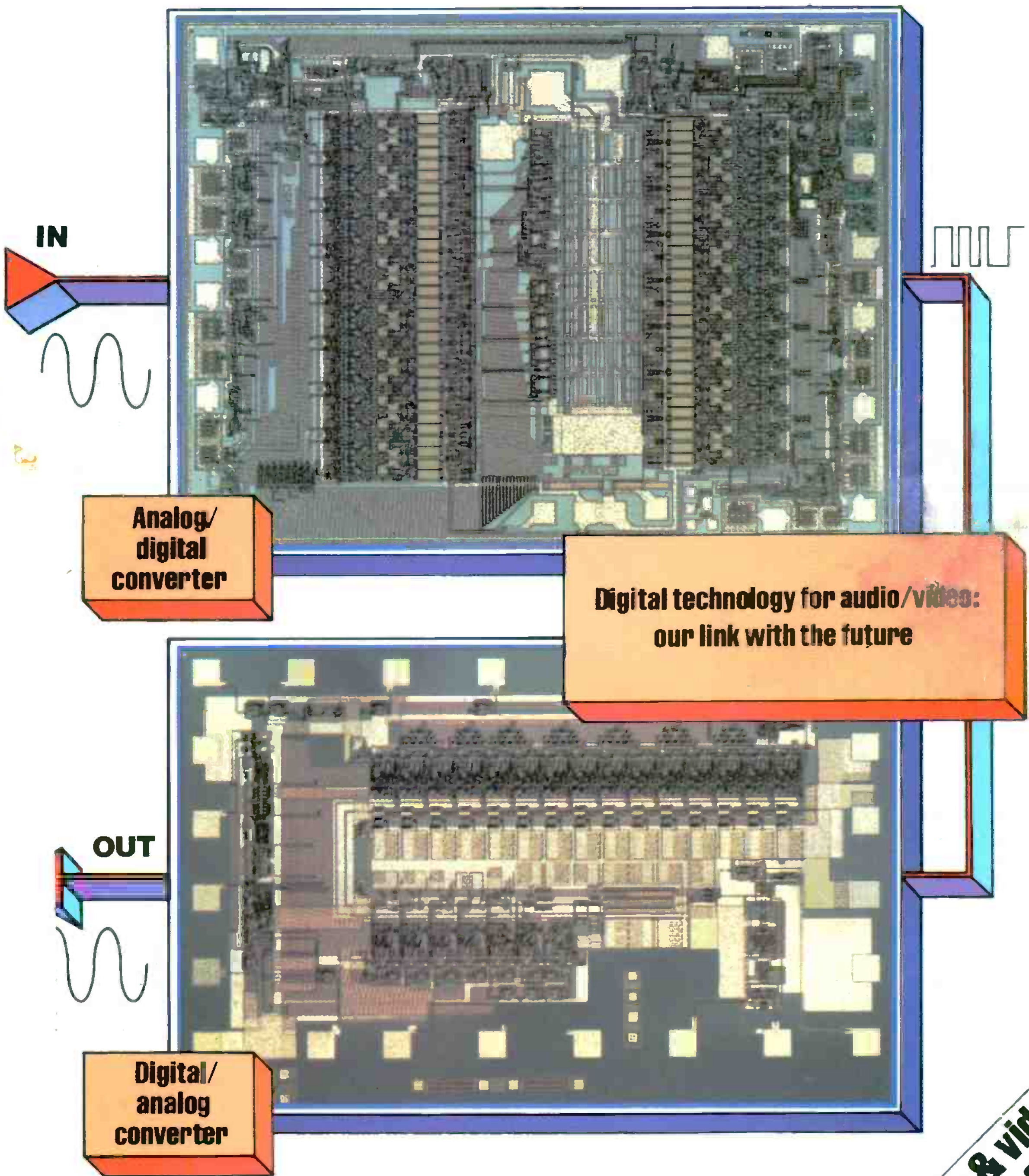
BROADCAST engineering

February 1985/$3



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BROADCAST engineering

The journal of broadcast technology

February 1985 • Volume 27 • No. 2

DIGITAL TECHNOLOGY FOR AUDIO AND VIDEO

Much of broadcasting's rapid change is being driven by new developments in digital technology. This month we examine how this equipment works and how broadcasters use it.

OTHER FEATURES

ISSN 0007-1994. $2.00 + 0.00.

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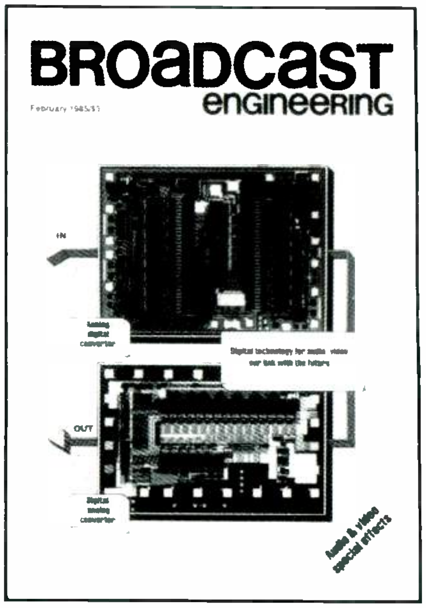

THE COVER this month shows the main weapons in broadcasting's digital revolution—*analog-to-digital* (A/D) and *digital-to-analog* (D/A) converter chips. The A/D die photo at the top is of a National Semiconductor ADC0820 converter, featuring 8-bit resolution and a built-in *track-and-hold* input stage. The die photo beneath it shows a TRW TDC1018 8-bit D/A converter. *(Photos courtesy of National Semiconductor and TRW.)*

DEPARTMENTS

Coming events
March 5-8
AES,
Hamburg, West Germany

April 14-17
NAB '85,
Convention Center,
Las Vegas, NV

NEXT MONTH

NAB Preview
- Exhibitor roundup
- Equipment listings
- Booth listings
- Exhibit guide map

National Radio Broadcasters' Association
1705 De Sales Street, NW
Washington, DC 20036
1-202-466-2030

Radio '85 convention set

The steering committee of the Radio '85 Management and Programming Convention met in Dallas in January to discuss possible speakers and entertainment, plan sessions and pinpoint the focus of this year's convention.

Sponsored by the NRBA and NAB, the convention will be Sept. 11-14 at Loews Anatole, Dallas.

All hospitality suites and entertainment will be at the Anatole, and all exhibits, panel sessions and luncheons will be at the nearby Dallas Convention Center. This will allow for easier access to all sessions and for more exhibit space.

More than 75 sessions will be held on management, programming, sales, engineering and allied radio topics.

A new feature of the convention is that it will be held Wednesday through Saturday, which will allow for an added day of panel sessions and events.

The first convention, held in Los Angeles in September, had more than 135 manufacturer exhibits (**BE**, December). Attendance was estimated at 5080.

National Association of Broadcasters
1771 N Street, NW
Washington, DC 20036
1-202-293-3570

DBA joins NAB

The Daytime Broadcasters Association was merged into the NAB on Jan. 4. The agreement was signed in December by Edward O. Fritts, NAB president, and James Wychor, DBA president.

The agreement became effective after ratification by the DBA board of directors.

Under the agreement's terms, the DBA will disband operations and will encourage members to join NAB. The new Daytime Broadcaster Committee will represent interests formerly covered by the association.

Society of Broadcast Engineers
P.O. Box 50844
Indianapolis, IN 46250
1-317-842-0836

Frequency coordination update

The SBE National Frequency Coordinating Committee has released an updated list of contact persons in 74 U.S. locations. The list includes several additions and changes to previously published coordinator lists.

Any user of radio or TV remote transmitting equipment is requested to check with the frequency coordination contact person in a given area before using RF equipment. These local coordinators do not assign channels. They, instead, make possible the licensee-to-licensee contact asked for in Part 74.24 of the FCC rules.

BROADCAST engineering

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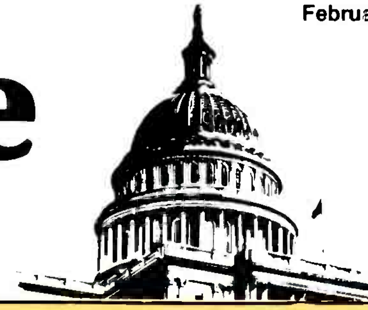
FCC update



By Harry C. Martin, partner, Reddy, Begley & Martin, Washington, DC

12-station rule modified

The FCC has affirmed its 12-station multiple ownership rule as it applies to AM, FM and TV stations.

With respect to television, however, an additional owership limit has been adopted. Entities may not acquire ownership interests in TV stations reaching more than 25% of the national audience. Audience reach will be determined by the Arbitron ADI market rankings of the percentage of national TV households contained in each market.

However, the commission has decided to attribute only 50% of a market's ADI reach when the station involved operates on a UHF frequency.

The commission also decided to eliminate the automatic sunset provision under which all numerical limitations on station ownership would have disappeared in 1990.

Further, the commission decided to permit group owners of radio and TV stations to have cognizable interests in up to a maximum of 14 broadcast facilities in the same service if two of the stations are minority-controlled, minority ownership and control exceeding 50%. Entities having cognizable ownership interests in minority controlled TV stations will be permitted to reach 30% (as opposed to 25%) of the national audience.

These changes in the commission's multiple ownership rules will become effective on April 2.

Power measurement amended

The FCC has adopted rules that allow more flexibility in the way AM, FM and TV stations measure operating power.

Under the new rules, AM stations may use direct reading radio frequency (RF) power meters to measure operating power. Further, if the antenna resistance of an AM station changes, the station now can resume power determination by the direct method once the new value for antenna resistance has been measured.

However, the station still must submit an application for license (FCC form 302 or 341) with the new measured value of resistance.

For FM and aural TV transmitters, the power meter now may be calibrated by either using an external wattmeter or by using an indirect method of power determination.

In relaxing its rules, the commission emphasized that the burden of accurately measuring power and properly calibrating measuring instruments rests with the broadcaster in all cases. Stations were reminded that they must assure that operating power never exceeds 105% of that authorized for AM and FM stations and 110% for television.

689 new FM channels

On Dec. 20, the FCC amended its table of FM assignments by assigning 689 new FM channels to communities throughout the United States. This was the first step toward implementing the FCC's new FM station classifications and mileage separation criteria, adopted in Docket 80-90.

A second implementing order, which was expected to be released in January, is to address application filing procedures, special treatment (if any) to be afforded daytime AM stations in the application process, and procedures for filing new petitions to change the FM table of assignments.

Cable Act rules

In a wide-ranging rulemaking proposal issued in December, the FCC proposed new rules designed to implement the Cable Communications Policy Act of 1984 (Cable Act), which was signed into law on Oct. 30.

The most significant proposals involve definitions of the terms "cable service" and "cable system" and regulation of rates for basic cable services. In response to other major portions of the Cable Act, the FCC is deleting its existing rules dealing with franchise standards and obscenity. These provisions have been superseded by the new legislation.

The proposed new definition of "cable service" takes into account Congress' distinction between programming services, which are exempt from common carrier regulation, and other types of communications services, which are not necessarily exempt. According to the Cable Act, "cable service" is defined as the 1-way transmission to subscribers of video or other programming services together with any subscriber interaction that is required for the selection of such programming.

On the other hand, services that allow subscribers to manipulate or otherwise process information or data are not classified as cable services and could be subject to state common carrier regulation. These include at-home shopping and banking, data processing, video conferencing and all voice communications.

However, pay-per-view video programming, teletext, 1-way transmission of computer software and catalog services, none of which allow direct customer purchases, will be considered as cable services under the commission's proposed rules.

In redefining the term "cable system" to conform to the new legislation, the commission proposes to make the following additional changes in its rules:

- A cable system will be defined as a facility that provides any type of video programming. Currently, a facility must distribute the signals of broadcast television stations to be considered a cable system.
- The commission will remove its exemption from regulation of systems with fewer than 50 subscribers.
- Systems that only retransmit broadcast signals will be exempt from regulation as cable systems. However, the commission is seeking comments on what regulations (if any) should apply to such newly exempt systems.
- SMATV systems that serve multiple-unit dwellings, regardless of whether they are commonly owned, controlled or managed, will be exempt from federal regulation if they do not use public rights-of-way. Currently, SMATV systems are exempt from regulation if they serve subscribers in one or more multiple unit dwellings under common ownership, control or management, regardless of whether they use public rights-of-way.

Concerning rate regulation, the new

Continued on page 116

By Jerry Whitaker, editor

The on-air performance of an AM stereo station is determined by the performance of the entire transmission chain, from the source machines to the antenna. A good on-air sound requires attention to every area of station operation. The phasing and phase stability of source, mixing and STL equipment are of critical importance and must be checked on a regular basis.

Establish a maintenance routine that includes measurement of all source equipment for proper phase coherence, frequency response, distortion, noise, wow and flutter. Be certain to use the proper test procedures when measuring the performance of source gear with *active-balanced* program audio outputs.

Most active-balanced (*electronic transformer*) output circuits should not be connected to an unbalanced test instrument. The test arrangement shown in last month's "AM Stereo Update" is appropriate for transformer-balanced or unbalanced source equipment, but it is not suitable for many active-balanced units.

The test setup in Figure 1 provides a way to accurately measure the performance of a unit with active-balanced input and output connections. Using an external transformer to make the conversion from balanced to unbalanced operation is not recommended, because the transformer may add its own phase shifts and amplitude variations to the test measurements.

Cartridge and reel-to-reel source equipment should be checked at a variety of frequencies across the audio band. Checking alignment at just one high frequency—such as 10kHz—could cause a 360° phase shift error to remain undetected.

Audio mixing and STL equipment should be checked on a regular basis for frequency response, distortion, noise and phase coherence. The test setup shown in Figure 1 can be used with an active-balanced output mixer or STL system by making the mixer or STL the *unit under test*.

Keep a record of the performance of each piece of equipment or link in the broadcast chain so that trends indicating a developing problem can be spotted early.

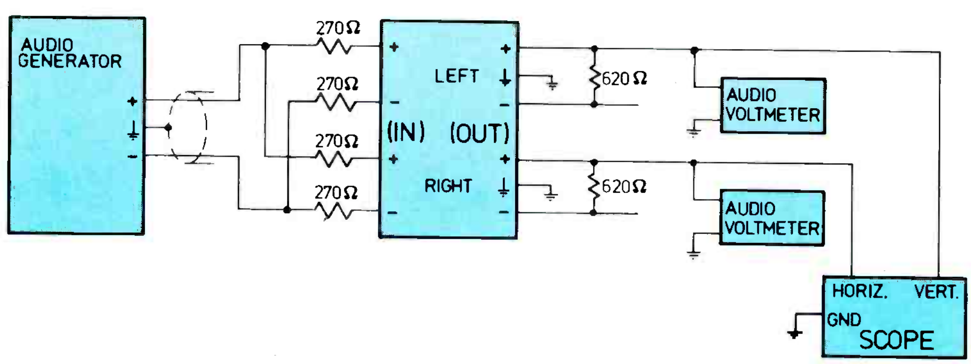


Figure 1. The recommended test setup for source equipment with an active-balanced output stage.

Harris joins Motorola

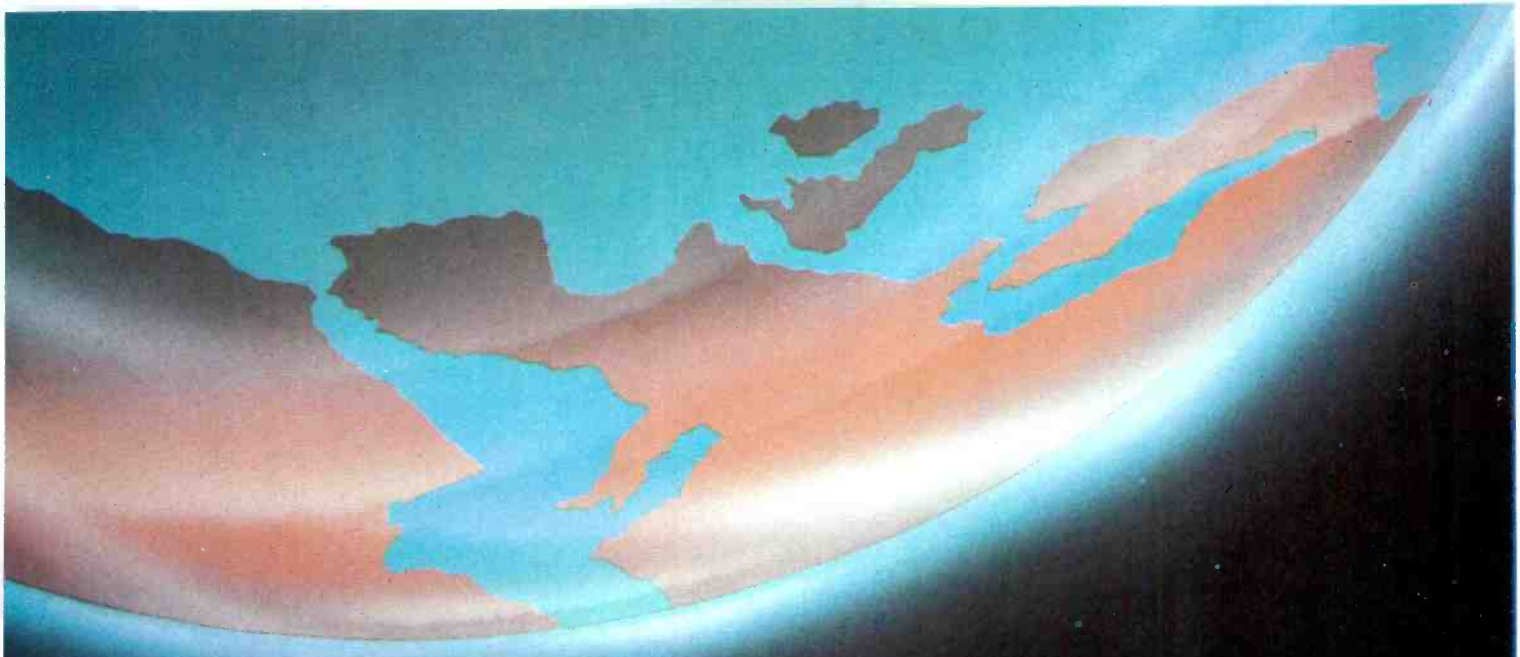
Harris and Motorola have announced a licensing agreement under which Harris will manufacture and market AM stereo exciters and monitors using Motorola's C-QUAM AM stereo system. The move gives a giant boost to Motorola's efforts to become the de facto AM stereo standard in the United States.

William Howard, Motorola senior vice president, said the agreement "underscores the acceptance and acceleration of the C-QUAM AM stereo system as the marketplace AM stereo standard."

Harris Broadcast Group Vice President Gene Whicker said the agreement was "in the best interest of all in making AM stereo thrive as a popular new broadcast technolgy and consumer medium."

Type acceptance for the Harris STX-1B C-QUAM AM stereo exciter has been filed with the FCC. Harris plans to offer users of its current system a modification kit for conversion to C-QUAM operation, once FCC-type acceptance has been received.

As expected, Leonard Kahn, president of Kahn Communications, which manufactures a competing system, has threatened legal action. In a press release, Kahn said that he had asked the government to initiate an investigation because "we believe that Motorola's conduct, including their recent agreement with Harris Corporation, raises serious antitrust problems under the Sherman and Clayton acts."



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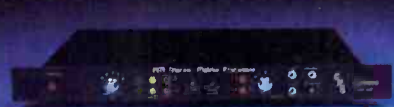

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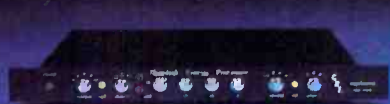

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Strictly TV

By Carl Bentz, technical editor

Transmission standards, Part 2

This month's column continues a look at the three major standards in use around the world. The acronyms are defined as follows:

- NTSC-National Television Standards Committee.
- PAL-Phase Alternation each Line.
- SECAM-Sequential Colors with Memory (from the French "sequential couleurs a memoire").

Within the PAL signal

PAL, which most closely resembles NTSC, offers a number of interesting differences, resulting from studies of NTSC and an attempt to improve upon it. For example, PAL receivers have no tint or hue control. It isn't necessary, because the system provides integral hue stability.

Five primary facts differentiate PAL transmission signals from NTSC:

- **Subcarrier.** The subcarrier frequency of 4.43361875Hz is used for monochrome compatibility with the 50 fields and 625 lines. This is similar to NTSC, where the subcarrier is the 455 harmonic of ½ the line frequency.

The best compromise for the subcarrier involves a quarter-line offset. In other words, the subcarrier must be an odd multiple of ¼ the line rate. To cancel interference patterns from frame to frame adds another restriction of a ½-frame frequency offset. The line rate is 15,625Hz and the frame rate is 25Hz. Thus, the subcarrier results from the formula, $f_{sc} = (1135/4 + 1/625)f_h$.

- **Color difference signals.** U and V have equal bandwidths that are approximate equivalents to the NTSC I component. The same gamma-corrected RGB signals are combined in a different manner. U involves B-Y, V is R-Y. In NTSC, both I and Q are derived from both the B-Y and R-Y components. Table I in January's "Strictly

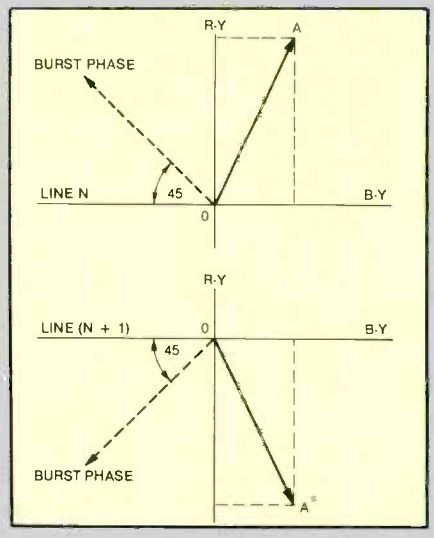


Figure 1. A swinging burst phase reference provides information on polarity of the R-Y or V component from line to line.

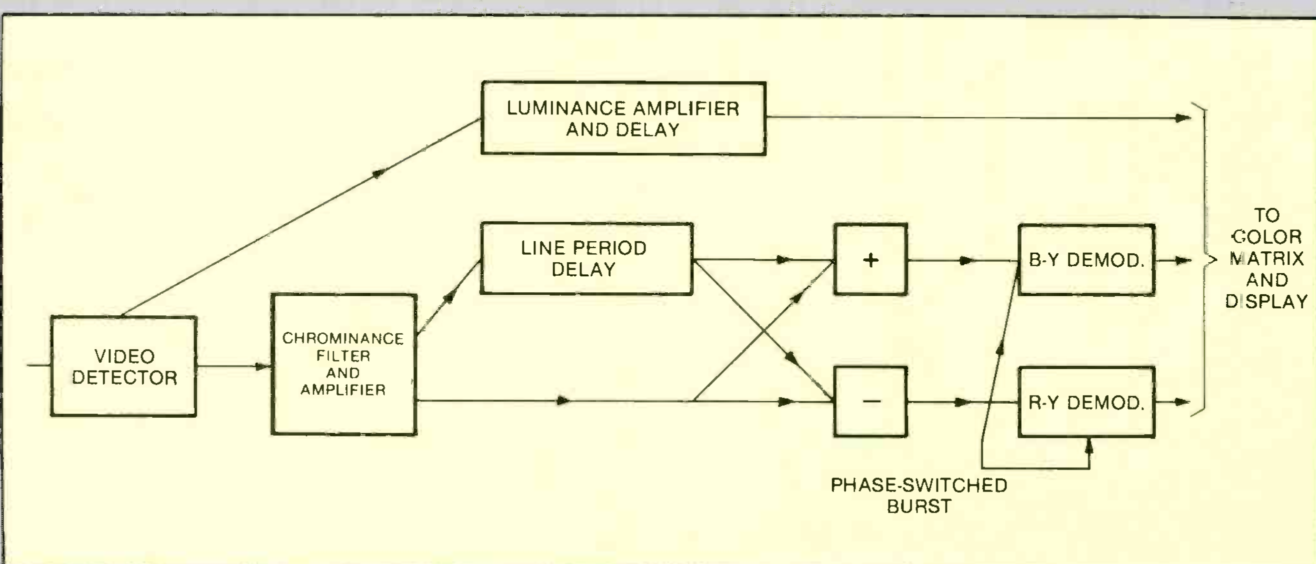
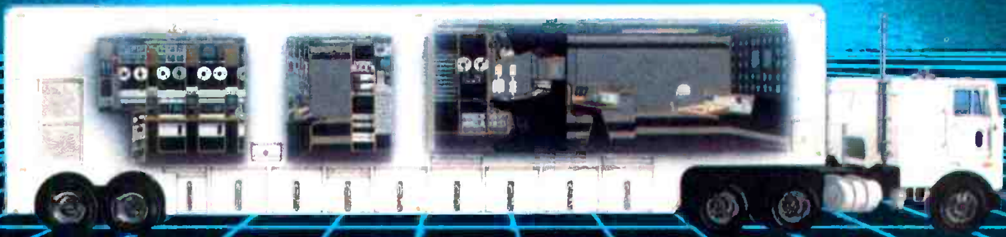


Figure 2. Color signal routing in a PAL decoder.

