COMMUNICATIONS TECHNOLOGY
Official trade journal of the Society of Cable Television Engineers

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John Malone

CT's 1993 Service in Technology Award recipient

- Byting into digital's promise
- The marrying of cable and PCS
- Back to basics with tech training

April 1993

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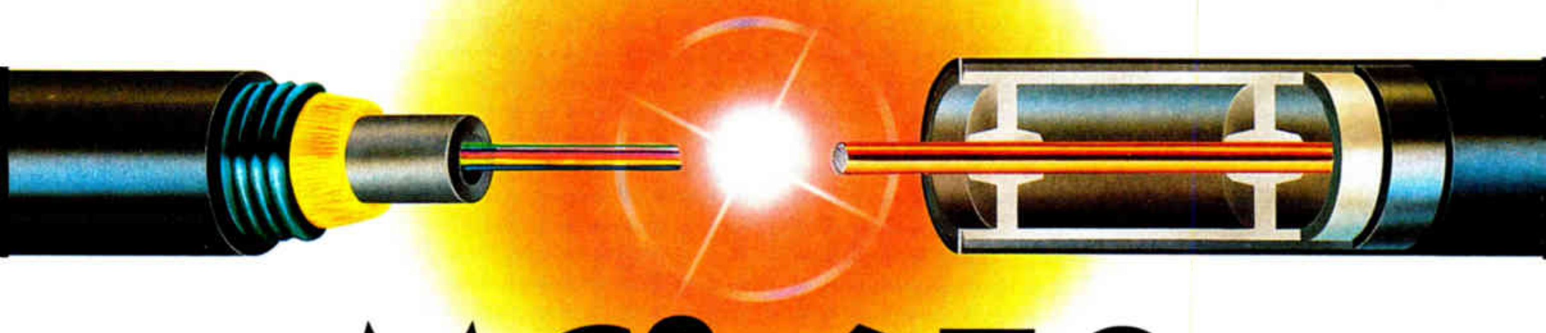

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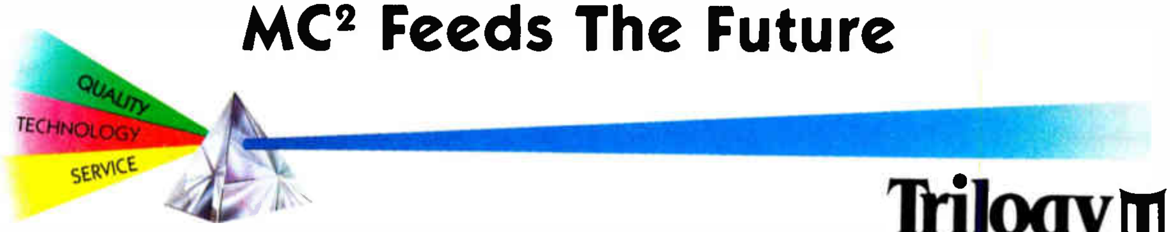

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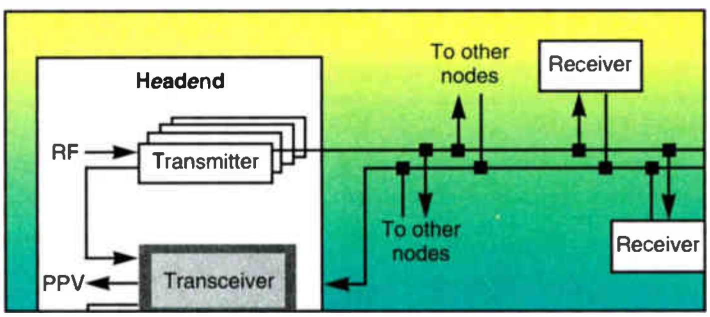

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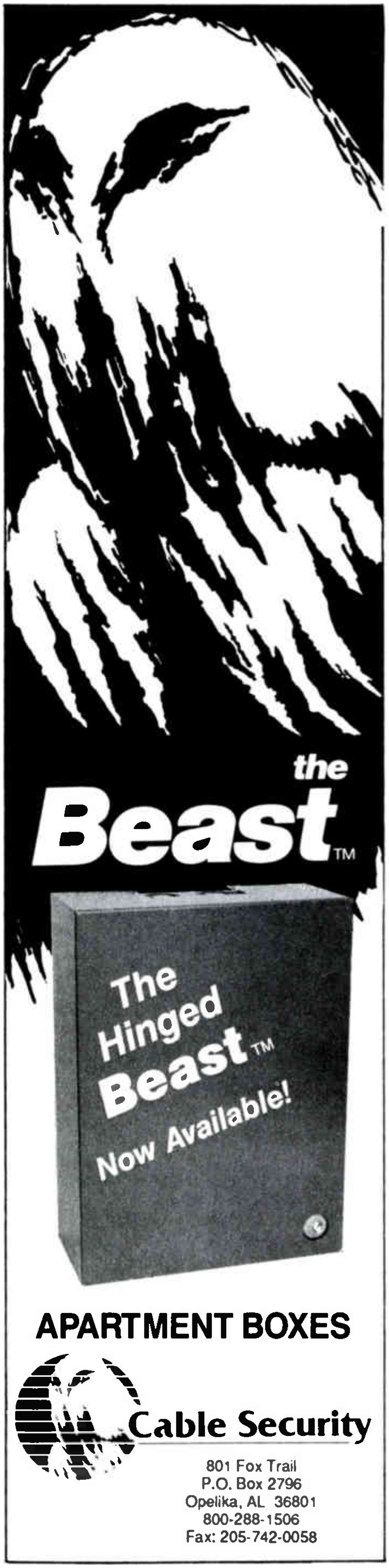

EDITOR'S LETTER

Farewell ... sort of

This month marks the end of my term as the Society of Cable Television Engineers chairman, as well as my tenure on the board of directors. I thought this issue's "Editor's Letter" would be a suitable forum to say a few words about my past six years serving the Society's membership, which now numbers in excess of 10,000 and represents 44 countries.

Almost seven years ago, then Region 2 Director Sally Kinsman approached me to consider running to replace her on the board, since she would soon be moving to the Pacific Northwest. At the time, I thought my chances of becoming a national board member were pretty slim, but gave it a shot. I want to personally thank the members of Region 2 for your support and encouragement since then!

During my three terms as a regional director, I've been truly honored to serve you, the national membership of SCTE. For a variety of reasons, my board duties have gone far beyond the boundaries that comprise the five-state Region 2. It's also been a pleasure to serve with the other industry professionals on the Society's national staff. In particular, they have been responsible for the day-to-day operation of our organization, as well as implementing the policies established by the board. My hat will always remain off to them, for they have perhaps the most difficult job of all. Many thanks for a job well done!

It's a good feeling to look back at the incredible growth of SCTE, and to have been part of the Society's progress. We can all be proud of the changes that have occurred, because without the support of you, the membership, none of this would have happened. Consider that today we truly live up to our mission statement — "training, certification, standards." But all of this progress is merely the foundation for our future.

Cable TV has become a global industry and it's one that is evolving at a blinding pace. New architectures are changing our core business and new technology challenges each of us daily. SCTE is now recognized as the clearinghouse for cable's continued evolution, working in conjunction with other organizations such as Cable Television Laboratories and the National Cable Television Association. What we as a Society do today paves the road of cable's next 20 years. I encourage all of you to take an active role in that future.

Kudos to Malone

Once each year, the editors and staff of *Communications Technology* recognize an individual, individuals or organization for vision and innovative leadership that have made a significant contribution to cable communications with our Service in Technology Award. Please join me in congratulating TCI's Dr. John Malone, the 1993 recipient of this distinguished honor. Details can be found in the section following page 98.

Ronald J. Hranac
Senior Technical Editor

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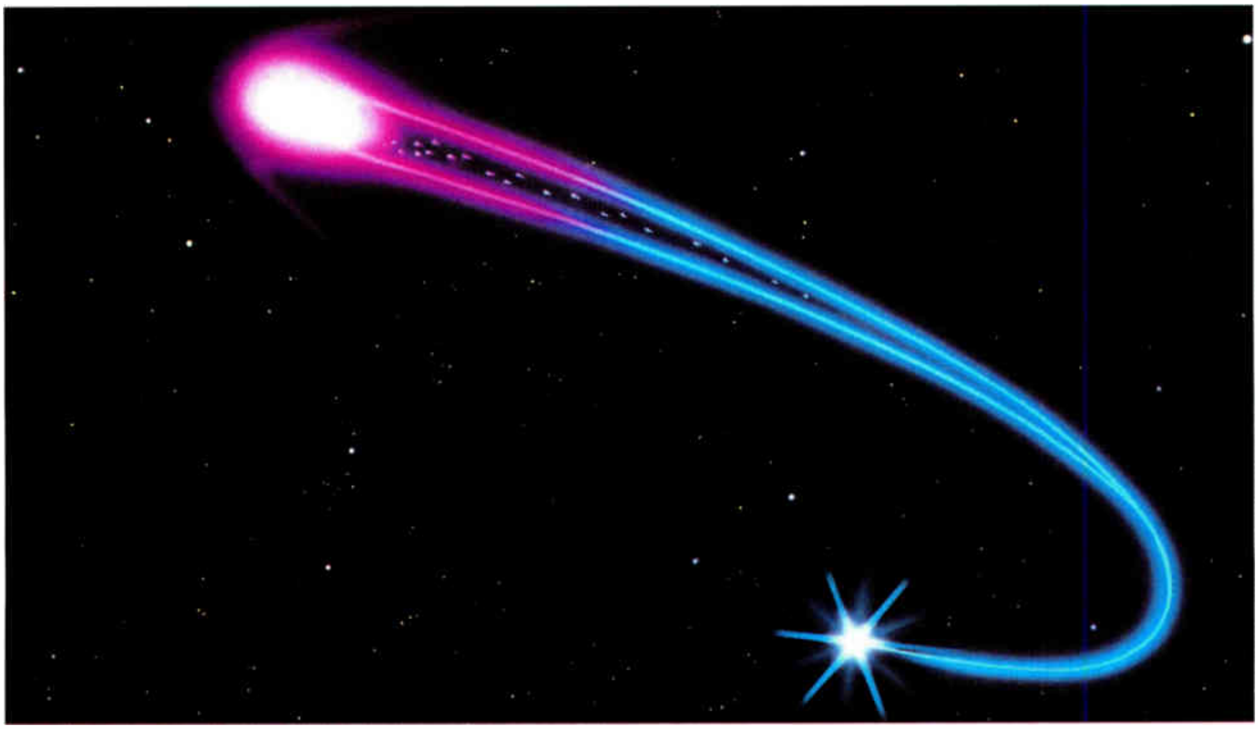

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No knives for installations?

I found Pam Nobles' September 1992 article in Communications Technology "F-connectors revisited" extremely informative. However, I was completely taken back by her recommended installation procedures. Installing standard F-connectors by using a knife to cut off 3/8-inch of jacket, is a poor choice when there are several low-cost stripping tools available to safely do this task.

The use of any knife for cable preparation should be discouraged. Let's talk safety and speed — it all adds up to economics. Uniform cable preparation, less preparation time and virtual elimination of accidental cutting of fingers or worse, translates to a better product and adds to the bottom line.

Chris Haelsen
Systems Manager
Capwell Components Co.

Author's response: Thanks for voicing your concern regarding the use of knives vs. preparation tools. I understand that there are numerous noteworthy prep tools available, and that there may be inherent problems with using these tools.

Cable systems may have more than one type of connector — or an installation contractor may have access to a variety of connectors and cables. In this case, the wrong prep tool may be used, and the problem not discovered until a service call is needed. Prep tools more often score the center conductor than do knives. Experienced installers and techs are just as safe and quick as their prep tool yielding counterparts. And a knife user will tell you there's a certain "feel" that cannot be accomplished with a prep tool.

Using prep tools vs. knives I feel basically comes down to experience, preference and the proper training. I have no problem with prep tools (remember the article illustrated both prep tool and knife) — as long as they are used correctly and for the correct cable.

Cover comment

Ouch! We have just spent a long year trying to convince our congressman that we aren't monopolies in need of regulation. We are still smarting from the cable bill, when I get my October 1992 *CT* and see my technical choices on a Monopoly board! I would suggest that a more likely game board would be checkers where we can deliberately make choices among several different moves, even jumping over some. I prefer this rather than rolling the dice to move one way around the same path for all players. Go directly to jail and don't pass go.

Otherwise, thanks for a great journal.

Daniel V. Liberatore
Vice President/Engineering
Adelphia Communications

→

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DX ANTENNA

Reader Service Number 19

Reconsidering gel batteries' role

This letter is in response to the February 1993 article in *Communications Technology* "Outage management, Part 3: Plant powering in cable TV systems."

Battery technology has not changed much in the last century. I truly realized this while attending an electric vehicle rally in Southern California recently. At this rally was an electric car that was built in 1933 and much to the chagrin of those battery people on the so-called "cutting edge," this car performed in a very satisfactory manner.

The cable TV industry has something in common with that old electric car. Both use battery technology that is 60 years old and the only difference may be the overall satisfaction of performance.

In the article I read that gel batteries can and should be used in all climates and environments and absorbed glass material (AGM) should be used in controlled environments and colder climates only.

I prefer to take a more moderate position and say, why not take advantage of both of these technologies?

Gel technology has been available for over 50 years and the benefit it brings to the cable market is its ability to "stay wet" and not dry out. The biggest enemy we face in this market, in regard to batteries, is heat, dehydration and inevitable battery failure.

However, the downside to gel batteries is that when gel dries around the battery plates, fissures or cracks are formed and effective electrical conductivity is reduced. AGM batteries have a tendency to dry out on "top," so to speak, but deal more effectively with the internal conductivity problem because the AGM technology is essentially a sponge filled with the liquid acid. This allows the battery plates to be immersed in acid, keeping electrical conductivity high.

To say that one technology is applicable in all climates and situations seems to be a broad stroke statement. And at first I thought it to be a self-serving statement to the gel technology, but after consideration I have come to the following conclusions.

The first is that, while cable TV may be considered by many to be a large market, the manufacturers of batteries for this market may not share that view and it may represent a very small market to them. If that is the case, it might be that the cable batteries they sell are designed for a larger automotive market and the cable industry is an afterthought. Therefore, you can only recommend what is available.

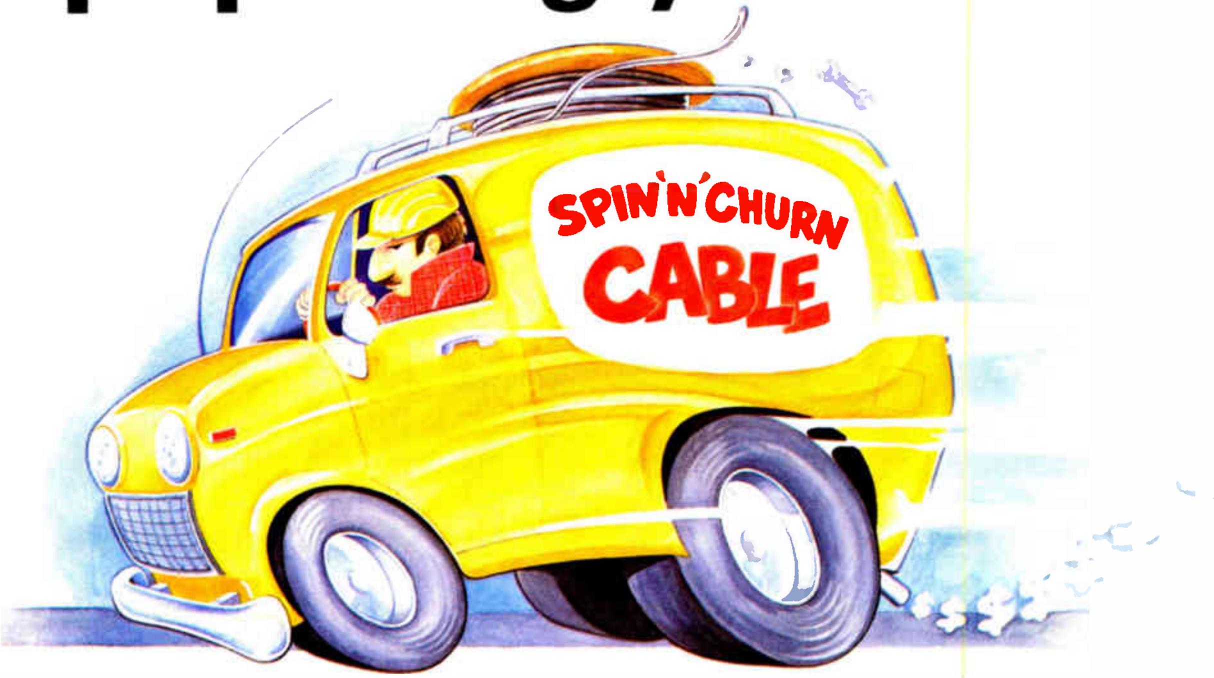
My other conclusion is that battery manufacturers have not done enough to meet the needs of the cable industry and should institute more dialogue with the end users and the power equipment manufacturers in regard to performance and design needs.

We simply need more imagination and commitment from everyone involved in this area of the cable business.

That old electric car may be able to function just fine with dated technology but I don't think that the cable industry can — not with the competitive-, regulatory- and performance-driven environment of the future.

Ed Parker
Teledyne Battery Products

Stop spinning your wheels!



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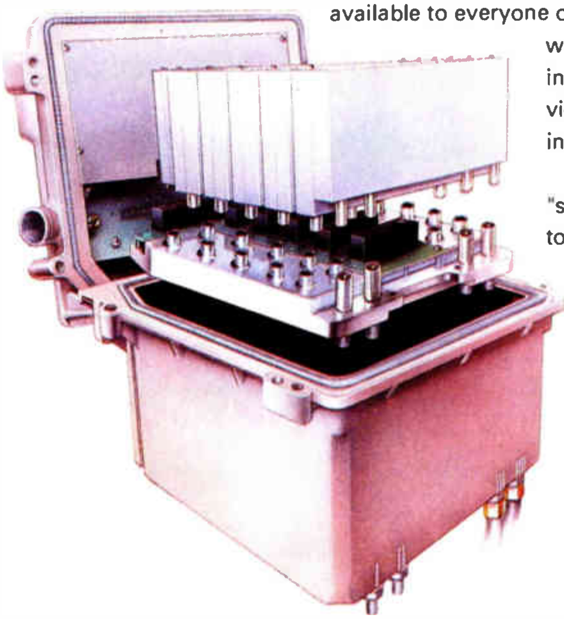

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OFC '93: The fiber in CATV focus

SAN JOSE, CA — Over 3,200 people attended the Optical Fiber Conference 1993 held here. The thrust of the conference seemed to be on the academic side, with most of the presentations focusing on the theoretical issues associated with fiber optics. There also was considerable interest in how fiber-optic networks are and could be deployed in cable TV networks.

