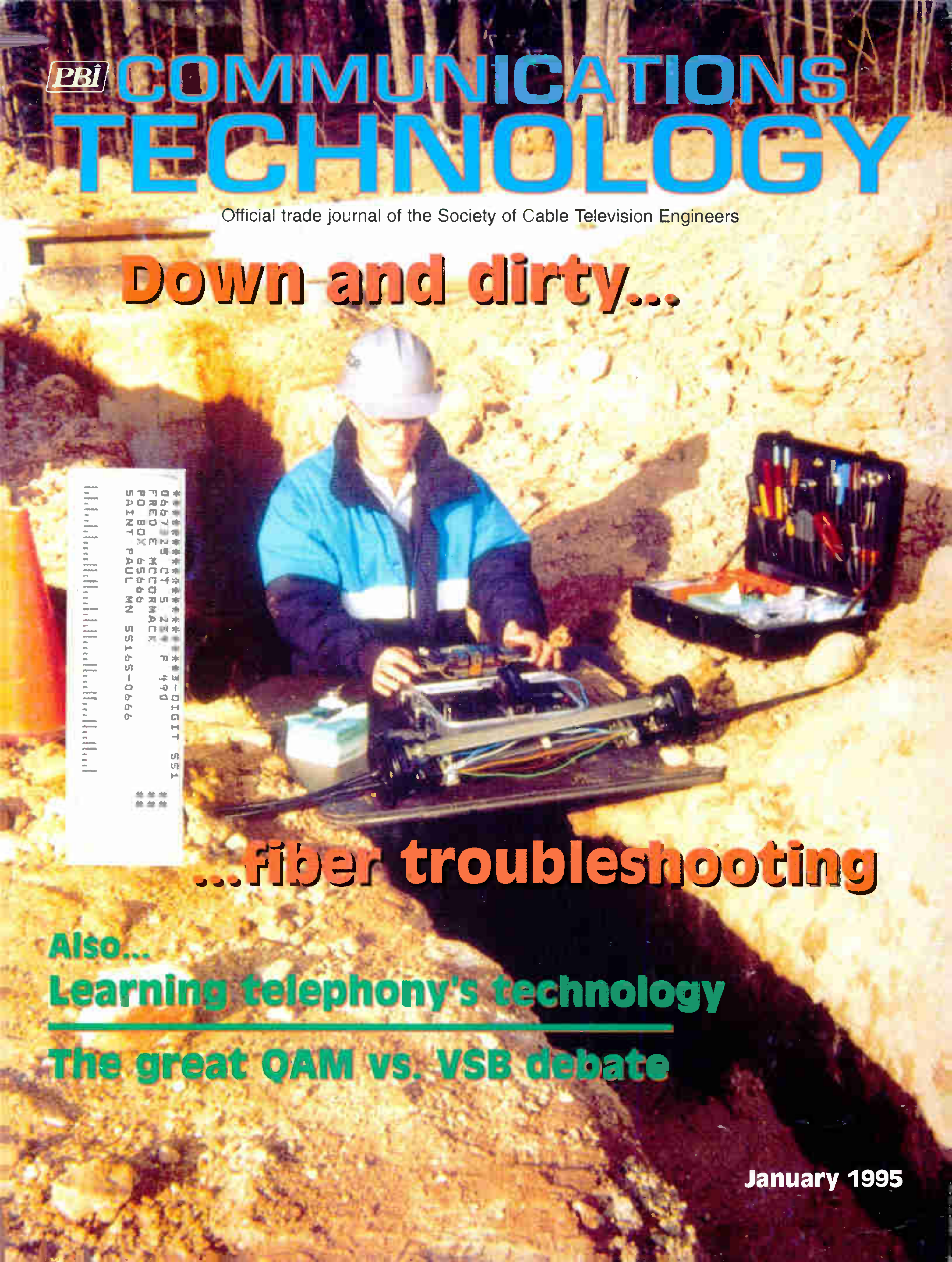


PBI

COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers

Down and dirty...

...fiber troubleshooting

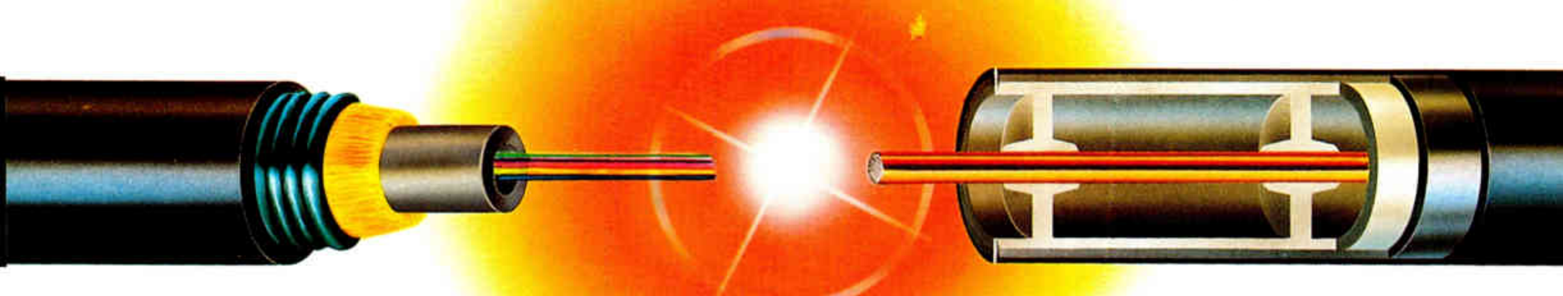
Also...

Learning telephony's technology

The great QAM vs. VSB debate

January 1995

The Perfect Marriage of LIGHT and AIR.



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Reader Service Number 3

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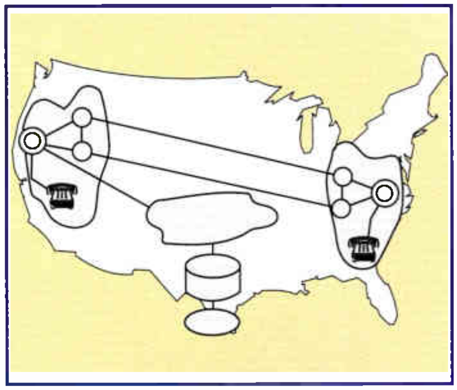

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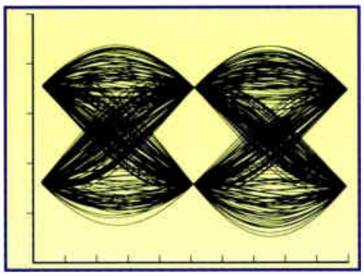

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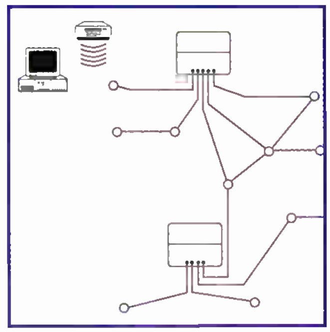

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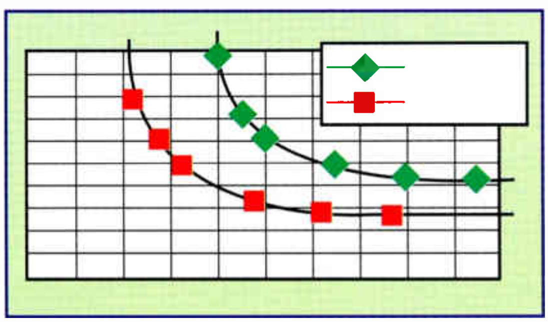

VSB 37

Features

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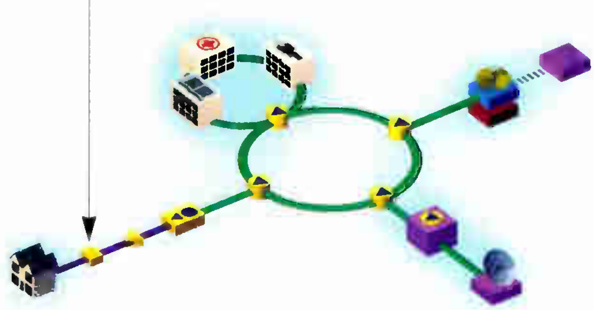

An unlocked pedestal invites trouble...like vandalism to the pedestal and the valuable equipment it protects. Or worse, tampering to result in unauthorized, unbilled cable service to homes.

ANTEC's Monarch brand of Slam Lock pedestals, built to ANTEC's design parameters by Reliance Comm/Tec, lock automatically when they are closed. Its self-locking mechanism assures with a "click" that the pedestal is securely locked until the next service. Unlocking by a field technician is simple with an industry-standard Diversified Control key.

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ANTEC
Network Know-how

Reader Service Number 5

Dear Uncle Sam

An open letter to Congress and the Federal Communications Commission:

When the 1992 Cable Act became law, you explained that it was to protect consumers. It was to protect them because cable had no effective competition. It was to protect them because we let rates get too high. And it was to protect them because some of us had let service become too shabby. Hopefully, by re-regulating cable, the playing field would become a little more level and new competitive services would enter the marketplace. Among other things, we were told to subsidize our competition by providing them our programming, so that they could more "fairly" compete against us. (This last one has always baffled me.)

"Do away with these ridiculous regulations, or at least make them a little more reasonable."

Well, competition is here and more is coming. The back yard C-band dish business has been enjoying great growth, adding something like 40,000 customers each month. DirecTv, one of a handful of new direct broadcast satellite (DBS) providers, is picking up 110,000 customers each month. MMDS ("wireless cable"), while not seeing the kind of growth some of the other competition is enjoying, is nonetheless boosting its figures about 15,000 every month.

Just around the corner is video dial tone, the telcos' version of competition. Traditional cable will be among the phone companies' offerings, too, if the courts continue to rule the way they have been.

Understand that I am not complaining about the competition. In most ways, it has been — and will continue to be — good for our industry. Because of competition, our service is getting better. Networks are being upgraded to provide new capabilities and improved reliability. Much of today's competition wasn't here when the Cable Act was being drafted, but a lot has changed in the past couple of years. Consumers now have several choices for their provider of multichannel video services.

Governmental micro-management?

So please explain to me the need for cable to remain so heavily regulated, while our competition is not! I thought you were attempting to level the playing field. We're the only ones providing multichannel video services who have our rates regulated. We're the only ones who pay franchise fees. We're the only ones who have to justify our channel lineups. Telcos are on the verge of getting into our business, yet more than 40 states prohibit cable from providing residential telephone service. This is fair? We're literally being micro-managed by the government!

I have a suggestion. Do away with these ridiculous regulations, or at least make them a little more reasonable. Now that competition is really here, let the marketplace decide. If prices are too high or service is the pits, consumers have alternatives. They'll speak with their checkbooks. But if you really want to make the playing field a level one, the existing rules aren't the way to do it.

Ronald J. Hranac
Senior Technical Editor

The 60 Hz danger

The term "bioelectromagnetics" is used to describe the study of RF electropollution and its effect on the human body. The RF spectrum under intense scrutiny right now is the ubiquitous power line 60 Hz magnetic field. This ELF (extremely low frequency) magnetic field is especially pertinent to the top hook phone splicer with 600 pairs to splice or the top hook cable splicer with a dual trunk amp with several feeder legs to splice. The top hook lineman spends more time on a power pole exposed to the 60 Hz magnetic field than say an installer who typically finishes in 15 minutes.

The jury is still out on whether exposure to a 60 Hz magnetic field is harmful or not. However, the jury was out on asbestos 20 years ago and look how it is treated today. Also, any ham operator knows to stay away from the RF field produced by a ham antenna because of damage to the eyes.

There is a great deal of literature and research being done on this topic. However, there are two reports that stand out from the rest. The first one was a U.S. Navy submarine communications proposal called the Sanguine project in the late '60s. The Navy proposed burying a giant antenna in Michigan and Wisconsin operating at the ELF range of either 45 or 75 Hz. A study was done to determine the effect on the general population. One of the experts involved in this study was Robert Becker. The project was called off after it was determined that only a one-day exposure to the magnetic field component of the Sanguine signal produced a significant increase in the serum-triglyceride in nine out of 10 subjects tested. Serum-triglycerides are increased by the body's stress response and above normal levels are a definite cause for concern.

The second report that stands out involved occupational case studies by the Bonneville Power Administration. A study done in 1987 by Savitz and Calle combined their test results with 10 other cancer studies. They showed a 1.2 to 1.5 increased PMR (proportional mortality rate) of Leukemia for persons in 10 different electrical occupations — such as linemen, electricians, motion picture projectionists, welders, etc. The PMR is an index for the relative importance of a particular cause of death compared to other causes. These results were further support for a hypothesis that 60 Hz magnetic fields are carcinogenic.

"It would be a prudent measure on our part to include suggested time limits (dosage) to 60 Hz fields for our linemen."

The fact that there is nothing conclusive yet prevents us from taking drastic measures about 60 Hz magnetic fields. However, it would be a prudent measure on our part to include suggested time limits (dosage) to 60 Hz fields for our linemen and let them make their own decision. Time limits (breaks) and distances from the pole line (primary power poles extend their magnetic fields farther than secondary power poles) for the break would be good information to have. The analogy here is like a muscle on an athlete being tired. After a rest or a break in the action, the athlete's muscle is ready to go again.

The following are suggested readings and contacts for the interested individual: 1) "Electrical and Biological Effects of Transmission Lines," Bonneville Power Administration; June 1989. 2) "Cross Currents — The Perils of Electropollution and the Promise of Electromedicine," Robert Becker MD, 1990. 3) *Journal of the Bio Electro Magnetics Institute*, (702) 827-9099, 2490 W. Moana Lane, Reno, NV 89509-3936. 4) EMF/EMI Control, (804) 493-0700, 11 Monument Dr., Montross, VA 22520.

Ken Eckenroth
Vice President, Engineering
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Reader Service Number 13

Bob Sullivan

Just inside this gateway some 21,500 attendees got a taste of cable's future. Next month, CT's editors and correspondents will provide a sampling of the Western Show's technical side.

FCC grants telco VDT trial expansion

The Federal Communications Commission gave Southern New England Telephone permission to significantly expand its current trial of video dial tone (VDT) service.

The current SNET trial area of 1,250 homes in West Hartford, CT, offers some video dialtone services including video-on-demand (VOD), traditional and premium channels, time-shifted news and time-shifted TV programming. The trial now will expand to 150,000 homes in Hartford and Fairfield Counties, CT. Plans are to offer a wide range of services in the future including digitized movies stored in a computer and delivered to customer TV screens on-demand, plus advanced interactive services such as home shopping, educational and health care services, and an array of business applications.

The expanded trial will begin offering service to customers in additional Connecticut communities early this year. During the initial stages of construction and testing, SNET will provide 78 analog channels. Participants can choose from traditional television, premium channels and pay-per-view (PPV), with the capability to time shift some programs.

By the end of 1995, plans are to supplement these channels to include a minimum of 200 digital channels capable of delivering movies and other advanced video programs on demand.

The trial is one of the first uses of I-SNET, Connecticut's broadband information superhighway, a hybrid fiber/coax cable network. The $4.5 billion statewide network was begun in April 1994, with completion scheduled for 2009.

In related news, SNET chose a team of five vendors to build the technological platform for the VDT trial. Hewlett-Packard Co., Sybase Inc., Scientific-Atlanta, AT&T Network Systems, and American Lightwave Systems, a unit of ADC Telecommunications, will provide hardware and software components for the analog/digital multimedia architecture.

Forming the heart of the trial's interactive video system will be H-P's MediaStream Server, which incorporates the company's Video Transfer Engine technology, designed especially for VOD services.

Sybase will supply content and transaction management, navigation and custom operational and business support applications for complete management of interactive services.

S-A will supply both the analog and digital subscriber home communications terminals, including the analog 8600^{X} system, and the analog and digital headend equipment.

AT&T will supply the asynchronous transfer mode technology needed to switch video streams among serving central offices, and ALS will provide digital transport technology to allow distribution of broadcast services.

DBS satellite launch on hold

The failure of the Arianespace rocket carrying PanAmSat's PAS 3, and Arianespace's subsequent hold on further launches, will delay the launch of DirecTv's DBS 3 satellite until at least summer 1995, DirecTv spokeswoman Linda Brill told *CableFAX*.

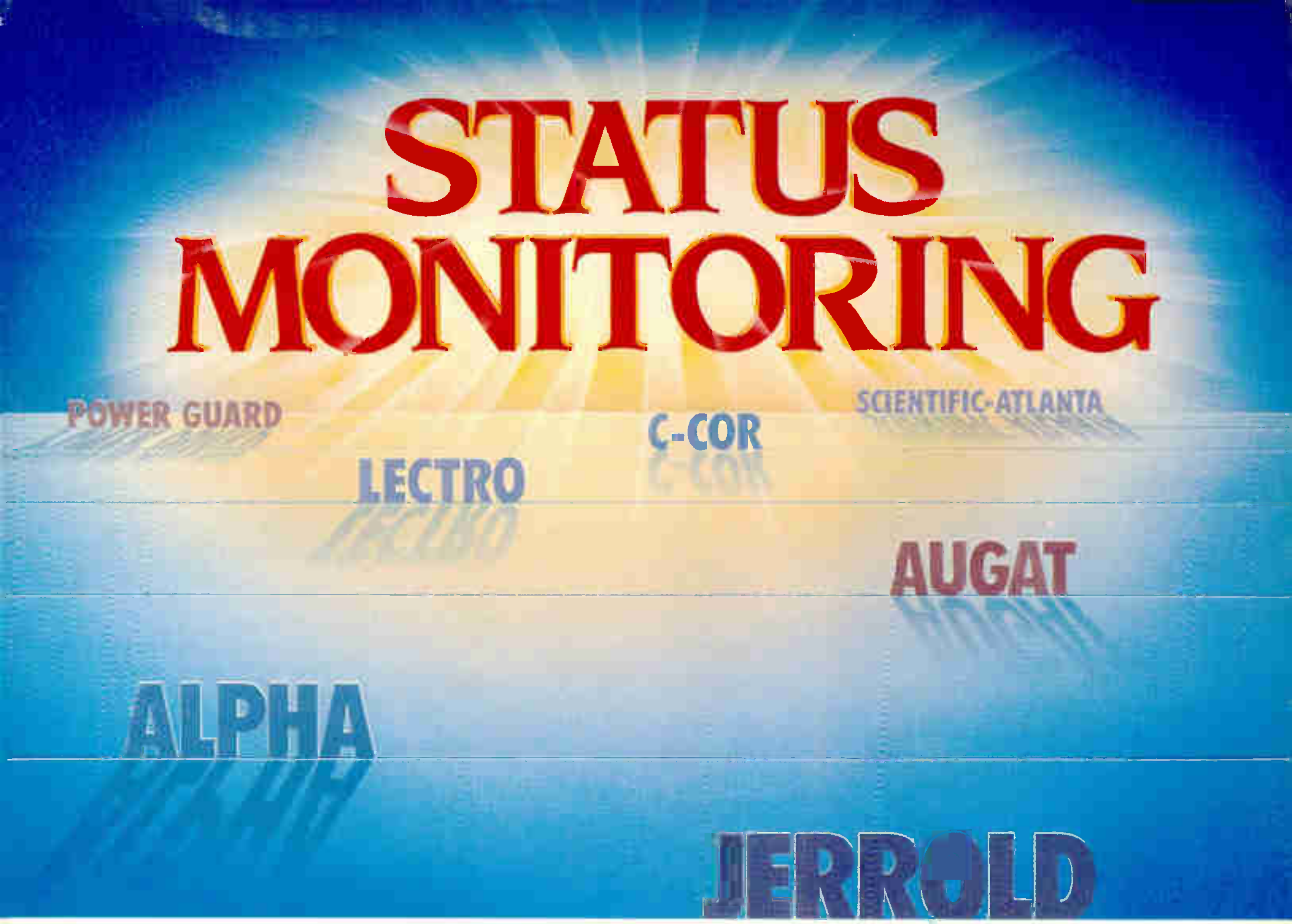
According to Brill, this will not have a significant impact on company business, as the satellite will be used as an in-orbit spare. DBS 3, which also will be used to test new services such as HDTV and a form of interactive TV, will enable the DBS provider to add as many as 30 new channels of cable programming.

Despite the failure — Arianespace's second in 1994 — Brill reiterated DirecTv's commitment to Ariane, noting that the company has no plans to switch to an Atlas launch, as it did with DBS 2 following its initial launch failure.

Digital allies with set-top vendors

Digital Equipment Corp. announced an alliance program aimed at ensuring compatibility between the company's media server and the many third-party set-top boxes that bring computer processing power to TV sets. The program is part of the company's strategy to develop open solutions that are integrated easily with the range of components used in end-to-end interactive information systems.

Set-top box suppliers involved in the program include Apple Computer, Compression Labs, General Instrument, Goldstar, Mitsubishi, Online Media,



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Reader Service Number 107

Philips, Samsung, Scientific-Atlanta, Stellar One Corp. and Zenith.

Digital is making the application programming interface to its media server open and available to all set-top box manufacturers and is providing these vendors with engineering assistance to ensure total compatibility.

In addition to complying with existing interface and operating system standards, the company is ensuring that its media server will work with key evolving standards. It is actively working with leading authoring tool vendors to accelerate the delivery of products that ease the development of interactive applications.

SGS-Thomson gets DigiCipher license

General Instrument Corp. licensed its DigiCipher II video compression technology to SGS-Thomson Microelectronics Inc. The agreement enables SGS-Thomson to develop dual-mode video decoder chips capable of processing both DigiCipher II and MPEG-2 video signals. The dual-mode video chips will expand on SGS-Thomson's family of MPEG-2 decompression products used in digital terminals for the digital TV market.

In other news, GI submitted its DigiCipher II/MPEG-2 system for Cable Television Laboratories Inc. video system conformance testing to verify the compatibility and interoperability of its compressed digital encoder and decoder.

Macrovision signs PPV protection deals

Macrovision Corp. signed agreements with Analog Devices Corp. and GEC Plessey Semiconductors authorizing the two companies to manufacture integrated circuits (ICs) that include Macrovision's proprietary pay-per-view (PPV) copy protection technology. The agreements allow the semiconductor manufacturers to incorporate the technology under a no-charge arrangement, provided that the manufacturers restrict sales of these components to Macrovision licensees.

Because the anticopy system is embedded within the ICs, it can be activated only through a secure software system that controls the operation of the digital set-top decoder, or through the application layer software of prerecorded media. In either case, the activation of the anticopy system is dictated by the copyright owner.

H-P adopts interactive Standford technology

Hewlett-Packard Co. (HP) adopted Stanford Telecommunications Inc.'s technology for use in interactive set-top box equipment for interactive applications. Stanford's QPSK return path modem will perform vital functions enabling subscribers to transmit information from their premises (home, business, etc.) to infrastructure network equipment.

Stanford's applications specific integrated circuits (ASICs) will perform the necessary digital signal processing to convert usable streams of information to encoded, modulated signals that are optimized to be sent over fiber or coax lines. While providing interactive capabilities, these components also may perform other telephony or data transmission concurrently.

CAI invests in ACTV

CAI Wireless Systems Inc. agreed to make a $500,000 investment in ACTV Inc. and will explore applications of ACTV's interactive TV programming technology in its own video delivery operations.

CAI plans to structure a commercial test utilizing ACTV's technology in providing services in video dial tone tests with a regional telephone company. Commercial testing is projected to commence by the end of 1995.

Initially, the company will purchase 50,000 new shares from ACTV for $250,000 and a subsequent investment of $250,000 in additional shares will be made on or before March 31, 1995, at the then current market price.

ACTV will grant CAI warrants to purchase up to an additional 800,000 shares of its common stock at $5.50 per share, excercisable until Dec. 31, 1995, assuming the commercial test begins by the end of 1995 and ACTV receives an additional $500,000 initial license payment.

In addition to CAI's wireless cable operations, the company is pursuing strategic relationships with regional telephone companies in areas in which it owns wireless channel rights. Currently, it has agreements with Southern New England Telephone and Rochester Telephone.

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SCTE tops 13,000 mark

The national membership of the Society of Cable Television Engineers has passed the 13,000 mark. SCTE's membership count has increased over the past 10 years to reach this important milestone in the Society's history.

This represents an increase from 1993's year-end membership count of 11,500, which signified an increase of 1,500 members over 1992's much-celebrated year-end figure of 10,000.

The historic figure of 13,000 members takes into account the Society's over 10,800 active national members, as well as the more than 2,200 that are SCTE members at the Installer level.

This growth can be partially attributed to the popularity and success of the Society's numerous programs and services, including the chapter development Program, Broadband Communications Technician/ Engineer (BCT/E) and Installer Certification Programs, Cable-Tec Expo, Annual Conference on Emerging Technologies, Technology for Technicians and OSHA/safety regional training seminar programs.

SCTE President Bill Riker comments, "Reaching the 13,000 mark is an important event in the Society's history. This figure indicates the telecommunications industry's ongoing commitment to and support of the training services provided by the Society. Today, as we stand on the forefront of a new era of evolution for the broadband communications industries, we look forward to increasing our efforts to serve our members and their employers."

Chapter meetings: Hiring, FCC testing

The Society's Ark-La-Tex Chapter held its first "Vendor's Day" event Aug. 3 at the Ramada Inn in Bossier City, LA. Twenty-five people were present to meet with representatives from 16 vendors, and, according to Secretary Randy Berry, "It was a successful first 'Vendor's Day' event, and a good time was had by all."

The Cactus Chapter met Sept. 17 at Dimension Cable's central facility in Phoenix, AZ. Secretary Michael Striegler reports, "Speaking on 'FCC Field Testing,' John Burrell of Tektronix discussed FCC field test requirements and demonstrated how to perform these tests using a CATV spectrum analyzer. Ed Harmon of Western Systems and Service gave a presentation on 'FCC System Proofs,' displaying and demonstrating test equipment used for FCC testing. Terry Gooding of Wavetek presented test equipment for FCC testing and system sweeping and demonstrated their usage."

The Chattahoochee Chapter held its Sept. 13 meeting at the Ramada Inn in Chamblee, GA. Secretary Johnny Ray reports, "In his presentation enti-

Reader Service Number 58

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Reader Service Number 63

tled 'Equal Employment Opportunity,' Greg Cook of GCTV discussed issues pertaining to changes in the federal and state EEO laws. Rouletti Vick gave a presentation on 'Lawful Hiring Practices,' discussing legal issues pertaining to the hiring of employees and leading group discussions on pertinent cases. Sandra Kirkland spoke on 'Equal Business Opportunity,' focusing on the advertising and promotion of proposed equal business opportunities. Sixteen people attended the meeting.

The Central Indiana Meeting Group met Oct. 6 at the Holiday Inn in Indianapolis. Bill Kohrt of Texscan gave a presentation on "New Amplifier Technologies" that offered an overview of amplifiers that are being used with new fiber architectures and covered higher bandwidths and dedicated hybrids on feed legs. Speaking on "Fiber Architectures," Salvatore Yorks of Philips covered fiber's integration into the cable world, focusing on architectures currently being utilized. The technical session concluded with a roundtable open forum in which higher power voltage, two-way interactive transmission and equalization were discussed.

