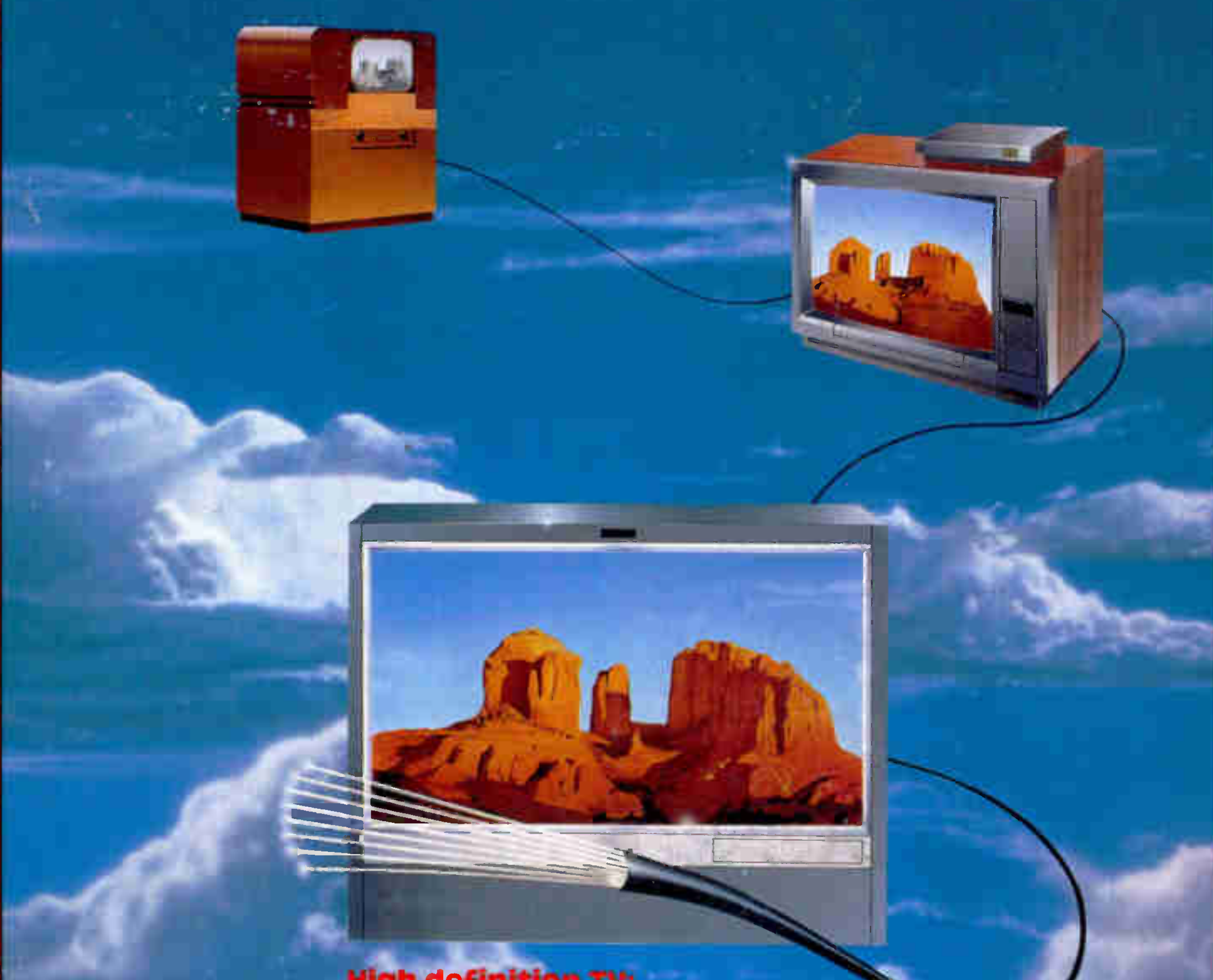
COMMUNICATIONS TECHNOLOGY

Official trade journal of the Society of Cable Television Engineers



High definition TV:
A revolution in evolution

October 1989

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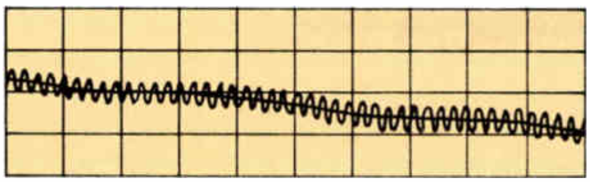

Features

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There's a certain pattern developing among the best CATV systems. To maintain and operate at peak performance, they're using Wavetek testing and measurement instrumentation.

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Reader Service Number 4.

High definition TV for fun and prophets

Talk about high definition TV is, well, high on many agendas. The acronym "HDTV" can be found almost everywhere you look these days, even though the real thing—hardware and programming—is almost nowhere. Sorry, but even in this issue of *CT*, the first we've done with such a wealth of information on the topic, you won't catch a live demonstration of MUSE, ACTV-II or other formats on any page.

Yet what our writers have to say about HDTV dares to be heard. Much of the content hasn't appeared elsewhere and some of it you might wish would disappear. In addition, some interesting questions are raised and discussed, such as: So what's wrong with how we deliver NTSC? Why do we need HDTV? What should be cable's role in development of standards?

Despite the cover illustration, HDTV is no longer a "blue sky" technology. The industry is spending an enormous amount of time and a little bit of money on predicting what the set manufacturers, Federal Communications Commission or the NCTA's HDTV Subcommittee is going to come up with next. Anyway, before we go on to other topics, let me quote a story that might appear in tomorrow's newspapers: "Faced with ever increasing U.S. trade restrictions, Japan's Parliament today placed an embargo on exports of its HDTV sets, components or other technology to the United States." Pretty scary, even for Halloween.

Hot tech ticket

Informative was the key word describing the very well-attended technical sessions offered at the recent Eastern Show, with its theme "Cable's hottest ticket." Organized by Jud Williams of Performance Cable TV Products under the auspices of the SCTE Chattahoochee Chapter, the four sessions were well put together and all presenters did an excellent job.

Bob Luff of Jones Intercable handled the first session, "The fiber build: Augusta case study." He gave a thorough overview of the Jones Cable Area Network architecture, including costs and the benefits already being reaped from fiber. Then, Metrovision's Dick Amell covered "CLI" from A to Z. One got the feeling from some attendees that their systems' management hasn't fully realized the ramifications of a failed (or non-performed) CLI; lots of luck!

On the second day, the tech sessions began with a combo presentation by Jud Williams ("Power supply basics") and Chuck Beckham of Voltex Batteries ("CATV battery basics"). This was a topic where an understanding of Ohm's law really paid off. Finally, Gary Godwin of the Georgia Power Co. ("Safety around conductors") not only covered the work environment but hit the home as well. Everyone attending this one emerged with a much greater respect for electricity and the hazards (sometimes fatal) that can befall the careless.

Speaking of trade shows, this month's Atlantic Cable Show in Atlantic City, N.J., will deal some high cards of its own (and probably register a full house), with its theme "Caring is good business." Scheduled events include SCTE technical panels on HDTV, CLI and fiber. In addition, Paul Beeman will present his legendary BCT/E Category II review course "Video and audio signals and systems." Also, Bill Riker will administer BCT/E and Installer Certification Program exams.

While we're on the subject of BCT/E, this month's *Interval* gives an up-to-date listing of those who have successfully completed the program at the technician and/or engineer level, as well as all the candidates who have enrolled. Is your name included? Why not?

Addressing the future

In a recent press conference at Jerrold's Hatboro, Pa., headquarters, Tele-Communications Inc. announced that it placed an initial order for 250,000 Jerrold Starport on-premises addressable control modules, to be first phased in throughout TCI's Boulder, Colo., system. The Starport unit is placed in a box attached to the outside of a sub's home. Four addressable ports and a disconnect feature control the flow of TV signals into the home, allowing or disallowing signals depending on the preference of individual subs. According to J.C. Sparkman, TCI's executive vice president and COO, "Our customers can hook up as many cable-ready sets, VCRs or other cable-ready video appliances as they want with no extra monthly charges and no additional converter equipment. The Starport commitment is just part of a multimillion dollar agreement between Jerrold and TCI.

And finally, *CT* would like to welcome aboard new advisor Paul Barth, corporate engineer for United Artists Cablesystems. He's been in communications for about 27 years; 20 years in the U.S. Army Signal Corps and seven years in CATV. He's been involved in virtually every aspect of the industry: fiber optics, microwave, earth stations, plant construction and FCC matters.

Rikki T. Lee

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Atlantic Show '89 announces agenda

ATLANTIC CITY, N.J.—With the theme "Cable cares," the eighth annual Atlantic Cable Show, cosponsored by the Maryland/Delaware/District of Columbia, New Jersey, New York and Pennsylvania cable TV associations, is scheduled for Oct. 3-5 in the East Hall of the city's convention center. As usual, the show will feature technical sessions coordinated by the Society of Cable Television Engineers.

The show's agenda, featuring technical sessions, is as follows:

Tuesday, Oct. 3
10:30-11:30 a.m.—Keynote speaker Bill Daniels, chairman of the board, Daniels & Associates
11:30 a.m.—Ribbon cutting ceremony
11:30 a.m.-6:30 p.m.—Exhibits open
Noon-3 p.m.—Lunch
2-3:30 p.m.—"Cable cares about high definition television," moderated by Paul Heimbach, vice president of engineering, Home Box Office
3:30-4 p.m.—Coffee break
4-5:30 p.m.—"Cable cares about signal leakage and CLI measurements," moderated by Brian James, director of engineering, National Cable Television Association
5:30-6:30 p.m.—Cocktail party

Wednesday, Oct. 4
9-10 a.m.—Associates meeting
10 a.m.-5 p.m.—Exhibits open
10-11:30 a.m.—"Video and audio signals and systems" (BCT/E Category II review course), moderated by Paul Beeman, vice president of engineering, Touchtone Video Networks
11 a.m.-3 p.m.—Lunch
1:30-5 p.m.—BCT/E and Installer Certification Program examinations, administered by William Riker, executive vice president, SCTE
3-3:30 p.m.—Coffee break

Thursday, Oct. 5
9:30 a.m.-noon—Exhibits open
10-11:30 a.m.—"Cable cares about fiber-optic technology," moderated by Michael Schooler, deputy general counsel, NCTA
11 a.m.-noon—Complimentary Bloody Marys
1 p.m.—Golf and tennis tournaments

Oceanic fiber trial yields high numbers

OAHU, Hawaii—Recent field trials of a Jerrold Cableoptics 5.4-mile AM fiber link installed here from a headend in Panaluu to a node site in Kaaawa reported excellent numbers. According to officials at the American Television and Communications Corp.'s Oceanic Cablevision, the link exceeded committed specifications for a 6 dB loss budget, including 52 dB carrier-to-noise (C/N), 65 dB composite triple beat and 60 dB composite second-order distortion carrying 55 channels over two fibers.

Oceanic's Engineering Vice President Mike Goodish said that "in comparison to the single-laser AM fiber systems Oceanic has evaluated and installed, the Jerrold system has delivered the best C/N and distortion measurements." He indicated that Oceanic would probably continue to use the link after the trials.

Jones approves use of Catel's TransHub

FREMONT, Calif.—Jones Intercable recently gave full approval to the first use of Catel Telecommunications' TransHub III (TH III) in the 800-mile CAN (cable area network) fiber-optic rebuild of the Jones system in Broward County, Fla. During a source inspection here at the Catel facility Aug. 10, the TH III units were certified to conform with all Jones specifications. Earlier this year Jones had given final approval to the system and product design specifications.

The completed portion of the TH III equipment, which converts AM-on-fiber to VSB/AM for coaxial cable, represents about 20 percent of the total to be delivered under the contract with Jones. Catel's total contract for the Broward County system (estimated at over $1 million), calls for more than 30 TH III units plus 1,700 miles of fiber and over 50 transmit lasers.

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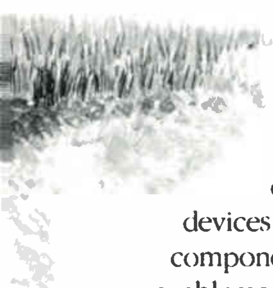
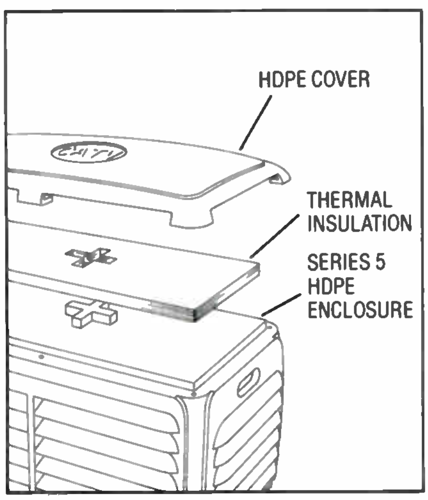


Have you considered what heat can do to your line extenders and trunk amplifiers after you splice them into pedestals? Excessive heat on CATV active devices is known to cause component reliability problems. It can keep your technicians busy in summer months responding to signal outages or necessary amplifier adjustments. That's why Channell has developed the ***new*** "Series 5" Heat Dissipation Covers (HDC).

These single insulated, dual cavity covers are 75% more efficient than metal in dramatically reducing temperature extremes



in your amplifiers, especially on the IC boards and power supplies. Independent field testing of "HDC" covers against competitive metal enclosures indicates this percentage could be even higher, depending upon the size of metal enclosure used in relationship to the amount of active and passive equipment spliced in it.

To prolong the life of your active equipment and increase system reliability, contact Channell today. Let us show you how our "HDC" covers can take the heat off your active devices, and assist you in preventing premature underground amplifier component degradation.

Put our high standards to work for you in your underground plant. Ask for information on Channell's complete family of above and below grade pedestals and enclosures, and Integral's full line of fiber and coax Cablecon® products.

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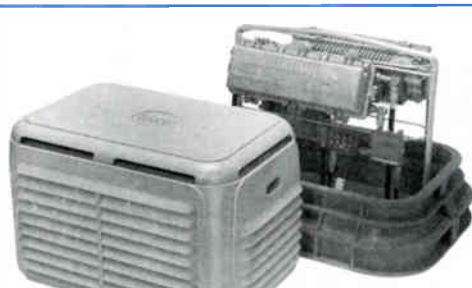

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SCTE to offer new tech seminar

EXTON, Pa.—The Society of Cable Television Engineers is offering its series "Technology for Technicians II," the second level of the SCTE's Technical Training Seminar Program, Nov. 13-15 at the Harvey Hotel in Dallas. The three-day seminar and lab sessions are designed for maintenance technicians, chief technicians and system engineers. Registration is limited to 40 attendees; the $245 fee includes all materials, including technical manual, scientific calculator, note pad and pencil as well as morning and afternoon refreshments.

Seminar topics will include mathematics and measurements, amplifier systems, powering, coaxial cable, common cable system faults, system operation and maintenance concepts, and CLI tests and measurements. The lab will feature spectrum analysis, signal leakage tests and measurements, and signal level meters.

For more information or registration materials, contact the SCTE at (215) 363-6888.

Chicago cops given communications net

CHICAGO—In a recent press conference, Mayor Richard Daley and Police Superintendent LeRoy Martin unveiled a new Police Communications Network that will use the cable system to enhance the police department's communications. The new network, installed by Chicago Cable TV (TCI) and Group W Cable, connects the Police Academy and district headquarters using the same cable lines that hook up over 250,000 subscribers. Special signal scrambling equipment allows the police to televise messages in code, thereby preventing the sub from seeing or hearing what is being transmitted.

According to Martin, Chicago is the only city to develop this type of CATV-based police network. It is planned to be used several times each day, usually at roll call, to disseminate the latest information to officers in each district. Police training films, meetings, emergency announcements and routine administrative matters also can be telecast.

TCI, Continental invest in Eidak Corp.

CAMBRIDGE, Mass.—Tele-Communications Inc. and Continental Cablevision Inc. recently reported that they have become minority investors in Eidak Corp, whose Copyguard System is designed to prevent unauthorized recording of pay-per-view movies and events. In addition, Eidak is seeking a matching investment from other operators; Daniels & Associates is acting as financial advisor. When completed, the new investments are expected to represent approximately 25 percent of Eidak's equity.

In two market tests, the eight major motion picture studios and two independents released movies to cable systems using Eidak simultaneously with home videocassette rental outlets. According to Eidak, preliminary results from these tests in Continental's Newburyport, Mass., system and Viacom Cable's Milwaukee system indicate the consumer's willingness to tradeoff the ability to tape for the opportunity to view an earlier release.

Pioneer, others join Smart House

UPPER MARLBORO, Md.—Pioneer Electronics (USA) Inc. of Long Beach, Calif.; Broadband Networks Inc. of State College, Pa.; and Canada Wire and Cable Ltd. of Toronto became the latest manufacturers to complete research and licensing agreements with Smart House Limited Partnership. The Smart House system provides for total home automation through a fully integrated approach to handling the distribution and control of energy and communications. Work will begin on prototype homes in Little Rock, Ark., and Oklahoma City. Homes in Columbus, Ohio, and Baltimore, are already under construction.

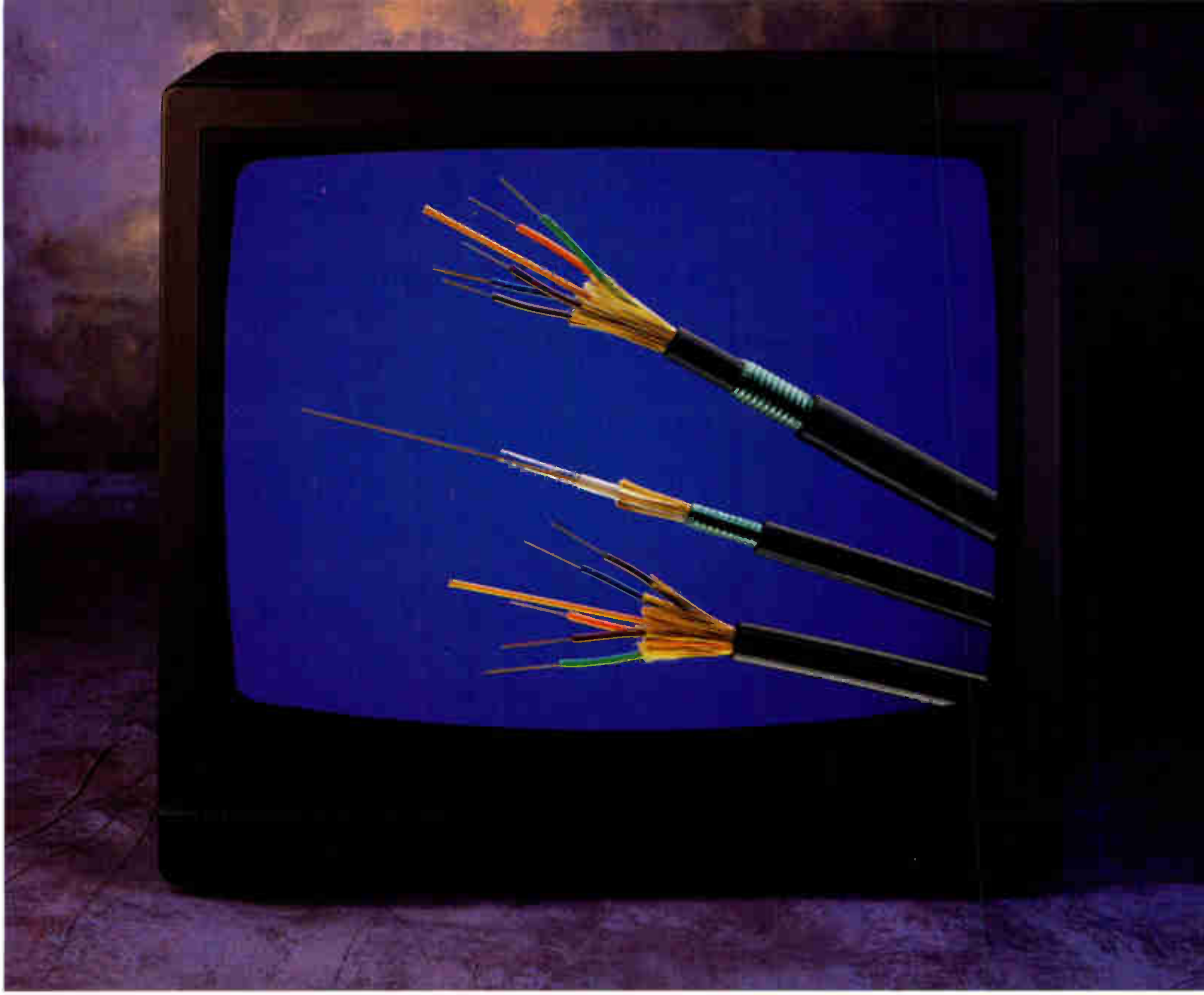
Pioneer plans to manufacture advanced consumer electronics products for use with a new home wiring system. Its contributions will include telephone handsets and answering machines, stereo amplifiers and receivers, and special adaptor units that will allow enhanced use of conventional audio and video equipment.

Through Broadband Networks' efforts of producing a "headend" for the Smart House, homeowners will be able to plug in a stereo receiver, VCR or video camera at any outlet and receive signals at any other outlet along with CATV or MATV signals. Other services would include HDTV distribution and computer networking.

Canada Wire will produce a unique hybrid cable that will be used to wire Smart Houses. The cable will be for branch wiring in homes and will carry 120 VAC along with 24 VDC uninterruptible power, phone communications, control and status information, audio, video and high-speed data signals to outlets in the home.

- Sachs Communications announced the recent opening of a new sales office and warehouse in Paris. Sachs France will introduce aerial construction and subscriber installation hardware to the French telecommunications market.
- Anixter Cable TV announced the opening of a new service center at 2901 Titan Row, Suite 124, Orlando, Fla. 32809, (800) 346-3069 (in Florida) or (800) 447-8396 (out of state). Also, the company opened a new facility at 888 Thomas Dr., Bensenville, Ill. 60106, (312) 350-7788.
- Pioneer Communications of America announced that Warner Cable will install Pioneer's BA-6000 series addressable converters and M3P addressable controllers in Warner's Milwaukee; Paul Springs, Calif.; Nashua, N.H.; and Osh Kosh, Wis., systems. Financial terms of the agreements total over $1.4 million.
- The Pennsylvania Cable Television Association (PCTA) is establishing the Joseph P. Connolly Award for Excellence in Community Service as a memorial to the association's former vice chairman; Connolly was killed in an automobile accident earlier this year. The first award will go to Connolly's company, BerksCable of Reading. Also, the PCTA approved the establishment of the Joseph P. Connolly Technology Center, which the association will use in the editing and dubbing of public service announcements and public affairs programming. Contributions can be sent to the Joseph P. Connolly Memorial Fund, c/o PCTA, P.O. Box 1141, Harrisburg, Pa. 17108.
- Effective Sept. 11, Channell Commercial Corp. relocated its offices to 27040 Ynez Rd., P.O. Box 688, Rancho California, Calif. 92390, (714) 694-9160. The new headquarters includes 120,000 square feet of manufacturing space, 18,000 square feet of office space and a 3,200-square-foot conference center.

Reader Service Number 11.



John Sie: On digital HDTV

On May 16, John Sie (senior vice president, Tele-Communications Inc.) gave testimony to members of the U.S. Senate Committee on Commerce, Science and Transportation's Subcommittee on Science, Technology and Space. His speech was titled "Developing a national technology strategy for high definition television." This month's "Technically Speaking" is a collection of excerpts from Sie's address.

The importance of HDTV: "HDTV means more to America than TV pictures with video quality comparable to 35mm film and with compact disc quality sound. Over the longer term, there also are expected to be many non-entertainment uses for the high resolution video technology including: interactive education, computer workstations, satellite photography, defense command and control displays, advanced weapons targeting and medical diagnostics. Most importantly, if the U.S. government takes the right actions, then American HDTV in the 21st century will use the most advanced integrated circuits and computer processes in a home environment. Whoever takes the lead in HDTV technology will have the advantage with respect to key components (semiconductors, etc.) and in related areas of computers, software and test equipment."

What the U.S. government should do: "The noted management consultant Peter Drucker has been quoted as saying that a competitor should never try to catch up—instead he should 'leap frog' the current leader. We could not agree more. Specifically, we call upon the U.S. government to:

"1) set a national goal of introducing by the year 2000 an American processed digital HDTV system that permits the transmission of a digital HDTV signal within 6 MHz;

"2) support efforts already under way in the private sector to develop and implement a processed digital transmission system;

"3) promote the introduction within two years of an interim analog-based HDTV system that uses the current 6 MHz NTSC standard, so that the more than $100 billion invested in broadcast and cable transmission equipment, TV sets and VCRs will not be rendered obsolete;

"4) reserve frequencies allocated for TV broadcasting, but not currently utilized, for processed digital HDTV during the transition period when broadcasters will simulcast compatible analog HDTV and non-compatible digital HDTV signals.

"These combined actions will: thwart attempts by foreign countries to introduce non-compatible HDTV systems in the United States, ensure that American viewers have access to improved TV pictures quickly, minimize the cost and disruption associated with introducing HDTV and maintain the ability of American broadcasters and cable operators to provide local and national news, information and entertainment programming."

Why we should focus on digital HDTV:

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To get the full story on the CSG-60, contact the SATCOM Division for the Standard representative near you.

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"Instead of sending each pixel of each frame new information every time, the processed digital system only sends new information when there is a change."

"Analog-based HDTV systems will not be competitive in quality or cost with the next generation of digital-based HDTV systems. For the purposes of TV signal transmission, 'digital' simply means converting an analog HDTV waveform to a series of binary bits of 1's and 0's.

"Digital-based HDTV will offer the same revolutionary advancement we have achieved, by way of analogy, with compact discs and digital audio tapes vs. standard LPs. A digital signal suffers from no transmission degradation, enables true studio quality image and sound in American homes, permits direct integration and signal manipulation between the home TV and home computer, and promises volume-efficient cost reductions in manufacturing digital HDTV sets."

The processed digital system: "A processed digital HDTV transmission system can be defined as any digital-based HDTV transmission system that reduces the frequency spectrum required to transmit a signal by taking into account three major factors: standard digital compression transmission techniques, the specific nature of the video waveform and the neural responsiveness of the human eye.

"Before discussing the design of processed digital, let's first look at transmission systems that only use standard digital compression techniques. Digital telecommunication systems today routinely exhibit bandwidth compression efficiencies of 4.5 bps/Hz: For every 4.5 bits of data, we need only one cycle of radio frequency (RF) spectrum to transmit them. For example, a 4.5 Mbps data stream can be transmitted using only 1 MHz of RF bandwidth. Most digital long-haul microwave transmission systems achieve this compression efficiency using a 64-level quadrature amplitude modulator (QAM). As higher levels (256-1,024) become available on the market, further bandwidth compression of up to 7.5 bps/Hz is possible with appropriate error corrections.

"Now let's design an HDTV system with the following characteristics: 1) a resolution of 1,050 × 1,050; i.e., the whole screen is capable of resolving into small cells called 'pixels,' 1,050 vertical by 1,050 horizontal so that the total number of pixels per screen is 1,102,500; 2) the screen is scanned at a rate of 30 times per second (in order to show continuous motion) with a 2:1 interlace scan; and 3) there are five binary bits of information each required to define the intensity (luminance) and color (chrominance) content for each pixel. The total amount of digital information needed to be transmitted every second in this system is 1,653,750,000 bits. Even using a transmission compression of 7.5 bps/Hz, the required RF spectrum is 220.5 MHz for just one channel of HDTV programming!

"Such a 'brute force' approach using so much spectrum for digital HDTV is not suitable for over-the-air transmission. There simply is not enough spectrum available without creating new demands on other spectrum users (e.g., land mobile radio, public safety radio, etc.). This is a serious drawback: It effectively would mean the end of the local broadcasting in the HDTV arena. Local broadcasting has been a hallmark of American TV policy since its inception.

"The only way to transmit such signals would be through fiber-optic cables. But it would be extremely expensive to install such cables throughout the country and telephone companies would not be able to lay fiber universally to every American home until well into the 21st century. In addition, there are serious technical questions about even the feasibility of transmitting more than a few HDTV channels requiring such great bandwidth even with fiber-optic cable. Within the foreseeable future, the state of the art in video switching using submicron integrated circuit technology is below 1 Gbps, or at best each video switch at the remote terminal can only handle four HDTV channels. Moreover, at a 1 Gbps switching rate, the cost of such switches are not going to be competitive at all.

"The brute force digital approach described utilizing 220 MHz bandwidth is capable of faithfully reconstituting all ranges of intensity and color for *every* pixel for *every* frame. But it is not necessary to do so given the nature of video images and the limitations on the ability of the human eye to perceive such information.

"Even with the most detailed scene and fastest motion, much of the content information from pixel to pixel and from frame to frame does not change. (A crude example of my point can be seen by advancing a videotape on a VCR frame-by-frame.) Therefore, instead of sending each pixel of each frame new information every time, the processed digital system only sends new information when there is a change. By doing so, much less transmission spectrum is needed.

"Furthermore, the pixels can be grouped into cells of several pixels each, further reducing the necessary bandwidth. A receiver can have the adaptive capability of interpolating the proper information for each of the pixels in each group from the coded 'change' information being received and processed. The reconstituted image will be perceived by the viewers as having the full resolution.

"Because of these factors it is possible to drastically reduce further the spectrum needed—that's the processed digital approach. Indeed, we believe that a processed digital signal need not require more RF spectrum to transmit than the current NTSC signal."

An interim analog-based American HDTV system: "Japan's MITI and its National Broadcasting Co. (NHK) have been trying hard to persuade U.S. policymakers that they (MITI and NHK) are the only ones with an HDTV system and are ready and able to make it available to U.S. consumers. What they downplay is that their system is incompatible with existing U.S. TV transmission equipment (broadcasting and cable) and TV receivers, all of which work with the current NTSC standard of 525 lines, 59.94 Hz frame rate, 4:3 aspect ratio and 6 MHz transmission standard. Thus, it is not hard to see the Japanese's true objective: the sales of new Japanese HDTV sets full of Japanese components. Yet, there is no need to suffer such problems.

"An American HDTV system exists *now* (Faroudja's SuperNTSC) that is NTSC-compatible and provides as sharp a picture as the full, original MUSE system for the largest of American TV screens (6-foot diagonal). The improved effect of the analog HDTV signal only appears on new TV sets. But Americans will be able to receive improved pictures on the existing 160 million TV sets because SuperNTSC reduces artifacts and color distortions. Moreover, costs of a new SuperNTSC TV set will be less than that of alternate systems because of its compatibility with the NTSC standard and successful use of VLSI chips.

"Remember: The ultimate goal is adoption of a digital-based HDTV signal. This necessarily will be incompatible with any analog TV set. Thus, there must be a transition period. By reserving frequencies allocated for TV broadcasting, but not currently utilized, for processed digital HDTV during this period, broadcasters will be able to simulcast compatible analog HDTV *and* non-compatible digital HDTV signals. Thus, the United States will be able to make the transition easily, with minimum cost and disruption, to a processed digital system that will serve us well into the 21st century—just as the NTSC standard has served us well in the last 40 years."

In praise of the press

By Isaac S. Blonder
President, Blonder Broadcasting Corp.

The courses in applied psychology that I attended back in 1935 taught us that the memory retention capability of the average human brain was no greater than about 5 percent of the inputted subject matter. If one were to use the same subject matter over and over again you might retain as much as 50 percent. Should you pursue a career in a field where the knowledge content grows exponentially—such as electronic engineering—you find yourself in a catch-22. One remedy, which leaves your ego somewhat deflated, is to specialize more and more in narrower and narrower fields as time passes, so as to keep pace with your innate capabilities. Of course, individuals vary in their mental memories; as witness, some of my students in engineering physics who possessed the amazing ability to forget even the basics of high school math when confronted with a physics problem.

At one time, when my company was engaged in a man-to-man campaign to persuade schools to install master teacher video systems for obvious benefits to all (we didn't make a single sale!), the president of a major medical school gave us this kindly advice: Don't go to a doctor who has been out of school more than seven years; his education is obsolete! It seems that he was offering graduate catch-up courses to his former students with few takers. Have I taken graduate courses to keep up with developments in RF engineering or in the explosive field of digital electronics or in management? No, no, a thousand times no! How about you? The same excuses of course: no time, no convenient school at hand, no spare money. Besides, if you want a really upscale retort, "We all know that schools have obsolete equipment and are years behind the state of the art."

But you can't hold your job or advance your career on the basis of 5 percent of your college education. Does the research going on in your company keep you abreast of your competition? Not unless your company is Bell. How about the peripatetic salesman who comes around with the latest semiconductors and whispers stories about how far ahead your competitors are by using his superior goods? Maybe you can hire away your competitor's chief engineer—maybe, maybe, maybe. Where to turn for knowledge? Never fear, the press is here! Yes, the trade press is our savior, our mentor, our shining beacon in the darkness of obsolescence.

No better exposition

First and foremost, the press presents the news of the industry. Reporters find tasty tidbits in every corner and break the news on sales trends and technology leaps before the participants even recognize their own children. Second, the advertisements of new products, in the usual excess of salesmanship, reveal their scientific strengths well in advance of the delivery date. Statistics, the lifeblood of the money managers, are regularly featured in the press. How much would it cost to judge the extent of the market for your new widget by way of your advertising agency, an outside consultant or, heaven forbid, your own sales department? Even the studies of the marketplace, carried out periodically by your industry association, are flawed by the reluctance of some companies to put their failures on record. It is usually better to rely on the critical eyes of the magazine and its reporters for the statistics to guide your engineers and salesmen.

Not to everyone's taste but absolutely invaluable to the scientists are the technical articles. Sometimes screened by one's peers or invited by the editors, there is no better exposition of the state of the art than what is found in the pages of our press. The hours spent in studying the thoughts and achievements of the country's top scientists, as selected by the press, are the most productive hours for the working engineer.

The benefits to our country in products and productivity resulting from the information cornucopia of the press, should surpass any like input from textbooks and the academic megalopolis.

"Let us salute the press ...for its unparalleled achievement in keeping us working engineers up to date."

And the price is right. Many of the best publications are free to the trade, supported by advertisers. Some of the most technical are part of one's membership in societies. Even the magazines that are wholly supported by subscriptions are positive bargains for the money. Once again, let us salute the press, our graduate school, for its unparalleled achievement in keeping us working engineers up to date and competitive in a painless and penny-pinching fashion.

HDTV: A point on the curve

By Ted E. Hartson
Vice President and Chief Engineer, Post-Newsweek Cable

In 1881, an article appeared in the *Telegraphic Journal* entitled "The Telegraphic Transmission of Pictures of Natural Objects." The first patent for apparatus to see by electrical transmission was granted in 1884. The most sophisticated of these systems utilized 30 scanning lines.

During 1931, RCA started work on a system using the cathode ray tube as a display device. The terms *kinescope* and *iconoscope* both evolved from these tests. The system used 120 lines progressively scanned with a frame rate of 24 Hz. The 1931-32 tests concluded "satisfactory television performance" would require "more than 120 lines" and a "repetition frequency greater than 24 Hz as image flicker was considered objectionable." Seems reasonable, doesn't it?

In 1933, 240 lines of progressive scanning at 24 frames was tested where "a television channel for picture and sound should be 2,000 kilocycles (2 MHz), and that the picture and sound carriers should be spaced by 1,000 kilocycles (1 MHz)." By 1934, RCA scan rates were up to 343 lines. And, for the first time, to address flicker, two fields of 60 Hz were interlaced; all synchronizing equipment was electronic as opposed to earlier mechanical timing devices.

During early 1935, the "high definition" operating standards were chosen. They were:

Number of lines	343
Frame frequency	30 per second
Field frequency (interlaced)	60 per second
Aspect ratio	4:3
Channel width	4.000 MHz
Visual aural separation	2.250 MHz

For the first time the words "high definition" and "high fidelity" were attached to the fragile art of television. Those standards lasted until 1937, when scanning lines increased to 441 lines, aural was moved 3.250 MHz up and video bandwidth (baseband) was 1.5 MHz. The picture was described: "The present yellow screen used for the 7½- by 10-inch picture (had) a brightness in the highlights of 4 foot-lamberts." The optimal viewing distance was three to four feet resulting in an arc subtended of about 20°—pretty small, pretty dim.

Satisfying the requirements

In only 56 years after the first seeing by electric signals we had reached the point where RCA could declare "the size and brightness of the 7½- by 10-inch picture of 441 lines appears to satisfy reasonably the requirements for pictures to be viewed in the home by the average family group."

