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Cutting-edge technology

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Radio: An industry in transition p. 64

News

By Dawn Hightower,
senior associate editor

SBE calls for papers

Abstracts are being accepted for engineering papers for the 1993 Broadcast Engineering Conference of the SBE National Convention, which will be held Sept. 29-Oct. 2 in Miami Beach, FL.

If you are interested in preparing a technical paper for presentation, submit an abstract outlining the scope of the paper and its importance to the industry no later than March 5. Also, if you are interested in participating in a panel discussion, submit a letter stating your interest. Only written abstracts and letters of interest will be accepted.

The SBE will also publish the *Proceedings* of the conference. Authors should be prepared to submit a camera-ready manuscript by Aug. 13. Send correspondence to: Broadcast Engineering Conference Chair, Society of Broadcast Engineers, P.O. Box 20450, Indianapolis, IN 46220.

AES announces date for fall convention

The Audio Engineering Society's 95th AES Convention will be held Oct. 7-10 at the Jacob Javits Convention Center in New York City.

The theme is "Audio in the Age of Multimedia."

The AES also has issued a call for papers. Interested authors should submit a proposed title, 60-word abstract and a 300-word precis of the technical paper(s) by April 1. Submissions should be sent to either Robert A. Finger, Matsushita Electric Corporation of America, Business, Engineering Center/1E-6, One Panasonic Way, Secaucus, NJ 07094; telephone 201-348-7768; fax 201-348-7807 or Ken C. Pohlmann, University of Miami, College of Engineering, Dept. of Electrical/Computer Engineering, Coral Gables, FL 33124-0640; telephone 305-284-3351; fax 305-284-4044.

NAB spells out broadcasters rights under cable law

In developing rules to implement the new cable law, NAB feels that the FCC should reject proposals that would limit a broadcaster's must-carry rights, including steps that make those rights dependent on where a cable system's main facility or head-end is located.

NAB outlined its views on how regulators should implement the must-carry and retransmission consent provisions of the new Cable Act. Must-carry requires cable systems to carry a complement of local TV signals. Under retransmission consent, stations can choose to give up their must-carry rights and instead negotiate for carriage with local cable systems. The FCC is required to have must-carry rules in place by early April.

NAB stressed that the new cable law grants all commercial TV stations must-carry rights on cable systems in their local markets, usually defined as the Arbitron-designated Area of Dominant Influence (ADI). NAB also said where a cable system locates its head-end is irrelevant to its carriage obligations.

NAB also urged that certain procedures be followed if a cable system believes a local broadcaster is not delivering an adequate signal to the cable system. Similarly, NAB outlined situations where a broadcaster would have to pay certain copyright costs to retain must-carry status on a cable system, if the station is classified as a distant signal.

In addition, NAB proposed that broadcasters be allowed 30 days after the rules go into effect to designate their preferred channel position. Thirty days later, or 60 days after the rules go into effect, cable systems would be expected to come into full compliance with the new law.

Radio stations also have full rights to control use of their signals by cable systems, NAB said.

Finally, NAB rejected arguments that broadcasters must get permission from program suppliers before exercising retransmission consent.

EIA releases metric standard

The Electronic Industries Association (EIA) has released a metric standard, EIA-310-D, for racks, panels, enclosures and associated equipment.

EIA-310 is a 2-part, fully metric document. Part 1 retains the sizes from the previous document expressed in metric dimensions. Part 2 is presented in hard metric dimensions.

The U.S. Navy intends to adopt the revised standard for use by the Department of Defense.

To obtain copies of EIA-310-D, contact Global Engineering Documents, 2805 McGaw Ave., Irvine, CA 92714; telephone 1-800-854-7179.

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INTERTEC PUBLISHING CORPORATION

Editorial

Keeping the beat to a video revolution

There is no stopping the forward march of progress within the TV broadcast and post-production industries. The changes within the business are many, and some of the most revolutionary include: the continuing transition from analog to digital technology, the emerging trend from a composite to component signal format, aspect ratio standards shifting from 4:3 to 16:9, and the entry of new service providers into the realm of advanced home video services.

The changing of the guard from analog to digital formats will be evident when attendees walk the floors of this year's NAB. Based upon our industry's desire for ultimate video quality, new products most likely will create migration paths that lead to digital component formats.

For the transition to component digital to be a success, bridges must be built that will link a predominant installed product base of analog and composite equipment with the new digital age. Responsible manufacturers must support existing product structures with transitional technology that will serve broadcasters and production facilities well into the future. Developing advances that leave users with obsolete equipment doesn't benefit anyone.

Although the FCC decision on an ATV standard is still forthcoming, chances are strong that it will be a component digital system. The selected transmission system will be an improved vehicle for getting signals to the home that will elevate the consumer's viewing experience to a new plateau.

Component digital also will result in more economical installations. Signals will be easier to route through broadcast and post-production facilities thanks to serial digital interfaces, which enable multiple video and audio signals to be routed through one cable.

In addition, the transition to component digital technology will ease the switch from a standard aspect ratio of 4:3 to 16:9 widescreen. In order to maintain the improved resolution of a 16:9 picture that carries greater signal information, lossless compression technology (namely bit rate reduction) will be extremely beneficial. This technique reduces the number of bits of video information needed to represent content. Images transmitted using this technology demonstrate no perceptible artifacts or degradation.

Once viewers see the difference between 16:9 and 4:3 pictures, they will want to view 16:9 television. This technological scenario will mirror previous breakthroughs, such as the emergence of FM radio and color television. Also, the FCC is expected to offer current TV stations a second channel allocation specifically for widescreen transmission.

Another revolutionary change comes with the proposed entry of non-traditional video suppliers, such as Regional Bell Operating Companies (RBOCs), Hughes Communications and assorted new players, into the fray. With advances in compression technology and as telcos move into the cable domain, more information will be sent via coax, copper or satellite, and expanded programming will be available to the home.

One example of a network taking advantage of such progress is the DirecTV network of Hughes Communications, which will employ its DBS facility to deliver more than 130 channels of on-demand programming by mid-1994.

Whether programming is distributed by cable, microwave or satellite, many interests not typically associated with television are using their special skills to become service and content providers for advanced home video services. Recently announced strategic alliances will deliver programming directly to PCs on the desktops of business and industry professionals.

Equipment manufacturers, broadcasters and post-production facilities must view these innovative developments with their eyes on the future. Many of these transitions are inevitable, and all can provide substantial benefits to broadcast professionals and viewers.

Together let's embrace these technologial advances for the broadcast industry that will boldly lead us into the 21st century.

Charlie Steinberg, President, Sony Business and Professional Group

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Circle (7) on Reply Card

FCC Update

Operational status reporting proposal

By Harry C. Martin

The commission has proposed requiring licensees of full-power commercial AM, FM and TV stations to report at the time of license renewal whether their stations are on the air or have ceased operations.

Section 73.1740(a)(4) permits broadcast stations to discontinue operations for up to 30 days without authority from the commission when events beyond the station's control make it impossible to stay on the air. Licensees are required, however, to notify the commission of discontinued operations no later than the tenth day after discontinuance. The licensee is required to request additional time if station operations are not resumed within 30 days. Generally, the commission will authorize a station to remain dark for significant periods of time as long as the licensee periodically seeks authority to stay off the air. Financial difficulties are a sufficient reason to authorize stations to remain silent. Licensees must yield their licenses to the FCC when discontinuance is permanent.

In making its proposal to require an operational status report at renewal time, the commission said it was aware of many stations that had discontinued operation without requesting permission. The new reporting requirement will provide an effective way to track the status of the stations and make sure the public interest is served by promoting expeditious restoration of service by facilities that are no longer operating.

Short-spacing limit on FM/DAs eliminated

The commission has reviewed and eliminated its policy regarding the 8km temporary short-spacing limit. The policy was imposed in 1988 when the FCC first allowed short-spacing between FM stations, provided interference protection to such stations could be shown. Under the rules adopted in 1988, interference protection justifying a short-spacing could be provided by the use of a directional antenna, a reduction in operating power or height or by taking advantage of terrain elevation in the direction of the short-spaced station.

Martin is a partner with the legal firm of Reddy, Begley & Martin, Washington, DC.

The 8km short-spacing limit was intended to reduce the number of applications that were expected to be filed under the commission's then-new interference-protection standards. Removal of the limit is now possible due to the commission staff's increased experience and greater computer capability in dealing with applications of the interference-protection standards.

Section 73.215(e) of the rules still restricts the short spacing that is permitted when an applicant specifies a directional antenna, even where full interference protection is afforded. The rule contains a table of minimum distance separations for each class of FM station.

AM radio	4,961
FM radio	4,766
FM educational	1,585
Total radio	**11,312**
UHF commercial TV	588
VHF commercial TV	558
UHF educational TV	239
VHF educational TV	124
Total TV	**1,509**
UHF TV translators	2,431
VHF TV translators	2,515
UHF LPTV	842
VHF LPTV	469
Total TV trans/LPTV	**6,257**

Table 1. *As of Nov. 30, 1992, the commission reported these totals of licensed broadcast stations.*

Quarterly issues/program lists

Broadcasters still are obligated to provide programming responding to the important issues facing their communities. To document compliance, broadcasters must prepare and maintain in their public inspection files quarterly issues/programs lists. Such lists must be placed in a station's public inspection file by the tenth day of each calendar quarter (Jan. 10, April 10, July 10 and Oct. 10). The lists must be retained in the public file through one license period (five years for television, seven years for radio).

Issues/programs lists must provide a brief narrative of the important issues facing the broadcaster's community of license and describe the programs that constitute the licensee's most significant treatment of those issues during the preceding three months. The FCC has eliminated the requirement that a minimum of five to 10 issues must be listed, and there is no maximum limit on the number of issues a licensee may describe. However, the commission has said that licensees listing significant programming directed at five to 10 community issues should demonstrate compliance with their public service obligations at license renewal time.

When listing the most significant programs that will address community issues, a licensee must include the broadcast time, date and duration of each program, as well as the title. The type of programming in which the issue was discussed (for example, public service announcements and call-in public affairs programs) also should be listed. If the licensee has used only one program to treat all of the listed issues, then the dates, times and names of participants on specific programs should be maintained to establish that each specific community issue was discussed.

Although the FCC requires broadcasters to list only their most significant programming directed to a particular issue, it is recommended that stations maintain detailed records on all non-entertainment programming. Such detailed record keeping may provide crucial information if a station's license renewal is challenged.

A good way to facilitate preparation of quarterly lists is to compile a separate listing for each issue of the programming being broadcast. Then, when issue-specific programs are broadcast, information about them may be entered on the individual lists. It should be easy to prepare quarterly issues/programs from these lists.

If a station feels that one or more of its issues/programs lists was erroneously prepared, a revised list may be drafted with a notification explaining why the list was modified. Any late-prepared list should be placed in the public file with an explanation for its late filing.

■

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Part 2

Strictly TV

Strictly HDTV

ATVA DigiCipher

By Curtis Chan

DigiCipher (DC) HDTV is one of two schemes proposed by the Advanced Television Alliance (ATVA). The other scheme, Channel Compatible DigiCipher (CCDC), uses progressive scanning at 787.5 lines/frame and 59.94fps. The CCDC display format shows square pixels with 720 active lines by 1,280 pixels per line in a 16:9 aspect ratio. The main attribute of CCDC is system modularity. Video processing, audio processing and transmission can be used independently.

DigiCipher HDTV is an all-digital system with 1,050 scan lines per frame, 59.94fps and 2:1 interlace. The display format has a 16:9 aspect ratio with 960 lines per frame and 1,408 pixels per line. Several types of digital coding provide compression and signal robustness. The primary picture coding uses discrete cosine transform (DCT) with motion compensation. Transmissions are by quadrature amplitude modulation (QAM) with four or five bits per symbol. The broadcaster has a choice of two data rates involving a tradeoff between picture quality and coverage area. The system accommodates either 16 or 32 QAM modulation.

Interoperability with NTSC

DC HDTV uses the 59.94Hz rate for compatibility with NTSC. The 960 active video lines are double the typical 483 lines in NTSC. Because 483 is an awkward number for conversion, there are two choices:

1. *Edge crop.* The HDTV picture fills 480 lines on NTSC with loss of the sides of the HDTV picture, or;

2. *Letterbox.* The full width of the HDTV picture displays in the full width of the NTSC picture, but unused areas at the top and bottom of the NTSC screen remain blank. Pixel values from the HDTV lines are stored in memory and read out at reduced speed to make NTSC lines. The range of pixels read and the clocking rate depends upon the conversion method.

Interoperability with film

The "film mode" accepts film shot at 24fps as 59.94Hz video, 2:1 interlaced, having been converted with the 3:2 pull-down technique. The encoder recognizes redundancy in each 5-field sequence as having originated in 24-frame film, and converts the 59.94-field video back to 23.98fps. Then, the image is processed and transmitted as 23.98-frame progressive. Finally, it is brought back to 59.94-field interlace in the decoder, using 3:2 pull down.

Future consumer receivers could be differentiated by either displaying progressive or conversion back to interlace. For instance, receivers could use 3:1 frame repeat to display a progressive scan at 72Hz or 30-frame film source, which comes to the encoder as 59.94-field video, is processed and then transmitted as 29.97-frame progressive. The benefit is more efficient coding and higher quality. Future possibilities could include receiving and processing images directly in 24- or 30-frame progressive.

Audio

DigiCipher provides four independent audio channels, each sampled at 48kHz (47.2kHz during testing) with 16-bit resolution. The system includes two Dolby AC-2 compression systems with 24-bit precision. The two compressed audio datastreams are formatted with a 1.2kb/s control signal into a single serial output datastream at 503kb/s and multiplexed into the transmitted signal. The total is four 503kb/s audio channels, 252kb for control, aux data, captions and text resulting in 18.22Mb/s output.

Within the DigiCipher proposal is a recommendation to include Dolby AC-3 composite coded 5.1 channel surround sound into the prototype prior to field testing. This offers mode flexibility, including dual-independent coded AC-2A channels. Packetization would permit numerous composite and independently coded audio channels to be transmitted, allowing the receiver to determine which process to use.

Getting it through the pipe

Reed-Solomon (RS) coding corrects errors within blocks, while data interleaving and trellis coding spread potential errors so that correction capability isn't exceeded in any one RS block. The data rate after this process equals 24.4Mb/s. A double sideband, suppressed carrier, QAM signal delivers the 24.4Mb/s through a 6MHz channel. QAM is similar to NTSC's subcarrier scheme, and the vector display would show 32 dots arrayed like pins in a connector plug for a 32 QAM signal. Each QAM symbol can represent one of the 32 possible meanings of a 5-bit number. In this way, 24.4Mb are transmitted by 4.88 megasymbols. DC claims error-free operation at carrier-to-noise ratios above 16.5dB.

DigiCipher HDTV is one of two schemes proposed by the ATVA.

Scalability and extensibility

At the time of testing, the receive and display clocks were linked, but they may work independently in the future. If so, the receiver could receive non-real time video at slower rates. Also, picture-in-picture and picture-out-of-picture would be possible with DC as receiver design options.

The area of extensibility has been addressed by the ATVA. The group has simulated compression at 30Mbs and believes that 40-45Mbs can be attained, constituting a distribution level of quality suitable for network feeds to affiliates. In the works is an investigation that would allow the transmission-level signal to be included in the distribution-level signal as a kernel. This would permit pass-through of the transmission-level signal at the local affiliate level by stripping away the distribution-level augmentation.

As decreasing costs in DSP enable increasing complexity at the encoder, improvements can be made without changing the receiver or the transmitted bit rate. These types of improvements will impact forward and perceptual analysis, motion compensation, coefficient quantization and special effects editing. ■

Chan is the principal of Chan & Associates, Fullerton, CA.

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Circle (9) on Reply Card

Monitor points

By John Battison, P.E.

If a directional AM station does not have an approved antenna sampling system, then it is required to make monitor point measurements once every three months or more frequently, if it has reason to believe that the fields are out. This is not an onerous requirement, but how many stations are actually doing it?

All directional AM stations are required to have a field intensity meter (FIM) in working condition and with recent calibration. How much business do you think the companies that calibrate FIMs are doing these days?

The FCC moves quietly, and many a chief engineer has been dismayed by a polite gentleman appearing at the station with the words, "Your monitor points are out."

Much has been written about monitor point changes with temperature, and the prescribed action in these cases is pretty well defined. FCC engineers are usually understanding and cooperative about such problems. But sometimes a monitor point goes bad within the 3-month interval or during the time when an approved sampling system is in use, and no measurements are made. This is when trouble hits.

A whole new world

In the past, when regular logging was required at closer intervals, trouble could usually be spotted well in advance as values changed in the wrong direction. Today, during a 90-day period, half a dozen new towers can go up around a broadcaster's transmitter site, with potentially serious effects on the station's pattern.

For example, one of my clients recently discovered that a new jail with a 200-foot tower had been built right on one monitor point. Shortly thereafter, the state had erected a training center with a 150-foot tower on another monitor point.

Unfortunately, neither of these new towers was close enough to my client's station to have required coordination with him during the interloper's application period. So, the influence of the new towers on the directional antenna's radiation was not noticed, and the possibility of placing the financial responsibility for the development of new monitor points on the state was slim. This is why staying on top of things is important.

Applicants for new towers in any band should examine the effect of their new construction on existing stations. For any proposed site within a half mile of an existing tower, the applicant is supposed to notify the station, and then cover the cost of taking an antenna impedance measurement and running eight radials *before* construction. After construction, this process must be repeated, again at the applicant's expense. If there is any adverse effect, or readjustment of the array is required, the new applicant has to pay for that as well.

Often, the new system operator does not know or care about this rule, and it is ignored. Once a new tower has been built, it is more difficult to place blame for an existing array that is out of specification, if the only preconstruction reference is a proof of performance made when the station was originally licensed 20 or more years ago. When monitor points are regularly checked, the affected station has more clout. This is another reason for regular monitor point checks, especially given the current rate of cellular and other telecommunication towers' construction.

In the aforementioned case, one of the affected monitor points could still be used, but the other could not. At the latter site, the new tower was almost exactly on the original measuring point, and the field there was above the allowable limit. Therefore, a new run on the affected radial had to be made.

Establishing a new radial

Before running a radial, it is important to verify that the transmitter is running at full power and that the antenna system is operating at correct parameters with licensed common point current. Include a statement to this effect in the report. (It was formerly a requirement.)

This particular run was fairly simple because the measurement points were clearly identified — an important practice that is not always followed. (See "re: Radio," July 1992.)

After running the radial, ratio each point value against its previously measured values. It's a good idea to ratio the new value against the original and the most-recent previous measurements to see how they compare. Then, determine the overall average by adding the ratios and dividing by the number of points — 10 is the usual number. The closer this average is to one, the better the new radial.

> *Every directional AM station is required to have a field intensity meter (FIM) with recent calibration.*

If the arithmetic average does not give an acceptable value, the logarithmic average can be used. This involves finding the antilog of the mean of the logs of each field-strength measurement on the radial. Sometimes this will produce an acceptable radial ratio when the arithmetic mean will not.

The application to the commission for establishing a new monitor point is informal. It must contain the radial data, a photograph of the new monitor point, a description of the route to the new site and an updated map marking the location. For the photograph, it is best to place the FIM on a tripod at the site, and include it and an easily identified permanent object (such as a power line pole) in the picture.

Form 302 is not required, but the engineers at the commission like to receive the technical section of the form, which completes the data-reporting requirements. The report should be signed by the engineer involved, and a letter from the licensee requesting the change should be included. ■

Battison, *BE's* consultant on antennas and radiation, owns John H. Battison and Associates, a consulting engineering company in Loudonville, near Columbus, OH.

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Circle (10) on Reply Card

Part 6

Management for Engineers

Dealing with the difficult employee

Make sure you aren't the difficult one

By Judith E.A. Perkinson

John was a good engineer, but he was plagued by a never-ending string of difficult employees. He was constantly having to work late because someone had not followed through on instructions, or a job had not been finished properly. John was beginning to think that good engineering help was impossible to find in his market area. One day he overheard a comment that threw him for a loop. Two people from another department were talking about the problems in engineering. One person asked the other, "Well, what do you expect? Who could work for a man like John?" In one shocking moment, John had seen the enemy, and it was himself.

Without realizing it, he was the source of many of his problems. He was a difficult supervisor, and this helped to create a difficult staff. Part of his problem was skill-related, and the other part was his attitude.

Start with honesty

If you are dealing with a difficult staff, it's time to examine your role. See the two tables for a number of self-examination questions.

If you can be honest with yourself, there is a simple way to determine if you are the difficult employee. If you discover that you are part of the problem, steps can be taken to correct the problem. Even if you aren't a difficult supervisor, many of these steps could keep you from developing problems in the future.

Perkinson is a senior member of the Calumet Group Inc., Hammond, IN.

Self examination

Think about your interaction with your staff and the performance of your employees. Then, answer the questions asked in the tables.

If you answer yes to more than 50% of the YES/NO questions and/or have marked the majority of your responses in the MOST OF THE TIME or OFTEN column, then it's time to take a hard look at how you might be contributing to the problems of your department.

Learn the three Cs

Management trainers often offer memory aids to help you retain an idea. Become familiar with the three Cs of good management and practice them regularly: communication, consistency and compassion.

1. *Communication.* Nothing in management is more important than communication. Often, the sins of supervisors are rooted in poor communication. Think about how and when you communicate.

It is common to hear frustrated supervisors making remarks such as, "They should know," or "It's only logical." This is a sure sign that the supervisor has not taken the time to communicate the job requirements or expectations. Remember, your staff does not know anything for certain unless you tell them.

2. *Compassion.* People respond to those who care about them. This doesn't mean you have to feel responsible for all of your employees' problems or turn your department upside down to accommodate your staff.

Listen to your employees' concerns, ideas and suggestions. You don't always have to agree, and you don't have to act on every suggestion that is offered.

3. *Consistency.* People need to know what they can expect. I have seen employees defend a boss who is a tyrant. When you ask them why, they will tell you that the boss may be hard to deal with but at least you know what to expect, and he treats everyone the same. Even working for a tyrant, the employees feel a level of security, because they know where they stand.

You are the master of your fate

Good employees can be ruined by a poor supervisor. Mediocre people can become solid employees under an effective supervisor. Good employees who are well-managed can achieve anything. Leadership is the key. Don't be the difficult employee in your company. ■

QUESTION	YES	NO
If your station has a grievance procedure, are there more than the normal number of grievances filed in your department?		
Is the turnover in your department higher than the station average?		
Do you dislike the people on your staff?		
Does your staff dislike you?		

QUESTION	Most of the time	Often	Seldom
Do you repeat instructions to your employees?			
Do you do the work yourself because you can't depend upon the job getting done right?			
Do your employees start out looking like they will be good and then turn out being as difficult as the rest?			
Do you have to find out from someone else when one of your employees has a problem?			
Do you change your stand on procedures, policies or decisions?			
Do your staff meetings run longer than you planned?			
Does your staff miss deadlines?			

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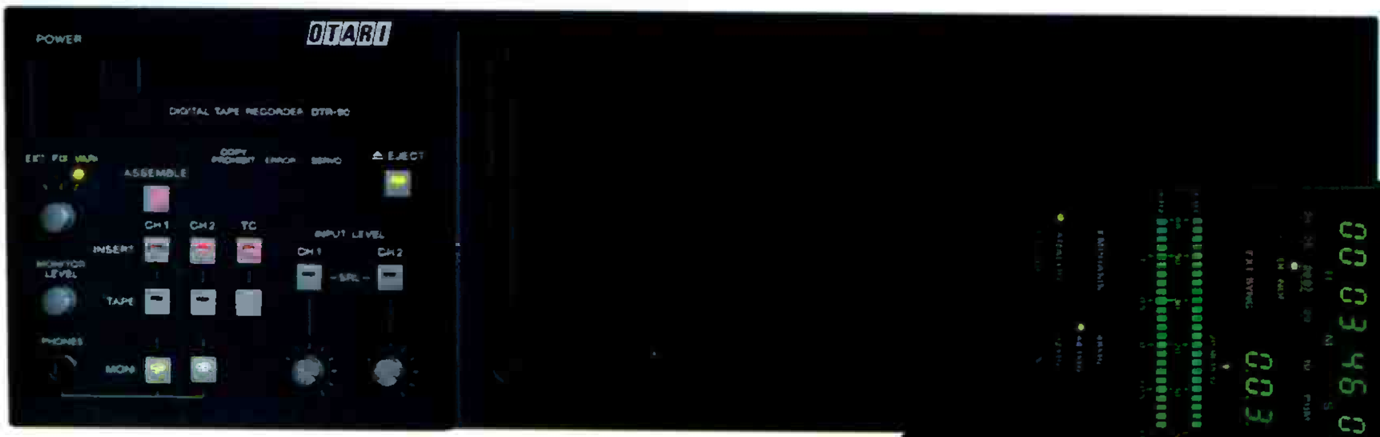

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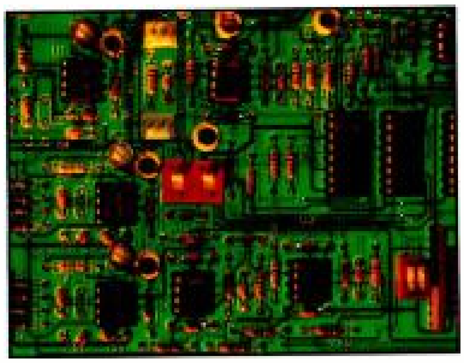
Circle (11) on Reply Card

Part 2

Circuits



Gateway to digital

1 + 1 = ...