Corning announced that the American market for fiber in 1992 grew at a phenomenal rate to 5 million km. The cable industry alone grew 100% in 1992 to 9% of the American market or 450,000 km. Corning expects the deployment of fiber by cable companies to grow by another 50% in 1993.

"Software is the compelling application that we will need to get consumers to throw money at the latest generation of video technology," argued Gary Kim, a Denver, CO-based consultant with Probe research. In a presentation entitled "Multimedia Platforms: How Much, How Soon?" Kim explained that the cable companies have been experimenting with interactive services since the early 1980s. However, the hardware capabilities and the technical capabilities were not yet here then for new services to really take off.

Now after nearly a decade of ATM machines and VCRs, consumers are finally ready and willing to pay for a technology that requires them to push buttons to achieve some result. Kim said that cable operators are now spending $100 to $135 for new set-top boxes to achieve a revenue stream of $30 a month. For operators to be willing to spend double or triple that on the latest generation of electronic wizardry, they will have to find a way to double or triple their income.

Kim believes that may be possible through video-on-demand (VOD) technologies. He estimates that if video rental outfits could continuously stock the 10 most popular videos, consumers would rent them 80% of the time. As it is, they run out, so they only account for 30-40% of all the volume at places like Blockbusters.

Currently the video rental industry generates more income than the cable industry. An investment to upgrade the cable network for VOD for the top 10 hits, could skim 50-80% of the video rental business for a cable operator.

Aleksander Futro, director of technology assessment at Cable Television Laboratories in Boulder, CO, gave a talk on the future of optical components for cable TV requirements. He stated that interactive service providers will need standards and common hardware approaches to ensure interactivity within the networks.

Although much current generation cable equipment has a maximum capacity of 750 MHz, there is no reason why we cannot go to 2 GHz using emerging technologies. "Before we were looking at fiber-to-the-headend," Futro said. "Today we are looking at fiber-to-the-hub, fiber-to-the-node and fiber-to-the-home."

Speaking to an audience consisting of fiber-optic component manufacturers, Futro bragged about the way in which the cable companies are able to supply more services using less fiber and fewer lasers than other industries, "If you use fiber our way, there are not many miles that need to be run, or lasers to be put in. If you deliver better lasers we will need fewer. But you would rather deliver more lasers per home. That is what cranks your cash register."

More powerful lasers mean longer links and more links at lower costs. Futro believes that we will soon have 20 mW DFB lasers for under $10,000. But Futro emphasized there is no reason why DFB lasers will not be challenged by more cost-effective microchip lasers.

Futro believes that there is no need for the deployment of optical amplifiers in the local loop today. However, at a separate discussion, experts from all over the world argued that optical amps will soon allow cable operators to improve services, reliability and flexibility with a minimum of cost. Most of the excitement is based on the development of erbium-doped fiber amps, which only operate in the 1,550 nm range.

Kwang Koai, a researcher at GTE Laboratories in Waltham, MA, did a "what-if" analysis on a wide area network that uses erbium-doped optical amps throughout two central rings to bring multimedia services to a large area at up to 10 Gb/s.

All-optical networks have been under development in long-haul, point-to-point networks for some time. However, no one is using them in a terrestrial network that contains multiple nodes. Koai believes that eventually such networks could provide improved reliability, flexibility and an easy way of upgrading to new technologies. Part of the beauty of an all-optical network, is that none of the optical components need to be switched out in order for new technologies to be deployed within the network.

The costs of optical amplifiers make them impractical today, but they will continue to plummet in price. Beyond cost, Koai cited three limitations to the development of such an all-optical network: signal-to-noise ratio, dispersion and nonlinear effects. The problem with having an all-optical network is that amplifiers tend to spontaneously emit noise. Koai said this could be minimized by having a continuous laser operating in the background to remove the excess energy from the amplifiers.

Another problem is that the fiber in the ground today has a tendency to disperse the light at 1,550 nm — which is required to take advantage of erbium-doped optical amps. Without installing special fiber, Koai's 10 Gb/s backbone would not be capable of propagating more than 100 km.

A third problem is that over distances, nonlinearities in the optical fiber tend to distort the optical pulses as they travel down the fiber. Koai said that these could be minimized over several thousand kilometers by keeping the power into the network down.

Tingyi Li, a researcher at AT&T Bell Labs in Holmdel, NJ, argued that erbium amps will allow cable operators to move to wavelength division multiplexing (WDM) to boost capacity incrementally. "Since 1980 we have been increasing network capacity by increasing the speed of the components. Now that we can use amplifiers, it makes sense to increase the number of channels to increase the aggregate capacity."

The problem with the electronic regenerators now used in fiber systems is that each one can only regenerate a single wavelength of light. So if a system has multiple wavelengths, each repeater station requires a separate regenerator for each wavelength. Amplifiers on the other hand can amplify every wavelength of light independently of one another. Amplifiers would make it possible to add several different wavelengths on top of one another, with the only incremental cost being the transmitter at the headend and each of the receivers. Li believes that 10 separate wavelengths could easily fit into the amplifier's bandwidth of operation.

Li said there are several rewards to be had in going to WDM systems. For starters it would enable operators to perform capacity enhancements of over 50 times — up to 100 Gb/s — throughout the life of the system, without switching over the internal components. It would enable mixed signal formatting — some signals might be analog while others would be digital within a single fiber. The initial cost for a system could be low, and the system could be incrementally upgraded as demand grows for new capacity. Not only that, but optical amps' high reliability would lower the cost of operating and maintaining the network.

Although erbium amps are the most-developed at the moment, others are working on ones in the 1,300 nm window, which are still only in the experimental phase. David Smith, a researcher at BT Labs in England, believes that praseodymium-doped amps could provide an easy upgrade path for existing 1,310 nm networks. BT for example has over 2 million km of 1,310 nm fiber in the ground.

Smith said that fiber amps are the future because they lead to higher splitting ratios and hence, lower laser costs. The real question is whether we can do amplification at 1,310 nm. He believes that praseodymium amps are in the same place erbium ones were three years ago, and could become commercially available in three years. (See "Correspondent's Report," *CT*, 5/92, for more on the status of 1,310 nm amps.)

The next generation of fiber-optic networks may use solitons as carriers, argued Linn Mollenaur. Solitons are a technique for coding laser pulses, which enable the pulses to hold their shape over incredibly long distances. Mollenaur recently succeeded in sending data at 17 Gb/s over 20,000 km using solitons.

Mollenaur believes that once the technology has been deployed in long-haul submarine fiber systems in 1997, the research costs will have been absorbed. After that, they will be as cheap as any other technology and they will provide a low-cost way of providing extremely high bit rates. He believes that operators will begin deploying solitons in commercial networks as early as 1998. (For more on solitons, see "Correspondent's Report," 8/92.)

Ed Callahan, vice president of technology at ANTEC in Englewood, CO, believes that we need to look at the development of the next generation of networks as a springboard for new services. He said, "As we identify new revenue streams, it will drive the interest to put these networks in place. There is an expense saving in not having to rebalance each time a new service is rolled out."

The new technologies will initially increase capital expenses. TCI, for example has announced it is doubling its annual capital expenditures to almost $800 million. The next generation of technology based on fiber has clear economic advantages, argues Callahan. "We don't think this requires a leap of faith. If we deploy 1 GHz networks to 500-home nodes, we wind up with improved core products and improved operational economies."

Japan is getting serious about the deployment of fiber-to-the-home, noted Tetuhiko Ikegami, deputy director senior manager with NTT in Japan. "Fiber-to-the-home is very strong but steady," he noted. By the year 2015 all houses in Japan will be connected by fiber. By 1995, consumers will begin receiving video at 1.5 Mb/s. By 1998, consumer will begin tapping into 155 Mb/s links that carry multiple channels of video and other data.

The message of OFC '93 seemed to be that fiber is here today, and getting cheaper and more powerful every day. The question it leaves cable operators with is whether or not they should deploy it today, or wait until the price goes down. But that may be too late as the next generation of satellite services like Hughes' DirecTv (see "Correspondent's Report," 2/93) comes into play. — *George Lawton*

US West to build mass video network

DENVER — US West Communications recently took the first step toward building a new combined video and voice communications network for residential and business customers. According to US West, the new network ultimately will make it as easy to dial up video programs as it is to place a phone call today.

President and CEO Gary Ames of US West said to the best of the company's knowledge, US West is the first telecommunications company in the U.S. to formally commit to building the infrastructure needed to bring video-on-demand and other video-based services to mainstream customers.

"We look forward to continuing to work cooperatively with cable TV operators within our region," said Ames. He was referring to the fact that in addition to traditional voice and data telecommunications services, US

West will use the new network to offer video dialtone service to anyone who wants to use it — including companies that operate existing cable TV franchises.

US West issued a request for proposals to traditional and non-traditional network equipment suppliers to submit bids for the components of a broadband telecommunications network capable of provided video, data and voice communications service. The network will carry these multimedia signals over a mix of optical fiber, coaxial cable and copper wire. The proposals were due by March 23 and US West expects to award one or more contracts by this summer.

Suppliers report fiscal results

Several hardware suppliers reported financial results recently.

Augat reported for the year ended Dec. 31, 1992, its net income was $6.6 million, or 36 cents/share, compared with a net loss of $22 million, which included a pretax restructuring charge of $22 million, or a loss of $1.21/share for 1991.

For the nine months ended Nov. 28, 1992, sales at California Amplifier were $25.4 million compared to $13.7 million for the same period of the prior year. This reflects an increase of 85%.

C-COR reported a net income of $739,000 on sales of $13,165,000 for the second quarter ended Dec. 25, 1992, compared to $271,000 and $11,067,000, respectively, for the second quarter of the previous year.

Scientific-Atlanta reported sales for the second quarter ended Jan. 1, 1993, were $186.6 million, up 40% from last year's $133.5 million. Net earnings were $1.4 million compared to $2.2 million in the same quarter a year ago. Although S-A sales were at a record level, net earnings were affected by higher than anticipated launch costs associated with its digital video compression product line.

Texscan reported a net loss for the fiscal second quarter ended Oct. 31, 1992, of $4.2 million on a revenue of $9.8 million compared to a profit of $109,000 on revenue of $10.3 million for the prior year's period. The loss includes a one-time charge for restructuring including the consolidation of the company's North American CATV operations presently headquartered in El Paso, TX, into its manufacturing facility in Juarez, Mexico.

Oak Industries' net income was $4.3 million or 5 cents per share for the fourth quarter ended Dec. 31, 1992. This compares with net income of $2.3 million or 3 cents per share for the same period of 1991. The 1992 fourth quarter net income included a non-recurring gain of $2.7 million relating to the sale of it investment in ComStream Corp., a $2.5 million income tax benefit resulting from the adjustment to its deferred income tax valuation reserve and a $1.5 million charge for the consolidation of facilities. Sales for the quarter were $35.8 million, an increase in 14% over 1991's fourth quarter.

CableLabs issues RFP on PCS technology

BOULDER, CO — Cable Television Laboratories, in conjunction with Rogers Cablesystems Ltd., issued a request for proposals to telecommunications vendor companies that may want to build equipment for cable operators' use in personal communications service applications. (Any purchases following from this RFP will be made directly by cable TV companies and not through CableLabs.)

Vendors are being asked to build equipment that uses the remote antenna driver (RAD) technology, which is proprietary to CableLabs and Rogers Communications Ltd. The deadline for responses is 5 p.m. EST April 16 at Rogers Engineering offices, located at 1 Valleybrook Dr., Don Mills, Ontario, Canada M3B 2S7. All technical inquiries should be addressed to George Hart, Rogers Engineering, (416) 442-2827, fax (416) 446-7424.

Klein urges pole strap safety

CHICAGO — Klein Tools announced in the interest of maximizing user safety and to prevent the use of another manufacturer's defective pole strap or lineman's belt with a Klein strap or belt, the company will no longer market pole straps with non-locking snap hooks or market lineman's belts and pole straps as separate items. To encourage workers to always use, when required, the necessary fall-arrest equipment with their lineman's belt and pole strap, which are only a positioning (as opposed to a fall arrest) system, Klein will only sell these components as part of a "lineman's system."

The company reports that although Klein Tools pole straps and lineman's belts now in the field are not defective, to discourage the use of another manufacturer's defective pole strap or lineman's belt with a Klein strap or belt, the company is offering several retrofit and inspection programs. Information on the programs is available from the company at 7200 McCormick Blvd., PO Box 599033, Chicago, IL 60659-9033; (708) 677-9500.

☛ Philips Broadband Networks has relocated its fiber-optics operations in Wallingford, CT (formerly Orchard Communications), to Manlius, NY, where the PBN's headquarters and manufacturing facilities are based.

☛ Four of Mind Extension Institute's video training programs for the cable TV industry now qualify for credit toward recertification by the SCTE. *Customer Service: Your Key To Success* and *Sales Through Service* are each worth one recertification unit in the Society's BCT/E Program. *Installer Safety* and *General Safety* are worth two each.

☛ Considerable sentiment for what's now being called the "grand alliance" among the remaining participants was expressed at a meeting of the Advisory Committee on Advanced TV. If progress toward a merger of systems became evident, retesting of the first of the remaining four systems was scheduled for April 1. Each evaluation is set to last a month. If an alliance can be formed, more time will be allowed to ready the new system.

☛ Wondering why you should attend Women in Cable's Management conference May 2-5 in Chicago? Here's what Pete Smith, vice president of engineering at Rifkin and Associates has to say about it: "I can't think of a better way for engineers to really understand how management decisions are made. WIC's management conference gets you thinking from entirely new perspectives and helps you be more effective with people from marketing, financial and government relations backgrounds. It's a must for anyone who wants to expand their management responsibilities." WIC: (312) 661-1700.

☛ RMS Electronics Inc. opened a branch office in Bramley, nr. Basingstoke, England. RMS U.K. will service England, Ireland and Scotland and other key European markets, including accounts previously served by Associated Broadband Products, its former distributor.

☛ Adelphia Communications and Times-Mirror Cable agreed to place MultiVail's digitally compressed commercial insertion technology in systems they own in West Palm Beach, FL, and San Diego, respectively. Plans call for a launch this month.

☛ Jerrold/General Instrument announced several contracts. Comcast Cable will purchase about 150,000 DigiCable compression converters and start implementing digital compression in 1994. GI's VideoCipher division made an agreement with ANTEC Communication Services (formerly Anixter Cable TV) to market commercial DigiCipher digital compression receiver/descramblers (IRDs) for the U.S. market. Under the agreement, ANTEC with Jerrold and VideoCipher will distribute the DigiCipher product. Also, Sammons selected DigiCable and will begin testing the technology in selected systems in early 1994. Sammons anticipates rolling out at least 70,000 units beginning in the middle of the year.

☛ Augat moved its communication products division from its west Seattle locations into a new $5 million, 75,000 square foot manufacturing facility at 23315 66th Ave., South Kent, WA 98032. The new phone is (206) 854-9802.

☛ SkyConnect ordered $1.5 million in MPEG-based digital video compression equipment from Scientific-Atlanta. As well, Cablevision Systems ordered $6.5 million in addressable interdiction equipment to launch a broadcast basic tier of service to subs in approximately 40 systems.

☛ Quality Cable and Electronics Inc. was recently formed to supply new and used headends, earth stations, actives, passives, cable, drop materials, tools and hard-to-find items to U.S. and international CATV, SMATV, MATV and MMDS markets. The address is 1950 N.W. 44th St., Pompano Beach, FL 33064. The phone is (305) 978-8845.

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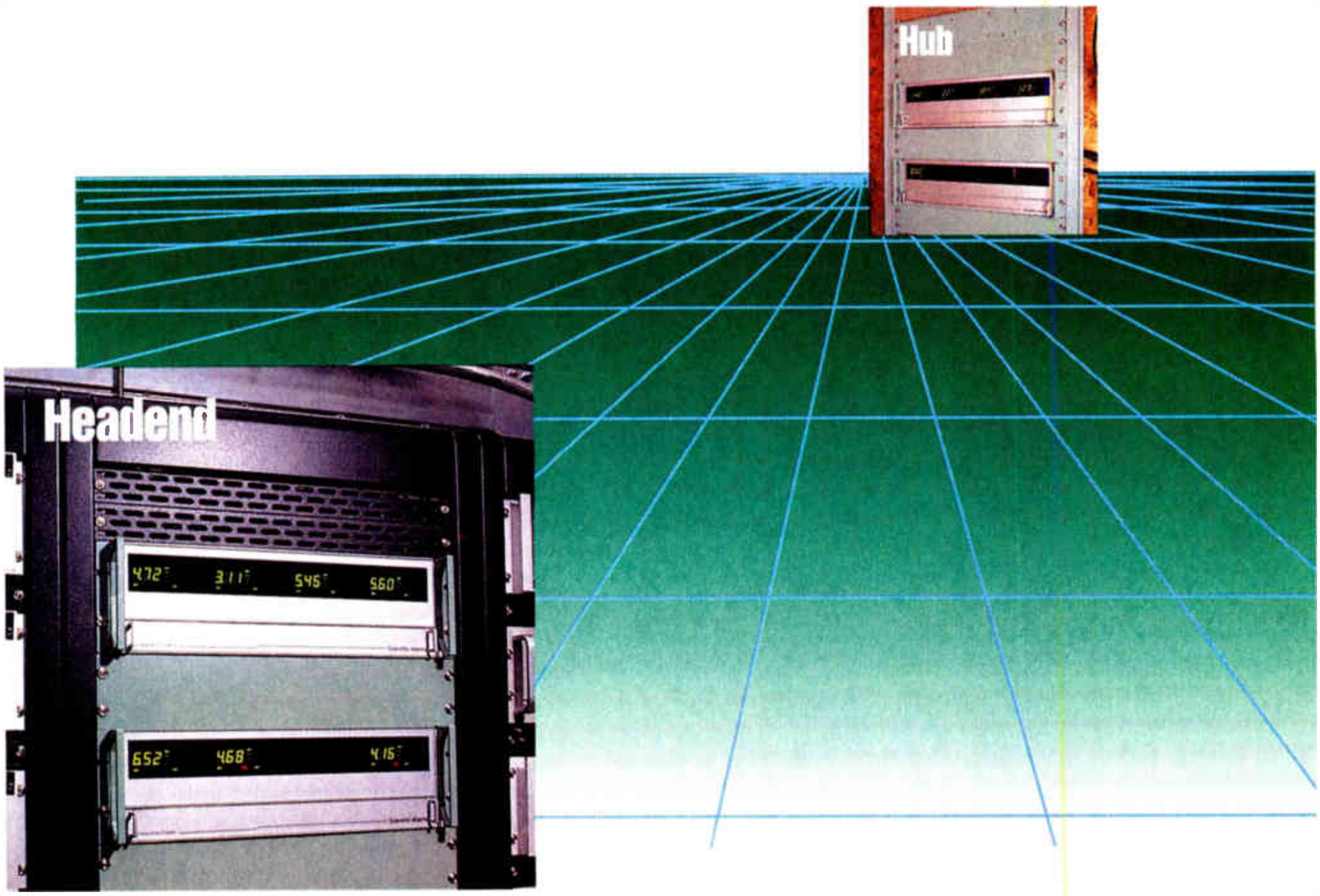

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The Dual Wavelength AM Supertrunk is simple and straightforward. Because it requires no signal conversion, the AM Supertrunk is ideal for digital compression, scrambling and digital audio applications.