1937 dismissed color with: "Color television at this time represents a most forbidding aspect to the already sufficiently harassed television experimenter and designer."

Late in 1940, the National Television System Committee (NTSC) was impaneled. In 1941, acting on the recommendations of the NTSC, the Federal Communications Commission permitted scanning lines to be increased to 525 and changed sound transmission from AM to FM. By the end of 1946, color was afforded this comment: "Color may compensate for, but not take the place of, loss of detail." On the issue of the cost of color: "(Cost) and the lack of detail are prohibitive handicaps at the beginning so black and white television will be used first." As early as 1940, RCA was working on time division color TV.

World War II curtailed the development of additional color TV research. In September 1947, RCA showed a "simultaneous color TV system" that used three full TV channels, acknowledging its wastefulness of spectrum. Shortly thereafter the concept of mixed highs was advanced, whereby spectrum was conserved and the color picture was interspersed along with the black and white picture.

By taking advantage of the spectral bandwidth of the various color components, a technique that involved using two RF channels emerged. July 1949 saw the first transmission within a single 6 MHz channel bandwidth; this technique, called "element-sequential fast multiplexing," suffered from excessive dot size, residual flicker and crawling dots along with a 33 percent deterioration in black and white resolution. The sampling speed employed in this process was successively raised to over 3.5 million; originally these systems were timed by the decay of the trailing edge of horizontal sync.

Everybody knows that 3,579,545 Hz is the versed frequency but it didn't start out that way. In the fall of 1949, RCA demonstrated a system on edge sync, sampled at 3.8 MHz. In November, it slowed down the sample to 3.6 MHz. By February 1950 the sample frequency was 3,583,125 Hz, controlled by burst synchronization.

No discussion of the color TV story would be complete without a whirl (literally) at the CBS Field Sequential System. The FCC granted permission to CBS to begin incompatible color transmission during the summer of 1950. The system used a spinning filter with red, blue and green segments in front of the pickup camera as well as the home receiver. The timing of World War II and the Korean War all delayed introduction and manufacture of this system.

Concurrently, RCA was working on a scheme to more efficiently apportion color signals. This process used balanced modulators; now the fog was lifting. By late 1950, with the help of some ideas from Hazeltine Electronics Corp., RCA had a system of two modulated subcarriers to carry the color information; even three equally rotated (120°) color subcarriers were experimentally used. By separating the monochrome signal from the color components and adding them

Edward Clay Wright Jr.

"Expanding your technical understanding and improving pictures today helps open the door for the next generation of television."

together at the CRT, the overall process of color production was simplified. In mid-1950, the "subcarrier folks" were playing with a scheme called "CPA" (color phase alternation) to minimize cross-talk between the color channels. On Nov. 26, 1951, NTSC adopted CPA and a 3.89 MHz burst frequency.

In 1952, burst frequencies were all over the map—3,898,125, 3,740,625 and 3,583,125 Hz (getting close now)—observations suggested that the lower the subcarrier frequency the better the color picture. While this tends to confound contemporary logic, it was due to cross-talk in that the effective bandwidth of the high sample systems exceed the linear bandwidth of the transmission system. A beat between color energy and sound was minimized by lowering the burst frequency about 3,500 Hz lower than 3,583,125, to about 3,579,625 (Gee, almost!); this took advantage of frequency interlacing whereby the color sideband energy would not add to the monochrome sideband energy. →

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On Sept. 12, 1952, at 1:10 a.m. 3,579,545 Hz was first broadcast. Today's color system made its debut in 1952. Bandwidth of color channels, quadrature modulation and constant luminance all sort of showed up with the help of Sarnoff's $130 million and over 100 engineers. The revised specifications for field test of NTSC-compatible color TV were released Feb. 2, 1953. So only 72 years after seeing by electrical signals, we had a plan for color.

Ready for the next step

Now some 36 years later (or 108 years after it all began) we are ready for the next step. We have put the bar up a few pegs, but it's still called high definition TV (HDTV). While a new HDTV system may say it starts with a "blank sheet of paper," we cannot fail to recognize the influence NTSC will have over any of its successors. Our degree of sophistication has grown both in technical competence and expectation. But there can be no assurance that any system less than fully exploiting the human visual sense will remain high definition over time, any more than when the term was coined in 1931.

The early days of television were a fascinating time; some interesting texts from the period include: *Vision by Radio* (Jenkins, National Capital Press, 1925); *Television Volume II* (RCA Institutes Technical Press, 1937); *Television Volume III* (RCA Review, 1946); and the petition of RCA, et al., to FCC regarding Docket 65008, June 25, 1953. Most of the reference items in this article were extracted from these publications.

Presently, the goal of most high definition proponents is to effectively double the horizontal and vertical resolution from those of NTSC capabilities. Today, NTSC develops about 260 lines of horizontal resolution when seen on the home receiver. No inconsiderable amount of the resolution reduction that occurs with NTSC is to be found in the transmission path and receiver design compromise.

One consideration advanced says, "In order to justify the expense of HDTV, it should be as visibly distinctive from current NTSC as color television was from black and white." The viewpoint goes on: "An increased aspect ratio would provide a better match between the display and the requirements of the eye..." The initial advantage of the increased aspect ratio would be that it is unmistakable; it provides the required distinction between HDTV and NTSC[1].

Dealing with reality and perceptions

In the remainder of this article we will explore how NTSC signals can be eroded through transmission impairments and consider some of the ways that we as cable engineers can evaluate and minimize impairments in our part of the TV chain.

I grew up watching Kukla, Fran and Ollie on my dad's 12-inch Motorola, watched the *Gillette Cavalcade of Sports* on grandma's Zenith 16-inch (the one with the nice big doors). My first TV set was an RCA color with a 16-inch screen and a case as big as an automatic washing machine (the cabinet needed to be because *Bonanza* was inside).

When Neil Armstrong took that giant leap for mankind, he stepped on my 23-inch rectangular Motorola. Looking back, I guess that the entertainment value exceeded whatever sensory deprivation we might have experienced. Was it dim, blurry or pastel? Sure, but it was television—that was what we had and that was what we watched. In the intervening years we have filled in the corners, brightened the screen by convincing the viewing public that orange is red and extended the mean time between failure to just about forever and, oh yes, put in stereo.

In the last two or three years talk of HDTV has dominated the industry with for the most part the notion that it is going to be perfect and eradicate that ugly, old NTSC. Some words of caution: We have noticed without pleasure or approval some of the published material of a rather wild sort dealing with television. The implication of such sensational statements is that the fortunate owner of a cheap TV receiver, seated in a comfortable armchair in his home, will touch a button and on the opposite wall will appear what looks like a huge motion picture in color, with sound, which reaches him by television. A twist in the tuning dial and he will see at will a battlefield abroad (a performance equal to the finest feature film), a football game or whatever other delights his fancy can conjure up.

Without wishing in any way to present a gloomy picture of what will actually occur, it is fair to say that those who expect what has just been described will be disappointed by the actual performance. A reasonable restraint in all statements made by individuals or by associations of manufacturers, broadcasters and engineers will be

useful in enabling performance to realize or, still better, to exceed expectations. These words recall the position of David Sarnoff in 1937, as sensationalism overtook reality in the development of television. Nova Beam projection TVs and CNN not withstanding, we are still waiting for most of this to come true.

If the TV industry is going to come close to fulfilling the vision of HDTV that's being sold as imminent reality, we all have a lot of work to do. The transmission path from film, tape or a live camera is full of peril—through space, clouds and coax—not so much limited by technology but limited by conviction. With regrets to Will Rogers, I would say I (almost) never met a picture I couldn't make better, and you can too. Before I make a few managers nervous, let me add "and not spend (almost) any money."

Try this test (kids, don't try this alone). Go in the headend, turn off the lights and sit down; it's important, psycho-sophisticates tell us, because you will see better. Tune through the channels. Don't look for the worst but for the best. Somewhere in all 30 or 50 of them is a Q Bird or Sister Angelica that knocks your socks off. Once you find that, focus hard because that is as good as it gets. This is state of the art 1989. No Kukla, Fran or reptile even got within 20 dB of this picture.

Get in a truck and go to a long cascade. Turn off the lights, get close—like four feet to the screen—sit down and look again. Don't arm yourself with NTC-7, a VM-700 or even so much as an extra F connector; let your conscience be your guide. Look hard, think about Sister Angelica or the Q Bird. If you think that the original NTSC version of the signal got to the subscriber's house in one piece, what's all the commotion about? But if your system visibly impairs NTSC you have some work to do. (By the way, if you have gotten this far, you deserve the truth: This article is not about HDTV, it's about reality.) If today's cable systems "bump off" 35-year-old NTSC, what chance does HDTV stand to get to the house in some recognizable form? Without your help, not much.

If you get a chance to see HDTV, do it; it is the ultimate calibration of your eyeball. My grandma (the one with the doors on her Zenith) used to say, "There is no zealot like a recent convert."

One of the definitions of HDTV is a visual image that has effective resolution equal to 35mm film. Brother, that is one tough assignment. All the technology, Kell factors and even quincunx sampling can't save you from the guy who writes the check because if it doesn't feel—make that *look*—good, he won't do it. If we as an industry expect to make a business of HDTV it's got to knock the average subscriber's socks off or we are wasting our time and money.

The road to first class

We need to start now examining what needs to be done so some day when a thousand lines of nifty video come coursing down our cable, we're ready. Whether "cable" means coax or fiber we have a real challenge to get the new pictures to the home in first class condition.

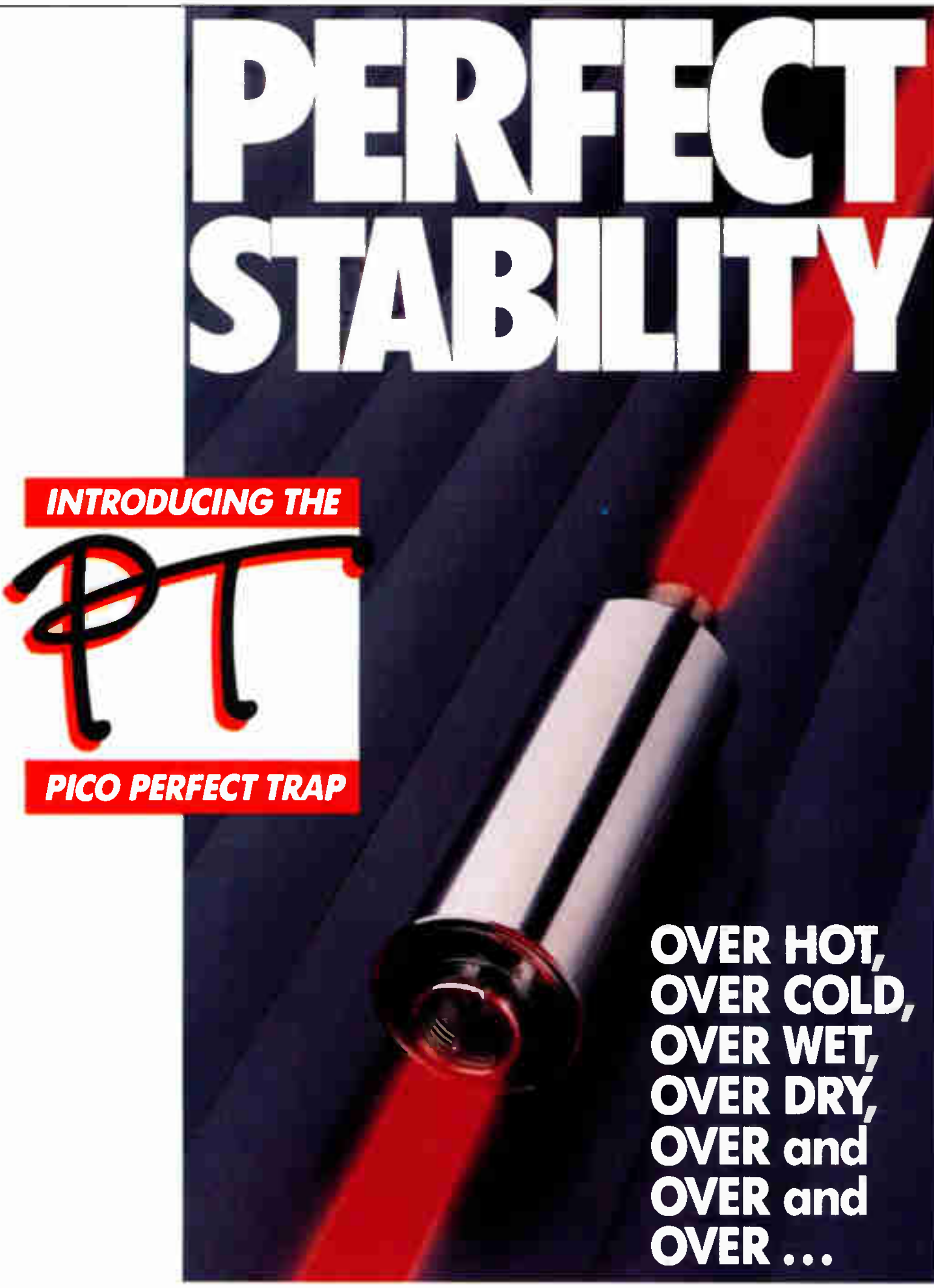
If the sub gets a look at better NTSC (it's likely, with Faroudja SuperNTSC or ATSC-E along the way), that's good because it starts him thinking about picture quality. A great analogy of what this entails is the compact disc. When Gabriel Heater or Fulton Lewis Jr. fought their way through a couple of kilocycles of bandwidth to get to the living room, that was state of the art.

Grandma probably would have not enjoyed, understood or lived through the spectral response of a heavy metal compact disc. The continuum from booming 12-inch speakers in the old Philco to the compact disc was ratified every step of the way by the end-user. He put his money down for hi-fi, stereo, cassette tape and CD. When DAT (digital audio tape) gets here, unless it's screwed up, he'll buy that too. These audio guys must know something we don't. When we made NTSC better through fully utilizing the hardware we have bought and paid for not only do we make the average sub aware of a good picture, we help instigate the same continuum in that having seen better, he asks, is there more?

Let's look at what can be done today to make sure we are fully exploiting the capability of our systems. This is sort of management by watching television.

Ever see stringy edges on a satellite picture, yellow or orange, that fills up with noise? More likely than not it's a faulty receiver or low input levels. Don't accept inferior satellite signals at face value; swapping around LNAs and receivers as well as examining power divider configurations may clear up a lot of what you thought came off the bird that way.

Get up close and personal with your headend. Look at levels, study pictures on a large-screen TV, look at video in vs. RF out, scrambler on vs. scrambler off. After combining, compare it to off-air. Don't expect pictures to get better, but when you give away some quality, know where and why. Careful A/B comparison can be more critical



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than sophisticated test equipment. Study the edges and fine grained detail; your eyeball with a good large-screen TV will rival the best test equipment.

Most systems carry off-air signals; in fact they are probably part of the original channel offering. Unless the wind has blown the old antennas away, there is a fair chance they are the oldest part of your system. Weak input levels, VSWR ghosts, electrical interference contamination and myriad other nasty things that would pass 20 years ago look awful today when only a click away from a 50 dB C/N satellite-delivered signal.

Most of these problems can be resolved for free; some may take money. Saying "it's always been that way" is a copout. Before you give up on a quality problem, be sure you fully understand what causes the picture impairment. Don't forget ground clutter; lots of good pictures die bouncing off the ground because local antennas are only a few feet in the air. Unfortunately, pictures are not always the best where your antennas happen to be. Signals plagued with close ghosts or multipath, selectively attenuating portions of the necessary spectrum, can frequently be dramatically improved by a slight relocation. Too often antennas for local signals have been sized with consideration only to the available output level. Higher gain antennas always have narrower beamwidths; this can help by reducing off-axis ghost arrival and performance limiting the field of view to noise sources.

The art and science of antenna configuration has gone slowly into the past of CATV. Log periodic antennas and quad stacks simply didn't exist all that long ago. Part of the popularity of modern antenna configuration is that it didn't rely on much local talent. You dragged it up the tower, peaked it up and there you were. For a large percentage of the cases that is good enough. Sometimes, however, quality was left on the tower in that more specialized arrays utilizing critical H lobe positioning or Z-stack rejection would be more effective; they are more complicated to assemble and get into place, but the benefits may be worth the extra effort.

A final point about off-air signals. Some systems have co-channel reduction systems based on a bucking signal being applied to minimize co-channel intensity in the downlead. If you have ever seen these things work, it makes you a believer. However, you may discover that pictures are softened through destructive addition. Or local electrical noise sneaks through the buck path, thereby contaminating the desired signal.

Every form of refuge has its price; just make sure you understand the tradeoffs. Incidentally, the behavior of your antenna (the one with the elements that the painters knocked off last year) may deserve a little attention. VSWR ghosts bouncing around in a few hundred feet of downlead are another sure way to prevent too good a picture from getting to your processor.

Frequently, hostile signals will far exceed the level of the desired signals on a downlead. The wholesale placement of preselection filters generally makes pictures worse than better. Most frequency selective devices also have some adverse impact on the desired signal. In practice it's not uncommon to see some rather large extraneous signals presented to the input of a processor. Take the time to study what's on the downleads and then make a decision what, if anything, you want to do about them.

What's all the buzz about

Let's talk about modulators. It doesn't take long to find out about video overmodulation; televisions will buzz about it and customers will call up, but who decides to turn it up? Undermodulated video degrades carrier-to-noise. Use a spectrum analyzer or demodulator with a zero carrier chopper; don't rely on built-in meters.

Most modulators are able to produce full (87.5 percent) modulation on as little as one-half a volt of video. Most receivers can produce a couple of volts of output. The point here is if you expect optimal performance it is important that the receiver and modulator be operated at their recommended levels. Some video sources have a very low source impedance so they tend to produce about the same output level whether terminated or not. Unless the electrical end of a video path is correctly terminated you run the risk of reflections at baseband softening luminance or upsetting the luma/chroma ratio. If you have 20 or 30 modulators in your headend, I'll bet a couple are screwed up!

Careful analysis of system performance may indicate a poor choice of operating levels. Many systems operate on levels that are largely historical. Incorrect sizing of pads and equalizers and their location relative to gain can dramatically upset signal-to-noise (S/N) ratios. Testing only the transmission plant on a low and high channel will point out problems of this nature. Most systems also rely on generalized output levels suggested by the manufacturers of amplifiers. You can bet that the best performance occurs at those levels *if* the circumstances of operation also match the specification sheet. This frequently is not the case, especially in the area of channel loading.

Too often quality gets bashed by not maintaining good position between the operating noise floor and the level of visibility for coherent (composite triple beat and cross-modulation) distortion. You may find that a system otherwise noisy can be significantly improved by raising operating levels. Conversely, systems that are very near visible coherent distortion may need lower levels. Nothing is magic about operating levels—the right ones position you in the Carson curve equally from noise and coherent distortion.

Tap levels and how they relate to converter input levels are another source of poor S/N. If your system is fully built out you probably can't do much about this. But as rebuilds and converter upgrades occur, care should be taken in maintaining sufficient input levels to the converter that C/N levels do not suffer. I wouldn't let the converter add more than 2-3 dB to the overall budget for noise.

Attachment of devices such as TV sets and FM tuners directly to the cable frequently provides a source of poor termination in that some sets and tuners are not characteristically terminated at 75 or 300 ohms. This produces a mismatch that will echo the house drop and soften pictures. Home receivers and tuners also may act as incidental antennas, picking up signals that are strong in the air and send them into the house drop, resulting in beats in certain channels.

Much has been said of late about the image of cable TV, the point being we as an industry have taken out more than we put back. This debate is likely to continue. Setting and obtaining technical performance goals is good for the customer, the industry image and ultimately ourselves.

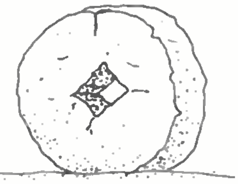
Keeping the door open

It is not so much that today's systems will be required to carry HDTV. In reality, many systems will probably be rebuilt yet again before HDTV comes to market. The issue that will most seriously affect cable's transmission of HDTV is the same issue that confronts NTSC today; that is, the ability of our engineering community to focus on quality and articulate sound engineering judgment to management. All of this won't happen over night, quality consciousness takes a while.

If you're in the beginning or middle of your cable career, HDTV is clearly in your future; you can help usher in the new wave of technology. Expanding your technical understanding and improving pictures today helps open the door for the next generation of television. These are exciting times and it's our chance to describe high definition; to place our point on the curve, let's put it high.

Reference

[1] "Perception Considerations for High-Definition Television Systems," Carlson and Bergen, *Television Image Quality*, SMPTE, 1984.



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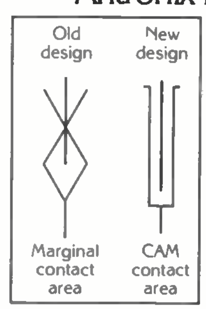

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The what, why and when of HDTV

By Isaac S. Blonder
President, Blonder Broadcasting Corp.

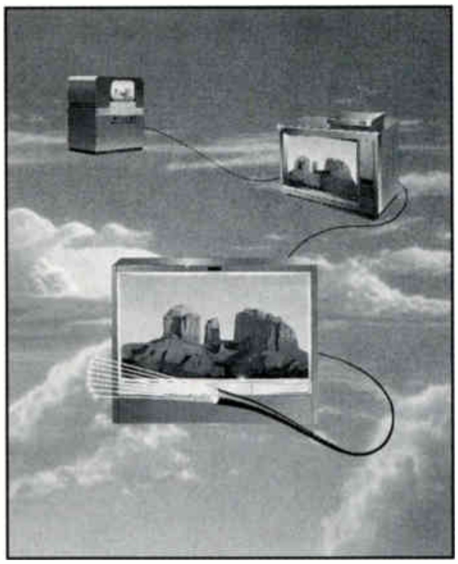
What is high definition TV (HDTV)? As technology has blossomed over the years so has the definition of TV image quality grown to match the limitations of the available apparatus. It now seems likely that engineers can produce images, under proscribed viewing conditions, whose quality exceeds the resolution capabilities of human vision. Picture quality is probably exponentially tied to cost; the problem facing the designers and regulators of home TV is what is the biggest bang for the buck.

The Federal Communications Commission on Sept. 1, 1988, with due appreciation of the available state of the art in TV engineering and concern for the consumer pocketbook, adopted a tentative decision in "The Matter of Advanced Television Systems and Their Impact on the Existing Television Broadcast Service." Every serious student of HDTV should possess a copy of this excellent overview of the present state of HDTV design and the options open to the FCC for implementing the service in the United States.

The commission announced three major tentative conclusions. First, the benefits of advanced TV (ATV) would be realized by the public most quickly if existing broadcasters are permitted to implement it. Second, it will require the initial ATV signals to be either compatible with existing TV (NTSC standard) receivers, or that broadcasters duplicate the program on another channel if the ATV system is incompatible with NTSC. Third, if additional spectrum is needed for ATV, it should be found within the existing VHF and UHF bands.

You may have noticed that the FCC uses the term "ATV" to characterize all forms of improved video and audio techniques. The commission states that "HDTV generally refers to systems that provide quality approaching that of 35mm film, whereas EDTV (enhanced definition television) refers to systems that perform better than NTSC but not on a par with 35mm film."

A good way to characterize the quality of a TV presentation is by the number of pixels (picture elements) contained therein. The number of horizontal lines is another commonly used standard of quality. The NTSC color pixel number is about 250,000. The new HDTV pixel number will be around 1.2 million, and a quality 35mm static print film jumps to 20 million(!), which takes about 4,000 lines of electronic means to replicate. Thus, 35mm film would seem to far surpass HDTV, except for the fact that mechanical and film processing deficiencies hold the actual showing to about 800 lines, which is still better than most proposed HDTV electronic schemes. The color quality and contrast ratio (difference in brightness between black and white) of film is measurably better than the best 1,000 line HDTV. Finally, Imax and Omnimax, the 70mm creations of Canadian science, have a film area 10 times larger than 35mm (thus 10 times more pixels) together with a rolling film gate and vacuum stabilized projector. These superb pictures have hypnotized audiences in every Disneyworld-like theme park on Earth.



Edward Clay Wright Jr.

"Rigorous field tests will prove the value of these ingenious schemes, but I suspect that the added picture quality will not be worth the cost."

The key to more pixels is more bandwidth—or alternatively a more effective use of the limited broadcast spectrum authorized by the FCC. While it is true that other transmission competitors (cable, satellite, laser discs) are blessed with more space, a common standard—or at the very least a compatible mishmash—is desirable so that all viewers could share the lower cost arising from mass production of the TV receivers.

Inducing reality

Psychophysics is concerned with the interpretation of the human visual system in physical terms that can codify the reaction of the human to the environment. An intimate knowledge of psychophysics is indispensable in the formulation of an HDTV transmission system that can induce the same response in the viewer on a lower spectrum budget. In my view, the first and most obvious defect in the attempt of all of the proposed HDTV systems to reproduce the original scene scanned by human vision is the fact that 2-D displays are not a substitute for 3-D human eyes and brain cells. An illusion of depth can be approximated by a clever director who manipulates perspective, size and color. Objects appear distant if they are small and dark and shadowed by the larger players. However, if the screen is enlarged to subtend a viewing angle of 90° or more, the human visual system can be induced into a state of pseudo stereo vision. Witness the effect on the audience watching such a large screen when a roller coaster ride is shown. The screams from the audience mimic the real thing, whereas the same shown on a small TV set would be boring.

There are several psychophysical aspects of the human visual system that help the HDTV system designer to reduce the bandwidth without affecting the perceived picture quality to the viewer. Flicker is not objectionable if the field rate is above 45, although with high brightness and contrast, 60 cycles is advisable. For a small-sized image, say, under 30 inches diagonal, the present aspect ratio of 4:3 is eminently satisfactory, as generations of movie goers have proven, with the extremely positive benefit of continuing a past practice at the lowest cost to the consumer. As an old designer of competitively priced electronics, I find it very painful in the pocketbook to read the very complex and obviously expensive proposals that do no more than widen the picture a minuscule amount, with darn little improvement in entertainment value—16:9 would never get past this chief engineer!

The biggest barrier to HDTV is the visual acuity of the eye, which is about 1 minute arc of solid angle for one eye pixel. Practically speaking, this limit to human vision results in no improvement over NTSC if the subject is seated 10 times the height of the picture screen away. The eye is insensitive to motion and sees motion as a blur; thus, the designer can use motion detection and cut the bandwidth sharply as it occurs. (Try counting the number of fingers on your hand as you move it rapidly past your eyes!) Color flicker can be tolerated down to 12 cycles, plus the eye's resolution for color is much poorer than for luminance; thus, bandwidth was saved here for NTSC as well as it will be for HDTV. Interlace was introduced as a sort of electronic shutter to raise the flicker rate to 60 cycles, and thus imitated the mechanical shutter of the motion picture projector. Unfortunately, eliminating the flicker with interlace brought on many other ills, which became more and more obtrusive as the other elements of television improved in quality.

Psychophysics is the key to reduced bandwidth HDTV, but it is an extremely esoteric and obtuse science for most engineers to master, including me. Any design team struggling to stuff HDTV into 6 MHz should work closely with the psychotheoretician and ask critically, "Is this minor improvement visible enough to be worth the cost and its possible transmission artifacts?" The FCC desires two designs—enhanced TV (improved NTSC) and high definition TV (roughly defined as possessing twice the resolution in both horizontal and vertical directions)—and it anticipates an open-ended increase in perceived picture quality where new standards will replace the old, *ad infinitum*.

Enhanced TV

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tained with extensive testing under field conditions. My experience is that any new idea takes at least two years from the concept to the production line, and you should add at least one year of user testing before the product is deemed a success. The announced timetables of the ATSC (Advanced TV Systems Committee) are wildly unrealistic—and they and the FCC should change standards only with proven, cost-effective technology.

Apparently the best suggestion for enhancing NTSC is to add a frame store to the receiver and read out the picture at twice the normal speed in a non-interlaced presentation usually called *progressive scan*. The vertical resolution is increased by about 40 percent, interline flicker is reduced and motion interpolation eliminates most of the temporal artifacts that plague the interlaced picture. Frame storage has another worthwhile feature: If the studio starts with an HDTV camera and transmits the picture elements in four sequential NTSC frames, the frame store receiver can then merge the information into a reasonable static replica of the original HDTV picture. I believe that no one has yet solved the motion artifacts.

The worst suggestion, in my opinion, for enhancing NTSC is augmentation via a non-contiguous frequency band. It involves more than the nuisance of a possible second antenna and a receiver, and it introduces variables like the signal level, noise content, time delay and shifting ghosts, for which there have not been reported sure cures.

Then there have appeared all sorts of ideas to add information via "holes" in the spectrum while retaining full compatibility with NTSC. These schemes add new subcarriers to the three existing carriers, mix modulation methods, time share the color subcarrier, and on and on. Rigorous field tests will prove the value of these ingenious schemes, but I suspect that the added picture quality will not be worth the cost. One bold brainstorm involves mixing a low level digital modulation into a complex analog format and dismissing the resulting poorer analog signal-to-noise ratio as being invisible. Let's not skip the field tests!

Combining and processing the multiplexed NTSC color and luminance at the transmitter and receiver is now an old art and worth the effort. One author estimated that equipping a TV broadcast station for HDTV would cost more than twice the price for color NTSC, which is a modern echo of the wails of financial agony that arose with the introduction of color.

Incompatible TV is another ballgame. The state of electronic art has advanced beyond belief—and maybe beyond understanding by us old scholars. There seems little doubt that a new NTSC committee could create a 1,000 line format based on a suppressed mid-band carrier, analog quadrature modulated with the high frequencies and with the low frequencies digitally modulated on the vertical blanking interval, blessed with four digital audio channels, secure scrambling and addressability. If the FCC does approve a 6 MHz incompatible HDTV system then the odds are that in one generation all receivers will be capable of dual reception, and good old NTSC will be no more!

Coping with change

Why do we need HDTV? If technology stood still, if our viewing devices remained the same, if the programming retained its intimate style, NTSC could withstand all criticism. But none of the above is true. I have been informed by unimpeachable sources that the next reasonably priced large-screen size will be 1 meter (3 feet diagonal) on which NTSC will look like the projector operator is asleep again at the focus control. Movies will be fed from a laser disc looking as good as the neighborhood movie theater. Every other means of delivery, except terrestrial broadcasting, will have the bandwidth needed for HDTV.

When will HDTV arrive? Once upon a distant time, NTSC was called "HDTV" by its proponents. Today, the FCC is defining HDTV as possessing approximately 1,000 lines of resolution. If the present pace of researching, designing and testing is not accelerated until a winner is selected and made the U.S. standard, we will be years behind the HDTV systems in vogue abroad. History seems to be repeating itself. At the time of our highly touted birth of television at the 1939 World's Fair in Flushing, N.Y., only 200 TV sets existed in New York, while across the ocean, England had been broadcasting for three years to 20,000 home viewers. Unfortunately, the United States is now a country with negligible research funds for television and "When will HDTV arrive?" is held hostage by Congress and the MBAs.

Reader Service Number 26.

Selected topics on HDTV: A tutorial on the basics

This article does not, in general, present any new information on high definition TV (HDTV). It provides a fairly concise explanation of several fundamental aspects of HDTV and its signal processing in one source. A general understanding of underlying techniques is helpful in evaluating various business and technical choices. References are made to more detailed papers for those who wish to pursue certain subjects.

By Gerald H. Robinson
Principal Engineer, Scientific-Atlanta

Resolution is the *raison d'etre* of HDTV, even though other parameters have great importance. Resolution in TV display is ultimately the degree to which fine lines can be distinguished. Resolution is limited by each step of the TV process: the camera lens and sensor, camera scanning aperture, video processing, transmission bandwidth and display device parameters, etc. An understanding of how resolution is measured and perceived is necessary in evaluating tradeoffs of system parameters.

Let's first look at the ability of the typical eye and brain to perceive fine detail. Consider alternating black and white lines of equal width. If the lines are made ever narrower while viewing distance remains fixed, they eventually appear to the observer as gray rather than separate lines; this is the limit of visual resolution. The disappearance of the line structure is gradual. A *limiting resolution* can be defined as that line spacing at which contrast sensitivity of the observer has dropped to some specified percentage of maximum sensitivity. This limit has been determined to occur when the spacing of the lines is about 1.5 to 2 minutes of arc[1,2] as shown in Figure 1. Equation 1 describes the relationship between minimum line spacing and viewing distance:

$$d = 2D\tan\left(\frac{\alpha}{2}\right) \quad (1)$$

where:
d = line spacing
D = viewing distance
α = minimum resolvable visual angle

Figure 1: Geometry of the limit of human visual resolution

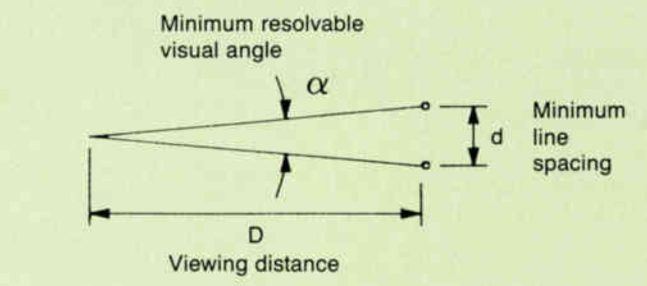
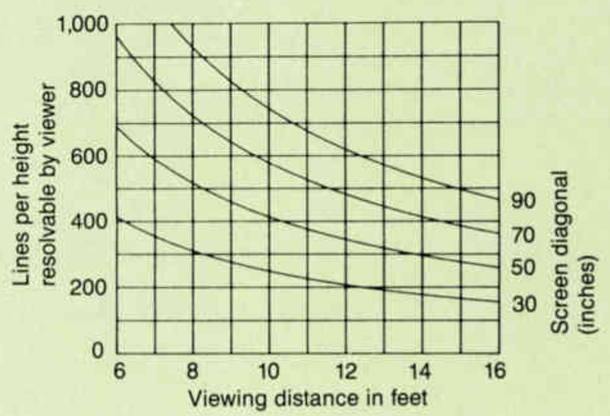


Figure 2: Resolution related to viewing distance and screen size



How display resolution is measured

Expressing resolution in degrees is a meaningful description of human visual acuity. A similar measure is needed for describing the resolution of a display. Here we seek a description of the smallest line spacing that can be resolved when viewing from such short range that the display, not visual acuity, is the limit. This is the maximum resolution of the display. Minimum line spacing could be used as a measure, but a given display type will have a fixed number of lines so that spacing varies with display height. The seemingly logical unit of lines per inch presents a similar problem as display size is varied. For displays, the logical measure is lines per picture height, which is a constant for a given system without regard to picture size.

Consider an array of lines extending to a height *H*. The number of resolvable lines within that height when viewed from a particular distance is:

$$R_v = \frac{H}{2D\tan\left(\frac{\alpha}{2}\right)} \quad (2)$$

where:
R_v = vertical resolution in lines per height (lph)
H = height of display

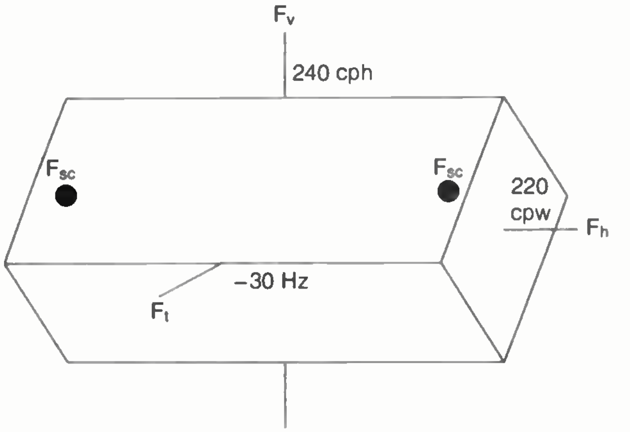
Lines per picture width would be equally useful but the unit for both vertical and horizontal resolution must be the same if consistent meaning is to be maintained. Lines per height has come to be the accepted unit. One frequently sees lines per height used for vertical and lines per width for horizontal resolution. While there is no correct and incorrect usage, it is more meaningful to convert those numbers given in lines per width to lines per height by dividing by the width-to-height ratio.

Actual measurement is usually accomplished by displaying a pattern of lines that are disposed along various axes (vertical, diagonal, etc.) and that vary in spacing along their length. The spacing at which they are "not resolvable" is noted by observers. This resolution chart could be produced by a camera or generated electronically, depending on what parts of the system are to be tested.

