, headend equipment, fiber optic electronics and multimedia taps to TITUS Communications Corp., a Tokyo-based multi-system operator providing integrated video, data and telephony.

A joint venture between Time Warner, US West, Toshiba and Itochu, TITUS has licenses to provide service to six areas around municipal Tokyo.

"At present, we have under construction connections to approximately 980,000 homes," said Craig Thompson, chief operating officer of TITUS. "Over the next few years, we expect to obtain licenses for approximately 10 service areas and to offer cable TV and telephone services to nearly 2 million households."

TITUS plans to deploy two of S-A's set-tops: one derived from the 8600 platform, and the other providing basic cable access only, or cable access to a second TV in the home.

Fujitsu opens N.Y. development center

RICHARDSON, Texas–Fujitsu Network Transmission Systems Inc. has established a new, 35,000-square-foot development center in New York's Hudson Valley. The center, combined with a planned 131,000-square-foot expansion of its Richardson, Texas headquarters facilities, will help the company meet the demand for fiber optic transmission products, and expand its engineering staff to speed development of next generation broadband communications systems, according to a statement.

The Northeast Development Center is located in leased space in Two Blue Hill Plaza, an office building complex in Pearl River. The focus of the center includes advanced network management, optical transport and broadband video systems development.

In Richardson, 80,000 square feet of a new multipurpose building will be dedicated to engineering, production and technical space. The remaining 51,000 square feet will be used for administrative and office space.

Construction is expected to begin by late 1996, with move-in slated for November 1997.

RELTEC intros cable services program

CLEVELAND, Ohio–RELTEC Services has introduced an offering of engineering, installation and field services to the cable television industry which includes program management and preventive maintenance/emergency services.

For voice transmission, video transport or power equipment, the company has the ability to engineer and install all aspects of a network.

RELTEC Services also offers a variety of preventive maintenance and emergency services to ensure that power-related issues do not compromise system integrity.

BetaDigital picks TV/COM's uplink gear

SAN DIEGO–BetaDigital has established a longterm delivery relationship with TV/COM International Inc. for the company's open architecture *Compression NetWORKS* satellite uplink equipment. BetaDigital will use the uplink equipment to provide more than 80 channels of digital video and associated audio programming in a digital broadcast system in Germany.

Delivery of the equipment, which includes compressors, modulators, scramblers and network management control, was scheduled to be completed sometime this past summer.

TV/COM began working with BetaDigital in 1992 and has collaborated with them on system specifications and DVB standardization.

Alcatel, Newbridge take Sonet direct

PARIS–Alcatel Telecom, through its Alcatel Network Systems unit, and Newbridge Networks have entered into an agreement that will enable carriers and corporate customers to deliver Sonet services from the public backbone network directly to customers' premises.

Signal Vision signs contracts with 2 MSOs

EL SEGUNDO, Calif.–Signal Vision Inc. will supply all of the PVC conduit, sweeps and accessories for Continental Cablevision's Western Division systems, under the terms of a two-year, multi-million dollar agreement.

In addition, Cox Communications Inc. has selected Signal Vision to supply high-end drop passives to all Cox systems, under the terms of a two-year contract, also valued in the multi-million dollar range.

StarSight patents background TV system

FREMONT, Calif.–StarSight Telecast Inc. has received an additional patent covering technology that allows television viewers to access program information while viewing a TV program that is in progress.

The viewer can obtain information about other programs currently in progress, or scheduled for showing at a later time.

The informational display can be as simple as an overlay screen which obscures only a small portion of the on-going program. The viewer can customize the display to show schedule information for a subset of channels, or to show the schedule info in a desired channel order or for a desired time period.

Integration Technologies acquires ETG

ENGLEWOOD, Colo.–Integration Technologies has acquired Engineering Technologies Group Inc. (ETG), formerly an independently-operated division of Antec Corporation. ETG specializes in cable television, telephony, microwave, satellite and fiber optic communications networks.

ETG's former field service capabilities will be folded into Integration Technologies' Technical Services Department. Ronald Cotten, COO of Integration Technologies and founder of ETG, will manage ETG's business, which will operate as a division of Integration Technologies.