The Dakota Territories Chapter held consecutive meetings held Oct. 19 at the Guest House Motor Inn in Watertown, SD, and Oct. 20 at the CableCom office in Fargo, ND. The technical seminar presented at both meetings, "Installer Training," featured speaker Kent Binkerd and covered all aspects of installs, as well as multiple dwelling units, safety, leakage, bonding and prewires.

The South Florida Chapter held a meeting Sept. 21 at the Holiday Inn in Fort Lauderdale, FL. Secretary Jim Jones reports, "Jim Goins covered the basics and delivered a tutorial for BCT/E Category III, 'Transportation Systems.' In his presentation on 'System Measurements/The FCC,' Steve Wedler of Hewlett-Packard covered FCC testing requirements and the proper usage of a spectrum analyzer. Speaking on 'Fiber Optics and System Amplifiers, 'Bob Glass of Scientific-Atlanta covered distribution systems, microwave technology and formulas related to these technologies; covered AM and FM fiber optics; and covered the evolution of quad power and feedforward amplifiers."

The Southeast Texas Chapter met Oct. 11 at the Holiday Inn in Houston. Vice President/Secretary Brian Gray reports, "In their presentation 'The State of the Industry,' SCTE Chairman Tom Elliot of TCI and Dan Pike of Prime Cable discussed DBS, MMDS, telephony and interactivity. Tom and Dan also spoke on BCT/E Category VII, 'Engineering Management and Professionalism,' which included the showing of a tutorial video on the topic and a discussion of different approaches to the category exam."

The Sept. 22 meeting of The Wheat State Chapter was held at the Red Coach Inn in Wichita, KS. Secretary/Treasurer Joe Cvetnich reports, "Dennis Main of Skywave Communications gave a presentation on 'Direct TV/DSS System,' providing an excellent demonstration of the DSS 18-inch dish and the set-top decoder. He explained Skywave's current services and discussed the services to be offered by the Direct TV DSS system in the future. Speaking on 'Cable Industry Strategies Toward DSS,' Larry Proffitt of Multimedia Cablevision explained the cable industry's strategies to compete with DSS. Jill Geier of Showtime discussed 'Customer Relations,' holding everyone's attention with role playing and contests for prizes that were related to sales and customer service."

Tech sessions: Western Show

The Society of Cable Television Engineers sponsored several technical sessions at the recent Western Cable Show held in Anaheim, CA, which was attended by over 21,500 people.

The show floor was laden with equipment that will be needed for building the network of the future and in SCTE's sessions, attendees had the opportunity to hear how all those tools could be put to proper use. Topics of discussion included an introduction to telephony, video proof-of-performance testing, an introduction to broadband telecommunications, interactive case studies, and a Federal Communications Commission Washington update.

Look for full coverage of these sessions in next month's *Communications Technology* in "SCTE News."

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As intelligence in CATV networks increases while on the often bewildering path into the future, it should prove rewarding to examine some of the phone companies' experiences in intelligent networks. For instance, to provide competitive telephone services, a CATV network has to do much ***much*** *more than just activate the upstream and provide two-way voice capabilities. As the telephone networks demonstrate, many more functions have to be furnished to provide an intelligent network.*

Obviously CATV networks will not duplicate all the intelligent network services developed by the phone companies but the following reprint is illustrative of the fact that the CATV networks will have to develop and deploy their own network intelligence for future services as they are added in order to stay competitive. "Electronic Design" magazine had Communications Editor Lee Goldberg research and write an excellent article on the subject. The magazine was kind enough to give permission for the following reprint. — Lawrence W. Lockwood, East Coast Correspondent; President, TeleResources.

Glossary of acronyms

ANI	Automatic number identification. Provides display of calling number on called phone.
CO	Central office of a phone company where the switch is located.
ESS	Electronic switching system.
ISDN	Integrated service digital network.
MOC	Maintenance operations console.
PBX	Private branch exchange. A small phone switch inside a company.
SCP	Service control point. CPU linked to SS7 that supports carrier services (800, ANI).
SSP	Signal switching point. Recognizes intelligent network (IN) calls and routes and connects them under direction of an SCP.
SS7	Signaling System 7. The latest ESS.
STP	Signal transfer point. Packet switch for SS7.
TCP/IP	Transmission control protocol/Internet protocol.
X.25	CCITT recommendation defining a protocol to access a packet switched network.

Network intelligence

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By Lee Goldberg
Communications Editor, *Electronic Design*

The intelligent network, a marriage of computer and communications technologies, has matured just in time to play a key role in the turbulent communications revolution. While sometimes over-promoted as a universal solution, the concepts behind intelligent networks represent a fundamental shift in the way communication is handled, and will impact most network technologies by the end of the century.

As 1994 drew to a close, most of North America had access to the "advanced intelligent network," AT&T's version of intelligent network technology. Designed to add flexibility to the telephone system's infrastructure, the advanced intelligent network lays the foundation for new services, such as mixed voice, video and data traffic on variable bandwidth, switched lines and personal telephone numbers that follow a user through the network. Not limited to telephone systems, the concept of the intelligent network applies to local and wide area networks (LANs and WANs) as well as other complex systems.

The term intelligent network resists a simple definition. What makes it so elusive conceptually is the fact that it's not a single technology. In fact, for the most part, it's really not a new technology but rather the evolutionary byproduct of a melding between two technologies, switching and computing.

By taking the root sum square of the prevailing industry hype, we can derive a good working definition of the intelligent network: An interconnection system that can implement significant changes to its attributes and functional behavior through software means instead of hardware. In addition, the architecture of intelligent networks is structured to permit centralized modification of systemwide control functions. This ensures that new functions and services can be quickly deployed on the intelligent network and behave exactly the same throughout the network.

But just what does this really mean? Generally speaking, networks will begin to look more and more like computers. If we had to swap out display cards and keyboards every time we stopped using a spreadsheet and wanted to play Tetris, computers wouldn't be terribly useful. These days, the only reason we reconfigure our computer's hardware is to add more capacity or functionality. Until recently, however, this wasn't the case with the telephone system.

Network evolution

A better perspective on the intelligent network can be constructed by closely examining telephony developments. Held over from its inception in the 1920s, the telephone system's architecture was based around a simple model of renting out sets of wires with a fixed bandwidth to a customer for a given period of time. Much like its contemporary, the Model T Ford, you could have it in any color you wanted, as long as it was black. Features such as automatic call

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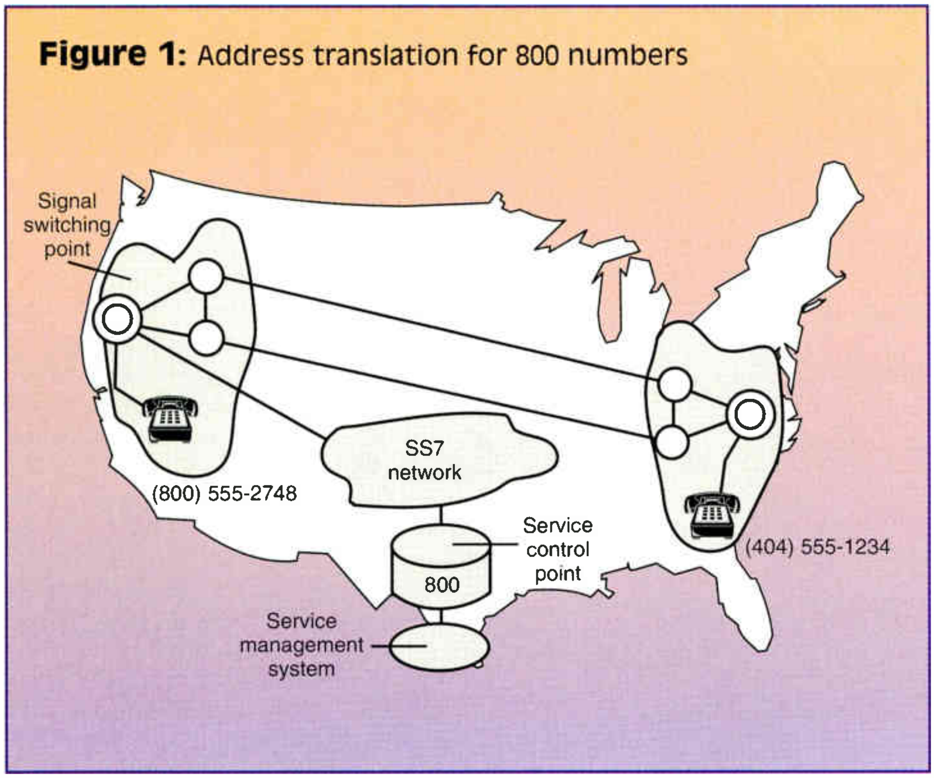

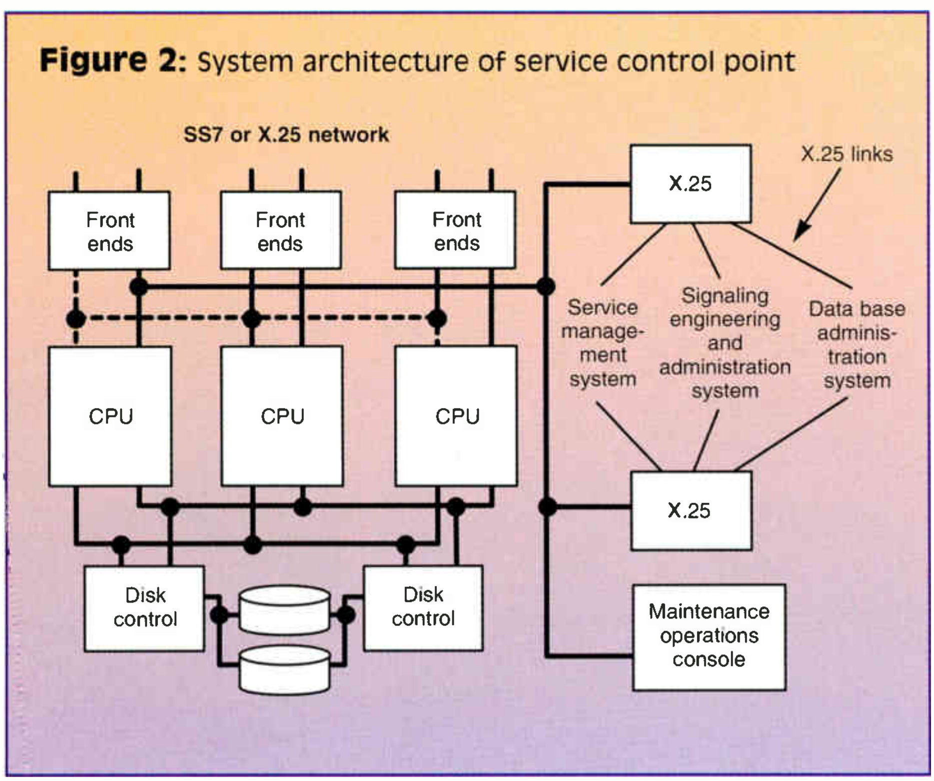

routing were first implemented with relay logic, following the simple model of telephony developed at the turn of the century. Human operators gave the network some level of intelligence, but its basic structure made providing any sort of nonstandard feature, such as three-way calling, call forwarding or toll free numbers, a difficult or impossible task.

In the following decades, the technology behind the telephone dramatically improved the reliability of the network, its capacity and the speed at which it could handle calls, while the model of how telephone service looked to the customer changed very little. Behind the scenes, however, the computer was rapidly replacing fixed relay logic with programmable logic to drive the switching gear, thus providing the foundation for a more flexible infrastructure.

Another important change in the switching architecture occurred when the signals that controlled the routing of calls were moved to a separate channel, known in telephony jargon as "out-of-band signaling." This meant that a second infrastructure grew up in parallel to the voice channels, and it was devoted exclusively to carrying routing and billing information between telephone switching exchanges. Initially, signaling was done using audio tones, but has been replaced in most cases by pure digital transmissions.

The outgrowth of these two technologies is the electronic switching system (ESS), which made its debut in the 1960s. In the past three decades, ESS has reached its seventh (SS7) incarnation and has become a de facto standard for all telephone exchanges within the United States, Europe and many other countries.

This new switching technology gave the telephone system the flexibility it needed to provide the user with expanded services. Thanks to the programmable switch, custom routing schemes could be developed for special categories of calls, defined by things like area code, the exchange number (the first three digits), time of day or the originating party's location.

SS7 in action

If you dial a toll free number, your local exchange recognizes the 800 prefix as a special case and doesn't immediately route the call. Instead, it hops on the signaling network and places a query to a large national data base that gives the local exchange two important pieces of information required to place the 800 prefix call (Figure 1). First, it translates the toll free telephone number into a standard format number that can be used to direct the call through the network. Along with address translation, the data base provides the billing instructions that direct the toll to be charged to the receiving party.

Similar functions are performed for credit card, calling card and 900 number services. The address translation capabilities of an intelligent network may eventually provide location-independent personal telephone numbers. This service could enable the network to locate a subscriber and route an incoming call to the user's choice of a per-

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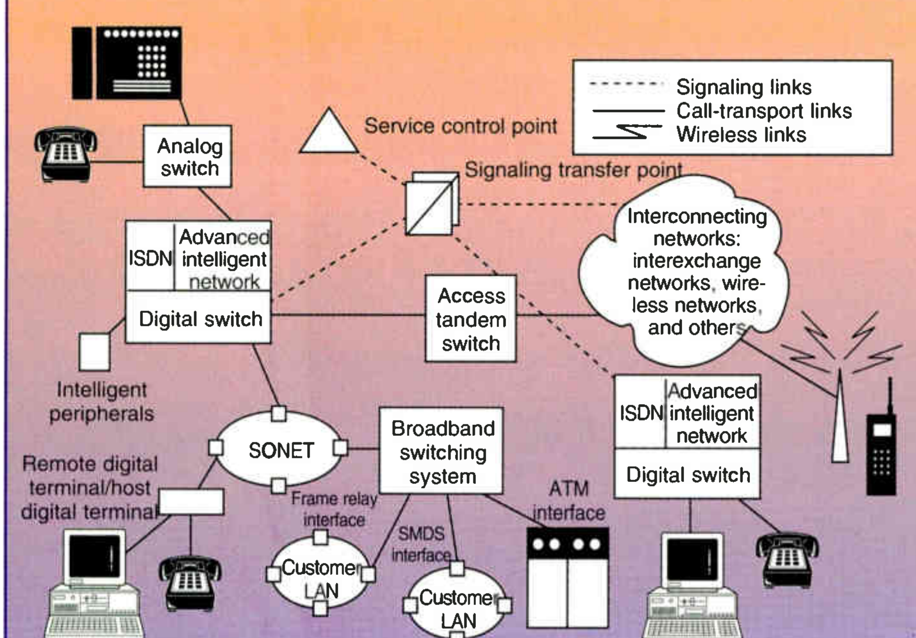
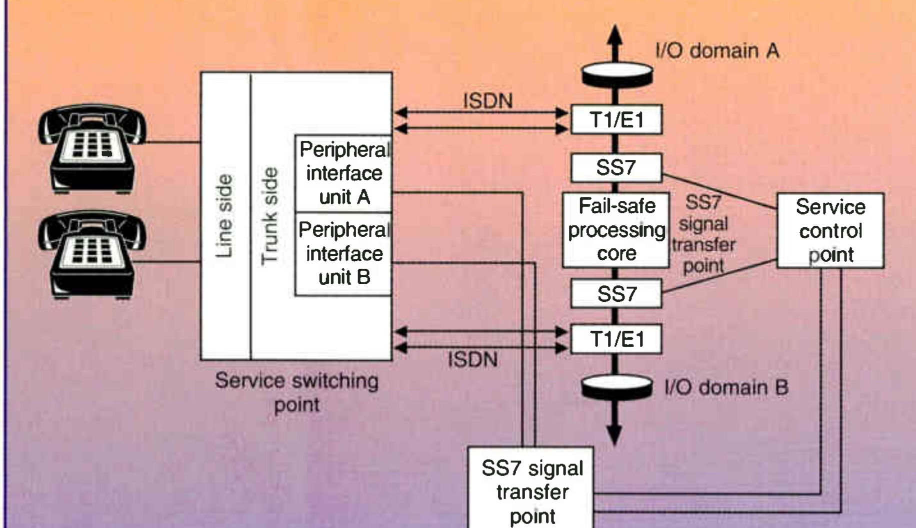
Figure 3: Intelligent network can act as on-demand WAN



(Courtesy Bellcore)

Figure 4: Intelligent peripheral



(Courtesy Motorola)

sonal communication service (PCS) or cellular handset, a nearby wired telephone, or even a network-based voicemail system.

Because the call routing and billing is handled by programmable computers and not fixed relay logic, it's relatively easy to develop software that provides different combinations of network services for each category of calls defined. This ability to program new responses to service requests is the foundation of intelligent network technology. The programmable nature of local exchanges makes it possible for the telephone company to offer various services that jack directly into the network's signaling system, such as call waiting, call forwarding, caller ID and last number redialing. The uniform network interface that the SS7 signaling protocol provides also enables equipment to be installed in the system, providing new services such as voice messaging, E-mail, text-to-speech services and data base access.

Network elements, systems

From a broad perspective, the telephone system is divided into two general categories of functions. The *network elements* are the portions of the system that actually carry customer calls and the information required to route them, while *network systems* handle control-related functions such as service control, service applications, billing and capacity management. Local exchanges connect a customer's equipment to the network through what is called "the last mile" of wire (or optical fiber cable). In residential applications, the local exchange acts as a network interface for anywhere from 1,000 to 100,000 telephone lines and provides local call switching. A local exchange is a collection of one or more units called signal switching points that have been bundled together.

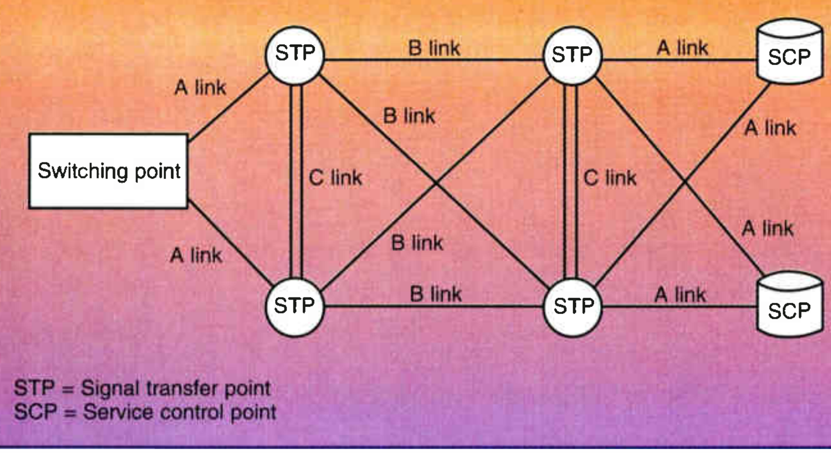
Signal switching points (SSPs), one of the most common network elements, are located within local exchanges and serve as the interface between customers and the rest of the intelligent network. The signal switching point is a stored-program switch that takes customer calls and generates routing signals that are sent into the SS7 signaling network via 56 kbit/s links. While these switching elements are relatively "dumb," they're programmed to recognize and intercept calls that require special handling, as well as launch queries to centralized data bases for the purposes of call routing and billing instructions.

Signal transfer points (STPs) usually lie deeper within the network, functioning as high-capacity, high-reliability packet switches that carry signaling information between the message carrying side (network element) of the network and the signaling and control (network system) infrastructure. The signal transfer point's basic function is to route the signals from one switch to another, or to and from the large data bases within the network control system.

Signal inputs to the signal transfer point usually consist of between 256 and 1,024 56 kbit/s SS7 network connections. Under normal operating conditions, a signal transfer point will process between 1,000 and 5,000 signaling packets per second.

Since they're connected to many switching nodes and cover large service areas, signal transfer points are run in fully redundant pairs that are geographically separated to guard against a natural disaster affecting both units. A single signal transfer point can handle the total

Figure 5: Redundant interface between STPs and SCPs



regional traffic load. But under normal circumstances, the pair distributes the load between themselves to guarantee that either unit is fully functional in case of a possible disaster.

The brains

The service control point (SCP) is a highly reliable, on-line data base that gives the intelligent network its "brains." This unit supplies the switching system with customized information on how to deliver and charge for special services or features requested by a specific user.

Service control points provide call handling information to the network's switches and service transfer points at rates of up to 300 calls per second. These units support regional and national services, such as routing and billing information for 800 and 900 number services. Alternate billing (credit card/calling card) services and special business services (e.g., virtual networks) also rely on service control point data bases.

Based upon a multi-CPU architecture, the service control point is interfaced to the network via multiple SS7 or X.25 communication links (Figure 2 on page 20). All CPUs share a common disk farm and a common interface to the signaling engineering and administration system that monitors and controls the network's configuration.

To ensure that the service control point's data base is always properly configured, it's tied to a data base administration system and a service management system. Another link to a maintenance operations console (MOC) provides network administrators with an ongoing appraisal of the service control point's health status.

An adjunct is a junior version of the service control point. Designed for work within a telephone local exchange, the adjunct supports call setup and local intelligent network functions known as custom local area signaling services (CLASS). CLASS includes such services as call waiting, last caller ring back, call forwarding and caller ID. Signaling between the adjunct and its local signal switching point is done through the Ethernet, while SS7 links are used to communicate with service control points throughout the network.

Overseeing each regional network is a signal engineering and administration system (SEAS). Linked directly to all of the signal control and transfer points, the SEAS keeps track of the status of every SS7 link under its jurisdiction. It also maintains the routing information used by signal transfer points.

The versatile peripheral

One somewhat unique brand of network systems devices are intelligent peripherals, because they can be located either within the network as embedded service providers or attached to the edge of the network by third-party operators who wish to sell their services to network subscribers. Connections to the network are handled much like other intelligent network boxes, with SS7 links being used for signaling and T1/E1 links for voice/data. The links between collocated intelligent peripherals will be run via Ethernet or some high-speed derivative. For their customer interface, intelligent peripherals can use either conventional analog connections or ISDN lines. ISDN is an all-digital telephone service that supports high-speed data and allows subscribers a limited form of out-of-band signaling (via the "D" channel). Using ISDN, a subscriber can send and receive control information from the intelligent peripheral and perform call setup to access other network functions.

The current generation of intelligent peripherals are being used to perform tasks similar to an adjunct such as voice messaging, voice response and voice recognition. If telephone companies have their way, the next generation of advanced intelligent peripherals will be able to offer more sophisticated services, such as video-on-demand (VOD) and direct access to the Internet.

The architecture of the intelligent network also has been designed to facilitate the integration of LANs, cellular radio systems and other types of networks (Figure 3 on page 22). This would allow customers to treat the telephone system like an extension of their own local network by providing on-demand, switched WAN services. The on-demand WAN will offer a great value to the many businesses with operations in several locations but insufficient traffic and/or capital to justify a dedicated link to each site.

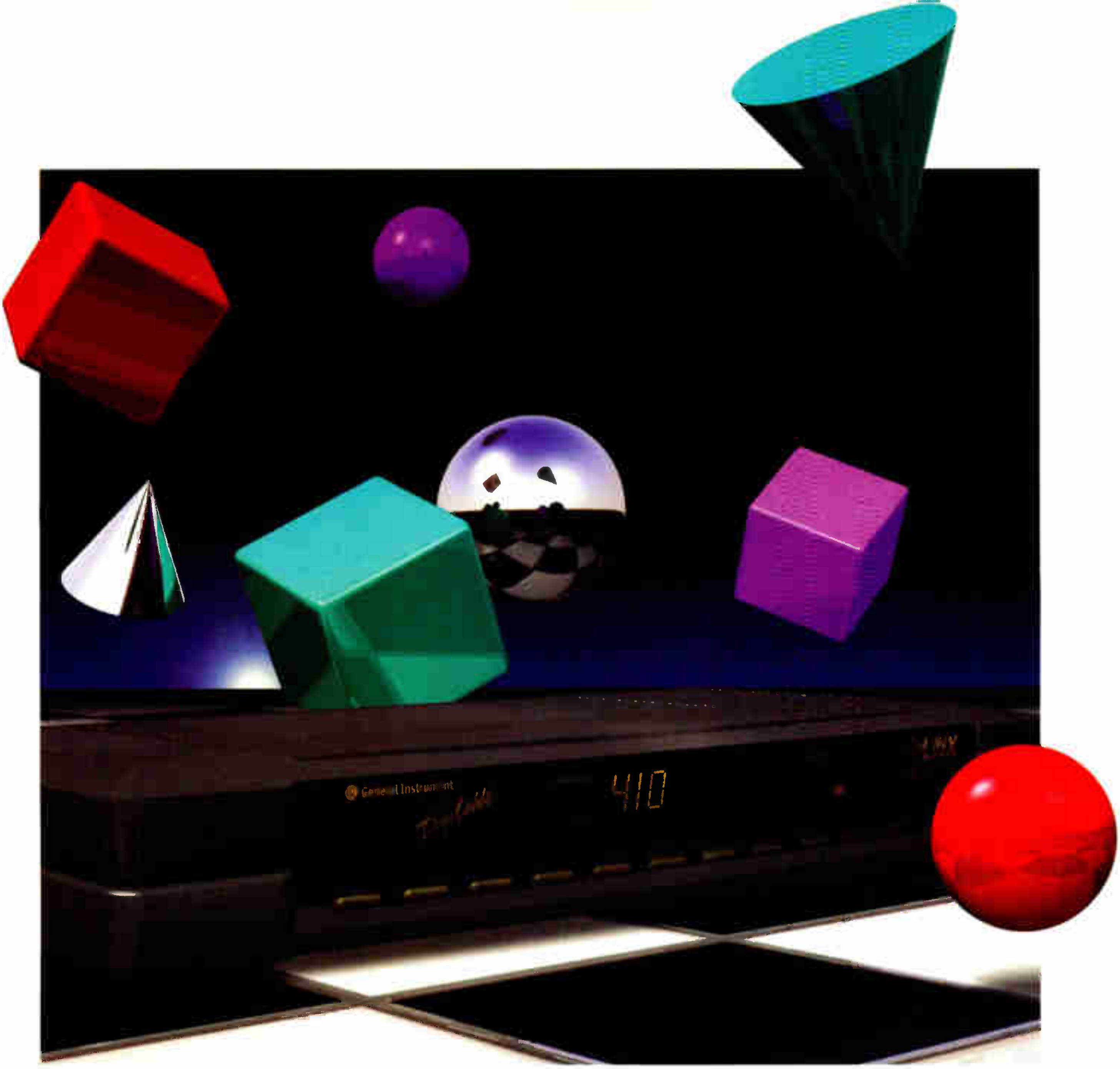
Where's the intelligence?

