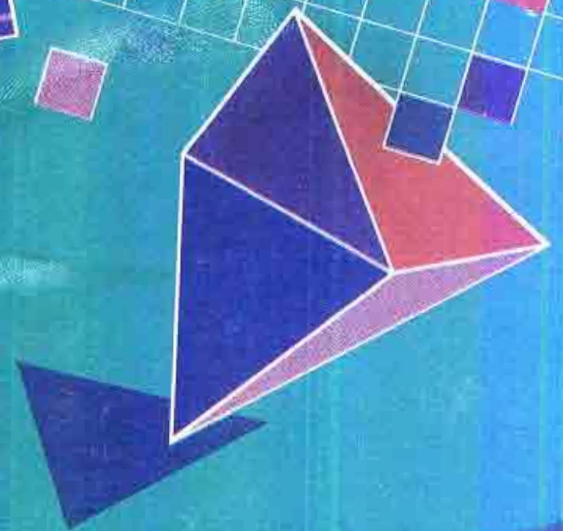
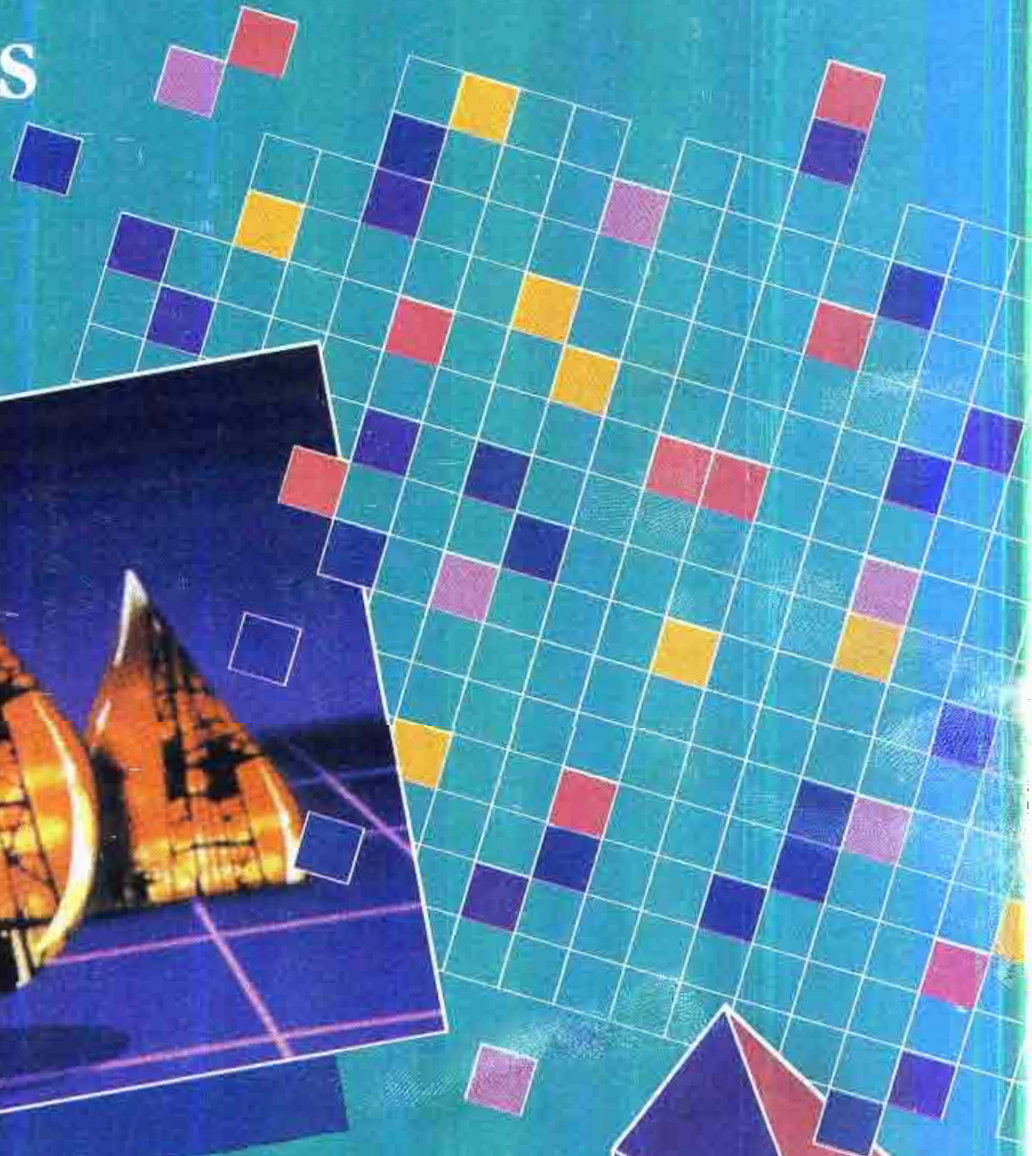


BROADCAST[®] engineering

February 1987/\$3

Digital graphics
from the
inside out



$$C(t) = [P^T + I] B$$

$$\begin{bmatrix} P_{i-1} \\ P_i \\ P_{i+1} \\ P_{i+2} \end{bmatrix}$$

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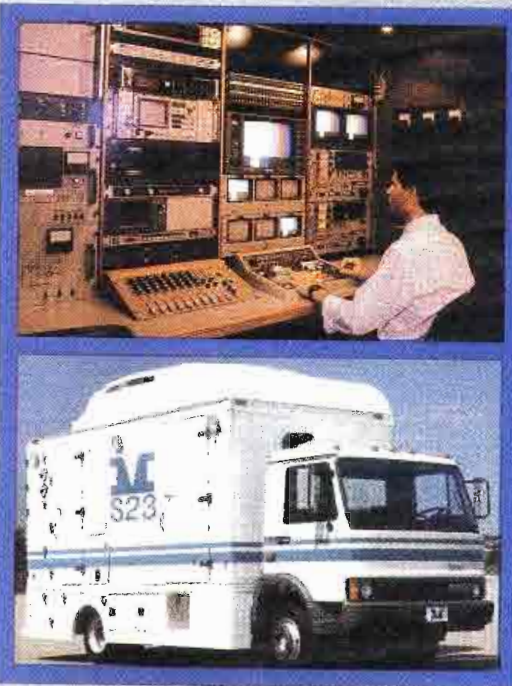


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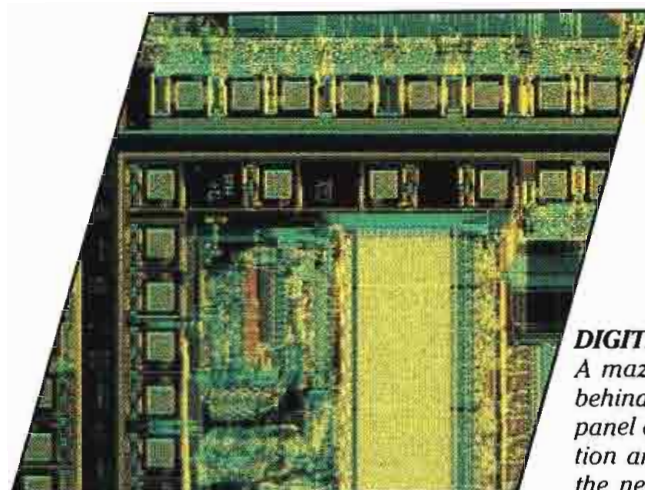
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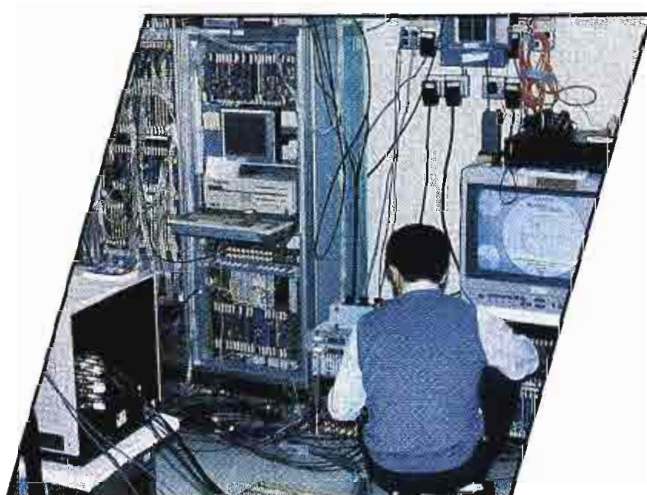


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BROADCAST engineering

DIGITAL TECHNOLOGY FOR AUDIO AND VIDEO:

A maze of computer circuitry and programming software lies behind the screen of a digital graphics system or the control panel of an audio special effects unit. This special emphasis section analyzes how digital technology is being applied to meet the needs of broadcasters and unravels the mysteries of how these systems work.



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22 Digital Graphics From the Inside Out

By Carl Bentz, special projects editor

A few hours at the controls of a graphics system is enough for almost anyone to operate the system with relative ease. The external simplicity belies the complex hardware and software that lurks behind the covers.

42 The All-Digital Studio

By Ned Soseman, TV technical editor

The use of digital processing technology opens the door for new production trends with significant market appeal. This special news report examines the current state of the all-digital video production center. A related article looks into the question:

- What Is 4:2:2?

60 The Future of HDTV

By Ned Soseman, TV technical editor

The operation of and potential for high-definition television have been discussed and debated for years. Only recently, however, have practical working systems been implemented. Related articles also examine:

- Can HDTV Survive?
- Hi-Vision Comes to America

86 Inside Digital Delay Systems

By Richard C. Cabot, P.E., Ph.D., Audio Precision

The growth of digital-based audio equipment for the broadcast industry has been explosive. Much of the new hardware is built around digital delay (memory) circuits. A related article discusses:

- Microcontrollers for Digital Audio Delay

ON THE COVER

Digital graphic systems have, more than any other single development since color, impacted the look of television. Once little more than a novelty, graphic elements generated by computer-based systems have become the mainstay of TV stations and production houses for a wide variety of needs. Our cover illustrates this trend and some of the elements that make it possible. Cover graphic design by Deb Walther, Overland Park, KS. The news graphic was prepared by Jerry Cappa, WABC-TV, New York (supplied courtesy of Ampex).

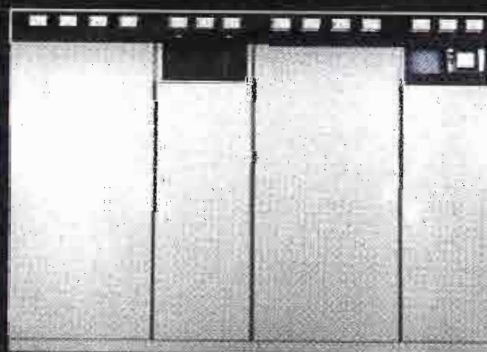
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NAB calls for EPA, FCC guidelines

The National Association of Broadcasters has urged the Environmental Protection agency to adopt federal radio frequency human exposure guidelines to pre-empt overly restrictive state and local measures. NAB called for adoption of the American National Standards Institute's standard, which has been chosen by the FCC. The association said the ANSI standard will provide more than adequate safety for the American public, yet will not impose unnecessary restrictions on electronic communication systems.

According to NAB, quick action is needed because broadcasters are experiencing delays, restrictions and prohibitions from constructing or expanding their facilities due to non-federal policies. NAB said the agency should be able to reach a decision well in advance of its December 1987 timetable.

NAB also has called for an independent study to determine how land mobile allocations in the UHF TV bands will affect the broadcast quality of UHF TV stations. Edward O. Fritts, NAB president, appeared as the keynote speaker at the Annenberg Schools of Communications Policy Forum on HDTV. He said the commission appears ready to give land mobile the UHF TV frequencies needed to transmit HDTV, which would cause interference to existing UHF broadcast and would prevent development of free, over-the-air HDTV service.

Fritts said these allocations are unnecessary because land mobile radio makes inefficient use of the frequencies it now has and could more than quadruple the number of stations within its present frequency allocations if it switched from FM to single sideband. He added that studies commissioned by the FCC already show that more land mobile allocations in the UHF TV bands will further degrade the broadcast quality of ex-

isting UHF TV stations. He said consumers may never be able to enjoy high-definition UHF, even though HDTV is a reality, citing the first UHF terrestrial broadcast of HDTV, beamed on Dec. 5, 1986 from WUSA-TV on channels 58 and 59. The broadcast was sponsored by the NAB, the Association of Maximum Service Telecasters and Japan's NHK.

Ampex submits digital format

Ampex has submitted its composite digital videotape recording format to the SMPTE Video Recording and Reproduction Technology Committee for consideration as a SMPTE/ANSI standard.

Sony also submitted the same composite digital format specification to SMPTE.

Through a cooperative effort between Ampex and Sony, all aspects of the format as it relates to an NTSC environment

Continued on page 136

BROADCAST engineering

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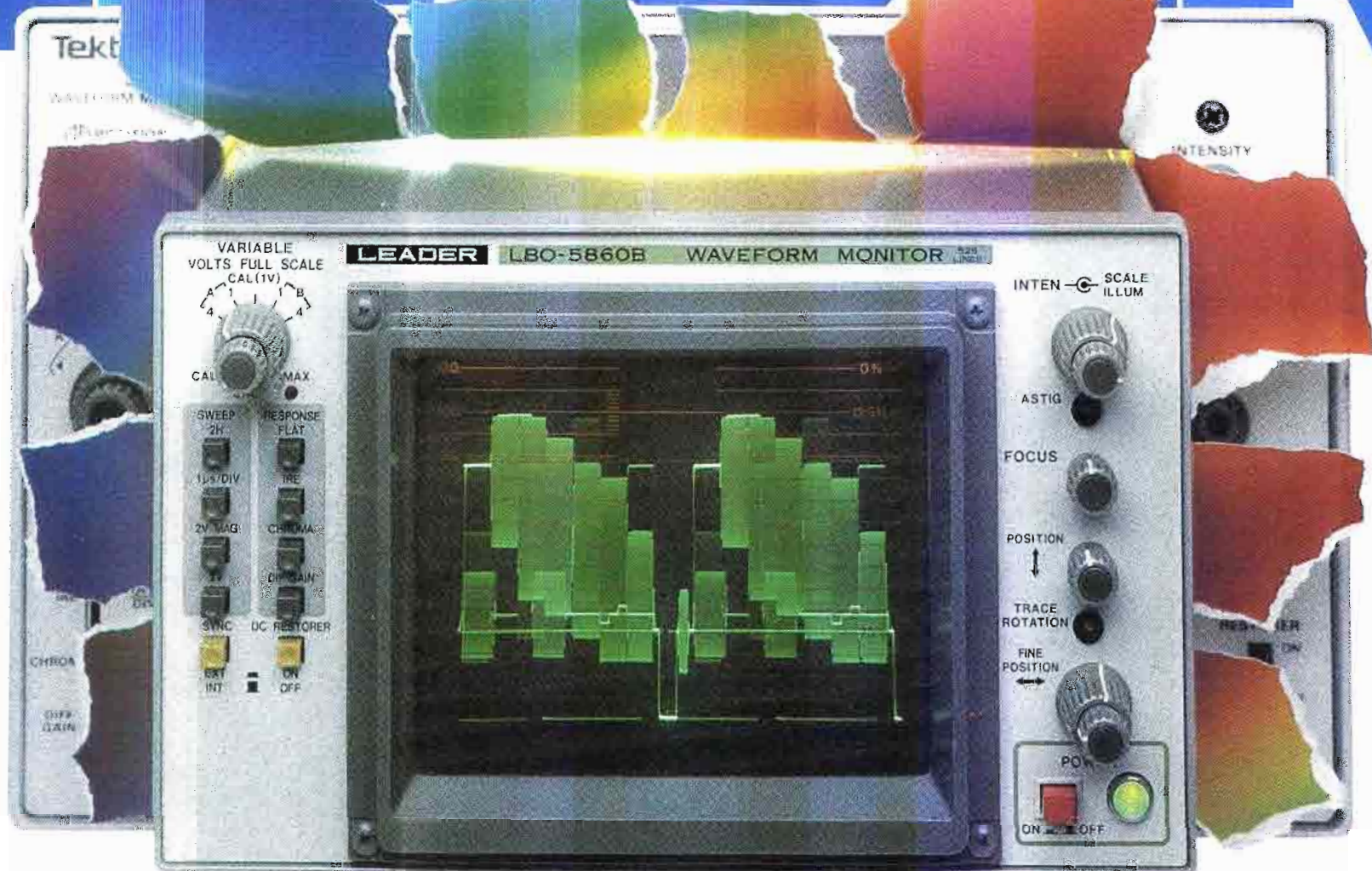
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Are standards obsolete?

"The cornerstone of the SMPTE, since the day it was founded, has been standards. The society has provided a valuable and needed service to the motion picture and television industries, providing hundreds of standards and recommended practices."

Opening remarks, 128th SMPTE conference

Richard Streeter, engineering VP

It is interesting to consider the purpose of SMPTE as the simplification of technical aspects of two highly technical disciplines through standardization. Those of you who have lived with television probably do not realize the amount of time spent getting television to its relatively compatible state. You probably cannot fathom the amount of money spent on travel and accommodations for those people who attend standards meetings.

Why do they do it? Glory? Recognition? Some participation in the SMPTE work may be for those reasons, but most standards participants take part because they (and their companies) believe that a standardized industry is an easier and better place to work. They believe that the development of standards by a non-profit, non-enforcement society is a realistic means of arriving at solutions to conflicts stemming from ingenious, corporately funded research and development engineers. In a majority of cases, their beliefs are correct and have prevailed.

Paradoxically, the standards makers who care about the industry are not the power to whom broadcasters must answer for their operations. The day-to-day station activities run according to a set of rules established many years ago by people who were knowledgeable of the technical quirks of broadcasting. A number of those rules have seemed oppressive at times, and we have all privately and publicly made our opinions of them known. Yet, they were established rules and we tried to follow them. The rules were, after all, a set of standards upon which radio and television were founded.

Those rules, couched in legalese, presented some difficulties as the industry changed. As a result, it was a pleasant surprise when Mark Fowler became head of the FCC, bringing with him the desire to clear away much of the underbrush that stymied industry growth. Little did anyone suspect then that the ruled standards we enjoyed would become oriented more toward economic than technical interests.

And so the problems remain, leaving major standards questions that cry for guidance to be tossed to a marketplace for decisions. But is the marketplace prepared (or capable) of making such decisions? It couldn't work out quadraphonic sound. It hasn't solved the AM stereo question. And frankly, it isn't likely to be the watchdog that keeps stations in compliance with accepted operating practices.

Although money, market share and profitability often have more impact than a station operated by a well-trained technical staff, technology does not stand still. Equipment necessary for today's television is increasingly complex and expensive, reflecting development costs and an effort to make new concepts compatible with existing systems.

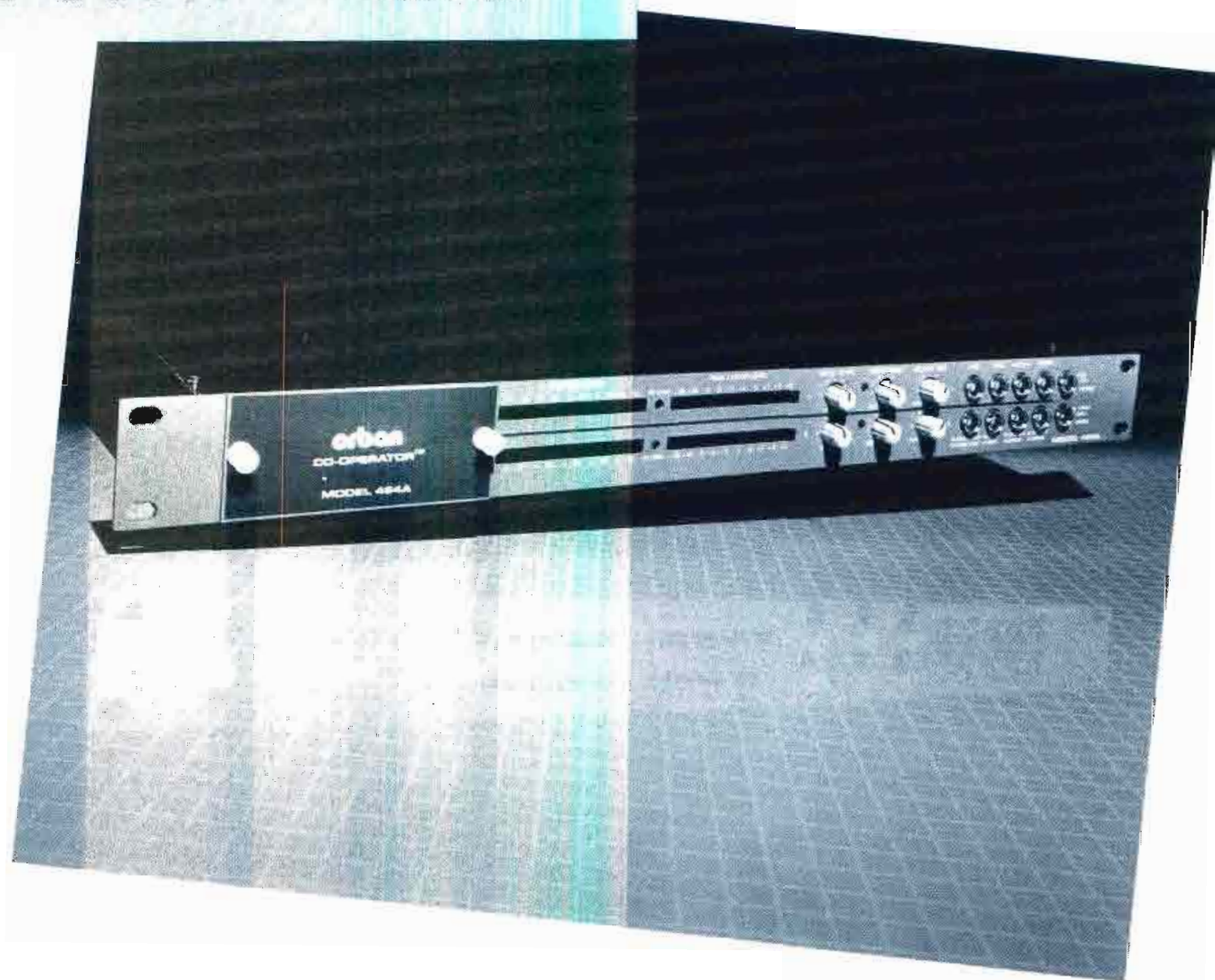
A good example is digital technology, the trend of tomorrow. Already digital islands for TV production exist, and they are growing. Individual black boxes are being interconnected with one another, most using RS-422, but a variety of communications buses exist and are being used. Each has advantages and disadvantages. Most are incompatible without translating interfaces.

Perhaps the problem is that typical innovation often breeds non-standard results. Then, because the manufacturer's expenditures of development must be recovered, the battle to establish a de facto standard begins. As the costs of such standardization methods escalate, an unfortunate trend has become common. More and more, company identities are disappearing through consolidating mergers, acquisitions and financial failures, often the result of fighting for non-standard causes.

It is, at best, an expensive procedure to arrive at a standard and one that ultimately is paid for by the users. Yet, achieving a standard through due process and the representation of users and manufacturers in amiable discussion is preferred to standardization according to the corporate bank account.

Is standardization in broadcast obsolete? Not by a long shot. It occasionally appears to be unemployed by some of those in command, but we can and we must put it back to work.

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Cable systems to use TV auxiliary frequencies

By Harry C. Martin

In a decision released in mid-December, the FCC amended its rules to permit cable systems and networks to use the 1.9GHz and 6.8GHz bands (1,990MHz to 2,120MHz and 6,875MHz to 7,125MHz) for the transmission of TV signals. Common carriers serving cable systems and networks also will be permitted to use these bands. Previously, the 1.9GHz and 6.8GHz bands were the exclusive domain of TV stations, which used them for TV studio-transmitter links, intercity relay stations and TV remote pickups. The commission's decision is controversial because in some areas the TV auxiliary bands are already overcrowded.

At the same time, the commission opened the 6.4GHz band (6,425MHz to 6,525MHz), used primarily by common carriers for Local Television Transmission Service (LTTS), to TV broadcasters and cable systems on a primary basis. Up to now, broadcasters were permitted to use the 6.4GHz band, but only on a secondary basis, and cable systems could not use the band at all. The commission said that this change in the rules would provide added flexibility in establishing microwave links for mobile TV pickup operations. Such flexibility is needed, because demands are increasing for the already heavily used 1.9GHz and 6.8GHz bands in some urban areas.

Freeze imposed on daytime AM applications

Effective Dec. 12, the commission imposed a freeze on the acceptance of applications for new daytime AM stations. The action was taken in anticipation of a formal rulemaking proceeding that will propose a permanent ban on acceptance of applications for daytime stations.

Applications for new daytime stations on file before Dec. 12, and applications filed thereafter that are mutually exclusive with applications listed on an "A" cutoff list, will be processed as usual during the freeze. The commission's action will not restrict the ability of existing AM daytimers to apply to modify their facilities.

The commission took this action in

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



order to preserve spectrum space for full-time stations. The continuing authorization of new daytimers complicates the task of offering relief to existing stations and perpetuates the daytime problems the commission has sought to address through its clear-channel proceedings, establishment of a "daytime preference" in FM hearings, and various treaty initiatives.

The commission's action is consistent with its ruling in 1985 under which applicants proposing new AM daytime stations were not permitted to apply for facilities made available on the foreign clears as a result of new treaties with Mexico and Canada.

Metric AM groundwave curves date deferred

The commission deferred until Feb. 1 the effective use of its new metric ground-wave curves (section 73.184 of the rules) used in calculating AM station signal strength. After Feb. 1, the new curves must be used for all studies filed with the commission.

The commission deferred the previous Jan. 1 deadline because there was insufficient time to enable users of the curves to employ them. The commission has made access to negatives of the curves and associated graph paper available to entities interested in offering the materials for sale. Also, a source listing of the computer program employed in calculating the points used in plotting the curves, and an approximately 650-page listing of those calculated points for use in "look-up" tables, is available. Contact the commission's public records contractor, International Transcription Services (telephone: 202-296-7322).

FCC comments in EPA RF radiation proceeding

In comments filed at the Environmental Protection Agency, the commission has urged the adoption of specific standards for limiting exposure of the public to RF radiation.

In July, the EPA published four suggested approaches to deal with this issue and asked for written comments on them. One of the approaches was to

develop educational programs and promote other activities dealing with the problem instead of adopting enforceable standards. The commission opposed this option, saying that the current lack of uniform guidelines is causing a proliferation of state and local regulations that are inconsistent, unreasonable and sometimes insupportable. The continued lack of a uniform federal standard will cause increasing difficulties in this area.

The commission did not take a position as to which of the EPA's alternative regulatory schemes would be best in terms of protecting public health and safety. The commission said it is not a health and safety agency and has neither the expertise nor the authority to evaluate the EPA's proposals regarding health protection. However, the commission urged the EPA to consider the relative impact on the telecommunications industry of any regulatory option it ultimately chooses.

Also in its comments, the commission told the EPA that FCC use of the American National Standards Institute's recommended guidelines has been satisfactory to date. More stringent guidelines would require greater agency resources, increase costs to the industries it regulates and reduce choices of transmitter sites.

The commission further pointed out that it is important for the EPA to recommend a uniform methodology for evaluating RF fields so all federal agencies will be consistent in their implementation. The commission suggested that the EPA adopt a procedural manual in order to dispel confusion and disagreement over appropriate measurement procedures, techniques and instrumentation.

Finally, the commission suggested that the EPA consider whether it should issue separate guidelines with respect to exposure to RF radiation in the workplace, where the greatest exposure potential exists. In this connection, the commission noted that coordination would be needed with the National Institute for Occupational Safety and Health and the Occupational Safety and Health Administration.

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www.americanradiohistory.com

By Carl Bentz, special projects editor

Output < Input.

Stereo audio for television follows the same relationship and may be more critical than the visual signal. In monaural, there are many places along the audio path where distortion and noise can ingress. With stereo, sources of signal degradation are at least doubled. The presence of two signals instead of one provides new sources of problems.

In the January "Strictly TV" column, comments centered on audio generation and mixing systems and their interconnections. Audio quality does not stop there. You must get the audio to the transmitter. That will mean some additional distribution amplifiers and routing or master control switching. Periodic inspection and tests of all active equipment should include distortion and noise tests.

Perhaps you use a manual patching system. Something as passive as a patch panel also should be inspected for clean, reliable connections. Patch cords should not be allowed to become intermittent.

If you are convinced that the audio leaving the studio is as good as you can get it, it is time to launch the audio to the transmitter. If you use an STL system, plan to perform a proof on the microwave equipment as well. There should be little difference between the signal-to-noise ratio, THD and frequency response

Editor's note: This information is adapted with permission from *BTSC Stereo: TV Aural Proof of Performance Guide*, available from TET Inc.

Where should the stereo generator be placed? Should it be placed at the studio and modulate a single STL subcarrier? Or should the right and left audio signals be carried by the STL for stereo generation at the transmitter site? That argument has been around since FM stereo began. There are pros and cons to both methods. Sending a composite stereo signal appears to be the more common approach. No matter how you excite your STL, the audio at the receiving end should not be significantly different than what went in.

The final concern with the stereo aural TV signal is the aural transmitter itself. An ideal location to make your test measurements is from the sampling point of the diplexer output. Measurements at this point will include the entire active audio path. The sampling point will usually be arranged to provide about 5V

rms. If it is higher than that, the signal could damage the input of your modulation monitor. The level can be reduced through a 10dB or 20dB attenuator pad in series with the monitor input.

Measurements at the diplexer test port should be closely related to the values of Table 1. If your transmitter is an IF-modulated design, and you have trouble achieving the values in the table, you may wish to check the sampling point of the transmitter IF section.

Recommended practices

To operate your TV transmitter in stereo requires attention to a number of factors that were not as critical with monaural sound. If you are planning to change to stereo, you should become familiar with FCC OST bulletin No. 60, the technical specifications for BTSC TV operation. Your regional FCC field office should be able to give you information on getting your own copy of the bulletin.

PRE-TEST	AUDIO FREQUENCY	LIMIT
A. Check S/N ratio	400Hz	60dB below 100% modulation
B. Spot check THD	50Hz 1,000Hz 14kHz	Below 1%
C. Spot check frequency response	50Hz to 50kHz 50kHz to 120kHz	± 0.1 dB ± 0.5 dB

Table 1. Pre-test limits, aural transmitter.

SERVICE OR SIGNAL	MODULATING SIGNAL	MAXIMUM MODULATING FREQUENCY kHz	ENCODING OR PRE-EMPHASIS	SUBCARRIER FREQUENCY
Monophonic	L + R	15	75μs	
Pilot				f _H
Stereophonic	L - R	15	dbx Encoding	2f _H
Second Audio Program		10	dbx Encoding	5f _H
Professional Channel	Voice or Data	3.4 1.5	150μs 0	6½ f _H

Table 2. BTSC system spectrum signal specifications.

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you to easily mix down stereo in your post production booth. It offers all the features of the popular M267 plus stereo capability and a stereo headphone amp.

FP31

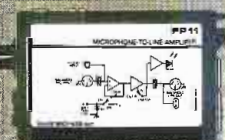


FP16

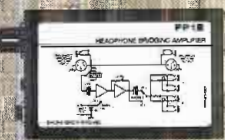


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2/87-BE-FP

Learning the basics

By John Battison, P.E.

The FCC initiated a notice of inquiry in 1977 to change the method of predicting AM patterns. In 1981, after a great deal of research, the commission adopted standard patterns for all AM stations.

Each standard pattern conversion is referenced by a number commencing with the station's frequency and followed by a serial number. For instance, KFAY is the first station in the series, number 550-01. Material to create the standard pattern comes from many sources: the FCC computerized database, construction permits, licenses, authorized plotted patterns from earlier construction permits including MEOVs, radiation patterns and measured patterns from recent proofs of performance.

In most cases, the standard pattern was computed from the theoretical rms and the Q value, as determined from the commission's rules. Comparisons were then made with the measured values, CP limits and authorized MEOVs. If there was a difference in values, augmentation was then applied as required to arrive at a *standard* table (pattern) of radiation. This table (see Table 1) allows an engineer to determine a station's radiation pattern.

Augmentation

Augmentation can be either negative or positive. Most engineers probably think of it as being positive because of a preoccupation with keeping patterns within licensed values. However, it is worth remembering that the commission has an interest in ensuring that broadcasters serve all areas within their licensed pattern area. Stations are seldom cited for operating with consistently low power, low monitor points or low values of inverse field on authorized radials. But, citations can be issued for such operation. The commission's rules specify a range of +5% or -10% for power. A consistently low value of I_{cp} could bring a citation.

Typically, the augmentation span is twice the angular distance, as measured in degrees, between the augmentation



azimuth and closest relevant radial—usually a measured radial. This means that sometimes the augmentation span is quite long. With older stations that commenced operation before the spectrum became overcrowded, augmentation spans may run as high as 86° or more.

Proper records

The information provided in a standard pattern conversion data page enables an engineer to ascertain the manner in which a given pattern was derived. The table also can often provide considerable help to the station engineer who is struggling to correlate the actual operating pattern with the station's licensed values.

In far too many cases, original engineering reports, applications and proofs of performance are lost in the continuing shuffle of station engineers. Any engineer, beginning work for a new employer at an existing station, should ask for the station's original engineering application, any modifications or amendments and the latest proof of performance. If these documents are not available, the engineer should demand that the station order the material. These

documents are crucial for proper maintenance and may be requested by an FCC inspector. If this type of data is not available, an FCC citation might be issued.

It is amazing how a station's operating parameters change as the station engineers change and the record keeping deteriorates. A new engineer should make a practice of looking at the station license as soon as possible—just to make sure the proper values are known. The next step is to verify all limits and readings against the license. Remember too, that the inspector will want to see your latest antenna impedance measurements. Sometimes these cannot be found, in which case you should order a copy of the last proof.

If you need to obtain standard patterns or other FCC reports, one supplier is ITS, Suite 140, 2200 M St. NW, Washington, DC 20037.

POWER kW 0.500	LATITUDE 40-17-56	LONGITUDE 83-02-46	PAT-MULT MV/M 98.14	TH-RMS MV/M 126.00	STD/AUG RMS-MV/M 132.72	PAT-RSS MV/M 138.79	Q-FACTOR 6.0000		
TOWER No.	PHYS-HI (A)-DEG	TL-HT (B)-DEG	TOT-HT (C)-DEG	TL-HT (D)-DEG	FIELD Ratio	PHASE DEG.	SPACING DEG.	ORIENT DEG-TR	REF FLG
1	68.5	.0	.0	.0	1.000	.0	.0	.0	
2	68.5	.0	.0	.0	1.000	108.0	80.0	355.0	
AUGMENTATION DATA									
CENTRAL AZIM. DEGREES TRUE	SPAN DEGREES		FIELD AT AZIM. MV/M		FREQ. kHz		CALL LETTER		CITY
17.0	20.0		12.0		1550		WDLR		DELAWARE
60.0	20.0		74.0						
105.0	70.0		158.0						
265.0	90.0		122.0						
355.0	10.0		17.5						
HORIZONTAL PLANE STANDARD/AUGMENTED RADIATION VALUES									
AZ. DEG	FIELD MV/M	AZ. DEG	FIELD MV/M	AZ. DEG	FIELD MV/M	AZ. DEG	FIELD MV/M	AZ. DEG	FIELD MV/M
0	15.2	60	74.0	120	177.1	180	199.9	240	164.7
10	12.2	70	89.4	130	185.9	190	198.8	250	149.7
20	10.5	80	111.2	140	192.2	200	196.4	260	131.8
30	13.2	90	131.7	150	196.4	210	192.2	270	111.7
40	28.4	100	150.0	160	198.8	220	185.8	280	90.1
50	47.0	110	165.2	170	199.9	230	176.7	290	68.2
CONSTRUCTION PERMIT LIMITS									
AZIMUTH DEG. TRUE	PRESENT MV/M	NEW MV/M	PATTERN MINIMA				PATTERN MAXIMA		
17.0	12.0	12.0	AZIMUTH DEG. TRUE	FIELD MV/M			AZIMUTH DEG. TRUE	FIELD MV/M	
355.0	17.5	17.5	10.5	12.2			14.5	12.4	
			24.5	8.4			175.0	200.1	
			329.0	6.3			355.0	17.5	

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

Table 1. The FCC's standard pattern conversion lists all of the required data to allow an engineer to recreate the antenna pattern for any AM station.

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Double illumination

By Elmer Smalling III

At the request of a reader, this column will be devoted to a process called *double illumination*. This is the process where two video signals share a single, wideband transponder. Double illumination saves transponder costs when a station group or mobile satellite news (MSN) network shares a single transponder.

Most stations who back-haul video from MSN units use a single, dedicated narrowband transponder (standard 36MHz bandwidth) for each feed. This means that a great number of transponders are used at prime feed times and during elections, sports and major news coverage.

A number of new satellites are equipped with wideband (54MHz) transponders. Wideband transponders were originally introduced to support high-speed FM data transmission services or multiple single-channel-per-carrier (SCPC) services.

Sharing a transponder

Although the characteristics of a wideband transponder are similar to a standard 36MHz transponder (other than bandwidth), users asked satellite owners, "Why not put two video signals on a single wideband transponder, and save the cost of a second transponder?" After testing and evaluating, satellite owner/operators determined that users can share a single wideband transponder (see Figure 1), if they are willing to accept a few small trade-offs.

The most serious trade-off problems are chrominance, crosstalk and carrier imbalance. If uplink transmission characteristics are not carefully controlled through adjustment of the uplink's traveling wave amplifier tubes (TWTs), the color from one user's video will interfere with the second user's video and vice versa.

This phenomenon is due to the natural process of amplitude modulation to phase modulation conversion that occurs when two signals share a single non-linear traveling wave tube. The phase modulation of one carrier will cause noticeable flutter of chrominance and



hue during the transmission of saturated colors such as color bars or a brightly colored set.

This disturbance is most noticeable during video that has no motion. Proper transmitter operation can reduce this chrominance crosstalk to an acceptable level ($> 1.5\text{IRE}$ units or -38dB). Because most MSN video is not used for multiple-generation recording or critical post-production, levels as high as -38dB may be tolerable. Video destined for high-quality recording or transmission should be transported on a single transponder at the present state of the art.

The second problem encountered when double-illuminating a transponder has to do with differences in power levels between sharing signals, called carrier imbalance. This imbalance occurs when one of the signals remains constant and the other changes up or down due to overcompensation at the uplink for rain attenuation or improper operating parameters.

The power output of the satellite trans-

ponder can change as much as 5dB if the two incoming signals are not maintained at the proper power level for a particular satellite. This output level may produce unusable video on marginal MSN links. Information relating to illumination signal levels can be obtained from the satellite owner's engineering department.

Proper operation

Traveling wave tubes used as RF amplifiers aboard communications satellites produce proportionately less gain when they are operated near saturation. Power backoff can be decreased at the uplink, thereby operating the TWTs close to saturation but generating minimum chrominance crosstalk.

Backoff is a confusing term that has evolved from satellite technology. When working with TWTs, the uplink's drive power at which output saturation occurs at the transponder is called the input saturation power. The ratio of input saturation power to drive power is called input backoff.

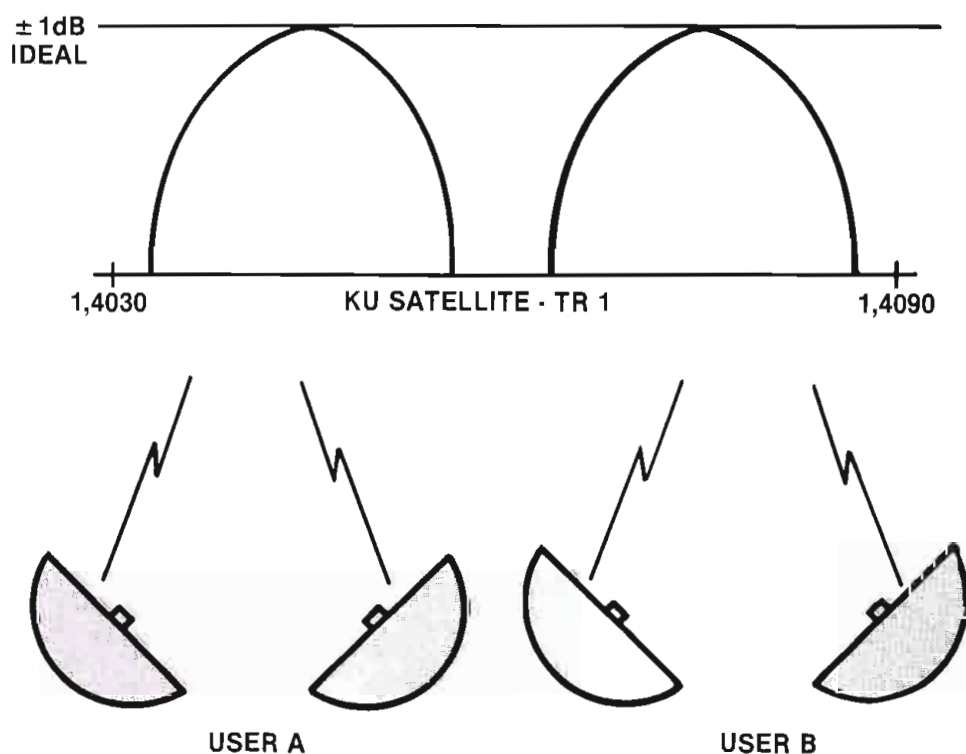


Figure 1. Two satellite users can share a single wideband transponder. An imbalance between carriers will result in unusable video.

Smalling, BE's consultant on cable/satellite systems, is president of Jenel Systems and Design, Dallas.

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Inside digital technology

By Gerry Kaufhold II

The January "Circuits" column introduced many buzz words used to describe various aspects of digital memory devices. Bytes of information are stored in memory cells, and each memory cell has a unique address or location.

When a circuit reads or writes to a memory location, it is called a *memory access cycle*. There are two parts to each memory access cycle. First, the unique address of the memory cell must be decoded to select the particular cell. Second, the data stored in that location is manipulated by either reading the existing data or writing new data. How does a digital memory decode its address?

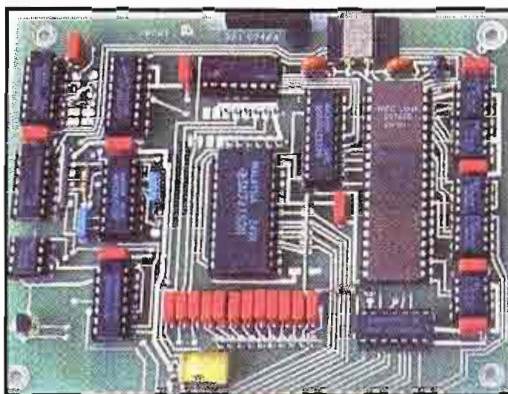
Memory organization

One way to access memory locations would be to design a unique decoder using AND gates and inverters for each memory cell. A decade ago, 16Kbytes of memory were available on a RAM board. Today, more than 500Kbytes of memory fit on the same board. Computer design engineers have created ways to organize memory so that memory decoding circuits are minimized, with the major benefit of more memory locations crowded into a smaller space.

Four-bit nibbles

The least significant nibble of any address contains four bits, numbered 0, 1, 2 and 3. These four bits provide 16 possible combinations of 1s and 0s from 0000 through 1111. A separate 4-input AND gate using inverters on its inputs could decode each of these 16 combinations. However, fewer gates are required if NOR gates are used when most of the bits are 0 (addresses 0000 through 1000) and AND gates are used when most of the bits are 1 (addresses 1001 through 1111).

By using multiple-emitter transistors for AND gates, and single transistor INVERTERS, the address decoder circuit will contain fewer active elements than the memory cell. This will enable more useful memory cells to be put on a



memory device. Note that the inverters are used so that each of the 16 possible combinations will provide only one TRUE output for each decoder gate shown in Figure 1a.

Sixteen sequential bytes of memory are called a *LINE*. The basic decoder circuit will decode the addresses for one LINE of memory, whose least significant nibble ranges from 0000 through 1111.

Next significant nibble

The next significant nibble of an address contains four bits, which provide 16 combinations of 1s and 0s. However, these four bits are used to select 1-of-16 LINES of memory. The circuitry that produces the LINE SELECT signal of Figure

1b is identical to the basic 1-of-16 decoder of Figure 1a. The LINE decoder is connected to address lines 4, 5, 6 and 7, and its outputs go to LINE SELECT gate.

If the circuit is wired as explained, the least significant 8 bits of an address bus can select 1-of-256 unique locations. This arrangement is so important that each 256-byte block of memory is called a *PAGE* of memory.

By connecting the same 1-of-16 decoder to address lines 8, 9, 10 and 11, a total of 4,096 unique locations can be accessed. By connecting another 1-of-16 decoder to address lines 12, 13, 14 and 15, 65,536 bytes can be addressed.

Next month: control signals and timing.

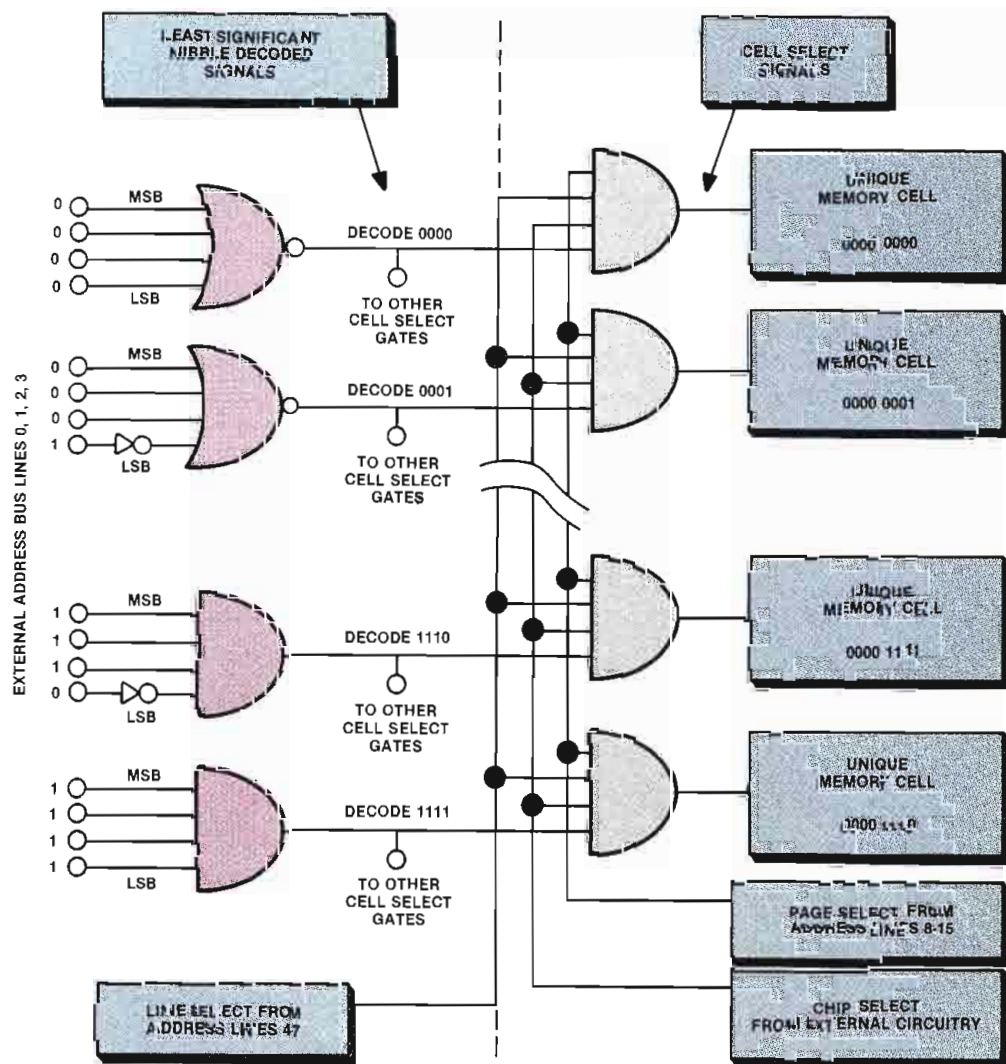
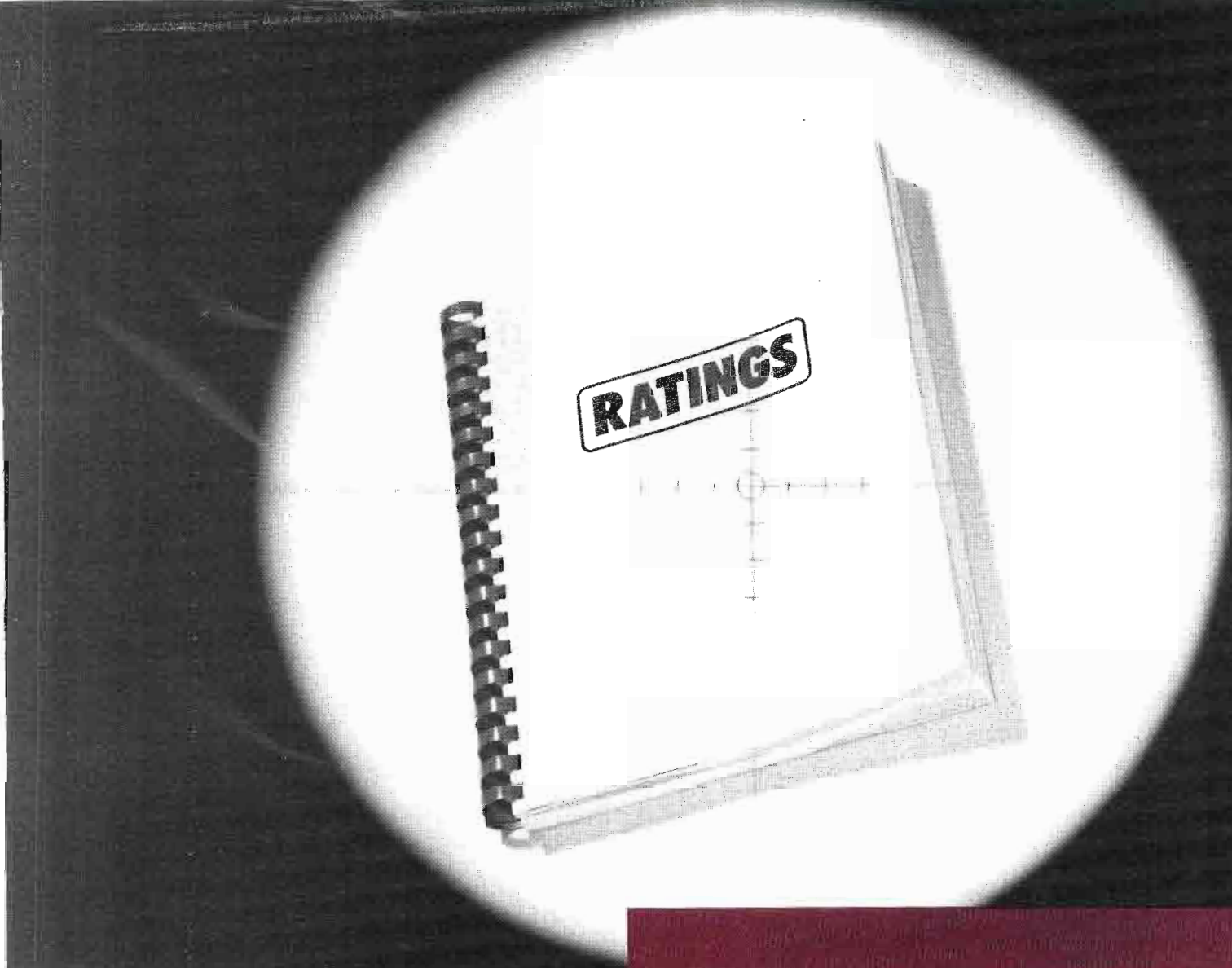


Figure 1a. Basic 1-of-16 decoder circuit using NOR gates, AND gates and INVERTERS.

