COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television

Pull-out RF spectrum wall chart

Correspondent's Report

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February 1993

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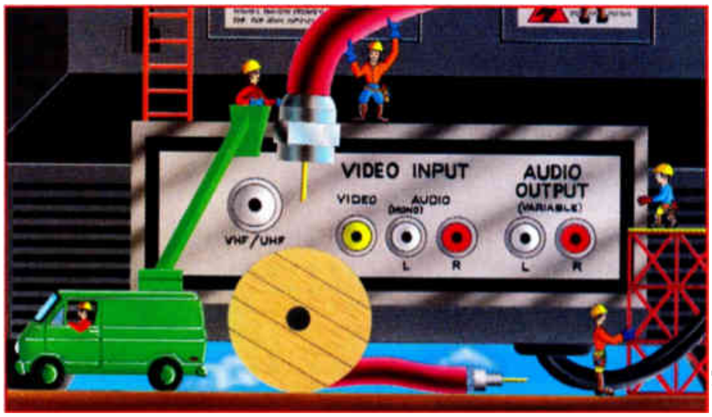
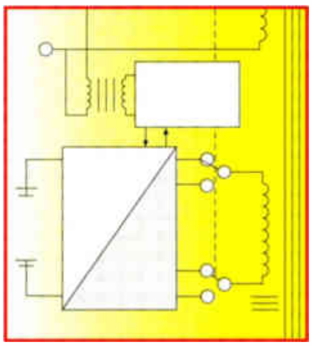
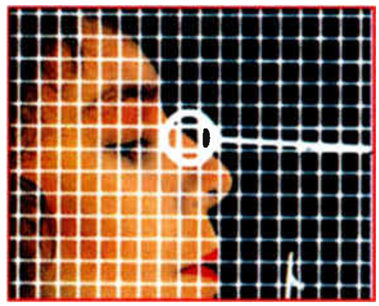
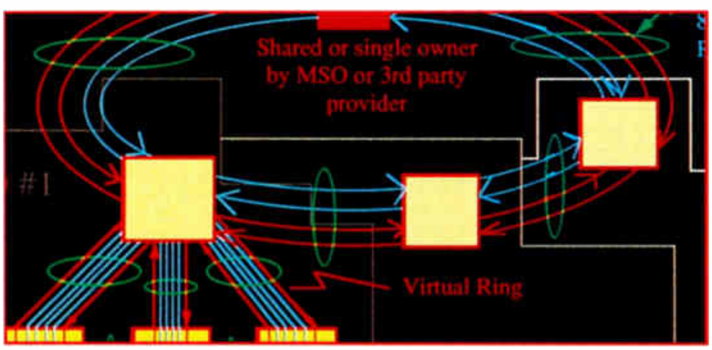


Geri Saye







Features

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EDITOR'S LETTER

Future-proofing cable

A few years ago the Society of Cable Television Engineers introduced its popular series of national fiber-optics conferences to address this exploding new technology. As the use of optics became more widespread, we found ourselves confronted with a number of non-fiber engineering advances, resulting in last year's conference being renamed Fiber Optics Plus. This trend has shown no sign of changing and this year the Society called its winter gathering "1993 Conference on Emerging Technologies." (See "SCTE News" on page 12 for more details.)

After listening to the presentations at this latest conference, as well as coffee break and after-dinner chatter, I came away with some interesting thoughts. A pervasive theme seemed to fill the air — one that could quite well be critical to our industry's future success. I'll get back to it in a moment.

More than entertainment

Consider that for several years cable has promoted itself as an entertainment delivery service. We've done this at all levels of the business, especially the political level. (Unfortunately we've failed to educate politicians about the real value and future potential of cable.) As an entertainment delivery service, you have to admit that we've done rather well, generating revenues of some $20 billion annually.

Not bad, but think about some of the related revenues we aren't sharing. Videotape rentals, for example, amount to $12 billion each year; data communications, $40 billion. Alternate access, bypass, POTS, LAN, MAN, WAN, teleconferencing and similar telco-type industries together generate revenues that I can only assume total in the hundreds of billions annually.

Despite our efforts to appear to remain a "small kid on the block," we have attracted attention. Not only did we get ourselves re-regulated, but potential competition is looming on the horizon in the form of ADSL, HDSL and video dialtone (the telcos); direct broadcast satellite; and the wireless cable folks: MMDS, and a new one called MLDS, or multichannel local distribution service (a.k.a. CellularVision). Even our new vice president, Al Gore, has been pushing for a national fiber-optic "digital highway."

Not a choice, a must

You see, we have an incredible untapped potential in the form of the broadband pipeline that we have wired past most of the households in this country. The telcos are limited by the twisted-pair local loop in terms of their ability to provide real broadband communications, and they know about our potential. Of course, other industries know about our capability, too. But do we?

The underlying theme I felt at last month's conference is simple. We have to move away from just being an entertainment delivery service and become a true telecommunications provider. That broadband pipe we call CATV has what will probably be a limited window of opportunity to become the leading communications service in America. We must prepare for the integration of video, data and telephony services on our networks. If we don't, our competition will, and the business we know as cable will be hard-pressed to survive.

Indeed, we have to ensure that our networks are capable of being "future-proof." This may be easy for technologists to understand, but the real work is going to be convincing the operations side of this industry that we have no choice.

Ronald J. Hranac
Senior Technical Editor

750 MHz design: What is it really?

By Margaret Gaillard
Manager Design and Drafting
Jones Intercable

Operating digital signals between 550 MHz and 750 MHz is generally accepted in the industry today. Some multiple system operators (MSOs) are considering carrying digital signals as low as 450 MHz. But how does this really affect design?

Articles on upgrading existing plant to 750 MHz are continually published with conflicting information including cost per mile and actives per mile. Does this mean some articles are providing incorrect information? Absolutely not!

Pros and cons

The cost of upgrading to 750 MHz depends on how a cable system designs for the digital signals. The signals can be designed like a fully loaded, 110-channel analog system at 750 MHz or designed based on the highest analog frequency such as 550 MHz.

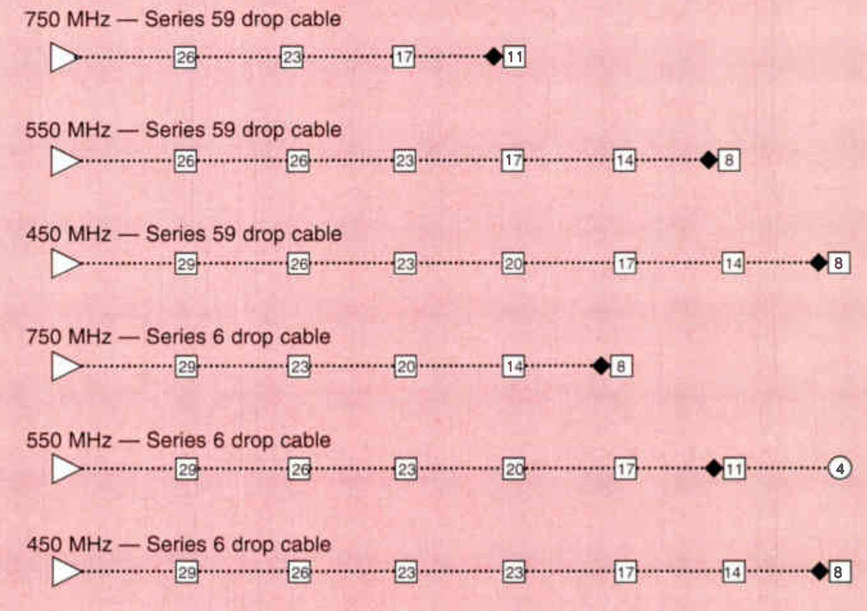
Proponents of designing the system as 110-channel analog contend that there are several unknowns about future services. Systems should be prepared to add any service that may be analog in the proposed digital realm. Some fear the Federal Communications Commission may order that a certain service be carried between 550 MHz and 750 MHz in an analog format. Systems not designed as fully analog would have to rebuild their plant in this scenario.

Advocates of design using 550 MHz parameters argue that digital is very forgiving and there are no FCC regulations at this time. Some MSOs believe that by the time the FCC addresses digital issues, the majority of cable plants will have been designed and rebuilt with the 550 MHz parameters and the FCC will take this into consideration.

Neither of these arguments are right or wrong. However, there is a big cost difference between the two philosophies. The cost of just the actives varies as much as 20% between the two views.

Minimum tap ports levels contribute to a major portion of the cost to upgrade to 750 MHz. The accompanying table shows the difference between using Series 6 and Series 59 drop cable at the different frequencies. Using Series 11 cable for drops at 750 MHz will closely resemble minimum tap port levels at 450 MHz using Series 6 drop cable. Since the most common drop cable found in systems today is Series 6 or 59, the accompanying figure will reference these two types of cable in the design comparison.

Design comparison with Series 59 and Series 6



Several unknowns will affect minimum tap port levels such as adding "smart boxes" to decrypt computer data transmissions, telephone signals and cable TV. Minimum tap port levels will continue to dictate the cost of upgrades and must not be overlooked when setting up system design parameters.

Assuming the upgrade is designed as a fully loaded, 750 MHz analog system, Series 6 will allow 20% further penetration compared to Series 59 drop cable. This will eliminate some actives in a 750 MHz design but will still average 5-7 actives per mile (depending on density and architecture) and average a 25-30% increase in the cost of actives for an upgrade.

To design a system at 750 MHz with the intention of operating the digital signal on a carrier 8-10 dB down from the 750 MHz output could have the same minimum tap port levels as a 550 MHz design. The reasoning is that the digital signal is distributed via a lower output power than the analog signals. However, the amplifiers must be spaced at 750 MHz.

If the system design parameters are set up so the output of the active device at 750 MHz is 48 dB, a measurement at 550 MHz would reveal an output level of approximately 46 dB. If these same parameters assumed the digital signals would be carried at 8 dB down from the referenced 750 MHz output, the actual digital sig-

(Continued on page 50)

Minimum tap port levels

	750 MHz	550 MHz	450 MHz	54 MHz
Series 6				
150 feet, two outlets	14	13	12	7
Series 59				
150 feet, two outlets	16	14	13	8

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Bell Atlantic involved in competing cable TV

TOMS RIVER, NJ — Bell Atlantic Corp. teamed up with a new company, FutureVision of America Corp., to form a plan to offer cable TV programming over phone lines here. The new system would compete against Toms River's existing cable operator, Adelphia Communications.

The 10-year agreement allows FutureVision to offer telephone customers a fiber-optic network capable of carrying 60 channels of video programming and regular phone service using Bell Atlantic's lines. The system will reportedly be fully interactive and would offer subs a variety of information services like home shopping and advertising services.

The Wall Street Journal reported that down the road FutureVision could end up competing with Bell Atlantic, which would like to offer its own video and information services.

The regional bell operating company has dove into other cable TV plans recently including a planned test of a video-on-demand service delivered over twisted-pair phone lines. Also, Bell Atlantic reported an agreement was made with Sammons Communications to provide a 60-channel system in Morris Township, NJ, where Sammons already has a system.

The Federal Communications Commission still has to give its approval before Bell Atlantic can begin constructing its hybrid fiber-to-the-curb systems in Morris Township and Toms River.

CableLabs seeks DPU test method

BOULDER, CO — Cable Television Laboratories issued a request for information and proposal to a number of test laboratories, universities and some government agencies in the U.S. seeking input to establish a method of testing TV sets and VCRs for direct pickup (DPU) interference. The deadline was in early January.

The result of the inquiries will be a technique for measuring the susceptibility of consumer electronics devices to DPU interference. CableLabs will share the information generated with the manufacturers of consumer electronics devices and with the Federal Communications Commission for its use in establishing performance standards for TV sets and VCRs as is called for under the recent cable legislation.

Augat awarded $40 million by court

MANSFIELD, MA — A Bristol County Superior Court judge entered a final judgment in favor of Augat Inc. in an unfair competition case brought in 1985 against Aegis Inc. and Jeremy D. Scherer. The judgment entitles Augat to recover over $40 million from Aegis and Scherer.

The case arose from improper activities of Scherer and Aegis in 1984 while starting a venture that competed with then-Augat subsidiary, Isotronics. The court found the defendants had worked with a former Augat subsidiary executive to improperly hire away key technical employees.

Oak, Gilbert in acquisition talks

WALTHAM, Mass.— Oak Industries and Bain Capital formed an acquisition company that is negotiating to acquire 85% of the outstanding stock of Gilbert Engineering.

Under the proposed structure, Gilbert management would retain ownership of the other 15%. Completion of the transaction would be dependent on, among other factors, a definitive purchase and sale agreement, debt financing, and regulatory approvals.

Satellite coalition cries GI monopoly

MACON, MO — The Consumer Satellite Coalition is urging the Federal Communications Commission to "end the monopoly that is currently enjoyed by the General Instrument Corp. in providing the decoders needed to unscramble TV transmissions received by home satellite dishes."

The CSC submitted comments for an FCC proceeding in which the coalition claims GI "abuses monopoly power." These comments include: a report on GI's alleged harassment of a Canadian company, Deltec, which attempted to market a competing decoder; comments to the effect that dish owners were repeatedly forced to buy new decoding equipment as GI altered its technology; and reports on GI's electronic counter measures to disable illegal decoder boxes that allegedly were used against owners of legitimate equipment.

☛ Ian Ruddy, an SCTE-certified installer subcontracting for Storer Cable, recently gave new meaning to *providing good service*. It was a normal day installing cable in an apartment in North Laurel, MD, when Ruddy heard screams coming from a neighboring unit. He soon found himself being asked if he knew about birthing babies. Having been a Lamaze coach, he was able to help and about three minutes later he delivered a 6-pound, 7-ounce boy to a woman who went into labor on her bathroom floor. It didn't end there though. The baby's umbilical cord was wrapped around his neck and he was blue. Ruddy again kept his cool and unwrapped the cord, enabling the baby to take his first breath. Paramedics arrived soon after to take over. Mother and child were reported in good condition later that day at the hospital.

☛ The Federal Communications Commission recently held an exhibit of emergency alerting systems as a part of its efforts to improve the Emergency Broadcasting System (EBS). Presenters at the exhibit included Dynatech Cable Products, Cadco, Scientific-Atlanta, StormWATCHER Systems, the National Weather Service, SAGE Alerting System, HollyAnne Corp., and TFT Inc.

☛ Ortel announced it successfully tested a DFB laser that produces 25 mW of power while meeting full CATV performance specifications for 60-channel transmissions. With 18 dB of optical loss, the carrier-to-noise ratio was 55 dB with composite triple beat and composite second order >65 dB.

☛ Zenith Electronics and GoldStar Co. jointly developed a digital high definition video cassette recorder for home use. The digital HD-VCR, developed for the Zenith-AT&T Digital Spectrum Compatible high definition TV (HDTV) system, is designed to record HDTV signals on standard Super-VHS (S-VHS) videocassettes.

1993 Conference on Emerging Technologies

More than 700 participants — up by over 20% from last year — took time from their busy schedules to go to New Orleans Jan. 6-7 to attend the conference.

NEW ORLEANS — The Society of Cable Television Engineers' 1993 Conference on Emerging Technologies goes down in the books as yet another successful SCTE confab. More than 700 participants — a figure up by over 20% from last year's Fiber Optics Plus — took time from their busy schedules to go to New Orleans Jan. 6-7 to attend the conference.

This year SCTE conducted a series of optional preconference tutorial sessions the day before the main conference, to provide a foundation for the next two days' presentations. Tutorial topics included "An Introduction to Digital Technology," "Modulation Techniques," Fiber-Optic Technology" and "Operator Experiences with Fiber Optics." Judging by the 400 or so who attended these introductory sessions, this popular format will likely play a role in future Society meetings.

That same evening during a preconference reception sponsored by SCTE, Corning and *CED* magazine, NewChannels Corp.'s Director of Engineering Tom Staniec was named the industry's first recipient of the new Polaris Award. This award was created to recognize individuals "in the field" who have been innovative in their application of fiber-optic technology. In addition, Corning donated $2,000 to SCTE in Staniec's name to fund fiber-optic education.

Following opening remarks by Society President Bill Riker, moderator Alex Best of Cox Cable kicked off the conference sessions. Best remarked that during the last four years our industry has installed more than 1 million miles of fiber, and in 1993 alone we'll install an additional estimated 1 million fiber kilometers. He added that this averages about "85 miles an hour." While this still is only the same as a single large RBOC, we are "the fastest growing industry using fiber," according to Best. This introduction was a prelude to the day's presentations on advances in fiber-optic components and architectures, and digital compression and transmission techniques.

Wednesday's keynote luncheon speaker was Alan Baratz of IBM. Noting that both the computer and cable TV industries share a common analog-to-digital evolution, Baratz described a future where the two can effectively work together. He spoke of gigabit multimedia that could bring such things as CNN to the desktop, movies-on-demand, head-to-head video games and desktop global videoconferencing — all shared-interactive technology via the power of computing and the broadband pipeline of cable.

Thursday's sessions looked at our future as a true telecommunications provider, including not only digital transportation, video-on-demand and personal communications services (PCS), but also the viability of integrating video, data and telephony on cable. Of interest to most attendees was a look at potential competitors such as ADSL, DBS and the recently introduced CellularVision, a 28 GHz FM "cellular" multichannel local distribution service.

Polaris Award recipient Tom Staniec of NewChannels Corp. receives congratulations from SCTE Chairman Ron Hranac.

The second day's keynote luncheon speaker, Digital Equipment Corp.'s Bill Styslinger, echoed earlier comments that cable is complementary to the computer industry, and that we "have a fabulous network" that includes fiber, increased capacity, interactive potential, a move to digital and a business plan for new services. Multimedia inside one computer isn't very exciting, according to Styslinger, who went on to say that we need to "move it around." He added, "There's a $40 billion market in data communications out there."

The underlying theme of this year's conference suggests that cable's future success will be determined by our ability to provide what amounts to "future-proof networks" whose key attributes will be flexibility, ease of expansion, ease of adaptation and performance consistent with the application. No longer can we count on entertainment delivery as our sole business.

The papers presented in both the preconference tutorials and the conference itself are available in separate proceedings manuals from the Society. Contact SCTE headquarters at (215) 363-6888 for more information. — *Ron Hranac*

Digital compression for real people: Part 1

This first installment of several planned articles will discuss certain fundamental concepts of digital video compression. Future installments will address the tricks used for compression and will likely finish with a discussion of what to expect from digital transmission, showing why our old concepts are not really applicable to this new order.

By James O. Farmer
Vice President, Electronic System Products Inc.
And William W. Woodward
Senior Staff Engineer, Scientific-Atlanta Inc.

Much has been written for the specialist in digital video compression, but we felt it would be beneficial to discuss the subject from a more intuitive perspective. This is not to supplant the plethora of more rigorous material.[1] Rather, we shall step back a little and contemplate what it is that we are doing.

Compression is, simply put, a collection of a bunch of tricks played on the viewer. Our present NTSC[2] TV

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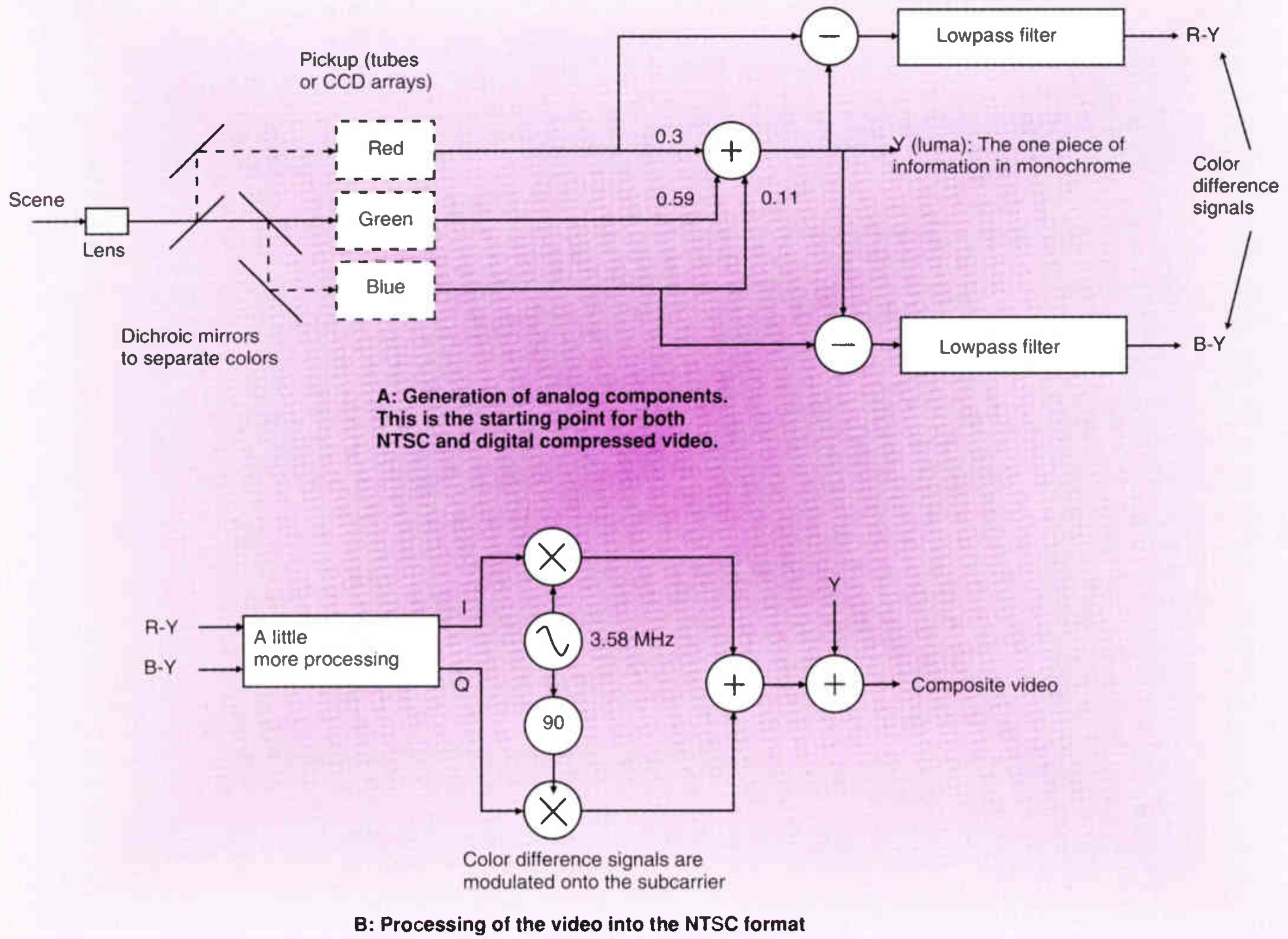
Figure 1: Analog component generation and NTSC video processing



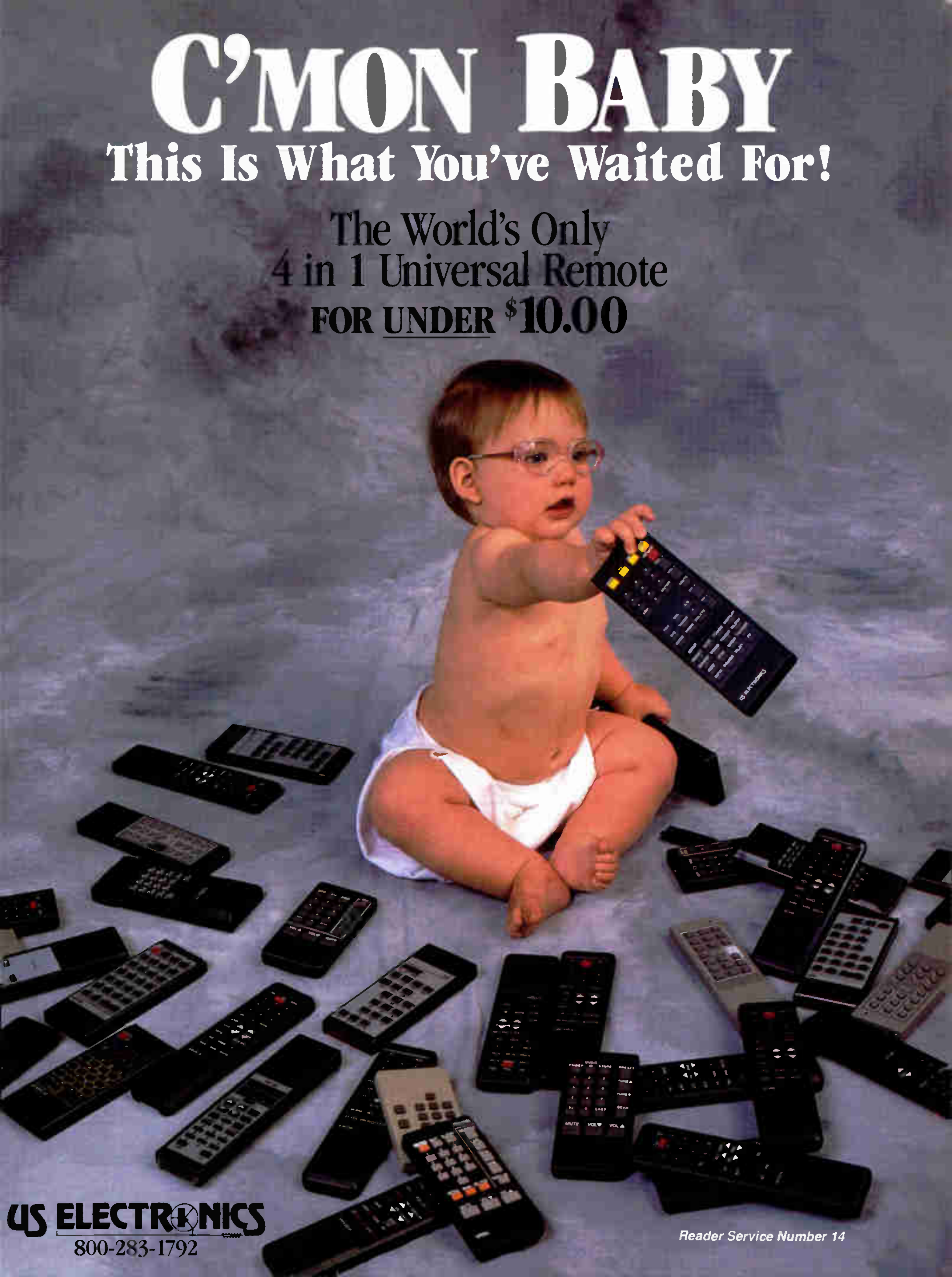

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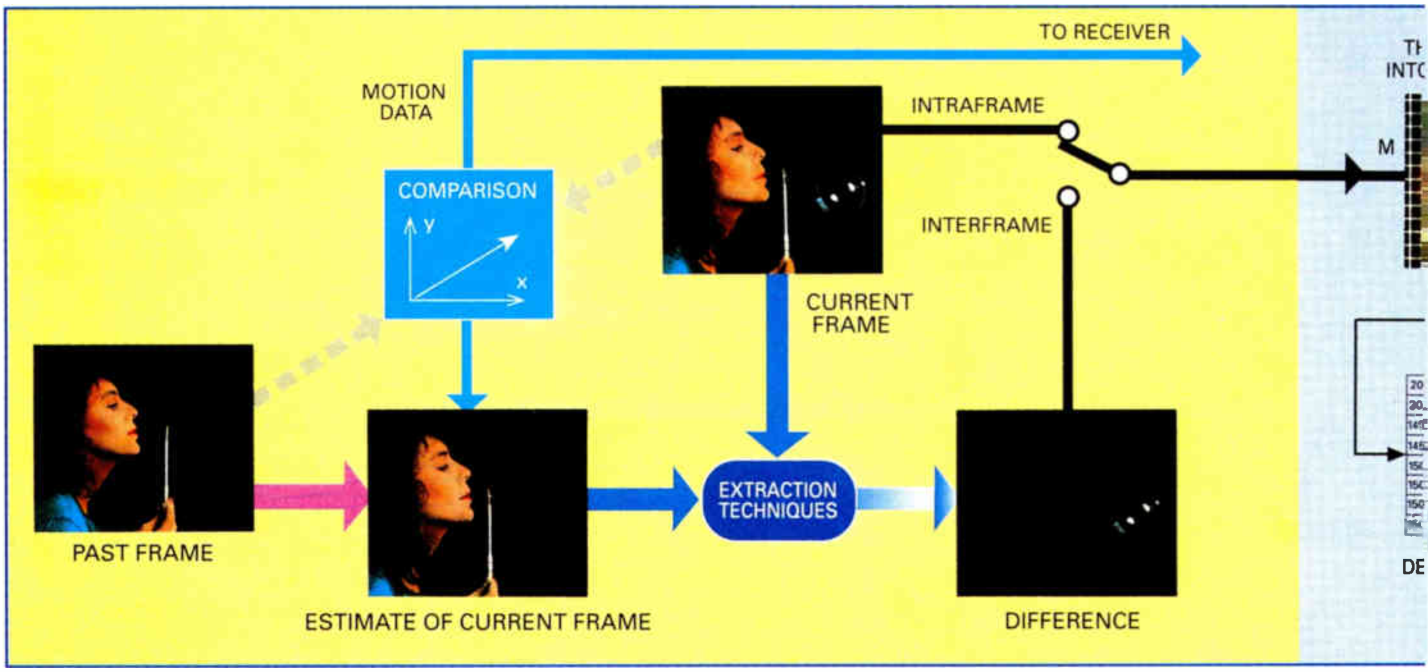
Figure 1: Motion processing (below) and DCT video compression (below right) techniques



The next revolution: Compressed digital video

By Amihai Miron
Director of Electronic Systems
Philips Laboratories

Visual information and communication play important roles in our society. The first practical applications of compressed digital video are the result of ten years of significant technological developments in VLSI, better compression algorithms, research on visual perception and the evolution of standards. More applications will follow. To be successful, those applications must result in perceived benefits to the end user, providing more information with higher quality, providing information in a more flexible way that suits new social trends, or adapting to a changing political scene. It is always the challenge of research to play a dual role by first bridging the gap between application and technology, and then defining applications for new technology.

Applications of compressed digital video

Compressed digital video applications range widely in their complexity and timing of their market introduction. The list of applications are prioritized by bit rate requirements with subsequent implication on display size. Some are already products, some will be products within one to three years, and some may become products only in the new century. The applications use symmetric compression or asymmetric compression. The accompanying table gives a rundown on current and future video applications.

Symmetric compression means compression is done as frequently as decompression. Therefore the complexity of the encoder is similar to the complexity of the decoder. Symmetric applications are VCR, VTR, electronic publishing for production, video mail, video telephone, and video conferencing.

The asymmetric applications of digital video are those where the encoder is used much less often than the decoder, and therefore, can be of higher complexity. Highly complex encoders allows for a greater compression ratio. Applications where the complexity of the encoder are less important include electronic publishing for education and travel guidance; video text; games; CD-I and broadcast entertainment television.

- *Video phone* (symmetric): Although video phone, or personal video conferencing, has been available for many years, it has not become popular. Recent advancements in technology may now make it a practical and a useful device. It can operate on existing phone lines and be based on flat screen LCDs.
- *Video conferencing* (symmetric): Video conferencing, used mainly by corporations, has been found to be a valuable alternative to both the expense of travel and the time associated with it. Video conferencing may be used more broadly, and can achieve higher picture quality based on recent advancements in digital video compression. As the channel capacity over the existing phone lines increases from 56 kilobits per second (kbps) to 2 megabits per second (Mbps), improved picture quality can be achieved.
- *Multimedia* (symmetric/asymmetric): Multimedia is a

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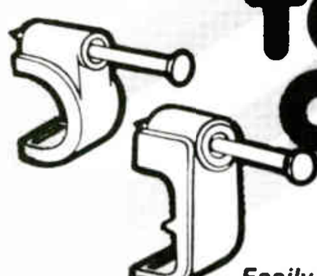

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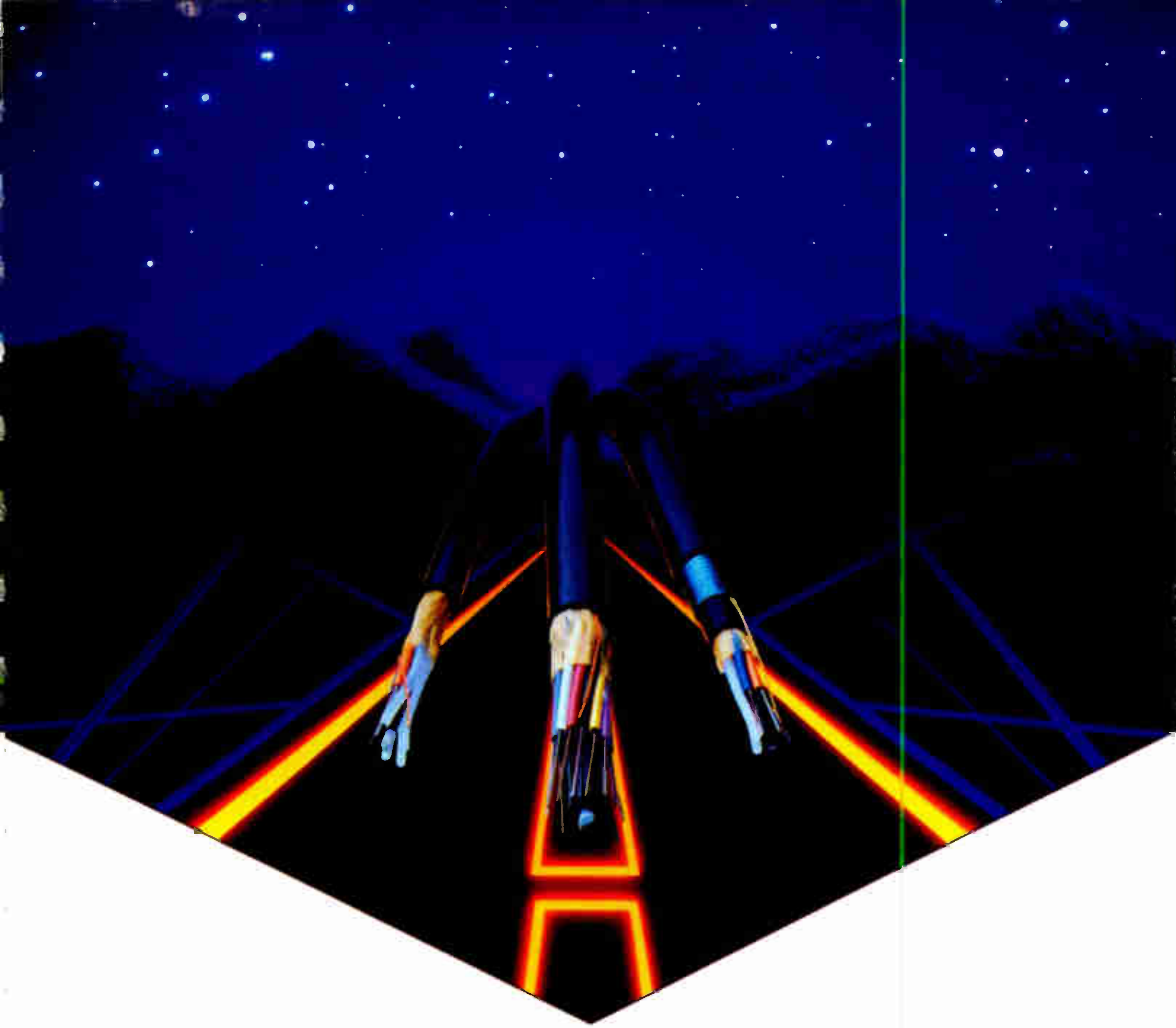

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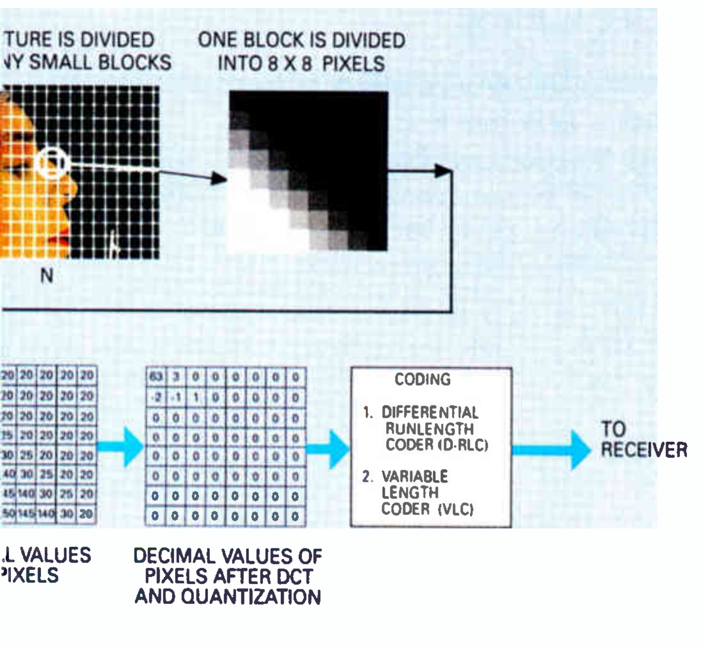


combination of different media used by a personal computer, and also may be displayed on a conventional TV set. CD-Interactive, or CD-I, recently introduced by Philips in the U.S., combines compressed digital video and audio with interactiveness that is based on computer technology. Applications like this will become more widespread and will benefit greatly from the development of compressed digital video. Since all digital data is identical to the data manipulated by computers, it is possible to combine advancements in computing technology with the advancement in digital communications and add to it what was, until now, the missing component: full motion video.