How much resolution is needed? The relationship between the limit of vertical resolution and viewing distance is shown in Figure 2 for several screen sizes. Take a screen size of 50 inches and a viewing distance of nine feet as an example. The limit of vertical resolution is about 460 lph. If the display resolution were increased to greater than 460 lph, the observer would have to move closer to appreciate the finer detail. The same applies to horizontal resolution expressed in lines per height. Imagine the same array of lines rotated 90 degrees and increased in number to fill the width while keeping spacing unchanged.

One might conclude that simply moving closer to smaller screens would allow appreciation of high resolution pictures. But other factors must be considered. People are not comfortable sitting too close to a display. When several viewers are involved, sufficient space must

Figure 3: Nyquist volume of interlaced NTSC luminance signal



be allowed for these viewers without their angle of view to the screen becoming so great as to cause them to lose aspect ratio and distort their perception of objects on the screen. There is no absolute resolution requirement that can be set, but 500 lph appears quite adequate for reasonable screen sizes and viewing distances.

A word about sharpness: Resolution of detail and edge definition are two separate parameters. Both are important to the perceived quality of a picture. Edge definition can be, and often is, improved without increasing bandwidth. Such improvement requires care if results are to be consistently pleasing. The point here is that there are parameters related to perceived image definition that are not directly related to measured resolution.

Scanning lines and interlaced scanning

There is a distinction between scanning lines and lines of resolution. Scanning lines represent vertical samples taken through some weighted aperture (image detector's "spot") of finite width and displayed through yet another aperture (display "spot"). Alternate scan lines can certainly be made to be white and black, but it does not follow that the display of an array of lines viewed by a camera would be accurately displayed at this limit. This brings up the often used and abused Kell factor[3]. Consider a progressively scanned image. The Kell factor gives the relationship between display resolution and scanlines, being the ratio of the former to the latter. The Kell factor was originally intended to disclose the system bandwidth required to permit equal vertical and horizontal resolution.

The Kell for progressive scan has been given values ranging from 0.53 (Mertz, 1934) to 1 (Wendland, 1984)[3]. One must look askance when values are ascribed to the Kell factor. A value of 0.7 is often used for progressive scan, but again this is more by convention than any measure. The point is that a scanned (sampled) image can only be displayed with resolution somewhat less than the number of scan lines. The reasons lie in the optics, scanning aperture of the camera and the display. It is better to discuss these parameters directly than to try to simplify the whole issue to a single number. This number proves difficult to define and even more difficult to measure. In any case, the Kell factor is related to the camera and display rather than an encoding or transmission system.

Interlaced scanning is a means to reduce the transmission bandwidth requirement. It displays two sets of scan lines offset vertically so that they interlace and offset in time so that one set may be transmitted after the other. When we introduce temporal considerations, two constraints are apparent: The complete image must be updated frequently enough to cause motion to appear natural and the pulsation of brightness must be at a rate faster than the eye can track so that flicker is not perceived. By displaying half the lines at a time and interlacing, these objectives can be met with less bandwidth than required by progressive scan.

It might appear that vertical resolution would be the same for interlace as for progressive scan. If both sets of lines were present at equal brightness at the same time, this would be true for static pictures where the interlaced information is exactly that needed to complete the picture. Often a Kell factor for interlaced scanning is stated, but this stretches the Kell factor beyond its limit. In order to understand how interlace is perceived, one must consider aliasing. When a signal is sampled less than twice per cycle (the Nyquist limit), the sampled output will display some other frequency, or alias.

Consider one field of an interlaced scan. Since half the lines are used in one field, vertical information is aliased unless the resolution of the source image is filtered to reduce its vertical frequency content to one-half that of progressive scan. Of course, this is not done, since unacceptable resolution would result. If the image of one set of lines persisted in the eye until the interlaced set were present, this alias would not appear because the missing information would now be present. But the persistence of the eye is not this great. If it were, motion blur would be bothersome in viewing natural images.

The situation for static images is that the resolution is present but so too is some alias. Trying to explain this effect as a reduction in resolution is a bit like saying I have 10 men, five of whom have a wooden leg, so I have seven men. The point is that interlaced scanning results in a perceived quality that is less than that of progressive scan. Line structure is more visible with interlace since one set of lines fades somewhat before the second set appears. This also causes lines to "crawl" up the screen. When a sharp horizontal edge is displayed, flicker occurs since one line at the edge is refreshed only every other field. During motion, the interlaced information is somewhat different from what is required to accurately represent the source. Interlaced scanning made television practical but it carries some undesirable baggage.

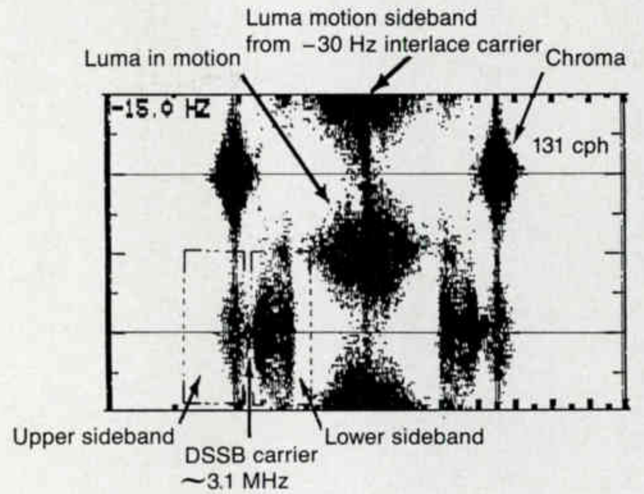
Three-dimensional spectra

Thus far vertical and horizontal resolution have been discussed and temporal concerns mentioned. It is possible to describe a TV system in terms of its ability to display spatial frequencies (i.e., vertically or horizontally varying luminance) and temporal frequencies (variation from frame to frame). Of course, real pictures have variations that are a combination of all three. This leads to the three-dimensional spectrum. It might be better titled "spectral domain" than "spectrum" since the possible range of the system is represented and not the specific spectral content of a particular scene. An understanding of many of the processing techniques used in enhanced NTSC and other advanced TV systems requires an understanding of the three-dimensional frequency spectrum. We will attempt to give a brief overview here. A more complete treatment can be found in Reference 4.

Figure 3 shows the three-dimensional spectrum for NTSC luminance. First, without concern for why the spectrum is of this shape, consider the axes and units. The axis labeled F_v represents vertical frequency in cycles per picture height (cph). If we think of sinusoidal variation of intensity along the vertical axis, a series of dark and light lines are perceived extending horizontally across the screen. In terms of lines per height, as used in the previous discussion of resolution, there are two lines per cycle.

As we will see later, the spectrum shape is related to sampling patterns and frequency filtering and ignores such things as camera aperture, etc. The highest vertical frequency is 240 cph, which corresponds to 480 lph (the number of active vertical scan lines in NTSC). Similarly, the axis labeled F_h represents horizontal frequency in cycles per picture width (cpw). We could have used cycles per picture height as for the vertical but since the spectra are often related to sampling, relationships between samples per line and spectral frequency are simpler when cycles per width is used. Sometimes, the horizontal axis is labeled in Hz[4].

Figure 4



There is a direct relationship between baseband bandwidth and maximum horizontal frequency. In horizontally sampled systems, there is a direct relationship between sample spacing in seconds and horizontal frequency in Hz. However, labeling the axis in this way can imply a relationship between the baseband spectrum and the spatiotemporal spectrum that is not accurate. For example, a point lying at 1 MHz on the horizontal axis of the spatiotemporal spectrum does not imply a spectral line at 1 MHz in the baseband spectrum as could be inferred from such labeling.

The remaining axis represents variation of intensity from field to

Figure 5

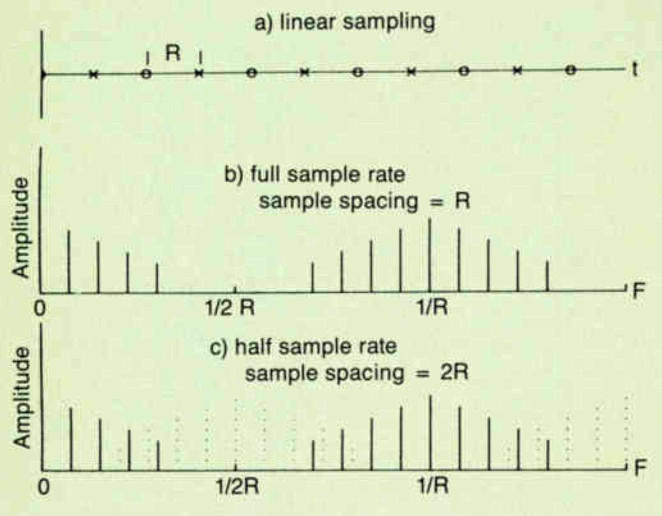
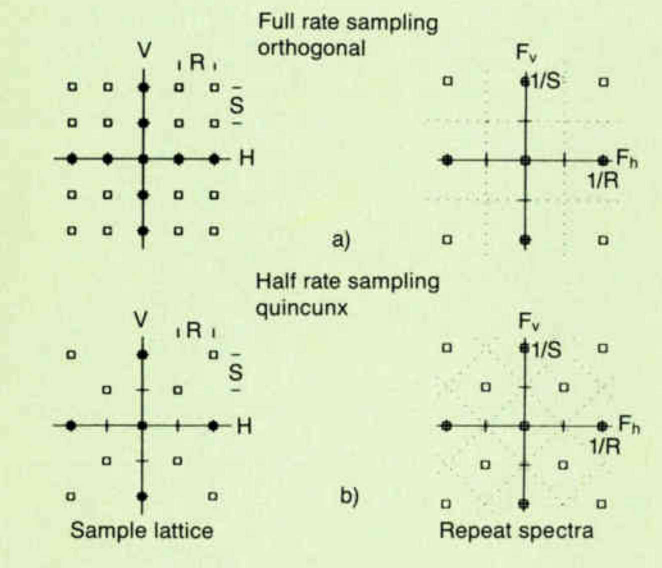


Figure 6



field and therefore with time. It is logically labeled in Hz or cycles per unit time.

We now see that points on each axis represent intensity variation with a unique parameter of the spatiotemporal domain. The origin represents an unvarying flat field of some intensity. Points on the vertical axis represent unvarying horizontal lines spaced vertically on the screen. Points on the horizontal axis represent unvarying vertical lines. Points on the temporal axis represent flickering flat fields. Note that nothing is implied about the amplitude of any component, only its frequency of variation with some parameter. As we move off-axis, we represent combinations of two or more types of intensity variation. Points off-axis within the vertical/horizontal plane represent more or less diagonally oriented lines. Similarly, off-axis points within the vertical/temporal plane represent horizontal lines moving up or down the screen. The spectrum is double sided; a given frequency appears as four symmetrically located points.

Real pictures have different components disposed spatially within the picture. There are static flat field regions, combinations of vertical and horizontal detail and areas in motion. A fourth dimension relating the level of these various elements is required if actual spatiotemporal spectral content of a scene were to be represented. Figure 4 (taken from Reference 5) gives some feel for this. The figure shows a two-dimensional section of the -15 Hz temporal plane. It includes an added subcarrier in the so-called "Fukinuki hole." This is a feature of ACTV-I as proposed by the David Sarnoff Research Center.

The black areas represent picture spectral content that exceeds an arbitrary threshold level. Only image that is moving has components in this plane shown in the figure. The central dark area represents moving luminance information. Chroma information appears in luminance as dots (a checkerboard) moving up the screen (see Reference 6, Figures 4 and 8) and therefore appears in the upper half of this luminance spectrum. Note the location of the color subcarrier in Figure 3; the chroma in Figure 4 is centered around this point. Also note that the figure includes areas outside the spectrum of Figure 3. The information content that is outside represents vertical/temporal aliasing due to vertical scanning (sampling) and temporal sampling (interlace).

The boundaries of the spectrum are set by aliasing constraints. The spectrum represents an alias-free region. More generally, it represents a *potentially* alias-free region. Usually, the spectrum shows the limitation imposed by the sampling pattern and not the results of actual spatial filtering. This is the case for the NTSC luminance spectrum shown. (More about sampling and the shape of the spectrum later.)

We now have, hopefully, a reasonable picture of the three-dimensional spectrum and to some extent how the boundaries are determined. A general understanding of the relationship between the three-dimensional spectra and baseband spectra is needed to understand how spatial and baseband filtering are used in compressing transmission bandwidth. We have seen at least one tie to the baseband spectrum or frequency domain in terms of the color subcarrier. Consider how a sinusoid at baseband would appear on the screen. Frequencies that are integral multiples of the line rate appear as static vertical lines because they begin each line at the same phase, each line containing an integral number of cycles. Frequencies well below 29.97 Hz appear as flickering flat fields. Frequencies that are multiples of 59.94 Hz but lower than line rate appear as static horizontal lines. Equation 3 yields the baseband frequency corresponding to combinations of spatial and temporal frequency:

$$F_b = F_hF_l + F_vF_{fd} + F_t \qquad (3)$$

where:
F_b = baseband frequency
F_h = horizontal frequency (cpw) in integer values
F_v = vertical frequency (cph) in integer values
F_t = temporal frequency (Hz)
F_l = 15.734 kHz (line rate)
F_{fd} = 60 Hz (field rate)

From this we can see that baseband frequencies that appear as only horizontal spatial components lie at integral multiples of line rate. Similarly, those that appear as vertical components lie at integral multiples of field rate. The diagonals are combinations of vertical and horizontal frequencies so that (at baseband) they lie between integral multiples of line rate. Baseband frequencies that include motion appear between the 60 Hz steps that represent spatial frequencies. For example, the color subcarrier frequency can be analyzed with Equation 3. It has components F_h = 227 cpw and F_v = 131 cph and F_t = 7.5 Hz. This corresponds to the locations in Figures 3 and 4. If the color subcarrier is alternated in phase from field to field, the same checkerboard moves down the screen. This corresponds to locations on opposite vertical temporal diagonal at the same horizontal frequency (the Fukinuki hole).

Phase alternation between fields adds other spectral lines. Other points within the spatiotemporal spectrum require more complex modulation. For example, frequencies along the horizontal axis that are not integral multiples of line rate require modulation of phase at the line rate.

Sub-Nyquist sampling

Sub-Nyquist sampling is a feature of most HDTV proposals; it occurs

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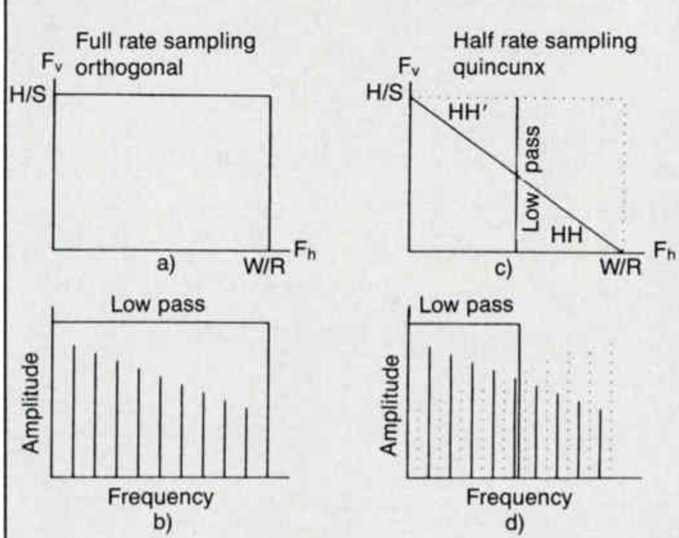

Figure 7: Spectrum folding

in NTSC. Stated simplistically, sub-Nyquist sampling means sampling at a rate less than twice the highest frequency of the sampled signal. This always and unavoidably produces aliasing, so how can this yield good results? The answer in the case of NTSC interlace is that the alias doesn't look so bad. In advanced systems, the answer lies in extending the sampling concept into two (or more) dimensions and judicious pre-filtering of the sampled multidimensional signal. Consider the one-dimensionally sampled signal of Figure 5 and its associated spectra. The signal being sampled in Figure 5a has different values vs. the variable *t*. The frequency spectrum of this signal is represented by the first group of spectral lines near zero frequency. The primary spectrum is disposed about zero frequency and repeated at frequencies that are integral multiples of 1/R (where R is the sample spacing). The repeated spectra show how higher frequencies appear to represent elements of the original spectrum.

If the signal is filtered to eliminate components above 0.6/R before sampling, the spectra will extend as shown in Figure 5b. There is no overlap or alias in this case. If there were no filtering at all, frequencies at 1/R would appear as DC in the output, for example. While the units could be seconds and Hz, they may be more general. Eliminating every other sample spaces repeat spectra at integral multiples of 1/2R, as in Figure 5c. The regions of overlap represent aliasing. Reducing the bandwidth of the sampled signal further would eliminate aliasing but also would exclude some information. The maximum bandwidth that can be supported by a particular sampling pattern is unique and readily determined for single-dimensional sampling, being one-half the frequency spacing between repeats.

We must extend our understanding of aliasing to the multidimensional case for the TV image[7]. We will compare two particular two-dimensional sampling patterns (Figure 6) that are of special significance. These are orthogonal (Figure 6a) and quincunx (Figure 6b) sampling patterns. Note that the units refer to the horizontal/vertical spatial plane but could be more general. Ultimately we wish to apply the results to different planes (say, the vertical/temporal in the case of interlace). The associated two-dimensional spectra are shown in the same figure.

Transformation of the sampling lattice to repeat spectra location is fairly straightforward and is covered well in References 4 and 7. Note that the quincunx pattern has half as many samples as the orthogonal and that alternate vertical and horizontal samples have been discarded, producing the "figure of five" grouping. Pre-filtering will clearly be required to eliminate aliasing. Now that two dimensions are involved, there is no unique filter to eliminate aliasing. A particular shape is shown around each repeat spectrum in Figure 6, but any shape that can be replicated around each repeat so that it exactly fills the plane would work. The shape shown is of significance among the possible tessellating shapes. It is formed by the perpendicular bisectors of lines joining the primary spectrum and nearest repeat spectra. The area of this shape is referred to as the primitive bandwidth of the sampled signal.

Digital filtering can more readily define this shape than some others[7]. Compare the area of these primitive bandwidths. The primitive bandwidth of the quincunx pattern is one-half the primitive bandwidth of the orthogonal pattern, which has twice as many samples. This is an extension of the Nyquist limit to the two-dimensional case. When the number of samples is reduced by half, so too is the alias-free bandwidth. Herein lies the advantage to be gained. The primitive bandwidth of the quincunx pattern retains the same vertical and horizontal resolution as for full orthogonal sampling with half as many samples. Only diagonal resolution has been lost. Diagonal resolution, which is not as important to the eye, was greater than either horizontal or vertical resolution before filtering.

The same quincunx pattern occurs with interlaced scanning when the vertical/temporal plane is considered. We again see that the vertical resolution of interlace can be the same as progressive scan from a sampling standpoint. This is not to say that this resolution can be fully perceived when alias, etc., is considered. The two sets of lines are not presented simultaneously at the same brightness, for example. Also, the shape of the actual vertical/temporal plane response is determined by scanning apertures, etc., which do not produce the filter shape of the primitive bandwidth. Of course, no filter is required if signal frequency content does not extend outside the Nyquist region.

Spectral folding

Refer again to Figure 6b showing the quincunx sample pattern and its primitive bandwidth. We have already noted that the diagonal frequency content of the signal must be removed to prevent aliasing. We also noted that full vertical and horizontal bandwidth is transmissible. When we consider the samples as a long string of one-dimensional samples (which is in fact how they appear from a transmission standpoint), the transmission bandwidth requirement is clearly one-half that for full rate orthogonal sampling. Where does the added information travel in transmission? In the spatial spectrum it can be viewed as folding the high frequency horizontal information into the region that represents diagonal frequencies, as in Figure 7. Full orthogonal sampling is shown on the left, giving the spatial (Figure 7a) and baseband spectrum (Figure 7b). The full rate signal is diagonally filtered before down-sampling to produce the spatial spectrum bounded by the solid diagonal line (Figure 7c).

Quincunx sampling then produces an alias in the area bounded by the dotted line. This is simply one quadrant of the spectral plane shown in Figure 6 extending to the first repeat. Low pass filtering limits the spatial spectrum as shown by the vertical line. High horizontal frequencies (marked HH) are repeated in the alias marked HH'. In the transmission spectrum, this energy is interleaved between lines of the original spectrum (Figure 7d). This interleaving is produced by the repeat spectrum introduced by halving sample rate (Figure 5). Remember that video spectra have energy concentrated around multiples of line rate and that concentration is dependent on spatiotemporal frequency content of the image. Analog component

systems have no interlaced subcarrier between these energy peaks to interfere with folded information. Diagonal information from the original image would have traveled here but was removed by the diagonal filter prior to down-sampling.

Proper resampling after transmission recovers the spatial information, unfolding the spectrum. In fact, filtering and sampling at full original sample rate produces interpolation of the missing samples.

This example shows folding that extends to DC. There are many choices that could be made. The folded energy could be limited to only the upper range of frequency, for example. Completely different types of folding could be used. Suppose a progressive scan image is quincunx sampled as in the previous example (after diagonal filtering). Then take the samples from alternate lines and move them up to fill the gaps in the previous line. This composite can be transmitted at the interlace rate. Vertical (line to line) differences would appear as high horizontal frequency in the transmission. These signals could be recovered at the receive end by simply filtering the baseband to separate the high frequencies representing vertical difference from the primary picture information.

Temporal effects

The sampling techniques previously described involve periodic offset of sample position. In the example of two-dimensional spatial sub-Nyquist sampling, the sample pattern is offset horizontally from line to line. Motion does not affect the results if all samples are from the same field and may be considered to be at the same time. With interlace scanning, the samples are offset vertically from field to field. We have discussed some effects of motion that occur because the offset is between fields and therefore at different times. The temporal effects of single-field offset with interlace are acceptable in NTSC. Sub-Nyquist sampling is extended further in some systems (MUSE, for example). Four-field offset is used in that system to allow large bandwidth compression.

Motion produces unacceptable errors in a sampling pattern spread over such a large time span. How one deals with motion depends on the degree of complexity that can be justified. Certain types of motion, pan and tilt, can be measured to a degree and this information transmitted. One can imagine combining the field memories in the receiver with appropriate offsets or rotation, etc., to correctly reassemble the image. Alternately, two (or more) different sampling strategies could be employed, one for high resolution and little motion, another for lower resolution and larger motion. One or the other or a mix could be transmitted along with information about the selection. The question is how much complexity and cost can be justified in the receive hardware and what artifacts can be tolerated.

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A testing program in preparation for advanced television systems

By Nick Hamilton-Piercy
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Rogers Cablesystems Inc.

An organized approach in preparation for advanced TV (ATV) systems by the cable industry started about two years ago when the NCTA Engineering Committee formed the Subcommittee on High Definition Television (HDTV). That subcommittee's purposes are twofold: 1) the technical characterization of the transmission of existing cable plants and 2) liaison with various ATV proponents to ensure they understand CATV transmission characteristics and are adapting their proposed standards for distribution through this medium.

The need to have a cable-compatible terrestrial ATV format is being clearly articulated to these proponents. Over 65 percent of American TV households are projected to be receiving their signals via cable at the expected launch date of ATV (and with over 85 percent of the homes being so connected in Canada).

The launching of Cable Television Laboratories occurred subsequent to the subcommittee's formation. Its timing was very fortunate, since much of the ATV testing had been very labor- and test equipment-intensive. Testing under the organization of the NCTA subcommittee would have placed too much of a demand on its loyal, voluntary supporters.

Summary of subcommittee's work

The NCTA subcommittee has conducted some overall generic cable system characterization and has focused on two sources of transmission impairment: the effects of phase noise and reflections. It also has participated in some feasibility transmission tests of an actual proponent system. The subcommittee evaluated the NHK MUSE format over several operating cable plants at the 1988 Western Show and through two different plants in the Washington, D.C., area in the spring of 1989. These tests showed that, at least for MUSE, transmission through existing cable plant presents no significant problems.

General transmission characterization tests were conducted in collaboration with the Canadian Advanced Broadcasting Systems Committee using several typical CATV plants in Canada that represent both old and state-of-the-art design. Field testing was concluded during 1988; preliminary results were presented at the 1989 NCTA convention.[1]

A somewhat sophisticated test method was used to evaluate many of the parameters. A specially formatted test pulse is passed through the system and mathematical analysis performed on the received pulse, which yields the extent of various transmission impairments. Extensive computer analysis is required in this evaluation; the final results were expected in the late summer. However, preliminary results show nothing unexpected and confirm that the specifications for such parameters as carrier-to-noise (C/N) and reflections on existing cable plants will require some upgrading to eliminate the degradation of an ATV signal. Traditional designs ensure a minimum C/N of about 43 dB at the subscriber's premises. Initial tests on at least two proposed ATV systems show C/N requirements of 49 dB or greater if noise is to remain imperceptible to the majority of viewers on a large-screen TV.

In the area of specific testing, the first tasks were to evaluate the effects of phase noise on an NTSC picture and to characterize the cable plant's contribution to this noise source. Traditionally, phase noise has been somewhat ignored by CATV engineers as a contribution to picture impairment. It originates in signal sources such as oscillators and in particular non-crystal stabilized oscillators (i.e., synthesized sources). An oscillator's phase noise is significantly increased if its fundamental frequency is subject to large multiplications, such as would be the case in a local oscillator for a microwave transmitter or receiver.

The subcommittee's tests confirmed that microwave transmitters, receivers, headend modulators and demodulators, and set-top converters all introduced phase noise—with the baseband set-top being the biggest offender. (These findings are discussed by Dan Pike and Rezin Pidgeon[2] and by Pike and Gerald Robinson[3] in the *1988 NCTA Technical Papers*.)

In many existing cable systems the amount of inherent phase noise is close to perceptibility on a good quality NTSC picture. In feeder systems involving complex signal processing, microwave distribution and baseband set-tops, phase noise may already be at the perceptible level. Perceptibility becomes even more pronounced in TV receivers with synchronous detector circuits. Unfortunately, these circuits are becoming more popular in the consumer electronics marketplace.

The detailed characterization of the effects of echoes and group delay proved a more challenging task than originally anticipated. This was due to the complexity of the echo simulating test bed and the need for a significantly representative sample of state-of-the-art TV receivers. Luckily, an excellent facility at the David Sarnoff Laboratories was made available for the group.

CATV engineers for many years have been using echo perceptibility specifications based on works by people such as Pierre Mertz, A.M. Lessman and others[4,5]. This early work utilized observations made on then state-of-the-art monitors that had black and white pictures of relatively small size with somewhat band-limited

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circuitry and were inferior by today's CRT technology. The net result was that the pictures were of a poorer resolution and lower brightness level. Intuitively it seemed that this equipment would provide early observers a more benign environment for the perceptibility level of echoes.

In late 1988, the NCTA subcommittee undertook its first tests at the Sarnoff Labs. These indeed showed the perceptibility level to be substantially more critical than originally depicted on the classical echo ghost curves used by cable and broadcast engineers. However, on subsequent analysis a fixed delay error had crept into the recorded results during testing, throwing some doubt onto the findings. Due to the importance of re-establishing these echo perceptibility curves, retesting was deemed essential.

"ATV signals (especially those involving substantial time compression) will be particularly sensitive to the effects of echoes."

A request was made to the newly formed Cable Labs to sponsor these tests, since travel and access to Sarnoff all required monetary assistance. Under the auspices of Cable Labs the testing was conducted early in 1989. Since the previous testing the facility had been upgraded to feature samples of each of the latest TV receivers including digital circuitry improved definition NTSC receivers. The findings from this test session confirmed that echoes were perceptible at a substantially lower level than depicted by the classic "Mertz curve," especially in the less than 250 ns region. Particulars of this testing is reported by Pike in *1989 NCTA Technical Papers*[6] (reprinted in this issue on page 46).

Cable Labs plans toward the end of 1989 to release a full research monograph on this echo perceptibility testing along with a revised curve. With the reflection requirements established for imperceptible echoes in CATV, further work is required in characterizing those echo-prone parts of the feeder plant. Changes, if any, that are required in the architecture or components specifications to improve echo performance can be determined from these findings. ATV signals (especially those involving substantial time compression) will be particularly sensitive to the effects of echoes. Headend combining networks, TVRO interconnections, feeders and internal home wiring around the VCR and TV set are expected to be the most significant contributors of short delay echoes.

Broadcasters' concerns

The principal focus in establishment of a North American ATV standard has been from the over-the-air perspective. This is driven by spectrum considerations. If sufficient spectrum is not available for the transmission of HDTV, broadcasters may be forced to accept a standard that gives substantially inferior HDTV quality than competing media or possibly be pre-empted from transmitting HDTV at all.

The Federal Communications Commission, in enacting its mandate of administrators of the spectrum, have by necessity gotten very involved in setting HDTV standards. Working Parties (WPs) were formed to study various aspects of the standards setting process including the testing of competing HDTV systems. The broadcasters have put together the Advanced Television Test Center (ATTC) as a facility through which each proponent can be thoroughly tested with the result passed to the FCC's WPs for evaluation and selection of an appropriate system.

In general, alternative distribution media (such as cable, videocassettes, satellite, microwave, etc.) are not a prime focus of the standard setting process—these don't use over-the-air spectrum. A standard quite inappropriate to these media could emerge, should the organizations associated with them not take a proactive stand.

An area of particular importance to CATV is the testing of proponent systems in a cable environment and an early assessment of how well each system performs when subject to various amounts of specific cable transmission impairments. Cable Labs through its HDTV Project Group is developing a cable-specific test plan and test procedures for this purpose. It has arranged with the ATTC to conduct the testing at the latter's facility. Cable Labs will provide the

(Continued on page 94)

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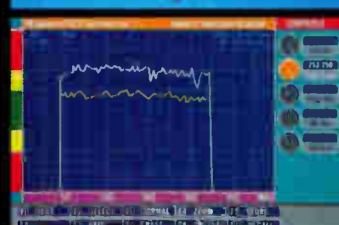
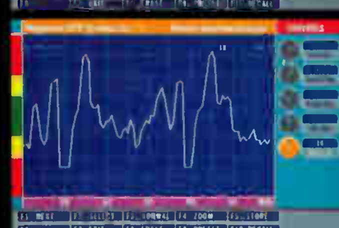


MLM display showing sweep response. White is actual response; yellow is stored response.



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The effects of reflections

By Dan Pike
Vice President of Engineering, Prime Cable

Group 1 of the National Cable Television Association's HDTV Engineering Subcommittee is charged with the investigation and documentation of signal transfer characteristics in cable systems with particular emphasis on parameters useful in forecasting the transparency of a cable system to various advanced TV transmission proposals. Improved quality of present cable service is also an expected result. Previous work was reported in the *1988 NCTA Technical Papers.*

As TV receiver display technology improves, screens get larger and viewing distance relative to picture height gets smaller, concerns increase about the effects of RF reflections in a cable system and whether they might limit acuity in the detected signal. The generally accepted guideline for impairment due to reflections comes from work done by Pierre Mertz[1] more than 35 years ago. This was done at baseband video and before color transmission was added to the NTSC signal. A.M. Lessman[2] considered the effects of echo in the color video signal in work done in 1972. Relevant work in the broadcast industry was reported by S.K. Goyal, et al.,[3] and Hans Schmid[4] in 1977 and 1979, respectively.

Very little work has been done on reflections for the cable industry. Trunk line mismatch was studied by A. Prochazka[5] in 1978; echo testing for the cable industry was proposed by Warren Braun[6] in 1984 and discussed by Victor Nicholson[7] in 1976. The carrier detection process was analyzed in work by Walter Ciciora, et al.,[8] and J.O. Voorman, et al.,[9] done on ghost cancelling systems. Recent work by Gerald Robinson[10] and Archer Taylor[11] considers the effect of reflections on HDTV systems.

The need became apparent to identify the nature of RF reflection impairments and their range and threshold of visibility. Work was begun by Group 1 and American Television and Communications in May 1988 with tests at the David Sarnoff Research Center in Princeton, N.J. Subsequent and conclusive testing, also at Sarnoff, was done last March by Group 1 for Cable Labs. The work focused on an examination of reflection impairments with implications to daily system operation, including methods of resolution and improvement.

The Sarnoff Center has a test system known as the "VHF television testbed," used to simulate transmission impairments. Its ability to generate controlled RF echoes was of great value to this study, especially the ability to generate and study very close reflections. The Sarnoff team conducting the tests was directed by Dr. James Gibson.

Figure 1 gives a description of the test bed. A wide variety of consumer receivers, including an IDTV (improved definition TV) model as well as studio grade monitors, was used to judge impairment, which was judged at just perceptible levels by trained observers at close distance. Program material used included resolution charts, various test patterns and the "harbor scene" commonly used in HDTV (high definition TV) demonstrations. The carrier phase of the reflected signal was varied for most perceptible effect.

There were three distinct impairment functions observed; they are plotted on Figure 2 smoothed from data taken, along with the original Mertz curve.

In the echo area above 500 nanoseconds the observed threshold of perceptibility generally followed the Mertz observation but at a lower level by about 5 dB. The implication of this for trunk lines is that with typical amplifier return losses and cable loss the channels in the lower octaves could build up reflections greater than the threshold of perceptibility, especially where the larger size low loss cables are used. Present values for cable structural return loss seem to be adequate. The effect can be resolved and tested for using RF sweep equipment capable of 0.25 dB resolution of multiple cycles per channel, such as a high resolution spectrum analyzer or with baseband testing using (sin x)/x waveforms. Group delay is also a sensitive indicator of echo reflections at the threshold of perceptibility, provided the test

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Figure 1: Test bed block diagram

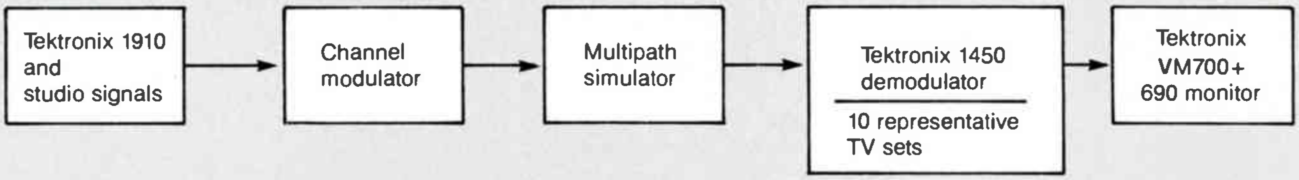
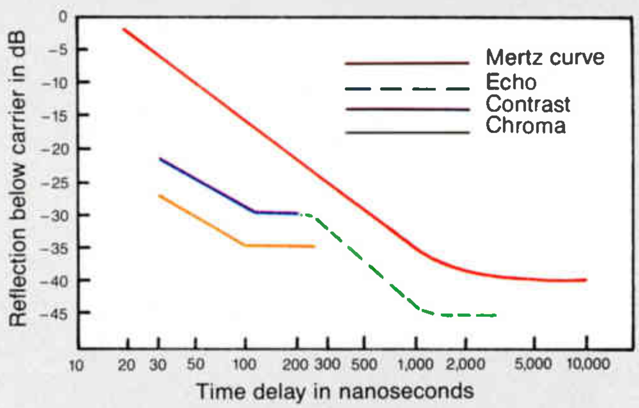


Figure 2: Reflection impairment curves



equipment can resolve multiple cycles of approximately 25 ns. This is consistent with the Prochazka work[3]. Figure 3 shows an RF plot of a 30 dB reflection resolved with a carrier-to-noise ratio typical of a long trunk line. Figure 4 shows the same reflection resolved with baseband testing.

The range between 250 and 500 ns is generally called the *close ghost*, where edge definition is affected on the near extreme and a distinct echo is observed at the other. This area is best characterized by baseband testing with traditional indicators of edge definition such as the 2T pulse and bar. As 250 ns corresponds to approximately one cycle in the baseband, sinusoidal ripple effects in amplitude and group delay can be discerned at reflection values of 250 ns or higher. Figures 5 and 6 show the resolution of a reflection at approximately 250 ns at the just perceptible level. The feederline in a cable system is the most likely portion to affect this range of reflections and, given typical component values of today, is not likely to affect perceptibility if power addition is assumed to be the method of reflection addition. Single reflections should be below the threshold of perceptibility.

In the range below 250 ns there are two distinct impairments. One is a contrast impairment, the other is a chroma level impairment or gain/frequency error across the channel. Their perceptibility is different although they are resolved in the same way.