Figure 1b. The output of a basic decoder ANDED with LINE SELECT, PAGE SELECT and CHIP SELECT signals. [1:~>))))]

Kaufhold is staff engineer for KAET-TV, Tempe, AZ.



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Test instruments can be rented

By Jack Cunningham

Not so many years ago, the title of "broadcast engineer" was synonymous with multifaceted genius; an individual who could operate, test and repair every electronic and mechanical widget at a broadcast station, any time of the day or night. Of course, this genius could also fix the general manager's TV set and the station's coffee pot. The defensive weapons in the wizard's arsenal were a soldering iron, VTVM, signal generator, general-purpose oscilloscope, mutual conductance tube tester and a stock of spare resistors, capacitors, wire and tubes.

Today, broadcast engineers, like the equipment they use, have become highly specialized. Specialization comes with the evolution of technology. From a business perspective, the primary negative impact of specialization is increased costs. Specialized people ultimately must be hired or trained, and specialized equipment is required for them to apply their special skills.

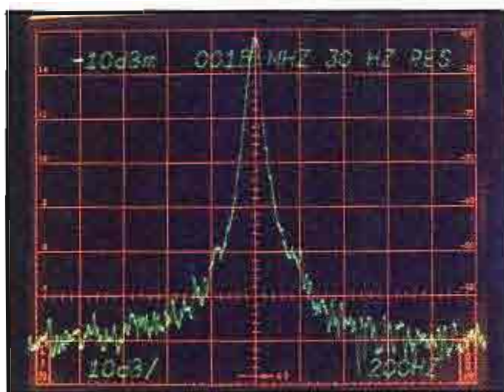
Few broadcasters, if any, can afford to purchase all the test instruments they would like to have. If your station could afford to buy all the test equipment it ever needed, keeping pace with the regular introduction of new and better test instruments would require a test instrument specialist and an unlimited budget.

Consider renting

There always seems to come a time when a particular, sophisticated test instrument is called for when recalibrating a circuit after component replacement. Perhaps you need to troubleshoot an intermittent logic problem with a digital storage oscilloscope or a logic analyzer. Usually, the instrument you need has little use around your plant for any purpose other than troubleshooting a typically uncommon problem. If the right instrument is not on your shelf, what do you do?

Virtually all types of test equipment are available from various rental companies. A phone call to any of a number of local or nationwide rental companies

Cunningham is senior vice president and general manager of U.S. Instrument Rentals, San Mateo, CA.



can fulfill your requirements. Many rental organizations maintain an inventory of nearly all items listed in leading test instrument sales catalogs. Once you establish credit, most instruments can be on your bench tomorrow morning, via overnight air freight.

As discussed in previous "Troubleshooting" columns, logic analyzers, digital oscilloscopes and other high-ticket test instruments are tremendously helpful from time to time for successful in-house repairs, troubleshooting and installations. It may be impractical or impossible for your station to invest in these devices, however, if they are needed only on rare occasions.

When renting, specific equipment costs can be isolated and may be assigned directly to individual projects. In this way, special equipment costs can be borne directly by the project or department that specifically benefits. Purchased equipment must be capitalized over a number of years as a charge against future earnings.

Depending on how your budget and your company are organized, renting test equipment may provide certain tax advantages, and it may be possible not to charge the rental to your capital equipment budget.

How rental works

Rental companies maintain permanent stocks of all kinds of test instruments and accessories. In most cases, facilities that rent test equipment also calibrate, maintain and rebuild instruments to meet manufacturers' specifications. Warehouse, shipping and calibration activities are usually integrated at one location, providing immediate access to ready-to-use equipment.

A rental company specializes not necessarily in sales, but in the application of instruments it owns. The company has the product knowledge and experience to readily answer technical questions about its instruments.

Test instruments can be rented for terms as short as one week, or as long as several years. According to industry sources, typical rentals range from three to eight months. A ballpark approxima-

tion of a 1-month rental ranges from 8% to 10% of the purchase price of the unit. This cost depends on what you rent, and for how long. Your actual cost could vary considerably, depending on the situation. As always, it pays to shop around.

During the rental term, the user is free from problems related to maintenance or service of the instrument. Most rental companies will replace a malfunctioning unit with an identical one, at no cost to the customer.

At the end of the rental term, equipment can be returned, renewed, upgraded or sometimes purchased outright. Some rental companies offer equity buildup plans. These plans allow the user to accrue equity in an instrument while it is being rented. The accrued equity then can be applied to the equipment purchase, or a predetermined portion of the equity can be swapped for purchasing or leasing a different instrument.

Rental companies also may be a source for the purchase of new and used test equipment. Most companies offer warranty protection on their used instruments and immediate delivery from stock.

Given the high price tags of most test equipment, it is critical that the test instrument is right for the job. Rental, among other things, permits you to try before committing to purchase, at no obligation. Renting also enables you to test comparable instruments, in your own environment, without sales pressures. In this sense, even those who prefer to purchase may benefit from the rental alternative.

Editor's note: The preceding was adapted from an article appearing in *Electronic Servicing and Technology* magazine, an Intertec publication, January 1987.

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Management for engineers

Managing the maverick

By Brad Dick, radio technical editor

Most staffs have at least one person who is known as being, for lack of a better term, independent-minded. This person may be difficult to direct and more than a little outspoken. As a manager, how do you handle someone who feels a need for more independence than you would like?

Case study

Chris is a dynamic employee. He usually tackles projects with 100% enthusiasm. Because he is known for being able to deliver, he is often assigned to last-minute or complex projects. His supervisor knows that if Chris is assigned to a task, it probably will be accomplished on time and with close attention to details.

Although Chris might at first seem to be an ideal employee, his behavior at the station sometimes creates problems. Even though he is able to accomplish a lot of work, he dislikes a team approach to projects. Chris likes working on his own, at his own pace and on his own schedule.

When completing an important or timely project, he often works late, on weekends or even at home. While the other engineers keep regular business hours, Chris is known for coming to work later than others. He seldom follows an 8-to-5 schedule, which is resented by his fellow employees within the station.

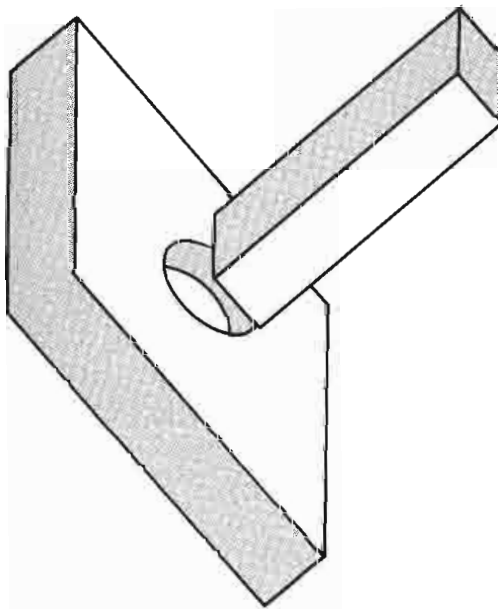
Chris also is outspoken. He likes to set his own agenda and decide how he will complete projects. Staff meetings sometimes turn into battles as other engineers complain about his tactics. To some of them, it seems they have to follow directions while Chris is left to do as he pleases.

Although Chris is a talented engineer, he is also a loner, tending to work alone and at his own pace. This type of person is often seen in technical environments such as broadcast stations. An independent-minded employee like Chris can easily acquire the label of being troublesome and uncooperative.

Tim, his supervisor, finds him difficult to direct because of the conflicts. Sometimes Tim's directives to Chris go

unobeyed. In some cases, when he makes suggestions to Chris on how to proceed on projects and drops hints about what is expected, Chris simply ignores them. Chris shows no intention of changing his behavior.

An important fact in this matter is that Chris was originally hired for his special expertise in computers. He is seen as the "fair-haired boy" by upper management. He also has a higher salary than some of the other engineers who have more seniority than he does.



Is there really a problem?

If you are confronted with a similar situation, first be sure there is really a problem. Is it the person's personality or performance that you don't approve of? If it's the personality, no action may be required. If, on the other hand, the person's performance is not meeting the company's needs, some action or discussion may be needed.

Often, a person who holds unorthodox opinions, is unwilling to fraternize or who fails to conform to an organization pattern is labeled as a maverick. Once such a label is attached to a person, it becomes difficult to see past it. The employee becomes branded with the characteristics of that label, even if there is later a change in behavior.

As a manager, examine the overall situation. If you discharge a troublesome

employee, everyone loses—you, the employee and the station. Conversely, if the employee remains productive on the job, you have retained a valuable resource for the station. Step back from the immediate issue to get a broader perspective before making a decision.

If you determine that the employee is not meeting the job requirements, it is your responsibility to deal with the situation. Be warned that dealing with a strong-willed employee who knows he is valuable can be difficult. This does not necessarily mean using a kid-gloves approach, but it also doesn't mean that you have to lock horns with the person over every issue.

Common ground and custom tailoring

In an example such as this, it is important to establish some common ground between the two parties. Sometimes an understanding can be developed through candid discussions. If the two parties can find at least one topic upon which they can agree, a basis is formed for future agreements.

The common ground may not even address the current issue. It may center on something as simple, yet important, as mutual needs. The manager will need to direct the discussions. The employee may not be looking to negotiate a settlement. Often, the employee is just looking for a "yes" answer to a specific request.

Tailor your approach to the individual and look for meaningful ways to reward. This will mean finding out what each employee finds important. It is obvious that Chris values his independence. What steps could Tim take to address this issue, without creating more problems?

This does not mean to indulge in special treatment, but rather, custom treatment. Once you identify what type of work and rewards are meaningful to an employee, you can design appropriate incentives. Properly used, these can greatly improve an employee's performance.

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Digital graphics from the inside out

By Carl Bentz,
special projects editor

**Outside, graphics
equipment must be easy to
use, transparent and fast.
Inside, complex hardware
and software achieve the
external design goals.**

How do you draw a circle, or even a straight line? Forget using the compass, straightedge and pencil, because this is to be done mathematically on a TV screen.

If you have taken an analytic geometry course, you may recall the general equation for a straight line:

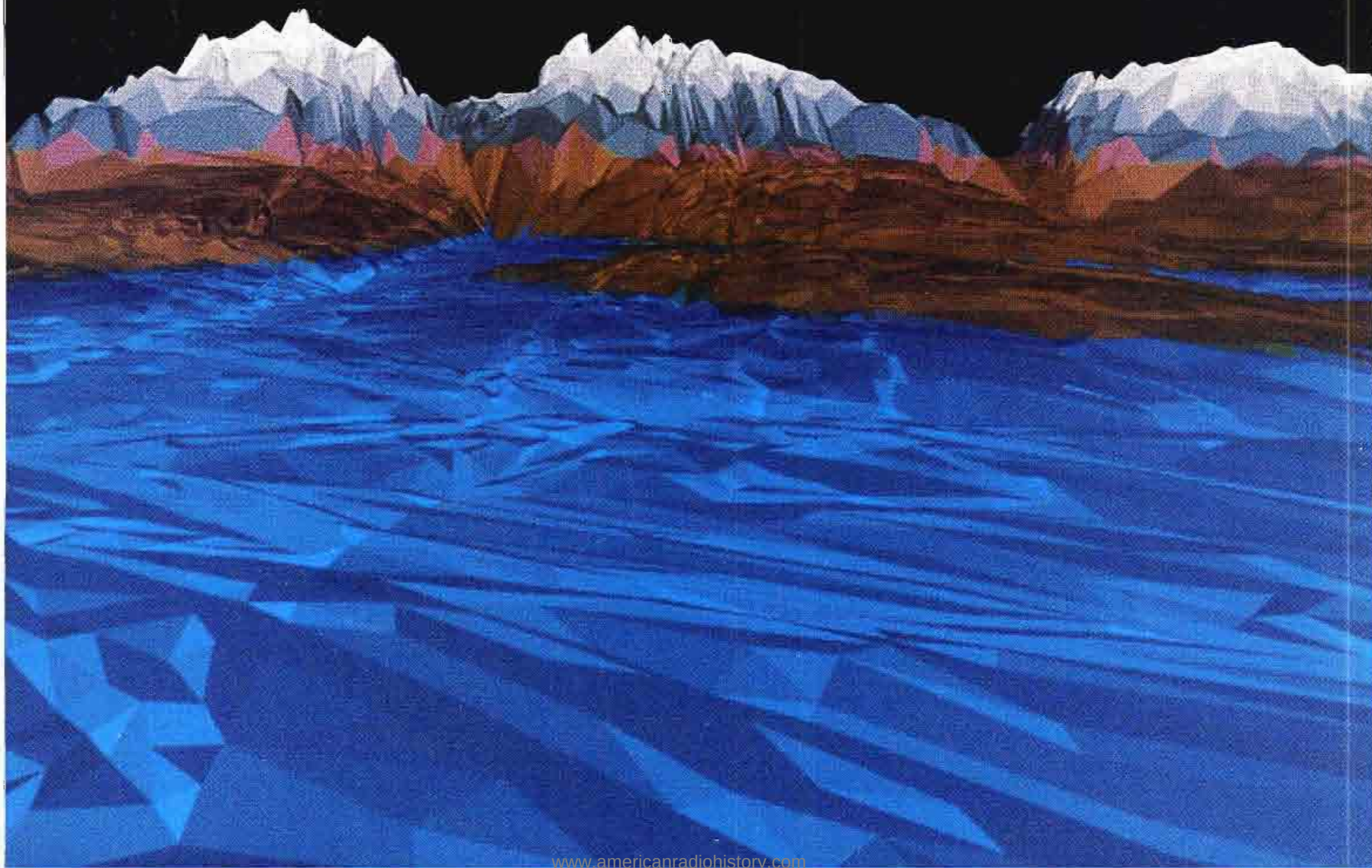
$$y = mx + b,$$

or $Ax + By + C = 0$,
where slope $m = -A/B (= \tan\theta)$,
the x-intercept is $-C/A$ and the
y-intercept b is $-C/B$. See Figure 1.

The locus (or plot) of all points (y) given by the product of slope (m) and variable (x) added to constant (b) describe a straight line. Constant (b) is the point at which the line crosses the Y-axis when $x = 0$. Constant (m) is the slope of the line, the ratio $\Delta y/\Delta x$ or tangent of the angle the line makes with the X-axis.

If you know m and b, you can draw a line on graph paper without calculating y for each x. Designate X- and Y-axes, locate point b, and by counting squares according to m, draw a line through b with slope m.

A computer could be used to determine y for each x between two points. For the points, $P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$, first find the slope



by finding the differences

$$\Delta x = x_2 - x_1$$

and

$$\Delta y = y_2 - y_1$$

Their ratio is $m = \Delta y / \Delta x$.

With BASIC, you might write the following:

```
5 REM FIND POINTS ON LINE
10 INPUT "X,Y for Point 1"; X1,Y1
15 INPUT "X,Y for Point 2"; X2,Y2
20 INPUT "# of X values between P1,P2"; N
25 INPUT "Line crosses Y-axis at"; B
30 DX = X2 - X1; DY = Y2 - Y1
35 DN = DX/N
40 PRINT "X-value Y-value"
45 FOR X = X2 TO X1 STEP DN
50 Y = X*DY/DX + B
55 PRINT X,Y
60 NEXT
```

The program prints columns of x and corresponding y values on the screen. From the table, you could plot the line, but why not let the computer do a screen plot? You can use a period (.) for each point.

Immediately there is a problem. The computer moves down one screen line for each print statement

not followed by a comma (,) or semicolon (;). To simplify the problem, define x as the vertical axis (the left side of the screen) and y as the horizontal direction. Confine y between 0 and 40.

To determine where to place each dot on a 40-space line, you can use a `PRINT TAB(y);"` statement. A maximum of $y = 40$ keeps the point on the screen line. If y is small, it will be near the beginning of the line. The location of the point from the left will be at $y' = (40 - (40 - y))$. You can replace line 50 of the program with:

```
50 PRINT TAB(40-(40-y));"
```

The plot produced by the program is coarse, because the point resolution involves X - Y character matrix blocks. This might be alright for some projects, but drawing a picture with such a program would be unsuitable. A way must be found to control the individual dots that make up a character, that is, to *bitmap* the drawing for increased resolution. Obviously, a more complex program is needed. If you own a personal computer, you probably have a graphics program that will do all this for you.

The general formula for a circle with center (c) at point $P(a,b)$ and radius (r) involves *squared* variables. That is,

$$(x-a)^2 + (y-b)^2 = r^2$$

For simplicity, place the center of the circle at the origin of the graph $P(a,b) = (0,0)$, leaving only

$$x^2 + y^2 = r^2$$

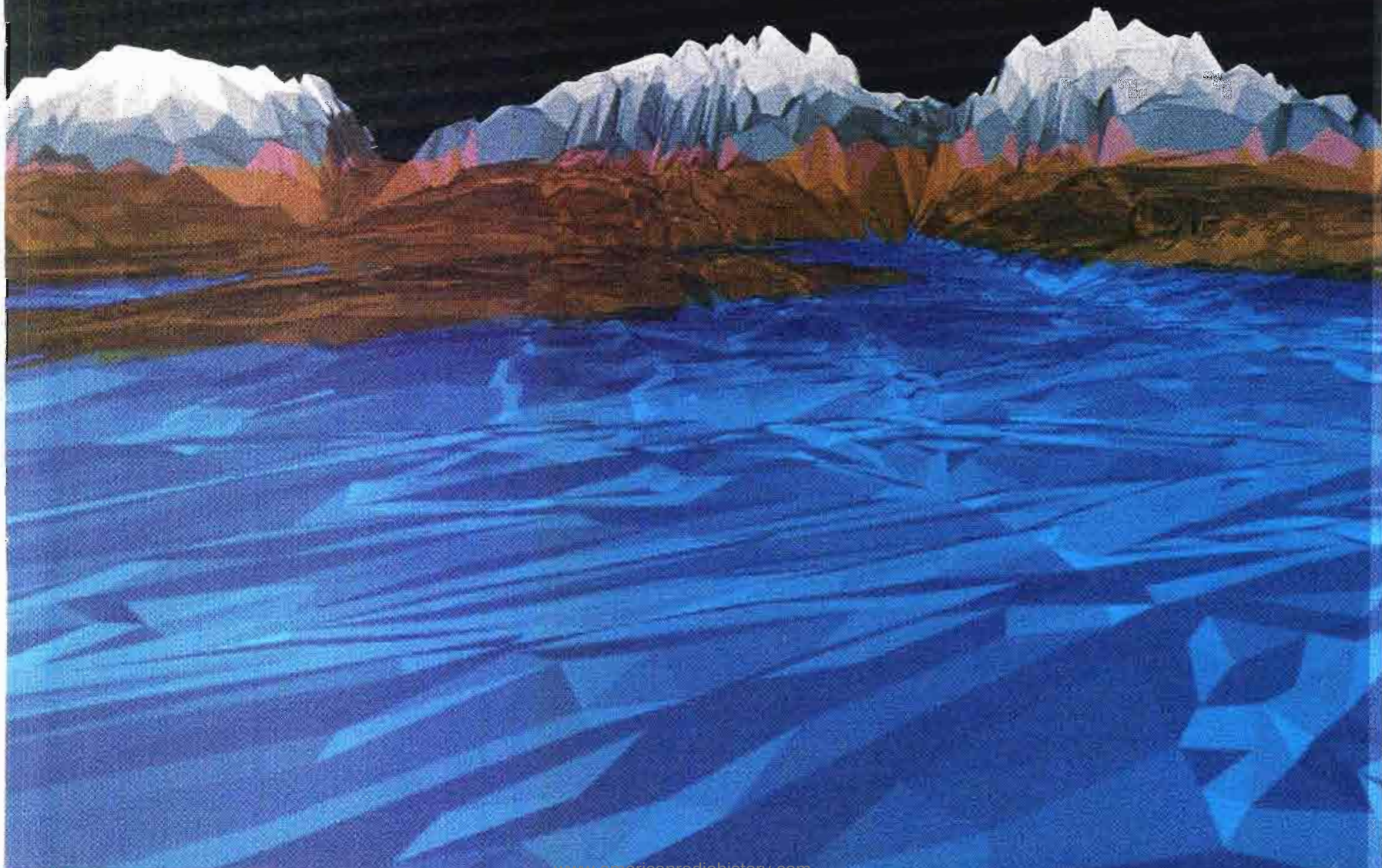
This can be solved with y as a dependent value,

$$y = (r^2 - x^2)^{1/2}$$

The prime concern is that the value inside the parentheses must remain positive. The square root of a negative number introduces an imaginary value, $i = (-1)^{1/2}$, which presents problems and unusual situations.

Continued on page 26

Advancements in digital processing have made possible a new level of image capabilities. Those advancements are based on computer hardware and the resulting increase in data-handling speeds. Equally important are continuing developments in software and applications of research in mathematical analysis. The use of fractals—fractional dimensions—can produce more realistic, yet artistic, surfaces. (This image was produced on the BTS FGS-4000.)



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Continued from page 23

Similar equations can be used to describe the ellipse, parabola and hyperbola. However, the fact remains that calculating points to plot a geometric figure directly to the screen usually does not produce the quality of graphics you would like to broadcast.

Algorithmical solutions

At the core of high-quality video graphics are a number of procedures called *algorithms*. These processes,

depending upon the problem to be solved, may or may not be defined by familiar mathematical formulas. For example, consider a Bresenham algorithm originally prepared to control an X-Y plotter. See Figure 2.

Assume you want to produce the line L1. You are limited to drawing with the eight horizontal, vertical and diagonal line segments shown in the inset.

If the problem was to draw line L2, with a whole number slope of 1, the problem would be trivial. To draw L1

with a slope of 3/5, you need to approximate or find the best fit. The method used is an algorithm.

The line, drawn by the computer, consists of segments, three M₂ and two M₁. Which segment is used is determined by the distance from the desired plot L1 to the mesh points on either side of that line. Mesh points closest to L1 will produce the best-looking straight line.

Let D₁ (0,0) be the origin, while D₂ (a,b) is the other end of L1. The differences are $\Delta a = x_2 - x_1$ and $\Delta b = y_2 - y_1$. Movement from D₁ to D₂ is toward increasing a and b, so that $\Delta a > 0$ and the ratio $m = \Delta b / \Delta a$ exists.

Assume that plotting moves to point P_{i-1}, segment M₂ providing the best fit to start. The next step is either segment M₁ (if $r < q$) or M₂ (if $r > q$). All of the shaded areas are similar triangles, so that $(r - q)$ always has the same sign (or sense). You can develop a formula $\nabla_1 = (r - q) \cdot \Delta a$ to determine if the next appropriate segment is M₁ or M₂.

For the computer, the algorithm requires several statements:

1. $\nabla_1 = 2\Delta b - \Delta a$
 $\nabla_{1+1} = \nabla_1 + 2\Delta b - 2\Delta a$ if $\nabla_1 > 0$
or $\nabla_{1+1} = \nabla_1 + 2\Delta b$ if $\nabla_1 < 0$.
2. $\Delta a = x_2 - x_1$, $\Delta b = y_2 - y_1$.
3. If $\nabla_1 < 0$, execute M₁,

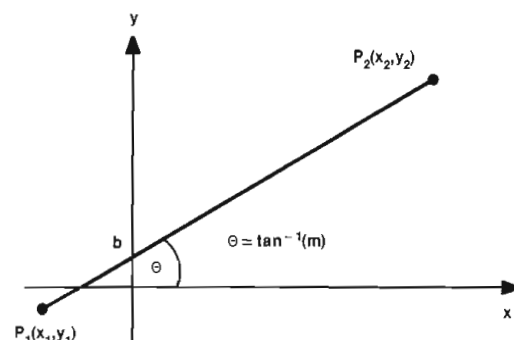


Figure 1. A straight line may be described on x,y Cartesian coordinates by two points, by the y-intercept (b) and an angle θ or by the intercept and the slope. The same concept may be used to illustrate imaginary numbers involving $\sqrt{-1}$, that is, $y = y \sqrt{-1}$.

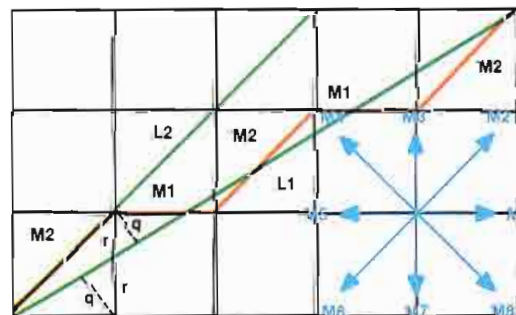
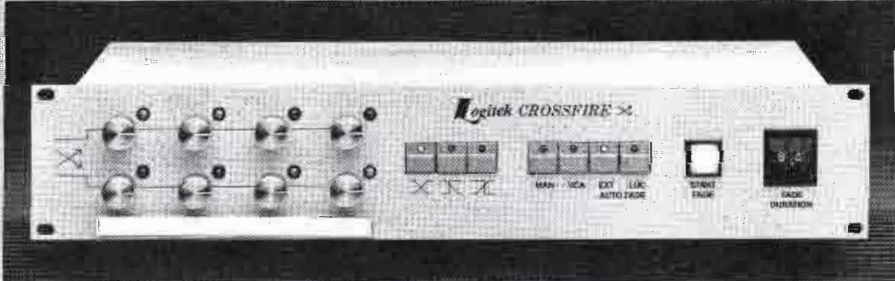


Figure 2. Magnified, the Bresenham algorithm to draw a line on an x-y plotter reveals a number of line segments, rather than a single continuous line. The line segment that fits best is determined by the nearest mesh point. Segments M1 to M8 are possible (see inset).

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or if $\nabla_1 > 0$, execute M_2 ,

for all $i = 1, \dots, \Delta a$.

For a point P_2 , such that $\Delta a < 0$ or $\Delta b < 0$ or both, the procedure must be modified.

Once the initial calculation is concluded, the instruction for drawing the line has been converted to and stored as a vector. The vector includes a starting location, the number of vertical steps necessary for each horizontal step and a length. If the line of Figure 2 were part of a letter, then many other such vectors would also be needed to define the character shape.

Unless you are accustomed to mathematical analysis, the algorithm probably appears to be much more complicated than the equation for a line. However, because computer operations are all accomplished through logical functions, the algorithm is a more efficient and much faster method.

Drawing a circle follows a similar method. The circle will consist of a number of straight lines. For a smoother circular curve, more line segments are involved.

To make the system usable by a non-mathematician, the graphic software requests two points to draw a line. For the circle function, the operator is prompted to enter two key points, the location of the circle's center and the length of the radius. The points may be entered from a bitpad, keyboard or from other input devices.

When initial calculations are concluded for the circular object, a plethora of vectors are stored in memory. Each contains a start point, a vertical/horizontal step ratio and a length.

Introducing matrices

Moving a line on a graph can be accomplished in at least two ways. You can give the line new X-Y points, or you can move the axes, the frame of reference. Suppose you move the origin so that the new X- and Y-axes are parallel to the original ones. Coordinates of the new origin, with respect to the original one, are $x = h$ and $y = k$. The x' and y' will be coordinates for points on the new reference. That is,

$$\begin{aligned} x' &= x - h \text{ or } x = x' + h \\ y' &= y - k \text{ or } y = y' + k \end{aligned}$$

COMBINED (FINAL) MATRIX						
1	0	0	X	$ZfxSxcos$	$ZfySxsin$	0
0	1	0		$-ZfxSysin$	$ZfySycos$	0
$-Cx$	$-Cy$	1		$Zfx(Tx + Cx)$	$Zfy(Ty + Cy)$	1
				$-ZfxWymin + Vxmin$	$-Wymin + Vymin$	

Figure 3. Using matrix arithmetic, the viewing and object transformation matrices combine to form the final transformation matrix.

If you wish to turn the X- and Y-axes through some angle to make the figure move, then a rotation angle Θ is needed in the new coordinates. The new point(s) involve trigonometric functions.

$$\begin{aligned} x' &= x \cos \Theta + y \sin \Theta \\ \text{or } x &= x' \cos \Theta - y' \sin \Theta \text{ and} \\ y' &= y \cos \Theta - x \sin \Theta \\ \text{or } y &= y' \cos \Theta + x' \sin \Theta \end{aligned}$$

The graphic art system again turns to algorithms for fast methods of solving the problem. The object (the line or circle) usually is moved from one location to another immediately, because the system needs to make only one calculation to place the object at the new location — the original x,y values plus their offsets.

In digital effects and animation, you may want the object to move smoothly from one location to another over a time of n frames. A new calculation of each line segment or point is required for each frame during the time segment.

The algorithms for such problems often involve *matrix algebra*, a special branch of mathematics. A matrix is an array of numbers that represent variables of mathematical equations. (See Figure 3.) Matrix operations follow specific rules, but can be programmed for rapid calculation in the graphics computer. Several matrices may be involved in one video effect.

An example is the problem of making an object turn in 3-D space, with proper dimensional perspective. In such a case, a product of several matrices involves the original x, y and z locations, any centers of rotations around x, y and z axes, any other object translation instructions (in x, y and z terms) and any additional perspective scaling procedures (also needing x, y and z terms).

Although matrix calculations for a 3-D effects movement are computation-intensive, not every matrix necessarily changes at the same time. Also, high-order matrix problems can be simplified by breaking them into several small ones. The smaller calculations are relegated to separate microprocessor systems operating in parallel. Such an approach is often called *pipelining*.

The X-Y data and instructional ingredients are poured into one end of the pipeline. All required operations are

determined by fader positions or the buttons selected on the graphic system control panel. At the end of the pipe a new set of X-Y values emerges to determine how and where information is displayed on the screen.

In mathematical terms, you would say that all X and Y values from one universe have been mapped onto a second universe according to a set of mapping instructions. (See Figure 4.) If the mapping involves a rotating plane, the instructions also include effects that perspective causes in each new x,y point.

Adding color

It is hard to imagine that pixels have not yet entered this discussion of graphics. Certainly, mapping for 3-D effects involves moving and combining pixels, but many calculations must be done before pixels are considered. Filling an area of the graphics screen with color likewise deals first with a series of calculations.

To fill a shape on the screen (see Figure 5), the polygon is broken into a list of edges. The edges are sorted from top to bottom, referenced to the topmost vertex point. Then, starting with the topmost edge, step down by scan lines, generating all edges as they intersect the current scan line.

Along each scan line, edges are sorted in left-to-right order and the scan is filled between each odd-even pair, starting at the beginning of the list. When the bottommost vertex is reached, the process ceases. As the fill proceeds, the result is directed to the display memory or frame

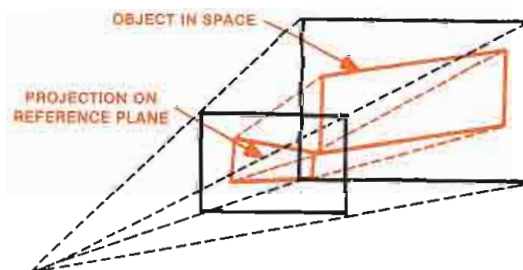


Figure 4. For the viewer to see 3-D effects, the object in virtual space must be projected onto the reference plane with correct perspective mapping functions.

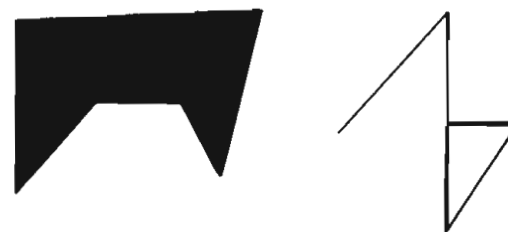


Figure 5. Fill procedures require that for every odd (toward the left) edge point, an even (to the right) point exists. In the figure on the right, a fill of the right triangle would work. An attempt to fill the left side would flood the screen.

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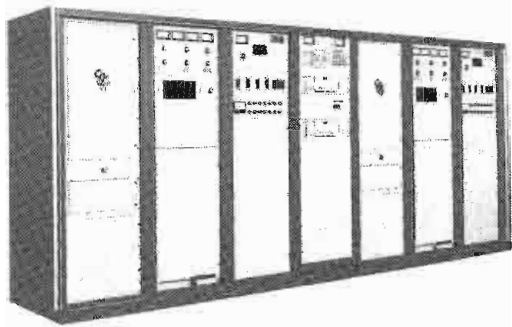
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buffer of the graphic computer.

If an odd number of edges along a scan line results in the sort, a problem exists. Consider the second object in Figure 5. As the fill scan proceeds, it finds odd-even pairs. Then, another odd point at the right initiates filling. But as the scan moves, no even point of a pair exists. The fill moves outside the defined object. Before the algorithm stops, it fills the entire screen. Depending upon the fill algorithm used, the order by which parts

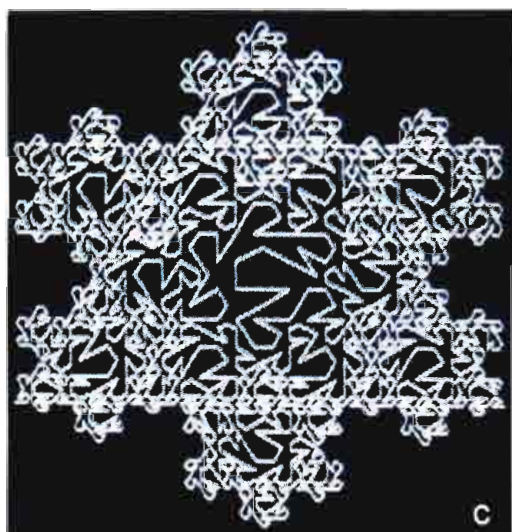
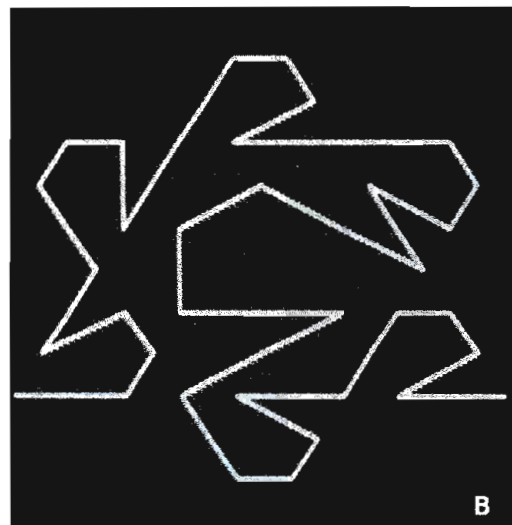
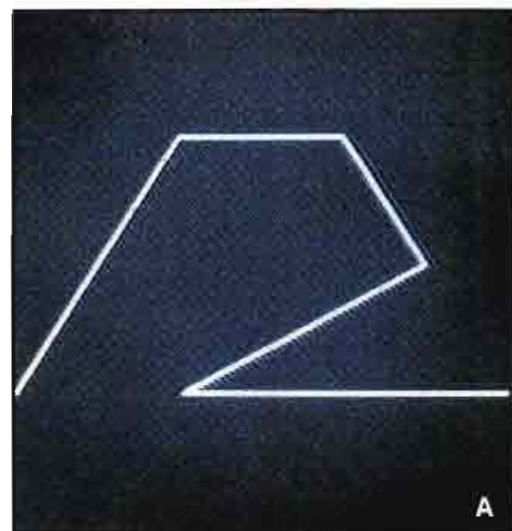


Figure 6. To create a fractal, start with a generator shape (a). The generator is then placed on each side of itself (b) over and over to form a complex pattern (c).

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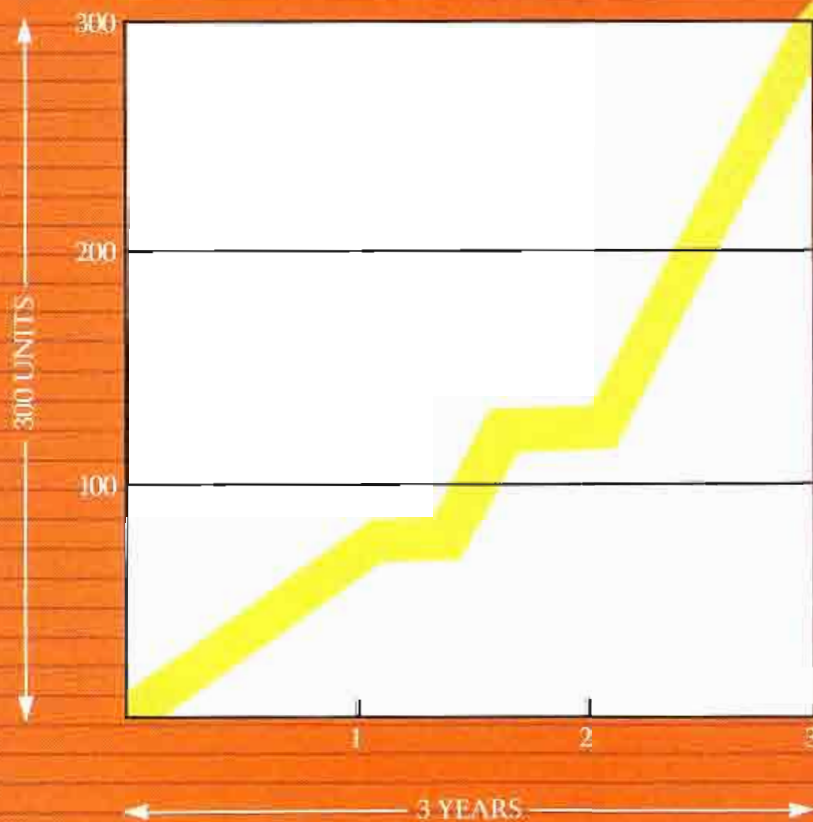
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Figure 7. Mandelbrot sets involve the complex number plane. If each of the small black nodules were magnified, each would have the same shape as the large black area.

receive color may sometimes appear quite unusual.

Nature by the numbers

Stylistic graphics are quite suitable for some presentations, but often the director wants the image as natural as possible. Many shapes of nature follow

mathematical equation precision. Of particular interest are shapes that appear to be generated by repetition. The popular term *fractal*, from fractional dimension, was coined by IBM research mathematician Benoit Mandelbrot, who investigated this unusual area of mathematical curves and surfaces. Fractals produce highly realistic images of rugged mountainous surfaces, random plant growth or planetary landscapes.

The concept of fractional dimensions does not follow the ideas of ordinary geometry. Consider a straight curve (line) as 1-dimensional, or having only length. If the curve is infinitely long and curves about in such a manner as to completely fill an area of the plane containing (and confining) it, the curve could then be considered 2-dimensional. If the curve only partially fills the area, it has a fractional dimension; that is, it is between one and two dimensions.

Fractals may be self-similar or self-replicating. In other words, starting from a generator or building block, the same block is used over and over to create a curve or shape. See Figure 6. Two types of self-replication curves are possible — self-contacting or self-avoiding. The first type allows contact, but not crossing, of the curve. Self-avoiding curves do not touch, although resolution limitations of the screen may indicate that touching occurs.

Another type of computer-generated images are *Mandelbrot sets*. (See Figure 7.) Mandelbrot sets involve complex numbers with $(-1)^{1/2}$, which may be plotted in complex space, that is x, y and iz. Values in certain regions of complex space behave in unusual ways when they are squared and the result is added to the original value. A point may grow rapidly compared to neighboring points, or it may not change at all. A region of the complex plane where this occurs is the Mandelbrot set. Like fractals, Mandelbrot set figures are characterized by repetition of shapes.

Realistic surfaces

The quest for visual realism in video images has resulted in 3-D rendering of surfaces. To make a surface *look* real, the apparent reflection of light from the surface must seem natural. Various approaches include those described by mathematicians Phong and Gouraud as well as a procedure called *ray tracing*.

If light strikes an object at angle θ , it is reflected from the point of incidence at an equal angle θ , as shown in Figure 8. On a flat, polished mirror surface, an image reflection of the light source can be seen. An unpolished surface reflects light in the same manner, but the reflecting efficiency varies with the nature of the surface. Although the angles of incidence

Continued on page 36



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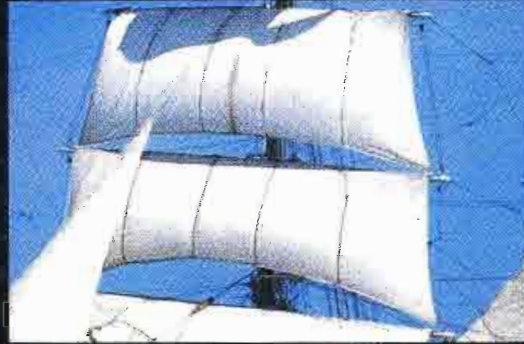
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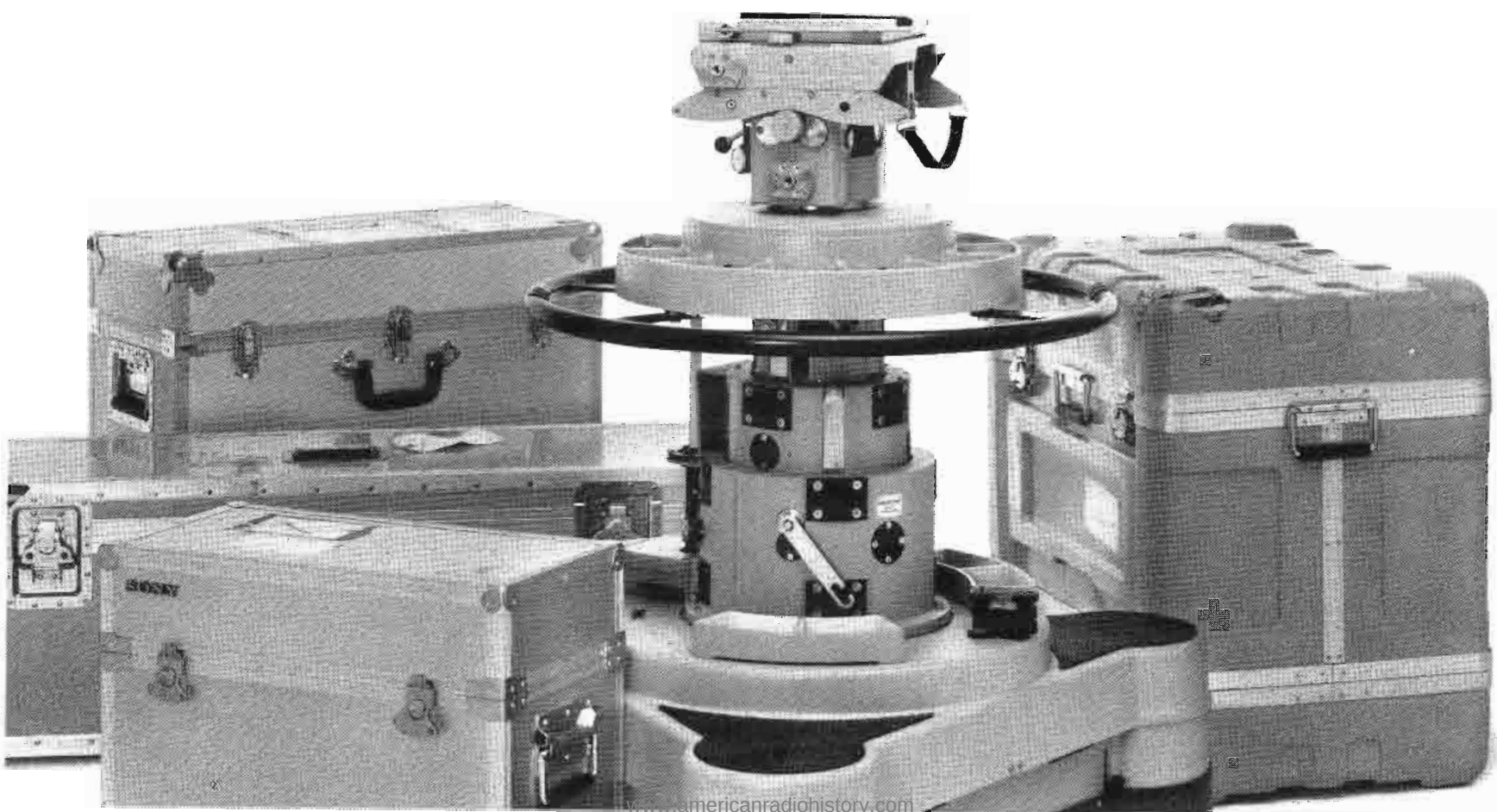
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Continued from page 32

and reflection remain equal for each ray of light, reflected light is scattered because the surface is no longer *flat*. The diffuseness of the incident light striking the surface adds to the overall effect.

Reflected light (FL) at a point is determined from the Lambert formula:

$FL = IL \times \cos\theta \times RC$,
where IL is incident light and RC is a reflection coefficient of the surface.

To produce dimensional shading, first break the surface into a myriad of small surfaces. (See Figure 9.) If shading were determined strictly by the Lambert formula, edges of the polygonal surfaces would be apparent. To avoid visible edges, the Gouraud algorithm develops normals (lines perpendicular to the surface) at each edge. Applying a reflection calculation at these additional points effectively removes the edges and the entire surface appears smoother.

The algorithm attributed to Bui Tuong Phong builds upon the Gouraud procedure and provides specular reflection, as on polished glass or metallic surfaces. With more exacting interpolation at edges and by controlling modulation of reflection according to preferred loca-

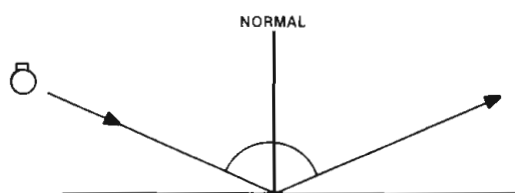


Figure 8. The general law of light reflection is that the angle of incidence is equal to the angle of reflectance, referenced to the normal from the surface.

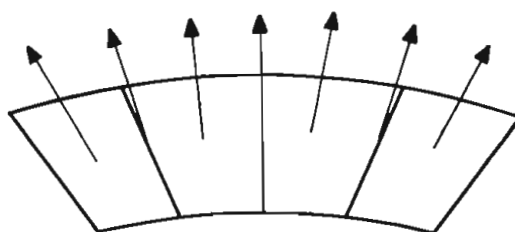


Figure 9. A complex graphic surface is divided into polygons. More polygons make the image smoother. If normals are interpolated upon the edges between polygons, the edges disappear, making the surface appear to be completely continuous.

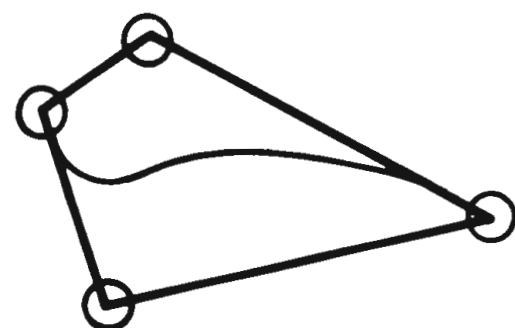


Figure 10. The Bezier curve arranges for the best fit relating the four reference points.

tions of incident light sources, the resulting image becomes more realistic.

The Phong algorithm provides for each pixel to be shaded individually. To do so, the size of the polygons creating the surface becomes finitely small (practically the size of a pixel). Mathematically, the Phong formula ties an additional term to the Gouraud formula. The term introduces a specular exponent to the reflected light. Also, Phong allows multiple light sources. Each can be of a different color and intensity.

Ray tracing brings another concept into the picture. Also involving multiple light sources, ray tracing determines the effect that light reflecting within the scene will have on the image as observed from outside the scene. Any 3-dimensional object in the image may have hidden segments that affect the rays of light. Ray tracing requires even more calculations to accomplish dimensional rendering.

Motion in memory

The calculations necessary to produce a realistically shaded object are computation-intensive. However, the *graphics engine* (dedicated microprocessor subsystems) of the effects unit becomes equally busy, depending upon the complexity of object movement in the digital effect.

A simple linear movement of an object on the effects system requires the orderly use of pixels, one after another, across the screen. Such a procedure should be reasonably straightforward. Interlaced scanning, however, adds a detour. For smooth movement, the address of affected pixels must change with each field of the image. Calculations for pixel addressing must be performed at a speed high enough to allow updating at the field rate.

Curvilinear motion adds another burden to the computer. To determine exactly how curving motion is made between effects key frames, one of two well-known procedures — B-spline or Bezier curves — are often used. The curves named for French engineer Pierre Bezier were developed originally for use on Renault automobiles.

A Bezier curve is defined by four points, P_1 to P_4 , as illustrated in Figure 10. A cubic formula is solved to develop

a smooth, best-fit line relating the four points. With matrix algebra, the graphics computer can make the required calculations rapidly. The Bezier curve for 3-D space in the x direction (referenced to time) is given by:

$$x(t) = (-t^3 + 3t^2 - 3t + 1)P_{1x} \\ + (3t^3 - 6t^2 + 3t)P_{2x} \\ + (-3t^3 + 3t^2)P_{3x} + t^3P_{4x};$$

P_{ix} represents only x coordinate of point P_i . The y(t) and z(t) addresses require the same formula, but with y and z values.

Some believe the B-spline algorithm is more versatile and produces smoother curves. This method also uses a matrix to calculate a more complicated formula. Again, four points define the curved motion at any point. For 3-dimensional work, y and z versions are identical with, $x(t) = (-1/6t^3 + 1/2t^2 - 1/2t + 1/6)P_{x(i-1)} \\ + (1/2t^3 - t^2 + 2/3)P_{x(i)} \\ + (-1/2t^3 + 1/2t^2 + 1/2t + 1/6)P_{x(i+1)} \\ + 1/6t^3P_{x(i+2)}.$

A matter of time

How fast graphic art or effects systems operate may determine their application. For a production company doing animation, in which each frame is recorded on tape as it is completed, real-time operation is not mandatory. Of course, speed is important, because minutes in the production house are counted in dollars.

In the broadcast station, real-time operation with effects also is critical. With the number of calculations required to move a picture linearly across the screen, while it revolves along all three axes and increases in size, a special approach is required to achieve the necessary calculations. One method of achieving greater speed is through *bit-slicing*.

If the graphics equipment operates on an 8-bit-byte architecture, each byte can be broken into four bits. The two smaller data words are handled simultaneously, in parallel, then recombined to an 8-bit format. In a full-color graphic art system, a total of 48 bits may actually be involved — eight red, eight green, eight blue, eight luminance and two additional 8-bit layers for cut-and-paste, transparency and other features. Obviously, bit-slicing already has been done to arrive at

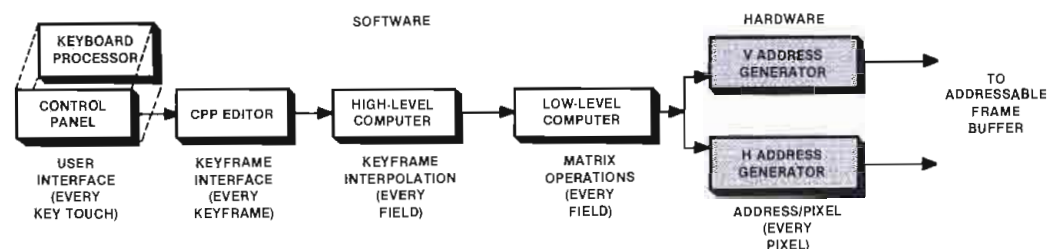


Figure 11. The anatomy of an effects processor shows the speeds at which various sections must do calculations. The greatest speed requirements fall in the address-generator sections. Separate H and V operations and dedicated microprocessors achieve the required rates.