• *Satellite entertainment TV* (asymmetric): Satellite TV is one of the most promising early potential applications of compressed video in entertainment TV because the communication networks consist of high capacity channels that are loosely regulated. Compression provides several benefits for transmission of video over satellite. Compression allows more channels to be transmitted over the same transponders, reducing the operating costs of program providers. Plus, the lower power required to transmit digital video allows for smaller dishes, which are more convenient and attractive. In addition, compressed video creates an excellent image free of such typical impairments as noise and interference.

• *Cable entertainment TV* (asymmetric): Cable systems can move quickly to embrace new technology since their signal is carried in a shielded, private transmission medium and is loosely regulated. In the short term, cable operators will benefit from the reduced cost of delivering programs from the program originators to cable headends. In the long term, operators will benefit from their ability to upgrade and increase the channel capacity of their system without the heavy capital investment required to improve the infrastructure of the cable system. In addition, increased channel capacity allows the cable operators to provide new services, and to enhance existing services. One such service, often referred to as near-video-on-demand (NVOD) will allow customers to choose first-release movies and view them at 15- to 30-minute intervals. Another service is extended pay-per-view (PPV).

• *Terrestrial standard definition entertainment TV* (asymmetric): Terrestrial standard definition entertainment TV will probably evolve in Europe since it has to compete with an existing system that operates quite reliably. Digital compression can allow for mobile artifact-free reception with smaller antennas. This concept is the basis for the digital video broadcasting (DVB) initiative in Europe.

• *Business and educational TV over satellite* (asymmetric): Business and educational TV can provide a private video broadcast to a moderate number of sites. Digital video compression will allow such broadcasts carried over satellite to cut down on transponder costs and dish size.

• *High definition TV* (asymmetric): HDTV promises to achieve about twice the horizontal and vertical resolution of current television and will use a wider aspect ratio (16:9). Currently there are three distinct efforts to develop high definition broadcasting standards in Japan, Europe and the United States. Japan standardized around a primary analog system (MUSE). Similarly, Europe stan-

(Continued on page 38)

Current and future video applications

Application	Bit rate	Standard	Commercially available
Video phone	64-128 kbps	H.261	Now
Video conferencing	56 kbps-2 Mbps	H.261	Now
Multimedia (CD-I) full-motion video	1.5 Mbps	MPEG-I	1992
Satellite distribution to cable headend (U.S.)	30 Mbps 4-10 Mbps/channel	MPEG-II* CCIR 601	1992-1993
Satellite-business education, entertainment TV	30 Mbps 4-10 Mbps/channel	MPEG-II* CCIR 601	1992-1994
Entertainment TV over cable (U.S.)	30 Mbps 4-10 Mbps/channel	MPEG-II* CCIR 601	1994-1995
Terrestrial broadcast of digital TV	4-10 Mbps	MPEG-II* CCIR 601	1998-2000
Terrestrial broadcast	20-30 Mbps	MPEG++*	1995-1997

*MPEG-II and MPEG++ are not yet standards

Digital compression from headend to home

This article presents a technical overview of digital compression systems, describing the specifics of the compression engine, headend interface options, transmission path specifications and bandwidth allocation. A discussion of programming and services enabled by the technology and associated converter features/options required to use this technology also is included.

By Daniel E. Sutorius
Project Manager, DigiCable
Jerrold Communications, General Instrument Corp.

Digital compression will give cable operators a powerful technological tool to deliver high quality video and audio as well as data services.

Previously, applications such as teleconferencing required forms of digital compression to transmit high data rate services down bandwidth-limited channels. Without being overly sensitive to encoder/decoder cost or picture quality, as is cable TV, this technology could be deployed earlier.

The advent of high definition TV (HDTV), with its tremendous bandwidth requirements, caused a rejuvenation of interest in compression technologies. As a side benefit, it was learned that in addition to compressing HDTV signals, this same technology could squeeze multiple NTSC signals into standard satellite and cable TV bandwidths that, until compression, could handle only one program at a time. The multichannel NTSC digital compression delivery system was the focus of a request for proposals (RFP) from Cable Television Laboratories in fall 1991.

Digital compression advantages

Digital compression increases channel capacity by offering virtual bandwidth expansion by allowing multiple programs to be compressed into the standard satellite or TV channel. Another benefit of digitization is that video programs can be transmitted at a higher quality level and better consistency than those typically achieved with analog transmission. Digital transmission delivers a picture at the receive site as good as the picture at the transmit site.

"Digitally compressed video programming will be deployed this year over satellite, with cable plant utilization to follow in the near term."

For cable, this means that digital signals do not gradually degrade in picture quality (as seen when going from 49 to 36 dB C/N).[1] In digital applications, the picture quality remains excellent because a threshold of system performance is maintained. The digital threshold is typically below the level deemed unacceptable for analog signals[2] (i.e., below 36 dB C/N). This also means that all digital subscribers throughout the cable plant will receive the same quality picture, without regard to their distance from the headend.

Digital processing also eliminates analog picture artifacts such as ghosts, intermodulation beats and noise. Compact disc-quality audio transmission is another benefit of digital compression. Besides allowing for the evolution to HDTV, digital compression can increase video and audio security via digital encryption techniques. Digital bits can be scrambled to a higher level of randomness than analog signals, which, if scrambled too completely, cannot be reconstructed into a quality picture.

Compression processes

An uncompressed digital NTSC signal requires approximately 100 Mbps, which is greater than can currently be transmitted within the standard 6 MHz cable bandwidth. Various processes, including intraframe and interframe, compress the signal. Intraframe processing takes advantage of areas within each picture frame that have similar image, color and intensity. Interframe takes advantage of similar, possibly displaced areas of successive frames.

Live video is taped at 30 frames per second. Film, which is easiest to compress, has a slower rate of 24 fps. High motion video, such as basketball games, is the most difficult to compress because of a lack of similarity between frames and a far greater amount of detail within each frame.

An efficient digital compression system would ideally take advantage of the varying degrees of compression among the various programs. Systems using multiple channels per carrier (MCPC) transmission can vary the data rates over time of individual programs within a single bit stream — a process called statistical multiplexing.[3]

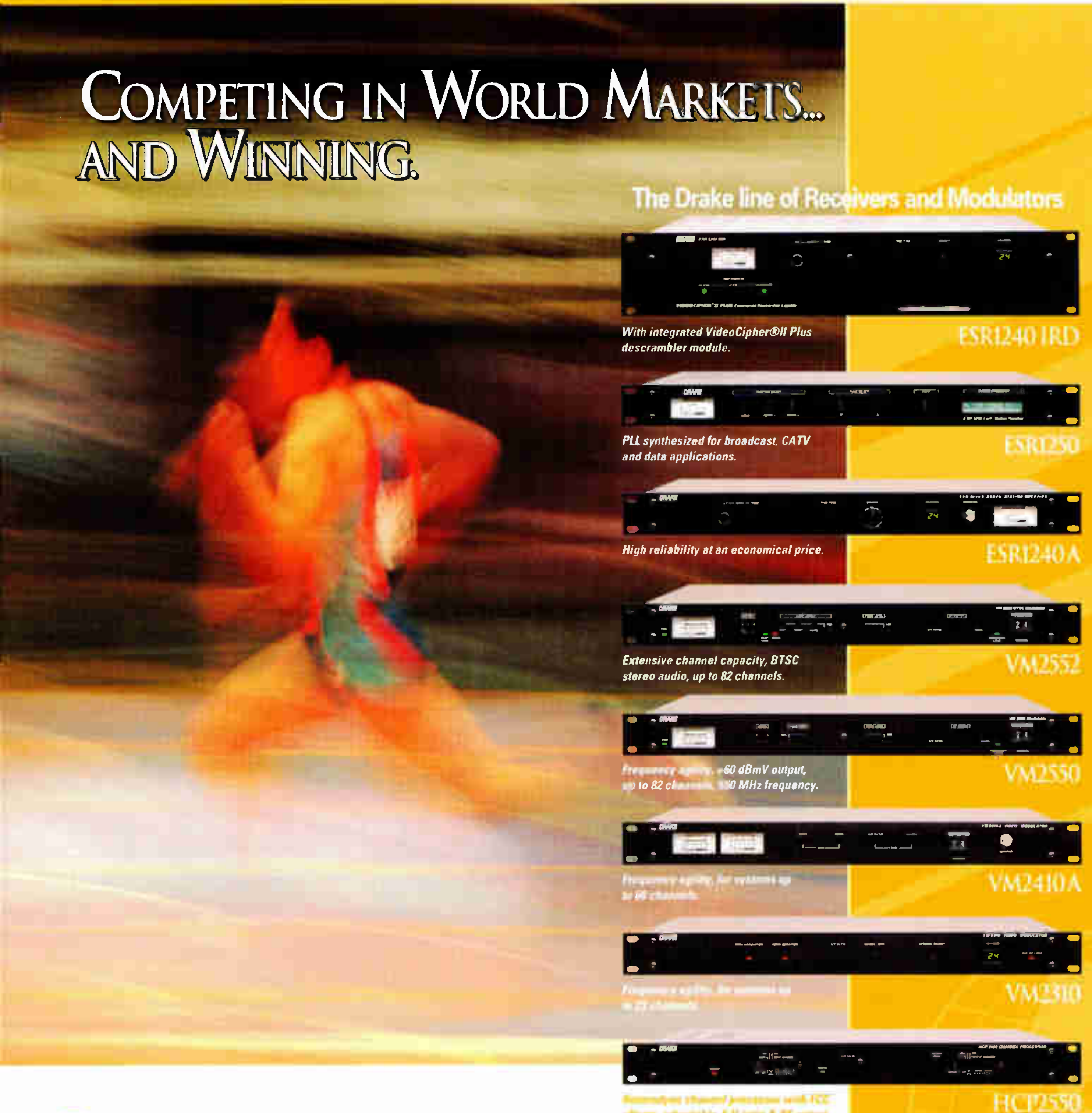
There are many different digital compression techniques using various versions of intraframe and/or interframe processing. One intraframe method is through a compression process called vector quantization (VQ). This relies on the notion that any given block of pixels can be adequately described from a finite set of possible pixel combinations once the desired quality level of the program is determined. At the encoder (the unit at the transmit site that converts standard analog signals into compressed digital) a "code book" serves as the source of the finite set of possible pixel combinations from which the appropriate vector or address surrogate code is chosen to replace the pixel block.

The process is then reversed at the receive site in a decoder. Depending on the desired quality level, the decoder has the potential to be low-cost because it is based primarily on inexpensive memory chips.

Another compression technique is called discrete cosine transform (DCT). This converts blocks of pixels within each frame into transform coefficients. Compression occurs as redundant information is filtered out along with video information that is not as critical to the eye.

While VQ and DCT are eliminate information (with little or no subjective picture degradation), the Huffman coding technique can be used to assign variable length codes to the coefficients. Coding length depends upon probability of usage. Highly used/probable coefficients are assigned shorter codes and less

(Continued on page 46)



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Reader Service Number 15

Outage management, Part 3: Plant powering in cable TV systems

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The CableLabs Outage Reduction Task Force was organized by several MSOs and the CableLabs staff to address the issues that stem from cable system outages. The intent of the developed solution to outage problems was that it would be fully supported by CableLabs' member companies.

CableLabs published the document "Outage Reduction" as a summary of the Outage Reduction Task Force's work. This is the third in a series of articles adapted from that document. This part is an overview of information gathering efforts done on CATV plant powering issues researched by the task force's plant powering subcommittee. (Subcommittee members were: H. Mark Bowers, CableSoft Engineering Services; David Eng, CableLabs; Del Heller, Viacom Engineering; and Tom Osterman, Alpha Technologies.)

By H. Mark Bowers
CableSoft Engineering Services

Given the theme of reducing plant-related outages and thereby improving overall plant reliability, one must ask the question: "What new or improved methods can be applied to cable plant powering techniques that will reduce exposure to plant outages from loss of commercial power source(s)?" The CableLabs Plant Powering Subcommittee's approach to this question created research and investigation ultimately along three separate but related fronts:

1) Possible new plant powering architectures that would significantly reduce exposure to loss of commercial power, compared with current design techniques. This approach primarily focused on "hardened trunk techniques," although it will be shown that it is possible to achieve improvements with current powering topologies as well.

2) The cable operator developing a closer interface with, and understanding of, commercial power grid design and power distribution principles. In other words, can we better understand and work closely with the local electric utility(ies) to improve plant powering reliability with a corresponding increase in commercial power reliability?

3) Better understanding and application of modern standby power supply technology to existing or improved cable power grid designs, toward the optimization of total plant powering. What are present standby powering technologies and limitations? How can maintenance be optimized in these applications? (Here, we must consider that a lack of optimal maintenance is considered to be a primary contributor to past standby applications often resulting in less than optimal results.)

The remainder of this article seeks to provide an overview of what has been learned to date in these research and information gathering efforts. Some work remains in the area of standby powering, and has been given over to a separate working group on that subject.

Powering architectures

Most cable plant powering designs utilize similar processes. The designer seeks to create a power layout for trunk and feeder systems. Typical goals are the provision of adequate load voltages to each active device with uniform current distribution through the plant, all while seeking to maintain a fairly moderate to heavy load on the power supply itself.

Typical techniques

The major problem with cable plant powering is that the cable system is optimized for distribution of RF signals, not AC power. The 75-ohm coaxial cable system is not designed nor optimized for the purpose of AC power distribution. Past and future techniques must ultimately deal with this very basic issue. Present methods of powering the trunk and feeder have served the industry fairly well, but can create reliability problems because of the power supply cascade in conjunction with the reliability of commercial power. Coaxial cable sizes used for RF distribution, the frequency of placement and type of RF electronics, and the operator's design technique and percentage loading of main AC supplies all combine to create some rather healthy power supply cascades. The term "power supply cascade" as used here describes the same effect encountered with cascades of amplifiers. For example, if a signal leaving the headend or hub site has to travel through 12 different power supply areas to reach a customer's home, then the power supply cascade is 12. The fact that trunk and feeder are powered simultaneously from the same power supply intensifies this cascading problem.

Modern AC supplies should be loaded at close to 100% of rated value for proper operational efficiency. If significantly underloaded (less than 75%), the supply's efficiency will fall off dramatically. At best, you end up paying for power that is dissipated as heat. At worst, you'll experience premature failure of supplies in your system. If your design dictates only 5 to 6 amperes at a given location, install a smaller amperage supply to maintain proper effi-

(Continued on page 49)

Digital Services Ahead

With the introduction of digital services, the cable industry has entered a whole new era. Never before has reliable, continuous power been so critically important. In the "old days" of analog television signals, a power dropout at worst caused a few lines across a customer's television screen. Now, without protection, that same power loss can mean a telecommunications disconnect, the loss of critical data, and most certainly, very unhappy customers.

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Reader Service Number 21

Power protection for digital services

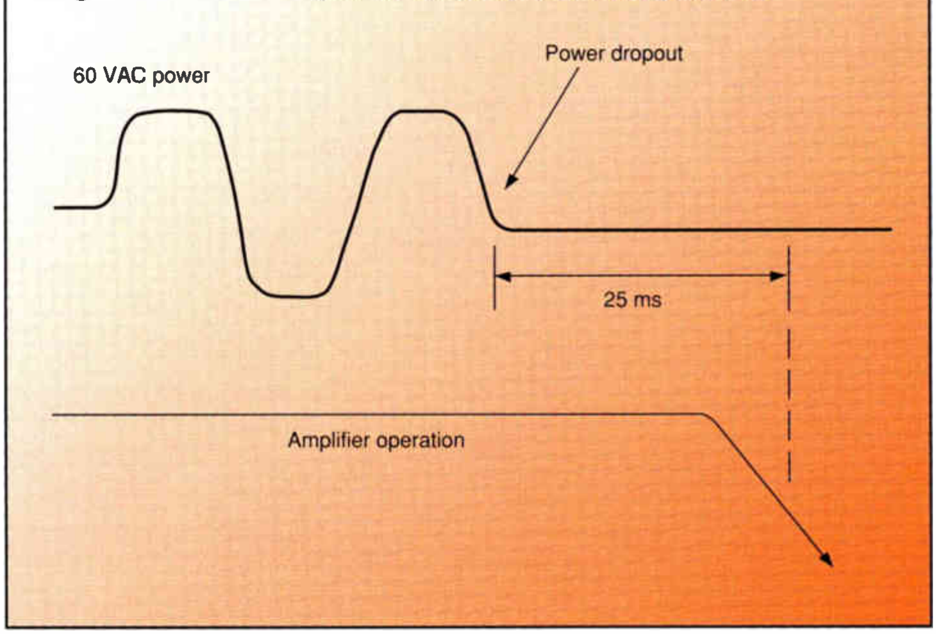
By Tom S. Osterman
Director of Research and Development
Alpha Technologies Inc.

With the advent of digital signal transmission over cable TV networks, reliable and uninterrupted powering of signal processing and transmission equipment has become extremely important. In the past, minor signal interruptions to the cable system were somewhat tolerable because the information transmitted was primarily entertainment.

A slight picture roll or a few second dropout was annoying but not necessarily critical to the continued operation of the system. Power fluctuations and transfer interruptions were tolerated, especially at the extremities of the distribution area where the cable loop resistance from the power supply exaggerated voltage fluctuations in power supply output.

With systems upgrading and rebuilding for higher bandwidth and transmission of digital video and audio, personal communications services (PCS), pay-per-view (PPV), data networking and other digital signal delivery services, powering reliability has become a critical component to the success of the system. It is very important to note the volatile nature of digital data, especially asynchronous transmission without error detection and correction. Even microsecond interruptions in signal flow result in a high bit error rate or complete data loss. These interruptions can cause annoying visual and audible effects for entertainment transmission but can cause significant problems for other services.

Figure 1: Effect of power interruption on signal flow



Several amplifier manufacturers have recently studied the effect of power interruption to their equipment in terms of effect on signal transmission. Their conclusion is that an interruption of power (or prolonged brownout) for longer than 20 to 25 ms (0.025 seconds) will cause a corresponding dropout in signal flow through the device. (See Figure 1.)

The "hold-up" time of the capacitors in the power supply within the amplifiers could provide several milliseconds of continued operation during a brief power dropout when new. But as they age, especially in warmer climates, the average capacitance value typically decreases and the hold-up time decreases as well. This often results in an amplifier hold-up time that is shorter in duration than the transfer interruption of many of the standby power supplies that are in service. It is clear that any momentary power fluctuation that may occur on the utility input can cause standby power supplies to transfer to standby. This is what the power supply is designed to do, but if the transfer time is longer in duration than the hold-up capability of any of the amplifiers, a drop out of data flow will occur. Can you imagine a network that provides digital services such as telephony dropping all calls in progress every time the power supplies transfer into standby? An obvious conclusion is the importance of uninterrupted power output from the cable TV power supply for reliable digital data transmission.

Uninterruptible power supplies (UPSs) have been used by the telephone and computer industries for over 30 years for reliability reasons. These UPS units tended to be large, inefficient and expensive. For cable applications, a standby power supply has been acceptable for years because of the aforementioned insensitivity of the network to minor interruptions.

With digital, this has all changed. To give an example, any power interruption longer than 25 ms to a PCN cell site or any data-carrying active in series could cause a complete drop and disconnection of all calls in progress within that cell. Any signal dropout of this duration to digital compressed video and audio can cause strange and annoying effects that can vary due to the compression algorithm used. Dropouts in other data services such as leased transmission via fiber can be catastrophic as well, depending on the error correction system (or lack of) and transmission speed of the data.

Digital compression ratios in excess of 10:1 have been advocated by several manufacturers of signal processing equipment. In conjunction with the compression system, high data transmission speeds are to be employed as well to provide the necessary video performance. At these high data rates, even a few millisecond interruption could result in data loss greater than all of the information contained in a several volume encyclopedia! As many of the local area network engineers have concluded, it is imperative to the

(Continued on page 68)

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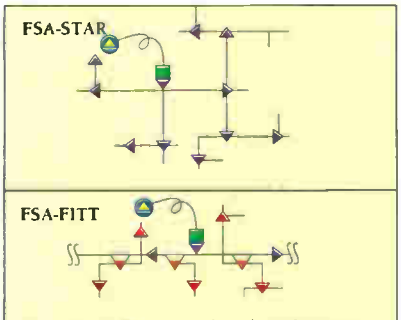

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Kelvin's Law and its applicability to cable TV powering

By Robert V. Moel
Vice President, Operations and Engineering
Paragon Cable

When cable TV companies build or upgrade systems, the designers currently limit their selection of cables to those that will satisfy the RF loss criteria. Designers replace or select cables because RF loss characteristics and hence carrier-to-noise ratio requirements are dominant factors. With price competition looming and fixed operating costs of service delivery becoming increasingly more important because of this potential competition, operators need to build systems that will use electrical energy more efficiently.

Power companies select conductor sizes with an eye on optimizing the trade off between I^2R loss costs (the loss of electrical energy resulting from heating) and carrying costs (the cost of financing and operating the span of cable in question per year). When these two costs are equal the overall fixed cost of operating the span and delivering power through it is minimized. This rule is called Kelvin's Law. Cable operators can make use of this rule in designing for minimum CATV network costs.

From an economic standpoint, Kelvin's Law can be applied and compared on a total cost basis or on an incremental cost basis. The examples in the article will look at applying this law on an incremental cost basis. This will mean looking at the differences in cost of placing one cable for another and the differences in I^2R loss costs of one cable with another.

Cable engineers select conductor sizes to achieve certain signal loss goals. For trunk this usually means selecting a .750-inch cable and for distribution this usually means selecting a .500-inch cable. Cable size is only increased if RF losses are too large for a given span. A .750 cable might be replaced with a larger, less lossy cable (such as a 1.000-inch cable) during an upgrade if its replacement mitigates needing to add amplifier locations. In general, the cable designer will select the smallest cable for the application, one that just meets the RF loss requirements. However, by applying Kelvin's Law, the design criteria are altered. To minimize overall cost and satisfy the law the designer might instead select either a larger cable or one with a solid copper center conductor.

Example 1

To simplify the analysis we will consider choosing between a solid copper center conductor cable and a copper-clad cable instead of assessing all the possible options. Other choices are possible including selecting larger size cables. Table 1 compares pertinent information about these two cable types. (The prices shown in the table are for illustrative purposes only and do not represent any vendors actual pricing.)

The span to be considered is 1,800 feet long, and will carry 8 amperes of current. Assume the power factor to be near unity. In addition, assume the cost per kilowatt-hour to be $0.18 and the carrying costs to be 15%. The loop resistance for the span using solid copper center conductor cable is:

Table 1: Solid vs. clad center conductor for .750 cable

Cable type	Loop resistance per 1,000 ft	Cost per foot
Solid center	0.56 Ω/1,000 ft	$0.586
Clad center	0.76 Ω/1,000 ft	$0.451

0.56 Ω/kft*1.8 kft = 1.01 Ω

The I^2R losses are:

(8 amps)^2*1.01 Ω = .0646 kW

The dollar costs of these losses are:

0.0646 kW*24 hrs/day*365 days/yr*$0.18/kWh = $101.86/yr

Similarly, the dollar losses per year of the copper-clad cable is $138.05. Therefore the incremental cost of operating the copper-clad cable is $36.19.

The carrying costs of the cable, on an incremental basis is related to the cost of the cable itself. The cost of cable construction is the same regardless of the center conductor composition. However, if the decision is to select a larger cable this might not be the case. For our example the cost of the cable with the solid copper center conductor is:

$0.586/ft*1,800 ft = $1,054.80

The cost for the copper-clad center conductor is:

$0.752/ft*1,800 ft = $811.80

The incremental carrying cost per year is:

($1,054.80 - $811.80)*15 = $36.45

In this instance, the increased carrying costs are close enough to the reduced I^2R loss costs to justify the placement of a more expensive, less lossy cable in this span. The opportunity cost for not doing this is detailed in Table 2 on page 26. By not putting solid copper center conductor cable in this span it will cost the cable operator an additional $72.64 per year in opportunity costs. ➡

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New advances in fiber-optic connectors and attenuators

By Mike Thaw
President, Radiant Communications Corp.

This article will attempt to show how new advances in fiber-optic connectors and attenuators are changing system architecture. We will examine: low backreflection connectors, including APC (angle) and some potential intermateability problems; problems at 1,550 nm; and new low backreflection attenuators.

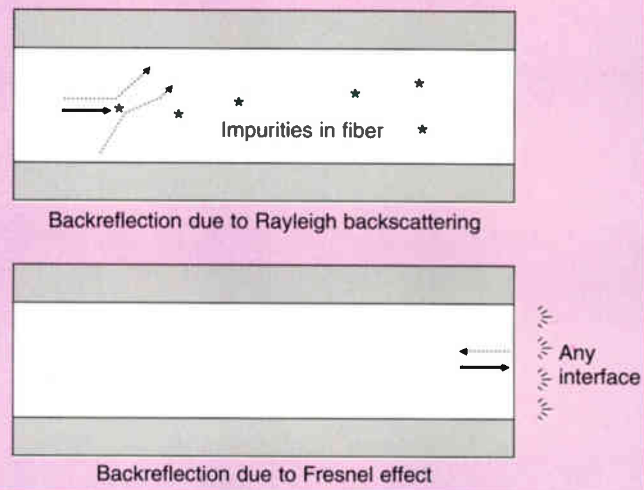
When fiber was first widely used for CATV applications, most systems were AM (amplitude modulation); and mechanical connectors were seldom used except perhaps at the receiver. Almost everything was spliced. Now there are AM, FM (frequency modulation) and digital systems. More channels mean better lasers with higher power. The applications also have changed. Many CATV companies are entering in the competitive access arena. There also are very near-term applications for bidirectional transmission (two-way) over the same fiber. In short, fiber installations are larger and more complex, systems are faster and the requirements are more diverse. What is needed is flexibility and that is precisely what connectors do.

Low backreflection connectors

For high bandwidth single-mode systems (above 300 MHz), backreflection is very important. Backreflection affects the laser by enhancing power fluctuation, pulse distortion and phase noise. Backreflection also affects the laser by a phenomenon called mode hopping. This causes the center wavelength to fluctuate. None of this is good.

Fiber reflection is a result of the following two different phenomena: Rayleigh backscattering and Fresnel reflection. (See Figure 1.) Rayleigh backscattering is caused by light bouncing off impurities in the fiber (typically hydroxyl ions). This "background noise" is how an optical time domain reflectometer (OTDR) measures attenuation in long fiber sections. It is best seen as the slope of an OTDR trace. (See Figure 2.) Fresnel reflections occur at discrete refractive index discontinuities (e.g., connectors, splice points and fiber breaks).

Figure 1: Rayleigh backscattering and Fresnel reflection



OK, now that we have established the need for low backreflection connectors, how much backreflection is needed and what type of connectors are available?

The first popular single-mode connector used was the biconic, with a maximum backreflection of -30 dB. As system speeds and bandwidth increased, this became unacceptable. The next advance used connectors with ceramic ferrules: FC/PC, ST/PC, D4/PC and SC/PC. PC means physical or positive contact, where the fiber end faces of the two mating connectors actually touch. The use of ceramic ferrules produce terminations of -35 dB backreflection with hand polishing. However, with proper automatic machine polishing, levels of backreflection of -40 to -50 dB are achievable. To get these results requires a sizable investment in procedures and equipment. This is not an operation to be performed in the field. It is highly recommended pigtails be purchased from a qualified source and you should fusion splice the pigtails to your trunk cable and/or fiber-optic splitters.

The back reflection limit of PC polishing appears to be -50 dB. Generally -45 dB or -50 dB will suffice for digital

Figure 2: Typical OTDR trace

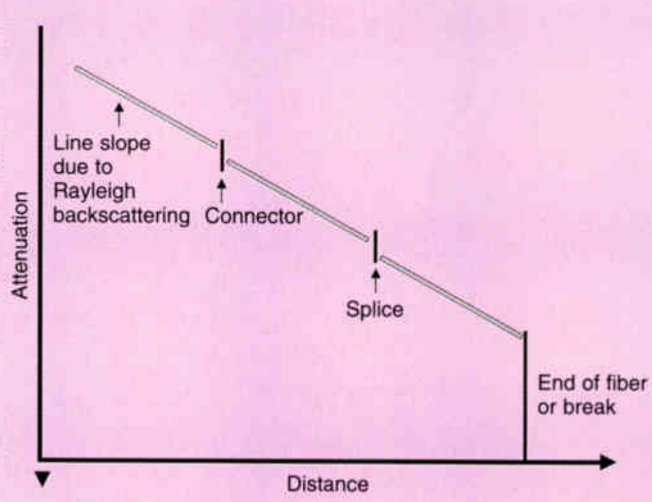


Table 2: Adding up opportunity costs

Scenario	I^2R loss costs	Carrying costs	Opportunity
Solid copper center	$101.86	$158.22	$56.36
Copper-clad center	$138.05	$121.77	<$16.28>
Total			<$72.64>

Table 3: Solid vs. clad center conductor for .500 cable

Cable type	Loop resistance per 1,000 ft	Cost per foot
Solid center	1.20 Ω/1,000 ft	$0.549
Clad center	1.72 Ω/1,000 ft	$0.287

Example 2

To see where Kelvin's Law would not indicate using more a more lossy AC cable, consider the set of facts in Table 3. The span is 400 feet long and has 1.5 amps running through it. Power costs are $0.18 per kWh and carrying costs are 20%. The loop resistance for the solid center conductor cable is:

1.20 Ω/1,000 ft*4 kft =.48 Ω

The loop resistance for the copper-clad center conductor cable is:

1.72 Ω/1,000 ft*4 kft =.69 Ω

The I^2R losses are 1.08 W for the solid copper center conductor cable and 1.55 W for the copper-clad one. The I^2R loss cost per year for the solid copper center conductor cable is $1.70 while the I^2R loss cost for the copper-clad center conductor cable is $2.45. The incremental cost is $0.75. The incremental carrying costs for this span is:

400 ft*($0.549 - $0.287)*0.2 = $20.96

Clearly, it makes no sense to change this span of cable to less lossy cable. If the powering costs are much larger than the holding costs, it would be wise to select a more expensive and even lower loss cable, perhaps even a larger outer diameter cable. On the other hand, if the carrying costs are larger than the power loss costs, it would be prudent to put the smallest cable in the design that will not jeopardize the RF performance.

While it may represent only $50 to $70 per span in deciding incorrectly on cable size, there may be thousands of these spans in a medium to large system and therefore, the economic impact on fixed operating costs may be in the tens of thousands of dollars per year.

Potential economic impact

Consider a cable system with 1,200 miles of plant. Assume that 25% (300 miles) of that mileage is trunk. If the spacing between trunks is about 2,000 ft, then there are approximately 792 spans of cable. Assume 75% of these spans are attached to distribution and hence have higher I^2R losses. The wrong economic decision might cost the operator $25 per span per year, amounting to about $14,850 per year in fixed costs. At 10% interest compounded annually in perpetuity, this economic decision cost the cable operator about $148,500. This assumes that powering costs will not grow.

You must analyze the situation in your system to determine whether any benefit can be realized. In addition, the impact that new architectures may have on the current draw per span also must be considered. There may be situations where the future bandwidth requirements may increase the current draw to a span of cable in the future. The decision to place a less lossy cable now as opposed to waiting must be considered economically as well.

Finally, solid copper center conductor prices are volatile. Before making any changes to your cabling plans, be sure to check the sensitivity of the decision on price.

Conclusion

While the RF requirements of a CATV design places a lower limit on cable size, considering the AC requirements places an upper limit on cable size and composition by virtue of economic costs. Operators stand to save on fixed costs by considering the impact that cable selection has on I^2R loss costs. **CT**

Reference

Electrical Distribution Engineering, Anthony J. Pansini, The Fairmont Press Inc., 1992.