Nortel wins contract for MITI

BOSTON, Mass.–Nortel (Northern Telecom) has been awarded a contract to supply fiber optic carrier and ATM digital switch equipment, worth $1 million, to a new statewide network known as the Massachusetts Information Turnpike Initiative (MITI).

Nortel proposed a configuration which minimizes the need for additional equipment hubs by making extensive use of long distance lasers.

The MITI network is a university-run program of the Commonwealth of Massachusetts and consists of a fiber optic backbone spanning 125 miles along the Massachusetts Turnpike from Boston to Westfield. The network will be used to transport university courses to homes and businesses throughout the state, support the Commonwealth of Massachusetts' education and public service initiatives, and establish a medical service network for homes and communities. CED

People on the move

Mark R. Evans has been named president of the Wiltron Company, which is a member of the Anritsu Wiltron Measurement Group. Evans, who was promoted from the post of chief financial officer, replaces the retiring David Friedley. His new responsibilities for Wiltron, which develops and manufactures communications test and measurement solutions, include leading Wiltron's research and development, as well as the company's worldwide manufacturing operations.

Toshiba America Electronic Components Inc. has named **Bob Brown** as president and chief operating officer, the first American to be appointed to such a position in a Toshiba America operating company. Brown is a 13-year veteran with Toshiba, having served in a number of positions including executive vice president and group executive.

Bob Brown

Arrowsmith Technologies has completed the reorganization of its senior management team with the appointment of **Lt. Gen. Arlen D. (Dirk) Jameson (Ret.)** as president, and **Carolyn Maduza** as vice president and chief financial officer. Jameson replaces Arrowsmith's former president, **Curt Bilby**, who became chairman of the board. Previously, Jameson was deputy commander in chief and chief of staff for the U.S. Strategic Command. Maduza, who has assumed responsibilities for financial policies and operations at Arrowsmith, was most recently at MASI Ltd., where she provided investment banking services to privately-held corporations, investor groups and Fortune 500 companies.

RELTEC Corporation has named **James A. (Jim) Guiseilo** to succeed the retiring **Robert A. (Bob) Dirks** as vice president and general manager for the company's international business unit. Guiseilo returns to RELTEC after serving as vice president-controller for the past two years at Reliance Electric. He joined Reliance in 1976, and since then, has held a number of positions in the finance area.

Jill Campbell has been promoted to vice president and general manager for Cox Communications in Santa Barbara, Calif. Campbell will be responsible for all operations of Cox's Santa Barbara cable system, which serves more than 65,000 customers, and will continue to oversee the management of the operator's Bakersfield, Calif. system, where she served as vice president and general manager since 1992.

Channelmatic has appointed **Michael F. Wells,** a 25-year veteran of the computer electronics industry, as its vice president of product development. A holder of four U.S. patents and attendee of the Owner/President Management Program of the Harvard Graduate School of Business, Wells will spearhead Channelmatic's product research and development initiatives. Channelmatic has also named **Jim O'Brien** as director of business development. O'Brien brings 27 years of cable and broadcast experience to his new post, which includes work with Jones Intercable and Time Warner, as well as automation consulting projects for Utah Scientific, TCI, EchoStar and other companies.

Thomas Steipp has joined Scientific-Atlanta as vice president and general manager of high-speed data systems, where he will oversee the introduction of interactive cable modem products. Previously, Steipp was with Hewlett-Packard Company for 15 years, serving most recently as general manager of H-P's Federal Computer Operation. He also held marketing management positions in H-P's mass storage, telecommunications and networking business units.

Siecor Corporation has named **Sanford (Sandy) D. Lyons** as vice president and director of strategic planning and business development. Lyons, who first joined the company in 1985, will be responsible for developing Siecor's growth strategies including mergers and acquisitions through market and customer evaluation, combined with product line expansion, in his new position.

Harmonic Lightwaves Inc. has announced the appointment of **Zee Shams** as vice president for North American sales and customer service. In his new position, Shams will lead Harmonic's direct sales and customer service organizations, as well as develop and maintain key relationships with system integrators and distributors. Shams has more than 15 years of experience in designing, marketing and selling telecommunications and cable television technologies and joins Harmonic Lightwaves from Teleport Communications Group, where he was director of operations. Prior to joining Teleport, Shams held engineering, sales and marketing management positions with ADC Telecommunications Inc., Siemens, AT&T and Motorola.