To understand why today's intelligent network looks so different from most networks, one must understand the history behind the telephone system. The current telephone system grew out of a control structure that was developed to tie together an enormous network using the simple technology available at the time. Due to the size of the network, automation didn't come in a single step, but rather in small increments over a period of four decades.

Human operators were phased out of local and then long distance calling as the telephone system was slowly automated by system engineers. These engineers used relay logic to implement complex tasks like random access call switching and billing based on distance and connection time.

The tightly held control system mimicked the hierarchical command structure used by the human operators. This was deemed necessary to maintain order within the vast telephone network empire, to ensure that network services worked the same throughout the country, and so that the system's resources were used efficiently.

When expensive mainframe computers were introduced in the 1960s, it made sense to maintain the paradigm of centralization to reduce the number of data bases that had to be managed, and



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to most efficiently use the high-cost facilities. Today's system still reflects many of the structural decisions that were made during this time. As an example, the routing for all 800 prefix telephone calls is still handled by a single data base system that's located in Kansas City, MO. What was sacrificed along the way was some of the potential flexibility offered by programmable switching technology. Despite all of the new computer systems, adding new services or features to the large, centralized infrastructure always involved millions of dollars in capital and years of time.

The intelligent network strategy developed by AT&T is an attempt to re-engineer its telecommunications network into a more flexible system while still retaining a fairly centralized control structure. As microcomputers have become less expensive, more plentiful and readily available, network intelligence has seen an outward migration to regional and local areas, but the control has remained concentrated in one point.

In contrast, some equipment manufacturers have taken advantage of this inexpensive computing power and put it to work at the network periphery in the form of the private branch exchange

"To provide competitive telephone services, a CATV network has to do much much more than just activate the upstream and provide two-way voice capabilities."

(PBX). Originally developed for business applications, the PBX places intelligence and control at the network's edge. Besides providing an interface between an office's telephones and the outside world, the PBX can provide sophisticated services such as voice-mail, call forwarding, selective screening of incoming or outgoing calls, and selection of long distance carrier based on lowest cost for a given time of day and destination.

Some advocates of PBX technology say that this decentralized approach may be more cost-effective and efficient for larger applications, too. For instance, in developing countries like China or Brazil, PBXs sometimes are used as local exchanges for villages and outlying areas, tying an area's telephones together with a smart switching system and providing long distance service through a limited number of tie-lines to the country's national infrastructure.

While the intelligent network works well, it may be a triumph of engineering over common sense. Some prominent critics argue that a network with distributed intelligence and control is more efficient, easier to upgrade and less expensive than a centralized control one, especially in terms of bandwidth minutes per dollar.

As previously mentioned, most of North America has access to AT&T's advanced intelligent network, which is the company's version of intelligent network technology. Around mid-1995, AT&T plans to open up the network to other service providers, according to Dave Maruitak, a senior member of the technical staff at AT&T Network Systems, San Diego, CA. He sees this as a great opportunity for persons interested in providing niche services for specific geographic regions, specialized business or professional communities, or other targeted market groups. →

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Network entrepreneurship

Once the telephone network adopts an open architecture, the intelligent peripheral will be a key tool for entrepreneurs who wish to sell services over the telephone system. Because intelligent peripherals behave as true peripherals to the network, they can be employed either as gateways to other networks or as large, remote disk farms for centralized archiving and data base management. Located at the periphery of the network, these privately owned intelligent peripherals will be able to offer clients backup services for distributed networks, on-line data bases, specialized switching networks, foreign-language voice recognition/response services, and even accelerate the onslaught of interactive home shopping clubs.

"Not only is there lots of new terminology, buzzwords and jargon to assimilate, but also a very different way of looking at networks."

Besides providing programming and information services, many other business opportunities are opening up within the intelligent network world. For those wishing to develop intelligent peripherals or other telecommunication products, the highly defined open system environment of modern telephone systems gives potential vendors a running start.

The evolution toward an open systems architecture is a beneficial byproduct of the move toward a standardized national intelligent network infrastructure. As the telephone network architecture developed, it became increasingly dominated by computer technology. By 1980, when the SS7 switching system began development, the decision was made to use an open systems approach and a layered protocol much like the open systems interconnection (OSI) reference model successfully employed by the International Standards Organization in the data processing world. In compliance with the open systems approach, software for network products now is written almost exclusively for a UNIX environment, most often in the C or C++ languages. This new paradigm reflects today's trend toward the client server model for data networks. In this case, the customer is the client and the service control point is the server, providing connections to intelligent peripherals and adjuncts throughout the network.

Most modern telephone equipment is built from different combinations of the same basic components. The open telephony platform model, for instance, has encouraged a building block strategy for network development, where specialized components are constructed from generic computer equipment and telephony interface hardware and then is customized using UNIX-based, application-specific software (Figure 4 on page 22).

At the center of nearly any network element or system is a computer with a redundant architecture, which usually sports a large disk array to house the data bases associated with its applications. One or more 56 kbit/s communication ports are used for SS7 signaling to the network, while an Ethernet or other high-speed LAN often is employed for data transfers between devices within the same facility.

A word of caution is in order, though, for those enterprising souls who are already dreaming of reaping the treasures of the intelligent network frontier. Despite many similarities to the conventional data processing world, it should be noted that network and data processing types will probably suffer serious culture shock upon their first exposure to the insular world of telephony, which has had 100 years to develop its own approach to everything.

Not only is there lots of new terminology, buzzwords and jargon to assimilate, but also a very different way of looking at networks. As an example, many network block diagrams used by the phone system devote only passing attention to the actual voice carrier channels and tend to concentrate almost exclusively on the much more complicated signaling infrastructure. One key to understanding how telephone systems are assembled is to remember that reliability is almost a religious issue in the telecommunications world. For regional services such as service control points, the maximum allowable down time is measured in minutes per year. To achieve this, any important system element must be supplied as a redundant pair, with any single unit capable of doing the job. The cross-strapping arrangement illustrated for a typical connection between a signal transfer point and a service control point is a good example of the redundant architecture used throughout the system (Figure 5 on page 24).

Strict requirements

In addition to redundancy requirements, all equipment used within the telephone system must conform to stringent mechanical and electrical requirement set forth by Bellcore in its network equipment building system (NEBS) generic equipment requirements standards. These specifications dictate the mechanical and electrical performance for each type of component. Among other things, a NEBS-compliant computer must be able to run on 28 VDC standard telephone company power; support the UNIX operating system; pass rigid flammability tests; be able to operate continuously in a dusty, nonair-conditioned environment and survive a Zone 4 earthquake.

One approach to meeting these stringent requirements is to purchase OEM equipment from telecommunication-smart manufacturers and provide added value engineering through system integration and software development. Several companies offer fault-tolerant, network-compatible computer systems that can be mounted directly into a standard size telephone equipment rack. Vendors of NEBS-compliant equipment include IBM, Motorola, Stratus Computer and Tandem Computer.

For low-volume applications or operations where development capital is limited, purchasing OEM modules and software can dramatically reduce up-front engineering costs. As an example, the Motorola Computer Group offers a complete line of open network system platforms, including the Series FT, VMEbus-based computers that feature a fault-tolerant architecture, automatic fault recovery, and intelligent configuration management. The UNIX-based software available for Series FT products provides a solid foundation for applications development with a process scheduler, several data bases and code modules that support communications protocols for TCP/IP, X.25 and SS7 signaling networks.

Software development for intelligent network products also is getting easier as the standards for open platform telephony become more well-defined. One of the most active players in the telecommunications software market is Chorus Systems of Beaverton, OR. The company's microkernel-based, object-oriented software platform is designed specifically to develop operating systems used in communication products. The Chorus architecture is fully scalable, permitting the same kernel that was originally developed for a PBX or service control point to be used in smaller applications, such as handheld PCS units and small intelligent peripherals, while maintaining the same attributes and protocols. The code's modular design also makes maintenance and upgrades easier and quicker to implement. Though originally developed for telephony, Chorus also has been successful in developing data communication products for LANs and WANs.

In summary, the intelligent network isn't a single technology or architecture. Instead, it's an approach to network architecture that permits rapid reconfiguration to support the changing needs of its users. Although nobody can predict what the next generation of networks will look like, you can probably expect that they will borrow heavily on the lessons learned from today's intelligent networks. **CT**

Part 1: Primer on telephony

The following is the first part of a series on the technology involved in the telephony network. This installment will summarize some of the voluminous material on how the present telephone network is structured and how connections are made between telephones, fax machines and answering machines. Succeeding installments will examine how voice signals are processed, digitized and transmitted along a wire or optical fiber and reproduced to intelligibility. Then we will look at the changes in physical topology (network layout) that have been occurring in telephone networks. We will examine what the future has in store for us when new switching technology comes on-line in the ever expanding information superhighway and personal communications networks (PCNs).

By Herm Braun
President, Multipoint Electronics

The telephone is the most familiar electronic device in the home or office. Because it's always there when we need it (almost always anyway), we take it for granted. Obviously there can't be much of interest inside one of those boxes. Or can there be?

I am sure there are many who may not appreciate the technology involved that it takes to dial a number and somehow, perhaps mysteriously, get another telephone to ring and have someone answer. Equally mysterious, perhaps, is the ability for two or more people to communicate with each other over great distances using either voice or digital data streams with unbelievable clarity and accuracy.

The modem public telephone system in this country is a highly complex network of wires, switches, control systems and interconnected computers that serve over 100 million telephones. Yet it is so easy to use that a child of four or five can make a call. Every day the phone system is expanding and becoming more complex. Still, it remains consumer-friendly.

History

By now everyone should have either heard or read about the Bell System divestiture and the resulting organizational structure in the telephony world that divestiture created. Competition spawned by the rapid growth of technology brought down the telecommunications giant, AT&T. We won't belabor the issues that have been discussed many times before except to point out changes in the telephone network structure. Under the stipulation of the Modification of Final Judgment, approved on Aug. 24, 1982, the United States was divided into 160 regions called local access and transport areas (LATAs) that were the operating regions for the seven newly created regional Bell operating companies (RBOCs). These companies, all independent of AT&T, are: Ameritech, Bell Atlantic, Bellsouth, Nynex, Southwestern Bell, US West and Pacific Telesis. In addition, the RBOCs have their own research and development laboratory called Bellcore, which they fund.

The divestiture also stipulated that each of the RBOCs were forbidden from providing inter-LATA service (between regions). That is, they could only provide intra-LATA service (within their assigned region). The divestiture created a host of new providers of long distance service.

AT&T's monopoly of telecommunications in the United States, officially came to an end on Jan. 1, 1984. Let's examine how the telephone system is structured today.

Subscriber loop

Figure 1 depicts an intra-LATA network where each subscriber is connected to a central office, sometimes referred to as an end office. Service is provided by the RBOCs — also known as the local exchange carriers (LECs).

In the past, as well as today, a telephone subscriber could obtain unlimited local service for a flat monthly fee. Long distance calls were billed according to distance and the length of time the connection was made. These were referred to as toll calls and the long distance network was called the toll network.

Prior to divestiture, the toll network was operated by the Long Lines Division of AT&T. Today, there are a number of long distance service providers making the toll network a conglomeration of independent telephone companies, which will be discussed later.

A subscriber may have more than one telephone. There may be fax machines, modems and answering machines. The telephone company refers to them as customer premises equipment (CPEs). A pair of wires from each of the CPEs is connected to a central point in the home or central office. These wires are called intrapremises wiring and are the sole responsibility of the user unless other arrangements with the telephone company have been made.

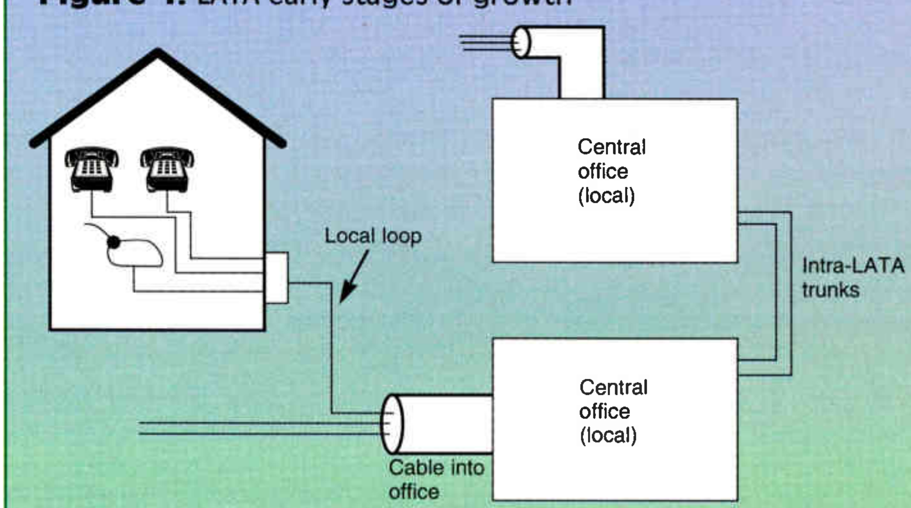
Switching

One could build a telephone network where a CPE is connected to every other CPE by a pair of wires. Obviously this would be impractical — too many wires. The practical solution would be to provide some form of centralized switching.

Figure 1 illustrates the basic concept. Each telephone, fax machine or answering machine is connected directly to a central office (or switch) where cross-connecting between the calling party and the called party occurs.

As long as the called party is in the same geographical area as the calling party, the same switch at the central office will connect them. If the called party is not

Figure 1: LATA early stages of growth



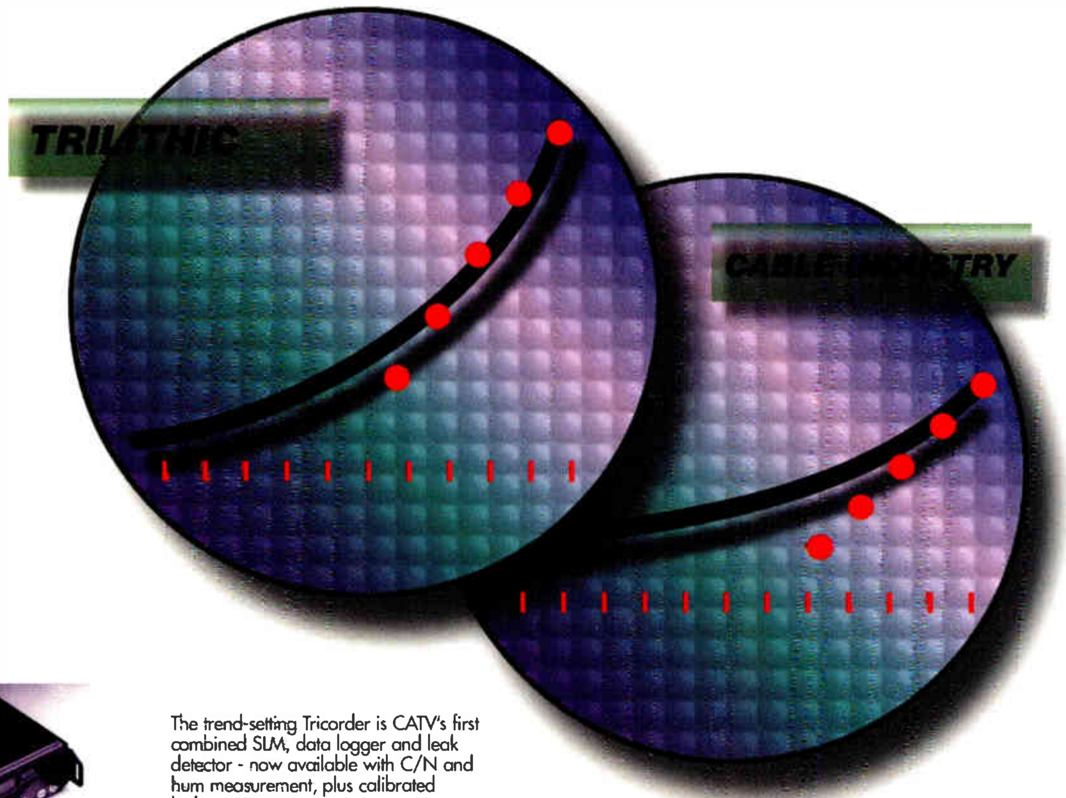


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Figure 2: How a tandum switch is used for intra-LATA calling

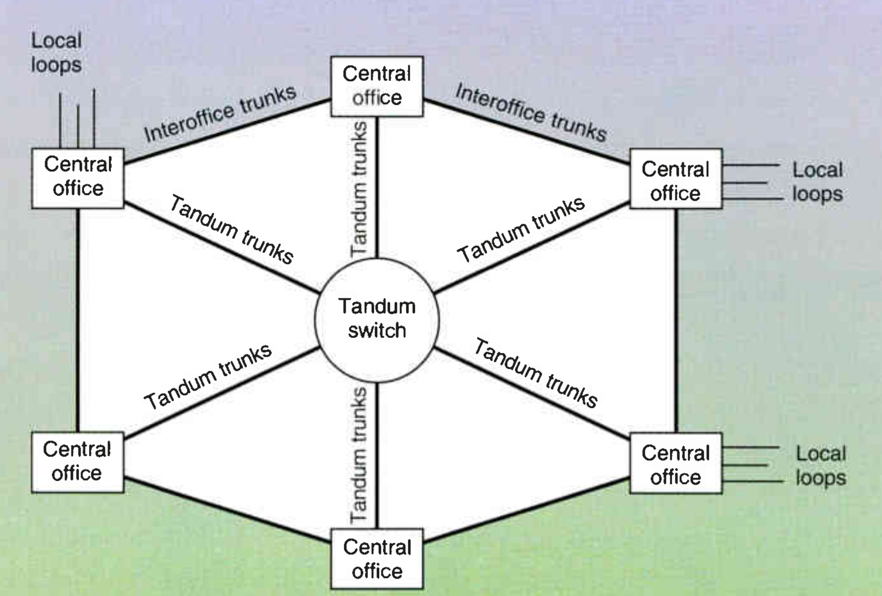
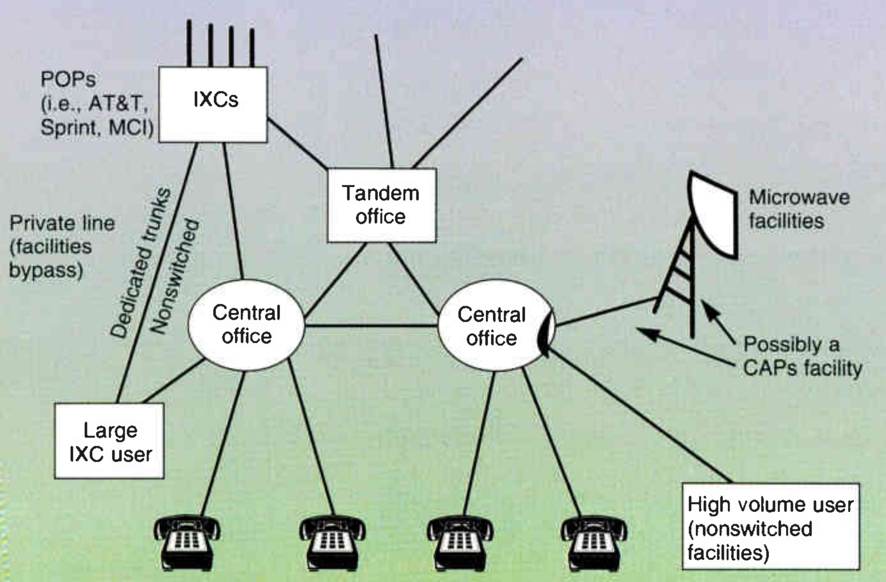


Figure 3: Overall telephone network showing interexchange carriers and CAPs



in the same geographical area but in the same LATA, the connection may be made through two or more central offices via dedicated interconnecting trunks. As long as there were only a few end offices to interconnect, trunking was fairly easy. But, as growth continued, central offices began to be overloaded with traffic passing through to other offices. Special switching offices called tandem offices were installed to handle the switching of traffic between each office as shown in Figure 2.

Divestiture resulted in the growth of such independent carriers as AT&T, MCI and Sprint. Included among the independents were much smaller carriers — competitive access providers (CAPs). CAPs lease lines and switching facilities from RBOCs or point of presence (POP) operators. A typical example of a CAP is the teleport, frequently used by corporations for handling data traffic via leased lines and satellite links.

Toll offices or interexchange carriers (IXCs) were installed to handle long distance toll traffic as illustrated in Figure 3. The interface between the LEC and the interexchange carrier is often referred to as the POP and are most often leased facilities from an LEC.

As demand for long distance telephone service grew, additional offices were installed to route traffic between geographically distant central offices. In the past, these offices were organized into a hierarchy of five classes; the central office, which is the lowest class where calls originate and terminate (Class 1); the central office, which is connected to a toll office (Class 2); the toll office, which is connected to a primary office (Class 3); the primary office, which is connected to a sectional center (Class 4); and the sectional center, which is connected to a regional center (Class 5). See Figure 4 on page 34.

A direct connection between the central offices is not always the best connection. During peak traffic periods, resulting in busy trunks, a connection may have to be made to the primary center near the calling party to a primary center or perhaps even a sectional center serving the called party. Sometimes many seconds would elapse with audible clicks before a call was completed. Today's long distance network is a nonhierachical system and all toll centers have equal ranking and handle calls according to switch capacity and connect parties much faster.

In the early days, the connection between parties was made by human operators at each of the offices. The earliest switch, designed to replace the human operator, was invented by Almond Strowger and is still used in many parts of the country today. The switch used electromagnets and electromagnetic relays. These switches had no intelligence whatsoever.

Later, crossbar switches were invented by L.M. Ericsson of Sweden. These too were electromechanical. However, the crossbar switch could handle multiple calls simultaneously while the Strowger switch could handle only one call at a time.

As technology evolved into miniaturization, Reed relays replaced the cumbersome Strowger and crossbar switches. Further evolution resulted in modern, state-of-the-art solid-state switches using sophisticated digital computer control systems. These switches will be discussed in later installments.

In general, a switch consist of three major components:

1) A periphery where all lines and trunks enter the building and terminate tone sources and recorded announcements by intercept operators.

2) The switching network consisting of relays, either mechanical or solid-state.

3) The controller, which today is a sophisticated highly reliable computer that

QAM for broadband networks: The right choice

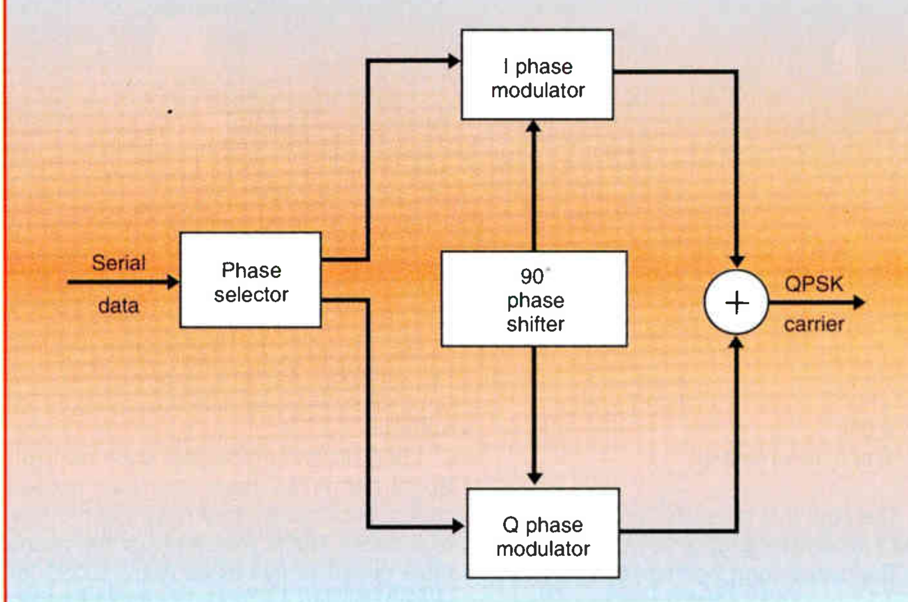
By Tony Filanowski
Applications Engineer, GI Communications Division
General Instrument Corp.

Sixty-four-QAM is the ideal data transmission format over cable because it provides high capacity, low cost and reliable performance. Since it requires low power, it blends well with the existing analog carriers. Tests show 64-QAM signals can provide near error-free operation in any CATV system that meets the minimum performance standards for analog transmission.

It also is important to note that 64-QAM can carry the entire capacity of a satellite transponder in a single 6 MHz channel slot. This is an important point because if a higher capacity modulation scheme is used, remultiplexing of the received satellite video is necessary to fill up the additional bandwidth. This is significant because remultiplexing of MPEG-2 encoded video is costly. Also, the higher signal-to-noise ratio required for a channel to achieve a specified level of performance for a higher order of modulation increases the complexity and cost of the system and its components.

QAM is the most common modulation format in use today in bandwidth-constrained channels because it achieves an excellent balance between complexity and efficiency. There are millions of QAM modems in use. QAM is used at the tens of kilobit data rates of voice-band frequencies to the hundreds of megabit data rates of high-capacity microwave transmission systems. Almost all telephony modem standards (e.g., V.32, V.33, V.34, V.36) use QAM technology. In contrast, VSB modulation, although used in a few applications in the early 1960s, has not had any significant impact on modem technology.

Figure 1: QPSK modulator



Digital communications basics and QAM

The basic concepts of digital communications include channel capacity, forward error correction (FEC), adaptive equalization and bit error rate. Because it is similar to a simpler modulation technique called quadrature phase shift keying (QPSK), QAM is introduced here via a discussion of QPSK.

In digital communications systems, the goal is to transmit information reliably at a desired rate. The ability of a channel to support a transmission rate such that reliable transmission can take place, is quantified in terms of channel capacity. This basic formula[1] is stated:

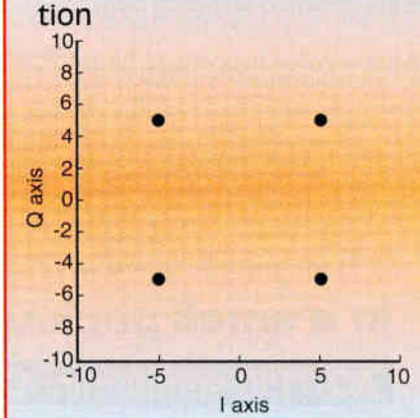
$$C = W\log_2(1 + S/N)\text{(bits per second)}$$

Where:
C is the channel capacity in bits per second,
W is the channel bandwidth in hertz,
S is the signal power at the receiver in watts, and
N is the noise power spectral density in watts per hertz.

As long as the rate of transmission is below C it is possible, in principal, to design an encoding/decoding procedure to recover the information at channel capacity rate reliably with an arbitrarily low probability of error.