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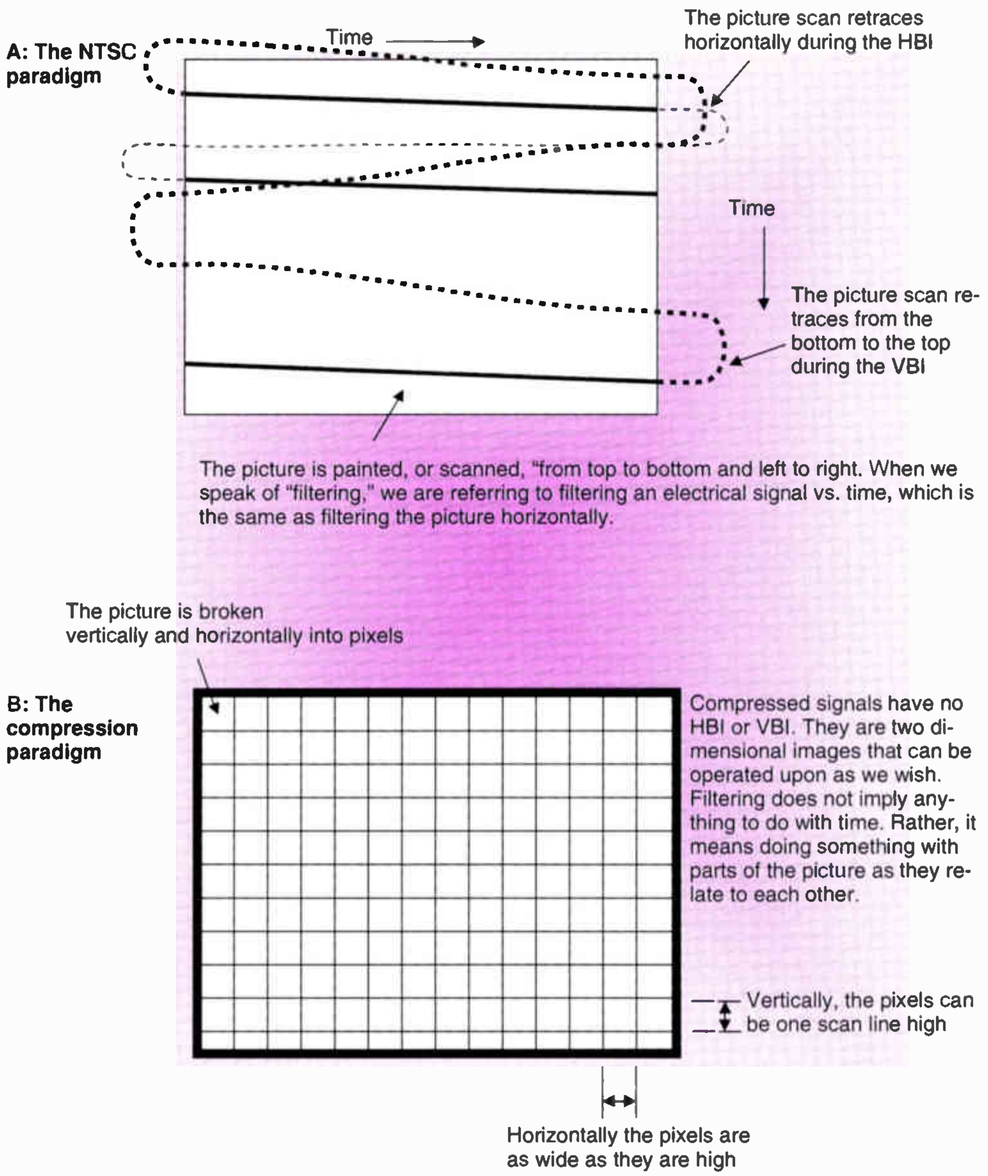
Figure 2: Comparing NTSC and compression paradigms



Compression for real people

(Continued from page 14)

system is itself a bunch of tricks, and we've learned more in the intervening 40 years. For example, in the NTSC system, we take advantage of our relative lack of perception of sharpness in colors. Color information is transmitted with lower resolution than is the black and white (monochrome) information. We shall show a multitude of other tricks that digital compression practitioners play.

A brief review

A TV picture begins life as red, green and blue (RGB) images. The three images are produced in the camera and are all necessary in order for the eye to perceive a nearly full spectrum of color. The receiver must, at every place within the picture, recover these three pieces of information in order to be able to reproduce the picture. We could transmit the red, green and blue values, but this has several problems. We must maintain compatibility with black and white TV sets, which need only one piece of information. That piece is not the same as that contained in any one of the RGB channels. Further, it would be impractical to transmit all three primary components at full bandwidth.

The solution used in present transmission system is to take the RGB information and encode it into a luminance signal and two chrominance components. The luminance, or black and white, component also is called "Y," "luma" or "monochrome." By definition in the NTSC system, the Y signal is made up of the RGB outputs according to the following equation (R, G and B represent the electrical output of the three camera pick-ups):

$$Y = .59G + .3R + .11B$$

The two color components are called "color difference signals" because they are calculated from the original RGB signals by subtracting the luma signal from a color. For instance, we can develop two color difference signals by subtracting red from luma (R-Y) and blue from luma (B-Y). We would then have three components for transmission: Y, R-Y and B-Y.

Figure 1A on page 14 shows the way we get the three components from the original camera image. In the camera, the scene is broken into red, green and blue primary colors by a series of specially coated mirrors that pass only the desired color(s). Pick-up tubes (often CCD arrays today) convert the light into an electrical signal. In order to derive the desired transmission components, the signals are then applied to a so-called "matrix," which does the following:

1) The three primary colors are added in different percentages (according to the human eye's relative sensitivity to each color) to derive the luminance signal. Luminance is the same as the black and white picture transmitted in the old B&W days. It is what you see on a black and white TV set. It carries the majority of information that we perceive as the "sharpness" of the picture, so we must provide a lot of bandwidth for it (more on this later). Remember in kindergarten they taught you to outline your drawing carefully? This was a primitive practice of the same thing: The drawing was perceived as sharper if it had a good black and white outline.

The Y signal has a low voltage (value) for picture content near black

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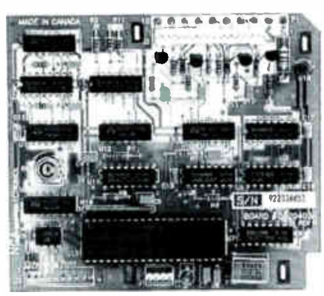

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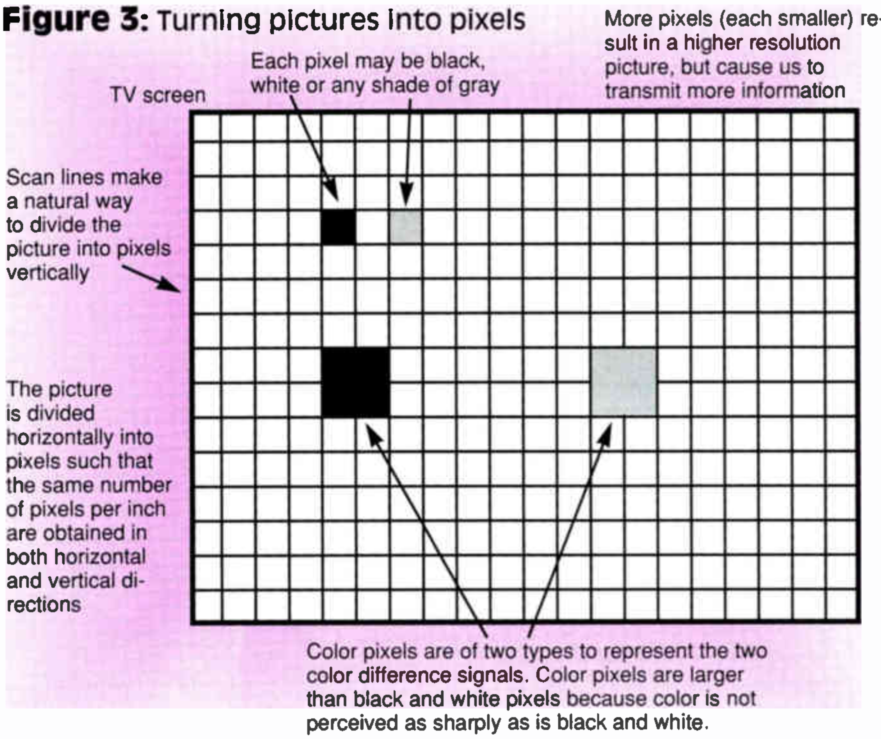
Figure 3: Turning pictures into pixels



and a higher value where the picture is light. Since there is no such thing as negative brightness of the picture. Y cannot take on a negative value. We'll see why this is an important concept later.

2) The luma is subtracted from, respectively, the red and blue, to form the R-Y and B-Y (spoken "RY" and "BY") components, which carry the color information.[3] These signals are not overly important to perception of picture sharpness, so we can filter them, saving bandwidth.

While the Y signal is always positive, that is not true of the color difference signals. These difference signals are not the "real" picture and we should not try to envision what they look like. They can and often do have negative values, though real pictures cannot be negative.

Now we have three signals — Y, R-Y and B-Y — that represent the image. They take on different values depending on the image that is being scanned. Figure 1B (page 14) shows what we do with these signals in NTSC. The difference signals receive a little more processing that is not really germane to understanding how the system works, and become the I and Q components. They are modulated onto a 3.58 MHz carrier called the "color subcarrier," and the result is added to Y to form the composite NTSC TV signal. The two signals are modulated onto the color subcarrier using amplitude modulation with a suppressed carrier. We can show that, by amplitude modulating the two difference signals onto carriers 90° out of phase with each other, they may be recovered independently.

In NTSC TV, we have called the transmitted color difference signals the "I" and "Q" components, from the way they are modulated on to the color subcarrier. In Europe, the color difference signals are derived a little differently, and are called the "U" and "V" components. We have no idea why. When we later refer to the color difference signals, we shall call them the U and V components.

A new paradigm

Words have a way of becoming fads, as do foods, clothing styles and cars. A word that has been "the rage" recently, is "paradigm" (don't pronounce the g). According to my dictionary, it means, "a pattern, example or model." It has been described as a way of thinking, and in this context, it is useful to bring into this discussion. We have a paradigm for thinking about NTSC transmission, but this paradigm won't do for compression. We need a new paradigm for thinking of compression.

Figure 2 on page 28 compares the paradigm for NTSC (also for PAL and SECAM) with the compression paradigm. In Figure 2A we show the NTSC paradigm[4] of scanning lines on the screen. The picture is scanned beginning in the upper left corner, moving to the upper right side. The scanning electron beam then resets to the left and scans the next line down. During the time the beam is resetting to the left edge of the screen, we have the horizontal blanking interval (HBI), during which horizontal sync and color burst are transmitted. When the beam reaches the bottom of the screen it resets to the top during the vertical blanking interval (VBI).

Thus, the NTSC paradigm is to sequentially (meaning over some period of time) scan the picture. Transmission of the picture information is broken by HBIs and by VBIs. During these times no picture information is sent. The time is partially used for synchronization and is partly available for other applications.

In the compression paradigm we don't worry so much about scanning the picture sequentially, though in fact this is done. We can begin with an NTSC picture. It is scanned into the compressor, but that is about where

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the similarities to the NTSC paradigm end. In digital compression we break the picture into "pixels," the smallest part of the picture we can have. Pixel stands for "picture element." It is black, white or some intermediate value, but it has no form or shape of its own. Figure 2B (page 28) illustrates the picture broken into pixels. The NTSC scan lines form a useful way to break the picture into vertical pixels, but we don't have an intuitive way to break the picture into pixels the other way. This must be done by taking picture samples the same distance apart as the scan lines are high. The way this is done is that the picture is sampled and the sample digitized. Following this, we move to the next element of the picture on the horizontal line and start over again on the new pixel. We have about 80 ns to digitize a pixel before the next one comes along.

In transmitting digitally compressed signals, we wouldn't want to waste transmission time on TV HBI and VBI, which don't contain useful picture information. We must spend a little time synchronizing the digital signal, something we'll take up much later. In digital transmission, forget about horizontal and vertical blanking intervals, color burst and vertical interval test signals (VITS) — they don't exist.

"Compression is, simply put, a collection of a bunch of tricks played on the viewer."

When we think of filtering an NTSC signal we think of applying a conventional filter that works on the signal as a function of time. The concept of a filter working against time is so ingrained into the engineering psyche that it will be hard to go beyond it, but this is really a restrictive concept of filtering. When we filter a signal, we are simply operating on one aspect of the signal vs. another aspect. Conventionally we operate on the electrical value vs. time. However, what we really want to accomplish is to modify one part of the signal against another. In conventional thinking (our NTSC paradigm) we filter against time, and since the electron beam is scanning at a fixed time rate over the face of the picture tube, we effectively get filtering against other elements in the horizontal line of the picture.

In studying compression, we must broaden our concept to two dimensional filtering, in which we operate simultaneously on square blocks of pixels. Thus, we filter, or operate, on blocks that consist of groups of pixels both horizontally and vertically. The filtering does not necessarily have to do with time.

The first step

Figure 3 on page 30 is another illustration of the idea of pixels. In the horizontal direction we have scan lines in a conventional picture, and the width (thickness) of a scan line makes a good definition of a pixel in the vertical direction.[5] In the NTSC system we have 525 lines in the total picture, of which 475 or fewer show up on the screen.

One has a little more trouble visualizing the breaking up of the picture into pixels in the horizontal direction. In NTSC the horizontal direction is continuous. We must, for the purpose of digitizing the signal, define pixel distance in the horizontal direction. Logically, we should assign pixels about as far apart as we have in the vertical direction. We have about 475 pixels vertically, one for each line in

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the viewable picture. Since the screen is 4/3 as wide as it is high, we could assume about 4/3 times 475 or 633 pixels horizontally. Thus, the picture would be made up or 633 pixels horizontally by 475 pixels vertically, for a total of 300,675 pixels.

We can think of pixels as the dots in a newspaper photograph. Look at the photo under a magnifying glass and you'll see that the picture is nothing more than a collection of dots placed such that they represent the picture. Sharper printed pictures such as in magazines also are made up of dots, but more smaller dots are used.

As we add more pixels (of a smaller size) to the picture we get a sharper picture, but we have more information to transmit. Thus, one of the tricks is to define the smallest number of pixels that will make the picture look sharp enough. The standard often used is VCR quality. When people speak of VCR quality they mean that the picture has about the same sharpness as does a picture from a consumer VCR. This quality is much lower than the 300,675 pixels we computed above, but the marketplace has shown that people are sometimes satisfied with this quality.

Returning to Figure 3 (page 30), we show the picture divided into a number of pixels. Each may be black, white or any shade of gray (think in terms of black and white for now — we'll add color later). As we stated previously, color information is less important in perceiving sharpness, so we can get away with using bigger pixels for color than for black and white information. Color pixels are larger than are monochrome pixels, both vertically and horizontally.[6]

Another basic concept: Digitizing resolution

Another concept involves digitizing the signal. We convert each pixel to a number representing its magnitude. In a later example we shall discuss representing pixels by numbers ranging from 0 to 1 or from -0.5 to 0.5. In the digital transmission system, we represent the picture using binary numbers, as in a computer. For now, we shall talk about the equivalent decimal number because it is easier to think in decimal terms. Each pixel will have a number representing its value. For example, we might assign a value of 1 to a white pixel, a value of 0 to a black pixel, and 0.5 to a 50% bright pixel. This is equivalent to assigning an IRE[7] level to a NTSC pixel. In the IRE scale, 7.5 represents black and 100 represents white.

In the analog world, we essentially have an unlimited number of levels to which we might assign a luminance level, since two good levels are, for example, 50 and 50.0000001. Of course this is not a practical difference — under ideal conditions one can barely perceive a difference between two luminance levels about 1/3 IRE apart. When we digitize the signal, we must decide how finely to divide the luminance levels. We call the fineness of division the *resolution* of the luminance. Note that this is not the same as the picture resolution we discussed previously, though "resolution" has the same sense in both cases: the higher the resolution the finer differentiations we can make. On the other hand, the higher the resolution the more information we must transmit. We need to discard any information we don't absolutely need in order to compress the signal as much

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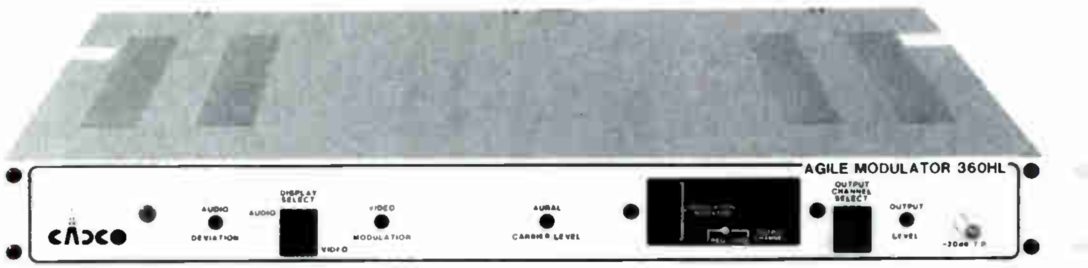

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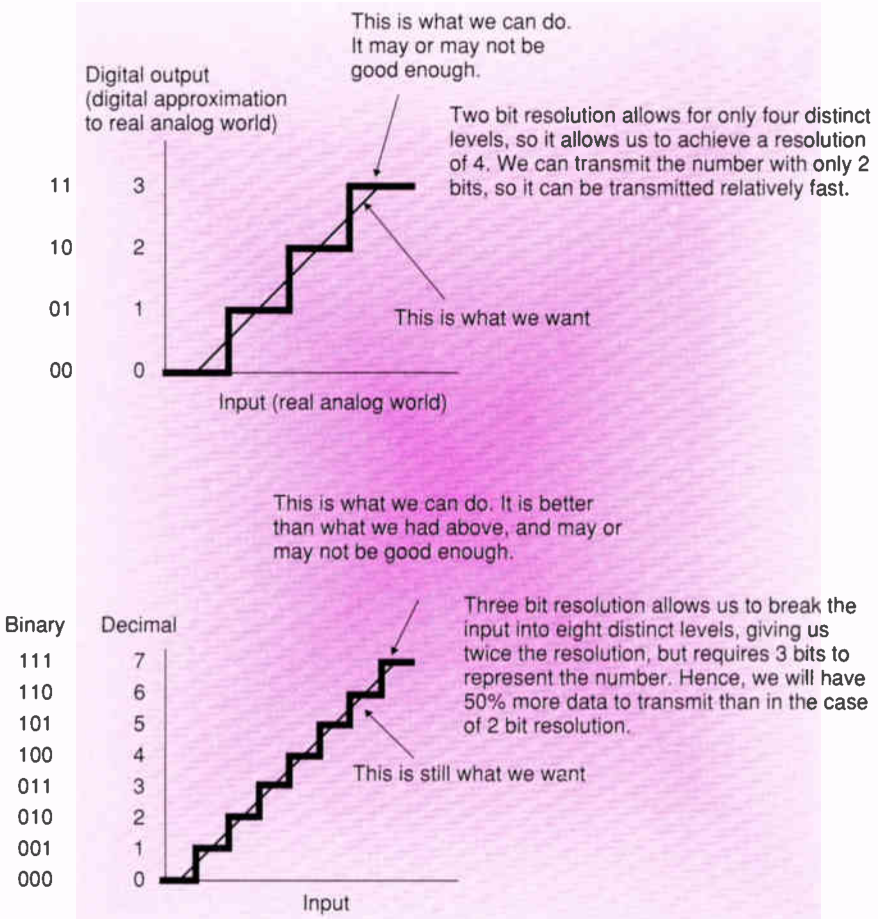
Figure 4: Resolution choices



The process of digitizing the signal is called "quantizing." The greater the quantizing resolution the more accurately we can represent the original analog input, but the more data we must transmit to do so.

as possible. Thus, we shall choose the lowest resolution that will yield an acceptable picture.

Figure 4 illustrates two choices in resolution. For a given analog input range we use either 2 or 3 (more in practice) binary bits to represent the signal. The top portion of the figure represents defining the input using 2 bits, in which case we have a total of four levels available to represent the input. We get a rather coarse representation of the input signal. In the lower portion of the figure we break the input into a total of eight levels, so we get twice the resolution. The penalty we pay is that we must use 3 bits to represent the levels and this means more data that must be transmitted. The designer of a digital compression encoder must make trade-offs in the resolution to which he encodes various picture attributes: He must encode enough bits to make the eye think it is accurately seeing the original analog signal, but the more bits he uses the more he must transmit. Using more bits is thus counter to the desire to transmit no more information than is absolutely essential.

Notice that when we added the third bit, we covered the same input level range. We used the extra bit to increase the resolution, or "fineness," of the digital approximation to the real analog world. In simple "brute force" digitizing of an NTSC signal, we generally find that we must use at least 8 bits of resolution to get a good picture. Fewer bits can make the picture look "splotchy." A blue sky that is lighter in one part of the picture will go darker in obvious steps. This is something the eye can recognize easily as not real world and therefore it is an artifact to be avoided.

Stay tuned

You have now read a little over 3,000 words hoping to learn something about compression — and now we leave you (we hope) unfulfilled. We've spent time in this article building up some of the background concepts needed to understand compression, without going into the techniques used. In the next installment we shall discuss the discrete cosine transform, the first step in compressing the picture (after it is digitized). We also will cover picture resolution/bandwidth and number of bits a little more. We urge you to not be too hard on us for leading you this far and dropping the topic for now — all of the concepts discussed here will be necessary for understanding what is coming next. Stay tuned. **CT**

End notes

1 "An Overview of the JPEG and MPEG Video Compression Specifications," W. Woodward, *1991 NCTA Technical Papers*.

2 The National Television System Committee was the industry group that developed our present TV system. Actually, there were two NTSCs — the first set up the B&W system after World War II and the second added color in the early '50s.

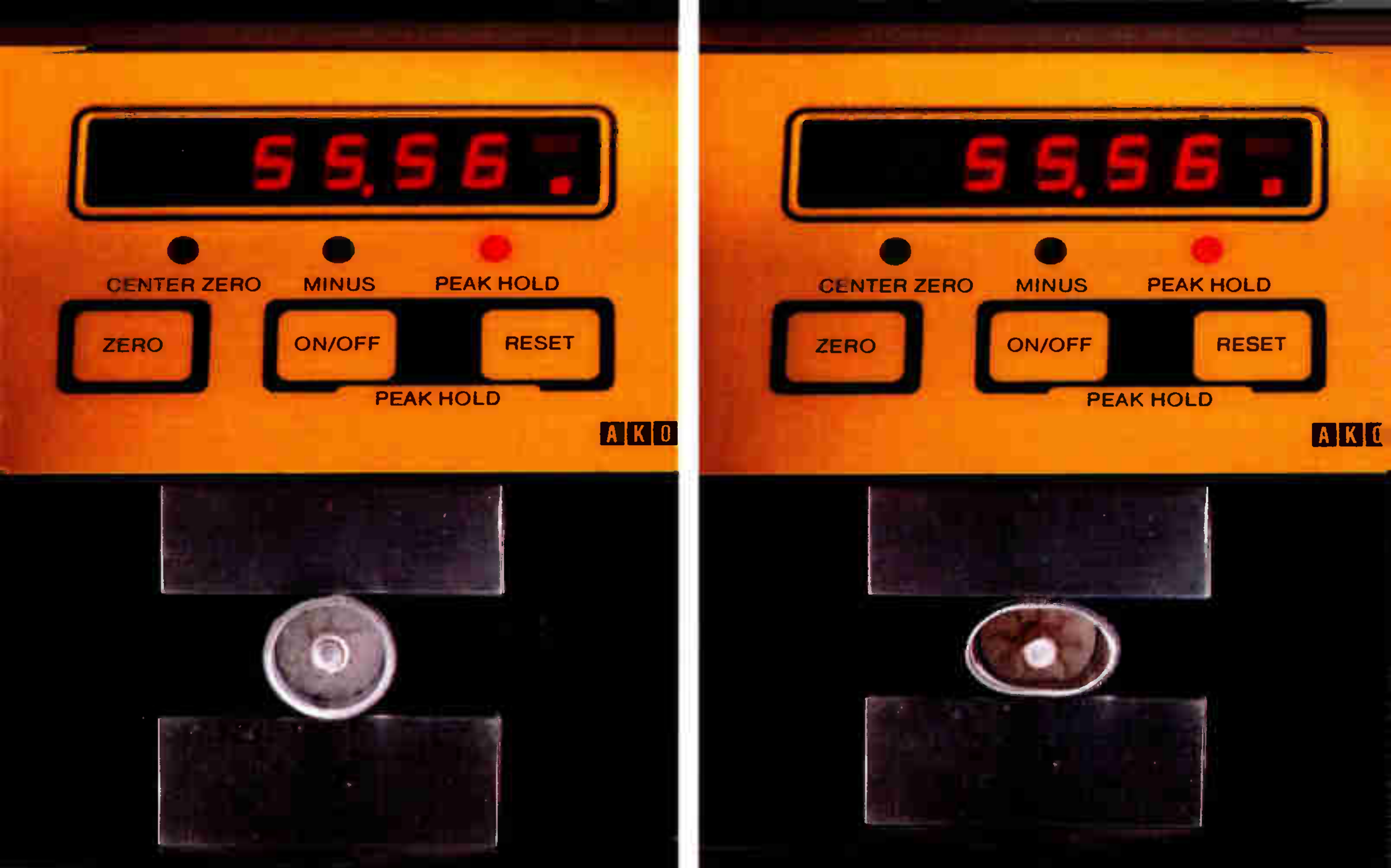
3 All three components, including Y, are required to recover the color signal. We must ultimately control red, green and blue electron guns in the TV set. In order to do so we must have three signals. This is the old "three unknowns require three equations" that you learned in high school algebra.

4 "NTSC paradigm" is term coined by the authors just for this article. Don't use it around others if you want to sound intelligent.

5 The use of "horizontal" and "vertical" in this context has always troubled the authors. Horizontal scan lines form a natural way to divide the picture vertically. Vertical lines divide the picture horizontally.

6 In NTSC the color resolution horizontally is about 15% of the maximum monochrome resolution, and maybe 25% of the commonly used monochrome resolution. Luminance and chrominance resolution are identical vertically, wasting a lot of bandwidth on chroma information that is not useful. Comb filters in high-end TV sets partially trade off this excess vertical chroma resolution for improved monochrome resolution and reduced cross color artifacts.

7 IRE stands for Institute of Radio Engineers, one of the predecessors to the IEEE. The IRE was active in establishing the NTSC standards.



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Compressed digital video

(Continued from page 17)

dardized around an analog system (HDMAC). The U.S., on the other hand, without the massive investments in analog technology by the government, chose to take advantage of digital technology. Compression and advancements in digital channel coding have enabled this choice.

The applications listed will succeed or fail based on the availability of attractive services they will provide to the customer. The software delivered in conjunction with these new services is key to their success.

Advancements in technology

Increasing density in VLSI, combined with the advancement in memory and computer technology, have made the implementation of complicated digital systems both greatly automated and cost-effective.

Advancements in signal processing and algorithms that can be used to first find and then reduce redundancy in video information, have resulted in hybrid techniques that yield improved performance at greater compression ratios.

Advancement in the research on visual perception, and identification of information that the eye is less sensitive to, allow for even greater compression.

The evolution of important standards over the last few years allows efforts to be concentrated on the implementation of VLSI for advanced video compression techniques. To illustrate the techniques used for video compression, we will list those used in the recently finalized MPEG standard.

Features that were identified as essential when the MPEG compression standard was developed are:

1) Random access to the compressed information (requires frames that can display the complete image by themselves without relying on adjacent frames).
2) Fast forward and reverse search.
3) Capability for reverse playback.
4) Audio and video synchronization.
5) Robustness for errors.
6) Editing on compressed video.
7) Flexibility to allow extension and adaptability to specific applications.
8) Cost-effective implementation.

To achieve the compression needed for a ratio between 20 and 100, two basic techniques are applied: 1) block-based motion compensation for the reduction of temporal redundancy, and 2) transform coding — specifically, discrete cosine transform (DCT)-based compression for the reduction of the spatial redundancy.

Standards

• *MPEG (Motion Picture Experts Group):* The MPEG committee is Working Group 11, of Subcommittee 29, of the joint International Standards Organization (ISO) and International Electrotechnical Commission (IEC). The initial efforts of MPEG video were to address the compression of video signals at about 1.5 Mbps, while MPEG

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audio addressed the compression of audio at a rate of 64, 128 and 192 kbps. This effort developed into the MPEG-I international standard for video and audio. The CD-I multimedia product uses this technology.

MPEG-I proved to deliver impressive audio/video quality with a wide range of bit rates. However, higher quality levels, as well as a wider application range, could be achieved. MPEG-II began development in 1991. The MPEG-II standard video enhances quality of both traditional services such as broadcast, cable and satellite TV, as well as new services such as video-on-demand, video phone, video dialtone, catalog shopping and virtual reality games. Furthermore, MPEG-II will support bit rates and resolutions up to HDTV. The development of MPEG-II has gained enthusiasm in a wide range of industries such as cable, consumer electronics and satellite.

The MPEG-II development is scheduled to be implemented in products some time in the middle of this year. The working draft will be frozen with respect to video enhancements next month. It will be in committee by November of this year and a draft to the International Standards by March of 1994. The MPEG-II development has made significant progress recently. Even though the standard won't be approved internationally until March of 1994, many products will be developed sooner to get an edge on the market.

MPEG-II video, technically, is more efficient than MPEG-I. MPEG-II utilizes advanced motion compensation algorithmic methodologies that have been proven effective. For example, the use of B frames in motion compensation. In addition, the committee is discussing additional methodologies. Core experiments have been conducted by independent companies to evaluate the merits of these methodologies. This approach allows for competition among various companies and provides for the best possible solution for MPEG. With advancements in IC development and a decrease in the cost for memory, we anticipate the future of MPEG-II to be bright. The products that utilize this technology will provide users with the best quality at the lowest cost.

The MPEG-II committees also are addressing system issues. The requirements for MPEG-II are much different than MPEG-I since MPEG-II is targeted at a wider application. There has been a lot of progress made with respect to broadcasting systems, such as multichannel multiplexing, error concealment, encryption and synchronization. The MPEG-II system is expected to advance rapidly over the next few months in providing a total solution, video, audio and transport.

• *CCITT H.261:* The H.261 standard was developed for video conferencing applications and is based on DCT and motion compensation. It compresses video to rates ranging from 64 kbps to 2.048 Mbps. H.261 uses symmetric compression techniques that result in lower performance than that achieved using MPEG. CCITT is a French acronym for the International Telegraph and Telephone Consultative Committee.

Techniques

• *Motion-compensated prediction:* Among the techniques that exploit temporal redundancy in a video signal, the most widely used is motion-compensated predic-

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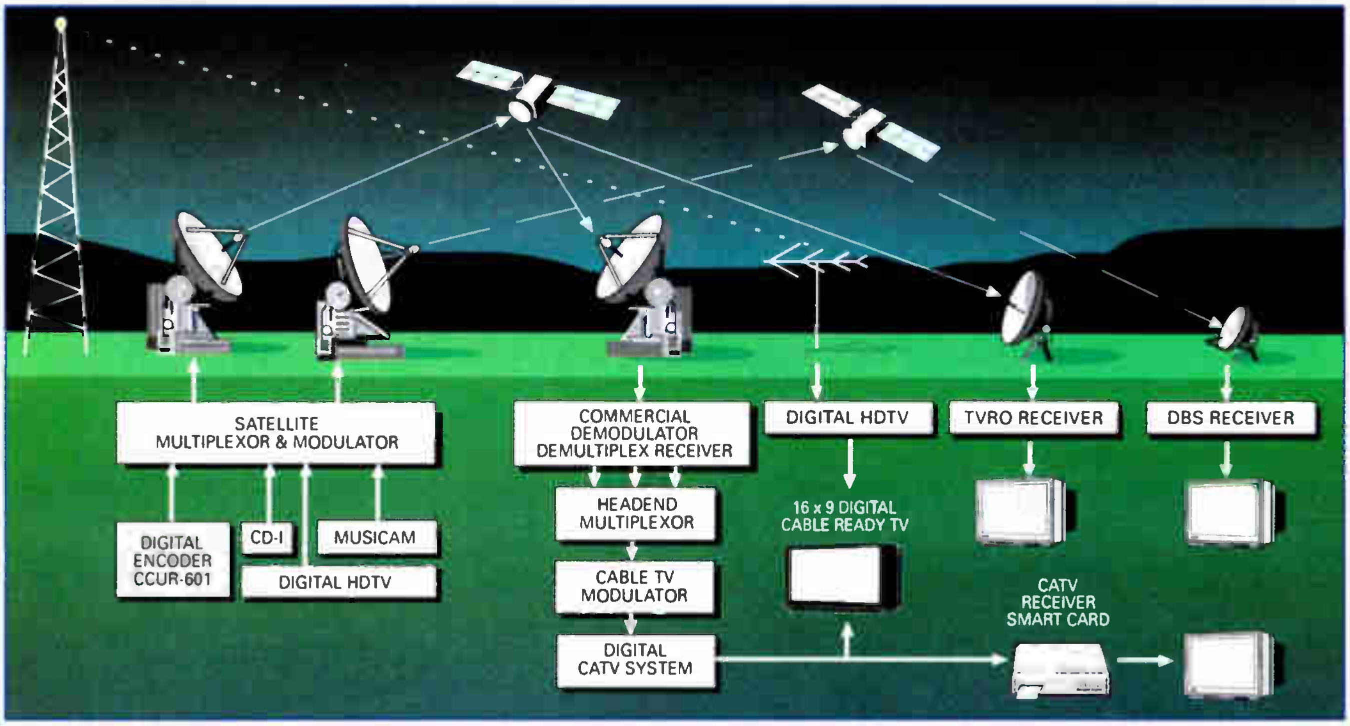
Figure 2: Philips digital video system



tion. Motion-compensated prediction assumes that the current picture can be locally predicted by a translation of the picture at some previous time. Locally means that the magnitude and the direction of the displacement may not

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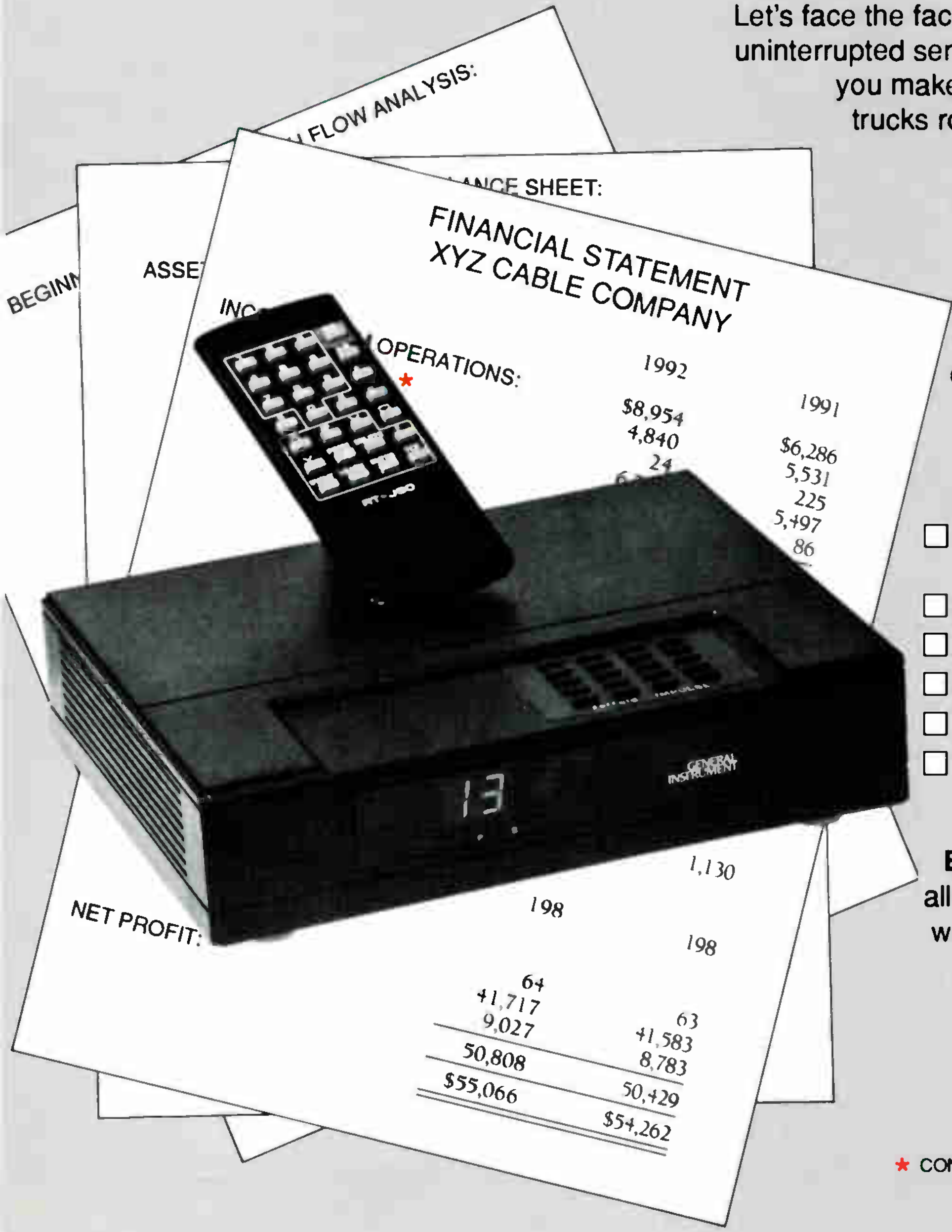

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"Compressed digital video is a technical revolution ready to happen ... Choosing the right applications and commercializing them is the next challenge."

be the same everywhere within the picture. Motion estimation covers a set of techniques used to extract the motion information from a video sequence. Motion vectors are associated with blocks of 16x16 pixels in the picture to support motion-compensated prediction in the decoder.