Zee Shams

TCI Communications Inc., an operating unit of Tele-Communications Inc., has named **Tom Beaudreau** to the newly-created position of vice president, TCI Digital TV Inc.; and **Doug Seserman** to the new position of vice president of long term product development for TCI's Digital TV business. Beaudreau, who began his career at TCI in 1985, will be primarily responsible for taking TCI Digital TV into the operational phase. Seserman, who joins TCI from the Quaker Oats Company, will be responsible for the long term strategic development of digital video products and service, including consumer concept testing and business plan development.

Victor Gates has joined Burnup & Sims TSI in the newly-created position of vice president of engineering. A 25-year cable veteran, Gates will be responsible for expanding the engineering operations of the company, including mapping, design and testing in support of Burnup & Sims' ongoing construction activities. Gates was formerly division vice president at Time Warner.

Victor Gates

Sprint North Supply has announced five appointments within the company's marketing and sales divisions. **Dick Summers** has been appointed director of marketing for the Public Networks Division. **Randy Garvey** has been appointed director of Bell and AT&T sales, and **Don Lancasty** has been named director of marketing for the Business Networks Division. Meanwhile, **Gerry Gleissner** has assumed duties as director of sales for the Business Networks Division, and **Laura Skinner** has been named as director of marketing for the Sprint Products Group.

Terry Campbell has been appointed materials director at TV/COM, a wholly-owned subsidiary of Hyundai Electronics America. In this newly-created position, Campbell is responsible for managing TV/COM's purchasing, planning and logistics departments. He joins TV/COM from Winfield Industries, where he was director of operations and administration. CED

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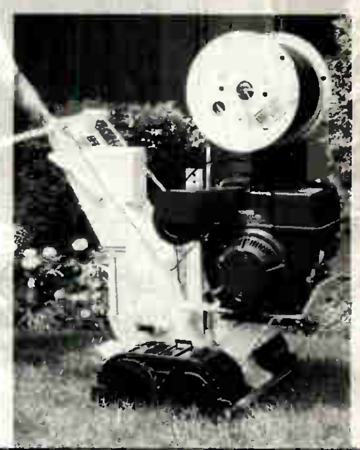

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Reader Service 59

TECHNICAL

What's Hot?

How about page-after-page of the broadband industry's newest products, services and informational offerings?

And, they're all available to you FREE in the next CED Product Literature & Source Guide November 1996 Issue.

Look For It!

Split fiber RF trunk redundancy switch

ST. LAURENT, Quebec, Canada–Tekron Communication Systems has introduced the RSS-2R dual-band split fiber RF trunk redundancy switch. The switch is designed for broadband monitoring of low- and high-band RF trunk feeds in headend or hub sites in cases where the two bands are received separately over split-band dual fiber receivers.

It automatically switches to the back-up trunk feed if the RF level of either band reaches the threshold point, and closes contact, which can be used to signal the fiber receiver for that band to switch to alternate fiber. It is built with delay and hysteresis for switch back when primary levels are restored. It is also built with voltage status indication for each band and remote control on the back of the unit, as well as with front panel switch control and LED status indication.

RSS-2R dual-band, split fiber RF trunk redundancy switch

Circle Reader Service number 66

Fiber optic transceiver

STATE COLLEGE, Pa.–Broadband Networks Inc. has introduced a fiber optic transceiver designed to provide bidirectional single fiber, single wavelength transmission capability for high-speed data LAN or Internet service.

The CyberFiber 1000 Series is compatible with RF data modems which operate in the 15 to 550 MHz range. The products also provide additional capacity which can be used to deliver FM modulated video and audio simultaneously with the birdirectional data service.

The CyberFiber design allows the installation of interactive high-speed data using one fiber strand operating only in the 1310 nm fiber window. This single wavelength, bidirectional service allows the 1550 nm window to be reserved across the network for other needs or service upgrades.

Model CF1015 can transmit over a 15 dB 1310 nm optical budget with symmetrical full motion video, audio and high-speed data.

Circle Reader Service number 67

Universal video field analyzer

PARSIPPANY, N.J.–Boonton Electronics Corp. has introduced the Expert 7831 Universal Video Field Analyzer that characterizes NTSC, PAL, SECAM, QPSK, MAQ and D[2]MAC broadcast signals.