By Carl Bentz, special projects editor

The ability of digital circuits to do calculations is one reason why digital technology has become so prevalent. Although digital arithmetic must be done in terms of 1s and 0s, such calculations can be made rapidly and repetitively. Digital arithmetic is an acquired talent for most people.

Addition

When decimal one and one are added, decimal two is derived. In binary, however, no working digit of two exists. Instead, decimal two becomes binary 10. If decimal one and two are added, the result is three. In binary, the result is 11. Adding decimal three and one produces four or binary 100.

Binary addition

(A)	0	(B)	1	(C)	10	(D)	11
	0		1		01		01
	0		10		11		100

From these three simple problems, the rules for binary addition emerge. In (A), 0 and 0 is 0. In (B), 1 and 1 is 0 with a carry of 1. In (C), 1 and 0 or 0 and 1 is 1. In (D), these are combined. In the units column, 1 and 1 produces 0 with a carry of 1. In the twos column, 1 and 0 is 1 with a carry of 1, resulting in 0 and a carry of 1. In the fours column, 0 and 0 and the carried 1 produce 1. The result is binary 100 or decimal four.

In part 1, we asked you to consider how decimal six and seven can be added to arrive at 13. First, convert each number to its binary equivalent.

$$\begin{array}{rcl} 6 & = & 0110 \\ \underline{7} & = & \underline{0111} \\ 13 & = & 1101 \end{array}$$

In the units column, 0 and 1 is 1.

In the twos column, 1 and 1 is 0 with 1 carried.

In the fours column, 1 and 1 is 0 with 1 carried, but remember that 1 is carried into that column; 1 and 1 and 1 is 1 with 1 carried.

In the eights column, 0 and 0 and the carried 1 produce 1.

One eight, one four and one one is decimal 13 (0D in hexadecimal).

Two circuits provide the addition function. In Figure 1, the half adder includes inputs x and y with outputs s (sum) and c (carry). The full adder expands the half adder with a *carry input.*

Subtraction and multiplication

To round out the requirements of arithmetic, subtraction or negative addition must be considered. To accomplish this, a 1s complement comes into play. The initial number is the *minuend*, while the number subtracted is called the subtrahend. To make the *subtrahend* a negative equivalent or 1s complement, the system changes 0s to 1s and 1s to 0s. Then, the two numbers are added to arrive at the difference.

For multiplication, we can add repetitively, but an alternative is even faster. If each digit of a number is moved to the left by one position, we have multiplied by the base of the number. In base 10, appending a 0 at the right end is equivalent to multiplying by 10. In binary arithmetic, moving all digits of a number to the left multiplies by two. Moving all digits to the right divides by two. These functions are provided by machine language commands, which form the heart of all programming languages.

Control structures

The same building blocks that perform calculations can make decisions equally as fast. In fact, control systems using digital gates have preceded signal processing applications in consumer and professional equipment. Only in the last few years have the complexities of performing linear functions with non-linear devices yielded to commercial practical designs. Some purists maintain that even with the most complex equipment, there are still artifacts of the digital realm that are obvious in the audio output of CD or RDAT players.

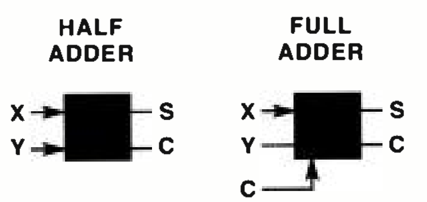


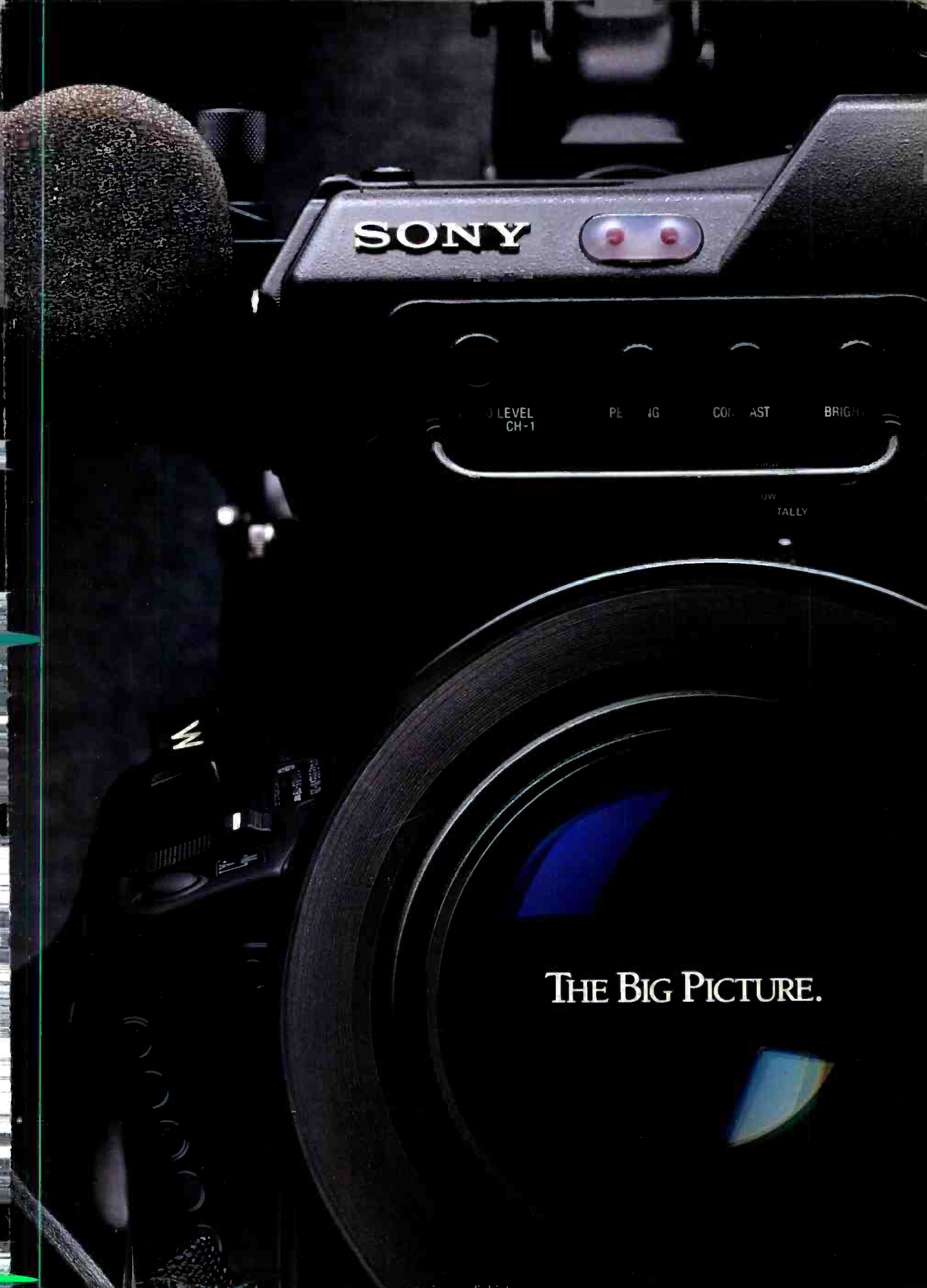
***Figure 1.** The half adder includes inputs x and y with outputs s (sum) and c (carry). The full adder expands the half adder with a carry input.*

The ability of digital circuits to do calculations is one reason why digital technology has become so prevalent.

Gates can generate digital signals based on timing requirements. The sync generator that forms the heart of any video facility uses a number of AND, NAND, OR, NOR and NOT gates to form each of the sync drive signals. RC time constants attached to various input lines control the pulses to exact required time durations. Even the 3.579545MHz subcarrier can be generated with a digital circuit configured as an oscillator or with a phase-lock loop (PLL) circuit using a crystal as the frequency determining element.

When television first appeared, semiconductors were little more than ideas. Racks of dual-triode vacuum tübes and accompanying components filled engineering areas of almost every TV studio. The same concepts of the original tube-type sync generators are now contained in a single solid-state digital IC.

The same circuits that create sync can be configured in the control system of a video recorder or switcher, a character generator or camera control unit, a transmitter control system or a satellite antenna controller. For such applications, perhaps the most difficult part is determining what outcome is desired or determining how critical inputs can be sensed. ■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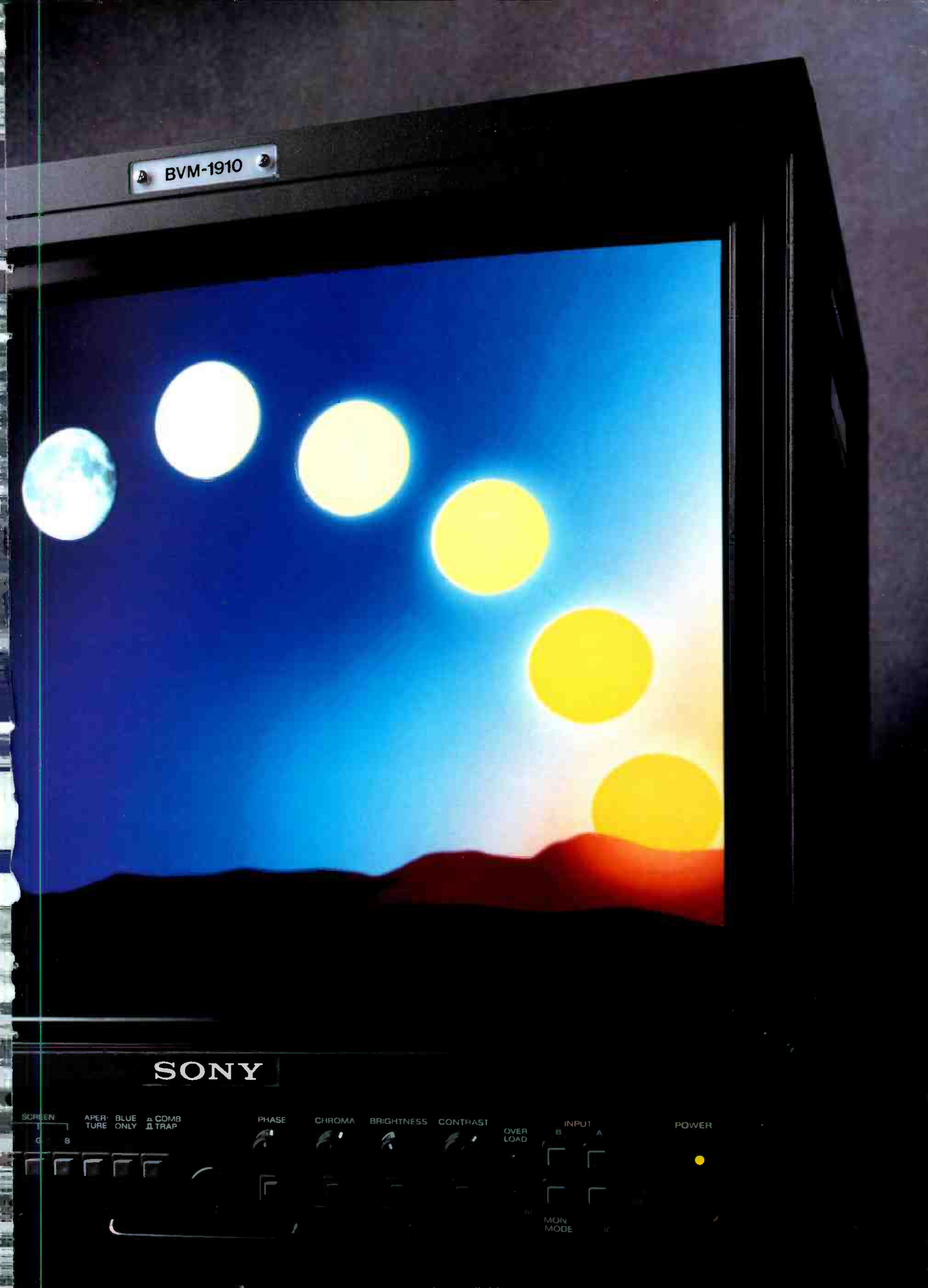
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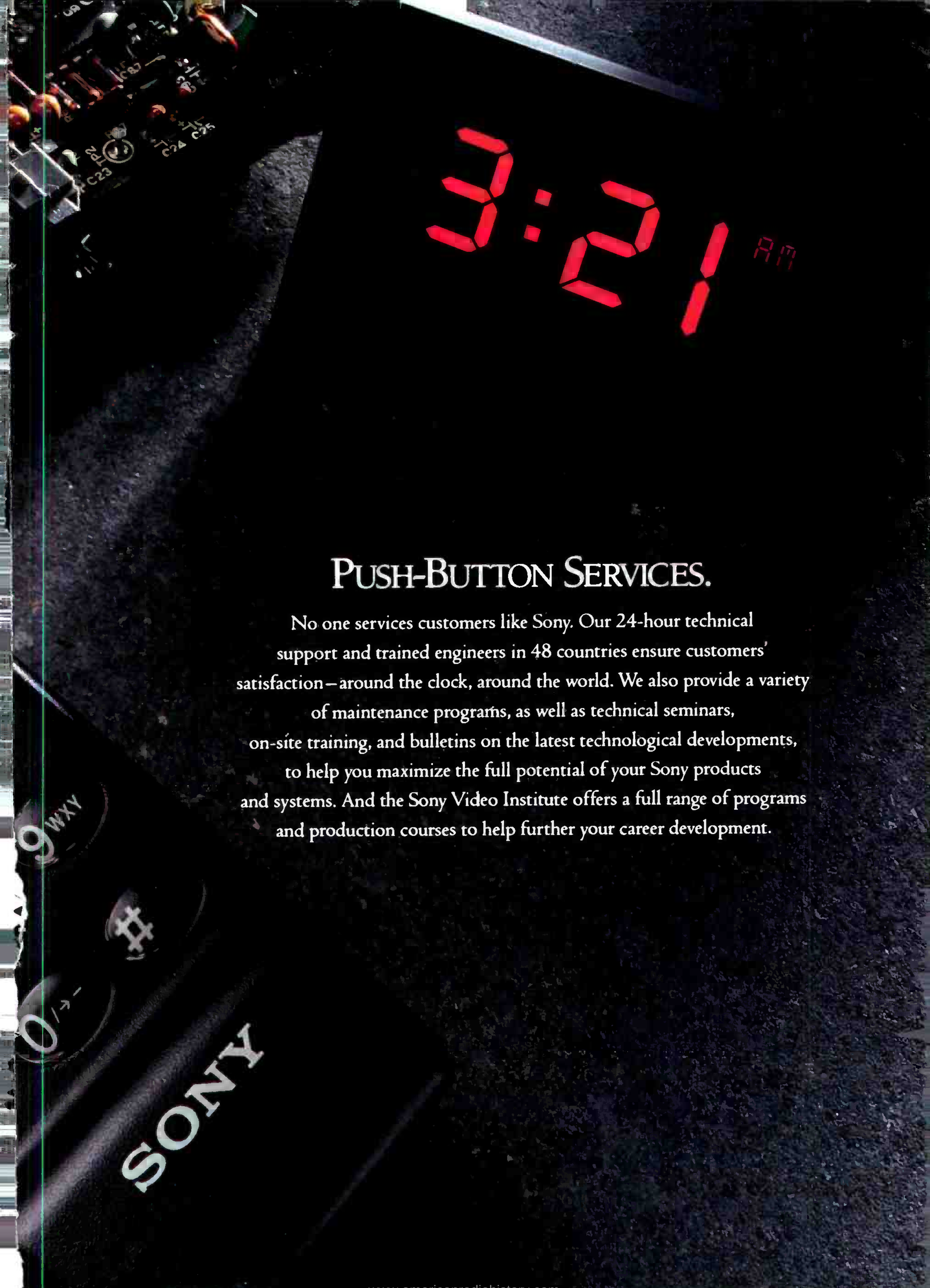
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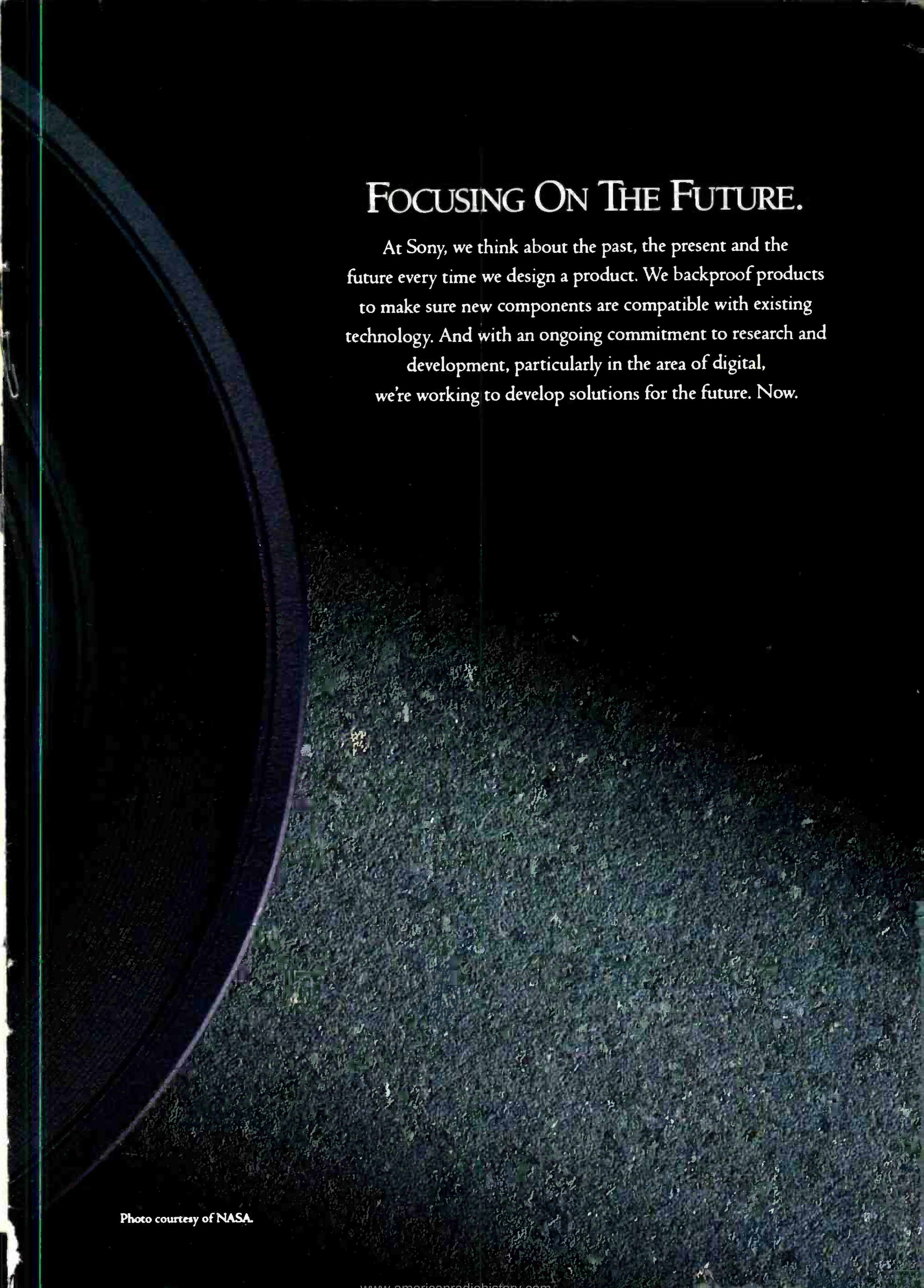
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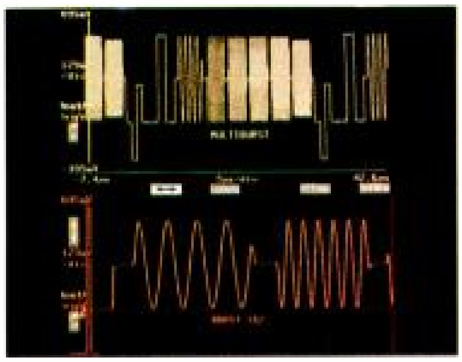
Photo courtesy of NASA.

Part 6

Troubleshooting



Maintaining telephone systems

T-1 service

By Steve Church

This final part of the telephone troubleshooting series considers the digital phone service generically called T-1 (it may go by another name at your local telco). Although it is typically used by telcos to carry multiple standard voice circuits, some broadcasters are using a full T-1 path for studio-to-transmitter links (STLs). Others use it for extending voice or data extensions to a remote studio location.

Because T-1 may be transported on copper, microwave, fiber, satellite and laser links without degradation, it is possible to have an essentially perfect audio path to/from almost anywhere. Various radio networks use T-1 systems to move multiple channels of varying bandwidth audio between domestic and even international locations.

T-1 can operate within the local portion of the phone network, because an ordinary copper phone pair can carry a much wider signal than the 4kHz required for a single analog voice conversation. Indeed, a pure metallic path of reasonable length is easily able to pass frequencies in excess of 100kHz.

T-1 can operate within the local portion of the phone network.

A single telephone voice channel in digital form requires 64kbit/s (resulting from the 8kHz sampling rate at eight bits per sample). When T-1 was developed, 1.5Mbit/s was about the highest rate that could be supported reliably on copper pairs over the standard one-mile distance between repeater sites. Therefore, 24 voice channels can be multiplexed, because 64kbit/s×24 = 1.536Mbit/s. To create the T-1 bitstream, the 24 8-bit channels are assembled end-to-end serially, and the equivalent of another 8kbit/s channel is added for synchronization. Thus, the ultimate data rate becomes 1.544Mbit/s.

The signal is converted into a digital

A pure metallic path of reasonable length is easily able to pass frequencies in excess of 100kHz.

bipolar bitstream (see Figure 1), using a special format called *binary 8-zeros suppression* or B8ZS. The voltage varies between −3V and +3V. Two pairs are needed for each T-1, one each for the send and receive directions.

Despite the difference in capacity and service, T-1 arrives at the end-user site rather unassumingly: There will be two conventional telephone wire pairs, one each for data send and receive. The physical connector used to be a DB-15 type, but the current standard is the common RJ-48C, an 8-position modular plug.

The T-1 line is first connected to a piece of equipment called the *Channel Service Unit (CSU)*. The CSU used to be considered part of the network and owned by the phone company, but it is now usually customer-provided. The CSU contains the last signal regenerator and a number of testing and maintenance features, such as provision for loopback testing by the central office. It may also include a system to collect and report error statistics.

The other components of a complete T-1 system are the *Digital Service Unit* (DSU) and the *multiplexer*. These functions are almost always combined into a single unit. The DSU handles the remaining digital housekeeping functions and data conversion from the bipolar T-1 format to a standard serial datastream. The multiplexer, sometimes called a *channel bank*, combines the multiple voice (or data) channels into a single bitstream required by T-1 transmission. When the T-1 system is used for standard telephone service, the multiplexer also converts each voice channel to and from the digital domain, and simulates typical telco lines at the user site by adding talk battery, generating ring voltage and detecting loop current.