The contrast impairment affects the acuity or ability to resolve detail, but it does not affect resolution as measured on a resolution chart. The effect is similar to the consumer adjustments of sharpness or peaking as described by Wayne Harlan[12]. Resolution of errors involves measurement of tilt. Multiburst waveforms at baseband, or in-channel response of the RF channel, are illustrative. To demonstrate the dramatic nature of the differences between the Mertz curve and the result of this RF reflection work, two reflection levels are shown in Figures 7 through 10; the 20 dB cases involve reflections about 3 dB lower than Mertz values, while the 30 dB cases are the observed perceptibility thresholds. It is interesting to note that in this case reflections above 30 dB can produce gain/frequency errors in excess of NTC-7 recommended values.

The chroma level impairment is a function of the tilt that reflections below 250 ns will produce. Significant errors between chrominance and luminance relationships can occur in the range from 30 to 250 ns. This is not of concern when signals are viewed on consumer grade TV receivers, as they generally incorporate automatic color level correction circuits. But it is of concern for any situation where equipment not incorporating similar circuitry is used to view signals impaired with such short reflections. It is possible that various current or future uses and configurations of baseband converters, monitors and VCR equipment could demand the better reflection levels so as to not be adversely affected. Similar chroma level impairment observations in the range above 140 ns were reported by Lessman[2].

Both the contrast and chroma level functions are most likely to be affected by reflections in the drop plant, although it is possible that reflections in the threshold area can be introduced in headend combining equipment and along the distribution plant by closely spaced

Figure 3

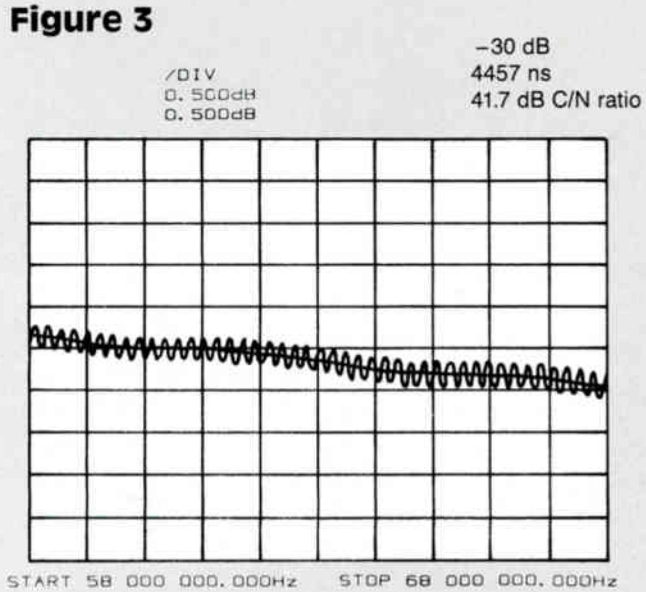


Figure 4

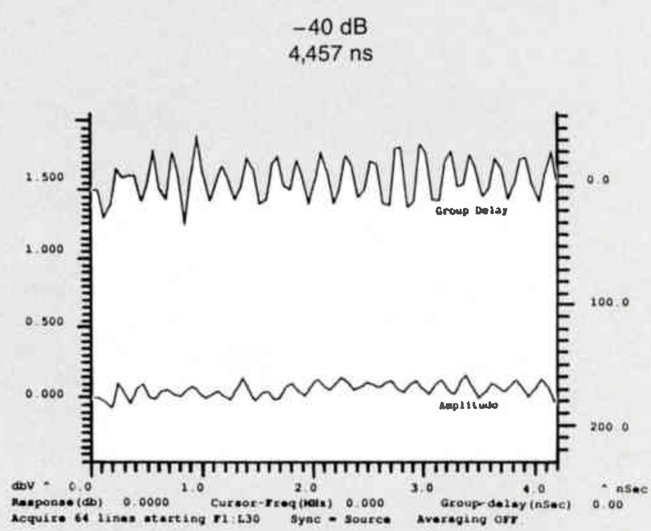


Figure 5

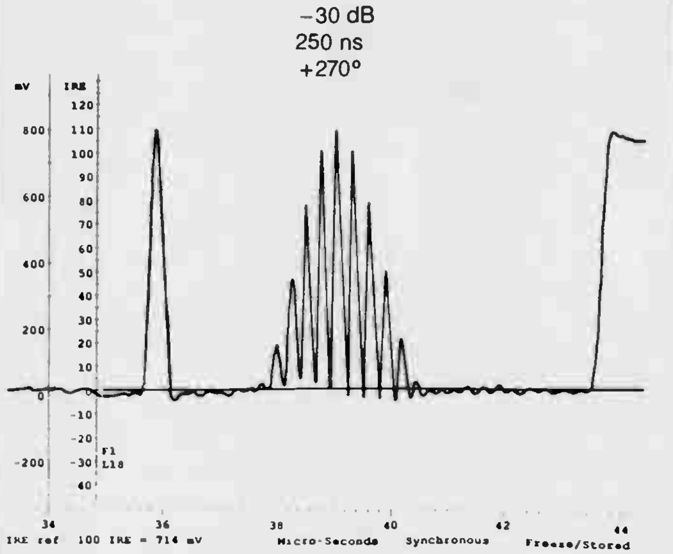
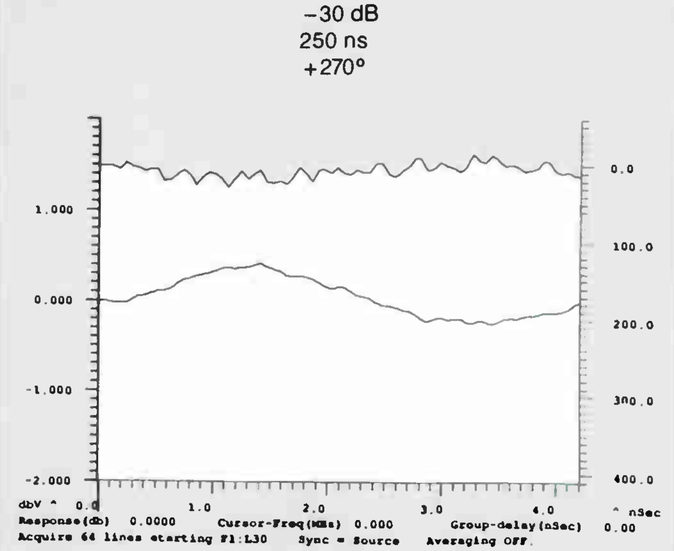


Figure 6



passive devices. The drop termination is generally considered a relatively poor match of only a few dB, and the potential exists, especially in cases with splitters feeding extra outlets, for reflections in the 100 ns range in excess of the threshold of perceptibility for either of the impairment functions.

In conclusion, the results indicate that there are existing conditions in cable systems that may exceed the threshold of perceptibility for various reflection conditions or might be a limit to enhanced NTSC or other high definition service. With the perceptibility and methods of measure now better understood, further characterization of actual operating results in cable systems can occur. Orderly improvement can be made to reduce the perceptible effects of reflections to the desired level.

Acknowledgements: Group 1 members participating in the full series of tests include Gary Chan, Rogers; Ted Hartson, Post-Newsweek; Gerald Robinson, Scientific-Atlanta; and Richard Shimp, ComSonics. All contributed to the work. Jim Gibson of Sarnoff was an invaluable

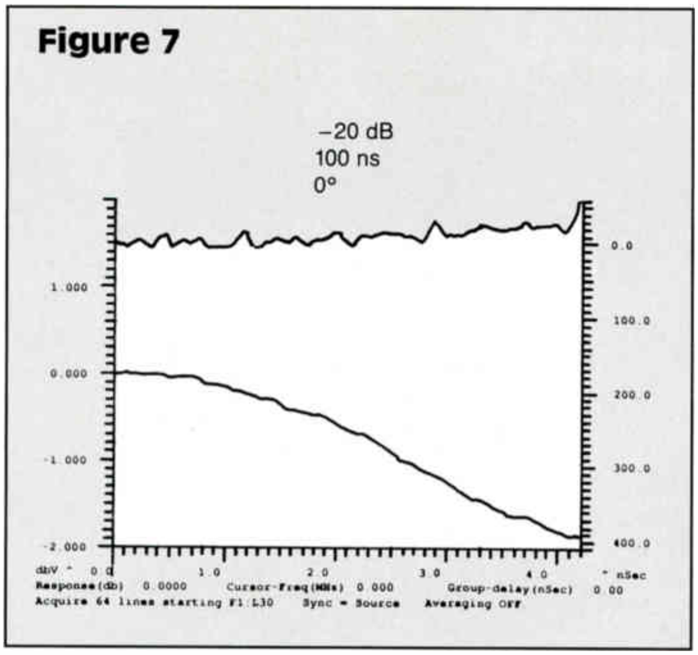


Figure 7

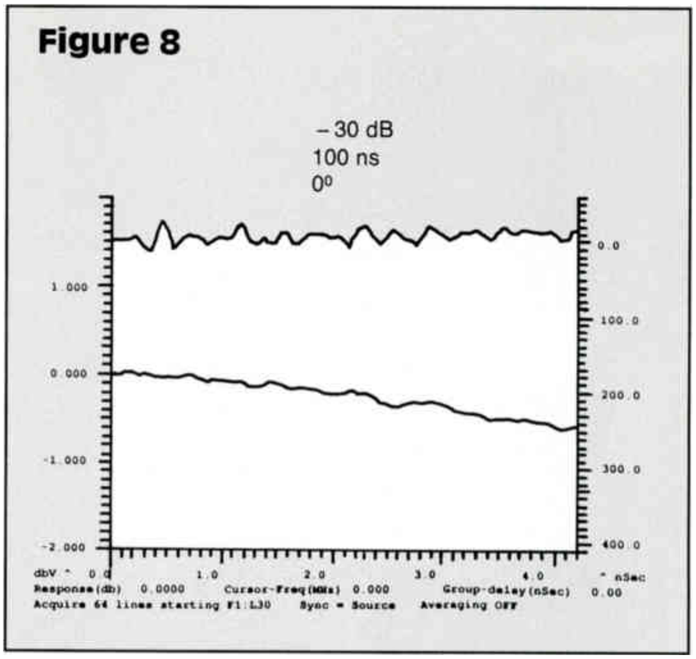


Figure 8

source of information and guidance. The work began with the support of ATC and concluded under sponsorship of Cable Labs.

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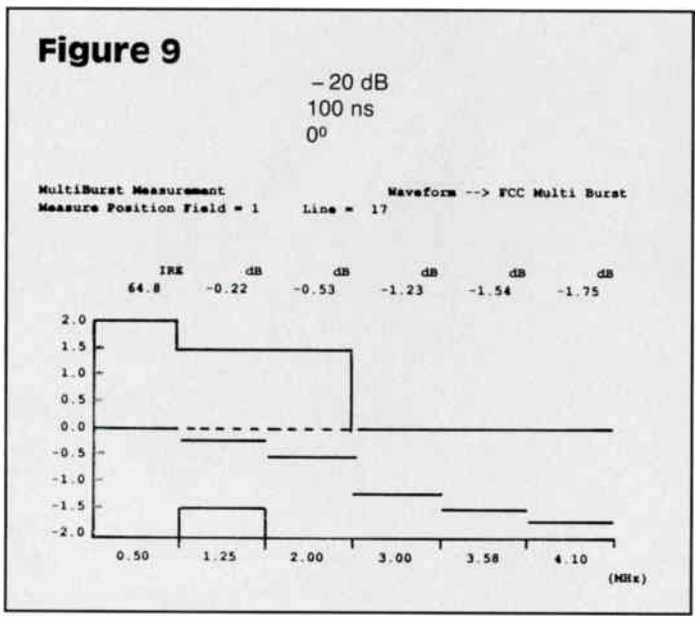

Figure 9

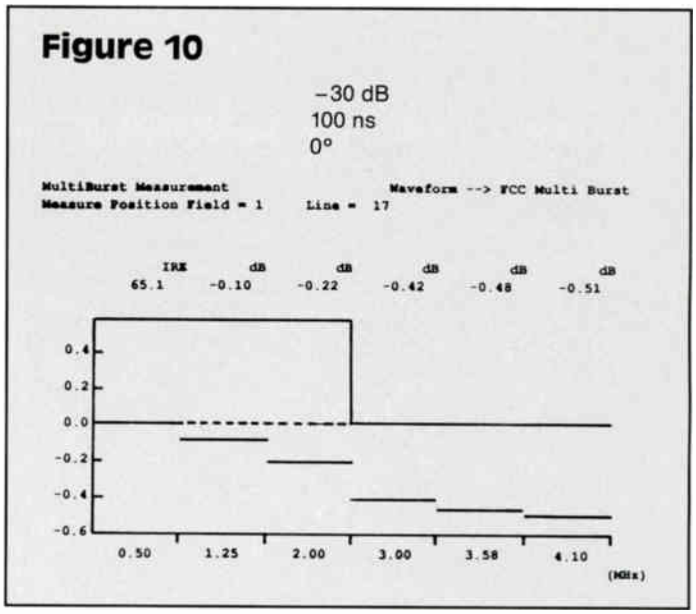

Figure 10

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CATV's ATV priorities revisited

In the October 1988 issue of "CT," the author presented "Cable's advanced TV priorities," an overview of this new technology as well as CATV's competitors in the field. Much has happened in the past year; just how has cable's role changed?

By Walter S. Ciciora, Ph.D.
Vice President of Technology
American Television and Communications, Stamford, Conn.

My definition of high definition TV (HDTV) is: a doubled resolution both horizontally and vertically, a wide aspect ratio and a really large screen, high quality sound, and the elimination of NTSC artifacts that have plagued big screen projection TV.

Cable's involvement in advanced TV (ATV)—and its subset, HDTV—is critical, both for cable and for ATV. Currently, cable TV is in 48 million TV households, translating into a penetration of 54.8 percent. But more important, this penetration grew 1 percent each of the last two quarters. Also, cable now passes 82 percent of TV households. We know that cable subscribers are early adopters of technology; that means the penetration of VCRs, home computers, cordless telephones and other advanced gadgetry is considerably higher among subs than non-subs.

All of these trends are expected to continue. By the time HDTV is commercially significant, we expect cable penetration will reach 75 to 80 percent. Essentially anyone who's interested in video will be a cable subscriber. This translates to the belief that 90 to 95 percent of the first purchasers of ATV receivers will be cable subs.

Now why does cable need to be involved in ATV? The first reason is to counter telco propaganda. Certain telcos have been saying that only they can provide HDTV, only digitally and only on fiber to the home. We know that's false, but we have got to get the message across and convince the regulators and the press that we are the proper and best providers of HDTV. Second, whatever the HDTV standard becomes, we'll have to live with it for at least 50 years, just as we've had to live with NTSC. That fact makes it important that we be involved in the development of the standard and ensure that it serves our interests. Finally, we need to know how to rebuild and upgrade the cable plant so that it's ready when ATV becomes commercially significant.

In deciding on our role in ATV development, we have our choice of four options:

1) Be a pioneer and try to make ATV happen. But being a pioneer means having arrows in the back. The only ones who can afford to be pioneers are those who stand to gain from involvement in this technology. Cable is not a big, potential gainer in ATV. That's because we will have a high penetration by the time ATV is commercially significant. Pioneering is risky; you could choose the wrong technology and spend money on the wrong approach. That can lead to a disaster—higher rates and all kinds of other problems.

2) Simply keep in step with ATV's progress. This option involves just keeping a measured pace and being there in time for ATV to become commercially significant.

3) Be only slightly ahead or (as I call it) strategically in the lead. The purpose for this strategy is to take the high ground and deny the competition a lead.

4) Fall behind. But if we do this, our subs may go elsewhere for their ATV programming.

Rational expectations

We had hoped that testing of ATV components could begin late this year; but it's now clear that it won't proceed as scheduled. In fact, testing will more likely begin toward the middle of 1990 (even though some are hoping for a start some time in the first quarter). However, Murphy's Law applies here. Management is telling the Federal Communications Commission that all is well and hardware will be available for testing. Engineers are working evenings and weekends, sweating and skipping vacations, and bringing their families close to divorce. Things will likely go wrong and it will almost certainly be later than management has promised.

So it is reasonable to expect that ATV components won't really be available for testing until mid- to late 1990. And once it starts, testing will take 1½ to 2 years. This means that the terrestrial ATV broadcast standard will arrive at the earliest in 1992, and it might be later. The most optimistic projection of your ability to buy an ATV set is perhaps Christmas of 1992. (If your set is on the fritz today, replace it with an NTSC set; it'll be a while before HDTV.)

Also, it's important to realize that when the first black and white TV set went on sale, it cost as much as a compact car. Likewise, the first color TV cost as much as a compact car. It is rational to expect that the first HDTV receiver will cost as much as a Hyundai.

There are the wide variety of projections of how fast HDTV will penetrate the market; some of these projections are self-serving. If we look at the history we find that color TV took 10 years to reach 1 percent penetration and 13 years to reach 10 percent penetration. So how long will ATV take? And what is a commercially significant level of penetration? My best guess is that it will take a minimum of seven to perhaps 10 years to reach 1 percent penetration after the introduction of ATV. It will take about 13 years to reach 10 percent penetration. So if ATV is introduced in 1992, we'll have 1 percent penetration in 2002 and 10 percent in 2005.

> *"At present we have excellent cooperation between the cable and broadcast technical communities."*

Faster projections of penetration demand an explanation. The question that needs to be answered is, "Why would HDTV be more of an improvement over color than color was over black and white?" HBO and the Massachusetts Institute of Technology have done consumer studies. In these studies it was found that consumers could not tell the different between good NTSC and HDTV if the pictures were viewed from more than five times the picture height. This means that large screens are necessary for consumers to appreciate the difference between HDTV and NTSC. But large screens are expensive, whether they be HDTV or NTSC.

What should cable's goals be in ATV? First, we must preserve our ability to remain competitive. Second, we must be able to deliver the broadcasters' signals. Third, we must continue to serve —and serve well—the NTSC population of sets. Fourth, we have a number of unique needs that broadcasters do not have; we must find a way to solve those needs. We must meet these four goals in a cost-effective manner so that the effect on subscriber rates is not too great.

An eye on competition

Cable's potential competition in ATV includes pre-recorded media (discs and tapes), telcos, DBS (direct broadcast satellite) and to some extent the broadcasters. Cable must have competitive video with all of these both in the short and long term. I am most concerned with pre-recorded media; recording is the video technology that has made the most progress in the past 10 years and has the potential for the most additional progress in the next 10. Several of us have seen the Mitsubishi 20 MHz baseband VCR. It uses VHS components and provides an excellent picture without any motion artifacts or compromises—just great video. This will become the standard of comparison and target that we must aim for.

The second priority is that we must carry the broadcasters' signals. Our subscribers demand it and it's simply good business sense to carry the signal. This means we must cooperate with broadcasters to ensure their signal is robust and can be handled with the processing that we do in cable plant not only today but in the time frame when ATV becomes commercially significant. We must have a quality picture in the home as good or better than what subscribers can obtain if they switch to an external antenna. This is in everyone's best interest. And there's good news: At present we have excellent cooperation between the cable and broadcast technical communities.

Our third priority is to continue to serve the existing NTSC population. Since ATV is a large screen phenomenon, it will only be in the principal viewing area of the home for a long time to come. This is especially true because large screens are so expensive. The rest of the house will be sprinkled with NTSC receivers, which increasingly will become an impulse purchase. Our viewers will see more video on NTSC than they will on HDTV for several more decades.

Whatever we choose to be the HDTV standard must not in any way compromise the quality that we deliver over NTSC.

Cable has unique needs that other deliverers of video do not. We must have addressability that is secure and fast. Also, we need to encrypt the video, for two reasons: 1) the picture must be sufficiently hidden so that those who object to the programming will not be offended and 2) the scrambling must be practically undefeatable. Another unique quality of cable is that we need to deliver our signal to headends via satellite.

In addition, we would dearly love to be able to control whether a particular program can or cannot be recorded on a VCR. In most cases we want our subscribers to be able to record and to do it conveniently. But in certain cases we may prefer to deny recording in order to get earlier windows or special treatment from program providers.

We need a cost-effective production standard if cable is ever to cover local events in HDTV. We must be able to afford cameras, VCRs and all the other equipment. What is currently under development is not affordable by cable or local independent broadcasters and maybe not by some of the networks. The production equipment must be cost-effective and compatible with CATV technology.

Also, both ATV and cable TV evolution must be in step because initially there will be very, very few ATV receivers out there. We can't afford a major investment to service 0.1 percent penetration of ATV receivers. The remaining subscribers won't tolerate rate increases to cover the costs of serving so small a population.

Edward Clay Wright Jr.

Finally, we must have the ability to upgrade the video as consumers get larger and larger screens. In 10, 15 or 20 years from now when wall-sized screens are common, we must make sure that our pictures remain competitive. After our subs view a rented tape or disc and then turn to a cable channel, we must not be embarrassed.

Cable is in an excellent position to achieve our ATV goals in this time frame. The National Cable Television Association has done a demonstration of HDTV on cable plant in the Washington, D.C., area. And this is something only we can say; only cable has demonstrated HDTV on existing, in-service, unmodified plant. Nobody else (not even telcos) has done that; all other tests have been on specially contrived situations.

But of course not all cable systems would be capable of demonstrating HDTV. Most of them could, but the major demands on plant to deliver HDTV are more spectrum, less noise, less nonlinear distortion and fewer microreflections. We have the tools to do that in a very cost-effective way; the tools for more spectrum and less noise are in the fiber-optic approaches. The tool for removing non-linearity and reducing microreflections is the Rogers approach, called "Superdistribution." (See "Rogers fiber architecture" by George Hart and Nick Hamilton-Piercy, *1989 NCTA Technical Papers*.)

I believe that all cable systems will evolve to be capable of handling HDTV in the time frame that HDTV becomes commercially significant. Driving this evolution will not be HDTV but our need for more spectrum for the additional channels coming on board and our desire to provide better and better NTSC. The natural order of things is that cable will be in a great position to deliver HDTV without burdensome costs for the subscriber.

This article is based on a discussion presented at SCTE's Cable-Tec Expo '89.

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1 (V) 3720	3 (V) 3760	5 (V) 3800	7 (V) 3840	9 (V) 3880	11 (V) 3920	13 (V) 3960	
2 (H) 3740	4 (H) 3780	6 (H) 3820	8 (H) 3860	10 (H) 3900	12 (H) 3940	14	39
1 (H) 3720	2 (H) 3760	3 (H) 3800	4 (H) 3840	5 (H) 3880	6 (H) 3920	7 (H) 3960	
13 (V) 3760	14 (V) 3840	15 (V) 3920					
1 (H) 3720	3 (H) 3760	5 (H) 3800	7 (H) 3840	9 (H) 3880	11 (H) 3920	13 (H) 3960	
2 (V) 3740	4 (V) 3780	6 (V) 3820	8 (V) 3860	10 (V) 3900	12 (V) 3940	14	39
1D (H) 3720	2D (H) 3760	3D (H) 3800	4D (H) 3840	5D (H) 3880	6D (H) 3920	7D (H) 3960	
1X (V) 3740	2X (V) 3780	3X (V) 3820	4X (V) 3860	5X (V) 3900	6X (V) 3940	7X	39
1A (H) 3720	2A (H) 3760	3A (H) 3800	4A (H) 3840	5A (H) 3880	6A (H) 3920	7A (H) 3960	
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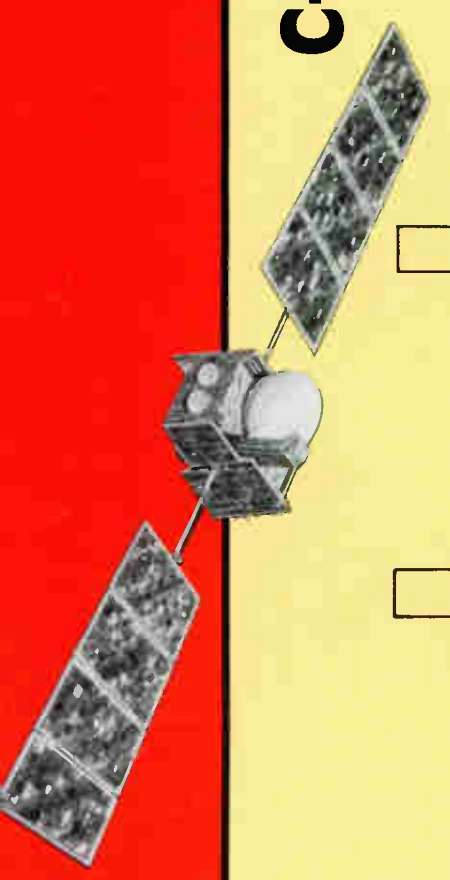

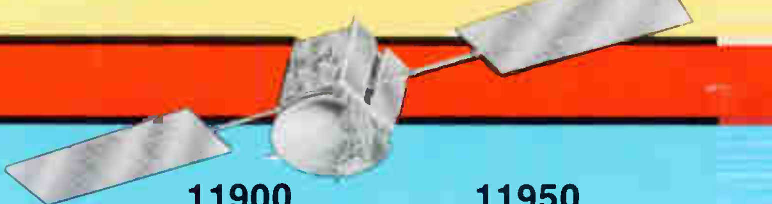

Ku-Band

(MHz) 11700 11750 11800 11850 11900 11950

19 (H) 11740	20 (H) 11820	21 (H) 11900	22	1198			
1 (H) 11725	2 (H) 11774	3 (H) 11823	4 (H) 11872	5 (H) 11921	6 (H) 11970		
1 (H) 11730	2 (H) 11791	3 (H) 11852	4 (H) 11913	5 (H 119			
9 (V) 11744	10 (V) 11805	11 (V) 11866	12 (V) 11927				
11724.00 1 (H) 11729	11782.32 3 (H) 11788	11840.64 5 (H) 11847	11898.96 7 (H) 11906	11957.28 9 (H) 11965			
Narrowband → 11767.74 2 (V) Full transponder → 11758.5	11826.06 4 (V) 11817.5	11884.38 6 (V) 11876.5	11942.70 8 (V) 11935.5				
T1 (V) 11717	T2 (V) 11743	T3 (V) 11778	T4 (V) 11804	T5 (V) 11839	T6 (V) 11865	T7 (V) 11900	T8 (V) 11926
T9 (V) 11961	T 11						
T17 (H) 11730	T18 (H) 11756	T19 (H) 11791	T20 (H) 11817	T21 (H) 11852	T22 (H) 11878	T23 (H) 11913	T24 (H) 11939
T25 (H 11974							

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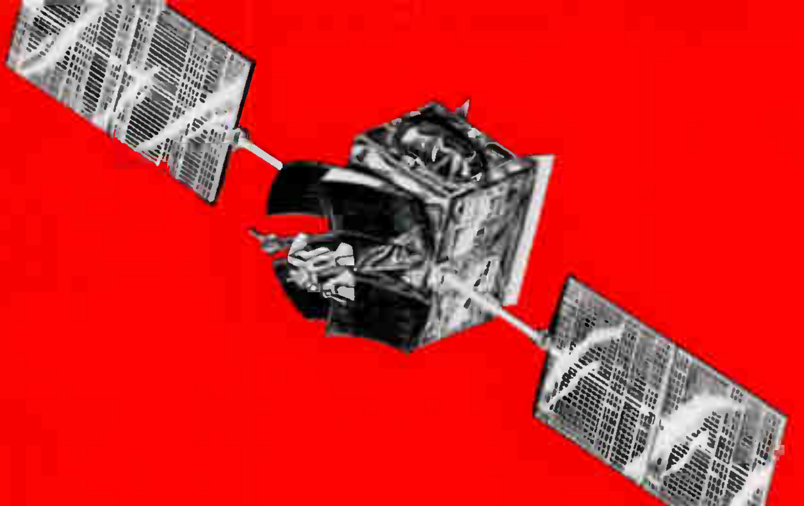


4000 4050 4100 4150 4200 (MHz)

Satcom F1R, F2R, F3R, F4 & F5

15 (V) 4000 | 17 (V) 4040 | 19 (V) 4080 | 21 (V) 4120 | 23 (V) 4160
H) 0 | 16 (H) 4020 | 18 (H) 4060 | 20 (H) 4100 | 22 (H) 4140 | 24 (H) 4180

Westar III and Spacenet I, II & III

8 (H) 4000 | 9 (H) 4040 | 10 (H) 4080 | 11 (H) 4120 | 12 (H) 4160

Spacenet I, II & III

16 (V) 4000 | 17 (V) 4080 | 18 (V) 4160

Galaxy I, II & III

15 (H) 4000 | 17 (H) 4040 | 19 (H) 4080 | 21 (H) 4120 | 23 (H) 4160
V) 0 | 16 (V) 4020 | 18 (V) 4060 | 20 (V) 4100 | 22 (V) 4140 | 24 (V) 4180

Westar IV & V

8D (H) 4000 | 9D (H) 4040 | 10D (H) 4080 | 11D (H) 4120 | 12D (H) 4160
V) 0 | 8X (V) 4020 | 9X (V) 4060 | 10X (V) 4100 | 11X (V) 4140 | 12X (V) 4180

Anik D1 & D2

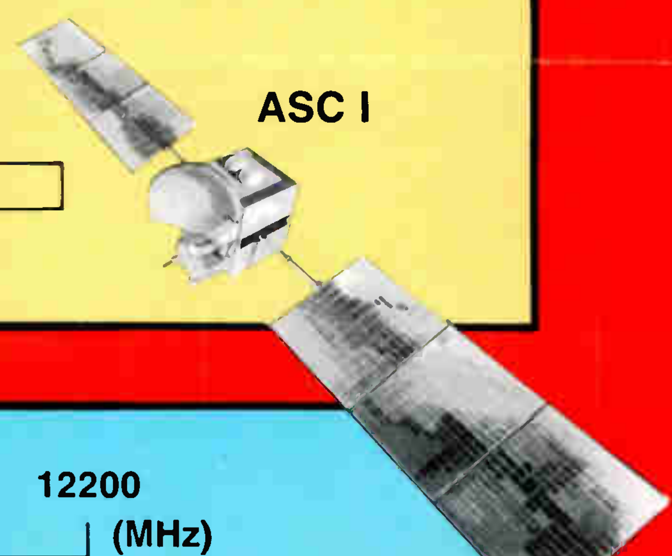
8A (H) 4000 | 9A (H) 4040 | 10A (H) 4080 | 11A (H) 4120 | 12A (H) 4160
V) 0 | 8B (V) 4020 | 9B (V) 4060 | 10B (V) 4100 | 11B (V) 4140 | 12B (V) 4180

Telstar 301, 302 & 303 and Comstar D4

8V (V) 4000 | 9V (V) 4040 | 10V (V) 4080 | 11V (V) 4120 | 12V (V) 4160
H) 0 | 8H (H) 4020 | 9H (H) 4060 | 10H (H) 4100 | 11H (H) 4140 | 12H (H) 4180

ASC I

) | 14 (H) 4060 | 15 (H) 4140
16 (V) 4000 | 17 (V) 4080 | 18 (V) 4160



12000 12050 12100 12150 12200 (MHz)

Spacenet I, II & III and ASC I

H)) | 23 (H) 12060 | 24 (H) 12140

SBS I, II, III & IV

7 (H) 12019 | 8 (H) 12068 | 9 (H) 12117 | 10 (H) 12166

GStar 1 & 2

74 | 6 (H) 12035 | 7 (H) 12096 | 8 (H) 12157
3 (V) 11988 | 14 (V) 12049 | 15 (V) 12110 | 16 (V) 12171

Satcom K1 & K2

12015.60 | 12073.92 | 12132.24 ← Narrowband
11 (H) 12024 | 13 (H) 12083 | 15 (H) 12142 ← Full transponder
2001.02 | 12059.34 | 12117.66 | 12175.98
) (V) 1994.5 | 12 (V) 12053.5 | 14 (V) 12112.5 | 16 (V) 12171.5

Anik C2 & C3

) (V) 87 | T11 (V) 12022 | T12 (V) 12048 | T13 (V) 12083 | T14 (V) 12109 | T15 (V) 12144 | T16 (V) 12170
T26 (H) 12000 | T27 (H) 12035 | T28 (H) 12061 | T29 (H) 12096 | T30 (H) 12122 | T31 (H) 12157 | T32 (H) 12183

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Reader Service Number 44.

A non-NTSC based HDTV system

By Pieter Fockens
Staff Consultant, Zenith Electronics Corp.

The Zenith Spectrum Compatible high definition TV (SC-HDTV) system is high definition in the generally accepted sense that, compared to NTSC (the current U.S. TV transmission system), it has doubled horizontal and vertical resolution. In SC-HDTV, the familiar NTSC chroma artifacts are absent. The trend toward larger picture size and shorter viewing distance not only requires improved detail in high definition pictures but also a more noise-free picture. It is a simulcast system, which means that the SC-HDTV and the NTSC versions of a program will be simultaneously available, each in a separate 6 MHz channel received independently on the current TV broadcast bands. Extra spectrum space for terrestrial broadcasting is available due to the transmission signal design, which enables significantly reduced mutual interference between SC-HDTV and NTSC channels. Consequently, currently unusable ("taboo") channel spectrum space in the existing TV bands is recovered for SC-HDTV channels.

Simulcasting prevents the 160 million to 180 million TV sets in current use from becoming obsolete. When these receivers are replaced by high definition or dual standard receivers, in perhaps 15 or 20 years, much of the present spectrum will become available for additional or other services. On the other hand, all NTSC-based proposed HDTV systems will lock up the existing TV band spectrum in perpetuity including the taboo constraints.

SC-HDTV also offers compact disc quality stereo sound. Most important, it is friendly to all consumer TV media: coaxial cable, fiber, VCR and DBS (direct broadcast satellite), as well as terrestrial broadcasting. Also, it can be processed and/or transmitted better than NTSC in all these media while providing high definition quality.

The high definition source is a progressively scanned 787.5 lines per frame and 59.94 frames per second video signal of 28.9 MHz bandwidth, for a line rate of 47,203 lines per second. By making use of the limitations of human vision and by transmitting motion at limited resolution but at full frame rate while transmitting static images at full resolution (but less often), the 28.9 MHz bandwidth can be reduced into two signal components of 3 MHz each for amplitude modulation (AM) or into one signal component of 6 MHz for frequency modulation (FM). Video encoding in SC-HDTV includes time expansion to reduce the transmitted horizontal line rate to exactly NTSC line rate. The vertical rate also equals the NTSC vertical rate and, consequently, the SC-HDTV transmission signal timing is made identical to NTSC timing. This in turn allows the application of precision carrier frequency offset between an SC-HDTV signal and a co-channel NTSC signal, which effectively reduces visible interference of the co-channel NTSC signal into the SC-HDTV channel. Interference of SC-HDTV into NTSC is significantly reduced by transmission encoding, which limits the average transmitted power to approximately 1 percent of NTSC power without reduction in service area or signal-to-noise (S/N) ratio.

Most of the video source signal power appears at DC and at low video frequencies. By removing these, the power of the remaining high frequency video averages to only 1 percent of the total. The DC and low frequencies are transmitted in digital form during the vertical blanking interval. As indicated in Figure 1, the next operation is temporal filtering (frame combing). Rather than transmitting each successive frame as is, the difference between the present frame and 75 percent of the previous frame is transmitted. This means that only 25 percent of static images is transmitted, representing another 12 dB power reduction.

Complementary temporal filtering in the receiver, in conjunction with the described precision carrier frequency offset, effectively reduces NTSC co-channel interference by static pictures. Movement in the SC-HDTV scene increases the transmitted level but this causes interference of a fleeting character into an NTSC co-channel and only in extreme conditions. Temporal filtering is followed by video signal compression. This contributes to peak signal reduction, which is not always guaranteed by average power reduction. Compression reduces the signal's dynamic range and improves the S/N ratio. Compression is followed by time dispersion, a radar technique that helps reduce signal peaks. Receiver de-emphasis (with complementary transmitter pre-emphasis) effectively reduces both NTSC co-channel and adjacent channel interference.

The two 3 MHz signal components—now of reduced level—amplitude modulate two carriers in quadrature in the center of a 6 MHz channel. The modulation is DSB/SC (double sideband suppressed carrier). The digital audio, digital DC, low video frequencies and certain control signals occupy the vertical blanking interval. The two simultaneous 3 MHz signal components can be combined on one channel to a 6 MHz signal by time compression. The 6 MHz signal is used for FM, which applies to satellite links and in VCRs. The NTSC signal format can be derived from the SC-HDTV source signal by a simple downconverter.