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No signal conversion also means less equipment to buy, install and maintain. So, you can have an AM Supertrunk for about half the cost of competing technologies.

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The AM Supertrunk delivers near headend quality signals to remote hub sites. That makes it well-suited for headend interconnections and remote hubbing in Fiber-to-the-Serving Area (FSA) applications. The modular design of the AM Supertrunk allows you to increase bandwidth without affecting performance simply by adding a single transmitter and receiver.

To find out more about the advantages of the AM Supertrunk, contact your nearest Scientific-Atlanta sales representative, or call 800-722-2009 today.

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Texas Show standouts

The 1993 Texas Show offered a variety of informative technical sessions (organized by the Society of Cable Television Engineers), tackling some of today's hottest topics and keeping us up-to-date on OSHA compliance and FCC re-regulation.

Bill Riker, SCTE president, introduced the panel discussion on current technical events. Roger Pience of the NCTA gave the Washington outlook, updated attendees on the legal status of re-reg and fielded questions from Dan Pike of Prime Cable and Tom Jokerst of CableLabs, helping make sense of the FCC's "technological esoterica." He reported on the progress for an HDTV standard and noted that the analog MUSE system was out of the running. Pending legislation and technical re-reg concerns were highlighted, including house wiring and anti-buy through. The problem, Pience stated, is that the cable industry is facing technical re-regulation decided upon by nontechnical people. "Keeping up with all the new regulations is enough to make your head hurt," Jokerst said, then added in jest, "regardless of what you did last night on the Riverwalk."

Bill Riker (left), Diana Riley (center) and Ralph Haimowitz (right) with the best overall individual winners of the Cable-Tec Games: David McCarthy, Jimmy Smith and Frank Anderson.

Bill Riker (left), Diana Riley (center) and Ralph Haimowitz (right) award the team gold to Texas Trash: Bob Cherry, Jimmy Smith, Alan Tabor and Frank Anderson.

Ted Hartson of Post-Newsweek Cable hosted a multimedia presentation entitled "FCC Matters/Technical Re-Regulation," highlighting the nuances of the new rules. In his opinion, everyone should be able to comply. Five years ago, when systems were leaking all over the place, everyone was worried about signal leakage noncompliance. Back then, getting ready for the test was difficult. "Now the testing is easy," he said, "it's the documentation that's hard." What is essential is figuring out what the FCC is looking for. People are collecting a lot of data that is not relevant to the commission's questions, hoping that if

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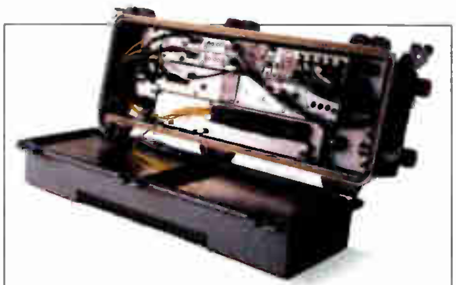

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Member of the Sumitomo Electric Industries, Ltd. Group enough data is collected, they'll hit upon what is needed. What is required, Hartson stressed, is for engineers to read every word in the rules and focus on what they are doing, why it is being done, what channels need to be tested, etc. Focus and concentration. It should make all the paperwork a lot easier.

SCTE's Ralph Haimowitz delivered the OSHA update, telling cable managers how to avoid unwanted fines (many of which have been doubled) and possibly jail. The Hazardous Material Communications and Training Program was in the spotlight. Recently, the U.S. Supreme Court upheld a state's right to charge company managers, officers and owners with criminal negligence if proper equipment and training to avoid health risk has not been provided. How to inform employees and keep accurate records was covered, as well as boot and protective clothing requirements. The hazardous materials list was a big topic for discussion. Haimowitz told managers that if their system does any soldering, converter cleaning, or has any bucket trucks or a fork lift, they are using materials on the hazardous materials list. A list of the most often cited OSHA standards and employee training checklists were provided.

And the winners are ...

Once again, the Cable-Tec Games proved who's the best in the field and provided a lot of fun for everyone involved. SCTE Cable-Tec Games Subcommittee and Texas Cable Television Association coordinated the event sponsored by SCTE, ANTEC and *Communications Technology.* Diana Riley of Jerry Conn Associates and Ralph Haimowitz of SCTE gave the play by play of the four tests of CATV skill. Tallying the scores were Don Olden of NCTI, Bill Riker of SCTE and Eric Butterfield of *CT.*

Events and their sponsors were as follows: "Cable Splicing," Gilbert and Comm/Scope; "Test Equipment — Operation and Measurements," CaLan and Riser Bond; "Fiber Optics — Splicing and Restoration," ONI and AT&T; and "Signal Level Meter Techniques — Operation and Measurements," Trilithic and Wavetek.

Team names like "Texas Trash," "Over the Hill Cable Gang" and "Paragon Red Hot Chili Peppers" added color to the festivities. Gold, silver and bronze medals were awarded for first, second and third place for each event as follows:

- Test Equipment: Gary Lloyd (Paragon Cable), first; Jimmy Smith (Lakewood Cablevision), second; and David McCarthy (Paragon West), third.
- Splicing: Fred Butler (Cable Constructors), first; Jimmy Smith, second; and Frank Anderson (Lakewood Cablevision), third.
- Signal Level Meter: Alan Tabor (Paragon San Antonio), first; Jimmy Smith, second; and Paul Cardanas (Paragon West), third.
- Fiber Optics: Bob Owens (TCS), first; David McCarthy, second; and Frank Anderson, third.

In the overall individual competition, David McCarthy walked away with the gold, Jimmy Smith with the silver, and Frank Anderson with the bronze. For the gold in team competition, "Texas Trash" edged out "Paragon Red Hot Chili Peppers" and "Paragon West," which won second and third respectively. Look for Cable-Tec Games at SCTE Cable-Tec Expo in Orlando, April 21-24. — *Eric Butterfield*

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A DSC-HDTV picture (left) compared to an NTSC one (right).

Washington demo of an improved DSC-HDTV

By Lawrence W. Lockwood
President, TeleResources
East Coast Correspondent

Each of the four digital high definition TV systems — DigiCipher (General Instrument), DSC-HDTV (Zenith/AT&T), AD-HDTV (Sarnoff/Philips), CCDC (GI/MIT) — has produced an improved system since testing by the ATTC (Advanced Television Test Center). Each is emphasizing the requirement of further testing of these improved systems before recommending a system to the Federal Communications Commission for decision as the HDTV standard. To underscore their desires for further systems testing, Zenith/AT&T demonstrated the performance of their improved Digital Spectrum Compatible (DSC-HDTV) system in Washington, DC, on Feb. 2, 1993, to federal officials and other key individuals.

Robert Graves, AT&T government affairs vice president, said: "Zenith and AT&T believe it makes all the sense in the world for the Advisory Committee to take a short period of time to evaluate improvements that have been made to the system before the recommendation of the HDTV standard that will serve the nation for decades." The photo above shows a comparison of NTSC and DSC-HDTV performance.

Key elements of the DSC-HDTV system that were demonstrated included:

- Low transmitter power over-the-air.
- "Upconversion" capability to convert an NTSC signal to the DSC-HDTV *signal format* — but not DSC-HDTV *quality*.
- Two HDTV channels over a single cable TV channel.
- A home digital VCR using standard Super-VHS (S-VHS) cassettes.

(Except where noted, the system specifications presented here are from the Zenith/AT&T demonstration.)

Over-the-air

The over-the-air system transmission was from WNVT (Ch. 53) from Independent Hill, VA (near the Quantico Marine base), to the AT&T building in Washington — an airline distance of 28.5 miles. (See the accompanying figure on page 28.) A conventional home-type indoor "butterfly" antenna was used for reception atop the

"New developments bring to the fore and emphasize important changing conditions that must be accommodated for in the development of an HDTV technical standard."

Zenith/AT&T DSC-HDTV broadcast via WNVT (Ch. 53) to Washington

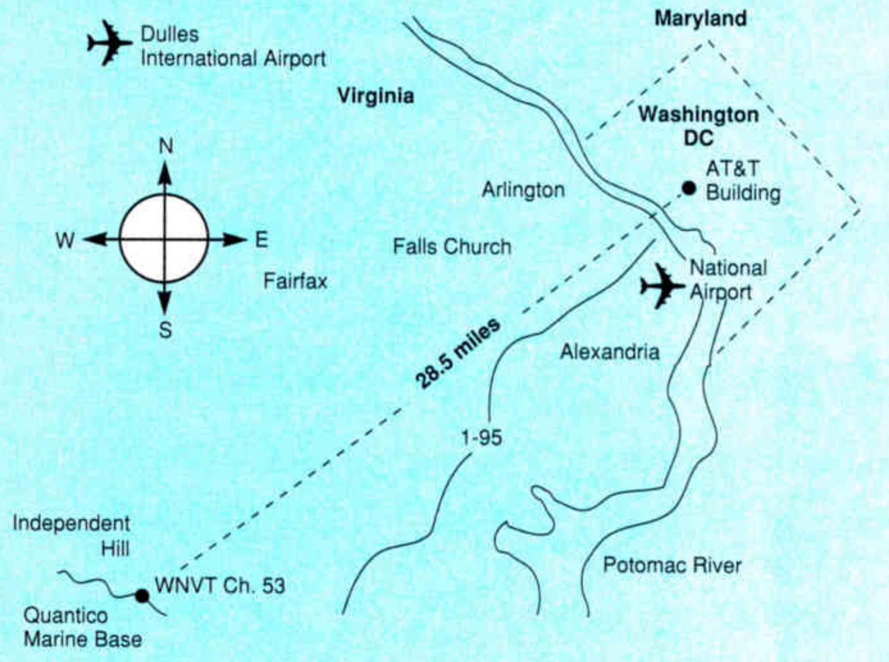

Table 1: Transmitter parameters

WNVT-NTSC (Ch. 53)	WNVT-DSC-HDTV (Ch. 53)
Frequency: 704-710 MHz	Frequency: 704-710 MHz
Transmitter power: 104 kW	Transmitter power: 6.6 W (-12 dB re. NTSC)
HAAT: 748 feet	HAAT: 748 feet
Grade B contour: 45 miles	Noise-limited contour: 45 miles

AT&T offices. The digital signal requires less than one-tenth the power used to transmit a full-power NTSC analog signal. See Table 1 for comparison of transmitter parameters.

Wayne Luplow, vice president of advanced television R&D at Zenith, showed an amazing example of the transmission capability. During the live over-the-air demonstration he was in telephone contact with the engineers at the transmitter. The received picture at the transmitter power shown in Table 1 of 6.6 kW (as compared to required power of analog NTSC signal of 104 kW) was very good. However, Luplow had the transmitter engineers reduce the transmitter power in stages. At the lowest power, the picture on close visual examination showed no difference in performance from the highest power — and that lowest power was at an eye popping value of 270 watts (about 25 times less than full digital transmitter power and almost 400 times less than full transmitter power for NTSC!).

And any possible apprehension regarding adjacent channel interference was shown to be of no concern in this over-the-air demonstration. The digital HDTV transmission in Ch. 53 had an analog standard TV adjacent channel companion, Ch. 54 (WNUV). The digital transmission over Ch. 53 produced no interference on Ch. 54, and conversely the standard analog TV transmission on Ch. 54 produced no interference in the digital HDTV reception of Ch. 53 — and most significantly not even when the digital transmission of Ch. 53 was reduced to *270 watts*! The test also featured the first-ever HDTV broadcast of digital six-channel audio using the Dolby AC-3 compression system.

Upconversion

With a simple "upconversion" process developed by Zenith and AT&T they claim many TV stations won't need immediately to make the costly switch to a full high-definition studio with new cameras, recorders and encoders. The stations would be able to "pass through" network HDTV programming, but for locally produced programming, they would use the new upconversion process to broadcast very high-quality NTSC images on the digital transmission system.

The upconversion process starts out with an interlaced, 525-line NTSC signal. In the first step of conversion, each interlaced line is doubled, resulting in a 525-line progressively scanned signal. In the second step, the line rate is increased from 525 to 787.5 lines — all progressively scanned. Upconversion is expected to be most commonly used in communities with populations less than 500,000. Luplow said "upconversion is the way to go for the smaller broadcaster who might otherwise look at a delay of several years before getting into HDTV."

Computer interoperability

As AT&T and Zenith said at the demonstration, they view "HDTV not only as a quantum leap forward in broadcast entertainment but also as a central part of emerging systems to communicate, manipulate and display information — for the home, for business and for the individual." They also said they believe that next to the video quality, computer interoperability will be the single most important factor in the *long-term* success of high definition video. They said "the choice of pro-

Table 2: ATTC static resolution measurements (on 1,000-line radial test chart)

System	Scan ratio	Scan type	Vertical resolution	Horizontal resolution (lines/picture height)
DigiCipher (GI)	1,050/59.94	Interlace	700	600
DSC-HDTV (Zenith/AT&T)	787.5/59.94	Progressive	720	600
AD-HDTV (Sarnoff/Philips)	1,050/59.94	Interlace	700	600
CCDC - Channel Compatible DigiCipher (GI/MIT)	787.5/59.94	Progressive	400+	300+

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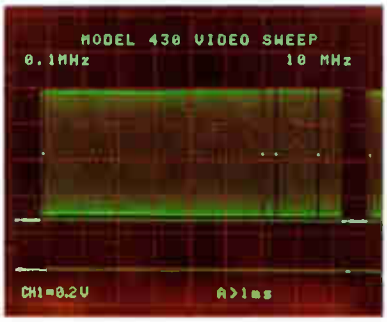

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Table 3: Zenith/AT&T comparison of VSB and QAM modulation approaches

	4-VSB	16-QAM	64-QAM	16-VSB
Data				
Total data rate (Mbps)	21.5	21.5	32.25	43
Number of data levels	4	4	8	16
Theoretical maximum data rate (bits/Hz)	4	4	6	8
Relative data rate	1	1	1.5	2
Carriage in 6 MHz cable channel				
Number of movie channels @ 1.5 Mbps video compression	11	11	17	23
Number of movie channels @ 2 Mbps video compression	8	8	13	17
Number of live video channels @ 4 Mbps video compression	4	4	6	9
Analog friendliness				
Composite triple beat rejection filter	Yes	No	No	No
Signal acquisition with noise/interference	Excellent	Good	Fair	Excellent
Channel equalizer	Yes	Yes	Yes	Yes
Cost				
Manufacturing complexity	Lowest	Low	High	Low
Cost of receiving equipment	Lowest	Low	High	Low

gressive scan is absolutely essential if HDTV transmissions are to be effectively interoperable with computer technology — interoperability that will be vital to the long-term success of the industry." They noted that "contrary to common argument, a progressive scan transmission standard does not sacrifice any effective spatial resolution over an interlaced system of the same bandwidth. In support of that view they presented ATTC test result on system resolutions as shown in Table 2 on page 28.

Two HDTVs on one cable channel

The cable environment is more friendly to digital signals than the terrestrial broadcast environment. The peak carrier-to-noise ratio in a 6 MHz cable channel is required to be greater than 40 dB. (It can be as low as 16 dB in a terrestrial environment.) This greater noise margin available in cable can be used to significantly increase the information carrying capacity or data rate on cable — without requiring more video or audio compression than the already massive compression needed to transmit digital video information.

The four-level vestigal sideband (4-VSB) modulation technology in the DSC-HDTV system achieves a data rate of 21.5 Mbps. Zenith's 16-level vestigial sideband (16-VSB) modulation approach for cable is an extension of the 4-VSB technology and yields twice the channel data rate, or 43 Mbps. (See my column "The Zenith/AT&T All-Digital Proposal," May 1991, for more details on 4-VSB.) This increased capacity could be used to send two HDTV programs over one cable channel, or one HDTV program plus multiple NTSC programs. In the Washington demo, Zenith/AT&T in cooperation with the District cable system showed two DSC-HDTV signals transmitted over one 6 MHz cable channel. The program originated on tape at the cable headend and the demo viewing at the AT&T offices was 11 amps deep

Table 4

DigiCipher	34″ widescreen direct-view receiver	56″ widescreen CRT-type projector
Signal processing components	$98	$98
Audio amplifiers and speakers	30	30
Scan system, power supply and video amps	60	176
Display	700	1,050
Cabinet	90	140
Total material cost	$978	$1,494
Receiver cost (estimated using a 2.5 multiplier)	$2,445	$3,735

Table 5

DSC-HDTV	34″ widescreen direct-view receiver	56″ widescreen CRT-type projector
Signal processing components	$116	$116
Audio amplifiers and speakers	30	30
Scan system, power supply and video amps	73	201
Display	700	1,050
Cabinet	90	140
Total material cost	$1,009	$1,537
Receiver cost (estimated using a 2.5 multiplier)	$2,523	$3,843

in the system (about one-half the total depth of the system.) The picture looked perfectly normal with no perceptible errors.

Luplow said "using the 16-VSB digital transmission system for standard NTSC signals, each 6 MHz channel on a cable system would be able to transmit 23 movie channels each compressed at 1.5 Mbps, 17 movie channels compressed at 2 Mbps, or nine live video channels compressed at 4 Mbps." Zenith/AT&T presented a comparison of VSB and QAM modulation approaches as shown in Table 3 on page 30.

Home DSC-HDTV VCR

Zenith and Goldstar Co. Ltd. have jointly developed a digital high-definition video cassette recorder for home use, which was demonstrated at the Washington demo. The quality of the DSC-HDTV picture on playback could not be visually differentiated from the over-the-air picture that it had recorded.

The new digital HD-VCR is designed to record HDTV signals on standard S-VHS video cassettes. It also will be able to record and playback programs in today's NTSC format. Luplow said "the first HDTV sets will be able to receive both standard and high definition signals, so it's crucial that HD-VCRs be able to play standard tapes from either source so that in addition to HDTV shows consumers would still be able to play conventional VHS tapes from their home video library and corner video store." He explained that to play HD tapes, the HD-VCR would not require video compression decoding, because the HDTV receiver would "decompress" the signal. The HD-VCR will be able to record and playback two hours of high-definition programming on an ST-120 S-VHS cassette (the same as conventional recording in the "standard play" mode). Although not in the recorder demonstrated, the marketed HD-VCR will have a full range of standard VCR features, such as fast forward, reverse, pause and scan. It also will feature digital audio with the same high-quality

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	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
5967BV 5967BVM 5967BEF	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
5995BV 5995BVM 5995BEF	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS	SPP-59-I
59TSV 59TSVM	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
59SSV 59SSVM 59SSEF	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-QS AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS-QD	SPP-59-IQ
560BV 660BVM 560BEF	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
590BV 590BVM 690BEF	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
6TSV 6TSVM	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
6SSV 6SSVM 6SSEF	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-QS AMF-6	.360 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS-QD	SPP-6-IQ

SCTE Interface Practices Subcommittee

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Foam Dielectric, APA Bonded Foil Tape, includes CATV (UL).