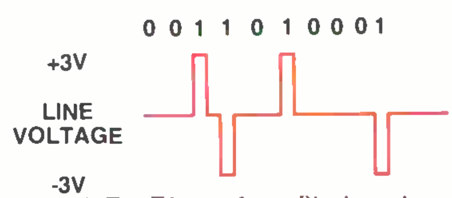


***Figure 1.** The T-1 waveform. Bipolar voltage variation is encoded according to the "alternate mark inverted" technique.*

Fortunately, multiplexers are generally constructed using a modular circuit card approach so that troubleshooting may be simply accomplished by swapping cards. Usually, LED status indicators help to find problems. Remember this bit of preventive troubleshooting: Avoid systems that use adaptive differential pulse code modulation (ADPCM) to permit voice channels to be halved from the usual 64kbit/s rate to 32kbit/s, thus doubling capacity. These add too much noise and distortion for on-air phone use, making high frequencies sound a little muted and sometimes buzzy.

Multiplexers are generally constructed using a modular circuit card approach so that troubleshooting may be simply accomplished by swapping cards.

If you suspect that the T-1 line has gone down, you can check with an oscilloscope for presence of the digital waveform. As with all phone lines, T-1 uses balanced transmission so the scope must not ground either side of the line. You can use a telephone or headphones for a simple go/no-go test. With a signal on the line, you'll hear a sort of rhythmic white noise.

In the not-too-distant future, all telco service will be provided digitally. It's worth becoming familiar with such systems now. ■

Church is president of Telos Systems, Cleveland.

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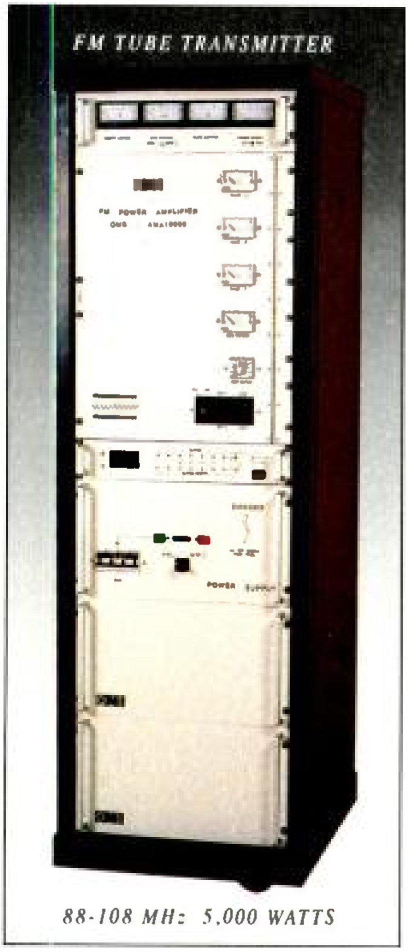

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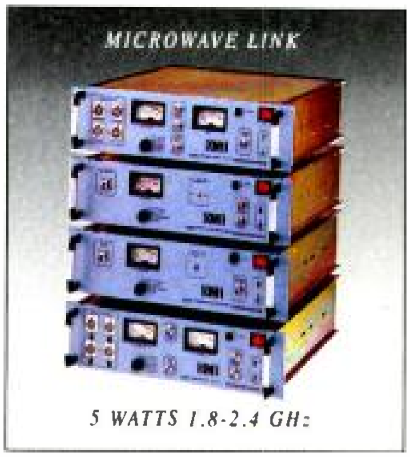

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Technology News

Doubling channel capacity

By Curtis Chan

Late in 1992, Zenith announced that it had devised a new modulation and transmission technology that would be able to double the digital video information in a cable TV delivery system without additional compression. The system is called 16-VSB (vestigial sideband), and uses auxiliary signals to allow acquisition and synchronization. As a result, the system will be able to send two digital HDTV signals on a single 6MHz cable channel and double the number of digitally compressed standard TV signals on a cable channel. This would mean as many as 23 movie channels, nine live video channels and two full bandwidth HDTV channels in each 6MHz analog cable channel.

The peak carrier-to-noise ratio in a 6MHz cable channel is required to be greater than 40dB. Other interfering signals are controlled to even lower levels on cable. This improved noise margin available in cable can be used to increase the information-carrying capacity or data rate on cable, without requiring more video or audio compression than the already massive compression needed to transmit digital video.

To increase the amount of digital data delivered through a 6MHz channel, a cable system must operate with a higher S/N ratio than a broadcast system. It also must acquire and lock the carrier, clock and synchronization information. According to Zenith, extracting all of this information from data is difficult in high-state digital modulation schemes, such as the 16 and 64 QAM approaches.

To achieve significantly increased cable channel capacity, Zenith's researchers extended the capabilities of the 4-level vestigial sideband modulation and transmission technology developed for the Zenith-AT&T DSC-HDTV system. By quadrupling the number of levels of digital data, the data rate was increased to 43Mb/s from 21.5Mb/s.

Compared with 8-level digital approaches, such as 64-QAM, the 16-VSB system would provide more usable digital data throughput. One of the unique attributes of the system is the use of a pilot carrier that can acquire and lock the digital signal even in adverse noise and interference conditions, which are inherent in cable distribution systems.

The 16-VSB system equivalent data rate would equal a 256 QAM approach. If applied, this new cable transmission technology would offer noise-free performance, noise-free digital audio and friendliness with computer, telephone and other digital communications systems that already process large amounts of digital information. ■

Chan is the principal of Chan & Associates, Fullerton, CA.

COMPARISON OF VSB AND QAM MODULATION APPROACHES

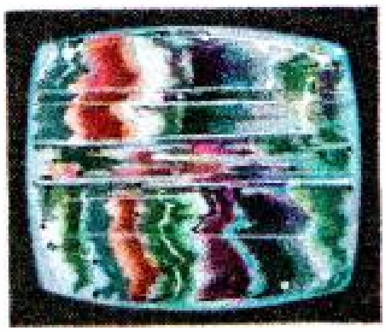
	4-VSB	16-QAM	64-QAM	16-VSB
Data				
Total data rate (Mb/s)	21.5	21.5*	32.25	43
No. of data levels	4	4	8	16
Theoretical max. data rate (b/s)	4	4	6	8
Relative data rate	1	1	1.5	2.0
Carriage in 6MHz Cable Channel				
No. of movie channels (1.5Mb/s VC**)	11	11	17	23
No. of movie channels (2.0Mb/s VC)	8	8	13	17
No. of live video channels (4Mb/s VC)**	4	4	6	9
Ruggedness				
Continuous wave interference rejection	Excellent	Good	Poor	Good
Phase noise rejection	Excellent	Good	Poor	Good
Forward error correction	Yes	Yes	Yes	Yes
Required carrier-to-noise + interference ratio without error correction	22dB	22dB	28dB	34dB
Required carrier-to-noise + interference ratio with error correction	17dB	17dB	23dB	29dB
Analog Friendliness				
Composite triple beat rejection filter	Yes	No	No	No
Signal acquisition w/ noise/interference	Excellent	Good	Fair	Excellent
Channel equalizer	Yes	Yes	Yes	Yes
Cost				
Manufacturing complexity	Lowest	Low	High	Low
Cost of receiving equipment	Lowest	Low	High	Low

*Although, theoretically, all four level approaches have the same relative data rate, the 4-VSB system uses a 21.5Mb/s channel bit rate — greater than any announced 4-level, 6MHz digital data transmission system. Thus, competing QAM systems have less than the indicated data rates.

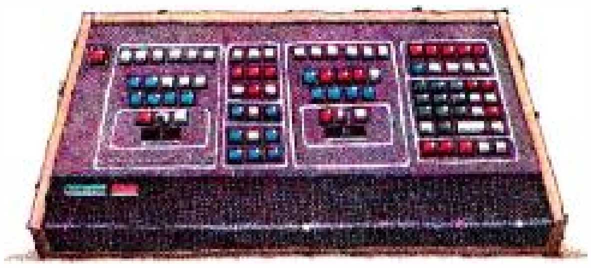
**VC = video compression

B-rolls

Production Switchers



Fuzzy Freeze Frames



Separate Edit Controllers

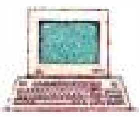
Multiple Source VTRs

Costs

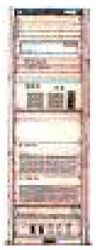
Things you can cut down on in a room with a VUES.™

If you want to be on the cutting edge of digital post-production while cutting down on costs, perhaps it's time to invest in a room with a VUES.

This high-powered digital editing system from NEC consists of a single rack of equipment: a computer-control workstation, the NEC DTW-102 wipe generator, a background color generator/shadow processor, a 20×10 routing switcher, NEC VUES interface, and the real heart of the system, the NEC VUES VSR-11 solid state recorder.



With VUES, all editing functions—from wipes and complex mix/effects to multi-layered composites—are performed in the VSR-11. Best of all, you only need to use one source machine, one channel of character generator and one channel of digital effects to accomplish all of these tasks. And with the use of the VSR-11's DRAM memory, each source can be used indefinitely without ever performing a B-roll.



The compact design of VUES requires less space, less cooling and less maintenance (because there are no moving parts). Plus, because VUES utilizes a computer-control workstation, there are no expensive production switchers or edit controllers to buy.

If you would like more information about the finer points of VUES, please call us toll-free at 1-800-323-6656.

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The pace at which electronic technology is changing reminds me of the Eveready rabbit. It just keeps going and going and going... For those who must manage changes, it's often a tough and tiring job.

With these changes comes a wide variety of improvements and disadvantages. For example, today's video and audio equipment provide more features per dollar than ever, not to mention a host of capabilities that were impossible a few years ago. Before we complain about things moving too fast, let's keep in mind that along with the growing pains of technology come significant benefits.

This month's editorial focus examines several new technologies that hold great promise for this industry. The first is ghost canceling, which may prove to be the greatest improvement for television since color.

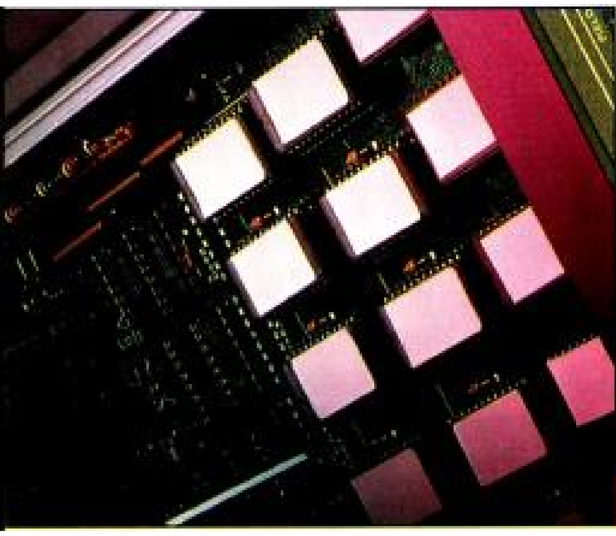
New audio recording formats are the second area examined in this issue. The days of having just two analog formats — reel and cassette — are gone forever.

With the aid of digital techniques, audio recording has leaped forward in quality and capability. Small, portable and high-quality playback, as well as recording capability, are now taken for granted. *BE* looks at three of the hottest ways to record audio: DCC, MD and NT.

Make sure you're not dragging in the dust left behind by the running rabbit of technology. Learn how to manage the changes for maximum benefit to your facility.

Brad Dick

Brad Dick, editor



Understanding video compression

Soon, video compression will be a fact of life.

By Dr. Tom Lookabaugh

The Bottom Line

One of the greatest challenges posed by digital video is an effective means by which large amounts of data can be transmitted from one location to another. Unfortunately, our current system cannot handle the data rates involved, and the spectrum for transmissions must be shared by other users. Digital video compression provides a means to reduce the original volume of data while maintaining a specific level of quality. Through compression, transmission channel bandwidths can be cut, along with the costs incurred by normal satellite usage. The technology offers new options in video production and distribution, as well as new communications capabilities.

Lookabaugh is director of research and new business for Compression Labs Inc., San Jose, CA.

Advances in signal processing and communication have helped to pave the way for the development of digital video. Compression has accelerated the transition, perhaps by decades. This article reviews the fundamentals of digital video compression technology and outlines the major processing components involved. It also examines the critical task of evaluating compression systems.

The use of discrete (digital) instead of continuous (analog) signals, when processing and communicating electrical information, has caused an explosion in electronic technology. The two key disciplines, digital processing and digital communication, are two of the prime components of compressed digital video.

Why compression?

Economics justifies compression. Compression is justified if the cost of the communication or storage decreases more than the cost of the compression and decompression equipment, yet the quality of the decompressed video meets the requirements of the application.

For example, consider that NTSC is the most widely used analog video signal in the United States, with a bandwidth of 4.2MHz. To digitize the signal, the Nyquist theorem requires sampling at a frequency of 8.4MHz at eight bits per sample resolution, giving us 67.2Mbps. Multiplying by three for the three color components (red, green and blue) yields a bit rate of 201Mb/s.

Dealing with such high data rates in moving and storing of information presents some difficulties. For instance, current floppy disks hold approximately 1.44Mbytes (11.5Mbits) of data. This means that storage of a typical 100-minute movie would require more than 100,000 floppy disks. Further adding to the problem, typical transfer rates between hard disks and computer CPUs are on the order of 2Mbyte/s or 16Mb/s, more than 10 times too slow for the required data rate. The highest speed modems for voice-grade channels in the public telephone network operate at less than 20kbps. Thus, 10,000 such channels would be needed to carry the signal. As you can surmise, many interesting applications of video would be problematic without compression.

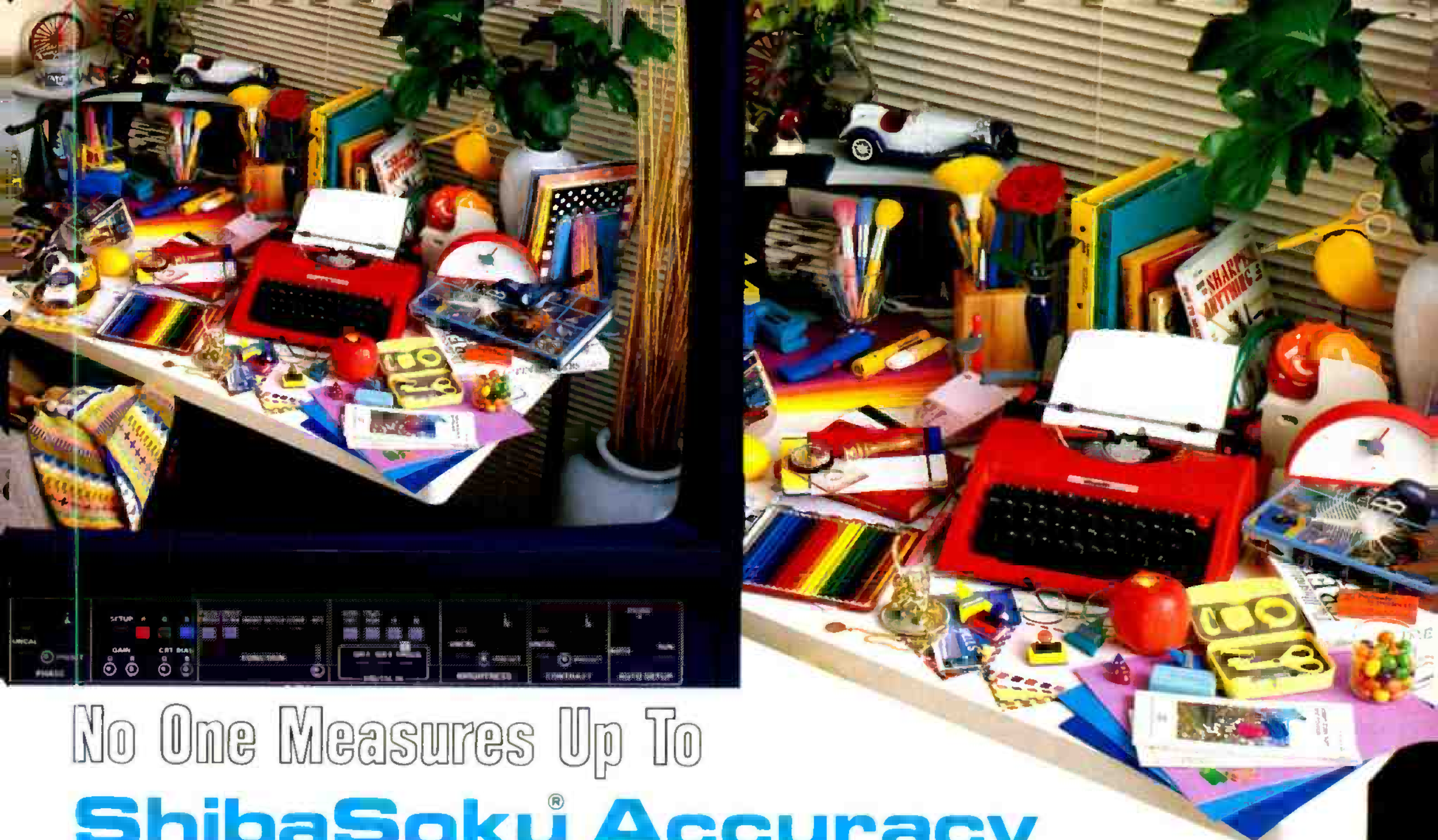
Compression techniques

In the different approaches to video compression, several key elements repeatedly appear. Although there are different algorithmic approaches and many tradeoffs associated with each element, they appear in almost all video compression systems in one guise or another. It also is important to note that the industry sometimes misuses statistics, such as "compression ratios."

When comparing systems, compression ratios are often misleading. Rather, the systems must be compared on one of two bases:

1. Which one looks better when they are operating at the same bit rate?
2. When they look approximately the same in quality, which has the lower bit rate?

Note that not all video compression techniques employ every one of the processing steps described in this article.



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Transmitting hidden data in video signals

By Charles Jungo

Broadcasters now have a way of offering data broadcast services without relinquishing spectrum. WavePhore has announced its VIDEO 7500, a data transmission scheme that sends data over standard video without interference. It enables high-speed data transmission over a conventional TV network. The system has the ability to insert data into the active portion of the video scan line with no visual degradation of the video. The technology does not use the VBI, the front- or backporch, the colorburst or the spectrum next to the audio subcarrier. Instead, the data overlaps the video spectrum and becomes an inherent part of the video information, but is not visible on the TV screen.

Two considerations make this possible:
1. The data amplitude is kept at a low level, approximately 10dB above the video noise floor. The actual level is adjusted to approach this condition for a given broadcast system.
2. An appropriate shaping of the data spectrum prior to insertion minimizes interference with the luminance and the chrominance by taking advantage of the spectral properties of the video signal.

The data cannot even be seen on the spectrum analyzer when normal video is present. In reality, however, a minute portion of white level has been displaced by digital data while the total IRE remains unchanged. This almost unmeasurable merging of the data into the video makes it almost impossible to strip off the data once it is added. This means that the system can guarantee the data integrity all the way through the distribution path.

Also, because the data is combined with the baseband video, it is independent of the mode of video transmission. Thus, the data can be carried by broadcasters' satellite, microwave, CATV cable or a combination of these.

A typical system configuration places the encoder at the originating site of video transmission. Decoders are located at the remote sites receiving the broadcast data.

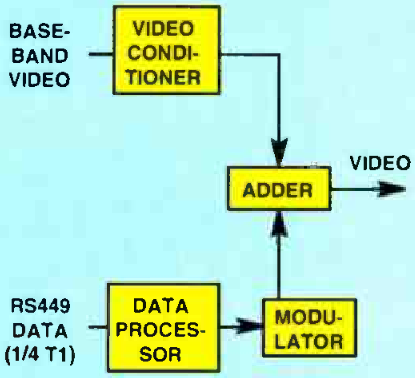

***Figure 1.** A simplified block diagram of the VIDEO 7500 encoder.*

The encoder has two inputs, one for baseband RS-170A (or PAL) video, the other for data from a host computer via LAN or from a CD ROM source, depending on the application (RS-422 interface). The encoder output is then upmodulated for transmission just like standard video. (See Figure 1.)

At the receiver, a decoder separates the digital data information from the video for further processing by a computer. The video can be viewed normally on a regular TV set or monitor.

Depending on the application, the data can be packetized for addressability or encrypted for security. Thus, a customer may access only his chunk of information and ignore the rest.

The reliability of the transmission is guaranteed when two factors are met. The TV signal must have at least 40dB of signal-to-noise ratio at the subscriber's end, and the signal has to be relatively free of artifacts, such as ghosts acquired during transmission.

The transmission system should comply with standard RS-250-C medium-haul transmission links. Also, processing of the baseband video signal after data insertion should be minimized because excessive group delay distortion or low-resolution digitizing (less than nine bits) can degrade data integrity. Specifically, filters with a cut-off frequency less than 4.2MHz should be avoided.

Tests performed on conventional broadcast facilities did not exhibit any problems because of transmission filters.

The VIDEO 7500 currently has a data rate of 384,000 bits per second, a speed sufficient for transmitting larger files, images and other multimedia information. This will enable cost-effective delivery of high-speed digital information using the most pervasive of networks — television. Higher-speed versions are currently under development. ❑

Jungo is vice president and director of engineering for WavePhore, Phoenix.

Systems that do not employ certain steps potentially could suffer significant performance disadvantages, yet show little cost benefit. This trend is expected to continue as implementation costs fall with improving chip-based technology.

Lossless vs. lossy compression

A critical design decision in developing a compressed digital video system is whether the compression should be *lossless* or *lossy*. Lossless compression guarantees (in the absence of channel errors) that the digital input to the compression system and the digital reconstruction at the output of the decompression system will be identical down to the bit level. Lossy compression does not provide this guarantee but may be more suitable for compressing digital video information.

Two important factors make lossy coding more effective for most compressed digital video applications. First, limitations of the human visual system mean that a reconstruction that differs from an original may appear the same (visually transparent). Transparent lossy coding typically can be done at approximately one-fourth the bit rate of lossless coding. Beyond transparent coding, the tremendous economies of compression make it acceptable to have some visual distortion if a low enough bit rate can be achieved at which the application becomes economical.

Economics justifies compression.

The argument for lossless coding in compressed digital video applications is weakened by a second factor. From a system perspective, it is impossible to deliver the image as viewed by the camera losslessly to the eye of the viewer, even if digital compression and transmission were lossless. This situation exists because every component in the system introduces its own distortion, and the system designer has already undertaken a trade-off in cost vs. performance in component selection. It is reasonable to make the same trade-off in the compression system. If the distortion introduced is low relative to the overall system distortion budget, yet the transmission cost savings are significant, then lossy compression is the correct choice. For these reasons, lossy compression is essentially universally preferred in the compressed digital video applications.

Compression steps

Figure 1 shows a block diagram of a basic video compression encoding algorithm. It will be used as a reference on which to base our discussion.