FEC is used to reduce the probability of error by introducing redundancy at the transmitter. This redundancy, while reducing the probability of error, reduces the transmission rate. For this reason, FEC is added in a carefully controlled manner that is appropriate for the characteristics of the signal and the channel. Extremely sophisticated techniques for adding FEC have been developed. These techniques take *k* information bits and sequence them into an *n*-bit sequence called a code word. The amount of redundancy introduced this way can then be described as the

Figure 2: QPSK constellation



(Continued on page 82)

Setting the record straight: VSB vs. QAM

By Ron Lee
Manager, Electronic R&D
Zenith Electronics Corp.

There have been many misconceptions clouding the on-going debate whether cable, telephone and wireless operators should adopt VSB (vestigial sideband) or QAM (quadrature amplitude modulation) technology for digital modulation. Although QAM proponents continue to perpetuate this debate, VSB is the superior and preferred system when one considers the facts: VSB provides superior performance, faster time to market, lower cost and significant compatibility benefits.

To set the record straight, this discussion will present the most recent publicly available test results, including data from the only simultaneous third-party testing of VSB and QAM, explain the superior performance of VSB in real-world conditions based on recent field tests, address the claims and criticisms about VSB and compare complexity, integrated circuit availability and cost of the two systems.

VSB in the real-world

The most recent test of the VSB system, done by the Corporation for Public Broadcasting (PBS) and Cable Television Laboratories Inc. on behalf of the FCC's Advisory Committee on Advanced Television Service (ACATS), yielded more encouraging data to support VSB's overall robustness and preferred efficiency.

The primary testing ran from May 3 through June 10, 1994, and took place in the Charlotte, NC, area. The VSB system was tested for both cable and broadcast sites. The 8-VSB broadcast testing included 199 sites, with 128 locations on eight radials extending to about 55 miles, and 71 locations on two large grids and three small grids.

The 16-VSB system was severely stressed in these comprehensive tests, and yielded high marks. The 16-VSB system was tested at 51 receiver sites in eight cable systems, over long amplifier cascades, microwave and fiber links, and in four systems on channels beyond the cable system's designed bandwidth.

The 16-VSB system performed superbly at all 51 locations, even those falling below FCC minimums for NTSC signal-to-noise. The system also was satisfactory on all signals meeting FCC specifications when fed through a "house in a box," simulating worst-case home cabling, splitting and poorly terminated taps. In practically every case, VSB proved it can provide the performance it has promised.

Table 1: Summary of 16-VSB modem test results

Test	Test measurement
C/N threshold	28 dB
CTB threshold	43 dB
CSO threshold	35 dB
Phase noise threshold	-82 dBc @ 20 kHz
Impulse/burst noise threshold	47 µs
LO pull-in	±100 kHz

VSB and QAM testing

Out of 21 extensive tests of VSB technology by the Advanced Television Test Center (ATTC) and CableLabs, 16-VSB's performance was, in the vast majority of cases, superior to 256-QAM. These results are impressive not only because of the level of testing, but also because there is no publicly available test data on any 64-QAM or 256-QAM cable modem except for those taken on a 256-QAM modem by the ATTC and CableLabs for the FCC's ACATS and the Digital HDTV Grand Alliance (GA). The positive results of these tests were subsequently used to support ACATS' eventual endorsement of VSB technology for both cable and terrestrial digital transmission, even though several QAM proponents are in the GA.

Additionally, in view of its claims of preference, the lack of public QAM data is certainly curious when contrasted to the wealth of 16-VSB performance data taken by third parties such as CableLabs, Videotron and France Telecom. This VSB data has been publicly available for more than a year. Table 1 summarizes results reported in a 1993 CableLabs report on tests of a 16-VSB modem.

The only comparative testing of VSB vs. QAM has been conducted under the auspices of the ACATS and the GA; these results are available as part of the ACATS public record. In these tests, side-by-side comparisons of both broadcast and cable modems were conducted by the ATTC and CableLabs. For broadcast applications, an 8-VSB modem and a 32-QAM modem both employing trellis coded modulation (TCM) were tested. For cable applications, a 16-VSB modem provided by Zenith and a military-grade 256-QAM modem provided by Applied Signal Technology for General Instrument were tested. CableLabs also has separately published its test results as part of the *NCTA 1994 Technical Papers.*[1]

The outcome of these tests is quite revealing. Theoretically, 16-VSB and 256-QAM should be comparable in a bit-rate payload, providing a raw 43 megabits per second in a 6 MHz cable channel for an effective bit rate of 38.6 Mbps. However, the test data clearly show the VSB system design is equipped for far more robustness, allowing for a more reliable signal delivery.

The 16-VSB system also provides one-third more data at a lower cost than 64-QAM. The effective bit rate for the most widely discussed 64-QAM approach is only 27 Mbps. (At least one 256-QAM approach being proposed by a cable equipment supplier provides an effective bit rate of only 36 Mbps — insufficient for transmitting two HDTV programs in one channel.)

Despite the availability of this verifiable data and the indisputable superiority of VSB, QAM advocates ignore these tests and claim superiority by selectively citing three of the 21 tests conducted by the ACATS where 256-QAM performed somewhat better than 16-VSB and conveniently ignore the other 18 tests in which 16-VSB outperformed 256-QAM in 14 tests and tied in four. Careful examination of the ACATS test

Table 2: ACATS single impairment tests

Test	16-VSB	256-QAM	Difference
C/N threshold @ 3 x 10^{-6} BER in 6 MHz	27.6 dB*	29.3 dB	1.7 dB
C/I composite triple beat (CTB)	44.0 dB*	46.5 dB	2.5 dB
C/I composite second order (CSO)	33.4 dB*	37.0 dB	3.6 dB
Phase noise threshold @ 20 kHz in 1 Hz BW	-83.0 dBc*	-84.2 dBc	1.2 dB
Residual FM	4.7 kHz	70 kHz*	65.3 kHz
Pull-in range	>±100 kHz	>±100 kHz	None
Hum modulation	7.6%*	5.7%	1.9%
Summation sweep — Wavetek (Errors above visible threshold — yes/no)	No*	Yes	
Summation sweep — CaLan	Zero errors	Zero errors	None
Minimum isolation required	30.0 dB	24.0 dB*	6 dB
Data loss during change	2.9 ms*	40.9 ms	38 ms
Avg. channel change time with impairments	0.54 sec	0.55 sec	0.01 sec
Peak-to-average power ratio for 99.9% of time	6.5 dB	6.4 dB	0.1 dB
Width of burst error @ repetition of 10 Hz	150 μs*	27 μs	123 μs
Repetition of burst error w/20 μs bursts	2.4 kHz*	0.03 kHz	80:1
Fiber-optic (threshold of errors)			
Depth of modulation	4.7%*	3.8%	0.9%
Carrier to total distortion	38.9 dB	48.6 dB	
CSO	57.2 dB	79.5 dB	
CTB	53.8 dB	60.2 dB	
Data rate	37.5 Mbps	38.2 Mbps*	0.7 Mbps

*Best performance

data reveals areas where both 16-VSB and 256-QAM are comparable but it also reveals some very significant disadvantages of 256-QAM.

The difference between 16-VSB and 256-QAM is even more pronounced when considering multiple impairments. Multiple impairment tests provide insight into how a system handles simultaneous impairments as would be expected to occur in the real world. The results of the four multiple impairment tests conducted on the 16-VSB and 256-QAM modems are shown in Figures 1 through 4.

The multiple impairment tests were CTB vs. Gaussian noise, CSO vs. Gaussian noise, phase noise vs. Gaussian noise, and residual FM vs. Gaussian noise. Table 2 shows the single impairment tests conducted by ACATS and the results measured on the 16-VSB and 256-QAM modems. The ACATS test results show significant advantages of 16-VSB over 256-QAM in the major performance categories of C/N, CTB, CSO and phase noise, while 256-QAM performed better in residual FM. These impairments are important because their presence in a cable system consumes operating margin required for all digital systems. For instance, since 16-VSB tolerates 1.7 dB more white noise, for the same operating margin 16-VSB can be transmitted 1.7 dB lower in power.

IC availability and cost

One concern surrounding VSB and QAM modems is the availability of production demodulator ICs. The 16-VSB technology, proven in public tests and demonstrations since early 1993, has been and continues to be on schedule for fourth-quarter 1994 chip availability. QAM availability on the other hand, has been delayed several times; it is now trailing VSB.

VSB implementation is substantially less complex and represents the lowest-cost solution for high data rate digital transmission over cable TV and telecommunications systems. QAM proponents have recently announced a prototype chip-set of a 256-QAM demodulator consisting of three large digital ICs not including the analog demodulator, de-interleaver or forward error correction (FEC). These ICs will purportedly be integrated into one IC sometime in 1995. With the need to add FEC, the integrated QAM receiver will be available later than VSB, and will cost at least one-third more than a VSB receiver.

Complexity comparison

Because cost is related to complexity, comparing relative complexities of 256-QAM and 16-VSB receivers will demonstrate the VSB design superiority and cost-efficiency.

• *Tuner.* The dominate characteristic of a tuner is its phase-noise contribution. Based on ACATS test results, tighter phase noise specs are required for 256-QAM than for 16-VSB. ACATS multiple impairment testing also showed

Figure 1: CTB and white noise threshold

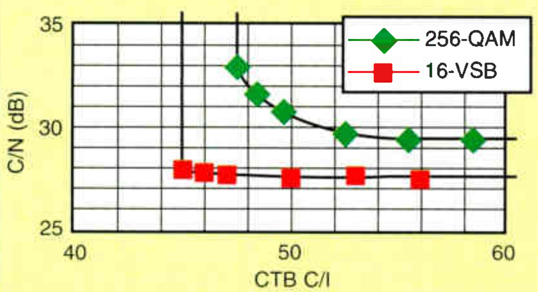


Figure 2: CSO and white noise threshold

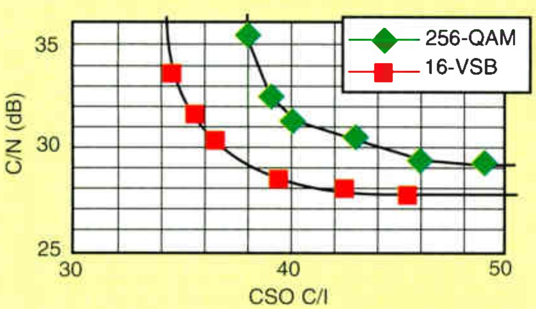


Figure 3: Phase noise and white noise threshold

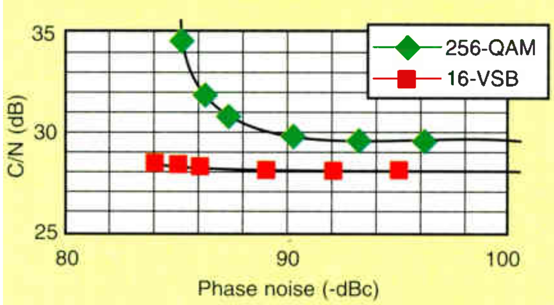
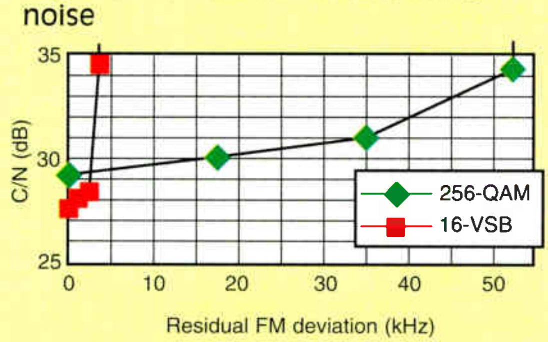


Figure 4: Residual FM and white noise



that 256-QAM loses considerable C/N performance in the presence of phase noise. The superior 16-VSB performance is due to phase tracking by both the pilot PLL and a unique phase-tracking loop used in the 16-VSB receiver.

• *Adaptive equalizer.* The 16-VSB modem uses a symbol-spaced equalizer running at 10.7 MHz. All VSB testing has been conducted exclusively with symbol-spaced equalization. In contrast to this, all reported QAM test results are exclusively for systems using fractionally spaced equalizers running at 10-20 MHz or faster. Despite this fact, QAM advocates consistently compare the symbol-spaced VSB equalizer with a symbol-spaced QAM equalizer, which they preach but do not use in practice due to the performance loss.

Another difference between the VSB and QAM adaptive equalizer is in the algorithm hardware. The VSB system adapts on a low-speed training sequence, thus only requiring one low-speed multiplier for calculations and thereby only raising the complexity slightly over the complexity of the 63-tap real programmable filter. Proposed QAM systems use blind equalization, which if designed to adapt each coefficient every sample time, requires as much algorithm hardware as needed in the programmable filter. Between the programmable filter and algorithm hardware, the net difference in equalizer complexity between the symbol-spaced VSB and fractionally spaced QAM equalizer can be as high as 8-to-1.

• *De-interleaving.* Interleaving data at the transmitter and de-interleaving at the receiver is required to protect against burst noise. Table 1 on page 37 shows that the impulse noise performance of the 16-VSB system is 47 μs for bursts repeating at 10 Hz, impulse noise performance for other VSB modes such as 8-, 4- and 2-VSB are progressively better. The major cost and complexity associated with de-interleaving is the memory block required to temporarily hold data being de-interleaved. The 16-VSB system uses a

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convolutional de-interleaving to minimize memory requirements. One 256-QAM proponent uses a 180 x 180 byte block de-interleaver, which requires 32.4 bytes (259.2 kbits) of memory or 12 times that used by the 16-VSB system.

• *Forward error correction.* FEC is employed to protect data from light errors that might occur. The 16-VSB system uses a Reed-Solomon (R-S) T = 10 code on each 188 byte MPEG-2 transport packet. Protecting individual MPEG-2 transport packets optimizes the FEC such that an unrecoverable error only affects one and only one packet, thereby limiting errors to one packet and one service. Trellis decoders are much more complex than R-S ones. One QAM proponent using only R-S coding is using 180 byte blocks, which does not match the MPEG-2 transport packet size and will suffer greater packet loss since one unrecoverable error will probably destroy two MPEG-2 transport packets.

Countering the criticism

Rather than solely basing comparisons of VSB and QAM on performance and cost, it also is imperative to respond to the unfounded criticisms QAM advocates have chosen to attach to 16-VSB for system choices.

• *Signal acquisition and lock pilot.* The VSB system sends a small pilot carrier to aid the receiver's carrier acquisition. QAM advocates claim the pilot power is wasteful. The 16-VSB pilot only raises the overall power by less than 0.3 dB and contributes to both hardware simplicity and improved performance. In fact, with the pilot, 16-VSB has tested to have virtually theoretical C/N performance. The implementation loss (actual vs. theoretical performance) experienced by QAM modems without a pilot far exceeds 0.3 dB, therefore making the pilot power a better choice.

• *Segment sync and frame sync.* The 16-VSB system sends segment syncs and frame syncs to aid the receiver's symbol clock recovery and adaptive equalization. QAM advocates point to the transmission of these signals as being "inefficient." These signals are part of the overall acquisition strategy developed for 16-VSB and, like the pilot, contribute to achieving theoretical performance.

In addition to aiding performance, the combination of pilot, segment sync and frame sync provide a valuable feature not found in QAM systems. Since 16-VSB acquisition relies on these very robust signals and not on data recovery, 16-VSB acquisition is achievable to 0 dB C/N. This means that even under very adverse conditions, the 16-VSB receiver can lock and provide valuable diagnostic information about the channel conditions. This is useful for pinpointing system faults. The robust 16-VSB acquisition also results in faster recovery of momentary disturbances that knock a QAM receiver totally out of lock.

• *All QAM systems are not compatible.* Because of the highly publicized VSB vs. QAM discussions, many tend to lump all QAM modems into one large compatible category. This incorrect perception also must be clarified. In reality, there are at least six companies offering different QAM systems that are not likely to be compatible. These companies have each worked independently to design QAM systems with symbol rates, FEC, interleaving and synchronization signals that are unlikely to be the same. Compatibility among different QAM systems is a myth and one vendor's QAM system is unlikely to work with another's.

Conclusion

The 16-VSB has proven its superior performance over 256-QAM in direct comparative testing and has been successfully field tested for robustness and effectiveness in actual cable systems. And even as more QAM advocates begin to shift to 64-QAM because 256-QAM data just doesn't stand up, it must be noted that 8-VSB is comparable to 64-QAM — and 2-, 4-, 8- and 16-VSB all offer the advantages associated with VSB over QAM. It also will be available earlier than 64-QAM.

QAM receivers, significantly more complicated than VSB receivers, especially in the area of adaptive equalization, fail to support this complexity with performance advantages. Therefore, a 16-VSB solution will be available with lower cost, higher performance and more rapid development than 256-QAM. Additionally, VSB compatibility with HDTV assures consumer compatibility as required by the FCC. **CT**

Reference

[1] "High Definition Television — Defining the Standard," Brian James, National Cable Television Association, *1994 Technical Papers,* page 375.

Digital modulation on coaxial/fiber hybrid systems

QAM and VSB performance comparison

Measurement	8-VSB	32-QAM	64-QAM	16-VSB	256-QAM
Signal-to-noise	14.8 dB	14.8 dB	22 dB	27.6 dB	29.3 dB
Composite triple beat	-12.6 dB	-32 dB		-44 dB	-46.5 dB
Phase noise	-77.1 dB	-81.3 dB		-83 dB	-84.2 dB
Data rate @ 6 MHz bandwidth	18.8 Mb/s	19.1 Mb/s	26.9 Mb/s	37.5 Mb/s	38.2 Mb/s

By Donald T. Gall
Senior Project Engineer, Time Warner Cable

If you haven't noticed already, the computer and telephone industries are in love with acronyms. It's true that every discipline has a unique language, cable included, but you need a code book to delve into the digital world. In this article, I will use English, at least the first time that I use an acronym.

The concept of the information superhighway (ISH — just kidding) has been around for many years. Ideas like video-on-demand (VOD), home shopping, etc., were being talked about in the early 1970s. Many attempts to implement one or more of these businesses were conducted over the years with varying levels of success. The main stumbling blocks were with the reliability of the large tree-and-branch networks, integrated high-speed digital chip sets and related consumer electronics, and the social acceptance of these services by the public. Several companies built radio frequency modems and wide area network (WAN) electronics, but subsequently discontinued them when the market did not materialize.

The missing pieces have fallen into place. Hybrid coaxial/fiber cable systems have reliability numbers very close to the telephony standard of 53 minutes average downtime per subscriber per year. Integrated circuits are increasing in speed at a logarithmic rate, and the advent of in-home computers, VCRs and Internet services have paved the way for social acceptance of the superhighway.

What that means for many of us in the cable industry is a crash course in assimilating the technology and language of digital transport into our everyday existence. Since we are dealing with the digital world incorporated into an RF environment, many of the terms used to describe distortions, etc., will be similar but may need to be treated differently. Many digital modulation schemes such as quadrature amplitude modulation (QAM) look and act like white noise on a spectrum analyzer. To measure level, you have to add a correction factor to compensate for the difference in resolution bandwidth relative to 1 Hz. I will outline the various modulation techniques that are being used and compare their strengths and weaknesses.

FSK, BPSK

Frequency shift keying (FSK) and binary phase shift keying (BPSK) are robust modulation techniques that have been utilized in the cable industry for many years. This simple technique assigns a value of 1 to a single frequency or phase and 0 to a second. Bandwidth efficiency can approach 1 bit per hertz. Even at its best, neither type of modulation would be practical for the high data rates needed in digital video. Both modulation schemes will continue to be utilized in the traditional addressable converter return and other low data rate polled systems where their immunity to noise outweighs the spectral inefficiency.

QPSK

Quadrature phase shift keying (QPSK) may be thought of as two BPSK systems in parallel and their carriers are in-phase quadrature. Although this modulation technique is less robust

Thanks To Sharon Roberts, The Chair Orders Kept Stacking Up.

American Cablevision had a seating problem. They had to make an emergency replacement of their data lines to a national stacking chair manufacturer. But it was Saturday – and with business booming, computer downtime was out of the question. So Sharon Roberts, senior inside sales rep at Sprint/North Supply, sat down and worked out a solution.

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With the new data lines in place, the chair orders kept on coming – thanks to Sharon's stand-up performance. It's typical of the can-do approach that's an everyday thing for us. So when you need broadband product, call Sprint/North Supply, your full-line national distributor – we never sit down till the job's done right.

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"With the proper engineering practices, digitally modulated carriers can be easily incorporated into the signal carriage formats of modern cable systems, at least from the headend to the tap."

than FSK or BPSK, it still has the noise immunity of frequency modulated methods and has a theoretical 2 bits per hertz efficiency. This format will probably be the best choice for the majority of the usable bandwidth in the return band.

QAM

Double sideband QAM uses two separate signals that modulate the carrier each being shifted in phase from each other by 90°. This allows each phase to be isolated and able to carry its own signal. QAM splits the original data bit stream in half with each half of the bitstream amplitude modulating its respective signal by discrete levels during each symbol time. For example, 64-QAM contains two, eight-level AM signals. Each level represents a sequence of 3 bits of which there are eight possible combinations. Since there are two signals, each symbol time represents 6 bits. The total bandwidth required for a QAM signal is a minimum of 120% of the symbol rate. This yields a bandwidth efficiency of approximately 5 bits per hertz.

VSB

Suppressed carrier vestigial sideband (VSB) amplitude modulation is a type of digital modulation that uses one bit stream to modulate the carrier with discrete levels, but removes most of one sideband as in an NTSC analog video channel. To recover the sideband and help with signal acquisition, a pilot carrier is included at the location of the suppressed carrier. Using 8-VSB, for example, each level represents a sequence of 3 bits. For any given symbol rate, only half the bandwidth is required, which is equivalent to the delivery of two times the symbols in the same bandwidth. Also using the same 120% bandwidth factor as in QAM, the bandwidth efficiency also is approximately 5 bits per hertz. As an example: (2 symbols x 3 bits)/1.2.

Direct sequence spread spectrum

Direct sequence (DS) spread spectrum (SS) is a frequency-hopping modulation that has been used in the United States for defense communications as early as the 1940s. The direct sequence format used today was first developed the 1950s. It was built to survive high interference levels and give a superior immunity from jamming and eavesdropping. In DSSS the digital bit stream is added to a pseudo-noise (PN) code generator and modulated by an RF carrier. This spreads the energy of resultant RF carriers across a predetermined bandwidth in a seemingly random manner. The receiver then reconstitutes the signal with an identical code generator. This method can be by far the most robust modulation method available and may have several applications in the potentially unusable portions of the return band. A projected efficiency by one company was approximately 1 bit for every 3 Hz.

Performance of digital RF is obviously not only based on spectrum efficiency. In the return band below 12 MHz a legitimate trade-off may be made in favor of a more robust modulations such as FSK or SS. Between 12 MHz and 42 MHz, QPSK may very well be the best answer. In the forward signal direction the deciding factor between QAM and VSB may be the cost of manufacturing the transmitting and receiving equipment. The accompanying table on page 42 is a comparison of test data, submitted by CableLabs[1] at a recent conference, comparing several minimum performance characteristics between different levels of both modulation formats. All the tested data modulation formats used at minimum one of the Reed-Solomon error correcting codes and the 8-VSB data stream is actually a 4-VSB data rate, Trellis coded to eight levels and the overhead used for error correction. The threshold error rate used for the test was 3×10^{-6}, which corresponds to the point where artifacts become objectionable to an average viewer.

Both the QAM and VSB modulated signals resemble white noise and the true level is lower than the apparent level when displayed on a spectrum analyzer. The pilot in VSB is a discrete carrier and can be measured as such. To calculate the correction factor for the resolution bandwidth being used, the following formulas[2] are used:

$Power^{digital} = (Power^{analog\ video} - 48.75 - \text{level offset}^{digital})$
$Power^{mw} = 10^{(power\ digital/10)}$
$Power^{total} = (Power^{mw} * \text{number of digital carriers})$
$Power^{mw/Hz} = (Power^{total}/\text{digital bandwidth in hertz})$
$Power^{dBm/Hz} = (10\log power^{mw/Hz} + 48.75)$
$Level^{digital} = (Power^{dBm/Hz} + \text{resolution bandwidth level for 1 Hz})$

Correction factors such as conversion from 50 to 75 ohms, or analyzer errors should be added to the measurement. The digital signal also should be measured using video averaging on your analyzer.

Currently most of the forward plant testing of our new fiber/coaxial architectures is being done with the digital carriers simulated by a white noise source, filtered to between 550 MHz and 750 MHz. Our digital carriers will be operated at 8 dB below the video carrier level. At these levels the distortion impact to the analog video channels is less than 0.5 dB, in many cases below the test equipment's accuracy margin. In the return direction, I have observed 1.5 Mb/s using QPSK modulation yielding better than 10^{-10} bit error rate in a fairly hostile environment.

As for 64-QAM, one manufacturer is claiming a 10^{-8} bit error rate, before error correction, using a 45 Mb/s data rate. With error correction, this same system tolerated a high level sweep for three days, before it was discovered.

With the proper engineering practices, digitally modulated carriers can be easily incorporated into the signal carriage formats of modern cable systems, at least from the headend to the tap. One of the challenges we still have ahead of us is the clean up of the house drop environment. Poorly made connectors and cheap splitters could degrade digital signals below acceptable levels. Error correction and adaptive equalizers will help compensate, but not cure, these problems. It's just one more piece in the information superhighway puzzle. **CT**

References

[1] "Digital Modulation Update," Brian James, director, advanced TV testing at CableLabs, CableLabs Conference, Keystone, CO, Aug. 2-4, 1994.
[2] "White noise simulation of digital carriers," Gregg Velatini, Scientific-Atlanta, June 30, 1993.

Remote fiber test systems in CATV environments

By Daniele Knapp
Product Marketing Manager

Darryl Rakestraw
Product Marketing Manager
Photon Kinetics

Since being introduced nearly five years ago, remote fiber test systems (RFTSs) have evolved to meet the needs of a variety of telecommunications providers. While much of the direction for the development of RFTSs has come from telephone companies and their associated standards groups, these systems are poised to offer excellent value to CATV providers. In addition to the basic fault locating and network testing features offered by RFTSs, several enhancements have been developed to answer challenges presented by the expanding CATV fiber networks and the increasingly competitive telecommunications environment. RFTSs enable CATV providers to achieve their goals of efficient field test equipment deployment, centralized and accurate network documentation, and competitive service guarantees. Many companies have taken advantage of the enhanced service assurance provided by RFTSs to gain new customers and service contracts.

In general terms, RFTSs provide centralized control of fiber-optic testing resources. A typical RFTS consists of three primary components: the test system controller (TSC), multiple remote test units (RTUs) and optical test access units (OTAUs). (See Figure 1.) The TSC is installed in the network operations center or alarm center. It is the heart of the RFTS and contains the cable route data base and provides centralized control of the RTUs, which are installed throughout the network. Most TSCs employ simplified menus and test reports to accommodate the requirements of a wide variety of users, including non-OTDR (optical time domain reflectometer) users and OTDR experts alike. The TSC enables users to perform fast accurate fiber fault location tests, detailed OTDR signature analysis and cable route updates on any fiber in the network without going into the field. RFTSs can perform tests on-demand or autonomously to meet service providers goals for fast restoration, efficient preventive maintenance and accurate network documentation.