The instrument has been designed to measure carrier level, spectral distribution, error rate, carrier-to-noise, DC volts, and, optionally, the quality of teletext and page displays. The 7831 displays results on a 4-inch, or optional 6-inch, diagonal color active

Three-port filter WDM

BERKELEY, Calif.–DiCon Fiberoptics has introduced a Filter WDM, used for multiplexing and demultiplexing in dense WDM (wavelength division multiplexing) systems. The design is based on dichroic bandpass filter technology and offers channel spacings as narrow as 3 nm.

DiCon Fiberoptics

Features include: low pass channel losses (0.5 dB typical), low cross talk (-55 dB), and miniature package size (46 x 15 x 9 mm).

The filter WDM is used for splitting the 1533/1541 band (which transmits in one direction) from the 1549/1557 band (which is transmitted in the other direction). The splitting capability is needed within bi-directional amplifiers, as well as in the terminal equipment.

DiCon has also announced that its newest model multi-channel fiberoptic switch, the GP700, is available in benchtop and rackmount housings. The GP700 is an integrated platform for control of up to four, 1xN modules and up to 16 solenoid (1x2, 2x2, or on-off switches).

The GP700's manual and remote interfaces (GPIB and RS-232) reduce training, programming and integration time, according to the company.

Circle Reader Service number 68

Pre-connectorized cable

CARROLLTON, Ga.–AT&T Fitel has introduced factory-terminated cables which allow end users to quickly install long lengths of cable or intrabuilding networks without time-consuming field terminations, says the company. AT&T Fitel's loose tube riser rated, pre-connectorized cable assemblies provide the link between transmission equipment and OSP cable. OSP pre-conn cable assemblies can be directly routed into the distribution frame.

Riser rated pre-connectorized cables are available in fiber counts from 2 to 216. OSP cable assemblies are available in a variety of sheath configurations, with fiber counts from 2 to 240. Fiber types for all cable designs include singlemode and multimode. The cables can be factory terminated on one or both ends with a

Boonton Electronics Corp.'s Expert 7831 Universal Video Field Analyzer

matrix LCD with 479 x 234 pixel resolution. Frequency ranges include 5 to 55 MHz, 86 to 108 MHz, 50 to 865 MHz and 950 to 2050 MHz.

The analyzer's rechargeable 12 VDC 5 Ah NiCd battery pack provides four hours of operation for terrestrial signal measurements, and one hour, 45 minutes with all options invoked. The 7831 also features a built-in impact printer that delivers hard copy output of measurements, including date, time, site, satellite and a 24-character user-defined message.

Operators can also use the unit's RS-232 connector to transfer data from a remote site to a central location.

Circle Reader Service number 65

variety of connectors, including FC, SC, ST, D4 and Biconic. The company's Super PC, Ultra PC and Angled PC polishes are also available.

Circle Reader Service number 69

Variable attenuator

LACONIA, N.H.–Noyes Fiber Systems has introduced the SVA-1 Singlemode Variable Attenuator which offers low back-reflection with over 60 dB of attenuation range at both 1310 nm and 1550 nm in a handheld package. The SVA-1 is available with a variety of connectors and reflectance options to better than 60 dB (with APC connectors). With two adjustments (coarse and fine), the SVA-1 is user-friendly, according to the company, and operates allowing bi-directional signal transmission with no loss penalty.

SVA-1 singlemode variable attenuator

It can be used for bit error rate (BER) testing, systems margin analysis and transmission receiver testing. Field applications include installation, new equipment turn-ups or routine maintenance.

Circle Reader Service number 70

Cabinets and closures

CLEVELAND, Ohio–RELTEC Corp. (formerly Reliance Comm/Tec) has introduced a line of Reliable Electric MESA (Modular Electronic Sealed Architecture) series cabinets. The cabinets can house a variety of cable TV, telephone and wireless configurations, including fiber optic transport systems and power hub and protection.

The company has also introduced above-ground, low profile, 360-degree access closures–TV1831H and TV1228H–for multiple applications of cable TV distribution equipment. Both versions offer ventilation through advanced louvering, which eliminates the need for special dissipation covers and ensures optimum cross-ventilation and heat dissipation.