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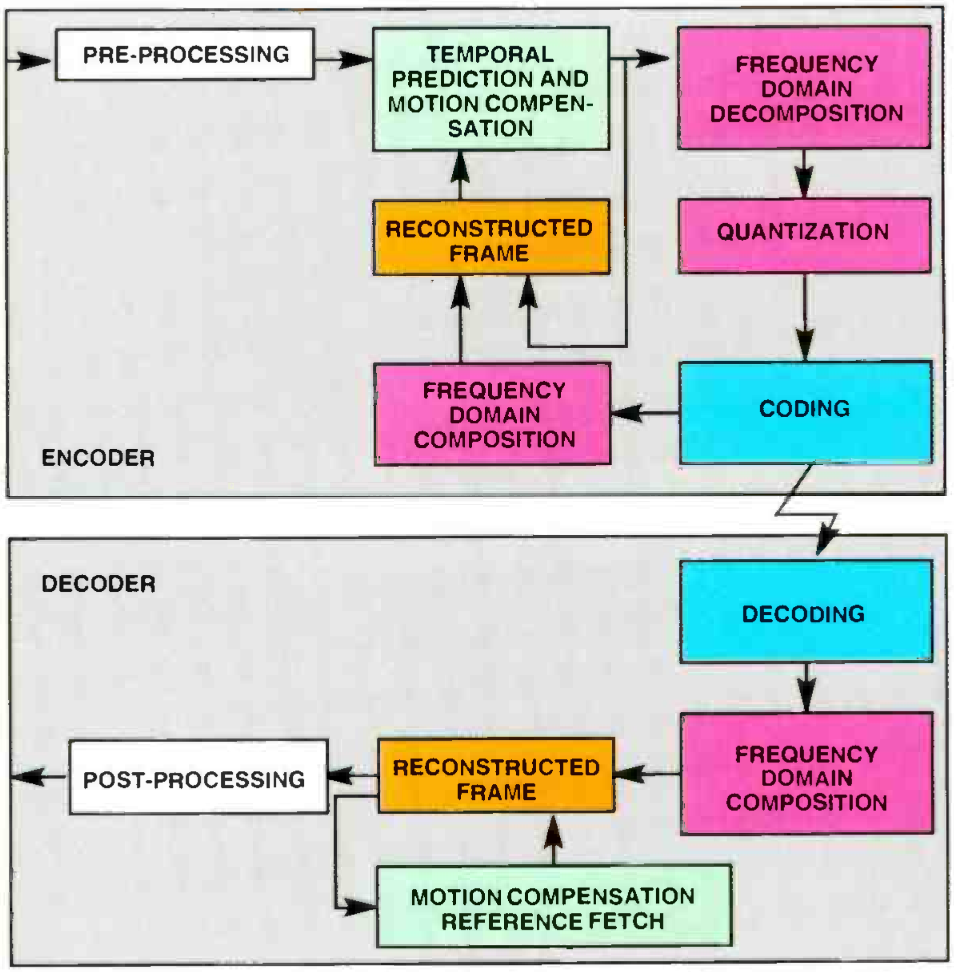

***Figure 1.** A block diagram of an encoder and decoder for compressed digital video applications.*

- *Preprocessing.*

Preprocessing attempts to remove information from a video signal that is most difficult to code, yet relatively unimportant to the visual quality. Typically, a combination of spatial and temporal non-linear filtering is used. Judicious use of preprocessing according to application is as much an art as a science. It is most effective when solid experience is married with careful experimentation using the particular system and application being developed.

- *Temporal prediction and motion compensation.*

Video sequences usually are highly correlated in time. In other words, each frame of a sequence is quite similar to the preceding and following frames. Taking the difference between frames and coding only the difference, instead of the entire original frame, reduces the amount of information that must be sent. Simple frame differencing can be improved by noting that many changes occurring from frame to frame can be approximated as translations of small regions of the image. By breaking a frame into small blocks (typically 16×16 pixels) and searching at nearby positions in the previous frame, it is possible to find an appropriate predictor block, so that only the position of the predictor block and the relatively small differences between the predictor block and the current block need be sent. Because this process helps greatly reduce the bit rate when portions of a scene are in motion, it is typically called motion compensation.

Although motion compensation is sometimes blamed for the introduction of motion artifacts, this is a misconception. Motion compensation does yield more efficient compression because much smaller differences have to be communicated. However, it introduces no distortion by itself. Motion artifacts can arise when insufficient bits are available to describe detailed and/or rapidly changing scenes, but they can also occur for other reasons. Typical examples include conversion from film to video, or use of a single "merged" frame to represent two fields of video, or when a non-motion-compensated system suffers varying quality because of varying scene detail. Hence, motion artifacts aren't specific to motion-compensated systems.

- *Frequency domain decomposition.*

The next step is to find a frequency representation for the signal representing the difference between the best offset in the previous frame and the current frame (a motion-compensation residual). The signal is analyzed into 2-D frequency components, much like a spectrum analyzer determines the frequency components of a one-dimensional signal. This has two advantages. First, the signal often has most of its energy concentrated in a small range

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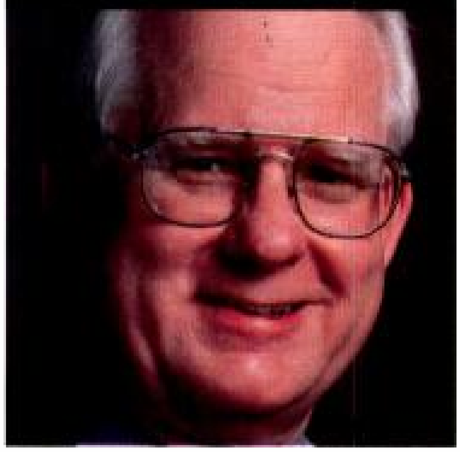

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of frequencies (typically at lower frequencies), so that relatively few bits are required to describe unimportant higher frequencies. Second, this frequency domain decomposition mirrors the process of human vision and allows tailoring of the subsequent quantization step to the sensitivity of the human visual system to frequency content.

The most-popular frequency domain decomposition technique is the *discrete cosine transform* (DCT). The DCT, a relative of the discrete Fourier transform, takes a block of the motion compensation residual (8×8 or 16×16 pixels) and converts it to a corresponding set of coefficients, representing different frequency components. DCT popularity stems from several factors:

1. It has a fast algorithmic implementation resulting in many VLSI solutions.
2. It is nearly optimal among transforms.
3. It has withstood competition of many alternatives by consistently yielding a superior cost-performance trade-off.

Alternatives to the DCT include subband decomposition, image pyramid decomposition and wavelets.

Subband decomposition involves applying a set of bandpass spatial filters to each frame of the sequence, with the center frequencies of the filters spanning the range of frequencies in the image. Because the output of each filter has a reduced frequency range relative to the original, the Nyquist sampling criteria allows us to resample each at a lower rate. When the total number of samples per image after decomposition equals the number of samples in the original image, the subband system is said to be critically sampled.

Image pyramid decomposition is a non-critically sampled subband system in which the image frame or motion-compensation residual frame is repetitively low-pass filtered and then subsampled. The resulting set of images of smaller and smaller size is called a low-pass pyramid.

A bandpass pyramid is constructed by interpolating the smallest image and subtracting it from the next smallest image to produce a bandpass image. The next smallest image also is interpolated and subtracted from its larger neighbor. The result of this repeated process is another pyramid in which each level contains a different range of frequencies. This bandpass pyramid can now be coded and transmitted.

In the general case, wavelet decomposition breaks an image or motion-compensation residual frame into components associated with scaled versions of an original prototype function. The advantage of this approach is a variable trade-off between spatial and frequency resolution as different frequency ranges are considered. Subband and pyramid techniques are less prone to the "tiling" that appears in transform images when high compression ratios are demanded. Depending on the other portions of the system, tiling can still appear in subband or pyramid systems — for instance, if vector quantization is employed.

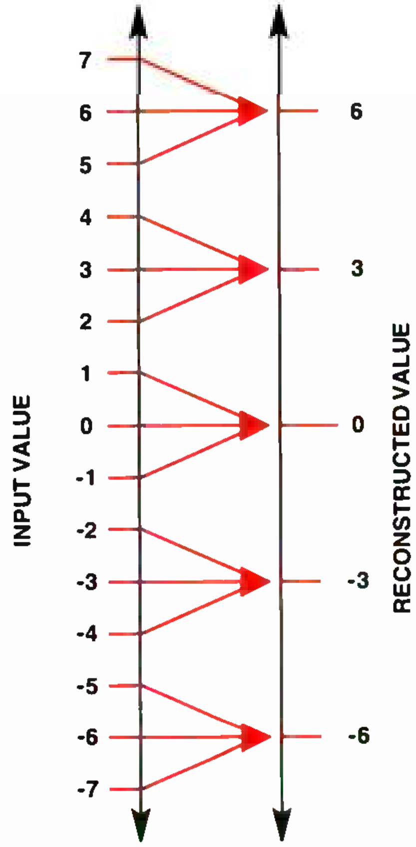

Figure 2. *In this diagram of a uniform quantizer, the step size is three, because the range of possible inputs is divided into bins of width three with a single reconstruction for each bin. The step size controls the trade-off between bit rate and visual quality, and can be adjusted dynamically to respond to system loading (for example, during an extended period of difficult-to-compress source material).*

Although work continues in frequency domain decomposition techniques, the DCT continues as the technique of choice for practical video compression systems.

- *Quantization.*

Motion compensation reduces the signal to be transmitted. The frequency domain decomposition concentrates the power into a few frequency coefficients and arranges the energy in a way similar to the human visual system. Quantization irreversibly reduces the amount of information that will actually be provided to the decoder about the signal.

Fundamentally, quantization accepts each coefficient from the frequency domain decomposition and reduces the precision with which it is described. Suppose a coefficient can range between −127 and 127 as an integer, requiring eight bits to send it as it is. Instead, the numbers −1, 0 and 1 can be grouped together and reproduced as 0 at the decoder, numbers from 2 to 4 can be grouped together and reproduced as 3 at the decoder, and so on. (See Figure 2.) By doing this, 85 different groups of numbers can be identified. Now, the decoder has determined which group was elected. This only requires seven bits to send (actually, quantizations can be grouped together to reduce the bit rate to the true minimum of 6.4 bits per sample). The compression effect is obvious.

Quantization is a noisy compression step. A decoder cannot accurately reconstruct each coefficient. Instead, it will produce an approximation of the coefficient that the encoder saw, resulting in some distortion in the decoded image. Quantizer design must optimize the required number of bits to be sent, while simultaneously minimizing the visibility of the distortion that is introduced.

- *Coding.*

Quantized frequency domain coefficients often have a zero value at many different frequencies. Also, large groups of such zeros may cluster together at the higher frequencies. Additional compression often is achieved by coding the number of zeros in a row rather than coding each individual zero by itself. This is called run-length coding. Non-zero coefficients are coded individually.

Non-zero quantized coefficients and the number of zeros in a row can yield to further compression, because some possibilities occur more frequently than others. By assigning short code words to frequently occurring possibilities and longer code words to infrequently occurring possibilities, a net savings in bit rate can be realized.

The most-popular technique in video compression for this additional compression is Huffman coding (see Figure 3), although arithmetic coding and Lempel-Ziv coding (common in compression of computer files) can also be used. Following the coding step, the resulting bitstream is ready for transmission to the decoder. The requirements of the particular communication channel may specify that synchronization and error-correction information may be added and encryption applied. Other bitstreams, such as compressed audio and accompanying data channels, might be multiplexed in. The receiver synchronizes to the transmitter, corrects as many errors as possible, decrypts the bitstream and separates out the other data types, sending the clean video bitstream to the decoder.

- *Decoding.*

Decoding undoes the operations of the encoder in a predictable way. The run lengths of zeros and coefficient values are looked up, and the reproductions that the encoding quantizer assumed assist in reconstructing the coefficients. The coefficients are applied to a frequency-combining process, undoing frequency decompo-


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sition. Then, they are added to the prediction that the encoder used during motion compensation, resulting in an output frame.

Decoding usually has a significantly lower complexity than the encoding. This asymmetry is partially offset by the fact that error correction, if performed, typically requires more work at the receiver than at the transmitter.

Systems that do not employ certain steps potentially could suffer significant performance disadvantages, yet show little cost benefit.

- *Post-processing.*

One additional step sometimes performed at the decoder is post-processing. This typically attempts to recognize the most annoying artifacts that may occur and directly reduce their visibility. Post-processing generally pertains to situations with fairly high distortion levels. In contrast, reduction in the visibility of artifacts from low distortion situations is difficult to perform successfully without simultaneously distorting the original signal in some other annoying manner.

Quality and performance

Video compression has made possible some applications that are otherwise economically unfeasible. Often, these do not have an established set of expectations of what is appropriate visual quality and methods of assessment by simple, objective and repeatable engineering measurements. These measures tend to be inappropriate and misleading when applied to compressed digital video systems. Many measurements prove non-sensical, while others underpredict or overpredict visual quality. Other impairments introduced by a compressed digital video system are not captured by any standard measurement. The level of sophistication employed in compressed digital video system design is such that no simple, yet accurate, objective engineering measurements are available to uniformly evaluate performance. Many practicing video engineers find this inconvenient and perhaps uncomfortable. Until good objective measures are developed, if the system looks good to the customer, then it is good.

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Although visual quality is a challenge to evaluate, other aspects of compressed digital video are easier than their analog video counterparts. Because the compressed bitstream is transmitted digitally, the bit-error statistics completely describe the quality of the transmission. This contrasts to analog transmission systems, in which many linear and non-linear distortions, as well as additive noise, can cumulatively degrade the signal.

User interface

Most compressed digital video applications place sophisticated digital processing and communications devices in the hands of users who have little or no interest in the sophistication of the technology. Most are only interested in achieving their communication purpose with minimum hassle. Good user interface design is a must. The current trend requires friendly, on-screen control of compressed digital video systems. Remote control couples systems that automatically adjust in most circumstances to changes in the environment. In some applications, such as videotelephony, system control may be limited to a small number of functions (i.e., self-view vs. far side view, video/audio mute and privacy, speakerphone vs. handset).

SYMBOLS	PROB-ABILITY	FIXED RATE CODE	HUFFMAN CODE
A	0.5	00	0
B	0.25	01	10
C	0.125	10	110
D	0.125	11	111

Figure 3. *A Huffman code example. Huffman codes provide their most dramatic savings on sources with large probability on a relatively small number of symbols.*

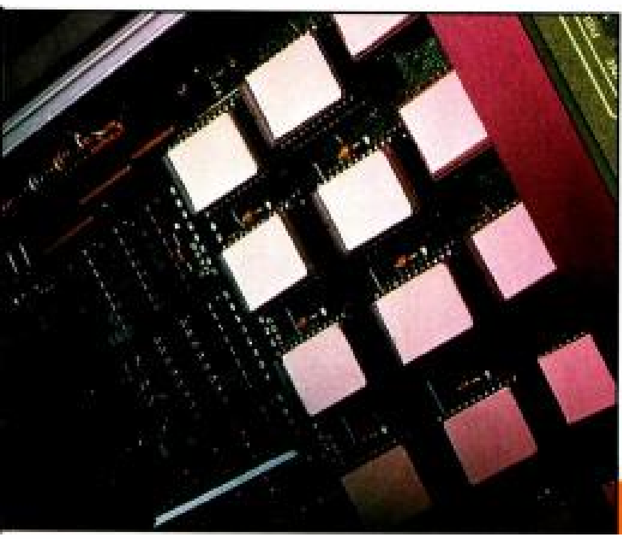
Beyond transparent coding, the tremendous economies of compression make it acceptable to have some visual distortion if a low enough bit rate can be achieved at which the application becomes economical.

Growing acceptance

Compression has found a significant acceptance in video production-type systems, where the reduction of video data speeds the editing process in desktop operations. The use of data reduction has applications in the transfer of information, permitting a reduction in the bandwidth of communications channels, such as satellite transponders, often with an associated reduction in the cost of transmission feeds.

With the technology now well past its infancy, its feasibility must no longer be proved. Video compression will find more and more acceptance as costs decrease. As with all technological innovations, compression will continue to be enhanced through new algorithmic discoveries and fine-tuning of those already in use. Just as PCs have found a useful place in millions of consumers' homes, video compression will, in time, also become a fact of life.

➡ *For more information on video compression, circle Reader Service Number 301.* ■



Cancel that ghost

Keep your viewers tuned in by keeping ghosts out.

By Stephen Herman, David Koo, Amihai Miron, Craig Greenberg and Chikiang Tung

The Bottom Line

The quality of the image your viewers receive depends on several factors. Some relate to the transmission system while others relate to the reception equipment. Ghosting, which is caused by reflections from buildings, aircraft and other objects in the environment, falls somewhere in between. Knowing how to keep your viewers from tuning to another channel for a clearer picture is critical to your station's profitability. Using the tools of modern electronics, TV receiver manufacturers can give viewers a greatly improved, ghost-free image.

Herman is senior member of research staff; Koo is principal member, research staff; Miron is director of electronic systems research sector; Greenberg is senior member of research staff; and Tung is member of research staff, Philips Laboratories, Briarcliff Manor, New York.

TV ghosts are multiple images caused by multipath echoes. In theory, TV signals travel along straight lines. The signal may have a short, direct path between the transmitting antenna and the receiving antenna. The same signal also can reach the receiver antenna over a different, longer echo path because of reflections off nearby buildings and other objects. Under such conditions, the receiver will show two images — a strong, main image and a weaker, shifted echo or *ghost*. These ghosts can seriously degrade received image quality.

Two types of ghosts exist. In the first, the ghosted image is a weaker replica of the main image, delayed to occur later in time. This is called a *post-delay ghost* or *post-ghost*. In the second type, a ghost occurs before the main image, resulting in a *pre-ghost*. Pre-ghosts can occur in cable systems, where it is possible for the strong, main image to have a propagation delay through the cable system longer than the time it takes for a weak, direct-broadcast pickup to be received. These two ghosts require different methods of cancelation.

Ghost canceling

The 2-step process to cancel ghosts at the receiver first requires characterization of the ghosting channel, and then canceling the ghosts by using adaptive filters.

To facilitate the channel characterization step, the broadcasting station transmits a *ghost-cancelation reference* (GCR) signal. The receiver compares the received, ghosted version of the GCR signal with a clear, stored replica of the same signal. The results of such comparisons are computed by a digital signal processor chip, which uses ghost-cancelation algorithms to calculate coefficients to be fed to digital adaptive filters that cancel the ghosts. The process occurs continuously, with the coefficients of the filters being constantly updated to follow transient conditions, as measured from the received GCR.

The two types of ghosts require different methods of cancelation.

Figure 1 on page 42 shows a simplified block diagram of the Philips ghost-canceler system. An A/D converter changes the received analog signal to digital form. The ghosted received GCR is captured, providing the computed settings for the ghost-canceling filter. The corrected signal, with the ghosts removed, is converted back to analog for normal display.

GCR history

The GCR signal forms the key link between the broadcaster and the viewer. It carries all of the information that the receiver needs to successfully cancel ghosts. Realizing that commercial ghost cancelation would not be possible without a standard GCR signal, the Advanced Television Systems Committee (ATSC) began search-

Continued on page 46

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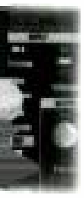

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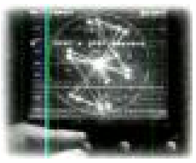

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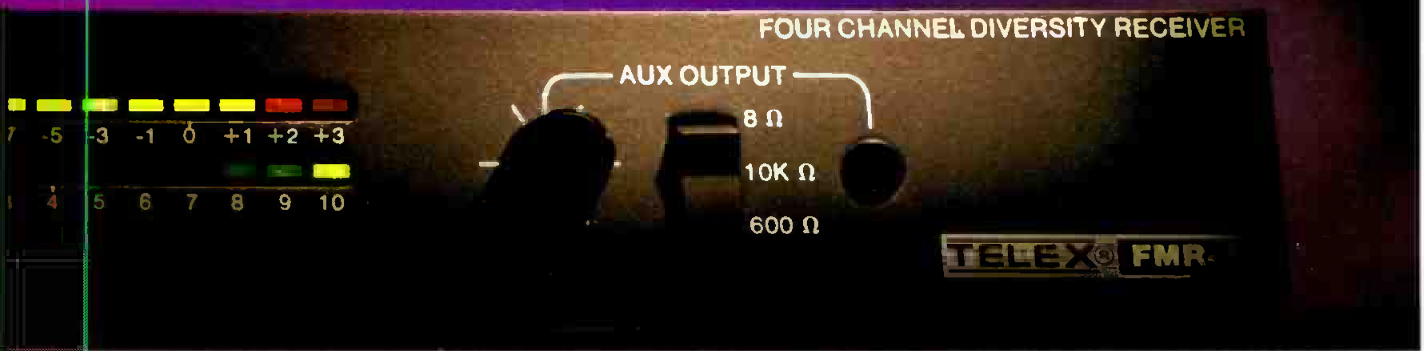

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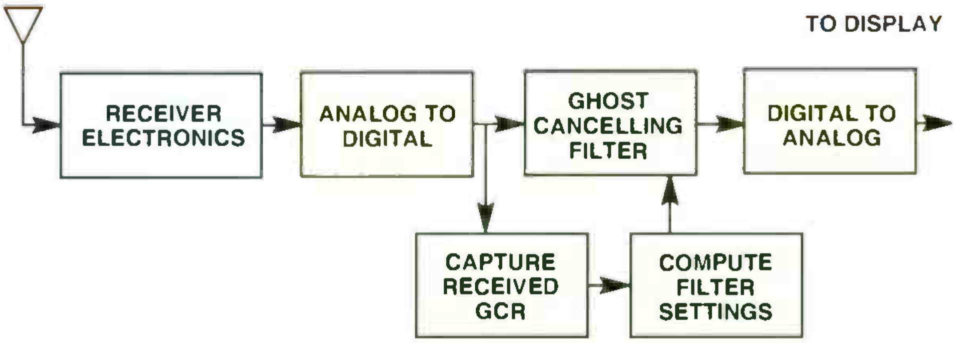


Figure 1. Simplified block diagram of a ghost-cancelation system.

Dynamic ghost simulation

By John Minck

If your goal is to rid TV pictures of ghosting, then why would you develop a ghost simulator? Well, for one, because it is used to generate ghosts for system design and evaluation.

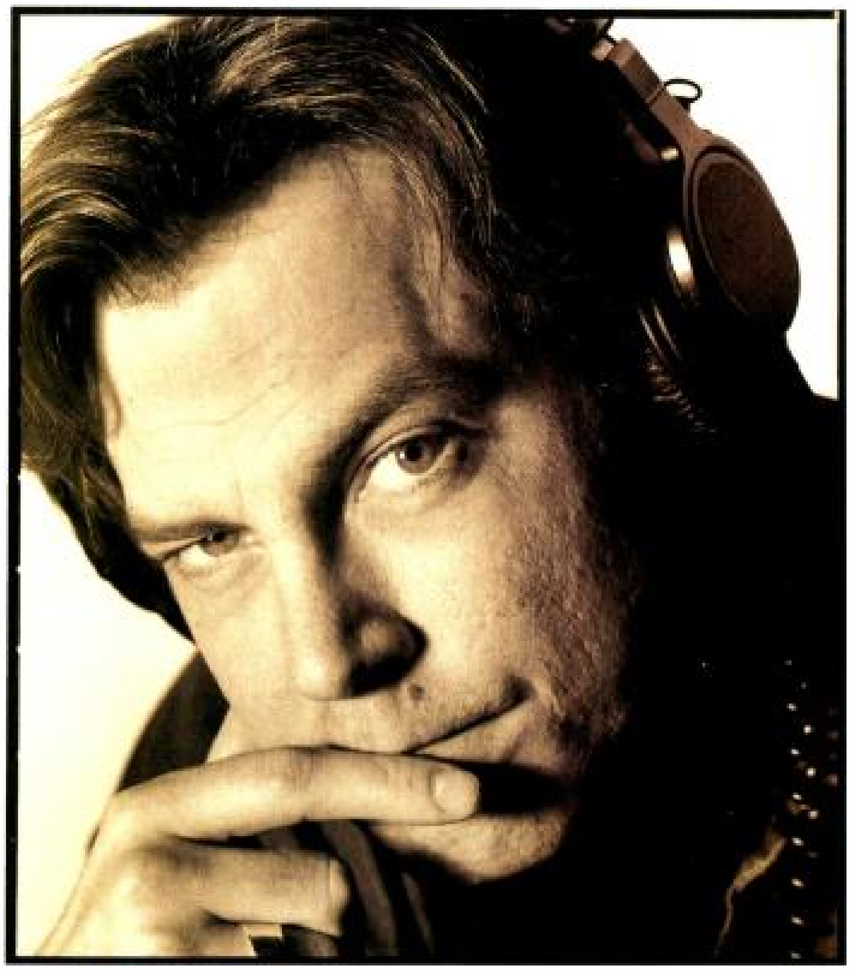
Although a standard GCR signal has been defined for the transmission side, no specifications exist for receiver manufacturers. In order to develop appropriate processing and filtering circuits, manufacturers need the ability to create numerous ghosting conditions, singularly and in combination. Reflecting surfaces causing multipath-induced image impairments are not all static. Aircraft, for example, are a source of intermittent problems. The overall success of a ghost-cancelation system will depend on its ability to simultaneously handle multiple problems, and manufacturers will vie for product advantages.

Although a standard GCR signal has been defined for the transmission side, no specifications exist yet for receiver manufacturers.

Figure 1 illustrates the concept of a dynamic ghost simulator and reveals how the baseband signals can be modified under computer control. The basic model provides six paths of modifiable signals. Each is separately programmable for signal delay, Doppler, attenuation and phase-shift parameters. Typically, one path is used without impairment to represent the direct signal, which leaves five paths available for simulating different ghosts.

The modulated signal input is downconverted to an intermediate frequency (IF) signal, with fully specified performance over a minimum bandwidth of 6MHz. Then, the IF signal passes

Minck is application engineer, SPD Division, for Hewlett Packard, Palo Alto, CA.