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The keyboard, bit-pad and trackball all are available to the artist for control of editing functions on the Quantel Harry, tying the Paintbox and Encore into a digital production system.

the six image layers. Each will be split again, depending upon the function to be performed.

Another approach to speed is through pipeline techniques, mentioned previously. A series of dedicated microprocessor blocks each are assigned specific tasks. Some of the larger graphic units available today may include 35 or more individual microprocessors to handle the intensive calculations. All are interlinked through an instruction control bus, allowing interactive communication among them. In some designs, RISC (reduced instruction set computer) processors add speed by omitting unnecessary microcode instructions in their repertoire.

A third method of increasing calculation speed is through separation of horizontal and vertical operations. Matrix algebra allows the 2-dimension mathematical processes to be accomplished by simplified means. Separation makes significant improvements in speed. See Figure 11.

Finally, a question causing some debate in the industry is the proprietary computer design vs. off-the-shelf PC software. The PC unit normally has a relatively fixed configuration with limitations as to how its RAM can be partitioned for multiple operations. If, on the other hand, the central processing system and its RAM are configured for the specific tasks they are intended to serve, there are fewer requirements to alter the configuration and overall speed is improved.

Logic says that a proprietary system is probably preferred. Continuing development in computer design may change

that approach to graphic system configurations.

Users vs. computers

According to most graphics system designers, the most difficult part of the system design is not how to draw a 3-D sphere. Rather, it is the interface of machine to human. How can the intense power of 35 separate small computers be placed under the control of a single operator? The answer is, of course, another microprocessor in the control panel with the sole purpose of interpreting a user's desires to the central processing hardware.

Not too many years ago, a mathematical mind was helpful (if not necessary) in operating graphics equipment. Points were entered with a keyboard in x,y pairs. Fortunately, algorithms were already programmed into the computers, but the availability of artistically creative, computer-literate operators held electronic graphic arts in check.

The advent of the bit-pad or tablet, touch-screen control, light pens, trackballs and the mouse caused a major change in who could use graphics equipment effectively. The artist finds nearly every necessary tool is provided by the graphic system through electronics. Little, if any, mathematical background is necessary to produce striking images.

An observation

When the quest into this subject began, a question was put to several graphic system manufacturers. *How does it work?* The response (from marketing people) was universal. *Don't worry about what's inside. You should be concerned only about how easy it is to use.* After a long pursuit, design engineers for several systems consented to discuss non-proprietary details.

In the long run, perhaps the marketing people are right. To fully understand the development of a dimensional sphere on the screen, lighted from sixteen different-colored sources, or the passing of Hamlet's ghost through the solid stone of the castle wall, is beyond the mathematical understanding of most people. Still, there is a fascination about computers and their capabilities that cannot be denied.

Acknowledgment: Abekas Video Systems, Ampex AVSD, BTS Broadcast Television Systems, Hewlett-Packard, Microtime and Quantel assisted in the preparation of this article. A Polaroid FreezeFrame provided some screen photographs from Commodore and IBM computers.

For more information on computers and graphics, helpful general background material may be found in several consumer publications, such as *Compute*, *Compute Gazette* and *Byte* magazines, all available at most personal computer shops and bookstores. *Digital Design* magazine often provides useful information on hardware and the *SMPTE Journal* occasionally includes articles on graphics topics.

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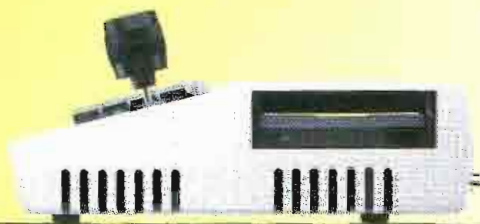
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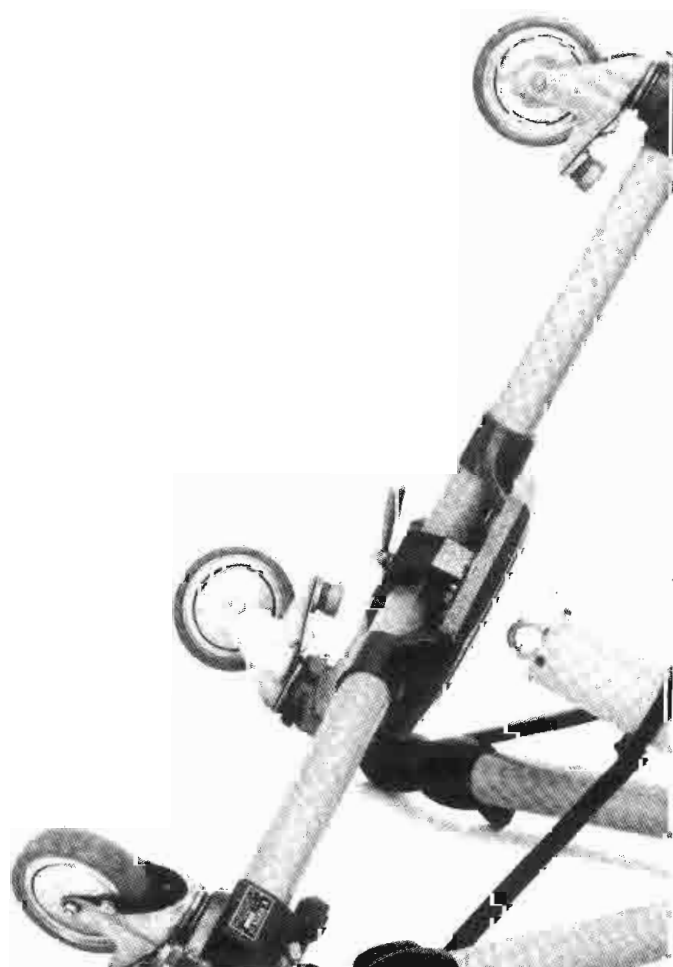
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The all-digital studio

By Ned Soseman, TV technical editor

Digital video opens the door for production trends looking for a place to happen.



Courtesy of Thomson CSF

The control room at the world's first all-digital studio in Rennes, France.

The invention of the wheel and the discovery of electricity marked the genesis of two important technologies. Progress in wheel technology yielded animal-drawn carts and buggies. Newer related technologies, based on the wheel, made motorized vehicles possible. These advancements enhanced man's ability to travel in two dimensions.

Harnessing electricity brought light without flame and electrical communication. As electrical technology proliferated, wireless, radio and television were invented and refined. Phonograph records and magnetic recording allowed the storage and reproduction of electrically generated sound and pictures.

A quantum jump for transportation was the airplane, which transcended 2-dimensional boundaries and the laws of gravity. A quantum jump from analog to digital electronics technology allowed the contrivance of digital computers and the rapid manipulation and management of stored information. In television, worldwide agreement on a single stan-

dardized component digital video code is also a quantum jump, because it is not subject to many fundamental laws previously considered to be as constraining as gravity was to transportation.

We are venturing across the threshold of this new video technology. Like airplanes compare to automobiles, digital video opens a new dimension for technological growth. In this new dimension, as illustrated in Figure 1, many accepted concepts and notions may no longer apply.

The basic postulate of analog electronics, the black box principle, is challenged in the digital domain. This cousin to Murphy's Law declares whatever comes out of a black box is never as good as what went in. The principle renders even the finest analog black boxes (equipment) and analog tape-recording techniques incapable of achieving absolute noise- and distortion-free throughput. In a purely digital world (in which no A/D or D/A conversion is necessary), the digital 1s and 0s don't suf-

fer the black box syndrome of distortion and noise addition, provided predefined data limits are not exceeded. Thus, distortion-free digital throughput can be achieved.

Manufacturers have been well aware of the benefits of digital video, and have been anxious to take advantage of its transparency. Until recently, a void of standards, combined with the limited supply of massive memories required to store and retrieve digital video data, limited the feasibility of bringing such products to the marketplace.

Thanks to the commercial success of computers, larger and larger digital memories have become available at more affordable prices. The timely establishment of component digital 4:2:2 standards has provided the catalyst needed by manufacturers to develop compatible digital video products.

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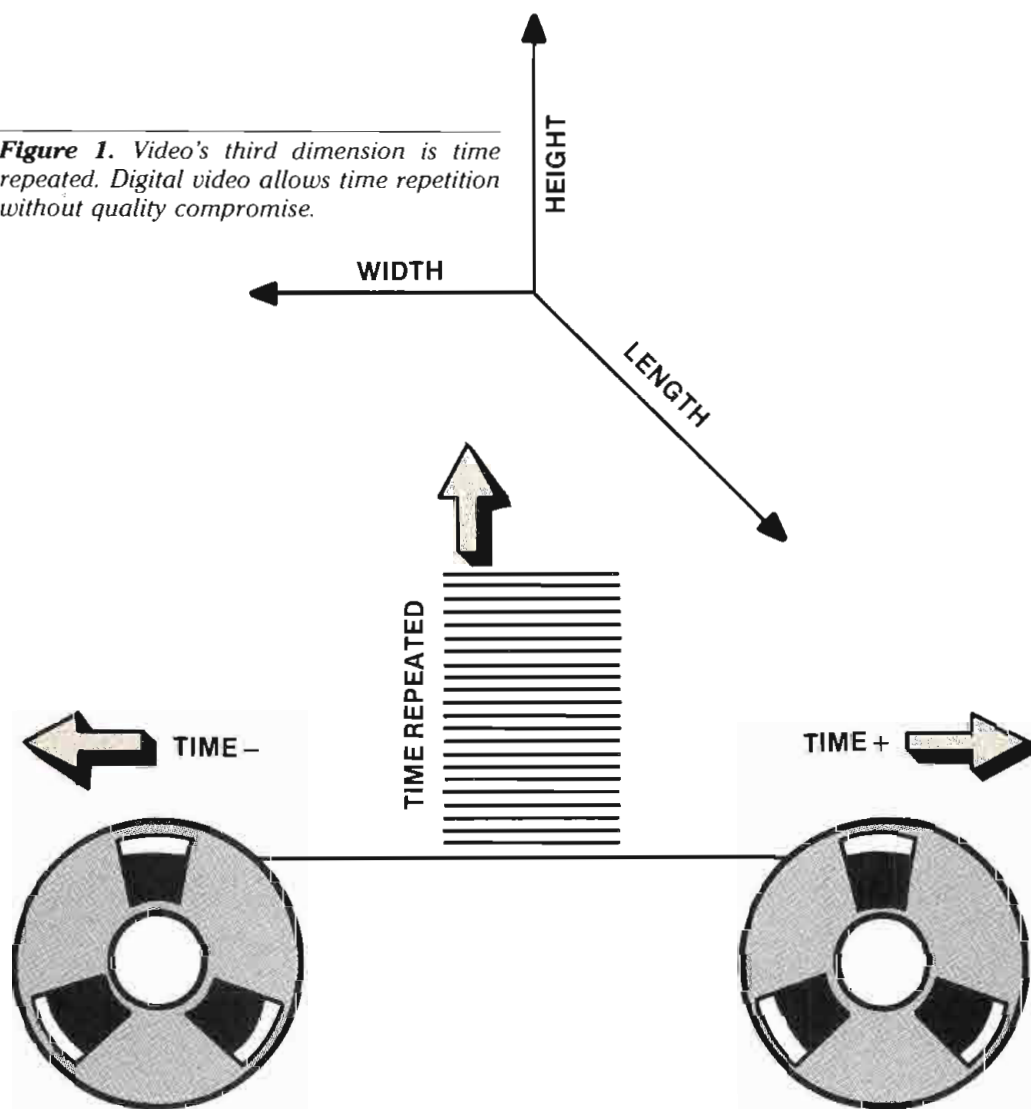
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Figure 1. Video's third dimension is time repeated. Digital video allows time repetition without quality compromise.



production system can be installed.

Beauty and speed

So, why all the brouhaha about digital video when typical viewers watch finished production work on an NTSC TV set, with perhaps a 33dB S/N, 230 lines of resolution and a ghost or two? *Beauty*, in terms of broadcast and video producers, is not necessarily in the eye of the audience, but is the subjective judgment of the producer, director and client, viewing a high-resolution (often RGB) studio monitor.

Since "the magic of videotape" was introduced more than a quarter of a century ago, multiple-generation video production (layering) has been a compromising situation that has intimidated and frustrated producers and engineers. The additional noise and graininess associated with layering is not unique to video. Regardless of format, when layered (composited), film sustains effectively similar additive noise and technical maladies.

Ubiquitous demand for layering has inspired hardware that defines the state of the art in analog transparency. Like digital effects and chroma keys, layering is not a fad, but a creative tool. One of the fundamental advantages of digital video is its inherent transparency.

With all-digital video, the first-generation properties of the picture remain intact, layer after layer, copy after copy.

Each pixel is simply no more than computer data composed of 1s and 0s, or magnetic poles aligned 180° out of phase with each other. Therefore, digital video is the key that opens the door to a new dimension in video layering.

Digital video also gives the user the opportunity to directly manipulate individual bits of picture components in the digital domain. Each "pixel" has an addressable luminance and color difference instruction. The all-digital domain allows virtually unlimited and flawless multi-pass special effects (the current record is more than 80 generations); digital graphics; animation; retouching; rotoscoping; variable speeds in either direction; time compression and stretching; and limitless, recallable color correction. The result is "camera output" quality on the edited master.

The beauty of digital video equipment, from an engineering viewpoint, is a massive reduction in the number of screwdriver adjustments (tweaking) that can be accessed by quasi-technical operators. Digital equipment contains a minimum number of such adjustable components.

Altering these adjustments from their original factory settings is usually not required unless a circuit component is replaced. Then, the adjustment should be performed only by an experienced technician with the proper test equipment and training. In theory, as digital video

proliferates, the witch doctor magic of the tweaking tool should become lost in video folklore, and no longer be the fountain of headaches it has been to many analog maintenance engineers.

Speed, in the editing process, is another aspect that appeals to the producer, director and client. Anything that can reduce the amount of actual on-line time required to edit material, such as eliminating prerolls, cuing, manual editor math, list management and lengthy previews, will save money. This also will make more time available for other projects. The picture quality is the icing on the cake.

When editing full-length tape media program material, speed may be more comparable to analog editing because mechanical shuttling between long scenes still will be required. In the business of spot production, however, the digital editing process can boost speed, creativity and beauty in the eyes of those who pay for editing time.

Two styles of all-digital production studios are in operation today. The original digital production studio principally uses Thomson CSF equipment; others mix 4:2:2 compatible equipment from several sources. The mixed manufacturer systems typically use magnetic and RAM storage combined with commercially available digital videotape recorders. The common ingredient of these systems is standardized 4:2:2 digital video, but their philosophy and design is significantly divergent.

Digital pioneers

The world's first operational all-digital studio is Le Studio Numerique, located in Rennes, France. It has been commercially operational for almost two years. The concept and initial design of this first all-digital studio was launched in 1981 by France's Centre Commun d'Etudes de Telediffusion et Telecommunications (CCETT). With the cooperation of Thomson CSF, the CCETT built the experimental studio at an existing local TV station, FR3, in Rennes.

The CCETT, Thomson CSF and FR3 are operating partners in this first all-digital studio project. The venue encourages research, because the CCETT and Thomson's video equipment research and development labs are both located in Rennes. By definition, the studio is an experimental project. The stated purposes of the project are technical research, development, implementation and training on high-quality digital TV systems.

The experiment is supported jointly by the French societies of the public broadcasting service (principally, TDF), Thomson CSF and the French Ministry of Industry. TDF assumed the technical and

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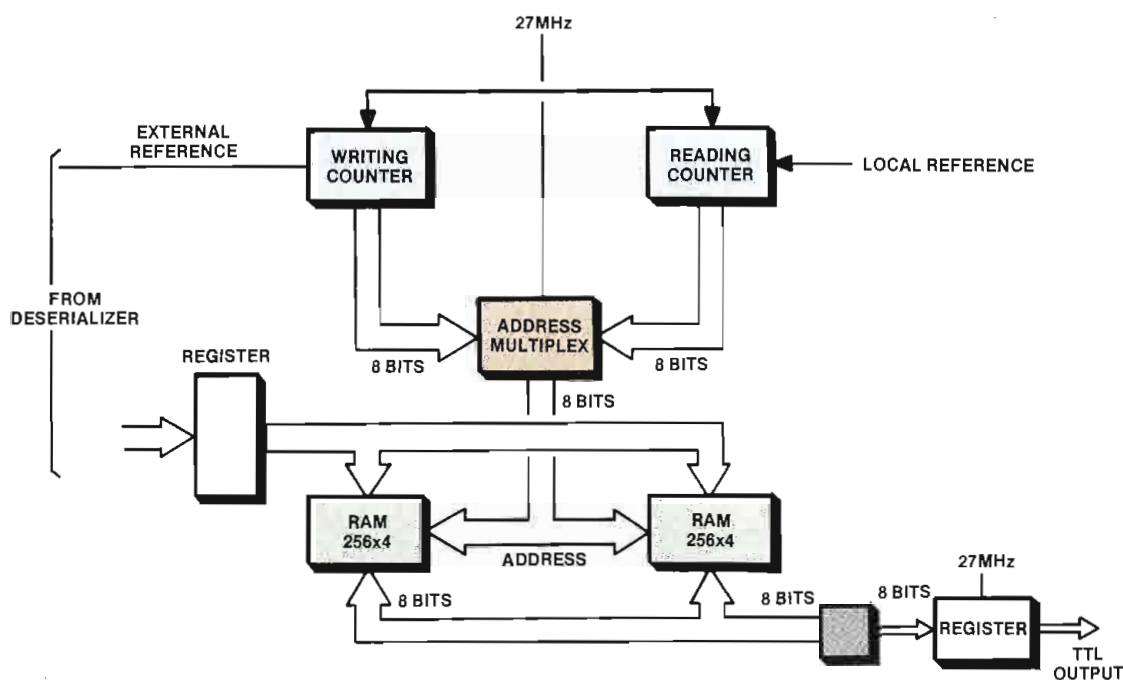


Figure 2. Block diagram of the unique automatic phasing system used at Le Studio Numerique.

financial responsibility to assemble and install the unique hardware.

Rennes system architecture

The experimental studio contains two color cameras with standard wideband analog CCU outputs. The development of digital CCUs did not fit the time frame of the project. Other analog devices in the studio include picture and waveform monitors (fed with RGB or Y+sync), house sync reference and all audio.

RGB to 4:2:2 (A/D) coders are used to convert analog sources (such as the studio cameras) to 4:2:2 digital. Each coder locks its internal 27MHz clock to house sync and provides a regenerated sync output with adjustable phase to time its analog source. The digital video output of the coder is parallel 4:2:2 (complying with SMPTE/EBU specs) and an additional, specially developed, 9-bit serial data port. The serial port permits single-wire interconnection and switching throughout the system.

Converting 8-bit parallel signals to serial data required development of a parallel-to-serial encoder. The encoder delivers a 9-bit serial datastream at 243Mb/s. Standard coaxial cable is used for interconnection at distances up to 800 feet.

According to project engineers, the 8/9-bit encoded signal appears to be the best compromise between bandwidth requirements and decoding complexity. Wider equalization tolerances (± 3 dB) appear to be adequate. After equalization, the signal is resampled with a serial clock recovered from the signal itself. This process ensures transparency.

The digital switcher

The heart of the Rennes project is a digital component mixer (switcher). Not unlike its multiple re-entry analog coun-

ters, this digital component mixer contains four picture planes (buses), two foregrounds and two backgrounds. The switcher is controlled similar to analog switchers by using either the manual control panel or data commands from an edit controller.

Component digital video allows the use of all luminance and chroma-key sources at any point, including downstream. Chroma-key threshold may be set and recalled using R-Y, B-Y or luminance.

The switcher accepts only serial digital video direct from digital sources such as the character generator, slide scanner, DVTR (digital videotape recorder) and video effects. Analog sources must be converted to 9-bit serial data for interface. Digital sources are synchronized at the switcher's inputs.

Each effects bus uses its own deserializer to deliver an 8-bit, 27MHz parallel signal from each serial asynchronous input. The deserializer includes serial clock extraction and synchronization word recognition. The detection of word "00" (called for in 4:2:2 standards) provides information for locking a divide-by-9 circuit. This circuit provides a parallel clock associated with the serial system.

Serial-to-parallel conversion uses a shift register (serial input, parallel output), which delivers a 9-bit parallel word. When assimilated with the local clock of the switcher, the parallel clock recovered from the serial datastream may contain some jitter. Instability is corrected by a *first in, first out* (FIFO) circuit using four words to resample the parallel signal with the local switcher clock. The 9-bit to 8-bit conversion is then accomplished with a PROM.

A fast-access RAM is used to automatically phase the system. Horizontal reference from the deserializer triggers a write counter, and a read counter is trig-

gered by the horizontal reference of the local (switcher), as illustrated in Figure 2. The line-phased signal is then demultiplexed to produce Y and R-Y, B-Y signals at the standard 13.5MHz rate.

Parallel-to-serial conversion is accomplished by using a phase-locked loop to develop the required 243MHz serial frequency from the switcher's local 27MHz clock. A PROM and a parallel input-serial output shift register is then used to execute the 8-bit to 9-bit conversion, as shown in Figure 3. Several parallel-to-RGB (D/A) decoders also are used to drive monitors and other devices that require analog video, such as the edit controller.

Color correctors

All color correction (except saturation) is achieved by re-interpolating and converting the incoming 4:2:2 signals to 4:4:4 YUV. The reverse takes place at the output. Correction is performed by software containing separate red, green and blue look-up tables with the appropriate transfer curves. The tables are then updated at a field rate. Color correction acts on the primary colors and allows operator control of pedestal, saturation and gamma transfer functions. Color correction also can be used for special effects such as radical gamma modification, posterization, video reversal and black inversion, by loading specially designed look-up tables.

Three color correctors are used in the Rennes studio. Two correctors are dedicated to A and B playback DVTR outputs. The third is a stand-alone unit, assignable (via serial) throughout the digital system matrix.

Custom DVTRs

At the time of construction, Bosch (BTS) was one of the few R&D labs actively experimenting with digital recording technology. The company custom-modified four BCN-50/51 (type B) 1-inch VTRs, to record and play the proposed 4:2:2 digital video for the project. Three of these modified recorders are used in the studio (A, B and record); the fourth is used for outside broadcast field recording.

With the digital modification, the custom DVTRs are capable of recording and playback only at normal speed. It was determined that features such as slow motion, stop action and picture-in-shuttle were too difficult to include and were not required to meet the goals of the experiment.

The modified machines use the same transport, control logic and analog audio

The digital effects.

COMPRESSOR RELEASE = 525ms	PARAMETRIC EQ. MID FRQ = 500 Hz	AUTO PAN DIRECTION= L↔R
TRIGGERED PAN PANNING = 525ms	FREEZE A REC MODE= AUTO	FREEZE B OVER DUB
PITCH CHANGE A BASE KEY = C 3	PITCH CHANGE B 1 FINE = + 8	PITCH CHANGE C L DLY = 0.1
PITCH CHANGE D F.B. GAIN= 10 %	ADR-NOISE GATE TRG. MSK= 5ms	SYMPHONY MOD. DEPT
STEREO PHASING MOD. DLY= 3.0ms	CHORUS A DM DEPTH= 50 %	CHORUS B AM DEPT
REV 1 HALL REV TIME= 2.6s	REV 2 ROOM DELAY = 20.0ms	REV 3 PLATE HIGH = 0.7
REV 4 PLATE HIGH = 0.7	EARLY REF. 1 TYPE = RANDOM	EARLY REF. 2 TYPE = RANDOM
STEREO FLANGE A MOD. DEPTH= 50 %	STEREO FLANGE B MOD. DEPTH= 50 %	STEREO FLANGE C MOD. DEPTH= 50 %
DELAY L,R Lch DLY =100.0ms	DELAY L,R MOD. DEPTH= 50 %	DELAY L,R MOD. DEPTH= 50 %
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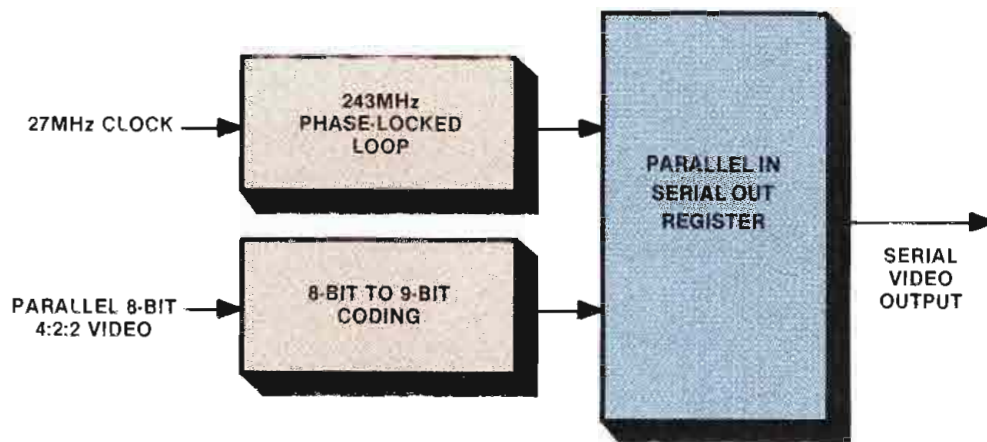


Figure 3. Parallel-to-serial conversion is used at Rennes for interconnection. This diagram shows how parallel video is converted to serial for switching.

sections as standard BCN-50/51s. However, the writing speed is doubled, tape speed is 50% faster and the footprint is 50 microns wide, which requires a custom video scanner.

The custom scanner contains four video heads and two erase heads. Two of the four video heads are used for luminance, the other two are used for color difference signals. The input and output for these heads is NRZ-ASE modulation code, processed by identical electronics. Error protection is achieved by leaving pairs of consecutive samples adjacent on the tape. Only the four most significant bits (MSBs) are error protected.

The Rennes project is an experiment, and at the time of its construction it was clearly ahead of its time. The studio was deliberately designed and built to facilitate changes and testing of new methods and equipment. Since the studio was opened for commercial business in 1985, client response has been openly positive.

And now for something entirely new and different

As unique as the Rennes experiment may appear, the foundation of its design exploits leading-edge digital video technology in a studio system and environment patterned after time-tested analog systems. A maverick approach to digital video production has emerged, essentially discarding customary operational and technical "video editing" methods.

In a truly all-digital environment, all that is needed to edit pictures is an incredible (to those of us who are still impressed by a megabyte) amount of memory, a single VTR or DVTR (for reading to and writing from memory), a single M/E switcher with a digital combiner, and a computer to control the system. Other items such as character generators, graphics, chroma-keys, digital telecine and effects still are necessary, but conversion of these digital devices from and to the analog domain is not. The elimination of A/D and D/A conversion supports the high degree of image transparency.

A thorough re-evaluation of studio requirements from the ground up is the basis for this approach, predicated on the unique virtues of digital video. It requires layering to eliminate the necessity for expensive multiple-channel and multiple-re-entry equipment found at major post-production facilities.

The patriarchs of this approach began by asking: "Is there really a need for an expensive, dedicated multiple-re-entry

Continued on page 52

Hearing out of focus?



Solved: stereo phase errors

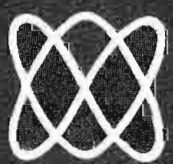
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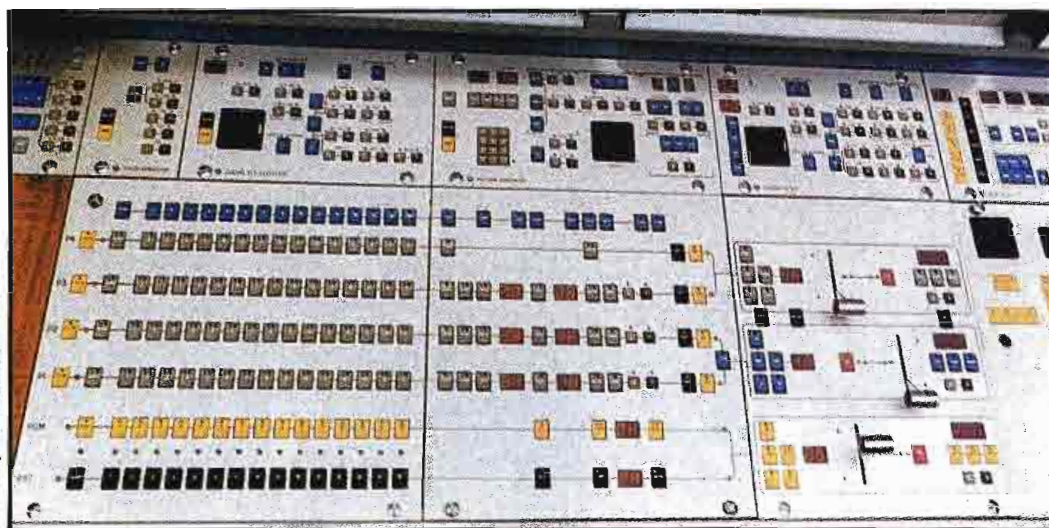
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The all-digital switcher used at Le Studio Numerique.

Continued from page 48

switcher, when a single M/E will do?" After all, the multiple M/E switcher was developed for live switching, to allow for real-time layering. Are A/B or A/B/C roll dedicated VTRs, TBCs and processing necessary if program segments can be read directly into memory? If multiple playback VTRs can be eliminated, then so can the hardware-intensive and complicated edit/machine controller.

Live programming still will require multiple-channel equipment, but digital post-production, using layering, can eliminate more than one-half million dollars of previously necessary dedicated equipment. Major users will surely create a demand for multichannel all-digital equipment. The serial digital video signal distribution research at the Rennes project will contribute to the future of digital system expansion.

What all this means is a redirection of a large portion of investment capital away from electromechanics, redundant channels and A/D and D/A conversion and

toward computers, large memories and pixel manipulation devices. Because digital 4:2:2 is not limited by the NTSC color framing sequence and does not rely on longitudinal time code, its single-frame editing accuracy is perfect. "Perfect electronic editing," the omnipresent battle cry of engineers, editors, producers, directors and clients, could have been achieved only at great time and expense before digital 4:2:2.

New-age video editing

To the non-technical editor, video editing has always been just plain overly complicated. After all, it has been said, you do not need to know how an engine works to drive a car. Since the introduction of Editdroid® in 1983, several editor manufacturers have developed products that radically depart from well-established video-editing methods.

Many of these new editor products are ergonomically designed by, and marketed to, film editors. Several simple devices, some using icons and a mouse

or tablet for control, have evolved. They all perform requisite editing functions without the usual technical bells, whistles and flashing lights. SMPTE time-code readouts, manual list cleanup and rippling, long search times and multiple previews have virtually been engineered out of these new-age editing systems. Most systems were designed primarily to take advantage of the rapid access times of videodiscs.

Combining new-age editor ergonomics with the capability to random access thousands of megabytes of digital video from memory enhances the benefits of both. Perfect color framing and absolute frame accuracy, combined with a reduction or elimination of search time and unlimited layering capabilities, is what digital video is all about. This new operating system provides the capability to preview and perform tasks that are expensive or impossible to achieve on analog systems.

System design

The control room used for random-access digital video editing is much different from the typical analog approach. Because many of the multimanufacturer digital systems use only one or two active inputs at one time, only one or two color monitors, a data monitor and an entry device are necessary.

As an example, Quantel's digital production system, shown in Figure 4, uses an internal single M/E digital mixer (switcher). An integrated digital combiner makes it possible to dissolve from one scene to another without match frames or rolling inputs. The digital com-

The control screen (see inset) lets the operator choose edit points from several frames from various segments displayed simultaneously. Input is via a light pen.



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biner is a random-access digital memory that can store frames from disk, modify those frames by interpolation or instruction and return frames to disk.

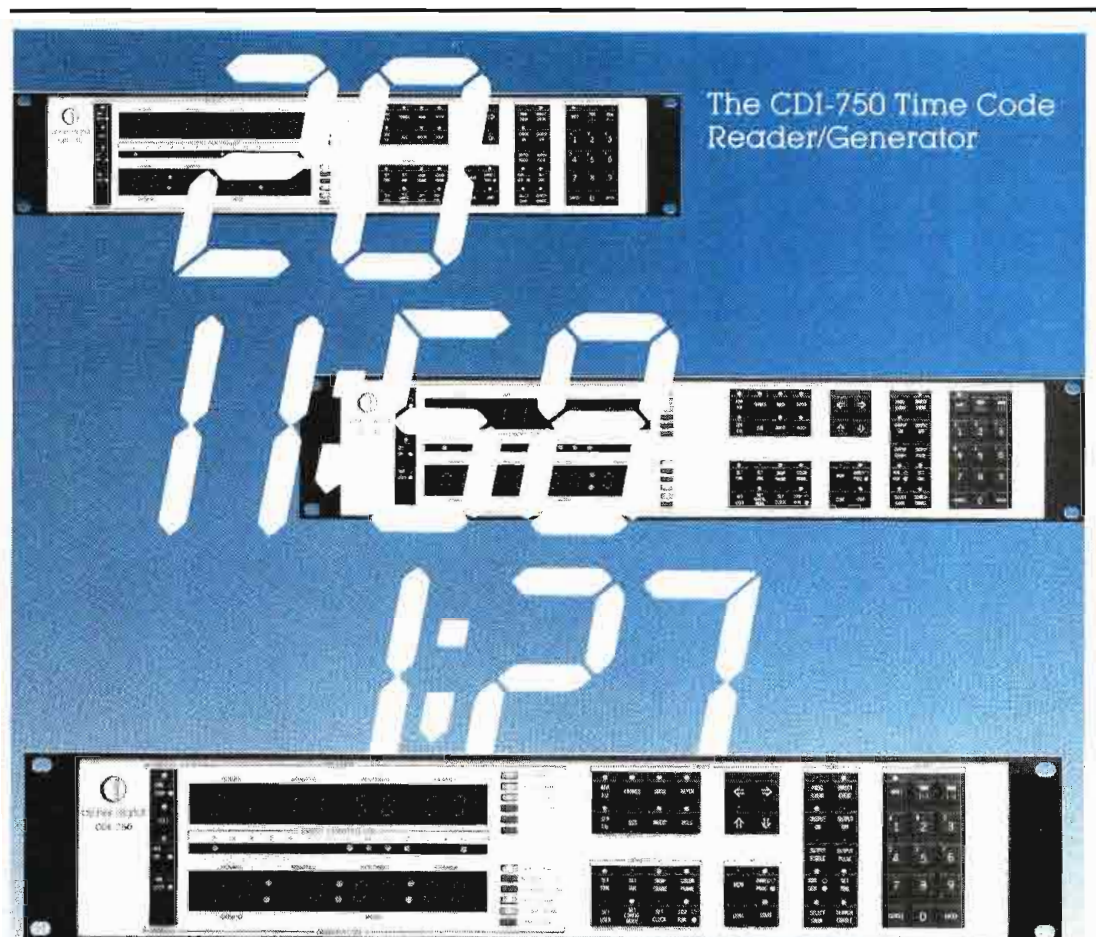
For dissolves and fades, the combiner interpolates the percentage of picture mix between each frame to be combined. The combiner uses an internal memory to create and store a new series of interpolated dissolving frames separately from either source. The combiner also is used for keying. Both luminance and chroma-keying functions can be used individually or simultaneous-

ly. A sophisticated hybrid of analog and digital keying is used to generate linear digital keying. The softening and exceptionally precise control generates keys that rival matte-film quality.

Time compression and expansion

With analog technology, time adjustments are made by selectively repeating or dropping frames of video to achieve the desired length. Typically this process generates an objectionable strobing, and is effective only with frames containing

Continued on page 58



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What is 4:2:2?

The 4:2:2 standard is the result of CCIR recommendation 601 (adopted universally by CCIR and SMPTE), which governs the coding of video signals into the digital domain. SMPTE EBU D-1 also has been standardized to conform to 4:2:2 sampling procedures. 4:2:2 is a parallel, component video system, using a 25-pin connector that carries Y, B-Y, R-Y and clock ECL signals at a 27MHz rate. The standard allows for 220 quantization levels of luminance and 225 levels of color difference. Every frame contains all color information; there is no color framing sequence in 4:2:2 video.

4:2:2's luminance sampling frequency is 13.5MHz, locked to house sync. This frequency was selected because it is a multiple of the horizontal frequency of both 525 and 625 line systems. The common denominator of 4:2:2 is equal to 13.5MHz/4, or 3.375MHz. The sampling rate of Y (luminance) is $4 \times 3.375 = 13.5\text{MHz}$. $2 \times 3.375 = 6.75\text{MHz}$, the sampling rate of both R-Y and B-Y. Hence 4(Y):2(R-Y):2(B-Y).

For each active line of video, 4:2:2 digital coding uses 720 samples/line for luminance, plus 360 samples for R-Y and another 360 samples for B-Y, for a total of 1,440 bytes in both 525/30 and 625/25 systems. By definition, each sample (byte) is an 8-bit word.

Typically, less than 500 lines of NTSC (525 line total) active picture information/frame are stored as the picture output is gen-locked to house sync. The total number of bytes/frame is approximately 720K, not including correction data (no overhead). Therefore, a 30-second NTSC spot, for example, would require approximately 633Mb of information, not including audio or overhead.

Advertised specifications for 4:2:2 DVTRs and equipment is $\pm >0.1\text{dB}$ to 5.75MHz. The noise floor is approximately -56dB. NTSC 1-inch type C VTRs are typically specified at $\pm >0.5\text{dB}$ to 4.2MHz, with a 48dB signal-to-noise ratio. Therefore, a 4:2:2 or D-1 digital recording should theoretically provide a better than 10% increase in horizontal resolution with less noise than 1-inch type C recordings.

Although distantly related, 4:2:2 is not the $4 \times \text{SC}$ (14.32MHz) sampling that is typical to most stand-alone digital devices such as TBCs and digital effects units. It also should not be confused with RS-422 communications standards.

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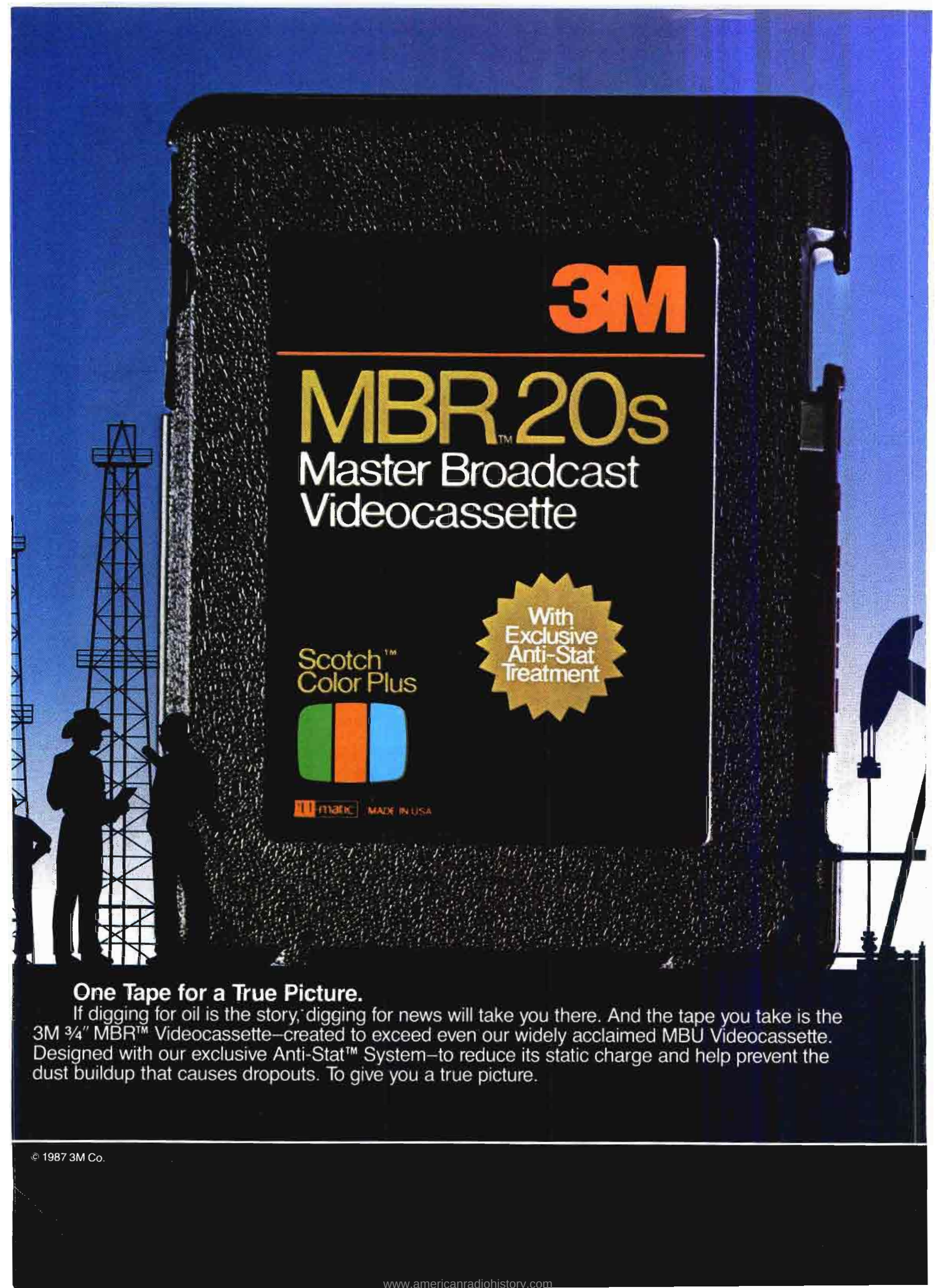
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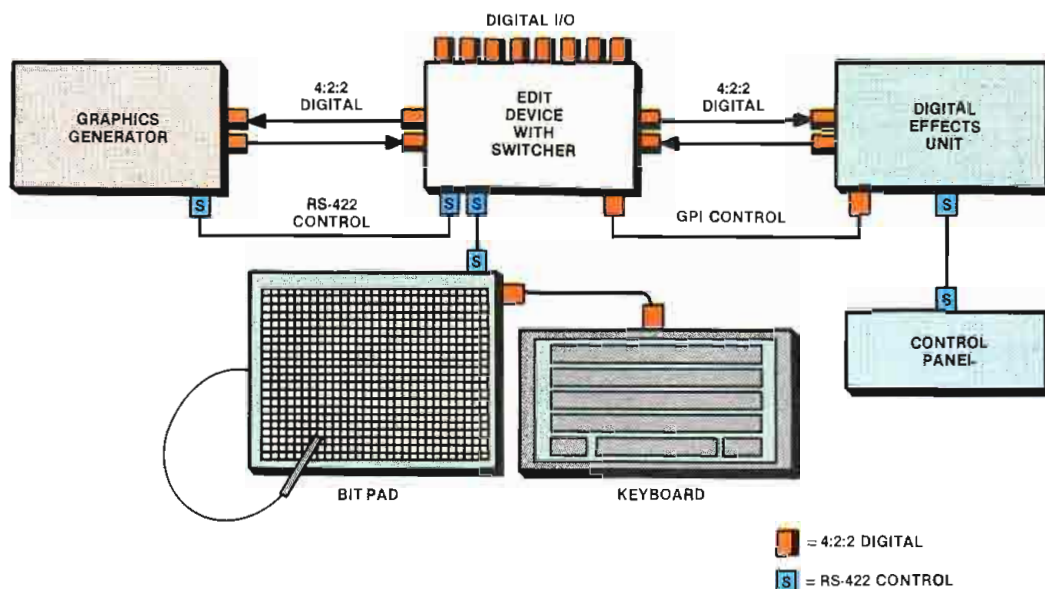


Figure 4. Simplified block diagram of the mixed approach to digital video system design.

Continued from page 54

little or no movement. The combiner interpolates movement between frames and generates new frames containing its interpolation, similar to fades and dissolves. Through use of the new interpolated frames, time adjustments are invisible. Slow motion also may be enhanced considerably by user-programmed weighted speed changes,

which smooth the transition between speeds.

Digital video in the real world

Because digital video is faster to work with, and offers expanded creative possibilities, producers will be tempted to try several different approaches to a visual situation to optimize the result. It also allows speedy changes to be made

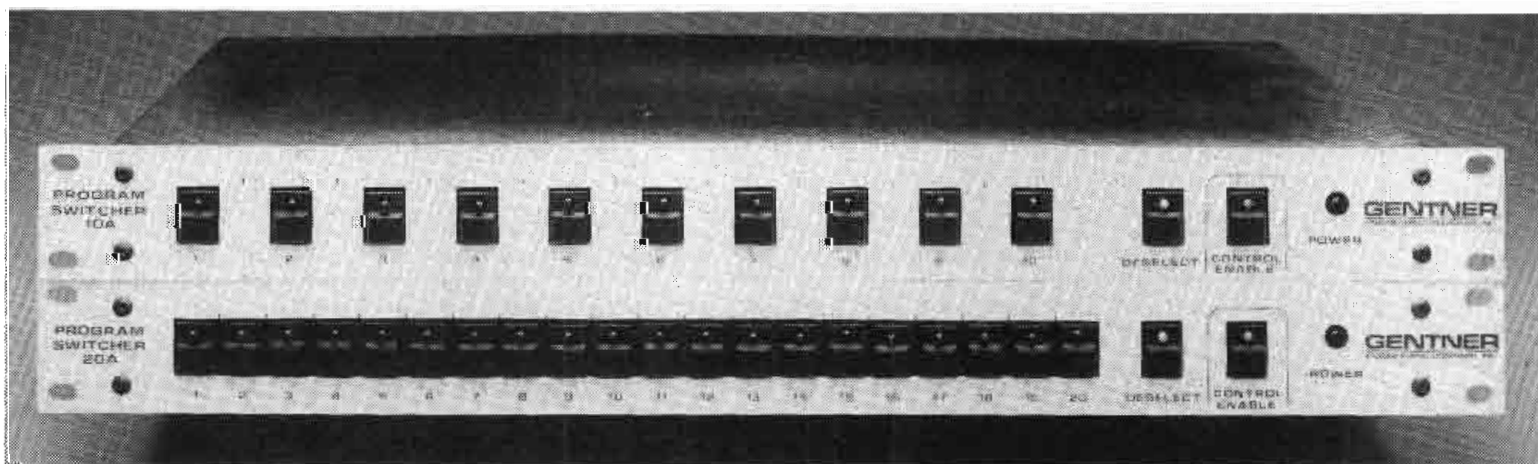
within a program without generation loss. Adding a few seconds of video and audio to a digital effect 250 events back can devastate the most laid-back analog editor. In an all-digital suite, such a change would be a clean and simple process.

What does all this mean to the broadcaster? On the network level, a few all-digital production systems already are being installed. At the local level, these new systems and concepts may have an impact on local production in the coming years.

No, 4:2:2 is not going to replace the NTSC transmission system, but it is destined to improve the quality of NTSC pictures created by zealous producers who don't take "no" for an answer. Ultimately, it must be assumed, distributed digital and analog dubs of digitally produced material will be direct from a DVTR, which will improve the picture quality and "dubability" of incoming material at the TV plant.

To the broadcast engineer, digital video (and audio) will most likely ultimately replace analog technology. To maintain digital equipment will require engineers with training and experience in repairing digital circuitry. It's only a matter of time. **1:~>)))**

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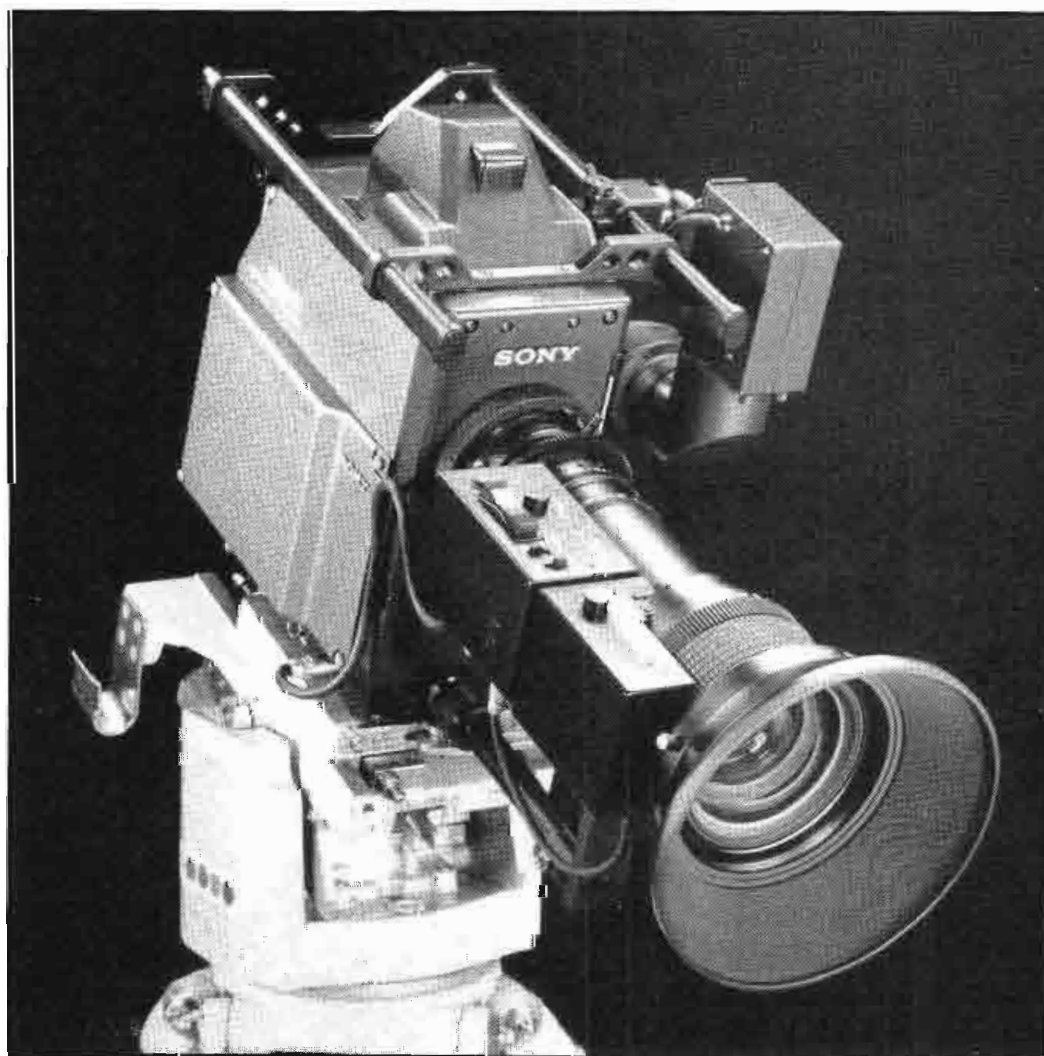
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The future of HDTV

By Ned Soseman,
TV technical editor

**The momentum of 1125/60
HDTV technology is creating excitement and demand
—and making video utopia more elusive than ever.**



The HDTV camera looks like a hybrid film/video camera. A lens that can resolve the detail needed for HDTV can cost more than \$30,000.