FROM CONCEPT TO REALITY



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TV" shows the signal compositions.

Recall that NTSC allows bandwidths of I and Q to be approximately 1.5MHz and 0.5MHz. PAL specifies an attenuation factor of less than 2dB at 1.3MHz for both U and V.

- **R-Y switching.** A phase reversal of 180° in the R-Y or V component occurs from line to line. The advantage of phase switching is reduced crosstalk between the color channels.

In NTSC, color fringing may occur if the Q-channel bandwidth in the receiver is insufficient for full double-sideband operation. Phase reversal creates a simulated double-sideband signal, even if high frequency components of chroma are restricted at frequencies nearing the PAL sound carrier.

- **Burst switching.** The phase of burst differs by 90° (actually ±45° with respect to the B-Y signal axis) on successive lines, giving the color decoder information on the polarity of the V component. Figure 1 shows the phase relationships on two successive lines.

The purpose of this switching is to reduce level-dependent phase errors. Vector OA in the figure represents the chroma in the signal or the resultant of vectors R-Y and B-Y. A change in either component results in a much smaller change in OA. Errors as large as 15° will produce just noticable effects in the picture. In NTSC, the just noticeable error is around 6°.

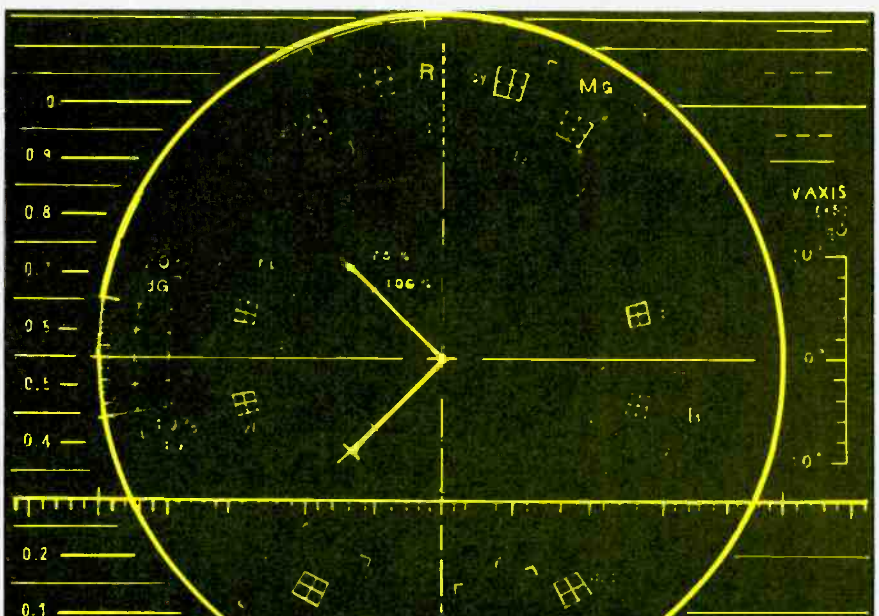
- **Phase angle vs. timing.** A sequence of eight fields (compared to four for NTSC) occurs before exact phasing recurs. The so called "Bruch sequence" becomes very important for processing of PAL video.

In the PAL receiver

Additional differences occur in the PAL receiver. Beyond the missing hue control, they include a high tolerance 1-line delay with a duration exactly equal to an integral multiple of 1/2fc; addition and subtraction of delayed and nondelayed chrominance to separate U and V; line-by-line switching information developed from the shifting burst signal; and wideband equal bandwidth decoding, with the locally generated 180° switched subcarrier feeding the V demodulator circuit.

Of these differences, addition and subtraction of delayed and non-delayed chrominance to separate U and V is one reason why PAL appears technically superior to NTSC. The addition and subtraction of the two chroma components create an immunity to level-dependent phase errors in hue. Each line of video is sent through a delay line (Figure 2).

A video line from the chroma filter/amp feeds a precision delay line as well as sum and difference circuits. An output from the delay line also feeds the sum and difference matrix. If the line presented by the delay is represented by +U,+V, then the signal coming direct from the chroma amp is +U,−V. The sum circuits deliver a +2U component to the B-Y demodulator. The subtractor presents a similar situation. With +U,+V and +U,−V inputs, the U signal cancels, and the value of V adds.



Courtesy of Tektronix

A PAL vector display.

On the screen

To the U.S. observer watching PAL for the first time, there is a definite flicker to the image. It does not take long to ignore the 50Hz field rate effect. What is difficult to ignore, however, is that color in the picture appears more phase stable and more saturated than NTSC.

If observers go across the English Channel to France, they may find the picture even better. SECAM differs fundamentally from NTSC and PAL in the transmission of color information.

SECAM and FM color

The SECAM signal is developed from typical gamma-corrected RGB inputs. R-Y and B-Y components are generated normally. Then a DR (from R-Y) and DB (from B-Y) forms modulated the 4.433MHz subcarrier. Frequency modulation is used, with DR being sent, followed by DB in a line sequential approach. The instantaneous frequency increases as DR or DB decreases.

In the receiver, a delay line and switching route the correct component to its own FM demodulator. Every displayed line will result from a B-Y component that is delayed or nondelayed, and an R-Y component that is nondelayed or delayed. Vertical resolution is somewhat reduced and a flicker along horizontal boundaries of high saturation colors may be noticed.

With only one color difference signal transmitted at any one time, SECAM receivers require no autophase control loops or synchronous receivers. Improved immunity from phase distortion and freedom from color crosstalk results, but some added noise appears in monochrome displays of color signals.

Transmission vs. studio

The comments made about NTSC and PAL generally apply to video in the studio as well as video transmitted via RF to the receiver. Fades and effects present no major difficulties. In the SECAM format, however, even simple fades become undesirable and any type of split screens and special effects become impossible. Conversion to NTSC or PAL are required before any production functions are performed.

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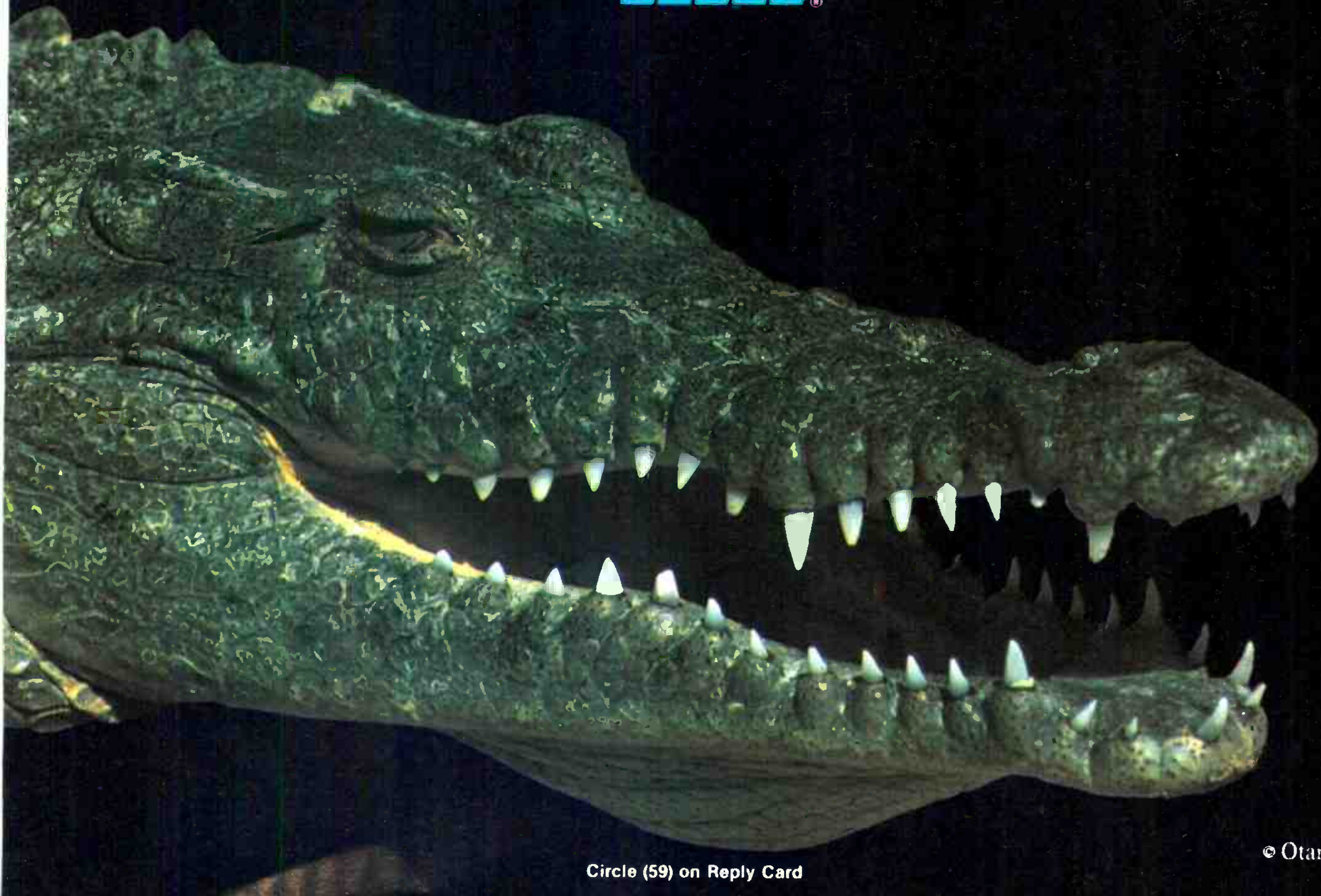

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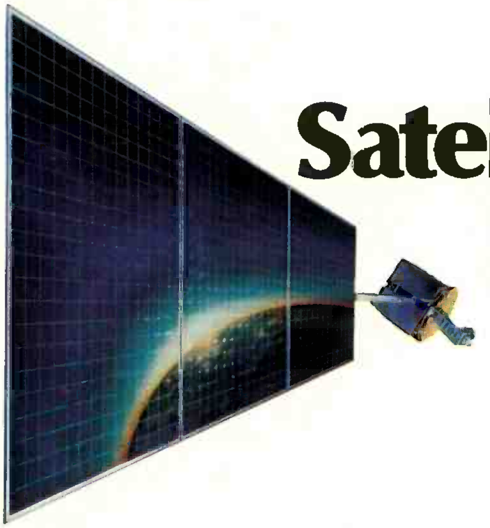
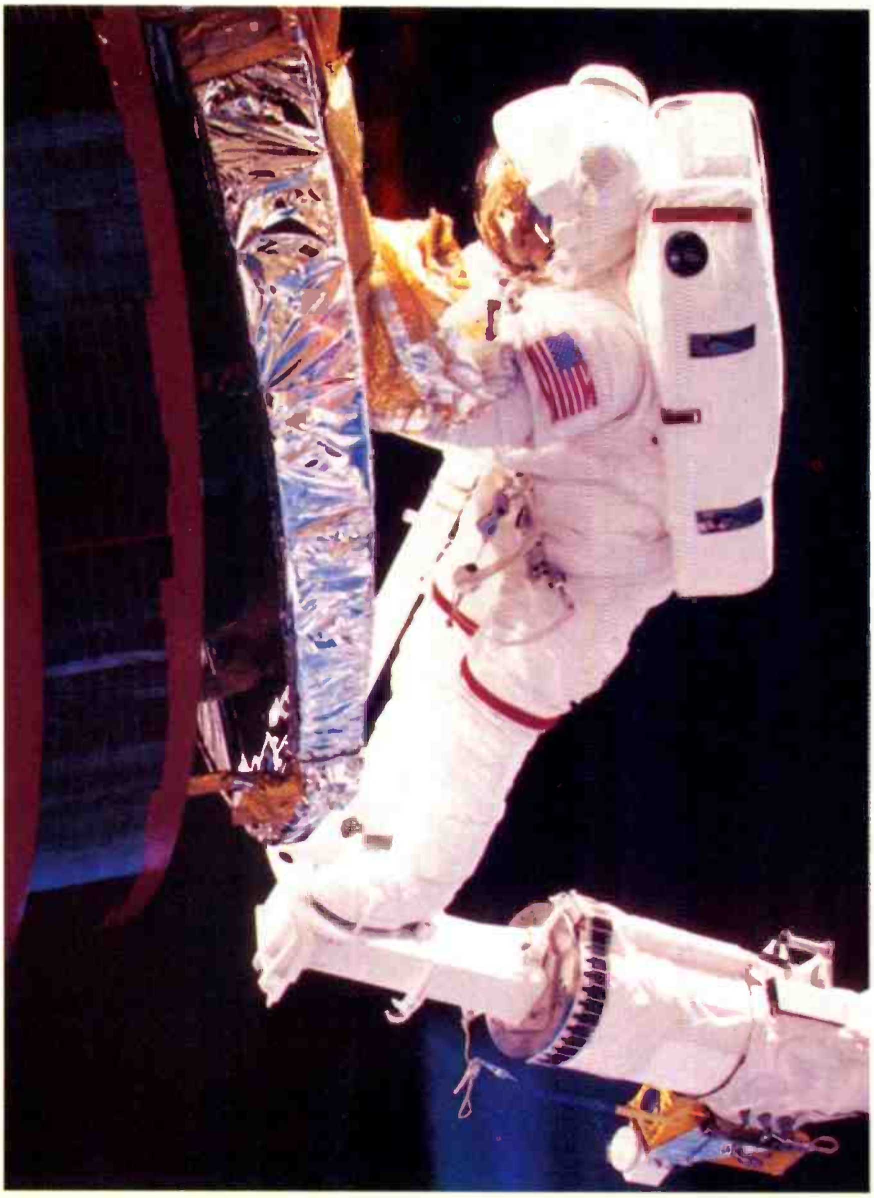


Satellite update

By John Kinik, satellite correspondent

Before the Space Shuttle crew could rescue two crippled satellites, ground crews on five continents worked for months to make the 2-day mission as easy as possible.



Astronaut Joseph Allen secures the Westar VI satellite as he stands on a mobile foot restraint attached to the Shuttle's remote manipulator arm assembly.

The November retrieval of the Westar 6 and Palapa B2 satellites from earth orbit by the crew of Space Shuttle Mission 51-A was dramatically portrayed in television, newspapers and magazines, giving tremendous visibility to the role of the astronauts.

But there was far more to the story than the space spectacular that the media focused on. Behind the scenes, there was an engineering spectacular going on for months prior to the actual shuttle mission. Starting in March, a team of satellite control and orbital analysis specialists performed analyses and conducted maneuvers to position the satellites in proper orbits to make the retrieval possible.

The effort involved three different phases of orbit maneuvers and the combined forces of personnel and ground facilities on five continents.

When the two satellites experienced virtually identical failure of their booster rockets after launching from the shuttle in February 1984 (see "Satellite Update," June 1984), their orbits were determined by ground tracking and radar stations.

The satellite owners, Western Union and the government of Indonesia, declared the satellites lost and collected insurance payments. The satellite manufacturer, Hughes Aircraft, called on its Orbital Operations and Analysis Team, headed by Jeremiah Salvatore, to determine whether a salvage mission was feasible, in view of the complex orbit maneuvers that were necessary. Based on the team's confidence in being able to achieve the tricky maneuvers required to bring both satellites to the shuttle for pickup, the mission was approved.

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Salvatore's team, together with support from other organizations in the Hughes family, and outside organizations, including NORAD and Intelsat, labored for nine months to coax the satellites into the orbit needed to match the shuttle's planned orbit. The overall management of the retrieval mission was handled by David Braverman, associate manager of the Commercial Systems Division at Hughes Aircraft. The first phase, conducted in May after two months of analysis and preparation, involved three tasks: equalizing the orbital planes, raising the orbits above the Earth's atmosphere and expending the apogee kick motor (AKM) fuel.

The satellites were in similarly shaped orbits, but in planes that were different and were diverging. The AKM burn (normally used to insert the satellite into geosynchronous orbit at the apogee of an elongated elliptical transfer orbit) raised each satellite's orbit as follows:

- Westar 6 to a 600nmi circular orbit from an initial orbit of 160nmi by 640nmi.
- Palapa B2 to a 650nmi circular orbit from an initial orbit of 140nmi by 615nmi.

Both satellite orbits were now in the same plane and were left in those orbits for the next two months.

The second phase, in August, involved one week of maneuvers to bring the satellites close together in a 560nmi orbit in a plane that matched the plane of the shuttle's orbit. This was accomplished with controlled firings of hydrazine gas thrusters, which are normally used to control satellite attitude and position during its orbit. Each maneuver, conducted during a satellite pass over the ground control station, would consist of some combination of thruster burns to change satellite attitude (spin axis attitude with respect to its orbital plane) or spin rate, or both. During the mission, a total of 331 maneuvers were performed, 183 for Palapa B2 and 148 for Westar 6.

The third phase of maneuvers, in the last five weeks before the shuttle launch, brought the satellites down to a 195nmi orbit, which coincided with the shuttle's orbit. This final phase took 55 firings of the hydrazine thrusters on each satellite, and involved a special orbit lowering procedure in which successive decircularizaton, then circularization, of the orbit was performed, until the desired lower circular orbit was finally reached for each satellite. The spin rate for each satellite was also reduced from more than 50rpm to 2rpm, to allow retrieval.

Throughout the maneuvers, the amount of hydrazine gas fuel left in the satellites' tanks had to be reduced to a minumum, but not below a lower limit for the satellites to maintain spin stability. Hydrazine gas, stored in the tanks as a liquid, is a volatile substance and shrinks when it freezes solid.

This presented a problem during the retrieval because the satellite retrieved first could not be exposed to the cold of space for too long while the shuttle bay doors were open during the retrieval of the second satellite. If the hydrazine gas had frozen, fuel lines might have ruptured when melting (expanding as it melted) in the heat of reentry. The satellite would have had to be jettisoned.

NASA provided special thermal shields to protect the satellites and employed shuttle attitude control maneuvers to prevent the freezing of the hydrazine.

Considering the technical problems that were faced and surmounted, the satellite retrieval mission was a tremendous success in terms that go far beyond the visible success of physical retrieval by the astronauts.

The technical team that made it possible, working behind the scene, deserve credit for a truly amazing accomplishment.

WHILE EVERYONE ELSE HAS BEEN PROMOTING A FORMAT, SONY HAS BEEN PERFECTING A SYSTEM.

Over the last three years, Sony's rivals in the combination camera/recorder arena have spent considerable time inventing wonderful things to say about their new formats. But apparently, they've overlooked inventing many wonderful new products to go along with these formats.

Sony has taken a different course.

In 1982, Sony introduced Betacam™ and the BVW-10 playback unit. An evolutionary system that didn't force stations to abandon their existing ¾" and 1" equipment.

Then, in 1983, Sony expanded the system with the three-tube Betacam, the BVW-40 edit/recorder, and the world's first battery-operated ½" field playback unit.

And this year at NAB, Sony announced a major breakthrough in cart machine technology with Betacart.™ A system

that demonstrated the Betacam format's strength beyond the newsroom, beyond the studio, and beyond field production.

At the same time, Sony also unveiled the world's lightest camera/recorder, the BVW-2 Newsmaker.™ And a prototype coder/decoder system that will make it possible for Betacam to be transmitted by microwave.

Each of these products is the result of Sony's dedication to the needs of the ENG and EFP industry. Work which has earned the Betacam format widespread acceptance by television stations and production companies around the world.

Which only makes sense. After all, in this business you don't win sales on the merits of your arguments. You win them on the merits of your products.

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Broadcast

Maintenance: The manufacturers' responsibilities

Guest editorial
by Larry Krupa,
maintenance supervisor,
WPBT-TV, Miami

"This thing is great...when it works."

That phrase is being used more and more at broadcast stations across the country to describe the serviceability of some of the highly sophisticated digital equipment found at radio and television facilities.

These maintenance problems are being caused not only by inexperienced and untrained station maintenance personnel, but also by manufacturers. Whether through the childish guarding of trade secrets or the ignorance of their technical departments, the lack of factory support for new hardware is seriously affecting the operation of many facilities. With the rapid pace of technology today, manufacturers must turn this situation around.

I can document dozens of examples of equipment manufacturers that have shipped new and highly sophisticated pieces of equipment that contain schematics that bear little or no resemblance to their equipment. I've seen prototype drawings sent as operator's manuals. I've seen etched circuit cards that contain hundreds of chips and components with no labels or numbers. I've seen equipment with boards containing microprocessors and ROM chips that came with no documentation at all.

A schematic might be issued by a company for a circuit card with a suffix of "01" or "02," but you have an "05" or "06" in your system.

One section of a particular piece of new equipment that I recently installed arrived with only a hand-drawn logic flow diagram. Further, all of the component designators on the drawing were scratched out and relabeled. This created a great deal of confusion in the pinout area of the edge connector.

When I called the manufacturer to ask for a new version of the diagram, the reply was, "The fellow that designed that section quit about four years ago and no one has quite figured out the circuit."

I am not speaking of small, fledgling electronic companies. Rather, I am talking about major companies that have the necessary resources to provide proper documentation to the users of their equipment.

The lack of factory support causes needless frustration for experienced maintenance engineers, not to mention less experienced personnel who must also repair the equipment. Who on earth would ever choose a profession that required you to service an item for which the manufacturer refused to provide competent technical support or documentation?