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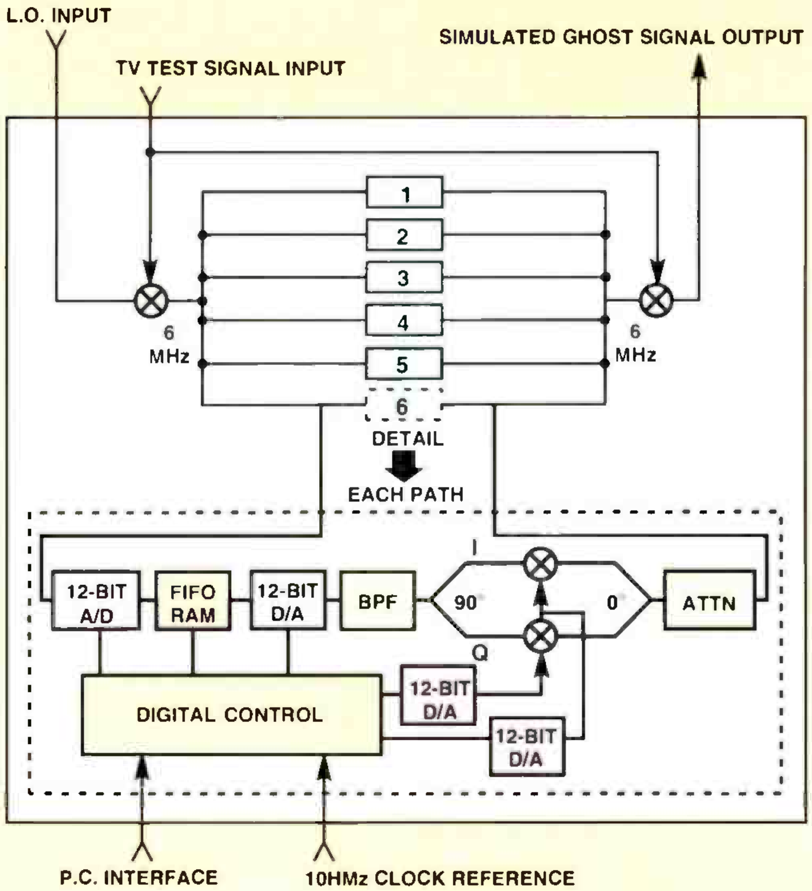


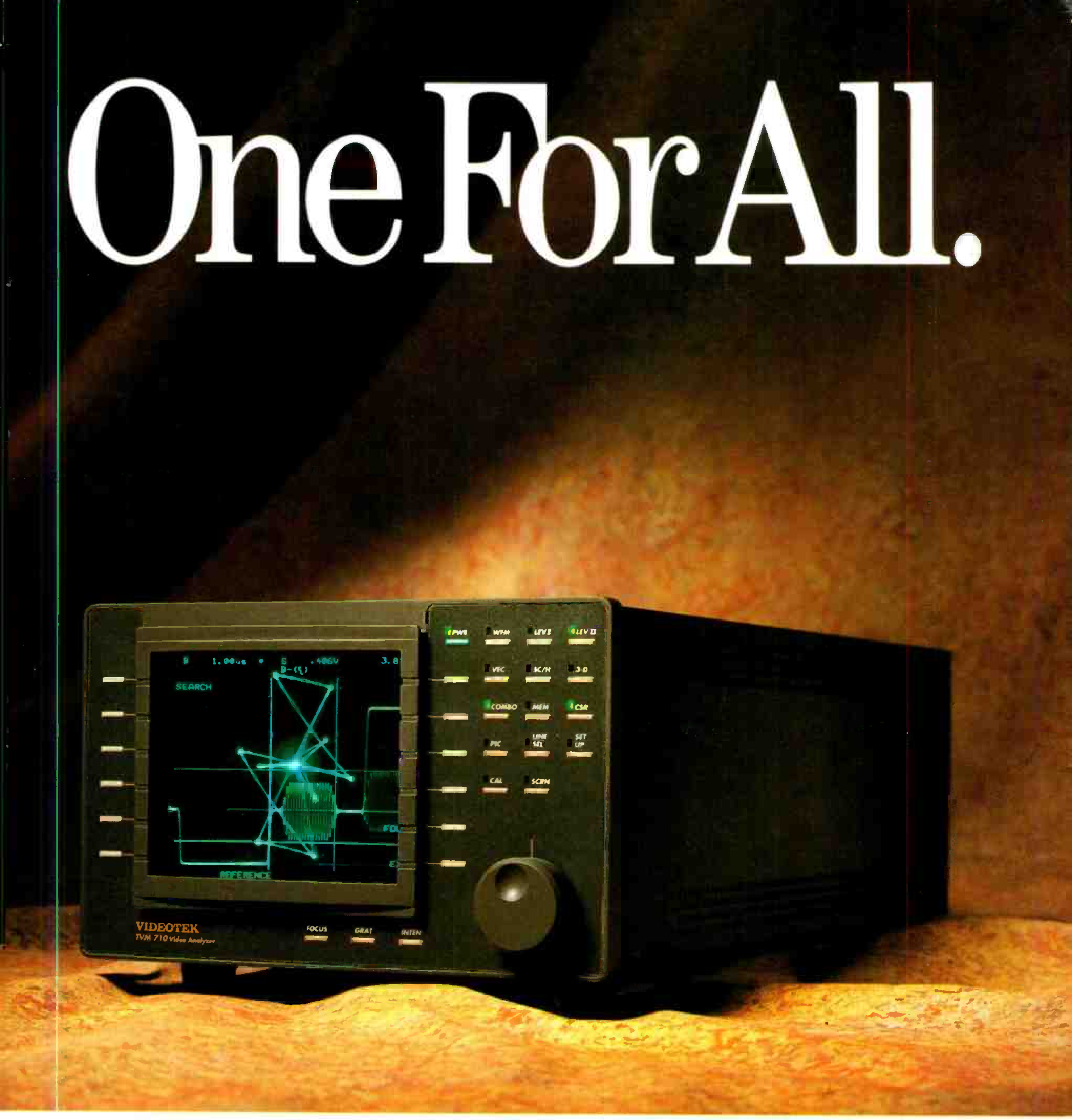
through a 6-way splitter, after which each path undergoes the following steps:

1. A 12-bit A/D converter creates and applies a digital datastream to the first-in/first-out (FIFO) memory. By controlling the FIFO, the path delay is adjustable in precise delay increments. After the delay is applied, the signal is converted back to an analog IF signal.
2. After filtering, amplitude and phase modifications are made on the IF signal with an in-phase/quadrature (I/Q) modulator. Amplitude and phase are precisely controlled by a 12-bit DAC, operating through the I/Q modulator, under the user's control.
3. Finally, the altered IF signals are converted back to an on-channel RF signal. Synchronization is maintained because the same LO signal is used for the upconversion and downconversion process.

Flexible user interface

Because ghosting may involve numerous factors simultaneously, the simulator is designed around a PC operator interface. Also, a wide array of instrumentation already exists for bus-control net-

Figure 1. The HP 11759D ghost simulator includes six identical signal paths, each of which can be characterized to simulate a different type of ghost condition.



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works. The result is a familiar interface for most users.

In addition, this approach allows for the software coding to be "open," permitting the user to modify, add or subtract required ghost characteristics. Path characterizations can be expressed in several terms — for instance, hertz or kilometers per hour — thereby providing for examples and routines, such as a single airplane, a tower sway effect or a static mountain reflection.

Because ghosting may involve numerous factors simultaneously, the simulator is designed around a PC operator interface.

Ghost simulations are divided into two classes, dynamic and static. For static simulations, the operator sets values for delay, attenuation, Doppler value and phase parameters. These values are set for each path, each representing a fixed ghost, such as a mountain, tall building or cable reflection effect.

Dynamic scenarios can be illustrated by the example for airplane flutter. One software sequence, called Travel Test, accepts instructions for the test, including location coordinates and direction and speed of the airplane, relative to the fixed locations of a transmitter and a receiver. The program then runs off-line and computes an ASCII file of parameter (the same as for static) data for each 0.01 second.

From the table of data computed, the test uses the information with a real time program sequencer. This checks the data for errors according to defined limits, and then outputs the results to the simulator to set the signal parameters dynamically, giving the precision signal modifications the user needs.

These sophisticated testing capabilities allow designers to build even more-effective ghost-canceling filters and circuits. The result will be better-received images for viewers, which in turn benefit broadcasters and cable systems. ❑

Continued from page 38

ing for the most-suitable GCR in 1989. The first step was the GCR adopted as a national standard by Japan's Broadcast Television Association (BTA). Between 1989 and 1992, the ATSC Specialist Group on Ghost Cancelation compared the BTA signal with candidates submitted by AT&T/Zenith, Sarnoff/Thomson, Samsung and Philips. The initial comparisons considered theoretical and computer simulation and laboratory criteria. The NAB, MSTV, Cable Labs, PBS and other organizations conducted the final and most-extensive field tests in metropolitan Washington, DC, during late 1991 and again (in a limited form) in mid-1992. Based on these test results, the ATSC recommended that the Philips GCR be chosen as the U.S. standard signal.

The GCR signal occupies one line of the vertical blanking interval (VBI). Line 19 was chosen as the most appropriate VBI line into which to insert the GCR. Because FCC regulations already reserved line 19 for a vertical interval (color) reference (VIR) signal, an FCC waiver was required to replace the VIR signal with the GCR. (Research proved that only a few TV receivers, manufactured through 1985 by the General Electric Company, used the VIR signals.) The FCC approved the sub-

stitution of the GCR into line 19 on Oct. 27, 1992, making the Philips GCR and its VBI location the official U.S. voluntary standard.

The GCR signal forms the key link between the broadcaster and the viewer.

The voluntary nature of the standard relies on the cooperation of the broadcasters. Most were enthusiastic about the possibility of improving received image quality for a low-cost investment in additional equipment at the transmitter site.

Using the GCR

To insert a GCR, a VBI signal inserter is required. Some manufacturers plan to modify existing inserters to make them functional for GCR applications. New products also will be available to make inserting the CGR signal easier.

A special set of PROMS already exists to allow the TEK-1910 to be used to insert the GCR. This chip set is available from Tektronix and Philips Broadband Networks of Manlius, NY, and costs approximately \$300 to \$500. Because many stations already own a TEK-1910 inserter, the upgrade cost will be minimal.

The GCR acts as a test signal in characterizing the impulse or frequency response of the "black box" representation of the ghosting transmission channel. The American GCR standard resembles a swept-frequency chirp pulse. It is not such a pulse, but is carefully synthesized to have a flat frequency spectrum over the entire 4.2MHz band of interest to NTSC applications. (The spectrum of a linear FM chirp pulse is not flat.) This signal is preferred to the BTA GCR, because it provides more energy, permitting more reliable operation under noisier conditions.

Although the primary purpose of the GCR signal is for ghost cancelation, the resemblance between the GCR and a linear FM chirp offers another use. Broadcasters can use this pulse as a qualitative indicator of the frequency response of their system.

The receiver ghost-canceler system

Although the broadcasters' expense and time to transmit the GCR signal is low, such a signal is useless without receivers that are able to use it. The first generation of ghost-canceling hardware consists of professional cable head-end demodulators.

However, home TV receivers with built-in cancelers are more appealing to broadcasters. Many implementations are possible at the receiver for a ghost canceler, and most receiver manufacturers plan such features. Prototype receivers with these integrated ghost-cancelation capabilities should be displayed at the '93 NAB Convention. Current projections suggest they could be marketed as early as 1994. The added cost of the ghost canceler will be comparable to the price of the picture-in-picture (PIP) feature on current TV sets.

The most-critical parts of this system are the digital filter chip hardware and the software needed to characterize the echo channel and compute the filter coefficients. In principle, many off-the-shelf digital filter chips could perform the neces-

Ghost canceling: An executive summary

By Larry Harrington

Ghosts began to haunt TV sets with the first over-the-air transmissions. The suggested solutions have generally been expensive, ineffective or simply not available in the United States. That situation recently changed when a U.S. industry standard was selected. Implementations of ghost removal have already begun with cable television. Soon, this improvement will be available to non-cable viewers as well.

Why worry?

For many years, broadcasters had a callous attitude toward ghosting, particularly when complaints came from a cable TV subscriber. If the picture wasn't acceptable, the viewer was directed back to the cable company. For non-cable viewers, little could be done, except trying to explain how rabbit ears could be adjusted or an outdoor antenna rotated slightly. The only solution was to reduce the strength of secondary signals.

More recently, a greater interest has developed to provide viewers with the best possible pictures. Better pictures equate to more viewers, whether they receive the signals directly or through a cable distribution system. And more viewers equals more revenue.

Two problems have impeded solutions. First, the cost of digital processing circuitry to implement comparison and filtering algorithms was expensive. In addition, there was no standard reference signal upon which the signal could be based.

The introduction of digital technology into many areas of communications has had positive results. The most important one for ghost cancelation is the reduction in cost of the devices needed to detect ghosting and filter the detected impairments out of the signal.

With a U.S. ghost-cancelation standard now in place, solutions are at hand to reduce the picture impairment almost immediately for cable subscribers and, soon, non-cable viewers. For the broadcaster, the cost of ghost cancelation is relatively small — at worst, the station will need to purchase a new VITS inserter with a internal GCR generator. For some, the cost will be \$300 to \$500 for a modular chip set that can upgrade the existing VITS unit.

Sensing ghosts

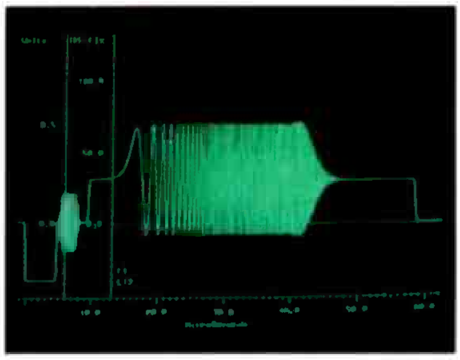
Ridding a signal of ghost impairments is relatively straightforward. The standard GCR signal inserted by the broadcaster experiences the same degrading influences as the video signal. A receiver module digitizes incoming video and compares a standard GCR reference signal within the module to the digitized input. The comparison produces a dynamic control for the filter that removes information from the picture consistent with the amount of delay experienced by the reference signal.

In a cable system, the operator will use a ghost-cancelation unit at the head-end

Harrington is manager, signal processing products, for Tektronix Television Products, Tektronix, Beaverton, OR.

to remove impairments resulting from multipath reception at the receive location. This will improve what is distributed to the subscribers, but it cannot remove any additional ghosting that occurs because of a viewer's location, relative to that of the broadcast station and the cable head-end reception point. The ideal solution is to integrate the cancelation circuitry into TV receivers, a move receiver manufacturers are already planning. Prototype receivers are expected to be shown at the 1993 NAB convention in April. Marketing of sets with GCR systems will likely begin during the first half of 1994. ❑

Courtesy of Tektronix



sary functions. In practice, only filter chips custom-developed for the application can fulfill the task requirements and economically meet the requirements of the commercial receiver market. With major set manufacturers now preparing such chips, it is hoped that by the 1994 estimated marketing date most broadcasters will already be transmitting the GCR signal.

➡ *For more information on ghost-canceling equipment, circle Reader Service Number 304.* ■

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The Philips Digital Compact Cassette (DCC)

The audiocassette goes digital.

By Mike Piehl

The Bottom Line

The compact cassette began as a mainstream consumer format, and eventually embraced high-end consumer and professional applications. Its inventor has released a digital upgrade for the format, once again starting out in the consumer marketplace. If history holds any symmetry, the Digital Compact Cassette (DCC) may end up in professional hands before long, as well.

Piehl is marketing director for Philips Consumer Electronics, Knoxville, TN.

The Digital Compact Cassette (DCC) is the digital successor to the analog cassette. It was introduced as a consumer product last November, and it was backed by all major record labels and blank media suppliers.

The introduction of DCC holds implications not only for the consumer market, but also for the broadcast industry. The advent of digital radio broadcasting and the current growth of alternate digital music delivery systems will increase the need for more flexible digital recording and playback devices in the broadcast environment.

From the earliest days of the compact disc's success 10 years ago, it was obvious that the analog compact cassette (now almost 30 years old) also would need to be replaced. The analog tape format simply could not match the wide dynamic range, enhanced frequency response and timing stability of digital recording, noise reduction notwithstanding. Compared to the near-indestructibility and long life of the CD, the compact cassette seemed flimsy and vulnerable, with its tape subject to a variety of physical ailments, such as stretching and breaking.

Philips, the inventor of the original analog compact cassette, concluded that its digital replacement would require the following attributes to become a successful consumer format:

- CD-quality audio;
- ability to accommodate analog cassettes from existing collections;
- new features made possible by digital technology;
- an improved cassette casing; and
- new packaging.

These were the design parameters that went into the development of the DCC. They resulted in a number of characteristics that clearly distinguish it from its predecessors. One such characteristic is its text mode display. Each player has a 12-character readout of album, track and artist information accompanying the CD- or DAT-like timing information, such as *absolute*, *track* and *remaining time* displays. The *track title* mode gives users direct access to specific cuts by title, rather than by referring to the cassette sleeve for a track number.

System basics

The DCC plays back and records up to 18-bit stereo digital audio. In addition, it supports sampling frequencies of 48kHz, 44.1kHz and 32kHz. To maximize storage efficiency, DCC recorders apply the Precision Adaptive Subband Coding (PASC) algorithm to the digital audio datastream before committing it to tape. This results in a data-encoding method that requires only a quarter of the bit rate used in the CD (16-bit linear PCM) format, without any loss of fidelity. Typical audio performance includes frequency response from 5Hz to 22,000Hz, dynamic range of 105dB, THD+N 95dB below reference level, and negligible wow and flutter.

The DCC uses a single, newly developed *thin film head* (TFH) with three sets of head elements: nine integrated recording heads (IRH) for digital recording, nine magneto-resistive heads (MRH) for digital playback and two MRH for analog playback. (See Figure 1.) Each head is divid-

ed into two sectors — one for working with new DCC tapes and the other for dealing with conventional cassettes.

The introduction of DCC holds implications for the consumer market and for the broadcast industry as well.

Sector 1 (digital) contains 18 integrated head gaps: nine IRH for write (each 185 microns high) and nine MRH for read (each 70 microns high). Eight heads in each set are used for audio data while the ninth handles control and auxiliary information. The smaller height of the playback heads minimizes their sensitivity to azimuth error. Meanwhile, sector 2 of the TFH is composed of two standard stereo analog playback gaps of the MRH variety.

The 384kbit/s audio data rate output by the PASC encoder is doubled by error-correction data to 768kbit/s, which in turn is spread across the eight parallel audio data tracks. Therefore, each track operates at 96kbit/s.

Auxiliary data includes the alphanumeric display information mentioned earlier plus numbered start-location and skip markers similar to the DAT format. As in DAT, start locations remain accessible during fastwind.

DCC tape characteristics

Analog and digital cassettes use the same tape speed of 4.76cm/s (1$^{7}/_{8}$ips). At the 96kbit/s/track write rate, a minimum recorded wavelength of 0.99 microns results. This allows the use of traditional chrome videotape, which is stronger and more durable than standard metal oxide audiotape and exhibits fewer dropouts. DCC tape, 12 microns thick and 3.78mm wide, has a special 3-4 micron coating of cobalt-doped ferroxide. A sample DCC tape that was played more than 1,000 times showed negligible signal loss, a significant improvement over its analog predecessor.

All DCC decks are autoreverse. Although the DCC tape is recorded bidirectionally, unlike its analog predecessor, it can only be loaded in the deck one way (it can't be turned over). Therefore, the DCC player's head physically inverts itself inside the deck at the end of a side. The format's auxiliary data also includes the provision for recording a reverse marker, which initiates autoreversing at any point on the tape during playback.

Analog cassettes use the bottom half of the tape for side A, while DCC tapes use the top half. The head configuration shown in Figure 1 is the side A positioning of the TFH. The deck determines whether an analog or digital tape is inserted from sensing holes on the cassette shell, and it therefore knows how to orient the head to play the desired side of the tape currently loaded. These sensing holes also indicate tape length and overwrite protection.

In addition, the DCC cassette shell has the same physical dimensions as the analog compact cassette, except that the DCC shell has uniform thickness, without the slightly thicker profile that an analog cassette has around the head/capstan area. The DCC shell also is built of tougher plastic than typical analog cassettes, to better protect the tape inside it and extend its operation over a wider range of temperatures. Furthermore, the shell has fewer moving parts, which makes it more shock-resistant and more reliable for a longer period of time relative to an analog cassette. Spindle holes are on one side of the DCC only (the bottom), with complete album graphics printed on the other (the top). This eliminates confusion over which way to load the cassette. The DCC tape is protected by a sliding metal door over the head opening, which is similar to the protective sliding gate on a 3.5-inch microfloppy diskette. When closed, this door locks down the tape hubs.

Another new feature in the DCC shell is its use of two azimuth locking pins (ALPs), as shown in Figure 2. In conjunction with the fixed azimuth tape guidance (FATG) mechanism fitted to the head assembly, the ALPs ensure improved head-to-tape contact and provide consistently repeatable alignment of the tracks on the tape with the heads.

A prerecorded DCC tape, showing bottom (in foreground) and top surfaces.

The ALPs increase the wrap angle of the tape around the head, laterally extending the tape-to-head contact area and stiffening the tape as it passes through this critical area. Meanwhile, the FATG mechanism acts as a set of two tape guides on either side of the head. The top edges of these guides are matched, square reference surfaces perpendicular to the top tape edge, while the bottom guide edges are sloped and gently force the tape up to the top guide surface without cupping it. The ALPs and FATG, combined with strict manufacturing tolerances and small play head gap height, virtually eliminate azimuth error.

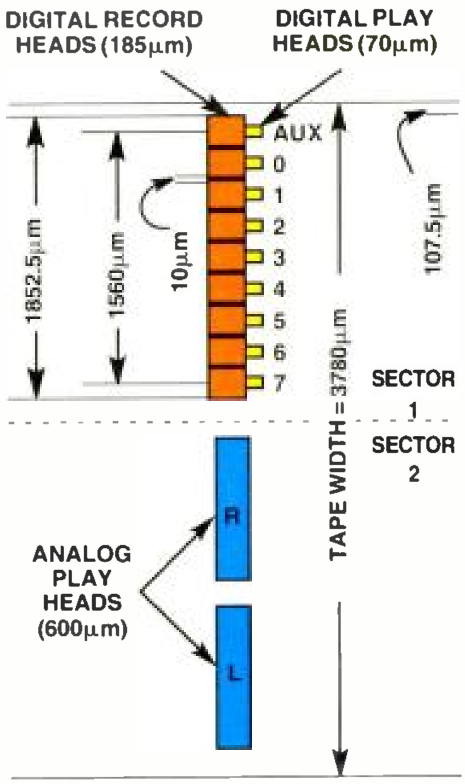


Figure 1. *DCC thin film head design and track format.*

The DCC cassette is packaged in a slide-on plastic sleeve rather than the easily breakable, hinged Norelco case used by most analog cassettes. The protection provided by the sliding metal door and the integration of album graphics on the tape label make a DCC self-contained. This outer sleeve can be discarded without damage to the cassette or loss of printed data.

Digital recording with a stationary head

The need for DCC player/recorders to playback analog compact cassettes required a few special elements in the development of the new system. In order to maintain compatibility with current compact cassette technology, a stationary head had to be used and a 4.76cm/second tape speed maintained. Furthermore, the number of tracks had to be small to allow for similar track and azimuth tolerance as compact cassettes. This placed fairly stringent limits on the total bit rate of the system. Because the system would use high-volume tape stock (videotape), the minimum recorded wavelength would be limited to approximately one micron.

The track title mode gives users access to cuts by title rather than by a track number.

Without the high writing speed normally associated with rotating head recorders, a new, streamlined encoding method was necessary to allow digital audio signals to be successfully recorded on a slow-speed, stationary head system.