Figure 1: Typical RFTS system

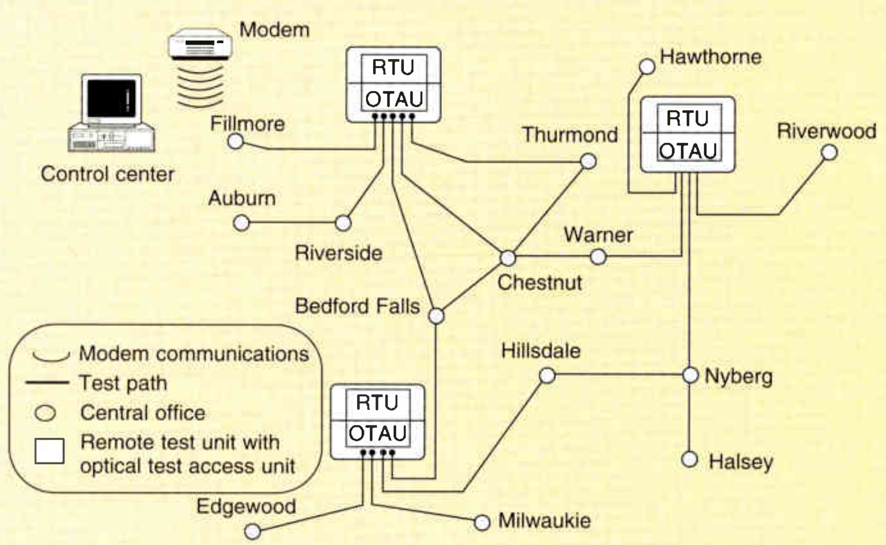
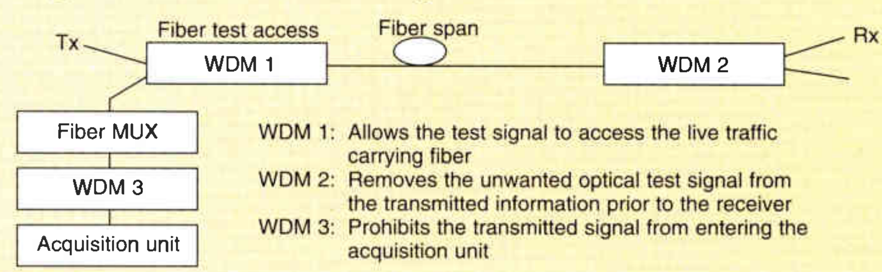


Figure 2: Active fiber testing



RTUs can be strategically deployed in various headends to provide optimum network testing coverage. RTUs are rack-mounted and typically communicate with the TSC via modem. RTUs are similar to OTDRs and feature additional automatic testing capabilities that require no operator interpretation. Each RTU commands one or more OTAUs, which are multiport switches. The OTAU enables a single RTU to access many fibers for testing. These RTU/OTAU pairs perform a variety of functions, including on-demand fault location tests and OTDR signature acquisitions, routine testing and automatic fault notification. Most RTUs respond to test requests from the centralized TSC and from local controllers via dial-up modem, the overhead bit stream or direct front panel connection. RFTSs excel at managing various functions related to maintaining the health of the fiber plant.

Proactive maintenance

An RFTS can operate either in on-demand or automatic mode. By testing the optical network periodically, telecommunication providers can monitor network integrity proactively to obtain better situational awareness and alleviate problems prior to service loss. This is especially true if a test wavelength of 1,550 nm is chosen. At this wavelength, fiber disturbances (i.e., microbending) can be detected before service is affected. A Bellcore study on causes of fiber failures indicates a high percentage of breaks affect the entire cable. Therefore, RFTSs usually are deployed on one dark (no transmission) fiber per cable, providing a more economical solution. →

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However, today, due to increasing transmission capacity, some of these same cables either do not have any dark fibers available for testing or will not have any dark fibers available in the future. Therefore, RFTSs may have to be deployed on fibers with live traffic, often referred to as active fibers. Active fiber testing requires added components to the standard RFTS configuration. These components must be determined jointly by the RFTS manufacturer and telecommunications company to prevent degradation to the existing communication signal.

"While much of the direction for the development of RFTSs has come from telephone companies and their associated standards groups, these systems are poised to offer excellent value to CATV providers."

Design issues

Additional components needed for active fiber testing allow multiplexing of both wavelengths on the fiber while providing required isolation for the system receiver and RFTS. Typically, these components are wavelength division multiplexers (WDMs) and/or filters.

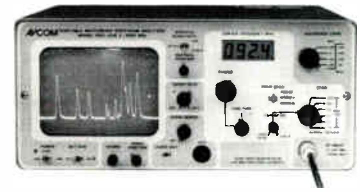
First the test wavelength must be determined — preferably one that is not close to the communication wavelength in the optical spectrum. Most network receivers are optimized for the transmitted wavelength, but usually can detect signals across the band of 1,200 nm to 1,600 nm. Early fiber networks usually were designed to carry information at 1,310 nm, which leaves 1,550 nm as the test wavelength — a valid choice since laser sources are readily available and longer cable sections may be tested by a single RFTS. If transmission takes place in the 1,550 nm window, an alternate wavelength must be used for testing. The test wavelength still should use fiber's low-loss properties, so an out-of-band wavelength can be used (i.e., 1,600 nm+). However, irregular lasers and special in-line components typically will increase RFTS cost.

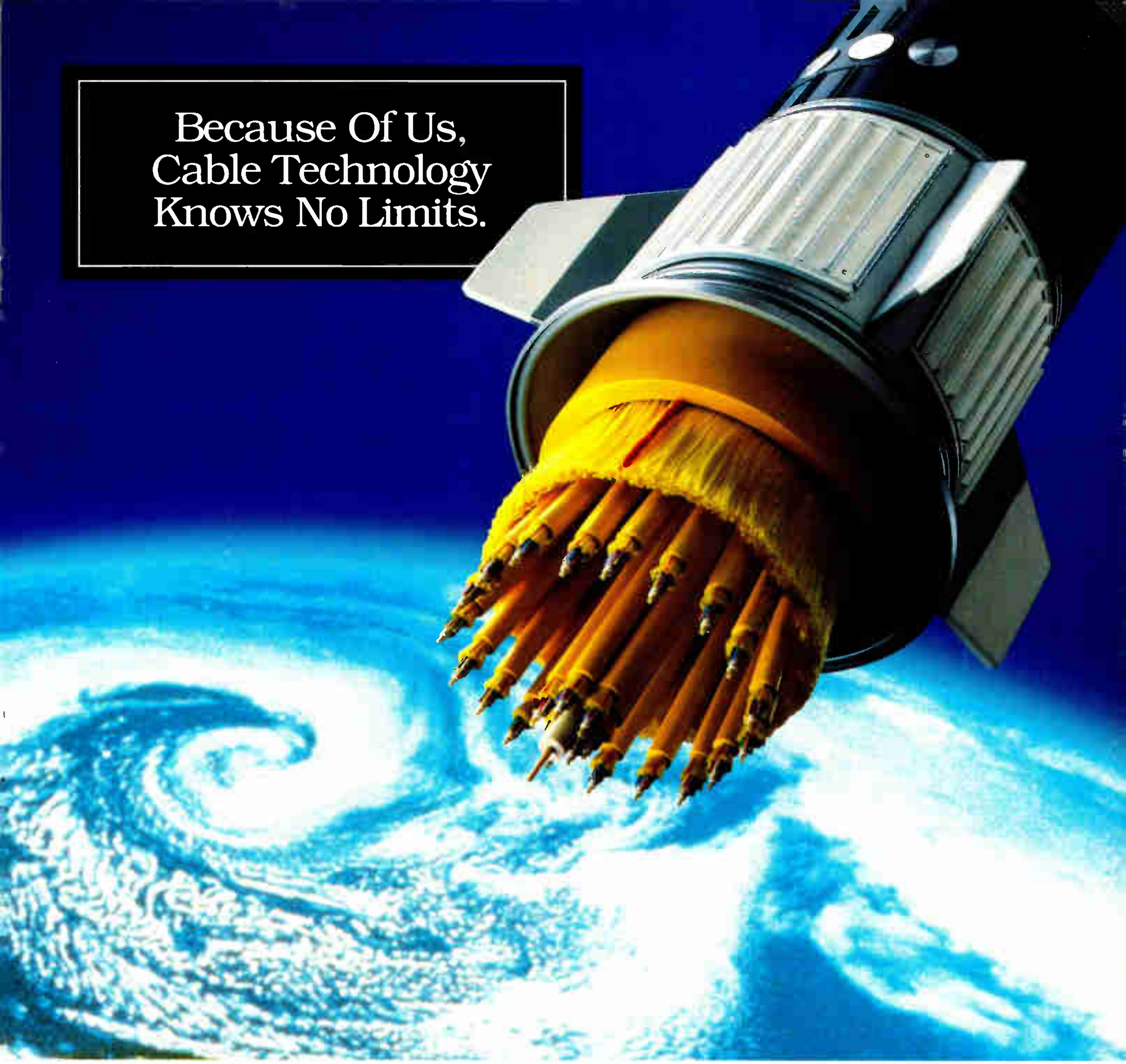
Active test components must be optimized for insertion loss, while providing necessary isolation. These are opposing performance requirements and usually require design modifications for different networks deploying active fiber testing.

Test signal strength and total route dictate required isolation for the network receiver. High isolation WDMs or filters are ideal choices because of their low insertion loss (<2 dB) and good isolation (>45 dB). Therefore, these devices should not contribute any bit errors. A WDM at the transmission point lets the transmission and test signals merge onto the fiber network without noticeable insertion loss increase to either source. Finally, another high isolation WDM is placed in series with the first WDM test leg to isolate the RFTS properly from the transmission source. (See Figure 2 on page 46.)

Conclusion

In today's competitive environment the need for telecommunication providers to guarantee service restoration and service quality is driving the use of integrated RFTSs. As the integration requirements of these systems increase it is necessary for telecommunication providers to work closely with RFTS suppliers to ensure network compatibility and that the quality of the signal to the customer is not adversely affected. **CT**





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Reader Service Number 39

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Winning the fiber race with an all-in-one OTDR

By Tim Williams
Product Marketing Engineer
Telecommunications Techniques Corp.

All-in-one OTDR vs. current instruments

Test performed	Current instruments	All-in-one OTDR	Time saved
Set up instruments	2 minutes, 40 seconds	1 minute	63%
Insertion loss	5 minutes, 38 seconds	15 seconds	96%
Return loss	1 minute, 16 seconds	10 seconds	87%
OTDR trace	3 minutes, 44 seconds	45 seconds	80%
Totals	*13 minutes, 18 seconds*	*2 minutes, 10 seconds*	*84%*

The competitive race to install and maintain today's fiber-optic network is won or lost on signal quality and the speed of technical response. Completely testing the entire network is the best way to ensure signal quality. Faster technical response comes from the right tools and an improvement in the way fiber is tested.

Today's high-speed networks require fiber performance that a customer can take for granted. Synchronous optical network (SONET) systems, along with analog video transmission, are creating the need for more than the traditional insertion loss and optical time domain reflectometer (OTDR) trace testing. Guaranteeing the performance of your fiber network now requires return loss testing as well. Insertion loss, OTDR trace testing and return loss will analyze the quality of your fiber and the splices in it. But these tests also can cost you too much and take too long to complete – unless you have a plan for testing efficiently. For Phil Jenkins, this comes down to a simple math equation: "Why spend five times more money to run the same three tests?"

Jenkins is the director of network engineering for Time Warner Communications in Memphis, TN. During recent field trials in Memphis, Jenkins managed a team that performed insertion loss, return loss and OTDR testing to verify the efficiency of using an all-in-one OTDR. The test results (shown in the accompanying table above) also suggested ways to control the costs of technical support as more cable technicians install and maintain fiber.

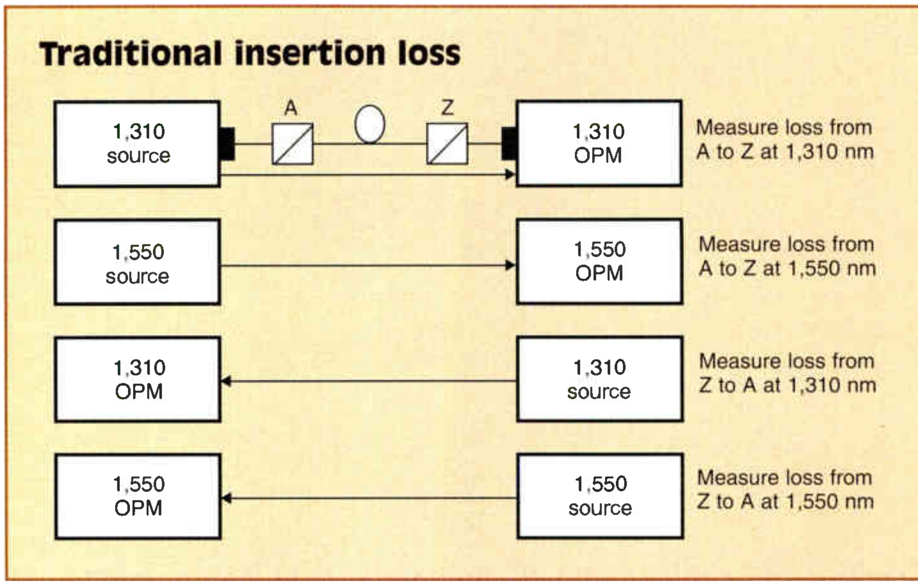
Testing loss

Any fiber-optic installation complies to performance criteria based on a design loss budget. This budget establishes maximum acceptable levels for lost light during transmission. Each type of loss reflects the characteristics of the transmission equipment, the length of the fiber and the number of splices. Based on the loss budget, the expected level of light must be high enough to satisfy the minimum sensitivity of the receiver. To verify compliance to the loss budget, insertion loss testing puts a technician on both sides of the fiber and compares the signal that is transmitted to the one received.

A complete insertion loss test will be done at both 1,310 and 1,550 nm in both directions (See the accompanying figure on the facing page.) The loss found in each direction is then averaged. The results are two numbers: the average loss at 1,310 nm and the average loss at 1,550 nm. Using multiple hand-held test sets in the Time Warner Memphis trial, insertion loss testing took over five and a half minutes to set up and complete. In contrast, the all-in-one OTDR completed insertion loss testing in less than 15 seconds, including the setup and averaging.

This time savings is a result of the

"Why spend five times more money to run the same three tests?"



testing process and the design of the instruments themselves. In the hand-held test, the sets had to be referenced at some point before the test. Then the source was connected at one end with a power meter at the other and measurements were made at both wavelengths. These numbers had to be recorded by hand. Then the connections were switched with the power meter and source at opposite sides of the fiber span. After the measurements were completed, they were averaged by hand. With an automated test, the fiber was simply connected to an OTDR at each end and the instrument took the measurement and calculated the averages.

OTDR trace

The OTDR trace provides a graphical representation of the distance from the access point to the end of the span. It also can be used to locate splice loss and connector loss and reflections that are not within specifications. This test averages about four minutes for a single fiber. But a single fiber is rarely tested in isolation, as Jenkins noted.

"If our technicians were to complete acceptance testing and documentation of 144 fibers, for example, these four minutes would total over seven hours of testing. That's why we measure a technician's efficiency in minutes and seconds."

Fortunately, improvements in OTDR technology, such as automatic parameter selection (e.g., pulse width and number of averages) and increased processing speed, have led to faster data acquisition. In the field trials, OTDR trace testing took almost four minutes using a mini-OTDR, and 45 seconds using the all-in-one mini OTDR. This 80% time savings cuts the seven-hour acceptance testing job to approximately 75 minutes.

Return loss testing

The telecommunications industry has established thresholds for cable, splice and connector loss. Too much loss on the signal will result in not enough light getting to the receiver for proper transmission. But if the reflectances in a fiber are too great, the transmission equipment can malfunction or the receiver can receive erroneous data. The higher the data rate, the more imperative it becomes to test reflectance.

Many current OTDRs provide a calculated return loss measurement. Unfortunately, this calculation is only an estimate. Wherever the OTDR receiver is saturated by the amount of the light pulse, a "dead zone" is created and proper calculation cannot be performed. The OTDR's receiver saturates at high reflectances, namely at connectors near the beginning of the fiber and often the end. Since most reflective problems occur at either end of the fiber – where connectors are used – they can be difficult to detect.

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tometer (OCWR) avoids this possibility of saturation. An OCWR is a continuous source that doesn't use pulses, so it can't become saturated. With an OCWR, the return loss measurement matches the return loss of the transmission equipment. When OCWR capability is part of an OTDR, a technician can measure and document return loss as a simple part of routine testing. Using a separate instrument to test return loss took over a minute in the Memphis trials. Using an all-in-one instrument, the same test took 10 seconds.

Future fiber testing — now

The future of fiber can be summarized in one word — fast. Faster data rates, faster installation and faster maintenance. Faster data rates will require more tests. To improve the speed of installation and maintenance, service providers have to measure efficiency against increasingly higher standards.

"At Time Warner," Jenkins notes, "we're looking at the cost of test setup, documentation and training on the equipment. It's all part of the mix. We've found that all-in-one test equipment helps us manage the network that much more efficiently."

Increasing amounts of fiber are being installed throughout the world. This is raising the demand for efficiency in testing and maintenance procedures. The all-in-one concept for OTDRs provides cost and ease-of-use benefits. More features using one laser saves initial instrument cost. Faster testing saves a technician time and this lowers the cost of technical support. Most importantly, the quality of the signal can be guaranteed with greater certainty, even as the network evolves in complexity. Service providers who begin to test at 1,550 nm (even when their network currently runs at 1,310 nm) are ready for the inevitable customer demand for higher speed services.

Improving the speed and the quality of fiber service requires the right tools and process for insertion loss, OTDR trace and return loss. Mini-OTDRs that combine these tests enable cable technicians to build efficiency into testing. This will provide a crucial edge to the competitive service race in fiber networks. **CT**

Dynamic waveform acquisition: Measurement with mini-OTDRs

By Ray Hoffman
Chief Engineer, Bend Cable Communications

If you have to trudge up one of the Oregon Cascade Mountains and dig through several feet of snow to find and test a fiber-optic cable that is distorting a signal and downgrading customer service, you are not going to want to do it more than you absolutely have to. Fortunately for fiber installation and maintenance personnel in cable TV, like me, new tools and new technologies are now available for exactly this purpose. They enhance our ability to test prior to installation as well as our ability to better identify the nature and precise location of faults and other events on the line.

Event table

Event #	Distance (kft)	Distance tolerance (kft)	Event loss (dB)	Loss tolerance (dB)	Return loss (dB)	Link loss (dB)
1	0.142	0.002	0.053	0.02	N/A	0.152
2	12.171	0.002	0.047	0.02	N/A	1.485
3	32.78	0.002	0.061	0.02	N/A	3.598
4	41.433	0.003	0.125	0.02	N/A	4.582
5	47.24	0.003	>9.749	N/A	>-21.8	5.327

Event finder

Module = 1,310 SM
IR = 1.4680
Units = English

Measurement range =22.7 dB
Event threshold = 0.05 dB
Scatter coeffficient = -80.2 dB

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Previous page
Symbolic table
Storage
Change setup

Opportunities, problems

Some of the particular challenges we face at Bend Cable Communications may be unusual. For example, we have had the power company damage our fiber line when it repairs faults because the two lines are bonded together. But every cable company moving to fiber will find distinctive local problems that, unhappily, they can call their own.

At Bend Cable, our system covers over 500 plant miles and 17,000 subscribers in and around Bend, OR, the largest town in Oregon's sparsely populated High Desert country. Fiber is an important part of our expansion strategy and we are already putting it to use. After successfully completing a seven-mile fiber conversion in nearby Sisters, OR, we installed 56 miles of fiber in Bend that support 35 nodes.

Converting our coaxial trunks to fiber has reduced the number of required amplifiers from 34 to 23 in our plant and, by next summer, it will be down to just nine. With each reduction, we reduce the need to deploy personnel to adjust amplifiers, enabling us to maintain system performance with fewer problems and far lower maintenance costs. We are now looking at installing three synchronous network hubs and are talking with area schools and businesses about tying them in directly to our fiber network.

Cable companies around the country began to join the fiber revolution in the late 1980s, for more or less the same reasons we did so at Bend Cable: the ability to deliver a clearer signal over longer distances while eliminating the need for headends and amplifiers along the trunk. But fiber also brings problems. Cable operators often rely on outside contractors for installation and testing but perform restoration themselves. So, expensive equipment used by contractors to put fiber systems in place may not be available to the cable TV operators later on. That can leave local and independent operators like us without the experienced personnel and test equipment more often available at larger regional or district offices. And if we want to perform installation and testing ourselves, to reduce costs, our need for appropriate tools and personnel is that much more acute.

Mini-OTDRs: Their time has come

New developments in optical time domain reflectometry technology are making it easier to meet these needs for installation and maintenance. While optical time domain reflectometers (OTDRs) have always been useful tools for fiber testing, they have traditionally been relatively large, expensive and arcane instruments. Many operators were not able to afford as many of them as they might want or to train enough personnel in their use. Now, a new generation of

Without modularity, your Mini-OTDR investment may be short lived.

Anritsu's MW9070 Modular Mini-OTDR. It answers your needs today...and tomorrow.

Don't fall into the trap of buying a Mini-OTDR with no future. There's only one Modular Mini-OTDR that won't let new technology pass you or your equipment by—and that's the MW9070. Modularity keeps you current with OTDR advancements in dead zone, dynamic range, etc. The mainframe and user interface are also a powerful platform, able to support other measurement applications you come up against down the road.

Maximum Modularity.

Only our MW9070 gives you the platform for the future with field-changeable components:

- Optical modules
- Battery modules
  - NiCd (rechargeable)
  - Dry Cell (alkaline)
- Visual light source— 635 nm
- Optical connectors

Upgrade in the field.

Hardware reconfigurations and software upgrades can easily be completed in minutes, so craftspeople will spend valuable field time *using* the MW9070.

Anritsu's MW9070 Mini-OTDR. The end of obsolescence is just a phone call away.

For detailed literature or a hands-on demonstration, contact us at 1-800-230-AWSC (2972).

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test instruments is available. These new instruments, especially mini-OTDRs, are easier to use, smaller, lighter and more rugged. They have more automated functions and cost less than standard OTDRs. At a time when re-regulation and budget cutting are prevalent, this new class of instruments can provide needed testing capability for installation and maintenance, while staying within budgets.

Cable TV operators now can choose a tool that offers both higher performance and lower cost for specific tasks. The mini-OTDR is designed to be used for installation, maintenance and restoration and is easy enough (and automatic enough) to be used by anyone to locate cable cuts. Mini-OTDRs typically cost $8,000 to $14,000, less than half the cost of full-featured OTDRs. The combination of sophisticated measurement capability and low-cost makes testing on a regular, scheduled basis more feasible. This is a tremendous opportunity for cable operators seeking higher levels of system reliability and customer service.

Speed and accuracy

Before we made the move to fiber, we took a close look at what we would be getting into, and an equally close look at the tools and technologies available to support a fiber installation. One of the first things we discovered: Not all mini-OTDRs are created equal. Users need speed, accuracy and repeatability, ease of use and low price. But some OTDRs on the market today provide simplicity and low price at the expense of performance. For example, mini-OTDRs are touted for being able to shoot an entire fiber length in a single test, saving the operator a tremendous amount of time and trouble. Some do this by leaving a dead zone large enough to hide near-in events, or by missing several events that may be grouped closely together.

The problem: They have sacrificed dynamic range for distance resolution. That is because their operating parameters — including pulsewidth, distance range and averaging — remain constant during the acquisition process, although no single pulsewidth can see the entire fiber length and all events along that fiber. Longer pulses result in less noise and thus greater range, but they limit the distance resolution available. Shorter pulses provide higher resolution, but only at shorter distances. To adequately evaluate a fiber link and make sure that nothing is missed, the operator must take several acquisitions at different settings to obtain good measurements at short, intermediate and long distances, thereby defeating the promised simplicity of a single push-button device.

Accuracy, range

At Bend Cable, we have chosen the Tektronix mini-OTDR because we think it is one of the one of the available products that solves this problem of dynamic range vs. distance resolution. Its dynamic waveform acquisition improves the speed, accuracy and repeatability of measurements, while relieving us of the time, trouble and expense of manual analysis. For example, a fiber with 20 events might take 20 or 30 minutes for an experienced operator to measure manually. With a dynamic waveform acquisition, the same fiber requires only two minutes. Faster measurements by more workers means that more of the fiber system can be checked and maintained more regularly. Training time also can be reduced.

At the heart of dynamic waveform acquisition are digital signal processing (DSP) and proprietary algorithms that determine when to switch pulsewidths during the test to maintain accuracy across the entire fiber length. The dynamic waveform acquisition technology controls the pulsewidth, amplifier gain, depth of averaging and distance range during the acquisition to ensure the best measurements on the fiber under test. The precise acquisition parameters selected by the software will depend on the length of the fiber, the number of events found, the spacing of the events and the loss of the fiber under test.

"Mini-OTDRs are easier to use, smaller, lighter and more rugged. They have more automated functions and cost less than standard OTDRs."

For example, while taking measurements near the instrument, dynamic waveform acquisition automatically uses short pulses and a small amount of averaging. As testing progresses down the fiber, the instrument automatically starts using longer pulsewidths and more averaging. The test set uses only the longest pulsewidths and greatest averaging for those sections of the fiber that are farthest from the instrument.

So, using dynamic waveform acquisition, the mini-OTDR we use can measure all events on a fiber to its highest resolution in a single acquisition cycle, from closely spaced events near the test set connector out to more distant events, greatly increasing measurement speed and operator productivity.

Intelligent event recognition

Dynamic waveform acquisition enables us to capture events both near-in and throughout the fiber. But are those real events or merely echoes? And what type of events — mechanical or fusion splices, kinks, etc. — are they? Intelligent event recognition software works hand-in-glove with dynamic waveform acquisition to provide the answers. It analyzes the automatically captured waveform for us and presents the results in the form of an easily understood displayed event table. The accompanying diagram on page 56 shows an event table generated by our mini-OTDR for the Bend headend location. Where dynamic waveform acquisition increases the speed of measurement, intelligent event recognition increases its accuracy and repeatability.

To be useful, intelligent event recognition must report events at least as accurately as an expert operator. The event parameters that are normally measured and reported are:

- Distance location and tolerance
- Loss value and tolerance
- Return loss
- Link loss

Loss per unit distance and the event's location relative to the other events on the fiber are reported as well. Factors affecting the measurement accuracy of a single event include data sample spacing on the distance axis, signal-to-noise ratio (S/N) around the event and the software algorithms used. For multiple events, the selected pulsewidth and dead zone response are important factors.