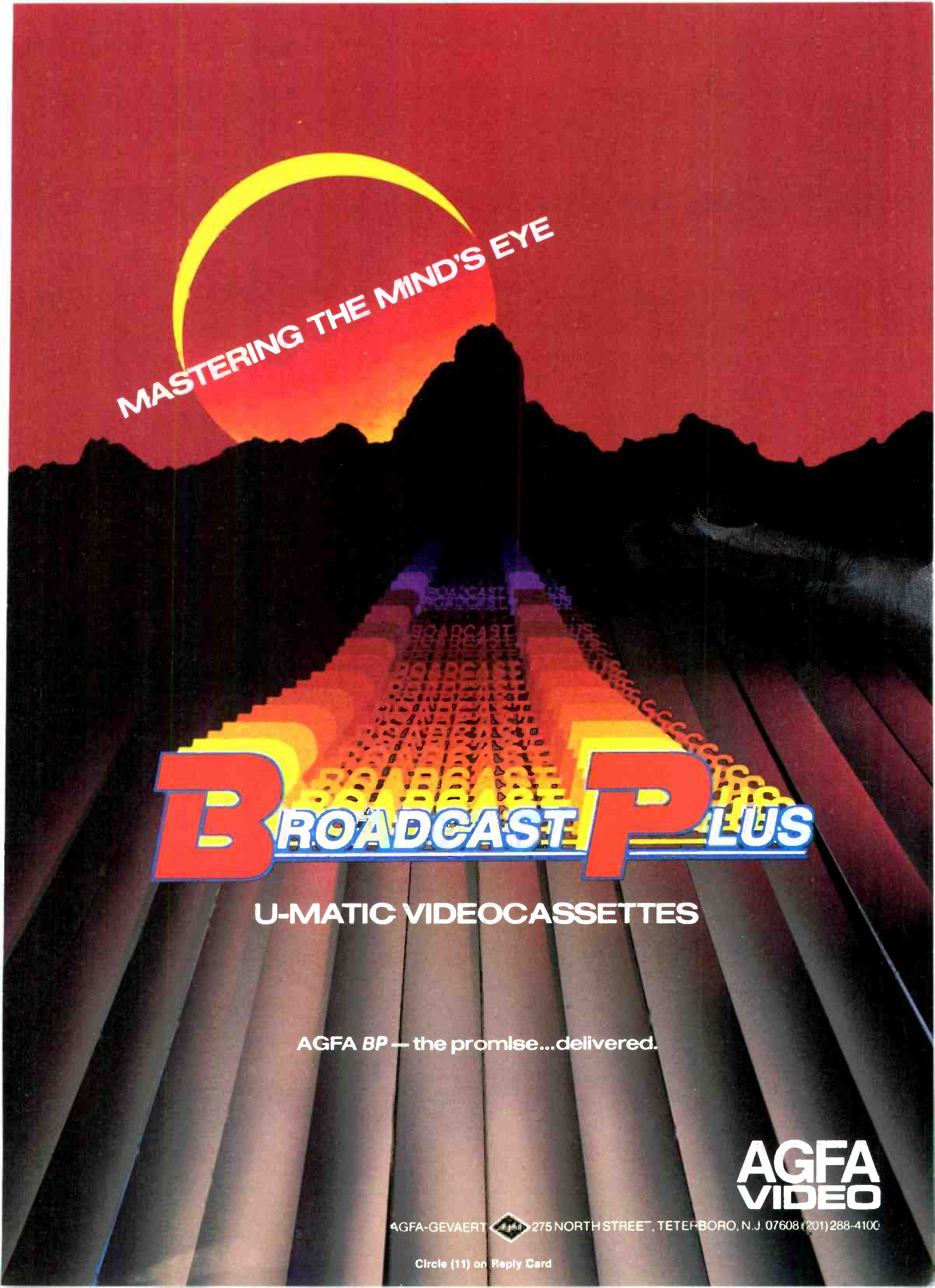
Broadcast manufacturers, you are creating some of the havoc that exists in the engineering community today. You could ease the burden on existing maintenance personnel by providing greater technical support. This would, at the same time, pave the way for technically inclined people to become our future maintenance engineers.

Supply equipment instruction manuals that discuss the theory of operation. Print accurate block, flow and schematic diagrams. Supply users with troubleshooting information, including waveforms, voltage levels, logic test points and ROM listings. Conduct on-site training seminars for station maintenance personnel.

When a piece of equipment fails in the field, it reflects on the company that built it. Good business sense demands that manufacturers provide station engineers with adequate information and technical support to keep their products operating properly.

Poor product support is one of the easiest ways a company can create a bad reputation within the broadcast industry. When engineers get together and talk, they generally talk about problems: problems they have had with equipment, or problems they have had with factory service departments.

A poor reputation within the broadcast community will inevitably result in lost repeat business for the company. Good engineering support after the sale is good business.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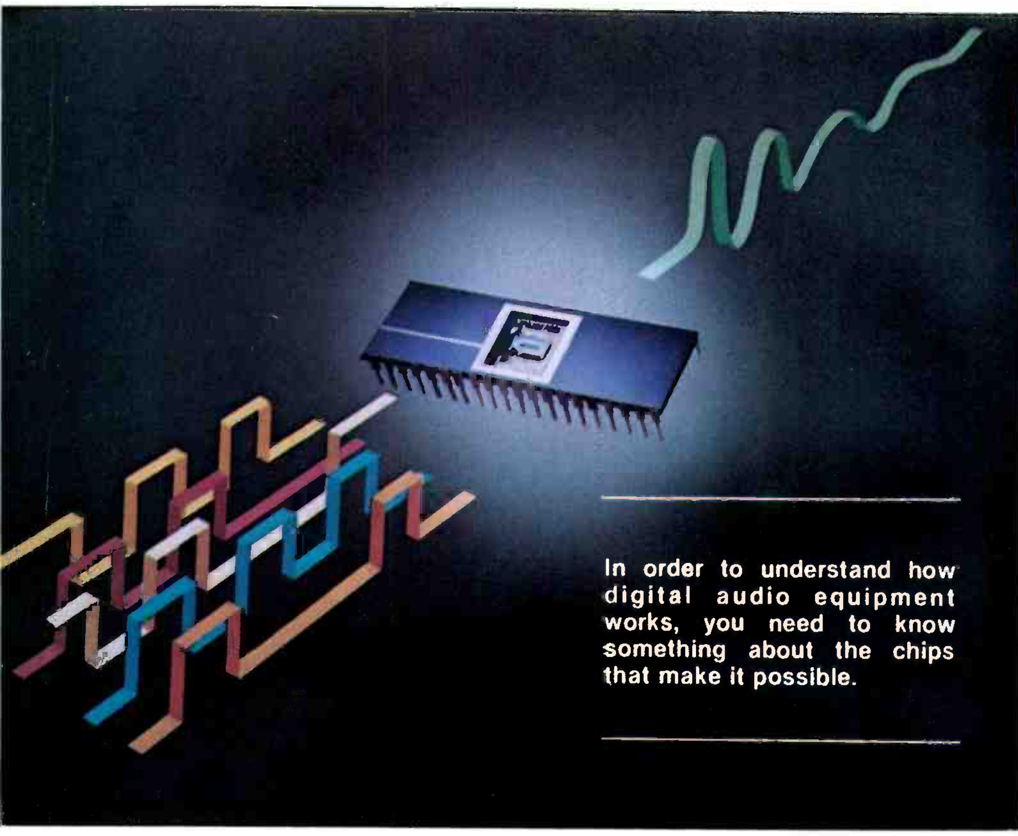
The roots of digital audio



In order to understand how digital audio equipment works, you need to know something about the chips that make it possible.

Courtesy of Harris Semiconductor

By Leonard Sherman, National Semiconductor, Santa Clara, CA, and Jerry Whitaker, editor

The rapid growth in digitally based audio equipment is closely linked to an even faster pace set by the computer industry for data acquisition system development. Sophisticated computers are commonplace in growing numbers of real world situations, and consequently, more uses are being found for analog-to-digital (A/D) and digital-to-analog (D/A) conversion hardware.

In certain types of broadcast equipment, digitally processing audio signals has become commonplace. Digital technology can be found in audio time delay units, special effects generators, satellite systems, tape recorders and audio consoles.

Digital audio is here. The need to understand how this new technology works cannot be overstated. There is often a tendency to treat a new discipline such as digital audio conversion as simply a *black box*, and to ignore what goes on inside the circuit.

However, to fully understand the capabilities and requirements of these chips, you should take a closer look.

The A/D converter is our bridge into the digital world. Most converters fall into one of three categories, which essentially define their basic mode of operation: *successive approximation*, *integrating* and *flash*.

Sherman is MOS analog applications engineer for National Semiconductor.

Successive approximation

Successive approximation is probably the most popular A/D conversion technique. Typical monolithic successive approximation register (SAR) converters have from 8- to 12-bit resolution, and conversion speeds from 10μs to 100μs. An SAR A/D converter operates by stepping through a sequence of *educated guesses* in which the unknown input is compared to a series of binarily weighted reference

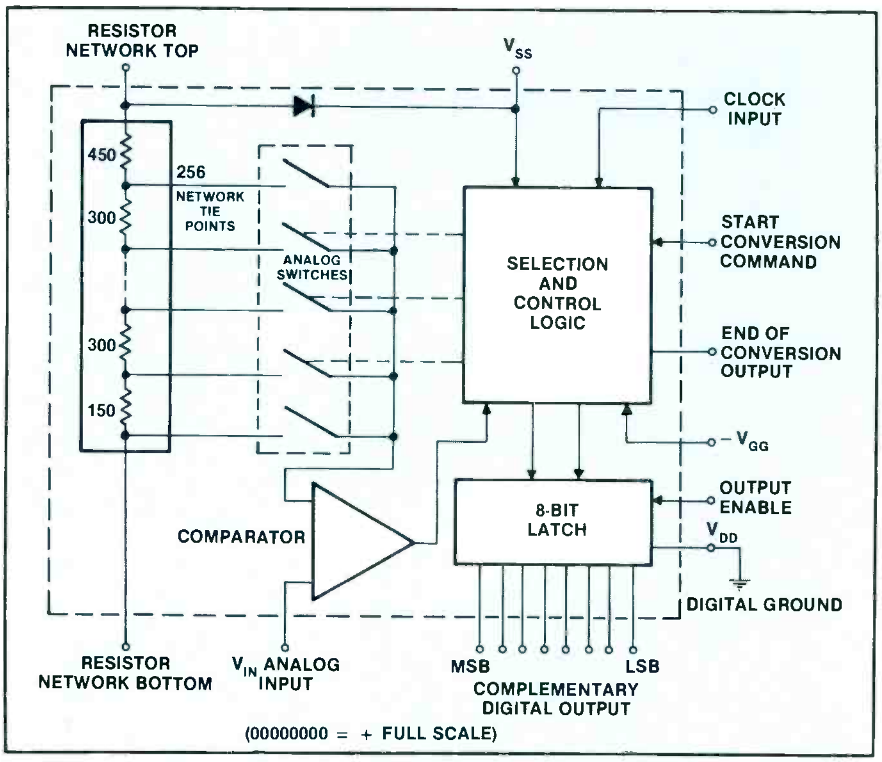


Figure 1. Block diagram of a successive approximation register (SAR) A/D converter.

levels. The result of each successive comparison helps to determine what the next guess will be.

Figure 1 shows the block diagram of one type of SAR A/D converter. The 8-bit device contains 256 series resistors and analog switches, control logic and output latches. Conversion is performed by comparing the unknown analog voltage with the resistor tie points using analog switches. When the appropriate tie point voltage matches the unknown voltage, conversion is complete and the digital equivalent of the analog voltage is presented at the output.

The number of bits of resolution provided by the converter is equivalent to the number of comparisons that are made. There are two primary advantages of this technique: Only one comparator is needed for conversion, and higher resolution does not greatly increase the conversion time.

For example, a 10-bit A/D converter will only be 10/8ths slower than an 8-bit device of the same basic type, because only two additional comparisons are made to obtain four times the resolution. The binary nature of the SAR search also makes the converter ideal for interfacing to computers and microprocessors.

Unfortunately, the SAR converter requires a large number of steps to complete an approximation routine and is susceptible to error if the analog input changes in the middle of the SAR search. For this reason, the noise rejection performance is usually not high. For certain inputs, a *sample-and-hold* stage or filter may be needed to stabilize the input signal while A/D conversion is under way.

Integrating converters

Integrating A/D converters, including single, dual and multislope designs, are most commonly found in digital meters and instrumentation. They are relatively slow, but this is usually not a problem because the results are used primarily for visual readout.

The strong point of an integrating A/D converter is high resolution, offering as many as 20 bits of digital data (six decimal digits). Even low-

Continued on page 26

Creating special effects

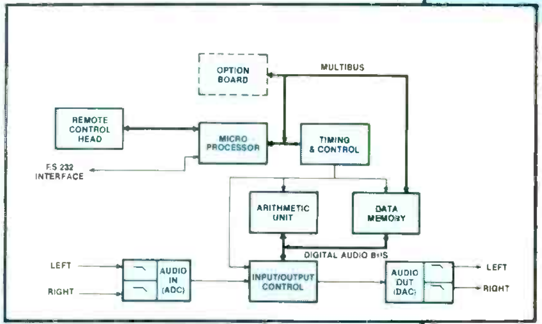
Advancements in digital technology have made possible the creation of a number of new and unique special audio effects ranging from complex reverberation to comb filters.

Once an audio signal has been digitized, special effects can be generated by the application of numerical calculations to the data. For example, gain control of an input signal is accomplished by multiplying the digital word by a control constant. Audio mixing is achieved by adding together numerical samples from two or more digital signals.

Limiting is performed by multiplication of the signal by a control number derived from the signal itself. Filtering and equalization are employed in arithmetic sequences involving time delay multiplication and addition of the resulting signals to previous samples. This arithmetic processing provides the digital equivalent of reactive circuits commonly used in analog filters.

High speed digital filters, constructed of bit-slice processors and multipliers, can be used to create replicas of familiar audio processing circuits, such as shelving equalizers and second order peaking filters. Because the signal processing is under software control, the digital effects generator is not limited to specific characteristics.

Instead, entirely new effects can be created by the user. Digital technology also allows specific effects to be stored in memory for later recall, further increasing the equipment's versatility.



Courtesy of Lexicon

Simplified block diagram of a new generation programmable digital reverberation system.

Reverbbbbbbbbb

Natural reverberation results from the combination of a sound signal with a large number of time-delayed versions of the original sound. The characteristic sound produced by the original audio signal and its reflections is determined by the intensity of each reflection, its time delay and frequency response characteristic.

Digital reverb is typically generated by feeding a digitized audio signal into a number of delay lines and then feeding back a controlled amount of the various signals to the different lines. This practice gives the user a wide variety of reverb options, all under software control, at reasonable circuit complexity.

The primary factors used to create specific reverb effects are the time delay of each segment, the amount of feedback used, the digital filtering applied to the feedback loops and the mixing levels of the delay channels. The creation of reverb special effects, therefore, incorporates the techniques of gain control, mixing, limiting and filtering. The software program for these parameters makes up the mathematical algorithm that simulates the characteristic sounds of the desired reverberation.

The figure above shows a block diagram of a digital reverberation system. Right- and left-channel input audio is passed through a low-pass filter and digitized in an A/D converter. A microprocessor and arithmetic unit processor operate on the digital data to produce the desired result.

The system can store data in memory, withdraw it at specific times, perform mathematical calculations on the digitally coded audio, and then mix the various signals—at various delay points—together. The resulting sum can either be presented to the output through a D/A converter and low-pass filter, or placed in the system's memory for further processing.

The complex reverb programs required for such a system are written in advance and stored in non-volatile memory. Users can recall a number of preset reverb situations (such as a particular concert hall or acoustic chamber) or create their own reverb effects. An operator can, in essence, electronically design the size and character of a room by adjusting the amplitude of each reflection, its time delay and frequency response.

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- One Sony BVU-820 ¾" VTR with Slo-Mo.
- One Sony BVU-800 ¾" VTR.
- Oned one Beta VTR.
- Harris HDE-200 Digital Effects System.
- Adda ESP II Still Store System.
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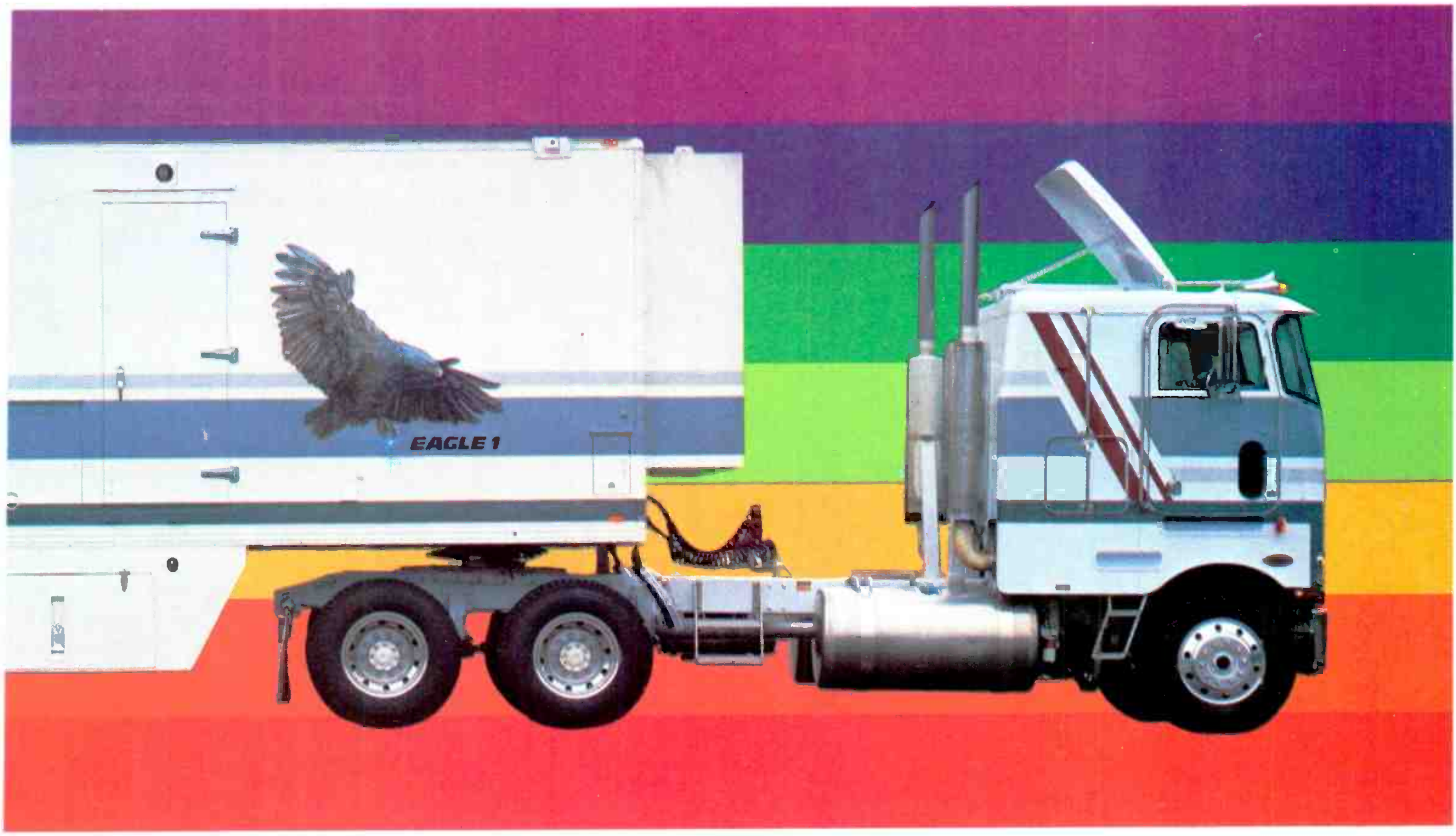

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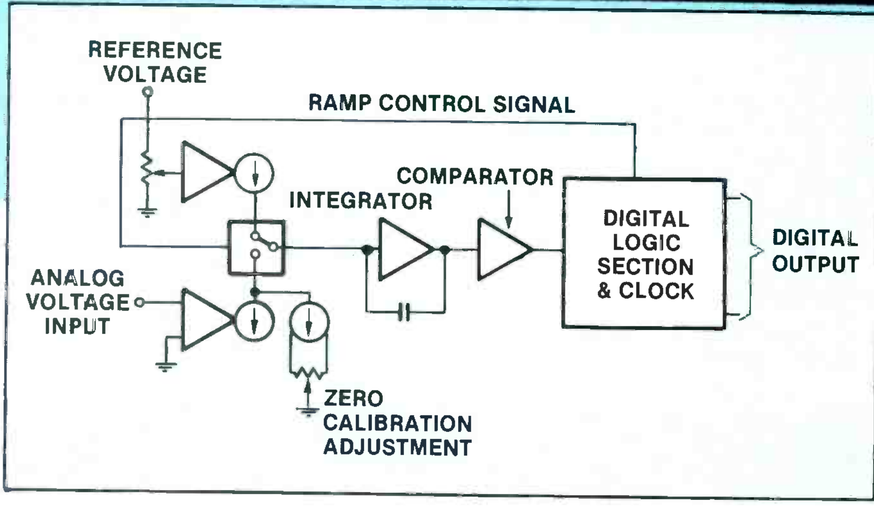


Figure 2. Simplified block diagram of a dual ramp integrating A/D converter.

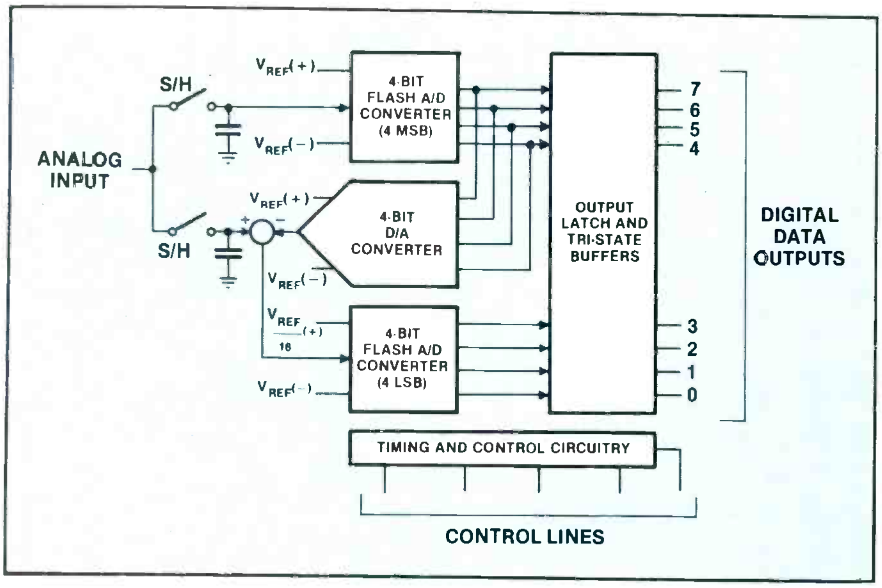


Figure 3. Block diagram of a half-flash A/D converter circuit. This 8-bit converter uses 32 comparators, a most significant 4-bit flash A/D and a least significant 4-bit flash A/D. The input signal is sampled and then held by a pair of S/H buffer stages. This converter circuit can be cascaded for greater resolution.

cost monolithic converters of this type commonly handle ±2000 counts, which is equivalent to 12 bits.

The most popular type of integrating converter is the dual slope design, in which the unknown signal is used to ramp the input of an integrator up from 0V for a time set by a fixed number of clock cycles. A reference voltage of opposite polarity is then used to discharge the integrator and return it to zero. The discharge time, which is proportional to the input voltage, is measured by counting the number of clock pulses (Figure 2).

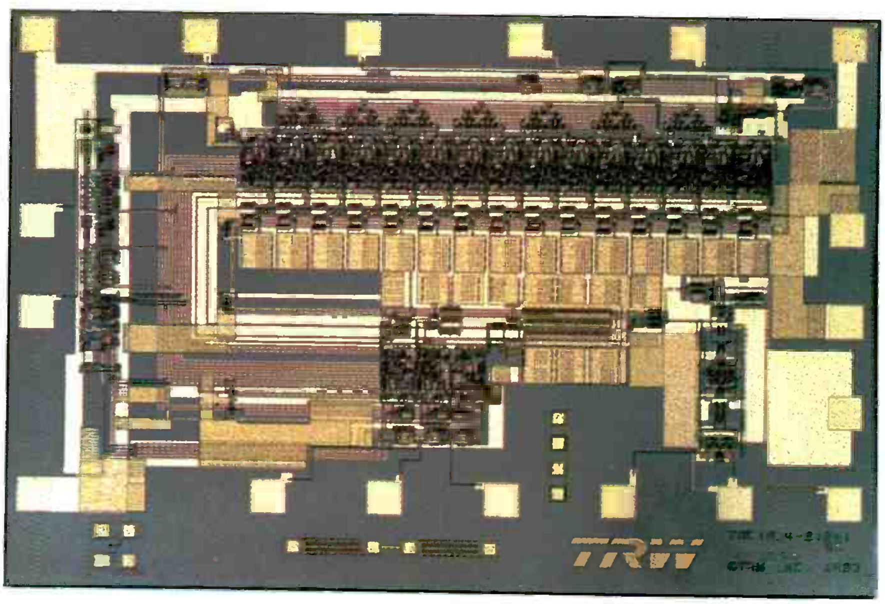
The dual-slope integrating A/D converter, by nature, has high noise rejection, because the output represents the average value of the input signal over the integration time. This circuit ignores changes in its integrator and clock because both are used to measure the reference, as well as the input, during each conversion cycle. This causes some of the drift and error terms to cancel.