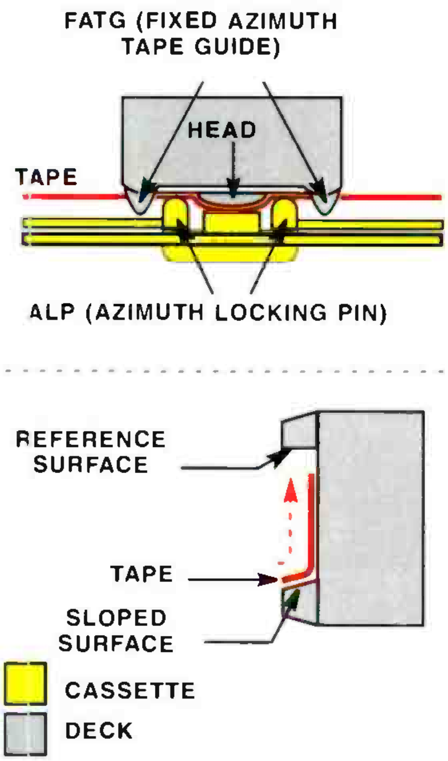


***Figure 2.** Tape-to-head engagement is optimized by DCC's unique tape guidance system, which incorporates elements in the cassette shell and the tape deck.*

This is where PASC comes into the picture. It is a perceptual coding system that exploits the insensitivities of human hearing through the use of psychoacoustic masking principles. PASC calculates masking thresholds by processing a 16- or 18-bit linear PCM signal through 32 subbands of equal width. Based on the signal levels in each subband, digital signals are adaptively re-encoded to achieve the highest possible coding accuracy over the entire frequency range.

During playback, the PASC-coded samples are reconverted into the PCM subband samples, and then the subbands are merged to form a broadband digital signal. Finally, digital-to-analog conversion is applied.

Although present DCC hardware offerings are of tabletop design, portable models will follow in the second half of this year. Prerecorded and blank media also are becoming available. Subsequently, professional applications of the format may arise as DCC is established as a reliable, high-quality, small-format digital recording system that also plays back analog cassettes in users' libraries. The DCC is expected to be a popular digital alternative for consumer use, and as the format grows, an important technology for the broadcast community.

➡ *For more information on DCC, circle Reader Service Number 302.* ■

The Sony MiniDisc (MD)

A new digital recording format combines random access and true portability.

By David H. Kawakami

The Bottom Line

The proliferation of portable CD players notwithstanding, the CD has not replaced the analog cassette as a truly carry-along medium. Facing a familiar dilemma, portability and random access once again seem mutually exclusive. The MiniDisc (MD) format is poised to break that tradition, with its high audio quality, random access storage, shock resistance and erasable recording media, all in a small-profile package. This set of attributes may find favor among consumers of today and broadcasters of tomorrow.

Kawakami is manager of MD promotion for Sony Corporation, Tokyo.

MiniDisc (MD) is a new disc-based digital audio recording format designed as an eventual replacement for the analog compact cassette. MD media include a conventional polycarbonate optical disc for prerecorded software and a recordable magneto-optical (MO) disc, both of which are housed in a protective cartridge.

Digital audio bit-rate reduction is used to achieve 74 minutes of playing time on a 64mm (2.5-inch) disc. A built-in buffer memory provides physical shock tolerance (to allow skip-free playback in portable situations), and the MO recorder has direct overwriting capability. The result is a high-quality, random access, recordable digital audio format suited to portable applications.

Prerecorded media

Playback-only MD media are similar to CDs in several ways. They can be manufactured on CD production equipment with minor modifications, using the same injection-molded polycarbonate plastic that is aluminized for reflectivity and coated for protection. Data in the form of physical pits in the disc substrate is read by a laser pickup positioned beneath the disc during playback. Therefore, a shutter opening in the protective shell is necessary only on the underside of the disc cartridge, freeing the entire top surface of the shell for displaying album artwork. Because the media does not allow recording, accidental erasure of program material is impossible.

The information layout of a prerecorded MD is identical to a CD. The lead-in area that contains the disc's table of contents (TOC) is on the inner circumference. This is followed by the actual program area. For MD, program information is stored in rate-reduced (or compressed) digital data form. Finally, the lead-out area is on the outer circumference. Like a CD, address information is found throughout the disc at 13.3ms intervals, allowing high-speed random access.

Recordable MDs

Although built upon the same polycarbonate base as prerecorded MDs, recordable MDs exhibit functional and physical differences from their playback-only counterparts. Recordable MDs use magneto-optical (MO) technology (see "Optical Disc Video Recording," February 1992) and are formatted with pre-grooves covering the entire recording area. These grooves are used for tracking and spindle servo control during recording and playback. They are "wobbled" at 13.3ms intervals to provide addresses for high-speed random access data.

The recordable MD's lead-in area is identical to prerecorded MDs, using physical pits created in the manufacturing process. This is followed by the recordable user table of contents (UTOC) area, where start and stop addresses for tracks are recorded. Next comes the recordable program area, followed by the lead-out area.

Recordable discs are housed in cartridges identical to prerecorded MDs except that shutter openings are provided on both sides, allowing simultaneous exposure to a laser below and a magnetic recording head above the disc.

A final unique attribute of both MD types is the use of a magnetic clamping

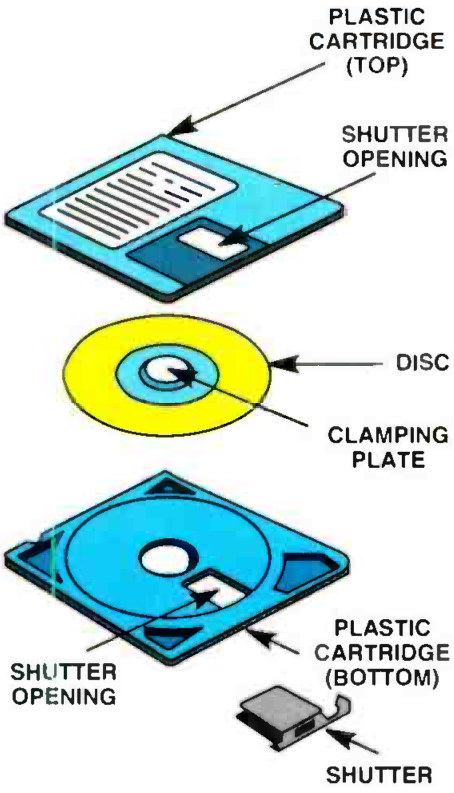


Figure 1. *An exploded view of recordable MD. Prerecorded discs omit upper shutter opening.*

plate that is ultrasonically welded to the disc substrate at the center opening. Unlike CDs, which are clamped from both sides during playback, MDs achieve stable rotation through magnetic contact from one side only, eliminating the need for center openings on both sides of the cartridge. Like CDs, the inner circumference of the disc substrate is used as the reference for centering. (See Figure 1.)

ATRAC data reduction

MDs are smaller than CDs for purposes of enhanced portability. The MD's diameter of approximately 2.5 inches (64mm) gives MDs a data capacity of only one-fifth that of a CD. If audio data was stored on the MD in the CD's 16-bit linear PCM style, playing time would be only about 15 minutes. However, the *Adaptive Transform Acoustic Coding* (ATRAC) algorithm provides a 5:1 bit-rate reduction encoding, allowing the MD to hold 74 minutes of digital stereo.

Unlike other rate-reduction systems that split audio data into frequency bands of uniform width, ATRAC uses non-uniform subbands in the frequency and time axes, based on psychoacoustic principles. Coding efficiency is increased with almost no degradation in sound quality. Data is then encoded with conventional eight-to-14 modulation (EFM) and an advanced cross-interleave Reed-Solomon code (ACIRC) error correction, and finally recorded onto the disc.

MO recording with direct overwriting

In conventional MO systems, previously recorded signals must be erased before new data is recorded. Two different rewriting methods have been in use. In the first, two lasers are used, one for erasing and one for recording. Approximately one-half disc rotation after the signal is erased with the first laser, the second laser records the new signal. The other approach uses a single laser for erasing and recording, but in two separate steps.

The first method is costly because two lasers are required. The second method is time-consuming and requires a complex servo mechanism. The MD uses a new magnetic-field modulation (MMO) system, which allows "overwriting" of new signals over old in a single operation. The system gets its name because, unlike previous systems, it modulates the magnetic field at high speed, creating specific magnetic orientations to represent the input signal.

Because the size of the magnetic signals recorded on the MO disc is controlled by magnetic flux reversal rather than by turning the laser on and off as in conventional systems, highly accurate recording is possible even for short wavelengths. Such recording was previously difficult because of thermal diffusion of the laser spot. Furthermore, because MMO allows the laser to be kept on continuously during record and playback, a simplified optical head can be employed, contributing to lighter and more-compact MD hardware.

MMO is made possible by the development of a highly stable magnetic disc layer that changes polarity with a coercivity approximately one-third of that required for conventional MO media, allowing the use of smaller, power-conserving magnetic heads capable of performing polarity reversals in about 100ns. Low power consumption prevents overheating inside the hardware and makes battery-powered portable designs practical.

Dual-function optical pickup

The optical pickup developed for the MD can read MO and prerecorded (stamped) optical discs. For prerecorded discs, the pickup operates just as a CD pickup does, sensing the intensity of reflected laser light (which changes according to the presence or absence of pits in the disc's reflective layer). To accommodate recordable MO discs, two photodiodes and a polarized beam analyzer were added. The latter detects differences in polarized light's direction of rotation.

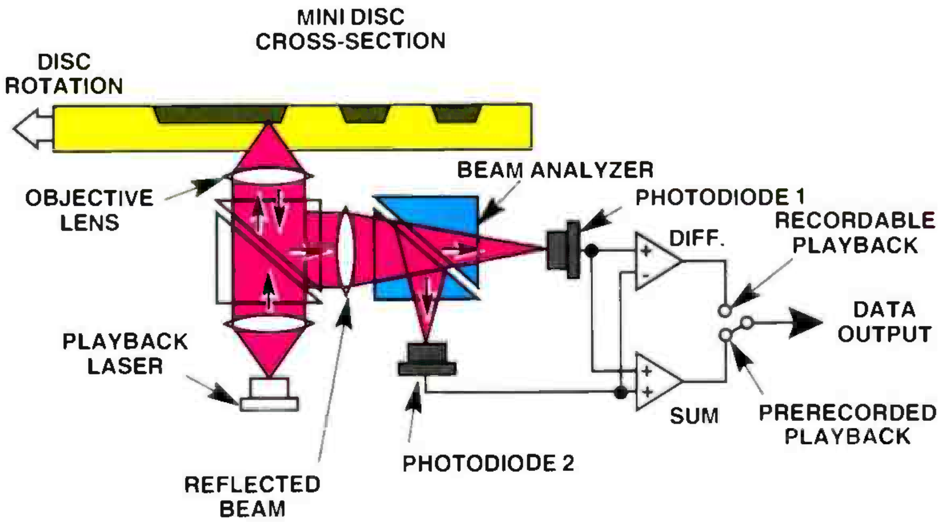


Figure 2. The MD playback mechanism. The laser illuminates the disc, and the reflected beam is sent to the analyzer. For recordable media, the analyzer sends polarity-rotated reflections to one or the other photodiode, depending on the rotation direction. Photodiode difference signal produces data output. For prerecorded media, reflections from unpitted sections pass through both photodiodes at equal levels, and the sum signal provides data output.

MO playback is based on the Kerr effect, which states that the magnetic polarity of a reflecting surface will slightly influence the rotation of the polarization plane for light reflected from it. During playback, the MD system illuminates the MO recording layer with a 0.5mW laser. The beam analyzer sends the reflected beam to one of the two photodiodes, depending on polarization direction. (See Figure 2.) The difference in electrical output of the two photodiodes is calculated, and depending on whether the difference is positive or negative, a "1" or "0" signal is read.

The same 0.5mW laser is used for playback of prerecorded MDs. The amount of light reflected depends on whether a pit exists in the disc's reflective layer. If no pit exists, a high proportion of light is reflected back through the beam analyzer to both photodiodes. If a pit does exist, some of the light is diffused by the disc, and less light reaches the photodiodes. The electrical signals from the photodiodes are summed in this case, and depending on the sum's level, a "1" or "0" is read.

Shock-resistant buffer memory

Conventional optical pickup systems can easily mistrack when subjected to shock or vibration. For CDs, this causes skipping or muting, which manufacturers have attempted to minimize by using mechanical suspensions and servo systems. The MD uses a buffer memory to solve this problem.

Although the MD pickup can read information at 1.4Mbit/s, the ATRAC decoder requires only 0.3Mbit/s for real time playback. This difference in processing speed allows the use of a read-ahead buffer, which is placed between the pickup and the decoder. If a 1Mbit memory chip is used for the buffer, it can store up to three seconds of digital information. If the pickup is jarred out of position, the correct information continues to be supplied to the ATRAC decoder from the buffer memory. As long as the pickup re-finds its place within three seconds, the listener will not experience mistracking or muting. As soon as the laser resumes its original position, it will read data from the disc at the 1.4Mbit rate and replenish the data in memory in less than a second. Because of address information found throughout prerecorded and recordable MDs at 13.3ms intervals, the laser usually can reposition itself within one second.

Because data enters the buffer memory faster than it leaves, the buffer eventually will become full. At that point, the MD pickup stops reading information from the disc and waits until there is room in the memory chip again. This differs from CD playback, in which a constant 1.4Mbit/s data rate is used.

Conclusion

MDs developers view the format as the eventual replacement for the analog cassette and expect the format to coexist with CD, as the LP and analog cassette did for many years. Just as the CD has now eclipsed the LP, soon the MD may better serve the needs now met by analog cassettes.

MD offers many of CD's advantages — high-quality digital audio reproduction, resistance to wear and fast random access — but it also is uniquely adapted to the needs of portable personal audio. Some of these same advantages may be applied to professional applications in the future.

➡ *For more information on the MiniDisc, circle Reader Service Number 303.* ■

News
Continued from page 4

NAB announces Engineering Achievement awards

The National Association of Broadcasters (NAB) will honor three individuals with Engineering Achievement awards April 21 at its annual convention April 18-22 in Las Vegas.

The NAB selects winners on the basis of a single significant contribution or contributions made over a period of time that have measurably advanced the state-of-the-art of broadcast engineering.

Herbert Schubarth, vice president, engineering, Gannett Broadcasting, is being honored for a 43-year career that helped nurture and shape the TV broadcast industry. Schubarth's development of Gannett TV plant facilities in Washington and Denver has become a model for the TV industry.

Robert Silliman, a consulting engineer and founder of Silliman & Silliman, Silver Spring, MD, is being recognized for his 55 years in radio engineering and his contributions to AM and FM antenna designs.

Stanley Baron, managing director, technical development, NBC, is being honored for his contributions to digital TV systems for more than 30 years. Baron has also made important contributions in the areas of video graphics and video signal processing.

Compatibility between broadcasting and aeronautical services

For some time, the problem of interference between FM broadcasting stations and aeronautical radio systems has been considered. At a September meeting of Task Group 12-1 of ITU's International Radio Consultative Committee (CCIR), 36 international experts drafted a recommendation entitled "Compatibility Between the Sound Broadcasting Service in the Band of About 87-108MHz and the Aeronautical Services in the Band 108-137MHz." This will allow countries to assure compatibility between the broadcasting and aeronautical services that use the radio frequency spectrum in the vicinity of 108MHz.

Telco plan doesn't meet video dial tone requirements

The National Association of Broadcasters (NAB) feels the Federal Communications Commission (FCC) should reject a telephone company proposal to provide video service in Ocean County, NJ.

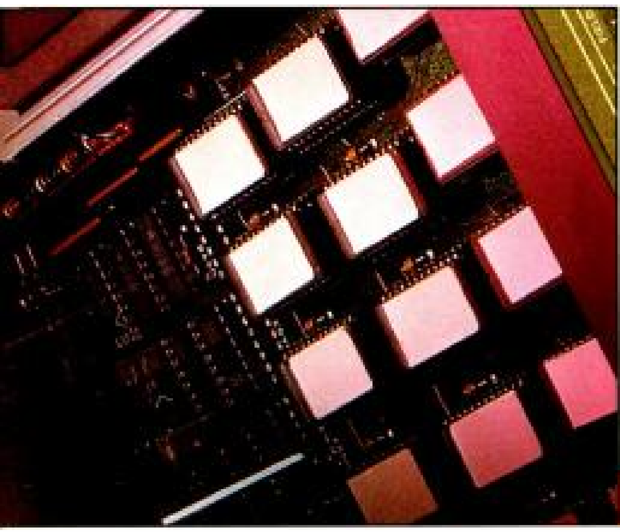
NAB told regulators that the video service does not meet the FCC's requirements for video dial tone, which requires that channel access be granted to all programmers, such as radio and TV broadcasters.

At issue is New Jersey Bell's application to build a 64-channel video system, which would compete with existing cable service in the area and may be expanded to several hundred channels in the future.

Sixty channels would be leased to a newly formed company, FutureVision of America Corporation, with the remaining channels available to other programmers.

NAB favors competition to cable systems, but urged the commission to refrain from placing the video dial tone label on a system that does not have a common carrier tier from the outset. In addition, NAB noted that only four of the 64 channels could potentially be used for common carriage.

Whether a system can be classified as video dial tone is important, because only video dial tone systems have been exempted from local franchising rules that apply to local cable operators and others. ■



New audio recording formats

"Orange-Book II" CD recorders and the NT tape format may find favor at broadcast facilities.

By Skip Pizzi, technical editor

The Bottom Line

Keeping up with the seemingly endless stream of new format introductions is no simple task. Complicating matters is a growing trend toward "backdoor" development of professional systems from products initially designed for consumers' (or another industry's) use. This means that broadcasters have to stay abreast of a wide range of technologies and markets, and actively seek out the most appropriate systems. This article presents two emerging technologies that could increase quality, productivity and cost-effectiveness for some broadcast operations.

As the second generation of digital audio systems matures, several new recording formats have been spawned. Two major tributaries are now established: *linear* (or tape-based) and *non-linear* (or disc-based). This article considers a significant new development with potential broadcast application in each of those two streams: the *NT* (Non-Tracking) tape format and the *recordable compact disc.*

NT technology

The NT format was developed by Sony primarily to replace the analog microcassette. Therefore, it is marketed as a consumer product, but may soon find significant professional applications.

NT uses 32kHz sampling and 12-bit non-linear coding to provide 15kHz stereo audio with 86dB dynamic range, making it adequate for many broadcast-quality voice and non-critical music recordings in the field. As with all digital recording formats, wow-and-flutter is negligibly low. The system uses a tape cassette approximately the size of a postage stamp — 1.25 × 0.82 × 0.19 inches (30 × 5 × 21.5mm) — to record up to two hours of audio. The tape is 2-sided, allowing uninterrupted recordings of up to one hour per side. (Currently, only 60- and 90-minute tapes are available, with 120-minute tapes expected in April 1993.)

The power efficiency of the system is valuable to field recording applications. The only NT recorder produced so far (Sony NT-1) carries a claimed battery life of seven continuous hours (recording) on a single AA battery. The unit is priced under $1,000, with tape costs in the $8/10-hour range.

The NT format is also non-loading. Although a helical-scan head design is used, the tape is not unloaded from the cassette by the recorder. Rather, a hinged door on the cassette is opened when the tape is loaded, and the head drum penetrates into the cassette, similar to analog audiocassette operation. (See Figure 1.) This approach provides simpler and more reliable tape handling, smaller size and weight, and the ability to load and unload the tape when the deck is off. Tape guides and pressure rollers are built into the cassette shell. A small rotary head and capstan are the only external elements that are engaged into the cassette for operation.

What non-tracking means

The format's name refers to a radical departure from the tracking approach used in traditional rotary-head systems. Although a specialized head drum, an ultra-thin metal-evaporated tape formulation and a low-deviation modulation scheme all help the system achieve its high recording density, the toughest challenge faced by designers of such a small rotary-head format is accurate tracking of tiny recorded tracks during playback, especially given the variations in tape-to-head contact inherent in the non-loading design. The non-tracking approach eliminates the need for traditional tracking servo control, fixed control heads and automatic track-finding (ATF) circuits and data, thereby reducing size and complexity. Its basic operation is fairly simple. (See Figure 2.)

Head gaps are placed on the drum with opposing azimuth to each other. Tracks are therefore recorded with alternating azimuth, as in other recent helical-scan formats. In the NT format, heads on the drum are switched such that during recording, a single write scan is made per revolution, while *two* read-scans are made per revolution during playback. This means that playback scanning will overlap multiple recorded scans, as shown in Figure 2. (NT head rotation speed is 3,000rpm while linear tape speed is 0.25ips [6.35mm/s.])

The NT recorder carries a battery life of seven continuous hours on a single AA battery.

An NT format recorder and cassette.

After several consecutive playback passes, all the data in a recorded track of matching azimuth will have been read. However, it will be in scrambled order and interspersed with data from other neighboring tracks. Data from each of the two playback heads (one of each azimuth orientation) is sent to a buffer, where it is recompiled into the proper order based on address data embedded in the recorded signals. This allows playback tracking to be rather freewheeling relative to the recorded tracks, and still recover data adequately. Error blocks from tracks of opposite azimuth appear between good blocks of data, keeping each head's good blocks separate in the buffer.

NT's 12-bit non-linear PCM data format uses smaller amplitude step sizes (quantization levels) at lower audio levels and larger steps at higher audio levels, in contrast to linear PCM systems, where all step sizes are identical. Audible performance approximates a 17-bit linear system's dy-

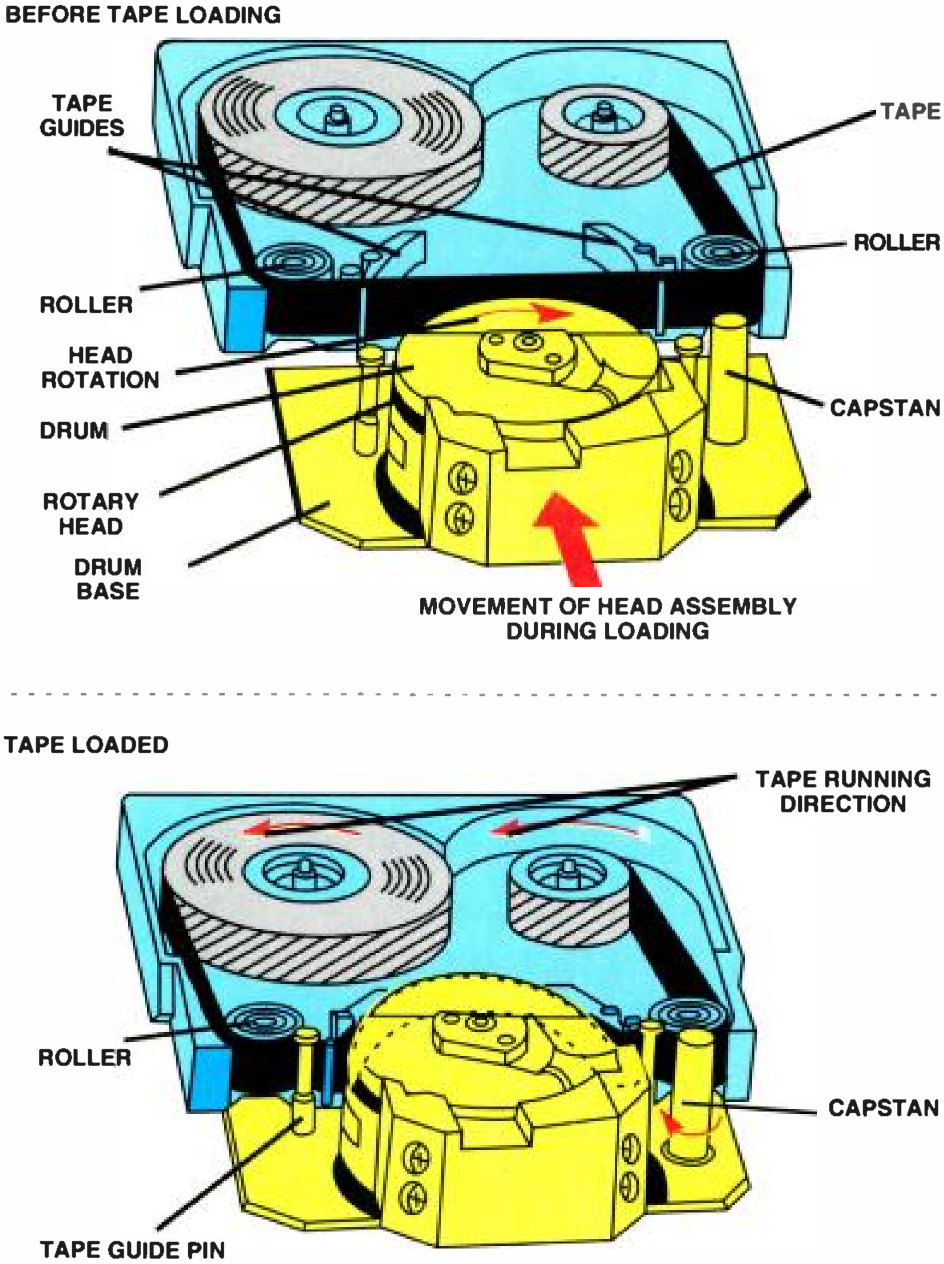


Figure 1. *Tape-to-head interface in the NT format. A hinged gate on the cassette covers the tape when it is removed from the deck.*

namic range, but with far less data output. This, coupled with 32kHz fixed sampling, creates a conversion architecture of inherently low data rate (approximately half that of the CD format). No perceptually coded bit-rate reduction algorithm is used in NT.