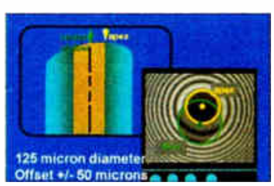
The TV1831H accommodates high-bandwidth and power-doubling trunk amplifiers, while the TV1228H is designed primarily to house line extenders.

Finally, RELTEC has announced Slam Lock, an automatic, self-locking mechanism for use with distribution enclosures.

Circle Reader Service number 71

Instructional video

NEW BRUNSWICK, N.J.–Norland Products has released an instructional video describing the basic theory of interferometry and how to effectively use it to ensure the quality of high performance, PC polished fiber optic connectors. Entitled *Interferometry for Quality Control of Connectors*, the 10-minute video is designed for anyone involved with polishing fiber optic connectors.



Norland's video on fiber optic connectors

The video features easily understandable graphics that illustrate the proper interference pattern for controlling the radius of curvature, offset of the polish and fiber undercut or protrusion.

Circle Reader Service number 72

Testing equipment

BEAVERTON, Ore.–Tektronix Inc. has introduced two testing and measurement products. Its new bitstream library, the STRM100 Video Compliance Bitstreams, which can be used with its MTS100 MPEG Protocol Test System, provides a comprehensive verification system of MPEG-1 and MPEG-2 standards for products under development.

Tektronix has also introduced the WFM601M Serial Component Measurement Set that addresses operational monitoring and technical test applications, as well as installation and maintenance requirements critical in the implementation of a digital television plant.

When used with the MTS100 Test System, the STRM100 bitstream library provides easy-to-understand, quantifiable measurements that provide a clear, highly visible indication of a product's MPEG compliance. Because the STRM100 can stress individual parameters, users can rapidly isolate problems to the relevant parameter, without the need for time-consuming off-line analysis.

Tektronix's MTS100 MPEG test system

Developed by the David Sarnoff Research Center, the STRM100 MPEG Video Compliance Bitstreams were designed for engineers and technical personnel who are designing and testing MPEG-based equipment such as MPEG decoders.

Tektronix's WFM601M Serial Component Measurement Set evaluates serial digital component signals from source to destination. It accepts a serial component video signal data stream, analyzes the data stream for conformity to accepted standards and indicates any data errors that may have occurred during signal transmission.

Tektronix's WFM601M measurement set

The WFM601M also incorporates capabilities targeted at installation and maintenance applications. This includes a data word listing similar to the logic analyzer that allows analysis of signals to determine conformance to standards, field/line/word cursors that provide an intuitive way to access data values, and a numeric jitter readout in addition to previous models' eye pattern jitter measurement.

The unit also features a real-time, full-field analog CRT display, which enables technicians to view the video signal in the familiar analog format.

Circle Reader Service number 73

SEPTEMBER

9-12 Internet Commerce Expo. Location: Anaheim Convention Center, Anaheim, Calif. Call (800) 667-4423.

9-20 Fiber Optic Technician Training, produced by FiberLight International. Location: Estes Park, Colo. Call (970) 663-6445 for more information.

10 T-1 Technical Seminar, produced by ADC Telecommunications Inc. Location: Edmonton, Alberta, Canada. Call (800) 366-3891 to register or for info.

11-13 Operating Hybrid/Fiber Coax Systems, produced by the Scientific-Atlanta Institute. Location: Atlanta, Ga. Call (800) 722-2009, press "3."

17-19 Cable Television Technology, produced by C-COR Electronics Inc. Location: Denver, Colo. area. Call C-COR Technical Customer Services at (800) 233-2267, ext. 4422.

18 Golden Gate SCTE Chapter, Technical Seminar. Call Mark Harrigan (510) 927-7060.

18-20 SCTE Regional Training Seminar: Technology for Technicians II. Location: SCTE National Headquarters, Exton, Pa. Call SCTE headquarters (610) 363-6888.

20 SCTE Piedmont Chapter Technical Seminar & Testing Session. Vendor show, and BCT/E certification exams to be administered. Call Mark Eagle (919) 220-3889.

23-24 Fiberworks: Compressed Video: Concepts and Transmission (CVCT), produced by Antec. Location: Antec Technology Center, Atlanta, Ga. Call (800) FIBER ME.