CATV and other delivery systems

Cable systems generally have only a few unusable channels. A few,

Figure 1: SC-HDTV transmission system

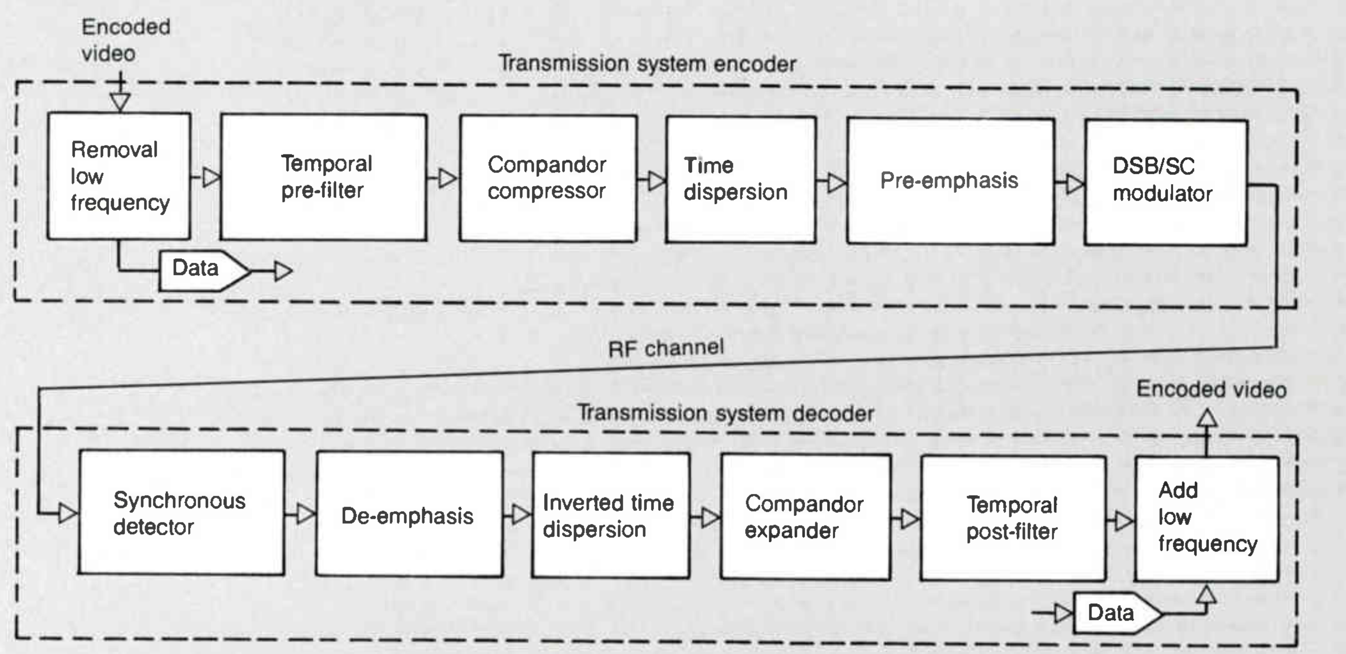
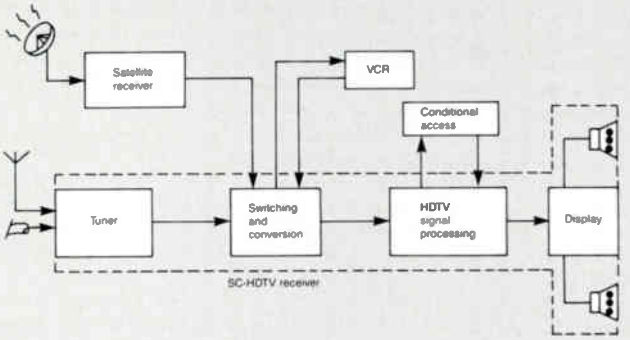


Figure 2: SC-HDTV receiver multimedia operation



however, can be found for the low-power SC-HDTV signals, either in the channels overlapping sensitive aeronautical bands and/or immediately above the highest NTSC channel. More channels become available by using the fiber backbone[1]. At a later stage when only a minority of the subscribers do not own an HDTV receiver, cable operators may make downconverters available to the lone holdouts with NTSC sets. It is interesting to note that NTSC-based HDTV systems are forever locked into NTSC and need augmentation channels, which are scarce. In contrast, SC-HDTV and other simulcast systems eventually have all cable channels available to them.

A cable system of only SC-HDTV channels will have negligible composite triple beat interference due to the signal's low power and the absence of carriers and subcarriers. Gradual introduction of SC-HDTV into existing cable systems will not add any intermodulation.

The digital portion of the transmission signal is a natural for encryption. Besides providing effective scrambling, this method has the advantage of not compromising signal quality even after repeated cycles of encryption/decryption. The conditional access box processes only the digital signal and thus avoids RF.

As mentioned previously, the single 6 MHz channel version of SC-HDTV is used on satellite links. The absence of DC and low video frequencies as well as the reduced transmission signal level cause a narrower, more symmetrical spectrum than results for NTSC signals. Thus the deviation can be increased within the same transponder bandwidth, improving noise performance and threshold behavior. As another advantage, FM noise is less noticeable on SC-HDTV than on NTSC. The signal part farthest removed from the FM carrier is most noise contaminated. In NTSC color suffers, but in SC-HDTV the signal farthest removed from the carrier represents mainly moving edges on which interference and noise are less noticeable.

VCRs also operate on FM signals. With a 6 MHz transmission signal it is possible to construct a VCR that is no more mechanically complicated than a current Super-VHS machine but is electronically simpler since no subcarrier modulation is involved. For recording, only camera signals need full encoding. Off-air and cable signals only need the AM to FM source signal conversion, while satellite signals and prerecorded videocassettes do not even need that. The receiver block diagram of Figure 2 illustrates an advantage of the system arrangement regarding VCR recording of encrypted signals. As a deterrent to unauthorized use, the conditional access box is placed downstream from the VCR so that no decrypted signal can be recorded.

Reference

1 "Fiber Backbone: A Proposal for an Evolutionary CATV Network Architecture," James Chiddix and David Pangrac, *1988 NCTA Technical Papers*.

Cable-ready HDTV?

By Dave Wachob
Director of Advanced Technology
General Instrument/Jerrold Division

Cable certainly is in a unique position to provide a truly spectacular high definition TV (HDTV) picture to its subscribers. While the broadcasters must await a decision from the Federal Communications Commission on terrestrially delivered HDTV (now slated for 1992 at the earliest), cable is in a regulatory position to deliver now, without such constraints. The spectrum issues facing the FCC and the broadcasters are also not limiting factors for cable, as more systems are upgraded to 550 MHz and beyond and the near-term promise of fiber becomes a reality. Technically, cable also may be at an advantage, since its controlled spectrum is not susceptible to multipath ghosting and environmental effects that represent technical hurdles for terrestrial augmentation channel systems.

With so many advantages, why then is cable not already providing HDTV services? The reasons lie in the related issues affecting the complete HDTV environment.

Compatibility and performance issues

If cable were an isolated business, it would be in a position to make independent decisions without regard to their impact on others. This is a straightforward statement but one that has particular significance in cable, since simplistically cable operates as a "pipeline" transporting entertainment and services that have been provided by others for ultimate presentation on subscriber hardware. The headend interface, with network-originated programming and satellite-delivered services, mandates some degree of cable transmission compatibility with the sources to minimize costs and complexity. At the home, cable transmission compatibility with the TV set is even more desirable, where cost and complexity are bigger concerns in terms of consumer (and pocketbook) friendliness, since the same TV set also should be NTSC- and broadcast HDTV-compatible. While transcoding between transmission standards at both the headend and home interfaces is possible, the added signal processing can introduce unnecessary signal degradation.

Cable compatibility with distribution system hardware also may require performance upgrades to support delivery of an HDTV service. Investigations are currently under way to determine the effects of thermal noise, phase noise, distortions, microreflections and other technical considerations in transporting an HDTV signal down cable. The CATV system effects of combining the augmentation channel with the main channel after transmission over cable, while not likely to be as severe as terrestrial delivery, need to be understood if an augmentation channel approach is chosen. Transport of QAM (quadrature amplitude modulation) data over cable, being proposed for several of the HDTV systems, also needs to be fully understood to be a viable option. Ultimately, system upgrades required to address any performance deficiencies uncovered in the previously described investigations, as well as applicable bandwidth expansions, will translate to increased MSO hardware costs.

Headend costs necessary to provide HDTV service have been estimated upward to $860,000 per headend, not including any system performance improvements. While substantially cheaper than the required HDTV upgrade costs for broadcast stations that have been estimated to be up to $40 million per station, the amount still represents a sizable investment for cable operators.

For the consumer, the investment required is also substantial, with HDTV sets projected to cost between $2,000 and $4,000. In addition to the consumer hardware costs, the subscriber also could expect an additional monthly service charge of at least $10+, provided HDTV cable delivery is a premium service. All this assumes that the operator and the subscriber would be willing to bear the additional costs in anticipation of the perceived benefits of HDTV.

Undeniably, HDTV can offer a fantastic picture in terms of increased resolution and wide screen presentation. It also offers improved audio performance. What remains to be seen however is how much the consumer is willing to pay for such enhancements. While considerable effort has gone into the technical evaluation of HDTV systems, only now is serious consumer research being proposed to understand the consumer and marketplace acceptance of HDTV.

Issues such as whether studio quality or improved definition NTSC alone could be acceptable to the consumer are still unanswered and may impact the success of HDTV. There are also those in the industry who believe that the interim analog HDTV approaches now being considered by the FCC only represent stopgap solutions to an eventual digital implementation.

If the FCC is successful at maintaining its anticipated evaluation and selection process for HDTV system proponents, a decision on an HDTV system could be possible by 1992. Assuming normal product design, evaluation and production times necessary to bring HDTV hardware to the marketplace, including perfection of required display technology improvements, initial FCC-endorsed hardware could come onto the marketplace around 1995. Projections for hardware penetration by the year 2000 of 1 percent are anticipated, with the estimated availability date and similar past product introductions.

All things considered, even with the advantages cable offers, the uncertainties regarding HDTV availability, standardization, compatibility, cost and consumer acceptance do not justify early adoption of a cable unique HDTV delivery system. This is one time where first is not necessarily best.

The CIE chromaticity diagram: What it is and how it is used

As noted in a previous column ("CT," May 1989), noise in an HDTV (high definition TV) system—and probably IDTV (improved definition TV) also—will be defined by measurements related to the noise that appears to the human observer from the display. Measurement techniques, also based on human observers' perception, will be used for determination of HDTV/IDTV color presentation capabilities. Such analyses are particularly important because, since most of the HDTV and IDTV transmission schemes do not suffer from the limitations of NTSC color transmission, they produce colors that are often referred to as "richer, truer," etc.

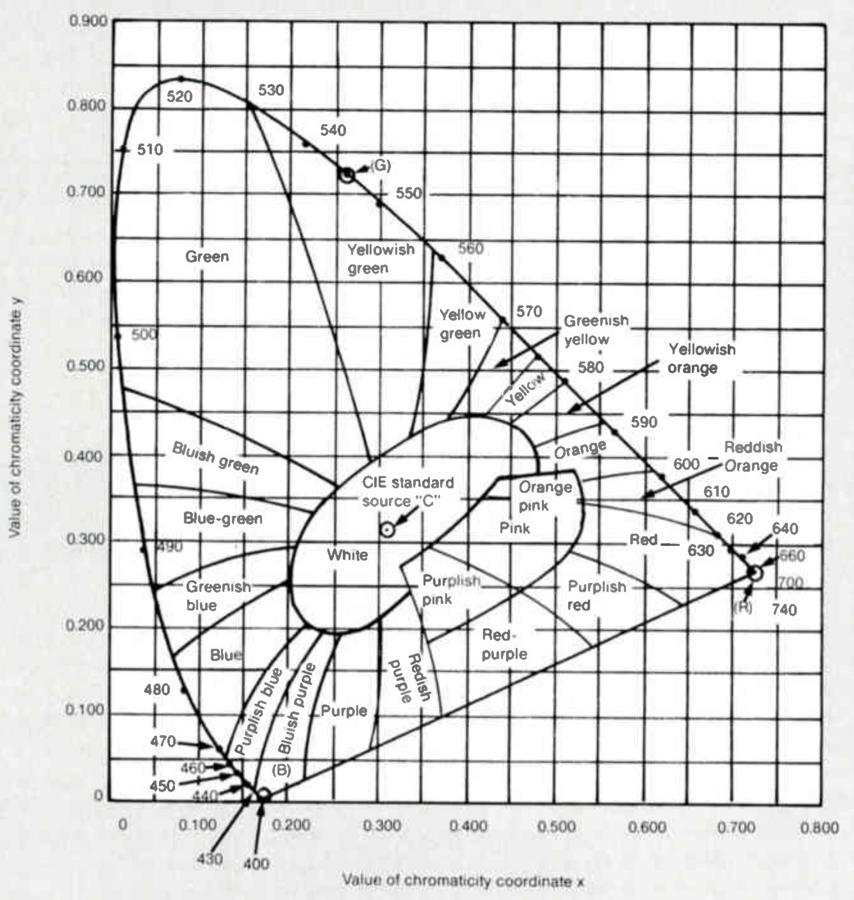
Light, including the spectrum that is visible, can be treated quite reasonably and thoroughly by the physical laws of electromagnetic radiation. But add the concept of color and confusion enters the picture. This is because the human has entered the loop. If color perception is thought of in an information theory context, the disturbing element becomes apparent. The transmitter is the source of light, with possibly some frequencies more dominant than others, the transmission channel is usually air only (although obviously other factors can disturb the channel; i.e., glass) and the receiver is the human being. And that is the problem. The receiver—the final transducer—does not obey any neat set of concise mathematical laws of physics that we presently know. Therefore, the main source of data about color vision is largely empirical. Multitudinous test data is the foundation for visual colorimetry.

It is at this point that the CIE chromaticity diagram enters the picture as an international standard for colorimetry specified by the "Commission Internationale de l'Eclairage" (CIE). This diagram, properly used, is an indispensible tool in the field of colorimetry. This article outlines its history, its derivation and its applications.

This is the second of four parts.

By Lawrence W. Lockwood
Principal Scientist-Video Technologies, Contel Corp.
East Coast Correspondent

Figure 1: CIE chromaticity diagram



With the discussion from Part I (*CT*, August 1989) in mind, we proceed to the numerical specification of color quantities. These specifications are quantitative indices of hue and saturation, which define the color filters and light sources used at the transmitter and receiver of a color TV system. The basis of the specification is the chromaticity diagram (Figure 1), which provides an elegant basis of visualizing the relationships of different hues and saturations. The diagram also provides a triangular figure that bounds the gamut of colors that can be matched by a given set of three primary colors.

The numerical specifications of a color comprise values representative of its brightness, hue and saturation. It is convenient to perform the computations on a basis independent of the brightness, thus removing one of the variables from the equations. This computational device is permissible because the match between the three primary colors and the matched color is preserved when the brightness of each color is multiplied by the same factor.

Since the subjective reaction of observers to colors varies widely among individuals, it is necessary to make measurements with a number of observers and to adopt as a standard the mean values of the quantities observed. The results of such tests, conducted by Guild and Wright, were adopted in 1931 by the International Commission on Illumination (ICI, generally referred to as the *Commission Internationale de l'Eclairage* or CIE) as the basis of the so-called "CIE System of Color Specification."

In the CIE system, the red, green and blue spectral primaries are defined as monochromatic lights of the wavelengths 700, 546.1 and 435.8 nm, respectively. The green and blue primaries are prominent lines in the spectrum of the mercury arc and hence are readily and precisely reproducible. The red primary is not

critical as to wavelength, since the hue in this region of the spectrum remains sensibly constant over an appreciable range of wavelengths.

Taking these primaries as light sources and combining them in a colorimeter (Figure 2), we can determine the relative amount of light flux (lumens) of each primary that must be combined in a mixture to match a given number of lumens of each hue in the spectrum.

These measurements are repeated for a large number of observers and average values are taken as representative of the "CIE standard observer." These standard values are plotted in three curves of Figure 3a. At the wavelength corresponding to one of the standard primaries, the amount of the other two required for a match must necessarily be zero, as indicated in the figure. Figure 3b shows the same data, when a power-measuring device is used to determine the amounts (in watts) of primaries and matched color on the respective surfaces of the colorimeter.

Not all colors can be matched by an additive mixture of red, blue and green primaries (or, for that matter, any set of three real primaries). In some cases it is necessary to add one of the primaries to the unknown as shown in Figure 2b before a match can be obtained. This is in essence "subtracting" the primary, explaining the negative amounts of the primaries shown in Figure 3; i.e., in the region of 450 to 550 nm.

Since any color can thus be matched by combining appropriate amounts of the spectral hues, Figure 3 contains information required to determine the amounts of the standard primaries required to match any color. But these curves give no evident indication of the interrelationships among the primaries, the spectral hues and the various saturations of mixture colors. These relationships can be explicitly indicated if the information in Figure 3 is transformed and related to a standard white light that contains equal amounts of the three primaries. The

Figure 2: Elements of a colorimeter, a device for matching an unknown color with a combination of three primary colors

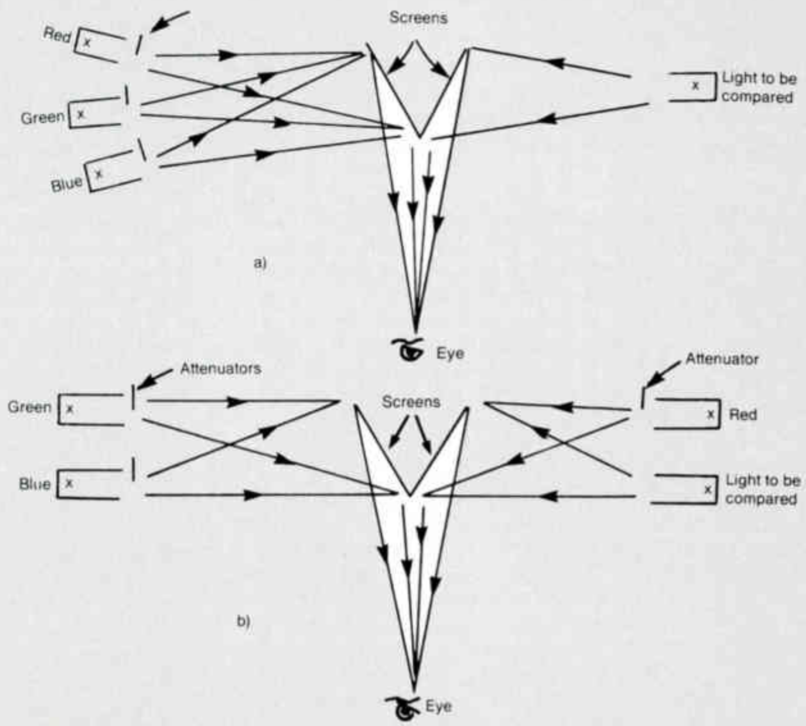


Figure 3a: The color mixture data of the CIE real spectral primaries, indicating the relative numbers of lumens of the three primaries needed to match one lumen of spectral colors at various wavelengths in a colorimeter, as measured by the eye

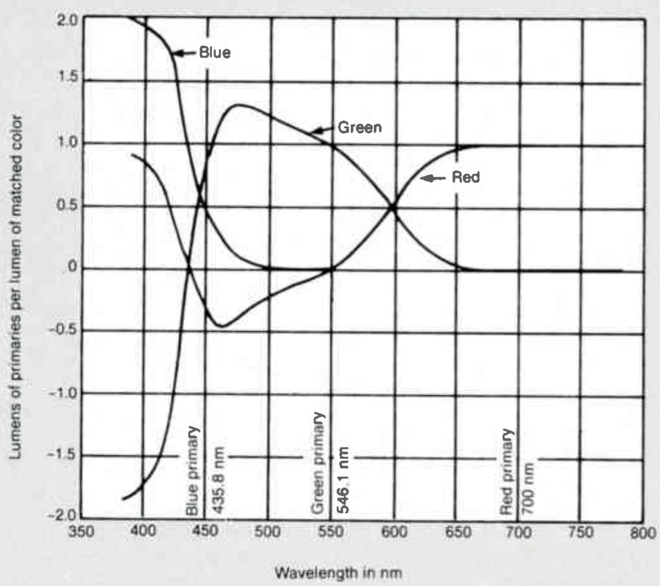
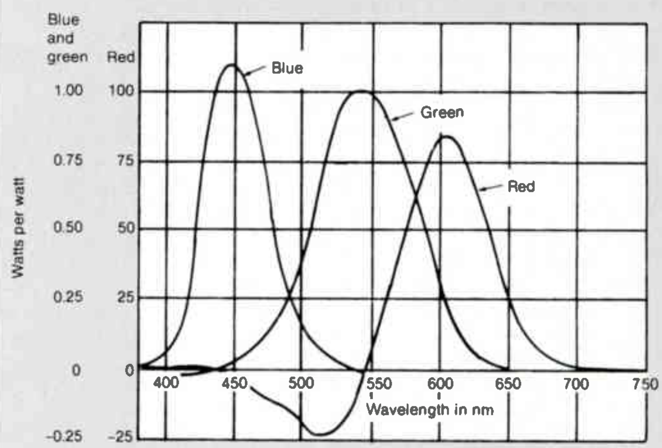
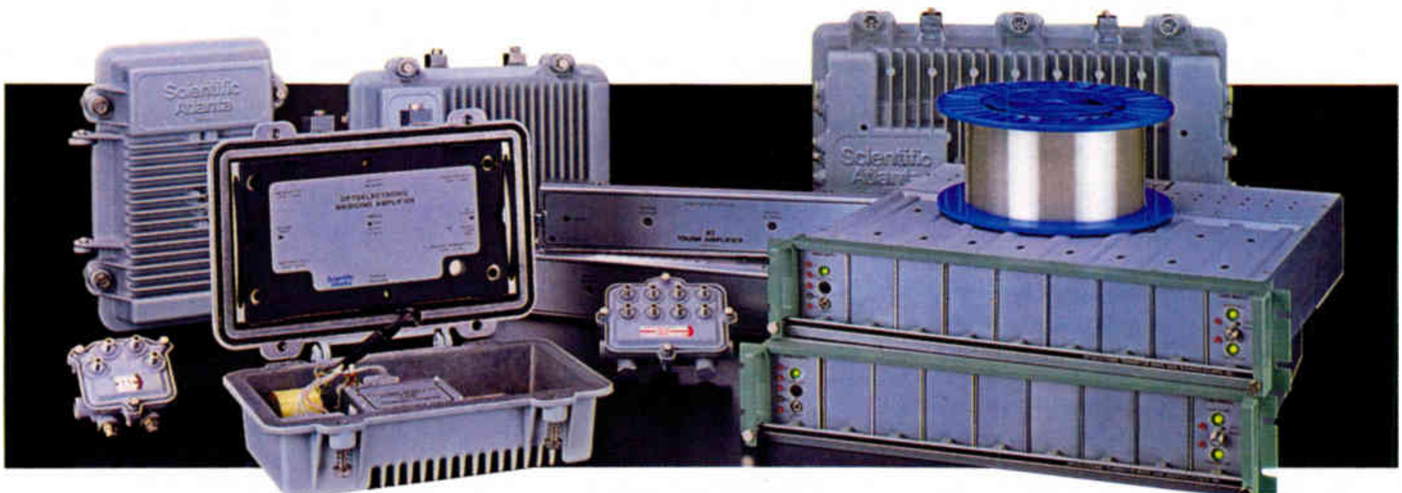


Figure 3b: Color mixture data of Figure 3a, replotted in terms of the power (watts) of the three standard real primaries required to match one watt of spectral color at various wavelengths as measured by a scanning spectroradiometer





result is the "chromaticity diagram," which gives directly the hue and saturation of all physically realizable colors, including the spectral colors.

There are two forms of the chromaticity diagram. The first, the so-called "RGB" diagram, is more readily understood in terms of the concepts just advanced but has the disadvantage that certain spectral and other highly saturated colors have negative values. This may lead to confusion if the negative sign is inadvertently omitted. The second type, known as the "XYZ" diagram, is a linear transformation of the first.

The transformation replaces the negative values with corresponding positive values of a different set of variables. The XYZ diagram is the one universally used to specify the numerical values of color quantities. The RGB diagram will be described first.

RGB chromaticity diagram

The RGB chromaticity diagram is based on a particular color match, that between selected primaries (e.g., the standard CIE spectral primaries) and a standard "equal-energy" white. This white is produced by combining all the hues of an equal-energy spectrum; that is, one in which the energy present in each wavelength is the same throughout the visible region. Such a white light can be closely approximated by fitting a tungsten lamp, operated at a color temperature of 2,854° absolute, with two color filters. The filters consist of blue liquids, one composed principally of copper sulfate and mannite, the other of copper sulfate and cobalt ammonium sulfate, in specific proportions.

In performing the match between the standard primaries and the equal-energy white, one-half the visual field of a colorimeter (Figure 2) is illuminated with L_w lumens of equal-energy white light. The amount of the selected standard primaries falling on the other half of the field is adjusted until a match is obtained, and it is found that L_{rw} lumens of red light, L_{gw} lumens of green and L_{bw} of blue are required to match the white light. The white light is then removed and the "unknown" color, whose numerical specification is desired, is substituted. The flux of this color is taken as $L_c = L_w$ lumens. It is found that L_{rc} lumens of the red primary, L_{gc} of the green and L_{bc} of the blue are required to match the

Figure 4: RGB chromaticity diagram

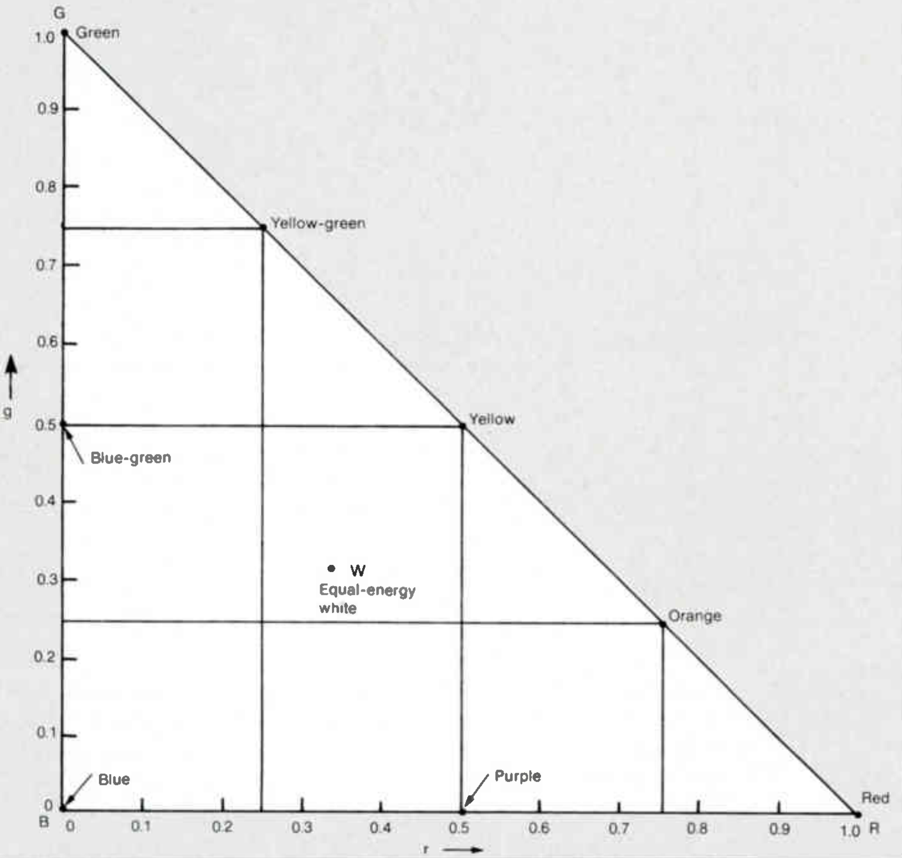


Figure 5: Color mixtures on the RGB diagram, two-color case

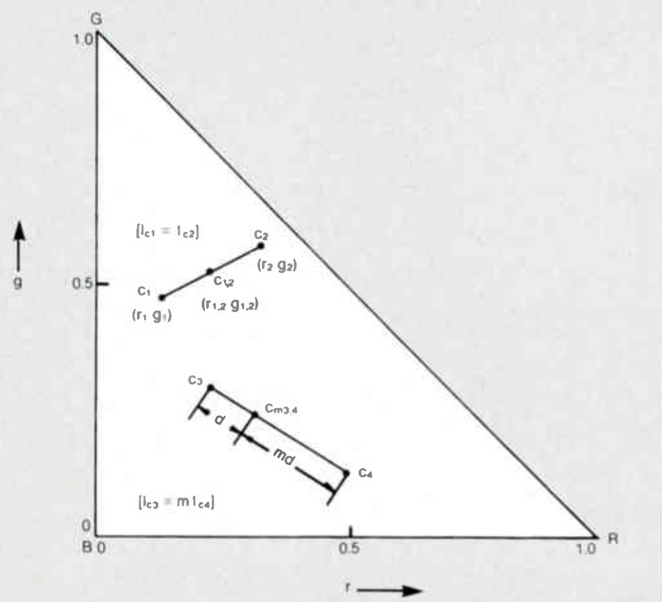
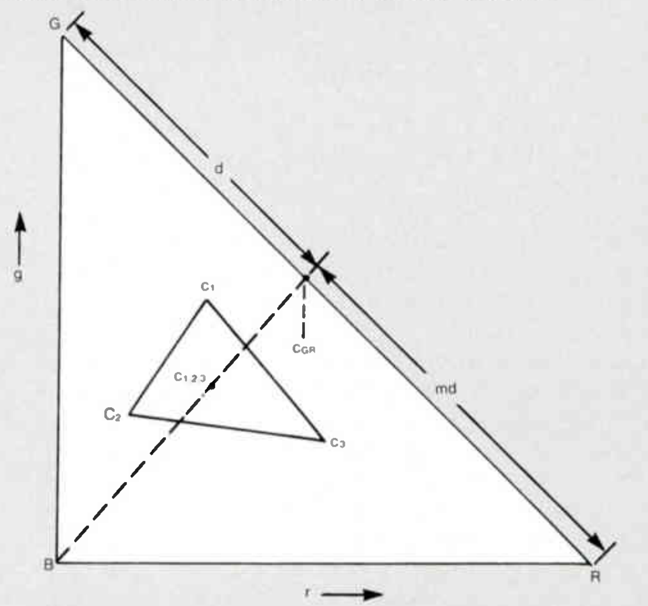


Figure 6: Mixture of three colors on the RGB diagram and resolution of a given mixture color into its primary components



unknown color.

We then define the following quantities as describing the unknown color:

$$r = \frac{L_{rc}/L_{rw}}{L_{rc}/L_{rw} + L_{gc}/L_{gw} + L_{bc}/L_{bw}} \quad (1)$$

$$g = \frac{L_{gc}/L_{gw}}{L_{rc}/L_{rw} + L_{gc}/L_{gw} + L_{bc}/L_{bw}} \quad (2)$$

$$b = \frac{L_{bc}/L_{bw}}{L_{rc}/L_{rw} + L_{gc}/L_{gw} + L_{bc}/L_{bw}} \quad (3)$$

The quantities r, g and b, plotted in rectangular coordinates, constitute the chromaticity diagram, each point on which represents the particular hue and saturation of a color that may be matched by combining the selected primaries.

Since there are three quantities—r, g and b—it might be thought that a three-dimensional diagram would be required. But inspection of Equations 1 to 3 shows that

$$r + g + b = 1 \quad (4)$$

so it is necessary to plot only the values of r and g in a two-dimensional plot. The coordinate b is available as $b = 1 - (r + g)$.

We note that the quantities r, g and b are independent of the actual numbers of lumens involved in the colorimeter, since they are defined as a ratio of the ratios L_{rc}/L_{rw}, etc. The chromaticity diagram is therefore independent of the brightness of the colors and indicates only hue and saturation.

The RGB chromaticity diagram (the plot of r vs. g) is shown in Figure 4. We can locate certain colors on the diagram as follows: The green primary evidently is matched by L_{gc} only, that is, $L_{rc} = 0$, $L_{bc} = 0$. So, by Equations 1 to 2, $g = 1$, $r = 0$. Similarly for the red primary $r = 1$, $g = 0$; and for the blue primary $r = 0$, $g = 0$. These points, identified as the apexes of the triangle RGB in Figure 4, represent the primary colors on which the diagram is constructed.

We also can locate the point corresponding to the equal-energy reference white on which the colorimeter measurements are based. For this color, subscript c evidently has the same meaning as w so $L_{rc} = L_{rw}$; $L_{gc} = L_{gw}$; $L_{bc} = L_{bw}$, provided $L_c = L_w$ as has been assumed. Then all the ratios in Equations 1 to 3 are unity and $r = 0.333$, $g = 0.333$, $b = 0.333$. This point, identified as W on the diagram, represents the equal-energy white. It occupies the center of gravity of the triangle, that is, the point on which a flat plate of uniform density having the triangular shape RGB would balance.

The central location of the equal-energy white point gives the clue to the distribution of other colors within the triangle. As a point recedes from the boundary of the triangle and approaches the point W, the corresponding color becomes increasingly diluted with white light, that is, the color becomes less saturated.

Other hues are identified by labels on Figure 4. Orange and yellow, in as highly saturated a form as the selected standard primaries can match, are located along the boundary of the triangle marked GR, the blue-greens along the boundary GB and the purples along the boundary BR. These hues, in less saturated form, also are found within the triangle, the saturation lessening as the point approaches the point W.

Mixture colors on the RGB diagram

The RGB chromaticity diagram, in addition to providing an array of points whose coordinates represent the hue and saturation of every color capable of being matched by the selected primaries, constitutes a highly useful basis for computing the hue and saturation of mixture colors arising from the additive mixture of any number of other colors. To show the method of combining colors, consider two colors, c_1—having coefficients r_1 and g_1—and c_2—described by r_2 and g_2—(Figure 5). When these two colors are added in equal amount ($L_{c1} = L_{c2}$) and the resultant mixture color $c_{1,2}$ is matched against the selected primaries in a colorimeter (as described in the preceding section), it is found that the coefficients of the mixture color are

$$r_{1,2} = \frac{r_1 + r_2}{2} \quad (5)$$

and

$$g_{1,2} = \frac{g_1 + g_2}{2} \quad (6)$$

As Figure 5 shows, the point representing the

Figure 7: Spectral locus plotted with reference to the RGB diagram

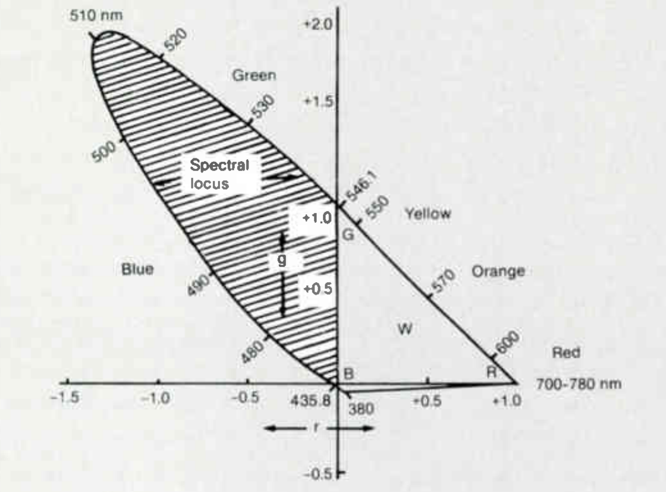
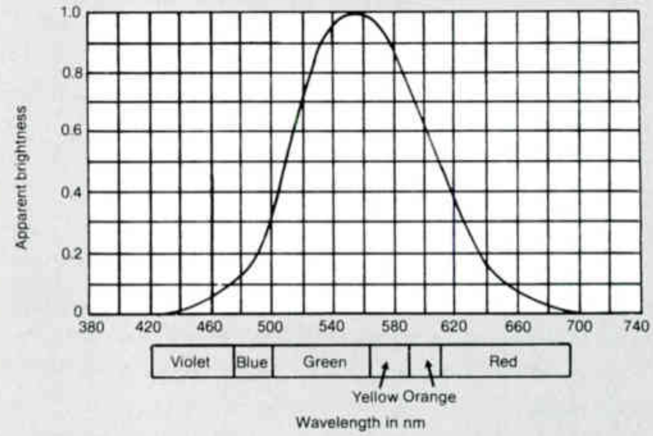


Figure 8: Luminosity function, indicating the relative sensitivity of the normal eye (CIE observer) to light of various wavelengths



mixture color $c_{1,2}$ is located at the center of the line joining c_1 and c_2.