In the history of television, high-definition television (HDTV) is probably the most talked-about and written-about technical standardization proposal since NTSC. During recent years, conventions, meetings and seminars around the world have become virtual HDTV forums, characterized by disagreement. While everyone continues to talk, one HDTV format is rapidly establishing a euphoric track record in the mid- to high-end production community.

The presentations, discussions and demonstrations of a seemingly infinite number of HDTV standards proposals and ideas have fueled the fires of controversy, interest and awareness. With more conservative intentions, others have proposed enhanced, and somewhat compatible, systems based on current transmission standards. How will HDTV affect broadcasters, producers and consumers in the future?

Because so many issues have been raised, it is beyond the scope of this article to present all of the opinions. Uses of HDTV extend well beyond the realm of production and broadcast to the medical, industrial and training community as well. This article will provide an overview and an understanding of the pros, cons and applications of HDTV for television and entertainment program production (closed-circuit), distribution (via RF, fiber optics, magnetic or optical media) and the acceptance, whatever new format emerges, by consumers.

Whether you are a broadcaster or a producer, you will feel the impact of HDTV in the near future, even before the CCIR. On Oct. 25, 1986, a major step was taken toward using HDTV production for standard on-air broadcast. During its "Sportsworld" broadcast, NBC ran almost seven minutes of the first HDTV pictures converted to NTSC to be transmitted by a U.S. network. On that date, NHK converted HDTV masters of a 3-camera HDTV production of the Asian Games to NTSC, and transmitted them to NBC via satellite.

According to NBC engineers, the HDTV video, converted to NTSC, looked better than video mastered on NTSC. An analogy of this observation would be comparing state-of-the-art, top-quality studio cameras using a standard $\frac{3}{4}$ -inch videocassette recorder to record the pictures from each camera.

Although the cassette recorder's bandwidth is much lower than the output of any camera tested, differences between cameras will be easily seen. Bandwidth and other limitations make NTSC far inferior to HDTV. In reality, however, recording converted HDTV pictures on an NTSC system produces better pictures than using dedicated NTSC equipment to produce NTSC pictures.

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www.americanradiohistory.com

Excited by the superior quality of HDTV downconverted to NTSC, NBC is planning to incorporate HDTV during its coverage of the 1988 Summer Olympic Games. Special wideband (36MHz) satellite transponder service has already been arranged to transfer the optimum-quality downconverted HDTV to NTSC feeds. NBC also is evaluating equipment and delivery schedules in an effort to acquire its own complete HDTV system. This system would be used not only for Olympics coverage, but in other areas as well.

Captain Video Studios, Paris, the world's first on-line HDTV production company, recently announced plans to open fully equipped HDTV production houses in New York and Los Angeles. According to HDTV pioneer David Niles, president of Captain Video, both facilities should be on-line before this summer. The L.A. operation is expected to go on-line first, this spring, and already has commitments for three full-length feature films to be produced on HDTV. Rebo Associates, New York, is now on-line with its HDTV studio and post facility. Many others, in various parts of the country, are expected to follow soon.

The Canadian Broadcasting Company and Northernlight & Picture Corporation

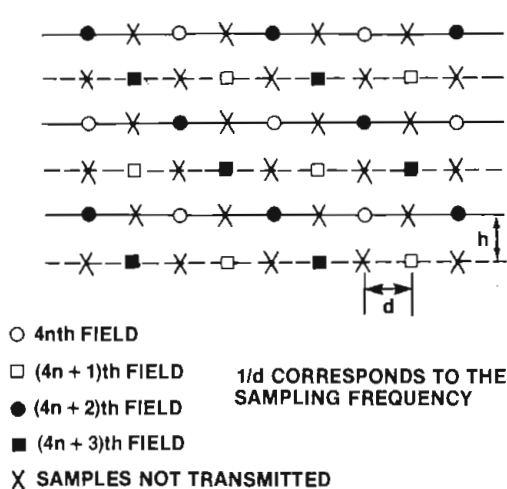


Figure 1. Sampling pattern used by the MUSE transmission system of motion-adaptive bandwidth reduction.

are currently in production of "Chasing Rainbows," a \$10 million, 13-hour TV series shot and edited entirely in HDTV. "Chasing Rainbows" is CBC's largest dramatic production to date. Set in Montreal in the early 1920s, the production calls for intensive compositing, the use of HDTV Ultimatte and film-style photography.

Typical lighting on the set is about 80 footcandles (fc) with 125fc key light, at

f/2.8. Scenes have been shot in dirt trenches and in rainy, dusty and hot environments without a single equipment failure. This milestone HDTV production is expected to air this fall on the CBC, after downconversion to NTSC.

Following last year's NAB, where an entire separate area was dedicated to display HDTV images and production equipment, a large number of serious inquiries and orders for HDTV equipment were received by manufacturers.

History

The idea of high-definition television is not new. The first such system was shown to the public in 1936, when the BBC demonstrated a 405-line system. Initial research leading to today's HDTV imaging began in Japan during the early 1970s, before the 3/4-inch format or ENG was introduced to the world. Anticipated new markets and an eye toward the future prompted NHK Research Laboratories and several Japanese manufacturers to begin developing a new system from the ground up, to improve television's visual images.

The Japanese were virtually alone during the early development phases until the CCIR adopted question 27/11 in

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Official video tape of the National Football League

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Converting a MUSE signal back to full HDTV bandwidth requires a MUSE decoder. Someday this will be on a single LSI chip.

1974. Question 27/11 simply asked, "What standards should be recommended for HDTV systems intended for broadcast to the general public?" SMPTE set up a study group in the late 1970s and shortly afterward, the European Broadcasting Union formed a special group to address HDTV issues.

The first demonstration of HDTV in the United States was at the SMPTE convention in February 1981. Following the demonstration, the Advanced Television Systems Committee (ATSC) and other engineering groups were formed to study HDTV, and to suggest possible improvements for current systems such as enhanced NTSC.

As Japan tried to sell its HDTV system to the world, the concept of worldwide standardization began to accelerate. In 1983, the CCIR established an interim working party (IWP) to prepare a single universal HDTV standard draft recommendation for studio and international program exchange. The draft was presented earlier last year, but several questions remained unanswered, and it was sent back to the IWP without ratification by the CCIR. The next opportunity for the CCIR to recommend a world standard is scheduled for 1988.

If a mass conversion is to take us all to a new format, this would be an ideal "window of opportunity" to establish a single common format. Clearly, there is widespread agreement that a worldwide format would be useful. Technical concerns, economics and an overcrowded RF spectrum have turned this idealistic goal into a political issue. Is it possible to please everyone in a time frame influenced by manufacturers and producers as well as by politics and economics?

Goals of HDTV

At the outset of HDTV development, the main goal was to produce electronic video images comparable to those produced with 35mm film. To create this appearance, a widening of the aspect ratio and a major increase in the number of scan lines had to be realized. Armed with these basic parameters, HDTV researchers developed a prototype system to show to key decisionmakers in the film and TV industries for their input.

In the meantime, a scientific approach was applied to psychophysical experimentation to determine the ultimate characteristics of the human/video display interface. A viewing distance of three times picture height (3H) was determined to be optimum for 1,125-line displays. An aspect ratio of 16:9 was selected to match the 3H viewing distance, because a 30° viewing angle is considered optimum for the home environment.

Measurements of the eye's sensitivity to motion detail, temporal and spatial resolution, as well as other optic responses, continue to be tested and researched. The information revealed by this research will enhance the HDTV experience by fine-tuning HDTV transmission parameters for human enjoyment within technical constraints.

Standardization

A de facto standard of 1,125 lines, 60 fields per second has been established by HDTV equipment manufacturers (see Table 1). Many valid, basic concerns have been expressed regarding HDTV formats. Compatibility with existing systems (NTSC, PAL and SECAM), transmission bandwidth requirements and the economics of investing in new

HDTV display equipment all are areas of concern. The primary objective of the CCIR is to recommend an HDTV system with simple downward compatibility to 50Hz and 60Hz field rates that satisfies all other aesthetic requirements.

While Americans are wondering how HDTV will fit into the broadcast RF spectrum and be compatible with older NTSC receivers, Europeans are more concerned with the introduction of direct broadcast satellites (DBS) in the 12GHz band. Europe has been preparing for DBS standards for more than a decade. Its goal is to transcend the limitations of PAL and SECAM, while minimizing consumer investment.

The CCIR adopted recommendation 601, which standardized digital video production on the 4:2:2 system. The CCIR also adopted the MAC (multiplexed analog component) family of standards, which allow digital signal quality to be transmitted directly to the viewer. Both of these approaches are evolutionary. The CCIR says 1125/60 HDTV is revolutionary, and not consistent with evolutionary work conducted on the basis of international cooperation.

Because 75% of the world's population is on 50Hz power sources, CCIR worldwide standards proponents say it would be unfair to adopt a system based on 60Hz. The considerations are beat frequency obstructions with some gas discharge lighting conditions for both recording and viewing. For recording, this problem can be solved simply by the use of a 60Hz ballast. For viewing, a gas discharge light must be so close to the screen that it almost washes out the picture. Most video equipment today operates on 50Hz and 60Hz, and does not depend on the power-line frequency to reference oscillators and circuits as was the case several years ago.

Countries that use 50Hz power sources don't agree with the 60Hz methods of transfer to and from film. In 50Hz countries, film is usually converted to video on a frame-by-frame basis by increasing the speed of the film by 4%. This results in a 25fps 1:1 conversion, which is ideal for picture transfer, but alters the frequency of sound and music on film, annoying 50Hz viewers with perfect pitch.

In 60Hz countries, standard 24fps film is transferred to 30-frame video by scanning alternate film frames with three fields per frame, then two fields per frame. This method of frame-rate conversion, when tied to HDTV, maintains the temporal resolution of HDTV to that of film (12.5Hz). The effect of this low temporal resolution is that moving objects develop serrated edges, and tend to strobe slightly.

Many ideas have been proposed to solve the film transfer problem. Common

Continued on page 73

BROADCAST engineering

The Chyron Group

Commitment to the future of video

AN ADVERTISING SUPPLEMENT



Grabbing a frame from the past

The scene is a video production operation of the not-too-distant past. Tension is building as the staff works feverishly to complete a project that is now behind schedule. Videotape operators listen carefully for beep tones and try for the 10th time to make a crucial edit.

As they verbalize their frustration, an "old-timer" from engineering reminds them that in his day they edited with razor blades. Meanwhile, in a back room, the operation's jack-of-all-trades is playing art director, laboring over press-on letters and black matte boards for the show's closing credits.

Then there is the client. Pacing nervously on the phone is the show's producer, calling the film lab for the fifth time to see if the opticals for the show's opening are finished. Slamming down the phone, the producer sees his career

of the trade for video. Tools for computerized editing, for electronic titling and graphics and for special effects.

Almost as remarkable, amazing and impressive as the devices, themselves, has been the relatively short time it has taken for these tools to move video out of the dark ages: less than 15 years. In reality this is a mere nanosecond on the time line of human existence.

The video picture today

Yes, the TV show from our scene from the past was successfully completed and made the air date—as most of them did. But, at what cost in terms of time, money and quality? Today, while tension remains part of the video scene, time-consuming, inexact and far-from-picture-perfect methods have become obsolete. Advances in video editing, titling and graphics, and effects have not only made the final product better and easier to produce, but also opened the way for more operations, both broadcast and non-broadcast, to buy and use the tools of the video trade.

At the same time that equipment improved, our television environment has expanded. More call-letter stations are on the air today than ever before. Cities and towns have been wired for cable and now satellites deliver special programming channels. Corporations, education and medicine, among others, are increasing their use of television after discovering its effectiveness as a communications tool. Half the homes in the United States, (and an even greater percentage in other countries), will own their own television

an entirely new type of operation: the graphics boutique.

In the private TV area, hundreds of corporations, not just the largest and richest ones, are either establishing or expanding their video operations. A similar trend can be seen in the areas of medicine, education and the military. And the video universe continues to grow as video expands its reach into new areas and applications.

Perspective on the customer-manufacturer relationship

The expanded television environment and the rapid advances in technology have presented both an opportunity and a challenge to committed video equipment manufacturers. On the one hand, with the demand for more programming and the expanded use of television, manufacturers have the benefit of a growing base of customers for their products. And by tapping into the latest technological breakthroughs in computers and digital electronics, hardware makers are now able to design more versatile, powerful and dependable devices.

In electronic editing, for example, innovative new products are currently expanding and enhancing the way videotape is edited as well as moving computerized techniques into the audio and film worlds. On another front, new titling and graphics products are adding to video's workload by providing unprecedented levels of resolution as well as speed, flexibility and creativity. And, moving into image manipulation, digital video effects

1971
CBS Laboratories and Memorex found CMX systems (CMX = CBS + Memorex)

CMX systems introduces CMX 600

1972
CMX Systems introduces CMX 300

1973
CMX receives Emmy for CMX 600 and CMX 300

1974
CMX introduces CMX 50

flash behind him as he calculates how much the delays have cost and wonders whether they will make the air date.

As he visualizes himself on the unemployment line, the producer ponders the question: If they can send a man to the moon, why can't they find an easier, faster and better way to produce a television show?

Shuttling forward

They have. In fact, at the time that this not-so-mythical-scene-from-the-past was set, engineers and manufacturers were developing and introducing devices that would soon become the everyday tools

recording and playback device, a VCR, by the end of this year.

The result has been an ever-increasing demand for programming to fill all the "channels" of our expanded television environment.

With this demand, new video production organizations are opening up and those already in existence are expanding. In the video facility area, state-of-the-art post houses are found throughout the United States, not just on the East and West Coasts. The advent of sophisticated and versatile electronic graphics and titling systems along with the clamor for more graphics on television has led to

devices, once the domain of the well-heeled few, are now affordable to a greater range of budgets.

But along with the enormous opportunities and advances that are beckoning hardware manufacturers are the many challenges in today's highly competitive, diverse and technologically intensive video world.

Foremost, manufacturers must be able to understand the range of needs of a varied customer base and translate those needs into actual products that meet those needs. Along with ascertaining customer needs, equipment companies have to recognize and address the fact that today, more than ever before,

customers are carefully scrutinizing the relationship between price and return on investment. In addition, the equipment decision-maker list at a television organization today includes not just the engineers but the creative and accounting people as well.

Finally, manufacturers must have substantial financial resources not only to manufacture products and provide customer support, but also to sustain ongoing research and development efforts. Because, in video, it always seems like the future is just a nanosecond away.

Zooming in on the Chyron Group

With these challenges as well as opportunities clearly in focus, the Chyron Group was created in 1985. The group is composed of Chyron Corporation, including the Telesystems and Video Products divisions; CMX Corporation; and Digital Services Corporation (DSC).

Over the years, each of these companies has developed a particular area of expertise in the design, manufacture, marketing and customer support of products on the cutting edge of video. As part of the Chyron Group, Chyron, CMX and DSC continue to pursue what each knows best: electronic titling and graphics at Chyron's Telesystems and Video Products divisions; computerized editing at CMX and digital video effects

buzzwords.

A relative newcomer to the video field, DSC was making its name known in the area of digital video effects even before the creation of the Chyron Group. Now, with the benefit of the resources and experience of the Chyron Group behind it, DSC has the potential to grow and expand more quickly than was possible for either CMX or Chyron in their earlier days.

The substantial financial resources of the parent organization, a publicly held corporation listed on the New York Stock Exchange, are available to all the members of the Chyron Group. These resources are managed by executives who have considerable experience in the successful financial operation of a video hardware company.

Supported by a well-managed flow of capital, the Chyron Group companies have the means to develop and market the video products required by video professionals. In the area of R&D, few companies spend as much as the Chyron Group: during 1986, R&D expenditures totaled more than \$4.6 million, representing 13% sales. And to further underline the Chyron Group's understanding of the importance of R&D in its future growth is

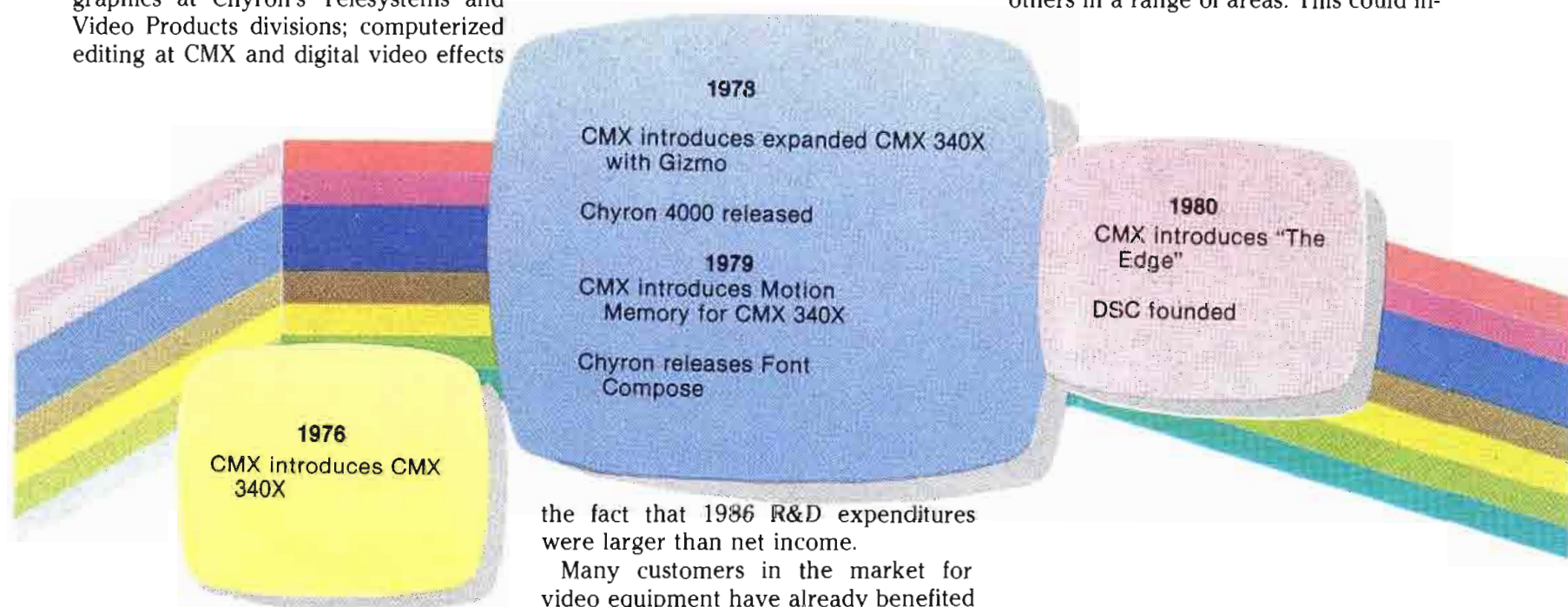
and their possible application in products from the other companies. These applications, which continue to evolve, have already led to increased user benefits and creativity.

For example, DSC's work in digital video effects made it possible for Chyron Telesystems to integrate the Motion feature in the Chyron 4200. With the Motion feature, which provides high-resolution dynamic graphics effects, titles, logos and background graphics can be manipulated using a number of digital effects and positioned anywhere on the screen. And graphics can be manipulated without tying up a switcher and a separate digital video effects device.

The result is a feature that not only increases design creativity but also operational flexibility.

In addition to bringing together an exchange of ideas and developments in the technical area, the formation of the Chyron Group has also led to communication among the marketing and sales people in the various organizations. Through their meetings, executives at CMX, Chyron and DSC share information on customer needs and problems. And the benefits to the industry are two-fold.

First, each company has an opportunity to benefit from the experience of the others in a range of areas. This could in-



at DSC.

In addition to their commitment to distinct areas of product development, the companies are also committed members of the professional video hardware world, combining over 30 years of experience serving the video industry. Evidence of this commitment can be seen today in many areas: substantial R&D spending, innovative new product introductions, regular manufacture and delivery of equipment as well as strong service and sales support operations.

This commitment and track record has earned the two senior members of the group, Chyron and CMX, an unusual distinction in the video industry: their names have become generic industry

the fact that 1986 R&D expenditures were larger than net income.

Many customers in the market for video equipment have already benefited directly from the financial resources of the Chyron Group. Recognizing the capital-intensive nature of the video business, the Chyron Group introduced the unique "Earns-Its-Own-Payments Plan." Through this practical and liberal plan, customers for many CMX, Chyron and DSC products have been able to add new equipment and watch it pay for itself, in what amounts to almost cost-free financing.

The companies in the Chyron Group also have the benefit of the technical expertise developed by the companies comprising the organization. Although maintaining distinct R&D operations, CMX, Chyron and DSC engineers meet regularly to discuss new developments

clude everything from ways to improve sales and service support to new approaches to training on equipment. Second, by sharing information on client needs and product capabilities, executives can identify new features and even new products that tap into the technical expertise of another company in the group.

The creation of the Chyron Group is also having an impact on the cost of producing equipment. Although each company operates its own manufacturing operation, the Chyron Group is taking advantage of its combined purchasing power in buying the many outside components used to manufacture the various

product lines. This buying clout makes it possible for the companies in the Chyron Group to produce equipment more cost-effectively, which translates into cost savings for customers on equipment.

Fast-forward

Despite all its R&D efforts, the companies in the Chyron Group have not yet been able to develop a special digital crystal ball to easily predict the hot product areas of future. But what distinguishes the group from other video equipment organizations is its unique approach to developing and planning for the future.

The Chyron Group has the benefit of specialists working independently in three distinct areas of video technology, areas that will continue to play an important part in the future of video. With the financial backing of the Chyron Group, these experts will continue to delve into the areas they know best to produce and market equipment that meets the needs of customers. But at the same time, Chyron, CMX and DSC each have the benefit of an exchange of information within the Group regarding new technological breakthroughs.

One area that the Chyron Group is watching is the development of new memory storage systems that will in-

crease the capabilities, speed and power of video systems. As chips become even more complex and lower in cost, they will be used to enhance the power of high-end systems as well as expand the capabilities of the more moderately priced machines. Also holding promise is the industry move to the all-digital studio and post room, where digitally based image and audio equipment will be linked and controlled by digital signals resulting in vastly improved quality for the final product.

What will the future look like? It could be something like this:

Preview on the future

The scene is a video production operation of the not-so-distant future. There is virtually no tension in the air because the project is well ahead of schedule. In one room, a video editor is working on the off-line edit of a TV program that will air in a few weeks. The company's jack-of-all-trades has just brought in some additional videodiscs, hot off the disc recorder.

In the graphics area, the in-house electronic artist is preparing graphics for the opening of the program. She is "calling up" and downloading a logo from another graphics station down the hall. In the effects area, the client—a producer—has just approved some rather complicated image manipulations that will be retrieved, along with the graphics, from digital discs during the on-

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line edit. Pleased with the work, the producer mentions for the fifth time that in the "old days" it used to take the film lab a week to finish this kind of optical work.

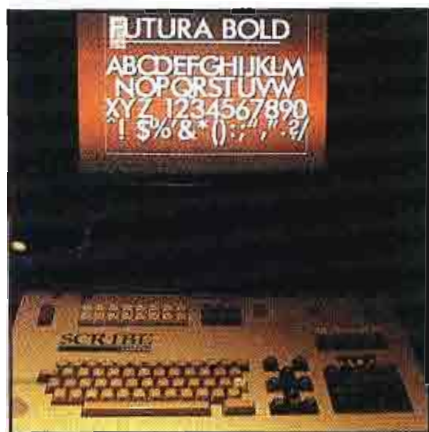
Returning to the editing room, the producer quickly reviews several different versions of the final segment. The selection is instantly entered by the editor, who estimates that the on-line edit will be ready the next morning.

With his feet up on the console, the client picks up the phone and plans his night out on the town and a short vacation starting tomorrow. Realizing how much money and time he has saved the company he works for, the producer fantasizes about a promotion and raise. As he pats himself on the back he wonders: How can video production get any better than this?

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Chyron Telesystems: leaders in character generators



Chyron Scribe text generation system.

When you stop and consider the many changes that have taken place in video production over the past decade, few have been as revolutionary as the way in which titles and graphics are produced. The leader in this revolution is Chyron Telesystems.

Chyron Telesystems is a division of Chyron Corporation, and one of the members of the Chyron Group. Its specialty is fast and high-resolution electronic text and graphics systems offering capabilities and features re-

customer needs as well as breakthroughs in technology, Telesystem's products, such as the Chyron IV series and the new Scribe, are designed as expandable and upgradeable systems.

Today, there are graphics composition, electronic painting and digital effects capabilities that increase the versatility of the Chyron IV series. As the mainstays of today's Chyron IV line, the Chyron 4200 with Motion and the Chyron 4100 EXB are available to customers either as an entire new system or as an upgrade to a Chyron IV they already own.

For the customer on a tighter budget, who wants the high-resolution

characters and graphics offered by the Chyron IV series, Telesystems also offers the RGU-2.

The latest member of the Telesystems family is the Scribe. Introduced in 1986, the Scribe is the state-of-the-art in text generation. Through the application of recent advances in digital technology, the Scribe is able to produce antialiased characters that are virtually indistinguishable from those produced on slides and typeset art cards.

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Scribe unique is that unlike other CGs, characters can be placed anywhere. Characters, words or rows of text, can be overlaid or underlaid on a single channel and will still maintain all of the antialiasing in each character.

Other areas where Chyron Telesystems continues its commitment to the video industry are service and sales. Most sales in the United States are made directly to customers, with some sales also generated by six select dealers, one in each of the sales regions. In the past year, Telesystems established sales offices in Los Angeles, St. Louis and Dallas, in addition to the sales office at company

headquarters in Melville, NY.

The division has also added a service operation in Los Angeles, which joins two other service centers in Melville and Chicago. The Los Angeles location also includes Telesystems' second training facility for equipment operation and maintenance; the first has been at company headquarters for a number of years.

In addition, Chyron, through installations of its equipment at Pratt Institute and Brooklyn College in New York, has made it possible for electronic graphics artists of tomorrow to learn about these tools of the trade.

Also in the past year, in order to bet-

ter serve their customers abroad, Chyron decided to take a different approach to its international operations. Telesystems now has its own dealer network abroad. This network is supervised from a Chyron service and sales support office in London.

Telesystems continues to communicate with its customers about new products and applications, through its division newsletter. And, in planning for the future, Chyron Telesystems continues its efforts in research and development.

Chyron Video Products: expanding the universe of video users



Chyron Chameleon paint system.



Chyron's Video Products division was established to provide high resolution character generators for the more moderately budgeted video operation. The division was launched in 1983 when it introduced the VP-1, a high resolution CG, designed to be driven by an out-board computer.

And, in the short time it has been in business, Chyron Video Products has managed to spread the Chyron name to thousands of new customers in settings such as corporations, schools and hospitals.

Since 1983, the Video Products division has added the VP-2, a self-contained and low-cost CG and graphics system, and the Chameleon, a low-cost paint system. To date, more than 5,000 Video Product VP systems have been sold and their customers in-

eclipseTM



Unretouched monitor shots illustrate Eclipse curved effects in two planes with perspective, picture twist, and cube builder with curved surfaces.



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clude not only private-TV operations but also smaller TV stations and post production facilities as well as cable operations.

And the expansion continues. Not only is the Chameleon being used to produce more creative videotape productions, it is also finding applications in "live" industrial training and teaching situations. The "old-timer" in the Video Products line, the VP-1, is moving into more areas that now clamor for high resolution information display. These include railroad stations, airports, betting parlors, race tracks, and other public facilities where information is displayed. The VP-1, with its flexible computer interface, is also learning new tricks as a peripheral to a growing number of personal computers.

Based at Chyron's Melville, NY, headquarters, the Video Products Group designs and manufactures systems for an ever expanding market. The group's R&D has made the benefits of advanced character generators economically feasible for a host of new customers. Chyron has established and trained a network of dealers which totals more than 100 nationwide, as well as a growing number of professional sales and service dealerships abroad. Customer service is provided by Chyron's technical centers in Melville and London, U.K. End users are kept abreast of new applications and product information through a periodic newsletter from Chyron.

1984

CMX introduces CMX 3400

Chyron releases RGU-2 and 4100EX

DSC introduces Illusion

Video Products releases VP-2

CMX: from the 600 to 6000



CMX 6000 editing system.

In 1971, computerized video editing became a reality with the introduction of the CMX 600. Capable of random access editing, the CMX 600 proved to be a system way ahead of its time. Despite the 600's speed and flexibility, its high price tag of \$250,000 for what was basically an off-line editing system made it impractical for even the best funded video production operations.

Realizing the potentials offered by computerized editing, in 1972 CMX introduced a more practical computer-based system with the CMX 300, a system that used SMPTE time code to perform linear edits. After the success of the 300, CMX went on to introduce

a range of products which have established CMX as the leader in computerized editing.

Over the years, it's been the 340X and its upgrades that have become not only the best-selling CMX products, but also the industry standard by which all other computerized systems have been judged.

A major reason for CMX's success has been its understanding of different customer needs: Systems are designed to be expandable as well as easy to interface with other video devices, regardless of brand, type or format.

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Which makes it ideal for editing brief segments, such as promos or news.

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the potentials of computer-assisted postproduction with four distinct product lines. In addition to its family of video editing systems, represented today with its LSS (large scale systems), the 330XL and 3400A, CMX is taking its technology into the worlds of film, audio and TV stations with three new product families:

The CASS 1 and CASS 1E are CMX's computer-aided sound systems. They are designed for use in audio studios and video operations that are involved in audio-for-video work.

With an eye on the film world, CMX has spent several years developing a practically priced, dependable, easy-to-use, random-access editing system. The result can be seen today in the CMX 6000, an off-line videodisc-based, computer-assisted film postproduction system.

CMX is also moving into other areas with its CMX 100. Designed with the realities of TV station production in mind, the 100 is an entirely new concept in editing, combining an audio/video switcher, audio mixing board and machine control system all rolled into one—an edit suite in a box. With the 100, the first in CMX's broadcast and industrial products family, stations will be able to produce local commercials, special programs, promos and news features more quickly and efficiently, using less manpower.

CMX headquarters are in Santa Clara, CA, which is where the company's R&D operations are located. Since joining the Chyron Group, the formerly financially troubled CMX has been provided with the resources to develop and manufacture exciting new products.

CMX's video editing (LSS) products are sold in the United States mainly by a CMX regional sales force located in New York, Atlanta, Dayton and Los Angeles, and by manufacturers and representatives. The 6000 and CASS series are also sold directly. (There are

international customers, who are served by distributors, CMX operates an office in Amsterdam. From this office, CMX oversees its foreign distributors in Europe and other parts of the world. CMX training courses are provided abroad on-site by many of the same instructors who teach in Santa Clara and New York.

CMX maintains a unique worldwide editors' advisory panel that includes hundreds of video professionals who use CMX equipment. Members are invited to call in with questions and suggestions on a special 800 number. In addition, CMX keeps its customers up to date with the latest applications in its regular newsletter.

DSC: for the effects



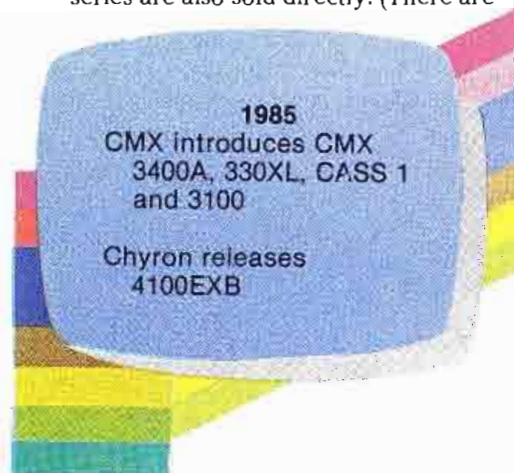
DSC Eclipse digital video effects system.

became involved with Chyron Corporation when the Florida company received a contract to develop the Digiflex feature for the Chyron IV. DSC was then also working on its first product, the Illusion. When the Illusion was introduced, it was heralded as the first affordable digital video effects device that also met broadcast standards. The Illusion continues to offer a wide range of effects capabilities at an affordable price.

Since the introduction of the Illusion, DSC has become part of the Chyron Group and added a sophisticated new system it calls the Eclipse. The Eclipse offers curved effects, picture twist and automatic cube building. It is operated from a control panel with a menu-driven screen and includes removable memory storage. Another product in the DSC line is the SX-2000D, which integrates digital video effects with a production switcher so that all operations can be managed from one panel. And DSC is also the company that developed the Motion feature, which is part of the Chyron 4200.

DSC's niche in the market continues to benefit not only from the demand for digital video effects but also the cost reductions in digital electronics. Even the moderately priced Illusion has come down in price since its introduction. And, DSC's pioneering efforts in bringing down the price of digital video effects have had their impact on the products and pricing of more established manufacturers in the field.

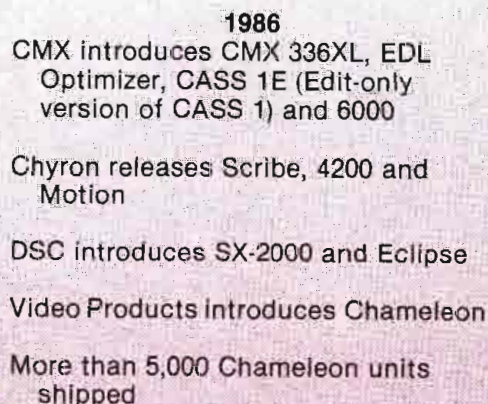
In its R&D efforts, DSC is examining component video and the possibilities it offers for improved resolution. But without a doubt, the technology that DSC believes will increasingly take



several audio specialty representatives offering the CASS product.)

Regional field service offices for CMX products are located at company headquarters in Santa Clara, Burbank, Indianapolis and New York. CMX also operates a training facility in Santa Clara, and offers regular courses in equipment operation at a New York post house.

For sales and service support for its



There was once a time, not too long ago, when video production operations could only dream of digital video effects devices. These magical systems were priced to meet the budgets of very few. But digital effects were in such demand by producers, that post houses and even many a broadcast operation threw sanity—not to mention financial plans—to the wind to keep up with the “new guy down the block,” or “the station across town” or even the “house across the street.”

Digital Services Corporation, experts in digital technology, has been doing its part to provide affordable digital video effects devices and bring into focus the relationship between price and return on investment.

Based in Gainesville, FL, DSC first

center stage in video is digital electronics.

DSC's products are sold directly to customers in the United States through six regional sales operations; overseas its equipment is sold through distributors. The company's main service center is in Gainesville but the company is planning service operations in each of its sales regions.

DSC also offers training courses and has established a customer advisory board to get feedback on its current products as well as to find out what customers would like to see developed in the future.

	HDTV DE FACTO	NTSC TRANSMITTED
TOTAL LINES	1,125	525
ACTIVE LINES	1,035	483
SAMPLES/LINE (Y)	1,920	450
R - Y (I SIGNAL)	15MHz	1.3MHz-1.5MHz
B - Y (Q SIGNAL)	15MHz	0.5MHz
SAMPLES/FRAME	2,000,000	217,000
FIELD RATE	60Hz (NON-DROP FRAME)	59.94Hz
TEMPORAL RESOLUTION	30Hz	30Hz
SCANNING	2:1 INTERLACE	2:1 INTERLACE
ASPECT RATIO	16:9	4:3
VIDEO BANDWIDTH	30MHz	4.2MHz*
VIEWING DISTANCE	3X SCREEN HEIGHT (H)	6H

*BANDWIDTH OF A HIGH-RESOLUTION CLOSED-CIRCUIT NTSC SIGNAL MAY EXCEED 6MHz.

Table 1. Contrasting the differences between HDTV de facto production standards and NTSC transmission standards. With MUSE transmission, samples are reduced to about 1,400/line, of which only 350 actually are transmitted. The frame storage at the receiver replaces samples that are not transmitted.

Continued from page 64

to each is an HDTV frame rate that is mathematically related to 24, 50 and 60. For example, one idea is to establish a frame rate of 72fps. At that rate, a single film frame could be scanned on three HDTV frames. A standards converter could be used to change to 60-field viewing (on NTSC) using a ratio of 6:5. To convert to 50-field viewing, a ratio of 36:25 would be used. These suggestions assume that a frame store at the receiver would be used to convert the 72fps signal to either a 50fps or 60fps output.

Another idea is to simply double the present number of active lines of each system. This would give 50Hz countries 1,150 active lines and provide 970 active lines in 60Hz countries.

It is noteworthy that, since the introduction of electricity in Japan, 50Hz power has been the standard in Eastern Japan and 60Hz power has been the standard in Western Japan. Since the first Japanese TV broadcast in 1953, all Japanese TV broadcasting has used the 525/60 NTSC system, which was chosen because engineers found the flicker on 50-field TV systems to be objectionable. Most programs are produced in Tokyo, a 50Hz city. There is no relationship between the TV frame rate and power-source frequencies. This difference presents few, if any, problems. It would seem reasonable that if this has worked in Japan for more than 30 years, 60Hz TV systems could be used in 50Hz countries on a worldwide basis too.

Scanning algorithms

Methods of picture scanning are also under scrutiny. When 2:1 interlace is used, the vertical resolution of a field is equal to approximately $0.65N/2$, where N equals the number of active video lines. Interlace is a method of subsam-

pling originally developed and incorporated to reduce the bandwidth requirements of transmitted TV signals (there were no VTRs at that time). There is an increasing interest in sequential (or progressive) scanning methods.

Progressive scanning increases vertical resolution and temporal frequency while eliminating *twittering* (the effect of only one line containing information in an interlaced system), and line *crawl*. Studies have shown that alias frequencies common to 2:1 interlace systems can be eliminated with progressive scanning by increasing the "distance to alias."

However, the bandwidth requirements for progressive scanning, compared with 2:1 interlace, are two to two and a half times greater. In addition, approximately 9dB noise power would be added from existing camera technology if progressive scanning were used.

Frame rate and scanning questions pertain as much to film transfer to HDTV as they do to increasing vertical resolution. Maintaining maximum picture transfer capability between film and HDTV, in both directions, is paramount. Worldwide, film accounts for about 80% of all TV pictures. In the United States, film still provides more than 70% of all prime time programming.

The annual consumption of 35mm negative stock has been estimated to be approximately one billion feet, with positive stock in the billions of feet. HDTV production is not expected to reduce this figure significantly. Therefore, the relationship between HDTV image scanning and film, in both directions, remains an important consideration.

Available hardware

It is generally agreed that the quality of today's 1125/60 system is comparable to

35mm film. Most producers who have worked with HDTV say it is more like 70mm. Obviously, it will not replace, but will interface with, film. Applications that require camera mobility and portability or battery operation will continue to be served by film because there are no portable HDTV products. HDTV best serves the needs of the medium- to high-end 35mm producer. Presently, all HDTV equipment is handmade and sold on a cash-only basis. Lens choices for HDTV cameras, which use 1-inch mixed-field saticons, are critical and few; a typical 7:1 ultraprecision zoom lens costs more than \$32,000.

In essence, an HDTV recorder is similar to a 1-inch type C VTR. It records analog audio (usually digital audio is synced), uses special highly polished 1-inch tape, and is set to record 1V peak to peak. HDTV video has no pedestal (setup) and looks like RGB parade video on a waveform monitor. The recorders contain 12 heads on the scanner assembly (head cleaning is a delicate science) to record four video channels simultaneously: red, blue, green 1 and green 2. Green is split into two channels for greater bandwidth because it contains the most detail information. Each channel is recorded separately, so dropouts are more easily masked than on encoded systems.

Building an HDTV system demands several special considerations. The high frequencies (up to 30MHz) require special video cable, such as RG/9, to minimize ringing and high-frequency attenuation. Using RG/9 with BNC connectors is a new art form HDTV users have had to learn. Because there are four discrete channels of information, much more cable is necessary than with encoded systems.

At Captain Video Studios, for example, a simple 4-machine edit system with a 10-input switcher, chroma-keyer and graphics generator uses about two and a half miles of cable. On the set of "Chasing Rainbows," the 16-foot mobile van/control room contains more than 4,000 feet of cable. Standard patchbays are ineffective; microwave patchbays are used instead. Video distribution is similarly critical, because there are few video DAs that are perfectly flat to 30MHz. Because of the nature of HDTV, maintaining system timing of the four channels is a highly precise science.

Editing with HDTV is actually simpler than NTSC, because there is no color framing. Time code is non-drop-frame. Standard edit products interface easily with HDTV systems, and several editor manufacturers are introducing systems that simplify keyboards and housekeeping requirements for HDTV film-style editing.

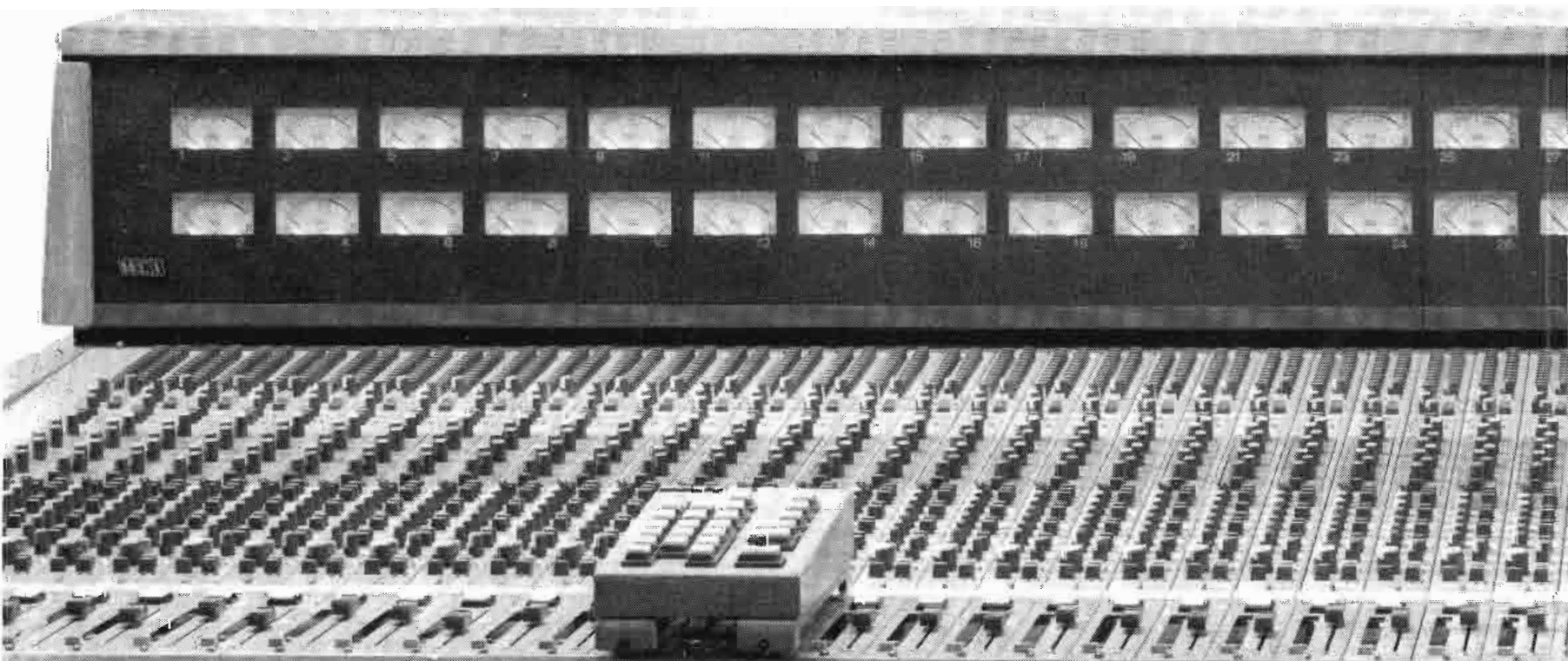
Continued on page 76

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Continued from page 73

Today, recorders, monitors, cameras, switchers, lenses, film telecines and graphics systems are available for 1125/60 HDTV. Soon, new products such as noise reducers, digital image manipulation, frame storage and digital dithering will be available. A digital HDTV recorder has been built by Hitachi and NHK Research Laboratories, although no plans for implementation have been announced. Research into camera pick-up tube technology is shifting to HDTV, as CCDs gradually replace tubes in medium-resolution (<700 lines) applications. The technology for CCD use in HDTV camera applications appears to be several years away.

The production community

Caught in the crossfire between engineering and politics is the production community. Given the rising costs and time-consuming nature of film production, HDTV's features and advantages make it a viable, economical alternative to 35mm film production. As with all other aspects of it, this one also draws some skeptics, but real-world HDTV pioneers are growing in number and ordering equipment faster than manufacturers can build it.

Can HDTV survive?

According to a Philips Research Laboratories presentation at the 1986 IBC convention, the way we answer these questions will affect the way in which we implement HDTV:

- **Technical:**
Can we do it with reasonably foreseeable technology?
- **Commercial:**
Do the viewers want it? Are they willing to pay for it?
- **Economics:**
Can broadcasters and production companies afford it? How will they finance it?
- **Operations:**
How will it fit in with existing media? Is it manageable?
- **Political:**
Does it fit the political aims of the country of origination?

In studio and controlled situations, the outlook for HDTV is promising. Production has the advantage of being a somewhat monolithic system. As long as adequate conversion to existing formats is available, standards are not an issue. The full benefits of this type of production can be realized, and then transferred to the desired format.

HDTV offers producers three major advantages over film:

- the ability to judge a scene accurately before, during and immediately after shooting;
- the freedom to try variations of special effects without the associated lab and printing costs; and
- highly consistent transfer characteristics.

In essence, HDTV brings the best of both worlds (film and video) together to permit a creative process that doesn't exist in film, in a medium that is immediate.

HDTV provides a contrast range beyond 20:1, which, combined with the higher resolution, borders on what producers and directors like to describe as "the film look." To generate a true film look requires totally random noise that occurs uniquely on film. Noise on any TV system is predictable; that is, it can occur only as pixels, each with a unique but


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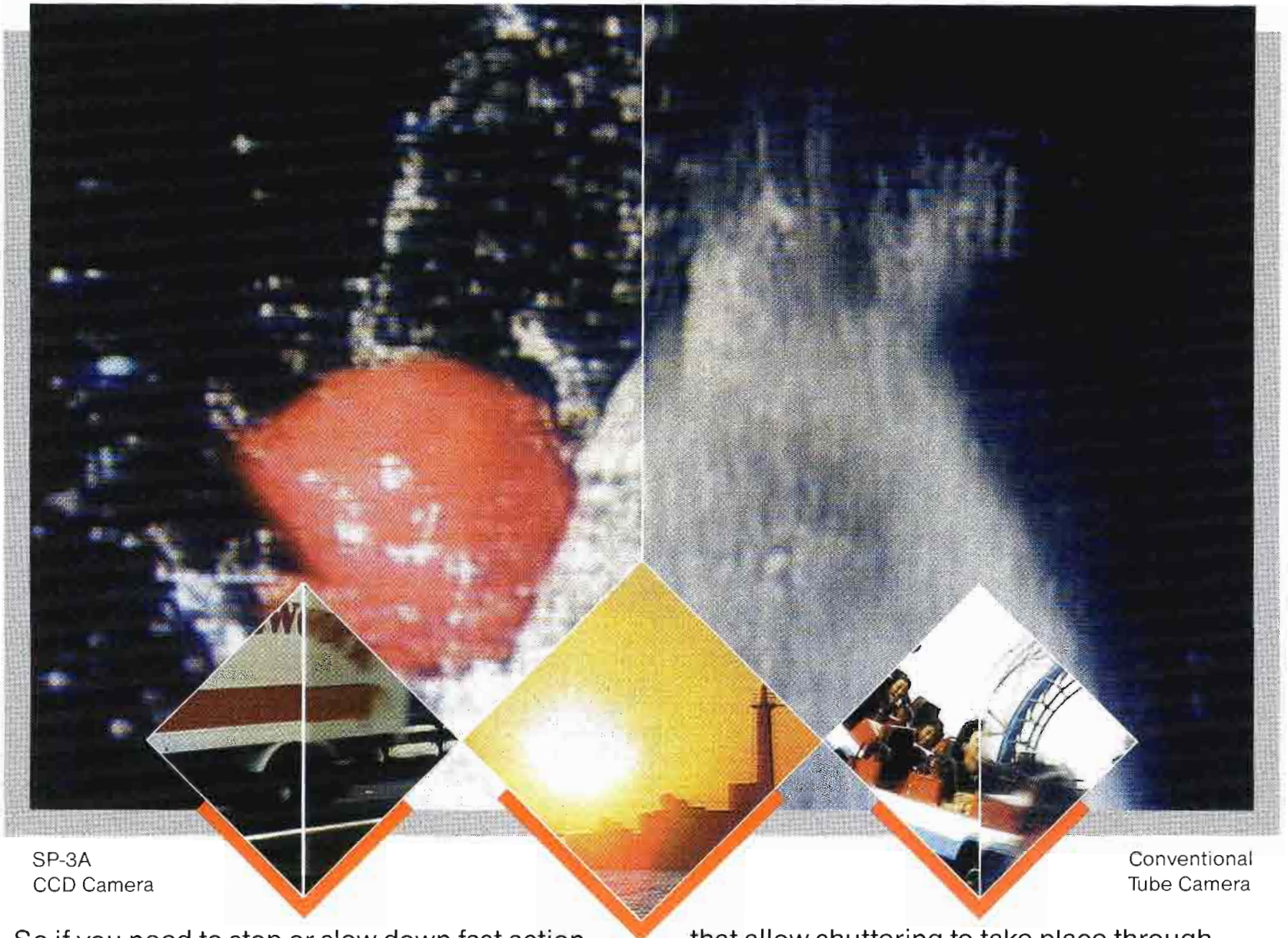
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recurring address, frame by frame. Film, on the other hand, has no pixels.

The grainy texture that appears on the images from even the best film stock is a result of impurities and inconsistencies that appear at random on the celluloid, with no relationship to frames or sprocket holes. The purpose of digital dithering for HDTV is to resample pixels on a frame-by-frame basis the way film grain would move from one frame to the next, to complete the film look requirements.

HDTV cameras exhibit characteristics similar to 50ASA at 3,200°K. Because of the high-resolution nature of HDTV, focus and depth of field require critical attention. In many cases, lens aperture must be adjusted for depth-of-field requirements before lighting levels can be determined. HDTV cameras have been found capable of handling mixed color temperatures better than film. The capability to control knee and slope allows nuances and subtle differences in colors and highlights to be seen better than on film.

With the increased contrast ratio, producers can light "film style" with artistic freedom previously reserved only for celluloid. Lighting can be adjusted using a monitor instead of the director's eye. To the film community, this is a tremendous advantage, eliminating retakes and allowing the director and crew to confirm that they have indeed achieved perfection in lighting and set design, before they bring in the expensive talent.

On the HDTV set, everyone talks the same language. Directors can use HDTV to show what they want changed by referring to the screen. HDTV production techniques should not be confused with *video assist*, the common practice of picking up images through the film camera's lens with a "parallel" video camera. The 8:1 contrast ratio limitations of NTSC used in video assist make lighting judgments invalid. At Captain Video Studios, HDTV has established a money-saving track record of about 30% less than 35mm film production.