• *Reduction of spatial redundancy:* Both still images and prediction error signals have a very high spatial redundancy. The most widely used frequency domain decomposition technique is the DCT. The DCT takes a block of either the motion-compensated residue or the original picture information and converts it to a corresponding set of coefficients representing different frequency components.

This has two advantages. First, the signal often has most of its energy concentrated in a small range of frequencies so that very few bits are required to describe unimportant components. Second, the frequency domain decomposition mirrors the processing of the human visual system and allows subsequent quantization procedures to be tailored to its sensitivity.

• *Quantization:* Quantization of the DCT coefficients is a key operation because the combination of quantization and run length coding contribute to most of the compression. It also is through quantization that the encoder can match its output to a given bit rate. Finally, adaptive quantization is one of the key tools to achieve visual quality. In principal, quantization reduces the precision with which we describe the coefficient from the frequency domain. The quantized frequency domain coefficients tend to have the value zero at different frequencies and large groups of such zeros are clustered at higher frequencies in many cases. Hence, additional compression often is achieved by coding the number of zeros in a row rather than coding each individual zero by itself. Non-zero coefficients are coded individually. Such coding is called run length coding.

• *Variable length coding:* The non-zero quantized coefficients and the number of zeros in a row each yield to further compression since some possibilities occur much more frequently than others. This process often is referred to as entropy coding. By assigning a short code word to frequently occurring possibilities and a long code word to infrequently occurring possibilities, a net savings in bit rate can be realized. The most popular technique in video compression for achieving this additional compression is Huffman coding. Following the coding, the video signal is ready for transmission. The transmission of the data is done differently dependent on the application.

Motion processing and DCT video compression techniques are shown in Figure 1 on pages 16 and 17.

An example: The U.S. scene

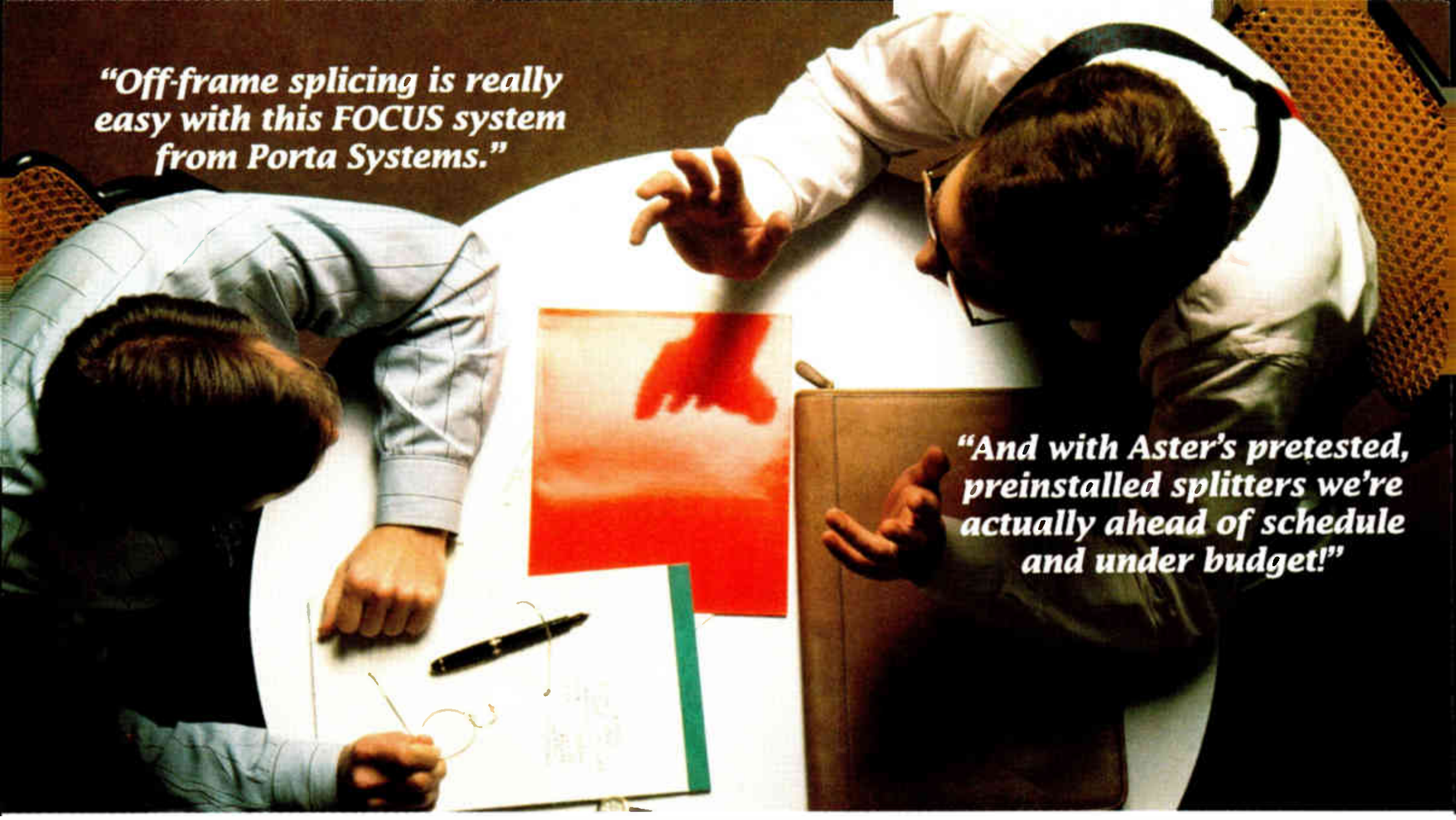
Two important events relating to digital compression of video are taking place currently in the United States. One driving force is the selection of an HDTV standard in the U.S.; the other is the new business opportunity of compressed digital video over cable and satellite. Cable operators see major business opportunities in NVOD and PPV services. Compressed digital video is the only realistic way to provide the necessary additional channels on limited-bandwidth cable systems.

The Federal Communications Commission is pushing strongly to set a digital simulcast HDTV terrestrial broadcast standard by mid-1993, with implementation to be accomplished within the following five years. The FCC claims that NTSC service will ultimately be terminated. Four digital HDTV systems are currently being tested: one from the Advanced Television Research Consortium (consisting of Philips, Thomson, NBC and the Sarnoff Research Center), one from Zenith and AT&T, one from General Instrument (GI) and MIT, and one from GI alone. (The Philips digital video system is shown in Figure 2 on page 42.) Broadcasters will have five years to implement, and will lose first right to the spectrum if they do not comply.

Summary

Compressed digital video is a technical revolution ready to happen. All the key requirements for applications technology and standards will soon be in place.

Compressed digital video offers many new options. Some applications can be practically realized in the short term, others require more time. Choosing the right applications and commercializing them is the next challenge. **CT**



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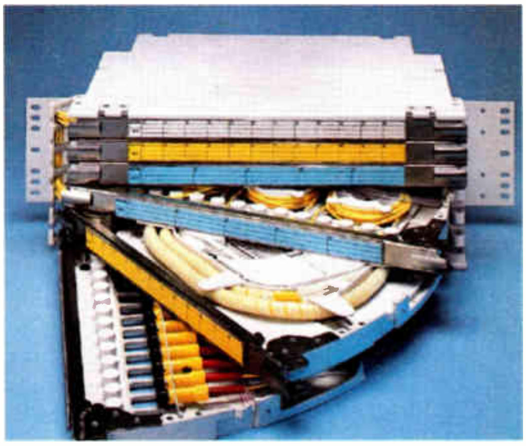

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Table 1: PC vs. APC (at 1,300 and 1,500 nm)*

Backreflection (dB)	-35	-40	-45	-50	-60	-70
PC (hand polish)	•					
PC (machine polish)		•	•	•		
APC (machine polish)					•	•

Insertion loss (in dB per mated pair)	Typical	Maximum
PC (hand polish)	0.2	0.4
PC (machine polish)	0.1	0.3
APC (machine polish)	0.2	0.5

APC connector	APC angle
FC/APC	8°
SC/APC	8°
ST/APC	10°

*Assuming correct fiber fitting techniques are used.

systems. However, for many high bandwidth analog CATV systems (above 600 MHz), -60 dB is necessary. To achieve -60 dB and beyond can only be done by using an APC connector. APC means angle physical (or positive) contact, not angle polish connector. The two fiber end-faces are touching.

APC vs. PC

There are various trade-offs between super PC (or ultra PC) and APC connectors. APC connectors have lower backreflection but higher insertion losses. (See Table 1.) Right now APC assemblies also are slightly more expensive. Most specifiers that use low backreflection connectors are aware of the above information. However, they may not be aware of the following: *Low backreflection due to PC polishing degrades with repeated connector matings, but APC backreflection does not degrade.*

This is very important. PC and APC connectors obtain low backreflection by entirely different methods. Low backreflection for PC connectors depends on the surface finish of the fiber. The finer the grain structure, the lower the backreflection. Remember that PC means physical contact.

When connectors are mated and remated, each fiber end face receives some very minor scratching from the other fiber end face. This scratching does not significantly affect insertion loss. Backreflection, though, is compromised. The data that we have gathered suggests that backreflection degrades at a rate of 4 to 6 dB per every 100 matings for PC connectors only.

Please note that our tests were performed in a lab environment. It may be worse in the field, depending on how

Figure 3: How low backreflection is achieved for PC vs. APC connectors

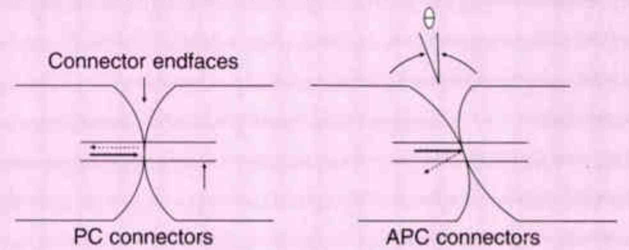
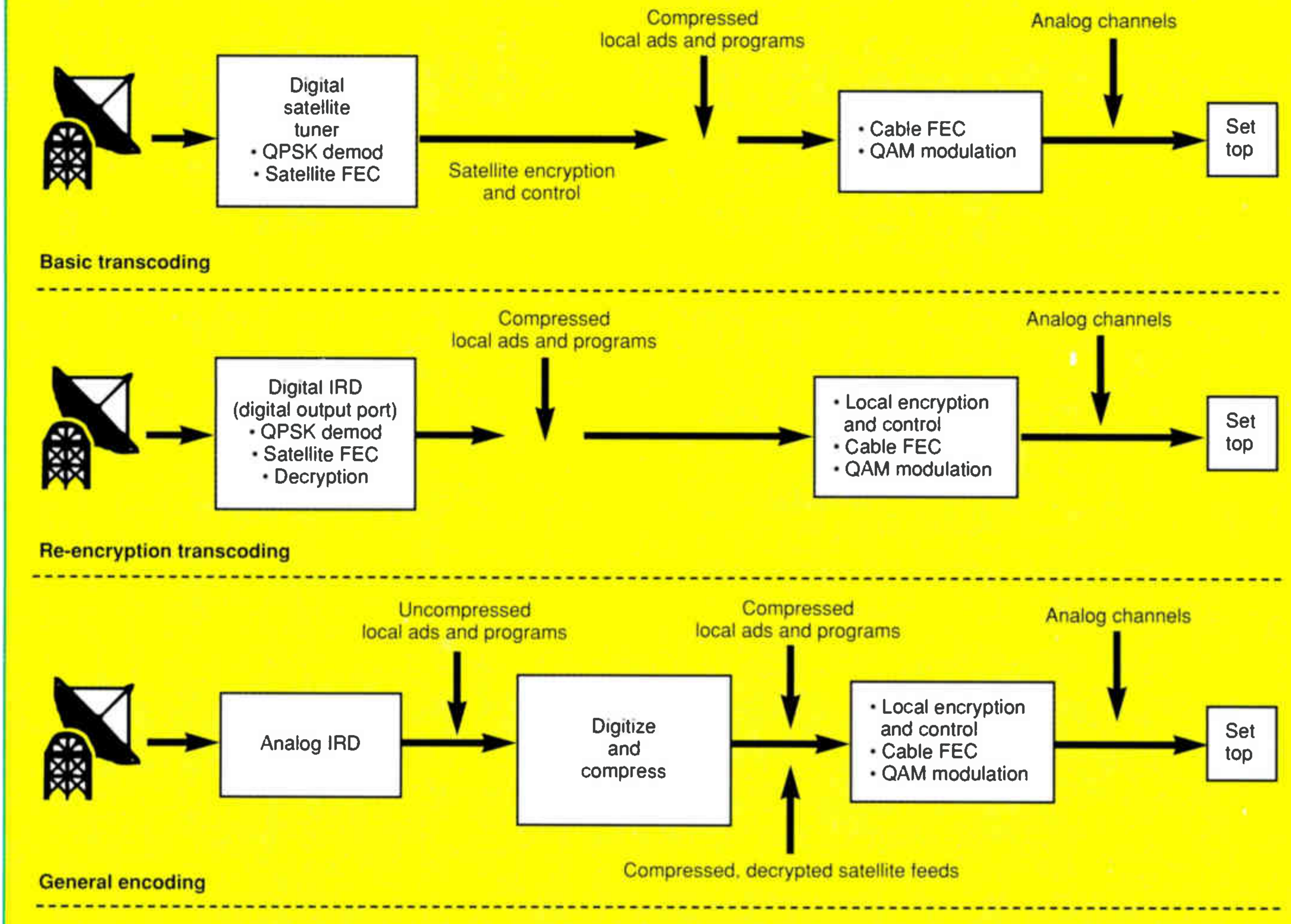


Table 2: Degradation of backreflection due to repeated connector matings (average 20 samples)

Number of matings	PC connectors	APC connectors
Average starting points	-50.1 dB, -45.7 dB	-73 dB (off scale)
25	3.1	0
50	3.3	0
75	4	0
100	4.5	0
Average ending point	-45.6 dB, -41.2 dB	-73 dB (off scale)

Figure 1: System configurations



Compression from headend to home

(Continued from page 18)

probable coefficients longer codes. This makes the information flow more efficient without deleting any further information.

Combining these and other compression techniques can reduce the amount of data required to less than 2% of the original with little or no subjective picture degradation. Figure 1 depicts several system configurations for deploying compression in cable systems.

Transmission processes

The compression processes previously described reduce the amount of information required to transmit digital signals through either satellite or cable TV. Reducing information makes the remaining data critical, leaving the system quality highly susceptible to errors. Forward error correction (FEC) techniques are employed to detect and correct errors, but since they add bits to allow error detection and correction, they also increase the total transmission data rate.

FEC techniques vary depending on the transmission media and formats. Satellite transmission requires high quality in low C/N ratio environments, typically as low as 12 dB. Satellite transmission formats like quadrature phase shift keying (QPSK) can offer high quality in noisy environments by using more bandwidth (24 MHz for example). Conventional NTSC cable TV channels are 6 MHz wide and require more bandwidth-efficient modulation formats such as quadrature amplitude modulation (QAM). Since cable TV plant is less noisy than satellite (typically 40 dB C/N or better vs. 12 dB C/N), high density modulation techniques such as 64 QAM can be used in only 6 MHz bandwidth.

Near-video-on-demand

Satellite digital compression will encourage many new and/or enhanced services by lowering economic barriers for programming services since multiple programs can now share the expensive satellite transponder leases. Multiplexed pay services and a greater variety of pay-per-view events are examples of services that could benefit from compression. Near-video-on-demand (NVOD) services also should be made possible with compression through the cable plant.

Cable TV can deploy NVOD services using fiber-optic nodes, digital compression and demand/trafficking empirical rules, as Jerrold has demonstrated with a profile called Cable-On-Demand. (See Figure 2 on page 48.)

The top section of Figure 2 shows an assumed program lineup of 55 standard analog programs, including five PPV channels. The "System facts" section assumes the use of fiber-optic nodes covering 2,000 homes and 1,200 subscribers per node (60% penetration). The 20,000 subscriber figure for this hypothetical system is irrelevant to the calculations in this model since the fiber nodes are assumed to be home run shots of fiber from the headend to the nodes without any field-

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splitting. If field-splitting is used for standard analog programming, then a few home run fibers to each node could be overlashed later as NVOD, narrowcasting or niche services were deployed.

The model assumes penetration rates (percentage of total subscriber base signing on to the service) and contention rates (percentage of penetrated subscribers who want to simultaneously use the service) typically highest Saturday nights for movie services. This particular model looks to the future and assumes a high penetration rate (25%) and an equally high contention rate (67%). This scenario would require 200 channels to provide fiber-optic nodes of 1,200 subscribers with the NVOD service. When required, each of up to 200 subscribers would have a dedicated channel over which the cable operator could offer any programming available at its headend or regional programming center.

With 8:1 compression (a reasonable assumption for movie services) the 200 digital channels would only need to occupy 25 standard analog 6 MHz channels, typically the highest 150 MHz for systems. Smaller fiber-optic nodes and/or lower penetration and contention rates (typical for current PPV movie services) would reduce the required number of NVOD channels to quantities for which all-analog 550 MHz systems could allow for testing and/or initial deployment.

Figure 2: Cable-On-Demand application model

Assumed cable system channel loading

Take rate	55 channels
100%	12 lifeline
99%	15 basic
95%	13 expanded basic
80%	10 premium
10%	5 PPV

System facts

Cable system	20,000 subs
Bandwidth	550 MHz
Average node size	2,000 homes
Cable penetration	60%
Avg. subs/node	1,200 subs

Cable-On-Demand (COD) channel requirement scenario
(Assumes 1,200 subs per node)

		Contention				
		20%	33%	50%	67%	80%
Penetration	10%	24	40	60	80	96
	15%	36	60	90	120	144
	20%	48	80	120	160	192
	25%	60	100	150	200	240
	30%	72	120	180	240	288

Number of channels

COD channel (program) capacity utilizing DigiCable system

System description	Standard analog channels	COD channels	Total channels	COD use of 6 MHz channels (@ 8:1)	Total 6 MHz channels
Analog 550 MHz	55	25	80	25	80
Analog/digital 550 MHz	55	200	255	25	80
Analog/digital 750 MHz	55	464	519	58	113
Analog/digital 1 GHz	55	800	855	100	155

Subscriber interface

While the thought of having potentially hundreds of programs to choose from sounds appealing, cable operators will need to use in-home equipment that will be as equally appealing to subscribers. Browsing through hundreds of programs will likely prove to be a time-consuming and frustrating task. On-screen displays and forms of electronic program guides will be required to help guide the consumer through the vast array of programming and functional features.

Summary

The rate of technical change within cable continues to accelerate. Fiber optics is now widely used in the engineer's ever-growing list of options. Now standards and technologies like HDTV and digital compression are rapidly emerging on the scene. Digitally compressed video programming will be deployed this year over satellite, with cable plant utilization to follow in the near term. **CT**

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Outage management, Part 3

(Continued from page 20)

ciency. Many power supply manufacturers now offer graduated values from 3 to 15 amperes. You can choose the size of supply that best meets your design needs. The true optimal value for supply loading has to do with the type of load powered (linear or switch-mode supplies), and whether the AC supply is standby or normal. Supplies powering a load that is predominantly switch-mode should be loaded to a lesser extent. Standby loading will impact total powering time on the batteries installed, which must be considered as well.

The outage task force recommends the following general power supply loading:

Load type	Standby supply	Normal supply
Linear	90%	100%
Switch-mode	85%	90%

Table 1 on page 50 shows system reliability calculations and uses a base model cable TV system with a cascade of 25 trunk amplifiers and varies the number of power supplies in cascade and the reliability of the commercial power. The resultant chart depicts power supply cascade numbers vs. commercial power reliability, seeking to determine supply cascade and commercial power reliability limitations. Data shown are outages/month for the worst-case subscriber. In other words, given some typical level of commercial power reliability, is a cascade of 25 power supplies acceptable? If not, to what must the cascade be reduced? If the cascade cannot be significantly reduced, what level of commercial power reliability is needed for that cascade of 25?

System component reliability used to calculate outage rates in Table 1 was determined by the CableLabs Outage Reduction Task Force to be the expected failure rates of the various types of equipment based on vendor recommendations and field experience. For example, the subcommittee has determined that 7% for amplifiers is the reliability that should be experienced with today's equipment.

The numbers shown in Table 1 represent outages/month experienced by a subscriber in the sample system. Again, these numbers represent all parameters at subcommittee-suggested levels, except commercial power reliability and power supply cascades. Commercial power reliability percentages are yearly numbers. Six-tenths of an outage per month per subscriber is deemed the maximum acceptable level, hence the results in Table 1 are in color where combinations of commercial power reliability and power supply cascade levels were at or below acceptable levels.

Table 1 brings us to some basic conclusions. For commercial power loss rates that are deemed "average" at this juncture (typically 30% per year), power supply cascades of around seven or less are mandatory to meet consistent system reliability requirements. Conversely, if a system's power supply cascades average approximately 10, commercial power reliability must be no more than 20% total downtime per year or the system will not be able to meet necessary reliability requirements. Standby powering at specific or all locations is always an option to lower the effective commercial power loss rate close to zero, but this brings new considerations to bear. →

Table 1: Power sensitivity chart (outages/month for worst-case customer)

% power fail/year	Power supply cascade level: 20	15	10	8	7	6	5	4	3	2	1
100	2.13	1.69	1.26	1.08	1.0	.91	.82	.73	.65	.56	.47
90	1.96	1.57	1.17	1.02	.94	.86	.78	.70	.62	.54	.46
80	1.79	1.44	1.09	.95	.88	.81	.74	.67	.60	.53	.46
70	1.63	1.32	1.01	.88	.82	.76	.70	.63	.57	.51	.45
60	1.46	1.19	.92	.82	.76	.71	.66	.60	.55	.49	.44
50	1.30	1.07	.84	.75	.71	.66	.61	.57	.52	.48	.43
40	1.13	.95	.76	.68	.65	.61	.57	.54	.50	.46	.42
30	.97	.82	.68	.62	.59	.56	.53	.50	.47	.44	.42
20	.80	.70	.59	.55	.53	.51	.49	.47	.45	.43	.41
10	.63	.57	.51	.49	.47	.46	.45	.44	.42	.41	.40
0	.47	.45	.43	.42	.42	.41	.41	.40	.40	.39	.39

Cascade of 25 trunks + 1 bridger + 2 line extenders

A general rule of thumb from this also emerges. This is, if the trunk-to-power supply ratio is four or more, supply cascades are probably acceptable if there are no more than 25 amplifiers in cascade. In other words, as an initial determination of whether power supply cascades are reasonable, take the number of trunk stations in the system and divide by the number of power supplies. Assuming the trunk cascades are limited to 25 or less, a trunk/power supply ratio greater than four is generally acceptable and indicates good powering methods with reasonable cascades. This assumes a commercial power reliability of around 30%, which seems to be an average with available data.

The question now to be considered is: "What new power distribution techniques can be utilized to reduce power supply cascades?" A better understanding of commercial power issues will then be addressed later in this article.

Power calculation methodology

The primary intent of this information is to explore new design topologies and techniques, but it would be shortsighted not to mention some general guidelines regarding AC design techniques with any architecture. Current AC powering designs usually involve only a general effort toward the calculation of load voltages and total supply loading. Often, cable system powering could have been designed with supply cascades at significantly lower numbers had the designer spent just a little more time with the layout and better understood the concepts of system AC calculations.

In most system AC designs, load voltages will typically be higher than calculated, and calculated supply loads are often less than measured. Why would this be true? The following guidelines explore some answers.

Actual system voltages often vary from calculated voltages for many reasons. This can be a frustrating exercise if the designer is not aware of this variance and expects to measure exactly what was calculated when field trips to compare results are conducted. Conversely, if you understand these limitations and caveats, they can be incorporated into your design to improve accuracy and reduce overall cascades. Our suggestion here is to take these variables into account, and to do so with careful supply placement and minimal cascades in mind.

The most common reasons for variation between calculated and actual levels are as follows:

- Manufacturers typically publish power consumption specifications for their equipment that are higher than the nominal range of values. This is done to allow for those very few amplifiers that exceed that nominal range. For accurate designs, controlled measurement of a random sampling of amplifiers utilized in the system is recommended, with the mean value of measured current/power drains used for the design layout.
- Many (if not most) designers lay out systems using fully loaded amplifier station values. For example, the rating for a trunk station that includes the reverse amplifier may be used, although the stations are subsequently operated without them. Use actual amplifier loading for the design to ensure accuracy.
- Often, actual system cable footages are less than those indicated on system maps. This can occur for a variety of reasons, but typically because it is a common practice during strand or as-built mapping to slightly overestimate footages. As an example, the real measurement is 102 feet, so the mapper writes down 105 or 110 feet to allow a little extra. This practice can inflate real footages by as much as 5% from actual with a significant effect on supply placement.
- Actual cable loop resistance values may be less than the cable manufacturer's published values. Obtain accurate measurements whenever possible.

Allowing the previous factors to accumulate without adjusting for them can inadvertently place many supplies that were not really needed, thus inflating the number of supplies and overall cascade(s).

In one design examined, these factors plus a lack of attention to proper supply placement lowered average loading on the supplies by almost 50%, and inflated the average supply cascade level to almost double what was necessary. Many cable design houses do not even consider the powering process an important part of system design. As has been already pointed out, this practice (or lack thereof) deepens the system's exposure to outages — with reduced overall system reliability.

Hardened trunk techniques

The term hardened trunk describes a general technique of separating trunk and feeder powering. In other words, provide separate power supplies for the trunk and feeder systems. Further, a basic premise is that the trunk portion must experience very little downtime. If commercial power does not meet specific and critical reliability considerations, then use of standby powering should be seriously considered. Thus, the hardened trunk powering technique will often utilize standby power at crucial locations in the trunk to meet necessary reliability standards. With the local supply in the feeder, the power to the subscriber's home is often off when the local supply is off. Thus, the subscriber is unaware that a cable outage is occurring. The hardened trunk technique generally employs the following methodology:

• *Trunk powering* — Trunk is powered via separate supplies. Strategic location (often standby, sometimes status monitoring) of the supplies is necessary for the optimal configuration. The two powering systems are typically separated within the trunk station, with some equipment brands allowing for this more easily than others.

• *Feeder powering* — Feeder is powered with separate local supplies. Unless feeder power requirements are unusual, as is sometimes the case with interdiction, a single local supply per trunk station is optimal. Standby will normally not be required with the local unit.

As stated, hardened trunk techniques are built upon the premise of strategically located supplies with established reliable commercial power feeds since the hardened trunk should always be kept energized. If commercial power reliability standards cannot be attained, trunk standby powering would be the next recourse with power supply status monitoring worthy of serious consideration. Implications of increased maintenance with standby powering are discussed later in this article.

Use of hardened trunk offers the following basic advantages:

• It significantly reduces power supply cascade levels. Typical cascade reductions are in the 60 to 75% range compared to normal design placement for identical RF plant layouts. Since the trunk is powered separately, supplies can be placed with some increased degree of flexibility, and often loaded to higher percentages when load types/conditions permit, thus increasing supply operational efficiency. As stated earlier, proper supply load percentage is dictated by many variables including the type of amplifier power supplies used.

• It allows standby power technology to be optimally applied and operated. Systems that employ extensive standby powering often experience difficulties because of higher required maintenance. Hardened trunk allows for a more specific application of standby to the trunk only, thus bringing maintenance efforts to focus on crucial front-end locations.

Since hardened trunk methods place more trunk stations on fewer supplies, a somewhat increased vulnerability occurs in that more customers will be affected when and if a trunk supply goes down from loss of commercial power, particularly when that supply is at the front end of the system. The first two or three supplies, at the very least, should therefore have the following characteristics:

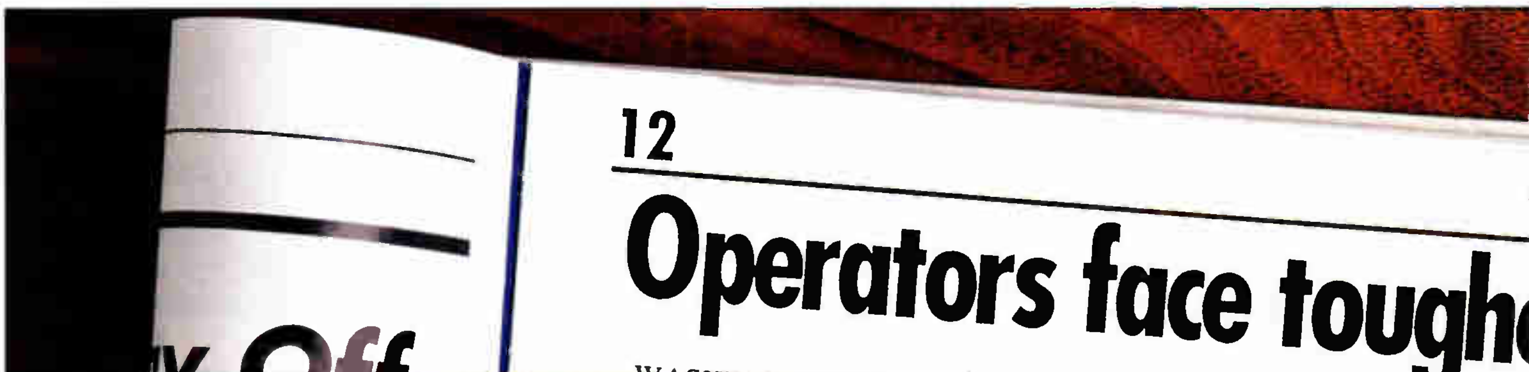
• Be optimally placed using power company statistics on highly reliable commercial powering locations.

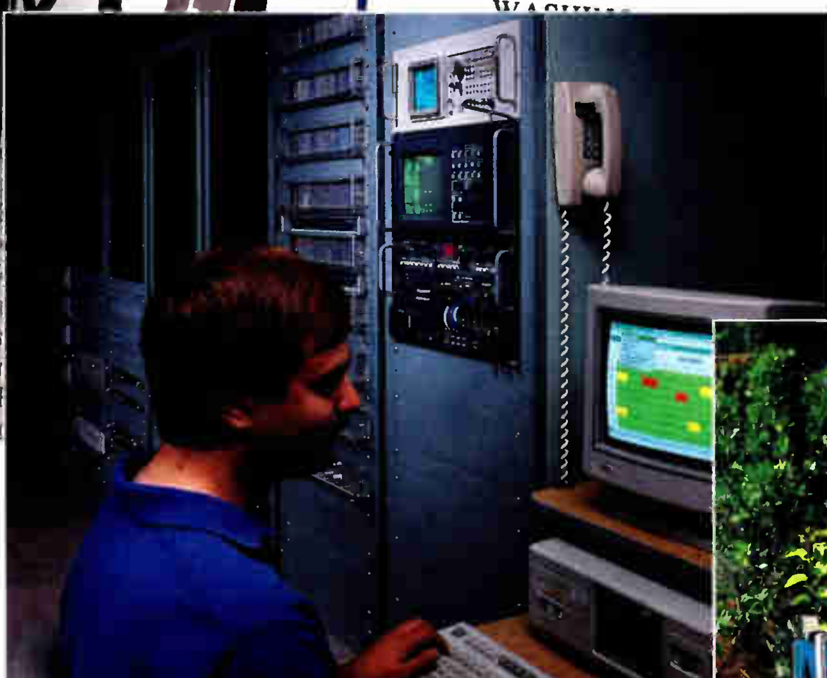
• Employ standby powering with appropriate maintenance practices.

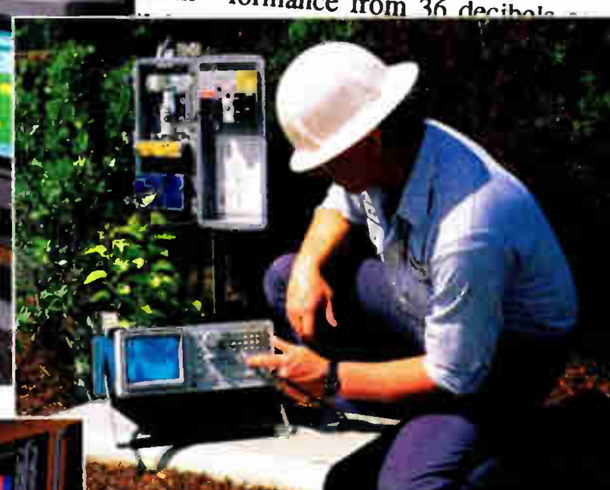
• If standby is employed, consider the use of status monitoring at those critical supplies, so that it is immediately known when a supply is without commercial power.

With hardened trunk, the overall amount of supplies in the system actually increases while the cascade of power supplies to any one customer is dramatically reduced. Table 2 on page 54 illustrates reductions possible. Sample powering designs were performed on a portion of an Ohio system comprising approximately 1,600 miles of plant. →

No problem!







(ABOVE) THE CMP500 CABLE TELEVISION MEASUREMENT PACKAGE — COMPLETE BASEBAND VIDEO AND RF MEASUREMENT CAPABILITY, INCLUDING ALL FCC PROOF-OF-PERFORMANCE REQUIREMENTS.

(RIGHT) A WAVEFORM MONITOR, VECTORSCOPE AND NTSC GENERATOR CONSTITUTE A LOW-COST SYSTEM FOR EFFECTIVE BASEBAND MONITORING.

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to comply with the new set of standards, operators will be required to conduct baseband video proof-of-performance tests. Specifically, these will include chrominance-luminance delay inequality, differential gain and differential phase measurements.

In order to create a uniform, nationwide scheme, the FCC said its standards will preempt local standards. However [illegible]

rural cable systems serving fewer than 1,000 people will be allowed to negotiate with the franchising authorities [illegible] less restrictiv[illegible] allowed redu[illegible]

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Table 2: Current design vs. hardened trunk technique

Supply section	Current	Hardened
Supply voltage	60	60
Total # system supplies	41*	91*
Worst-case supply cascade	13	5
Average supply (I) loading	8.05 A	10.26 A
Average # trunks/supply	2**	9**
Estimated outages/month: End of cascade	0.45***	0.17***

* Total supplies increase to 91. Each feeder area fed from a trunk has a local supply (total of 82) plus nine supplies for the hardened trunk system.
** This number was discussed as a general rule-of-thumb for good performance: (<4 = problems; >4 = OK.) The number 9 calculates supplies on the trunk system only.
*** The outages/month number shown represents only those outages caused by commercial power or power-related issues. Outages from other system sources are not included in these calculations.