Similarly, if colors c_3 and c_4 are mixed in unequal proportion, such that the flux L_{c3} is m times the flux L_{c4}, the mixture color $c_{m3,4}$ will then lie on the line joining c_3 and c_4, but the distance from c_4 to $c_{m3,4}$ will be m times the distance from c_3 to $c_{m3,4}$ (as shown in Figure 5).

When three or more colors are combined, they may be taken in pairs, each pair in the manner of c_1 and c_2 as previously described. The mixture color $c_{1,2}$ of this pair is then combined in the same manner with c_3 to find a third mixture color $c_{1,2,3}$ and so on until all the colors are combined. The same point is ultimately reached, regardless of the order in which the colors are combined.

Figure 6 shows a typical example involving three colors in a mixture. The mixture color $c_{1,2,3}$ lies at the center of gravity of the triangle formed by c_1, c_2 and c_3, when all are present in equal amount. When the component colors are present in unequal amount, the mixture color point lies within the triangle, but the color point is displaced toward the predominant color or colors.

The process of combining primary colors to find the resultant mixture color can, of course, be reversed, so as to find a combination of primary colors that will match a given color. In this case, there is an infinity of possibilities depending on the relative amounts of the primaries taken. A typical case is shown in Figure 6. In this case, a line connecting one primary and the color to be matched is extended until it strikes the opposite side of the triangle RGB. The point of intersection with this side represents a mixture color of the remaining two primaries. The inverse ratio of distances from the intersection point to the apexes gives the relative amount of each of these primaries required to complete the match.

"The subjective reaction of observers to colors varies widely among individuals."

Spectral locus on the RGB diagram

The RGB diagram just described has been set up using the CIE standard primaries, which are spectral colors. (A similar diagram can be based on any three primaries, spectral or otherwise, saturated or desaturated, provided only that each primary cannot be matched by a combination of the other two. If one could be matched by the others, the triangle would degenerate into a straight line.) Other spectral colors can be located on the diagram, and the line passing through all the spectral points is known as the *spectral locus*. Figure 7 shows this locus, with the wavelengths of the various spectral hues marked on it. It will be noted that the left-hand portion of the locus (shown shaded) lies outside the triangle RGB. This means that the corresponding spectral hues (i.e., the saturated blues and greens) cannot be matched by combining the three selected CIE spectral primaries. Rather, these spectral colors can be formed only in desaturated form; i.e., by combinations represented by points within the triangle RGB. This limitation of matching with primary colors is not a serious matter, because the highly saturated green and blue colors represented at the left of the line BG (although perceivable by the eye) seldom exist in nature.

The procedure for finding a point on the spectral locus is as follows. Consider the spectral light of wavelength 500 nm. To find the corresponding quantities r, g and b in Equations 1 to 3 we must perform two color matches, one between the primaries and the equal-energy standard white, and the other between the primaries and the 500 nm spectral hue, the amount of flux L_w of the white light being equal to the flux L_c of the spectral hue.

The first step is to convert from the power units to light units (i.e., convert from watts to lumens). This conversion is performed with the aid of the "relative luminance curve," shown in Figure 8, which gives the response of the normal eye (i.e., that of the CIE standard observer) to a given amount of energy of each wavelength in the spectrum. The area under this curve is proportional to the number of lumens (L_w) produced by a given number of watts of the equal-energy standard white light.

From the same curve we can find the relative luminosities of the standard CIE primaries; these are in the ratio red:green:blue = 1.0:4.6:0.06. Finally, from Figure 3, we can find the relative amounts of the standard primaries required to match the 500 nm spectral hue. These are in the ratio red:green:blue = -17:0.40:0.17. Taking the luminosities in corresponding pairs to form the ratios L_{rc}/L_{rw}, L_{gc}/L_{gw} and L_{bc}/L_{bw} in Equations 1 to 3, we can find the values of r and g from these equations and thus plot the point for the 500 nm spectral hue. The negative amount of red light required in the match places the point to the left of the line BG; that is, r has a negative value.

The RGB diagram, with the spectral locus, could be used as the basis of color specification, were it not for the fact that the saturated blues and greens lying between the spectral locus and the triangle involve negative values of the quantity r. If the negative sign is inadvertently omitted in the specification or computation of a color, the color point has the wrong position. To avoid such confusion and to simplify color and luminosity computations, the RGB diagram is placed on a new set of coordinate axes, x, y and z, such that no negative values appear, and the specification is stated in terms of x, y and z.

Views expressed here are the author's and do not necessarily reflect those of Contel.

Small systems— The last frontier

"It is sound practice to use messengered drop cable for all aerial drops."

This is the seventh in a series of articles designed to help the small system operator or entrepreneur avoid some basic (and perhaps fatal) mistakes. This installment concludes a discussion of headends and signal processing. Editor's note: Any opinions expressed are those of the authors, based on their experiences in building small systems.

By Bill Grant
President, GWG Associates

And Lee Haefele
President, Haefele TV

Without imposing equipment specifications we would like to offer some guidelines or recommendations for your consideration.

We favor block conversion at the dish itself, which permits the use of RG-6 or RG-59 entrance cable. Receivers should be crystal controlled with detent or "click stop" tuning. It is important that the receivers and converters be stable; that is, that they do not drift in frequency. Unstable headend gear will be a constant maintenance problem, so look for guaranteed drift-free performance.

Satellite receivers must be fully compatible with the descrambler you intend to use; don't forget to check with the descrambler manufacturer before making any purchase. Insist upon front panel video and audio adjustments. When evaluating receivers, ask about possible later conversion to Ku-band. Some units can be converted quite inexpensively, while others may not. There are receivers now on the market capable of receiving both bands.

In purchasing modulators, output capability between +40 and +45 dBmV is usually adequate. It's a good idea to have the first system amplifier in the headend anyway and this will compensate for the lower output modulators. Equipment that can provide +60 dBmV output will cost $100 to $150 more than the lower level output units. Some fixed frequency modulators cost less and (in our opinion) may be more reliable in the longer term. One replacement spare might be a tunable unit, however. RF output, sound carrier, and video and audio levels should all be available as front panel adjustments.

In general, we do not recommend buying older, used equipment here. There have been significant technical improvements in the last five years or so and some cost reduction as well. In this case, used gear doesn't make a lot of sense. The best course of action is to visit several systems and ask for their recommendations if you have no direct experience in this area. It would be wise to allow two to three months for delivery of this equipment since it is not always as readily available as line amplifiers or taps may be.

Headend facilities

We've all seen some pretty awful headend shelters; this is a short-sighted way to save money. The key to successful small systems is low maintenance costs. Structures not well-insulated and air-conditioned inevitably end up producing unstable signals and unhappy subscribers. A tight, well-built building is essential. Off-air antenna support structures should be well-designed and solid (though they need not be costly or elaborate). Simple H-frame structures using two poles are inexpensive and will work well. In some cases, it may even be possible to use the commercial power entrance cable pole for an antenna support. However, check with your local utility on this.

It's difficult to put a cost figure on headend facilities because of the wide range of alternatives available. But costs between $3,000 and $7,000 should be reasonable and sufficient, including a simple antenna support structure, electrical wiring, air-conditioning, etc. We suggest that the building itself be large enough to provide extra space. Sooner or later you'll want to stock some spares there. You certainly need some space for test and adjustment activity, sometimes for several people for several hours.

Negative and positive traps

Since nearly all commercial TV receivers tune standard Chs. 2 through 13, a very small system can actually operate without the use of any converters at all if it limits the number of channels carried to 12. Pay services can be accommodated in such installations by simply using passive exclusion or negative traps at those drops that only subscribe to the basic package. In some instances potential subscribers are too sophisticated and/or too familiar with cable to accept this reduced level of service, but it is practical and possible.

Negative traps to exclude a single or several channels from an individual subscriber are not expensive but can introduce some problems. Since they must attenuate some transmission spectrum drastically but introduce only nominal loss into adjacent spectrum, they are designed with narrow bandwidth and sharp response characteristics. Such units must be thermally stable; as the ambient temperature of the system drifts naturally, the frequency response notch or attenuation of the traps ideally should not change.

In our experience, these traps are as apt to change their attenuation characteristics as they are to shift the rejection notch within the transmission spectrum. The condition of frequency shift seems to be more prevalent in single-channel high-band traps. Given a choice, we would opt for trapping within the low- and mid-bands exclusively. Chs. 2 and 5 are good candidates for effective passive trapping.

Positive trapping is a technique where jamming carriers are intentionally introduced into a specific signal, discriminately removed only at those locations where the viewer subscribes to this pay service. Positive trapping presents the opportunity to introduce an entirely new service either initially or subsequently into a system.

Although this technique introduces additional cost into the subscriber terminal, the cost is only incurred with subs who actually pay for the new service. Compared to the cost of descrambler set-top converters, positive traps can be quite cost-effective.

One very attractive option that positive trapping makes available is that all subs can be permitted to view this channel quite easily. You simply remove the interfering signal for a period of time. This can be an effective marketing tool by allowing all subscribers to preview the new service for special offerings or short periods.

Terminal equipment

Since all receivers are not "cable ready," they cannot tune all the frequencies that CATV systems generally utilize. Since we cannot, as a practical matter, transmit UHF signals on cable plant of any significant length, most systems are obliged to provide some type of converter at many if not all subscriber drops, but this is not mandatory. A converter is an active, power-consuming device of some complexity. We must place it in a relatively hostile environment where members of the household may abuse it. If every sub requires one and the units are fragile or unreliable, then it is obviously going to have a very undesirable effect on operating costs over the long term.

Although there is a wide range of converter types available, you are advised to research the operating history of such units carefully before making any purchases. There are some opportunities where larger systems are being upgraded to more sophisticated terminal devices. If unit costs are low enough in such cases, then the small operator may be able to simply buy from the upgrading system a large enough inventory to simply replace and discard units that fail later.

As a rule, the simpler the converter, the less trouble and cost it will present in the long term. The small operator is well-advised to avoid such refinements as addressability or converter descrambling, particularly considering the substantial cost of any headend computer or software required. However effective or profitable such units may be in large systems they will always cost more—and most probably more than the small system can realistically hope to retrieve from its distinctly limited service revenue.

Although it may be possible to buy used converters at a low cost, unless the price is significantly lower than a new converter (somewhere in the range of 20 percent of the cost of a new

(Continued on page 97)


Lectro
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Automated multichannel ad insertion for NuStar

This is the final installment of a three-part series on commercial insertion.

By Steve Fox
Marketing Manager-Cable, Wegener Communications

Cross-promotion of satellite-delivered cable channels is a new concept gaining rapid acceptance by the industry. The idea is simple: Insert network promos on unused local avails to inform subscribers of upcoming programs and encourage viewership. There are a number of ways to accomplish this. However, in this article we will discuss the NuStar system and the ProSwitch (a registered trademark) automated multichannel insertion switch used to place NuStar promos in the headend.

NuStar offers eight to 20 promotional avails per day per network, for a total of at least 300 30-second spots each day. Promos are inserted on specific channels when local ad insertion is not being used. A cable system with unsold avails as well as one not presently taking local ad avails at all may insert promos. The service is automated and no additional headend staff or channel space is required. Networks currently working with NuStar include Arts and Entertainment, BET, CBN, CNN, CVN, The Discovery Channel, The Disney Channel, ESPN, FNN, HBO, Headline News, Lifetime, MTV, Nickelodeon, TNN, TNT,

Figure 1: Inserter input interface

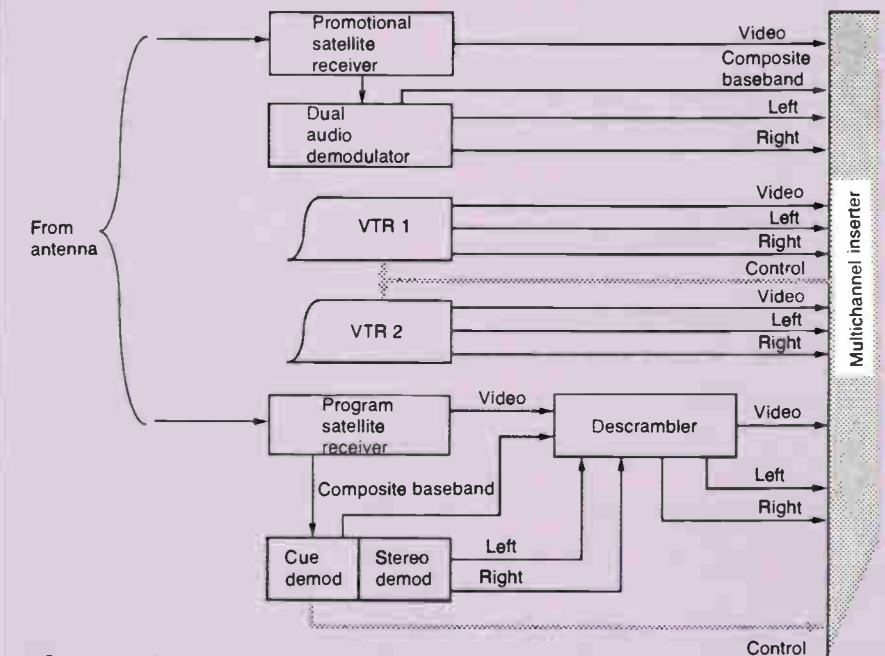
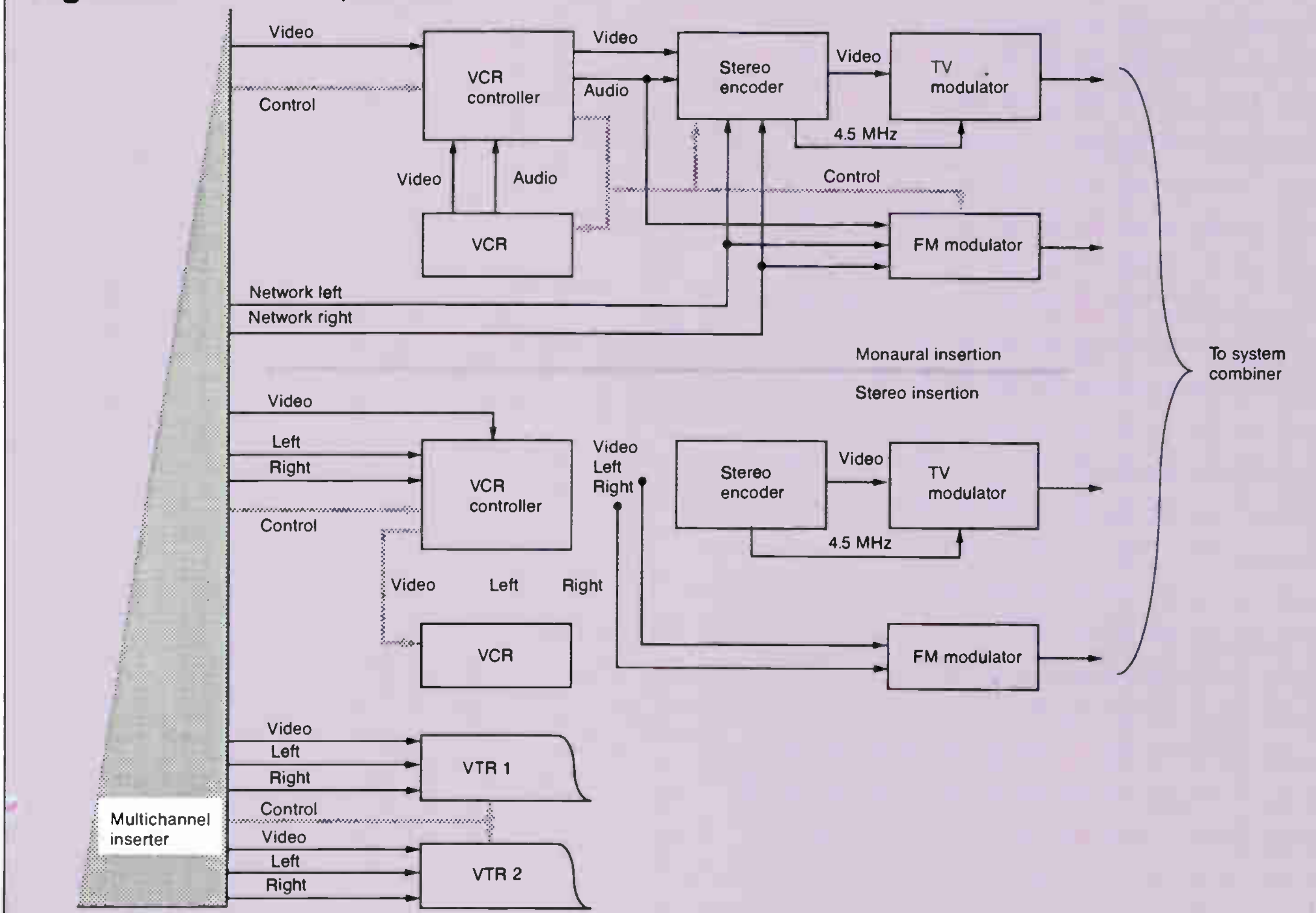
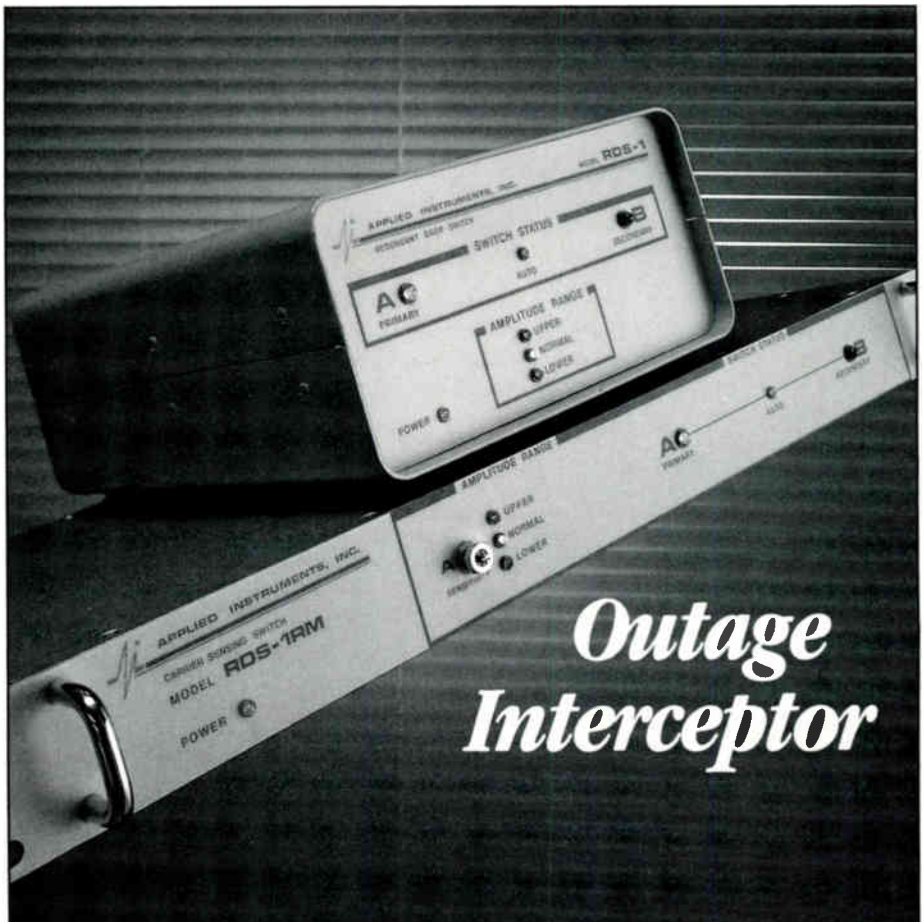


Figure 2: Inserter output interface



"Promos may be inserted in mono or stereo, with selection on a channel by channel basis."



USA, VH-1 and The Weather Channel.

The multichannel insertion switch is an automated 2:8 audio-follow-video switching system expandable to 2:16. The chassis provides all controls and indicators, an FSK data demodulator for the satellite-delivered control signals, a telephone modem for remote operation and a tape controller module for optional promo recording. It accepts the promos transmitted over the NuStar transponder and routes them to the specific channel programmed by the local operator. The inserter interfaces with the ad insertion equipment and allows normal local insertion when the switch is not active.

One insertion switch allows promos to be inserted on up to eight channels; a second switch can be added. The switch is programmed locally by way of a key pad to allow insertion on only the NuStar-supported channels the headend is currently receiving. Each cable system decides what promos will be received, onto which channels they will be inserted and how often a promo will be shown on each channel interfaced to the switch. Promos may be inserted each time a specific network transmits a cue or only during specific breaks, allowing a mixture of local ads and promos determined by the operator. Also, promos may be inserted in mono or stereo, with selection on a channel by channel basis.

The insertion switch can be addressed by the network, available on three levels: 1) Individual addressing allows information to be sent to a specific headend. 2) Group addressing allows headends to be placed into a number of network defined groups. A group might consist of all systems of a particular MSO, all headends in New York or all CNN affiliates. 3) Addressing also can be accomplished on a global basis.

How does it work?

At the uplink, the local ad insertion cues transmitted by the NuStar-supported networks are monitored. The projected times of these local avails are pre-programmed into the uplink computer along with promos intended for each avail. As each cue is received, the designated promo is transmitted over Transponder 12 of Galaxy III. Addressing and other data are transmitted simultaneously to the inserters located in NuStar affiliate headends.

At the headend, the inserter is already locally programmed to determine if the promo will be aired. Audio and video for each programmed cable network is input to the inserter along with network cues. If a promo is to run on that channel at that time, the network signals are intercepted and the promo is output to the appropriate headend equipment. If the promo is not to run, network signals are output directly from the inserter. By routing these signals through the insertion switch, local control is maintained; simultaneous insertion of a promo and a local ad is prevented.

Figure 1 illustrates the input interface to the insertion switch for a single network. A conventional satellite receiver provides NuStar video, monaural audio and control signals. An optional audio demodulator is available to receive promotions in stereo. A second satellite receiver either provides network audio and video directly to the inserter or through a descrambler. Again, an optional stereo demodulator may be used if unscrambled network stereo is available. VTRs may be used as a source of prerecorded promotions, if desired.

FM and/or BTSC modulators may be utilized with the inserter. Figure 2 shows the output interface with both stereo and monaural local ad insertion, stereo promo insertion and both FM and BTSC encoders. During promo insertion, stereo audio is routed to the FM and BTSC modulators while monaural local ads are input to the ad insertion controller from the local VCR. When stereo rather than monaural ads are inserted, the stereo promo audio is output directly to the local ad insertion

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A diverse endeavor

By Pam King
Staff Engineer/Training, Jones Intercable Inc.

The position of chief engineer includes a myriad of responsibilities; thus, the theme of Jones Intercable's eighth annual Engineering Conference was "You, the diverse engineer." This theme was not unlike those presented during previous conferences. In fact, it was meant to bring together all the elements of what a chief engineer does, tied up in a neat package, called "Countdown to Quality." In this program, the vital signs or elements important to each system's technical health are organized, prioritized and tracked. During the four days of the conference, held this year in Keystone, Colo., the chief engineers had the opportunity to actually develop the program.

We opened our conference in Denver on Friday, July 14 with reviews of the Society of Cable Television Engineers' BCT/E Certification Program. These reviews were both informal (or self-study) and formal. In addition to the reviews and exams, opening remarks were presented by some of our corporate communications and operations personnel, including Group Vice President of Operations Jim O'Brien, Vice President of Corporate Communications Jim Carlson and President Greg Liptak, as well as Group Vice President of Technology Bob Luff.

Identifying quality standards

Countdown to Quality was unveiled Sunday afternoon. This is a program of technical opportunity that will assist each system in identifying quality standards, establishing target goals, developing quality strategies and creating a feedback mechanism for tracking system progress. At the heart of the program is a simple Lotus spreadsheet listing the major performance categories.

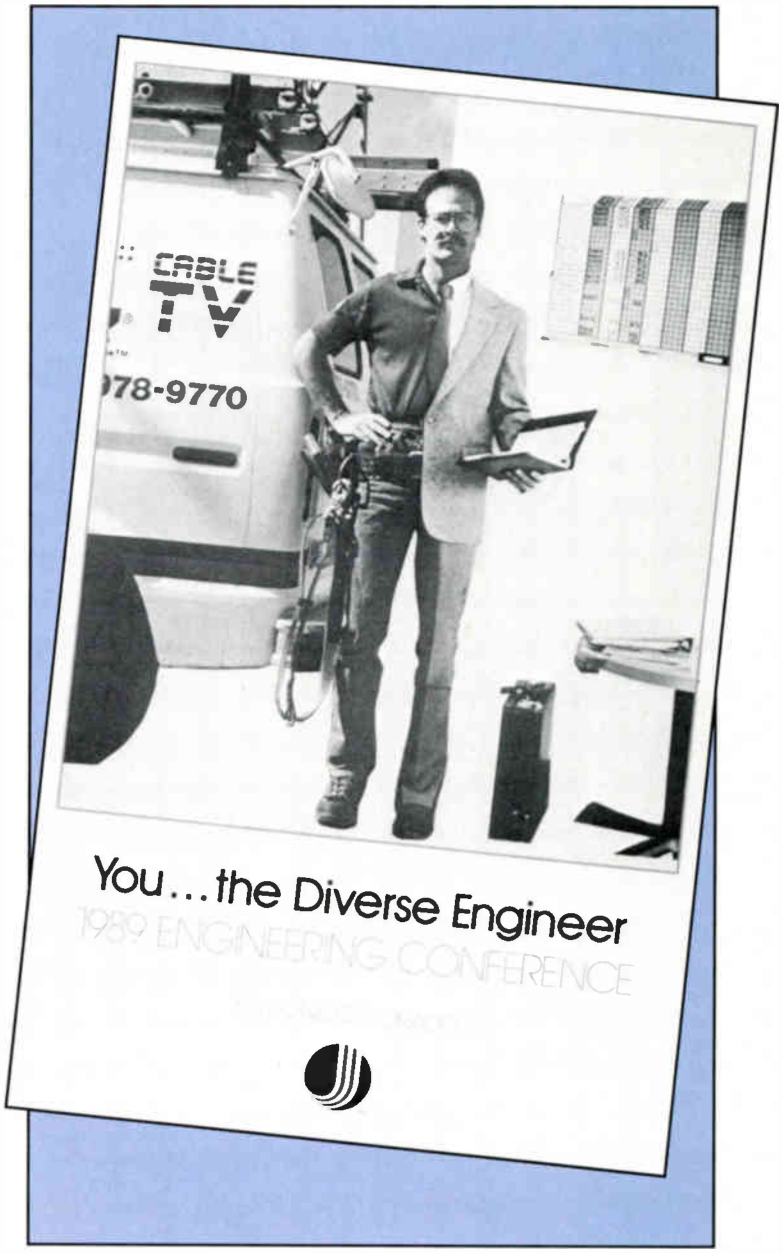
The first afternoon in Keystone included a slide presentation that outlined the mission upon which the chief engineers were about to embark. Vital signs included such topics as "Complying with CLI," "Reducing staff turnover" and "Qualified Installer Program compliance." A color dot on the engineers' name tags identified the vital sign they were assigned to explore; each group consisted of an average of eight members. These teams met during free time and meals to develop strategies and prepare for a brief presentation to the entire group. To help establish the initial performance standard, team members received forms to interview one another. Countdown to Quality has not yet been officially launched at the system level, since the process of analyzing data is still under way. Except for the insufficient time allocated to work on this project at the conference, the program was received with enthusiasm.

Continuing with the conference: Monday began with Thomas Mitchell from Management Dynamics, who discussed managing diversity in the workplace. Additional workshops included "Product management" with Dean Sotiriou (University of Denver), "Selecting high performers who fit" with Edward Barton (Eclecon) and "Coaching" with Denny Kercher (Mountain States Employers Council). These people were all from outside Jones, which was different from previous conferences. Typically members of the corporate engineering staff, assisted by system engineers, make the presentations. However, as we become more diverse in our needs, more diverse instruction is necessary.

On Tuesday, Jerry Strickland from Jones' Albuquerque system led a discussion on safety. Associates from Jones' securities, accounting and operations departments discussed the financial side of the chief engineer's job—one that is very important but unfortunately so often forgotten. Also, David Zonker, CEO of Jones International Securities, reviewed "The how and why of partnership funds."

Then we divided into smaller working groups. The basics of accounting were explored by Mike Bartolementi and Larry Kaschinske of the general ledger accounting department. A session on budgeting and accountability was conducted by Fund Business Managers Kevin Bethke and Tom Glendenning and Spacelink Business Manager Rick Larson. Steve Gines, director of materials management, gave an update on his specialty.

Tuesday evening's awards dinner with CEO Glenn Jones is always a popular event. He shares significant happenings as well as the direction of the company with the engineers. Also, the Medallion of the Alliance (the highest honor within the Jones International companies) is presented. This year there were two winners: Mike Scott of Augusta, Ga., and Gary McDonald of Spring Valley, Calif. Scott is currently managing Augusta's fiber upgrade, while McDonald has been responsible for preventing potential obstacles in a new-build situation. Congratulations to both!



A more traditional agenda

Wednesday we returned to a more traditional agenda, presented by the corporate engineering department. "Lightning protection techniques and safety for headends and towers" was examined by Roy Ehman. A series of advanced technology topics were explored, including data (with Del Guynes), fiber (with John Brouse from Broward County, Fla.) and the Jones Cable Area Network (with Bob Luff). Wayne Davis from Anne Arundel, Md., gave an update on high definition TV. Also, for our viewing pleasure, the Jones system in Hilo, Hawaii, showed a video on what it's like to work in paradise. Finally, Doug Greene, Frank Eichenlaub and Ron Hranac reviewed measurements—audio, video and RF, respectively.

On Thursday, the closing session included a discussion on technical training (with me) as well as a conference and Countdown to Quality wrapup with Luff.

The Jones engineering staff worked hard to make this the best conference ever. The comments we have received to date indicate that it was well worth our efforts. ■

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Status monitoring in fiber-optic systems

By John Holobinko
Vice President of Sales and Marketing
American Lightwave Systems Inc.

Consider the following scenario: A number of fiber-optic interconnects are installed. Each interconnection is 10 times more reliable than the one it replaces and serves 10 times the subscribers than the previous one. On the average, customers connected to this system will experience no improvement in overall reliability after fiber is installed.

As this scenario illustrates, fiber doesn't necessarily guarantee greater reliability systemwide. This is especially the case if the system design has been conscientiously optimized to provide the most cost-effective implementation of fiber. In this example, since each fiber serves more subscribers than its coax predecessor, one outage affects considerably more subs than previously.

A CATV fiber system that significantly improves reliability while maintaining a prudent, cost-conscious design requires that it have additional functionality beyond that of simple Point A to Point B transmission. Ideally, it should provide information about its operation; anticipate, pinpoint and eliminate failures; and allow very rapid correction of any failures that cannot be foreseen. This is the purpose of status monitoring (SM).

Status monitoring has been utilized on a limited basis in coaxial plant for a number of years. In fiber plant, the cost of implementing SM has come down dramatically and may now represent only 2 to 4 percent of the total cost of the fiber system. Additionally, new optical transmitters are available for under $2,000 are capable of sending a single channel of video and a number of data carriers back to a headend.

The functions that such a system can provide include: indication of hard failures, indication of "soft" failures or abnormal conditions, identification of failure causes (e.g., module, parameter), intelligent pre-emptive action upon detection of failure, trend analysis of operation and automatic inventory tracking of modules including spares.

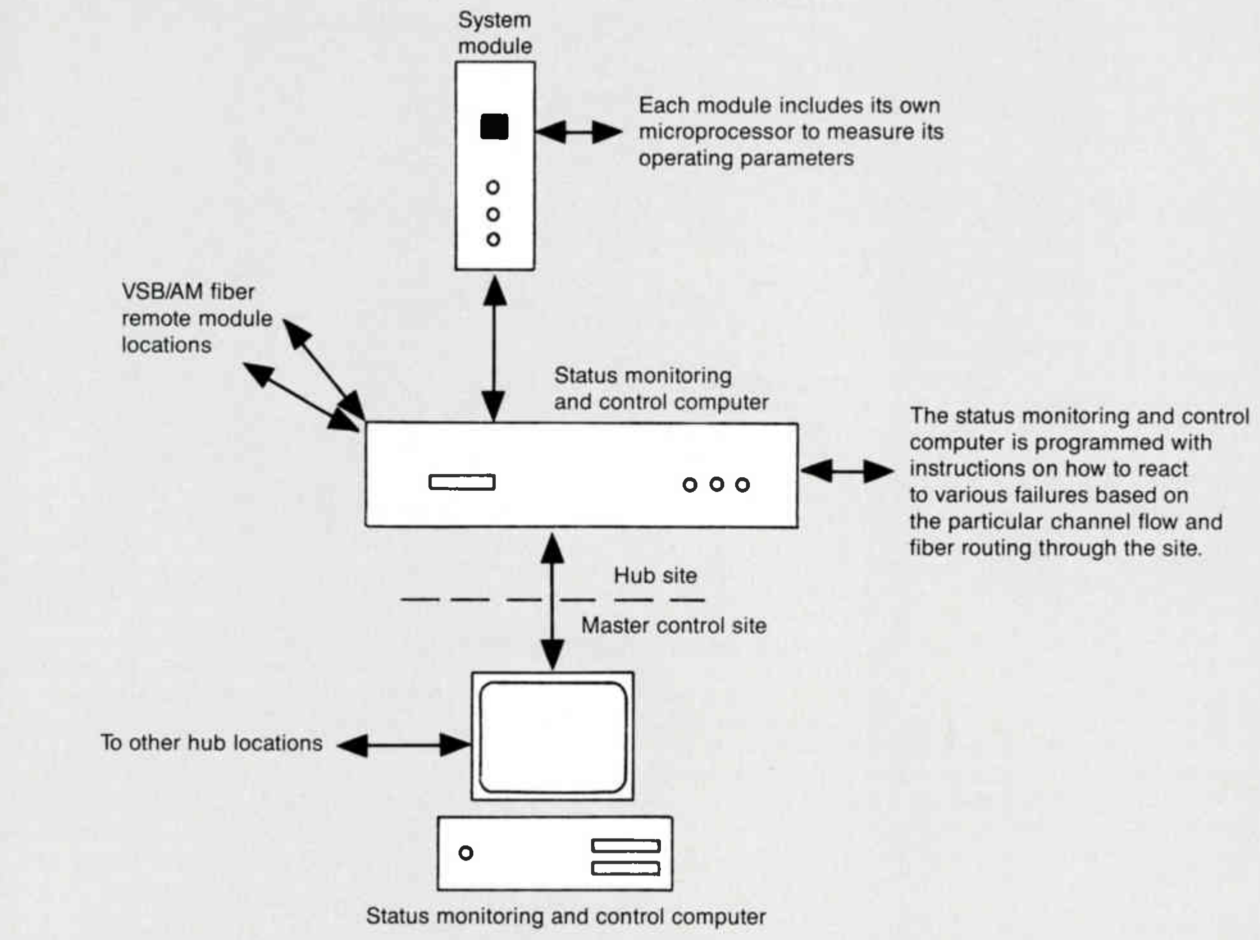
SM can be characterized by levels of functionality. From the most basic to the most complex, these are as follows:

Level 1—Dry contact closure. An internal sensing circuit in the module is triggered by some set of predefined failures. Usually a hard failure will energize the contact closure, which is normally sensed by external polling to report the alarm. The disadvantage of dry contacts is the limited ability to report the cause of an alarm or provide any information to the user before a hard failure occurs. The advantage is that it is easy to integrate multiple manufacturers' equipment under a single alarm.

Level 2—Microcontroller-based SM. Here, a microcontroller is used within a module (or group of modules) to monitor certain parameters within the operating hardware. The analogy is made to a built-in digital voltmeter within the hardware. This approach requires a polling computer to retrieve the information from each module. The advantage of microcontrollers is that they provide additional data beyond hard failures so that some parameters can be measured and the cause of a failure can be pinpointed from a central site.

However, a number of disadvantages also exist. In a fiber plant, ability to control SM or take advantage of its information from more than one location is limited, since only one computer can talk to it at a time. Also, the types of data and action that may be taken as a result of an alarm are limited. Finally, since the SM hardware loca-

Distributed intelligence monitoring



tions are polled one by one from a central site, as the plant grows the time for polling the network increases. Hence, outages cannot always be sensed at the instant they occur.