May require special cable prep dimensions and/or tools.

rt umber	Gilbert		LRC		PPC		Pyramid		QF	Stirling
	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
)10)11)12	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
)60)61)62	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS	SPP-59-I
)70)71)72	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
)90)91 92	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS	SPP-59-I
)50)51)52	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-QS AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS-QD	SPP-59-IQ
)00)01 002	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
060 061 062	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
070 071 072	GF-6-AHS-312 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
090)91)92	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
)50)51)52	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-QS AMF-6	.360 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS-QD	SPP-6-IQ

BELDEN

59 Series

Braid Coverage	Part Number
67% Braid	9104 9105 9067
95% Braid	9108 9109
Tri- (67%) Shield	9050 9110 9111
(77%)	9052 9053 9063
Quad-Shield	1186A 1187A 1188A

6 Series

Braid Coverage	Part Number
61% Braid	9116 9117 9066
90% Braid	1530A 1531A 1532A
Tri- (61%) Shield	9056 9057
(77%)	9058 9059 9062
Quad-Shield	1189A 1190A 1191A

TIMES FIBER

59 Series

Braid Coverage	Part Number
67% Braid	2183 2185 2186
95% Braid	2545 2547 2574
Tri- (53%) Shield	2602 2603 2604
(80%)	2607 2608 2609
Quad-Shield	2245 2247 2274

6 Series

Braid Coverage	Part Number
60% Braid	2360 2364 2386
90% Braid	2560 2564 2586
Tri- (53%) Shield	2622 2623 2624
(80%)	2627 2628 2629
Quad-Shield	2260 2264 2286

OMM/SCOPE

Foam Dielectric, APA Bonded Foil Tape, includes CATVX and CATV (UL).

Series

May require special cable prep dimensions and/or tools.

d erage	Part No.	LRC	PPC	Raychem
		Fitting	Fitting	Fitting
d	F5967BV F5967BVM F5967BEF	PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
d	F5995BV F5995BVM F5995BEF	PNL 59	QUIK-LOK 59Q	EZ Twist-59-S/T
(67%) ld	F59TSV F59TSVM	PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
d- ld	F59SSV F59SSVM F59SSEF	PNL 59	QUIK-LOK 59Q	EZ Twist-59-Q

6 Series

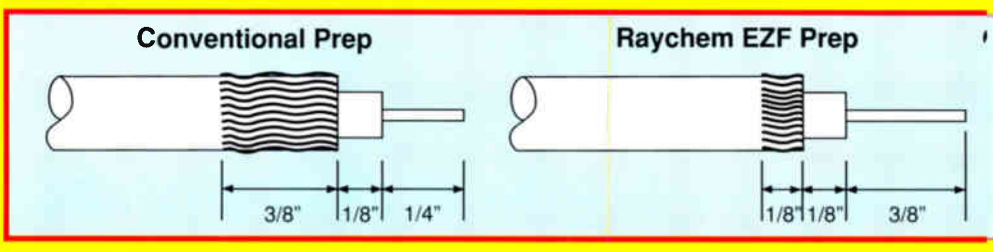
Braid Coverage	Part No.	LRC	PPC	Raychem
		Fitting	Fitting	Fitting
60% Braid	F660BV F660BVM F660BEF	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
90% Braid	F690BV F690BVM F690BEF	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T
Tri- (60%) Shield	F6TSV F6TSVM	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
Quad-Shield	F6SSV F6SSVM F6SSEF	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T

TIMES FIBE

59 Series

Braid Coverage	Part No.
67% Braid	2183 2185 2186
95% Braid	2545 2547 2574
Tri- (53%) Shield	2602 2603 2604
(80%)	2607 2608 2609
Quad-Shield	2245 2247 2274

ENCE



Environmentally Sealed F-Fit

Foam Dielectric, APA Bonded Foil Tape, includes CATVX and CATV (UL).
May require special cable prep dimensions and/or tools.

Amphenol		Gilbert		LRC		PPC		Raychem	Stirling
Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59QS-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-OQ
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6QS-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-OQ

COMM/SCOPE

Foam Diel

59 Series

Braid Coverage	Part Number	Amphenol Fitting	Crim
67% Braid	F5967BV F5967BVM F5967BEF	6531-59	.276
95% Braid	F5995BV F5995BVM F5995BEF	6531-59	.276
Tri- (67%) Shield	F59TSV F59TSVM	6531-59	.276
Quad-Shield	F59SSV F59SSVM F59SSEF	6531-59	.276

6 Series

Braid Coverage	Part Number	Amphenol Fitting	Crim
60% Braid	F660BV F660BVM F660BEF	6531-6	.325
90% Braid	F690BV F690BVM F690BEF	6531-6	.325
Tri- (60%) Shield	F6TSV F6TSVM	6531-6	.325
Quad-Shield	F6SSV F6SSVM F6SSEF	6531-6	.325

R Foam Dielectric, APA Bonded Foil Tape, includes CATV (UL).
May require special cable prep dimensions and/or tools.

Amphenol		Gilbert		LRC		PPC		Raychem	Stirling
Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
6531-59	.276R	GFWL59-AHS-USA	.360	SNS-59QS-NS AMF-59S	.360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-OQ
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
6531-6	.325R	GFWL6-AHS-USA	.360	SNS-6QS-NS AMF-6S	.360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-OQ

TRILOGY

Foam Dielectric,

59 Series

Braid Coverage	Part Number	Amphenol Fitting	Crim
67% Braid	5910 5911 5912	6531-59	.276
95% Braid	5960 5961 5962	6531-59	.276
Tri- (67%) Shield	5970 5971 5972	6531-59	.276
(95%)	5990 5991 5992	6531-59	.276
Quad-Shield	5950 5951 5952	6531-59	.276

6 Series

Braid Coverage	Part Number	Amphenol Fitting	Crim
60% Braid	6000 6001 6002	6531-6	.325
90% Braid	6060 6061 6062	6531-6	.325R
Tri- (60%) Shield	6070 6071 6072	6531-6	.325
(90%)	6090 6091 6092	6531-6	.325R
Quad-Shield	6050 6051 6052	6531-6	.325R

R Foam Dielectric, APA Bonded Foil Tape, includes CATV (UL).

May require special cable prep dimensions and/or tools.

LRC	PPC	Raychem
Fitting	Fitting	Fitting
PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
PNL 59	QUIK-LOK 59Q	EZ Twist-59-S/T
PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
PNL 59	QUIK-LOK 59 & 59Q	EZ Twist-59-S/T
PNL 59	QUIK-LOK 59Q	EZ Twist-59-Q

6 Series

Braid Coverage	Part No.	LRC Fitting	PPC Fitting	Raychem Fitting
60% Braid	2360 2364 2386	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
90% Braid	2560 2564 2586	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T
Tri- (53%) Shield	2622 2623 2624	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
(80%)	2627 2628 2629	PNL 6	QUIK-LOK 6 & 6Q	EZ Twist-6-S/T
Quad-Shield	2260 2264 2286	PNL 6	QUIK-LOK 6Q	EZ Twist-6-Q

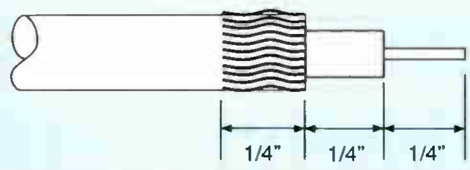
TRILOGY

Foam Dielectric, APA
May require special
sions and/or tools.

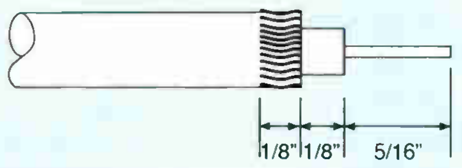
59 Series

Braid Coverage	Part No.	LRC Fitting	PPC Fittin
67% Braid	5910 5911 5912	PNL 59	QUIK LOK 5
95% Braid	5960 5961 5962	PNL 59	QUIK LOK 5
Tri- (67%) Shield	5970 5971 5972	PNL 59	QUIK LOK 5
(95%)	5990 5991 5992	PNL 59	QUIK LOK 5
Quad-Shield	5950 5951 5952	PNL 59	QUIK LOK 5

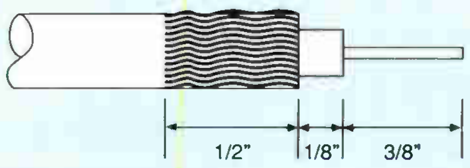
Gilbert USA, LRC SNS, Amphenol Prep



Stirling Prep



PPC UV & SUV Prep



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ectric, APA Bonded Foil Tape, includes CATVX and CATV (UL).

May require special cable prep dimensions and/or tools.

Gilbert		LRC		PPC		Raychem	Stirling
Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59QS-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-OQ
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6QS-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-OQ

SCTE Interface Practices Subcommittee

APA Bonded Foil Tape, includes CATV (UL).

May require special cable prep dimensions and/or tools.

Gilbert		LRC		PPC		Raychem	Stirling
Fitting	Crimp	Fitting	Crimp	Fitting	Crimp	Fitting	Fitting
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-O
GFWL59-AHS-USA	.360	SNS-59QS-NS AMF-59S	 .360	CFS-59-SUV CFS-59-SU	.360 .360	EZF-59	SPP-59-OQ
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-O
GFWL6-AHS-USA	.360	SNS-6QS-NS AMF-6S	 .360	CFS-56-SUV CFS-56-SU	.360 .360	EZF-6	SPP-6-OQ

Indoor F-Fittings

Bonded Foil Tape, includes CATV (UL).

cable prep dimen-

Raychem
Fitting
EZ Twist-59-S/T
EZ Twist-59-S/T
EZ Twist-59-S/T
EZ Twist-59-S/T
EZ Twist-9-S/T

6 Series

Braid Coverage	Part No.	LRC	PPC	Raychem
		Fitting	Fitting	Fitting
60% Braid	6000 6001 6002	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
90% Braid 6062	6060 6061	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T
Tri- (60%) Shield	6070 6071 6072	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
(90%)	6090 6091 6092	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T
Quad-Shield	6050 6051 6052	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T

Hex Crimpers*

Ben Hughes/Cable Prep

Part Number	Minor Hex	Hex	Major Hex
HCT-116	.324		.472
HCT-360	.068		.360
HCT-659	.262		.324
HCT-USA			.360
HCT-611	.324		.410
HCT-6QS	.324		.360
HCT-660	.324		.384
HCT-986	.324		.360
HCT-669	.262	.324	.384
HCT-902	.100	.324	.475

LRC

Part Number	Minor Hex	Hex	Major Hex
CT-596	.262		.324
HCT-6QS	.324		.360
CT-611-QS	.360		.470
CT-2460	.324		.360

Ripley/Cablematic

Part Number	Minor Hex	Hex	Major Hex
CR-596-B	.262		.324
CR-596-Q	.324		.384
CR-596-QR	.324		.384
CR-596-11	.324		.410
CR-596-QL2	.068	.324	.360
CR-360			.360
CR-360-R			.360
CR-596-QL	.324		.360
CR-596-QLR	.324		.360
CR-611-Q	.324		.475
CR-611-Q2	.100	.324	.475
CR-611-QL	.324		.470
CR-775	.068/.100	.324	.384

Gilbert

Part Number	Minor Hex	Hex	Major Hex
G-CRT-659	.262		.324
G-CRT-660	.324		.384
G-CRT-804	.262	.324	.384
G-CRT-986	.324		.360
G-CRT-USA			.360

Lemco

Part Number	Minor Hex	Hex	Major Hex
R-360			.360
R-731	.262	.324	.384
R-953	.324		.360
R-842	.324		.360

PPC

Part Number	Minor Hex	Hex	Major Hex
HCT-360-SUV			.360

Sargent/Rostra

Part Number	Minor Hex	Hex	Major Hex
3150-CCT	.262	.324	.384
3152-CCT	.068	.178	.324
3154-CCT	.324		.360
3350-CCT	.262	.324	.384
3354-CCT	.324		.360
4158-CCT	.068/.100	.324	.360
6158-CCT	.068/.100	.324	.360

* Identify the fittings and hex crimp sizes you need, then find the appropriate tool from the above list.

Round Crimpers

Amphenol

Part Number	Minor Crimp	Major Crimp
65-1432	.276	.325
227-1432	.276	.325

Ben Hughes/ Cable Prep

Part Number	Minor Crimp	Major Crimp
RCT-659	.276	.325

Ripley/Cablematic

Part Number	Minor Crimp	Major Crimp
CR-59-531	.276	
CR-6-531		.322
CR-59-531R	.276	
CR-6-531R		.322

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Non-Sealed F-Fi

BELDEN

59 Series

Foam Dielectric, APA Bonded Foil Tape, includes CATVX and CATV (UL).
May require special cable prep dimensions and/or tools.

Braid Coverage	Part Number	Gilbert Fitting	Crimp	LRC Fitting	Crimp	PPC Fitting	Crimp	Pyramid Fitting	Crimp	QF Fitting	Stirling Fitting
67% Braid	9104 9105 9067	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
95% Braid	9108 9109	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-QS AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS	SPP-59-I
Tri- (67%) Shield	9050 9110 9111	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
(77%)	9052 9053 9063	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
Quad-Shield	1186A 1187A 1188A	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-QS AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS-QD	SPP-59-IQ

6 Series

Braid Coverage	Part Number	Gilbert Fitting	Crimp	LRC Fitting	Crimp	PPC Fitting	Crimp	Pyramid Fitting	Crimp	QF Fitting	Stirling Fitting
61% Braid	9116 9117 9066	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
90% Braid	1530A 1531A 1532A	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
Tri- (61%) Shield	9056 9057	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
(77%)	9058 9059 9062	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
Quad-Shield	1189A 1190A 1191A	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-QS AMF-6	.360 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS-QD	SPP-6-IQ

TIMES FIBER

59 Series

Foam Dielectric, APA Bonded Foil Tape, includes CATV (UL).
May require special cable prep dimensions and/or tools.

Braid Coverage	Part Number	Gilbert Fitting	Crimp	LRC Fitting	Crimp	PPC Fitting	Crimp	Pyramid Fitting	Crimp	QF Fitting	Stirling Fitting
67% Braid	2183 2185 2186	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
95% Braid	2545 2547 2574	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS	SPP-59-I
Tri- (53%) Shield	2602 2603 2604	GF-59-AHS-290 GF-59-AHS-USA	.324 .360	F-59-CH AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
(80%)	2607 2608 2609	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-HB AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-ALM F-59-UNI	.324 .360	QF-59-RNS	SPP-59-I
Quad-Shield	2245 2247 2274	GF-59-AHS-312 GF-59-AHS-USA	.324 .360	F-59-QS AMF-59	.324 .360	CFS-59-UV CFS-59-U	.360 .360	F-59-UNI	.360	QF-59-RNS-QD	SPP-59-IQ

6 Series

Braid Coverage	Part Number	Gilbert Fitting	Crimp	LRC Fitting	Crimp	PPC Fitting	Crimp	Pyramid Fitting	Crimp	QF Fitting	Stirling Fitting
60% Braid	2360 2364 2386	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
90% Braid	2560 2564 2586	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
Tri- (53%) Shield	2622 2623 2624	GF-6-AHS-322 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-ALM F-56-UNI	.324 .360	QF-56-RNS	SPP-6-I
(80%)	2627 2628 2629	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-CH AMF-6	.324 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS	SPP-6-I
Quad-Shield	2260 2264 2286	GF-6-AHS-342 GF-6-AHS-USA	.324 .360	F-56-QS AMF-6	.360 .360	CFS-56-UV CFS-56-U	.360 .360	F-56-UNI	.360	QF-56-RNS-QD	SPP-6-IQ

COMM…
59 Seri…
6 Series
TRILOG…
59 Seri…
6 Series

Indoor F-Fittings

BELDEN

59 Series

Foam Dielectric, APA Bonded Foil Tape, includes CATVX and CATV (UL).
May require special cable prep dimensions and/or tools.

Braid Coverage	Part No.	LRC Fitting	PPC Fitting	Raychem Fitting
67% Braid	9104 9105 9067	PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
95% Braid	9108 9109	PNL 59	QUIK-LOK 59Q	EZ Twist-59-S/T
Tri- (67%) Shield	9050 9110 9111	PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
(77%)	9052 9053 9063	PNL 59	QUIK-LOK 59	EZ Twist-59-S/T
Quad-Shield	1186A 1187A 1188A	PNL 59	QUIK-LOK 59Q	EZ Twist-59-S/T

6 Series

Braid Coverage	Part No.	LRC Fitting	PPC Fitting	Raychem Fitting
61% Braid	9116 9117 9066	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
90% Braid	1530A 1531A 1532A	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T
Tri- (61%) Shield	9056 9057	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
(77%)	9058 9059 9062	PNL 6	QUIK-LOK 6	EZ Twist-6-S/T
Quad-Shield	1189A 1190A 1191A	PNL 6	QUIK-LOK 6Q	EZ Twist-6-S/T

Compiled by Barry Smith, Mega Hertz

Pull-out Wall Chart

COMMUNICATIONS TECHNOLOGY's

F-Fitting Cross-Reference Chart

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While the connectors listed are the manufacturers' recommendations based on various parameters such as pull strength, esthetics, ease of assembly and cable trim specifications, etc., it is not a negative recommendation if manufacturers and connectors are not included. This tabulation is a starting point for the proper selection of a cable and connector combination.

When publishing data of this nature, problems of a remarkably short useful life occur almost immediately. Therefore the SCTE Interface Practices Subcommittee recommends contacting the appropriate manufacturer for the most current information available. Another way to determine an acceptable connector and cable combination is to send samples of the cable along with requirements to your connector supplier.