With HDTV production techniques, talent costs can be streamlined as the necessity for retakes and safety takes are eliminated. HDTV post-production techniques, emphasizing small format off-line, allow experimentation with variations of scenes, and even wholesale scene changes, at a low cost. Complicated special effects that would terrify an optical house, such as chroma-keys (traveling mattes), computer-generated graphic images, and digital frame manipulation, are produced and developed at a minimal expense. Pictures can be previewed and modified as necessary to achieve the desired effect as it will actually appear on the screen.



A typical HDTV production VTR appears similar to a typical 1-inch machine. The similarity is only cosmetic.

Producing with HDTV is similar to recording audio tracks in a recording studio. Material is recorded "flat" with no gamma or colorimetry adjustments. During post-production, the enhancement, gamma, setup and gain of each channel (R, G and B) are available for adjustment. Similar to a digital reverb memorizing the acoustics of various rooms, different color temperatures can be memorized, and recalled and duplicated during post-production.

HDTV images must be downconverted in Japan. Only a handful of Japanese facilities offers conversion to the format of choice (NTSC, PAL, SECAM or film). NHK uses a laser system to convert from HDTV to film, while Sony offers an electron beam recorder (EBR) for conversion to film. By the summer of 1987, downconverters for HDTV to NTSC, PAL and SECAM will be commercially available. Sony hopes to install EBRs in both Europe and the United States sometime in 1987.

Worldwide broadcasting

The promise of HDTV as a worldwide broadcasting standard is an admirable goal attracting a great deal of interest and attention. Beyond the political ramifications, the capability to broadcast the Olympics, for example, on a worldwide basis without standards conversions, is appealing. DBS transmissions from one country to homes in other countries have many politicians and broadcasters dreaming of applications.

There are many obstacles between this goal and the realization of video utopia. Beyond frame rates, lines and scanning

is the problem of bandwidth requirements for a 30MHz-wide HDTV transmission. Again, several clever and feasible ideas to reduce bandwidth requirements have been presented and a workable solution is at hand.

The MUSE system

The method of bandwidth reduction most widely recognized is the MUSE (multiple sub-Nyquist sampling encoding) system. This method, compared with vertical-only subsampling (interlace), subsamples both horizontally and vertically by using memory. Developed by NHK Research Laboratories, the MUSE system reduces the 30MHz HDTV signal to approximately 8.1MHz.

The MUSE system working with the 1125/60 HDTV system would use a 4-field sampling pattern as shown in Figure 1. The basic sampling period is 15.4ns. Because there are 1,125 lines and 30fps, this gives 1,920 samples per line. Only one-fourth of these samples are transmitted for any given line of video. Because the samples are transmitted as an analog signal, bandwidth is reduced by 75%, requiring approximately an 8.1MHz channel. Stationary portions of the picture are reproduced using data from all four frames of a MUSE cycle so that a high-definition picture results.

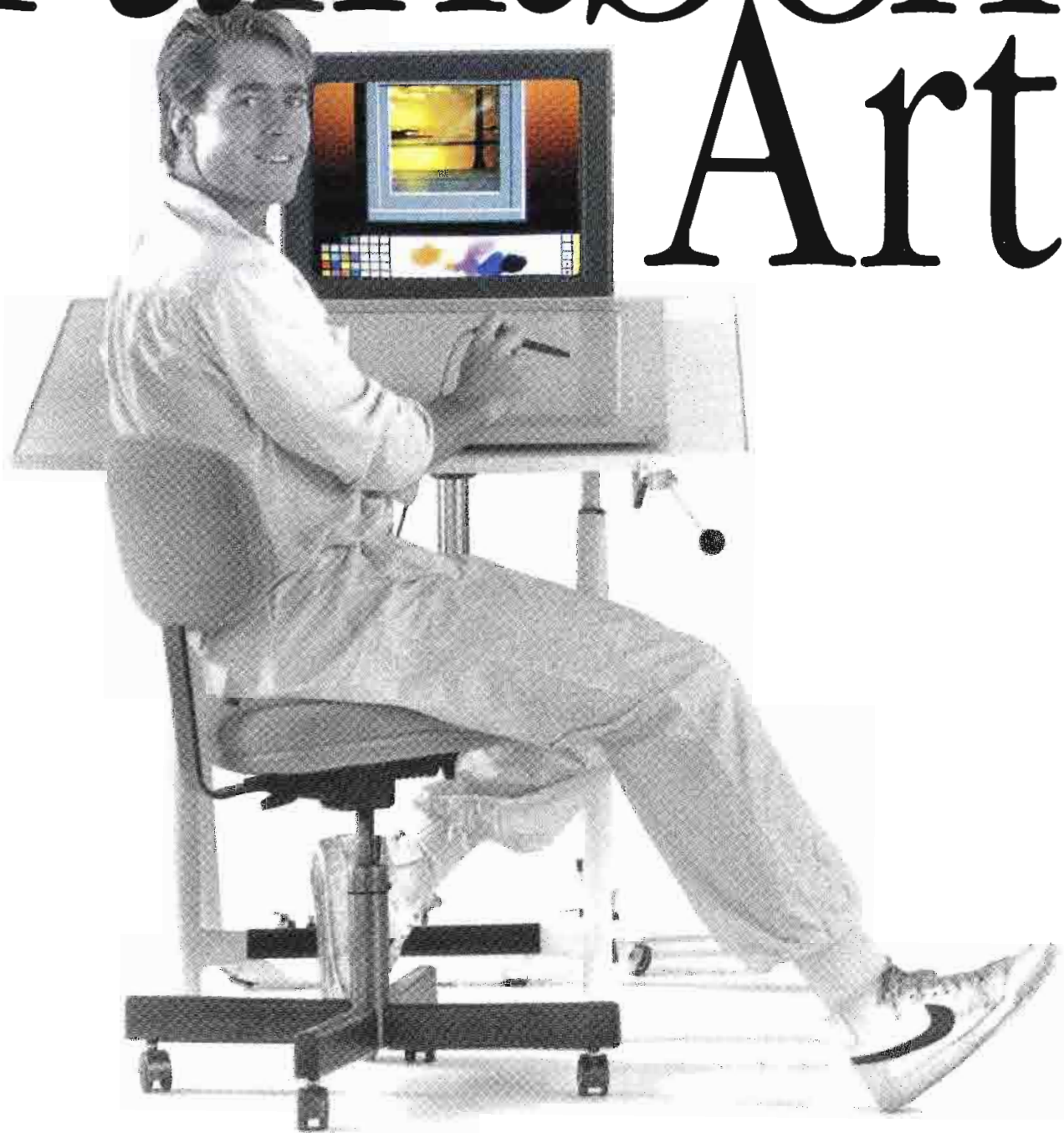
This scheme seems as if it would not work for rapid motion because of the blur that would result from constructing an image using data taken from four sequential fields. To deal with this problem, the MUSE system uses motion-detection circuitry that works with single-field information.

The resulting resolution is considerably less (approximately one-fourth), but this is not noticeable because the eye's sensitivity to detail decreases with motion. For example, even on high-resolution film, it is hard to read the number of a football player running on a field in front of a stationary camera, although the grass might appear as individual blades. If the camera is panned in unison with the runner, the individual blades of grass will disappear, although they will remain the same color and basic texture, and the numbers on the runner will become easier to read.

The system also is designed to take into consideration situations in which there is uniform motion of a portion of the image, such as when a camera pans a scene. Because all elements of an image or a section of an image are moving together, it is possible to detect the rate and direction of that motion. This data can be used to shift all data from the first field to properly align with that of the second field, and so on, to maintain maximum resolution.

Another benefit of the MUSE system is its capability to transmit up to four chan-

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nels of audio during the vertical interval. Use of the MUSE system, which requires field memories at both the transmitter and the receiver, would allow for transmission of HDTV signals occupying the space of two standard U.S. TV channels.

Other methods of delivery

Beyond HDTV converted to local standards for broadcast transmission (such as by NHK/NBC), the first true HDTV pictures will probably become a reality in the home via closed-circuit (monolithic) systems. Mediums such as videodisc, videotape, fiber-optics or, possibly, DBS will be used. Market demand for increased video data terminal resolution, coupled with HDTV needs, is producing CRT and projection system technology with resolution that will meet the requirements of HDTV. Special theater boutiques, with 120-inch to 200-inch high-resolution, high-brightness projection systems, may provide the first exposure of the general public to true HDTV presentations.

Last year, the "IEEE Journal" included an article on a 1/2-inch consumer-type VCR capable of recording up to two hours of HDTV. Although no official announcements have been made, several

manufacturers are close to introducing systems for the consumer market. These systems also will be monolithic, because they will require their own dedicated video displays, players and software. Initial research indicates a great deal of interest at the same esoteric consumer level that helped make FM, stereo, color television and TV stereo possible, and killed quad sound and CED videodiscs. Only time and economics will tell.

The future

HDTV is here today. It will affect the quality and cost of TV and film production for years to come. Agreement on worldwide standardization may not come soon enough to stop 1125/60 from grabbing an even firmer foothold. In today's production world, producers make decisions to keep directors happy, and to stay within budget. If HDTV works for producers, the production world isn't going to wait for anyone to proclaim video utopia. Nor will it wait the length of time necessary to design and manufacture production equipment using the worldwide system.

There is more than one "window of opportunity" available for worldwide standardization. After HDTV, there will be

VHDTV (very high-definition television), then UHDTV (ultrahigh-definition television), 3-D, holography and so on. Scientists agree that to satisfy the resolution of the human eye, more than 2,000 lines are necessary for the optimum delivery system. This ultimate system would require a screen measuring at least 126" x 63", viewed at a distance of eight feet. Besides the huge screen, a 200MHz bandwidth would be required.

Improvements in display resolution will reveal a need for even higher-definition recording technology. Some day, as in the movie "Brainstorm," a direct interface to the brain will challenge future generations. In the meantime, HDTV will be treated like any other new technology: if there is a need, or it saves money, it will be used.

Acknowledgment: Input for this article was provided by Larry Thorpe, director of studio product management, Sony Communications Products; Charles Jablonski, director of technical strategic planning, NBC Operations and Technical Services; David Niles, president and founder of Captain Video and Voir Studios, Paris; and John Galt, president of Northernlight & Picture Corporation and director of photography and co-producer of "Chasing Rainbows," Scarborough, Ontario, Canada. Additional information was obtained from HDTV papers presented at IBC, Brighton, England, September 1986; and SMPTE, New York, October 1986.

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Hi-Vision comes to America

The so-called Hi-Vision (NHK's term for MUSE system HDTV transmission) system made its public debut in Washington, DC, in early January. WWHD-TV, licensed to the NAB, took to the airwaves on channels 58 and 59 with a 1.5kW ERP digital Hi-Vision signal. The demonstration was the culmination of efforts by the NAB and the Association of Maximum Service Telecasters (MST). The goal was to raise the knowledge level of FCC members and other Washington decisionmakers about recent developments in video technology.

Specifically at issue is the upper UHF band, which is being threatened by land-mobile expansion and possible sale. If that broadcast spectrum is lost, there may be no room for terrestrial HDTV broadcasts using any known transmission methods. The demonstration was meant to educate decisionmakers about the imminent arrival of technologies that will require the



Behind the neatly draped tables in the FCC conference room is a "spaghetti city" of interconnection among adapters, converters, coders and decoders.

broadcast industry to use that portion of the spectrum.

Transmitters for the AM vestigial sideband audio and video signal on channels 58/59 were located next to WUSA-TV's transmitter, across town from the FCC. A parallel 13GHz FM signal also was transmitted for AM/FM comparison. Both transmitters fed directional antennas mounted at the 300-foot level of the station's on-site tower. The FM transmission was 25MHz wide and contained pre-emphasis.

Receivers were installed in the commission's meeting room. Members of the press packed the meeting room as the first program HDTV signals came on. The press conference captured the attention of the national media, the commission and the general public. Comments overheard ranged from "fabulous," to those of several who could see well enough to find the room, but couldn't appreciate the dif-

wired or wireless feed to the sportscaster for his cue phone.

But with the AT4462 and Modu-Comm, cue is fed through the announcer's mike cable already in place. Add a small accessory decoder to the end and plug both the cue phone and the microphone into the same cable. Cue can be program, an outside line, or "talk over" from the mixer. No extra wires, no crosstalk, and no change in audio quality! Nothing could be simpler or more efficient.

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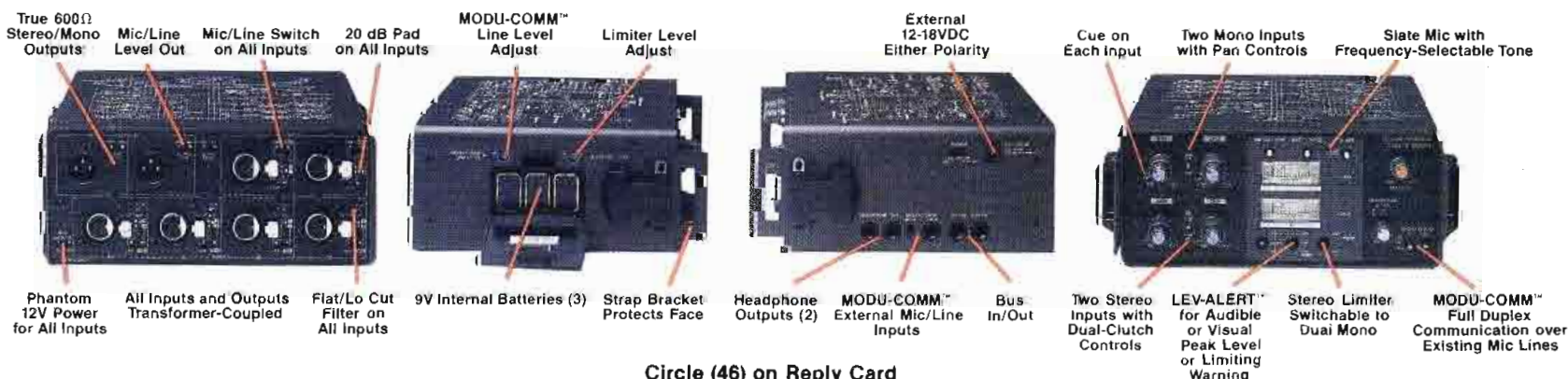
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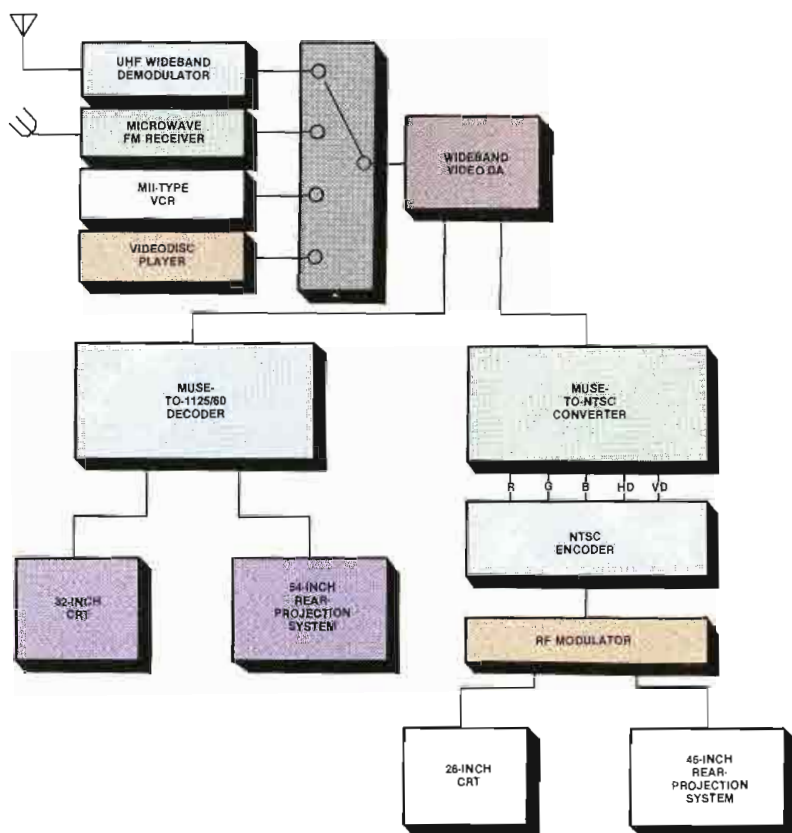
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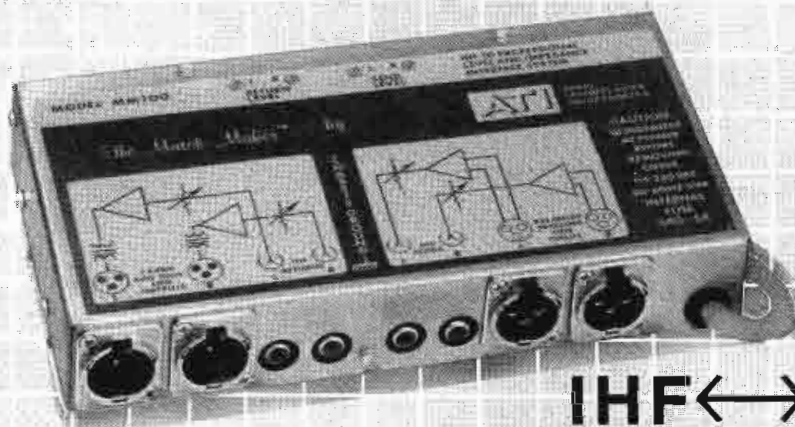
A simplified block diagram of the picture signal flow at the FCC demonstration. Note the variety of signal sources being compared.

ference between NTSC and HDTV.

The receiving system was a special wideband demodulator that fed the digital MUSE signal to a MUSE decoder. The decoder then fed analog HDTV video directly to a 32-inch CRT and a 54-inch rear-projection unit. An NTSC signal was derived from a special MUSE:NTSC converter and then converted to RF on channel 3. The RF fed a 26-inch CRT and a 45-inch rear-projection system. These particular screen sizes were selected because the heights of the respective screens are equal, thus enhancing the wider aspect ratio of HDTV. Digital audio also was derived from the MUSE decoder and was used to drive a large, 2-channel audio system.

Other items on hand at the demonstration included a consumer HDTV videodisc player, and two M-II-like HDTV VCRs. Their outputs also were available for viewing and comparison via a switch that also was used

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Pictures measuring the same height are compared. Here, an NTSC receiver was compared with an HDTV monitor with simultaneous feeds. Both pictures are approximately 18 inches high.

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- Direct Reading in X: -300 to +300 ohms, standard -900 to +900 ohms, optional
- Measures VSWR: $Z_0 = 0$ to 400 ohms

OIB-3



The **OIB-3 Operating Impedance Bridge** provides extended resistance and reactance ranges, measuring up to 1000 $\pm$ j900 ohms. The bridge has a built-in carrying case and RF amplifier for improved nulling.

- Frequency Range: 500 kHz to 5 MHz
- Through Power Rating: 5 kW Modulated 10 kW Carrier only
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- Accuracy: R and X, 2%, $\pm$ 1 ohm

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to compare the reception of AM and FM signals.

Each VTR, with outboard equipment to accomplish its HDTV function, filled a 6-foot rack cabinet. Similarly, the MUSE decoder was so large it couldn't be rack-mounted, and was hidden under a table. Regardless of size, the system performed well.

To ensure the success of the demonstration, NHK assigned approximately 20 Japanese engineers to install and check out the equipment and supervise the transmission and demonstration. Work began in early December.

For several days following the press conference, several tutorial seminars and continuing demonstrations were held in the meeting room. There were highly technical presentations by NHK developers of the MUSE system for FCC personnel, to general explanations for non-technical curiosity-seekers.



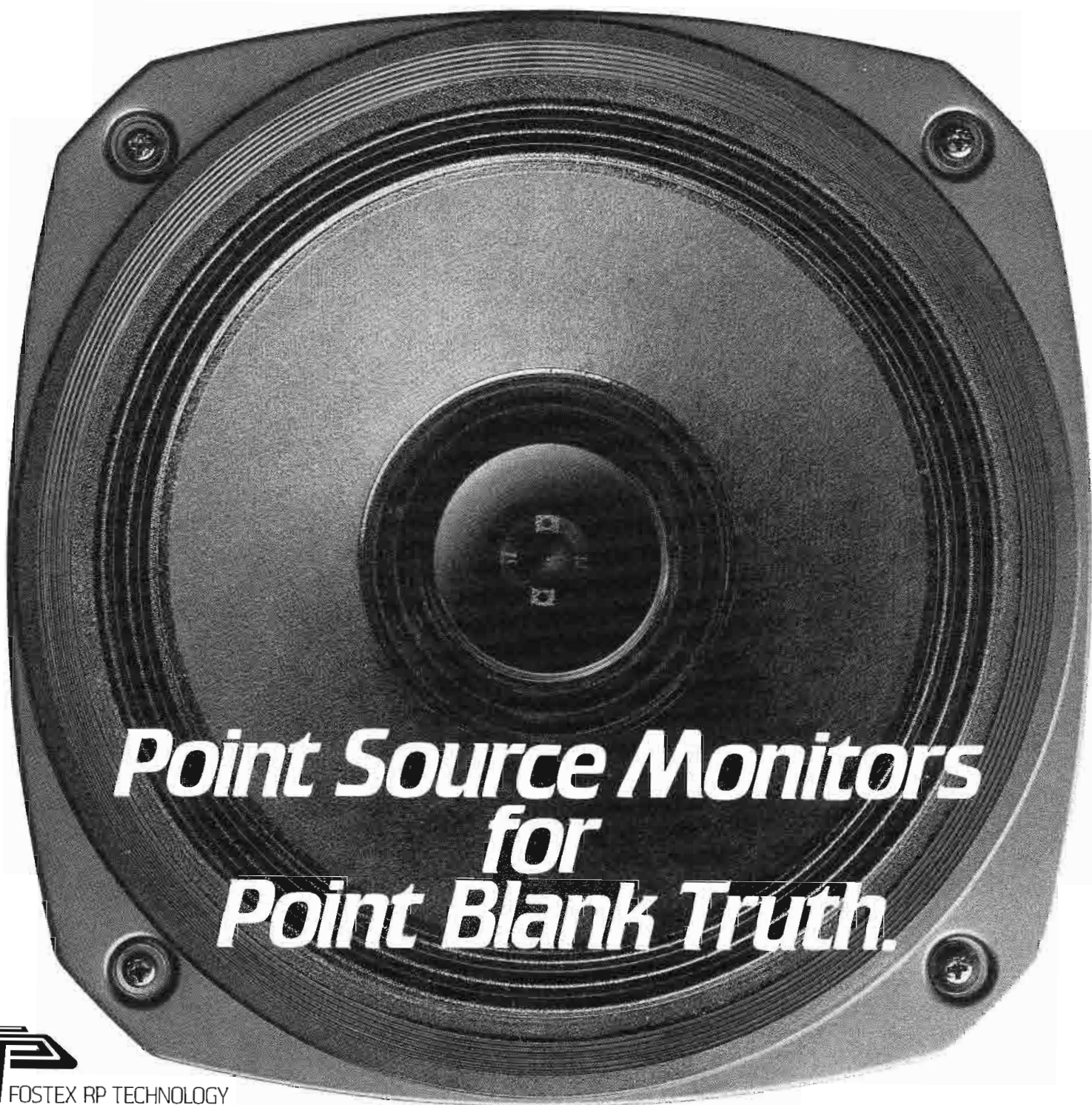
In a corner of the transmitter room at WUSA-TV, history is being forged—with varying degrees of difficulty—by NHK engineers.

This may not be the only public demonstration of HDTV transmission systems. Tentatively scheduled to be demonstrated are two more HDTV systems that are based on the 1125/60 system and are both NTSC compatible. These compatible systems combine the standard NTSC transmission with a special "detail augmentation" signal on a standard UHF channel.

If the plans of the commission do not include HDTV, broadcasters should be concerned that HDTV will find other methods of coming into the home, either by direct satellite broadcast, cable (or fiber), videotape or videodisc. The developers have invested so much money in HDTV that they are obligated to find—or create—a market for it.

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Inside digital delay systems

By Richard C. Cabot, P.E., Ph.D.

Digital signal processing is an evolving science. Evaluating today's crop of digital effects requires a certain measure of caution.

Because of the proliferation of digital technology—everything from compact disc players to music synthesizers—digital delay and reverberation products are enjoying a rapid growth in the commercial marketplace. Plummeting prices for the electronic components used to build these products have played an equal part in fueling their popularity.

Basic filtering

Fundamental to all digital systems are the concepts of *sampling* and *quantization*. Various schemes exist for trading sampling rate against *bits of resolution* in quantization. This article will focus on linear pulse code modulation (PCM) systems because they are the most prevalent type of design used today. (See

Figure 1.)

To prevent alias components from appearing in the sampled signal, all audio components above half of the sampling rate are removed by a steep low-pass filter called the *anti-alias filter*. Because practical filters cannot have an infinitely sharp cutoff, anti-alias filters must start their filtering action substantially below half the sampling frequency. This creates the first problem in a digital audio system: *high-frequency response rolloff and distortion*.

Typical low-pass filters are ninth-order elliptic filters with response ripple of less than 0.5dB. The corresponding phase response is also steep, resulting in more than 360° of phase shift at the cutoff frequency. This means the filter's square wave response will show substantial ringing. Indeed, all time-domain measurements will show substantial ringing on the signal's waveform. The

audibility of this extreme phase shift is currently the subject of intense debate.

Experiments show that a signal passed through several of these filters suffers clear, audible degradation. However, one or two well-designed units used in the signal chain probably can't be detected.

Another problem with steep low-pass filters is high-frequency distortion. The sharp cutoff response requires *high-Q* sections in the filter. These high-Q sections must handle large swings of signal current and voltage when the signal frequency approaches the filter cutoff. If the filter is a passive LC design, the large current swings drive the inductors into non-linear behavior, resulting in distortion. In the case of an active filter, the op-amp slew rate and output current limitations produce distortion near the cutoff frequency. This distortion does not always show up with a THD test because the harmonics are above the cutoff frequency and never reach the filter output.

Sample and hold

After filtering, the next stage in the signal path is the sample and hold. This circuit looks at the signal for an instant and holds this value long enough for the analog-to-digital (A/D) converter to convert the voltage into a binary pattern. The audio signal is constantly changing, requiring the sample and hold to grab the value in a short amount of time. Otherwise, the circuit will introduce an artificial smoothing of the signal over the sample time. The result is high-frequency response rolloff.

The time required to grab the signal is called the *aperture time* and is a critical

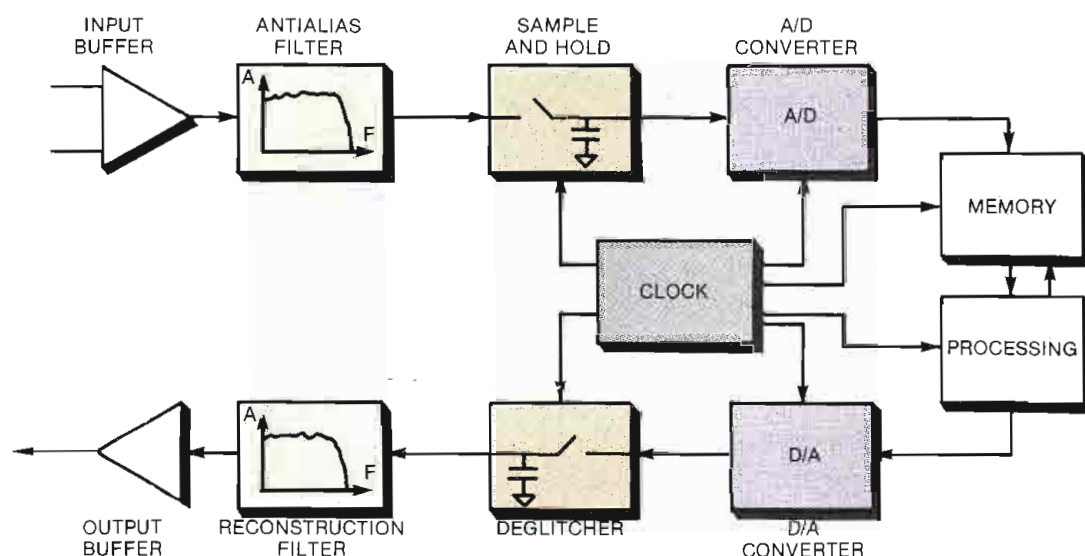


Figure 1. A simplified block diagram of a digital delay or reverberator.

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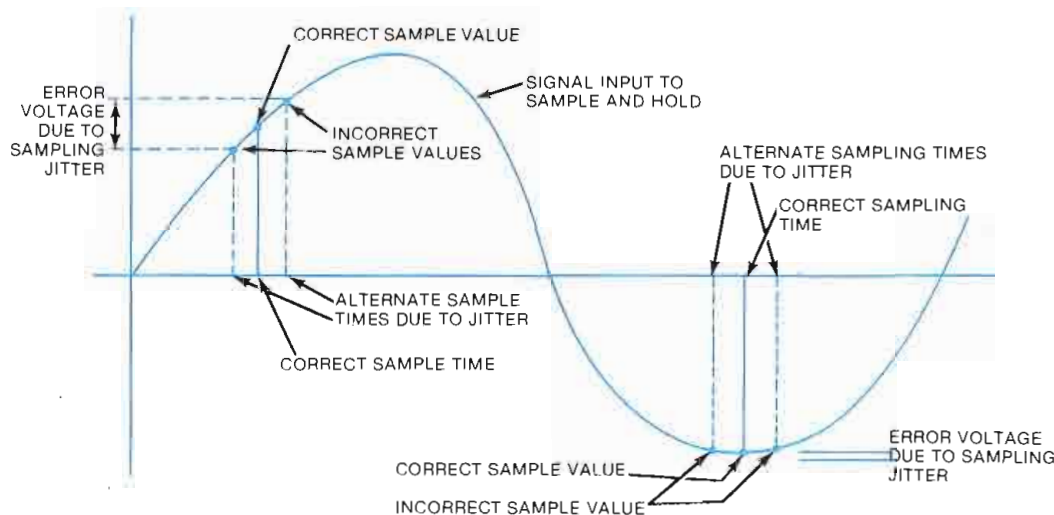


Figure 2. The effect of sampling jitter.

specification of a sample-and-hold circuit. A 1kHz signal must be sampled with less than 2.4ns aperture time to result in less than one-half least-significant bit (LSB) error on a 16-bit conversion.

When a sample and hold is driven with a large high-frequency signal, it must be able to change from the maximum positive signal voltage to the maximum negative signal voltage in one sample interval. This process often imposes severe slew rate and settling-time limitations.

The error on the new sample value

depends on the last sample value. If the last value was close to the existing value, there will be little error because the adjustment to a new voltage was an easy change to make. Deficiencies, however, generally show up as high-frequency distortion similar to that introduced by the anti-alias filter.

Sampling intervals are set by a master clock in the digital circuitry. This clock must be extremely stable or the resulting samples will not be equally spaced in time. The instability of the samples is

called *jitter*, and results in an error in the amplitude of the sample. This error is larger if the slope of the signal is steep in the vicinity of the sample. Figure 2 illustrates this effect.

The error waveform may be thought of as a signal-dependent noise source, much the same as modulation noise in tape, but at much smaller magnitudes. The amplitude of the noise will increase with rising signal frequency. Jitter may also be introduced in the sample and hold itself, but the effect is the same. A 100dB signal-to-noise ratio on the previously described 1kHz tone requires less than 1.6ns of jitter.

A/D converters

The A/D converter circuitry must faithfully translate the signal's voltage signature into binary words. Most A/D converters are limited to fewer bits of accuracy than they have resolution. This limitation shows up as a higher noise and distortion floor than the resolution would imply. For example, in a system with 16 bits of resolution, the noise and distortion should be approximately 96dB below the amplitude of a full-scale sine wave. A converter with less accuracy results in a higher noise and distortion floor than specs would indicate.

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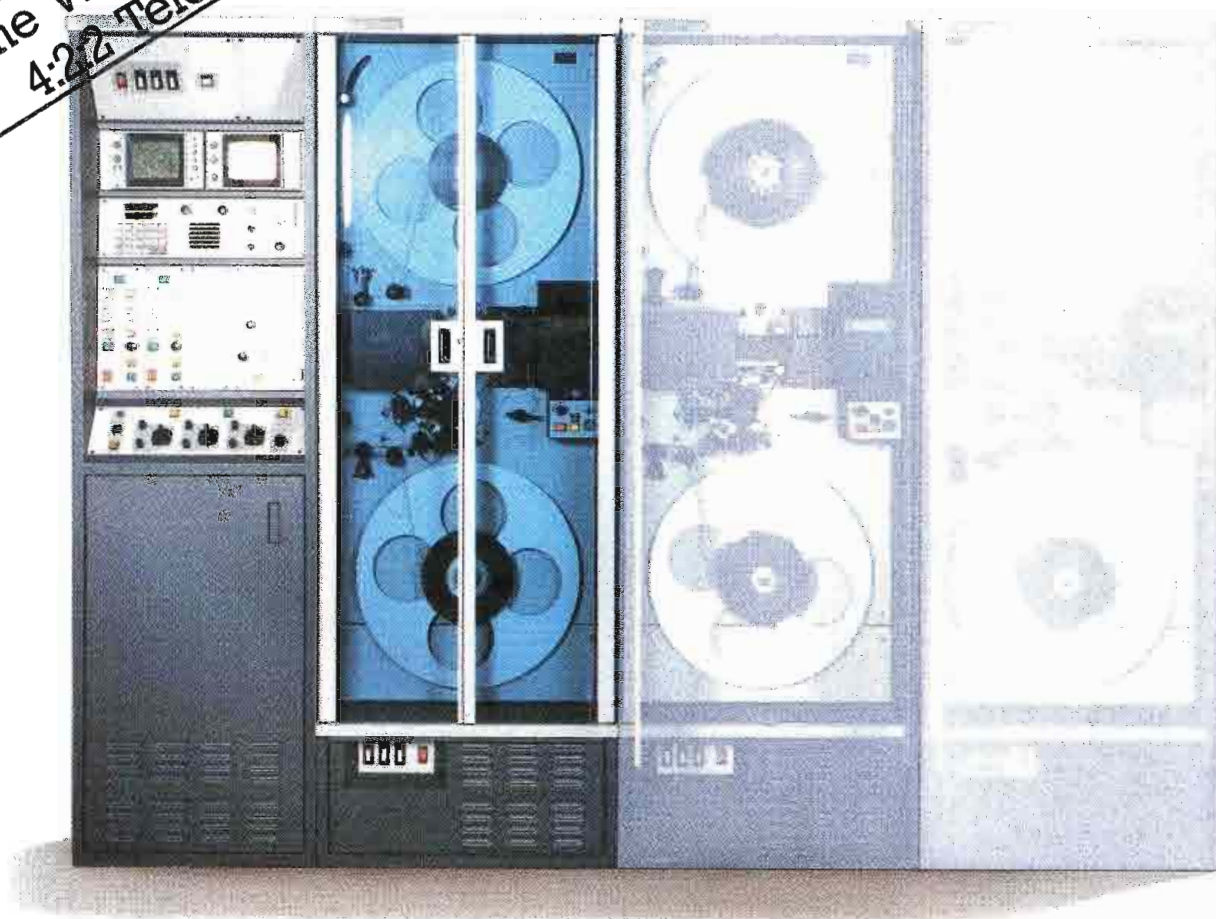


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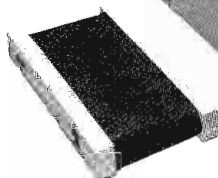


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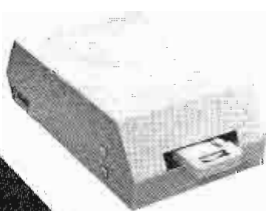
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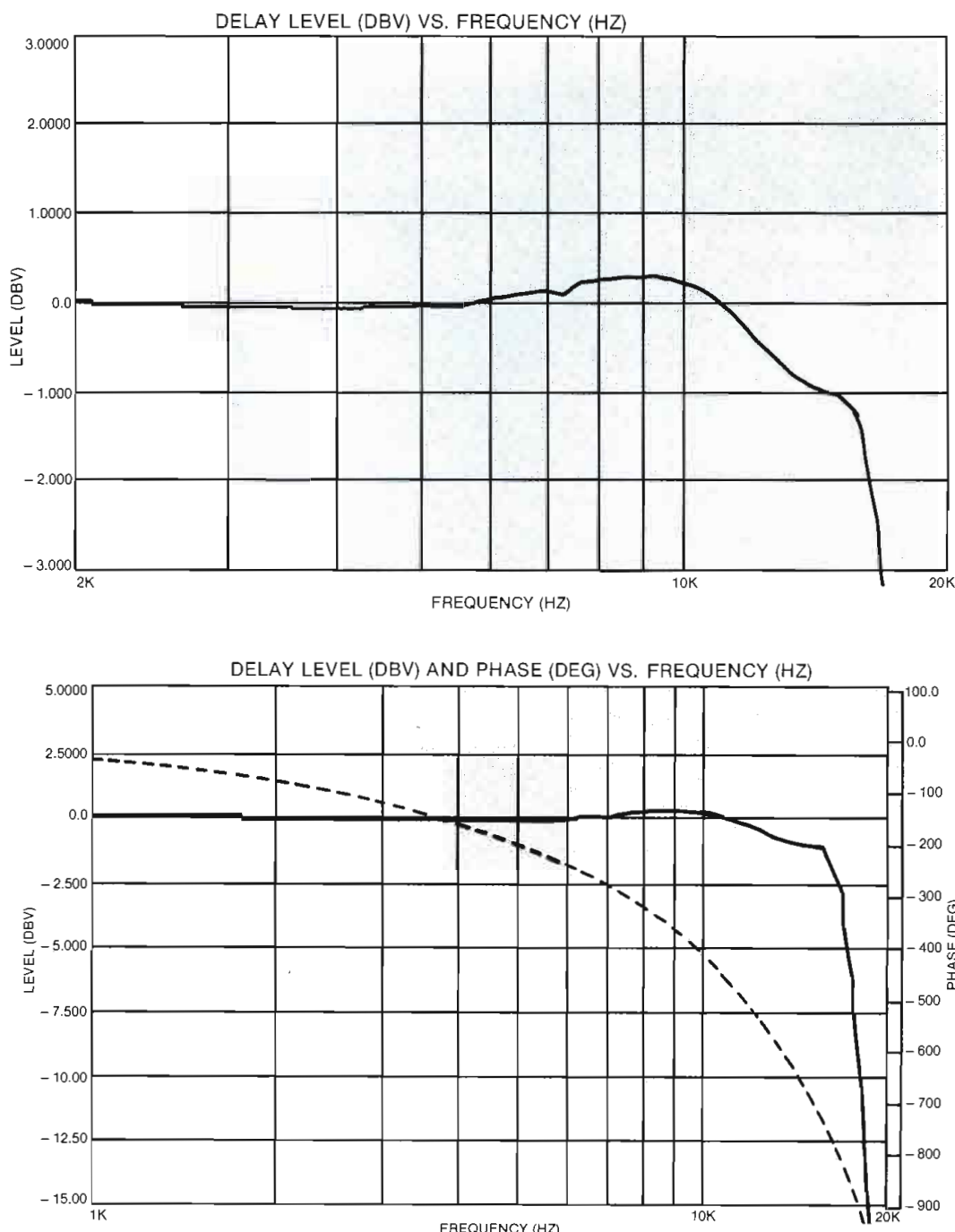


Figure 3. Amplitude and phase response of a typical digital delay system.

Data sheet claims of 16-bit conversion are to be taken with a grain (or maybe a pound) of salt. A/D converters that are accurate to 16 bits cost several hundred dollars and represent the current state of the art. The typical accuracy of commercial 16-bit converters, used in digital audio, is about 14 bits. Substantial progress is being made in this technology, which should yield true 16-bit converters at affordable prices in the next few years.

Output filtering

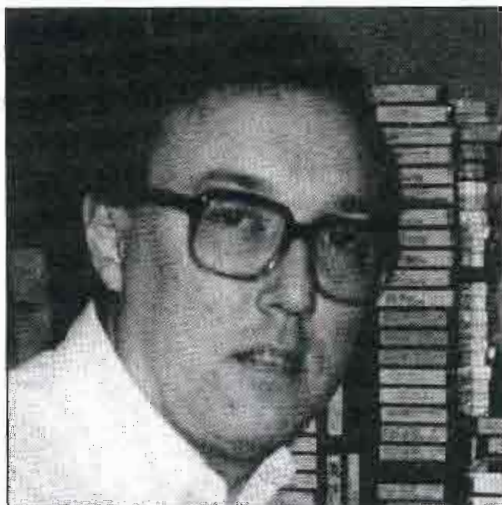
In delay lines, the digital values representing each sample are placed in a memory and retrieved later after the appropriate amount of time. The delayed samples are then fed to a digital-to-analog (D/A) converter to reproduce the analog signal. When the binary input to the converter changes, the analog output will not transit smoothly from one state to the next.

When the bits all change at slightly different times, the switches inside the D/A will change at different rates, causing the converter to produce spikes at the edges of each sample. These spikes are called *glitches*. A special circuit required to remove them is called (what else?) a *de-glitcher*. The circuit is essentially a sample and hold that is switched into the hold mode when the changes are sent to the D/A. Unfortunately, these circuits have many of the same problems as the input sample-and-hold circuits.

To remove the staircase-type edges from the signal, a filter is placed at the output of the sample and hold. This is essentially the same as the anti-alias filter used at the input, but this filter is called a *reconstruction filter* because it reconstructs the analog waveform from the staircase output of the D/A. The same comments on distortion, overload behavior and phase response for the anti-alias filter apply to the reconstruc-



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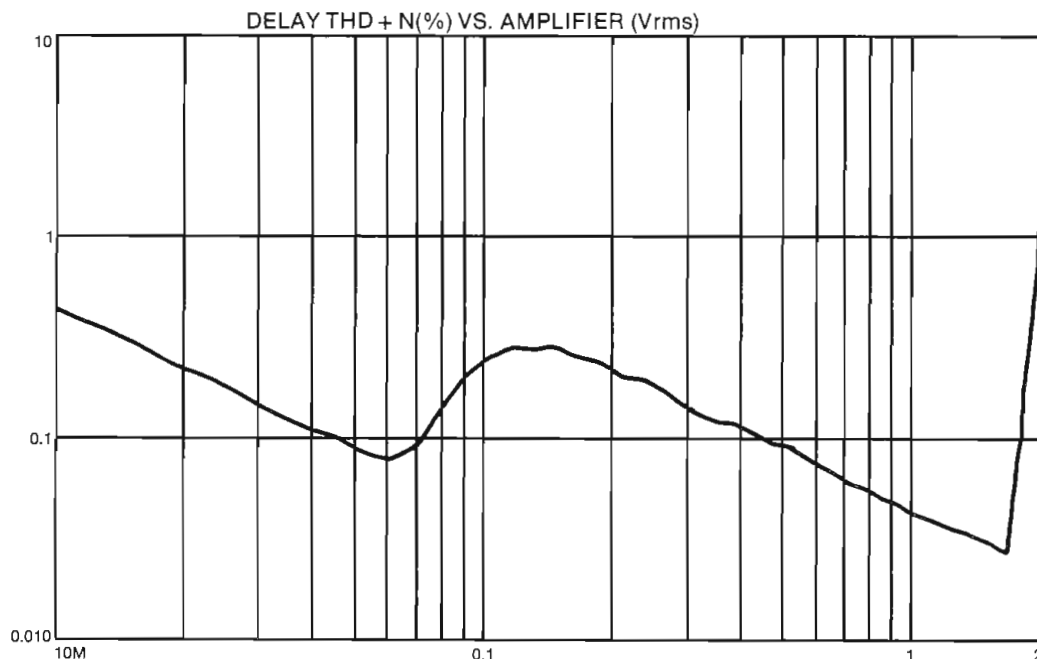


Figure 4. A 1kHz THD+N test as a function of a signal level.

tion filter.

However, harmonic distortion above the filter's corner frequency can appear in the output signal. This is because there is no sampling process afterward to alias the harmonics to lower frequencies.

Because the signal passes through two sharp low-pass filters, the phase and

amplitude responses described previously are magnified by a factor of two. A typical delay's frequency response is shown in Figure 3. The total system frequency response is down 1dB at the high end and peaks up 0.5dB an octave lower. The phase shift is similarly doubled to more than 700° at cutoff.

Compressor circuits

Many of the distortion mechanisms previously discussed can be seen on THD+N tests. A 1kHz THD+N test, as a function of level, was run on the unit mentioned. The data are given in Figure 4. An interesting bump can be seen in the measurements, which is most likely due to non-linearity in the converter. These data show not only the distortion in the classic sense, but the change in noise floor as a function of signal level because of ranging in the converter.

Another test for the presence of any compressor circuits and for noise modulation, due to ranging in the converter, was developed by the British Broadcasting Corporation. The test involves applying a low-frequency signal to the device and filtering it off at the output with a high-pass filter. This removes the signal and its significant harmonics and allows measurement of the noise level in the presence of signal. The signal level may then be varied and the noise level plotted.

This measurement was performed using a 10Hz tone, a 100Hz high-pass and a 10Hz notch on the delay tested previously. The results are plotted in Figure 5. Note the broad rise in noise level below

Main story continues on page 98

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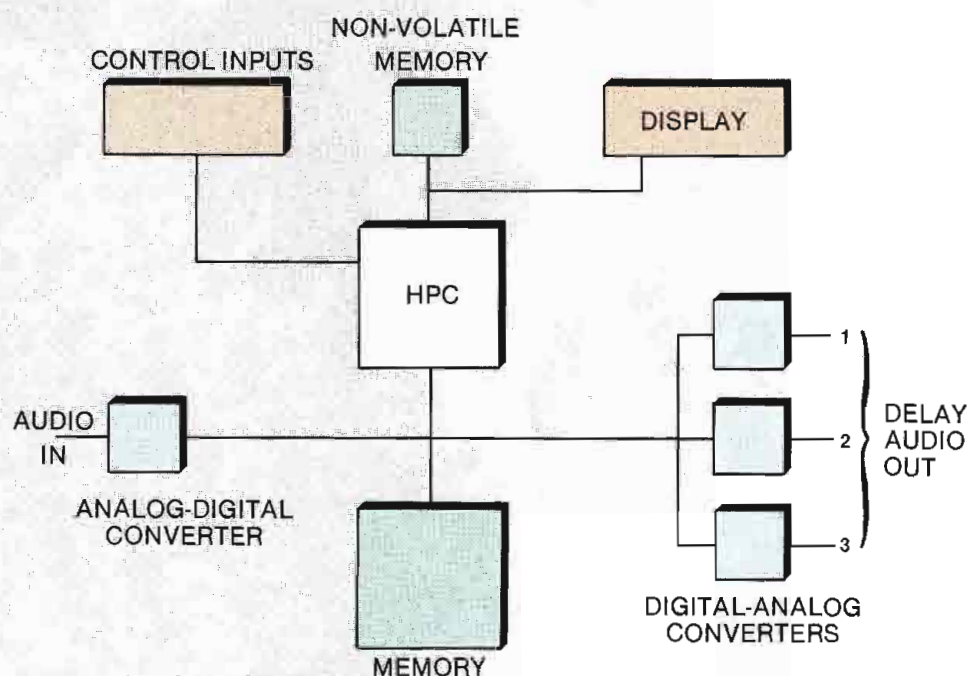
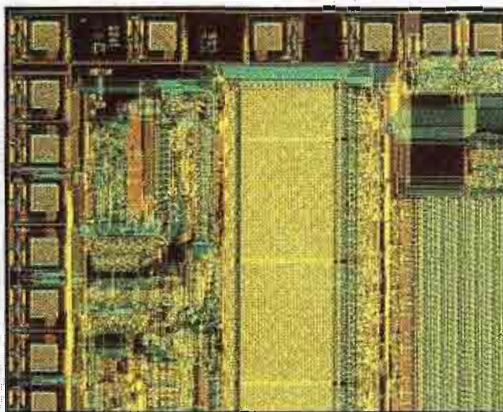
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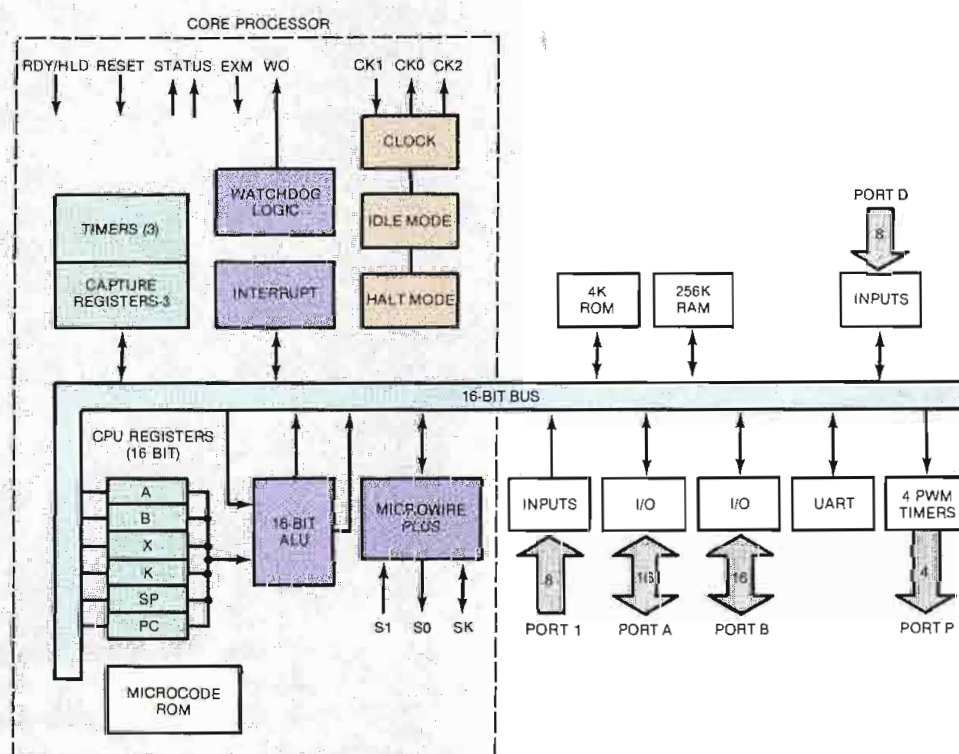
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Microcontrollers for digital audio delay

By Charles B. Mitchell



A typical delay system designed around a high-speed microcontroller.



This microcontroller block diagram shows the architecture of the National Semiconductor HPC1640 core processor.

One key to the successful implementation of a digital processing system is the controller chip. These chips, called *microcontrollers*, are the heart of modern digital equipment. Originally derived from the technology developed for calculator chips, the microcontroller is a complete computer system on a single silicon die. It differs from the *microprocessor* in that memory and input/output (I/O) elements are contained within the defined architecture. It differs from the *microcomputer* in that both the instruction set and the internal hardware support are designed for direct interface to control mechanisms. The most common use for the microcontroller is in the area of human-to-machine interfacing.

One new microcontroller, a National Semiconductor HPC16040, is designed around a core processor, which is duplicated for each member in the IC family. Around this core are placed the ROM, RAM and various market-specific I/O devices. The sizes of the memory devices may be varied by adding or deleting cell structures from the layout. Alternate peripheral implementations can be placed in the alterable die sections.