If you think this is trivial, consider the problem of rain fade in a microwave system. A perfect real world example is that of the subscriber who programs the VCR to tape a movie. Upon arrival home, the sub watches the tape, only to find a 30-second gap in the middle of a scene two-thirds of the way through (the result of a midday rainstorm). Now consider a fiber system in the same scenario with polling capable of hot standby optical switching. An optical failure occurs but polling takes a few seconds to sense it. Is this an improvement?

Level 3—Distributed intelligence-based SM. In this technology, local programmable intelligence is used to measure and detect abnormal conditions. Optionally it makes local, immediate and real-time decisions about switching or other actions required to correct the condition. If designed to be polled, it only reports to the central computer if a problem has occurred, as well as the appropriate course of action taken to correct the condition, when required. (Other important functions include timed rerouting or switching of must-carry signals to certain hub locations on a fixed time schedule basis.)

If this sophistication seems farfetched, consider that the price of microprocessors has come down in price recently below that of microcontroller prices of one or two years ago. SM with this functionality will be available to the CATV industry by the end of this year. With Level 3, the entire time spent polling a fiber plant can be eliminated. The SM equipment can operate in a real-time environment wherein each station is allowed to transmit to the central computer immediately upon sensing a failure. In earlier days this approach would have wreaked havoc on SM in the case of a single failure affecting many sites. Today, if multiple failures occur, each station can try to give the master computer its information until successful. Failures can be reported on a real-time basis without the SM "crashing" due to communications collisions among stations.

Now, re-examining the scenario of the CATV customer taping a movie, the results are quite different. With intelligent microprocessor-based SM, the optical failure is sensed as it occurs; the channels are immediately switched from the failed fiber to a standby path. The result is a gap of less than 200 milliseconds in the customer's tape, eliminating both the loss of flow in the program material on the recording and the customer's irritation from an outage.

Other benefits are possible. For example, all serial numbers of modules can be placed in non-volatile memory on the module. If a module is changed in the field, the central computer can be posted of the change by the local SM processor. The spares list can be updated by the computer and automatic warnings issued if the last spare has been used. If a technician has neglected to send failed modules for repair when taking spares from inventory, this can be an extremely valuable warning device. A report of actual inventory in the field at any time would be welcomed by many an operations manager.

CATV monitoring and control

The highest level of integration of SM is when a number of SM systems, each independent from one another, can be combined to form a single, plantwide SM. This means linking the non-fiber components together with the fiber ones. Unfortunately, there exists no universal interface standard for CATV amplifier, fiber, modulator and converter manufacturers for the purpose of interfacing SM systems to one another. IBM's Netview and Hewlett-Packard's OSI/ISO-based software are attempts at a solution. Hopefully, improvements in this area will soon resolve the issue.

Advanced forms of SM are economically viable in today's CATV fiber systems. In the next few months, rapid advancements in this area will make these features highly attractive, in light of the continuing focus on increasing customer satisfaction in an economic manner.

It is important to note that SM cannot be added on to an older fiber system that was not designed with this functionality as an integral part of its architecture. Future CATV designs will require that monitoring and control be available for all fiber-based transmission. CATV engineers need to keep this critical factor in mind when planning for rebuilds and expansions.

Twenty questions: CLI quiz

The following series of questions was originally formulated as a quiz for a system's technical staff and for an SCTE chapter seminar; this is the first of two parts. Test your knowledge by filling in the blanks. Answers are provided on page 110.

By Mark Harrigan
Bay Area Chief Engineer, United Cable of Alameda

1) Flyover leakage testing is to be done at what altitude above ground level? ____________ feet or ____________ meters. The maximum leakage level at this altitude is ____________ μV/m.

2) Federal Aviation Administration radio navigation signals fall between ____________ and ____________ MHz, are set up with ____________ kHz centers and must be offset on cable by ± ____________ kHz. FAA radio communications signals fall between ____________ MHz, ____________ MHz and ____________ MHz and are set up with ____________ kHz centers; these must be offset on cable by ____________ kHz.

3) There are three emergency frequencies; one at ____________ MHz from which cable signals must be offset by ____________ kHz and may be carried on a cable system at no more than ____________ dBmV maximum; and two at ____________ and ____________ MHz, from which cable signals must be offset by ____________ kHz. These also cannot be carried at a level above ____________ dBmV on a cable system.

4) Frequency stability is as important as leakage itself. Standard and IRC equipment must be kept within ____________ kHz. FAA frequencies must be kept within ____________ kHz, giving us a minimum separation of ____________ kHz. An HRC comb generator must be kept within ± ____________ cycle of a frequency of ____________ cycles. This provides a minimum offset of 5,700 Hz at Ch. 14 (120 MHz) and a maximum offset of 19,800 Hz at Ch. 53 (396 MHz).

5) Every system must meet a minimum ____________ CLI$_{\infty}$ by ____________ or face the loss of up to ____________ channels and/or fines of up to ____________ per day.

6) The formula for calculating mV from dBmV is: ____________. To calculate μV/m multiply this by ____________ times the ____________ of the leak and move the decimal three points to the right. To calculate ground-based CLI (by the I_{∞} method), square all leaks over ____________ μV/m, add them together, multiply by ____________ and take the log of that number times 10.

7) Compute the following example:
Given:
100 miles drive out of 110 total plant miles
3 leaks at 60 μV/m
15 leaks at 110 μV/m
1 leak at 440 μV/m = a CLI of ____________.
Does this pass? ____________
Would a single leak of 1,600 μV/m pass? ____________

8) A minimum of ____________ percent of your system must be driven out during a ground-based CLI. This must include the ____________ portions of your plant.

9) Are we still concerned with repairing leaks below 50 μV/m? ____________

10) When will the Federal Communications Commission start accepting CLI test results? ____________

11) Are cable plants undergoing a rebuild exempt from leakage requirements? ____________

12) Are recently purchased systems exempt? ____________

13) What range of frequencies are recommended by the FCC for a leakage detection signal? ____________

14) Is underground plant included in leakage and CLI? ____________

15) If a plant is interconnected via ____________ or other non-mechanical link, can it be considered separately? ____________

16) Are leaks created by subscribers in their homes the cable operator's responsibility? ____________ Does the same go for apartment buildings? ____________

17) Are all systems included when it comes to leakage requirements, regardless of size? ____________

18) An FCC inspector who comes to your system will generally drive out ____________ miles of plant before coming to visit the cable office.

19) How long must leakage and CLI data be kept? ____________ years

20) Would trapping out the FAA bands to "leaky" apartment buildings be sufficient? ____________

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Test equipment for baseband

By John Horn
Product Marketing Manager, Television Division, Tektronix Inc.

CATV engineers are taking a new approach: They're testing their baseband video and don't depend solely on spectrum analyzers to find signal impairments. In other words, RF is not the only consideration any more.

Many problems can continue to exist if testing is done only in the RF domain; we can avoid these errors by demodulating and testing video. The problems can be detected early and corrected before they are transmitted. If you're not convinced that baseband test equipment is the answer, there are some ideas to consider.

Cable subscribers are more quality conscious, expect better signals and are not satisfied with low technical quality. They view the video signal on much improved TV sets that can show a bad picture for what it's worth, while yesterday's models were much more forgiving. Even tuners in VHS and Super-VHS VCRs are continually improving. Also, the viewer doesn't concentrate on special effects alone; technical excellence is as important as the information and artistic content of a TV program.

The expectation of the viewer will always change as technology advances. As it develops, the new formats presented and added devices in the signal path make for a very complex process, resulting in more potential for loss of signal quality. If high definition TV delivers what is being proposed for the future, the limitations we know of today as "state of the art" will be unacceptable. And if signal quality being used now doesn't even meet today's expectations, there will be a lot more catching up to be done later.

Complex processing also adds to signal degradation. A slight differential gain problem may go unnoticed for up to three generations of videotape duplication but by the fourth generation it's noticeably ugly. In effects sequences the key signal must be clean; jitter and noise can become very distracting with further processing.

Multiformats also can present problems. If the original signal converted from one format to another is not carefully controlled, there could be clipping in a channel (resulting in loss of part of the information). Damage like this can't be repaired later. In addition, if different sources are used for a finished program, changes can occur in color or contrast. Again, these technicalities must be checked before transmission.

The equipment

Measuring and monitoring the baseband video signal have been a kind of ritual with broadcasters for many years. There are certain types of equipment being used in the broadcast industry that cable operators are now recognizing as essential in delivering a quality video product. The choice of test and measurement equipment depends on the features needed, cost and the operator's personal preference. The minimum setup for testing should include a test signal generator, waveform monitor and vectorscope.

"The minimum setup for testing should include a test signal generator, waveform monitor and vectorscope."

The monitoring and measuring done from waveform monitor and vectorscope displays provide a means to identify and learn the extent of problems with signals and equipment. Generators offer a group of test signals to be used for verifying the performance of equipment. A generator is also valuable as a genlock source by which signals can be properly displayed and transmitted.

In the past, the concerns about including test equipment in an engineer's daily routine have been the time involved and skill needed to put it to good use. Manufacturers have responded by applying the latest technology to equipment. Hence, test and measurement gear is easier to use with its digital control techniques and automatic capabilities. Microprocessors are taking over a large portion of the recall, front panel control setup and calculation tasks formerly required of operators of test equipment. A manually operated measurement set requires an operator to interact with it, but comprehensive microprocessor assistance makes tasks faster, easier and more accurate. Some measurement sets are specialized computer systems that can be used in the more common manual mode or as fully automatic and unattended monitoring devices that might be needed in a remote location.

Test signal generators are benefitting from advances in microprocessor, memory and control technologies as well. The benefits are affordable, with some digital generators selling less than $1,300.

Increased level of awareness

Changes in the complexity of signal processing, new technologies and an increased level of awareness by subscribers should be taken into account. These changes affect the way engineers must maintain their equipment systems and transmitted signals. Appropriate test equipment is very important and necessary.

ATV testing

(Continued from page 44)

coaxial cable and fiber transmission test bed and the appropriate testing resources. The evaluation of the effects of CATV cascaded with broadcast transmission will be conducted as part of the tests.

Considerable merit is seen in development of the Cable Labs/ATTC relationship. It provides a one-stop testing site for the proponent, avoids unnecessary duplication, ensures a consistency in quality and readily enables the combined testing of over-the-air transmission with CATV distribution.

The Cable Labs development of detailed CATV test procedures also is being carried out in close cooperation with the ATTC staff. This ensures a uniform format for both cable and broadcast procedures. It also maximizes sharing of common test equipment, etc., thus saving capital. However, final procedures are not expected until late fall. Cable Labs will circulate to the various proponents the procedures and will likely invite the proponents to comment both on these procedures and cable distribution of their proposed systems. Although the timing has not yet been fixed, "hell week" is being contemplated when each proponent can address specific concerns of the industry.

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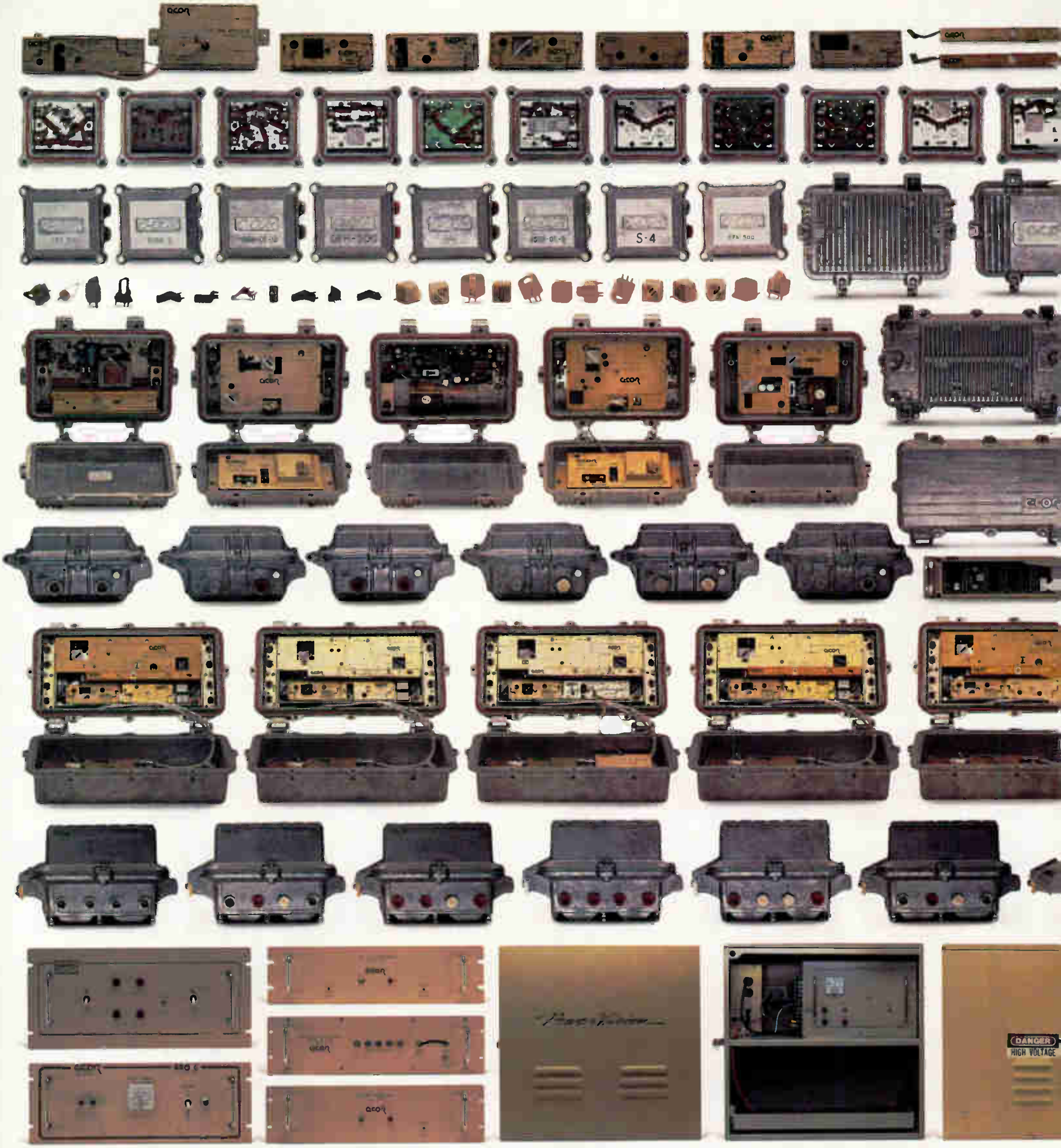
This article was based on a presentation at the 1989 National Show and updated by the author.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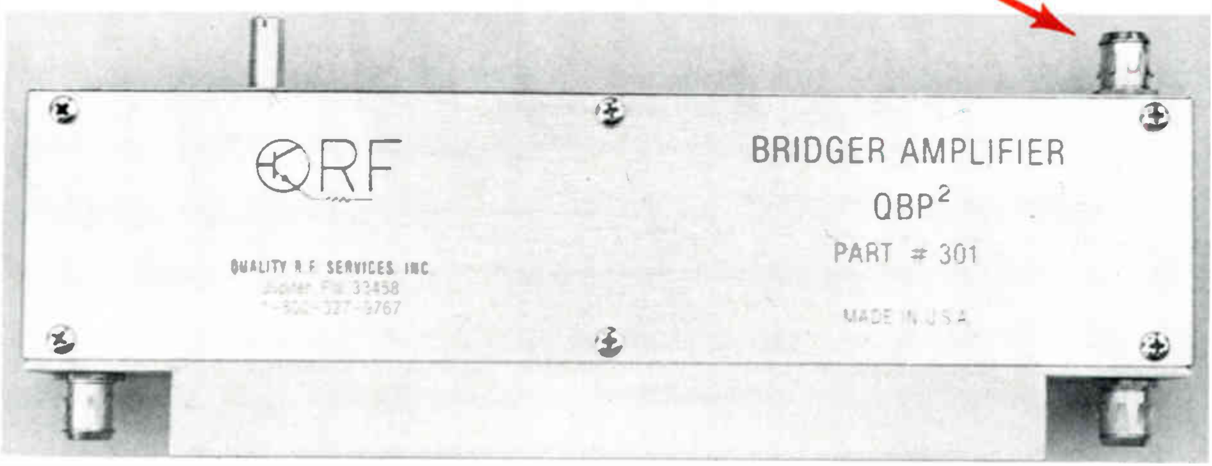

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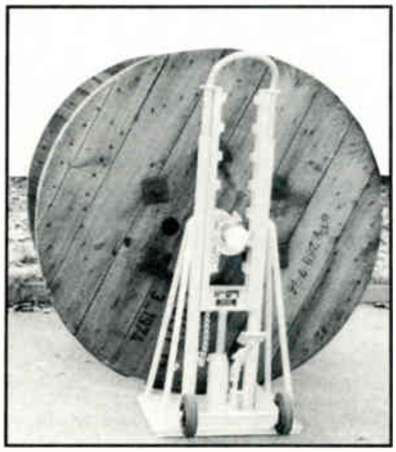
Drum jacks



Cable drum jacks from Lancier can be used from cable yard to installation site. According to the company, high flexibility allows them to be operated by one person because the wheels have rubber tires and rotate on ball bearings. The adjustable spindle support may be set at a number of vertical positions so that only the minimum of jacking by way of a pedal is required. The jacks can handle drum sizes of 126 inches in diameter and will hold up to 22,000 pounds of cable. The hydraulic jacks have a chromium-plated piston rod and are safe to use in confined areas.

For additional details, contact Lancier Inc., 1416 Parkway View Dr., Pittsburgh, Pa. 15205, (412) 787-5225; or circle #135 on the reader service card.

Stereo encoder

Cadco is offering its Model 380 stereo encoder. The product is a true dbx stereo, meets Federal Communications Commission OET-60 broadcast standards for BTSC. It also has phase-locked aural and video IF for precise 4.5 MHz audio/video separation. The product features multiple outputs to interface with any modulator requiring baseband composite stereo audio, 4.5 MHz BTSC subcarrier or 41.25 standard aural subcarrier.

For additional details, contact Cadco Inc., 2706 National Circle, Garland, Texas 75041, (214) 271-3651; or circle #130 on the reader service card.

Tool accessories

Ripley introduced additional accessories for its CST combination core and strip tool. According to the company, the new accessories will allow the tool to produce the exact center conductor cut lengths necessary for popular brands of feed-through connectors. Lengths to a maximum of 3 inches will now be available. The accessories, which can be used with either the CST combination tool ratchet handle or the drill adaptor, consist of a tool extension and a strip stop.

For more details, contact Ripley Co. Inc., Cablematic Division, 46 Nooks Hill Rd., Cromwell, Conn. 06416, (203) 635-2200; or circle #140 on the reader service card.

Sweep storage

Available from CaLan, File Server is designed to help the user increase productivity and flexibility when using CaLan integrated sweep systems. Traces stored in the field can be recalled and printed at the end of the day. Greater flexibility is said to be possible using the stored references and tables. The product has been developed to provide storage of 10 response traces, four reference traces and an additional sweep setup table.

For further information, contact CaLan Inc., R.R. 1, P.O. Box 86T, Dingmans Ferry, Pa. 18328, (717) 828-2356; or circle #112 on the reader service card.

Amplifiers

Viewsonics announced three new amplifiers for outdoor/indoor use, both exceeding 100 dB RFI. Model VSA-20-12WS is a splitter/amplifier with 12 outputs and a 6 dB gain per port; it is rated at 77 channels. Models VSA-10-550-2WZ and VSA-20-550-2WZ are bidirectional amps with passive returns. Gains are 10 and 20 dB. Power is 110 volts at 60 Hz or 220V at 50 Hz. These come with plug-in adapters powered by coaxial cable, permitting variable distances for powering.

For more information, contact Viewsonics, 170 Eileen Way, Syosset, N.Y. 11791, (516) 921-7080; or circle #136 on the reader service card.

Port cleaner

Multilink is offering its tap port cleaner for cumulative leakage index maintenance. According to the company, the cleaner and thread chaser tool are three tools in one. One side of the tool cleans off the tap threads like a battery terminal cleaner. The second wire brush cleans the facing of the port where the signal makes contact with the F connector. The other end of the tool retaps the threads on the tap port. Each of these features is said to ensure better connectorization and signal contact with the F connector.

For more details, contact Multilink, Communication Division, 196 Morgan Ave., P.O. Box 955, Elyria, Ohio 44035, (216) 324-4941; or circle #138 on the reader service card.

Addressable control

The Jerrold Division of General Instrument Corp. introduced the Model ACC-1000, an addressable control computer that is said to bring cost-effective addressability to small- and mid-sized cable systems. It can handle up to 32 services and 32,000 subscribers, as well as ANI, ARU and CSR pay-per-view ordering. The computer is compatible with the company's entire line of one-way addressable converters, including the Impulse 7000 series. →

Small systems

(Continued from page 84)

unit, perhaps), then second-hand units may not really make sense at all. The small operator can ill-afford a multiplicity of service calls and the subscriber dissatisfaction that could develop.

We are obliged here to put some cost figures on converters. We must qualify these costs as representative rather than specific; the small operator may do much better or worse in some cases. A suitable brand new converter for 35 channels might run between $20 and $36 each. It seems unnecessary to quote costs for 20-channel units, since we do not believe many small systems would actually purchase such equipment. Some operators recover converter costs or limit this expense by charging subs a refundable cash security deposit.

Subscriber drops

We recommend that the small operator standardize on one size of drop cable. RG-6 is a happy compromise between transmission loss and cable cost. Since the system will be operating with a minimum of personnel, it is sound practice to use messengered drop cable for all aerial drops to minimize system disruption from wind or ice storms. Underground drops may be best from the point of view of long-term service costs. However, in many parts of the country plowing in drop cable is simply too expensive, just as it is for the rest of the plant.

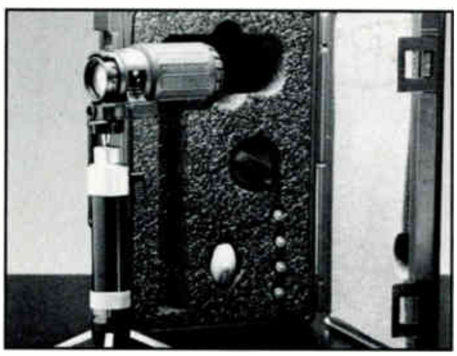
Installed service drops should run about $30 to $40 per sub, which includes the grounding block, drop cable, fittings and an installation labor estimate. This figure does not include the subscriber taps (which were figured into the plant costs) nor does it include terminal units, such as converters or traps.

For more details, contact Jerrold Division, General Instrument Corp., 2200 Byberry Rd., Hatboro, Pa. 19040, (215) 674-4800; or circle #132 on the reader service card.

Design software

Two PC software programs for designing CATV and RF local area networks are scheduled for release in October from ComNet. The company is supplementing its Broadband System Engineering (BSE) software with the introduction of BSE-Pro and BSE-II. The BSE-Pro features pull-down menus, dialogue boxes and speed keys, and is said to be capable of designing major CATV systems or broadband LANs from 1 MHz to 2 GHz. The BSE-II is a scaled down version intended for limited budgets, occasional designing or smaller applications.

For more details, contact ComNet Co., 3310 Western Dr., Austin, Texas 78745, (512) 892-2085; or circle #139 on the reader service card.



FO viewer

Quantex Corp. is offering a hand-held IR viewer that permits viewing of infrared wavelengths past 1 micron. The Nirscope 1500 makes it possible to view IR signals in the 1,000 to 1,600 nm range. According to the company, lab techs and engineers working with 1,300 to 1,500 nm fiber-optic and laser system are now able to view lower wavelength signals. Applications include laser beam alignment, fiber-optic coupling, fiber continuity tests, instrumentation, laser detection and night scene viewing.

The product features include a cast aluminum housing with machined surfaces for added durability and precision optics capable of focusing down to 10 inches. It can be mounted in v-blocks or on optical tables and instrument stands. The detachable handle incorporates an optional tripod for stand-alone use.

For more information, contact Quantex Corp., 2 Research Ct., Rockville, Md. 20850, (301) 258-2701; or circle #133 on the reader service card.

Application note

KeyTek Instrument Corp. announced the availability of an application note describing oscilloscope probes and techniques for measuring surge voltages to 6 kV. Note AN-121 provides detailed information on using high voltage oscilloscope probes to measure high voltage surge transients with front times as fast as 10 ns. Emphasis is placed on differential measurements to minimize errors due to high frequency interference. Difficulties encountered with previous instrumentation are described, including the higher sensitivity of typical prior-art oscilloscope probes to compensation adjustments. Probe impedances, physical size and other considerations are discussed.

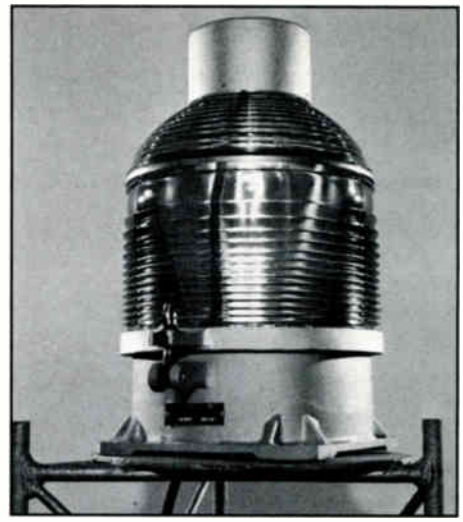
For more information, contact KeyTek Instrument Corp., 260 Fordham Rd., Wilmington, Mass. 01887, (508) 658-0880; or circle #114 on the reader service card.

Cable locator

Fisher Research Laboratory introduced its Model TW-6 pipe and cable locator. The new product locates and traces underground metal objects such as pipes, cables, manhole covers, vaults and valve boxes. According to the company, the tracing distances of pipes and cables when energized inductively or with a direct hook-up to the transmitter have increased 50 to 100 percent from the company's previous model.

New features of the product includes crystal controlled frequency in both transmitter and superheterodyne receiver, a voltage controlled oscillator with a wider signal range and specific noise cancelling circuitry to eliminate power line reference.

For more information, contact Fisher Research Laboratory, 1005 I St., Los Banos, Calif. 93635-4398, (209) 826-3292; or circle #137 on the reader service card.



Tower beacon

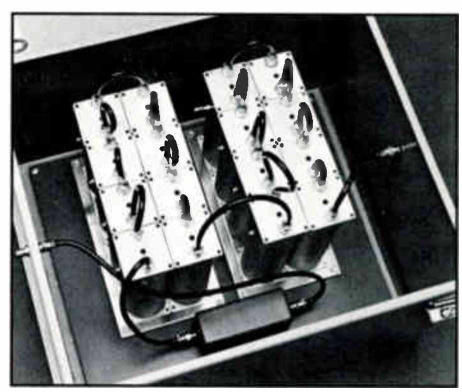
Brighter Idea Strobes introduced the Model SH-2001-I, its new 300 mm code beacon for lighting communications towers. The product is a smaller version of the standard incandescent beacon. It features a glass and cast aluminum housing, lighter wiring requirements and reduced windload. Optional controllers and wiring kits are available with this unit.

For further information, contact Brighter Idea Strobes, P.O. Box 54, Verona, Wis. 53593, (608) 845-6753; or circle #134 on the reader service card.

Power supply

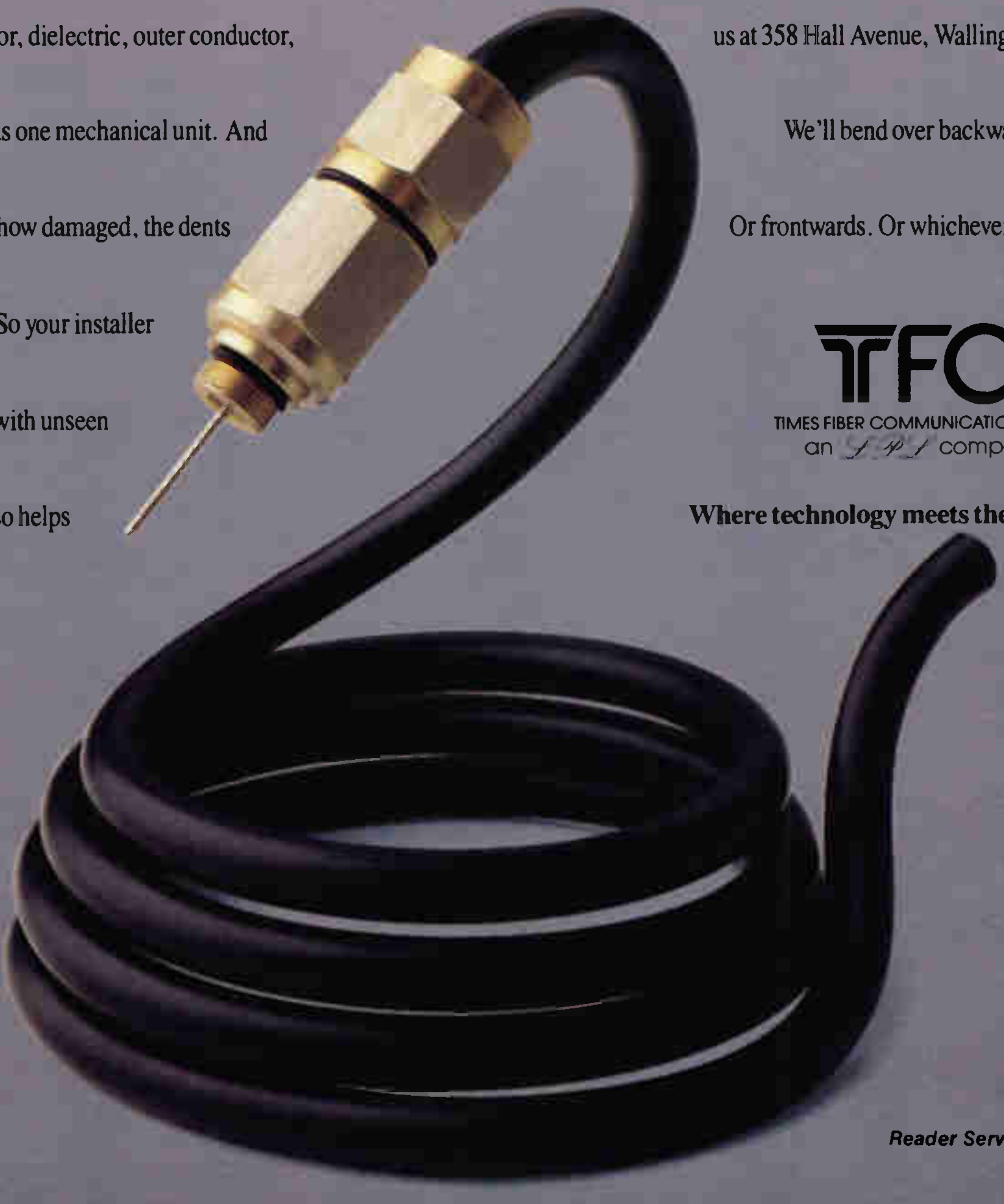
A three-phase uninterruptible power supply (UPS) is now available from LorTec Power Systems. The new 18 kVA UPS features totally on-line transistorized operation, which provides no-break power in the event of a commercial power outage and continuous complete power conditioning and surge suppression. Its small footprint (dimensions are 38.5 × 31.5 × 72 inches) and light weight (1,400 pounds) make it considerably smaller and lighter than other LorTec models.

For further details, contact LorTec Power Systems Inc., 145 Keep Ct., Elyria, Ohio 44035, (216) 327-5050; or circle # 125 on the reader service card.



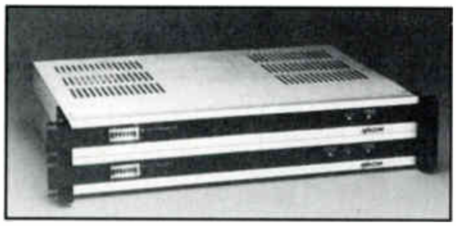
Channel deletion

The Series 6558 special channel deletion networks from Microwave Filter Co. remove and re-



insert channels in local area networks (LANs). Low passband for Model 6558-1 is 5 to 41.5 MHz, insertion loss is 3 dB maximum, high passband is 61.25 to 174 MHz, stopband is 43 to 59.75 MHz and rejection is 50 dB minimum. Model 6558-2 has a low passband of 253.25 to 450 MHz and insertion loss of 3 dB; stopband is at 234 to 251.75 MHz and rejection is 50 dB minimum.

For more information, contact Microwave Filter Co. Inc., 6743 Kinne St., East Syracuse, N.Y. 13057, (315) 437-3953; or circle #119 on the reader service card.



Microwave link

M/A-COM MAC introduced the Model MA-18CC FM wideband video microwave link for use in the 18 GHz band. The RF head is available in simplex (10 pounds) or duplex housing (22 pounds) intended for rooftop or tower pipe mounting. Multiplexing allows up to four RF transceivers to be mounted to a single 2-, 4- or 6-foot diameter antenna. According to the company, the transceiver is field tunable over the full 470 MHz using DIP switches and fine tune control for versatile field deployment.

For additional details, contact M/A-COM MAC Inc., 5 Omni Way, Chelmsford, Mass. 01824, (617) 272-3100; or circle #120 on the reader service card.

Mono/stereo AGC

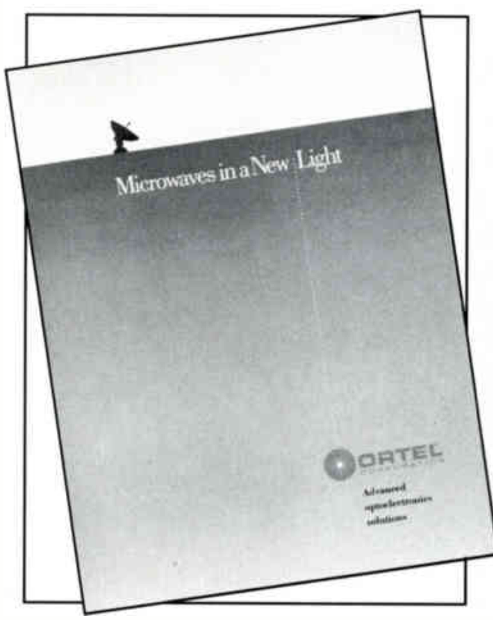
The AGC432 from Leaming is a dual mono/stereo audio automatic gain control designed to maintain average program levels within a reasonable range without reducing the dynamic range of the audio. It utilizes a gated gain compressor that detects when the program level falls over 20 dB below normal levels. It assumes that there is a pause in the program and holds its gain setting for 10 seconds. A peak limiter is used to keep sudden peaks from causing overmodulation.

For more details, contact Leaming Industries, 15339 Barranca Pkwy., Irvine, Calif. 92718, (714) 727-4144; or circle #131 on the reader service card.

Monitor/vectorscope

Leader Instruments announced the availability of the Model 5872, a new combination waveform monitor/vectorscope. Features include simultaneous vector and waveform display for video signal monitoring and dual channel display for observation of two video sources on the same screen. According to Leader, a switching mode power supply automatically adapts the unit to a wide range of AC (90-250 VAC, 48-440 Hz) voltages, making the instrument ideal for ENG/EFP applications. The product is housed in a metal cabinet with a handle and feet for bench use. The cabinet is removable for rack mounting purposes.

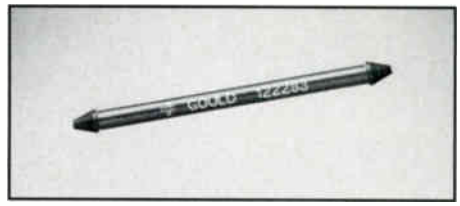
For further information, contact Leader Instruments Corp., 380 Oser Ave., Hauppauge, N.Y. 11788, (516) 231-6900; or circle #118 on the reader service card.



Brochure

Ortel is offering a six-page illustrated brochure highlighting the company's fiber-optic product line for RF and microwave analog applications. *Microwave in a New Light* includes application diagrams and charts summarizing typical link performance levels and the advantages of analog fiber-optic links.

For additional information, contact Ortel Corp. 2015 W. Chestnut St., Alhambra, Calif. 91803, (818) 281-3636; or circle #121 on the reader service card.



Fiber filters

Gould Fiber Optics Operation announced its line of passive, single-mode wavelength filters designed to provide additional wavelength isolation. The in-line filters are said to provide at least 15 dB isolation over a 40 nm passband within the 1,300 or 1,500 nm wavelength regions with low insertion loss. Applications include fixed in-line attenuators and enhanced isolation for wavelength division multiplexing/demultiplexing.

For additional details, contact Gould Inc., Fiber Optics Operation, 6730 Baymeadow Dr., Suite D, Glen Burnie, Md. 21061, (301) 787-2802; or circle #117 on the reader service card.