Amphenol Corp.	(203) 743-9272
Belden Electronic Wire and Cable	(800) 235-3362
Ben Hughes/Cable Prep	(800) 394-4046
Cablematic/Ripley Co. Inc.	(800) 528-8665
Comm/Scope Inc.	(800) 982-1708
Gilbert Engineering	(800) 528-0199
Lemco Tool Corp.	(800) 233-8713
LRC Electronics Inc.	(800) 332-8428
Production Products Co.	(800) 468-2288
Pyramid Industries Inc.	(800) 829-4529
QF/Signal Vision	(714) 586-3196
Raychem	(415) 361-2288
Sargent/Rostra Tool Co.	(203) 488-8665
Stirling Connectors Inc.	(416) 475-6920
Times Fiber Communications Inc.	(800) 677-2288
Trilogy Communications Inc.	(800) 874-5649

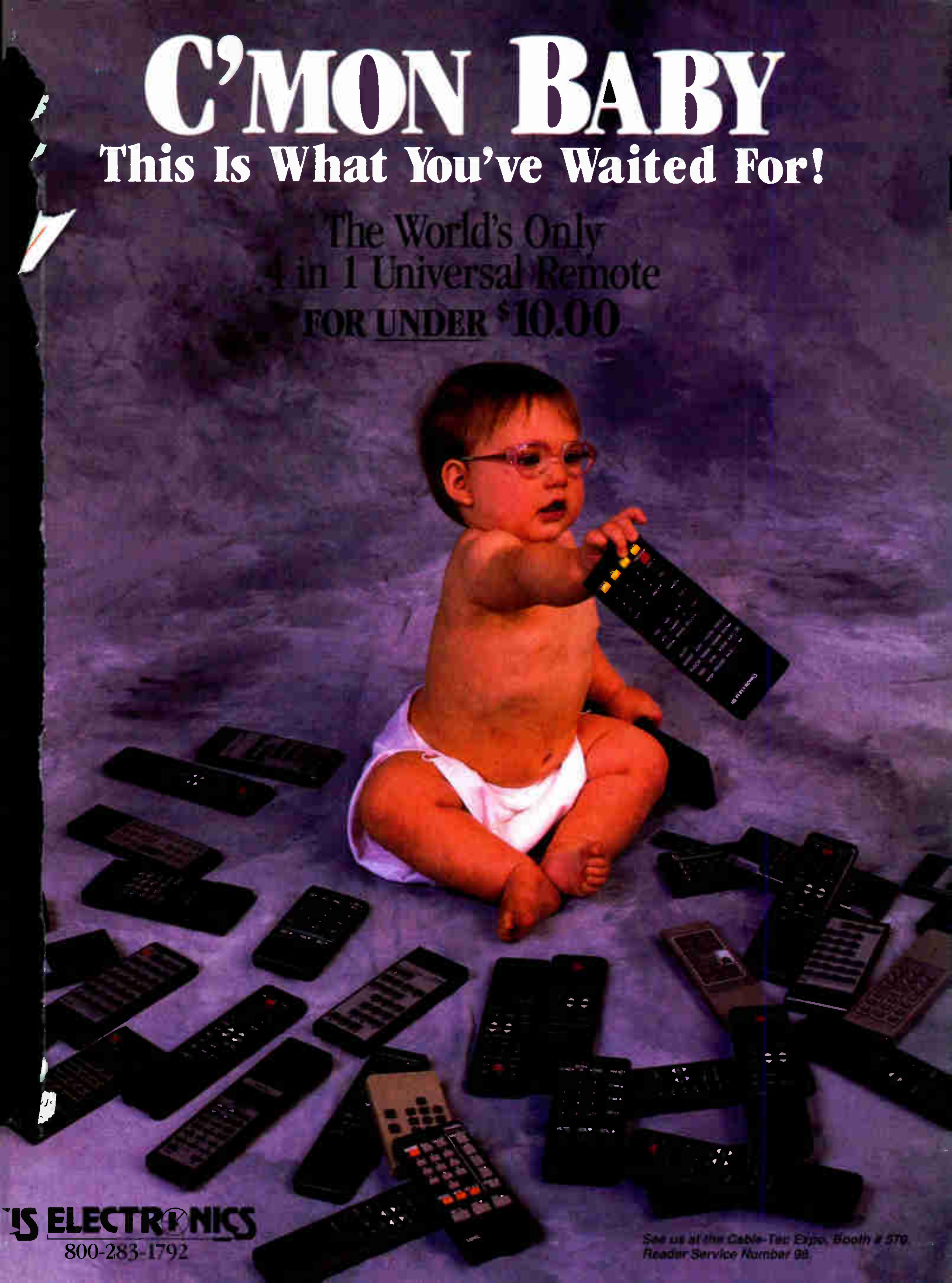
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Table 6

AD-HDTV	34˝ widescreen direct-view receiver	56˝ widescreen CRT-type projector
Signal processing components	$127	$127
Audio amplifiers and speakers	30	30
Scan system, power supply and video amps	63	176
Display	700	1,050
Cabinet	90	140
Total material cost	$1,006	$1,522
Receiver cost (estimated using a 2.5 multiplier)	$2,515	$3,805

Table 7

CCDC	34˝ widescreen direct-view receiver	56˝ widescreer CRT-type projec
Signal processing components	$124	$124
Audio amplifiers and speakers	30	30
Scan system, power supply and video amps	73	201
Display	700	1,050
Cabinet	90	140
Total material cost	$1,017	$1,545
Receiver cost (estimated using a 2.5 multiplier)	$2,543	$3,863

audio found in today's compact disc technology. The demonstration Zenith/Goldstar prototype VCR was built around "off-the-shelf" S-VHS head technology making it very cost-effective. They expe that the VCR would be sold in the U. for about $1,000 beginning in 1996.

Other interesting consumer HD cost figures are shown in Tables (page 32 and this page), which pres preliminary estimations of HDTV c sumer costs by the FCC Advis Committee on Advanced Televis Services.

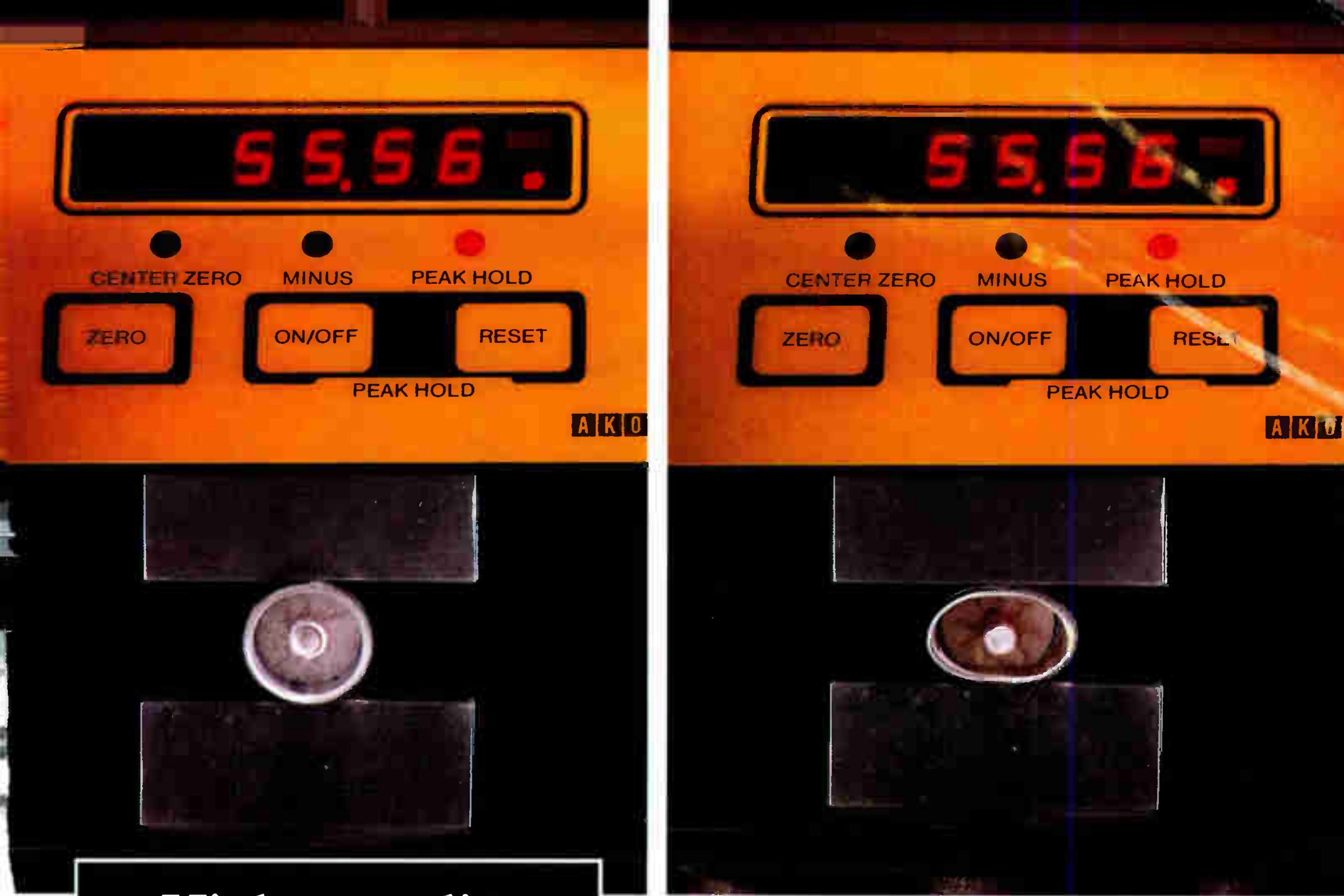
Conclusions

As a demo, the Washington sh ing was a success for Zenith a AT&T. As previously mentioned, s eral features deserve special note the successful *very* low power tra mission, the two HDTV channel tra mission in one standard cable channel, the "upconversion" of a NTSC signal to the DSC-HDTV sig format and of course the home V Although the three other digital HD proposers have not yet demonstra their improved systems, each of HDTV system proposers present their current systems to a panel of FCC HDTV advisory group in a m February week-long meeting just o side Washington. The general c sensus was that none of the syste was clearly superior to the others a the panel recommended further te ing.

The panel also recommended dr ping the NHK analog system from further consideration. There was tal the meeting of a possibility of merg the three industrial groups (GI/M Zenith/AT&T and Sarnoff/Philips) int single team to combine the best e ments of each proposed digital HD system to make the best HDTV st dard. Such a merger would offer sev al attractions — aside from the obvi technical advantages, it would produ no loser to tie things up in court or years with legal challenges.

Stay tuned ...

All these new developments bring to the fore and emphasize important



Higher quality low loss cable always pays off in a pinch.

A simple compression test dramatically demonstrates Times Fiber TX cable's (left) superiority over a leading competitor

Maybe you thought low loss cable was all pretty much the same. Maybe you weren't aware that Times Fiber TX cable's thicker, stronger outer conductor not only resists dings and dents in the first place, its triple bonding assures that if there ever is damage, you'll be able to spot it quickly.

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changing conditions that must be accommodated for in the development of an HDTV technical standard. We have successfully lived with the analog NTSC standard first promulgated in 1941 — with modifications over the 52 years — color in 1953, data in vertical blanking, etc. But *all* these developments fitted into the 1941 standard. This is important because any HDTV standard must be flexible enough to adapt to new and currently unanticipated developments — hopefully for as long a period of time.

New developments in the analog age came at a relatively leisurely rate. However, as exemplified by the four "improved digital HDTV systems," we are into a new age of rocket-paced developments and it will not slow down. Also, the HDTV standard will be a part of a world that is more than entertainment alone — it must live with computers, digital transmissions of all kinds and Lord only knows what we don't even yet see over the horizon. These are some of the reasons that we must bend *every* effort to do our *very* best to make the standard flexible enough to survive and adapt in this brave new world. **CT**

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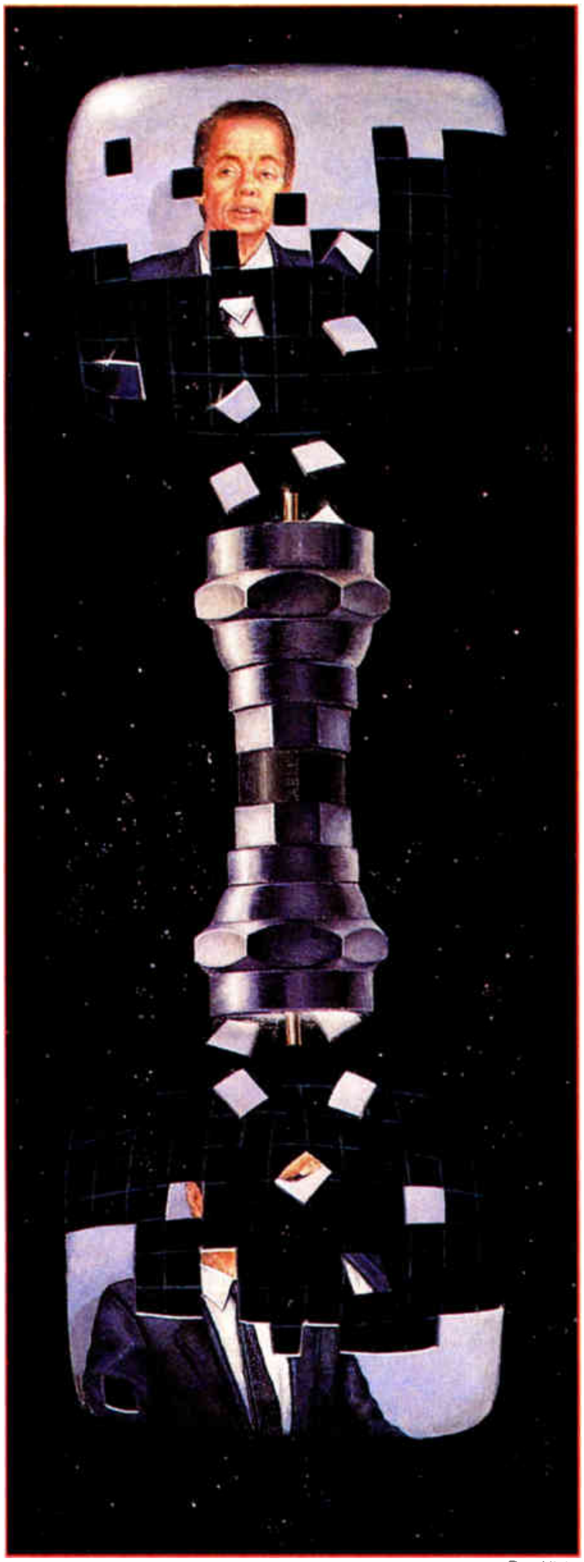
The bits are coming: Deploying digital for video services

By George Lawton

The digital revolution is profound. It has struck almost every segment of the communications industry and left it completely altered. Until recently, the computing horsepower was not cheaply abundant enough to make digital technology cost-effective for video technologies. However, the push for ever smaller and faster silicon chips coupled with the immanent adoption of commercial standar for compressing full-motion video, is on the threshold of driving the deployment of digital technology into every segment of the cable plant — and telephone network for that matter.

Digital video is affecting several areas of video transmission. From broadcast studio to the cable headend, from the headend to the set-top box, bidirectional networks for interactive services and switched networks that could offer an infinite number of virtual channels are here now or are just around the corner.



Ron Hicks

Satellite compression

Imagine squeezing four times as much information into the same space with only marginal increases in equipment costs. Ontario, Canada-based Rogers Cable has begun deploying General Instrument's DigiCipher technology in its systems to process digitally compressed signals coming off satellite. Nick Hamilton-Piercy, vice president of engineering at Rogers, said that national satellite transponders can cost $1.3 million a piece. "With a four-to-one compression ratio your distribution costs are substantially reduced," Hamilton-Piercy said.

Aside from the commercial issues, Hamilton-Piercy said telecasters want to get experience with this new digital medium because they know it will be a requirement when new services like high definition TV come on-line. In addition, it allows them to begin the social experiment — seeing if narrowcasting can gather larger total subscribers.

The Canadian Home Shopping Network began digital transmission to Rogers' systems on Jan. 1. Another channel, Youth TV, is scheduled to go digital in May, and Vision (an independent programmer) is scheduled to be digitizing this summer.

As well, Home Box Office has already started offering digital signals to a few dozen operators across North America via Transponder 18 on Galaxy I. The service began Jan. 1 and HBO plans to digitize more as time goes on.

John Zitter, vice president of technology at HBO said, "We want to compress video so cable operators are not faced with a 7,000-dish decision." Digital compression will enable HBO to provide all of its multiplex channels on already crowded satellites rather than requiring operators to acquire additional dishes for more satellites.

In addition to the programmers getting their feet wet, Hamilton-Piercy said, "We believe we need to get hands-on experience. This is part of our tradition of taking the leadership role."

Hamilton-Piercy said that Rogers plans to begin putting more consortia together with other programmers. He believes that the cable companies have to push the development of digital technology, or they face losing market share to direct broadcast TV.

"We know that DBTV will start in mid-'94 and we need to respond. We have to take it seriously. If you don't take it seriously, it's too late to react. You can't afford to have 4, 5 or 6% of your cash flow disappear."

(Continued on page 58)

Distortion produced by digital tranmission in a mixed analog and digital system

By Joseph B. Waltrich
Manager, Advanced Television Systems
Jerrold Communications

As compressed digital video makes its way onto cable systems, it is reasonable to expect that digital and analog signals will be sharing the spectrum for some time to come. Therefore, the effects of channel impairments in a mixed analog/digital system must be considered. Among these effects are distortions produced by CATV system amps. For analog video signals, distortions due to amplifier non-linearities result in the well-known composite second order (CSO) and composite triple beat (CTB) effects produced as a result of video carrier sum and difference frequencies. The effect of distortions produced by digital transmission is, however, quite different.

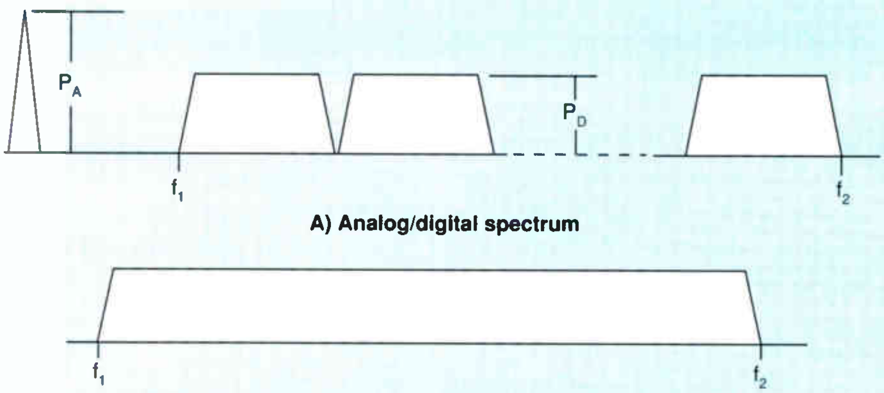
A digital signal, when viewed on an analog TV receiver, appears as random noise and, because of its uniform power distribution, produces a spectral energy distribution, which, in the case of third order distortion, spreads into the adjacent analog channels. This article discusses the nature of distortions produced by multiple contiguous digital channels. The effects of distortion on adjacent analog channel carrier-to-noise are examined and analytical results are verified by test data. Distortion is examined both with respect to digital signal power and as a function of the number of digital channels. Using the data presented here, it is possible to predict the effect of digital distortion on adjacent analog channels by means of a few simple measurements.