A major disadvantage of the integrating A/D converter is the difficulty often experienced in interfacing the device with a microprocessor because of the converter's slow speed and sometimes unusual output format. Obtaining higher resolution also requires longer integration times and, therefore, significantly longer conversion periods. Each additional bit of resolution will typically double the A/D conversion time.

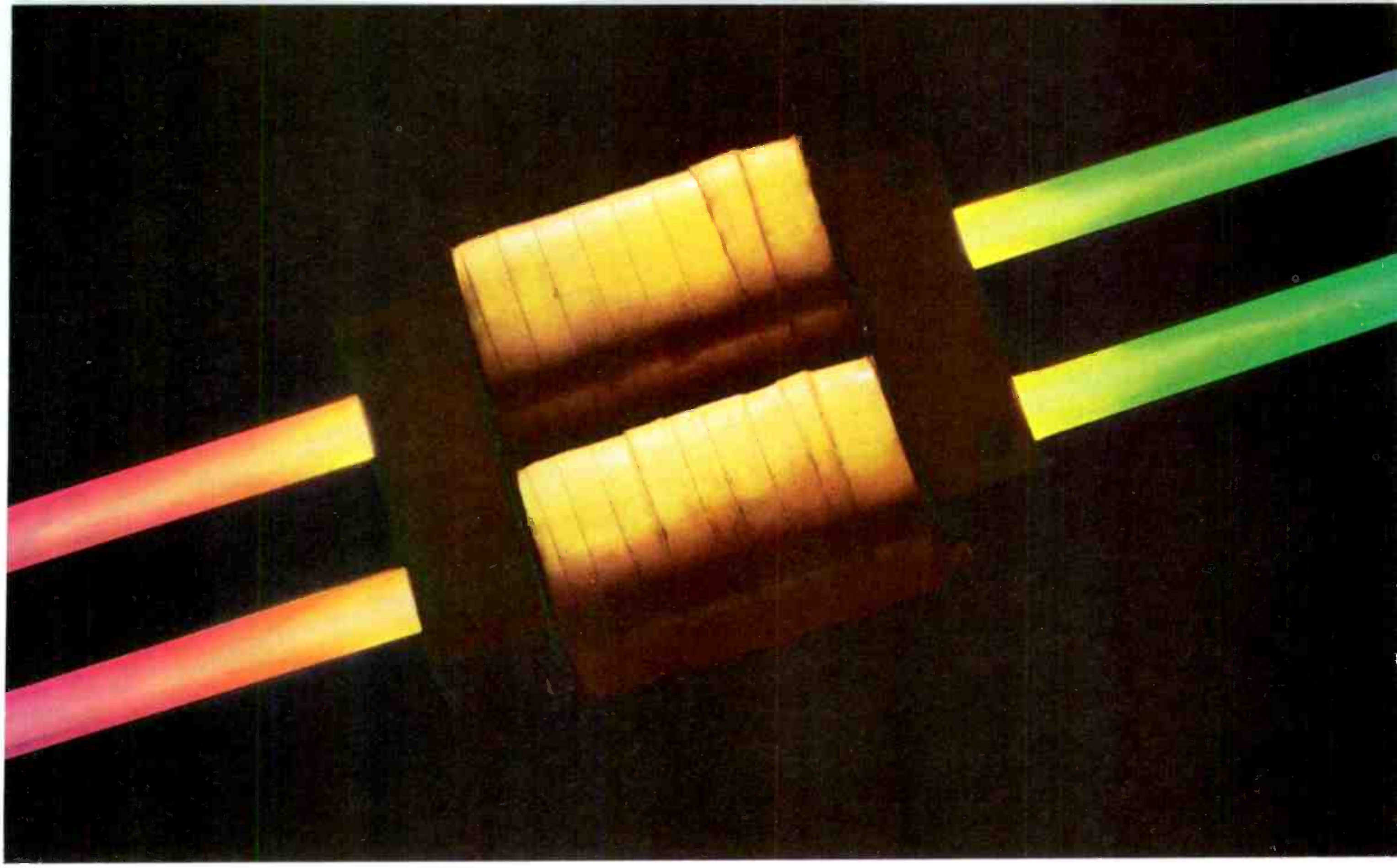
Flash converters

Flash A/D converters are the fastest devices presently available in either a discrete or monolithic form. The operating principle of the flash converter is in some ways opposite that of the SAR. Rather than using one comparator repeatedly to make a number of comparisons, a flash converter uses a large number of comparators to make all of the checks at once.

A consequence of this technique (besides high speed) is a relatively high cost per bit. The number of required comparators increases geometrically with greater resolution.



Die photo of the TRW TDC1034 4-bit D/A converter chip, which can operate at a maximum conversion speed of 125 million samples per second.



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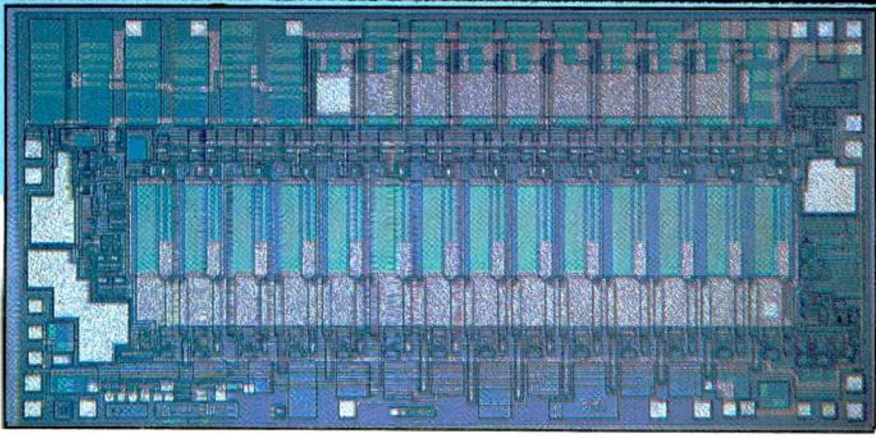
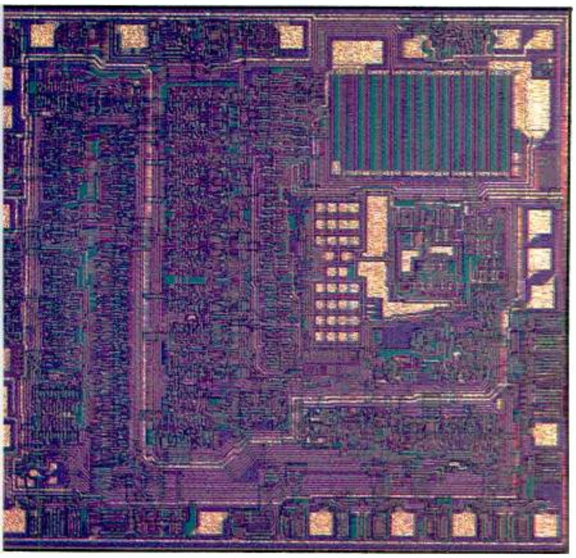


A close-up of the architecture of the Harris Semiconductor HI-5618 8-bit D/A converter chip.



Die photo of the National Semiconductor ADC0811, an 8-bit serial I/O A/D converter, which features built-in sample-and-hold circuitry.

For example, a 10-bit flash converter requires 1023 comparators. For this reason, flash converters are not commonly employed for applications that demand more than 8-bit resolution. They are, however, widely used in high-speed 6- and 8-bit applications, such as video signal processing.

Some new A/D converter devices have been introduced, which combine flash and SAR techniques to provide high speeds without using huge numbers of comparators. One example of this approach is the *half-flash* A/D converter, which performs an 8-bit conversion by combining the results of two 4-bit flashes. Figure 3 shows the basic concept of the half-flash converter.

Resolution/accuracy

Resolution is the number of discrete segments into which a data converter divides an analog signal. It is quite different from *accuracy*, which is a converter's estimated error in deciding the absolute magnitude of an input voltage. By common definitions, data converter accuracy and resolution have no relationship to each other, although the magnitudes of the specifications may be comparable on a given device.

Assuming that a converter's accuracy will match its resolution can be a mistake. This is especially true for higher resolution (10- and 12-bit) devices where 0.1% or greater accuracies are difficult to achieve.

For example, a typical 10-bit A/D converter will be able to resolve 10V input range to within 10mV. The output, however, will generally not be accurate to specifications without trimming the device's external circuitry.

D/A converters

From an applications standpoint, discussions of process differences between semiconductor components are often academic. But in the case of CMOS and bipolar D/A converters, there are significant operational differences related to fabrication which warrant attention.

Bipolar D/A converters are fabricated with the same process used to produce standard linear devices such as op amps and voltage regulators. The key to their performance is the IC manufacturers' ability to build precision matched current sources that can be switched at high speeds (Figure 4).

The magnitudes of these current sources are binarily weighted and each is controlled by a digital input bit. The output current of the D/A converter is the sum of the current sources that have been switched on. The full-scale output of the device is set by an internal or external reference voltage.

CMOS D/A converters are also essentially current output devices, but differ from bipolar converters in that they are passive in the analog signal path (Figure 5). The current output is controlled by using matched resistors and analog switches, rather than active current sources.

CMOS converter technology (basically the same process used for low power CMOS logic devices) permits the fabrication of resistors and switches with high precision. Because

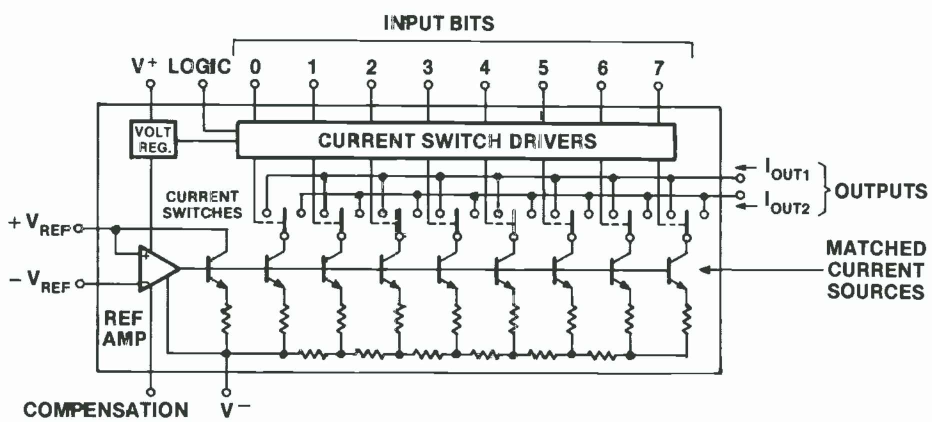


Figure 4. Functional block diagram of a basic 8-bit bipolar D/A converter. Two outputs are provided (I_{out1} and I_{out2}) to handle various external circuit requirements.

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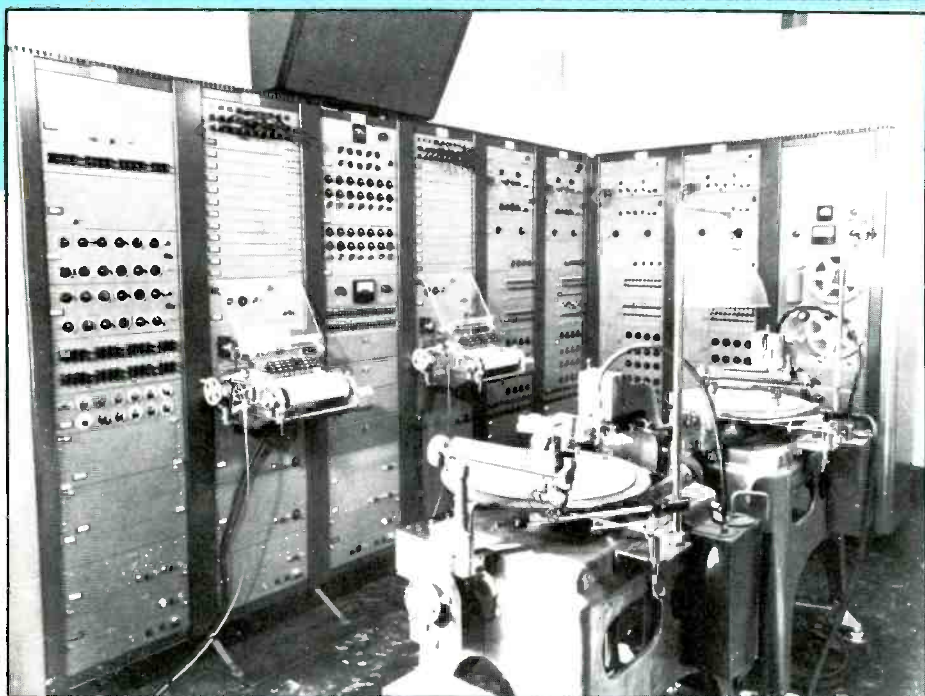


Courtesy of the Electronic Arts Foundation

The RCA synthesizer, Mark I, special audio effects system, developed in 1955. Two Scully record cutting lathes are shown in front of the synthesizer.

The history of special effects

The creation of special audio effects by electronic means is an art form with a rich history. Most people probably think of special effects as fairly recent developments, but they have been around for decades.

The first known means for modifying electrically generated sound dates back to the late 19th century, when Thaddeus Cahill created a machine he called the *Telharmonium*. The instrument used the principle of additive tone synthesis for sound manipulation and modification. The individual tone colors were built up from fundamental and overtone signals, generated by huge dynamos. Pure sine waves were produced by tuning the individual generator coils with capacitors.

With the advent of the vacuum tube, scores of electronic and electro-mechanical musical instruments were invented with sound modification features. The Hammond organ, first developed in the 1930s, is of special interest, because it evolved from Cahill's work years earlier.

Development continued through the decade of the 1940s, producing new effects. The variable audio delay line, capacitive scanner and new frequency modulating techniques gave musicians new tools with which to work. One product from this age was the *Melochord*, developed by Harald Bode. The Melochord featured user control of attack and decay envelopes and vibrato.

The 1950s brought increased reliance on electronic components to generate special audio effects. The complex *RCA synthesizer* moved sound modification into a new frontier. Developed by Harry Olson, the RCA synthesizer made its debut in 1955.

The unit was controlled by preprogrammed punched tape. It offered features such as digitally controlled filters, variable attack and delay envelopes, digitally controlled pitch and waveshape, random noise generation and frequency and amplitude modulation effects.

At about the same time, Les Paul became famous with his multitrack guitar recordings, using tape speed transposition and the repetition effect. Besides being an outstanding performer, Paul was also an outstanding innovator. He introduced the multitrack recorder (eight tracks on 1-inch tape) in cooperation with Ampex. He also created *Sel Synch*.

The ring modulator was a little-known sound modification device until the mid-to-late 1950s. Before that time, the ring modulator was applied only as a switching circuit used mainly in single sideband communication systems. It was only after ring modulators were built with diodes which operated in the square law region of their transfer function (provided by certain germanium diodes), that the circuits started to perform as 4-quadrant multipliers and became musically interesting.

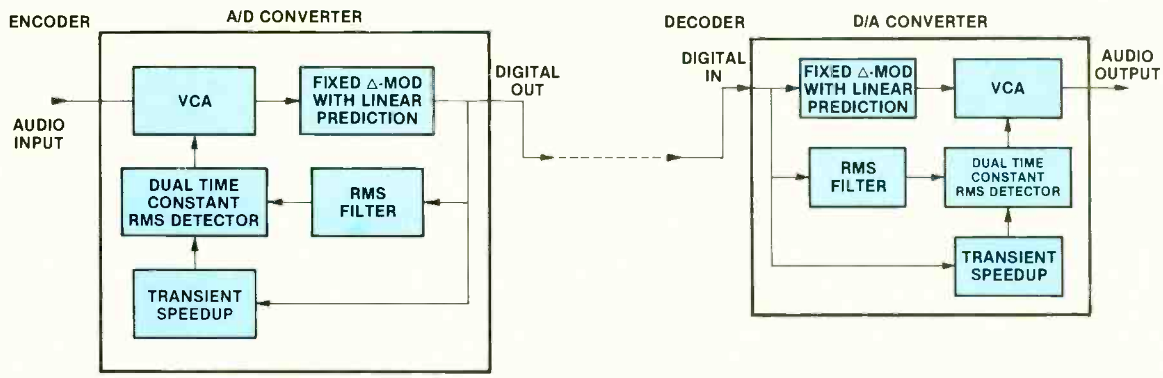
An important ingredient in sound modification is the addition of reverberation to program material. In the 1930s, echo chambers were used to create reverb effects. Then, in 1941, came the invention of the Hammond spring reverberation device, which was incorporated into the Hammond organ. The device also worked well in studios.

In fact, its offspring are still popular today. A different approach to the generation of reverb was taken by D. W. Martin of the Baldwin Piano Company, who used coil springs mechanically coupled to the loudspeaker cone to produce reverb effects.

A popular sound effects device that came upon the scene in the mid-1960s was the so-called *fuzz box*. The story goes that the fuzz effect was discovered by Jeff Beck while making a guitar recording and overdriving a deficient preamplifier on his tape recorder. The first successful fuzz boxes included the *VOX distortion booster* and the *Arbiter fuzz*, both introduced about 1964.

The history of electronic sound modification is as old as the history of electronic musical instruments and electronic sound transmission, recording and reproduction. The special audio effects that we take for granted today are—in large part—based upon the work of pioneers decades ago.

Editor's note:
This article was adapted from an article, "The History of Electronic Sound Modification," by Harald Bode of Bode Sound, North Tonawana, NY, which appeared in the October 1984 issue of the *Journal of the Audio Engineering Society* (pages 730-736).



Courtesy of dbx

A companded predictive delta modulation A/D converter (a) and a companion D/A converter(b).

Delta modulation: Another approach

The A/D conversion techniques discussed in the main article—*SAR*, *integrating* and *flash*—make up a family of converters using the pulse code modulation (PCM) method of digital encoding. There are, however, other methods of A/D conversion, including various types of delta modulation (DM).

The basic form of DM has been known for years to be a simple, low-cost means of A/D conversion. In this process, the data produced by the converter represents differences between successive sampled voltages, rather than the instantaneous voltage of the input signal at each point in time (the conversion method of a convention PCM A/D system).

Delta modulation in its basic form, however, generally produces less than acceptable performance for broadcast applications, with a dynamic range of about 55dB. Although certain versions of DM can offer a 90dB dynamic range, they may suffer from noise modulation problems and noise floors that exhibit a distinct tonal character.

In order to overcome the limitations of conventional DM conversion for broadcast audio applications, variations on the basic concept have been developed. One is the companded predictive delta modulation (CPDM) method of digital encoding, developed by dbx.

The CPDM conversion process differs from basic delta modulation in two respects. First, the CPDM converter uses a compandor circuit in which the signal itself is varied with a voltage-controlled amplifier to avoid overloading the fixed delta modulator. Second, the DM stage uses a linear prediction filter, which relies on the *history* of the audio signal to predict its *future*. The figure above shows a block diagram of a CPDM system.

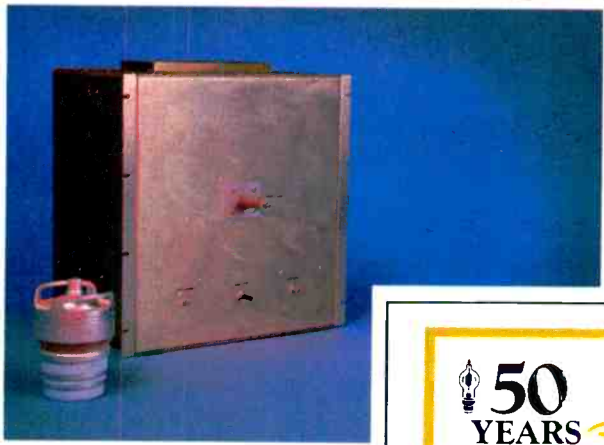
Linear prediction

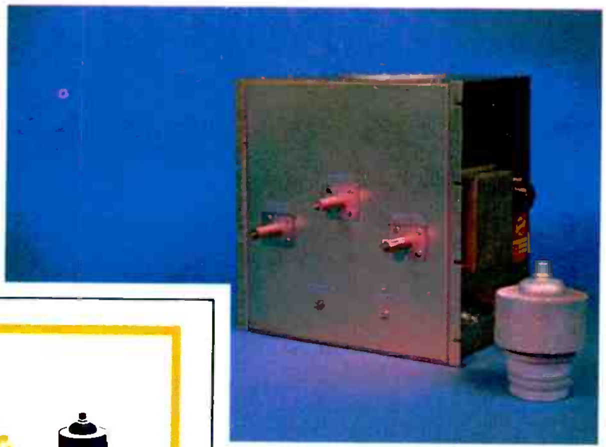
One of the problems affecting DM, adaptive DM (an improved version of delta modulation) and companded DM systems is that the noise floor can change with signal level. This occurs because the step size changes to follow the input, and it is the step size that determines the level of quantization noise.

As an example, assume a situation where the delta modulator has a fixed step size of 10mV. If the system's last approximation of the input signal was too high, the next will be 10mV lower. Of the last 10 approximations of the input signal voltages, seven were too low and three were too high. You might reasonably infer that the signal level was increasing, and shift the step sizes from ± 10mV to + 15mV/ − 5mv.

This is in line with our expectation (based on the recent history of the signal's behavior) that the signal is more likely to change in a positive direction than in a negative direction. Note that doing this does not change or lower quantization noise: The difference is still 20mV between + 10 and − 10, or + 15 and − 5. But it does increase the maximum slope (steepness, or slew rate) that the modulator can follow without slew rate limiting. Hence, dynamic range is increased as well.

In practice, this alteration in the balance of plus and minus step sizes is achieved by a linear prediction filter. This filter is substituted for the simpler filter (integrator) normally found in a delta modulator, and is designed for maximum dynamic range.





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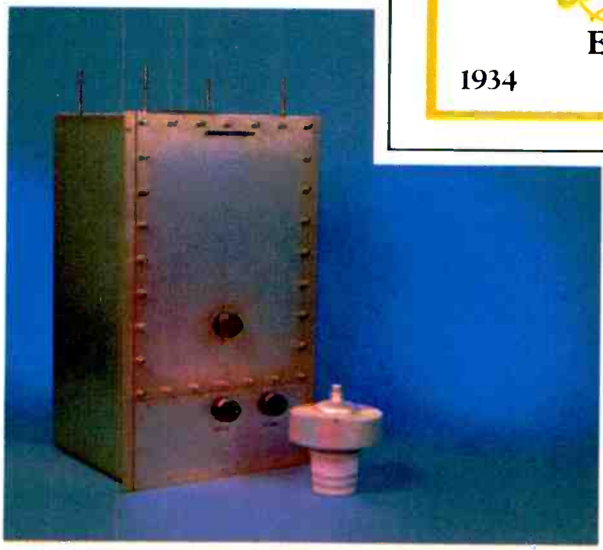

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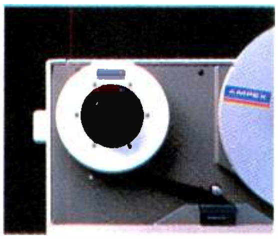

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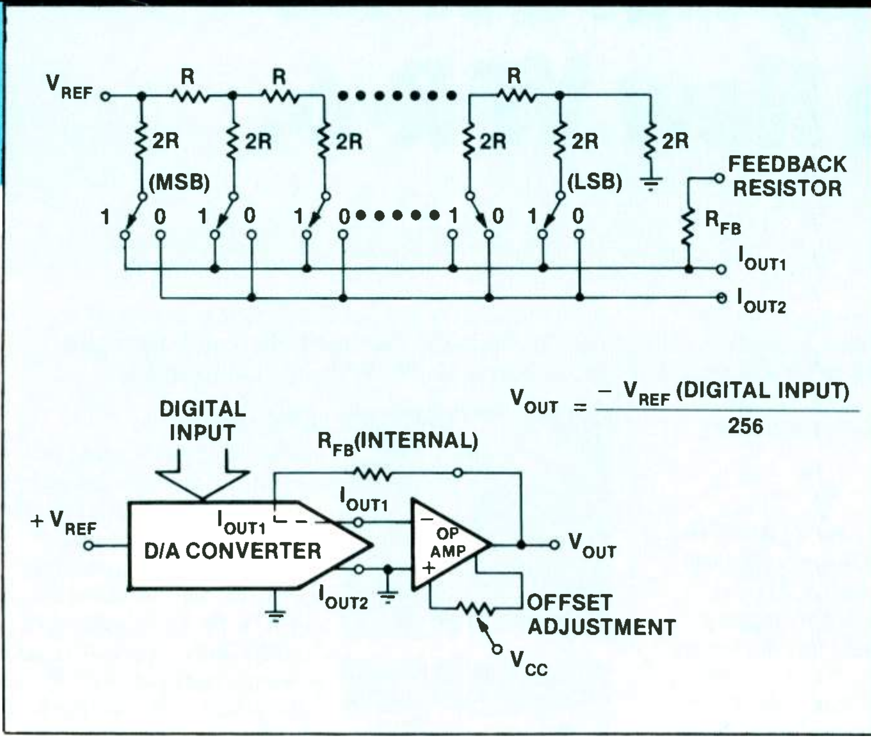

Figure 5. Simplified block diagram of a typical CMOS D/A converter showing the internal resistor switching configuration (a) and connection of the device to an external operational amplifier (b).

a wide variety of signals can be applied to the D/A converter reference input, and therefore controlled by the digital input code, these devices are often referred to as multiplying D/A converters.