23-25 Chattahoochee SCTE Chapter, Technical Seminar and Testing Session. Location: Atlanta, Ga. Call Johnny Ray (770) 977-6916.

24-26 Broadband Communications Technology, produced by C-COR Electronics Inc. Location: Fremont, Calif. Call C-COR Technical Customer Services at (800) 233-2267, ext. 4422.

25 T-1 Technical Seminar, produced by ADC Telecommunications Inc. Location: Seattle, Wash. Call (800) 366-3891 to register or for info.

30 Broadband Network Overview, produced by General Instrument. Location: San Diego, Calif. Call Lisa Nagel (215) 830-5678 for more information.

OCTOBER

1-3 Telecommunications Network Engineering for Technicians, produced by General Instrument. Location: San Diego, Calif. Call Lisa Nagel at (215) 830-5678.

1-4 Fiber Optics 1-2-3: Installation, Design & Maintenance, produced by The Light Brigade. Location: Denver, Colo. Call (800) 451-7128.

7-10 Fiber Optics 1-2-3: Installation, Design & Maintenance, produced by The Light Brigade. Location: Atlanta, Ga. Call (800) 451-7128.

14-16 19th Annual Newport Conference on Fiberoptics Markets, produced by KMI Corp. Location: Newport Marriott Hotel, Newport, R.I. Call Jackie Ferguson (401) 849-6771.

14-17 NCF/Infovision '96. Location: Rosemont Convention Center, Chicago, Ill. Call Isabel Bauer or Dan Hutton at (312) 559-3323 or (312) 559-3324.

21-23 Private and Wireless Show, produced by Globex. Targeting private and wireless cable ops. Location: Wyndham Anatole Hotel, Dallas, Texas. Call (713) 342-9826.

22-24 Mid-America: 39th Annual Meeting and Show. Sponsored by Mid-America Cable TV Association. Call Patty O'Connor (913) 841-9241.

29-30 Planning for Cable Telephony, produced by Scientific-Atlanta Institute. Location: Atlanta, Ga. Call (800) 722-2009, (press 3) to register or for more information.

Trade shows

September

18-21 PCS '96, produced by PCIA. Location: Moscone Center, San Francisco, Calif. Call PCIA (800) 269-8999 (U.S.) (reg. info); or (805) 654-1397.

23-25 The 1996 Eastern Cable Show, produced by the SCTA. Location: Atlanta, Ga. Call (404) 252-2454; or use FastFax for information (888) 814-0303.

September/October

9/30-10/2 *Convergence* magazine's Digital Television & Internet Conference & Expo. Location: San Jose Convention Center, San Jose, Calif. Call Fax-on-demand at (800) 488-1396, or Gary Lemons at (303) 393-7449.

October

13-15 Atlantic Cable Show. Location: Baltimore Convention Center, Baltimore, Md. Call SLACK Inc. at (609) 848-1000.

December

11-13 The Western Show. Location: Anaheim, Calif. Call the California Television Association at (510) 428-2225.

The issue: Emergency alerting

A recent FCC rulemaking that overhauled the Emergency Broadcasting System has a direct impact on cable operators, most of whom now have to be prepared to add headend equipment and be an active participant in the new, modern Emergency Alert System. MSOs have until July 1 of next year to comply. Are you ready?

The questions:

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

❑ Yes ❑ No ❑ Don't know

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

❑ Yes ❑ No ❑ Don't know

3. Are you aware of the FCC proceeding that made the cable industry part of the new national alerting system?

❑ Yes ❑ No ❑ Don't know

4. Does your franchise agreement require emergency alerting capability?

❑ Yes ❑ No ❑ Don't know

5. Do you have plans to add emergency alerting equipment to your headend in the next year–or have you already done it?

❑ Planning to ❑ Already did ❑ Don't know

6. How much will your system have to spend to comply with the EAS rules?

❑ More than $1,000 ❑ $500 to $1,000 ❑ Don't know

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

❑ Yes ❑ No ❑ Don't know

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

❑ Audio only ❑ Audio and video ❑ Don't know

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

❑ Yes ❑ No ❑ Don't know

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

❑ Monthly ❑ Few times a year ❑ Don't know

Your comments on EBS:

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RESULTS

If survey respondents are to be believed, DBS providers aren't doing any better at stealing away cable customers than they were a year ago. Sixty-four percent say DBS is doing a "poor" job of capturing customers, compared to 75 percent last year.