This mini-OTDR uses patented, intelligent pattern match-

ing algorithms to enhance distance resolution and reject noise, ensuring that it makes accurate and repeatable measurements. The unit displays the tolerances on distance and loss as part of the event table so that our operator can clearly see the accuracy of each measurement.

Another important aspect of intelligent event recognition is its ability to set thresholds low enough to see very small events accurately and repeatably. How small can a nonreflective event be before the mini-OTDR can no longer detect and analyze it? Since noise increases with distance, it also is important to know the range at which the measurement can be achieved. For example, the mini-OTDR we use has a threshold that can be set as low as 0.05 dB within its measurement range, enabling us to accurately detect and measure fusion splice losses of less than 0.1 dB. That gives us enough performance for installation and more performance than traditional OTDRs can muster when viewing an entire trace.

Repeatability is a crucial issue for cable operators. Two operators can measure the same fiber or a single operator can measure the same fiber twice, and come up with different measurements through no fault of the test equipment. They can take their measurements differently, causing differences in event readings that do not reflect any changes or degradation in the fiber. Obviously, this is a cause for concern.

Intelligent event recognition eliminates these operator discrepancies, providing accurate location and measurement of events. This is especially important at long ranges, where noise on the trace interferes with the operator's assessment. The measurement algorithms in the mini-OTDR we use are, frankly, more consistently accurate than a manual operator can be on successive fiber tests.

Intelligent event recognition software is especially challenged by three types of complications:

- Noisy traces at long range
- False events due to noise
- Closely spaced events

Noisy traces are a fact of life in fiber testing because links are getting longer and test times need to be shorter. Low loss event thresholds compound the problem since the magnitude of the noise variation can easily exceed the threshold set by the user. To ensure that a loss threshold of 0.05 dB can be used effectively in a mini-OTDR, intelligent pattern matching algorithms must be used.

It is important not only to locate all valid events, but also to reject invalid ones. A mini-OTDR that locates, measures and tabulates nonexistent events could easily waste more time than it saves. The algorithms must be robust enough to reject noise spikes without losing the events of interest. I like the fact that our mini-OTDR monitors the noise around events to determine if the event is statistically significant or not and whether to report it.

Well-designed, intelligent event recognition software also identifies echoes. Echoes are pulses of light that return to the OTDR after reflecting more than once. They appear as real events on the waveform. Echoes can be confusing to an OTDR operator and, if they overlap real events, can affect measurement accuracy. Echoes cannot be eliminated by changing any of the setup parameters, such as range or pulsewidth, but well-designed software will identify and mark reflections that are echoes.

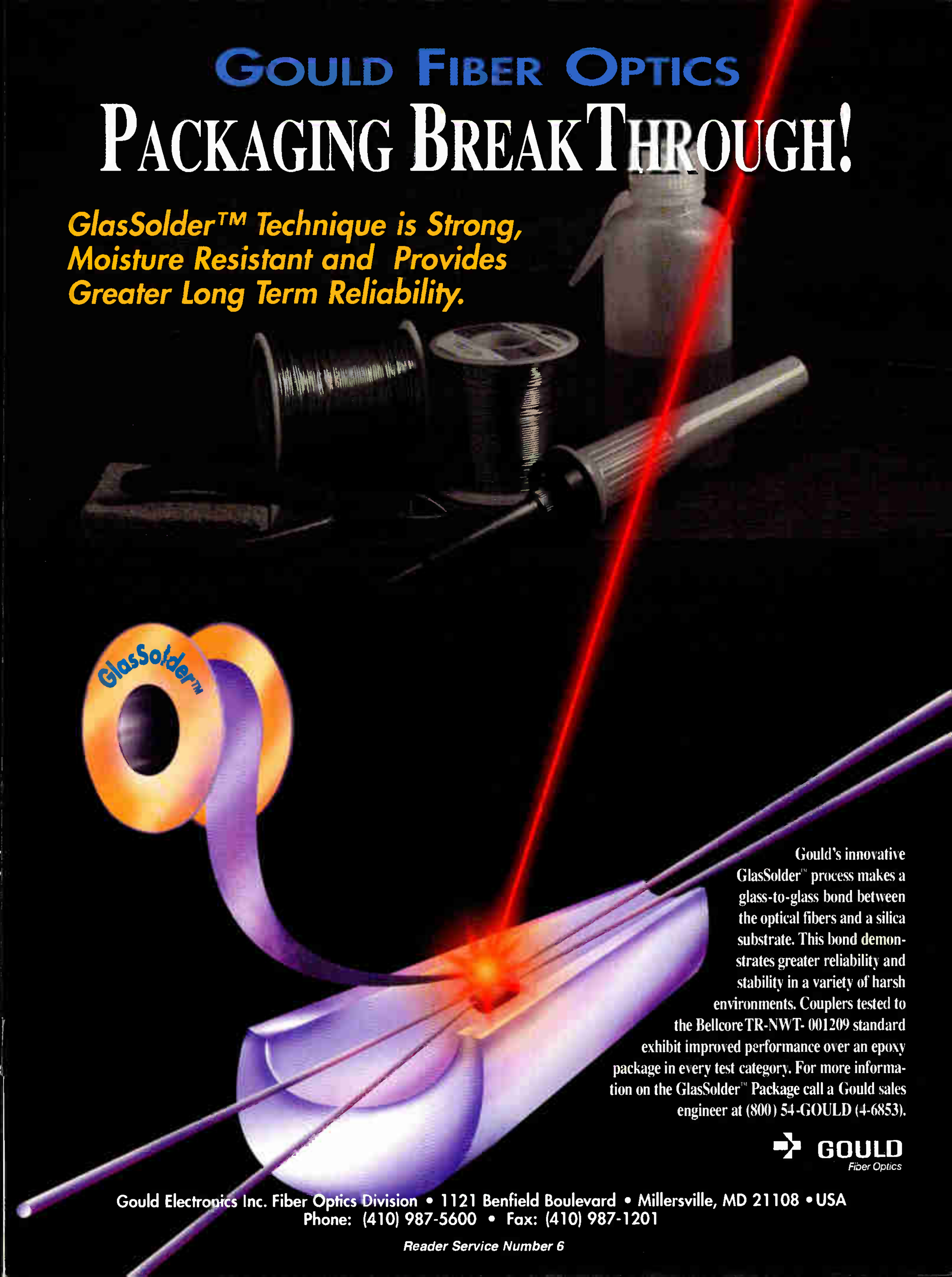
Putting it all together

The benefits of dynamic waveform acquisition and intelligent event recognition have proven to be a tremendous help to Bend Cable as we expand our fiber system. We have been able to shoot reels of fiber in the yard prior to installation to alert us to fiber damage during shipment. Shooting the same fiber after installation enables us to see if fiber quality has been maintained.

Our Sisters, OR, fiber site has benefited greatly from the speed, accuracy and repeatability of the mini-OTDR. It has enabled us to note high losses near-in that needed resplicing. A mini-OTDR with a standard dead zone would have missed these. The mini-OTDR we use also has enabled us to identify multiple splices within 100 feet of each other, while still seeing to the end of the cable in a single shoot. That has prevented us from replacing the wrong splice or missing a splice problem entirely.

Looking at our experience overall, these features and benefits mean we can deploy the mini-OTDR more broadly throughout the field, simplifying and accelerating maintenance. Staffing has become more flexible because any of our four technicians, not just the one trained in OTDR use, can easily use the mini-OTDR, even the first time they pick it up. That has enabled us to conduct troubleshooting and repair more quickly when needed. It also has reduced our training costs, a large but often overlooked cost of a maintenance program.

Taken together, these benefits contribute to the mission of our company: higher uptime at lower cost for greater customer satisfaction. And the next time I have to dig through a 12-foot snowfall to reach a cable at least I'll know I'm digging in the right place. **CT**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Video testing step by step — Part 5

The new Federal Communications Commission-required "video tests" are less than a year away. Remember that systems subject to the new rules are required to pass and document the tests by July 1, 1995. This article is one approach to fulfilling the testing requirements. Part 1 covered FCC reporting requirements and baseband video basics. Part 2 focused on two specific recommended tests — in-channel frequency response and percent modulation. Part 3 tackled signal-to-noise ratio (S/N) and hum modulation. Part 4 examined the "color tests" — differential gain, differential phase and chrominance-to luminance delay. This final installment includes information on a few additional tests that may benefit picture quality and system troubleshooting.

By Jack Webb
Product Manager, Sencore

Figure 32: Line time distortion

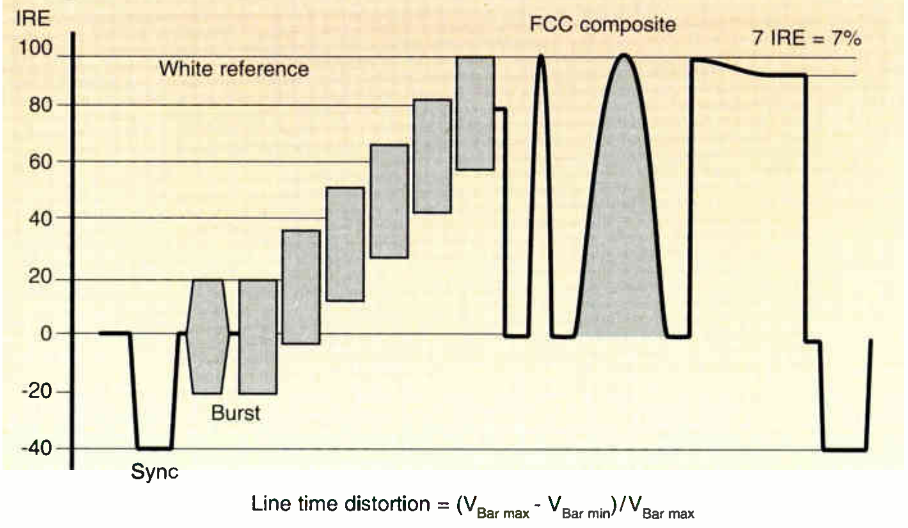
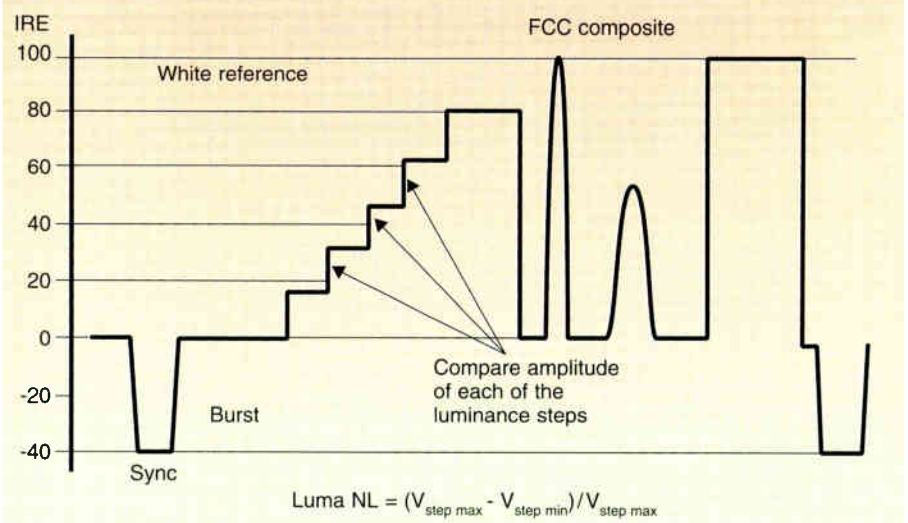


Figure 33: Luminance linearity



The following information is taken from various reliable sources and is believed to be accurate at the time of printing.

Line time distortion: No FCC proof-of-performance (POP) requirements apply to line time distortions. Line time distortions include those distortions that are 1 to 64 microseconds in duration, manifesting themselves as tilt in the reproduction of medium length pulses in the 1 to 64 microsecond duration range. The percentage of line time distortion can be measured by viewing the FCC composite tests signal, setting the white reference pulse to 100 IREs, and comparing the tilt of the white reference bar to the 100 IRE reference. (See Figure 32.) Typical performance for headend equipment will be <15%. Like phase distortions, filters and traps will increase the line time distortion of the video signal.

Luminance linearity: No FCC POP requirements apply to luminance linearity: a measurement of the distortion of the video signal as the luminance level increases from 0 to 100 IRE in the waveform monitor mode. Luminance nonlinearity typically occurs at the higher luminance levels and manifests itself as poor resolution in the brightest portion of the picture. Measuring luminance linearity is similar to measuring differential gain, except that a staircase without modulation is used. The step-to-step height is compared on each step to identify the largest and smallest steps as noted in Figure 33. The difference in amplitude is divided by the largest step amplitude resulting in the percent of nonlinearity. Modulators are the most likely cause of luminance nonlinearity. Acceptable performance should be <10% distortion. Measurements should be made with the demodulator in the synchronous mode.

Chrominance phase distortion: No FCC POP requirements apply to chrominance phase distortion. Chrominance phase distortion results from a phase shift in chrominance signals as the level of the chrominance signal changes, resulting in changes in hue as the color saturation changes. This is typically evident at higher chrominance signal levels. Chrominance

phase distortion can be measured using the modulated pedestal test signal and the CATV video signal analyzer in the vectorscope mode as illustrated in Figure 34. Adjust the burst position control so that the most counterclockwise dot is on the horizontal graticule and read the degrees of phase distortion of the vector most clockwise from the baseline. Chrominance phase distortion should be <10° in the headend.

Chrominance gain distortion: No FCC POP requirements apply to chrominance gain distortion, which results from the nonlinear reproduction of the amplitude of the chrominance signal, resulting in improper color saturation in the picture. This is typically evident at higher chrominance signal levels. Chrominance gain distortion can be measured using the modulated pedestal test signal and the CATV video signal analyzer in the waveform monitor mode. (See Figure 35.) Set the center packet of chrominance burst at 40 IRE using the vertical gain control, note the amplitude of the other two packets, and divide their measurement by their expected amplitude. The largest percentage is the chrominance gain distortion. The first packet should be 20 IRE and the last packet should be 80 IRE.

Chrominance-to-luminance intermodulation: No FCC POP requirements apply to chrominance-to-luminance intermodulation. Chroma-to-luma intermodulation results from the nonlinear reproduction of the amplitude of the luminance signal as the chrominance signal level varies. This is typically evident at higher chrominance signal levels. Chroma-to-luma intermodulation results in variations in brightness as color saturation changes in the picture. It can be measured using the modulated pedestal test signal and the CATV video signal analyzer in the waveform monitor mode as shown in Figure 36. Turn on the luma filter to remove the chrominance information on the modulated pedestal test signal. Set the vertical gain so that the luminance pedestal is displayed at its nominal 50 IRE level. The chroma-to-luma intermodulation is equal to the minimum to maximum level of the pedestal signal variations compared to the pedestal level.

Conclusion

While only the chroma-to-luma delay, in-channel frequency response, differential gain and phase tests are required by the FCC, many of the tests mentioned in this series of articles will be helpful in troubleshooting or evaluating headend performance to ensure that quality pictures are delivered to your customers.

I hope that this information will aid in making the new proof tests and be beneficial in setting criteria for evaluating instrument requirements to perform the new tests. Following these guidelines should help make the new video POP tests easier and more accurate. Further information is available from many sources. Refer to the SCTE or NCTA for reference materials.

References and sources of

Figure 34: Chrominance phase distortion

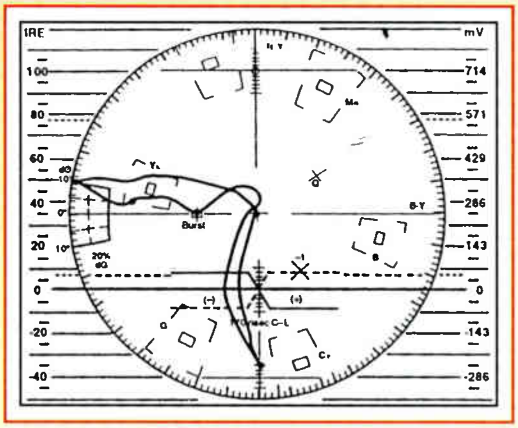


Figure 35: Chrominance gain distortion

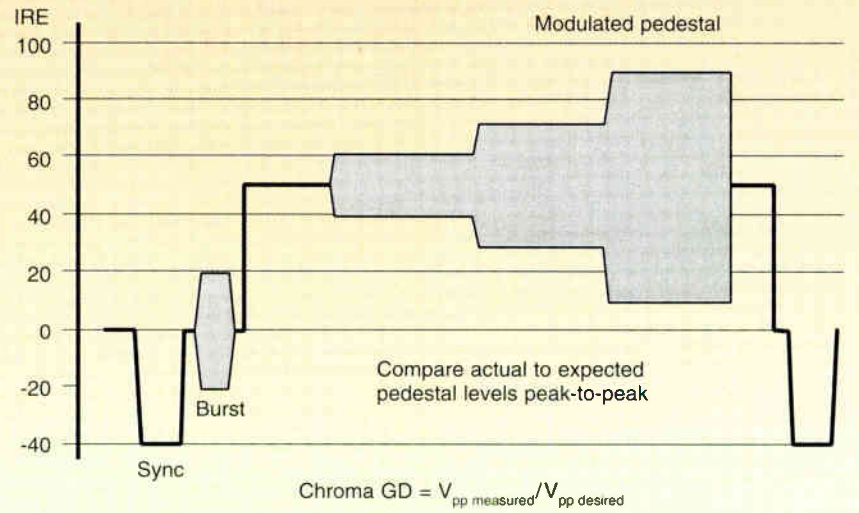
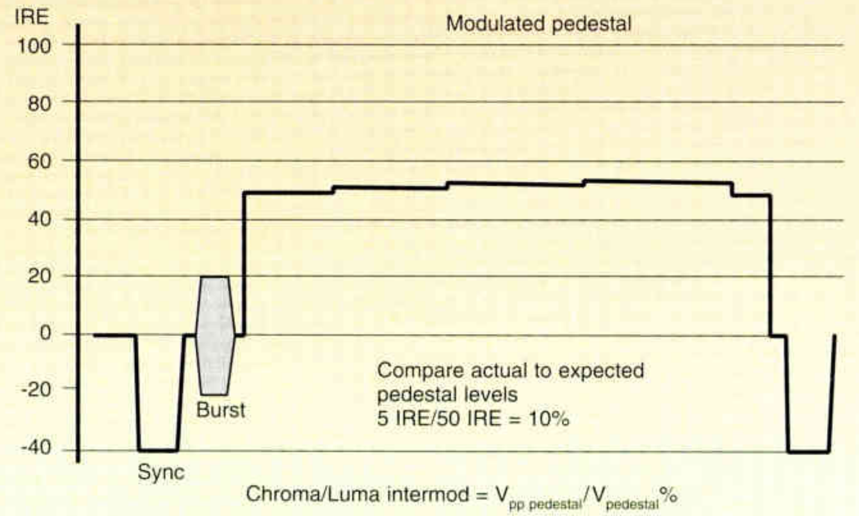


Figure 36: Chrominance-to-luminance intermodulation



Measurement units conversion chart: IRE to mV

The following chart, showing the relationship between volt and IRE, can be helpful when making video measurements.

IRE	Volt
140	1.000
135	0.964
133	0.950
130	0.929
126	0.900
125	0.893
120	0.857
119	0.850
115	0.821
112	0.800
110	0.786
105	0.750
100	0.714
98	0.700
95	0.679
91	0.650
90	0.643
85	0.607
84	0.600
80	0.571
77	0.550
75	0.536
70	0.500
65	0.464
63	0.450
60	0.429
56	0.400
55	0.393
50	0.357
49	0.350
45	0.321
42	0.300
40	0.286
35	0.250
30	0.214
28	0.200
25	0.179
21	0.150
20	0.143
15	0.107
14	0.100
10	0.071
7	0.050
5	0.036
0	0.000

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2) "NCTA Recommended Practices (revision of section 1)," *CED*, July 1993.
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6) *Video Engineering*, Andrew Inglis, 1993.
7) *Electronic Communications*, Hill, 1982.

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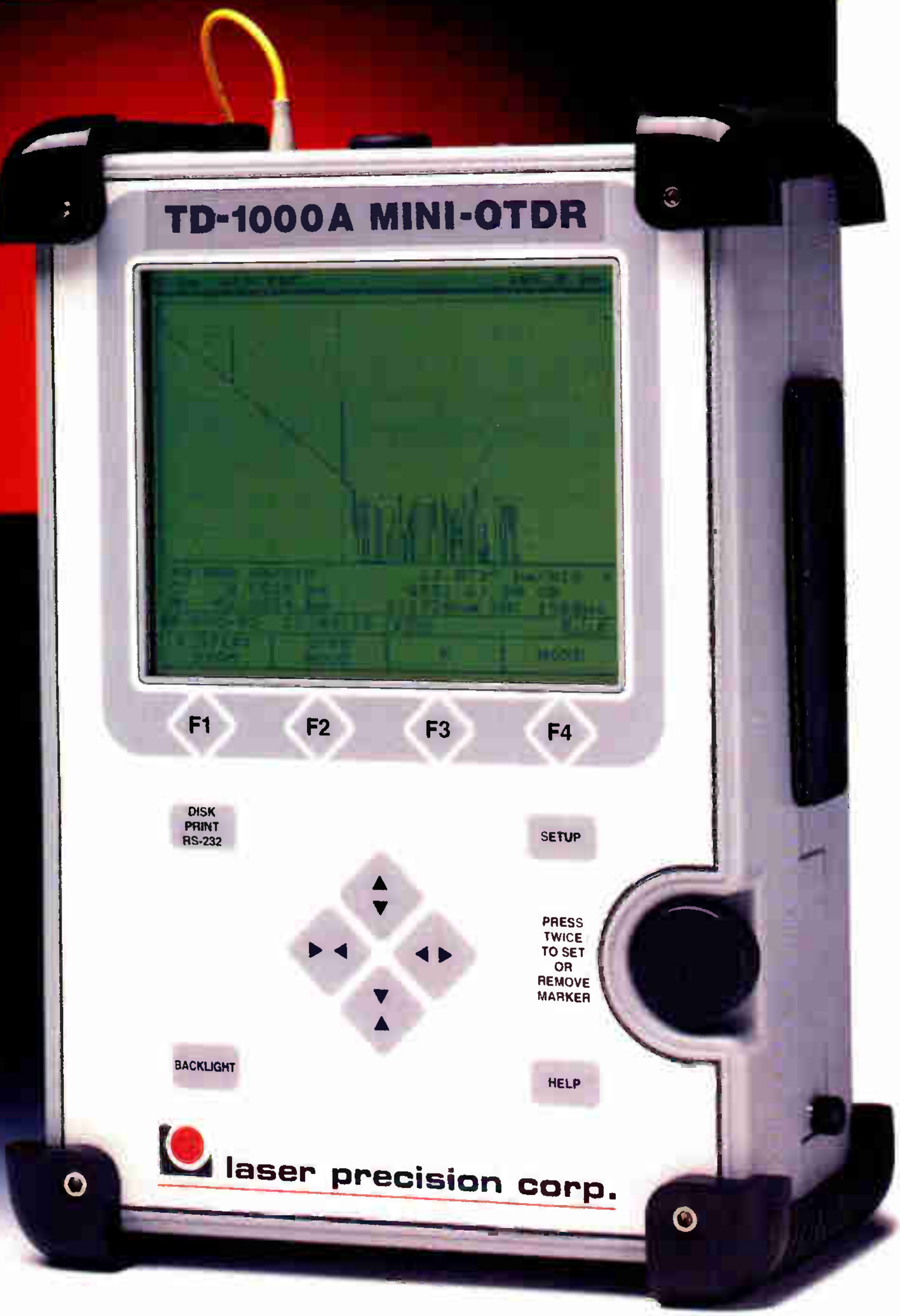

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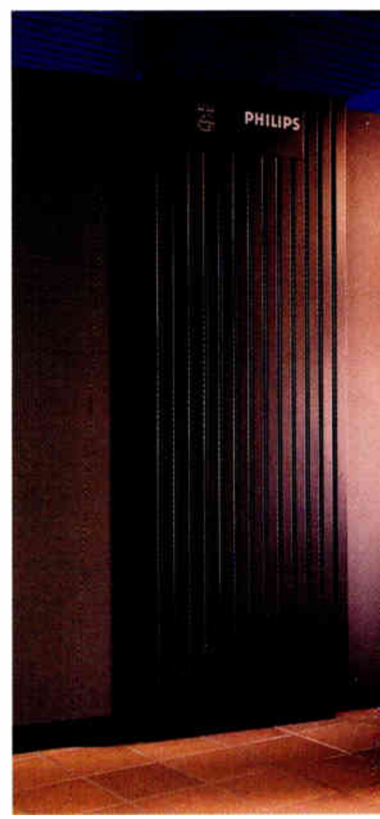

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Accuracy verification in carrier-to-noise measurements

By Benny Smith
Metrology Manager
Microwave Instruments Division, Hewlett-Packard

Carrier-to-noise ratio (C/N) is one of several measurements required by the Federal Communications Commission for proof-of-performance of a cable TV distribution system. C/N is defined as the difference (in dB) between the peak carrier level and the average in-channel noise level. (See Figure 1). C/N is an indicator of the quality of the video signal delivered to a cable subscriber's receiver. A C/N of 36 dB provides a signal that is so noisy and full of "snow" that it is barely watchable. A C/N of 50 dB provides a near studio quality image.

The FCC requires cable TV operators to measure C/N at least twice a year at multiple points within their systems. These measurements are referenced to a 75 ohm impedance and a 4 MHz bandwidth. Currently, the minimum C/N allowed at a cable subscriber's receiver is 40 dB. After June 30, 1995, the minimum C/N will be 43 dB. Cable TV system operators need an efficient and accurate way of measuring C/N to ensure that their systems comply with the FCC regulations.

Several instruments are available for measuring C/N, including power meters, spectrum analyzers and specialized signal level meters designed specifically for CATV. These instruments differ in convenience, efficiency and accuracy of measurement. Of these, the power meter is the most accurate. The spectrum analyzer, which offers unrivaled convenience and versatility, will be shown to have an accuracy in measuring C/N that rivals that of the power meter. While the FCC regulation does not specify the accuracy required in measuring C/N, cable system operators must know whether, and by how much, their systems actually exceeds the minimum.

Measuring C/N

Figure 2 shows the ideal setup for measuring the C/N of a CATV signal. The bandpass filter has a perfect, rectangular, 4 MHz bandwidth, as specified by the FCC requirement. The power meter has an infinite dynamic range that accommodates the highest carrier levels allowed in a CATV system as well as noise levels approaching the theoretical minimum of kTB (-174 dBm in a 1 Hz bandwidth at 25°C). Unfortunately, real power meters have a limited dynamic range (typically <50 dB) and real filters do not have rectangular-shaped passbands or constant bandwidth as they are tuned across a range of center frequencies. Nevertheless, a real world power meter/filter combination still offers the highest accuracy in C/N measurement.