When an amplifier is operated outside of its linear range, its output is given by the following equation:

$$e_o(t) = k_1 e_i(t) + k_2 e_i(t)^2 + k_3 e_i(t)^3 \quad (1)$$

Where:
$e_o(t)$ = amplifier output voltage
$e_i(t)$ = amplifier input voltage
k_1 = amplifier gain
k_2, k_3 = constants that define the second and third order distortion performance of the amplifier

Figure 1: Mixed signal spectrum



Since multiplication in the time domain is equivalent to convolution in the frequency domain, the spectrum of the distorted output may be obtained by convolution of the input signal with itself. This yields the following equation:

$$X(f) = k_1H(f) + k_2H(f) * H(f) = k_3H(f) * H(f) * H(f) \quad (2)$$

Where:
$X(f)$ = distorted output spectrum
$H(f)$ = input spectrum

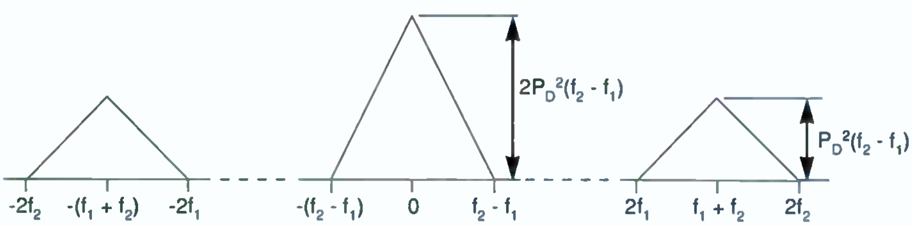
The * denotes convolution. For continuous spectra, the function S(f), resulting from a convolution of the variables H(f) and G(f) is given by the equation:

$$S(f) = H(f) * G(f) = \int_{k=-\infty}^{k=\infty} H(k)G(f-k)dk \quad (3)$$

or, in discrete form:

$$S(f) = \sum_{k=-\infty}^{k=\infty} H(k)G(f-k) \quad (4)$$

Figure 2: Spectrum of second order distortion



Additional information on convolution may be found in a number of reference texts.[1, 2]

Distortions in a mixed system are the result of three types of signal interactions:

- Analog carriers beating with analog carriers.
- Analog carriers beating with digital channels.
- Digital channels beating with digital channels.

(Continued on page 64)

MPEG-II with B Frames: Video compression standard for the decades to come

By Robert E. Chalfant
Director, Technical Marketing
TV/COM International

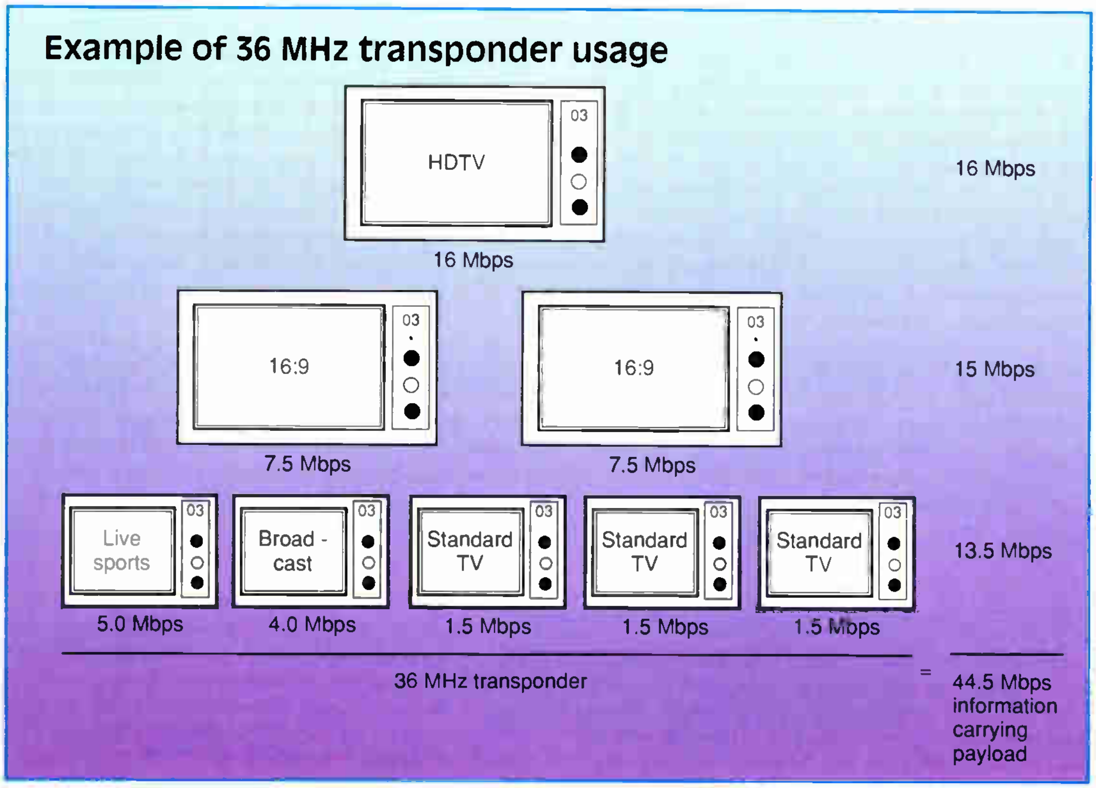
My grandmother used to tell me: "Old age isn't for wimps." Well, neither is the cable TV industry. Operators, programmers and vendors are again (or still) on the brink of technical, political and institutional changes that will alter our business in a fundamental way. The "next-generation" cable TV systems will be carrying compressed digital video, audio and data on hybrid fiber/coax networks. More adventurous operators will add bidirectionality, offering additional services in telephony and multimedia.

The combination of video compression and fiber optics means substantially greater channel capacity to offer new sources of revenue, and improved picture quality and reliability for greater return from the existing programming. The soon to be agreed-upon video compression standard referred to as ISO MPEG-II (Motion Picture Experts Group) with B Frames provides the framework for these new sources of revenue, greater subscriber satisfaction and eventually multivendor hardware availability.

With typical compression ratios of 12:1, or as high as 30:1, depending on programming content, MPEG-II digital video compression with B Frames lets programmers and operators make more efficient use of their satellite and cable transmission systems. In its most basic terms, one can cost-effectively put "12 pounds of service in a 1 pound channel."

The International Organization for Standardization (ISO) is in the final stages of agreement on a worldwide standard for the coding of moving picture and associated audio information. The MPEG-II format with B Frames is the consensus standard of the world's leading video and audio compression experts. And on a side note, Tele-Communications Inc. (TCI) has publicly and repeatedly ex-

(Continued on page 78)



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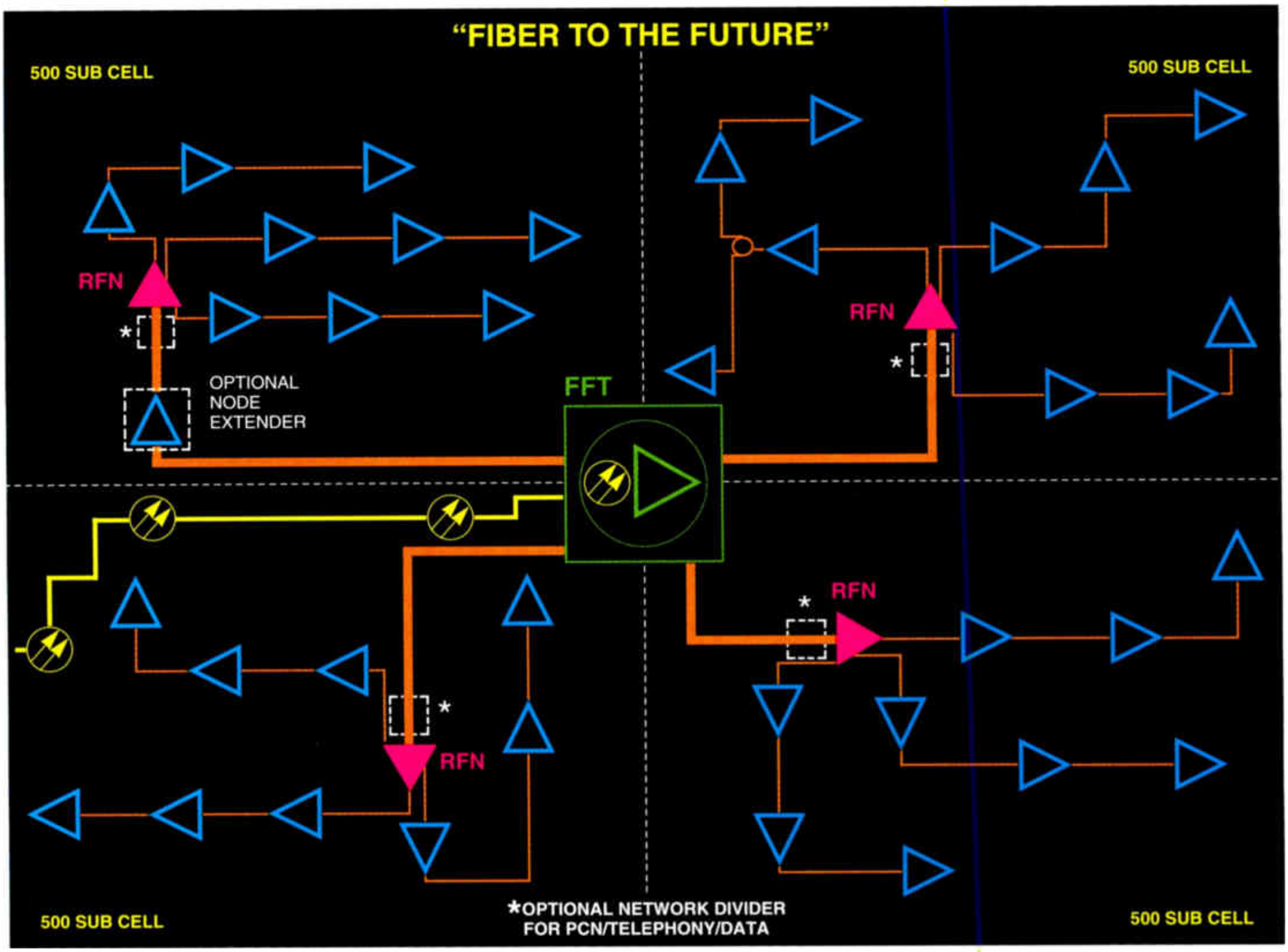
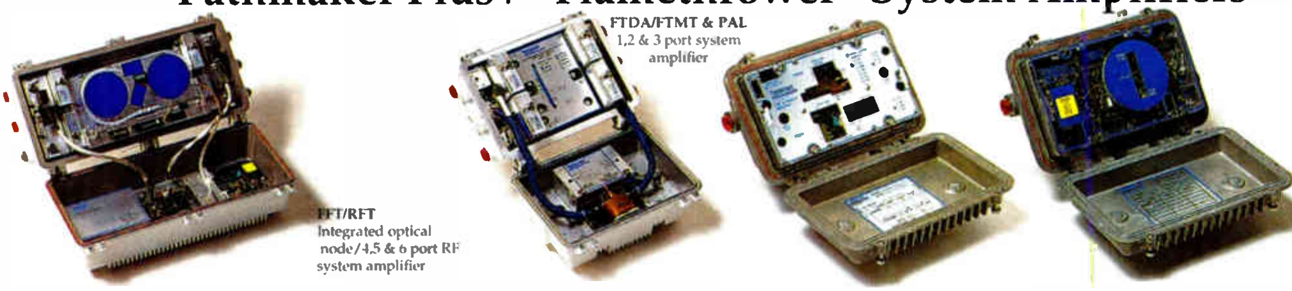


Pathmaker Plus+ "Flamethrower" System Amplifiers



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Digital modulation and transmission technologies for cable applications

By Vito Brugliera
Vice President, Marketing and Product Planning
Cable Products Division, Zenith Electronics Corp.

The TV pictures that are familiar to us have been around for over 50 years. Over the years TV receivers have become less expensive. The pictures have become bigger, brighter and have gone from black and white to color. And audio has gone from mono to stereo and surround sound. All of these improvements have been evolutionary. The underlying NTSC signal technology has remained basically the same: 30 frames per second of 525 lines transmitted as two fields consisting of 256.5 lines. Each horizontal line consists of discrete picture elements called "pixels." Each pixel element is defined by an analog signal representing its brightness value and color using a technology called amplitude modulation.

When used on cable, the analog signal degrades each time it is processed. Each time it passes through an amplifier in the cable plant, distortion and noise are added. When a signal goes through 20 or 30 amplifiers in cascade the noise and distortion increase and visibly affect the signal quality. Fortunately fiber has allowed modern plant design to limit amplifier cascades to as few as four. At best, cable TV signals typically approach an over-the-air signal in quality.

Much of the TV information that is transmitted is redundant. Each picture frame is similar to the preceding frame. Only the moving parts of the picture change from frame to frame. Not much new information is conveyed from frame to frame. It is only when there is a scene change that large amounts of information are needed.

Comparison of VSB and QAM modulation approaches

	4-VSB	16-QAM	64-QAM	16-VSB
Data				
Total data rate (Mbps)	21.5	21.5*	32.25*	43
Number of data levels	4	4	8	16
Theoretical maximum data rate (bits/Hz)	4	4	6	8
Relative data rate	1	1	1.5	2
Carriage in 6 MHz cable channel				
Number of movie channels @ 1.5 Mbps video compression	11	11	17	23
Number of movie channels @ 2 Mbps video compression	8	8	13	17
Number of live video channels @ 4 Mbps video compression	4	4	6	9
Ruggedness				
Continuous wave interference rejection	Excellent	Good	Poor	Good
Phase-noise rejection	Excellent	Good	Poor	Good
Forward error correction	Yes	Yes	Yes	Yes
Required C/N (plus interference)**	22 dB	22 dB	28 dB	34 dB
Required C/N (plus interference)***	17 dB	17 dB	23 dB	29 dB
Analog friendliness				
Composite triple beat rejection filter	Yes	No	No	No
Signal acquisition with noise/interference	Excellent	Good	Fair	Excellent
Channel equalizer	Yes	Yes	Yes	Yes
Cost				
Manufacturing complexity	Lowest	Low	High	Low
Cost of receiving equipment	Lowest	Low	High	Low

*Although, theoretically, all four-level approaches have the same relative data rate, the 4-VSB system uses a 21.5 Mbps channel bit rate — greater than any announced four-level 6 MHz digital data transmission system. Thus competing QAM systems have less than the indicated data rates.
**Without error correction.
***With error correction.

The digital age arrives

As a consequence of recent efforts, especially in work leading to the development of advanced TV systems such as high definition TV (HDTV), a new approach is being taken toward TV technology. These advances deal with digital transmission and compression of video and audio.

In the familiar NTSC technology, each picture element is represented by an analog signal. Each picture element also can be represented digitally — in effect, in 1's and 0's. The advantage of using digital representation is that a digital signal can be restored to its original condition each time it is processed. The degradation suffered by analog signals during signal processing can be eliminated. This means that the digital signal in a subscriber's home at the end of the cable plant can be as good as that at the headend.

The redundant nature of picture information allows us to process it and select only the significant picture elements for transmission and to reassemble the picture into an excellent representation of the original scene. The representation will not be an exact replica of the original because much less information is actually transmitted, but the

(Continued on page 80)

MPEG digital audio transmission

By Ron Merritt
International Marketing Manager
Wegener Communications Inc.

Figure 1: Typical digital audio single channel per carrier transmit block diagram

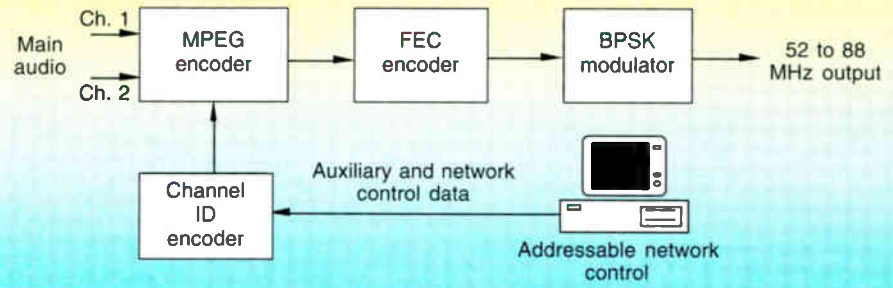
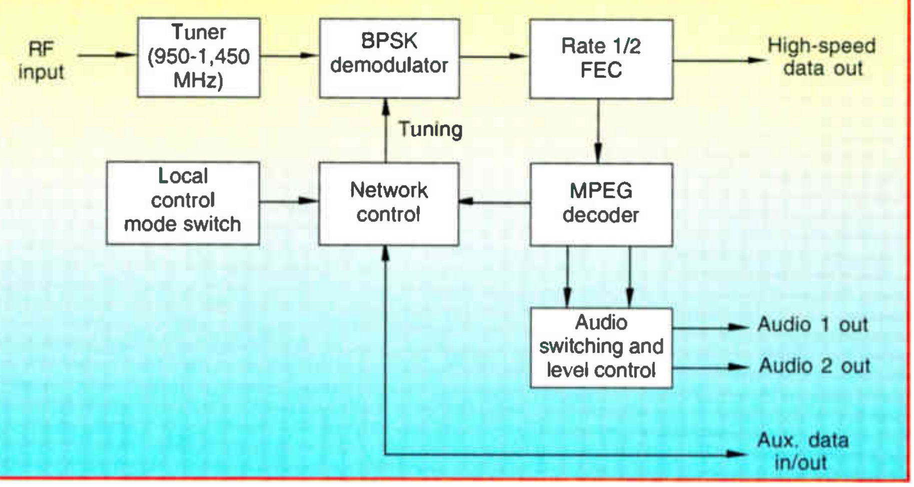


Figure 2: Typical MPEG digital audio single channel per carrier receive block diagram



The ISO MPEG or "MUSICAM" audio compression algorithm represents the next step in audio transmission advancement. For some time the professional recording and broadcast studio environments have been transitioning from analog to digital media and production techniques. A driving factor has been the competitive necessity to improve audio quality. Although digital techniques available for transmission products maximized audio quality, they have not yielded significant savings over analog companding in space segment efficiency. In addition, they have generally been substantially costlier to implement. The MPEG standard is changing that. See Figures 1 and 2 for typical single channel per carrier transmit and receive systems incorporating MPEG technology.

MPEG technology reduces the bit rate for transmission of high-quality stereo audio to less than 200 kbps. While achieving this dramatic reduction in bit rate, the MPEG coding algorithm maintains audio integrity as perceived by the trained ear.

The algorithm has been developed based on psychoacoustic research — that is, study of the human sound perception and the information processing of the brain. Essentially, the MPEG algorithm evaluates an audio signal for redundant information and makes the decision not to transmit that information. Audio signals contain a substantial amount of this type of information that does not contribute to recognition by the brain of the signal. The application of this algorithm to transmission systems allows an unprecedented reduction in data rates and therefore space segment.

The MPEG algorithm also takes advantage of other techniques for data compression. It is possible to transmit a certain amount of quantizing noise so long as the level is maintained below an audible threshold. An audio signal masks smaller amplitude signals close to it. A masking threshold is derived from the aggregate of all masking tones within a signal. Elements of the audio signal below the aggregate masking threshold are inaudible. The MPEG algorithm identifies those elements and makes the decision to transmit only those details that will be perceived by the listener.