Initial system statistics for the sample area were as follows: 85 miles of plant; 82 trunk amplifiers; 471 line extenders; and 41 power supplies. The worst-case supply cascade is 13. This system was upgraded from 300 to 550 MHz, with quite heavy electronics loading introduced.

As shown in Table 2, the total number of supplies increases, but supply cascades and projected system outages due to powering alone are reduced 62%. Power supply outage numbers were calculated using actual outage data from the system subsection while changing the supply cascades only as shown. Actual system commercial power reliability also was utilized for the calculations. With an overall system goal of 0.6 outages/month for any customer, the 0.45 due to powering alone is unacceptable with a power supply cascade of 13.

The ability to separate trunk and feeder powering in amplifiers and equipment varies a great deal from manufacturer to manufacturer. In some brands, the simple clipping of a wire on a fuse panel is all that is necessary. With others, internal modifications plus the addition of external power inserters will be necessary. It is the consensus of this task force that any design changes and modifications necessary are well worth the effort when power supply cascade reductions are absolutely needed to obtain the requirements illustrated in Table 1 (page 50).

Other techniques

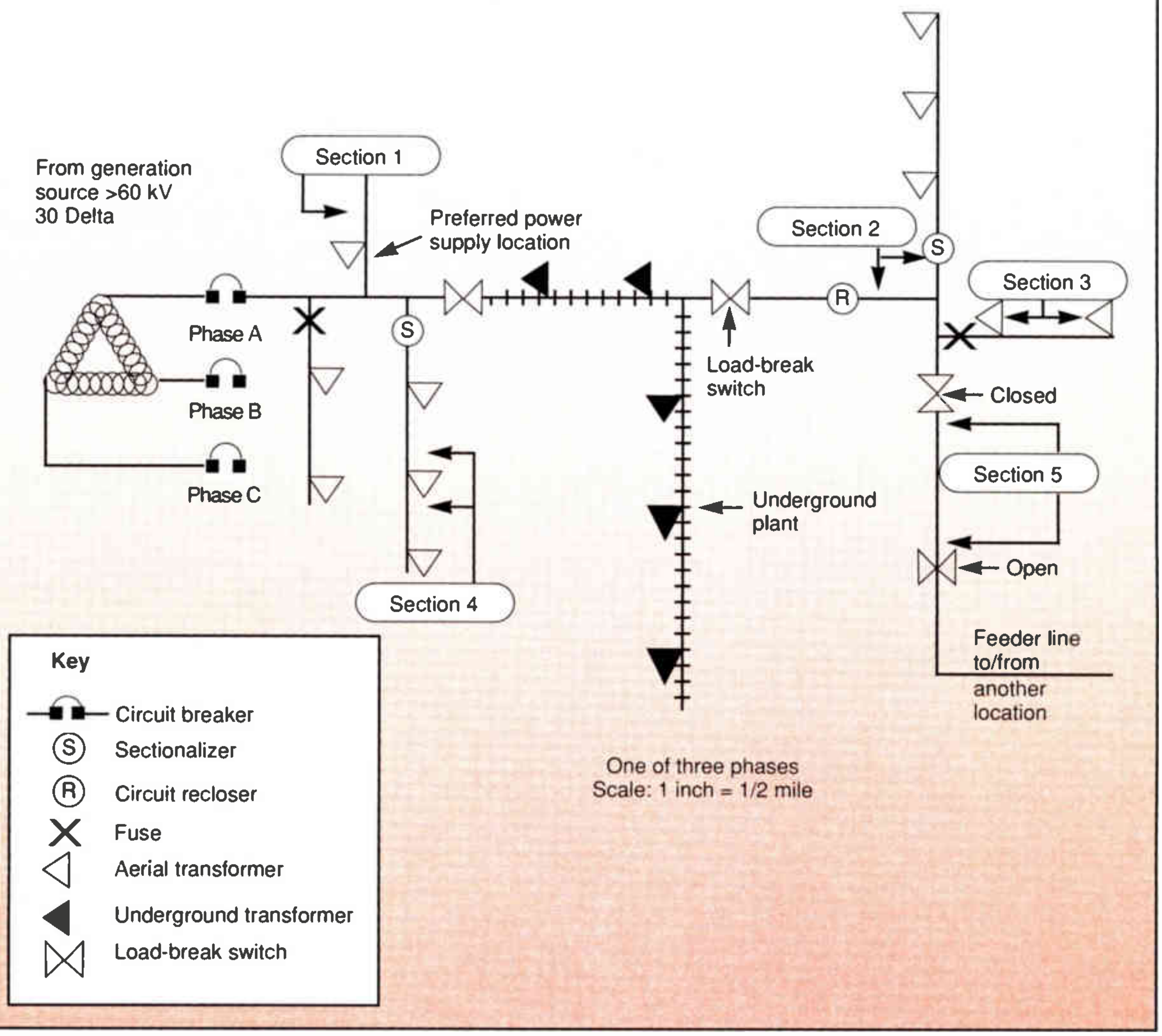
The following two techniques are described here for discussion and research purposes. Actual implementation is not necessary yet since hardened trunk achieves satisfactory power supply cascade reductions in most applications examined.

One of these additional techniques is to reduce equipment load voltages, which generally reduces power supply cascades (whether normal design or hardened trunk was employed). This technique also provides some further gains in "flexibility of placement" of supplies, whether trunk-only or trunk and feeder. The task force found that further reach and placement flexibility can be gained from lower acceptable load voltages and amplifiers. Details are in CableLabs' outage reduction document.

The equipment employed in the system and manufacturers' specifications on amplifier voltage flexibility (range-selects, etc.) will determine the extent to which this technique can be applied.

A second technique other than hardened trunk is higher supply voltages. Research has been conducted into the possible use of higher supply voltages (greater than 60 VAC) for the cable TV industry. The voltage range examined in most detail was 300 to 400 VAC quasi-square wave. In fact, some cable systems in operation in the United States today use supply voltages in this range. Some of the advantages with this approach are considerable, but the greatest by far is in increased flexibility of supply placement. However, a number of concerns exist with this approach, including code approval, trunk short-circuit analysis, possible connector problems, and personnel safety.

Typical power distribution system



The local power utility

This part of this article will cover the local electric utility system layout and its implications for overall cable system reliability. Are there ways to optimize reliability for the power drawn from them? How much does supply placement really affect reliability?

Commercial power grid

The accompanying figure represents the typical commercial power distribution grid. The front-end of the system (that closest to the substation or power source) is shown as three-phase while the remainder of the grid is shown single-phase for simplicity's sake. Keep in mind that the entire primary system is three-phase, connected in either a wye or delta configuration. Most, if not all, of the components shown in the figure will be present in a well-engineered system.

Basic principles of power grid design are safety (for the general public and utility workers), the limitation of high fault currents to protect the system from catastrophic damage, and the ability to restore service to the largest number of customers in the shortest time possible even under the most severe conditions of weather or plant failure.

The following provides a general description of the primary protective devices shown in the figure, their functions and limitations.

- *Substation:* Serves as a "voltage step-down transformer," outputting a voltage in the range of 4 to 35 kV to each distribution feeder served by the substation.
- *Substation circuit breaker(s):* This has a fault-response curve that is dependent on the magnitude and length of time that a fault is present. Fault currents above a certain magnitude generate an immediate response from the breaker, while faults of lesser value incur a time delay before the breaker reacts. The substation breaker is typically programmed to perform three cycles or operations before it permanently opens during fault conditions. The substation breaker is designed to react more slowly than other feeder protective devices. The idea is to isolate the fault with other devices before the substation has to take down the entire feeder.
- *Reclosers:* This is the next level of fault protection in the feeder leg. A recloser reacts to fault currents just as the substation breaker does. Reclosers and breakers are said to be "coordinated," which means that their fault detection characteristics are complementary. A recloser re-

acts to a load-side fault much more quickly than the substation circuit breaker can. With this type of coordination, a recloser would isolate a fault before the substation circuit breaker interrupts the entire line. Reclosers are typically placed in a portion of a feeder line that is expected to have (or has had statistically) a higher level of fault incidence due to such things as dense trees, potential car-pole accidents, etc.

• *Sectionalizers:* This is the next level of fault protection. A sectionalizer reacts to loss of power rather than fault currents. Basically, sectionalizers are simpler and less expensive than a recloser or circuit breaker. They are used to isolate or "section-off" portions of a feeder system when faults occur. The number of customers affected is minimized by isolating sections of feeder during fault conditions. Since sectionalizers operate on loss of power rather than fault currents, they are essentially "triggered open" when the source-side device opens (substation circuit breaker or recloser).

An internal counter tracks the number of times that power is lost on the distribution line. They are generally set to remain open after experiencing one less fault operation than that of their source-side protective device. For example, if the substation circuit breaker is programmed to "lock-out" after three unsuccessful attempts to reactivate a feeder line, the sectionalizer would be programmed to remain open after the second loss of power.

• *Fuse:* This provides the simplest level of protection. Fuses are typically located in feeder line spurs that exceed five pole spans in length where reclosers or sectionalizers are not used. They are fast-acting, require manual reclosure and would probably be one of the last elements of a feeder line system to be reactivated. On the other hand, a cable power supply located downstream of a fuse could potentially be more reliable than in a section of feeder that contains a sectionalizer since the fuse reacts only to a fault that occurs downstream from it.

• *Load break switch:* This is the remaining major component of a feeder system. These switches are located throughout a feeder system in order to conveniently reroute power around damaged sections of plant and to restore service to segments from different directions. Aerial load-break switches can be recognized by the presence of a switch handle on the side of a pole that is attached to a long insulated rod running up to the switch location. The switch handle resembles a shovel handle and is always padlocked.

Given the figure back on page 55 and the subsequent component descriptions, the following general guidelines can be given regarding cable TV power supply placement:

1) Where possible, keep power supplies close to substations, but on short side spurs to avoid the high fault/switching currents that can exist on main feeders close to the substation. The preferred location for a power supply would be a short side spur that does not include a fuse or other protective device, as illustrated in the figure.

2) Avoid areas downstream of reclosers such as Sections 2 and 3 of the figure. They are normally utilized by the power utility in high fault areas.

3) If possible, avoid areas fed by sectionalizers, such as in Section 4 of the figure.

4) Avoid power distribution areas between load-break switch points as in Section 5 of the figure.

5) Where possible, avoid distribution lines protected by fuses. As stated earlier, however, they are preferable to recloser or sectionalizer feeds since they only blow when fault current conditions occur downstream of the fuse location. Generally, feeder lines or spurs less than six pole spans in length do not have protective or switching devices installed. These are often optimal locations for power supply placement, particularly where they extend from main lines close to substations.

One approach for existing cable systems would be to relocate power supplies, where necessary and possible, to a point where they can take advantage of the automatic fault restoration capabilities of the power feeder system (circuit breakers), and avoid those locations where they may be shut off for long periods of times, such as downstream of reclosers or sectionalizers. Placing power supplies downstream of devices that require manual resetting such as sectionalizers will increase cable system exposure to lengthy commercial power outages.

One final caveat must now again be recognized regarding supply placement areas. Present cable plant powering layout techniques do not allow anything beyond a very modest flexibility in supply placement. The hardened trunk techniques described earlier provide improvement in supply placement flexibility. The reduction of acceptable load voltages provides a further modest improvement. Only the use of higher voltages offers a quantum increase in supply placement flexibility. When we discuss moving supply locations to avoid areas past reclosers or sectionalizers, the size and scope of the commercial power grid area requires a great deal of flexibility in supply movement to fully resolve issues in this manner.

Utilizing outage data

The preceding part of this article sought to determine power utility grid reliability based on our understanding of the function of certain protective devices. It is important to identify power grid sections that are demonstrated to be unreliable, by examination of the power utility's own plant outage data. Data is available from most utilities that can facilitate an operator's understanding of power distribution grid sections to avoid based on performance. This in turn can be used to locate or relocate supplies to optimize commercial power reliability.

While data will vary from different localities and companies, early conclusions seem to indicate the following:

1) Aerial power plant is generally more reliable than underground, primarily because underground plant is more difficult to repair and takes longer to fix during emergency restoration conditions.

2) Street light circuits are maintained separately from other electrical distribution circuits. While it was initially surmised that they would be more reliable than other distribution circuits, that has not been the case upon further investigation. Street light circuits should generally be avoided for supply powering. Outage data is normally not kept on these circuits and they are typically also the very last to be repaired under emergency conditions.

(Continued on page 66)

CABLE-TEC EXPO® '93

REGISTRATION PACKAGE

ORANGE COUNTY CONVENTION CENTER ORLANDO, FLORIDA
APRIL 21-24, 1993

THE FACTS ABOUT CABLE-TEC EXPO® '93

DATES

Annual Engineering Conference, April 21, 1993
Workshops and Exhibits, April 22-23, 1993
Certification Testing, April 24, 1993

LOCATION

Orange County Convention Center
Orlando, Florida

HISTORY

Cable-Tec Expo® '93 is the eleventh annual convention/trade show sponsored by the Society of Cable Television Engineers, Inc., combining a wide variety of technical programs, hands-on training and breakout technical workshops with instructional hardware exhibits. The Annual Engineering Conference will be SCTE's seventeenth yearly conference dedicated to current engineering issues, FCC compliance and technical management. In addition, the Society has presented more than 77 national technical programs in cities across the United States over the past twenty-three years, attended by more than 22,000 engineering and technical personnel from the broadband communications industries.

ATTENDANCE

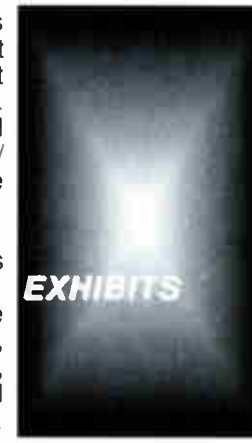
Attendance is open to individuals within the CATV industry as well as anyone involved in broadband communications. Over 2,000 registered attendees are expected from all levels of the cable television and related businesses, including all levels of non-technical personnel.

PROGRAM

The Annual Engineering Conference will be packed with six hours of technical and management papers presented by many of the industry's engineering leaders. The annual membership meeting, held at the conclusion of the conference, will afford attendees the opportunity to meet members of SCTE's national Board of Directors.

The two-and-one-half day Cable-Tec Expo® follows the Annual Engineering Conference and combines practical workshops with "hands-on" technical training and hardware displays. The program features many schoolroom-style workshops to choose from. No other activities are scheduled during workshop sessions in order to guarantee maximum attendance and participation.

As with all SCTE activities, the main purpose of Cable-Tec Expo® '93 is to provide the maximum amount of training opportunities for the lowest possible cost. The event has been coordinated to fulfill this purpose, as it offers a wide variety of informative, up-to-date technical training programs. Additionally, Expo '93 will give attendees the opportunity to prepare for and participate in the Society's Broadband Communications Technician/Engineer (BCT/E) and Installer Certification Programs, gaining valuable knowledge and practical skills in the process.



The exhibit floor has a focus on education, with many industry suppliers presenting live technical demonstrations of their products.

Over 200 hardware exhibitors are expected to reserve space on the Expo '93 Exhibit Floor. Exhibits will include all types of products, supplies, services and equipment used in the design, construction, installation, repair, maintenance and operation of cable television systems. The exhibit floor will also feature a Technical Training Center for further equipment demonstrations.

CABLE-TEC EXPO® '93 REGISTRATION FEES

(UNCHANGED SINCE 1986)

	Until March 15, 1993		On-Site**	
	Member	Non-Member	Member	Non-Member
Engineering Conference and Expo*	$195.00	$295.00	$235.00	$335.00
EXPO only	$145.00	$245.00	$185.00	$285.00
Engineering Conference only*	$120.00	$200.00	$160.00	$240.00
Spouse Registration*	$95.00	$95.00	$95.00	$95.00

* Includes ticket to the Awards Luncheon on April 21. Additional luncheon tickets are available for $20.00 each.

** Attendance at the Awards Luncheon is not guaranteed, but will be made available as seating permits.

Admission to all events will be through color coded badges to be picked up at the registration desk upon arrival.

SCTE has designated Delta Airlines as the Expo's official air travel carrier. Avis Car Rentals is offering special rates to attendees (see information below). Transportation from the Orlando Airport to your hotel can be economically arranged through Transtar Airport Shuttle, with booths located near the baggage claim area.

Delta Airlines: 1 (800) 241-6760 (U.S. and Canada)—Refer to #D0475

Avis: 1 (800) 331-1600: Refer to Meeting #B791430

Most Expo '93 hotels feature a tour desk with brochures covering area attractions, dining, nightlife and sightseeing activities. The discounted hotel rates are in effect for Expo attendees wishing to stay in Orlando for three days before or after the conference.

Society of Cable Television Engineers Inc.
669 Exton Commons, Exton, PA 19341
(215) 363-6888; FAX: (215) 363-5898

SCTE®

PRELIMINARY PROGRAM

Engineering Conference

SESSION A: ***Applications of Digital Technology*** with Roger Brown, *CED* (moderator); Scott Bachman, CableLabs; Richard Clevenger, Kblecom; and Tom Elliot, TCI.

SESSION B: ***Cable and Telephony Integration: Balancing Revenue Opportunities and Network Evolution*** with Dean DeBiase, Antec (moderator); Chris Bowick, Jones Intercable; Fred Dawson, Publisher; and Larry Lehman, Brooks Telecommunications Corp.

SESSION C: ***New Technologies and Their Effects on the Subscriber*** with Michael Smith, Adelphia Cable Communications (moderator); Claude Baggett, CableLabs; Jim Farmer, ESP Inc.; and Jud Hofmann, Panasonic.

SESSION D: ***Pay-Per-View Technology Update*** with Paul Levine, CT Publications (moderator); Paul Harr, Scientific-Atlanta; Geoff Roman, General Instrument; and Terry Wolf, TCI.

Expo Workshops

★***Distortion Analysis and Troubleshooting*** with Rick Jaworski, Tektronix; and Frank Little, Scientific-Atlanta.

★***Effective Personal Communications Skills*** with Tom Brooksher, Cable Publishing Group; and Jim Hurley, TKR.

★***Fiber Optic Architectures and Construction Practices*** with Ted Huff, Hyperion; Joe Selvage, Adelphia Cable Communications; and Les Smith, Cable Constructors.

★***Fiber Optic Documentation, Restoration and Testing*** with David Johnson, Siecor.

★***Introduction to Digital Technology*** with Rand Reynard, ONI.

★***One-on-One with the FCC*** with Mike Lance and John Wong, FCC Cable Branch.

★***Outage Reduction Techniques*** with Scott Bachman, CableLabs.

★***Safety: NEC, NESC and OSHA Regulations*** with Ralph Haimowitz, SCTE; and Jim Kearney, Malarkey Taylor Associates.

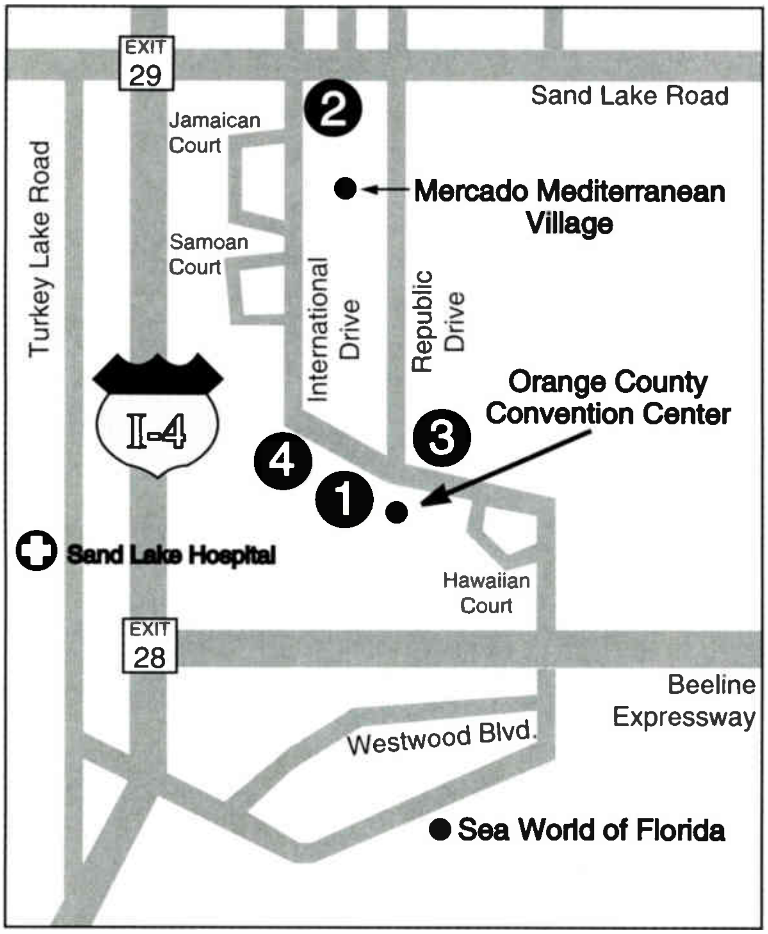
★***Test Procedures Under Technical Reregulation*** with Syd Fluck, CaLan.

★***Using Basic Test Equipment*** with Ron Hranac, Coaxial International; and Steve Johnson, Time Warner.

CABLE-TEC EXPO® '93 SCHEDULE OF EVENTS

	Registration	Training	Exhibits	Testing	Special Events
Tuesday, April 20	Attendee Registration 4 - 8 p.m.				NCTA Engineering Committee Meeting 9 a.m. - 5 p.m. In-Home Cabling, Maintenance Practices & Procedures and EBS Subcommittee Meetings 2 - 3:30 p.m. Interface Practices, Design & Construction and CLI Subcommittee Meetings 3:30 - 5 p.m. Arrival Night Reception 6 - 8 p.m.
Wednesday, April 21	Attendee Registration 7:30 a.m. - 4 p.m.	Engineering Conference 8:30 a.m. - 4:30 p.m.			Awards Luncheon 12 noon - 1:30 p.m. SCTE Annual Membership Meeting 4:30 - 5:30 p.m. Welcome Reception 6 - 9 p.m.
Thursday, April 22	Attendee Registration 7:30 a.m. - 3 p.m.	Expo Workshops 8 a.m. - 12:15 p.m.	Exhibit Hall Open 12 noon - 6 p.m.	BCT/E and Installer Certification Testing 10 a.m. - 2 p.m.	Expo Evening at Sea World 7 - 10 p.m.
Friday, April 23	Attendee Registration 7:30 a.m. - 3 p.m.	Expo Workshops 8 a.m. - 12:15 p.m.	Exhibit Hall Open 12 noon - 6 p.m.	BCT/E and Installer Certification Testing 10 a.m. - 2 p.m.	Ham Radio Operators' Reception 7 - 9 p.m. International Good Neighbor Reception 7 - 9 p.m.
Saturday, April 24				BCT/E and Installer Certification Testing 8:30 a.m. - 12 noon	Golf Tournament 7:30 a.m. - 1:30 p.m.

CABLE-TEC EXPO® '93 HOUSING



	HOTEL	ROOM RATE	# OF ROOMS AVAILABLE
1	Clarion Plaza	$89 S/D	600
2	Marriott Orlando	$82 S/D	500
3	Peabody	$125 S/D	300
4	Quality Inn	$51 S/D	300

1 **Clarion Plaza**—Newly constructed hotel adjacent to the convention center featuring pool, nightclub, two restaurants and a 24-hour deli.

2 **Marriott Orlando**—Resort hotel on 48 acres, one mile from the convention center, featuring three pools, four lighted tennis courts, a jogging trail, health club, restaurants, lounges and a 24-hour deli. (Bus service will be provided during show hours).

3 **Peabody**—Luxury hotel across the street from the convention center featuring a pool, four tennis courts, a health club, three restaurants and a lounge.

4 **Quality Inn**—Budget hotel 1/4 mile from the convention center featuring a pool and restaurant. The same room rate applies for occupancy by one to

INSTRUCTIONS

1. **Deadline:** Cable-Tec Expo® '93 Registration Forms must be received by SCTE National Headquarters on or before March 15, 1993. Forms received after that date cannot be processed and will be returned to the sender. If you do not preregister for the Cable-Tec Expo in advance, you must register on-site in Orlando.
   - ☞ Use a separate form for each individual (forms may be copied)
   - ☞ Appropriate registration and activity fees must be enclosed for this form to be processed.
   - ☞ Hotel reservations must be made using the enclosed Attendee Housing Form before March 15, 1993.
2. **Registration Cancellations:** All cancellations must be received in writing by SCTE National Headquarters on or before March 29, 1993. A $50 cancellation charge is applicable to all registrations cancelled after March 15, 1993. Substitutions will be accepted until April 5, 1993. **NO REFUNDS WILL BE GRANTED AFTER MARCH 29, 1993.**
3. Telephone requests for cancellations and substitutions will not be accepted. All requests for cancellations must be submitted in writing and be received before March 29, 1993 and all requests for substitutions must be received before April 5, 1993. (SCTE FAX #: 215-363-5898)
4. Return the Cable-Tec Expo® 1993 Registration Form with the appropriate fees to:

   SCTE
   669 Exton Commons
   Exton, PA 19341
   Attention: Anna M. Riker
5. Please make flight reservations through Delta Airlines or your local travel agent using the special numbers listed on the "Registration Fees" page. Rental car reservations may be made through Avis.
6. Please use the enclosed Attendee Housing Form to make hotel reservations in Orlando. Indicate your first, second and third choices of hotel. Confirmation of your housing reservation will come directly to you from the appropriate hotel.
7. **EXPO '93 DRESS CODE:** The Program Subcommittee has established a dress code for this year's Expo. All attendees are encouraged to wear comfortable clothes for Florida (slacks, jeans, short sleeve shirts—**NO shorts or tank tops**).

PLEASE NOTE DEADLINES

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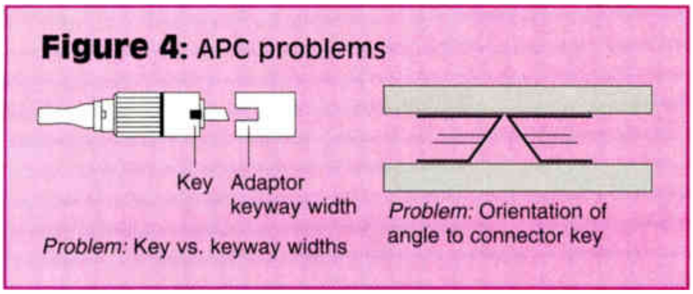


carefully the connectors are taken apart and remated. APC connectors, on the other hand, reflect light back at an angle. Angles anywhere between 6° and 12° seems to be optimum. This reflected light then exits the fiber. Any minor scratching has no effect on backreflection. See Figure 3 and Table 2 on page 46.

FC/APC intermateability problems

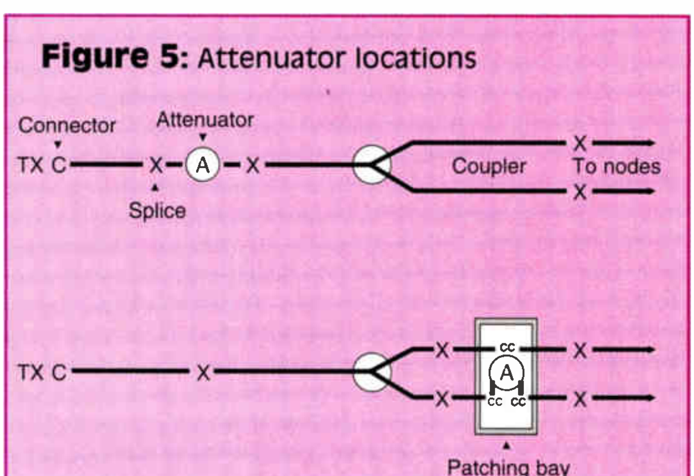
The biggest problems when using FC/APC connectors concerns intermateability. As opposed to FC/PC, there is no standard defining intermateability of FC/APC connectors. Different manufacturers orient the angle in the bulkhead differently. In other words, if the pigtails, patch cords and bulkheads are from different suppliers the orientation of the angles of the two mated connectors could be 90° or 180° apart. Also, there is no standardization regarding the width of the key (connectors) and keyway width (bulkheads). The last is the major concern. In many cases, Connector A will not physically fit into Bulkhead B. Or if the connector key is very small compared to the bulkhead keyway, the fit will be extremely loose. The result is that the insertion loss will be very high. It is strongly recommended that a statement regarding APC intermateability be a part of your specification and ordering process. See Figure 4.

There are two other questions that come up frequently regarding low backreflection connectors. Where should they be used? They are only needed at the headend because any backreflection returning from the receiver is attenuated by the losses in the fiber. The other question concerns the level of backreflection. How much is enough? It turns out that -65 dB is the maximum that will ever be needed until a better single-mode fiber is available. At that level, the Rayleigh backscattering component in the fiber becomes larger than the APC connector backreflection.

Low backreflection attenuators

Low backreflection attenuators represent another new advance in passive components. Up until recently, the only way to configure your system for maximum performance, was by using fiber-optic couplers in the headend or else by making adjustments at the receiver. The problem with adjusting the receiver is that it may have to be done from the top of a bucket truck. It is much easier to do any system tweaking or troubleshooting at the headend.

Fiber-optic attenuators were not used previously because the backreflections were too high. Now, there are both fixed and variable attenuators available with backreflections better than -60 dB. The variable attenuator would typically be used to tune the system during installation. Then you simply would install the fixed attenuator with the correct value. Low backreflection fixed attenuators have several advantages over fiber-optic couplers. One is simply a matter of cost — they are less expensive. The other has to do with how couplers are used — to split the output of the laser transmitter to feed two or more nodes. Couplers are ordered beforehand with specific split ratios. The fixed attenuator, however, can be installed on either the input leg or the output leg of the coupler. So it can be used to attenuate the entire transmitter output; or else the signal strength to any individual mode. See Figure 5.



The reason for using attenuators is very straightforward. Systems are designed and ordered using worst-case specifications — cable, connector and splice losses, transmitter output and receiver sensitivity. After installation, it is frequently discovered that the power received at a particular node might be as much as 3 or 4 dB too high for optimum performance. Changing the coupler might affect the performance of other nodes. Now there is another way to handle this type of situation using a low backreflection attenuator. The attenuators are available in 1 dB steps.

Consistent solutions

The purpose of this article is to suggest solutions that can be used for many applications. It is not good practice to have different connector types (or attenuators) for digital systems or AM systems. That gets very confusing and difficult to maintain. In case of problems, do you really want to keep a stock of two, three or more types of pigtails and jumpers? By using low backreflection connectors and attenuators in your cable plant you will never have to replace them for any system installed in the future. Remember, the electronics can change but the cable plant is forever.

Other potential problems

As a system designer, there are two other potential problem areas that you should be aware of regarding fiber-optic assemblies. The first concerns splicing. There are two competing single-mode fibers in the market — matched clad (Corning) and depressed clad (AT&T). It is unusual to hear of trunk cables being spliced together with dissimilar fibers. Then why does it frequently happen with pigtails and drop cables?

The reason for that is the ordering process. Generally, when laser transmitters are ordered, a fiber pigtail is supplied with each unit. Receivers also may come with CATV fiber-to-the-feeder drop cables. In many cases, the type of fiber is not specified by the customer. The customer takes the product that is provided with no

Outage management, Part 3

(Continued from page 56)

3) Reliability of the three-phase primary system often will vary from phase to phase depending on design architectures used. Some discussions should be held with the local utility to determine if one phase is more or less reliable than others, and if the utility is willing to allow the concentration of cable loading toward the more reliable phase(s).

4) Other individual and increased reliability circuits sometimes exist in the power distribution system (e.g., a high reliability feed placed to serve a local hospital). It is sometimes possible to place power supplies along these types of runs.

Working relationship with utility

Most major utilities have a distribution operations office, which, among other functions, electronically monitors the condition of electrical feeder systems in its jurisdiction and coordinates outage restoration, circuit switching, maintenance and construction activities in its district. Cable operators should become acquainted with the operations manager for their power company district. The operations center can provide planned service outage information, as well as the location of unplanned outages.

Further work with power utility engineers has suggested that if the cable system were to label or designate cable supplies in a manner that would relate them to the device number of their nearest upstream electrical distribution protective device, the cable system could quickly pinpoint any affected power supply locations by providing this number to the utility's operations center. Such a labeling scheme also could be helpful in notification of planned service outages. This engineering tie to the electrical power plant could be incorporated into system maps, billing system outage tracking schemes or other outage data tracking systems.

Optimized standby powering

Standby powering technology has been available for quite some time, but many operators have experienced less than successful results in its application. This lack of optimal application and results has to do with the complexity of the technology and in particular the correct selection and maintenance of batteries required. This section of this article begins the task of seeking answers to some of the industry's misunderstanding and misinformation associated with standby technology.

There is much work remaining in this area. Ultimately, the goal here is to answer to past failures and to make recommendations for change and optimal application in the cable system. How can this technology be best applied? How can we achieve desired results with minimal maintenance applied in critical areas?

Due to the detail and extent of research necessary in this area, a separate working group was established to:

- Develop recommended standby and non-standby equipment specifications.
- Develop recommended application methods for supply electronics and batteries (particularly charging circuits).

"Use gel cell batteries for standby power supply use in all climates, AGM batteries in controlled environments or colder climates, and ... avoid the use of liquid lead acid batteries."

Results and recommendations from that group will be forthcoming soon. Meanwhile, the following represents some early conclusions.

Design and reliability

Several manufacturers offer standby power supplies in a number of configurations. Most utilize a ferroresonant power transformer as the key component in the design. Ferroresonant transformers are very effective at providing voltage regulation, spike attenuation, noise filtering, high reliability and output short-circuit current limiting. The additional components necessary for the standby function are: battery charger, batteries, inverter circuit and logic control circuit/status monitoring interface. Standby power supplies are less reliable than non-standby supplies in terms of mean time between failures, primarily because of higher electrical component count. The most significant factor affecting standby power supply reliability is the batteries — how they are maintained, choosing the correct type for the application, correct charging and float techniques, and ambient temperatures encountered by the batteries.

There are three main battery types available for use in standby power supply applications: gel cell, absorbed glass mat (AGM) and liquid lead acid (automotive-type battery). Selection of the proper battery for use in standby power supplies is the first and foremost action that a system operator can take to improve system reliability.

The current task force recommendation is to use gel cell batteries for standby power supply use in all climates, AGM batteries in controlled environments or colder climates, and to avoid the use of liquid lead acid batteries.

Several factors affect battery service life, including ambient temperature, charging procedure, prolonged storage without charge and unequal battery voltages in series string connections.

Options for status monitoring

Particularly in this area, additional research is necessary before final recommendations will be made. The task force's "first pass" yielded observations that follow.

Status monitoring interface capability is available for some of the standby power supplies currently manufactured. There are two primary communication methods for the status data: 1) parallel interface for connection to the power supply monitor port in a dedicated data transponder; and 2) or in conjunction with amplifier status monitoring systems.