ARU computer

CableData is offering its TeleClerk 386 as part of its line of automatic response units. The product is based on the 32-bit Intel 80236 microprocessor chip and can provide for up to 32 phone lines in one chassis. According to the company, it is capable of handling ANI data integration, automated attendant, voice recognition, voice mail and outage alert. It also offers multitasking and interapplication transfer, customized reporting and other features.

For further details, contact CableData, Sacramento, Calif. 95873, (916) 636-5800; or circle #141 on the reader service card.

Ad insertion

(Continued from page 87)

controller from the inserter. You may notice that if a network satellite receiver and descrambler (if used) were substituted for the insertion switch, the input and output connections for the remainder of the system would not change.

Not shown in Figure 2 are the optional remote personal computer and local printer. The internal VTR controller module supports remote operation, electronic mail and VTR operation. Using a "password" system to provide security, an internal dial-up modem interfaces with the PC to provide remote inserter programming and status monitoring through an RS232 interface. With access to the NuStar satellite feed and two separate VTR video signals, any two of these three promotional video sources may be run at the same time. The printer output port provides electronic mail transmitted from the uplink to a local 300 baud serial printer.

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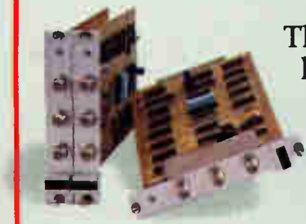

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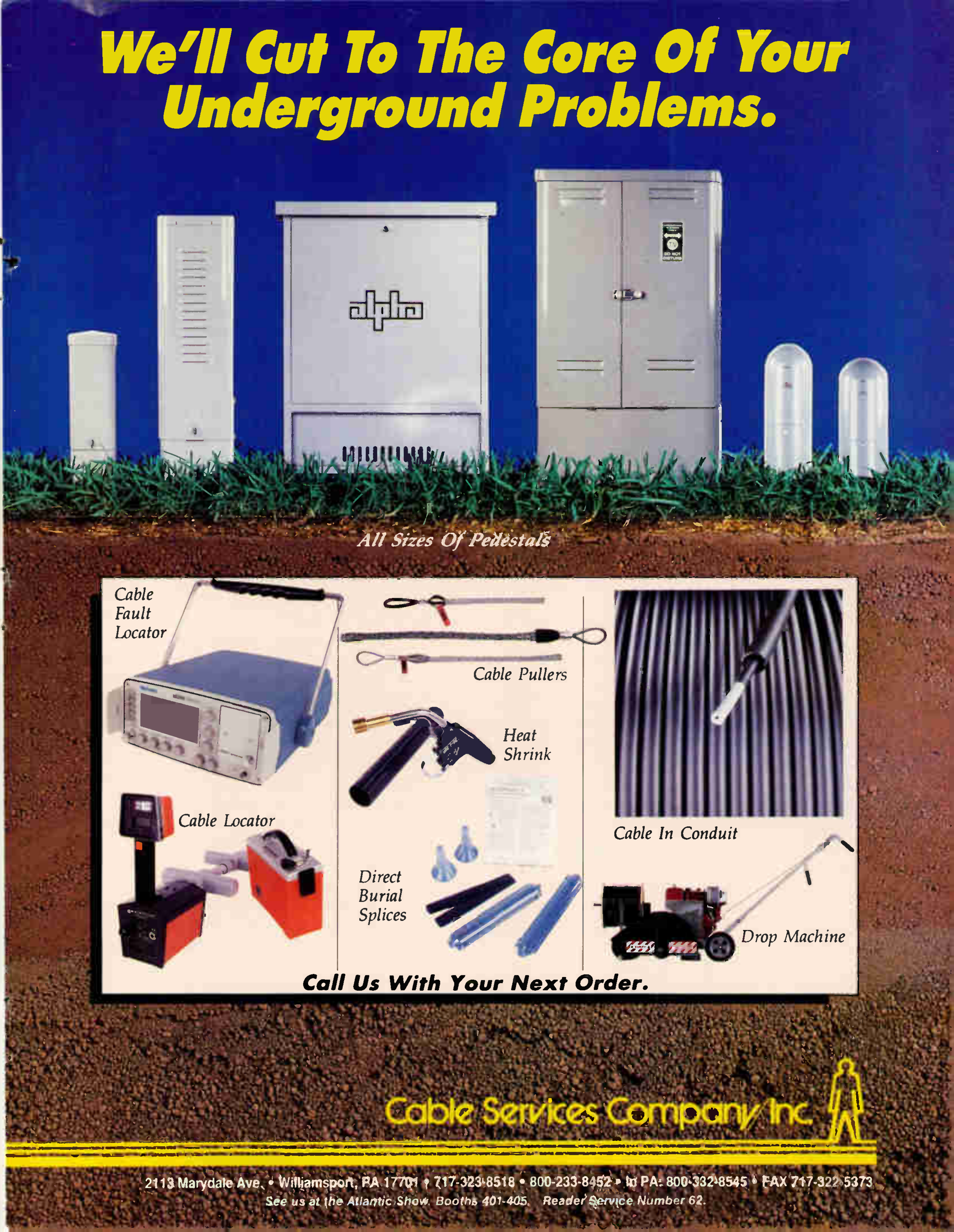

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October

Oct. 3-5: Atlantic Show, Convention Center, Atlantic City, N.J. Contact (609) 848-1000.
Oct. 4: SCTE Upstate New York Chapter technical seminar, Buffalo, N.Y. Contact Ed Pickett, (716) 325-1111.
Oct. 5: SCTE Upstate New York Chapter technical seminar, Auburn, N.Y. Contact Ed Pickett, (716) 325-1111.
Oct. 5-8: Society of Broadcast Engineers annual convention, Kansas City, Mo. Contact (800) 225-8183.
Oct. 9-12: Siecor Corp. technical seminar on fiber-optic installation and splicing for LAN, building and campus applications, Hickory, N.C. Contact (704) 327-5539.
Oct. 10: Ohio Cable Television Association and **SCTE Ohio Valley Chapter** seminar on CLI, Radisson Hotel North, Columbus, Ohio. Contact Maryann Kafer, (614) 461-4014.
Oct. 11: SCTE Wyoming Meeting Group technical seminar. Contact Matt Forgas, (307) 324-2286.
Oct. 11-13: Magnavox CATV technical seminar, Raleigh, N.C. Contact Amy Costello Haube, (800) 448-5171.
Oct. 12: SCTE Golden Gate Chapter technical seminar on CLI for management, Pleasanton Fairgrounds, Pleasanton, Calif. Contact John Parker, (408) 437-7600.
Oct. 12: SCTE Chesapeake Chapter technical seminar on system performance, Holiday Inn, Columbia, Md. Contact Tom Gorman, (301) 252-1012.
Oct. 12: SCTE Ohio Valley Chapter technical seminar on CLI, Park Hotel, Columbus, Ohio. Contact Bill Ricker, (614) 236-0523.
Oct. 12-16: MIPCOM, Palais des Festivals, Cannes, France. Contact (212) 967-7600.
Oct. 14: SCTE Rocky Mountain Chapter technical seminar on signal processing centers. Contact Rikki Lee, (303) 792-0023.
Oct. 16-20: George Washington University course on modern communications and signal processing, Washington, D.C. Contact (202) 994-6106.

Planning ahead

Dec. 13-15: Western Show, Convention Center, Anaheim, Calif.
Feb. 21-23: Texas Show, Convention Center, San Antonio.
May 20-23: National Show, Convention Center, Atlanta.
June 21-24: Cable-Tec Expo, Nashville, Tenn.

Oct. 17-19: C-COR Electronics technical seminar, Boston. Contact Binky Lush, (814) 238-2461.
Oct. 17-19: Mid-America Show, Hyatt Plaza Inn, Kansas City, Mo. Contact (915) 841-9241.
Oct. 18: SCTE Florida Chapter's South Florida Group technical seminar, Holiday Inn, Fort Lauderdale, Fla. Contact Denise Turner, (813) 626-7115.
Oct. 18-19: SCTE Heart of America Chapter technical seminar and BCT/E testing. Contact Wayne Hall, (816) 942-3715.
Oct. 19: SCTE Florida Chapter's First Coast Group technical seminar, Holiday Inn Airport, Jax, Fla. Contact Denise Turner, (813) 626-7115.
Oct. 20: SCTE Miss/Lou Chapter technical seminar on distribution theory and batteries, Seaview Resort, Biloxi, Miss. Contact Mike Latham, (601) 226-2886.
Oct. 21: SCTE Chaparral Chapter technical seminar on headend equipment and audio/video signals, Holiday Inn, Clovis, N.M. Contact Jim Dickerson, (501) 777-4684.
Oct. 21: SCTE Razorback Chapter installer seminar, Days Inn, Little Rock, Ark. Contact Jim Dickerson, (501) 777-4684.
Oct. 21-25: Society of Motion Picture and Television Engineers technical conference and equipment exhibit, Convention Center, Los Angeles. Contact (914) 761-1100.
Oct. 23-26: Siecor Corp. technical seminar on fiber-optic installation and splicing for CATV applications, Hickory, N.C. Contact (704) 327-5539.

Answers to CLI quiz

(from page 92)

1) Flyover leakage testing is to be done at what altitude above ground level? *1,500* feet or *450* meters. The maximum leakage level at this altitude is *10* μV/m.

2) Federal Aviation Administration radio navigation signals fall between *108-118* and *328.6-335.4* MHz, are set up with *50* kHz centers and must be offset on cable by ± *25* kHz. FAA radio communications signals fall between *118-137* MHz, *225-328.6* MHz, and *335.4-400* MHz and are set up with *25* kHz centers; these must be offset on cable by *12.5* kHz.

3) There are three emergency frequencies; one at *121.5* MHz from which cable signals must be offset by *100* kHz and may be carried on a cable system at no more than *28.75* dBmV maximum; and two at *156.8* and *243* MHz, from which cable signals must be offset by *50* kHz. These also cannot be carried at a level above *28.75* dBmV on a cable system.

4) Frequency stability is as important as leakage itself. Standard and IRC equipment must be kept within *5* kHz. FAA frequencies must be kept within *1* kHz, giving us a minimum separation of *6.5* kHz. An HRC comb generator must be kept within ± *1* cycle of a frequency of *6,000,300* cycles. This provides a minimum offset of 5,700 Hz at Ch. 14 (120 MHz) and a maximum offset of 19,800 Hz at Ch. 53 (396 MHz). Even with these new restrictions the FAA is not happy and will continue to fight to have the frequencies dropped from cable's usage.

5) Every system must meet a minimum *64* CLI_∞ by *July 1, 1990*, or face the loss of up to *34* channels and/or fines of up to *$20,000* per day. No ifs, ands or buts.

6) The formula for calculating mV from dBmV is: *antilog dBmV/20*. To calculate μV/m multiply this by *.021* times the *frequency* of the leak and move the decimal three points to the right. To calculate ground-based CLI (by the I_∞ method), square all leaks over *50* μV/m, add them together, multiply by *system miles/miles driven* and take the log of that number times 10.

7) Compute the following example:
Given:
100 miles drive out of 110 total plant miles
3 leaks at 60 μV/m
15 leaks at 110 μV/m
1 leak at 440 μV/m = a CLI of *56.3*.
Does this pass? *Yes*
Would a single leak of 1,600 μV/m pass? *No*

8) A minimum of *75* percent of your system must be driven out during a ground-based CLI. This must include the *worst* portions of your plant.

9) Are we still concerned with repairing leaks below 50 μV/m? *Yes*. CLI testing is for FAA public safety reasons only. We still have to be concerned with all other over-the-air users we might infringe upon, such as ham operators, police radio, etc.

10) When will the Federal Communications Commission start accepting CLI test results? *Jan. 1, 1990*

11) Are cable plants undergoing a rebuild exempt from leakage requirements? *No*. But working with your local FCC office with detailed plans and timetables may be helpful.

12) Are recently purchased systems exempt? *No*

13) What range of frequencies are recommended by the FCC for a leakage detection signal? *108-137 MHz*

14) Is underground plant included in leakage and CLI? *Yes*

15) If a plant is interconnected via *AML microwave* or other non-mechanical link, can it be considered separately? *Yes*

16) Are leaks created by subscribers in their homes the cable operator's responsibility? *Yes*. You must disconnect those subs if they cannot be brought into compliance. Does the same go for apartment buildings? *Yes*. The FCC has jurisdiction over state and local officials in this matter.

17) Are all systems included when it comes to leakage requirements, regardless of size? *Yes*

18) An FCC inspector who comes to your system will generally drive out *10-15* miles of plant before coming to visit the cable office. The inspector is generally looking for big leaks, at least for now.

19) How long must leakage and CLI data be kept? *2* years

20) Would trapping out the FAA bands to "leaky" apartment buildings be sufficient? *No*, because FCC rules prohibit cable system signal leakage greater than 20 μV/m at 10 feet for any signal in the 54-216 MHz band and also prohibits leakage greater than 15 μV/m at 100 feet from any signal in the band up to and including 54 MHz and in the band above 216 MHz.

Off-air Ch. 10

By Steven I. Biro
President, Biro Engineering

This is the ninth in a series of maps with technical and program parameter listings for off-air Channels 2-69, designed to be used when the cable system experiences co-channel interference. With this information, the headend technician can pinpoint the closest (i.e., the most probable) offenders, determine their directions and start the verification process with the rotor-mounted search antenna. Based on the tabulated technical information, the search can be concentrated on the most powerful stations or those that have the highest transmitting antenna towers.

The computer program for the maps was developed and data for the listings was collected by the staff of Biro Engineering, Princeton, N.J. The information is accurate as of Sept. 1, 1988.

Key to listing

Call letters: Ch. 10 station identification

City: Station location or the area served by the station

Network affiliation:

C/A	CBS and ABC programming
C/N	CBS and NBC programming
A/N	ABC and NBC programming
ACN	ABC, CBS and NBC programming
ED	Educational station (PBS)
IND	Independent station
CBC	Canadian Broadcasting Corp.
CTV	Canadian Television Network
RRQ	Reseau Radio Quebec
TVA	Canadian Independent Programming
SRC	Societe Radio-Canada
SP	Spanish language programming

Power: The effective visual radiated output power (in kilowatts)

Offset: The offset frequency of the station

0	No offset
–	−10 kHz offset
+	+10 kHz offset

HAAT: Transmitting antenna height above average terrain (in feet)

Call letters	City	Network affiliation	Power	Offset	HAAT
WBIQ	Birmingham, Ala.	ED	316	–	1320
WALA	Mobile, Ala.	NBC	316	+	1246
KTSP	Phoenix	CBS	316	–	1700
KTVE	Eldorado, Ark.	IND	316	–	1500
KXTV	Sacramento, Calif.	CBS	316	0	1965
KGTV	San Diego	ABC	316	0	750
KREY	Montrose, Colo.	C/N	6	+	80
WPLG	Miami	ABC	316	+	1003
WTSP	St. Petersburg, Fla.	ABC	316	–	1500
WALB	Albany, Ga.	NBC	316	0	964
KMEB	Wailuku, Hawaii	ED	31	0	5940
KISU	Pocatello, Idaho	ED	66	0	1450
WGEM	Quincy, Ill.	NBC	316	–	814
WTHI	Terre Haute, Ind.	CBS	316	0	960
KLOE	Goodland, Kan.	CBS	316	0	980

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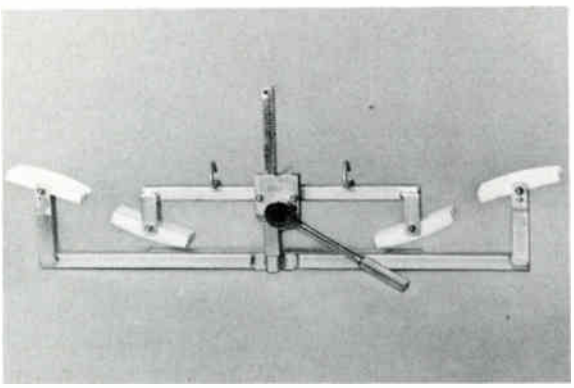

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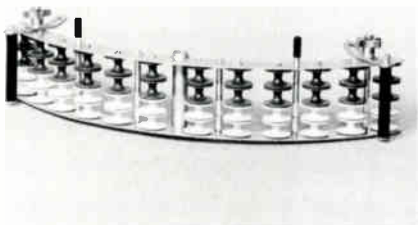

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Call letters	City	Network affiliation	Power	Offset	HAAT
KAKE	Wichita, Kan.	ABC	316	–	1030
KLFY	Lafayette, La.	CBS	301	0	1748
WCBB	Augusta, Maine	ED	316	–	1000
WMEM	Presque Isle, Maine	ED	316	+	1093
WILX	Onondaga, Mich.	NBC	316	–	980
WWUP	Sault Ste. Marie, Mich.	CBS	316	+	1210
KWCM	Appleton, Minn.	ED	316	–	1200
WDIO	Duluth, Minn.	ABC	316	+	1010
KTTC	Rochester, Minn.	NBC	316	0	1250
KBRR	Thief River Falls, Minn.	IND	130	0	442
KOLR	Springfield, Mo.	CBS	316	0	2070
KOLN	Lincoln, Neb.	CBS	316	+	1490
KSTF	Scottsbluff, Neb.	C/N	240	–	840
KLVX	Las Vegas	ED	295	+	1220
KBIM	Roswell, N.M.	CBS	316	–	2000
KWNM	Silver City, N.M.	ABC	9	+	1590
WTEN	Albany, N.Y.	ABC	316	–	1000
WHEC	Rochester, N.Y.	CBS	316	+	505
KMOT	Minot, N.D.	NBC	214	–	680
WBNS	Columbus, Ohio	CBS	316	+	945
KTEN	Ada, Okla.	A/N	316	+	1460
KTVL	Medford, Ore.	CBS	132	+	3309
KOAP	Portland, Ore.	ED	316	0	1740
WTAJ	Altoona, Pa.	CBS	224	–	1110
WCAU	Philadelphia	CBS	191	0	1160
WJAR	Providence, R.I.	NBC	316	+	1000
WIS	Columbia, S.C.	NBC	316	–	1546
KTSD	Pierre, S.D.	ED	316	+	1600
WBIR	Knoxville, Tenn.	CBS	316	+	1790
WKNO	Memphis, Tenn.	ED	316	+	1080
KFDA	Amarillo, Texas	CBS	316	0	1530
KZTV	Corpus Christi, Texas	CBS	316	–	940
KWTX	Waco, Texas	CBS	209	+	1820
WAVY	Portsmouth, Va.	NBC	316	+	990
WSLS	Roanoke, Va.	NBC	316	0	2000
KWSU	Pullman, Wash.	ED	123	–	1350
WMVS	Milwaukee	ED	309	+	1010
KFNE	Riverton, Wyo.	ABC	170	+	1725
CBRT	Coronation, Alberta	CBC	190	0	700
CBRT	Lethbridge, Alberta	CBC	222	–	676
CBUD	Cranbrook, British Columbia	CBC	2	0	3475
CHKL	Penticton, British Columbia	CBC	1	0	1175
CKVU	Vancouver, British Columbia	CBC	325		2040
CBWT	Fisher Branch, Manitoba	CBC	51	+	559
CJCH	Canning, Maritime Provinces	CTV	18	0	886
CBHF	Cheticamp, Maritime Provinces	CBC	8		786
CJWB	Bonavista, Newfoundland	CTV	13		724
CJWN	Corner Brook, Newfoundland	CTV	1		250
CITO	Kapuskasing, Ontario	CTV	2	0	155
CFPL	London, Ontario	CBC	325	0	1000
CKNY	North Bay, Ontario	CTV	132	–	610
CBWE	Red Lake, Ontario	CBS	1	–	275
CFTM	Montreal	IND	325	0	972
CBGA	Murdochville, Quebec	CBC	5	–	1300
CJFB	Riverhurst, Saskatchewan	CTV	1	–	900
CBKM	Willow Bunch, Saskatchewan	CBC	66	+	839
CICC	Yorkton, Saskatchewan	CTV	69	0	444
XHXY	Monterrey, Mexico	SP	330	+	275
WBNB	Charlotte Amalie, Puerto Rico	CBS	113	–	1709

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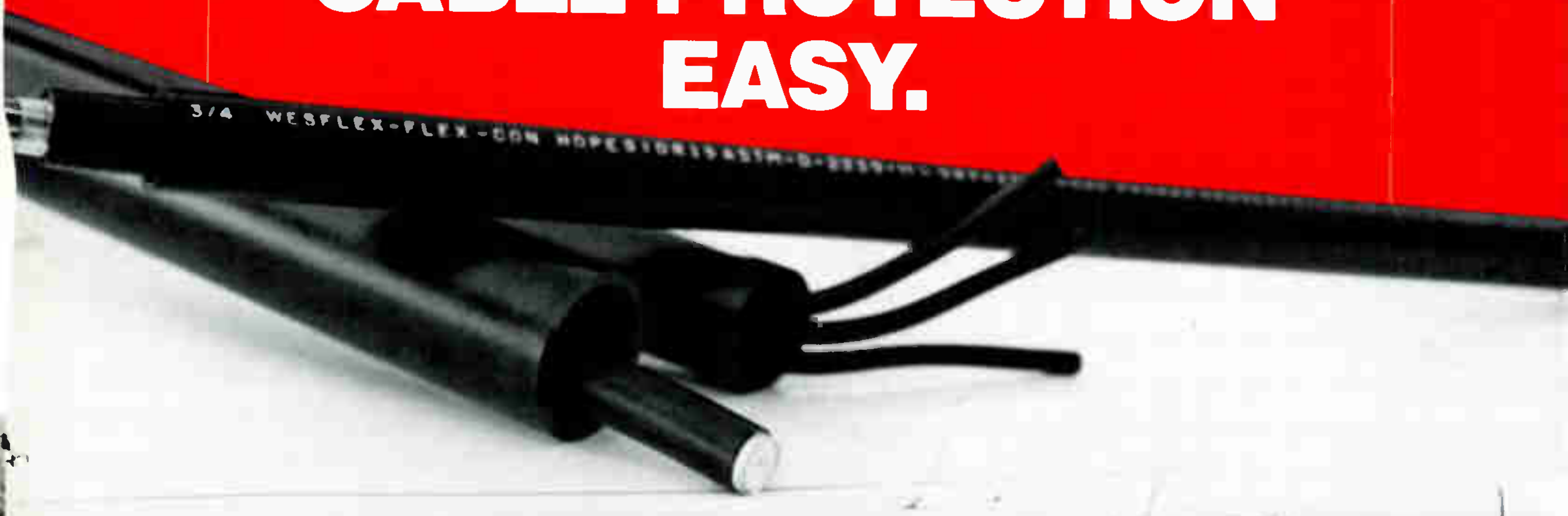

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FCC leakage limits

By Ron Hranac
Jones Intercable Inc.

The Federal Communications Commission has set signal leakage limits for cable system operators in the United States. Leaks are not to exceed 15 μV/m on frequencies up to and including 54 MHz at a measurement distance of 100 feet; 20 μV/m from above 54 MHz up to and including 216 MHz at a distance of 10 feet; and 15 μV/m on frequencies above 216 MHz measured 100 feet from the cable. As well, operators must include all leaks above 50 μV/m when calculating a system's cumulative leakage index. The following table provides those leakage limits in dBmV for each standard cable channel up to 400 MHz. The formula used to create the table and examples of how to use it are on the next page.

Channel	Frequency (MHz)	15 μV/m	20 μV/m	50 μV/m
T-7	7.00	−19.82		− 9.37
T-8	13.00	−25.20		−14.74
T-9	19.00	−28.50		−18.04
T-10	25.00	−30.88		−20.42
T-11	31.00	−32.75		−22.29
T-12	37.00	−34.29		−23.83
T-13	43.00	−35.59		−25.13
2	55.25		−35.27	−27.31
3	61.25		−36.17	−28.21
4	67.25		−36.98	−29.02
5	77.25		−38.18	−30.22
6	83.25		−38.83	−30.87
98 (A-2)	109.275		−41.19	−33.24
99 (A-1)	115.275		−41.66	−33.70
14 (A)	121.2625		−42.10	−34.14
15 (B)	127.2625		−42.52	−34.56
16 (C)	133.2625		−42.92	−34.96
17 (D)	139.25		−43.30	−35.34
18 (E)	145.25		−43.67	−35.71
19 (F)	151.25		−44.02	−36.06
20 (G)	157.25		−44.36	−36.40
21 (H)	163.25		−44.68	−36.72
22 (I)	169.25		−44.99	−37.04
7	175.25		−45.30	−37.34
8	181.25		−45.59	−37.63
9	187.25		−45.87	−37.91
10	193.25		−46.15	−38.19
11	199.25		−46.41	−38.45
12	205.25		−46.67	−38.71
13	211.25		−46.92	−38.96
23 (J)	217.25	−49.66		−39.20
24 (K)	223.25	−49.90		−39.44
25 (L)	229.2625	−50.13		−39.67
26 (M)	235.2625	−50.35		−39.90
27 (N)	241.2625	−50.57		−40.11
28 (O)	247.2625	−50.79		−40.33
29 (P)	253.2625	−50.99		−40.54
30 (Q)	259.2625	−51.20		−40.74
31 (R)	265.2625	−51.40		−40.94
32 (S)	271.2625	−51.59		−41.13
33 (T)	277.2625	−51.78		−41.32
34 (U)	283.2625	−51.97		−41.51
35 (V)	289.2625	−52.15		−41.69
36 (W)	295.2625	−52.33		−41.87
37 (AA)	301.2625	−52.50		−42.04
38 (BB)	307.2625	−52.67		−42.22
39 (CC)	313.2625	−52.84		−42.38
40 (DD)	319.2625	−53.01		−42.55
41 (EE)	325.2625	−53.17		−42.71
42 (FF)	331.275	−53.33		−42.87
43 (GG)	337.2625	−53.48		−43.02
44 (HH)	343.2625	−53.64		−43.18
45 (II)	349.2625	−53.79		−43.33
46 (JJ)	355.2625	−53.93		−43.48

Channel	Frequency (MHz)	15 μV/m	20 μV/m	50 μV/m
47 (KK)	361.2625	−54.08		−43.62
48 (LL)	367.2625	−54.22		−43.76
49 (MM)	373.2625	−54.36		−43.91
50 (NN)	379.2625	−54.50		−44.04
51 (OO)	385.2625	−54.64		−44.18
52 (PP)	391.2625	−54.77		−44.31
53 (QQ)	397.2625	−54.90		−44.45

The following formula was used to create the table:

dBmV = 20log(microvolts per meter/.021/frequency in MHz/1,000)

Problem: Signal leakage on Ch. 14 (121.2625 MHz) is not to exceed 20 μV/m at a measurement distance of 10 feet. What is that limit in dBmV?

Solution:

dBmV = 20log(20 microvolts per meter/.021/121.2625 MHz/1,000)
= 20log(952.380952/121.262500/1,000)
= 20log(7.853879/1,000)
= 20log(0.007854)
= 20(−2.104916)
= −42.098316
= −42.1 dBmV

Problem: What would the leakage limit be for the previous example if Ch. 14's frequency were offset −12.5 kHz instead of +12.5 kHz?

Solution:

dBmV = 20log(20 microvolts per meter/.021/121.2375 MHz/1,000)
= 20log(952.380952/121.237500/1,000)
= 20log(7.855498/1,000)
= 20log(0.007855)
= 20(−2.104826)
= −42.096525
= −42.1 dBmV

Problem: You are using Ch. 98 (109.275 MHz) to determine your system's cumulative leakage index. When measuring leakage at that frequency, leaks above what level (in dBmV) are to be used to calculate CLI?

Solution:

dBmV = 20log(50 microvolts per meter/.021/109.275 MHz/1,000)
= 20log(2380.952381/109.275000/1,000)
= 20log(21.288629/1,000)
= 20log(0.021789)
= 20(−1.661770)
= −33.235402
= −33.2 dBmV

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In-home wiring—Problems, potentials

By Walter S. Ciciora, Ph.D.
Vice President of Technology
American Television and Communications Corp., Stamford, Conn.

The two other wire-based service companies, power and telephone, have a very different policy regarding the wires that run through the home. As with everything, there are advantages and disadvantages to their approach. It is time to review the situation and come to some conclusions.

The power company

Today, no one would think of calling the power company to install wiring in their home or to fix the problem when a fuse blows or a circuit breaker trips. The phone book has pages of electrical contractors who will help the unskilled or the intimidated with repairs and installations. Do-it-yourself stores have well-stocked aisles of hardware for those who are (or think they are) handy with tools. Books, videotapes and Saturday homeowner seminars provide some degree of information. Procedures and methods are standardized and well-accepted. Supplies bear approval stickers. Local building codes cover the legal and accepted ways of doing things. A system of permits and inspectors to enforce the laws is in place.

Another significant difference in policy is that the power company does not attempt to charge for each separate outlet. You can have as many plugs and lights in your home as you like, but you only pay for the power you use and for having it available at your house.

It may be that the power company is in the most enviable position regarding in-home wiring. If this becomes our conclusion, then the power company model should be our ultimate goal.

The phone company

The phone company is a relative newcomer to the concept of subscriber ownership of wiring. In fact, it was forced into accepting the idea; for decades it resisted. Part of the resistance was a genuine fear that unskilled or even malicious subs would damage the telephone network. This would be expensive, cause other customers to complain and impair public safety. The other part of the phone company's resistance was the loss of an attractive revenue stream for the rental of in-home hardware.

"The primary difference between the power and the phone companies' and the cable system's wiring is...signal leakage."

The charges collected for extension phones was no small issue. If subs became comfortable with doing their own wiring, they'd probably add their own extension phones. The phone company even had a mechanism for checking from its office to determine how many extensions you had. Since the bell is rung by capacitively coupled alternating current, the phone company measured the capacitance of your circuit to determine how many ringers you had. This was done automatically at night when you probably wouldn't use the phone. It took just a few seconds. More knowledgeable subs realized that if they disconnected the bell in their self-installed extension phones, they could avoid detection. If the telephone repairman had to make a visit, you disconnected and hid your extension phones.

Subs had a bit more reverence for the telephone. They recognized it as their link to a doctor, the fire department or the police. They felt that even if they didn't need to make an emergency call at the moment, their neighbor might. Years of being told to relinquish the party line in an emergency taught subs to view the phone line as almost sacred. For some folks, there was the suspicion that since the phone was such a wonderful communications device, just maybe the phone company could tell what you were doing by listening in on the other end.

This has all changed now. As labor rates continued to increase and as subscribers added extensions anyway, the phone companies realized that continued control of in-home wiring was no longer attractive or enforceable. The grand old revenue streams from inside the home no longer even covered the costs. The phone companies have now turned over the responsibility to the sub and made a virtue of having done so. Significant charges accrue to the sub who needs in-home wiring serviced by the phone company. Service has become a profit center in many phone com-

(Continued on page 122)

AD INDEX

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Is Europe taking another look?

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

For many years, Europeans have held American TV, and especially American cable TV, in disdain. They say our pictures are fuzzy. Our color is poor. We have ghosts everywhere. Our technology is low tech. Our programs are insultingly lowbrow. We don't even have teletext and minitel. Listen to what one equipment supplier says in a sales brochure (in English, mind you!):

"In United States of America due to an older tradition, and due to less demanding TV standard which both allows more channels in the VHF band and allows the use of cheaper converters, VHF only networks are common place."

An Israeli official recently explained: "In general, the Ministry of Communications tried to find a compromise between the market-oriented systems of North America, where cost is the most important factor, and the high technology systems found in Europe during the last 15 years."

With only a trace of condescension, some Europeans attribute this sorry state of affairs more to the traditional American attachment to entrepreneurial profits than to lack of technical expertise or competence. Perhaps they are right. Because of more intrusive and detailed standards in many European countries and more expensive underground construction everywhere, higher subscriber payments are required for fewer and less attractive programs. Whether or not European broadcast and cable TV are technically better than American, the fact remains that 17 percent subscriber penetration ("take-up," in European terminology) of TV households can hardly be called a popular success, not to mention financially profitable.

This seems to be changing. First of all, Europeans have had to turn to American entrepreneurial money to support cable TV ventures. Jones Intercable, United, Comcast, US West, Pactel, Nynex and others are now being encouraged to provide financial support for cable TV in Great Britain, Ireland, Scandinavia, Hong Kong and a growing number of other countries.

Second, it is beginning to be noticed that the STOAT (same tired old American tree) topology is a more efficient, less costly way than star topology to distribute a variety of TV entertainment and information to the public. Just as in the United States, the European public seems to have little interest in paying for interactivity, information retrieval or the use of the cable plant for transactional services. To stimulate interest in the minitel, home terminals were provided free by the French government. In Great Britain, teletext is widely available—not because the public pays for it but because the decoders are built in to all TV sets and advertising supports the operation. Evidence is growing that the star network, either switched or non-switched, is coming to be recognized as a technologically neat but costly way to serve a largely non-existent market.

Third, existing and potential cable operators in Europe are beginning to reconsider distribution to subscribers at UHF (470-862 MHz). Initially this seemed to be a good way to avoid the set-top converter, since all TV sets were designed for 49 UHF channels. The extra cost of UHF distribution (including channel-by-channel converters at hubs) was partially offset by savings in set-tops. However, as in the United States, some kind of device is needed for conditional access to scrambled channels. This may be either a converter or simply a separate descrambler connected by means of the European "peritel" or "SCART" multiport connector.

But now, European operators are showing increasing interest in the American 450 or 550 MHz approach. TV sets with the non-standard "special" S-channels (i.e., cable-compatible) are becoming widely available. France and perhaps other countries now mandate the SCART multiport connector on all color sets. Technical problems with UHF cable distribution can now be avoided by using VHF distribution and cable-compatible sets.

Finally, both national and international technical specifications (standards) are gradually conforming to American practice and experience. For example, IEC (International Electrotechnical Commission) Publication 728-1 includes the CW composite triple beat measurement essentially as described in the *NCTA Recommended Practices*. IEC specifies 54 dB C/CTB ratio, which is virtually the same as the 53 dB NCTA performance objective. Although IEC still has under consideration a method for measuring system leakage, the American "cuckoo" technique is described in an appendix as a practicable interim method for leakage monitoring and assessment.

Not all of the European allegations concerning the quality of performance of American cable systems can be totally discounted. It has long been apparent to American observers that the care and precision of European technical operations, in both broadcasting and cable, account for some real superiorities in performance. Broadcast technicians, for example, continuously monitor video test signal waveforms against a go/no-go template. In the United States, performance parameters of the TV station are checked only periodically, not continuously. Moreover, even those checks exclude network interconnections, remote links and other potential variables.

Cable operations in Europe must pass demanding proof of performance tests, with fractions of a decibel precision. "Good enough" is not acceptable. Penalties imposed for violations that are well within the probable error of measurement certainly appear to us to be unwarranted. On the other hand, depending as we do on customer trouble calls to discover system faults appears cavalier to others.

International cable TV is evidently moving in the direction of the American practice. Perhaps we need to consider seriously the extent to which cash flow and bottom-line considerations are unduly affecting the day-to-day quality of our technical performance and customer service. Couldn't we do better without pricing ourselves out of business?

Ciciora's Forum

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panies rather than just a cost center. After just one of these expensive service calls, most subs will view the monthly option of an in-home wiring service contract as an attractive alternative. In most cases, the contract is more attractive to the phone company since the next service call is likely not to come for years.

The phone companies worked with the Federal Communications Commission to institute a series of standards. Manufacturers of telephone customer premises equipment must comply with these standards. The products must be registered with the FCC and the designs "type approved." The manufacturer itself certifies that the product is in compliance; the FCC does not verify every design. In addition, there is a "ringer equivalence number" that the sub is expected to supply the phone company. Almost certainly the vast majority of subs are not even aware of this obligation. Those who are aware don't treat it seriously. Have you reported all your ringer equivalence numbers? Do you know anyone who has? There does not appear to be an effective means of monitoring compliance with these standards.

Cable's differences

The primary difference between the power and the phone companies' and the cable system's wiring is that of cable's potentially dangerous signal leakage. The rules on cumulative leakage index (CLI) that we all must observe have serious consequences for an in-home wiring policy. Since cable is an enclosed, self-contained spectrum, it is allowed to occupy spectrum normally used by other services in the external environment.

Two problems occur when the cable system is not completely sealed: Cable signals leak out into the environment and cause interference. Environment signals leak into the cable and also cause interference. The interference with other signals in the environment is more serious. Some of these frequencies are used for emergency communications and others for aircraft navigation and communications.

Next month we'll continue our consideration of in-home wiring.

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