Other innovative features of the system include use of flexible circuit boards (allowing surface-mounted connectors and further miniaturization), digital AGC (switchable in/out), LCD tape counter/time-remaining display, time and date stamping of recordings, and a variety of powering options.

Recordable CD systems

Write-once compact discs (CD-WO) have been around for a while, but recent changes have made the format more appropriate for broadcast use.

One continuing adjustment is price. Recorder costs initially approached $20,000, but some units are now available for less than $10,000. Blank media costs are currently around $40, available in 63- or 74-minute lengths. This is still somewhat expensive for many station applications, but because a CD-WO disc is playable on any standard CD player, there are a few areas where the system makes economic sense. Among these are network or station-group distribution of custom recordings, long running spot or theme packages, announcer tracks for automation, custom sound effect drop-ins and program demos.

Another recent modification is the release of an updated standard for the CD-WO format, as detailed in the standards document known as *Orange Book, Part II.* The original Orange Book mandated that once a CD-WO recording began, it could not be paused or stopped and restarted. The new standard allows recorders to pause or even stop, unload and restart later (perhaps on another recorder), making the format more friendly to the sequential assembly process typical in broadcast applications.

No perceptually coded bit-rate reduction algorithm is used in NT.

The write-once nature of the CD-WO still sets some limits, however. First of all, once audio is recorded, it cannot be erased. Even false starts are there for good. Thus, many users first assemble to DAT, and then digitally transfer to CD-WO.

The TOC problem

Another issue involves the table of contents (TOC) file. In order for a CD to be playable on a standard CD player (governed by the so-called *Red Book* standard), a TOC file must be placed at the start of the disc. Like a computer disk's directory, the CD's TOC tells the CD player where each cut starts and ends, and provides other identifying data. Without a TOC, a CD-WO is not playable on a standard CD player. Naturally, the necessary TOC timing/location data for a CD-WO is only known after the audio programming is recorded on the disc. Because this TOC data is written to disc after such audio assembly, the process is called *post-TOC.*

Recent changes have made CD-WO more appropriate for broadcast use.

Once a post-TOC has been written, any additional audio recorded on the disc will *not* be playable on standard CD players.

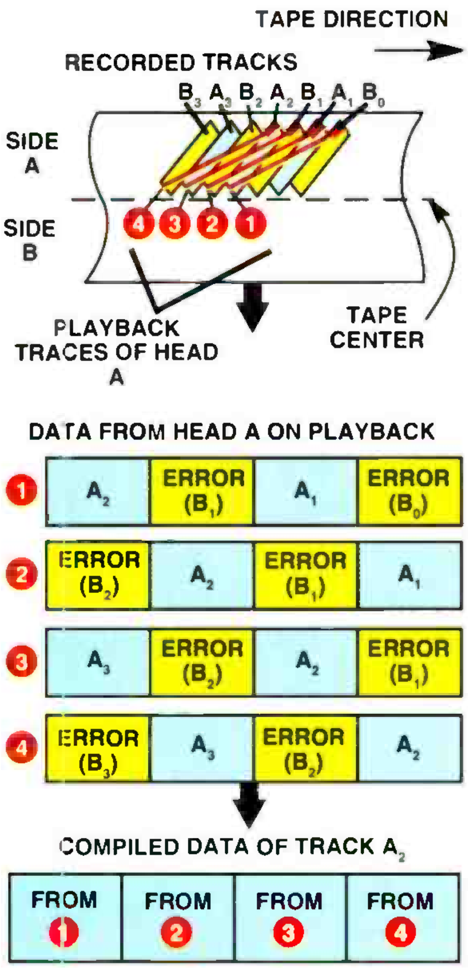


Figure 2. *Track format and playback head tracing of the NT format, showing a typical resulting datastream and track reassembly. A and B refer to opposing azimuths of head pairs.*

This is because the format's write-once nature does not allow the TOC to be replaced or updated. Only a CD recorder (Orange Book II) can play non-TOC-listed audio or a CD without a TOC.

One manufacturer addresses this issue by offering the option of preformatting the CD-WO disc with 10-, 30- or 60-second tracks. Under this so-called *pre-TOC* approach, audio program data is written in the first available track, and writing continues in uninterrupted fashion across track boundaries until the recorder is stopped. When restarted, the recorder finds the start of the next unrecorded track and continues. The user simply notates the disc's cue sheet with the appropriate preformatted track numbers rather than simple sequential cut numbers. For example, cut 1 of the audio program will start at track 1 on the disc, but cut 2 of the program may begin at track 7 on the disc. In this case, if track 2 were selected for playback, the CD player would simply pick up cut 1 in progress.

This approach not only allows a CD-WO disc to be sequentially assembled and added to over time, but also keeps all of its contents playable on standard CD players at any time.

CD-WO recorder costs initially approached $20,000, but some units are now available for less than $10,000.

A disadvantage of the pre-TOC method is a reduction of useful capacity of the disc when 10- or 30-second track lengths are used. Because the CD Red Book standard allows for a maximum of 99 tracks per disc, 10-second pre-TOC formatting limits CD-WO recording time to only 16.5 minutes (99 × 10 ÷ 60), and a 30-second pre-TOC provides only 49.5 minutes. The recently added option of a 60-second pre-TOC eliminates this difficulty, but limits the track capacity of a disc to 63 or 74 tracks, depending on the media used.

The CD-WO and NT formats are two recent developments in the evolving digital audio marketplace. Broadcasters should examine each new system they encounter for potential application in their facilities. Some systems will be accepted and some rejected, but without exploration, progress toward improved broadcast service quality and profitability cannot occur.

➡ *For more information on the NT format, circle Reader Service Number 305.*

➡ *For more information on CD-WO, circle Reader Service Number 307.* ■

Courtesy of Enco Systems

Digital audio storage systems

Disk-based recording plays an increasing role in radio.

By Curtis Chan

The Bottom Line

Pressure to make radio operations faster, better, cheaper and easier has never been more prevalent. Many new systems have been introduced to serve these ends at the radio station. A common element among many is storage on random access magnetic media. This technology's speed, quality and cost-effectiveness make it ideal for the job. When it is married to sensible software and reliable system design, worthwhile new products can result. $

Chan is the principal of Chan & Associates, Fullerton, CA.

Digital audio storage systems come in many forms, but perhaps the most interesting to radio broadcasters today are those that incorporate magnetic disk recording. (For other new digital audio storage formats, see "The Philips Digital Compact Cassette (DCC)," "The Sony MiniDisc (MD)" and "New Audio Recording Formats" features in this issue.) The reliability, low cost and fast access of these systems make them appropriate to consider for cart replacement and production workstations at the radio station.

Current hardware offerings in this area can be split into four categories:

1. The simple cart replacement unit. This is a stand-alone unit that uses some sort of removable medium (microfloppy, floptical or Bernoulli disk) in place of a cart. The unit usually has a few simple buttons and functions, and several machines can often be stacked. Typical costs are approximately $2,500-$5,000.

2. The more sophisticated cart replacement system. This unit generally doesn't use removable media, and has a screen interface that allows for simple editing and playlisting. Typical costs are approximately $7,500-$10,000.

3. The station automation system. This system is usually PC-based and typically provides basic editing, prescheduled playlisting (with interface to traffic software), remote automation via satellite and networking with other units. Large-capacity hard disk drives are used for audio storage, although machine control for other playback hardware also may be available. Typical costs are $17,500-$20,000.

4. Low-end and mid-range workstations. These systems can be found in stereo or multitrack varieties. They usually have a dedicated or PC-screen control interface, along with enhanced editing features, automated mixing and advanced playlisting. Audio processing also may be included. Typical costs are $10,000-$35,000.

Most digital cart decks offer an LCD or fluorescent screen for titling, timing and editing display.

Simple cart replacement

Many different and incompatible systems are available in this category. (See "Replacing the Analog Cart Machine," July 1992.) However, they all share similar features and performance specifications. Most emulate a standard cart in appearance and operation, but some offer sophisticated editing features and playlist capabilities. Most use (or offer use of) a perceptually coded bit-rate reduction algorithm to increase storage capacity.

These devices typically support sampling rates of 48kHz, 44.1kHz, 32kHz and 22.05kHz. Capacities range from a few

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minutes to more than 10 hours per disk, depending on the system, media and sampling rate selected. Mono typically doubles capacity over stereo, and if bit-rate reduction is optional, using it can increase storage as much as sixfold.

Not many workstation systems are absolutely appropriate to radio production.

Because the cart replacement device must interface to the real world broadcast studio, most systems include one or more control interfaces, such as RS-232, RS-422, a parallel automation port or simple start/stop/record inputs for fader starts. Some systems include options for inboard or outboard hard drive interface.

Many of these units allow non-destructive editing for trimming heads and tails of audio cuts, or adding fades and other level adjustments. Unlike their analog counterparts, most digital cart decks offer digital inputs and outputs (typically AES/EBU), and an LCD or fluorescent screen for titling, timing and editing display.

Sophisticated cart replacement

The more advanced cart replacement systems distinguish themselves by having some sort of key-entry and screen display that allows for simple editing and playlisting. These systems can often support more than two channels of audio and have flexible recording times, with or without bit-rate reduction. Most use internal hard drives, although systems using removable magneto-optical storage are available.

Remote-control devices for use by board operators at the mixing console may allow access to some functions, while more-advanced features may only be available at the master keyboard/display. Some systems use proprietary platforms, while others work on common PC platforms. Some event-list editing is usually offered, and direct console interface (audio and control) may also be included. In addition, networking of multiple systems may be possible for systems at this level.

Station automation systems

The next category of systems are generally PC-based and more comprehensive in their design. In many cases, the entire audio operation of the station can be controlled from such a platform. These systems can interface to traffic software and satellite-delivered program streams, and multiple stations can be networked.

Simultaneous control of multiple-channel playback and time-shift recording also can be handled by some systems, making them ideal for the multicasting model of the future. Crossfading, audio scrubbing, varispeed and touch-screen control are other features found on various systems.

Workstations for radio

Although the digital audio workstation market is maturing, not many systems are absolutely appropriate to radio production. Nevertheless, a few systems are ideal or easily adaptable for many radio production needs.

This area can be broken down into three distinct categories. First, plug-in cards for PCs offer on-screen editing of stereo audio, and some have compatibility to third-party sequencers or sequencer software packages. The next level involves a custom hardware unit with a PC interface. These systems, although low in price, share some common features with their higher-priced brethren. Expect to find such features as RAM editing, sampling and sequencing, wave shaping, MIDI/SMPTE automation and DSP functions. Some mixing may be offered, and control/display is virtual (i.e., on-screen). The top category includes custom-built units with integrated DSP functions, automated mixdown, multitrack capability and dedicated hard control surfaces (instead of or in addition to virtual control) emulating mixers and tape transport controls.

User interface should be operationally intuitive.

All three categories have broad application, and may find use in sound effects design, basic recording and editing, dialogue editing and conforming, ADR/Foley, and CD premastering, spotting and synchronization.

Radio's requirements

The professional radio marketplace has become inundated with magnetic-disk recorders. A station's choices in this area should be based on an assessment of the following attributes.

- The user interface should be operationally intuitive. Many current systems, especially some that are fully virtual, are cumbersome and slow. They don't take into account the speed at which professionals must get their work done. An intelligent combination of familiar hard control surfaces and good software design seems to be the best solution.
- Terminology and software design should be radio-specific and familiar.
- The user must be able to learn the system quickly and efficiently. On-line help and training must be included. New tools should simplify work.

A combination of hard control surfaces and good software design seems to be the best solution.

- Consider how truly expandable the system is. This includes an assessment of software updates, hardware capacity and ease of future interface to other systems.
- A related concern is future ability to further integrate the facility. How will any new purchase figure into that goal?
- Similarly, is the system likely to be surpassed, outmoded or become obsolete anytime soon? Modular design can help avoid this problem.
- Removable media can help eliminate the upload/download delay, and simplify backup and restore processes. This also can accommodate the common need in radio for multiple sequential users in the production studios.
- Successful systems may attract third-party software development, expanding the palette of possibilities for the user.
- Consider the *value* of the system, not only in price vs. performance relative to other comparables, but also in terms of productivity increases and workplace efficiencies that the system will engender. Within the overall context of station operations, if a device doesn't pay for itself fairly quickly, it may not be worth the investment — especially if the equipment it's supposed to replace has some useful life.

Magnetic disk recording lies at the heart of many new technologies applicable to radio broadcasting, today and in the future. Further exploration of several specific areas mentioned here (newsroom, production studio, automation) will appear in upcoming installments of the *Radio in Transition* series.

➡ *For more information on digital audio storage systems for radio, circle Reader Service Number 306.* ■

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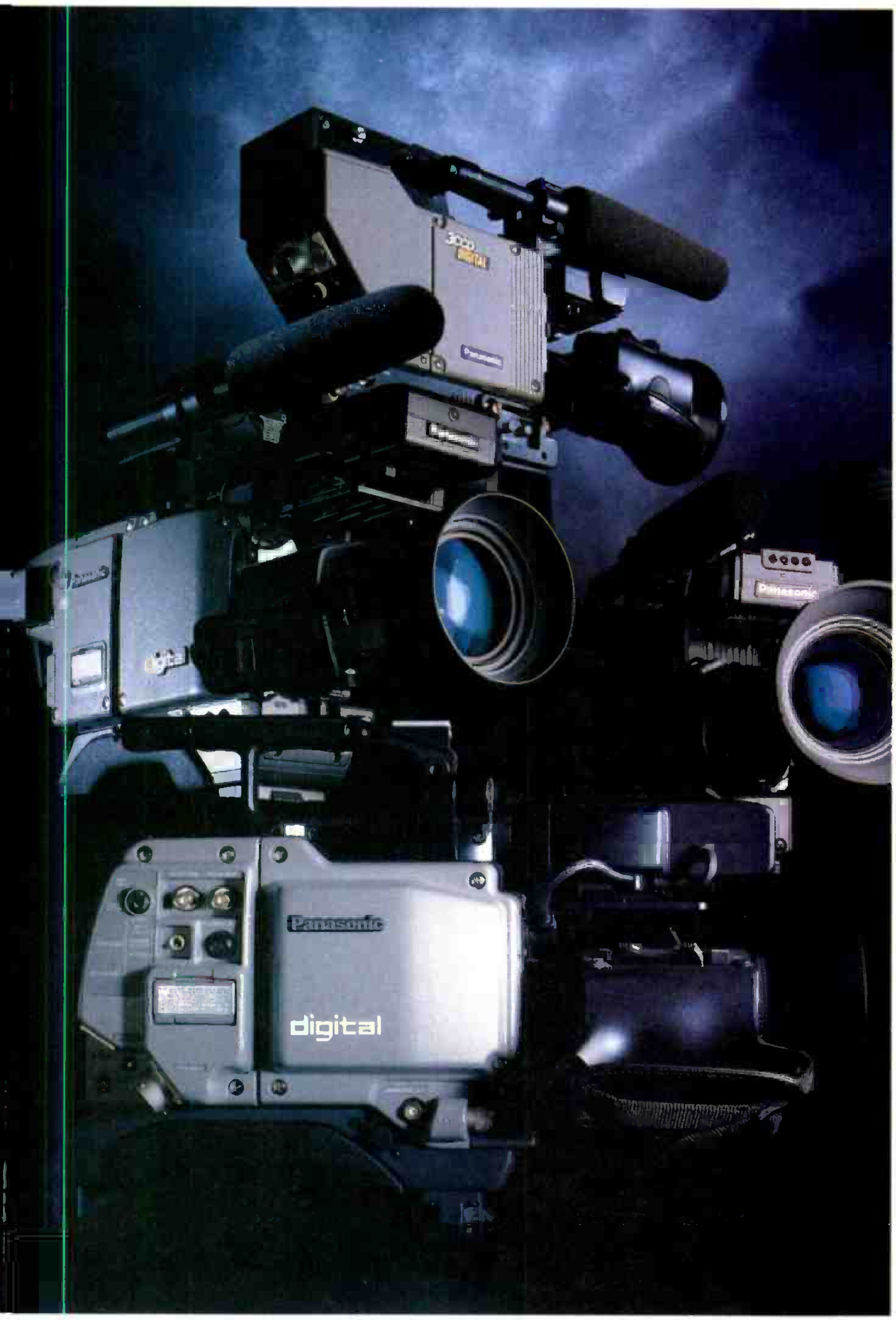

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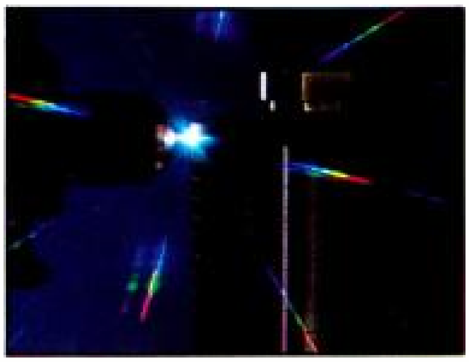


Ampex DCT 700d tape drive

Easy to maintain

By Michael Arbuthnot

In 1992, Ampex unveiled its DCT product line, an integrated production system, to the broadcast and post-production community. Among the advantages of this system is that all signal processing occurs in the component digital domain.

Another important part of the package is a new videotape format using digital video component recording. In addition to the concepts used in the tape format, other factors contribute to the criteria behind the product design. One such aspect of the system is its overall serviceability and maintainability.

Ampex has always taken pride in the serviceability of its products. However, with the advent of Application Specific Integrated Circuit (ASIC) technology, coupled with advances in head and transport design, the need for constant service has been minimized in favor of maintainability. This newfound philosophy allows end-users to maintain their own systems with a significant decrease in service time. The philosophy also has made the DCT 700d drive easy to maintain and service.

Thinking small

The first step toward maintainability was to reduce the system's board (hence, component) count. The entire signal system is contained in five boards. Through a layered architecture, all audio circuitry is included on one board. Similarly, the other boards account for the video, ECC, DCT, and equalizer functions. Two other boards contain the main CPU, AST servo and servo MDA functions. Not only does this result in significant reductions in real estate, but also power, weight, electrical anomalies and performance lag. The DCT tape drive uses more than 100 ASICs to accomplish this goal. As a result, the entire drive draws only 465W of power.

To guide the user through the system, the control panel includes many E-to-E looping paths. It is easy to follow the video coming in as it goes from board to board and to the scanner. Playback signal paths are similarly documented for easy reference. If the signal paths through the machine should fail, closing the loop on the first board quickly indicates whether that board is working. A systematic check of the following board determines where the signal stops. At that point, a request to the Ampex service department for assistance or a replacement card can be made with assurance that the problem is at hand.

Arbuthnot is new product development manager for Ampex, Redwood City, CA.

A rugged transport

In part, the reliability of a video recorder depends on the basic construction of the unit. The frame of the DCT 700d transport consists of an aluminum sandcast structure. This leads to a rigid base that permits the transport assembly to be rotated 90° to the service position while the machine is in operation. Full access to the top and bottom as well as all mechanical components is provided.

The first step toward maintainability was to reduce the system's board (hence, component) count.

Another critical element is the air filtration system, which supplies a lubricating air film to all of the guides. This filter, which lasts 2,000 to 3,000 hours, includes a differential meter that provides a replacement indication — a simple but effective step in approaching modern-day maintainability of equipment.

The tape path

The DCT drive draws upon established, proven technologies from other Ampex products. For example, the pinch rollerless, direct capstan control system has served well on transports for the quad, Type C and D-2 formats. The pinch rollerless system includes a closed-loop servo system that links the reel servos back to the capstan. In contrast, most tape transports use torque transports. To rewind, the supply motor runs with high torque and pulls the tape off of the take-up reel.

Because the tape follows a complex path, tension applied to the tape is increased by each of the bends or changes of direction. The resulting tension significantly reduces head life. A comparison of head lives for different transports reveals some surprising facts. Typical head life for Type C machines is approximately 1,500 to 2,000 hours. Head life on a closed-loop servo VTR (VPR-3) is 7,000 to 8,000 hours. With a closed-loop system, there are never any tension changes around those areas. This same type of pinch rollerless technology is used in the DCT 700d transport.

Air guides

Another feature borrowed from previous designs is gas film technology. The concept is simple and elegant, and is aimed at reducing the friction between tape and guide. This is accomplished by providing an air bearing between the two surfaces. Air is injected into the center of every guide that the tape passes. Holes drilled with a laser disperse the air so that the tape actually rides over a film of air.

This layer of air creates an almost frictionless transport. When combined with direct capstan control, it results in the capability to go from stop to full 60X play speed in one second. In the edit suite, recuing a 30-second spot takes 1.5 seconds. No time is wasted waiting for the tape transport to cue and lock. Editors can control the machine with a 30-frame preroll, resulting in an extremely responsive transport.

AST heads

Another feature of the DCT drive arose from present limitations in the piezoelectric head assemblies used in slow-motion analog VTRs. In a typical analog VTR, a piezoelectric crystal mounted onto a head causes the head assembly to move up and down as 200V are applied. With Type C, an expansive 130μm track width makes slow motion relatively easy because of the large landing zone. In digital recorders, to transverse three track widths for 525-line signals (four track widths for 625-line sig-

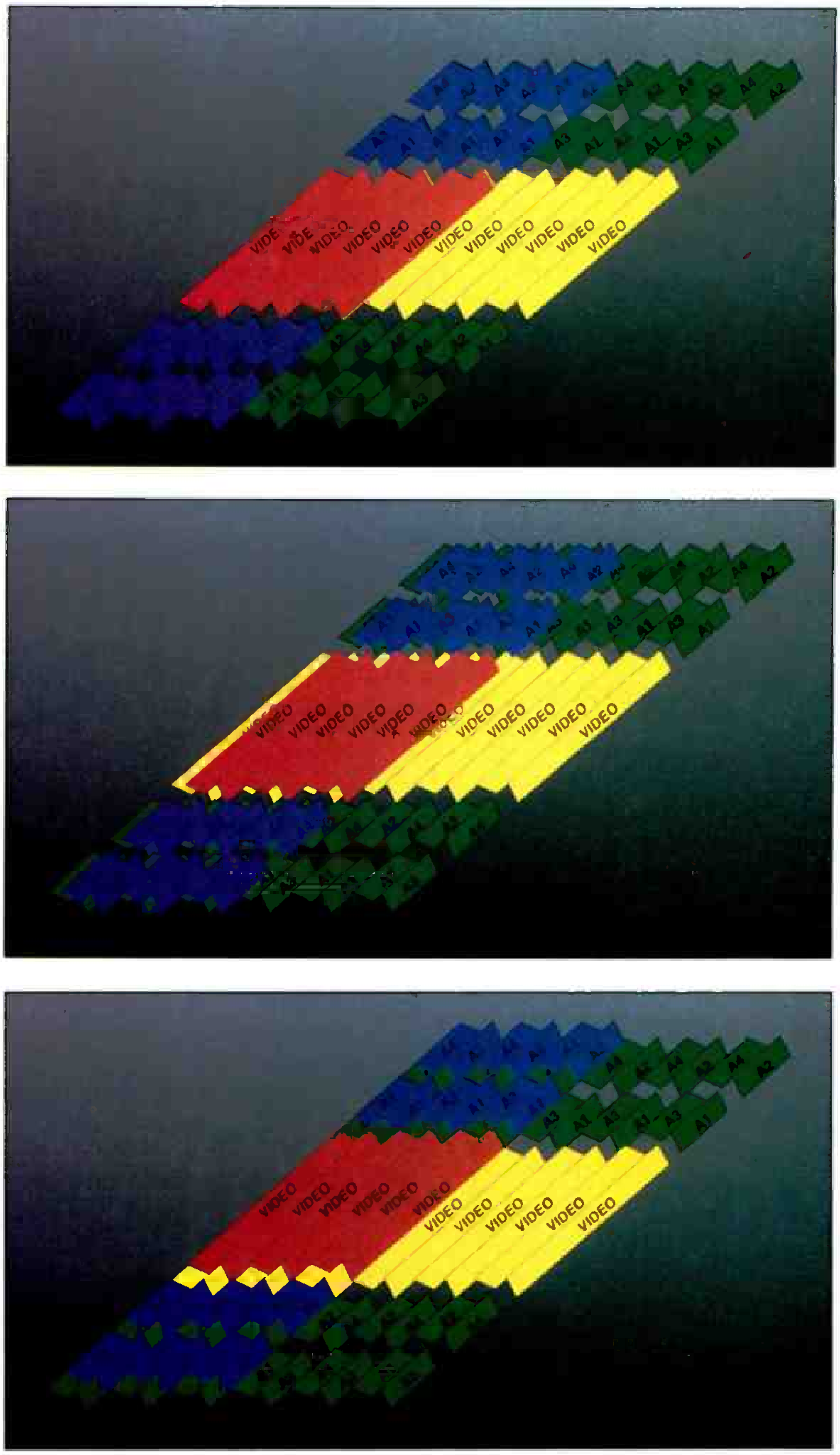


Figure 1. Three views of tracks of recorded information following insert edits indicate: a) correct tracking and scanner phase; b) incorrect tracking; c) incorrect scanner phasing.