When a power supply goes into standby mode because of a utility outage, the status monitor system can immediately notify the dispatch center. By monitoring the rate of discharge of the batteries, an estimation of standby time can be achieved and a generator truck can be dispatched to the location to continue operation after the batteries have discharged and until utility power returns. By frequent remote tests of each power supply, marginal batteries, blown fuses or circuit malfunctions can be identified and corrected prior to a power outage. This capability greatly increases the powering reliability of the system, results in reduced maintenance visits (lower cost because of fewer truck rolls) and provides statistical data on power supply and battery performance.

Status monitoring always has been considered to be of high operational cost because two-way plant is typically the proposed method. Telephone lines or RF transmitters could be installed at each supply location, but this typically has met with serious concerns for a variety of reasons. A new idea under consideration would utilize the forward cable plant, plus data accumulators and a few telephone return lines (or RF transmitters) in the following scenario:

1) Data transmitters at each standby location would transmit data in the downstream path toward the end of the trunk line. Besides power supply "health," the data stream would include a unique identifier code for each location. Each unit would transmit in even and established time intervals to a receiver (data accumulator) located toward or at the end of the trunk line or standby powering section.

2) Since transmission is in the downstream direction, each cable system would be able to utilize this method as long as several forward frequency choices were available. One possibility would be the spectrum located between Chs. 4 and 5 or perhaps in the FM band.

3) A data receiver/accumulator would be located at the end of this string of standby power units. It would collect data and monitor the output of the unit for unusual activity.

4) A transmitter would dial into dispatch or contact the cable technical operations in some established fashion, if problems at upstream supplies were to occur.

This approach holds the promise to resolve many of the past concerns with status monitoring of supplies in the cable plant. Early studies indicate that a fairly large system could be monitored with a minimum of accumulator areas. One system examined contained a total of 500 plant miles, and could be monitored with around four or five receiver areas in total — with careful location of the alarm receivers.

The task force's recommendation is to implement status monitoring for maximum effectiveness of standby powering in the hardened trunk topology whenever possible and practical. Incorporate this with critical front-end supplies at the very least. For maximum reliability, implement at all hardened trunk locations.

Conclusions

There are definite areas in plant powering methodology that can reduce commercial-related plant outages. Cascades of power supplies and associated commercial power reliability feeding each supply are key items in system reliability. Design philosophies are currently available that provide a 50 to 75% reduction of power supply cascades when existing supply cascades or plant architecture necessitates redesign. Hardened trunk is the recommended practice when significant cascade reductions are necessary. Other techniques considered were the use of higher voltages and extended (lowered) load voltages, which also provide further extension in reach and an important increase in supply placement flexibility. The subcommittee does not recommended them at this time, since hardened trunk powering provides most improvements necessary in cascade reduction and can be easily implemented compared to the other techniques examined.

"Hardened trunk is the recommended practice when significant cascade reductions are necessary."

A better understanding of the local electrical power distribution grid provides knowledge for the correct placement of supplies when flexibility in placement is possible. Working with the local electric utility also provides for a better understanding of optimal locations for supply placement, also further creating a good working relationship with the utility. This interface provides for information on planned maintenance and emergency restoration work during outage conditions.

Finally, standby powering is an established but often misunderstood and misapplied technology for keeping unreliable but critical commercial powering locations in service. Proper supply/battery maintenance is essential. In some instances status monitoring provides for absolute reliability when supply(ies) cannot be out of service. **CT**

Protection for digital services

(Continued from page 22)

data integrity of the network that power be completely uninterruptible.

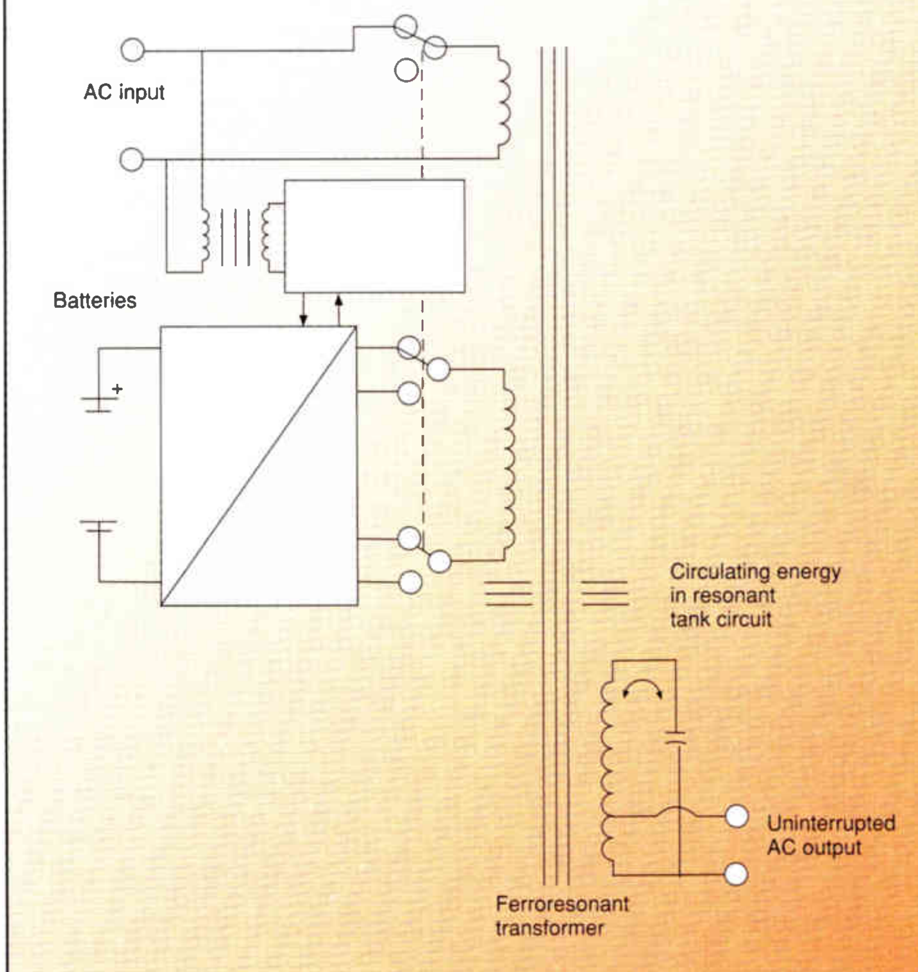
Many cable operators who are active in system planning for networks that will carry data in the near future have recognized the importance of UPS powering for all of the critical signal processing equipment from the headend to the subscriber. With the right design concept, uninterrupted output from a power supply does not require many additional components or extra cost.

Standby power supply design differences

In cable TV applications there are basically two standby power supply design approaches — the single ferroresonant transformer UPS and the "two-module" standby.

• The single ferroresonant transformer concept for cable powering was introduced over 15 years ago and is available in outside plant standby power supplies as well as UPS for office or headend powering. The single ferroresonant design features two primary inputs (AC line and battery inverter) and one isolated resonant secondary winding output. The output is always connected to the transformer and is isolated from primary side transients and noise by 60 dB. The output voltage is regulated in both AC and standby modes and is consistent in voltage, wave shape, frequency and phase during AC and standby operation. Input power is routed either to the AC input primary from the utility or from the solid-state crystal-controlled inverter fed by the battery string when operating in standby mode. The circulating energy in the resonant tank circuit on the output winding provides continued output power during the transfer on the primary side from either line or inverter. This energy storage provides the uninterrupted output in all modes of operation, during transfer in either direction. (See Figure 2.)

Figure 2: Single ferroresonant UPS functional block diagram



• The two-module approach available from most manufacturers uses essentially two power supplies with their outputs connected to the contacts of a relay. The wiper of the relay is connected to the cable system and selects from the output of one or the other power supply outputs depending upon AC or standby operation. In normal line operation, a nonstandby ferroresonant transformer power supply provides output power to the cable system. When AC power browns out or completely blacks out, the inverter module waits for the output voltage of the ferroresonant power supply to drop below the holding current of the transfer relay (or a sensing circuit) before the relay switches the cable system to the output of the inverter module output. This results in a significant brownout on the output (which can drop end-of-line actives out of operation) prior to a significant power output interruption of 35 to 70 ms or more before the inverter starts to power the cable system.

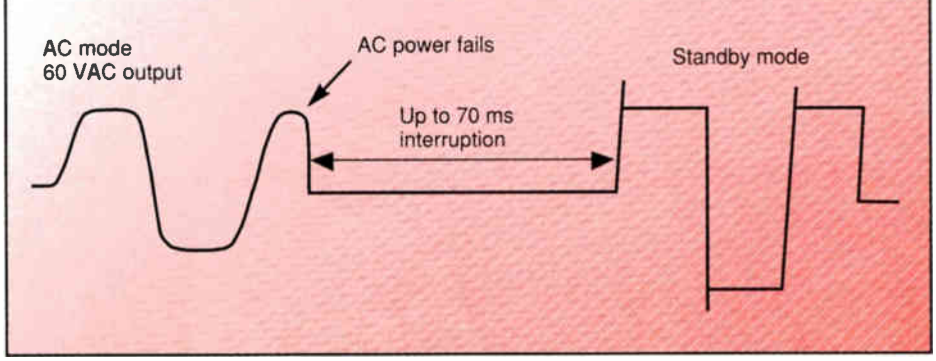
According to the amplifier manufacturers, a 20 to 25 ms interruption is all that is required to drop signal. This effect is much worse at the end of cascade where the actives operate at a lower average voltage and have less hold-up time. (See Figure 3 on page 70.)

The other problem with this design is that the transfer from line to standby is not synchronized in phase. The output is switched by a relay with variable switching time and no means to synchronize to the AC line prior to retransfer after an outage. The inverter frequency is free-running in many of these designs and can vary from 45 to 90 Hz depending on temperature, battery voltage and output load. When operating in standby, these designs can produce a high harmonic square wave output that can cause interference in the subscriber tap. This interference unfortunately also interferes with digital signals through the tap. The interference caused by the rapid rising and falling edges of the square wave output causes a signal blanking of up to 200 µs in the tap.

Office and headend

Power reliability is not only important in the outside plant. In most offices now, computers are an integral part in plant design, billing systems, addressability and other applications. Even the office telephone system is critical in most systems for subscriber pay-per-view (PPV) transac-

Figure 3: Power output interruption in a two-module standby



standby generator to start and come up to stable voltage and frequency before transfer of the load to generator. This is assuming that the generator starts up properly the first time; many generators will retry several times if they are having difficulty starting. This situation can occur often during cold weather in outdoor installations that can increase starting difficulties. Even if the generator starts up properly within 40 seconds or so, most computer-based equipment has long since shut down. Interruptions of 8 ms or less can drop out most computers. Many of the newer installations

tions and needs to be protected from power failure. A few minute power interruption during PPV peak ordering time can easily result in enough revenue loss to pay for a UPS several times over.

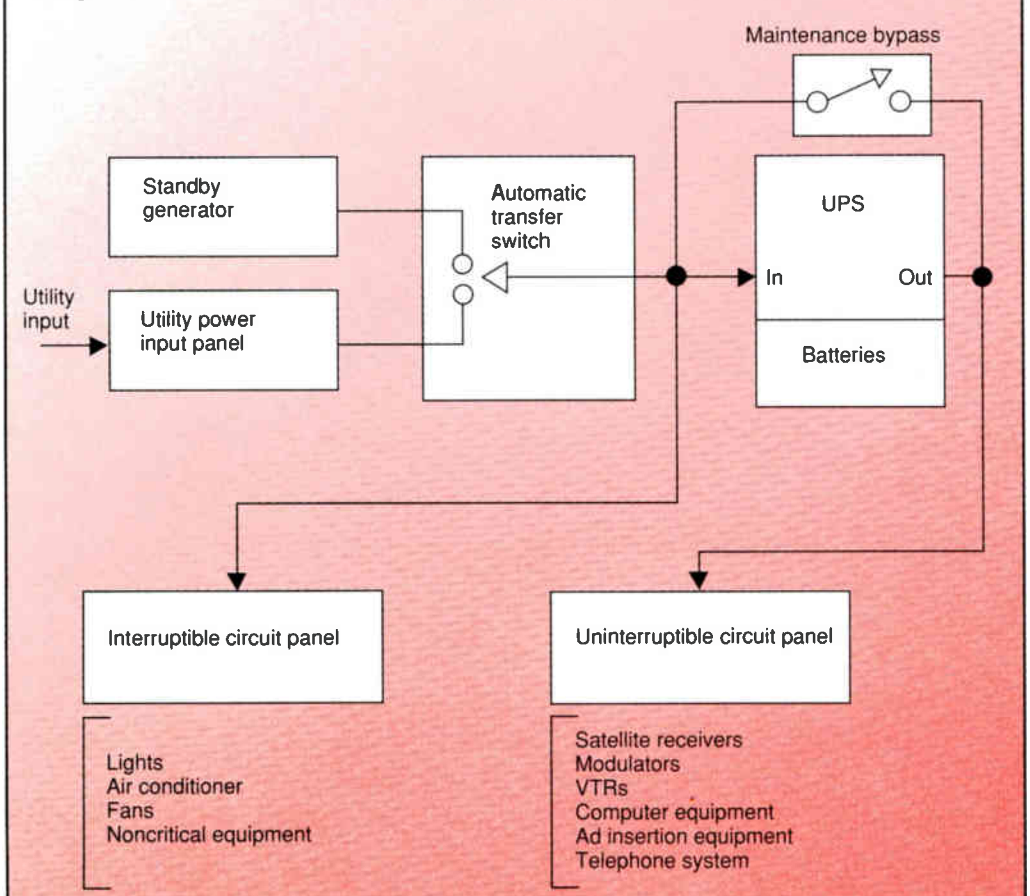
In the headend, new digital equipment is being installed in many systems from commercial insertion equipment to microprocessor-controlled modulators, receivers and digital music systems. Many of the computer-controlled devices will not reset after a power interruption and may require manual reprogramming in order to restore correct operation. This clearly can be a problem in remote headend locations where it can take a significant amount of time to get someone on site to correct the problem. Even installations with standby generators are not immune from problems. It can take up to 50 seconds for an automatic

are being designed with power reliability in mind. One approach to powering in the headend is the use of both interruptible and uninterruptible branch circuits for equipment power. (See Figure 4.)

The interruptible circuit is powered by the standby generator and usually consists of the devices that can withstand a momentary interruption in power with no ill effect upon operational reliability. An example of devices on this circuit include:

- Most lighting
- Air conditioners
- Circulating fans
- Noncomputer-based equipment

Figure 4: Office and headend protection



The uninterruptible circuit is powered by a UPS that also is powered by the standby generator. When a power outage occurs, the UPS continues to provide output during the start-up delay of the generator. Even if the generator took several attempts to start up (or did not start at all) most UPS systems can provide continued output up to 30 minutes or longer. After the generator starts, the UPS is powered by generator and transfers out of standby mode and immediately starts recharging its battery bank. The UPS provides another significant function while operating from the generator — voltage regulation and filtering.

Most smaller generators are not very stable in terms of frequency or voltage regulation. When heavy electrical loads are suddenly placed on the generator such as an air conditioner, motor or lighting, the voltage and frequency can sag for many cycles until the generator speed governor and voltage regulator circuit compensate for the load change. The same is true when heavy loads are removed from the generator output, except in this condition frequency can increase and voltage can overshoot or spike until the governor can compensate. During generator operation, the UPS can filter all of the damaging voltage spikes and fluctuations from the generator output and provide clean power to the sensitive computer equipment. Devices on the uninterruptible circuit could include:

- Satellite receivers
- Modulators
- VTRs
- Ad insertion equipment
- Computer controllers
- Microprocessor-based equipment
- Telephone system
- Emergency lighting

By implementing a dual-circuit power system in the headend, the UPS need only be large enough in capacity to provide power to the devices connected to the uninterruptible circuit. This saves both cost and physical size with no sacrifice in reliability of the critical equipment. By coordinating this approach with the electrical contractor during the building design phase, maximum flexibility in installation of equipment racks powered by each circuit can be achieved. A simple checklist of all of the intended equipment, which circuit is desired and load requirements is all that is required to design the system and size the UPS and generator.

It is important to pay close attention to electrical grounding details to ensure that both the interruptible and

"For reliable implementation of digital services throughout the network from the office to the headend to the subscriber, (uninterruptible power supply) powering is required."

uninterruptible circuits share the same "single point" ground location to eliminate potentially damaging ground loops. Your electrical design contractor can assist in this area.

Conclusion

Unlike in the two-module standby design, the single ferroresonant UPS provides consistent voltage, frequency, low harmonic wave shape and phase during all modes of operation with no interruption in output power during transfer. With the ever increasing emphasis on powering reliability for outside plant cable networks, a "cable UPS" provides the complete solution. UPS systems are being implemented in the office for protection of the phone system (PPV), for the billing system computers, in the headend, at the fiber-optic hub sites and for powering of traditional amplifiers and other actives in distribution. For reliable implementation of digital services throughout the network from the office to the headend to the subscriber, UPS powering is required. **CT**

February 1993

BACK TO BASICS

Spotlight on drop installation

The training and educational supplement to Communications Technology magazine.

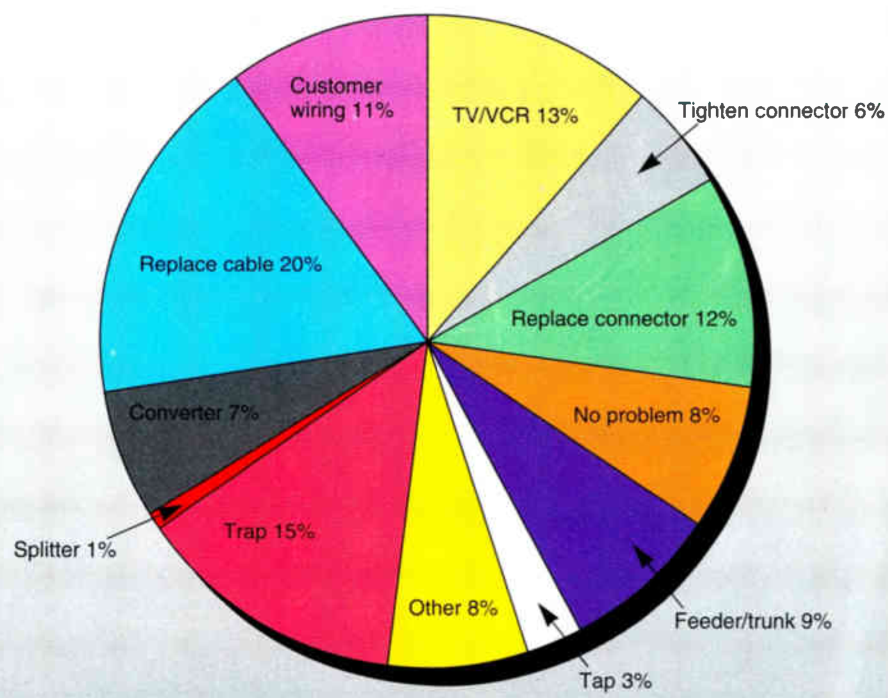
Table of Contents

Installation of drop systems in the era of full-service communications

This article introduces digital compression signal concepts and how installation can affect performance. It also presents recommendations for improved standardization, training and quality control.

By Brian Bauer
Applications Engineering Manager, Raychem Corp.
And Bruce Habeck
Product Manager, Antec Communications Services

Figure 1: Causes of service calls



Source: "The Indoor Challenge," *1990 NCTA Technical Papers*

A drop is a drop is a drop. Maybe this was true once upon a time, but certainly not with today's advancing technological needs. We should no longer think of providing only cable TV service through the drop coax. Instead, we should think of it as a full-service drop network or system.

That is, a drop must be a reliable gateway for not only standard CATV, but also for digital video and audio services, interactive services and possibly telephone services. However, if we hope to provide a drop network capable of 1 GHz bandwidth and digital and interactive services, we must improve upon our traditional installation practices.

Past practices led to a high percentage of drop-related service calls. Figure 1 shows the results of a three-system study where approximately 80% of service calls were drop-related (shaded area). Without improvements in these practices, the rate is bound to increase with greater and more varied technological demands.[1]

Due to the nature of the digital signal, drops that provide satisfactory NTSC signals today will in many ways be insufficient for signal quality in the future. To assure signal quality and avoid the revisit of many drops when it comes time for the upgrade to compression, it is important to have an understanding of the implications of digital compression.

Digital compression

• *Future signals.* The future spectrum of CATV will likely consist of both analog and digital signals. In order to compact multiple programs into the 6 MHz channel, the signal must be compressed through the use of redundancy schemes and digitally modulated in order to get the highest possible transmission rate.

The two modulation schemes most commonly discussed — 16 and 64 QAM (quadrature amplitude modulation) — rely on multiple discrete phase angles and amplitude levels. Due to the reliance on discrete levels, the decoding of the signal is quite robust to signal disturbances that do not exceed manufacturer-recommended signal-to-noise ratios. However, when the signal is disturbed, undesirable results could occur, such as freeze frame, blanking and muting. Higher QAM levels may provide higher compression, but the sensitivity to impairments will be increased.

• *Signal impairments.* Several potential types of noise may dangerously affect the digital bit streams that are to be deployed. The degree to which the signal can withstand impairments depends upon the use of error correction techniques at both the headend and at the terminal device.

If correction equipment is utilized, many of the predictable noises, such as microreflections, may be filtered out. However, shocks to the system, or "burst noise," will result in temporary picture failure. Therefore, more important than minimizing the steady-state problems, it is critical to minimize burst noise.

Several sources of burst noise exist, including impulse noise, ingress and certain microreflection characteristics. Intermittents also can cause undesirable results. Each of these impairments can be minimized through care in installation practices and component selection.

Avoiding impairment influences

• *Installation practices*. Each of the impairments mentioned has key installation causes or preventative solutions. The first, impulse noise, is caused by electrical surges, electrostatic discharge and electrical arcing. Signals from these sources couple electromagnetically into the feeder system.[2]

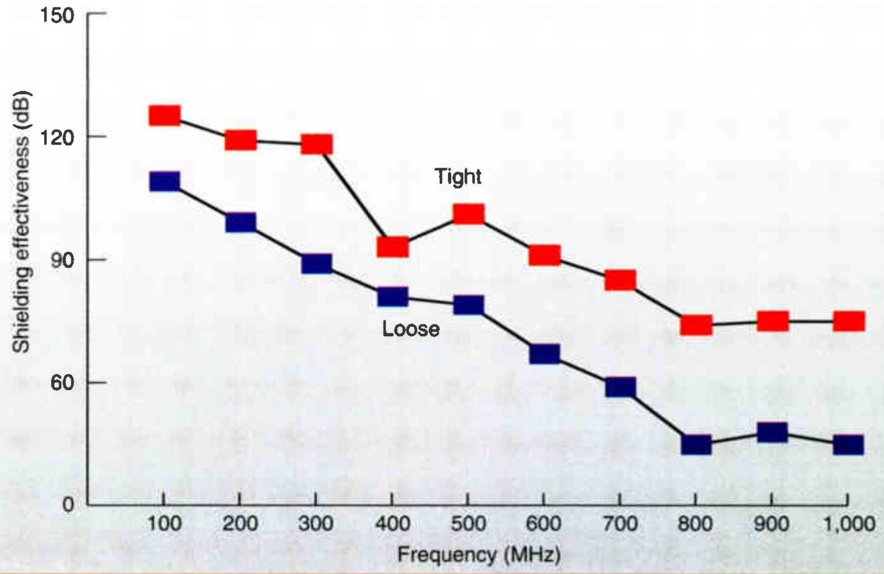
To minimize impulse noise, the drop should be well-bonded according to Society of Cable Television Engineers, National Electric Code (NEC) and local utility company recommendations for grounding. Because most impulse noise is at low frequencies, the installation of a lowpass filter or AC isolator may further reduce the chances for disruption.

Higher frequency impulse noise can be minimized through maintaining high shielding standards. Shielding effectiveness of the drop system will not only reduce higher frequency impulse noise effects, but it also may minimize the effect of off-air ingress, which can do substantial damage to the digital information stream. Potential sources of strong ingress are FM band radio signals, two-way radio, pagers and cellular telephones. "Bursts" from these sources can be reduced by taking a few important precautions.

First, only well-shielded passives, connectors and cable should be used. Second, and probably most important, all connectors must be tightened to comply with the manufacturer's recommendation. Figure 2 shows that a large decrease in shielding effectiveness results when a standard swivel connector is not properly tightened. The degradation of shielding is substantial throughout the 1 GHz spectrum and can be as high as 30 dB. This occurs because the outer conductor components within the connector get separated, causing an "antenna effect." The ideal connector might be one that cannot be put on wrong and cannot easily come loose.

Dog chews and corrosion also can significantly reduce the shielding effectiveness of the cable. Loosely hanging cable that may be accessible to dogs or machinery should be attached or eliminated. Flooded cable and sealed interfaces should be used in areas where any cable damage could lead to moisture ingress (e.g., where cable is buried or susceptible to immersion).

Figure 2: Shielding effectiveness for standard swivel connector



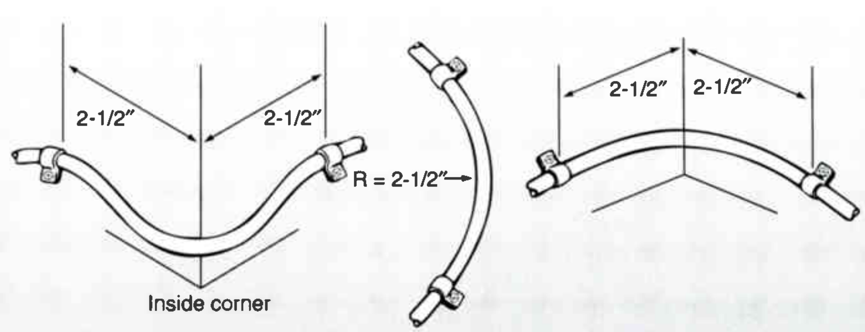
Proper torque of well-designed, mechanically stable connectors will assure that intermittents do not occur in the system. Intermittents can cause signal drop outs, which result in an intolerably long pause in proper signal quality.

Microreflections, depending upon the level of error correction and phase of the reflected signal, can add or subtract to the bits in stream. If they occur at high enough levels, signal breakdown results. Causes come from any point in the drop where impedance is disrupted, causing return loss problems.

When installing cable, reflections can be reduced by taking special care to avoid changing the impedance of the cable. Take care not to kink the cable to less than a 2.5-inch bend radius. (See Figure 3.) When using cable-mounting hardware, care should be taken not to puncture the jacket or deform the outer conductor. Puncturing the jacket may induce corrosion and/or short the center conductor. Deforming the outer conductor may cause reflection-inducing impedance changes.

• *Component selection*. When it comes to passive devices, a great deal of improvement can come from choosing new devices that will improve upon return loss. Most F-81s (barrel splices) used in ground blocks, wall plates and splices, have undesirable return loss

Figure 3: Guidelines for cable routing



Change direction
Radius = 10 times OD (outside diameter) of cable

Source: *Integrated Drop System Training Manual*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characteristics. If compression schemes are indeed affected by moderate reflections, replacing these F-81s may be worthy of consideration. The splitter is another product that often has poor return loss.

Another important criteria for assuring clean digital signal delivery is that consumer devices, such as stereos and TV sets, be isolated from reflections that may originate from adjacent devices. If proper port-to-port isolation is not achieved at splitter outputs, "channel surfing" by an adjacent TV set may disturb the incident digital signal with reflected signals.

Most drop components in use today were designed to operate under 600 MHz. Future networks will likely operate to 1 GHz. Thus components (e.g., cable, connectors, passives) should be designed to operate to this level. Finally, hardware should be chosen (e.g., clips, clamps and wraps) so as to not affect the impedance of the cable.

The quality of the signal delivered to the drop and the actual installed drop conditions will determine the level at which components should perform. Cable Television Laboratories is currently exploring the performance levels of various drop components and as well as the use of digital transmission and encoding on real drops. This information will go a long way in setting appropriate goals. As more is learned about practical digital signal deployment, appropriate installation practices and components should be standardized and incorporated into formal training and quality control programs.

Implementation of improved installation practices

• *Standardization*. Much of the cable industry realizes the need for standardization and is addressing this through SCTE engineering subcommittees, such as the Interface Practices, In-Home Cabling and the CATV Design and Construction subcommittees. Each of these subcommittees is comprised of operators, manufacturers, contractors and suppliers, and is establishing recommended standards in many areas that affect the cable drop system.

When it comes to standardizing the drop, we should learn from the experience of the telephone industry. For example, when walking from house to house in a small suburb of San Diego, one can see standardization in the installation technique and in the quality of the telephone products. One can

"With the advent of high bandwidth digital compression, it is clear that installation and component selection will need increased attention."

then go city to city, state to state, from California to Maine and see consistent standardization of both product and installation techniques. In the CATV industry, one typically can go from house to house in the same city and find minimal consistency.

As telephone technology evolved over the years, it has not been necessary to replace the basic copper wire drop due to corrosion or to accommodate change. These drops are essentially permanent. As a result, truck rolls and component usage are kept to a minimum. Higher standards in corrosion protection and switching techniques will reduce the chance for poor connections and help move the CATV industry toward more permanent drops.

• *Training*. Analyzing the installation techniques and components to be used in a system is just the first step in qualifying a new drop network. Implementing and enforcing a quality training program is essential. There is absolutely no substitute for good training. All systems have some form of training, but typically drop installations are learned on-the-job (OTJ). Measures should be taken to assure that the OTJ training is in line with proper practices. This may not always be easy, since many installers feel they are already "experts."

Many systems have good installation manuals and promote courses through the National Cable Television Institute and SCTE. Often internal installation training courses exist and this should be commended. For those systems without such courses, now is a great time for implementing an internal training course.

The program should include both classroom and hands-on training on the proper way to install each of the drop components. Each person should be certified not only for product installation, but also installation techniques (i.e., routing, drop loops, radius bends, equipment placement, bonding). Before certification takes place, each installer should sign off that he or she understands and agrees with the program. After initial certification, additional training should occur regularly to ensure continued compliance with proper techniques.

• *Quality control (QC)*. Installers are responsible for the capillaries of the CATV bloodstream. They need good quality training. They are who the customer perceives the cable company to be. Appearance, attitude, performance and craftsmanship are all part of this professional job description. An installer is an essential part of the cable system and needs to be trained, respected and acknowledged for his or her performance.

A disciplined quality control program should be mandated. Without an explicit QC program, people will take short cuts; not because they are bad installers, but because that is human nature. Installers should be held accountable for their work and monitoring systems should be implemented. Problems identified should be addressed with some type of disciplinary action. Individuals should be expected to correct problems on their own time, if need be.

A QC program needs to be understood and approved by all managers and involve all in-house employees and outside contractors. Do not expect less of contractors than your own people or visa versa.

Summary

With the advent of high bandwidth digital compression, it is clear that installation and component selection will need increased attention. To assure appropriate practices are implemented, standardization, training and quality control measures need to be enacted. Times and technology are changing and now is the time to act and get involved with your drop system. **BTB**

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[3] *Integrated Drop System Training Manual*, Integrated Drop Systems Standards Committee.

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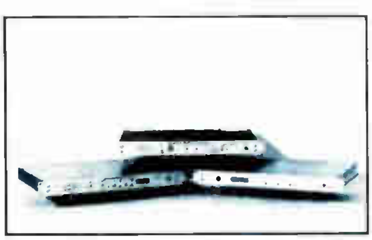

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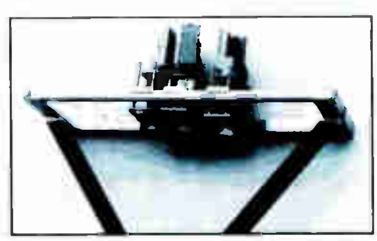

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Taking the drop to new heights

By Barry Smith
Connector Specialist, Times Fiber Communications

Today's drop systems are already being pushed to their limits with increased bandwidth, multiple outlets and components, giant screen TV sets, cumulative leakage index (CLI) requirements and demanding customers. Distribution of digital signals poses a great challenge and will force us to take the drop to a higher level of quality and reliability.

The drop system is a critical and integral part of the cable plant. The drop represents the greatest amount of cable, connectors, labor, maintenance and service calls in the entire cable system. Over the past five or six years, a great deal of research and product development has been done to improve the drop system. The following will address some basic characteristics of building a reliable, professional drop system.

Mechanically/electrically sound

Like anything, a quality drop begins with quality parts. You must make sure that each of the components of the system are compatible — connectors must match the cable, the prep and installation tools must match the connectors, and the manufacturer's instructions must be followed. The choices you make today will impact system performance and maintenance for years to come.

Connectors and drop components are becoming more sophisticated and specialized, and many components are not necessarily compatible among manufacturers. Installation and service personnel must have a thorough understanding of product usage and be kept up to date on new products, policies and procedures.

The cable

Building a drop system starts with selecting the drop cable. Choose a cable with low attenuation and high shielding. Most operators have already switched to 6 Series drop cables for lower attenuation. The Society of Cable Television Engineers Interface Practices Subcommittee recommends a minimum of 59% braid coverage for shielding requirements. (Tri- or quad-shield may be required in areas with very high strength off-air signals.)

For any length of aerial drop, messengered cable should be used. Drop grips that hold the cable itself should be avoided — most are harmful to the cable even under minimal loading. Termination of the messenger is simple: two wraps around the hook, at least three wraps around the messenger itself, then a few wraps around the cable and messenger to keep them from separating; or a messenger drop grip may be used.

"On the high-speed freeway of today's fiber-optic/digital systems, don't deliver your service through a drop that's a dirt road."

For underground drops, a flooding compound that will flow and heal minor jacket nicks must be used. While no cable is shovel- or trencher-resistant, buried drops must at least be deep enough to avoid being cut by lawn mowers and aerators. Underground flooded cables must not be confused with the newer aerial and indoor flooded cables, which will not flow and are not intended to be buried.

The connectors

Once the cable is selected, connectors must be selected that match the braid coverage of the cable. Many connectors are size-sensitive, requiring different connectors for quad and single braid constructions. Most manufacturers also have "one size fits all" type connectors that work equally well on quad, tri and single braids.

Not only must the connectors match the cable, but consideration must be given to the end use of the connector. Outdoors, all connectors *must be sealed*. The seal can be made either by external means (such as shrink tubing, spark plug boots and grease or other encapsulants) or by using one of the newer integrally sealed F-connectors. Whatever sealing method you choose, the sealing mechanisms must be prop-

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erly installed and assembled with care. For example, if you use the Raychem EZ-F, the proper sealing sleeve must be installed to protect the threads. If you use boots, there must be grease in them (without grease, moisture will be trapped around the connector and corrosion will be accelerated). Even the slightest amount of moisture will corrode the small delicate braid wires. (See "CT's Lab Report" in the April 1991 issue of *Communications Technology* for more detail on corrosion and F-connector performance.)

Indoor connectors present a different challenge. The problem is not corrosion, but loose connectors or broken ports. Here too, there are a number of new products available that address connector problems inside the home. Some use a push-on concept, while others use a wing or knurled coupling nut. Both concepts are intended to be more consumer-friendly and to reduce problems associated with loose or overtightened connectors. With the number of connectors inside the home increasing annually, these new connectors deserve serious consideration.