The advantages of a CMOS D/A over a bipolar converter are lower power consumption, single supply operation and the capability of handling a wide range of analog signals (at the reference input). CMOS devices also have excellent gain stability, which depends mainly on the tracking of the chip's resistors.

On the negative side, because CMOS converters are passive, they have no *output compliance* as current sources. This means they cannot drive their output current linearly into any load but 0V.

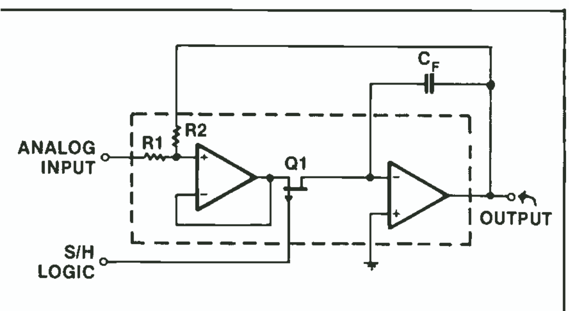

Figure 6. Block diagram of a sample/hold buffer amplifier. When the S/H *logic line* is low, Q1 conducts and the output of the device follows the analog input. When the S/H line is taken high, Q1 switches off and the output is held constant at the last input value by C_f.

Although somewhat less versatile than CMOS, bipolar devices in general are faster and have improved settling characteristics. They can sometimes be used in multiplying applications, but only in a limited fashion.

D/A output amplifier

Output amplifiers are nearly always used with CMOS D/A converters, and are often used with bipolar devices as well. The performance limits of the output op amp will have a significant impact on the output signal of the converter. The op amp must be able to change and settle accurately to a new value within a specified time. Amplifiers with a high slew rate may start quickly, but are often of little value if they are not well behaved while settling to their new level.

The dc specifications of an output op amp are important, but not for the reasons usually applied in analog circuitry. Most D/A converter amplifiers are operated with a closed-loop gain of one or lower, so that device offsets appear at the circuit's output unamplified. Therefore, the output shift because of op amp input offset is usually not a great concern.

However, with a CMOS D/A converter, this offset has a major effect in a completely different way by causing the converter's current output to be terminated at a non-zero level.

Because the passive CMOS output has no compliance as a current source, the interaction between this voltage and the converter's linearity becomes a complex issue. The situation is further muddied because the output impedance of the D/A converter changes with the input code.

Sample/hold circuits

The conversion of an analog audio or video signal to digital information often requires the use of a sample/hold (S/H) circuit to freeze the analog information so that it can be accurately measured. Trying to measure a signal while it is changing is like trying to photograph an object while it is in motion. A typical S/H circuit is illustrated in Figure 6.

The amount of accuracy lost during the A/D conversion process when a varying signal is present depends upon the type of converter (and conversion speed) used in the application. Systems employing a SAR converter typically use a S/H circuit at the input. Flash converters on the other hand, rarely need input holding circuitry to maintain accuracy.

In a SAR device, the basic operating principle assumes that the input will not change by more than one-half the magnitude of the least significant bit (LSB) during an entire conversion cycle. Because each approximation in the SAR search tells the converter what its next step will be, any change in input level during the comparison sequence can disrupt the conversion process.

Input isolation of an analog source can be accomplished in a number of ways. The most direct is an isolation amplifier, usually a module or hybrid circuit (they do not as yet exist in monolithic form) incorporating a transformer or other technique to provide an electrical barrier to interfering signals.

The future

The future holds many exciting possibilities for A/D and D/A converter technology. New device designs and chip fabrication methods promise to give users increased conversion speed, higher resolution and improved accuracy. These products will form the basis of sophisticated new equipment for broadcasters.

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DASH: Where it is, Where it's going

A key aspect of any new development in recording technology is compatability with recording systems built by other manufacturers. Regardless of whether any material is ever shipped out of house, the ability to interface with machines in another facility is important to the user.

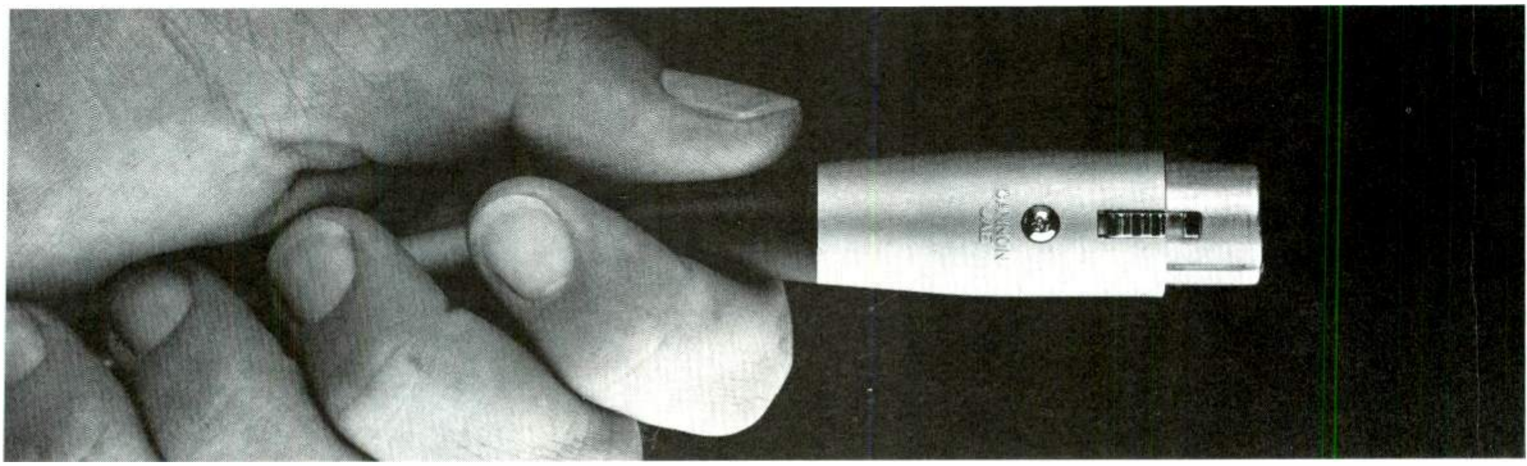
DASH, which stands for digital audio stationary head, represents a significant first attempt at an industry-wide standard for digital audio recording. The DASH format, now a little more than a year old, was developed by three major recording equipment manufacturers: Studer, Sony and Matsushita. The format represents a compromise between the three companies' contributions to digital technology.

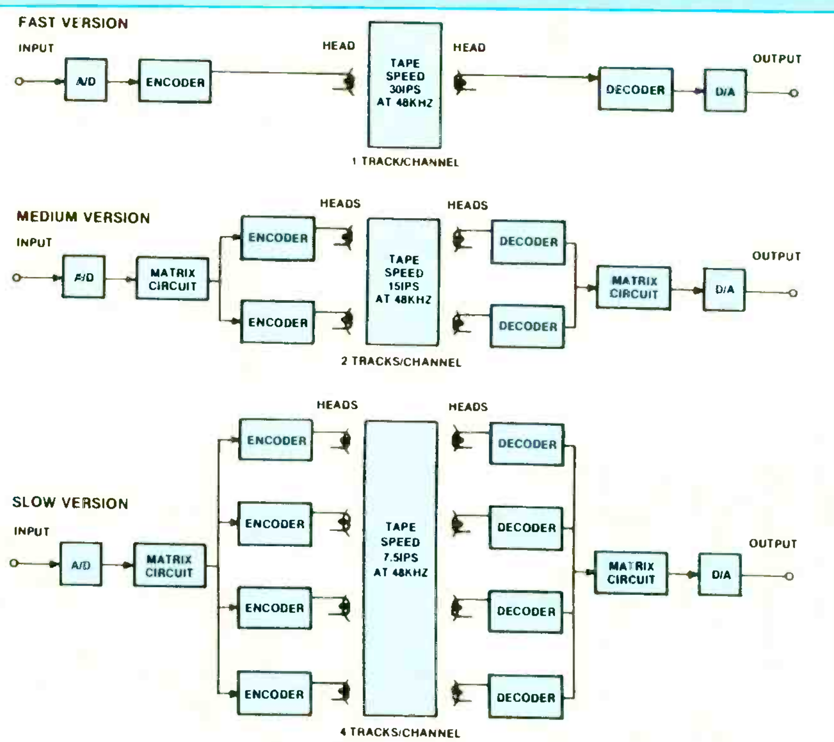
The format agreement takes into account recent developments in technology, including the possible use of thin-film heads, a format for low-speed recording with increased signal processing and the recommendation of the AES Standards Committee on Digital Audio for standardization of a 48kHz sampling frequency.

The DASH specifications and features are designed to accommodate a wide variety of future technological improvements and still retain machine compatability. A recent enhancement to the format is a revised symmetrical track geometry that is designed to make the DASH system more universally acceptable. An announcement by the DASH committee—made up of representatives of the member companies—said that this feature is being incorporated into new digital tape machines.

Format details

DASH covers a wide range of applications from 2-channel recorders (using ¼-inch tape running at 7.5ips) to 48-channel recorders (using ½-inch tape running at 30ips). The format has three versions, depending on the desired tape speed: slow, medium and fast. The minimum number of





Block diagrams of the three tape speed versions of the DASH digital audio format. The encoders and decoders in all versions of the system are identical.

tracks required to record one digital channel is one for the fast version: two for the medium speed version; and four for the slow speed version. The figure above shows a block diagram of the three DASH recorder systems.

Error correction is an important aspect of any digital recorder, and this has also been addressed in the DASH format. The encoders shown in the figure use a *cross interleave code* (CIC) correction scheme with a large amount of interleave between the even and odd input samples. Error correction is independent on each track in each version of the DASH system. If one track is seriously damaged, the error correction performance of the other tracks is not affected.

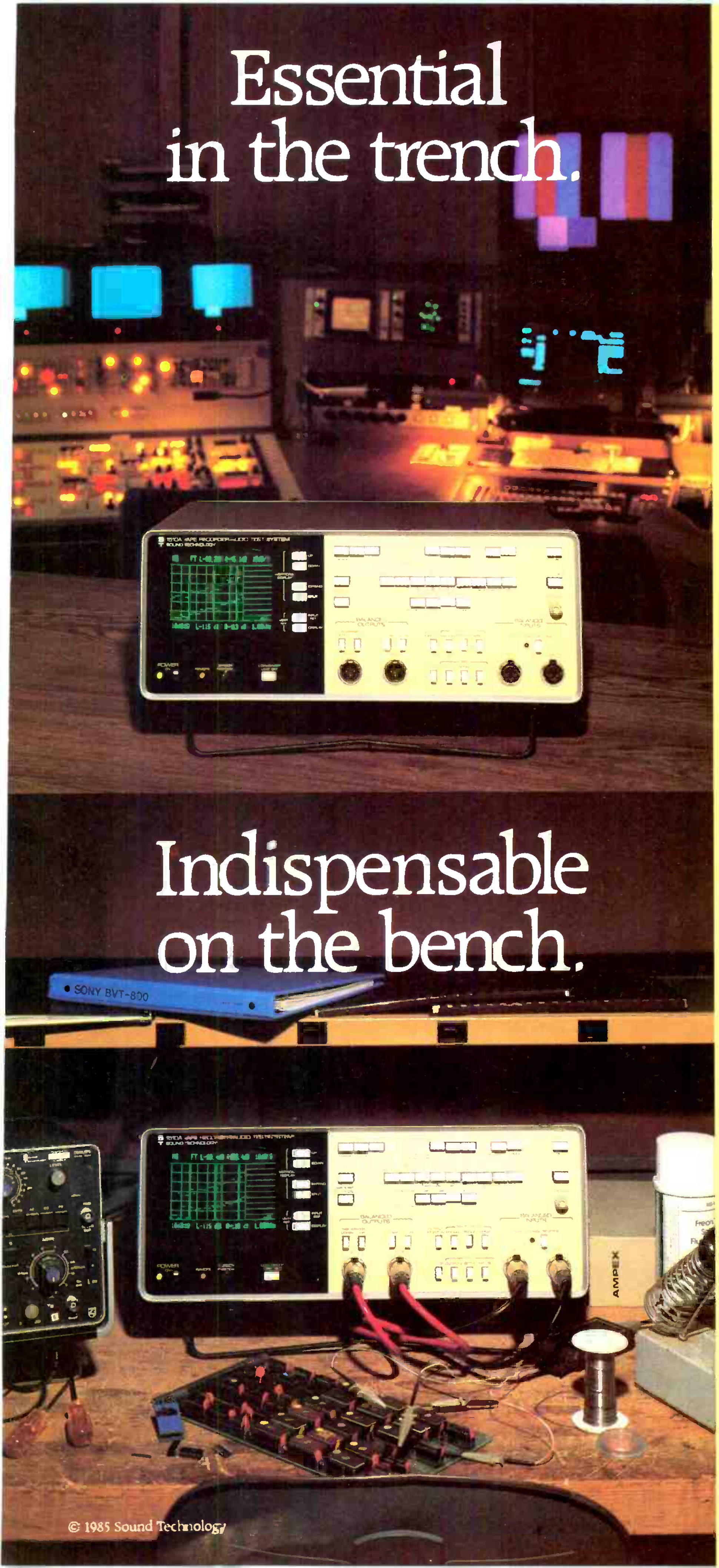
Editing can be accomplished in one of the three ways: punching in/out, tape slicing and electronic editing.

For the future

The adaption of thin-film heads will increase the number of recorders with double track density in the future, providing increased versatility and tape economy to the end-user. Manufacturers, taking advantage of new developments in large and very large scale integration ICs, will realize further improvements in system size, weight, power consumption and cost.

The Sony PCM-3324 digital audio recorder.

The Studer D820 digital audio recorder.



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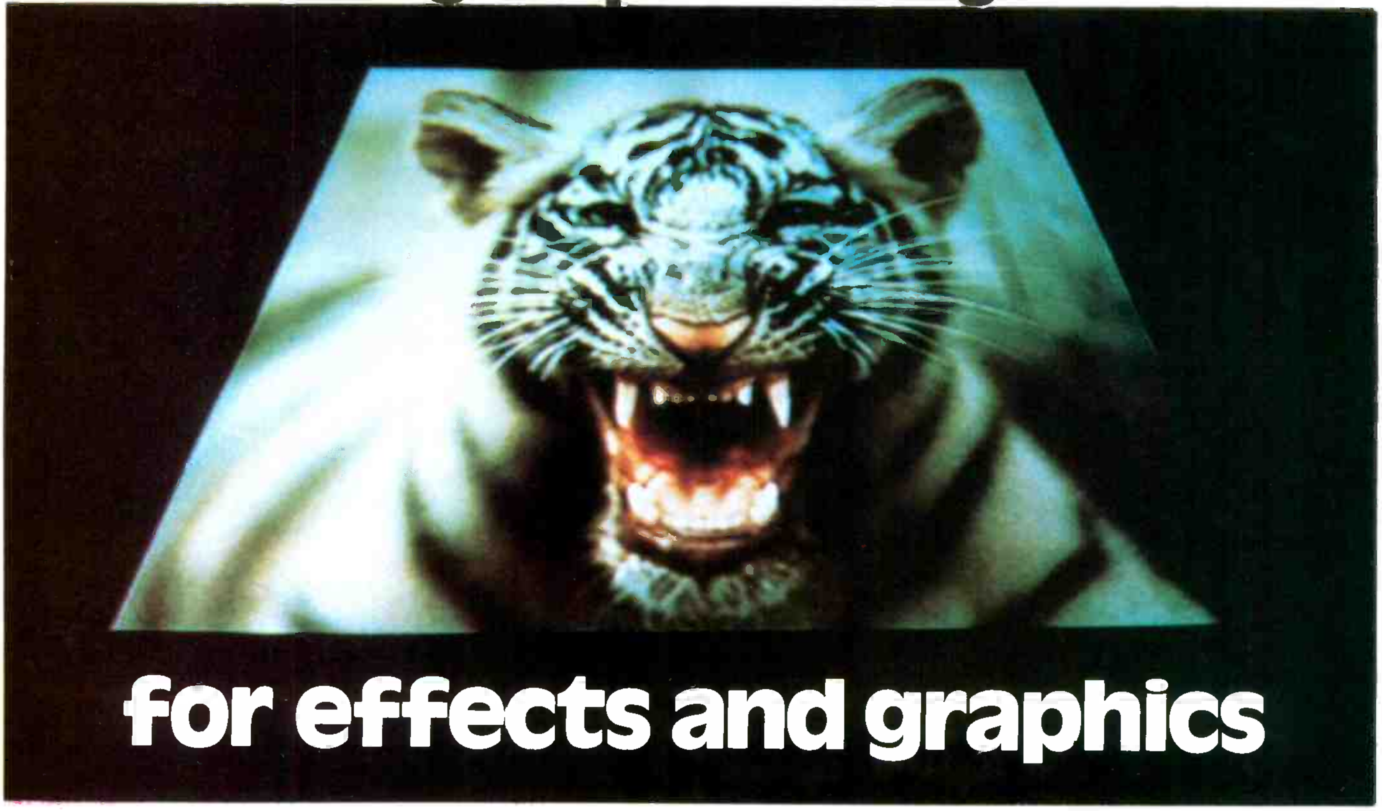
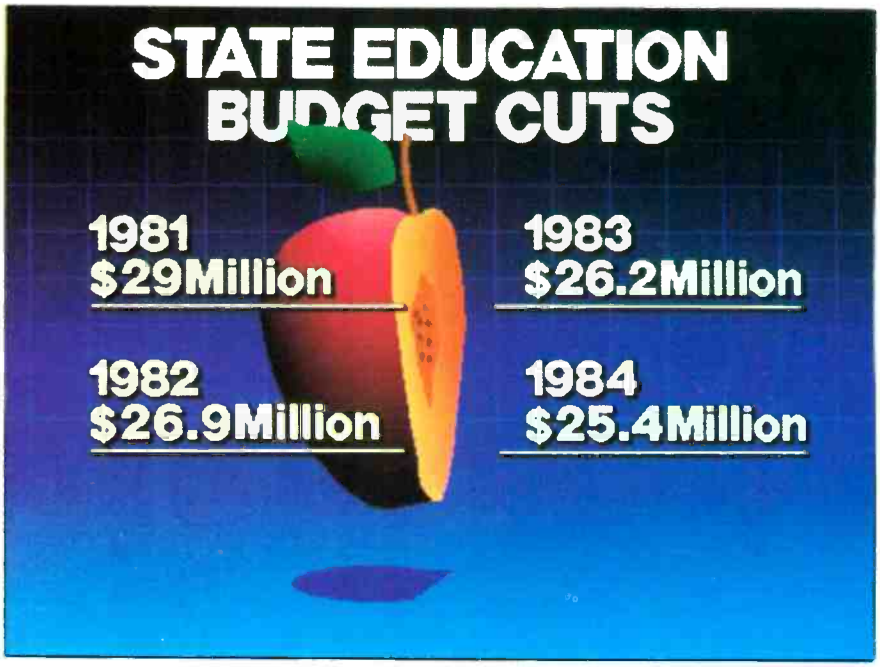
Digital processing for effects and graphics



Ampex

By Blair Benson, TV technology consultant



Aurora Systems

Early attempts in television to produce electronically generated graphics and effects more complex than simple dissolves and supers were restricted by constraints of analog processing. Creation of geometric forms and reproduction of discrete video signal levels were limited by bandwidths of the color-encoding system and random noise in camera signals.

Multiple steps of encoding and decoding to permit processing of timing precision. Furthermore, the imperfect scanning geometry of color cameras negated the use of more than one signal source for graphics mechanicals where overlays and image matching were required.

With the advent of digitizing and storing full frames of video signals, more complex graphics and effects, such as those in film animation, became possible. The breakthrough was the digital frame store, developed for the international exchange of TV programs with different line number and color encoding standards.[1] The frame store provided a basis for development of graphics as well as special effects, which duplicate even the most sophisticated film opticals and animation.[2]

Digital processing was aided by advances in computer and disc storage technology and a concurrent dramatic reduction in the cost of solid-state digital memory devices and microprocessors.[3] A cost reduction of nearly 10:1 in a decade has provided the designer the freedom to choose between hardware and software to provide a variety of functions.

Graphic effects may generally be broken into two classifications:

•Creation of images in a digital video signal format. The images may be generated digitally by a computer or in an analog form from a camera and converted to digital signals.

•Manipulation of digitized images. Manipulation involves processing of digital signals to create image distortions and movements with virtually infinite variety of colors. Both planar and 3-dimensional perspectives may

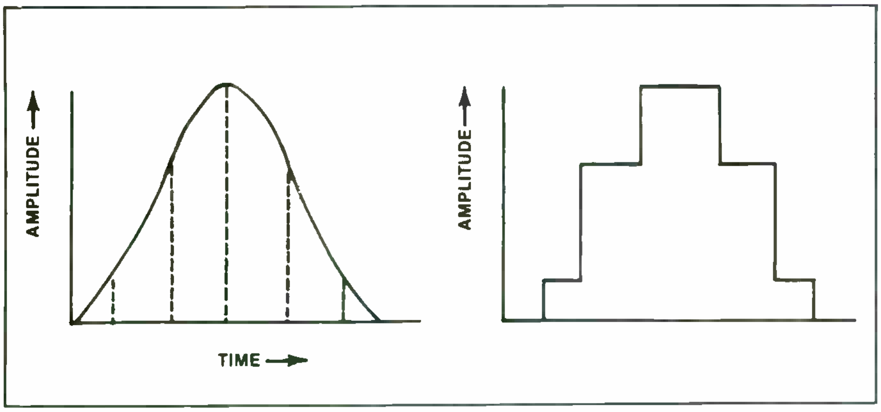
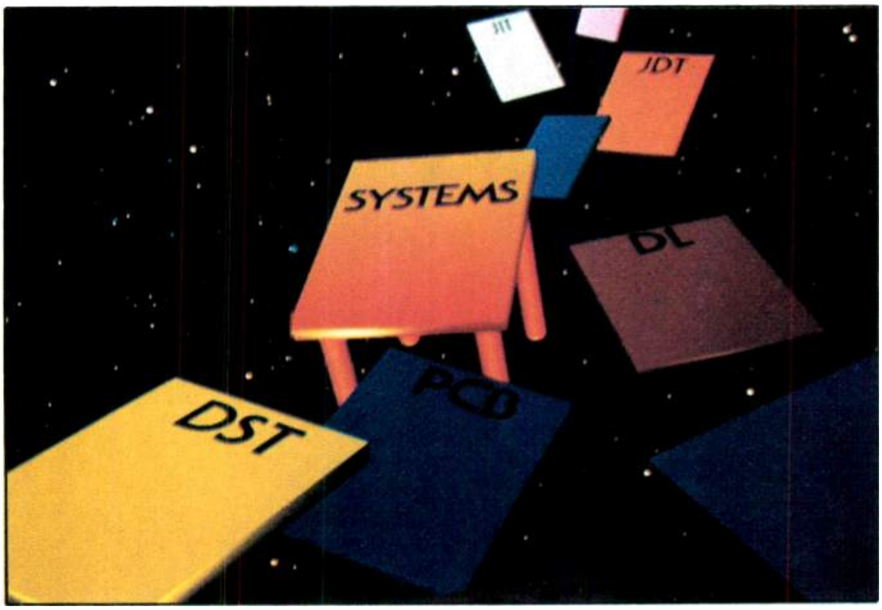


Figure 1. Sample-and-hold output is retained in a frame-store. A: An analog waveform. Dashed lines indicate amplitude samples. B: Sample-and-hold output waveform.