The core processor contains the basic 16-bit CPU and system support elements. The CPU consists of the arithmetic and logic unit, the CPU registers and the microcode elements, which define the instruction set and address manipulation. System support includes the interrupt logic, power-save facilities, watchdog logic, serial interface structure, system clock and propriety circuits.

Because time measurement is a consistent requirement in controller applications, a sophisticated group of four 16-bit timers with capture registers is incorporated into the core.

Packaged in a 68-pin lead-chip carrier, this IC also contains, in addition to the core structure, an internal memory configuration consisting of 4Kb of ROM and 256 bytes of RAM.

Mitchell is a senior field applications engineer for National Semiconductor, Santa Clara, CA.

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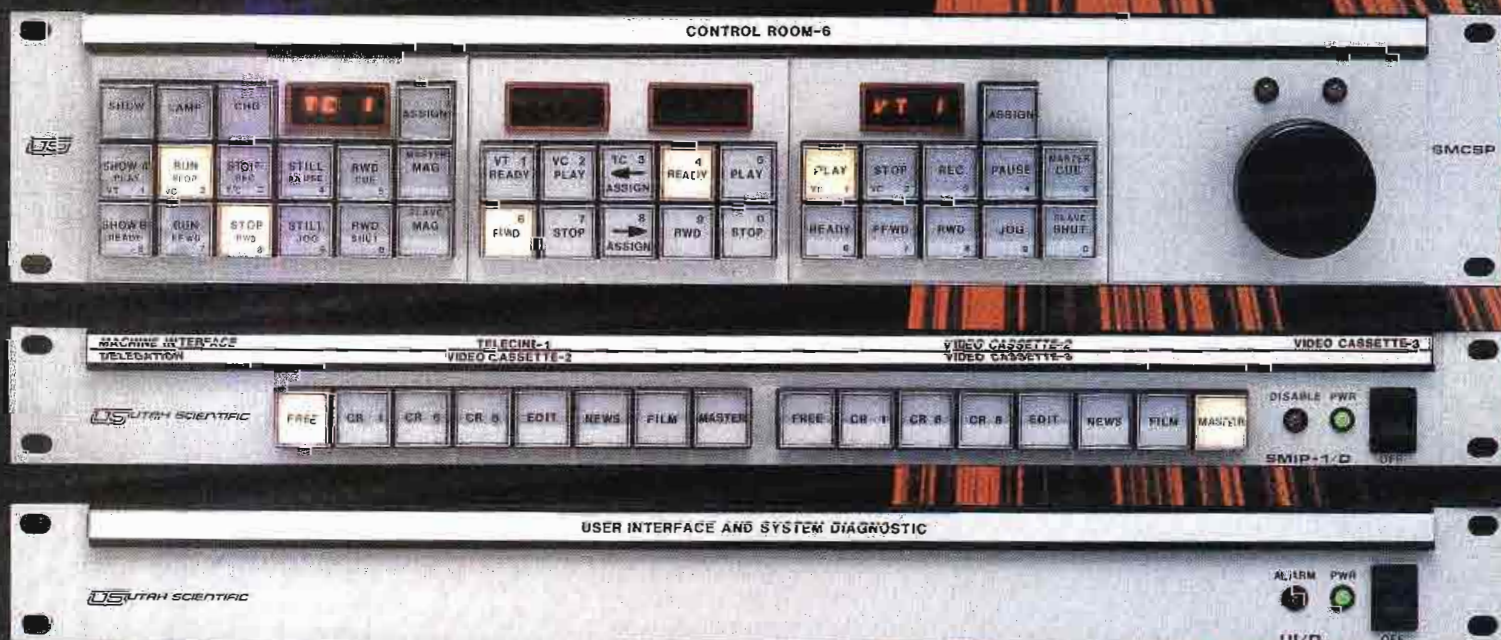
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The chip's I/O consists of two 16-bit bidirectional ports, two 8-bit input ports, a serial communications device (UART) and four additional 16-bit timers, configured for use either as general-purpose counters or for pulse-width modulation.

Audio delay criteria

Digitizing analog signals requires an input sample rate of at least twice the highest signal frequency. With today's full-bandwidth audio, this frequency is generally acknowledged to be 20kHz. Therefore, any A/D converter must operate at a minimum of 40kHz. Due to various inaccuracies introduced through the use of non-ideal devices such as filters and data converters, most modern audio delays perform the audio sampling at 50kHz.

This rate allows 20 μ s for the executing of all data-related I/O tasks. Even for state-of-the-art programmable devices, this is a formidable task. The process is compounded by the requirements for servicing more mundane background requirements such as controls and displays.

Application

In a simple audio delay, one without an effects generator, the prime task is

that of data movement. In a 3-channel delay, the data must be fetched from the A/D conversion unit and placed in memory in an ordered sequence. This process allows retrieval for later placement in the output devices (D/A converters).

The data are placed in memory sequentially. In many discrete logic-driven systems, this is all that is required. When the counter's maximum address is reached, the next address will be comprised of 0s and the count proceeds in a circular manner. Incoming data simply overwrites old data.

However, in a computer-controlled system, memory must be shared between the instructions for the processor and the actual data. If a simple sequential deposition of data without bounds occurs, then the controller instructions may be overwritten. In the case of a ROM-based system, the data would be lost.

In one microcontroller design, four superimposed buffers are maintained. The first stores the incoming data. The other three are output buffer positions delayed in count by the required time, a parameter entered into the system by the operator.

Processing the front-panel inputs and display driving also must be

handled by the microcontroller. The utility routines for these tasks are constantly in action. For this reason, the movement of data is based on an *interrupt-driven* routine. Using one of the available hardware timers, a periodic pulse is generated by the microcontroller and transmitted to the A/D converter, starting a conversion.

When the A/D conversion is complete, the converter signals the microcontroller via an interrupt line. The controller then ceases its background tasks and commences data movement. It will return to the previous task after loading the A/D data and depositing delayed data to the three output areas.

An additional feature of this family of controllers is the 16-bit-wide data-bus. This allows movement of data in 1-word increments, instead of two 8-bit/byte words, common to some other controllers. The net result is a fast, relatively inexpensive programmable device capable of dealing with the severe throughput requirements of a full-bandwidth digitized audio signal.

Modern microcontrollers are providing equipment designers with capabilities never before possible. Devices such as these ultimately will provide broadcasters with many new and exciting features.

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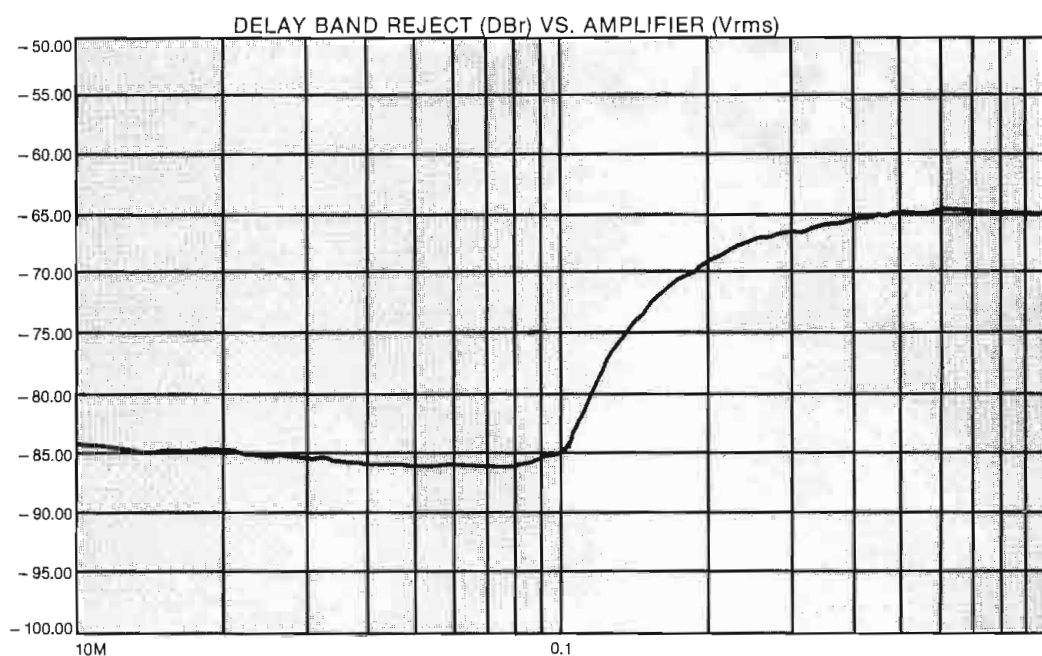


Figure 5. Quantization noise vs. amplitude using a 10Hz test signal, 10Hz notch and a 22Hz high-pass filter.

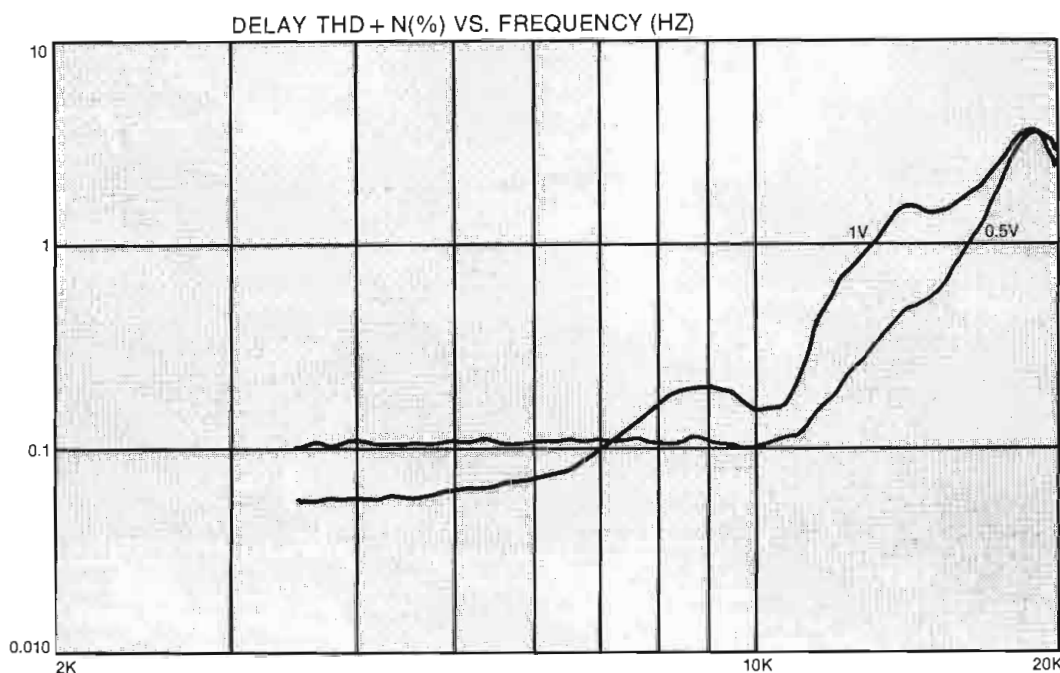


Figure 6. THD+N as a function of frequency at 0.5V and 1V levels as measured on a typical digital delay.

Continued from page 92

0.1V. This indicates a ranging converter or a compressor circuit. This type of test shows the fallacy of measuring this unit's noise level with no signal applied.

Distortion tests

High-frequency distortion tests are an interesting prospect in digital systems. Measuring harmonic distortion in band-limited systems such as tape machines has always been a problem at high frequencies. Because the harmonics are filtered off, they fall outside the system bandwidth. This phenomenon limits THD measurements in a 20kHz bandwidth to about 7kHz for valid results.

This problem does not occur in digital systems because harmonics above one-half the sampling rate will alias down in-

to the passband. They will not be at harmonic multiples of the fundamental frequency, but they will still appear. By measuring THD+N, a *figure of merit* may be obtained. However, care must be exercised not to mistake inadequately filtered sampling glitches for distortion.

THD+N, as a function of frequency, was measured on a typical digital delay and is shown in Figure 6. The two curves were run at input levels of 1V and 0.5V. To the extent that the two curves track each other, the rise in distortion at high frequencies may be sampling leakage.

Intermodulation tests clearly show distortion behavior, and will indicate the audible side effects of the filter. Figure 7 shows a delay excited with a pair of test tones close to its cutoff frequency. Distortion products will be generated at the dif-

ference frequency between the tones and at the offset frequency from the two high-frequency tones. A plot of the difference frequency distortion on a 14kHz and 15kHz tone pair as a function of amplitude is shown in Figure 8. The broad rise in distortion at higher amplitudes stems from bona fide distortion mechanisms in the converters and low-pass filters.

Digital calculations

Digital reverberators differ from delays in that they contain a digital arithmetic unit, which combines samples according to a formula. This mathematical processing adds noise and distortion to the signal, often as a function of the signal characteristics and the reverb algorithm.

There are two main causes. When samples are scaled (multiplied by a constant) and added, the processor used has a finite number of bits (precision) in its calculation. The round-off errors can accumulate over several calculations and contribute significantly to the system's noise and distortion.

The other reason is more subtle. Suppose the arithmetic unit has 32 bits and the A/D converter is supplying it with a properly *dithered* 16-bit word. (Dither is a process by which quantization errors are reduced or mitigated by the use of random noise signals.) In this case, the processor is capable of performing many thousands of calculations before it runs into round-off error limitations. However, more likely than not, the results of this high-precision calculation must be truncated to 16 bits in order to pass through the output D/A converter.

Consider the effect of this process on a single reflection path, such as a sample that is delayed and scaled down in amplitude. If the original signal is properly dithered for the 16-bit resolution of the converter, this dither will be lost when the samples are attenuated. For the case of 12dB of attenuation, the 16-bit properly dithered signal has been turned into a 14-bit undithered one.

The solution lies in digitally dithering the results of the calculations to the resolution of the next step in the signal path. This resolution limitation is usually imposed by the D/A converter. However, the limitation also may be the size of the memory words used to store the results for use in another calculation.

Commercial units exist that delay digitally and perform the combining function in the analog domain. These units suffer from a related set of problems. The delayed signals are output through a D/A converter and combined in an op-amp at the input to the delay. Each simulated reflection is passed through the A/D and D/A process once for each simulated wall in the room. A single late-arriving reflection may have

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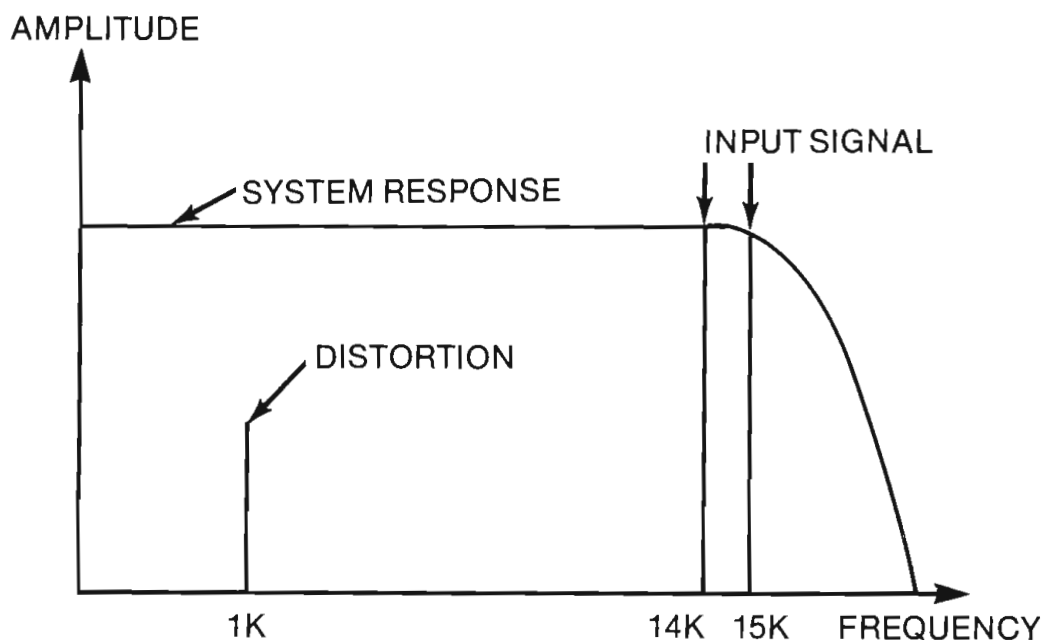


Figure 7. Difference frequency (CCIF IM) distortion measurements.

passed through the conversion process hundreds of times. Although the signal degradation can be enormous, the signal is attenuated each time through and contributes a small amount of the total reverberant energy. The average degradation of the reverberation quality is related to the average number of times reflections pass through the chain.

Artificial reverberation

From a broadcast point of view,

reverberation is becoming an important tool in the production suite or studio. Dry voice or instrumental tracks often need reverb added prior to final mixdown or broadcast. Now that we've looked at the theory behind digital delays and reverbs, let's look at implementation.

The simplest way to make a reverberator is to take some of the signal, delayed appropriately in time, and add it back to the input. The process results in a series of reflections, all

spaced at a specific time delay interval from each other, as illustrated in Figure 9. The problem here is the uniform spacing and amplitude delay of the resulting comb filter.

Early designers attempted to solve this problem by cascading several stages with different delays. This interleaves the notches in the response, resulting in a closer approximation to a flat frequency response. The increased echo density and the variation in echo spacing produces a substantial improvement in the sound quality.

There is an alternative architecture for an artificial reverberator that avoids the problem of comb-filter effects. The design is illustrated in Figure 10. The signal is recirculated around a delay line, scaled by the gain constant K , as in the previous implementation. A second scale factor is applied to the output of this stage, before adding it to an inverted and scaled version of the input signal, to obtain the result.

By choosing this scale factor equal to $1-K^2$, the total gain through the reverberator becomes *unity*. The impulse response test gives a better insight as to how this works. Although not obvious from the block diagram, the gain is independent of frequency, that is, an all-

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pass. Hence this architecture is often called an *all-pass reverberator*.

Although the steady-state frequency response of all-pass reverberators is flat, the sound is still unnatural. This is because the echo density is low and the spacing is regular. In other words, there aren't many echoes and they are all spaced equally apart. Cascading several all-pass reverberators will improve matters, but it is not a cure-all.

As with the original reverberator design, the delay time of each cascaded stage must be set to a different value. The selection of delay times for optimum reflection-timing uniformity requires all times to be prime number ratios, so that none of the reflections will occur simultaneously. This is true also for other schemes with multiple-tapped delays.

The next step in the reverb's evolution was to combine the generic reverberator schemes that have been described with specific early reflection patterns. This becomes easy when using a software-based reverberator. The early reflections tend to give the reverberation the character of a particular room or hall. Figure 11 shows the impulse response pattern of reverberation in a hypothetical room.

The direct sound from the source to

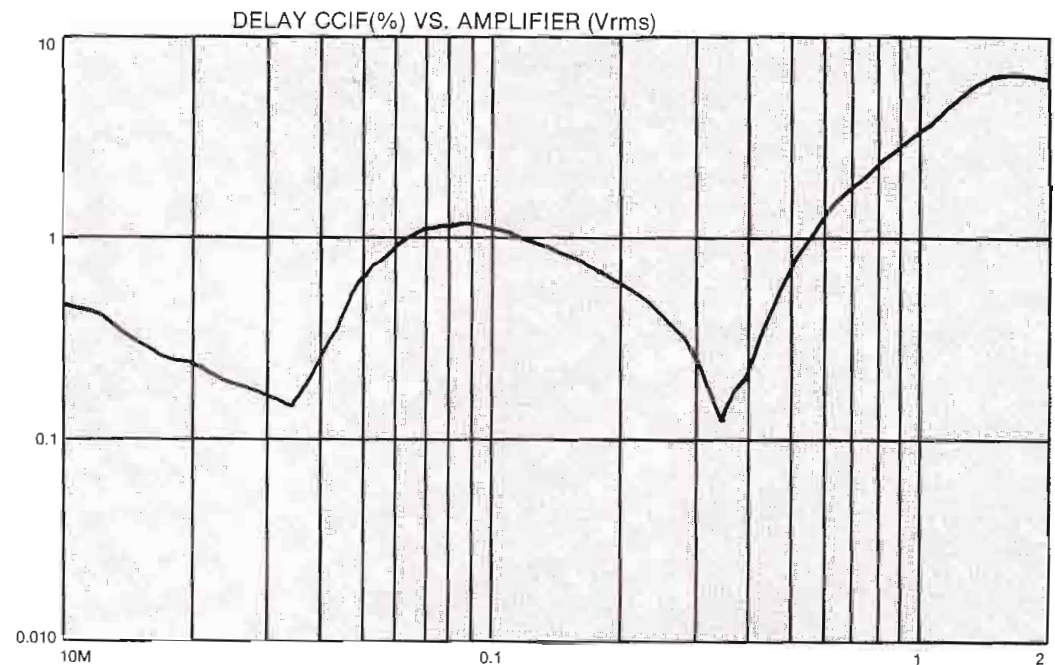


Figure 8. Difference frequency distortion with a 14kHz and 15kHz tone pair plotted as a function of amplitude.

the listener is followed by the first reflection after a delay of several tens of milliseconds. This delay is called the *initial time delay gap*. Several reflections will follow, spaced fairly widely apart. Some time later, the main body of the reverberation will arrive. This is composed of a large number of reflections, spaced closely in time, which decrease in amplitude at an exponential rate.

The spacing of the early reflections

depends greatly on the characteristics of the space being simulated. Because these reflections are introduced by the first bounce off the surfaces of the room, the initial time delay gap will scale linearly with the size of the room. The spacing between the early reflections also will scale with the room dimensions. The reflection's exact distribution depends on the shape of the room and hence dictates the sound character of the room.



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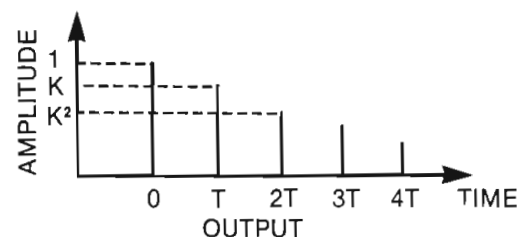
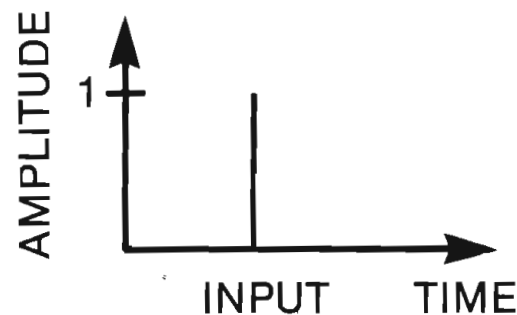
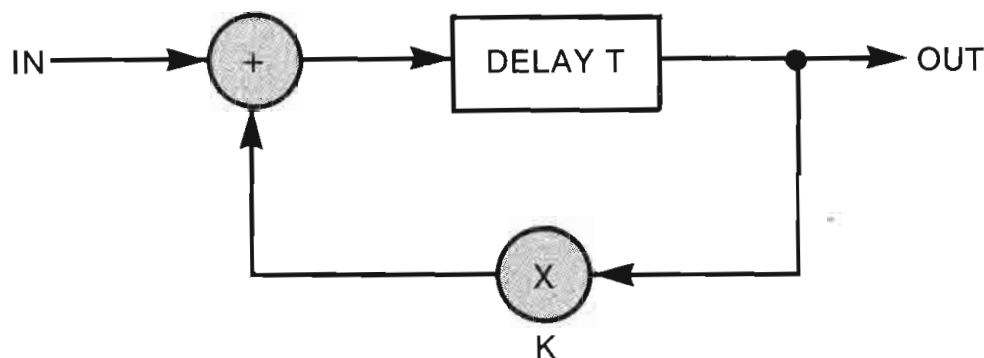


Figure 9. A simple single-stage reverberator.

If the main body of reverberation is fairly smooth and uniform, only its decay rate (the reverberation time, R_T) will have much of an effect on the perceived sound. In most rooms, this decay rate will be a function of frequency.

Simulated rooms

To simulate the response of real rooms, it is necessary to imitate many of these characteristics. One approach to this is shown in Figure 12. The early reflections are simulated by adding suitably delayed versions of the input signal. These are then mixed with the output of a reverberator, which produces the main body of the reverberation. The signal being recirculated or fed back around the reverberator is passed through a filter. This allows the path's frequency response to be adjusted, resulting in reverberation time that varies with frequency.

The delay taps for the early reflections, the reverberation time and the frequency response of the reverb may be set for the characteristics of the hall to be simulated. This is usually done by front-panel selection from a number of preset choices or by entering numbers representing hall size, high-frequency reverb time, low-frequency reverb time and so on. The selection of the non-adjustable parameters, and even the implementation of the adjustable ones, is not a trivial design task. Exact details of the reverberation algorithms in commercial units are closely guarded secrets of the respective manufacturers.

Digital filtering

Digital equivalents of conventional analog filters have been within the capability of available hardware for several years. Digital filters are widely used in compact disc players as a replacement for highly complex analog

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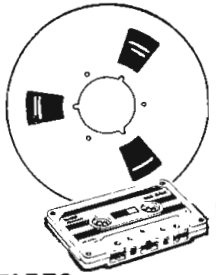
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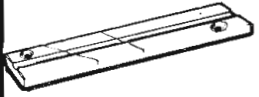
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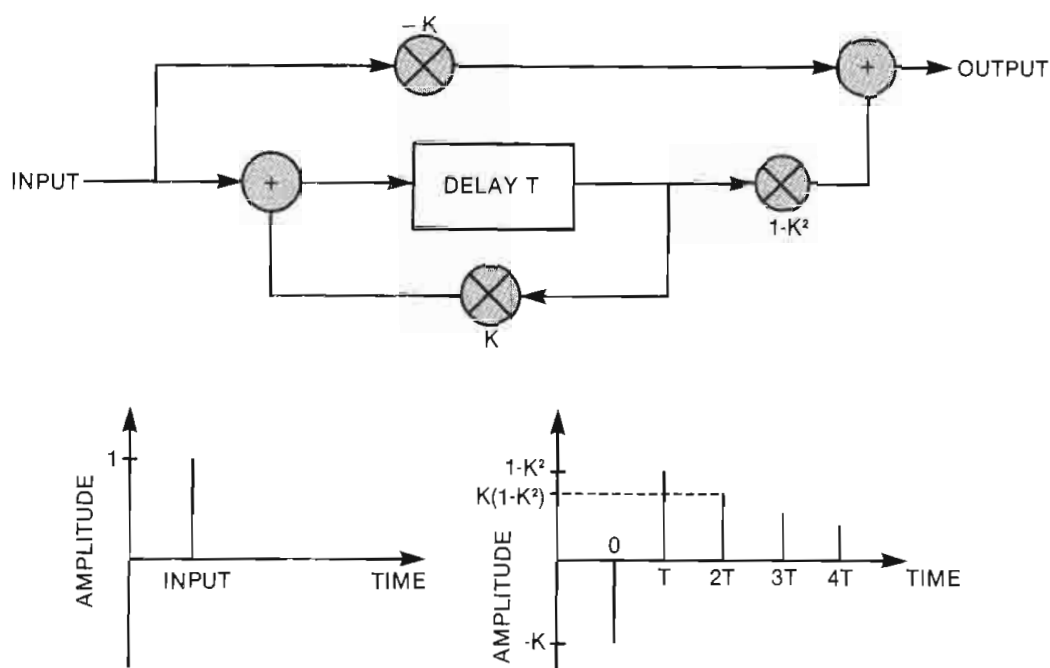


Figure 10. An all-pass single-stage reverberator.

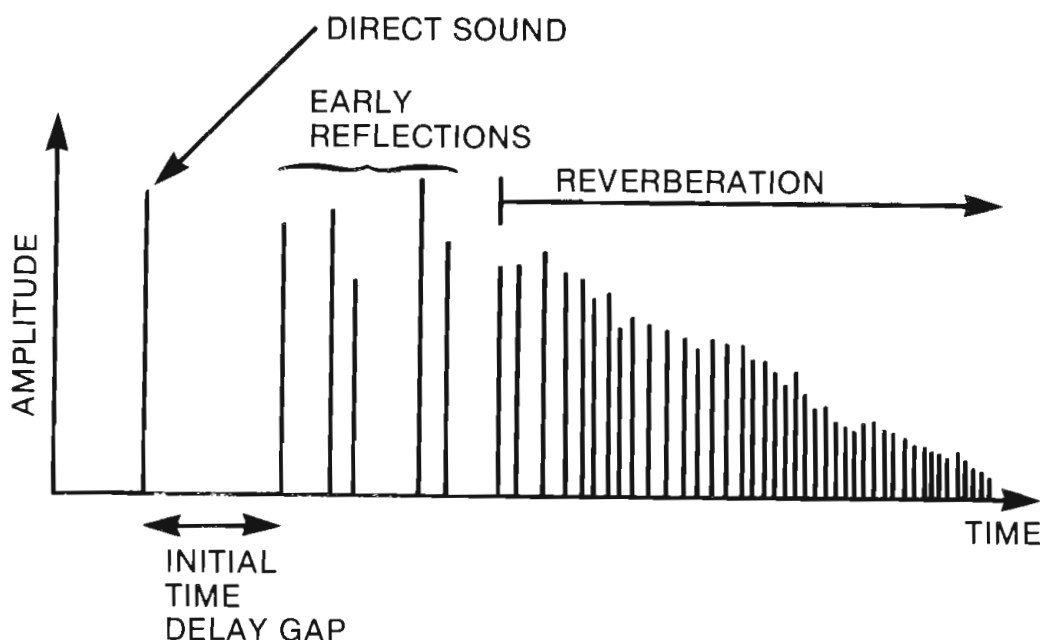


Figure 11. A simplified room impulse response.

anti-alias filters. Digital filters also have been applied successfully to equalization requirements inside digital reverberation units and fully digital consoles. These are all applications in which the signal is already digital for other reasons and the filtering is easier to perform in the digital domain. Indeed, the costs of converting an audio signal to the digital domain purely to provide equalizing functions are currently prohibitive.

A simple digital filter block diagram is shown in Figure 13. The block diagram's nature implies a hardware design. As with the reverberation topologies described previously, however, it may be implemented on a general digital signal processor. Several alternative topologies exist for digital filters. They differ in the trade-off between multipliers and adders as well as some performance attributes.

Analog and digital filters

The fundamental characteristic of a filter is its amplitude vs. frequency response. This is easy to define for

analog filters because there is no upper limit to the available frequency range. However, in digital systems, aliasing occurs above one-half the sampling frequency. This aliasing also will occur on filter responses, folding that portion of the response above the sampling frequency back down, into the passband.

The easiest way to make a digital filter is to take an analog design and convert it. This usually results in a digital filter shape different from the original analog design. In fact, only low-pass filters, whose cutoff frequencies are far below the sampling rate, can be directly converted without modification. This direct conversion from an analog filter to a digital filter is called an *impulse invariant design*, because the filter's impulse response remains unchanged. Because two filters have the same impulse response, they also will have the same frequency response.

To realize other filter designs, transformations have been developed that convert an analog filter alignment to a



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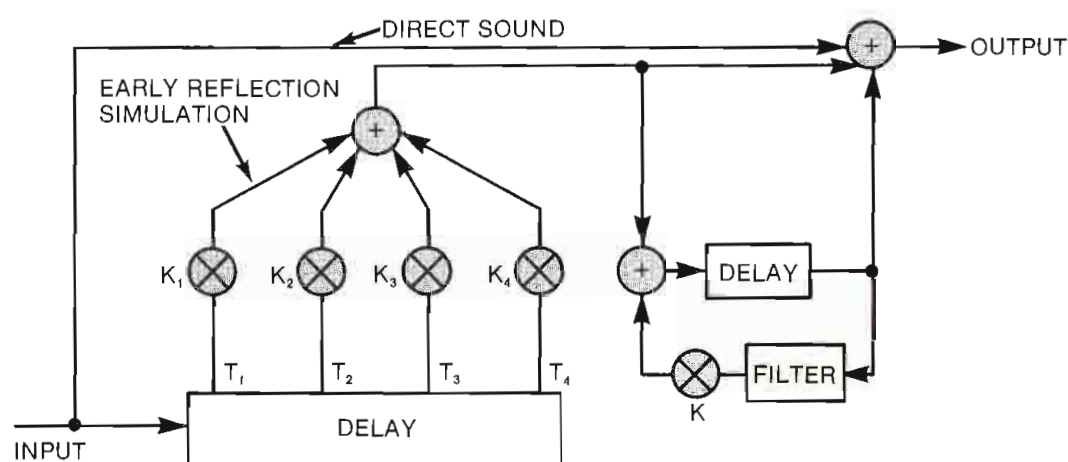


Figure 12. A simplified block diagram of a room simulator.

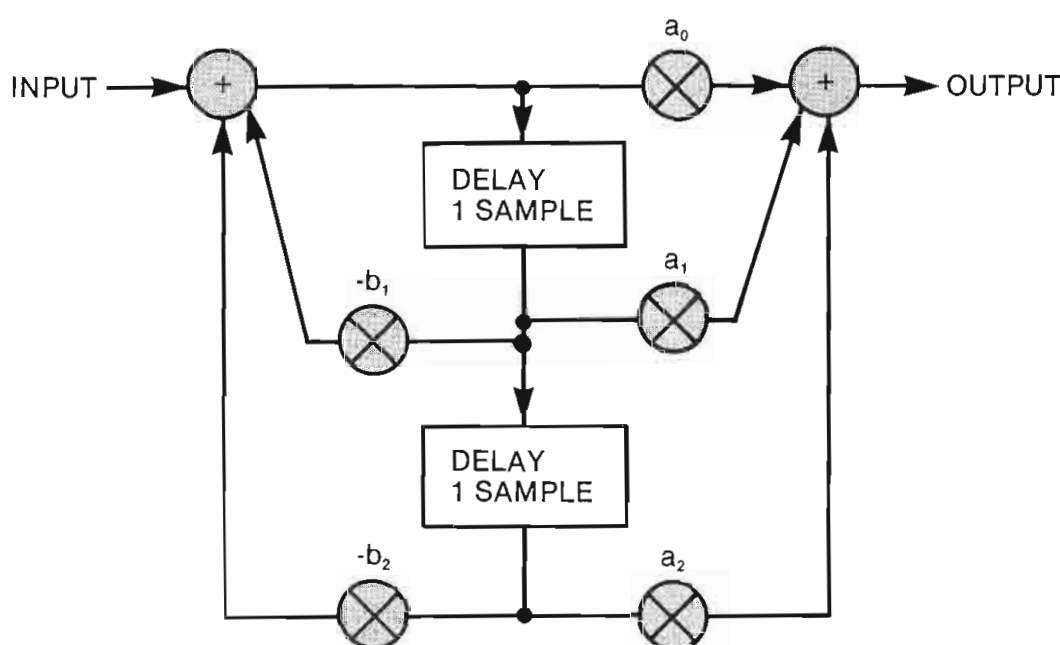


Figure 13. A basic 2-pole digital filter.

digital filter alignment. These transformations map the entire frequency range of the analog domain into the digital range from dc to one-half the sampling rate. Therefore, there will be no aliasing problems in the response.

However, the free lunch principle still applies. These transformations distort or warp the frequency axis to achieve this mapping. The resulting frequency response will be different from the original analog one. The process requires the analog response (the pole and zero locations) to be predistorted before the transformation. As you might expect, this involves trade-offs and the original analog response can never be achieved in digital designs for both amplitude and phase response over the entire frequency range.

Because digital filters contain delay elements, they can be designed to perform tasks that are difficult or impossible with conventional analog filters. An example is the phase response of a high-order, low-pass filter. Typical analog filters have a square wave response that

peaks on the front corner. This peak is due to a non-constant delay vs. frequency through the filter. A digital filter can be designed for constant delay vs. frequency to linearize the phase response, thereby making the square wave's leading and trailing edges symmetrical. This also can be accomplished with analog filters by adding several all-pass phase shift stages to flatten the delay.

As mentioned previously, there are several topologies that can be used to implement a digital filter. They differ in the order in which delays, additions and multiplications are performed, and in the relative number of these operations. A greater number of delays requires more memory operations, and more multipliers introduce more round-off errors. With some early-generation hardware, the digital processing also took more time. Round-off errors introduce distortion, noise and low-amplitude oscillations, which never die away.

Modern integrated circuits have eliminated the difficulty of implementing multiplications as well as the extra time

required. Architectures are now viewed in terms of the total number of operations required and the effects of round-off errors.

Digital limiters

There are many digital devices available that perform other signal-processing tasks; some are specialized for unique tasks such as chorus, flanging and echo. Beyond the standard digital delay system, perhaps the next most-desired device is a digital audio processor.

Although not yet available, it is likely that a commercial limiter using digital signal processing is just around the corner. A limiter, which introduces a several-hundred-millisecond delay into the signal path, would have this time available for the control circuits to sense the level. The limiter could then totally eliminate overshoot because it would effectively know what the signal level would be several hundred milliseconds later.

Such a unit has been built and used by the BBC and appears to work as expected. Such units will likely become available in the next couple of years, as the cost of A/D conversion decreases.

Evaluation

In the meantime, broadcast engineers will continue to be faced with a multitude of "digital options." More and more equipment will take advantage of digital electronics. For many, the expanded options may pose a problem: how to judge the unit's quality.

As discussed, there are no easy ways to evaluate the performance of some digital processing equipment. In the case of reverbs, the problem is analogous to measuring the distortion of signals in a room. There are sharp peaks and dips in the frequency response curve caused by the reflections mixing with the direct sound and with each other.

Even standard THD and noise tests may fail to provide an adequate measure of a unit's performance. Perhaps the safest way, for now, to evaluate the performance of delays and reverbs, is to perform your own measurements. Seldom are the performance specifications presented in sufficient detail to permit adequate comparisons.

If you can't borrow a unit before purchase, try to get distortion specifications as a function of frequency and as a function of level. Noise should be specified over a range of signal levels, not just with no signal present. Frequency response should be checked in the mode you will be using. These devices often perform differently in various operating modes. Finally, you should listen to the unit you are considering. If all else fails, trust your ears.

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Technology behind DVE System 10

By K. Kashigi, K. Hirayama, T. Yamashita and S. Kawabe



Digital visual effects equipment has become indispensable to TV program production. Applications for effects run the gamut of video, from broadcast to corporate video, from fashion displays to education. Although initial systems restricted manipulations to two dimensions, the capabilities soon expanded to rotations and other linear and non-linear movements in 3-dimensional space.

The effects repertoire of a system is determined by several factors. The most obvious is the working memory accessed by a central microprocessor (CPU) and peripheral computing equipment. Within a given n -bit architecture, effects complexities and sophistication are based on formulas optimized for the high-speed calculations necessary for real-time image presentations. The formulas or algorithms are mathematical models that describe a desired effect.

Design criteria of the NEC DVE System 10 called for a physically smaller system than previous NEC units, but with many features of earlier products and additions to the repertoire. Signal processing had to be transparent, yet allow smooth image transitions. For all practical purposes, an unlimited number of key frames would define the movement. To accomplish these goals, both 8- and 16-bit architectures were selected.

The authors are members of the Digital Development Department and Broadcast/Video Equipment Division, NEC Corporation, Tokyo.

Assembling the components

The physical housing for the main processor section requires two 5-unit 19-inch rack-mounted frames with a separate 3-unit power supply. A controller panel connects to the main processor through an RS-422 link with all commands and return tallies transferred serially. Effects parameters are displayed on a black-and-white monitor driven from the controller. A 3.5-inch floppy disk drive stores and recalls effects sequences.

In the functional block diagram (see Figure 1), the system has two video inputs (A and B). In a rotating plane effect, as image A turns, input B appears on the reverse side. Switching between the inputs for the effect is within the system.

The video input first passes through low-pass filtering (LPF). High-frequency components that would create aliasing noise in subsequent A/D conversion are removed. Sampling to 8-bit words occurs at four times the subcarrier, 14.31818MHz, on the composite video. The composite video is separated in a 2-line comb filter to luminance (Y) and chrominance (C) components. Chrominance is decoded to I and Q. The three components are processed in parallel.

Next, a variable LPF prevents aliasing as aspects of the picture are converted. This filter is more complex than the initial one, because it has a variable cutoff frequency.

When an input signal is dimensionally altered (see Figure 2), the compression ratio is smaller near (a) than near (b). The sampling rate over the screen space, however, remains constant. Higher frequencies in the source signal must be reduced as the compression ratio is increased. As a consequence, the variable LPF cutoff must be lower for portions of the signal near (b) than (a).

Filter control is calculated from the respective compression ratios for the entire picture area. To do this, the image is divided into many small rectangles. X and Y ratios are calculated for each rectangle and become the control signal for the filter.

From the variable filter, the signal moves to the main memory, where it is stored and retrieved with address data from a high-speed address generator. At the output of the main memory, the visual effect is nearly complete, and the signal passes to the submemory.

A major role of submemory is picture integration for multiple picture effects, such as in a random multifreeze. An on-screen locus tracking picture movement across the CRT is another application.

Following effect construction, I and Q are reconverted to mixed chrominance, then combined with Y to composite video. In the encoder, blanking and new burst signals are inserted. Finally, a D/A stage produces an NTSC analog output.

Providing control

To produce an effect, the *effect-select* buttons on the control panel initiate digitally coded signals. Fader arm angles and joystick X-Y-Z axis information also are digitized and all go through the RS-422 link to the processor. Control data is processed in the main computer and immediately returned to the controller panel for display on the black-and-white monitor to confirm the operator's intentions.

Control processing is a 3-step procedure. First, a high-level CPU interprets the commands and prepares numeric data. Operator errors are detected and corrected at this point.

In the second step, a low-level CPU converts the data format for the address-

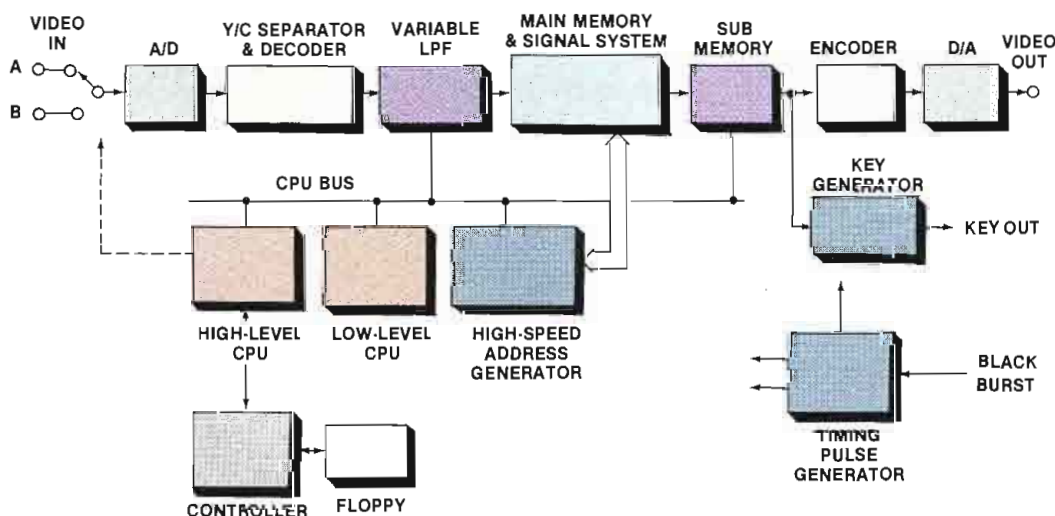
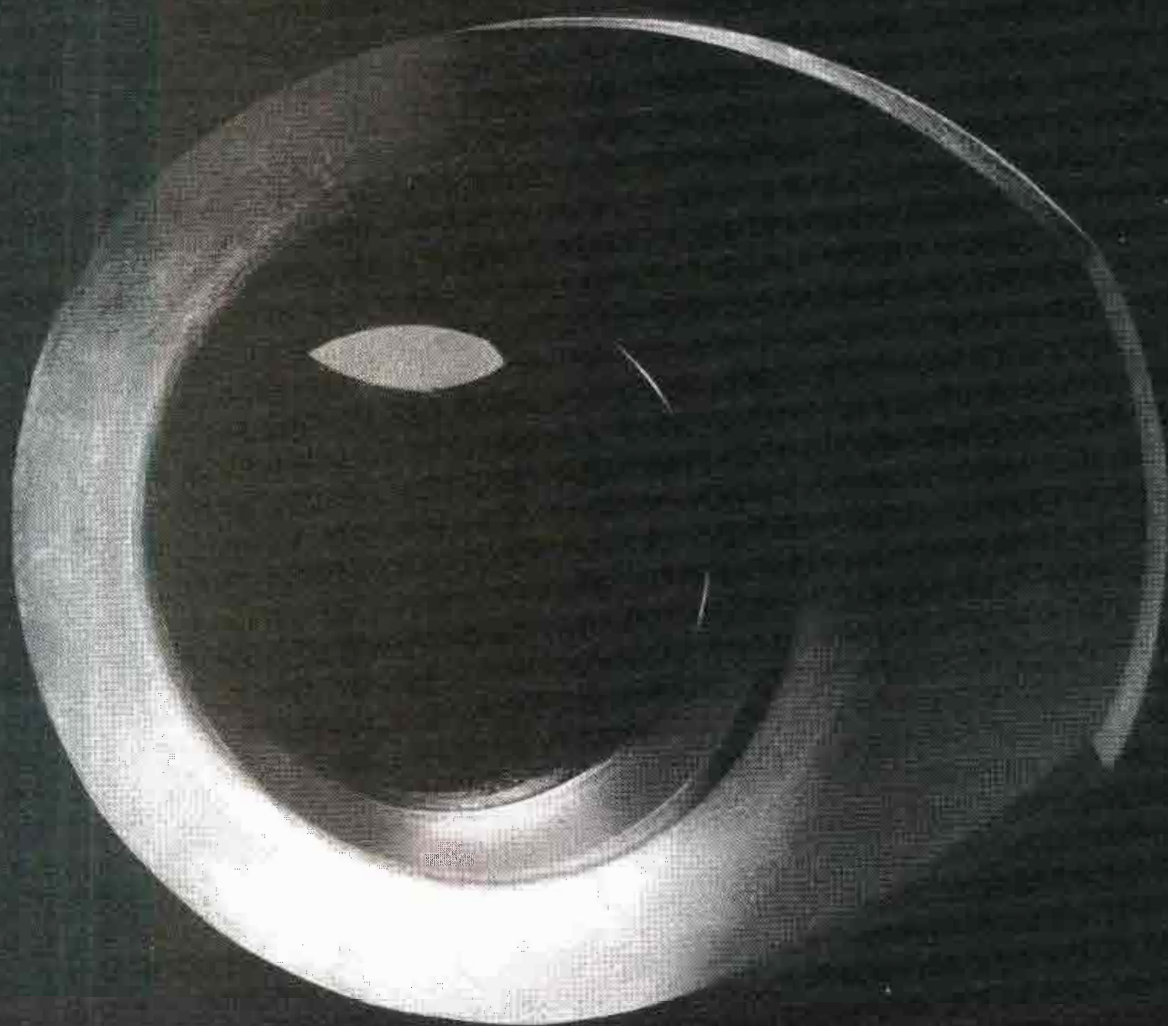


Figure 1. Functional block diagram of the NEC DVE System 10.



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ing hardware that follows. Calculations on control data occur at relatively low speeds.

Positioning data from the low-level CPU drives the high-speed address generator. Current position information for each field is converted to memory-addressing control data at high speeds. The addressing determines how video is written into and read from the main memory to create an image manipulation. For smoothest movement, 16-bit architecture serves this function.

An effect is determined by mathematical calculations performed by the low-level CPU on control panel data. Specific effects result from algorithms contained within the low-level CPU and selected by the controller panel. Some algorithms are tools in hardware to achieve higher speed. Other manipulations are accomplished through software.

Executing a mathematical model

A popular effect is 3-D rotation. Dimension change without attention to perspective can be effective, but proper perspective is preferred.

To visualize how 3-D effects are accomplished, consider the picture as initially positioned on the reference frame (P_1) in Figure 3. When the picture rotates in space, it moves to a new spatial location (P_2) behind the reference frame. To a viewer, the reference frame is a window or translucent screen upon which the repositioned image is projected. To the

matrix consists of 4x4 elements and constitutes a homogeneous¹ coordinate expression.

The calculation is applied to each incoming pixel. Large matrix calculations consume a good deal of time, however, so the process is accelerated by using several smaller steps. Each matrix step consists of affine² and bilinear³ conversions and is attributed to two formulas:

$$X = \frac{A \cdot x + B \cdot y + C}{P \cdot x + Q \cdot y + K}$$

$$Y = \frac{D \cdot x + E \cdot y + F}{P \cdot x + Q \cdot y + F}$$

x and y are horizontal and vertical pixel addresses from incoming video, while X and Y are corresponding output pixel addresses to be defined. Quantities A to Q are slow-rate variables defined for each field and based upon parameter values specified by the algorithm matrices for rotation angle, size and so on. These quantities are updated at the relatively slow field rate and do not require high-speed calculation.

The calculation of X and Y occurs at high speed and is accomplished in dedicated hardware. The solutions for X and Y are obtained at a 70ns data rate and determine addressing of video pixels being placed into memory and subsequently read from submemory.

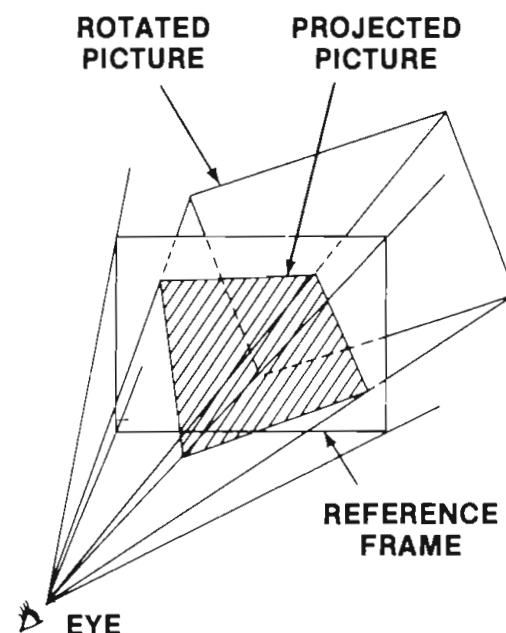


Figure 3. An illustration of the mathematics necessary for 3-D manipulation.

Images in transition

Most video effects should appear as smooth as possible. If the motion involves 3-D space, then parameters for X , Y and Z are all necessary. Also, any rotational centers and positions require three parameters each. It is impossible for a human being to simultaneously control all of these values. It also is impossible to exactly reproduce an effect move once it has been created.

Within the System 10, motion control is accomplished by storing certain key points during a rehearsal of a series of movements. That is, the computer learns the move. When the sequence is performed, the object moves through the points along lines connected through multipoint fair-curve fitting.