All connectors must be tightened. Outdoors, 20 to 40 in/lbs is usually sufficient; indoors, especially on consumer equipment, 20 in/lbs is too much — connectors must be snug but not overtight.

The tools

Next, the cable preparation tools must match the connectors. Older, conventional crimp type connectors require 3/8-inch of braid folded back. Most of the newer "one size fits all" type connectors (and others) require 1/4-inch of braid folded back, while other connectors require only 1/8-inch of braid. Preparation tools are available for each of these preps, but connector performance may be compromised if the wrong prep or prep tool is used.

Crimp tools also must match the connectors. Many crimp tools look alike, with only 0.025- to 0.050-inch difference in the crimp size (most without the sizes identified). The newer "one size fits all" connectors, used with a single cavity crimp tool, can eliminate much confusion. Crimp tools are not hammers or pliers, they are precision instruments that should be checked regularly for calibration and can be easily adjusted or rebuilt.

Installation

Routing and installation of the cable also is critical to the life and performance of the drop system — as well as being a reflection of the professionalism of the installer. Routing should be kept short and the cable should be hidden where possible, while following your company's installation procedures. Remember to treat each installation as if it were your own home.

In attaching the cable you should use clips, *no staples*. If you use plastic clips, make sure they are UV- and ozone-stable so they will not deteriorate with time. If metal clips are used, try to find ones that will not rust and stain the side of the house. And, as always, avoid bending the drop cable too tight as this may damage it and reduce the shielding performance or electrical integrity of the drop.

Each outlet should be a "home run," being one continuous wire from the bonding point to the outlet inside the home. There should not be any splices or splitters in areas that may be difficult to access in the future.

Disconnects

Disconnects also are an area of concern. A disconnected drop should not be left exposed to the environment — corrosion takes place whether the drop is active or not. If security terminators are used, the drop should be "parked" on the terminator and all environmental seals reassembled as though the drop were active. If the drop is not "parked," the connector/cable should be covered or plugged to protect it from moisture. This may take an extra minute, but it will save replacing the drop when reconnected.

Do it today

If we are to be the entertainment/information providers of the future, we must build reliable trouble-free drops today. Fiber is not magic and it will not make up for a poorly built drop system. On the high-speed freeway of today's fiber-optic/digital systems, don't deliver your service through a drop that's a dirt road. **BTB**

Dynamic bandwidth allocation

By the Staff of Cable Television Laboratories Inc.

Interactivity plus extension of fiber to nodes serving 200-home neighborhoods — two existing trends in cable architecture — will make possible a major transformation: dynamic allocation of bandwidth in the coaxial plant.

Says Stephen Dukes, CableLabs' vice president for advanced network development: "Imagine bandwidth at the touch of an application, with an interface to the network that is dynamically configured for the duration of the transaction and reconfigured to the network's original state at the completion of that transaction."

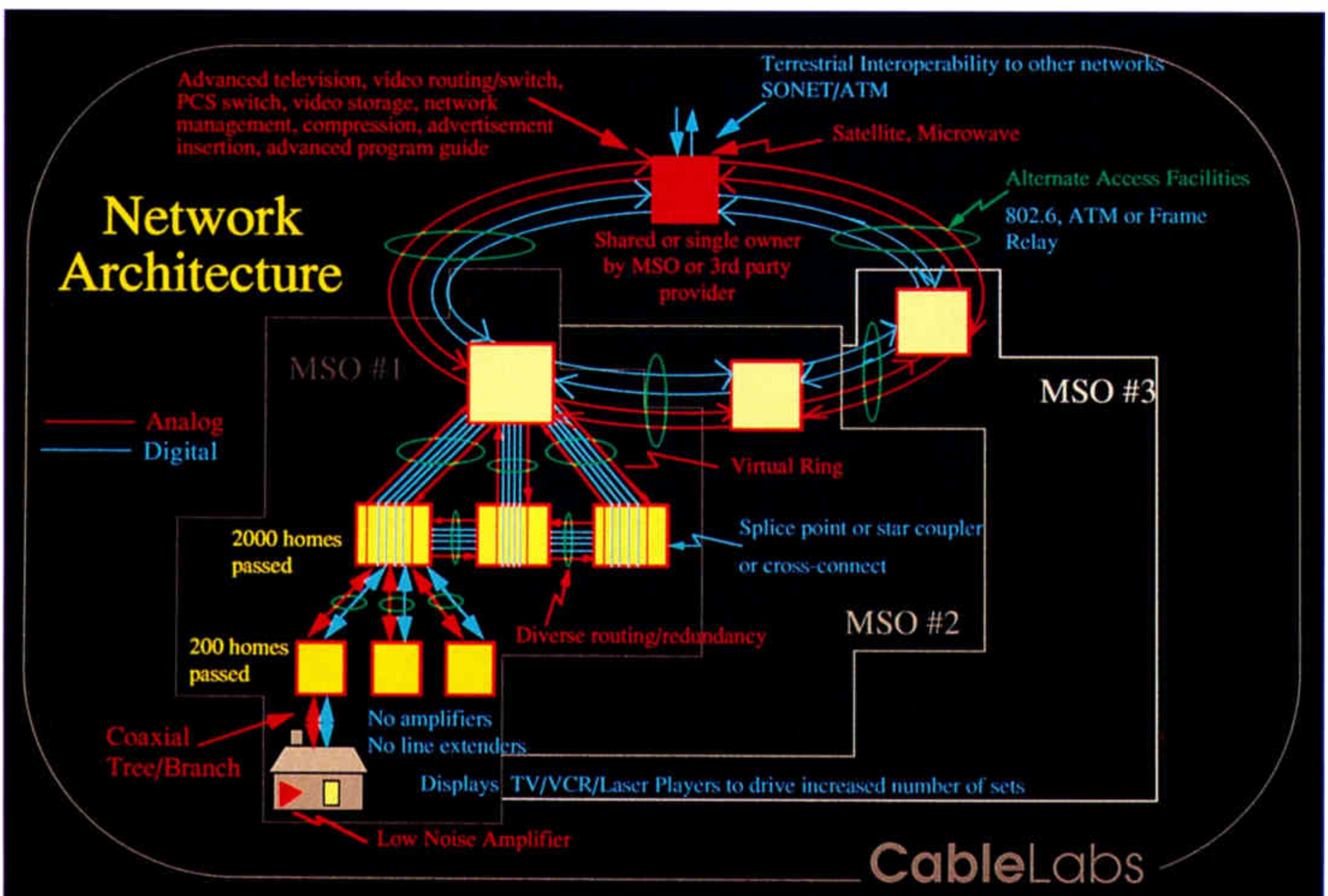
Such a dynamic-allocation plan would not affect the industry's basic plan of "overlaying" digital signals at higher frequencies on the coaxial drop from the fiber hub to the home, with analog channels in fixed spectrum positions. Further, some digital applications like digitized pay-per-view (PPV) movies, ad insertion and electronic program guides, might well occupy fixed spectrum locations, Dukes said.

What's different is that many other digital applications, especially those that demand large, two-way pipelines (multimedia and personal communications services — PCS), would travel over spectrum allocated as needed on a per-session basis. Multimedia in its various forms — including cable-commuting, education and training, and information delivery to professionals — is "the biggest bandwidth hog," said Dukes. For example, a cable-commuter accessing a remote workstation might need to set up a 10 Mbps data link for the duration of the transaction. The emerging Moving Pictures Experts Group (MPEG-2) standard, which is expected to prevail in the multimedia field, calls for data rates of up to 10 Mbps near-term, and possibly higher rates in the future, Dukes said.

The notion of "transaction-oriented" allocation of bandwidth "may be viewed as a bit controversial at a time when everybody still has the fixed way of allocating spectrum in mind," Dukes conceded.

How is it possible?

CableLabs researchers have been working for about a year to prove that as fiber is extended down to nodes serving about 200 homes, the remaining short coax drop can function as a "passive coaxial network" — i.e., one that contains no active electronic components such as amplifiers or line ex-



tenders. However, the dynamic allocation of bandwidth also will work in systems that have active components in the coaxial tree/branch infrastructure.

These components, when present, necessarily dictate a fixed allocation of upstream and downstream traffic. But, if the signals are amplified at the point of optical/electrical conversion at the fiber node, and reamplified by a low noise amplifier (LNA) in the home, "you eliminate the active components that have confined you," Dukes said.

"Right now we are pursuing an iterative process with a computer-aided design (CAD) system, essentially 'back-solving' to see what equipment upgrades would be required of manufacturers to support such a passive environment," he explained. Although the initial implementation of such an LNA "is intended to be fairly simple," Dukes said, in the longer term it "would become more than just an amplifier, and would probably get a new name, i.e., the network interface unit (NIU)." Serving as "the line of demarcation between the network and the home," it would manage this process of dynamic spectrum allocation, as well as probably carrying out compression/decompression and encryption/de-encryption functions, Dukes said.

Spectrum allocation "would be managed on a contention basis," he said. "The tree-and-branch architecture present in what's commonly called a 'distributed star-bus' architecture is really a *series* of buses that are intersecting with each other," he continued. "The drop is essentially a LAN connection to the bus outside the home. From that point on, there is a series of buses that are contending with each other until you get to the fiber node or hub."

How to manage this contention?

Dukes' CableLabs group has been studying existing protocols, focusing on IEEE 802.6, which was developed for wide area networking, and DQ-RAP (distributed queuing-random access protocol), a variant specifically developed for the cable environment.

DQ-RAP supports variable data rates, which Dukes believes must be supported in a compressed-digital environment. CableLabs' current proposal to the MPEG Working Group calls for compressed NTSC transmission over cable at a fixed data rate. But CableLabs is also defining two "data stream protocols" intended to support diverse types of digital traffic, one for a fixed-rate 19.2 kbps channel and the second an MPEG-2-compatible protocol supporting variable rates up to 10 Mbps — and eventually higher.

The dynamic allocation could utilize statistical multiplexing techniques, Dukes noted, such as the asynchronous transfer mode (ATM). Pointing out that at least two major cable MSOs are studying use of ATM, Dukes said it is no longer a "telco-only" standard, but rather one that is evolving with computer industry and cable industry input as well.

Debate over spectrum

The amount of spectrum that is needed in the coaxial drop remains a major issue among MSOs, said Dukes, with some planning for 1 GHz upgrades but others thinking that 550 MHz or less will be sufficient. Channel allocation under these two upgrade options is shown in the accompanying table.

Look at a 550 MHz system carrying 5-30 MHz upstream traffic and analog channels in the 50-300 MHz portion, Dukes said. "The thinking of some companies is, 'If we can do 10:1 compression per 6 MHz channel, we can get 400 channels in that 40-channel piece of spectrum (300-550 MHz).'"

Dukes said a minority of operators are considering midsplit channel-allocation alternatives. These open up more upstream bandwidth than the usual subsplit approach, which blocks out only 5-30 MHz for upstream, but at the sacrifice of bandwidth (108-174 MHz) that is usually prime space for downstream analog channels, he noted. The spectrum for a typical midsplit system is 5-108 MHz dedicated to return path, and 174 MHz on up. The highsplit system is 5-174 MHz with 234 MHz and up.

Two approaches to coax spectrum allocation

	550 MHz system	1 GHz system
Upstream	5-30 MHz	5-30 MHz
Analog	50-300 MHz	50-550 MHz
Digital	300-550 MHz	550 MHz-1 GHz

Source: CableLabs

"Once you've made this leap to an environment of more dynamic bandwidth allocation, you open the door to managing spectrum in a much different fashion."

The digital spectrum may well be partly fixed and partly nonfixed, Dukes said. Services like multichannel PPV and multimedia may have dedicated spectrum. This, said Dukes, "is an important issue, one that the industry needs to get to early on before too many allocations become fixed."

"Once access is granted, a dedicated link is established for the duration of the transaction," he explained. "Upon completion, the frequency returns to the available pool for new requests. The subscriber then goes back to looking at what they originally would get in their standard tier of product." Other approaches may be utilized that include time division multiple access (TDMA) and carrier sense multiple access (CSMA).

Control and synchronization of all this traffic wouldn't require much spectrum, but it would require a return path, and hence interactivity, Dukes pointed out. Fortunately for those designing these systems, utilization of the bandwidth-hogging applications will be very low initially, migrating slowly toward more usage over time.

"However," Dukes said, "we may find that the holding times of these kinds of transactions far exceed the normal 2-1/2 minutes of a voice call. They may be 30-minute, 40-minute, one-hour or even two-hour transactions, which will have significant ramifications in terms of how you allocate bandwidth. Any contention means subscribers are waiting to access the network. The question is: How long will people be willing to wait before they don't want to use the service?"

On the fiber plant, "we may have separate fibers dedicated to digital and analog transmission, all within the same sheath, with the digital overlay occurring at the fiber node," he said. The entire network, he added, will be "self-healing," meaning capable of detecting failures and shifting traffic onto backup capacity in a way that is transparent to the user. This feature will be

(Continued on page 85)

Standards should be humanized

By Isaac S. Blonder
President, Blonder Broadcasting Corp.

Standards are a fabric of civilization. Nothing of consequence exists without following the guidelines set by custom or edict. The average citizen usually is not aware of the documents that dictate his lifestyle, but they are delineated in written form in enormous quantities and are presided over by bureaucrats engaged in busy study who add still more standards to the pile.

Since the quality of life and the prosperity of an individual country's inhabitants are heavily dependent upon the attention and intelligence lavished upon standards, its officials devote much time and funds to keep them current. However, the progress in science seems now to have run far ahead of the human abilities to appreciate the significant improvements in sight and sound originations. Additionally, the price to be paid by the public for the enhanced standards is ignored by the scientists, who usually reply to my questions on the cost/benefit ratio with the off-hand answer, that it is not their problem. Or, the other brush-off of the cost issue is, that time and clever manufacturers will lower the price to an acceptable level.

What is inferred by the tale "Standards should be humanized" is that there should be two standards formalized: one that equals the capacity of the average human being to utilize the level of information in the proposed delivery system, and secondly a standard, ever being upgraded, geared to the state of the art. I suggest that the actual system in use, at the discretion of the operator, be set at the financial goals essential to a profitable system, not necessarily at the highest technical level.

Since my interest lies in the field of electronics, and particularly in broadcast and cable TV, my comments will be confined to those areas.

Broadcast TV

The resolution of the human eye is about the same as the quality of an NTSC picture on a 20-inch TV set at the usual viewing distance of 8 feet. The proposed high definition TV (HDTV) systems with a four times increase in resolution (H+V), can have no beneficial effect for the average viewer, but the onslaught to the pocketbook could prevent HDTV from entering the home. HDTV should be standardized and continuously improved, since the real target is not the home viewer, but the professional theater and industrial markets.

In my 40 years as a manufacturer of antennas and home amplifiers, no complaints have ever come our way regarding the basic defects inherent in NTSC. Cross color, interlace artifacts, hum and resolution were never mentioned. Excessive noise, echoes and intrusion by adjacent or concurrent signals were the only problems that reached our applications engineering department. VHS tape with a performance one-third reduced from NTSC, exists happily in 70% of the American homes, and I have not personally encountered one complaint about the picture quality therefrom.

The scientists, who are creating digital compression in order to achieve the bandwidth needed for HDTV, may have unwittingly gifted the home viewer with a technology far more important than a picture quality only suited for a superman. Digital compression is apparently capable of transmitting four or more NTSC signals on a standard 6 MHz channel! Suddenly the broadcaster on terrestrial or satellite transmitters can offer four programs at practically the same cost as for one. Only the home receiver has to be modified, but this is just a matter of chip complexity — and my chip expert is confident that the price will be right.

Among the numerous committees on which I served was BTSC, charged with adding stereo sound to NTSC. In the early days of stereo FM radio, my company, Blonder-Tongue,

"Standards should be as flexible as possible, so that the human needs of the population are fulfilled at the price and quality level they desire."

joined in the race to produce what was then supposed to deliver high quality sound in the stereo format. I quickly became disillusioned with the inability of the entire enterprise, from the technology to the equipment (including speakers), to duplicate the live performances. With this experience, I must have been a fifth wheel on the BTSC committee, as I deplored the inherently poor quality of an analog FM modulation scheme tied to cost-conscious TV stations, performed by 3-inch speakers side by side under the picture tube for the pleasure (?) of stereo-deaf listeners. By this date, surely millions of stereo sound equipped TV sets have been manufactured at a substantial cost increase to an unappreciative audience.

Just recently, I was privileged to be invited to a very high tech, theater quality, sound demonstration of a proposed surround sound system for HDTV. Sorry to report that, to this set of ears, it was just a lot of noise from all directions, and hard to connect with the flat screen video picture. Thus, my appeal to the regulators: Allow the lower quality standard, NTSC, to coexist with any new HDTV system. Avoid any edict that forces the consumer to switch to a high-cost technology with minimal improvement in viewer gratification.

Cable TV

Basking in the high bandwidth capabilities of cable, there may be no urgency to add four times as many programs by means of digital compression, as is likely to occur in the broadcasting world. However, if digital receivers are approved for broadcast, and the price is right, cable will follow the crowd. A very positive benefit to cable is the ability of digital to uphold the picture quality under the many adverse transmission artifacts common to cable systems.

Cable has been handicapped from birth as a child of the broadcasters. If the regulators ever remove the heavy hand from cable's future, it could follow its own path to the heart of the home viewer.

First and foremost, the TV set could be a monitor (leased?) and answerable only to the cable technology. Many other services could be included, other than TV entertainment, such as banking, shopping, education and numberless interactive transactions. Tied to the telephone network, wired and wireless, one could have the option never to leave home and enjoy all of the benefits of civilization, without facing the hazards of an unfriendly outside environment!

Cable TV is a prime example of the growth one can expect from a new technology very loosely controlled by the government regulators. It is my belief that standards should be as flexible as possible, so that the human needs of the population are fulfilled at the price and quality level they desire, instead of the relentless progress of technology beyond the capabilities of human flesh to enjoy or need. **CT**

CableLabs' Report

(Continued from page 83)

particularly important at the regional-ring level being constructed to link headends together across metro areas. The accompanying figure (page 83) shows an overview of the network architecture hierarchy.

Getting in position

Cable is working with the computer industry on delivery of multimedia services. "Overall, said Dukes, "we have a clean sheet of paper. We're looking at the protocols that will most efficiently transport all the functionality we need for entertainment video, multichannel PPV, multimedia, PCS and other applications that become more transactional and interactive as you move up the scale."

Dukes said he hoped he hadn't "scared people into thinking that you have to have ATM switching. I don't want to scare people off, but on the other hand I want to point out that once you've made this leap to an environment of more dynamic bandwidth allocation, you open the door to managing spectrum in a much different fashion. And, yes, you may be using telephony technology like ATM. That kind of functionality will ultimately come.

"The point is that telcos don't have the bandwidth in the last mile that we do, and we have the opportunity to take that technology and apply it to our infrastructure in a much different way than they ever could in their infrastructure, even with ADSL."

A strictly point-to-point, switched approach means "starting the same movies over and over again at tiny intervals, each time eating up a dedicated link in your switch." He compared this to his earlier calculation that a 550 MHz system could provide a 200-home node with more than 400 effective programming choices. Between analog channels and time-shifted digital movie channels, plus another 360 channels available to serve other market niches, "I'm meeting about 95% of the demand out there."

Cable's emerging hybrid multicast and point-to-point approach, said Dukes, "will have the flexibility to provide a full range of services while maintaining the feature that has made us the low-cost provider of video entertainment." **CT** questions asked. If dissimilar fibers are spliced together, the result may be increased splice loss. There also could be increased modal noise and backreflection. If these problems develop they might be blamed on something else while the real culprit is fiber incompatibility. There is a lot of concern in the industry regarding "laser chirping" and other discontinuities. Mismatched fibers could be part of the problem.

The other potential problem concerns 1,550 nm performance. At 1,550 nm, single-mode fibers are extremely microbend-sensitive. Patch cords and pigtails that exhibit acceptable insertion and backreflection losses at 1,310 nm, may change for the worse by several orders of magnitude. I have personally witnessed the following:

FC/PC	1,310 nm	1,550 nm
Insertion loss	0.3 dB	3 dB
Backreflection loss	-40 dB	-10 dB

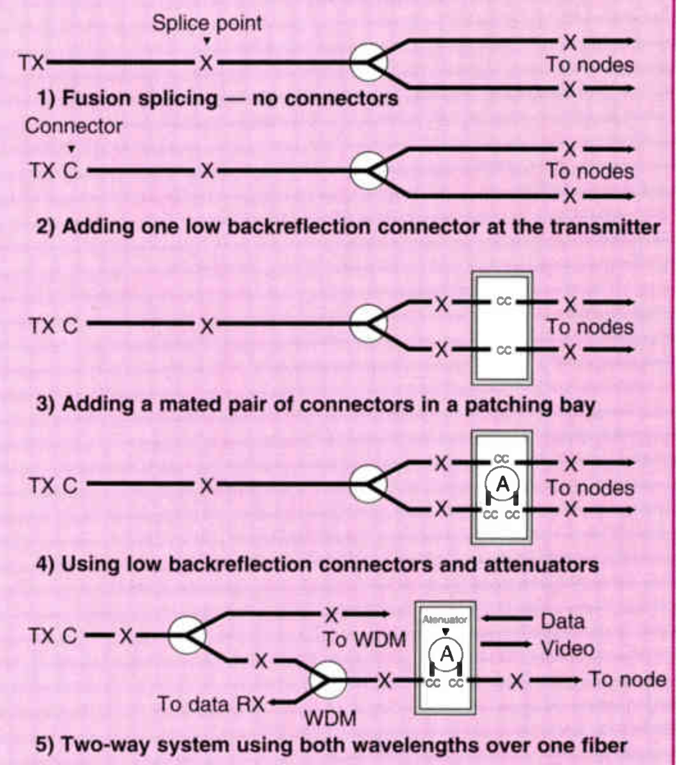
This is strictly a matter of equipment and expertise caused by poor termination or polishing techniques. When improperly terminated connectors are mated together, tightening the nut may cause excessive fiber microbending inside the connector. At 1,310 nm the effect is minimal, but not at 1,550 nm.

Low backreflection and insertion losses for cable assemblies at 1,550 nm are readily achievable and available. Just be sure to require 1,550 nm test data when ordering the assemblies.

Putting it all together

At the beginning of the article, it was said that adding connectors to your system also adds flexibility. This is illustrated with five schematics in Figure 6.

Figure 6: System schematics



Schematic 1 is the established way of designing a CATV fiber-optic system. Everything is spliced. If anything fails anywhere in the system, there is no easy way for repair without a relatively long outage. Schematic 2 adds one connector at the transmitter in case of laser problems. However, it does not address any potential problems in the rest of the cable plant.

There are two common failure points in most CATV systems: at the laser or somewhere in the outside plant. Schematic 3 addresses both areas and seems to be the most popular design today. For this flexibility, the price to be paid is an extra 0.25 dB (typical) for one mated pair of APC connectors. Schematic 4 adds a low backreflection attenuator for the nodes where the power level is too high. Please note that (for this example) the attenuator is patched into the system rather than spliced. This can be quickly done without any outage and utilizes the patching bay, which is very accessible. And, of course, when an attenuator is used connector losses are not a problem.

Schematic 5 illustrates how a bidirectional system might be configured. Once again, only one additional mated pair of connectors is used.

There are many variations of the system designs listed previously. If increased flexibility is important, add another mated pair of connectors. That is, between the laser and the coupler in Schematic 3 replacing the splice point, or between the coupler and the WDM in Schematic 5.

I know of one MSO that has a fully redundant fiber system in the headend — two sets of lasers, patch and splice centers, couplers, etc., and two separate racks of equipment; one in operation and the other on hot standby. For that MSO, reliability was the key issue. **CT**

750 MHz design

(Continued from page 42)

nals would have an output of about 40 dB at 750 MHz.

Active equipment must be designed and spaced at 750 MHz for the modules to function properly. Once the passives are determined based on the analog channels, the spacing is refigured using the passive insertion losses and attenuation at 750 MHz.

Approaching a 750 MHz design based on 550 MHz parameters will increase the cost of active equipment in an upgrade only 10-15%. Most designs utilizing this approach to digital signals will average two to three actives per mile.

Where to place digital signals on the spectrum is a dilemma each operator must address before designing a system. How the design specifications such as slope, output and tap levels should be set up is a task each operator will be addressing in the near future. **CT**

The author would like to thank Jones associates and industry personnel for providing feedback on this article.

Technical references

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2) Bellcore Document #TR-TSY-000326, "Fiber-Optic Connectors for Single-Mode Optical Fibers."
3) Bellcore Document #TR-TSY-000910, "Generic Requirements for Fiber-Optic Attenuators."
4) "Principles of Lasers," by Orazio Svelto, Plenum Press Publishers, #ISBNO-306-40862-7 (Library of Congress).
5) "Group Session Backreflection Measurement," by Vedrana Stojanac, EXFO Corp.

DirecTv — A digital DBS

By Lawrence W. Lockwood
President, TeleResources
East Coast Correspondent

"Technically, the DirecTv system appears eminently workable ... However, other portions of the system should be closely examined and with perhaps a soupçon of skepticism."

Another direct broadcast satellite (DBS) system? DirecTv from Hughes Communications Inc. (HCI) has at least two important advantages over other DBS systems. DirecTv will be the United States' first high-power Ku-band DBS and the first to employ satellite delivery of digitally compressed TV to the home. This compression will permit delivery of 150 channels by the DBS system. The high power will permit the home receiving antenna to be very small — 18 inches. (See Figure 1.)

DBS transmission

The following facts are largely from the Federal Communications Commission filing by Hughes with additional information supplied by Thomas Bracken, manager of communications at Hughes, and Al Baker, manager of DBS development and engineering at Thomson.

An alliance between Hughes Communications and United States Satellite Broadcasting Inc. (USSB), a subsidiary of Hubbard Broadcasting Inc. of Minneapolis, enables this new satellite system to utilize all 32 licensed DBS frequencies at the 101° west longitude position. The uplink frequencies are in the 17.3 to 17.8 GHz band and the downlink frequencies are in the 12.2 to 12.7 GHz band. Two Hughes' high-powered Ku-band HS 601 satellites are currently under construction and the first is scheduled for launch in December 1993 and the second in mid-1994. DirecTv service is scheduled to begin in early 1994, shortly after the scheduled December 1993 launch of the first of the two satellites.

The two HS 601 body-stabilized satellites will be collocated at 101° west longitude with each satellite carrying 16 120-watt transponders — each with a bandwidth of 24 MHz. Employing circular polarization, the satellites will provide coverage over the entire continental U.S. Hughes has contracted with Thomson Consumer Electronics Inc. to provide the home equipment — antennas and receivers to be sold under the RCA brand name. The home unit of the antenna and integrated receiver decoder (IRD) will be sold to the subscriber at an estimated $700. Thomson will supply the MPEG-based digital compression technology that will allow up to four TV channels of live programming per transponder and up to eight TV channels of film programming per transponder.

A comparison of the antenna con-

Figure 1: Typical DirecTv home antenna installation

figurations for DirecTv and those for the familiar home-sized C-band units is shown in Figure 2.

DirecTv earth station facility

Hughes Communications is expanding its Castle Rock, CO, earth station facility to support its DirecTv satellite distribution system. The Castle Rock broadcast distribution center will be the first facility for a DBS system to implement total serial digital technology. Sony will equip the center with more than 300 videotape machines for playback. All programming sent through the DirecTv satellites will be digitally compressed and encrypted at the playback facility. In addition, some of the programming will be received by satellite at Castle Rock, encoded and encrypted and retransmitted to the DirecTv satellites. The center will have two 13-meter transmit antennas for initial service, eight 6.1-meter receive-only antennas and plans for two additional 13-meter transmit antennas. Figure 3 on page 88 shows an artist's depiction of the Castle Rock facility.

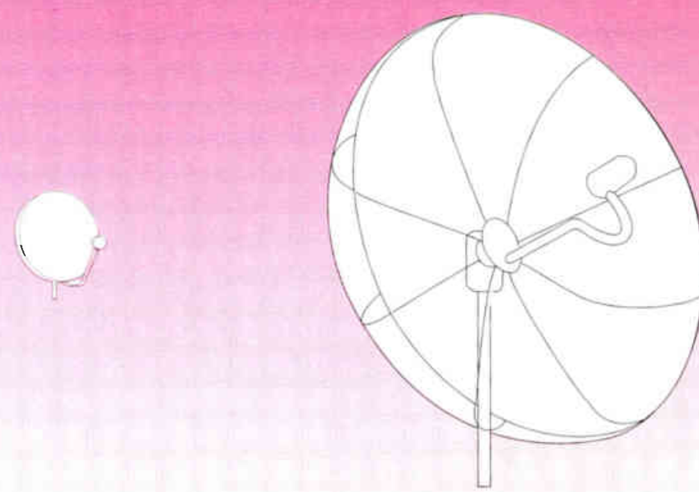
DirecTv signal

As previously noted, Thomson uses an MPEG-based technology to compress the video. This is not unexpected since Thomson is a member of the Advanced Television Research Consortium (ATRC), along with the David Sarnoff Research Center, North American Philips, NBC and Compression Labs Inc., whose HDTV proposal called AD-HDTV uses a version of MPEG for its compression. All of the compressed video information from several sources (such as NTSC) or a single source is time division multiplexed (TDM) into a single high rate data stream. This format allows the number of bits per second allocated to each source to vary either with the source content (live action sports vs. movies) or the particular source format (NTSC, HDTV, CCIR 601-1, etc.). The TDM format is more power- and bandwidth-efficient than the other formats. Before compression the digital data rate of the digitized NTSC video is 270 Mbits. MPEG digital compression[1] allows a single NTSC channel to be reduced to approximately 3.75 to 7.5 Mbps. The TDM stream is capable of transmitting up to 30 Mbps or four to eight TV channels.

Figure 2: Comparison of DirecTv Ku-band and C-band configurations

Direct broadcast Ku-band satellite TV

Current C-band satellite TV



Dish size: 18 inches
Equipment cost: $700 (approx.)
Average satellite capacity: 128 channels
Installation: Homeowner installed (bolted), in a fixed position, pointing south (also can be mounted on mobile home)

Dish size: 8-10 feet
Equipment cost: $2,000 (approx.)
Average satellite capacity: 24 channels
Installation: Professionally installed in a large, open area, free of obstruction; must be moved and pointed at each of 18 different satellites

Thomson is reluctant to discuss the details of DirecTv data stream format but Baker of Thomson, when pressed, allowed that a comparison to the AD-HDTV format would not be illogical. Figure 4 (page 88) shows the AD-HDTV data stream format, but of course some of the values of individual parameters specified here for HDTV transmission might very well be different for DirecTv use. (See my column on "ATRC's all-digital HDTV proposal" in the June 1991 issue of *Communications Technology*.)

The DBS signal will be enveloped in a powerful forward error correction (FEC) code, involving concatenating a Reed-Soloman block code with a convolutional code, until it reaches the indoor IRD. This combined with the high-powered Ku-band DBS signal will achieve an availability of 99.7% or a total signal outage of about two hours a month, largely during heavy rains.

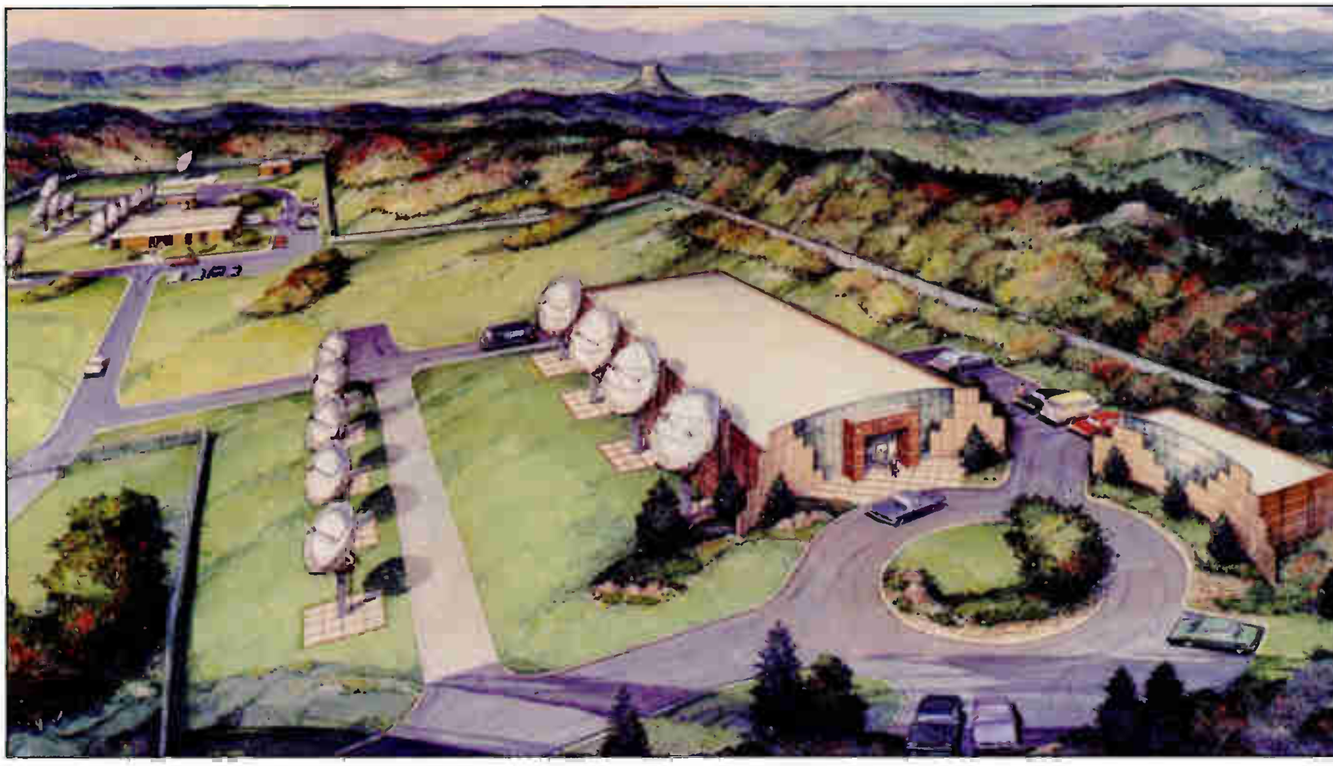
The wideband digital stream is encrypted bit-by-bit with an encryption algorithm similar to the Data Encryption Standard (DES). This is far superior to current CATV scrambling methods that are analog-based (at least for the video).[2] Encryption of this type is transparent to the service type to be encoded, whether digital video, digital audio, data or text. The TDM data stream is transmitted by QPSK (quadrature phase shift key) modulation at 20 x 106 QPSK symbols per second. A block diagram of the DirecTv system is shown in Figure 5 on page 89.

According to Baker, the IRD requires only 16 Mbits of memory, the same as the AD-HDTV proposal. The ATRC puts the cost of this memory at about $13 per receiver. A photo of a preliminary mockup of the IRD is shown in Figure 6 (page 89). A sample link budget — in this case for Chicago — is shown in the accompanying table on page 90.