Other signal components above the masking threshold only require the level of quantization to keep quantization noise below the masking threshold, and thus the quantization-induced noise remains inaudible. Quantization noise can be better adapted to the masking threshold of the human ear by splitting the frequency spectrum into subbands.

The quantization of the analog time samples required for each individual subband is dependent on the minimum masking value in each subband.

"The ISO MPEG or 'MUSICAM' audio compression algorithm represents the next step in audio transmission advancement."

This minimum masking level is a measure of the allowed quantization noise that is just below the level of perceptibility. Subbands whose desired signal are well below the masking threshold (and are thus irrelevant to the human ear) do not need to be transmitted.

In each 24 millisecond period, a calculation of the masking threshold is

(Continued on page 82)

The dynamic duo: PCS and highly compressed digital voice

By Paul S. Gardiner
Director of Business Development
Intellibit Corp.

Much has been written lately concerning the efforts and plans of cable TV companies, telephone companies, cellular telephone firms and other entities to provide personal communications services (PCS). On Dec. 5, 1991, the Federal Communications Commission held an "en banc" hearing wherein parties interested in providing PCS had an opportunity to give testimony regarding the definition of services, spectrum requirements, technologies and regulatory issues impacting on the development and growth of PCS. Representatives from cable TV, telephone operating companies, cellular communications, local exchange bypass carriers, hardware manufacturers, research institutions and other organizations gave their views and opinions concerning PCS.

A review of the testimonies presented before the FCC indicates that there is not total agreement on a definition for PCS. However, the testimony of John DeFeo, president and chief executive officer of US West NewVector Group, appears to summarize the views and opinions of many of the hearing participants: "In US West's view, PCS is not a single new service but a broad continuum of both existing and new products and services that meet customer demands for mobile and fixed communications, including paging, cordless telephone (CT-1), telepoint-like service (CT-2), limited-mobility PCS service (Enhanced CT-2), PCN, cellular, and satellite services, landline telephone service and other services yet to be defined.

"All PCS providers, present and future, should be able to offer many different combinations of price and functionality, some standardized and some customized to meet specialized requirements."

Efforts are currently underway in Europe and Japan to provide PCS-like services, and these activities set the stage for potentially large numbers of foreign imports into the United States. Japanese and European business leaders recognize the head start advantage for their own suppliers in satisfying the demand in both home and global markets for new PCS equipment. Most of the participants in the en banc FCC hearing believe that the creation of PCS is the next step in the evolution of wireless communications and that the United States must maintain a leadership position in terms of technological and service development in this extremely important marketplace.

The size of the PCS market

Estimates of the size of the PCS market vary widely and are dependent on the particular PCS capability being offered. A recent study by Bellcore indicates that approximately 36% of U.S. consumers are strongly interested in a new wireless shirt-pocket or purse-size portable telephone (handset) that would be restricted to making and receiving calls within designated zones but would not need the capability of working in a moving car.

Arthur D. Little Inc., in recent testimony before the FCC, states that it has done extensive market research into the demand for different types of PCS. The company gives market estimates that are based on different types of information and feedback gained from the following: 1) 30 focus groups throughout the United States in large and small metropolitan markets; 2) 6,000 systematically sampled interviews in the United States with residential and business decision makers; 3) a Delphi research project conducted with numerous global experts in telecommunications concerning possible PCS scenarios; and 4) interviews with potential service providers in the PCS market.

Arthur D. Little states that PCS is the first true market-driven telecommunications offering in more than 100 years. Potential PCS users know what they want and they would buy today if the services were available. Generally, users want to call or be called anywhere; they want small handsets that can fit comfortably in a pocket; they want low service prices (less than cellular, more than regular phone service); and they want to pay less than $200 for a single handset.

The demand for PCS is large and very immediate. Fourteen million PCS subscribers are predicted in North America in the first three to five years after implementation. After 10 years, over 60 million PCS subscribers are estimated for North America. (This number is 10 times the size of the present cellular market.) It is estimated that basic service revenues will range between $30 billion and $40 billion annually, which is one-half the size of the current revenue stream of local telephone companies.

PCS technologies

It is quite evident that in order to provide many of the services contemplated, certain technological developments and equipment interoperability standards must evolve. Bellcore states that there is a need for some minimum set of standards that are definitive enough to enable the interoperability of customer handsets among the offerings of different wireless access providers. This important capability will allow users to change PCS providers without obtaining a different handset. It also will promote competition and enable more efficient spectrum assignments. Statements have been made regarding the interexchange portion or backbone transmission of PCS by telephone companies, cable TV firms, cellular communications companies and other existing service providers giving reasons why their particular networks and architectures are ideally suited to carry PCS-type communications.

Because many of the contemplated services will be wireless and make use of an already congested radio frequency spectrum, it is well recognized that digital compression techniques must be used in PCS in order to make more efficient use of allocated spectrum, provide better quality audio than current analog cellular systems, and provide some level of communications security. Although there are numerous digital encoding and compres-

(Continued on page 88)

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Preparing your plant for PCS

By Paul Schaller
Vice President, Sales and Marketing
Harmonic Lightwaves
And Mike Shafer
Product Line Manager, Optronics
ANTEC Network Systems

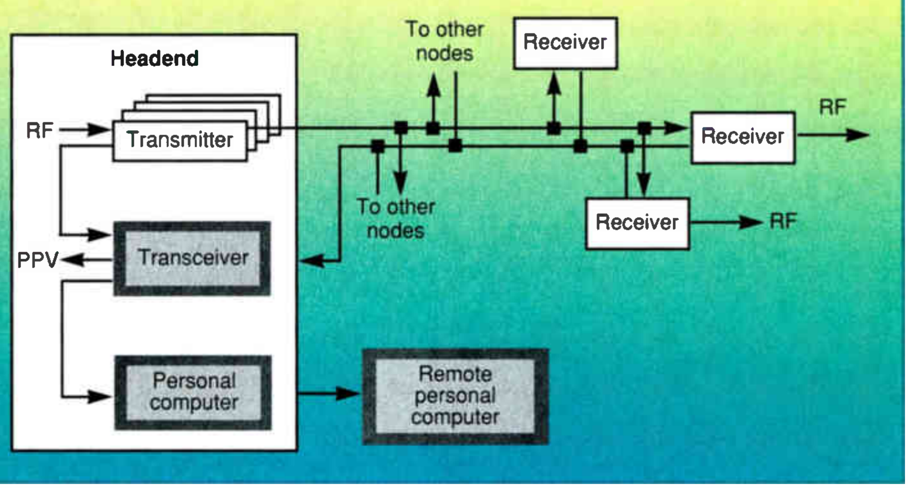
For cable to successfully make the transition from an industry that distributes only one-way video to one that also delivers a range of two-way communication services — including full-duplex personal communication services (PCS) — fundamental changes in network design and management are required.

For example, the primary source of "status monitoring" in many cable systems has historically been the subscriber; many operators first learn of outages or other service problems when customers call to complain. This will no longer be an acceptable means of network management if cable operators also are delivering phone service. One obvious reason is that a phone outage would mean subscribers cannot call to alert an operator of an outage. Another is that phone service is considered an essential utility: For businesses a prolonged outage could mean large amounts of lost revenue; though this is less of an issue for residential service, there is the possibility that availability of phone service could be a matter of life and death in an emergency situation. Although subscribers facing an outage on Super Bowl Sunday might argue to the contrary, cable TV, in contrast to telephony, has never been viewed as an "essential" service.

Today, many operators are well underway with a first step toward becoming "communication network" providers. The increased deployment of fiber to neighborhood nodes of 500-2,000 homes has limited the number of customers affected by outages and also can decrease system component failures in the trunk plant. It also provides the more reliable, relatively noise-free two-way path needed to support PCS and other two-way services.

But fiber is not enough. Other changes in network design also are needed, along with an improved network management system and an enhanced system support capability. Implementation of these changes presents new challenges to operators, technology providers and system integrators who together must develop new hardware, software and business practices to support this network evolution in a cost-effective manner.

Status monitoring can provide early detection of problems



A new standard of reliability

Reliability is a core concern in the telephone industry, where the standard for performance is a bit error rate (BER) of 10^{-6}. A key element in achieving this high level of reliability is redundancy, which can take a number of forms. Part of the answer lies in product choice, another in system design and integration. These two factors are intimately connected, as some combinations of equipment are particularly well- or ill-suited to achieve reliability goals when deployed in specific system configurations.

As in any investment decision, these technology options must be evaluated through the filter of cost-effectiveness. To accurately gauge cost-effectiveness, however, operators must understand not only their current business, but also their future businesses. A cost-cutting measure may not be cost-effective, for example, if it ends up causing unacceptable reliability problems that result in the rejection of an operator's telephony offerings by potential customers.

Among the specific investment decisions that must be made in planning for future services are the choice of equipment and the need for backups, hot-standby switching and route diversity, including the use of redundant fiber rings.

In making decisions about redundancy, factors to be considered are:

- Where the equipment is located and its vulnerability to environmental mishaps (e.g., cable cuts, lightning strikes).
- The level of service required (business customers may, for example, require higher service standards than residential customers).
- How critical each component is to maintaining that service level.
- How quickly a piece of equipment can be replaced if a hot-standby is not available.

These factors must be weighed against the cost of redundancy. Hot-standby costs might vary depending upon what equipment is involved. For example, while a single spare transmitter in the headend can back up multiple operational transmitters, a hot-standby capability for field receivers might involve much higher incremental costs since a separate backup unit might be needed for every operational unit in the field. This cost could be cut, however, if the receivers were designed to handle redundant

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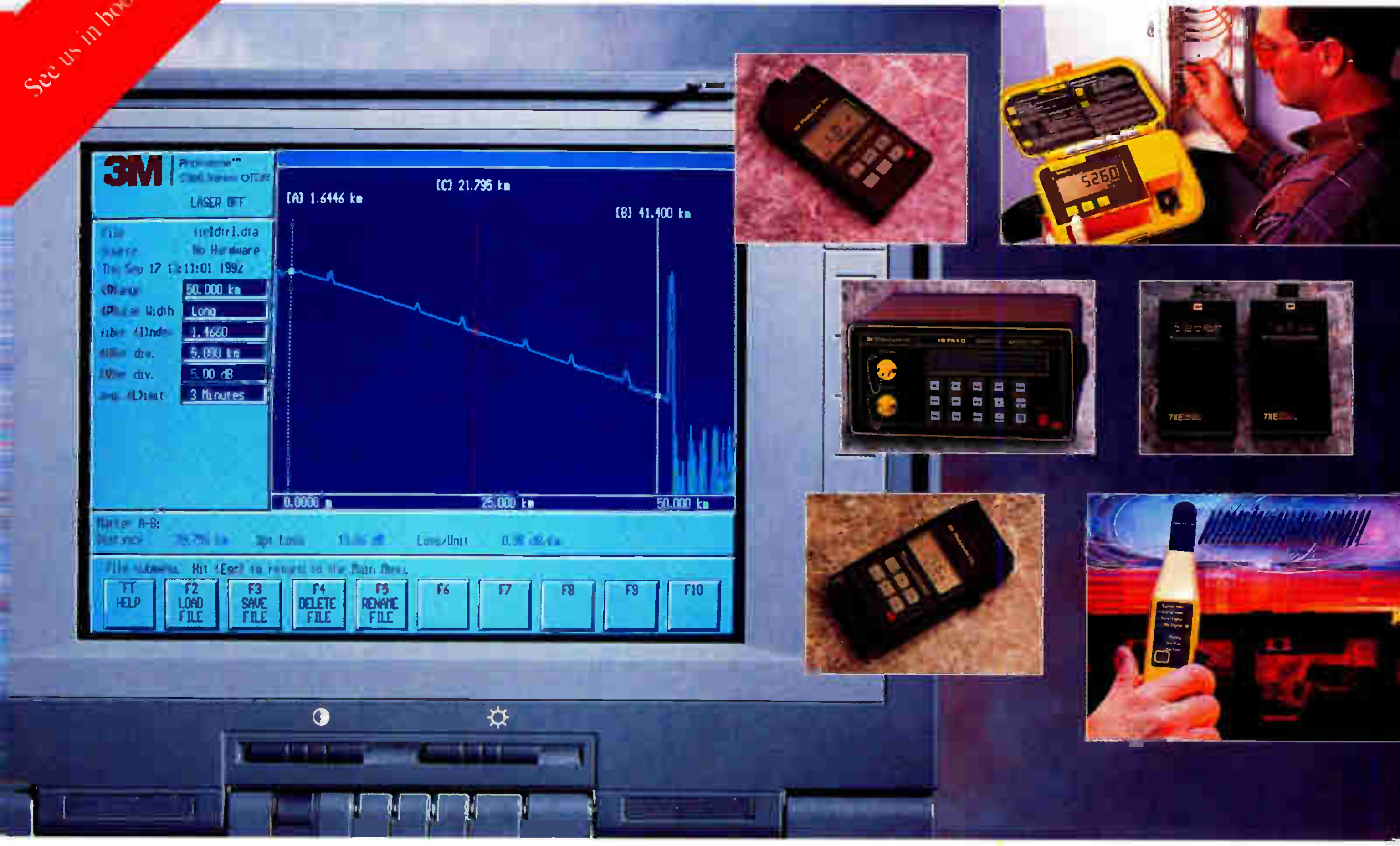

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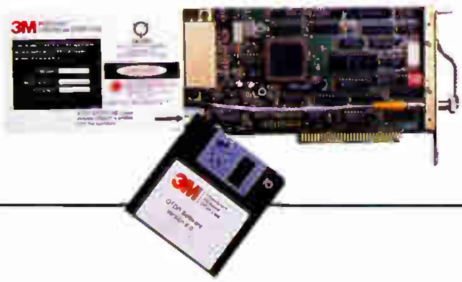

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Reader Service Number 62

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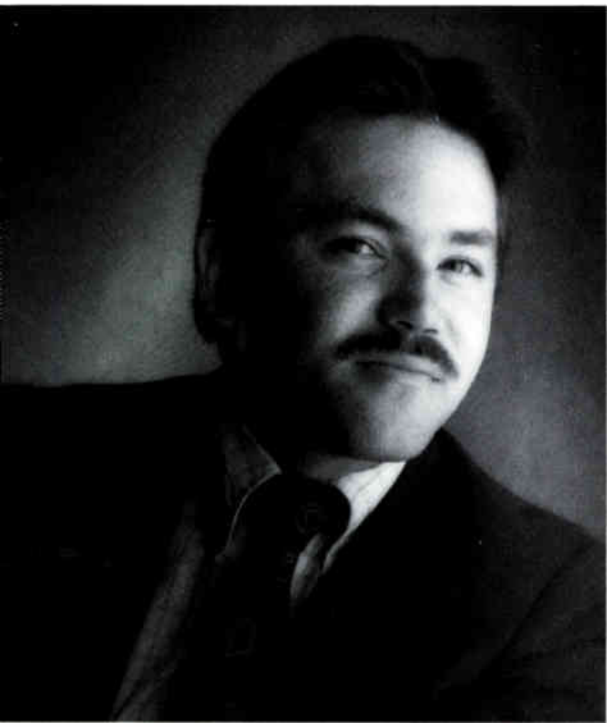

Jerry Neal
Senior Software Engineer
Pioneer Communications of America
Cable Systems Division

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Route diversity is another key cost issue. Though it may be considered essential by some business customers, it may not be required for residential service. In cases where route diversity is added later in response to demand, the costs of doing so may depend, in part, upon decisions made in the initial system design.

Though redundancy and hot-standby capabilities are key factors in achieving the reliability needed for provision of telephone services, there are other elements in the reliability equation. Among the other factors that can affect BER are microreflections and unterminated drops.

Training also is an important factor, as is engineering field support and provision of a 24-hour technical hotline that can help system engineers troubleshoot a problem.

Related to this is vendor ability to quickly deliver components that an operator may not have on hand. This need became increasingly important when fiber optics was introduced to the industry. Though systems usually maintained spares for relatively inexpensive RF equipment, local stocking of laser transmitters, which initially cost $30,000, was less common. Though the declining cost of transmitters has made this less of an issue, the ability to "over night" equipment to systems is likely to remain an important need as new equipment and higher reliability standards come into play in the future.

An evolution from status monitoring to network management

The reliability required for PCS and other voice services also requires that the cable industry employ a new level of network management. In traditional cable networks this function, if it existed at all, was supplied by relatively primitive status monitoring systems. These, often added as modules to other vendors' equipment, were typically limited to sending alarm functions when key components failed.

Entry into the telephone business will require more advanced network management systems that integrate hot-standby switching and are tied to other backup and support systems. These will be required to constantly poll a variety of network components and deliver status messages to technical personnel in a thorough, yet easy-to-understand fashion.

This will allow problems to be anticipated through diagnosis based on changes in status measured before full failure occurs. It also will allow problems to be handled more quickly because the network management system will provide a more precise understanding of the problem and will more quickly mobilize the support systems necessary to correct it.

As it does in other elements of the reliability equation, the cost-effectiveness issue is an important one with regard to a network management systems. And, as in the case of these other reliability factors, the broad long-range picture must be considered.

For example, while the piecemeal addition of status monitoring components may suffice in a system that provides only traditional cable TV service, an operator considering PCS or other new services might be wiser to invest up front in an integrated network management package that can be easily upgraded to support these new services.

This flexibility is particularly important given the uncertainty about PCS regarding such fundamental questions as whether base stations and antennas will be collocated at fiber nodes or in the coax plant. In the latter case, a network management system would probably have to integrate some status monitoring information from the RF portion of the plant.

It also is important that a network management system be relatively easy to install and use and that it allows a system engineer — whether located at the headend facility or at home with only a laptop computer — to comprehensively monitor real-time network status, including a range of key electrical, optical and physical parameters.

To support fast and effective troubleshooting, users should be able to quickly move between screen-displays of global system performance and other displays indicating the status of particular transmitters and receivers, including digital or alarm levels as well as analog or parameter levels. The network management system also should allow the operator to exercise various control functions, including AGC and A/B switch activation.

Flexible designs needed for future-ready networks

Though most operators may not have near-term plans to implement voice service, many see this as a realistic possibility farther down the road. To be prepared for this eventuality, operators should consider flexible technologies and designs when undertaking an upgrade or rebuild. This is particularly true with regard to PCS, since so many questions remain about the ultimate form PCS technology and networks will take.

Things that must be considered in this regard are:

1) The amount of fiber that may be needed in the future for new services and/or additional nodes.

2) Whether home-run fiber designs are demanded by the requirements of downstream video and/or upstream data and voice signals.

3) The module configuration, capacity and upgrade flexibility of optical receivers and other key network components.

4) The ease with which particular fiber-optic systems can support the addition of new nodes.

5) The ability to integrate network management components as they are needed.

Particular technology choices can increase an operator's design options. Systems using external modulation, for example, allow operators the flexibility to employ field-splitting as well as home-run fiber designs, since such systems are largely immune from back reflections. This flexibility can be further enhanced if a system's optical receivers can support relatively high loss budgets and broad frequency windows to support a variety of return-path transmissions.