Figure 3 shows a vastly simplified version of a spectrum analyzer, which is actually a highly sensitive tuned RF voltmeter. Spectrum analyzers incorporate high selectivity filters whose bandwidth and shape stay constant as the analyzer is tuned over a wide range of center frequencies. Spectrum analyzers typically have a wide dynamic range and are optimized for measuring the discrete frequency components of a signal. Measuring noise is difficult for a spectrum analyzer because:

- The analyzer itself contributes a certain amount of noise that, if too large, can obscure the noise being measured.
- The selectivity of the analyzer, provided by steep-skirt, high-aspect ratio filters, under-represents the amount of noise actually present.
- The bandwidth of the analyzer's filters is not exactly 4 MHz, as prescribed by the FCC for C/N measurement.
- The conversion of volts, as actually measured by the analyzer, to dB (m, mV, etc.) as indicated by the analyzer, contributes to error.

These sources of error result in correction factors that must be applied to the C/N readings taken by the analyzer in order to obtain accurate results over a wide range of input levels.

Figure 1: Carrier-to-noise ratio

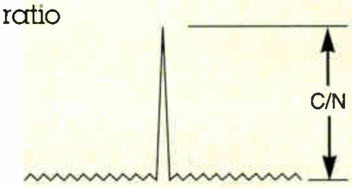


Figure 2: Ideal setup for measuring C/N

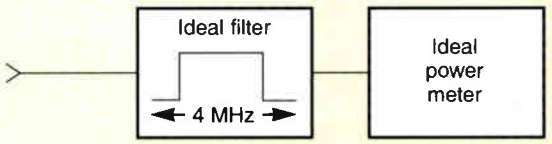
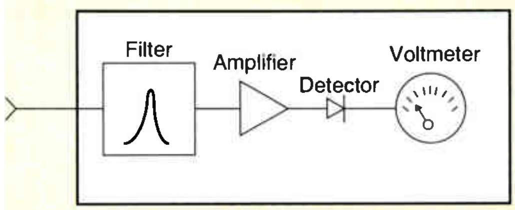


Figure 3: Simplified version of a spectrum analyzer



Accuracy verification

By comparing the measurements of a known C/N made by a power meter and a spectrum analyzer and by taking the power meter measurement as the reference standard, we can establish the accuracy of the spectrum analyzer. Figure 4 on page 74 shows a recommended setup for making this comparison. The remainder of this article deals with the specifics of measuring C/N. Hewlett-Packard equipment is used as an example.

Equipment list

The following is an equipment list for measuring C/N with H-P equipment: HP 8481D power sensor; HP 438A power meter; NVU noise generator bandpass filter (tunable to channel frequency of interest); HP 8656B signal generator; HP 8591C and 8591E spectrum analyzers; matching pad, transformer and attenuator; and three-resistor, 75 ohm power splitter.

Uncertainties

Since C/N is a ratio measurement, most of the usual sources of amplitude uncertainty will appear in both the carrier measurement and the noise measurement, effectively canceling as the C/N is taken. The list of the most significant absolute amplitude uncertainty factors is shown in Table 1 (page 74) for the power meter and the spectrum analyzer. Shown in italics are those that apply for a ratio measurement. Note that except for a negligible second-order term, mismatch uncertainty cancels out of the C/N result.

For the measurement setup shown in Figure 4 (page 74), the C/N indicated by the spectrum analyzer is subject to an uncertainty because of resolution bandwidth switching, reference level switching, digitization and the log display process. The combination of these uncertainties for the HP 8591C/E cable TV analyzer measurement of C/N is specified as ±1 dB. (See appendix for complete uncertainty analysis.)

The C/N indicated by the power meter is subject to an uncertainty of about ±0.02 dB. (See appendix.) For this comparison, the power meter is used as a reference for the accuracy of the spectrum analyzer. Since the uncertainty due to the power meter is so low in this ratio measurement, the power meter is effectively measuring the true C/N present. Several spectrum analyzers were compared to the power meter of this example to determine their relative accuracy.

Table 2: C/N with power meter and average from four analyzers

	Carrier level (dBmV)	Noise level (dBmV)	C/N (dB), corrected
Power meter	+28.65	-20.25	50.3
Spectrum analyzer (manual)	+28.95	-46.63	49.9
Spectrum analyzer (automatic)	—	—	50.0

Results

C/N was measured on four analyzers (two each of HP 8591C and 8591E) in both manual mode, and in automated CATV mode via the 85721A cable TV measurement personality. Averaging was employed to achieve a final reading. Table 2 shows the measured result with the power meter and the average result from the four analyzers. The analyzers had just emerged from the final electrical test in manufacturing. The resulting C/N for the four analyzer samples agree closely (within 0.4 dB) with the power meter measurement.

References

1) "Spectrum Analysis Basics," *Application Note 150*, Hewlett-Packard, 1989.

2) "Visual Carrier-to-Noise," Section I.D., *Recommended Practices, Second Edition*, National Cable Television Association, October 1993.

3) Bullinger, Rex, "Wide Dynamic Range Carrier-to-Noise Testing," *1993 NCTA Technical Papers*, page 330.

4) *Cable Television Systems Measurement Handbook*, Hewlett-Packard Co., July 1993.

5) Thomas, Jeffrey L., *Cable TV Proof-of-Performance*, Prentice-Hall.

Appendix

- Measurement uncertainties:

Power meter linearity/instrumentation/digitization = ±0.02 dB

Spectrum analyzer log scale display = ±0.75 dB

Reference level switching = ±0.5 dB

Resolution bandwidth switching = ±0.25 dB

Digitization = ±.01 dB

RSS combination = ±1 dB (actual 0.968 dB)

- Uncertainty in the values of the correction factors:

1) Power meter

Equivalent noise power bandwidth = -0.52 dB (Bandpass filter: center frequency = 300 MHz; Passband = 6.23 MHz) — Uncertainty: ±.01 dB (accuracy of measuring the actual filter bandwidth)

3 dB bandwidth to 4 MHz bandwidth correction = -1.92 dB — Uncertainty: ±.05 dB (accuracy in measuring bandwidth with network analyzer)

2) Spectrum analyzer

Equivalent noise power bandwidth = +0.52 dB — Uncertainty: ±0.01 dB (accuracy of measuring the actual filter bandwidth)

30 kHz to 4 MHz correction = +21.25 dB — Uncertainty: ±.04 dB (accuracy of 30 kHz resolution bandwidth)

Log/envelope detection = +2.5 dB — Uncertainty: None (calculation)

Noise-near-noise correction = +1.5 dB (can be zero to a maximum of +7 dB) — Uncertainty: ±.05 dB (due to log scale readout of noise-near-noise differential) **BTB**

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SPECIFICATIONS

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PARAMETER	SYSTEM M/N	SYSTEM B/G	SYSTEM D/K China*	SYSTEM I
VIDEO SECTION				
Input: C3F Neg	NTSC	PAL	PAL	PAL
Input Impedance	75 ohms unbalanced	75 ohms unbalanced	75 ohms unbalanced	75 ohms unbalanced
Frequency Response	±0.5 dB	±0.5 dB	±0.5 dB	±0.5 dB
Bandwidth	4.2 MHz	5.0 MHz	5.0 MHz	5.5 MHz
Differential Gain	2% max	2% max	2% [illegible]	2% max
Differential Phase	2 degree max	2 [illegible]ree [illegible]	[illegible]	2 degree max
Hum & Noise	-60 dB	-60 [illegible]	[illegible]	-60 dB
AUDIO SECTION				
Input: 50 Hz-15 KHz	0 dBm (.8V)	[illegible]	[illegible]	[illegible] 8V)
Impedance	600 ohms balanced	[illegible]	[illegible]	[illegible]
Frequency Response	±1.0 dB	[illegible]	[illegible]	[illegible]
Frequency Tolerance, ±500 Hz	4.5 MHz	5.5 [illegible]	[illegible]	[illegible]
Frequency Deviation	±25 KHz	[illegible]	[illegible]	[illegible]
Harmonic Distortion	1% max	1% max	[illegible]	[illegible]
Preemphasis	75µs	50µs	[illegible]	[illegible]
IF SECTION				
Video IF Level	+37 dBmV +97 dBµV	+37 dBmV +97 dBµV	+ [illegible] dBm[illegible] +97 dBµV	+3[illegible]mV -97 dBµV
Audio IF Level	+22 dBmV +82 dBµV	+27 dBmV +87 dBµV	+27 dBmV +87 dBµV	+27 dBmV +87 dBµV
Return Loss	>14 dB	>14 dB	>14 dB	>14 dB
IF Frequency				
Video Carrier	45.75 MHz	38.9 MHz	38.0 MHz	38.9 MHz
Audio Carrier	41.25 MHz	33.4 MHz	31.5 MHz	32.9 MHz
Video-Sound Spacing	+4.5 MHz	+5.5 MHz	+6.5 MHz	+6.0 MHz
Vestigial Sideband Width	0.75 MHz	0.75 MHz	0.75 MHz	1.25 MHz
RF SECTION				
Output Frequency	470-750 MHz			
Frequency Tolerance	±2 KHz			
Output Level adjustable	+60 dBmV max +120 dBµV			
Output Impedance	75 ohms unbalanced			
Spurious Output 470-750 MHz @+60 dBmV/+120 dBµV Output Level	<-60 dBc			
Return Loss	>14 dB			
Frequency Response	<2 dB			

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Three ways to extend the life of tower-mounted equipment

By Mike Wohrle
AML Technician, Falcon Cable TV

The headend is the single largest contributor to customer satisfaction in a cable TV system. But what about secondary elements that support the operation of the headend such as tower-mounted equipment? The quality of signals delivered from that headend are directly related to how well the installation is performed and the climate in which it must operate. It only makes sense to give that equipment the best possible chance of survival.

Tower downleads

The Cableguard coaxial cable product produced by CommScope in .500, .625 and .750 sizes, provides superior protection from hanger clamps and ice falling off the tower. Originally designed for underground installations, Cableguard's jacket consists of compartmentalized cells for crush- and impact-resistance not available in standard jacketed cables. See Figure 1.

On standard jacketed cables, any dent in the jacket usually means damage to the outer aluminum shield. With Cableguard cables, hanger clamps used for attaching the cable to the tower can be securely fastened around the cable without interfering with the performance of the cable inside. See Figure 2.

Winter storm icing and falling ice chunks will damage standard jacketed cable, but Cableguard resists this sort of damage. This means more reliability and longer life for the system. The flooding compound is no problem because the bottom connector is sealed with heat shrink tubing to prevent migration out of the cable end.

Connector booting

Another way to extend the life of your tower work is to seal all exposed connectors with heat shrink tubing. This includes antenna connectors, preamplifiers and waveguide connectors. Since microwave connectors can get quite large in size compared to standard CATV connectors, Canusa's CFTV 2750 boot easily slides over waveguide connectors, like Andrew Corp.'s 1127DC microwave connector assembly, especially when an outdoor LNA at the antenna is used. See Figure 3. The Canusa heat shrink tubing product line is available from Gilbert Engineering and TVC Horizon.

Coastal or other harsh environments can corrode connector parts beyond the possibility of removal (see Figure 4 on page 80), but by booting all exposed metals of the connector and cable assembly, they are preserved in a newly installed condition.

Waveguide connector boot installation

Take a sealant type tape like Bishop #8065 bi-seal tape and wrap it around the rigid waveguide behind the feedhorn flange to about 3/8-inch thick buildup (so the recovered boot will fit snugly). Cut a piece of the 2750 boot about 18 inches long and slide it over the connector. Then complete the connector to feedhorn attachment. Slide the boot up firmly behind the rear of the dish and begin heating at the main connector body in the center area working outwards in each direction uniformly heating for even shrinkage. See Figure 5 on page 80.

The mastic does a good job of sealing up the gaps and once cooled, the boot can be easily trimmed around the air screw for removal to purge the dehydration sys-

Figure 1: CommScope Cableguard jacket

Figure 2: Hanger clamps won't interfere with Cableguard cable performance

Figure 3: Connector booting

"If the spring (on the back of the reflector) continues to load up with ice, it will pull sideways on the feedhorn and permanently damage the rigid waveguide feed."

tem. The shrink tubing also does an excellent job in suppressing small air leaks around the connector assembly. On properly installed connectors that are booted, air leakage of only a few pounds a year is easily achieved. Once the air screw is replaced, a quality brand of electrical tape can be wrapped over the opening.

For feeds with an LNA

Tape over the power connector port on the LNA and follow the instructions mentioned earlier on boot installation. Once cooled, trim the boot from around the LNA power port and slide a #11 shrink tubing over the power lead, connect the power lead to the port and shrink the tubing over the connector. The mastic will seal the port quite satisfactorily. Use electrical tape to finish sealing around the power port. Finally, the heat shrink tubing gives that area from the last support clamp to the antenna extra strength from wind and shock.

Anti-icing microwave antenna upgrade

Andrew Corp. now offers an antenna feed guy wire upgrade to prevent feedhorn damage due to ice buildup on the spring assembly on the back of the dish. See Figure 6.

During certain icing conditions, a large ball of ice can form on any of the springs on the back of the reflector. As it grows in size, the spring will bend, pulling the feed off center and fading the path to some degree. If the spring continues to load up with ice, it will pull sideways on the feedhorn and permanently damage the rigid waveguide feed. This means a replacement cost ranging from $1,000 to $3,000 for a new single-polarized feedhorn. Andrew now offers an upgrade kit to replace all three feed guy wires. The new feed guy wires are designed with the spring assembly on the inside of the reflector where it is more protected when a radome is used. See Figure 7.

To determine if your installation needs this upgrade, answer either of the following:

1) Did you have had to replace a feedhorn during winter icing?

2) Did the annual inspection of the antennas show that the spring assemblies behind the reflector were not all close in length and/or the spring had bends in it?

To order the upgrade kit, look up the part number for the antenna you ordered or, if possible, the part number of the feed system. This is not the reflector part num-

Figure 4: Corroded connector parts

Figure 5: Waveguide connector boot installation

Figure 6: Andrew antenna feed guy wire upgrade

Figure 7: Spring assembly on inside of reflector

ber such as "D8E—21" but an antenna number like "P10-122D" or a feed part number like "2045433." This tells the company's customer service which antenna and feed you have. Each kit ordered includes extensive instructions, vinyl gloves, conductive grease and one guy wire assembly.

A team of at least three should perform the upgrade. The feed for most single polarized antennas can be removed from the back of the antenna, so no dish movement is required to perform the upgrade, cutting downtime to a minimum.

A crew member should be posted at each guy wire to keep tension as the feed is removed. A string must be tied onto the old guy wires as they are removed, then attached to the new guy wire for pulling into place. Once all three new guy wires are attached to the tip of the feed, tape over the three wire ends to keep them from falling off as the feed is reinstalled through the rear of the dish.

This is a new product Andrew has made available to 12 and 13 GHz users. Part #224401 covers P8-122D and P10-122E series antennas as well as the high-performance (HP) versions. Call Andrew's customer service department at (800) 255-1479 for more information on this new product — special anti-icing guy wires.

For information on other products mentioned in this article, call CommScope at (800) 982-1708 and Canusa at (800) 845-6808. **BTB**

Table 1: Test 1 summary

Parameter	Measurement
Broadband channel	A-3 (102-103 MHz)
Digital signal level	7 dBmV
Analog C/N	44 dB
Digital C/N	32 dB
Raw BER	3.4×10^{-4}
Coded BER	1.4×10^{-7}
Errored seconds	7
Test duration	12 hours
% availability	99.99

Table 2: Test 2 summary

Parameter	Measurement
Digital signal level	-3 dBmV
Digital C/N	22 dB
Errored seconds	65
Test duration	51 hours
% availability	99.96

Table 3: Test 3 summary

Parameter	Measurement
Cable channel	58 (96-1,102 MHz)
Digital signal level	11 dBmV
Analog C/N	41 dB
Digital C/N	32 dB
Raw BER	1.3×10^{-4}
Coded BER	0 errors
Errored seconds	0
Test duration	19.5 hours
% availability	100

channel. When the noise in the channel increases, the noise around the constellation points spread. Ideal performance is a very small point. An eye diagram displays the relationship between the amplitude levels of one phase of the carrier. As intersymbol interference increases, the eyes close. Constellation diagrams are useful in identifying other system impairments. Distortions, unequal phase gain, phase noise, co-channel interference, multipath, etc., all have a characteristic appearance.

QAM performance data

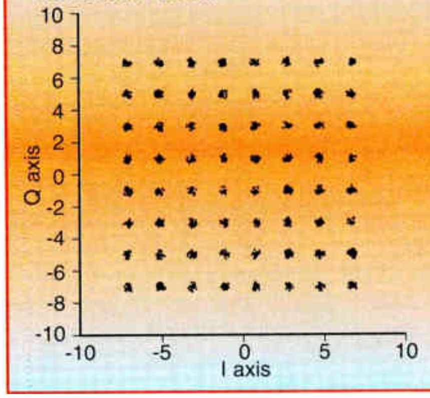
QAM on cable has been tested considerably. What follows is the result of testing performed by General Instrument in conjunction with several broadband operators. These results were previously published in several NCTA journals.[2] The most important conclusion that can be drawn is that QAM is an effective, cost-efficient and proven technique.

The accompanying tables show a raw BER, a coded BER and the total errored seconds. The raw BER refers to the data prior to FEC decoding. The coded BER rate refers to bit errors that the FEC was unable to correct. The total errored seconds refers to the number of seconds in which an error occurred. Even though a bit error occurred, it does not mean that an artifact will appear in the digital video. The DigiCipher II digital video decoder conceals errors by looking to previous frames and substitutes an estimate for the lost bits. The test setup is illustrated in Figure 9.

"Cost, availability, implementation options, risk and vendor support all tend to support QAM as the conservative choice for system designers."

The output of the 64-QAM modulator is a double-sideband suppressed carrier AM signal, centered at 44 MHz, with a 3 dB bandwidth of 4.88 MHz. The output of the modulator was upconverted to a cable channel, combined with the system's analog channels and sent over the cable plant. At the receiving site, the RF signal is converted to IF using a frequency agile downconverter that uses a low phase noise frequency synthesizer for its local oscillator.

Figure 7: 64-QAM constellation



The 64-QAM demodulator was equipped with an RS-232 port that was connected to a PC for data logging. Both raw errors and errors after FEC were collected. The tap values of the 64-tap adaptive equalizer in the demodulator also were logged. The PC software used for the test is structured so that the error data and equalizer data can be stored in separate files for offline printing.

Three tests were conducted with this equipment. The first was over two fiber-optic links plus a 23-trunk amplifier cascade terminating in a bridger amp and one tap. Table 1 gives a summary of these test results.

The next test was conducted over a

Figure 8: 64-QAM eye diagram

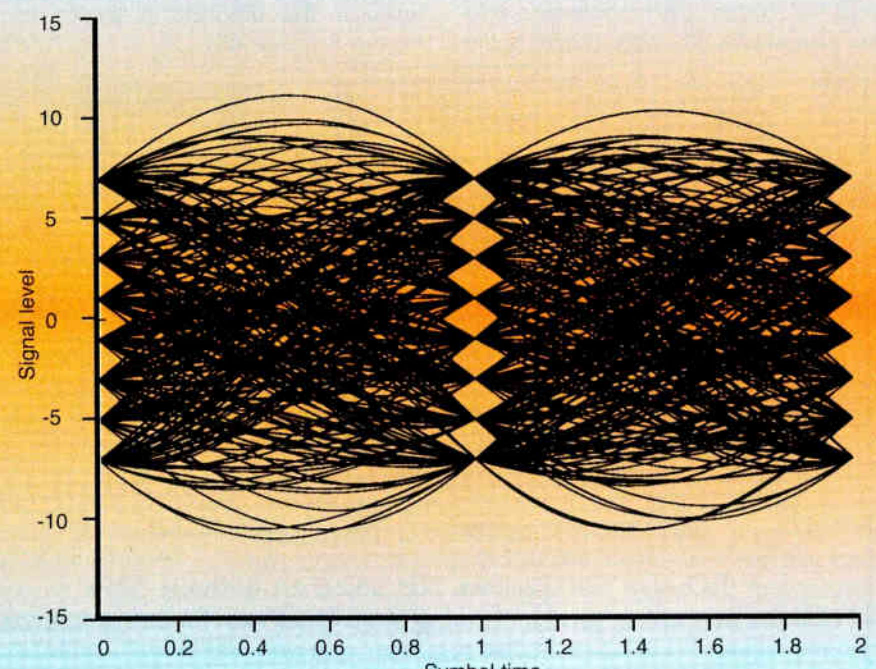
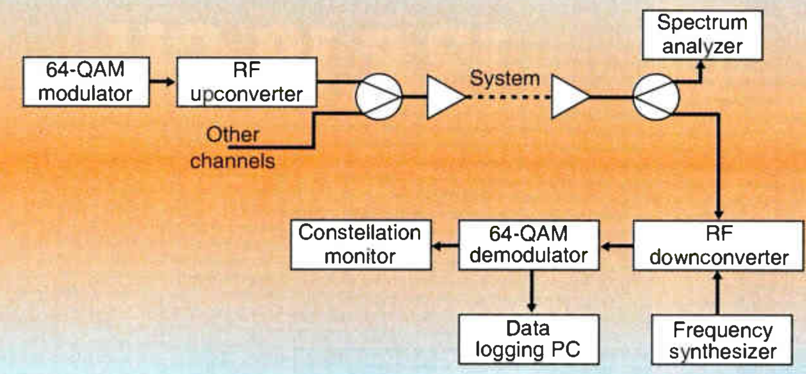


Figure 9: Test equipment setup



24-trunk amp cascade, plus two taps, plus considerable wiring to the receiving site (a hotel room). This test data includes a loss of signal due to an intermittent problem in the downconverter's power supply. See Table 2.

The third test was run over a cascade of 41 trunk amplifiers, plus two line extenders and 22 taps. Table 3 summarizes this test data.

Because these tests were conducted at the lower end of the cable spectrum, it can be assumed that the system echoes were near worst case due to near minimum attenuation. It is noteworthy that the equalizer tap coefficients recorded show that nearly all echoes were canceled by only 14 taps. The conclusion was that most of the system echoes were of relatively short duration. This finding is consistent with other testing.[3] The conclusion of these tests was that QAM provides a robust and reliable communications channel for high-speed data transfer in CATV systems.

QAM and VSB

VSB modulation for data transmission is obtained by passing a pulse amplitude modulated (PAM) signal through a single-sideband RF modulator. Theoretically, the channel capacity of both QAM and VSB are the same. Thus the primary arguments in favor of QAM lie in the technical implementation of the proposed systems.

In the proposed VSB systems, a pilot tone is used for carrier recovery. Although this option is possible for QAM, it is not used because it robs signal power, leaving less power for the transmission of data. The proposed VSB system uses a training sequence in the transmitted data for equalizer operation. This is an option not used in QAM systems because it robs data bandwidth. QAM systems typically use blind equalization, which is implemented simply and provides fast data acquisition.

Because QAM is a mature technology that has been studied for many years, there exists a vast amount of research in the public domain on it. This increases the likelihood that the course of development and cost reduction will be much faster for QAM. In fact, three-device VISI implementations have already been demonstrated for QAM systems. Single-device solutions are anticipated by the beginning of next year. A highly integrated VSB modem has not been demonstrated.

Cost, availability, implementation options, risk and vendor support all tend to support QAM as the conservative choice for system designers. For these reasons, 64-QAM has been selected for the European digital video broadcast (DVB) specification. Many equipment vendors in the United States, including General Instrument, AST, AT&T, Broadcom, Hewlett-Packard and Scientific-Atlanta, have selected QAM because of its wealth of implementation options, elegance and simplicity. **CT**

References

[1] *Telecommunications and the Computer*, James Martin, Prentice Hall, 1976.

[2] "64-QAM Transmission of Digital Data Over Cable and Alternate Media," Joseph Waltrich, *NCTA Technical Papers*, 1993.

[3] "Performance of Digital Transmission Techniques for Cable Systems," Richard Prodan, *NCTA Technical Papers*, 1992.

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• Technicians • Engineers • Managers • Sales
Send resume with salary requirement to address below.
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MANUFACTURERS REPS-CATV
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RALPH BAILEY, DSM 814-362-3690

porta systems corp.

CATV Bench Technician,

CA based repair facility is looking for an individual with over 5 years experience repairing CATV line equipment. Knowledge of HE and Test equipment a plus. Must be able to troubleshoot to component level. Please send resume and complete salary history in confidence to:
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Sacramento, CA 95827
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•Foreman •Linemen
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Viacom Cable, the leader in the cable broadcast communications industry, is seeking a Technical Trainer for our Bay Region Systems operation. It's an opportunity for career development, combining technical cable background with leadership opportunities.

You'll be responsible for developing and coordinating technical training programs and materials, conducting classes and new hire orientation, and assisting supervisors in identifying training needs through job task analysis. Operational and skill/performance improvement recommendations, and development of performance measurement and testing programs are a key aspect of the job.

To qualify, you must have demonstrated technical competence in cable-related construction, installation and maintenance plus technical/safety policies and practices, 3-5 years field experience and math/electronics theory knowledge preferred; proven skills in employee motivation and good communication essential.

Send your resume to:
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Cable TV Operator seeking a "hands on" Maintenance Technician with customer service, Cable and Fiber Optic knowledge. Proven experience in pole climbing, National Electrical Code, two years experience as a Technician, a valid California Drivers License and a satisfactory driving record required. Offering competitive wage and benefit pkg.