Other DirecTv business relations

Hughes has reportedly already invested over $500 million in DirecTv and has established additional business relationships with several companies to ensure a smooth startup and ongoing operations. Hughes has announced an agreement with MATRIXX Marketing Inc. to provide the national telephone marketing and cus-

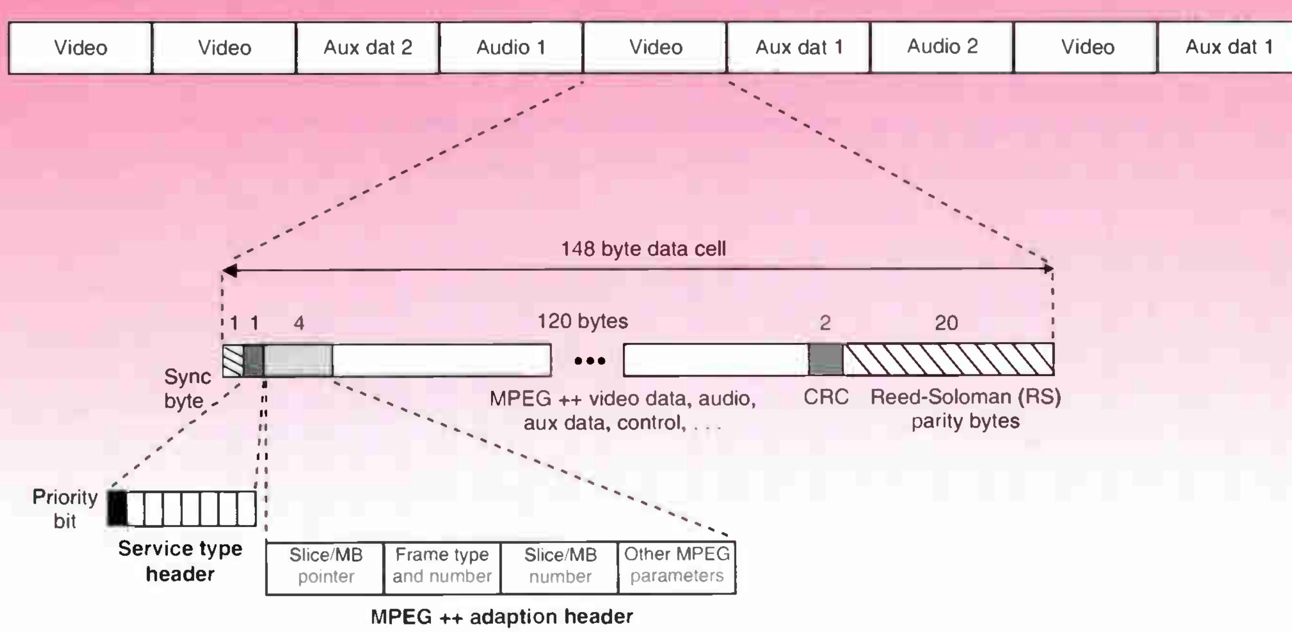
Figure 3: Artist's rendition of the Castle Rock DirecTv broadcast distribution center



tomer service center and an agreement with the Digital Equipment Corp. (DEC) and the Network Computing Corp. (NCC) to provide a national billing system for DirecTv. Last summer USSB purchased five transponders on the first satellite and will provide its own programming services. DirecTv has the remaining 11 transponders on the first satellite of which five are designed to deliver 20 to 40 TV channels of popular cable TV programming to rural areas served by the National Rural Telecommunications Cooperative (NRTC). DirecTv owns all 16 transponders on the second satellite.

In addition to these alliances and the aforementioned one with Thomson for building the home equipment a most significant one is with the NRTC. The National Rural Telecommunications Cooperative is a nonprofit corporation owned by more than 700 telephone and electric systems (about 500 rural electric co-ops, 70 telephone co-ops

Figure 4: Overall AD-HDTV data stream



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5	24	43	62	81	100	119	138	157	176	195
6	25	44	63	82	101	120	139	158	177	196
7	26	45	64	83	102	121	140	159	178	197
8	27	46	65	84	103	122	141	160	179	198
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10	29	48	67	86	105	124	143	162	181	200
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and 100 commercial telephone companies) serving 48 states. NRTC assists its member companies (serving 12 million homes) in meeting the media and telecommunications needs of 25 million consumers who live in rural areas of the U.S. Currently a major component of NRTC's operating business is Rural TV, which provides over 70,000 consumers a cable-like satellite C-band TV service through 285 rural electric and telephone systems. Rural TV offers more than 50 popular scrambled channels such as HBO, ESPN, CNN, Showtime, Disney, etc. Development of the NRTC/Hughes DBS project will make up 120 channels of advanced TV available to noncabled rural areas. It is next to impossible to accurately determine how many homes are not passed by cable. Even the National Cable Television Association presents widely ranging estimates (from various sources)[3] — 5 to 15 million homes. So the NRTC estimate of 10 million homes not passed by cable is a reasonable approximation.

Fritz Stolzenbach, communications coordinator for NRTC, stated that already nearly 250 of its member companies have signed up to provide the DBS service. He further claims that NRTC expects to sell DirecTv to about 30% of the 12 million homes served by NRTC members in five years. This 3.6 million home figure is important for at least two reasons: first it is for a rural and not a cable-served market and second, Bracken of Hughes says that the DirecTv break even point is about 3 million homes. Hughes projects an eventual 10 million home sale of DirecTv. If all these fond desires come to pass, it would appear that DirecTv would become a profitable ongoing DBS business — especially with the Hughes' efforts to market DirecTv substantially beyond the NRTC customers.

Conclusions

Technically, the DirecTv system appears eminently workable. In fact, on Nov. 19, 1992, a successful transmission test of a DirecTv signal was made via the Hughes Communications SBS 6 satellite to the David Sarnoff Research Center in Princeton, NJ. However, other portions of the system should be closely examined and with perhaps a soupçon of skepticism. Where is the programming going to come from? No doubt deals with filmmakers can provide movies, but the availability of CATV programming is far from a done deal. The Cable Act passed last year has provisions requiring CATV programmers to sell to any and all buyers, but that provision could be held up in the courts. Bracken says that about 80 of the 150 channels of DirecTv will be allotted to pay-per-view.

At a recent Cable Television Administration and Marketing Society seminar on PPV, Pete Warzel, president and CEO of United Artists Theaters, predicted that in 10 years the PPV business will make $2 billion annually from movies alone. However, much has yet to learned about proper marketing of PPV. Bracken of Hughes and Stolzenbach of NRTC both say

Figure 5: Block diagram of DirecTv DBS system

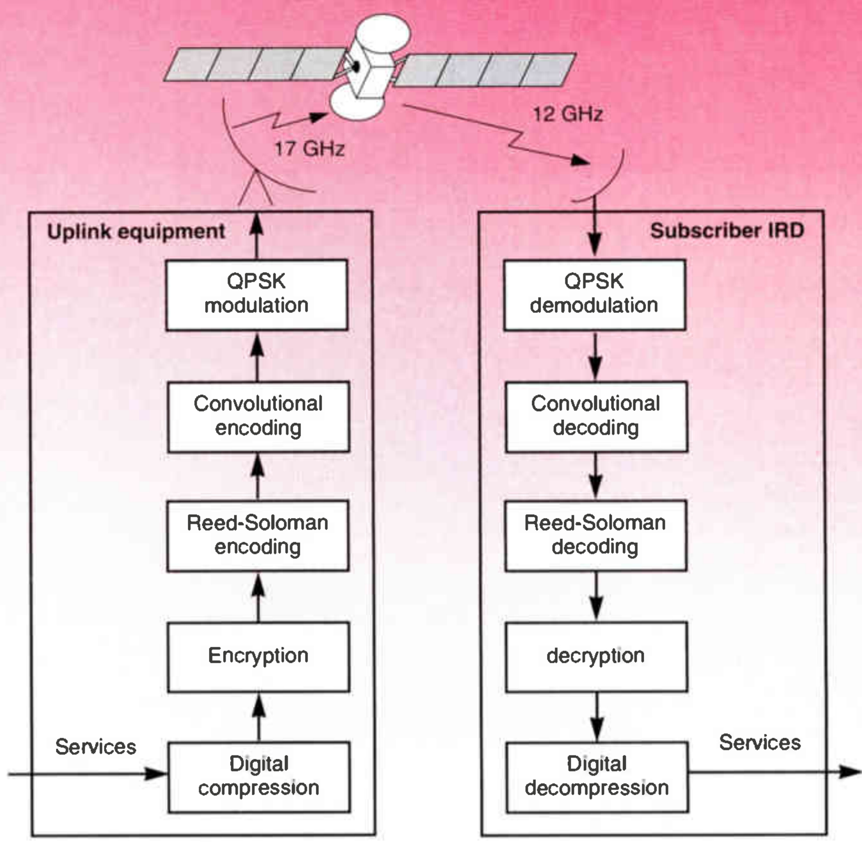

Figure 6: Photo of a mockup of IRD beside a TV receiver

Link budget example (for Chicago)

Uplink	Clear	Rain up	Rain down
	Link environmental conditions		
Transmit EIRP, dBW	78.8	88.8	78.8
Uplink path loss, dB	-208.9	-208.9	-208.9
Atmospheric loss, dB	-0.3	-0.3	-0.3
Uplink rain loss, dB	0.0	-20.0	0.0
Satellite G/T, dB/K	0.0	0.0	0.0
Bandwidth, dB-Hz	-73.8	-73.8	-73.8
Boltzmann's constant, dBW	228.6	228.6	228.6
Uplink C/N (thermal), dB	24.4	14.4	24.4
Downlink			
Satellite EIRP, dBW	51.0	51.0	51.0
Downlink path loss, dB	-205.9	-205.9	-205.9
Atmospheric loss, dB	-0.1	-0.1	-0.1
Downlink rain loss, dB	0.0	0.0	-1.8
Rain temperature increase, dB	0.0	0.0	-2.4
Pointing loss, dB	-0.3	-0.3	-0.3
Ground G/T, dB/K	13.0	13.0	13.0
Bandwidth, dB-Hz	-73.8	-73.8	-73.8
Boltzmann's constant, dBW	228.6	228.6	228.6
Downlink C/N (thermal), dB	12.5	12.5	8.3
Totals			
Uplink C/N (thermal), dB	24.4	14.4	24.4
Downlink C/N (thermal), dB	12.5	12.5	8.3
Cross-polarization interference, dB	23.6	22.8	23.1
Adjacent satellite interference, dB	20.9	20.8	20.9
Total C/(N+I), dB	11.4	9.7	7.8
Total Eb/No, dB	11.6	9.9	8.0
Required Eb/No for 10-10 BER, dB	7.1	7.1	7.1

that their programming charges for DirecTv will be competitive with CATV — but what about the $700 receiver? NRTC has plans to permit rental at an additional monthly fee. However, an outright sale to a rural subscriber in a noncabled area makes more sense than a sale to a subscriber in an area with CATV. No matter how annoyed a CATV subscriber may be with his cable system, how many will be ready to lay out $700 for something that will be a very expensive paper weight should he stop DirecTv service?

Then there is competition from the CATV industry as it anticipates DirecTv. At the '92 Western Cable Show, TCI President and CEO John Malone announced plans for satellite delivery of digitally compressed TV services to backyard dish owners beginning in mid-1993 following completion of a $20 million central uplink and order processing facility. As competition to DirecTv or any DBS service, Cable Television Laboratories is studying plans for a "headend in the sky" to deliver a digital TV service package of basic and 40-50 PPV channels. This would enable small system operators with low channel count systems to compete with the higher channel delivery of DBS.

"Hughes and ... NRTC both say that their programming charges for DirecTv will be competitive with CATV — but what about the $700 receiver?"

How all this will play out is not at all clear and perhaps a legal phrase best describes the situation — "lis sub judice" (a case not yet decided). **CT**

References

[1] "Motion Picture Experts Group Standard 2 (MPEG-2)," a tutorial overview presented at the Federal Communications Commission by Thomson, Dec. 2, 1992.
[2] "Video Signal Security," L. Lockwood, Communications Technology, June 1987.
[3] "Cable Television Developments," National Cable Television Association, May 1992.

Test set

A dual wavelength fiber-optic test set is now available from the 3M Telecom Markets Division that measures 1,300 and 1,550 nm wavelengths simultaneously, reducing measurement time, inaccuracies due to connect/reconnect problems and the time and cost involved in making two separate measurements.

The Photodyne brand 2260XFX dual test set features easy-to-use two-button operation and a large liquid crystal display (LCD) showing both the wavelength and associated loss at all times. The LCD panel also displays the dBm reference.

The company says its laser-based test set has a 55 dB dynamic range for today's longest link needs. The unit can be powered by either AC or rechargeable batteries and can be used in the central office (CO), CEV or field.

Reader service #207

Addressability

PageTap Inc. announced a new line of off-site addressability to facilitate the system operator in providing cable services to consumers in apartment complexes. The company says PageTap allows for complete control of the system, eliminates the need for converter boxes while not adding equipment to the headend, and makes off-site addressability cost-effective for apartment complexes with as little as eight subscribers.

Being faced with a decrease in revenues and an increase in expenses, advantages to the operator include: full accounting of all records, both receivables and hook-ups/disconnects; instant hook-ups/disconnects 24 hours a day, seven days a week; reduction of truck rolls (and their subsequent expenses), allowing the operator to retain a more substantial percentage of hook-up charges; ability to retrofit any existing trap tiered system without adding separate power supplies or headend equipment; eight tiers and 32 ports for unlimited viewing options; and no more converter boxes — ending worries of theft, maintenance and capital investment.

Reader service #208

Storage vaults

Moore Diversified Products has introduced a series of buried fiber-optic cable storage vaults. The MOV-1 and MOV-2 enclosures are designed for below grade installations to serve as slack storage chambers or cable pull boxes. They are constructed of high density polyethylene (HDP) and, according to the company, can support H-20 live loads when properly installed. The company says the lightweight construction provides easy installation compared to conventional precast concrete-type enclosures; and that they are large enough to store over 400 feet of cable without compromising the bend radius. Also, the vaults allow a technician to work safely inside without violating OSHA underground work standards.

The MOV-1 features a reinforced galvanized steel lid, stainless steel pin allen bolt locking option and 48-inch diameter. The MOV-2 features an HDP concrete-filled lid, locking lid option and 48-inch diameter.

Reader service #203

Power protection

Current Technology Inc. is now offering its advanced Generation II DPA Series Power Siftor product line. The new models, part of the company's MasterPLAN family of power protection products, offer power quality solutions for pre-existing panel board installations.

The new surface- or flush-mounted models now include the company's exclusive seamless technology design engineering concept. According to the company, seamless technology combines the attributes of self-protected metallized polypropylene high-energy capacitors, nonlinear voltage dependent metal oxide varistors and synergistic geometry to provide maximum performance and reliability.

The units are available in a variety of voltages and configurations. Standard features include a high performance suppression system with a repeated surge current withstand capacity in excess of 100,000 amps per phase, the industry's first integral diagnostic test point for easy DTS 1000 test set interface and a UL 1283 high frequency extended range tracking filter that actively tracks the sine wave to dissipate low level surges, sharp wavefronts and error-producing high frequency noise bursts, according to the company.

The company says the integral fused disconnect decreases installation costs and simplifies maintenance procedures while permitting system testing to be performed without interruption of facility power. Protection integrity is monitored by long-life, solid state LEDs that provide continuous display of the operational status of each phase.

Surface-mounted models weigh 60 pounds; flush-mounted models weigh 40 pounds. All are UL 1449 listed and CSA approved.

Reader service #201

Video system

Fiber Options Inc. introduced its Series 170B video system, designed for use where long video runs are required or where transmission lines are subject to high levels of interference or ground loops.

According to the company, the system can be used in place of coax cable wherever runs are greater than 1,000 feet (305 meters) and signal quality must be maintained. It also can be used where video signals are run in open space between buildings. System bandwidth is 10 MHz with a signal-to-noise ratio of greater than 67 dB for short distances (10 feet or 3 meters), and greater than 54 dB over long distances.

The system consists of a transmitter and a receiver, and includes level-loss indicators for determining received optical power and video-presence status indicators. Automatic gain control circuitry based on received optical power also is included. According to the company, these features ease installation of the fiber-optic links and eliminate the need for adjustments either at installation or periodically thereafter.

It can be ordered for single- or dual-channel operation in either stand-alone or rack modules. The latter fit into the company's Series 515R card cage system or Series 517R racking system.

Reader service #206

Lightning detector

Airborne Technology Corp. unveiled the M-10B advance warning lightning detector and severe weather monitor. According to the company, the unit detects intracloud lightning, invisible to the human eye, 10 to 30 minutes before dangerous cloud-to-ground lighting begins. It is a battery-powered portable

device that allows the operator to tell the difference between simple dark clouds without lightning and those with lightning.

When directed at suspicious-looking clouds, the unit detects intracloud or cloud-to-ground lightning by sensing rapid subtle changes in light intensity. When this occurs, the unit beeps. By counting the seconds between beeps, and the sound of thunder, the operator can also determine how close a storm is to the observer. The detector can be hand-held or tripod mounted.

A second mode called field change estimates storm distance from 20 to 500 miles. A patented feature links the two modes to verify each lightning stroke and eliminate false alarms.

Reader service #205

External modulator

United Technologies Photonics (UT Photonics) announced a linearized external modulator for fiber-optic CATV signal transmission systems. This fiber pigtailed module, which combines a high performance amplitude modulator with automatic bias stabilization and predistortion linearization circuitry, is characterized by an 860 MHz bandwidth and excellent CSO, C/N and CTB performance, according to the company. The module is available for operation in either the 1.3 or 1.55 µm wavelength region and can operate with up to 200 mW of fiber-coupled optical input power. The company says the high bandwidth and high power handling capabilities enable more flexibility in system design than typical DFB laser transmitters.

The amplitude modulator is fabricated in $LiNbO_3$ using the patented Annealed Proton Exchange (APE) process that, according to the company, results in devices with low insertion loss, low drive voltages, single polarization operation and improved power-handling capability.

Reader service #204

Digital audio

Wegener Communications has begun production of a new line of single channel per carrier (SCPC) products utilizing MPEG II (MUSICAM) compression technology. The company says this compression technology permits the transmission of near CD quality audio programming yet occupies less than half the transponder bandwidth of an equivalent analog transmission.

The Model DR96 digital audio receiver derives mono or stereo audio channels from a digital data stream. Upon receiving a highly compressed data channel transmitted by MPEG compression algorithm, the receiver uses its demodulation, error correction and MPEG decoding algorithm to restore the audio to high quality mono or stereo. Its application of MPEG compression technology allows for increases in carrier access and reductions in backhaul costs while audio quality is maintained, according to the company.

Reader service #199

The CALAN family of test, measurement and monitoring solutions is designed to support the most important goal of system operators: Maximum Subscriber Satisfaction. Each of these systems consists of its own family of hardware components as well as a distinct internal software package capable of generating reports required by management and the FCC.

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CALENDAR

February

1: SCTE Old Dominion Chapter seminar, the new FCC standards, Holiday Inn, Richmond, VA. Contact Margaret Davison, (703) 248-3400.

2-3: Arizona Cable Television Association meeting, Hyatt Regency, Phoenix, AZ. Contact ACTA, (602) 955-4122.

2-4: SCTE Technology for Technicians II, Holiday Inn, New Orleans. Contact (215) 363-6888.

2-4: Jerrold seminar, digital transmission, fiber optics, advanced addressability, rebuild/upgrade planning, FCC compliance, system design and corrective maintenance, General Instrument Corporate Education Center, Phoenix, AZ. Contact Jim Barthold, (215) 956-6448.

3: SCTE Ark-La-Tex Chapter seminar, power protection and batteries, Holidome, Shreveport, LA. Contact Randy Berry, (318) 238-1361.

3: Tektronix seminar, how to evaluate your system, Foster City Marriott, Foster City, CA. Contact Kathy Richards, (503) 627-1555.

4: SCTE Great Plains Chapter seminar, terminal devices, and Installer and BCT/E exams to be administered in Categories IV, V, VI, and VII at both levels, Courtyard Cafe, Bellevue, NE. Contact Jennifer Hayes, (402) 334-2336.

5: SCTE OSHA/safety seminar, maintaining records and developing safety training programs required of the industry, Holiday Inn, New Orleans. Contact (215) 363-6888.

5: Tektronix seminar, how to evaluate your system, Westin Bonaventure, Los Angeles. Contact Kathy Richards, (503) 627-1555.

9: SCTE Chattahoochee Chapter, Installer and BCT/E exams to be administered in all categories at both levels, Atlanta. Contact Hugh McCarley, (404) 843-5517.

9: SCTE Desert Chapter seminar, FCC testing. Contact Greg Williams, (619) 340-1312, ext. 277.

9: SCTE Southeast Texas Chapter seminar, Warner Cable, Houston. Contact Tom Rowan, (713) 580-7360.

9: SCTE West Virginia Mountaineer Chapter, Charleston, WV. Contact Joseph Jarrell, (304) 522-8226.

9-12: Siecor fiber-optic training course, fiber-optic installation, splicing, maintenance and restoration, Hickory, NC. Contact (800) SIECOR1, ext. 5539 or 5560.

10: SCTE Delaware Valley Chapter seminar, system distortions, and BCT/E exams to be administered in Categories I and V at the Technician level, and in Categories I, III, IV, and V at the Engineer level, Williamson Restaurant, Willow Grove, PA. Contact Lou Aurely, (215) 675-2053.

10: SCTE Hawaii Chapter seminar, technical parameters and installation techniques, coaxial cable specs/proper coaxial connector prep, Mililani Complex Tech Park, Mililani, HI. Contact Michael Goodish, (808) 625-8355.

10-11: SCTE Sierra, Central California and Golden Gate Chapters and Shasta Rogue Meeting Group seminar, Holiday Inn, Fairfield, CA. Contact Steve Allen, (916) 786-8597.

10: SCTE West Virginia Mountaineer Chapter seminar, Fairmont, WV. Contact Joseph Jarrell, (304) 522-8226.

11: SCTE Satellite Tele-Seminar Program, to air from 2:30 to 3:30 p.m. ET on Transponder 14 of Galaxy I. Contact (215) 363-6888.

11: SCTE Music City Chapter seminar, fiber optics, Ponderosa Steak House, Nashville, TN. Contact Dale Goodman, (615) 244-7462.

11: SCTE Sierra Chapter, BCT/E exams to be administered in all categories at both levels, Fairfield, CA. Contact Rocco, (916) 354-3500.

17: Miss/Lou SCTE Chapter, Slidell, LA. Contact Dave Matthews, (504) 923-0256, ext. 309.

17-19: Scientific-Atlanta training course, fiber optics, Atlanta. Contact Bridget Lanham, (404) 903-5516.

20: SCTE Cactus Chapter, Installer and BCT/E exams to be administered, Phoenix, AZ. Contact Harold Mackey, (602) 352-5860, ext. 135.

21-26: OFC/IOOC '93 conference, San Jose Convention Center, San Jose, CA. Contact Margaret Edgell, (202) 416-1950.

24-26: The Texas Show '93, San Antonio Convention Center, San Antonio, TX. Contact (512) 474-2082.

25: SCTE Iowa Heartland Chapter, BCT/E exams to be administered in Categories III and IV at both levels, Newton, Iowa. Contact Mitch Carlson, (309) 797-2580, ext. 3700.

25-26: Scientific-Atlanta training course, 8600 System operation and maintenance with System Manager 10, Atlanta. Contact Bridget Lanham, (404) 903-5516.

27: SCTE West Virginia Mountaineer Chapter, BCT/E exams to be administered in all categories at both levels, Charleston, WV. Contact Joseph Jarrell, (304) 522-8226.

March

8: SCTE Desert Chapter seminar. Contact Greg Williams, (619) 340-1312, ext. 277.

9: SCTE Wheat State Chapter seminar. Contact Lisa Hewitt, (316) 262-4270, ext. 191.

9-11: SCTE Technology for Technicians II, Hyatt Regency, Minneapolis. Contact (215) 363-6888.

10: SCTE Heart of America Chapter seminar. Contact Don Gall, (816) 358-5360.

11: SCTE Satellite Tele-Seminar Program, to be aired from 2:30 to 3:30 p.m. ET on Transponder 14 of Galaxy I. Contact (215) 363-6888.

11: SCTE Gateway Chapter seminar. Contact Chris Kramer, (314) 949-9223.

11: SCTE Penn-Ohio SCTE Chapter seminar. Contact Marianne McClain, (412) 531-5710.

15-17: North Central Cable Television Association convention, Hyatt Hotel, Minneapolis. Contact (612) 641-0268.

16: SCTE Cascade Range Chapter, Holiday Inn, Wilsonville, OR. Contact Cynthia Stokes, (503) 230-2099.

17: SCTE Golden Gate Chapter seminar, hands-on FCC proof-of-performance testing. Contact Mark Harrigan, (415) 358-6950.

17-18: SCTE Ohio Valley Chapter seminar, data/transportation, Cincinnati. Contact Jon Ludi, (513) 435-2092.

18: Central Indiana SCTE Chapter seminar. Contact Gregg Nydegger, (219) 583-6467.

18: SCTE Lake Michigan Chap-ter seminar, construction. Contact Karen Briggs, (616) 947-1491.

18: SCTE Mount Rainier Chap-ter seminar, Eastgate, WA. Contact Gene Fry, (206) 747-4600, ext. 107.

18: SCTE North Country Chap-ter seminar, Hyatt Regency, Minneapolis. Contact Bill Davis, (612) 646-8755.

18: SCTE Ohio Valley Chapter seminar, data networking and architecture, Cleveland. Contact Jon Ludi, (513) 435-2092.

20: SCTE Cactus Chapter seminar, hands-on system and FCC testing. Contact Harold Mackey, (602) 352-5860, ext. 135.

20: SCTE Cascade Range Chapter, BCT/E exams to be administered, Paragon Cable, Portland, OR. Contact Cynthia Stokes, (503) 230-2099.

Planning ahead

April 21-24: SCTE Cable-Tec Expo '93, Orlando, FL. Contact SCTE national headquarters, (215) 363-6888.

June 6-9: National Show, San Francisco. Contact (202) 775-3669.

Aug. 24-26: Great Lakes Cable Expo, Indianapolis. Contact (517) 482-9350.

Aug. 25-27: Eastern Cable Show, Atlanta. Contact (404) 252-2454.

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

☛ *Cable System Technology Meeting Subscriber Expectations* — This tape features Margaret Combs (moderator), Jonathan Kramer and Thomas Robinson. "Your franchise administrator can be one of your effective subscriber retention representatives." This presentation explores the issue of what the cities want and need to deal with cable operators properly. It clearly defines a "key role" that technical managers can and should play to help ensure good relations with the franchising authorities. Ask yourself: "Who is telling my franchising authority about the factors necessary in delivering a quality signal?" Then view this and find out. (45 min.) Order #T-1113, $45.

☛ *Current Events in Cable TV Technology: Fiber Optics, HDTV, PCN and Outage Reduction* — This presentation features Thomas Jokerst (moderator), Edward Callahan, James Chiddix and Thomas Elliot. The difference between success and failure often is the result of the right technology deployed effectively and cost-efficiently. This program discusses comparisons between the new Star Star Buss (SSB 500) and fiber-to-feeder architectures, as well as factors that will drive advances in fiber-optic technology. It offers a unique vision of how we will use our increased bandwidth in the future, including HDTV, personal communications networks, possible 16 x 9 NTSC and how new consumer equipment may drive the services we must provide. (78 min.) Order #T-1114, $45.

Note: Videos listed this month were recorded at Cable-Tec Expo '92 in San Antonio, Texas. They are available in color and in the 1/2-inch VHS format only. Videotapes are available in stock and will be delivered approximately three weeks after receipt of order with full payment.

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

To order: All orders must be prepaid. Shipping and handling costs are included in the continental U.S. All prices are in U.S. dollars. SCTE accepts MasterCard and Visa. To qualify for SCTE member prices, a valid SCTE identification number is required, or a complete membership application with dues payment must accompany your order. Orders without full and proper payment will be returned. Send orders to: SCTE, 669 Exton Commons, Exton, PA 19341 or fax with credit card information to (215) 363-5898.

A listing of other publications and videotapes available from the SCTE is included in the March 1992 issue of the Society newsletter, "Interval."

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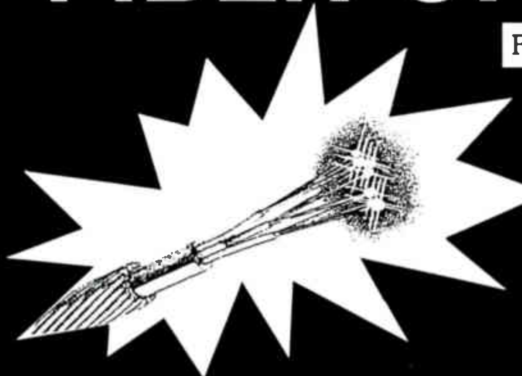

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R-15D	1½" RISER GUARD	BEIGE	7,744'	30/FT
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R-10D	1" RISER GUARD	BROWN	4,760'	.21/FT
		REDWOOD	1,576'	.21/FT
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M-750D	¾X1 ¼" H MOLDING	BEIGE	7,040'	24/FT
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President, Society of Cable Television Engineers

Society of Cable Television Engineers membership benefits — what are they? Do you use any or all of them? If you don't use them, start to do so now! They include:

• *Reduced registration fees to Cable-Tec Expo and all SCTE seminars, including Emerging Technologies, Technology for Technicians and Occupational Safety and Health Administration seminars*. These give you the opportunity to learn firsthand from some of the finest trainers and individuals in the broadband communications industry.

• *Professional certification as an Installer, Broadband Communications Technician or Broadband Communications Engineer (BCT/E)*. Installer and BCT/E certification proves your knowledge and expertise. Employers are increasingly seeking certified personnel and you can immediately see the rewards of investing time and effort in yourself.

• *A free subscription to the Society newsletter, "Interval."* Read this publication every month to get the latest on SCTE happenings around the country.

• *Member discounts on all SCTE publications and videotapes*. These make it easier for you to learn more about your industry and how to help it progress into the next century. (See page 87 of this magazine or the March 1992 issue of *Interval*.)

• *The Tuition Assistance Program*. It's open to any deserving SCTE member to advance himself or herself by pursuing National Cable Television Institute or other technical training courses.

• *Seventy-four chapters and meeting groups all over the nation*. These typically offer in-depth seminars every six to eight weeks on the subjects you are interested in. Members register at lower rates and are insured against personal injury while attending SCTE functions.

• *Health insurance is available at group rates to supplement your existing hospital or comprehensive medical insurance program*. SCTE members also can obtain life and accident insurance at competitive rates.

• *Free or reduced-rate subscriptions to industry publications such as "Communications Technology," "CED" and "Multichannel News."* These help you keep up to date on the latest technology and corporate developments.

• *SCTE's Satellite Tele-Seminar Program*. These are hour-long training seminars downlinked every month — completely free to our members.

• *Corporate rates for hotels and rentals cars*. This can help during business travel or at vacation time (or a special weekend for you and your spouse).

• *Your free copy of the "Annual*

Membership Directory and Yearbook." It allows you to keep in touch with all of the people you met at SCTE functions during the year! Besides a complete membership listing, it contains a wealth of photos and information on the Society's activities and programs.

• *SCTE's Employee Dishonesty insurance coverage*. This has been extended to our entire membership. The employer of any SCTE member who is charged and convicted of employee theft or dishonesty will be indemnified by the Society's insurance.

So, don't you think it's time to take advantage of us? These benefits are for you — please use them! **CT**

Fiber deployment considerations in a converging marketplace

The following is adapted from a paper that ran in the Society of Cable Television Engineers "1994 Conference on Emerging Technologies Proceedings Manual."

The deployment of broadband interactive networks represents a considerable capital cost and market risk for both cable TV operators and their potential competitors. As a result, several mergers and acquisitions recently have been announced between cable TV operators and telephone companies to share the market risk, gain network economies of scale, and more effectively utilize each other's strengths.

With this increased cooperation with telephone companies, cable TV operators face new service challenges and planning considerations as they continue to evolve their networks. This article will review how cable TV and local exchange carrier (LEC) fiber-based residential networks are evolving toward similar architectures and will consider different scenarios for fiber-based networks in meeting today's requirements while providing for maximum flexibility in the future.

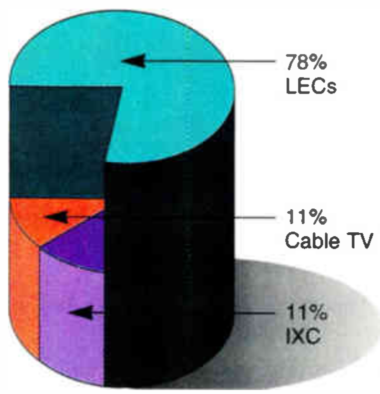
By Douglas E. Wolfe
Senior Applications Engineer

And John S. Lively
Senior Industry Analyst
Corning Inc.

With regulatory barriers falling and technological advances reaching new heights on what seems to be a weekly basis, the race has begun among wireless, telco and cable TV operators for primacy in the residential broadband services industry. Cable TV and telco convergence is causing both entities to rethink how they deploy their networks to best deliver both existing and future services. The choice of network architecture best suited to deliver those services depends heavily upon the type of services to be provided (with varying levels of reliability), the type and condition of the existing plant, and of course, the installed cost.

As the desire to provide new interactive broadband services grows, network bandwidth requirements increase and more and more service providers are embracing optical fiber as the medium of choice for their networks. Both cable TV operators and LECs have been deploying optical fiber aggressively for the last several years with no end in sight. Cable TV's rate of fiber deployment doubled in 1992 from 1991, compared to a 30% increase for local exchange companies. Anticipated fiber deployment growth rates for 1993 over 1992 for the cable TV and regional telephone industries are 60+% and 15-20%, respectively. Figure 1 illustrates the relative amount of fiber deployed by cable TV and telephone companies in 1992.

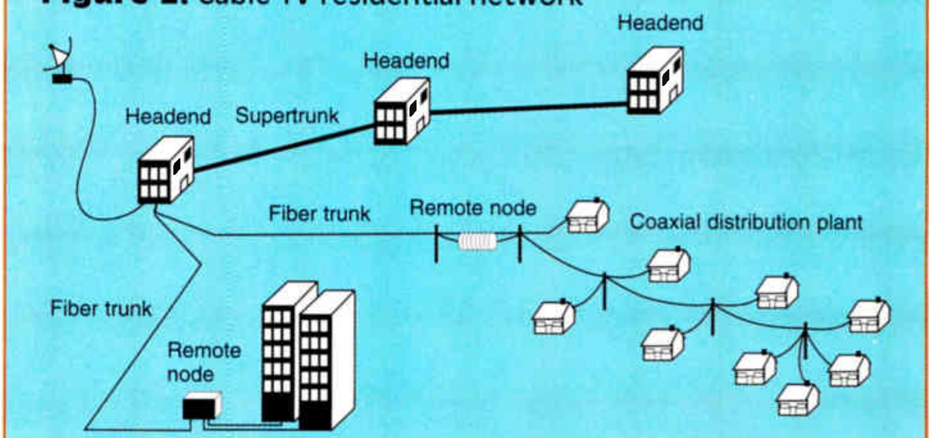
Figure 1: North American fiber volume by application segment, 1992



The cable TV residential network

The headend is the origination point for signals in the cable TV system. It has a variety of antennas for receiving satellite-delivered program signals and over-the-air broadcast signals. In addition, the headend usually contains equipment for receiving and playing back locally originated and prerecorded programming. Headends now are routinely being in-

Figure 2: Cable TV residential network



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