Consider an example. An image moves from the upper left to the right of center screen with a concurrent gradual enlargement. From the central position, the image then begins to rotate and move downward, reaching the lower edge of the frame exactly as the 180° revolution around a vertical axis concludes. As the backside of the image

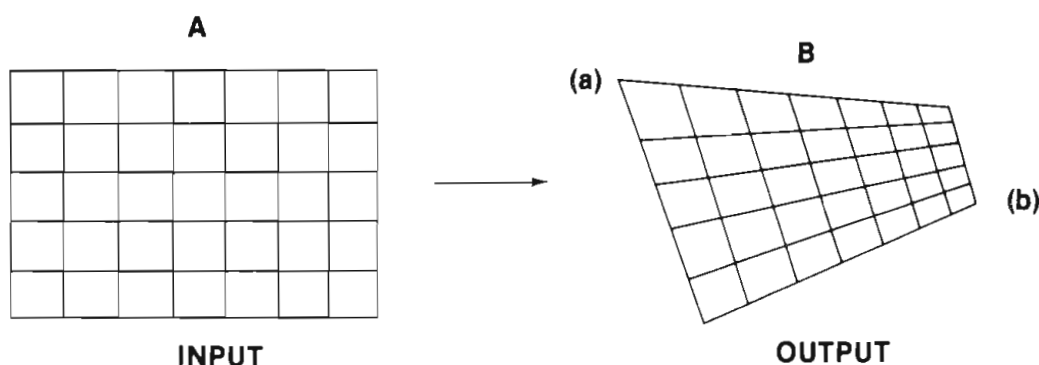


Figure 2. A possible image conversion required for 3-D manipulation.

viewer's eye, any part of the projection falling outside the reference window frame is not seen.

Although the image moves in space, portions located further from the eye are projected smaller on the reference frame. The projection of pixels from the source image is determined by the following method.

The location of each pixel from the source picture is converted to a position in the output image by matrix calculations. Elements of the matrices include values for size, position, X - Y - Z axis rotation, rotation position designation, and perspective operation. The overall

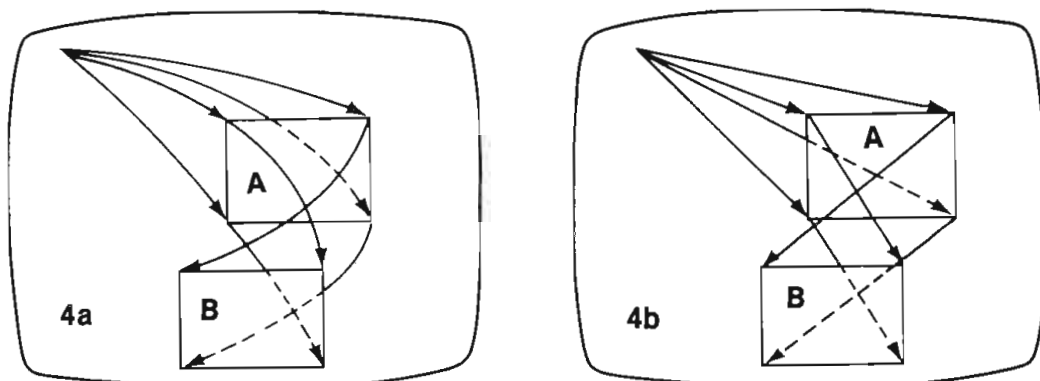


Figure 4. Possible linear and curvilinear paths for image transitions.



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becomes visible, it contains the second video input signal. (See Figure 4.)

Reproducing this motion requires that at least three points or events are stored (initial, center screen and final). Straight lines could be used for this movement, but curvilinear motion is preferred. Therefore, the concern is how to create curves passing through the specified points. Many effects systems use a method of *spline* curves. Spline curves are predefined curve segments (a template) in memory, one of which will provide the best fit through points.

System 10 approaches curve-fitting problems differently by satisfying five objectives:

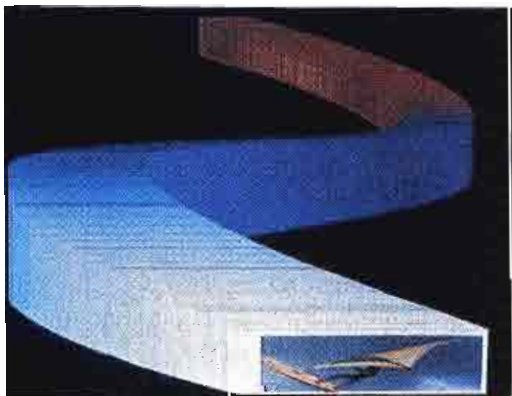
- Creation of curves is easy and requires little calculation time.
- When a point is modified, the entire curve is not recalculated.
- When a point is modified, the curve form does not change excessively except near the changed point.
- The transition time when moving from one point to another can be designated distinctly for every point—moving speed changes smoothly.
- The curve form is not changed by varying point-to-point transition time.

These objectives are attained by distinctly designating a curve form and the speed of movement along the curve.

In Figure 5, the basis of curve forma-



The control panel for the DVE System 10 includes effects selection by buttons with joystick and fader parameter control. Custom sequences may be created and saved with the 3.5-inch floppy data disk.



The submemory produces a trailing locus as the image size, position, color and aspect ratios are changed.

tion is illustrated. e_{-1} to e_2 denote a series of events in time and values P_{-1} to P_2 are corresponding locations. Curve forms to connect between two adjacent points ($P_n - P_{n+1}$) are determined. The adjacent curves are similarly connected smoothly at events.

Various methods can produce smooth connecting lines. The DVE System 10 uses a number of small, straight lines between two points. The method finds a gradient⁴ at a certain point on the curve under construction. This gradient is obtained from the simple arithmetic average of the gradients of two straight lines on each side of the point under consideration. In other words, the gradient D_0 (a mathematical differential value of curve) at event e_0 is an average of the gradients of the straight lines $P_{-1}P_0$ and P_0P_1 .

Similarly, gradients at each of the other points are average values of the straight lines connecting adjacent points.

The curve between P_0 and P_1 must satisfy the conditions of passing through point P_0 at e_0 with a gradient D_0 and through point P_1 with gradient D_1 . A differential equation of minimum order to satisfy these conditions is an expression of third order.

A solution over the range of specified conditions is found from a general formula:

$$P = P_{-1} \cdot g_{-1}(x) + P_0 \cdot g_0(x) + P_1 \cdot g_1(x) + P_2 \cdot g_2(x) \dots$$

In this expression, $g_{-1}(x)$ to $g_2(x)$ are polynomials in x with a maximum order of 3. x is a value of position between events and varies from 0 to 1 as time elapses (that is, the time between events). P_n values represent rotation angle, position and other parameters. $g_n(x)$, once calculated, may be common to several different parameters and so facilitates real-time calculations of the entire expression.

Using this algorithm to modify data for a certain event, the range affecting the

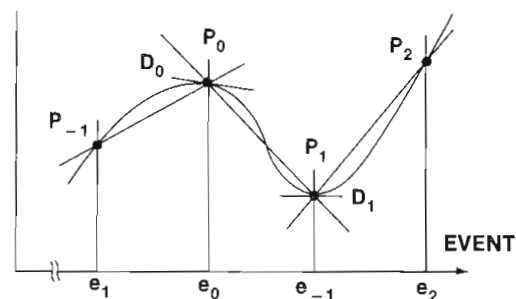


Figure 5. An illustration showing straight line segments for complex curve fitting.

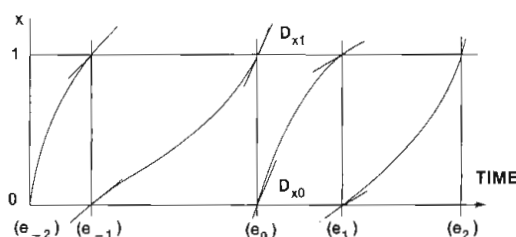


Figure 6. Determination of motion of x with respect to time.

curve form is two spans each on both sides of the relevant point or a total of four spans. The conversion is fast and has little influence on other areas.

The increase of x per unit time must also be smooth between events and can be determined by the same method of calculation just discussed. However, because time cannot be reversed, a correction is made so the differentiated value of x with respect to time (dx/dt) is always positive. (See Figure 6.) An arrangement assures that the gradient D_{x0} at the start of event e_0 and the gradient D_{x1} at the end of previous event e_{-1} are the same. Also, the average of the gradients between events is inversely proportional to the transition time.

The complexity of visual effects is dependent upon mathematical models and by the speed at which the computer can calculate those models. With an algorithm that independently controls the position and speed of movement on a picture, the five required objects are satisfied.

Footnotes

1. Homogeneous expressions contain terms of the same degree or same dimensional units.
2. Affine conversion is the mathematical transformation of a coordinate system equivalent to the translation of with respect to a fixed origin and fixed coordinate system.
3. An expression is bilinear if it is linear with respect to each of two variables or positions.
4. A gradient vector is related to the slope of a plane at a point on a surface described by a function. Its components are partial derivatives of the function.



Size, perspective, rotation, color, location and locus trail combine for this presentation.

Acknowledgment: This material is adapted from the NEC Synchronizer, Spring 1986. [:-D:))]]

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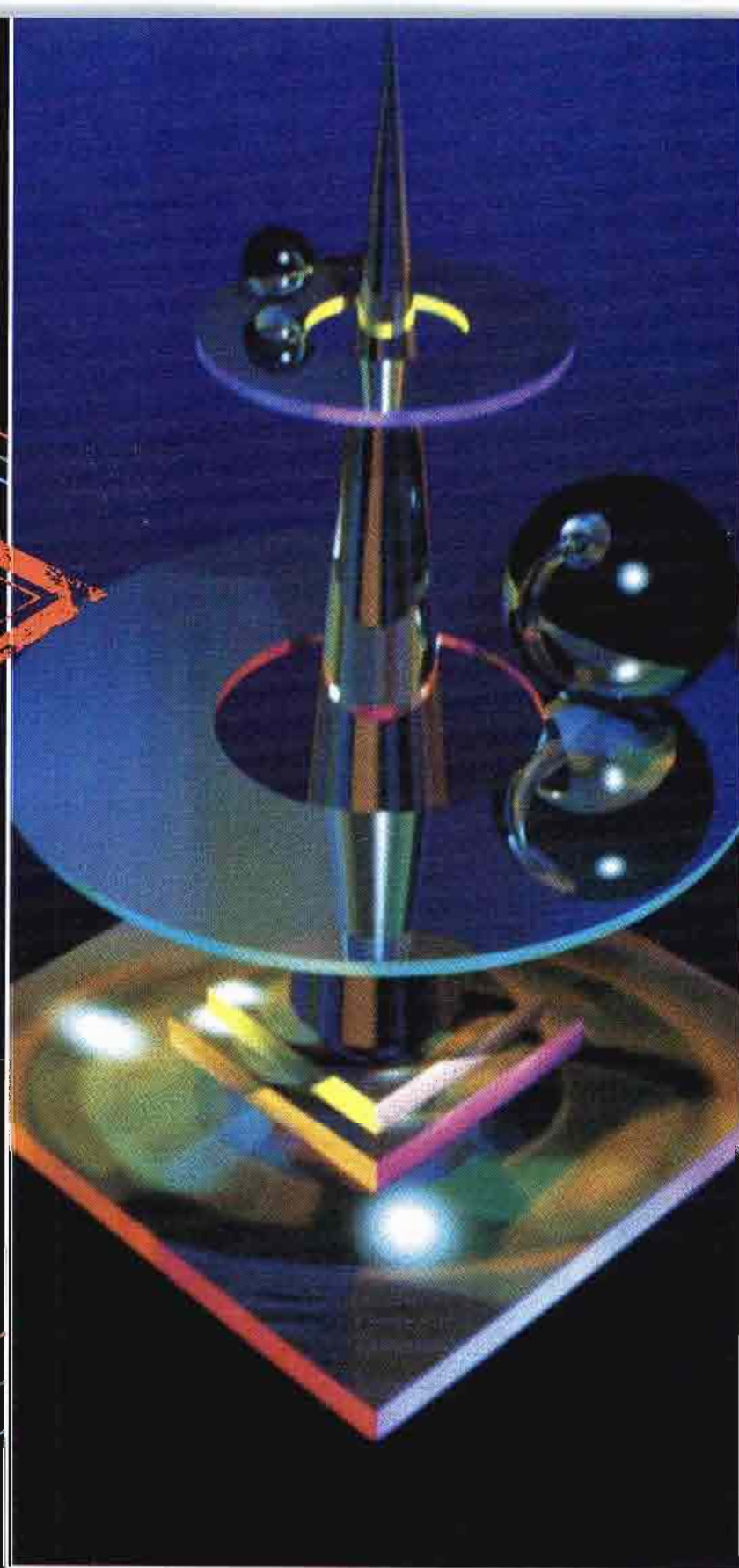
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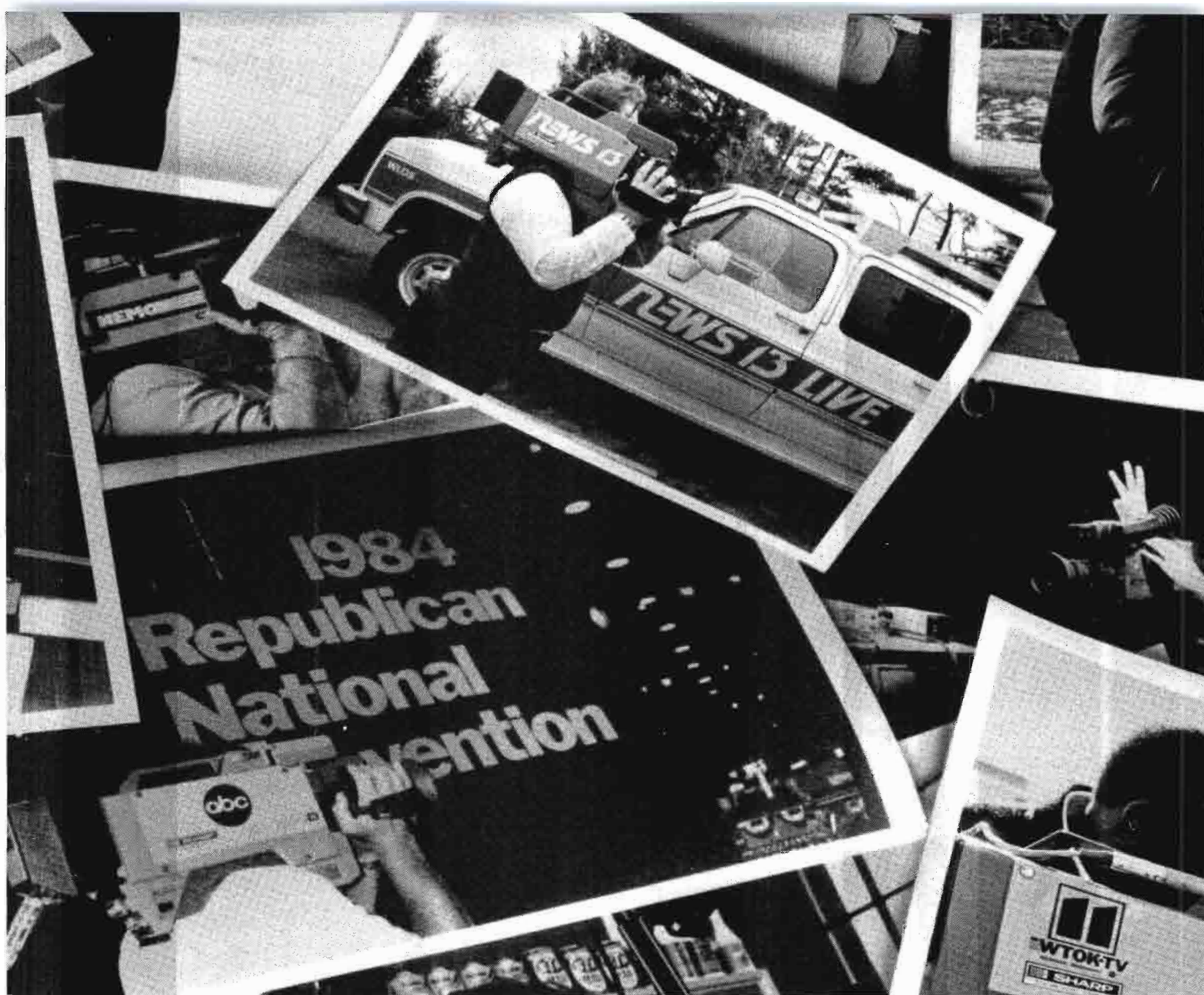
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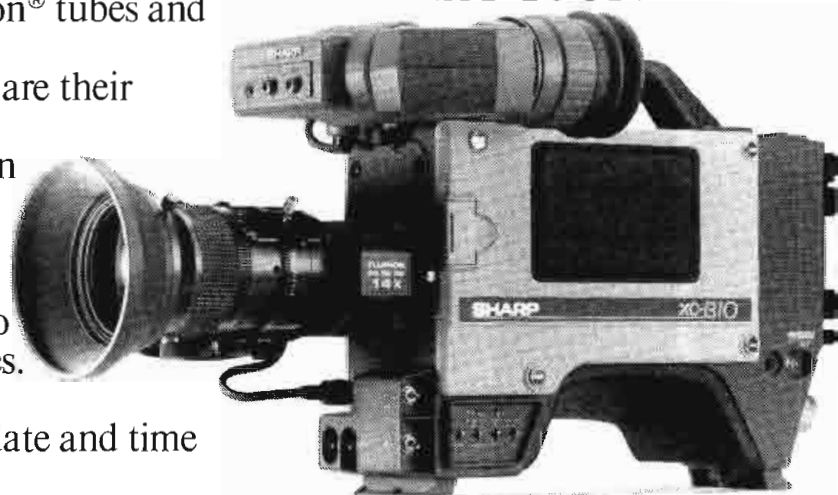
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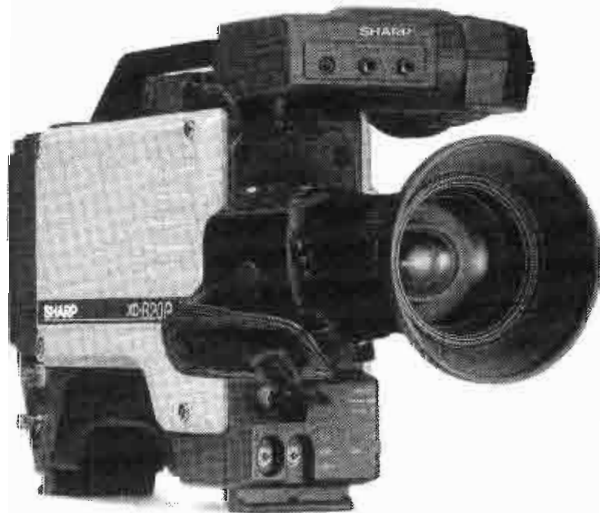


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Polaroid FreezeFrame video image recorder

By John Long

Product applications often extend beyond the designed intent. Such is the case of the FreezeFrame video image recorder, a joint project of Polaroid and Toshiba. Although the unit introduces new technology, it combines established concepts into an economical photographic recording unit.

Many people consider photography a tool for TV production. They suggest that engineering applications are for non-technical record-keeping. In the event of damage or theft, for example, photographs of the physical plant and equipment can be valuable evidence for insurance claims. A case can be made, as well, for photographic documentation of station technical operations.

An engineering tool

Along more technical lines, instant photography appears in nearly every TV proof-of-performance report to illustrate compliance of video waveforms and RF envelopes to FCC requirements. To obtain the photo, a special oscilloscope camera is usually attached to the bezel of a waveform monitor or spectrum analyzer.

An off-the-monitor record of picture

Long is chief engineer at KCPT-TV-19, Kansas City, MO.



Performance at a glance

- Power consumption: 40W
- Dimensions: 9.5"x17"x5.7"
- Weight: 14.3 pounds
- Video systems: EIA (525-line/60-field NTSC-RGB/RS-170(A) (1Vp-p, 75Ω) digital RGB/standard TTL levels
- Monitor output: 1Vp-p, 75Ω
- Film formats/types: 3"x4" Polaroid No. 339 integral color 35mm Polachrome, Polapan, ISO-100, ISO-200 transparency films
- Horizontal resolution: >350TVL NTSC; >700TVL center RGB
- Vertical resolution (at CRT): 350TVL minimum
- Freeze field (NTSC mode): 128-level, 7-bit 10.7MHz sampling

quality on a regular basis could photographically document engineering operations. Often interference in the video portion of the signal, for example, does not appear obvious in a waveform presentation. Multiple images merge into the complex display. In off-screen pictures, however, both conditions would become visible.

An experienced technician can often diagnose a fault from its effect on pic-

tures. Just as voltages and currents on the transmitter logs may divulge developing conditions, a series of photographs may carry visual signs.

Explaining the visual appearance of video problems to an uninitiated engineer is difficult. Photographic evidence of poor and correct signal conditions easily illustrates concepts in training new staff members. The photos also aid diagnosis of trouble that occurs when the experienced technician is off duty.

Successfully shooting off-screen pictures requires care in setting camera exposure parameters. Shutter speed is especially critical. Because a complete frame requires about 1/30 of a second, shutter speeds faster than 1/30 produce incomplete pictures. A slower shutter speed may get a complete picture plus blur if motion occurs between frames. Motion between fields will show at 1/30 speed.

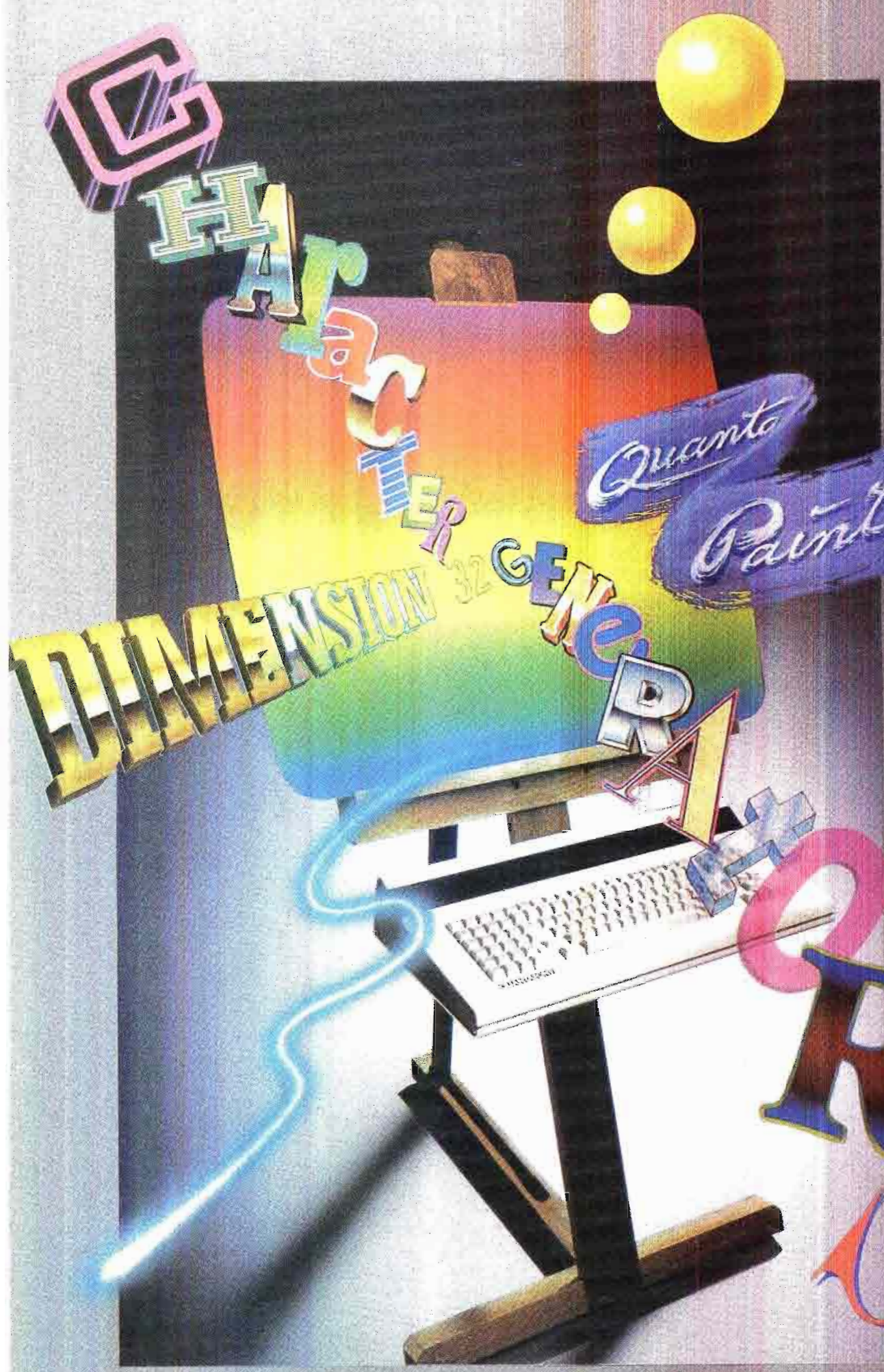
The video printer is a solution that has existed for several years, but most seem to have been priced for the research lab. Designed primarily for computer graphic and CAD/CAM use, they commonly offer RGB inputs and operate at scan rates much higher than NTSC, PAL or SECAM. Scanning adjustments are available, but an RGB decoder for NTSC signals may mean an additional investment.

An example of how the FreezeFrame video recorder can be used to document equipment problems. Here, a secondary color subcarrier causes diagonal rainbow stripes across the picture.



The aural carrier of a local channel 4 interferes with the visual carrier of channel 3.





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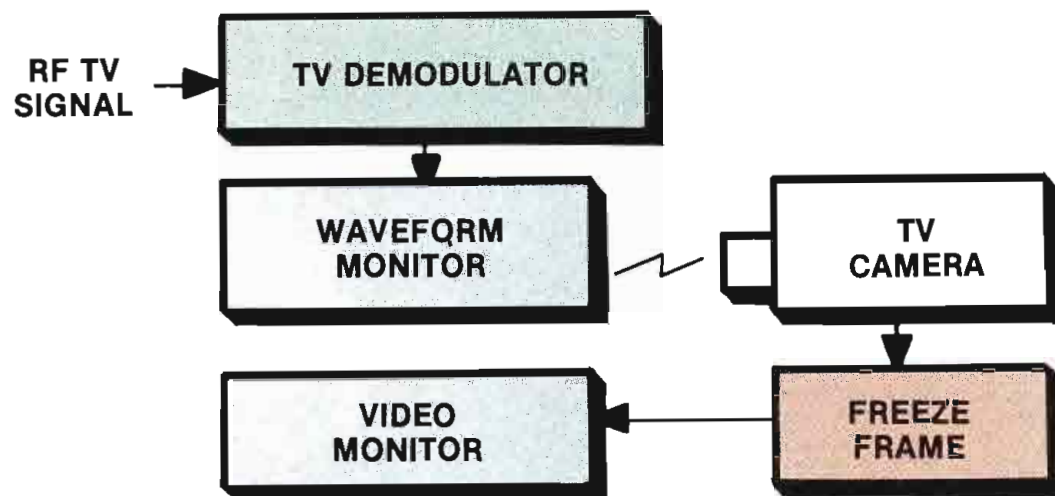


Figure 2. System configuration with TV camera driving FreezeFrame to photograph video waveform.

A look inside

The video image recorder suggests applications for screen analysis. The unit, designed for television use, offers 15.75kHz horizontal scanning with RS-170(A) video. In addition, it satisfies RS-375A and accepts IBM PC TTL inputs.

The system handles print and slide formats, accommodating either with *instant* film types. Jumpers in the film back interconnecting cable set exposure factors for type 339 3"x4" color print film. For 35mm slides, the operator selects between a default instant, ISO 100 and 200 films. Two significantly different optical systems are integral to the film backs. For engineering use, the 3"x4" instant prints will usually prove more useful.

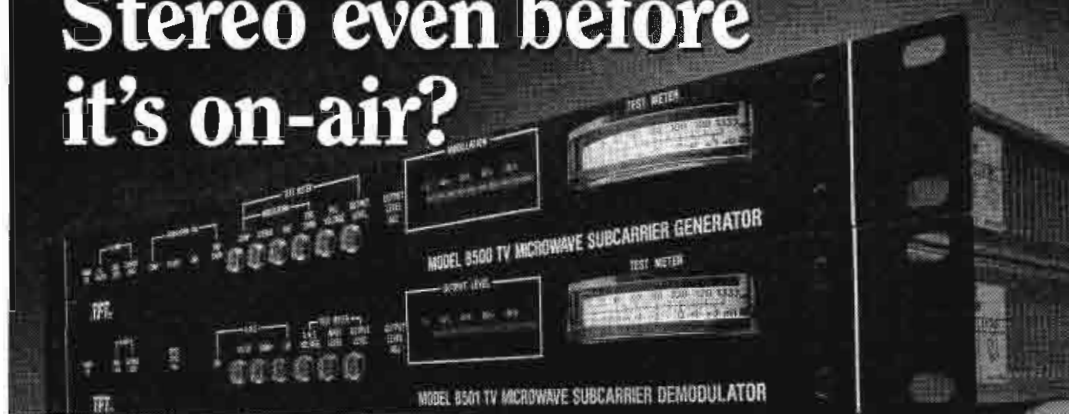
To expose the film, a small 3.5-inch diagonal P3 phosphor CRT produces a black/white image. For color films, a filter wheel sequences through red, green and blue. Synchronized with the filters, the tube sequentially displays red, green and blue components. The total duration of the exposure cycle is less than eight seconds for print film, after which the motorized film back ejects the exposed film and starts development.

The long exposure period is fine for still images. Movement during the 3-step exposure creates interesting effects, but for engineering, the single frame freeze is necessary to avoid ambiguities of motion. That requires digitized video and memory. (See Figure 1.)

Digital sampling occurs at 10.7MHz or three times the subcarrier with an analog-to-digital conversion of 7-bit resolution. Most digital video products use 8-bit sampling, so a small loss of gray scale occurs. It might become obvious on large, smoothly shaded backgrounds. For engineering off-screen applications, the single bit difference appears unnoticeable.

The unit stores video into the memory in an unusual manner. The image is divided into three parts, the thirds being stored simultaneously into three banks of standard computer-type memory chips.

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The memory feature is available when using an NTSC composite input. Also associated with the NTSC mode are chroma level, hue and sharpness controls. With luminance level and contrast, it can sweeten the image for the photograph CRT and an external monitor. A fill function is automatic in the memory mode, but may be defeated in non-memory operation. These controls do not alter information stored in the memory.

For color component equipment imaging, the recorder includes two modes for RGB. Three analog signals, with sync-in-green or separate sync, can be connected through RCA phono plugs. For broadcast purposes, BNC connectors would have been more convenient. Three TTL component signals connect through 9-pin type D fittings. For all input types, termination, analog/TTL and NTSC/RGB switches must be correctly set.

In RGB mode, luminance level and contrast are active, but color, tint and sharpness are inactive. The fill control, if activated, inserts video into the raster between scanning lines. The fill information is derived by repeating the previous line.

Diagnosis by photo

Transmitter maintenance never allows leisurely observations. Time means dollars and, consequently, repairs must be made as soon as possible. The results of transmission line reflections, impedance mismatches and faulty luminance/chrominance delay adjustments often show visibly on a monitor. If the film recorder is driven from a demodulator, sampling points in the RF chain can narrow down the source of problems.

Consider a VTR with or without dynamic video head control. A *VTR still frame* may not always show signal conditions that exist when the machine is pulling tape. An image, frozen as the machine runs, documents the fault.



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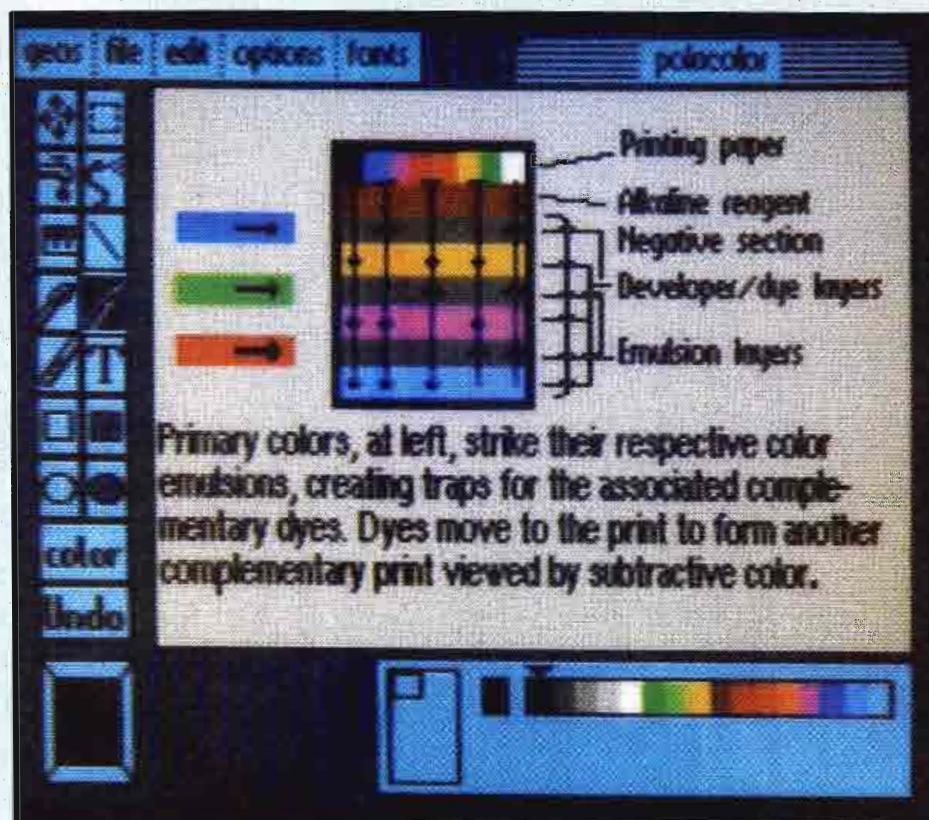
In 1947, Edwin Land astonished the world with black-and-white pictures in a minute. One photographic equipment dealer said it was a fad that would soon pass, but Polaroid camera users now number in the tens of millions.

Although other black-and-white films had to be developed into a negative and then printed onto a positive photo paper, Land film put negative and positive materials in a package with developing chemicals. Processing began instantly as the photograph was pulled from the camera through rollers that spread the developing chemicals over the film. In about 60 seconds the job was done. A fixing gel, smelling strongly of acetic acid (vinegar), was spread across the surface of the instant print to halt development and seal the picture.

The popularity of color films in the early 1960s led to predictions that black-and-white photography would be abandoned. Land again stirred the complex photographic chemistry by producing color pictures in a minute in 1962. Subsequent improvements have increased processing speeds to times substantially less than a minute.

Chemically more complex than standard film types, the Polaroid process also involves a multilayer package. Three layers of emulsion, each with an associated developer-dye layer, form the 0.002-inch thick negative material. Also in the package is a 4-layer positive paper and a separate layer with pods of an alkaline developer/activator.

The negative layers are sensitive to primary colors red, green and blue. As



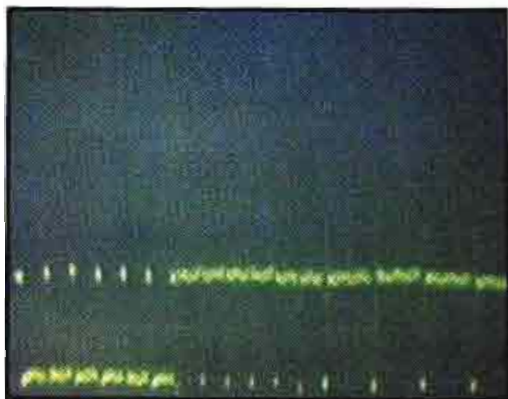
The concept of Polacolor instant color film presented in a computer graphic display.

the film is pulled from the camera, the alkaline chemical seeps through all the layers, activating the developer/dye molecules almost immediately. The dyes begin to migrate toward the print material. As dye molecules move through the negative layers, exposed silver in a color layer traps the dye associated with that layer, but allows other color dyes to move freely to the print.

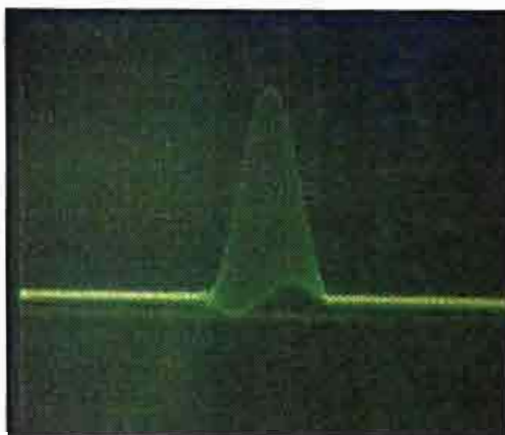
In the negative, a blue layer is associated with a yellow developer-dye. Next, the green layer carries a complementary magenta dye. Finally, the red layer is tagged with cyan. With silver particles exposed in blue, a trap

is formed to keep the yellow dye from reaching the print. Cyan and magenta, however, move freely to the print to form various blues from blue green to magenta. Similarly, exposed green particles trap magenta dyes, while passing yellow and cyan. Red particles stop the migration of cyan dyes, but pass magenta and yellow.

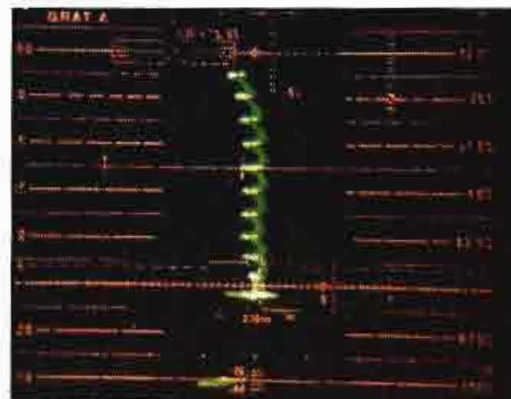
In the print layers, the alkaline dyes neutralize the acid chemicals, forming water, which washes away any excess alkaline chemicals and stops the process. As the chemicals neutralize each other, the negative and positive dye chemicals are linked to form a permanent bond in the completed picture.



An unknown 32kHz interference rides through the vertical interval at sync and blanking levels.



An ICPM trace appearing over the standard NTSC graticule.



A camera with the demod and waveform monitor shows excessive luminance/chroma delay from the transmitter.

ENG equipment is sometimes operated by non-technical people. Many of them soon learn the technical jargon, but others will have unusual descriptions for

video equipment malfunctions. If the equipment operates at all, a quick photograph of the machine output documents the malfunction. If the repair

technician receives complaints of not having solved the problem, pictures on file indicate the trouble that was found and fixed. Examples of troubleshooting

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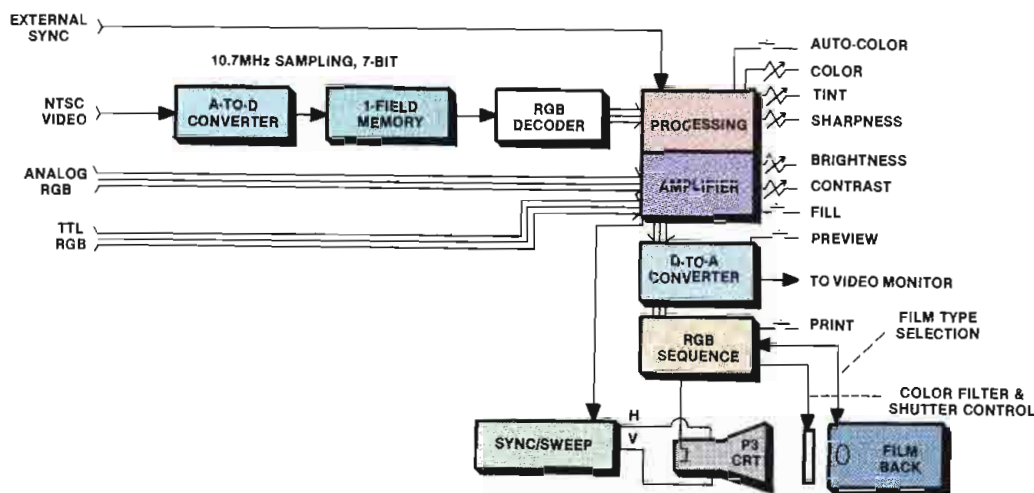


Figure 1. A block diagram of the Polaroid/Toshiba FreezeFrame video image recorder.

using photodocumentation are shown in the preceding pictures.

More afield

With an oscilloscope the technician steps through circuitry in search of signal disparities. Unless the technician is very familiar with waveforms, however, composite video complexity on the scope can disguise problems. If the photo recorder was linked to a video output from an oscilloscope (or waveform monitor with a test probe input), the preview monitor would display a picture from the composite signal existing at various points through the circuit.

A high-impedance input, matching a typical oscilloscope probe, would allow the unit an additional test mode. In essence, the recorder with its preview monitor could function much like an oscilloscope with pictures.

Documenting video and related waveforms would be a useful feature. Using an optional sweep system with 2H and 2V time bases and rerouting video normally linked to the cathode to the vertical deflection, the recorder could photograph waveforms conveniently. Because the CRT uses electromagnetic deflection, the concept of sweep/time base change is difficult at best.

An alternative means to capture waveforms drives the recorder from a TV camera focused on the waveform monitor. The camera would not need to be color, but the differentiation between the green scope trace and the red/orange of the graticule is helpful. (See Figure 2.)

A TV camera may not always be able to track all pertinent subtle gray scale variations in fine waveform details. Some careful adjustment of pedestal and iris, as well as luminance and contrast on the recorder control panel, may be necessary to show the waveform best. The linearity of the camera sweeps should be checked carefully as well.

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tronic graphics offer RGB representations, along with encoders to produce composite outputs. By having both types of signal input available, the technician can quickly assess encoder quality. The trend to increased analog and digital component designs for image processing suggests more than switch-selected analog RGB, TTL-RGB capability and NTSC composite inputs. With format interchange circuits already in existence, the extension of this unit to other component sets becomes practical.

Visual acuity

Compared to other methods of communicating, visual presentations have proved to be the most effective. TV sets are used on the average more than seven hours per day in most American homes, according to the Television Advertising Bureau. One reason for the popularity of television is the capability to show what would take many words to explain adequately. As a result, television has become a leading supplement to education as well.

Image quality plays an important part in the effectiveness of visual communication. It seems reasonable, then, that technicians responsible for keeping image quality at its highest may find off-screen photography to be worth a thousand waveforms in troubleshooting video equipment. The concept is worth consideration.

Editor's note: The field report is an exclusive BE feature for broadcasters. Each report is prepared by the staff of a broadcast station, production facility or consulting firm.

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Power supply is heart of audio equipment

By Jon Gaines

At the heart of every piece of audio equipment is a power supply. It is a simple, yet essential circuit that converts 120Vac to one or more dc voltages which, in turn, power the active components of an audio or control circuit.

In most contemporary signal-processing equipment, the power supply is a bipolar, regulated type. Usually the output voltages are +15Vdc and -15Vdc. Voltage regulation ensures that the output remains constant, regardless of varying load conditions.

The power supply described here provides an accurate, well-regulated output voltage. Also described is an optional output voltage monitor. The voltage monitor measures the output voltages of the supply and under normal conditions lights two LEDs.

Circuit description

The power supply's schematic is shown in Figure 1. The circuit contains three basic sections: transformer/rectifier, capacitor input filter/regulator and output voltage monitor.

The power transformer primary must be fuse-protected, and a power on/off switch used if desired. With a primary voltage of 120Vac, the transformer secondary voltage should fall within the range of 26Vac to 50Vac (center-tapped). A nominal value of 40V at 0.5A is ideal. If the voltage drops below 26Vac, the regulators will be unable to maintain proper regulation. If the voltage rises above 50Vac, the regulators may be damaged.

The transformer secondary is connected to a full-wave bridge rectifier consisting of diodes 1 through 4. The transformer center-tap connects to the circuit ground.

Capacitors C1 and C2 smooth the rectified dc voltage at the inputs of the voltage regulators. These capacitors should be approximately 1,000 μ F. An unregulated voltage output is available from points A and B.

Regulators IC1 and IC2 are 3-terminal



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Table 1. The parts shown are common and can likely be found in many stations' inventories.

ICs. The output voltage is accurate and ripple rejection is excellent. The LM series of regulators is available in both positive and negative output voltages over a broad range of voltages. Output currents up to 1.5A are easy to develop with these devices. Because of the internal thermal overload protection and short-circuit current limiting, the ICs are essentially immune from overload and accidental shorts.

It is important to remember that, in order for the regulator to do its job, the unregulated dc voltage at its input must be at least 3V higher than the desired dc output. That is, 18Vdc for a 15Vdc output. However, a dc input higher than 35V may destroy the regulator.

Capacitors C3 and C4 enhance the

stability of the regulators, while clamp diodes D5 and D6 prevent reverse-voltage conditions from causing regulator damage or latch-up. Use the same type of diodes here as used for the bridge rectifier assembly, D1-D4.

Additional reverse-voltage protection is provided by diodes D7 and D8. These devices will protect the power supply from fault conditions where the unregulated source voltage drops below the stored charge in the output capacitors. The 1N4003 diodes provide a path around the regulator under this fault condition.

To prevent the IC regulator from oscillating, high-frequency decoupling capacitors are placed near each IC input and output. Either 0.1 μ F ceramic or 1 μ F/35V tantalum capacitors will provide the needed protection.

Voltage monitor

The output-voltage monitor circuit is an optional feature that neither improves nor degrades the basic performance of the power supply. It does provide a handy visual indication of correct power supply operation.

Four zener diodes provide a voltage reference window. If the output of the power supply is correct within a couple of volts, the LEDs will light. If the output voltage exceeds 17V or falls below 13V, the LEDs go out.

A simpler circuit would only connect an LED between each output to ground, lighting whenever a voltage was present. However, a regulator could fail and the LED would still light, negating its usefulness. Regulator failures are unpredictable, and the output voltage could be anywhere from 0V to 35V in the failure mode.

The circuit presented here covers all the bases at minimum extra cost. Note that the resistor values given are for a nominal 15V supply. For higher output voltages, the voltage-divider resistors should be appropriately scaled.

The LEDs may be any shape, color or size, with brightness controlled by resistors R7 and R8. The LEDs can be relocated to a chassis or front panel, if desired.

Gaines is director of the engineering staff at Ashly Audio, Rochester, NY.



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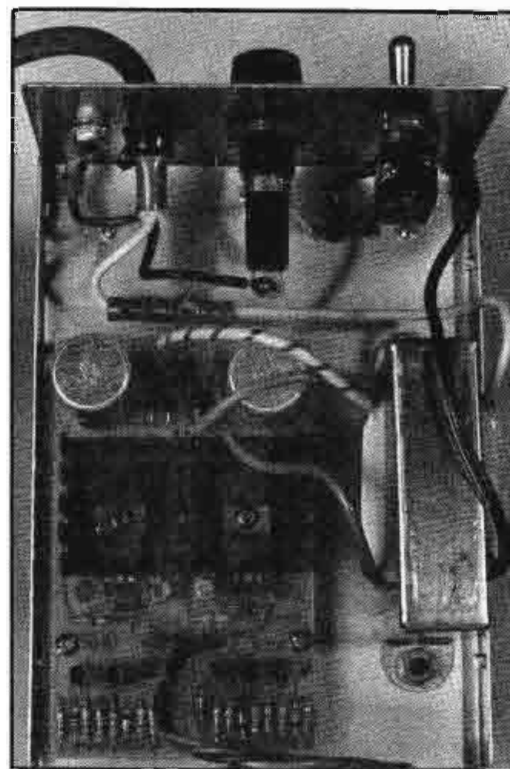
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Safety

No high voltage is exposed on the PC board. However, the transformer primary and fuse do attach to the power line, so exercise caution when assembling the project.

To minimize the exposure to high voltage, use wire nuts, shrink tubing and electrical tape as appropriate. Use a fuse as indicated in the schematic, but do not substitute a higher fuse should the correct one blow. Use a 3-wire grounded-type cord and connect the ground wire to the power-supply enclosure or chassis.

External wiring

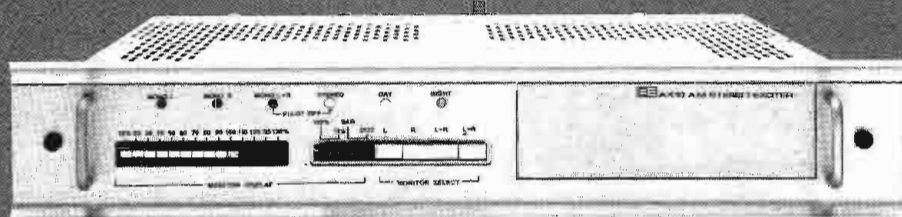
The photo above shows the power supply mounted in a typical enclosure. For illustration purposes, the terminals in the photograph were left uninsulated although, in practice, they should not be.

The power cord is a grounded-type with the green ground wire attached directly to the chassis wall as shown in the upper left-hand corner of the photograph. The cord itself is secured with a plastic strain relief. The white (neutral) wire from the power cord attaches directly to the transformer primary, which in this case, also is a white wire. The connection was made with an insulated butt-splice connector.

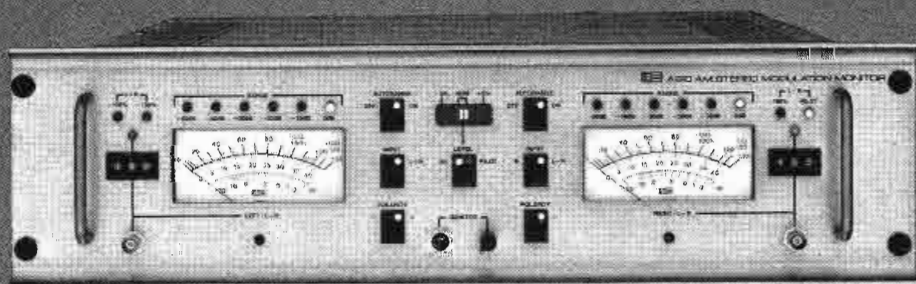
The black (hot) wire from the power cord connects to one terminal of the fuseholder. The other end of the fuseholder connects to the power switch. The second terminal on the power switch then connects to the remaining transformer wire, which is black on this transformer.

Banana jacks or a terminal strip can be used to provide an output connection. Don't use any type of jack that could be misinterpreted as an audio or signal jack.

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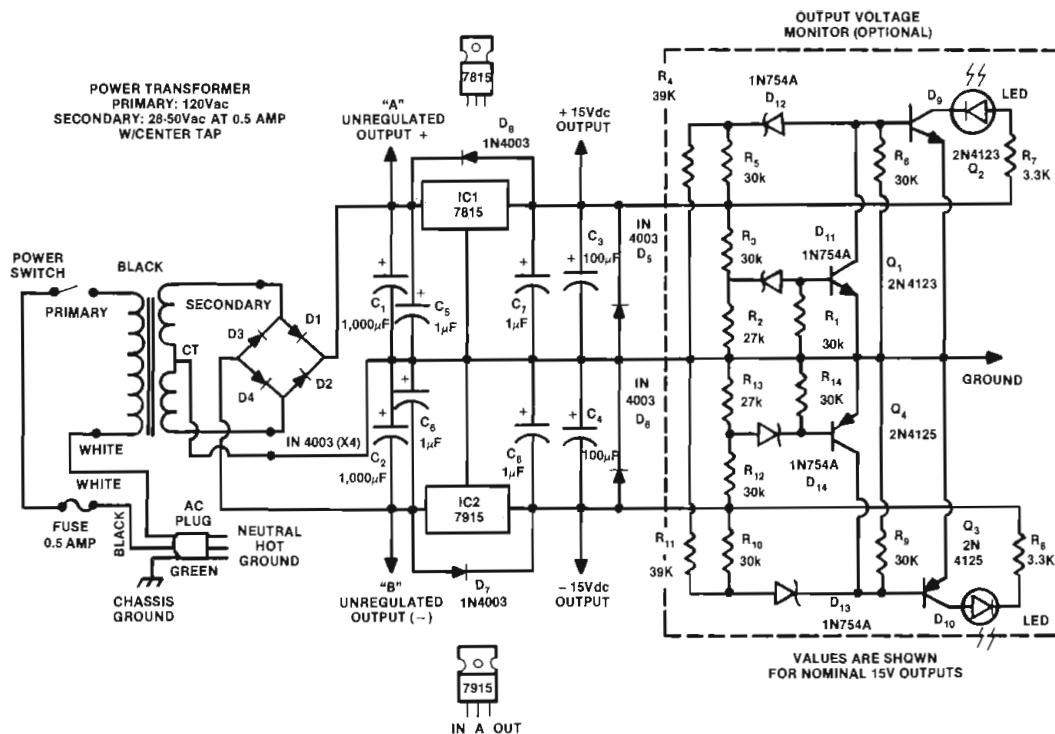


Figure 1. Schematic of power supply unit showing optional output voltage monitor.