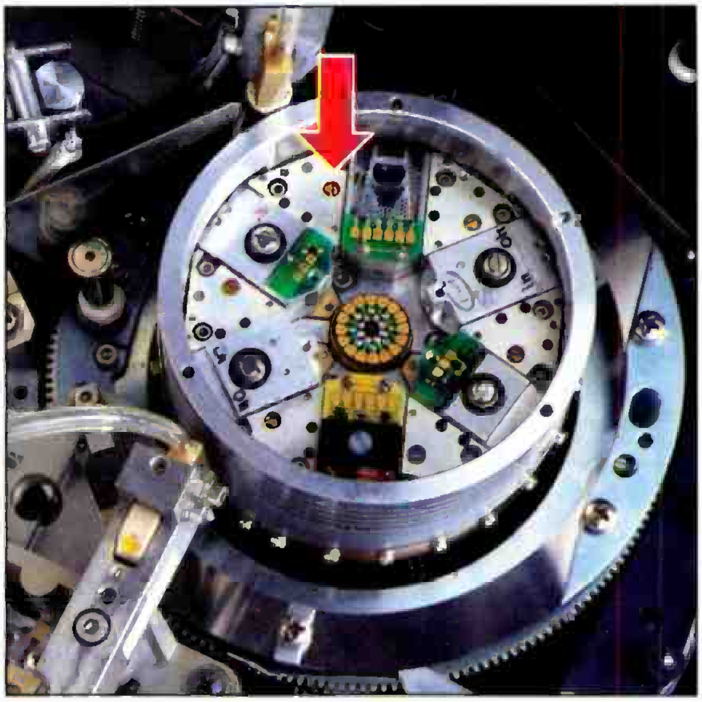
nals) and get to the next field requires a jump over six or eight tracks.

The result was a new development on the design of the Automatic Scan Tracking (AST) head. Like the design of hard disk systems for computers, the head is driven by a voice coil that uses a construction similar to a speakerphone. The head p and down with this voice coil. coil technology for these heads ster and considerably more accurate. The design permits heads to be field-interchangeable. In the DCT drive, if a head is worn, you can replace one or all of the heads in approximately 10 minutes.

Slow motion

The use of AST heads facilitates a slow-motion range, which is −1X reverse play speed all the way up to 3X play speed. Slow-motion ranges include real time

The Ampex DCT series 700d transport was built with serviceability in mind, with detailed diagnostics available at the front panel.



In this scanner assembly, the AST heads are positioned at top and bottom. To replace a head, a quick-release screw is provided at the side of each head assembly (see arrow).

control-track lock reverse play speed. Therefore, if you transfer a video from film in one direction, the recorder can play it back in the other direction with the control track perfectly in play speed lock. The slow-motion feature permits 1% increments from real time reverse play speed all the way through to 3X forward play speed.

Flying erase heads

Initially, D-2 did not have flying erase heads, because Miller-Squared coding was used to write the information on and off tape. The record head actually overwrites the previous information. If current is applied to a record head, it becomes more efficient until saturation occurs. At that point, efficiency drops.

To guide the user through the system, the control panel includes many E-to-E looping paths.

In the D-2 world, consider a recording made at the pinnacle of the record current adjustment range. If that tape is sent to another facility where the current is not equally optimized, full erasure of the original information may not be possible. One of the problems with the D-2 format is the exceedingly narrow adjustment range of the record current.

Placing flying erase heads into the system opened up the range of adjustment. At first, the design team considered putting the erase driver on the rotating preamplifier. Because of concern for crosstalk and other generated artifacts, the erase driver was embedded into the head assembly. As a result, the DCT drive does not need flying erase heads for edit accuracy.

Guides

A stainless steel band around the scanner adds to the system's maintainability. Most manufacturers mill the bottom tape guide — the ridge at the bottom of the scanner on which the tape rides (also called the rabbet guide) — out of the aluminum surface of the scanner. Unfortunately, after a few years of use, the guide wears, the tape drops, and the format and interchange are gone. Analog machines with the 130μm track width have a large measure of leeway. When the track width is 39μm, just a little wear on that guide can create problems.

In this format, an added stainless steel band mounts around the scanner. Our tests indicate that the band should not need to be replaced for the life of the scanner. Loss of interchange will not occur on these machines because the guide wears out.

Auto edit optimize

At some point in the life of a video recorder, the scanner will need to be replaced. When this happens, scanner tach phase must be adjusted. With most tape machines, each revolution of the scanner produces a tach pulse. When a scanner is changed, the alignment procedure uses an electronically generated pulse to help realign the leading edges. Often, however, a small, residual error in the scanner phase can go unnoticed. If an error in scanner phase exists and a recording from that machine is sent to another facility where the scanner has no error or an error in the other direction, then the format dropout moves.

In the digital world, it is even more critical because audio is added into the same track with the video. Scanner tach phase determines where the track starts and ends on the tape, so if an error exists in the scanner tach phase or if the phase of the scanner is changed, the track changes its effective position on the tape. The effects are particularly apparent if another facility must make insert edits on the tape. One way to avoid this problem is to copy the tape to another VTR, which means a time delay before the job can be accomplished.

The frame of the DCT 700d transport consists of an aluminum sandcast structure.

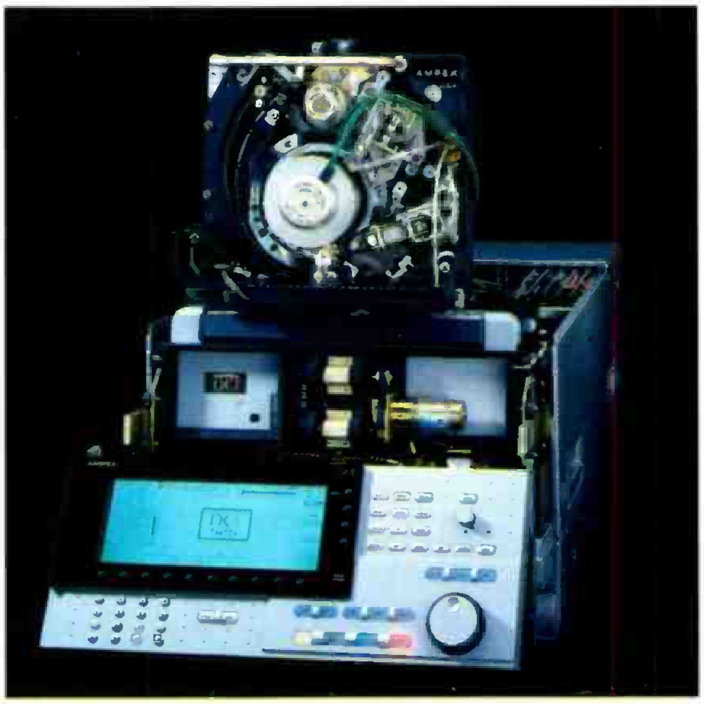
The Auto Edit Optimize feature on the DCT transport alleviates this problem. When inserting edits into tapes from another studio, simply press the insert and edit optimize function. In a 7-second preroll, the transport adjusts tracking to place the head exactly on top of the track. Then, the scanner learns where the tracks start and end on the tape. If a tape shows a certain scanner error from the recorder, the system induces a matching error into the playback scanner to compensate. This guarantees a perfect insert edit.

Information regarding the errors is stored in a memory register. For future edits, as little as a 3-second preroll is needed to track the machine and phase the scanner. If the error exceeds the information stored in the register, the edit is aborted, and the system returns to a 7-second preroll to learn what errors now exist. In the end, the system will always perform an insert edit correctly. With regard to maintainability, this automatic adjustment feature compensates for the unexpected.

Floppy disk drive

In the past, upgrading the software of equipment meant the machine would be out of service for at least a day. The process required carefully removing all of the old PROMs and replacing them with a new set, and hopefully not bending any of the pins. For a friendlier approach to upgrading, the DCT tape drive includes a 3.5-inch floppy disk drive that is accessible from the front of the machine. It takes approximately 60 seconds to upgrade the soft-

The transport assembly is modular, allowing easy access and servicing of any component.



The tape drive is built with a modular architecture and remains operational even with maintenance access to the circuitry.

ware. If any incompatibility in the new software appears, another 60 seconds will read in the previous software release and return the VTR to its previous status.

Power supply

Equipment reliability often depends on the power supply. In the DCT unit, a power-factored power supply is used. It is self-ranging and self-sensing. Operation is practical from 47Hz to 70Hz and from 90VAC to 250VAC. If necessary, the supply can be replaced relatively quickly — only four screws and three connectors tie the supply to the rest of the system.

Diagnostics

Diagnostics was another area of focus in designing the transport. Under normal operation, functions happen fast in a transport. Because it is difficult to see exactly what is happening, a number of maintenance routines in this system track the events. For example, to eject a tape requires approximately five seconds. It happens so fast that trying to diagnose a problem would be difficult.

For maintainability, the transport includes diagnostics function menus that:

1. Show information pertaining to the servo section — directions, velocities and currents.
2. Generate added test functions into a called-up test mode. For example, if something is wrong with the elevator, the user can select the elevator and actually control it from the front panel.

Designed for profitability

Often, the time required for equipment service is time taken away from profitable pursuits. Preventive maintenance finds problems before they require extensive service procedures. Unfortunately, the maintenance procedures can be as time consuming as the servicing. By improving maintainability and serviceability in the DCT-700d transport, profitability also was enhanced.

■

New Products

Signal options

By Abekas Video Systems

• **Ethernet, SCSI interfaces:** provide options for transfer of images between the A66 digital disk recorder and computers accepting the UNIX rcp command; permits recorder control from other equipment; Exabyte archiving through SCSI port; handles CCIR-601 or RGB file formats; A65 recorder includes the interface.

Circle (366) on Reply Card

Desktop editing

By California Paltex Corporation

• **EDDiSXsystem:** self-contained A/B-roll desktop editing control from a PC with Windows; serial-video switcher, NewTek Video Toaster and Panasonic WJ-MX50 mixer control; 999-line EDL memory and utilities; animation, auto-assembly modes; NTSC, PAL support with drop, non-drop frame timing.

Circle (365) on Reply Card

ERM update

Please note the following corrections and additions to the *1993 Equipment Reference Manual:*

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110 South Main (address change)
Owasso, OK 74055
1-800-852-1333; fax 918-272-8452
Circle (201) for more information.

Chyron
Member of Pesa Chyron Group
265 Spagnoli Road
Melville, NY 11747
516-845-2026; fax: 516-854-3895
Note: the **Pesa Chyron Group** includes Aurora Systems, CMX Editing Systems and Pesa (America) Switching Systems
Circle (202) for more information.

Digital Broadcast Associates
826 North Victory Blvd.
Burbank, CA 91502
818-567-2873; fax: 818-567-2917
Manufactures digital cart replacement using Floptical disks.
Circle (203) for more information.

Enco
1866 Craigshire Drive
St. Louis, MO 63146
303-422-1689; fax: 303-425-4287
Manufacturer of DAD486/486X digital audio delivery systems.
Circle (204) for more information.

Hollywood Digital
6690 Sunset Blvd.
Hollywood, CA 90028
213-469-3177; fax: 213-469-8055
Circle (205) for more information.

McCurdy Radio Industries
108 Carnforth Road
Toronto, ONT Canada M4A 2L4
416-751-6262
Circle (206) for more information.

Ramko Research
3501-4 Sunrise Blvd.
Rancho Cordova, CA 95742
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fax 916-635-0907
Product line includes various small audio mixers.
Circle (207) for more information.

Zaxcom
20 Passaic Street
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Product line includes digital audio post-production mixers, TBC remote controllers, D-1 signal processors.
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Professional lens

By Canon (USA) Broadcast Equipment

• **YH13×7.5KRS:** ENG lens for ½-inch cameras with 7.5-97.5mm focal length for 13:1 zoom ratio; MOD of 39 inches; high optical performance in a 2.1-pound package.

Circle (356) on Reply Card

Production titling

By Grass Valley Group

• **Presto 200:** medium-priced, anti-aliased character generator with real time display effects; 32 master Bezier fonts, z-axis rotation and 8-400 scanline font sizing; hard drive storage of fonts, program and text storage; 3.5-inch floppy and removable cartridge drives for additional storage; KolorGrab option captures RGB video to use in images.

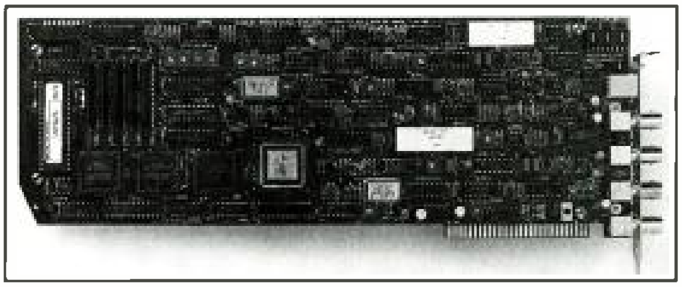
Circle (357) on Reply Card

PC synchronizer card

By Digital Processing Systems

• **VS-2400 MicroSYNC:** 4-field synchronizer on PC plug-in card also fits ES-2000 series rack-mount expansion system; for composite NTSC signal processing; RS-232 serial interface, field/frame freeze, variable strobe; for satellite, network feeds, mobile production, router input timing, CATV head-end synchronization and computer graphics storage.

• **ES-2000 expansion unit:** 12-channel rack-mount unit accepts eight MicroSYNC or Personal TBC II/III cards and V-Scope waveform/vector display cards, video DA, routing switcher cards.



Circle (358) on Reply Card

Extended storage capability

By Quantel

• **15-minute Henry:** uses arrays of 3.5-inch disk drives (code named Dylan) to extend the 5-minute capability of the Henry concurrent editor to 15 minutes with 20Gbyte random access storage; tolerates disk errors, including total failure of individual disks; bandwidth exceeds that required for video.

Circle (353) on Reply Card

Image transfers

By fast forward video

• **Bandit:** digital-video recording system transfers computer images to digital RAM before writing data to videotape or display on a standard monitor; eliminates single-frame recording equipment; includes compression to 15:1, retaining 450-line resolution or 640×480-pixel NTSC images.

• **Outlaw:** editing and effects unit; digitizes and compresses analog video, digital images and animation files; software-based editing, effects control via keypad and track-ball console; dual time-code channels and standard machine protocol to control VTRs.

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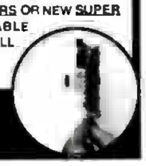
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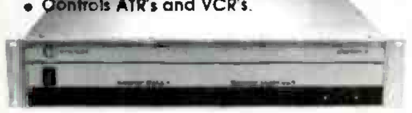

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ABEKAS A42 • hard & tape drives $21,500
AMPEX ADO-1000 • 2 Ch. $45,000
GVG 300-3AN • 24 Input, 3 M/E Call!
MAKE OFFER
BTS FGS-4000, IKE 312 3 camera pkg., IKE SK-96 3 camera pkg., Sony BVE-5000 & BVE-500 editors, ITC Delta carts, Marconi GM-4002, & BTS TCE-2000 Encoders, Tek 1440 AVC, Sony VDX-1200 Videotexes, Datatek Router.
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Advertiser	Page Number	Reader Service Number	Advertiser Hotline
Abekas Video Systems	*19	13	415-369-5111
Acrodyne Industries, Inc.	53	54	800-523-2596
Ampex (AVSD)	24-25	16	415-367-2011
Antex Electronics	71	48	213-532-3092
Asaca/Sibasoku Corporation	27	17	213-827-7144
Auditronics, Inc.	3	5	901-362-1350
Belar Electronics Laboratory	44	28	215-687-5550
Broadcast Video Systems Ltd.	50	41	416-764-1584
BTS Broadcast TV Systems	77	57	800-962-4BTS
Canare Cable, Inc.	72	49	818-365-2446
The Chyron Corp.	49	33	
Clark Wire & Cable	44	29	708-272-9889
Clear-Com Intercom Systems	76	52	510-527-6666
DPS	70	47	606-371-5533
Dynatech Corporation	11	9	608-273-5828
Electro-Voice	34	22	616-695-6831
Enco Systems, Inc.	74	53	800-ENCO-SYS
Grass Valley Group	10,37	13,24	800-343-1300
Harris Allied Systems	1	4	800-622-0022
illbruck	61	39	800-662-0032
ITS Corp.	55	35	412-941-1500
Jampro Antennas, Inc.	30	19	916-383-1177
JVC Professional Products Co.	5	6	800-JVC-5825
Leitch Inc.	BC	3	800-231-9673
Magni Systems, Inc.	39	25	800-237-5964
Maxell Corp of America	33	21	800-533-2836
Midwest Audio/Video Exchange	79	56	708-251-0001
NAB Broadcasters	69	46	202-429-5350
NEC Corp.	21	15	
Nesbit Systems	48	32	609-799-5071
N Vision	75	55	916-265-1000
OMB Sistemas Electronicos	*19	14	347-627-4537
Opamp Labs, Inc.	50	43	213-934-3566
Orban, Div of AKG Acoustics	7	7	510-351-3500
Otari Corp.	15	11	415-341-5900
Panasonic Broadcast & TV	67		800-524-0864
Pesa Switching Systems	IFC	1	205-880-0795
Quantel	31	20	203-656-3100
Research Technology Intnl.	58	37	708-677-3000
Schmid Telecommunication	65	45	800-955-9570
Sharp Copier Division	IBC		
Sierra Automated Systems	50	42	818-840-6749
Tascam	46-47	31	213-726-0303
Telex Communications, Inc.	40-41	26	612-887-5530
Television Technology Corp.	29	18	303-665-8000
Varian Associates Inc.	35	23	
Vega, A Mark IV Company	42	51	818-442-0782
Videotek, Inc.	45	30	800-800-5719
The Winsted Corporation	72	50	800-447-2257
Zero Stantron Enclosures	51	34	800-821-0019
3M Pro Audio/Video Products	43	27	612-733-1959
360 Systems	9	8	818-342-3127

*Denotes demographic coverage

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Shinjuku-ku, Tokyo 162, Japan
Telephone: (03) 235-5961,
FAX: (03) 235-5852,
Telex: J-33376 MYORIENT

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John Williamson
Hastwell, Williamson, Rep. Pty. Ltd.
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Frewville 5063, South Australia
Phone: 799-522, FAX: 08 79 9522
Telex: AA87113 HANDM

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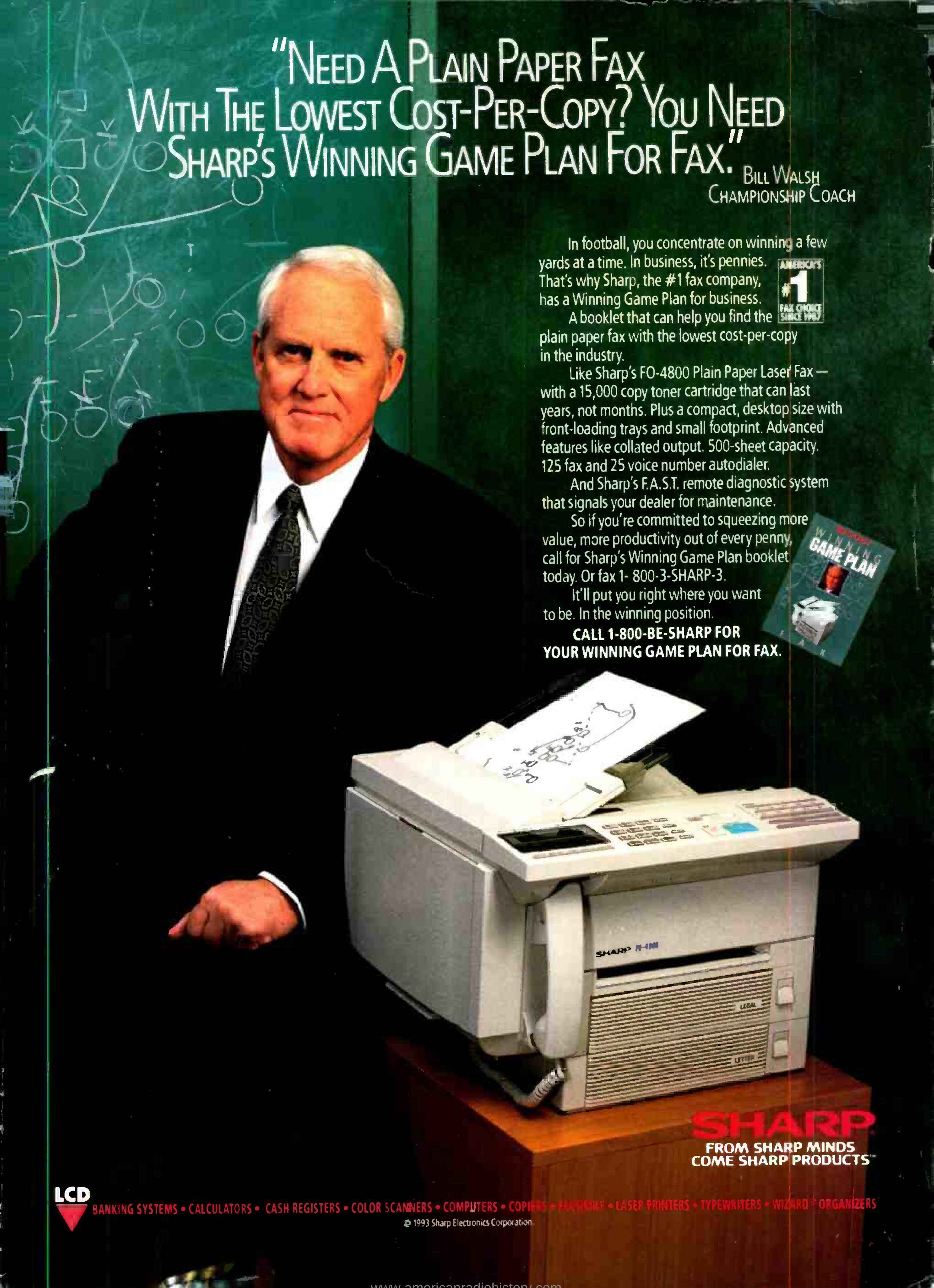
Renée Hambleton, P.O. Box 12901,
Overland Park, KS 66282, 913-967-1732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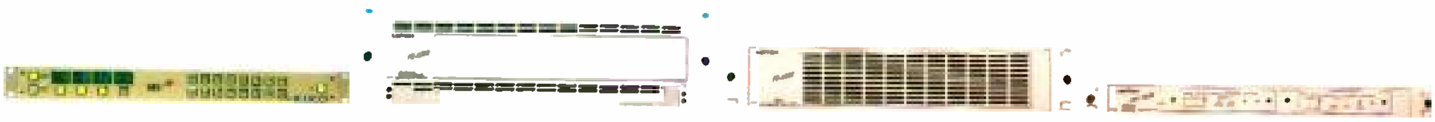

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