But perhaps the real news is that half believe it will have an impact within the next two years, which is up from 25 percent last year, while no one this year thinks it will take as long as six years for that to happen (last year, 25 percent said it would take that long).

The other big change from a year ago involves the competitive landscape in general. Whereas nearly six of 10 respondents last year said they thought telcos were more formidable opponents, this year, half gave the nod to DBS.

Outside of those issues, operator reaction to the DBS threat is about the same as last year: they generally think DBS is for non-cabled homes, and they haven't really had to do anything to blunt the effect of the service.

Most say they have a leg-up over DBS because of hardware costs and cable's ability to offer local programming and interactive services. And once again, a large majority say they would implement digital compression today if it were available.

Congratulations to John Norcutt of Mid-Atlantic Cable, the latest winner of $50. To make yourself eligible for a future drawing, fill out the survey on the previous page and send it in!

The issue: DBS competition

One of the most successful new products in the consumer electronics world has been digital TV–or more specifically, DirecTv. Since its launch about two years ago, DBS has exploded onto the multichannel video marketplace, signing up millions of subscribers between DirecTv and PrimeStar. And now, EchoStar is up and running, and others are soon to follow. Meanwhile, cable operators are forced to wait to implement digital technology, probably until next year. What impact has this had on local cable systems?

The results:

1. How well would you say DBS is doing at signing up customers–both your subscribers and people who have never subscribed–who reside in your cable system?

Excellent	Good	Poor
7%	**29%**	**64%**

2. How soon do you think DBS will have a measurable impact on your system, in terms of number of subscribers served?

Already has	Within 2 yrs	2-5 yrs	6 yrs or more
7%	**50%**	**29%**	**14%**

3. Do you think consumers see DBS as a better financial investment than cable TV over the long run?

Yes	No	Don't know
7%	**64%**	**21%**

4. To what degree has the launch of DBS affected your system's rebuild or upgrade schedule?

A lot	Some	Very little
21%	**14%**	**64%**

5. In your opinion, what is DBS' "weak link" when compared to a cable system?

Hardware cost	Programming cost	
36%	**21%**	
No return path	Broadcast-only	Other
36%	**36%**	**29%**

6. What percentage of your former subscribers have already switched to DBS services?

1-4%	5-10%	10%-20%	More than 20%
86%	**14%**	**0%**	**0%**

7. How likely is it that the success of DBS will hasten your system to upgrade to more channels and/or new services like data and interactivity?

Very likely	Somewhat likely	Not at all
21%	**51%**	**29%**

8. Do you think most DBS subscribers are rural residents who haven't been wired for cable?

Yes	No	Don't know
71%	**21%**	**7%**

9. Which do you think is a more formidable competitor to your system over the next three years–DBS or the telcos?

DBS	Telcos	Don't know
50%	**43%**	**7%**

10. Has your system either lowered prices or offered any special promotions to ward off DBS competition?

Yes	No	Don't know
21%	**71%**	**0%**

11. If it was available, would you implement digital compression today to increase your channel count?

Yes	No	Don't know
71%	**14%**	**14%**

Your comments:

"We have constructed new subdivisions more quickly to cut off DBS sales."
– *John Norcutt, Mid-Atlantic Cable, Washington, D.C.*

"DBS is a real threat until cable TV offers a true return path."
– *Gregg Brazee, Auburn Cablevision, Auburn, N.Y.*

"We need to . . . hasten the deployment of new interactive services to strengthen our competitive positions."
– *Rachel Rybarczyk, Harron Communications, Pembroke, Mass.*

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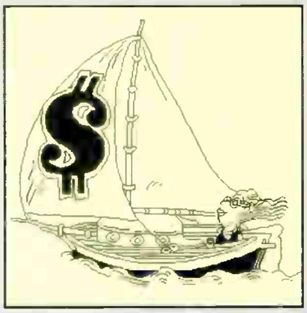

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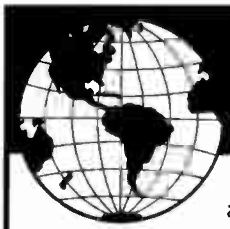

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The whole is greater than the sum of the parts

By Thomas G. Robinson, Director of Regulatory Affairs and Technology Development, River Oaks Communications Corp.