Bosch

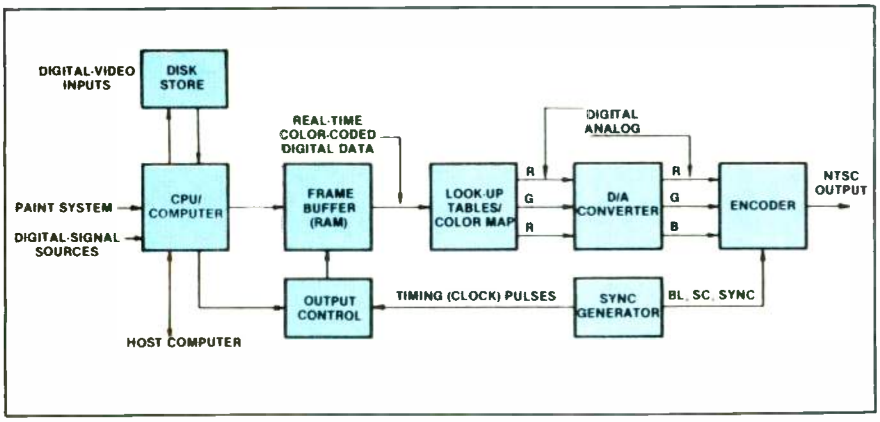


Figure 2. Block diagram of basic elements and functions for digital video graphics generation. The frame buffers, output control and some or all of the computer operations may be integrated into the CPU in some hardware designs.

be involved in real time or frame-by-frame under manual or programmable computer control.

The proliferation of videographics equipment and techniques has created a lack of understanding of basic system design.

For a comprehensive view of video graphics and its technology, consider the functional aspects of the systems and their elements, rather than dwelling on specific hardware designs and operational programs. A knowledge of the fundamentals and the steps in signal processing and control will aid in understanding the equipment.

Input signals

The input signal may come from an external analog source or a digital signal generator. Analog signals could be from an animator's pencil sketches, such as those used with conventional film animation, single frames from a digital still-store memory, a video recording, a character generator or a computer. The last two, which produce a digital signal directly, may be integral parts of the digital video effects or paint system.

Analog input signals are translated to a digital format for each of the three colors. This is done by sampling the analog signal voltage along each scan line at a series of repetitive decision points corresponding to picture elements, or pixels. Pixel amplitude levels from the sample-and-hold operation are retained in a framestore for subsequent digital signal coding. Sample-and-hold waveforms are illustrated in Figure 1.

The sampling rate for analog-to-digital (A/D) conversion is at least twice the high frequency cutoff of the baseband analog input video signal. This permits later analog reproduction of the signal and reduces interference between sampling-sideband components and high frequency components.

Because of imperfections in the input signal, it is usually necessary to provide digital noise reduction (DNR) even for camera signals. Some frame manipulation may be necessary to position and scale the image to match other analog sources and computer-generated patterns. This occurs after A/D conversion in conjunction with other digital manipulation processes.

The computer or CPU

After any necessary processing, the digital signals may be retained in a magnetic disc framestore, under central processing unit (CPU) control, or in a solid-state memory, as shown as Figure 2.

The CPU is a complex multipurpose component that provides logic, interfacing and control for the system. This includes input signal equipment, any operating or control panels and display devices. The CPU may actively generate geometric forms and patterns from its integral computers for integration with other graphic-image sources. Provisions allow expanding

CPU capabilities by using another computer, if need be.

Frame buffer

Computerized data from the CPU framestores, still in separate red, green and blue components of color and 2-dimensional spatial information, is fed to the frame buffer. More complex than a framestore, this unit stores color identification information with position and amplitude data.

RED 15, 0, 0	GREEN 0, 15, 0	BLUE 0, 0, 15
YELLOW 7, 7, 0	MAGENTA 0, 7, 7	WHITE 7, 7, 7

1	3	5
2	4	

INPUT CODE	OUTPUT COLORS
1	R, 15
2	R7, G7
*	*
*	*
*	*

Figure 3. A: Pixel color and values of red, green and blue. B: Pixel coding by frame buffer. C: Look-up translation of color codes to definitions.

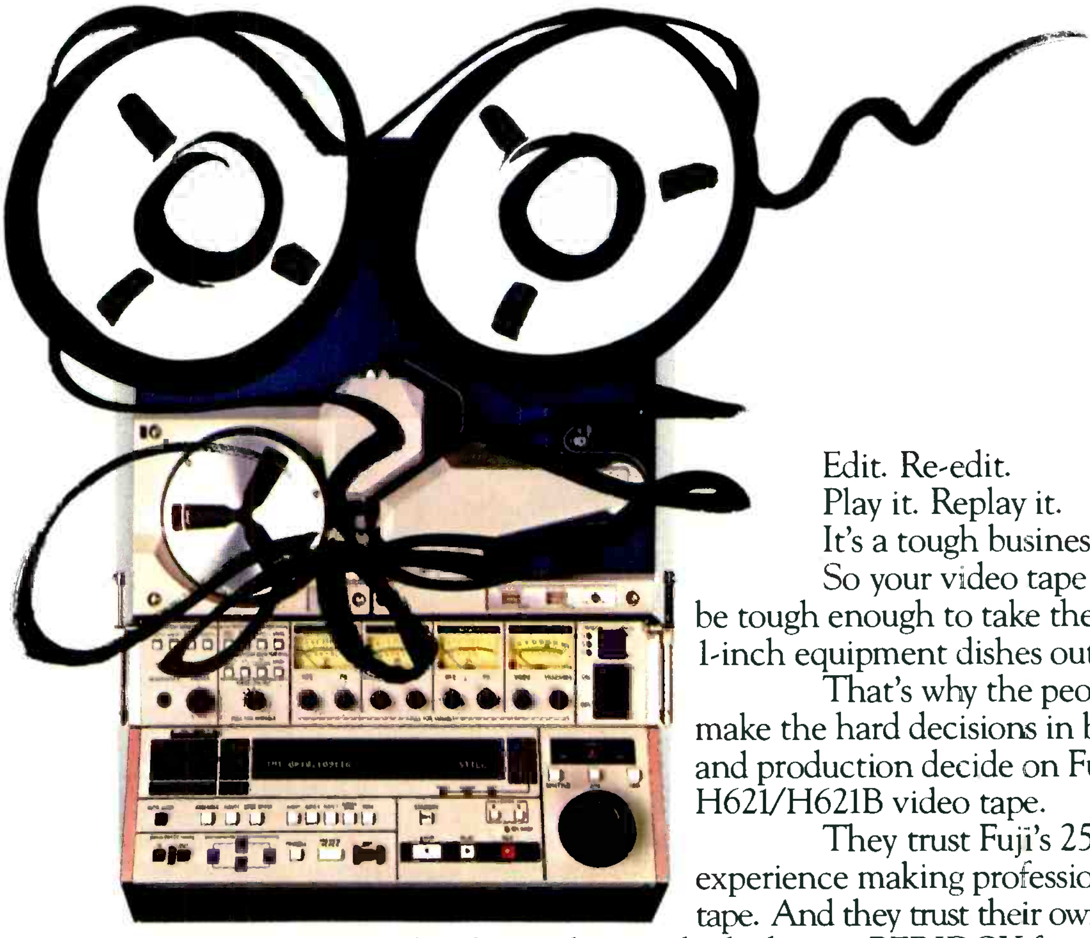
The data are coded as RGB percentage values for each pixel, rather than defining each primary color separately, as shown in Figure 3(a) and (b). The process may be simplified by using a unique digital number for each color.

For example, a total of 256 colors can be identified by eight bits of digital information.

Under control of the CPU, the buffer output is modified to introduce size and position changes in images by appropriate variations in the rate of pixel readout.[4] By modifying the coding of pixels, the intensity and color of pixels or pixel areas can be changed.

In some instances two frame buffers may be used, one being loaded from storage while the other is being read. Dual buffering increases the operating speed materially, albeit at the expense

What good is a $75,000 video recorder when the video tape gives a two-bit performance?



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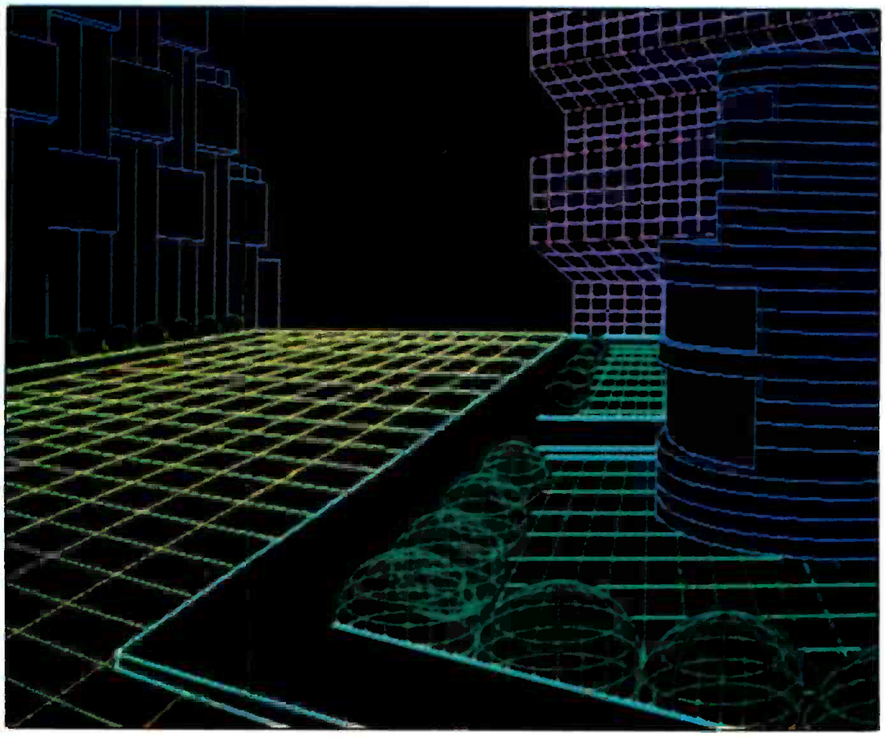


Digital Graphics

of increased cost and additional CPU output control circuitry.

The look-up table

The output of the frame buffer is fed to a look-up table or color map, where the identification numbers associated with each pixel are translated into color signal values (Figure 3(c)). Look-up tables, in conjunction with frame buffer storage, were used in early character and graphic generators primarily to reduce the storage capacity requirements of the frame buffer.

Some systems use look-up tables for other signal processing such as gamma correction and color correction. More recently, they have been effective in reducing the memory requirements for frame-by-frame animation.

Output

The color map output signals, as red, green and blue digital video signals, are converted to conventional analog signals for monitoring and encoding into the desired transmission

Just for effects

Chyron

Some of the most intriguing products for television are digital video effects systems. No matter how baffling these magic black boxes appear to be, there is definite logic to them—a large amount of digital logic.

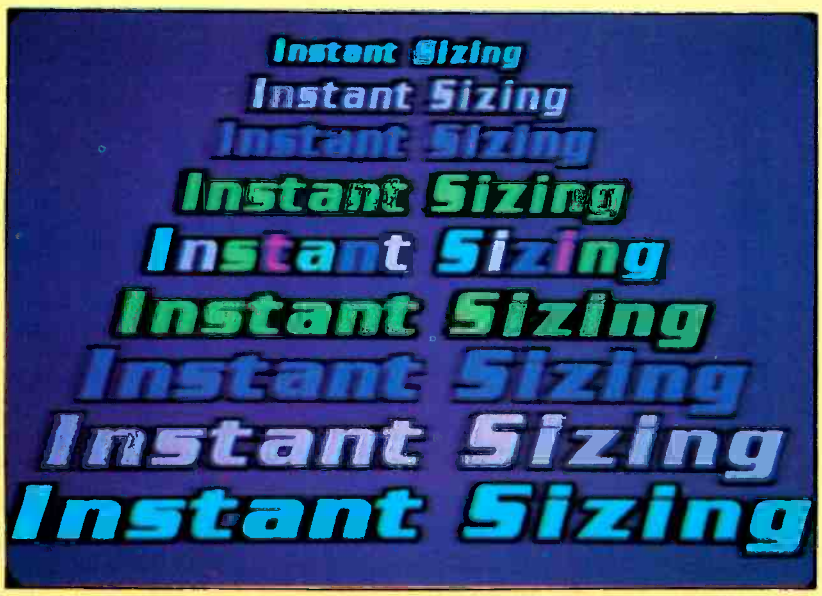
Reading, writing and RAM

Like synchronizers and TBCs, video effects involves A/D converters to sample incoming video. Digitized signals pass to a RAM framestore memory. Finally, a D/A converter recombines the bits to an analog output. The secret, however, is what happens in the memory.

Simple effects could result from how information is written into and read from the memory. Dropping bytes or rereading bytes alters the image size. Changing clock rates distorts perspectives. But such methods are not fast enough for video manipulation. A multistage computer control system is used instead.

One microprocessor system talks with the frame memory, either by moving bytes around or by handling read/write addressing. A second computer does complex calculations according to effects algorithms or formulas and converses with the memory controller about the results. The calculations use LSI combinations of logical *AND* and *Or* circuits called X-Y multipliers, which work with 16- and 32-bit parallel data at accelerated clock speeds.

Effects algorithm selection occurs on a keyboard or control panel through dedicated or programmed *soft* keys. Pressing one button inputs a set of parameters from ROM and RAM to the computer. The structure of the control and operating system determines the ease of using the sytem.



Quanta

Pivotal points

One approach to programmed effects uses the concept of keyframes. A keyframe is a start, stop or intermediate point of an effect. The keyframe data consists of various types of information, including flags to indicate the type of effects.

These include borders and backgrounds, H and V splits, mosaic and solarizing, image inversions of trajectories and frame or field freeze.

Which flags are set determine the subroutines (basic preprogrammed moves) to be called from an effects ROM. Default values for each keyframe flag simplifies the programming process. The operator may alter any default condition from the control panel. The computer will later use the flag status for comparisons, much like *IF-THEN* logic.

After setting flags, a group of variables with preset, but changeable, default values define: image and position; border and background colors, saturation and luminance; degrees of cropping, solarization and compression along x or y axes; and the time duration desired. These variables will be used in mathematical formulas to calculate the effect parameters when the program is invoked.

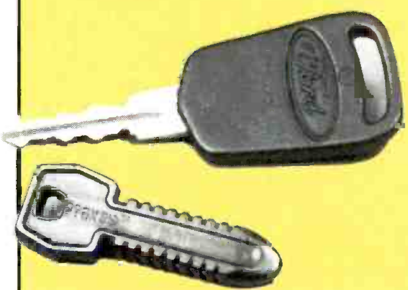
To set effects parameters, some systems require that values be entered from a keyboard. Others "read" the values of such devices as joysticks or fader bars. Some systems use both methods.

To determine the positioning of the controllers, potentiometers attached to the joystick or fader act as voltage dividers, the resulting voltage level being digitized and stored. The position could also be determined with binary switching or even by optical methods. When the positions are sensed, the parameters have been learned by the system.

With all factors selected, the operator may store the keyframe in an internal data bank for later use. Or, if the effect is not needed for some time, the operator may elect to save the effect data in an external device. External memory choices, system dependent, include Winchester or floppy discs, bubble memories and solid-state electrically alterable ROM.

For complex effects, the operator works through a series of keyframes sequentially. Editing is possible, should a sequence need to be altered. And once a sequence is programmed, it may be saved internally or externally for later use.

One approach to effects control uses six soft keys under the effects display, which can choose one of 36 choices. After a group of six is selected, a new menu appears.



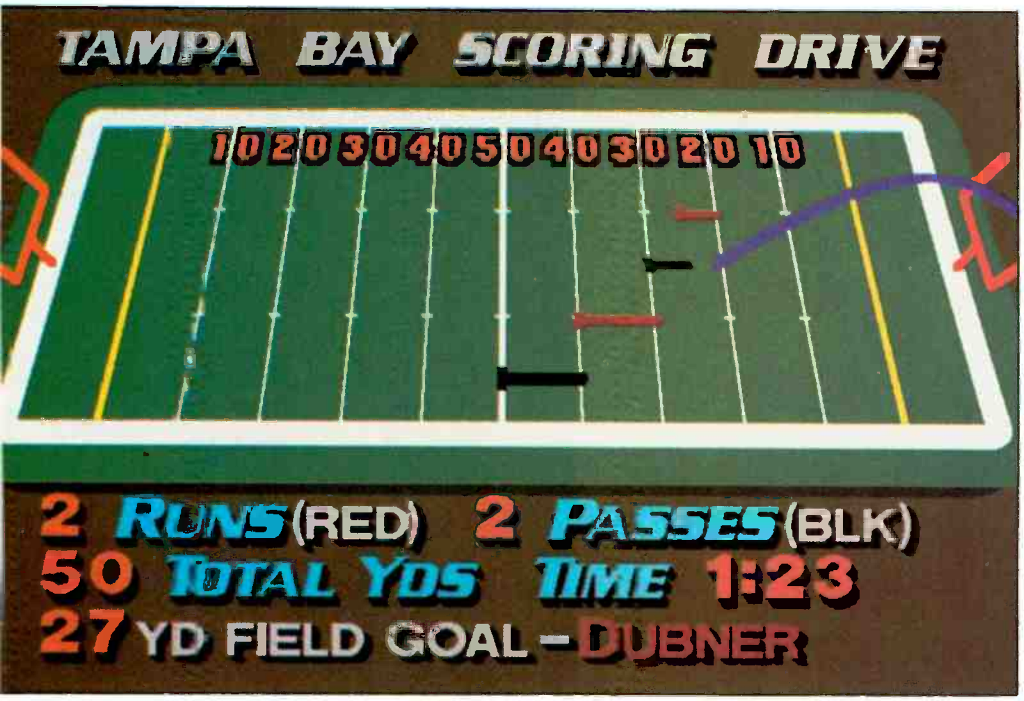
Effects sequences are stored in an electrically erasable ROM, housed in a key-shaped package.

Taking control

For ease in system use, you must know the status of various parameters. Menus do that, as well as giving instructions to the operator. CRT, LED and display panel approaches are available with different systems.

Methods of operator control may vary, depending upon the application. There are differences between the on-air and production needs. On-air operators require the ability to alter effects parameters fast. You may need to access an effect from the external memory only seconds before it is needed.

In post-production, a more lenient atmosphere allows the operator to conveniently make changes. However, the investment required for digital video effects suggests that most TV stations would be using the same system for both functions. In other words, the control panel must be logically arranged and easily understood. Menu messages should be quickly readable.



Dubner

standard. Because the digital outputs are a component format, the D/A conversion is a relatively simple translation of the digital values of each pixel to analog voltages.

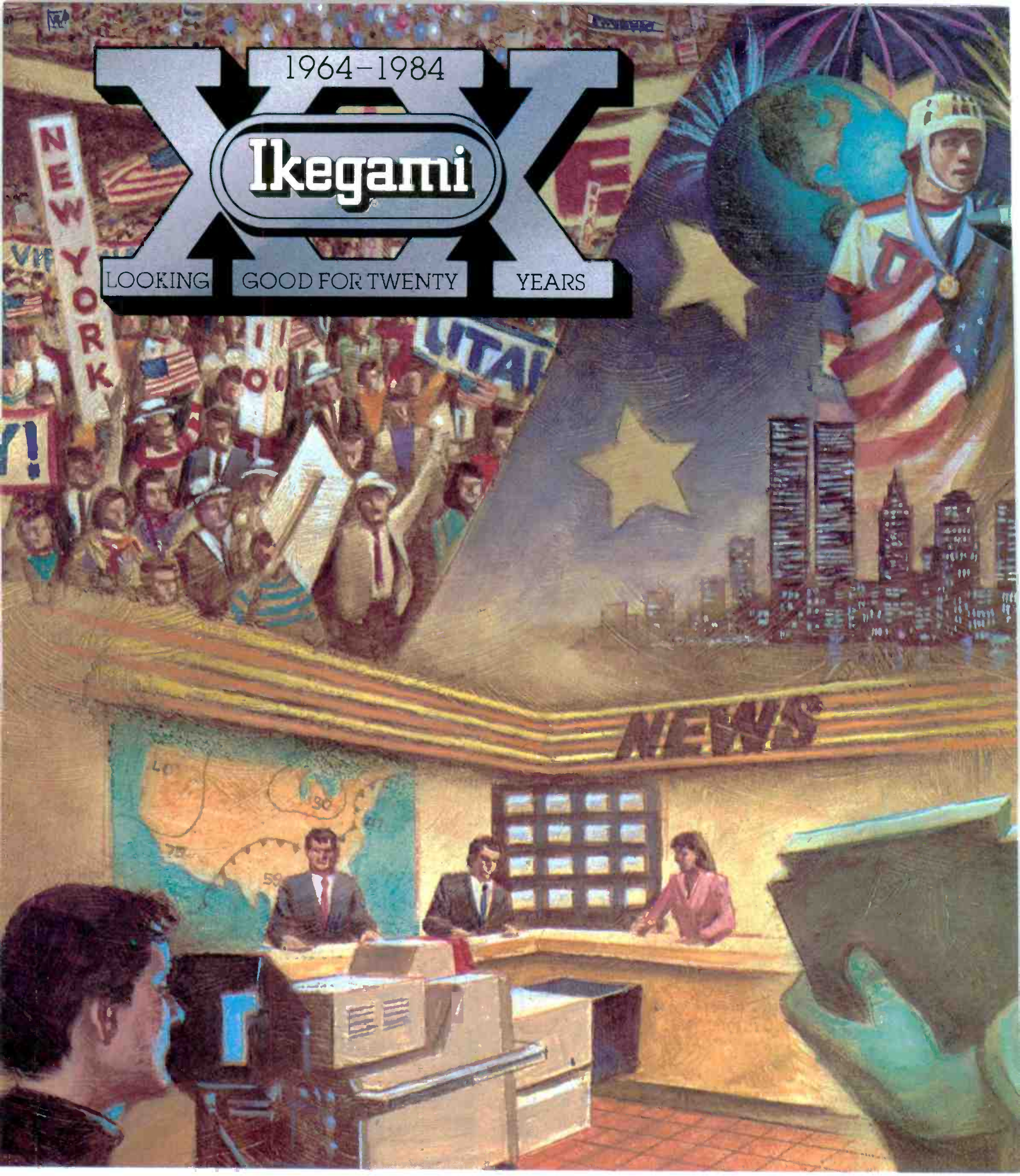
Image manipulation

Elementary squeeze and zoom effects require the rate of reading from frame memory be faster or slower than that at which the signals were written. This requires a simple framestore, rather than a frame buffer with its complex color coding. By discarding every other pixel in the readout, the pictures are reduced or squeezed by a ratio of 2:1.