Such a practice only invites someone to make a mistake, with predictably disastrous results.

Testing the supply

When properly connected and turned on, the two output LEDs should be on. If

they're not, or the fuse blows, unplug the power cord and begin troubleshooting the circuit. Measure the output voltage. If it is within a volt of the regulator's rating, proceed with the remainder of the check-out procedure.

If the supply seems to be working properly and the LEDs are glowing, it's time to check the short-circuit protection of the ICs. After all, what better time to see if the devices will fail than when the power supply is on the bench.

Momentarily short circuit each output to ground. The ICs should shut down and the LEDs should go off. When the short is removed, the supply should immediately return to a proper operating condition.

When in use, the LEDs should glow fairly brightly and the regulators should be warm to the touch. If the ICs get too hot to touch, there may be a problem with excessive current being drawn, or poor heatsinking. The other devices in the circuit should not generate any heat.

For further information on typical power supply circuits, consult any of the IC manufacturers' manuals. Supplies similar to this can be constructed for a wide range of both fixed and adjustable voltages.

1:~:~)))))

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Ennes Foundation fills officer positions

By Bob Van Buhler

The SBE board of directors recently filled the officer and board of director positions on the Ennes Educational Foundation. Richard Rudman, SBE president, will serve as president of the foundation. Jack McKain, SBE vice president, will serve as foundation vice president. Brad Dick, SBE officer, will serve as secretary and Wally Dudash, SBE officer, will serve as treasurer.

Mary Beth Leidman, Jim Wulliman and Bill Harris, SBE board members, will serve as foundation board members. Roger Johnson, SBE past president, was appointed to serve as director-at-large to the foundation.

The SBE board felt it was necessary to establish a separate entity to serve the society's educational needs. The board has consistently supported education for broadcast engineers and the foundation strengthens that commitment. The Ennes Foundation will foster action in continuing education, certification and entry-level training and education. The foundation allows the society to more effectively serve these important interests and make effective use of the financial opportunities that exist.

Fellowships conferred

By unanimous board action, two charter members of the SBE were elected fellows of the Society of Broadcast Engineers. Charles Morgan, director of engineering for Susquehanna Broadcasting, was awarded his fellowship at the national SBE convention in St. Louis. Morgan served as SBE national board member in 1977 and was a member of the first SBE certification committee. He served as panelist and session host at the NAB convention and is active on the AM Improvement Committee and the NAB Engineering Advisory Committee.

William T. Orr, vice president of engineering and chief engineer for WBNS-TV-AM-FM in Columbus, OH, was also awarded a fellowship. He served on the board of directors and the National Certification Committee since 1978. He also is a member of AFCCWE, SMPTE and the IEEE.

Van Buhler is chief engineer for WBAL-AM and WIYY-FM, Baltimore.



A third fellowship was presented to Donald Strauss, supervisor of video engineering for McDonnell-Douglas in St. Louis. He is a past chapter chairman for the St. Louis Chapter and is currently chapter certification chairman. Strauss served for four years as exhibit chairman for the SBE St. Louis national convention. He also participated in the setup of the certification education program at John Woods College in Quincy, IL.

Election to the grade of fellow within the SBE is a special distinction. It is awarded to members who have made an exceptional contribution to the advancement of broadcast engineering or rendered special service to the society.

Other board actions

The past president's committee met at the October national SBE convention, and developed several recommendations. One of those recommendations is for the SBE to hire a full-time executive director. Coupled with that recommendation was the suggestion to move the SBE national offices to Washington, DC, within a reasonable period of time.

For years, the board has recognized the advantage of having the society's offices located in Washington. With the exception of SMPTE and IEEE, most major broadcast industry organizations are headquartered in Washington, DC.

The SBE can strengthen its presence and ongoing dialogue with the FCC, NAB and other major broadcast organizations by being located there. The location also will help develop close alliances with related organizations. And, as the society continues to grow, the importance of being on the scene of regulatory developments becomes even greater.

Docket 86-367

The SBE filed comments with the FCC in response to the Notice of Inquiry regarding private sector preparation and administration of commission commercial operator examinations. The inquiry examines the possibility of the commission contracting with a private company to administer the commercial licensing process.

Richard Rudman, speaking for the

membership and board, expressed strong reservations about the NOI's proposal. Rudman pointed out that such an organization could develop its own certification program, enjoying an unfair advantage with respect to those programs that are already in place.

The SBE proposes that the various radio services be administered separately. This would allow numerous qualified entities to perform the commercial testing for their particular areas of expertise. The process also would allow marketplace forces to prevent a single entity from dominating the licensing procedure.

In its comments on the inquiry, the SBE also stressed the need for the commission to provide proper oversight to whichever organizations are selected. The oversight is necessary to ensure fairness and that the tests are current and meaningful.

In the area of broadcast licensing, the SBE is uniquely qualified to comment on the proceeding. The society has certified about 3,000 broadcast engineers since April 1975, making it perhaps the largest broadcast certification program in existence.

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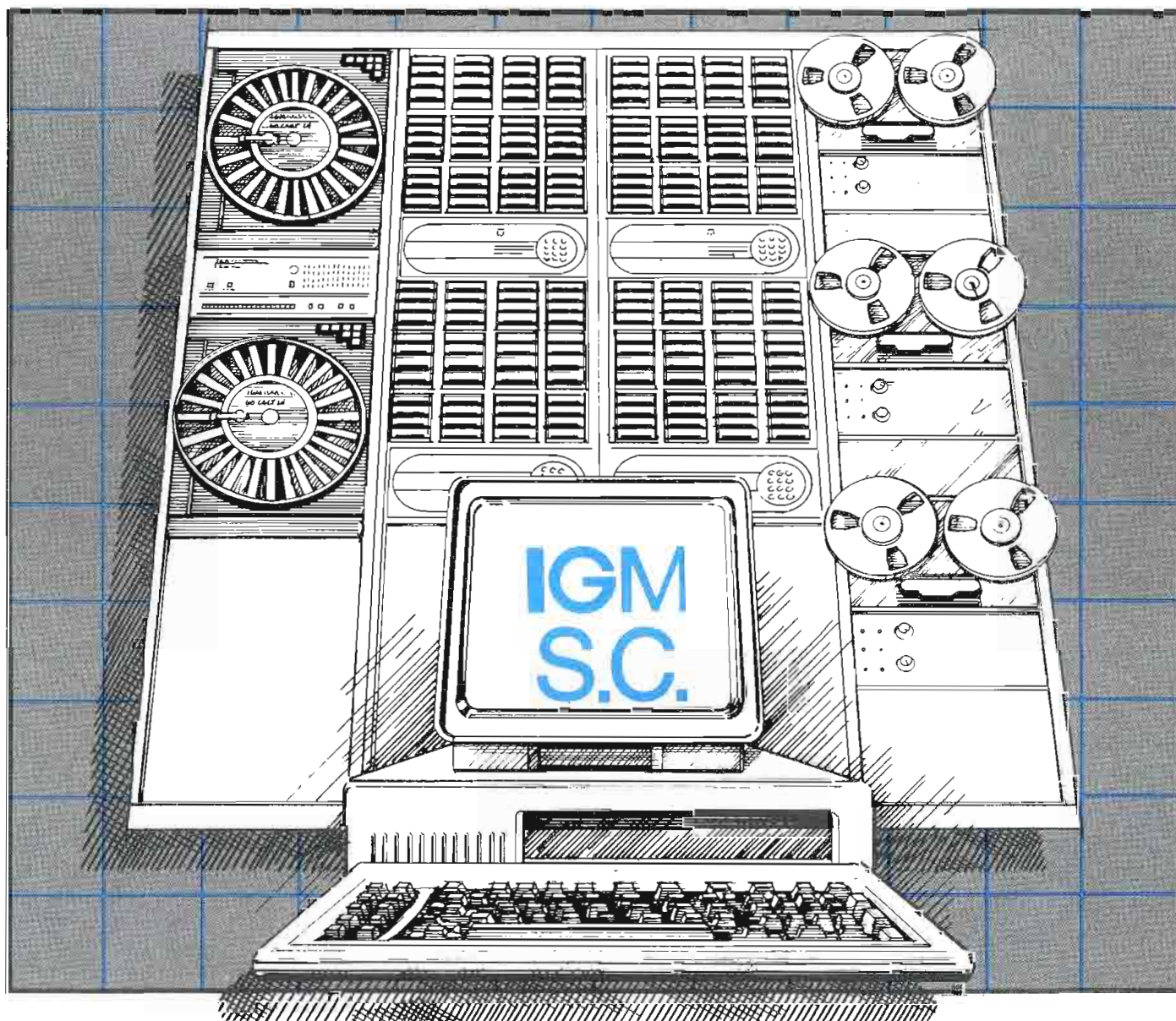
The SBE also recently filed comments with the EPA, regarding Docket A-81-43, Federal Radiation Protection Guidance; Proposed Alternatives for Controlling Public Exposure to Radio Frequency Radiation. This is the regulation receiving so much publicity within the broadcast industry because of its effect on stations.

The society's comments support the adoption of the ANSI standard, C95.1 released in 1982. The standard is the only one that is based on empirical data.

The board of directors resolved to file the comments after expressing the view that without a national standard, unrealistic local standards would develop. Local standards might be developed more out of fear, rather than solid scientific evidence. More restrictive standards could adversely impact upon both current and future broadcast stations.

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3M and Nagra announce standardization

Nagra Magnetic Recorders, Los Angeles, and 3M, St. Paul, MN, have announced that all newly produced Nagra recorders for sale in the United States and Canada will be aligned to operate with 3M's new-generation 808 mastering tape. The companies also have agreed to initiate a pack out arrangement in which 3M products will be included with every T-Audio, IV-S (TC) and 4.2 recorder shipped to the two countries. The machines had been standardized on 3M's 208 tape which has been discontinued and replaced by the 808 tape.

Agfa-Gevaert expands training centers

Agfa-Gevaert, Teterboro, NJ, has announced the relocation of its Dallas marketing/training center and regional distribution center to 4251 West Highway 114, Irving, TX 75063; telephone 214-258-1441.

Agfa-Gevaert has also expanded its

Atlanta marketing/training center. The facility is used as a product demonstration and training center for all the company's marketing divisions. The center is located at 380 Interstate North, Suite 200, Atlanta, GA 30339; telephone 414-955-4326.

Conrac begins shipping of color monitors

Conrac, Covina, CA, has begun volume shipments of its Micromatch color monitor system to the TV industry as well as to OEM suppliers and distributors.

The system, consisting of the 6545 color monitor and 6550 photometer, offers automatic monitor setup capabilities that reduce in-studio monitor setup time to 20 seconds per monitor.

Convergence offers training seminars

Convergence will conduct operator training seminars on a monthly basis throughout the year at its headquarters in Santa Ana, CA. The 4-day sessions will

cover operation of A/B roll video edit-controllers, and post-production planning, the use of time code, developing the off-line edit decision list, list management and cleaning, and preparation and execution of the on-line edit session. The seminars will run Monday through Thursday, from 9 a.m. to 5 p.m. About 30% of the sessions will be devoted to hands-on use. Class size will be limited to 10. Cost is \$300 per student. For information contact Shannon Marie at 714-835-6000.

Scientific-Atlanta receives equipment order

Westwood One Radio Networks has ordered digital audio equipment from Scientific-Atlanta, Atlanta, GA. Westwood's affiliate stations will use the DAT-32 digital audio terminal and the Series 9000 2.8-meter antenna in the network's conversion from an analog to a digital system. The DAT-32 digital audio terminal is designed for the reception of satellite-delivered radio broadcasts and digitized data.



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Fuji awards scholarships

Fuji Photo Film U.S.A., New York, has announced The Fuji Professional Tape Scholarship. The scholarships will be awarded to undergraduates whose major course of study includes television and video. The universities participating in the program include St. John's University in New York; the University of Tampa, Florida; UCLA; and Northwestern University in Illinois.

A \$1,000 Fuji Video Award also will be presented to the student or students in each of the four universities who submit the best original videotape as part of their required assignments. A selection of Fuji videotape products will be donated to the TV/video department for use during the school year.

Audio Kinetics granted patent on VCA circuitry

Audio Kinetics, England, has been granted a patent from the United Kingdom (a U.S. patent has been applied for) on its high-quality VCA fader circuit,

which is a part of the MasterMix automation system. Various versions of these faders are supplied with MasterMix on Trident, Soundcraft, Neotek, Neve and DDA consoles.

Amek has chosen to fit the MasterMix digital grouping interface to its new 2520 console. To upgrade to full level and mute automation, the MasterMix storage computer with disk drive is all that is needed.

TBS converts worldwide ENG to Betacam

Turner Broadcasting System will equip its new CNN and Headline News headquarters at CNN Center with Betacam format news gathering and production equipment purchased from the *Sony Communications Products Company*, Park Ridge, NJ. The CNN Center will be completed in April and will feature more than 200 Betacam editing and playback systems, which will record video sent via satellite from TBS news bureaus. Plans call for the conversion of all 18 TBS news

bureaus in the United States and abroad to Betacam field-recording systems in the near future.

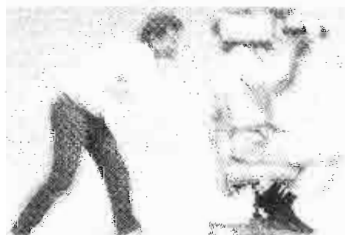
CBS adopts PAG mounting system

CBS News is adopting the PAG-lok camera/battery mounting system developed by *PAG Limited*, London, and *PAG America*, Asheville, NC. The system is being installed after a year-long testing and recommendation from CBS Engineering and Development and other networks. CBS News will install PAG-lok camera brackets on cameras and camera/VTR units, and will use PAG-lok batteries, which are available in 2Ah and 4Ah sizes with regular or super cells in conjunction with PAG microprocessor chargers.

Abekas relocates headquarters

Abekas Video Systems has relocated its headquarters to 101 Galveston Drive, Redwood City, CA 94063; telephone 415-369-5111. [:-)]]

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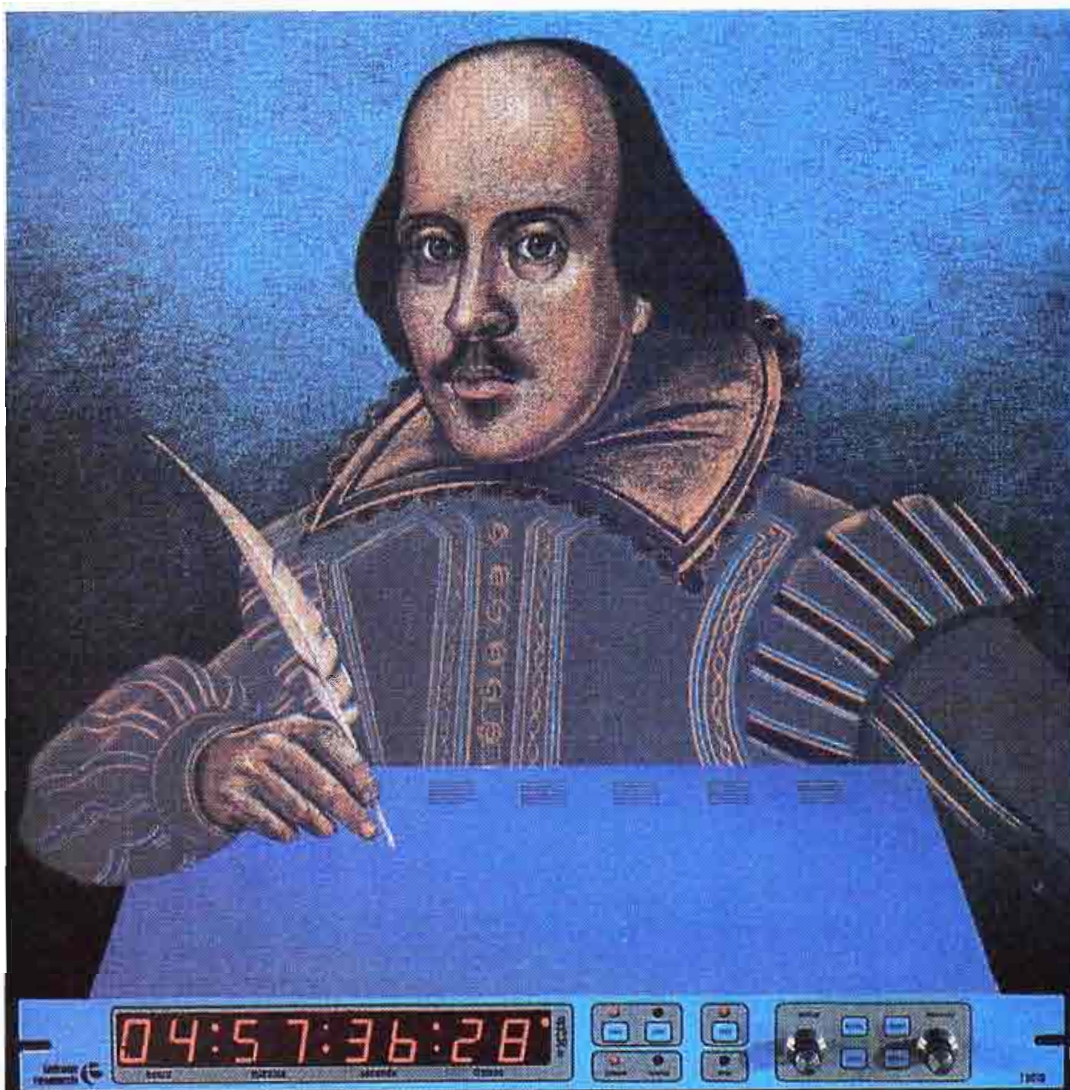
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The T6010 decodes time and user data and displays either on its read-at-a-glance .8" high LED's. Use it to insert data on the monitor as you view the master, and on the working dub for edit selection. 80 times play speed is fast enough for any VTR, and 1/10 play speed plus color framing indicator lets you be very picky!

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News

Continued from page 4

have been detailed in eight documents, which follow the organizational structure of the D-1 standard documents. Based on a sampling frequency that is four times that of the subcarrier, the format uses 19mm D-1 cassettes with metal particle tape and shares many mechanical components with D-1 VTRs. Development work for 625-line versions are under way.

Vintage VTR donated to museum

One of the earliest videotape machines, an Ampex VR-1000, has been restored to full operation for donation to the American Museum of the Moving Image in Astoria, Queens. Rebuilt by Merlin Engineering Works, Palo Alto, CA, to commemorate 30 years of video recording, the vintage VTR will be on display at the AMMI's public opening in January 1988. The VTR was one of the first production models made by Ampex. Delivered to the University of Missouri in Columbia in 1959, it continued in service until 1984, when it was donated to the Restoration Project by the Academic Support Centre.

NBC and NEC enter into agreement

A multiyear agreement between the National Broadcasting Corporation and NEC America, has been announced by NEC Broadcast Equipment Division.

The agreement involves the purchase of large quantities of the SP-3A CCD camera system for use by NBC news and NBC's owned and operated stations primarily for use with Panasonic's M-II VTR format.

Using three CCD devices as the imaging sensors, the camera features a built-in variable speed electronic shutter to provide sharp images of fast-moving objects during slow motion playback. Shutter speeds are selectable from 1/60th to 1/2,000th of a second. The camera will accept both Beta and M-II format VTRs in an integral configuration. It also may be used in remote control, triax or standard NTSC configurations.

Lab and field tests, including the use of an SP-3A during the broadcast of the 1986 World Series, were conducted by NBC before the final agreement was reached.

Delivery of the first cameras to NBC will begin immediately. **!:-T-))]]**

Circle (34) on Reply Card

Al Wilson, Bob McAll and **Jim Moneyhun** have been named to positions with Dynair Electronics, San Diego, CA. Wilson is the central region manager. He joined the company in 1981 and is the former region sales manager and dealer/OEM sales manager. McAll is the Eastern region manager. He is responsible for all business conducted in the northeastern United States and eastern Canada. Moneyhun is the Western region manager. He will be based in San Francisco.

Robert C. Hagerty has been named assistant manager of the Audio-Video Systems Division of Ampex Corporation, Redwood City, CA.

Leonard F. Coleman has been promoted to vice president and manager, regional business unit, by the motion picture and audio-visual products division of Eastman Kodak, Rochester, NY. He will be responsible for the United States, Canada and Latin America.

Jason Farrow has been promoted to vice president, corporate communications, at Sony Corporation of America, Park Ridge, NJ. He will plan and direct all communications activities. **M. Morizono**, deputy president and representative director of Sony, has been awarded the SMPTE Progress Medal Award.

Akiya Imura and **Kiyoshi Seki** have been appointed positions with Matsushita, Secaucus, NJ. Imura is president and chief executive officer of Matsushita Electric Corporation of America. He succeeds Seki who will return to Japan as president of Matsushita Electric Trading Company, a major subsidiary of Matsushita Electric Industrial Company. Seki will be responsible for the entire overseas strategy of the MET, including import activity. Imura is a director member of the board of MET. He is responsible for the corporate planning division, the service division and the publicity division of MET.

Thomas M. Stanback has been named national sales manager, satellite communications, Sony Information Systems Company, Park Ridge, NJ. He is responsible for developing new markets for a variety of satellite related products and technologies.

J. Thomas MacAllister has been promoted to sales manager, satellite communications division, for Microdyne, Ocala, FL. He will be responsible for setting sales goals and projections, coordination of sales teams, and overseeing sales efforts in the cable TV, radio and TV broadcast and commercial satellite markets.

Mark Gray and **David Fabian** have been appointed positions with Pinnacle Systems, Santa Clara, CA. Gray is executive vice president and chief operating officer. Fabian is marketing manager. He will focus on product development and the distribution channels to service market needs. **I-7-2-9111**

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MODULA, MINI MODULA, AND SUPPORT EQUIPMENT from BSM Broadcast Systems

PROBLEMS:

1. Expandability
2. Programming
3. Cost

1. BSM Broadcast Systems solves your expansion planning problems for video and audio signal routing with **MINI MODULA**, in matrix sizes from 8 x 8 to 24 x 32, and **MODULA**, for matrices as large as 256 x 256. Both products use the same circuit cards to preserve your initial investment in an expandable system.

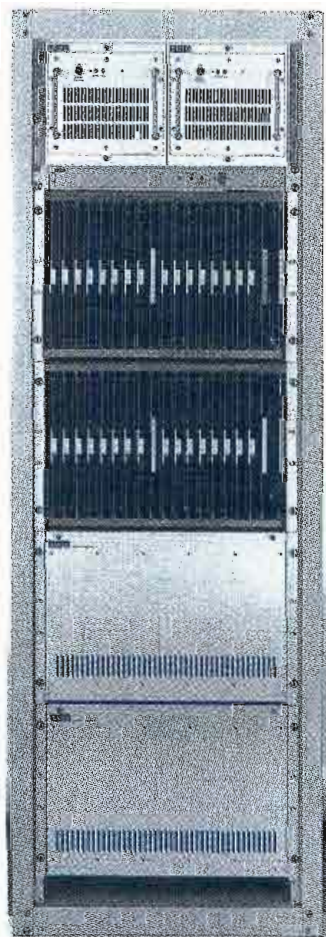
2. Both **MODULA** and **MINI MODULA** solve your custom programming needs because the systems are software driven. You re-program to the matrix without sending equipment back to the manufacturer.

3. You can see that BSM system costs are highly competitive—user programming, no hybrids, virtually maintenance free. **MODULA** and **MINI MODULA** expandability enhances your initial investment through growth phases of your development.

BSM also offers a complete line of distribution amplifiers and smaller video or audio switchers to complete your system.

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MODULA

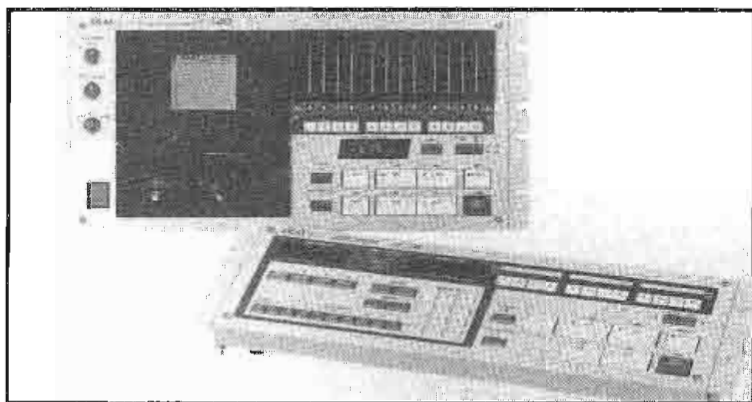


MINI MODULA



BROADCAST SYSTEMS, INC.

Recorder, autolocator



MG14D recorder

- Akai has introduced two rack-mountable recording devices:
- The MG14D 14-track recorder features a super gx glass fer-rite head, 12-segment LED bar graphs for signal level display, 12 audio tracks, a synctrack and an internal time control track. The recorder is SMPTE compatible.
 - The ML14 autolocator allows all transport controls along with record/playback status to be controlled and viewed from one unit. The SMPTE push-button operation of the unit's controls yields computer-assisted functions such as memory search, multiple event, auto punch-in/punch-out, multiple event, auto playback, mute and repeat.

Circle (350) on Reply Card

PAL version TBC/effects system

The ALTA Group has introduced a PAL version of its Cygnus single-channel production system/time base corrector and synchronizer. The PAL unit features: infinite-window time base correction, digital picture freeze, variable picture freeze strobe, variable posterization, variable mosaic and drop-out compensation. A 4x1 audio and video routing switcher and horizontal and vertical image enhancer also are standard features.

Circle (351) on Reply Card

Video graphics systems

Artronics has introduced two video graphics systems:

- The Video Paint Library is a high-resolution paint system with dual painting buffers, full-frame real-time animation, still store capabilities of up to 1,200 frames that can be automatically sequenced into animations, an image-management system and an undo function.
- The Video Graphics System/VGS Turbo XI is a high-power version of the VGS-3D. The system offers increased rendering speed and more powerful model construction and animation options. It consists of 3-D modeling and animation packages and 24/32-bit paint programs.

Circle (352) on Reply Card

Expanded software, interfaces

Audio Kinetics has released an upgrade of software for the Eclipse audio editor. Additional commands are available for the user-programmable Q•Keys, including a wait command. An on-line loop editing mode allows the operator to select, display and edit any of the 100 loop memories and display the contents of the event memories.

Audio Kinetics has also expanded its range of machine in-

terfaces for Q•LOCK to more than 80. Additions include: Sony MCI 16/24, MCI 110 and PCM 3324; JVC CR 850/90 and 8600; Stellavox TD9; Mitsubishi X850; Studer A812 and; Tascam ATR60 388 and 52/58/44/48/MS16.

Circle (353) on Reply Card

Digital video effects system



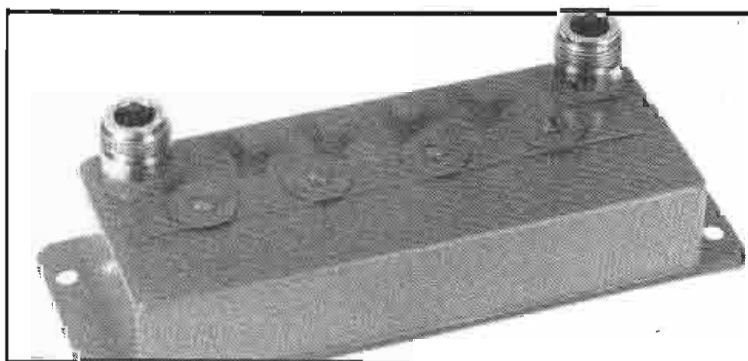
RP-1 digital video effects system

Microtime has introduced the following products:

- The Genesis 1 ACT 1 digital video effects system features continuous variable filtering and interpolation cards. These enhancements result in compressed images with enhanced resolution and clean, anti-aliased picture edges. The system offers a selection of effects and has the capability of operating with composite or component video.
- The RP-1 3-D digital video effects system offers 3-D variable axis rotation and variable perspective, continuous compression and expansion, freeze and strobe, full 3-D manipulation of a frozen image, linear or curvilinear trajectory, and crop and border. Features include: built-in downstream linear keyer, plug-in digital compositor for dual-channel system, self-test diagnostics and high-resolution display or 525-line monitor, undo key, built-in 3½-inch micro-floppy disk drive, left or right side joystick mounting, future interface to CCIR-601/SMPTE digital studio, dual video inputs and automatic input timing.

Circle (354) on Reply Card

Radio relay filter



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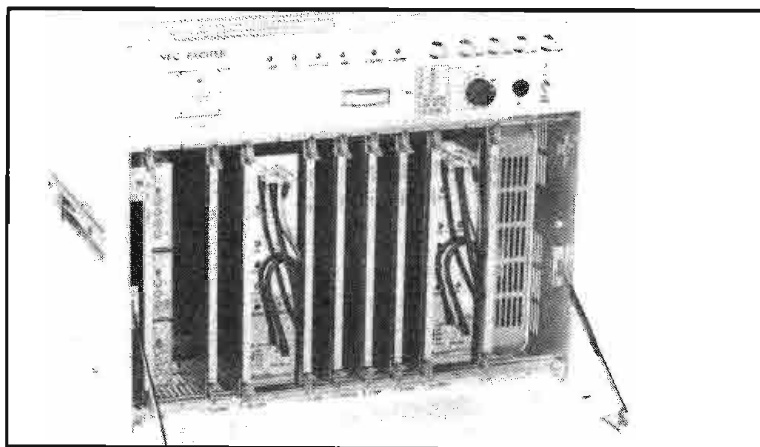
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Circle (92) on Reply Card

Microwave Filter Company has introduced the model 3160-161(6) bandpass filter that prevents interference caused by FM transmission signals at a 2-way receiver in a remote pickup radio relay link. The filter is installed indoors on the input of the 2-way receiver. The filter passes 160-162MHz with less than 1dB loss and attenuates at any FM signal's 60dB minimum. Return loss is 16dB minimum. Impedance is 50Ω and power handling is 25W. The unit has type N connectors.

Circle (355) on Reply Card

Special effects/CCD camera/TV exciters



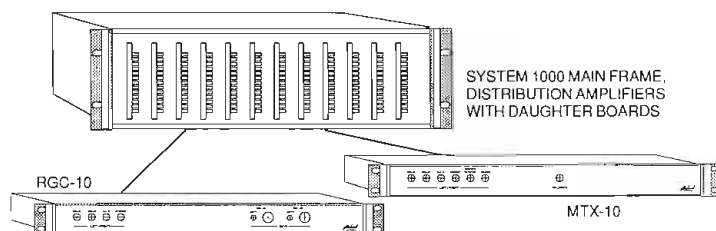
TV exciter

The Broadcast Equipment Division of NEC America has announced the following products:

- The DVE System 10 digital video effects software upgrade package. The transition effects package provides the system with the capability to create 2-D effects that have the look of 3-D effects. These preprogrammed effects will be available through the DVE System 10 soft keys as push-the-button-and-manipulate functions. Effects include: curl, roll and fold or peel.
- The SP-3A CCD camera with electronic shutter uses interline frame-transfer CCD chips. The electronic shutter features multiple step-variable speeds from 1/60th through 1/2,000th of a second. Solid-state operational characteristics of the cameras feature accurate and permanent registration that is free from geometric distortion and immune to high EMI environments, with resistance to shock and vibration. The camera is free from burn-in, sticking and comet-tailing. The camera provides NTSC, component video and direct RGB outputs as well as the choice in videotape interface formats.
- The DVE System 10C is a component video effects system that combines many of the effects featured in previous NEC systems with 3-D rotation and perspective.
- The NEC TV exciter is compatible with all stereo generators. It features an all solid-state, frequency-synthesized, high-performance exciter. Non-linear distortion

Continued on page 143

HOW MANY CONTROLS SHOULD AN AUDIO DA HAVE?



The SYSTEM 1000, Audio Processing and Distribution system puts you in control with options such as....

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LET'S TALK KEYERS



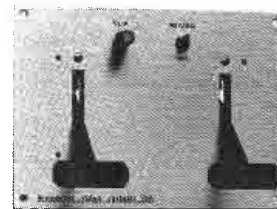
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PLUS A/B ADDITIVE MIX.



DK-400

SAME FEATURES AS
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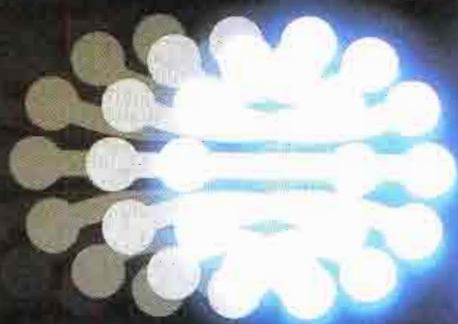
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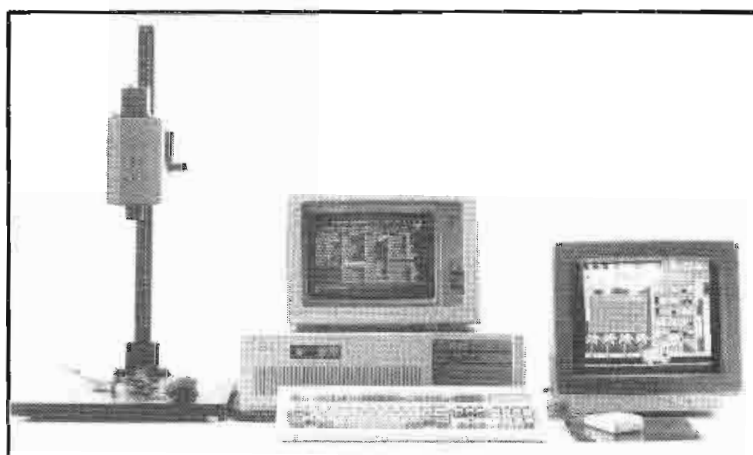
BROADCAST
engineering

Continued from page 140

is corrected at the IF stage. The pedestal AGC circuit system maintains constant visual/aural output power levels within a range of about ± 1 dB. A wideband transistor power amplifier is used to drive the klystrons in UHF transmitters.

Circle (356) on Reply Card

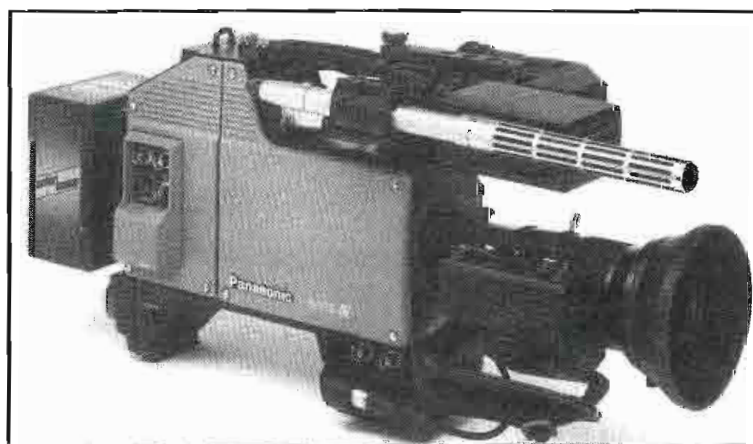
Graphics work station



NORPAK has announced the IPS4/IMAGE system graphics creation work station. The system is configured on an IBM PC AT. All user input is via the AT full-function keyboard or 3-button optical mouse. The workscreen displays the picture in process in 512 x 400 pixel resolution. An additional alphanumeric text screen provides system control, pull-down menus, commands and checklists for total user control. The system is delivered complete with a full megabyte of memory, a 30Mb Winchester disk drive, a 1.2Mb floppy disk drive, a high-resolution analog RGB monitor, a 12-inch test monitor, and a digitizing camera and stand.

Circle (357) on Reply Card

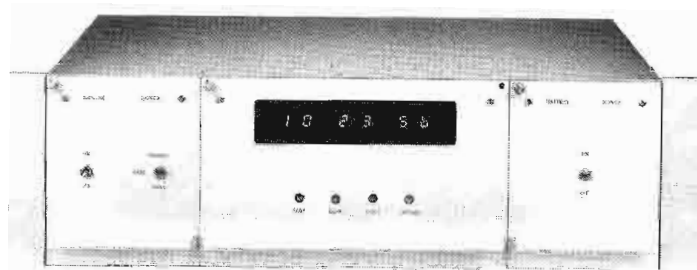
CCD camera



Panasonic Broadcast Systems has announced the AK-400 CCD color camera. It can be attached directly to the M-II format AU-400 camera recorder without an adapter. The camera weighs a little more than seven pounds and has three high-density CCD chips to provide the unit with a high-resolution of 650 lines. The camera provides a signal-to-noise ratio of 58dB and is equipped with an electronic shutter that minimizes lag and permits the creation of stop-action effects. The camera also provides black stretch to compensate for highlight situa-

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If seeing the same time on all your clocks is important, select **ES 192E-Line** frequency timebase, for only \$358.

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Circle (100) on Reply Card

tions. The unit also features a 4-position, double filter wheel. The camera can be gen-locked when docked to the M-II AU-400 recorder. It is equipped with a built-in monitor speaker and a multifunction monitor circuit in the viewfinder.

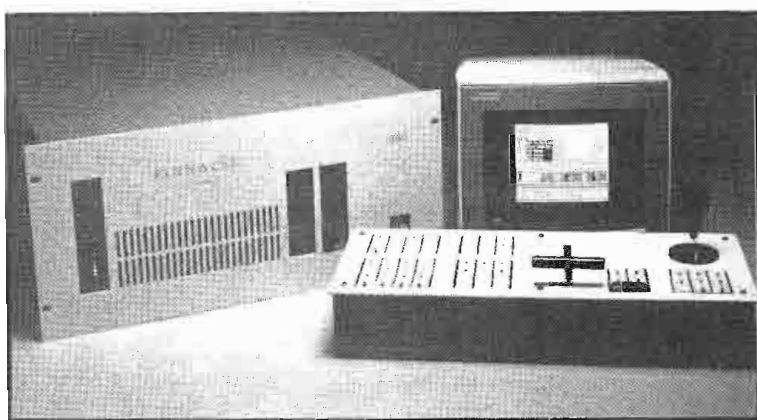
Circle (358) on Reply Card

Battery charger

Perrott Engineering Labs has introduced the Micro-Mini-charger model PE 383. It charges all 12V-14.4V 4Ah nicad batteries. It features built-in Minicharger technology and -115/230Vac switchable, weighs about 1 pound, and has fused VTR battery pigtail-type socket output.

Circle (359) on Reply Card

Software-based effects system



2010 digital effects system

Pinnacle Systems has introduced the following products:

- The System 2010 is a software-based digital effects system featuring on-site expandability and transparent picture quality. The color menus are controlled from the user panel that integrates a 3-axis joystick, a control bar, cursor keys, numeric pad and several dedicated function keys in a compact package. Features such as key input and output, RS-422 remote control and built-in keyer are standard.
- The system 2020 combines a high-performance effects system and slide store in one package. In addition to manipulating live video images, the user can create a multilayer graphic of stills and then store it on a built-in Winchester disk drive. The stored slide can be retrieved, manipulated and added as the next layer in a multilayer composition. All the processing is done in the digital domain.

Circle (360) on Reply Card

Mixing consoles

Soundtracs has announced the Midi PC series MIDI-intelligent audio mixing consoles. The series has an in-line configuration with 16 or 24 input/output module mainframe with 16-track monitoring and 16 subgroups. The consoles have 32 or 48 MIDI-controlled inputs with additional MIDI control on four auxiliaries, plus eight optional MIDI-controlled effects returns. Control of external MIDI effects may be programmed from the console.

Circle (361) on Reply Card

Audio equipment and monitors

Sony Professional Audio Products has introduced the following products:

- The ECM-44 is a general application lavalier microphone

with omnidirectional pickup and an 8.5mm capsule diameter. The mic has a frequency response from 40Hz to 15,000Hz and is available with either XLR connectors or a pigtail.

- The MXP-2000 stereo audio mixing console, designed for on-air and post-production use, is a modular design with switchable dual mic/line inputs, five kinds of solo, selectable audio or VCA grouping, cough switching, 3-band EQ sweepable from 300Hz to 3kHz, direct or group outputs, and on-air/rehearsal logic switching. Stereo capabilities include two independent stereo outputs and four stereo external monitor inputs. Options include a user-assignable dynamics processor module, fader start capability and a video editor interface.

- The BVM-1900C 19-inch monitor has all the features of the BVM-1900, plus a component input interface that enables switching between RGB video inputs or Betacam Y, R-Y, B-Y component signals. The monitor has 900 lines of horizontal resolution, pulse cross and underscan functions.

- The BVM-1310 14-inch monitor has a built-in current feedback system that ensures color temperature drift to less than 1% over 500 hours. Resolution of 700 lines in the center and 600 TV lines in the corners is made possible with a CRT pitch of 0.25mm. Convergence is within 0.03mm at the center and 0.06mm at the corners.

- Betacam SP is a format extension of the Betacam system. Chrominance and luminance track widths are 73μm and 86μm respectively. The system has two AFM channels and accepts 30- or 90-minute Betacam cassettes, available with standard oxide or metal particle tape. Three models are available: the BVW-505, which is a BVV-5 recorder unit combined with Plumbicon, Saticon or CCD Betacam cameras; the BVW-35, a portable recorder/player; and the BVW-75, a studio editor/recorder/player.

- Three shipper cases accommodate BCT series Betacam cassettes, KCS series U-matic cassettes and KCA series U-matic cassettes. The cases are made of a high-density, anti-static plastic and have a tongue-and-groove dust seal and a latch-and-lock mechanism to prevent accidental opening.



BVW-35 Betacam SP portable recorder/player

Circle (362) on Reply Card

Transmitters

Spectrum Communications has announced a new line of high performance VHF and UHF portable transmitters and

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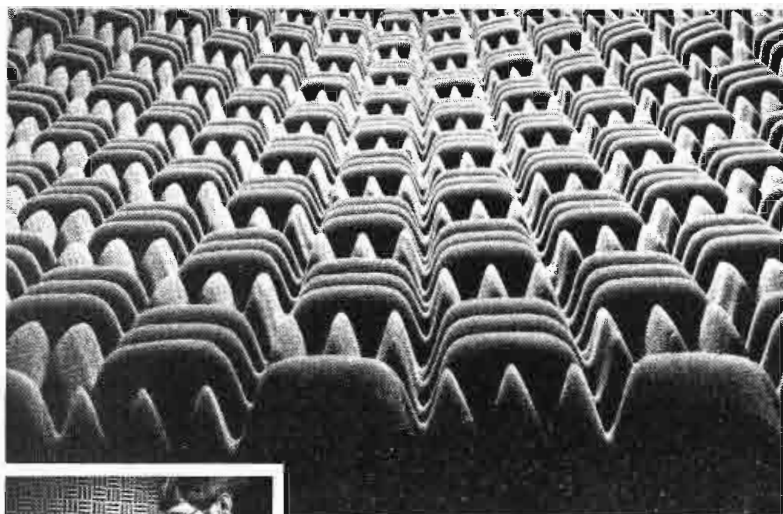
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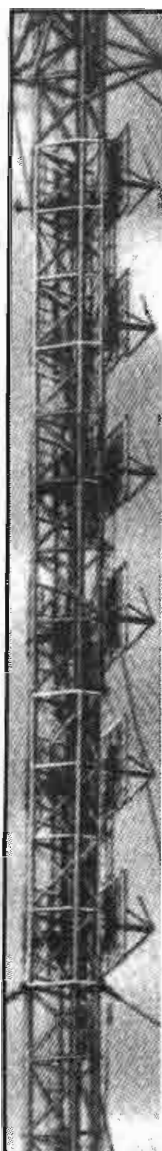
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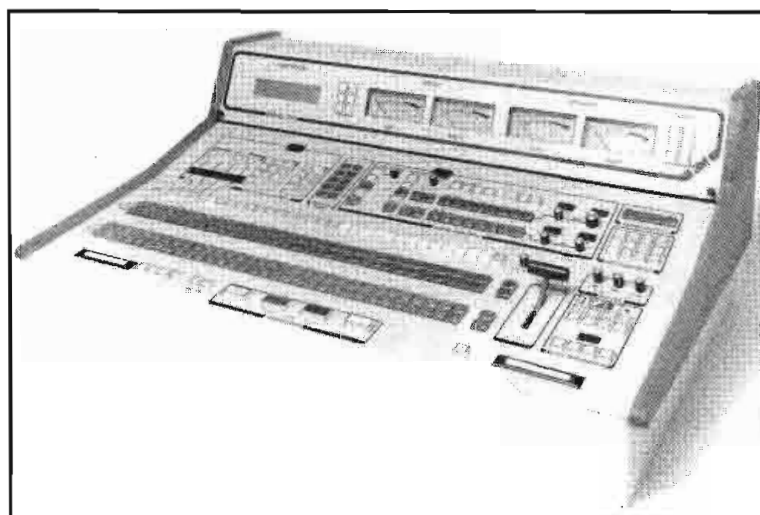
452 Five Farms Lane, Timonium, MD 21093
(301) 561-1999 Telex: 053-4962

Circle (104) on Reply Card

receivers. The SCT5-1P pocket/body transmitter features 100mW RF output, built-in condenser mic and nicad battery pack, a flexible wire antenna and an external mic jack. The automatic audio gain control option helps maintain constant transmitter FM deviation level. The SR250 is a portable/desktop monitor receiver that includes one to six channels, a large built-in speaker, battery pack, ac power supply, 12Vdc input, and a signal strength/battery meter. Audio and COR outputs are provided. Switchable audio low-pass filter and tone controls filter out high-frequency noise.

Circle (363) on Reply Card

Switchers



324 master control switcher

3M has introduced the following products:

- The model 324 master control can be used stand-alone or integrated with 3M switching systems. It provides 32 audio-video inputs, four assignable inputs with alphanumeric readouts, and full audio over and under capability. Features include: full analog VU meter with digital peak indicators; four programmable, user-definable transitions; a backup system; eight audio inputs with auto cart start; three video buses; manual fader; and two matte generators.
- The series H 64 x 64 routing switcher is designed using redundant circuits for all critical functions. It provides two levels of switching, one video and one audio. The system can control up to five independent levels of audio. The switcher matrix is controlled by the model 6600 microprocessor controller.
- The series H 32 x 32 routing switcher provides one video and one, two or three switching levels in the same enclosure. Each audio level is independently addressable. The switcher offers I/O ports for RS-232 computer terminal control and standardized I/O protocol to allow for external CPU control.

Circle (364) on Reply Card

Auto focusing and automation systems

Total Spectrum Manufacturing has introduced the following products:

- The SportsFocuser auto focusing system features quick setups, holding focus while live and no focus overshoots. The system tracks precisely to within one foot in 100 yards and within 1/10th of a second.
- The HS-110P studio camera automation system is a high-



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Stations identify with us. Not only at "break" time, but from sign-on until sign-off. Because they can't afford dead air and inferior performance, broadcast engineers go with audio components they know and trust. Result: Switchcraft parts are part and parcel of hundreds of AM, FM, Shortwave and TV stations worldwide.

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speed programmable pan and tilt head capable of supporting a studio camera with a 44X zoom lens and a teleprompter. The system uses the software-driven MultiController. The system is capable of supporting 250 pounds and features precision motion control with 18 arc/sec repeatability, 180°/sec velocity, 90°/sec acceleration, uses digital/analog servos, has RS-422 control and may be pedestal or ceiling mounted.

Circle (365) on Reply Card

Headsets

Technical Projects has introduced lightweight headsets. An active circuit, hidden in the earphone cup, requires no batteries or external power supply and permits the cardioid dynamic microphone of TecPro headsets to operate in this application. An internal control may be preset to the microphone loudness required by a particular camera system.

Single and dual muff versions with or without a momentary TALK button are available.

Circle (366) on Reply Card

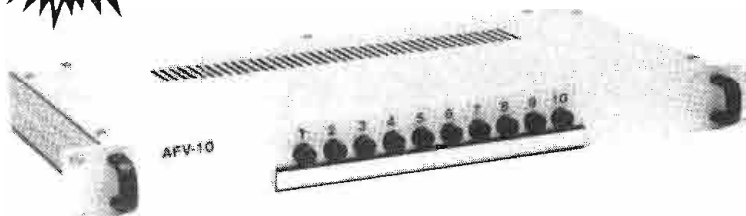
Optical detection system

Television Equipment Associates, U.S. marketing agent for Elcon, has announced the focused optical detection system for the ¾-inch cassette and 1-inch evaluation machines. The system makes it possible to clean and inspect recorded videotape. The EA750IR ¾-inch cassette is a 4-track focused optical system and the 1200IR 1-inch unit is a 5-track focused optical system. Information from these optical assemblies is combined with Elcon's 3-grade profiling system that will identify both the location and severity of physical damage on the illuminated front panel.

Circle (367) on Reply Card

1:~)))

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- Rack Mount 19" x 1-3/4"
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- Multiple Edge-Board Audio Connector
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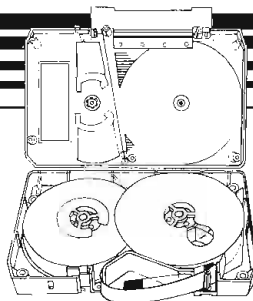
Before we'll reload a ¾" u-matic videocassette we take it completely apart and rebuild it inside and out. We replace wiper flaps, friction pads, tape guides and leader — everything that's needed to make the cassette test as good as new. Only then will we reload it with new 3 M videotapes or other major brands. If we can't rebuild it we won't reload it.

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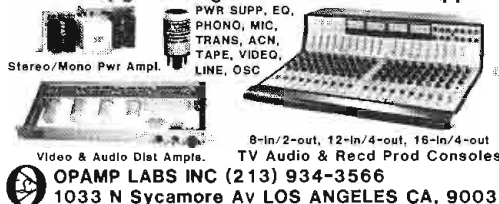
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The self-powered, 3 1/2" rack mounting units include LED status readouts and offer the choice of VU only (M405F), or dual VU/PPM (M405D) scales. The unique portable M405, with rechargeable ni-cad batteries, gives additional convenience and flexibility for measuring systems levels on a totally floating basis in those hard-to-get-at places.

The M405 Series . . . traditional Ward-Beck quality, carefully made-to-measure!



First by Design.

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