Other characteristics of equipment also impact on the goal of design flexibility. Some questions to keep in mind are:

- How much extra work is required when the configuration of receivers served by a transmitter is changed?
- Does the fiber system have the power and flexibility to support a shift from a fiber-to-the-feeder design to the redundant ring-type architecture favored for telephone service?

Though certain equipment or network configurations may appear to save money initially, they may end up requiring an expensive and disruptive change-out later on to meet growth in demand or the requirements of new services. The more cost-effective alternative in this case might have been to deploy a technology platform that, though costing more up front, can be upgraded to meet capacity in a graceful, relatively inexpensive manner.

"A system platform that is both flexible enough and powerful enough (can) ensure that cable operators will be prepared to succeed in their future role as providers of full-duplex services."

A coordinated effort is needed

For traditional cable TV networks to evolve to highly reliable full-duplex networks capable of supporting PCS, additional training is required in the areas of digital transport and wired and wireless telephony. The need for training is not limited to the technical side of the house, however. To succeed in a telephony venture, the business staff also must have an understanding of the new technologies involved in order to provide customers with high-quality service at competitive costs.

These changes also will require new forms of support from vendors, who must supply not only the right mix of equipment but also expanded technical field support and training. Increasingly, vendors that have been serving the cable TV industry for years are forming alliances with outside companies that have high-level expertise in emerging technologies and services. These and other new products and vendor alliances can help operators make the challenging transition from one-way video to a family of two-way services, including PCS.

The scope of change required and the uncertainty about PCS strongly favor a system platform that is both flexible enough and powerful enough to ensure that cable operators will be prepared to succeed in their future role as providers of full-duplex services. Creation of that platform entails a number of interrelated factors, including careful product selection and integration to achieve high reliability and flexible system design, expanded training and field service support, and new investments in network management. **CT**

Deploying digital

(Continued from page 38)

Rogers also is planning on getting into interactive services eventually, but will probably start simple. Hamilton-Piercy said that the first service was likely to be an interactive program guide. "Once you have 400-500 channels, we are going to need an interactive program guide just to navigate the poor customer," Hamilton-Piercy said.

System-level compression

In one of the most ambitious projects to date, Tele-Communications Inc. has agreed to invest more than $200 million with General Instrument and AT&T for set-top boxes capable of decompressing digitized video signals. These boxes could eventually offer as many as 10 home-quality video channels in the same space now occupied by each analog channel.

Tom Elliot, vice president of technology development at TCI, said, "I think the switch from analog to digital will surprise a lot of people. Normally once a technology hits any penetration that is measurable, full deployment goes pretty quick."

TCI's significant investment may be just the thing to get the pump primed for low-cost digital set-top boxes.

TCI, along with several other members of Cable Television Laboratories, has set forth its demands for an open standard for digital video compression. It is based on the MPEG-II standard that is being developed by the Motion Picture Experts Group.

Rogers' Hamilton-Piercy said, "It is still on a convergence toward a standard, but everyone is moving toward MPEG. If there was not interoperability, then every affiliate would need different equipment for every different component."

The technology is not new, but it has not been cheap to deploy on a large scale. Elliot said, "The only thing holding it up has been getting powerful enough processing capability to do compression in real time." With this large scale of orders, and the latest generation of computer chips, TCI hopes to be able to sell the units in the $200 range.

Elliot said that he has been following the technology seriously since 1988, when it was decided that computer processors that could execute 100 mips (million instructions per second) would be required for compression. That time has come. Working with CableLabs, TCI put out a request for information (RFI) in 1991, and then a request for proposals (RFP) last August.

Elliot said that TCI picked AT&T and GI because it appeared that those two companies had the best picture quality. But they were not working with MPEG yet, which seemed to be gaining ground as a standard for video compression in every other industry.

Elliot said, "By getting AT&T and GI to work together, TCI hoped it could get the two companies most downstream working with people in MPEG to bring the best possible quality and delivery."

Interoperability between the different implementations is likely to lower the cost of all consumers of video technology, said Elliot. Mass volumes of the same MPEG will lead to economies of scale in their production. Elliot said, "If we could work toward those goals, that helps everyone and that is what MPEG is all about."

Elliot believes that the technology will completely redefine the way we see video in ways that we cannot yet

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C ☐

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imagine. He explained, "Any time that you have a new technology that has the kind of capacity that this has, you are always going to see that as an enabling technology. I think that we will look at this the same way we put the interstate highway across the United States.

"The thing we are doing is putting a very high-speed digital system that will benefit society in all kinds of ways. When people are talking about highways, no one thought about what impact it would have on the cities. When this gets into place, it will enable new services, some of which are very hard to imagine what they might be."

Renting telco plant

It has been tough for the telephone companies to get into video business. The federal government still has a strong code preventing any telco local exchange carrier from programming their own network. Also, predivestiture era rate rules put the brakes on any serious profit-making activities. They are finding that other service providers are able to eat into some of their most profitable ventures, while they are forced to carry the financial burden of universal service.

"The technology is here today and the standards for video compression are almost hammered into a code."

In spite of these burdens, Bell Atlantic has been aggressively pushing to integrate video services into its telephone network. In at least one venture it is working with an established cable operator, Dallas-based Sammons Communications. Sammons hopes to take advantage of the economy of scope by buying up 60 channels on Bell Atlantic's Dover, NJ, video network, which is scheduled to go on line later this year.

But the financial aspects are not yet clear for Sammons. Edwin Comstock, vice president of technology at Sammons, said, "The financial picture is a little difficult to analyze in the sense that you are trading capital costs in plant investment for monthly use expense."

Bell Atlantic's subsidiary, New Jersey Bell, will own and maintain the plant and lease capacity to Sammons. Sammons will have no plant maintenance and no indirect costs related to plant maintenance. But it will have increased monthly use expense from channel lease. Comstock said, "We also will lose some depreciation advantages."

Initially, Comstock just wants to get the system up and running. In the meantime he will be looking at different services for programming and information. But the big service potential is switched video-on-demand. In that system, the customer would have total control of all 60 channels.

Each customer will still have two lines coming into the house. When they need service, a truck with "New Jersey Bell" written on the side will show up (not "Sammons").

Comstock added, "It is still Sammons providing service to subscribers."

From the customers' point, their 37 channels will jump to 60. Comstock does not anticipate a price increase for existing service.

Sammons is committed to the trial for the next 10 years. Comstock said, "It is a trial as far as providing the existing service, testing the potential for new revenues and testing the relationship with New Jersey Bell.

One of the added benefits of New Jersey Bell's network is that it uses an architecture that will enable Sammons to target their video programming by area. For example, a predominantly Hispanic section of town could have more Spanish programming than a predominantly white upper class section.

Switched video

Cable operators can continue to stuff more channels onto each cable going into consumers' homes, but perhaps the returns on these added channels will only lead to marginal improvements. The next evolutionary step will provide an unlimited number of channels. If subscribers could call up to a video service anywhere in the country, then anywhere they dialed would be like a separate channel.

An emerging technology called asymmetrical digital subscriber line (ADSL), which is being developed at Bell Labs and deployed by Bell Atlantic, can provide switched video over the existing copper network.

Larry Plumb, a spokesperson at Bell Atlantic, said, "We believe there is a paradigm shift underway."

Plumb maintains that customers want choice and convenience, which 50 and even 500 channels could bring to a greater extent. "But it is still essentially broadcast in its form," explained Plumb. "Compare that to switched: you can go from 50 channels to one and get more choice. With server technology you can duplicate much of the functionality of a VCR. On top of that we will be able to stop the film and go back and restart. It will bring not only choice but customer control."

New computer disk storage devices (called servers) are capable of storing tens of movies on-line. Customers could dial into these servers, which several subscribers could watch simultaneously, while still maintaining the power to pause and go forward or backward like a VCR.

Plumb is excited because "the entertainment industry is a high margin business. Once this is in place it can be anything. The endpoint we are after is two-way broadband interactive. It will be in fashion as early as 1994. We will have heavy deployment in 1995 to 1996."

Not only that, ADSL will let Bell Atlantic deploy the service line by line. Says Plumb, "I don't have to dig up the front lawn to install fiber. We can build video-on-demand to reach critical mass and then take the ADSL modems for another market."

When need is apparent for fiber-to-the-curb, then Bell Atlantic can begin to deploy it. At that point, the same high-speed modems can be deployed in virgin territory.

Plumb said, "We are going into markets with zero market share. From our perspective, it is a growth opportunity."

In Orlando, FL, Time Warner plans to go ahead with bidirectional communication to the home in the very near future. It plans to have the network operational by the end of the year with service available for residential customers in early 1994. Initially the service will operate in an area with approximately 4,000 residential customers. Time Warner's entire Florida operations serves 500,000 subscribers.

Time Warner recently released the RFP and is waiting for a response. Dave Pangrac, an engineer at Time Warner, said that they were planning on implementing an ATM-like network, which could support voice, video and data on the same network.

The path Time Warner takes is not cast in concrete. Pangrac said, "As we go forward we will be selecting the vendors that will supply different parts of the system. We don't have only one way to get there. Now that the proposal has been made public, we are looking at which combination gives us the best strategy to deploy."

A short way off

The technology is here today and the standards for video compression are almost hammered into a code. TCI's decision to buy a substantial quantity of compression equipment from AT&T and GI is likely to pave the way for other operators to jump in with less risk and greater benefit.

On the other side of the playing field, the telcos now have the opportunity and the technology to get into the video game. Digital technology will enable them to leverage their substantial investment in infrastructure. However, they still face a barrage of regulatory hurdles that limit their incentive to participate. **CT**

Distortion by digital transmission

(Continued from page 40)

The first case produces an output spectrum containing the original signals plus additional frequency components that are functions of the sum and differences of the input carrier frequencies (i.e., CSO and CTB). The second and third processes will be examined in the following paragraphs.

An example of a mixed analog/digital cable spectrum is shown in Figure 1A (page 40). In this example, it is assumed that the digital channels are located together at the upper end of the spectrum since this is where most MSOs are planning to put their digital channels. It also is assumed that the digital signal power, P_D, is the same for all digital channels and that the analog carriers are all at the same peak power, P_A. For purposes of simplification, the spectral notches created by the individual digital channel filters will be ignored and the digital signals will be treated as a single contiguous spectrum, occupying a portion of the cable spectrum between frequencies f_1 and f_2 as shown in Figure 1B (page 40).

The spectrum of second order distortion produced by digital/digital interaction is obtained by the convolution of the digital portion of H(f) with itself. This produces a set of triangular spectra as shown in Figure 2 on page 40.

From Figure 2, it is seen that digital second order distortion generates three triangular shaped spectra, centered around DC and $\pm(f1 + f2)$, respectively. The amplitudes of the second order spectra are proportional to the square of the digital signal power, P_D. If the digital channels are grouped at the upper end of the cable spectrum, then the high frequency spectra will be out of band and, therefore, will not contribute to the in-band distortion. Depending on the bandwidth occupied by the digital channels, the low frequency component of the second order spectrum may affect the return path and/or some of the low end channels in the system.

The spectrum produced by analog/digital signal interaction is a flat spectrum, extending throughout the range of analog signals and is given by the equation:

$$D2_A(f) = [P_D P_A (f_2 - f_1)/W] \qquad \textbf{(5)}$$

Where:
$D2_A(f)$ = second order distortion due to digital/analog interaction
P_A = analog carrier peak power
P_D = digital signal power

Since the second order spectrum described by Equation 5 is proportional to the product of the analog and digital signal power, assuming a constant analog carrier amplitude, the distortion will change by 1 dB for each dB change in digital power.

To obtain the spectrum produced by third order distortion, it is necessary to convolve the input spectrum H(f) with the second order spectrum. For digital/digital interaction, this yields the bell shaped curves shown in Figure 3. For positive frequencies, this curve may be expressed as a combination of the following three quadratic equations:

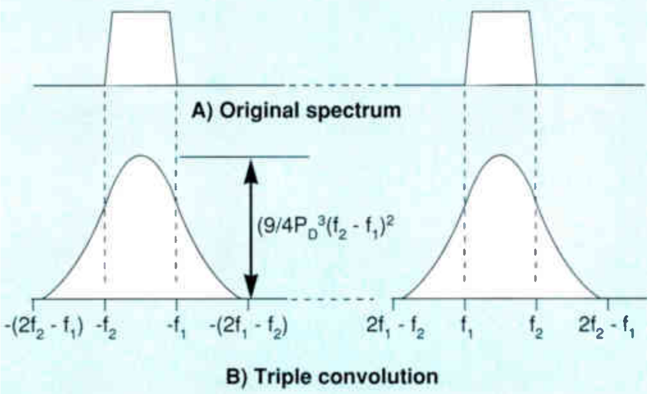
$$D3_D(f) = P_D^3[1.5f^2 - 3(2f_1 - f_2)f + 1.5(2f_1 - f_2)^2] \quad (2f_1 - f_2 \le f \le f_1) \qquad \textbf{(6)}$$

$$D3_D(f) = P_D^3[-3f^2 + 3(f_1 + f_2)f + 1.5(f_1^2 + f_2^2 - 4f_1f_2)] \quad (f_1 \le f \le f_2) \qquad \textbf{(7)}$$

$$D3_D(f) = P_D^3[1.5f^2 - 3(2f_2 - f_1)f + 1.5(2f_2 - f_1)^2] \quad (f_2 \le f \le 2f_2 - f_1) \qquad \textbf{(8)}$$

From Equations 6-8, it is seen that the amplitude of the distor-

Figure 3: Spectrum of third order distortion



tion is proportional to the cube of the digital signal power. Therefore, as with analog CTB, digital distortion increases by 3 dB for each dB increase in digital power. The distortion also increases by 6 dB for each doubling of the digital bandwidth as shown in the example presented in Table 1.

From Figure 3, it also is seen that the spectrum of digital third order distortion covers a frequency range that is greater than the original digital spectrum by a factor of three. Therefore, third order distortion produced by the digital signals will affect adjacent analog channels. However, the adjacent channel impairment will appear as random noise rather than beats. The worst-case distortion will occur in the analog channel immediately adjacent to the digital spectrum. For the lower adjacent channel, the average value of the distortion in the channel is given by the equation:

$$(D3_D)_{AV} = \frac{1}{W}\int_{f_1-W}^{f_1} D3_D\,df \qquad (9)$$

As in the second order case, third order distortion produced by analog channels beating with the digital channels produces a flat spectrum, which is given by the equation:

$$D3_A = [P_D^2 P_A (f_2 - f_1)^2/W] \qquad (10)$$

The relative contributions of both types of third order distortion may be determined by calculating the ratio $(D3_D)_{AV}/D3_A$. At equal analog and digital power levels, this ratio is about 137 dB for eight or more 6 MHz digital channels. Therefore, the dominant form of third order distortion is that produced by the digital signals beating with themselves. Table 2 (page 66) is a summary of the effects of the various forms of distortion.

When operating a mixed signal cable system, it is desirable to use as high a digital signal power as possible in order to provide good signal quality while minimizing the amount of data overhead required for error correction. At the same time, the digital

Table 1: Variation of distortion with digital bandwidth

Digital channels	f_1 (MHz)	f_2 (MHz)	Peak $D3_D$ (dB)*
8	354	402	-6
16	354	450	0
32	354	546	+6
64	354	738	+12

*Relative to $D3_D$ for 16 channels.

signal power must not be so high that digital distortion affects the noise floor of the adjacent analog channels. Based on the analysis described in the previously, it should be possible to find an acceptable power level that will provide optimum operating conditions. Therefore, a test program was undertaken at Jerrold to determine the effects of digital distortion in a mixed signal system.

Tests of distortion were conducted using the setup shown in Figure 4 on page 68. The IF output of a 16 QAM modulator was split 16 ways and the splitter outputs were then input to the RF sections of 16 Jerrold Commander V modulators. The modulator RF outputs were then combined to form the digital portion of the spectrum. The digital signals were output on Chs. 42 to 53 and 62 to 65, thus generating a continuous digital spectrum from 330 to 426 MHz. The digital signals were combined with 46 channels from a Matrix generator to form the mixed signal spectrum. The combined spectrum was input to a four-amplifier cascade driving a single line extender whose output was fed to a spectrum analyzer. Step attenuators were inserted in both signal paths for independent control of digital and analog signal levels.

Initial tests consisted of verifying the effect of purely digital distortion. This was done by first setting the analog input to the line extender to the desired level and then setting the digital signal power equal to the analog power. The Matrix generator was then disconnected and the system noise floor was measured at 3 MHz below the lower edge of the digital spectrum. (The center of the lower adjacent analog channel, if it were present.) In order to separate noise from distortion, two noise floor measurements were made: the first with the digital signals present and the second with the IF input to the modulators disconnected. The distortion was then calculated by subtracting the second measurement from the first. This was repeated for several levels. In order

Table 2: Effects of various distortions

Distortion type	Effects
Second order digital/digital	Triangular spectrum centered around DC. Decreases by 2 dB for each dB decrease in digital signal power.
Second order digital/analog	Flat spectrum. Decreases by 1 dB for each dB decrease in digital signal power.
Third order digital/digital	Bell shaped spectrum centered around the digital spectrum. Decreases by 3 dB for each dB decrease in digital signal power. Distortion extends into adjacent analog channels and is the dominant form of distortion in the system.
Third order digital/analog	Flat spectrum. Decreases by 2 dB for each dB decrease in digital signal power.

to eliminate the need for analyzer noise floor correction, measurements were made in units of noise power spectral density (dBm/Hz). Results are presented in Table 3 (page 70) and shown graphically in Figure 5 on page 71. From Figure 5 it is seen that the calculated data points for distortion lie fairly close to the 3 dB/dB curve predicted by theory. Also, as might be expected, the noise increases by 1 dB for each dB increase in signal power.

The distortion was calculated from the data in Table 3 as:

$$D = 10\log(10^{(n+D)/10} - 10^{n/10}) \quad (11)$$

Where:
n + D = noise floor with digital modulation on
n = noise floor with digital modulation off →

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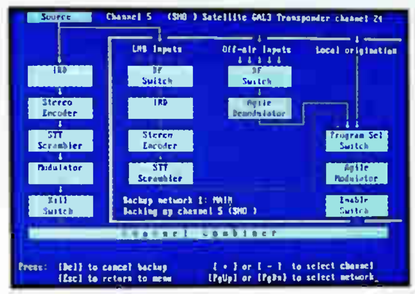

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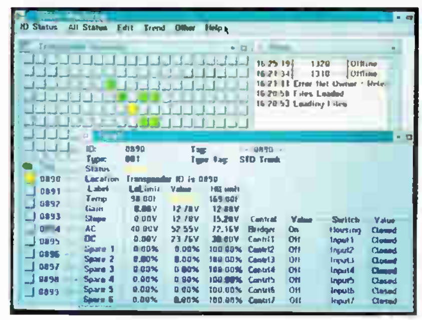

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