Conversely, by repeating pixels in the readout the image is doubled in size and cropped by the active scanning raster. The portions cropped will depend upon where the readout is started.

In both squeeze and zoom there is a loss in resolution. It is of most

Continued on page 52



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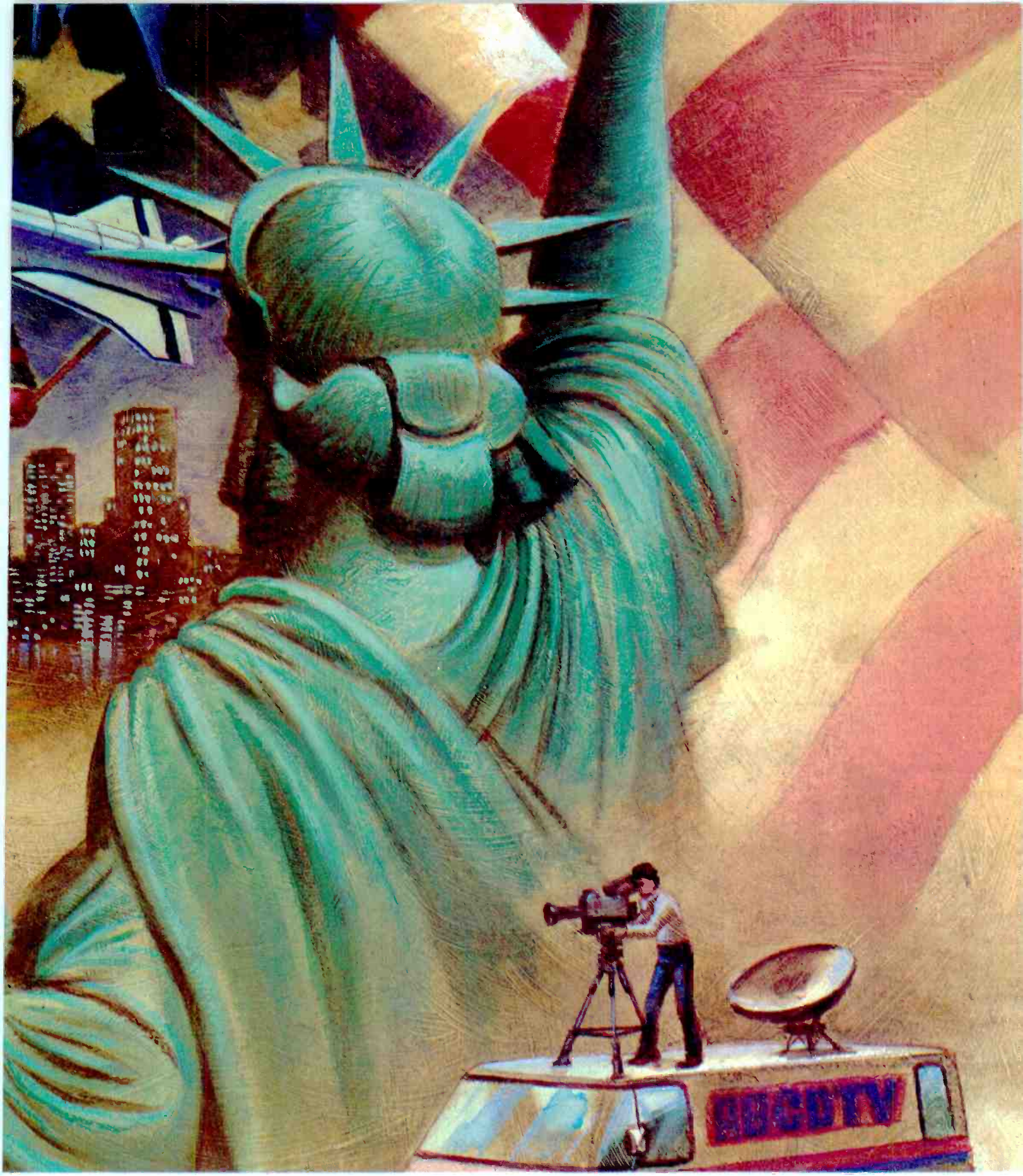

Continued from page 48

Faces and fonts

Trends in product design seem destined to arrive at a single piece of equipment that does everything. Categorizing such products can be a problem. For example, the mention of a character generator brings several different product types immediately to mind.

What most people mean is a unit, using digital techniques to produce alphanumeric titles. Either through its own keyer or through a downstream keyer on the production switcher, the unit presents textual information within the TV picture.

A second product type places alphanumeric data on the screen as well, not intended for viewers but as an aid to editing or as source identification information.

A third type gives information about system parameters, like diagnostic displays in camera viewfinders or on oscilloscope CRTs. Technically, all three do the same thing. From a data bank of the required shapes, the units generate characters.

TV titling falls in a general category of TV graphics. Most titling systems include free-form graphic capabilities as options. On the other hand, video art systems can produce alphanumeric characters as well. Both place informative lettering on the screen. Confusion results without some definitions.

First, the TV titler is in essence a typewriter that uses the TV screen rather than paper. As a basic unit, the TV titler places information onto the screen for the viewer. It should allow some character manipulations, such as type size, screen position, centering of lines or pages, colorizing and shading.

The data needed for formation of the characters is kept in the unit in a special memory section called a map. Some systems include the map as integral ROM memory. In others, the data are loaded from an external storage medium, such as floppy disk.

A simple titler includes RAM memory formated as video pages. Each of the memory cells in a page contains a value that designates the character you want to appear in that location on the screen. The value is based upon the American Standard Code for Information Interchange (ASCII) concept of 8-bit groups.

The ASCII values reference the data stores in the map, where the character is described in a rectangular matrix (for simplicity, a 5x7 matrix), as on page 54.

When a video page is presented, the 1s and 0s necessary to form each scan line through a character are called from a character memory map. The 1s appear as points of light on the screen, while 0s join the black background.

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much larger matrices may be used, but the same principle applies. A video keyer is used to mix the characters with some type of background video, such as a solid color, colored bands or externally generated TV images.

Because of the framestore attribute of the page memory, free-form graphic options may be used with many titlers, either as software or hardware packages. The basic purpose, however, remains the presentation of textural material in a TV format.

Free-form graphics

The video art system is a free-form graphic unit. Its intent is to produce full or partial frame images. Those images may or may not include alphanumeric information. Characters may be drawn onto the screen through an electronic drawing pad.

Most systems also include an input for composite video to allow pictures or letters to be scanned into a portion of the memory. Again, software and hardware options may provide different sets of type, but the basic purpose of the system is for free-form artistic presentations.

Faces vs. fonts

Typography defines a style of lettering as a typeface. Examples include Helvetica, Old English, serif or san serif. In the true TV titler, a face is the information held in the character map.

From the data that describe a typeface, the titler creates character fonts or type sizes. Size might vary from a single pixel to a full TV screen in height, but intermediate sizes, ranging from perhaps eight points to 32 points, will provide useful size characters for easy reading by the viewer. The

0	0	1	0	0
0	1	0	1	0
1	0	0	0	1
1	0	0	0	1
1	1	1	1	1
1	0	0	0	1
1	0	0	0	1

The 5x7 matrix representing the letter A.

system should allow more than one font displayed simultaneously on the screen.

Even an italic font with controlled slant should be available from the typeface in the system's memory. That is, the italic form of the serif face should not require a separate load operation from the type face library. Mixing of italic and non-italic fonts should be possible with a single display page or even line.

For more artistic treatment of the characters, the basic titler becomes more involved. Character coloring, for example, implies additional bit storage to hold each character's color map data. Smooth characters may require anti-aliasing to get rid of jagged edges, either through hardware or software. Shadow effects are desirable to make a title stand out against a background over which the characters are keyed. Multiple colors make far more interesting titles. Reveal windows simplify captioning functions or rolls and crawls of multipage information.

Each added capability on a per-character basis places a new requirement to both hardware and software of the system.

Character resolution

Characters or graphic objects are formed from pixels. The sharpness of the display is dependent upon the size and number of pixels that the system displays. But how big is a pixel?

On any NTSC TV screen there are about 485 visible lines out of the 525 lines forming a frame. About 40 are involved in the vertical blanking interval and are unusable. The smallest practical height for a pixel is one line. In time related to horizontal distances, that amounts to about 81ns.

Pixel width, however, has greater variability. With some mathematical calculations, it can be shown that for a 1:1 ratio of width to height on the 4:3 aspect ratio display, the pixel is about 80ns wide, or an 80ns resolution. A 20ns resolution would present a pixel with a width that is ¼ the height.

Practical limits of today's TV receivers suggest that a realistic horizontal resolution for titling systems should fall in the area of 27ns. A much larger value will require greater anti-aliasing attention. A much smaller value would render unreadable titles.

Buying a system

What is your graphic requirement? Is it strictly to add captions and credits to a program? If that is the case, a titler is probably what you need. Let your production switcher help with keying the letters into video and you on your way. If your need is more artistic, look for a titler with art graphic options or a full-fledged art system.

MCI/Quantel

significance in the zoom, where the magnification is not accompanied by a proportional increase in fine detail. Noticeable degradation is introduced as well by the enlargement of random noise.

A 3-dimensional perspective is achieved by varying the rate of the horizontal readout. The rate varies with each successive scan line during the squeeze or zoom operation.

Inversion or mirroring requires a reversal of the readout direction. A combination of the change in rate used for squeeze and zoom, and reversal of readout can, by proper programming, produce tumbling or spinning. Rotation is more difficult, requiring a matrixed change in rate and selection of pixels on horizontal and vertical axes during the readout.

In all of the manipulations described, there may be instances when the image extends off the screen. In these slide-on/off effects a new set of coordinates is used to permit pixel position assignment in areas of as much as three times the normal screen size.[5]

Interpolation

To maintain image quality during non-linear manipulations, such as rotating and scaling, it is necessary to interpolate or average among samples. This corrects for the variations between samples resulting from the difference between the readout sampling rate and the horizontal and vertical rates corresponding to pixel location.

The simplest example is a straight line at an angle to the horizontal scanning lines. The effect is similar, but more complex, to that encountered in TV standards conversion where the relationships are static and only on the x and y axes.

Aliasing

Sampling errors of one pixel per scan line or frame can occur on objects slightly larger than one full pixel. Alternatively, movement of such subject matter can cause a brightness change not related to the motion.

This distortion of reproduction is apparent as moire patterns on fine detail, or ragged edges on diagonal lines. In manipulations, the effects on diagonal lines and edges are reduced by interpolation.

On the other hand, in camera-originated material, there is no pat solution. Such interference or picture degradation effects are seen regularly in analog TV pictures where the camera scanning lines beat with fine detail patterns in the scene material.

Digitally generated material can produce more serious aliasing artifacts than analog TV, primarily because of the sampling processes. Filtering may not be possible to remove them. Filtering is also not a practical solution in the analog domain, because of the resultant loss in resolution.

One digital technique used in alias reduction is to sample the amplitude of several (say eight) pixels and to reject any values outside of a predetermined range. This is effective in memory readout of static graphic material. However, reduction of aliasing on moving objects proves quite difficult, because it involves the dimension of time, in addition to x and y.

Fine arts graphics

A paint system is essentially an adjunct to the basic elements of computer graphics. The paint program

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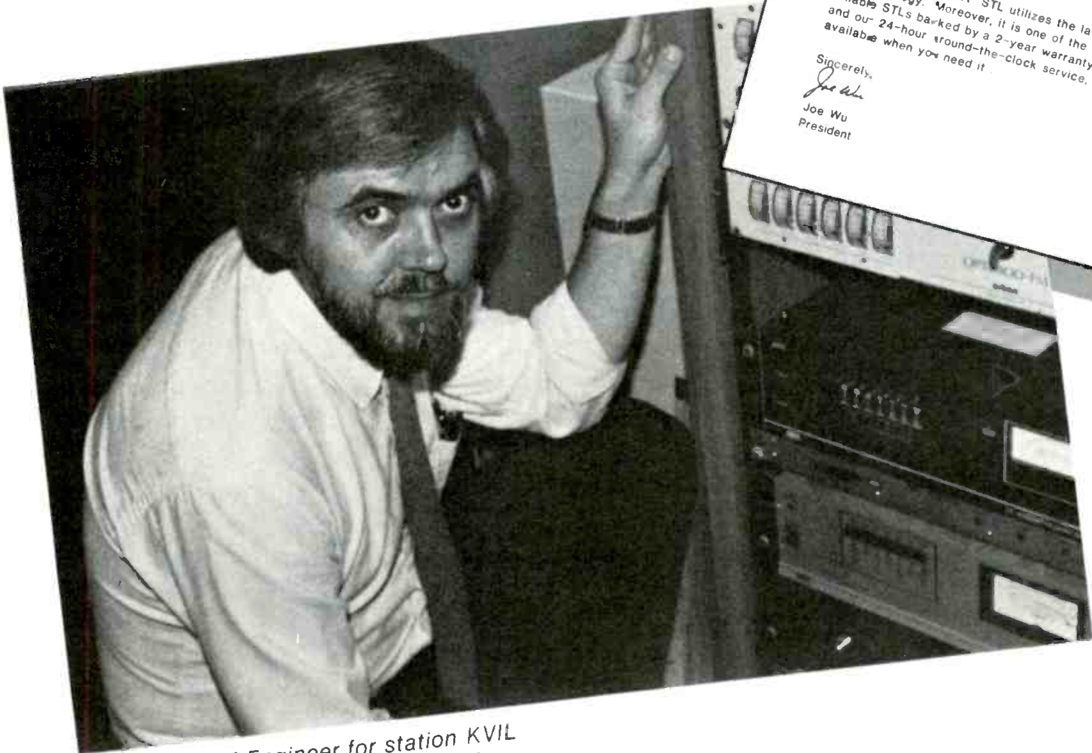

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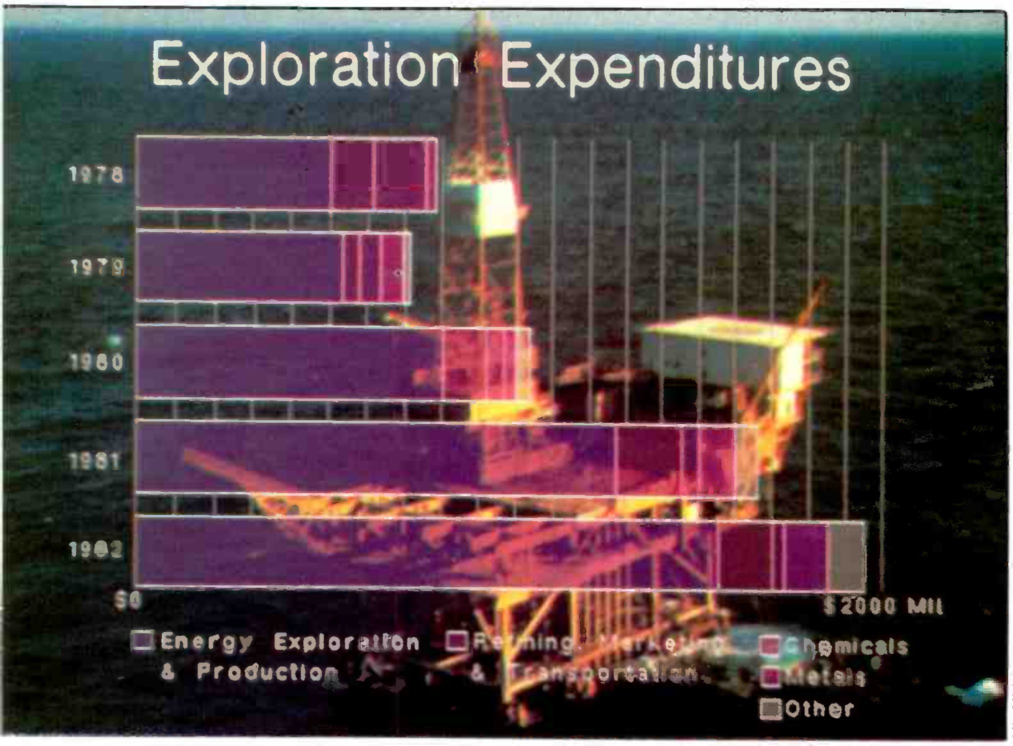

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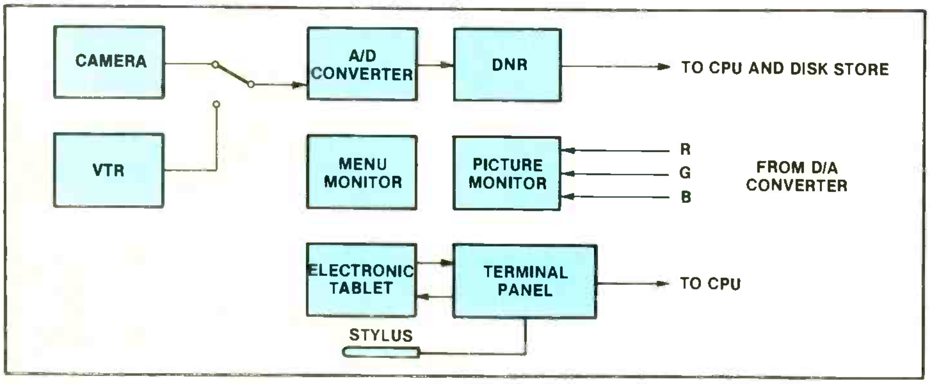
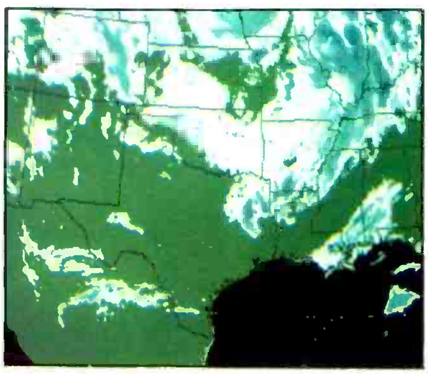
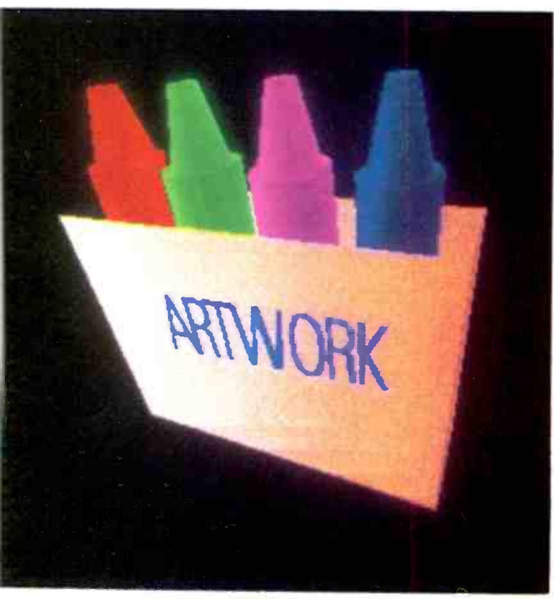


Figure 4. Block diagram of typical paint system elements. Pictures can be recalled from the frame buffer and disk storage for display, and subsequent paint and manipulation operations.



Thomson/CSF



West End Artwork

allows an operator to draw on a screen using a stylus. Stylus movements are translated into electrical signals.

The sophistication of the system may range from turning individual pixels on and off to simulating the artist's tools (oil paint, water color and airbrush) and techniques (line thickness, area colors, texture, edge composition, overlays, transparency and matting).

Depending upon the talent of the artist and the level of system capability, an electronic paint program can produce outputs equivalent to images from live cameras or conventional graphics material. The elements of a typical paint system are shown in Figure 4.

Most paint systems use a manually operated input device (the graphics pad), similar to an artist's canvas, to provide two degrees of planar image creation and manipulation. The artist selects a command from the menu displayed on a monitor screen or, in some cases, from a keyboard.

With monitor menu displays, the stylus is placed on the desired command and a button on the stylus is pressed to activate the command. The same screen may provide both the drawing and command displays. More conveniently, separate monitors are used for the two functions.[6]

In addition to the canvas or tablet valuator, and the picture and menu displays, the paint program uses the CPU to direct and receive input data and to control the buffers and color tables for processing.

A typical paint program can be summarized as three primary tasks: to track the pointer or stylus to receive the commands for organization as digital data; to manipulate the buffer storage and color look-up table in accordance with the input data; and to store and retrieve picture information, using the system computer.

The graphic advantage

Watching electronic graphics systems in operation creates an aura of magic. Through a logical combination of complex digital techniques, they have provided creative talent with new tools that contribute a greater artistic freedom.

At the same time, electronic effects and graphics give the producer a means to greatly reduce the time required to complete effects and animation, which in the film medium often entailed days or even weeks to bring to fruition.

Related articles were written by Carl Bentz.

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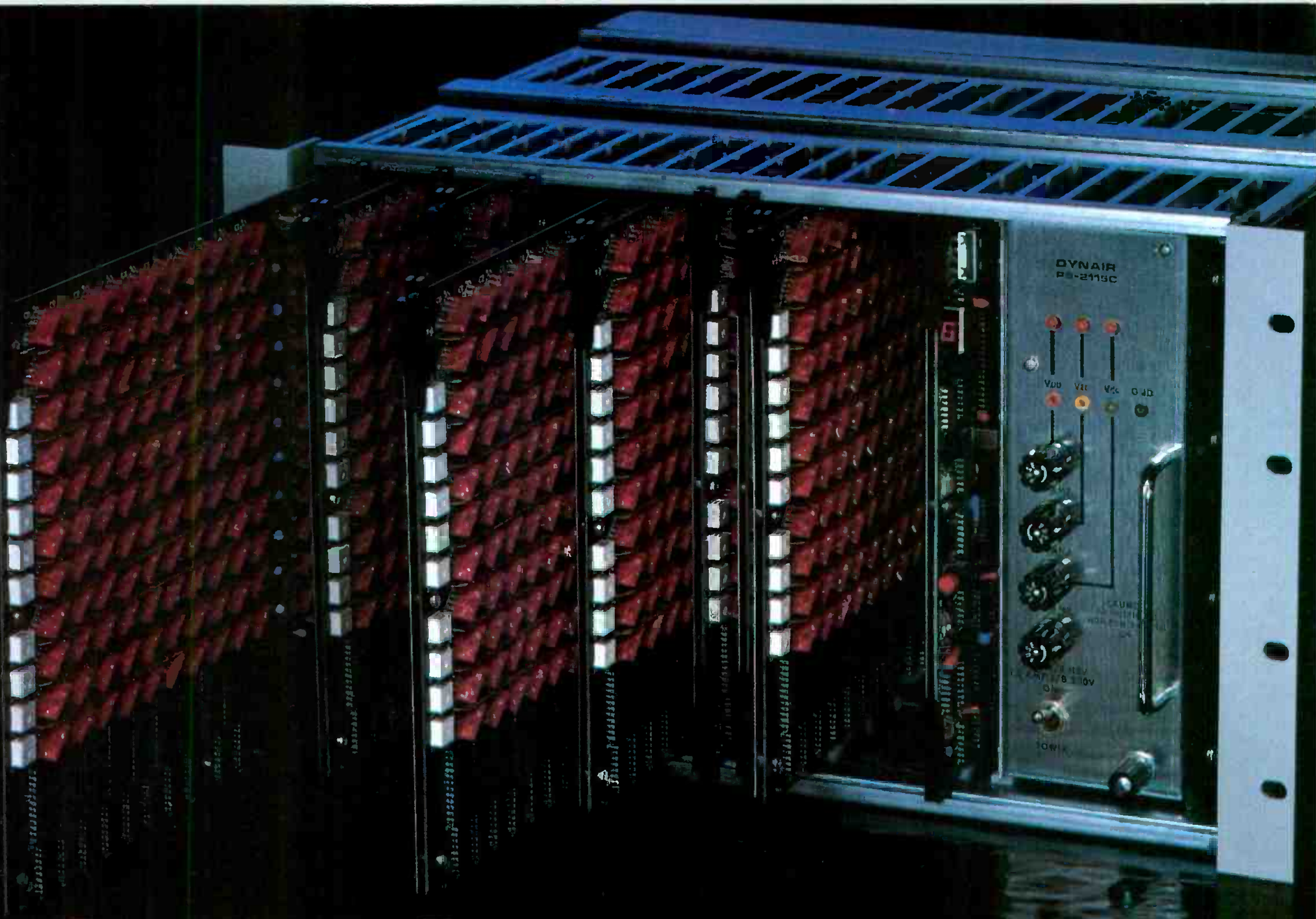
DYNAIR

Speaking of television, digitally

By Elmer Smalling III, cable systems consultant

For more than 40 years, television has been an analog phenomenon, as has most of the communications world.