We've often heard it said that the whole is greater than the sum of the parts. As I watched the Centennial Olympics in Atlanta, this point seemed to hit home again and again. The U.S. women's gymnastics team winning the gold medal, while not faring well in the individual all-around competition, is just one example.

This concept applies to many things in the telecom world, including network delivery systems that effectively meld seemingly every different kind of technology imaginable. From a local government perspective, one sterling example of the validity of this concept is municipalities banding together to form commissions and consortia to address many facets of cable and telecommunications, including technology and program production and delivery issues.

As an example, the North Suburban Cable Commission (NSCC) represents 10 communities outside of St. Paul, Minn. The NSCC and its companion North Suburban Access Corporation (NSAC) perform a variety of tasks for the 10 cities, including the production and distribution of public access television over CTV Channel 15 on the Meredith Cable system in that area. The NSCC also assists in the production and distribution of government access programming. This programming is routed through two headends and CTV's master control using standard RF assignments upstream to the headends, fiber interconnects between the headends and Di-tech routing switchers at the headends, such that each of the 10 government access channels is ultimately programmed discretely to each respective community.

The NSCC performs a host of functions related to the effective operation of this network, such as: operation of network master control; technical interface with Meredith Cable; operation of pooled resources; insertion of regional programming to all 10 cities concurrently; and equipment specification and cooperative purchasing.

The NSCC also serves as a focal point for institutional network development. It is assisting school districts with broadband Ethernet implementation; member municipalities with Internet access; and a variety of entities with GIS network implementation.

NSCC officials believe that the successful operation of the commission has created the potential for even greater cooperation among the member jurisdictions on other issues like economic development and transportation planning. Additionally, it has facilitated some of the communications needs of the school districts that cross jurisdictional lines but fall within the commission's 10-city area. What the member jurisdictions and other entities have found is that they can do things more efficiently through the commission than they could do on their own.

Officials of the neighboring Ramsey-Washington Suburban Cable Commission (RWSCC) echo the same beliefs. The RWSCC represents 12 communities totaling more than 52,000 homes with more than 26,000 subscribers and provides programming services to its member jurisdictions through GTN, the Government Television Network. By pooling their resources into GTN, the RWSCC members are provided a variety of benefits: the level of original programming is increased; the technical quality of production is enhanced through the use of centrally-housed Betacam equipment, which would be too expensive for individual jurisdictions to employ; and all different types of technical and programming expertise are shared, enabling production of a high quality of programming. GTN also produces training tapes for the member jurisdictions that assist in improving a variety of governmental operations.

Parts is parts

These types of intergovernmental organizations have been effective nationwide in meeting the needs of their member jurisdictions, especially as the cable industry has begun to pursue more network regionalization, and as the telecom industry continues to evolve into a competitive marketplace. An example of this can be found in the workings of the Metropolitan Area Communications Commission (MACC) which represents 15 cities and Washington County outside of Portland, Ore. Since its creation in 1980, MACC has served as a model for other intergovernmental organizations that have followed. Throughout the last 16 years, and franchise transfers to Columbia Cable and TCI, MACC has provided a wide range of services for its member jurisdictions, ranging in population size from under 100 to more than 70,000, including I-Net services such as telemetry, broadband Ethernet and Internet access to a host of city and regional agencies, and interconnect services for a dozen school districts. MACC has found that its long history of resource sharing and effectively addressing regional communications needs has significantly benefitted its member jurisdictions by now providing the ability to address broader telecommunications issues.

Similarly, the Greater Metro Cable Consortium (GMCC), representing 24 jurisdictions in the Denver metropolitan area, has found that the consortium has significantly benefitted its members in addressing regional telecom issues, including the technological upgrade of TCI's mammoth regional system. It is evident that local government consortia are effective in meeting technological, programming and regulatory challenges, especially in today's complex and evolving telecom environment.

I don't remember much about my human anatomy class in high school (I think this was due to the phenomenon known as "formaldehyde fog"), but I do remember that the essence of the class was that individual organs, even the brain, were essentially just parts. However, when you add them all together, and the parts function in concert, as my old biology teacher used to say, "Now ya' got somethin' special!" CED

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