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or call
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7	33	59	85	111	137	163	189	125	241	267	293
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9	35	61	87	113	139	165	191	217	243	269	295
10	36	62	86	114	140	166	192	218	244	270	296
11	37	63	89	115	141	167	193	219	245	271	927
12	38	64	90	116	142	168	194	220	246	272	298
13	39	65	91	117	143	169	195	221	247	273	299
14	40	66	92	118	144	170	196	222	248	274	300
15	41	67	93	119	145	171	197	223	249	275	301
16	42	68	94	120	146	172	198	224	250	276	302
17	43	69	95	121	147	173	199	225	251	277	303
18	44	70	96	122	148	174	200	226	252	278	304
19	45	71	97	123	149	175	201	227	253	279	305
20	46	72	98	124	150	176	202	228	254	280	306
21	47	73	99	125	151	177	203	229	255	281	307
22	48	74	100	126	152	178	204	230	256	282	308
23	49	75	101	127	153	179	205	231	257	283	309
24	50	76	102	128	154	180	206	232	258	284	310
25	51	77	103	129	155	181	207	233	259	285	311
26	52	78	104	130	156	182	208	234	260	286	312

A. Are you a member of the SCTE (Society of Cable Television Engineers)?
01. ___ yes
02. ___ no

B. Please check the category that best describes your firm's primary business (check only 1):
Cable TV Systems Operations
03.___ Independent Cable TV Syst.
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05. ___ Cable TV Contractor
06. ___ Cable TV Program Network
07. ___ SMATV or DBS Operator
08. ___ MDS, STV or LPTV Operator
09. ___ Microwave or Telephone Comp.
10. ___ Commercial TV Broadcaster
11. ___ Cable TV Component Manufacturer
12. ___ Cable TV Investor
13. ___ Financial Institution, Broker, Consultant
14. ___ Law Firm or Govt. Agency
15. ___ Program Producer or Distributor
16. ___ Advertising Agency
17. ___ Educational TV Station, School, or Library
18. ___ Other (please specify)____

C. Please check the category that best describes your job title:
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20. ___ Management
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Technical/Engineering
22. ___ Vice President
23. ___ Director
24. ___ Manager
25. ___ Engineer
26. ___ Technician
27. ___ Installer
28. ___ Sales/Marketing
29. ___ Other (please specify)____

D. In the next 12 months, what cable equipment do you plan to buy?
30. ___ Amplifiers
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32. ___ CATV Passive Equipment including Coaxial Cable
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43. ___ Vaults/Pedestals
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50. ___ Telephone/PCS Equipment
51. ___ Power Suppls. (Batteries, etc.)
52. ___ Video Servers

E. What is your annual cable equipment expenditure?
53. ___ up to $50,000
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74. ___ OTDRs
75. ___ Power Meters
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AD INDEX

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Talk set

Noyes Fiber Systems unveiied the latest addition to its line of fiber-optic test equipment and services: the Model FTS 3 fiber-optic test set, a complete voice communications set and stabilized light source in one package.

Primarily used over spare fibers, the unit enables quick connections and simple operation. Features include single fiber full duplex (no "push to talk" necessary), 40 dB range on single-mode fiber, conference call function, 2 kHz tone for fiber identification and stabilized output for loss testing. The unit is housed in a rugged package with weather resistant membrane switches and is battery operated.
Reader service #206

Test kit

RF Industries introduced the RFA-4017-0 cable testing kit, designed for the bench and field technician for quick and easy testing of cables with female mini-UHF, TNC or UHF and male and/or female BNC, N or SMA terminations.

The important center piece of the kit is the RFA-4017-01 coaxial cable tester. Powered by a 9 V battery, this tester is lightweight, small and portable. The LED panel indicates pass or fail. If the result is fail, the panel saves valuable diagnostic time by indicating whether the failure is due to a short, open conductor or open shield.

Free cables can be tested by attaching each end of the cable assembly to the unit. Installed cables can be tested easily by using two coaxial cable testers. To do this, disconnect the cable from all equipment and attach the remote end to the right jack of one tester. Attach the local cable end to the left jack of the second tester. The cable status will be displayed on the LED panel of the local tester.

In addition to the coax cable tester with BNC female termination, contained in the foam-lined zipper case are 16 adapters, two of each of the following: BNC male to BNC male; BNC male to UHF female; BNC male to N female; BNC male to N male; BNC male to SMA male; BNC male to SMA female; BNC male to TNC female; and BNC male to mini-UHF female.
Reader service #208

Oscilloscope

Leader Instruments Corp. announced the Model 8104 oscilloscope featuring 100 MHz bandwidth and three-channel operation. The unit features cursor measurements of voltage, time, frequency and phase, and displays on-screen notices of sensitivity, time base and delay time settings.

Calibrated delayed sweep with alternate sweep is offered so that the main and delayed traces can be viewed simultaneously. Six traces are displayed in the ALT sweep mode when the three channels are active. However, the SUM (or difference with Ch. 2 inverted) of Ch. 1 and 2 also can be displayed together with Ch. 1-3, making an eight-trace display possible. The main time base ranges from 50 ns/div to 0.5 s/div in 22 steps, and use of the x10 magnifier put the fastest sweep speed at 5 ns/div. A single-sweep mode is provided to catch one-time events.

Trigger facilities include a time-saving automatic source selection coordinated with V-mode operations. (If only one channel is active, it becomes the trigger source. Ch. 1 is automatically the trigger source in dual-channel operations.) However, manual override allows the source to be selected from any of the three channels plus the power line. Trigger modes include auto, normal and fixed. In the latter, the trigger point is maintained within the p-p signal excursion to hold sweep stability despite large swings in signal amplitude.

Ch. 1/Ch. 2 vertical sensitivity ranges from 1 mV/div to 5 V/div in 12 steps. Bandwidth is restricted to 20 MHz in the 1 and 2 mV/div settings. Identical signal delay is provided in all three channels to vies trigger transitions. X-Y operation is provided, and rear panel Ch. 1 output permits the scope to act as a high-gain preamp to drive other equipment such as frequency counters.
Reader service #207

Power meter

EXFO's new FOT-70 fiber-optic power meter combines two separate channels in one instrument. The two fully independent channels can be operated separately to obtain two simultaneous readings, at two separate wavelengths. They also can be paired to provide a third direct reading of the power difference between the two channels. In the difference mode, this dual-channel unit is well-suited for monitoring, R&D, manufacturing, wavelength division multiplexing (WDM) and security environments.

Readings can be taken in absolute or relative (referenced) mode. The unique difference mode enables many advanced applications such as: monitoring of power variations caused by a device under test, hooked up to one channel, compared to a known reference connected to the other one in environmental testing; simultaneous monitoring of optical power at two different wavelengths in WDM applications; and quality control of splitting ratio in coupler manufacturing, etc.

Because of its alarm feature, the unit can be used in any testing situation where a loss of power requires an immediate and specific response. Alarm thresholds can be defined for each channel. When power levels fall below the set threshold, the unit generates a code that can be interpreted by a computer through the RS-232 interface. A coaxial SMA connector, over which individual alarms pulses also are generated, provides even more flexibility for developing appropriate circuitry for response control. Insidious, gradual and unexplained power drops will no longer go unnoticed. Typical applications for this feature include warning against fiber degradation and detection of tapping.

A flexible storage feature permits the manual logging of readings or the automatic acquisition of data in one of three distinct banks of 512 permanent memory registers. When ready for analysis or printout, results can be downloaded to a personal computer and viewed with the help of the supplied application software.
Reader service #205

The following is a listing of some of the videotapes currently available by mail order through the Society of Cable Television Engineers. The prices listed are for SCTE members only. Nonmembers must add 20% when ordering.

☛ *Basic Electronic Fundamentals in the Analysis of Cable System Powering* — The National Cable Television Institute's Ray Rendoff discusses the fundamental characteristics of AC and DC voltage, AC standby power supplies, coaxial cable and various amplifier configurations that establish overall system powering requirements. Mathematical calculations using Ohm's law are performed on a sample system powering configuration. Typical powering problems and corresponding troubleshooting techniques conclude this technician level program on system powering analysis. (1 hr.) Order #T-1030, $35.

☛ *Category IV Review Course: Distribution Systems* — Category IV Curriculum Committee member Bill Grant presents a five-hour review course on the basics of distribution systems in preparation for technician level certification exams. (5 hrs.) Order #T-1033, $95. **(Reference for BCT/E Category IV)**

☛ *Category II Review Course: Video and Audio Signals and Systems* — Category II Curriculum Committee Chairman Paul Beeman presents an in-depth look into this BCT/E category. Information concerning both technician and engineering level certification exams is presented in this tape. (4 hrs.) Order #T-1034, $95. **(Reference for BCT/E Category II)**

Note: The videotapes are in color and available in the 1/2-inch VHS format only. They are available in stock and will be delivered approximately three weeks after receipt of order with full payment.

Shipping: Videotapes are shipped UPS. No P.O. boxes, please. SCTE pays surface shipping charges within the continental U.S. only. Orders to Canada or Mexico: Please add $5 (U.S.) for each videotape or book. Orders to Europe, Africa, Asia or South America: SCTE will invoice the recipient for additional air or surface shipping charges (please specify)."Rush" orders: a $15 surcharge will be collected on all such orders. The surcharge and air shipping cost can be charged to a Visa or MasterCard.

To order: All orders must be prepaid. Shipping and handling costs are included in the continental U.S. All prices are in U.S. dollars. SCTE accepts MasterCard and Visa. To qualify for SCTE member prices, a valid SCTE identification number is required, or a complete membership application with dues payment must accompany your order. Orders without full and proper payment will be returned. Send orders to: SCTE, 669 Exton Commons, Exton, PA 19341 or fax with credit card information to (610) 363-5898.

Listings of other publications and videotapes available from the SCTE are included in the March 1994 issue of the Society newsletter, "Interval."

Our ad agency said,

"too much text". But this is really important stuff!

The new Model 1205 is the ultimate TDR ... GUARANTEED! With new features and simplified "no menu" operation, the Model 1205 Time Domain Reflectometer, Cable Fault Locator is fast becoming the new standard in waveform TDRs. Take a look at just two of the exclusive Riser-Bond Instruments' features.

SUPER-STORE WAVEFORM DATA STORAGE

SUPER-STORE provides storage of the entire cable under test. Both on-screen and off-screen waveform information is stored. You can move the cursors, change the VOP, and increase the gain of the stored waveform as though you were still at the cable site. You can even correct errors! SUPER-STORE provides up to 1500 times more storage information than any other competitive TDR. It is like comparing a snapshot to a full screen movie!

WAVE-VIEW PC SOFTWARE

Unlike any other TDR, Model 1205 comes complete with WAVE-VIEW software, turning your PC into a virtual TDR. All instrument keys and settings are shown on-screen allowing you to manipulate the waveform. Upload stored waveforms for unlimited storage and provide TDR training right on your PC. You can even modem waveforms to another location. **Try that with any other TDR!**

AND MORE...

Model 1205 also features exclusive independent cursors for measuring between any two points, AUTO-SEARCH which automatically places the cursors, multi-function noise filtering, and automatic fault severity calculation. **Know the facts before you buy your next TDR.**

800-688-TDRs
402-466-0933
Fax: 402-466-0967

Riser Bond
INSTRUMENTS

Reader Service Number 103

January

4-6: Society of Cable Television Engineers Emerging Technologies conference, Stouffer Orlando Resort, Orlando, FL. Contact SCTE national headquarters, (610) 363-6888.

9-12: Siecor training course, fiber-optic installation and splicing, maintenance and restoration for CATV applications, Hickory, NC. Contact (800) 743-2671, ext. 5539 or 5560.

10: SCTE Cascade Range Chapter seminar. Contact Cynthia Stokes, (503) 230-2099.

10: SCTE Central Indiana Chapter testing session, BCT/E and Installer exams to be administered, Connersville, IN. Contact Gordie McMillen, (317) 353-2225.

10: Scientific-Atlanta training course, fundamentals of the hybrid fiber/coax network, San Francisco. Contact Bill Brobst, (404) 903-6306.

10: SCTE Penn-Ohio Chapter testing session, Installer exams to be administered, Pittsburgh. Contact Marianne McClain, (412) 531-5710.

10: SCTE Pocono Mountain Chapter seminar, safety, Holiday Inn, Hazleton, PA. Contact Anthony Brophy, (717) 462-1911.

10-12: SCTE Wheat State Chapter testing session, BCT/E exams to be administered, Wichita, KS. Contact Jim Fronk, (316) 792-2574.

11: SCTE South Jersey Chapter seminar, fiber management, splicing and restoration, distribution systems, design and optic network solutions, Ramada Inn, Vineland, NJ. Contact Mike Pieson, (609) 967-3011.

11-12: Scientific-Atlanta training course, hybrid fiber/coax field test and measurement, San Francisco. Contact Bill Brobst, (404) 903-6306.

11-13: The Light Brigade fiber optics training course, working with single-mode fiber, Kent, WA. Contact Valerie Johnsen, (206) 251-1240.

12: SCTE Gateway Chapter seminar, video test measurements, Overland Community Center, St. Louis. Contact Duane Johnson, (314) 272-2020.

12: SCTE Lake Michigan Chapter testing session, BCT/E and Installer exams to be administered, Morley, MI. Contact Brad Baumann, (313) 243-9426.

12: SCTE Mid-South Chapter testing session, BCT/E exams to be administered, Memphis Cablevision office, Memphis, TN. Contact Keith Bell, (901) 365-1770, ext. 4108.

14: SCTE Cascade Range Chapter testing session, BCT/E exams to be administered, Portland, OR. Contact Cynthia Welsh, (503) 667-9390.

Planning ahead

Feb. 22-24: Texas Cable Show, San Antonio, TX. Contact (512) 474-2082.

Mar. 20-21: Ohio Cable Television Association convention, Columbus, OH. Contact (614) 461-4014.

May 7-10: The National Show, Dallas. Contact (202) 775-3669.

June 14-17: Society of Cable Television Engineers Cable-Tec Expo, Las Vegas, NV. Contact (317) 845-8100.

THE SCTE VIDEO STORE Presents *TV: Your Primary Diagnostic Instrument*

Since SCTE began providing video training tapes to its members, the tape entitled *Diagnosing Common Cable Faults* (catalog # T-1001) has consistently been the Society's most widely-requested program. Since it was produced over 15 years ago, it could not demonstrate many of the picture impairments found in modern cable TV systems.

Although SCTE recognized that this tape was no longer current, the problems of arranging for laboratory facilities to isolate and demonstrate the various impairments was difficult, especially when you consider that baseband video impairments would also have to be included.

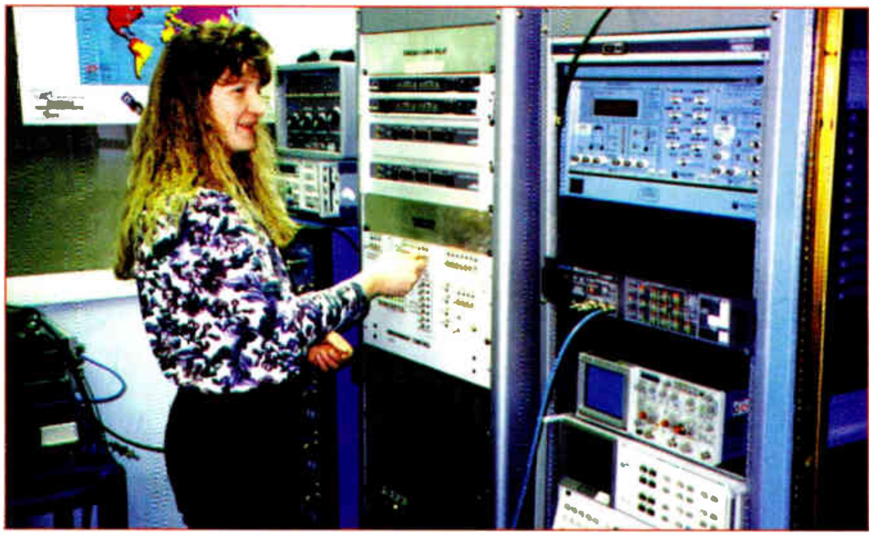
The new T-1001A, *TV Your Primary Diagnostic Instrument*, was introduced in SCTE's latest videotape and publication list. Since we expect this tape to become the most popular SCTE videotape of all time, making it the new "flagship" of the SCTE library, we chose to retain part of the old tape's number so it would be placed first in the new listing.

T-1001A clearly demonstrates the picture impairments found in modern cable TV systems by providing comparisons to unimpaired pictures, both before/after and split screens. It also discusses how to differentiate between the various impairments and the possible causes.

Impairments covered include: carrier-to-noise ratio, composite triple beat, low signal, excessive signal, hum, impulse noise, ghosting (reflective and ingress/direct pick-up), cross-modulation and terrestrial interference.

Video impairments include: chroma/luma delay, low video modulation, excessive modulation and differential phase. Differential gain is discussed but not demonstrated, because it seldom appears by itself, and when isolated is difficult to see in a TV picture.

When we set out to produce this program, we wanted to develop a presentation that would be a primary reference tool. We hoped that it would enable technical personnel, both distribution and headend techs, to more accurately diagnose system problems. In addition, we wanted the illustrations to be a valuable training tool for customer service representatives, helping them better advise their technical departments of potential system problems. We believe that we accomplished both goals.



Patty Wood of General Instrument adjusts a phase noise generator during the production of the Society's "Diagnosing Common Cable Faults" videotape.

The production of T-1001A took approximately one year. Impairments were recorded on digital tape and mastered on 1-inch videotape. Every effort was made to maintain the highest quality, including having the VTRs go through a textbook alignment by manufacturer-trained personnel.

The development of this program truly was a "broadband" effort. It was produced with the participation of personnel from General Instrument's Jerrold division, Hewlett-Packard CaLan, Jones Intercable, Malarkey-Taylor, Hickory Mountain Associates, Boettcher Video Services, Innovative Marketing and the SCTE national headquarters staff.

Since our intent was to develop a reference tape, and some of the low-level impairments can be difficult to see, we chose to distribute the tape on higher formats only. Copies in the 3/4-inch format have been produced directly from the edited master. In this way, we minimize the effect of compound tape distortions contaminating the impairments being demonstrated.

Due to the rapid acceptance of this program as a training tool for customer service representatives, we have decided to also offer the tape in the VHS format. We do not recommend, however, that VHS copies be used by engineering and technical personnel. Every system engineering department should have an original 3/4-inch submaster copy for reference.

This 40-minute videotape is available in the 3/4" format for $59. VHS copies are $45. Please specify your preferred format when ordering.

To order: All orders must be prepaid. Shipping and handling costs are included in the continental U.S. All prices are in U.S. dollars. SCTE accepts MasterCard and Visa. Prices listed are SCTE member prices. Nonmembers please add 20%. To qualify for SCTE member prices, a valid SCTE identification number is required, or a completed membership application with dues payment must accompany your order. Orders without full and proper payment will be returned. Videotapes are shipped UPS. No post office boxes, please. A $15 surcharge will be collected on "rush" orders.

Send orders to: SCTE, 669 Exton Commons, Exton, PA 19341 or fax with credit card information to (610) 363-5898.

Reader Service Number 1

Fibering the superhighway

This month our fiber expert answers questions on fiber's role in the much-touted information superhighway.

By Don C. Vassel
Senior Applications Engineer, Corning Inc.

How and when will futuristic, high-speed networks be utilized?

Tomorrow's regionally interconnected high-speed network will provide a broad range of applications, including video-on-demand (VOD), high-speed data, telephony, distance learning, telecommuting and other services that potentially could become high revenue producers. For a regionally interconnected network to provide the platform for new business opportunities, the network infrastructure must have the capacity to accommodate anticipated service requirements.

Today, many communications systems operate at 2.4 gigabits per second (Gbps). However, industry analysts and future trends suggest that 10 Gbps systems will begin to appear over the next few years. Future cable TV networks will require a network infrastructure to support the handoff of regional voice traffic to the public switched telephone network or long distance carrier. In another example, assume you have a master headend that services an entire regional network. To accommodate VOD for just 5% of a regional network serving 50,000 subscribers, 2,500 simultaneous video streams of data are needed. Each video stream requires a 4 Mbps MPEG-2 format (Motion Picture Experts Group compressed video technology). Multiply 4 Mbps by 2,500 video streams and you come out with 10 Gbps — the capacity a cable TV system may need for tomorrow's applications.

> **"Industry analysts and future trends suggest that 10 Gbps systems will begin to appear over the next few years."**

Future cable TV networks most likely will resemble the broadband integrated services digital network (BISDN) model. BISDN is a layered architecture that describes the protocol to be used in tomorrow's communications systems. The key technologies that will build this network are MPEG-compressed video, asynchronous transfer mode (ATM) and synchronous optical network (SONET). Although these technologies are in varying stages of development, they set the stage for processing high bandwidth applications over a high-capacity optical network.

What impact will digital communications have on cable TV system architectures in building the information superhighway?

Many future cable TV systems most likely will consist of digital networks that will provide video, voice and data transmission over large regionally interconnected networks. These systems will require data rates of millions to billions of bits per second over long distance optical networks. Moving forward, the biggest challenge for cable TV operators lies in provisioning their networks to accommodate these future services.

At 1,550 nm, the optimal attenuation performance is less than 0.25 dB/km for both standard single-mode and dispersion-shifted fiber, thereby allowing cable TV operators to design longer link spans. Taking advantage of several key component technologies, such as erbium-doped fiber amplifiers (EDFAs) operating within the 1,550 nm window, will assist in the development of high bit-rate systems. This also will facilitate the design of longer fiber runs without regeneration.

To maximize the benefits of these component technologies in the 1,550 nm window, cable TV operators should consider the attributes of standard single-mode fiber vs. dispersion-shifted fiber. For high bit-rate systems operating in the 1,550 nm window utilizing already installed standard single-mode fiber, dispersion is a limiting factor. In order to design these systems to accommodate high bit rates over long distances, cable TV engineers must consider other techniques to offset dispersion, such as dispersion-compensating fiber.

However, dispersion-shifted fiber, which combines low dispersion and low attenuation in the 1,550 nm window, provides an efficient design solution for these large, regionally interconnected high bit-rate systems. Because of lower dispersion, optical signals can go greater distances over dispersion-shifted fiber compared to standard single-mode fiber.

Overall, component technologies and high-capacity fiber are some of the options cable TV engineers may want to consider when building high-speed digital communications systems on the information highway. **CT**

Look for your election pack in mail

By William Riker
President, Society of Cable Television Engineers

Once again, we are approaching the annual board of directors election and I would like to take this opportunity to express my appreciation to our 1994 board for dedication and involvement in overseeing the activities of the Society. It has been a very busy year, and one of great growth in every area of the Society. Membership increased, our training and certification programs are at their highest enrollment ever, we are making great progress with standards setting subcommittees, enjoyed the largest Expo to date and saw steady support at local chapters.

The past year has been one of planning for the future and the board has laid the groundwork for many new initiatives to improve and expand the Society's programs and services. As a result, the incoming board is facing a challenging year, and we are more than pleased with the spirit of involvement and anticipation that this year's candidates are bringing to the election process.

Running for the at-large positions (two open seats this year), representing the entire United States, are Wendell Bailey of the National Cable Television Association; Bill Karnes of ISC DataCom Inc.; Don Shackelford of Time Warner; and Wendell Woody of Sprint. Running for Region 1, representing the states of California, Hawaii and Nevada, are Kathy Horst of Main Line Equipment and Patrick O'Hare of Viacom Cable. Region 2 covers the states of Arizona, Colorado, New Mexico, Utah and Wyoming and the candidates are Ron Hranac of Coaxial International and Steve Johnson of Time Warner. Candidates for Region 6, representing Minnesota, North Dakota and Wisconsin, are Richard Henkemeyer of ADC Telecommunications and Robert Schaeffer of Star Cablevision. Region 9 candidates, representing the states of Florida, Georgia and South Carolina, are Hugh McCarley of Cox Cable and David Spallinger. Running for Region 11, representing Delaware, Maryland, New Jersey and Pennsylvania are Gene Coll of Diamond Communication Products, Bernie Czarnecki of Cablemaster's Corp. and Dennis Quinter of Time Warner.

Society name change

Included with the election package will be a proposal to change the name of the Society. For 25 years, the Society of Cable Television Engineers has maintained its goal to serve the "broadband industry's technical community." We are currently seeing that broadband industry evolve and rapidly expand as more and more applications are found for our technology. Accordingly, as the Society continues to serve the technical community and promote the sharing of operational and technical knowledge, our future membership also will expand to include these developing businesses and new technologies. The diverse groups now becoming involved in broadband communications are being described as the new "telecommunications" industry. In the interest of maintaining an accurate representation of our evolving membership, our industry and our overall purpose, the board of directors has voted to recommend that the name of the Society be changed to the: Society of Cable Telecommunications Engineers. This recommendation is the result of research conducted over the past 10 months since a name change was initially discussed by the planning committee at the '94 Texas Show. Subsequent research included questionnaires to the membership via the *Interval* and Cable-Tec Expo registration packages, plus and open meeting of the planning committee held at Expo to discuss the proposed name change.

Strengthening the proposal was the result of a second SWOT analysis (analyzing the Society's strengths, weaknesses, opportunities and threats) held in April 1994. Of the final recommendations from that group, the first and foremost recommendation was changing the name of the Society to reflect changes in the broadband environment.

In addition, the proposal has been discussed with SCTE's attorney, the publisher of *Communications Technology* (our official trade journal), and groups of members at local chapter meetings and other gatherings.

We are not the only ones to recognize the changes in the industry and to take steps to incorporate those changes in our outreach. The former Community Antenna Television Association is now the Cable Telecommunications Association. Effective Jan. 1, 1995, Women in Cable became Women in Cable & Telecommunications. At the state level, the Pennsylvania Cable Television Association is in the process of finalizing a name change to the Pennsylvania Cable & Telecommunications Association. Industrywide, organizations are adjusting to the technological developments and the participants represented.

The culmination of the analysis was a recommendation by the planning committee to the board of directors at the Nov. 29, 1994, meeting in Anaheim, CA, in favor of changing the name of the Society to the Society of Telecommunications Engineers. The board in turn voted to recommend to the membership an amendment of the national bylaws to reflect the name change.

It is in our interest as a society to progress in the same manner that our industry has, incorporating the new with the old to maintain our relevancy in the evolving telecommunications community. This name change reflects our desire to represent the entire technical community and demonstrates our participation and leadership in the changes taking place. As the premiere training resource for the industry, we are in the position to provided the education new participants are looking for, as well as incorporate their input for the continued education of our current membership. Additionally, our standards setting efforts will become even more critical as the innovative ideas of today become the standard operations of tomorrow.

Election packages with ballots for the name change as well as open seats on the SCTE board will be mailed to all active national members this month.

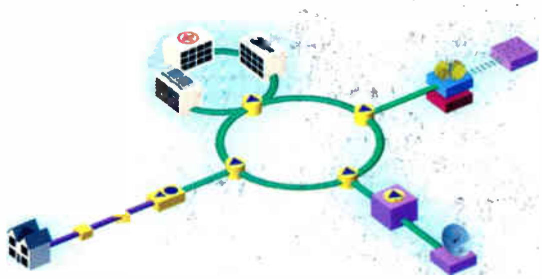
I urge you to exercise your ability to guide the future of the Society — VOTE! **CT**

The System That's Certain...For a Future That Isn't.

Digital is a reality. Chances are, you're passing these signals through your network today, in the form of digital services. If you're like most broadband providers, you've already discovered the digital limitations of your drop – and so have some of your subscribers.

ANTEC's Integrated Drop System® (IDS) is your solution for today...that also prepares your network for the interactive digital services of tomorrow. IDS drops are thoroughly tested in a QPSK digital format for carrier-to-noise ratios, microreflections and EMI shielding. IDS can put an end to service interruptions by ensuring quality analog and digital transmissions, up to 1 GHz.

Ensure your pipeline to the home can deliver today's and tomorrow's services – call your local ANTEC consultant to learn more about the benefits of IDS.



Our Cable Integrated Services Network (CISN) provides a "blueprint" for building a broadband network that accommodates interactive services in a 1 GHz spectrum. IDS provides the solution to the final, critical link of the broadband network, the subscriber drop.

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