Voices, pictures and other signal intelligence have been represented by voltages that vary in proportion to levels, frequencies and phase angles of the signals. When any device along the transmission path acts in a non-linear or abnormal fashion, the signals become distorted. Common examples include the end result of a long-distance phone call or blue faces on television.

Engineers have struggled with circuit and path non-linearities. Yet, just as technology was about to find cures for many of our analog aches, digital technology allows us to treat signals in a manner far more manageable than analog methods have allowed. Advanced systems based on applied mathematics use rather simple circuitry with word streams of 2-level bits for distortion-free transmission.

Analog vs. digital

Analog signals are transmitted intact, without varying their complex internal relationships of amplitudes, phases and frequencies. The signals should remain similar to those generated by transducers, such as microphones or camera tubes (although in reality, mixing may be required).

Ideally, when a received and decoded signal is heard or displayed, the result retains the same internal, complex relationships. In practice, however, many of the relationships become altered and distortion results.

Digital signals are derived from their basic analog parents through analog-to-digital (A/D) conversion. The analog signal is broken into millions of discrete components, which can be represented by data words. Each word consists of four, eight, 16 or even 32 bits, depending upon the available system.

Now, instead of a complex waveform to represent our signal, we have a string of data words, a digital format that may be easily handled or transmitted as a serial flow of bits. Each bit may take on a value of 1 or 0, signifying on or *off*.

The time represented by each word is called the *sampling time*. The shorter the sampling time (the greater the number of samples per unit of time), the higher resolution our signal will have. The sampling rate is determined by a system clock and the speed of *sample and hold* circuits which cause some delay while a sample is being quantized.

Once the signal is in a digital form, a simple microprocessor may handle control of processing. The signal may be stored in a memory or it may be altered. Time base correctors, frame synchronizers and digital video effects units use video that is stored or manipulated as data words.

Signal conversion

Using an analog video signal as an example, the signal enters the A/D device and is examined and sampled at a rate at least two times that of the highest frequency component of interest within the original signal. At a rate less than two times, the sampling time is too slow to capture signal detail. The two times rate is termed the *Nyquist rate*.

Each sample could consist of three 8-bit data words. Each word may represent a number as high as 256. The first word of each sample might represent the magnitude of the video signal voltage (0 to 1V, divided into 256 steps). The second and third words might contain 256, the third a maximum of 104, giving a total angle of 360°.

Although an analog voltage can represent any number of voltage levels or degrees of phase, conceivably an infinite number, and because our 8-bit system can only represent finite levels, the signal has been *quantized* into 256 levels. (See "Binary and Beyond," page 62.) Quantized is derived from quantum, which refers to a discrete value, no matter how large or small. Quantization levels do not overlap.

LDA, STA, BEQ

With the analog video converted to data words, you have almost complete freedom in working with the data. You can manipulate or store the signal as you would other types of data. You can transmit signals from machine to machine or across the continent with little or no distortion from non-linear devices.

In a digital video effects unit, you can modify the data from a keyboard, using preprogrammed computer software to manipulate the video picture. The effects system allows you to use various subroutines in a computer machine language program to achieve the effects you desire.

Similar operations in the video painting system or electronic easel allow you to add color, texture or shapes to the original video image. Or you may decide to erase the stored image and draw new material with a light pen, mouse, keyboard or graphics pad. In either case, you are changing the 1 and 0 values of bits in the 8-bit words stored in memory.

Analog animals

People require analog input. For this reason, you must reconvert any digital signals back to an analog form for listening or viewing. Eyes are stimulated by continuous and relatively smooth signals at very low data rates; low, at least, in comparison to the microsecond clocking rates of standard microcomputers. This change is accomplished with the digital-to-analog (D/A) converter, which operates in reverse of the A/D converter.

In the D/A device, the data stream of words is applied to logic gates to derive preset levels. Words, containing digital values, generate 0 to 256 parts of a 1V peak to peak or up to 360 parts of phase video signal. The level data are fed through smoothing circuits to recreate a new analog version of the original video voltage.

The digital-to-analog fabricated voltage can be no smoother than the 256 levels of quantizing you began with in the A/D converter. The resulting detail is dependent upon the number of discrete sampling levels you used, no matter what amount of smoothing or filtering is applied.

Talking digitally

Dealing with digital processing obviously requires speaking a different language. To assist in a better understanding of digital processes,

the following information will serve as a partial glossary to some of the terms of digital.

•**Quantization noise**–Problems encountered when attempting to divide a signal into n equal parts (for the 8-bit case, n = 256 parts). These include errors that result from defective ICs, video noise from external interference, timing jitter and the electronic noise caused by the sampling process itself.

•**Sampling noise**–The rate of sampling for digital video is commonly set at four times the color subcarrier, i.e., 14.31815MHz. Circuits that sample the input signal turn on and off at this fast rate and in the process generate switching noise. Equipment designers must attenuate this noise to avoid introducing image degradation. Most of the noise appears in the form of spurious frequencies that are non-Gaussian. In other words, the spurious products do not fall within the bell-shaped statistical Gaussian curve in terms of their amplitudes, relative to their frequencies.

•**Quantization error**–A number of samples not correct or some samples larger or smaller than others (a non-linear conversion). This error is often the result of supply voltage problems or a large amount of noise on the video signal initially.

•**False contours**–When an insufficient number of samples is taken and curves cannot be smoothly recreated. False contours will be most apparent in sizable gray areas of the picture. They will show as steps of luminance change, quanta, where no such steps existed in the original signal.

•**Tapered quantization**–Quantization steps made larger than others to define all possible detail. For example, a picture with large gray, flat areas and a great deal of fine detail in black and white areas may be sampled with different sized steps. Larger steps are used for flatter gray areas, while smaller steps cover the black and white sections. As a result, 256 levels are retained, but much greater detail is provided in the more important black and white areas than in the less detailed grays.

•**Mosaics**–The result of limited quantization levels. If you use five levels (3-bit words required), you could reproduce black, three levels of gray and white–hardly enough for an aesthetically pleasing picture. The finished product would have harsh edges with five shapes of gray and resemble an overclipped video signal. This block-like, low-level quantization, called mosaic tiling, is offered in many video effects units.

•**Dither**–A low-level, random oscillation that may be added to shift

Binary and beyond

Bits? Bytes? Confusing, perhaps, but these terms make digital technology easier to understand.

A bit, short for *binary digit,* is the smallest piece of data that can be handled. Like an electrical circuit, a bit is on or off. In digital equipment, on is represented by 1, and off is represented by 0.

By itself, one bit isn't terribly worthwhile. But combined into groups, bits are the basis of computer operation. Eight bits create a *byte*, while four bytes make a *word.* In smaller terms, four bits make a *nybble.*

Two types of processing are possible. If the eight bits of a byte are handled in order, the circuit is called *serial.* Only a single wire is used to connect one circuit to another.

Faster processing of information is possible by using a *parallel* structure, in which the eight bits of a byte are handled simultaneously. Larger systems using 16, 32 and 64 bits are common and 128-bit computers are just around the corner.

Counting in digital systems is confusing, because of how we normally think of numbers. In the decimal system, there are 10 counting digits, 0 through 9. These digits are used in positions that have place values of units, tens, 100s, etc. Ten is written "10," meaning one ten and no units. The number 9753 is nine 1000s, seven 100s, five 10s and three units.

In binary counting, the counting digits are 0 and 1, with places values of ones, twos, fours, eights, etc., the powers of two. Decimal 63 is written as binary 111,111. Binary 10 is decimal 2.

Obviously, large numbers in binary become unwieldy on paper, but not in electronic circuitry. For people to better understand what's happening, other systems, which relate to binary numbers, have been introduced to reduce the volume of digits in a number.

Octal systems count with digits 0 and 7 and places values of ones, eights, 64s, etc., the powers of eight. Decimal 255 becomes octal 377. Octal 777 equals decimal 511.

The digital number system most used is hexadecimal, with counting 0 to 9 and A to F. In a 64k memory system, the four place values are ones, 16s, 256s and 4096s, that is, base 16. Here, A equals decimal 10 and F equals 15. Hex 10 is decimal 16, A0 is decimal 160. FFFF becomes decimal 65,535.

Decimal	Binary	Octal	Hexadecimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10,000	20	10
31	10,001	37	1F
32	100,000	40	20
33	100,001	41	21
255	11,111,111	377	FF

How decimal, binary, octal and hexadecimal systems relate to one another.


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The gist of Nyquist

Almost every article about digital processing refers to the *Nyquist Criterion.* This rule states that in a digital system the sampling frequency must be at least two times the highest frequency component of interest in the signal to be sampled. Sampling at a slower rate will produce undesirable results.

Sampling is a form of modulation or mixing of two signals. If we modulate a carrier with a tone as in AM radio, we are actually creating two new RF signals, which we call upper and lower sidebands.

For example, if a carrier of 1000kHz is modulated with a tone of 5kHz, the result is a sum of 1005kHz and a difference of 995kHz.

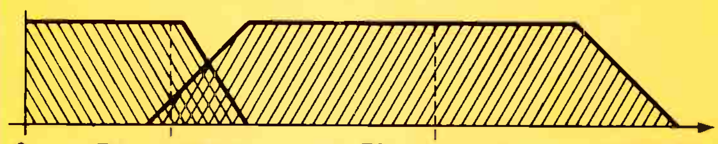
Video is a complex combination of sync, luminance and chroma, which covers a bandwidth of at least 4.2MHz in a composite signal. As a result, the mixing of video with a sampling frequency results in a much more complex set of upper and lower sidebands than AM. The sampling frequency must be high enough to take all possible video frequencies into consideration.

In the figure below, the result of sampling a 4.2MHz video signal at twice the subcarrier (7.159MHz) includes an area of overlap of the mixed information with the original signal. Interference created by the overlap of signals is called *aliasing* and may be visible in pictures as moire.

According to Nyquist, sampling for NTSC would be a minimum of 8.4MHz for a 4.2MHz bandwidth signal. The second figure illustrates sampling at a much higher rate than is required for the Nyquist criterion. Without the overlap of the signals, sampling interference in reduced.

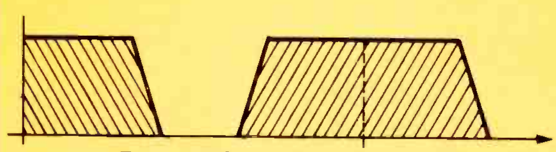
Most digital products for NTSC are presently designed around sampling at four times subcarrier, or 14.31818MHz. If the highest frequency of interest in the video is 4.2MHz, sidebands extend from 10.1MHz to 18.5MHz.

For international digital work, a standard of 13.5MHz has been set for sampling of luminance, with chroma component sampled at 6.75MHz.



0　FV = 3.58MHZ　FS = 7.16MHZ　FREQUENCY

Use of 7.16MHz as a sampling frequency causes an overlap of the original and sampled signals.



FV　(FS − FV)　FS　(FS + FV)　FREQUENCY

A sampling frequency fs much greater than two times fv avoids overlap of the signals spectra.

quantizing levels up and down slightly when the number of steps of quantizaton is limited. This blurs the edges of the picture detail to reduce the mosaic effect.

In low-resolution systems of less than 64 quantizaton levels, dither is required to produce an acceptable picture. Dither (or pseudo-random noise PRN) may also be used to reduce false contouring that results from low-level quantization. False contouring would appear as exaggerated edges and outlines in the final televised picture, especially when edge enhancement circuits are used.

•**Pixel**—Video signals divided into a large number of very small parts. Pixels are the smallest element of video that may be manipulated or quantized. Pixel size is commonly measured in nanoseconds and is determined by the sample rate, scanning beam size, image scanning rate and circuit bandwidths.

•**Smoothing**—Noise treated by use of a position invariant operation, which averages noise signals over areas adjacent to the pixel being quantized. Adjacent areas are called neighborhoods. Smoothing takes an orthogonal (at right angles) average, or mathematical integral, of the video level in pixels

Continued on page 117

Color-mapped vs. full color

By David Fabian, product manager, Ampex

More and more video graphics are becoming trademarks or signatures, which identify a TV station's programming and image.

Because of this, it is important for everyone on the station staff to have a rudimentary knowledge of the graphics equipment responsible for the station's on-air look. This isn't always easy, because different types of equipment, such as still-stores, character generators, and video arts systems, may have similar graphic capabilities.

Video art systems have always seemingly been confusing. One source of confusion is the basic differences between color-mapped and full-color systems. This article will explain some of the technical differences in the two systems.

With the color-mapped system, the video content of a pixel is assigned a number from a color palette. The number will be determined by the nearest match from the palette for the particular pixel of the incoming video. This process is analogous to a paint-by-number kit.

Imagine, for example, a low-resolution video screen consisting of 25 pixels arranged 5x5. If a picture of a blue square box on a red background were scanned into the system, the system would assign a number to each pixel, according to the content of the picture at each location.

Now, imagine a very limited color palette, consisting of two colors, represented by 0 and 1, as shown in Figure 1.

The colors 0 and 1 are determined by assigning an 8-bit numerical value (0 is no color, 255 is fully saturated color) for each of red, green and blue to the two colors in the palette, or color map. The video observed on the screen would be determined by the amounts of red, green, and blue mixed together for each color in the map. Our color map has only two colors, so

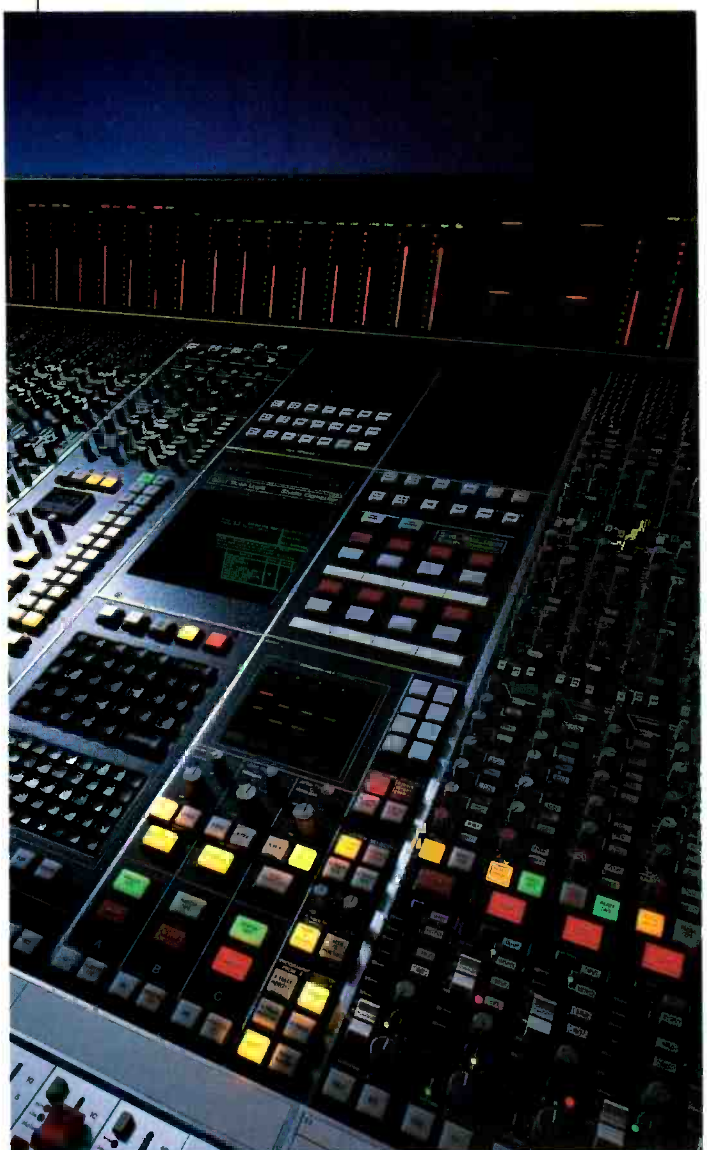
There's more to than meets

Producing effective multichannel sound isn't easy. Though the procedures borrow heavily from recording studio and film sound techniques, audio for video is a specialist art with a unique set of requirements.

As its early practitioners have discovered, the inherently complex process of stereo teleproduction and post-production can be made even more difficult by cobbling together a collection of modified equipment in the hope of serving these advanced needs.

While makeshift arrangements may satisfy the technical minimums of the task, they introduce tradeoffs in operational flexibility and efficiency which can ultimately affect both production quality and costs.

Fortunately there is an alternative, developed for the leading post-production houses and refined in collaboration with major broadcast organizations throughout the world: The SL 6000 E Series Stereo Video System from Solid State Logic.



SSL Puts it all Together

The SL 6000 E Series is a thoroughly integrated system designed specifically for the stereo video environment. Combining the most advanced aspects of multitrack, motion picture and broadcast audio technology, it provides extensive signal processing, routing and mixing capabilities as well as comprehensive machine control and communications—all commanded by a single operator at a logical, unified control panel.

SSL's multichannel mix matrix allows separate stereo music, effects and dialogue mixes to be created at the same time as the stereo program mix. In live production, multiple stereo splits or mix-minuses can be structured at the touch of a button. Mono composites of each mix are always available, and a mono programme feed is provided. Advanced formats such as stereo plus a secondary audio programme or centre-channel dialogue are also supported.

Changeover between live and post-production modes and different output configurations is instantaneous. The rigid architecture of ordinary consoles is replaced with patchfree audio subgrouping and pushbutton signal processor routing, allowing the engineer to customise the signal flow for each project.

Stereo Television the eye.

Meticulous electronic design creates the shortest signal path for each requested function, allowing SSL to maintain a dynamic range and bandwidth that far exceeds the performance of even the best 16-bit digital recorders, converters and routing switchers.

Complete Machine Control

The SSL Stereo Video System also provides the operator with central control of up to five synchronised audio, video and film transports. Cue points are stored and called by timecode, foot/frames or key words.

The SSL Studio Computer provides complete list management with floppy disk storage, video display and hardcopy printouts. Distributed processors ensure rapid search and lock-up. There's even a Sync Preset function which automatically calculates offset values between reels and stores these for subsequent setups.

Dynamic Mixing Automation

The machine control functions are integrated with SSL's audio mixing software to provide powerful, versatile and efficient assistance. Engineers can retain their existing mixing methods, or supplement them with simple yet powerful new routines that allow unlimited frame-accurate mix revisions to be performed with outstanding results and uncanny speed.

SSL's computer assisted rollback and pickup recording enables mixes to be assembled within the automation itself, using traditional techniques. Video layback can then take place in a single first-generation pass, directly from the multitrack!

Beyond fader automation, the SSL System optionally provides programmable parametric equalisation, dynamic stereo panning, and multiple Events Control of up to 32 external devices—each with its own pre-roll memory.

Total Recall™

SSL's Total Recall computer records the settings of every control on each I/O module. A high resolution display of the stored values interacts with the console, allowing fully detailed setups to be restored to a control accuracy of a quarter dB. Total Recall greatly reduces setup time, maximising productivity and creative continuity.

Stereo Perspectives

Not all stereo channels were designed to serve video requirements. Only SSL provides parametric stereo EQ, filters, compressors, gates and expanders on stereo inputs as standard, along with image width and stereo reverse controls. There is no easier or more effective way to match music, ambience and effects perspectives with television images.

Get the Full Picture

As you can see, there is a lot more to producing stereo television than meets the eye. To help you get the full picture, Solid State Logic has published a forty-page colour booklet which thoroughly explains the functions, applications and operation of the SL 6000 E. If you are involved in television production, outside broadcast, video post-production or music video, we'd like to send you a copy. Just drop us a line or give us a call.

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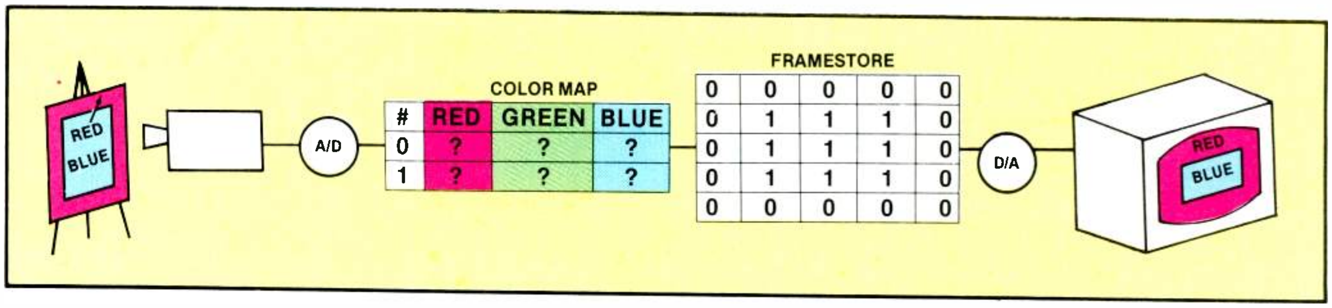

Figure 1. In a limited-resolution, 2-color art system, data in the framestore indicate where actual color information is held in the color map.

the system only displays two colors on the screen at any one time.

Because an 8-bit number can have as many as 256 different values, each color in the palette can be chosen from 256 shades each of red, green and blue, yielding 16,777,216 (256x256x256) color combinations. For the system to reproduce the picture faithfully, the color map shown in Figure 2 would have to be chosen.

Obviously a framestore has more than 25 pixel's worth of memory, and there are more than two colors displayed on art systems, but the principle is the same. Typical systems have framestore memories representing horizontal rows of 512 pixels, arranged vertically to correspond to the scan lines of standard NTSC video.

The typical framestore assigns each pixel with an 8-bit value, between 0 and 255. As a result, the system can display up to 256 colors at a time from the palette of more than 16.7 million. In a simultaneous display of 256 colors, it must attempt to emulate as many of the colors as possible.

One reason that color-mapped tems were developed was cost. Framestore memories are expensive. The color-mapped system requires only one framestore capable of assigning an 8-bit value for each pixel.

Another reason was speed. Given microprocessors available several years ago, the system taxed the computer's processing speed to the limit to provide an acceptable response time to the artist's input.

The color-mapped system allows fair resolution, good operating speed and acceptable colorizing capability for many graphic purposes.

Full color

A full-color system discards the color map and stores the actual color of the pixel into the framestore's memory. Simple, right? Not quite.

For a system to scan in a true full-color image, it must reproduce all 16,777,216 of the colors available in the color-mapped palette *simultaneously*. This means that a full-color system framestore must allow 24 bits of digital information for *each* pixel, eight bits for each primary color.

Typically, the full-color video art system memory is arranged as three individual 8-bit deep framestores, one each for red, blue and green. In such a system, the scanned-in image can be realistically displayed and colorized with any color in the system.

#	RED	GREEN	BLUE
0	255	0	0
1	0	0	255

Figure 2. A 2-color map providing only fully saturated red and blue.

Using the previous example of the blue box on a red background, the pixels are colored in the framestore memory as they are put into the system, with the result shown in Figure 3.

Twenty-four color bits (eight bits each of red, green and blue) assume their individual shades. Such a system requires three times as much framestore memory and a computer operating three times faster to respond as quickly as an 8-bit color-mapped system.

A matter of evolution

Three factors led to the development of the full-color system. First, a desire for a graphic system with the added color capability while allowing images to be scanned in and manipulated. Second, framestore memory devices had decreased in size and cost, while speed increased. Third, the needed microprocessors had followed the memory devices in dimension, cost and speed.

Some systems reduce the number of bits per color component to emulate

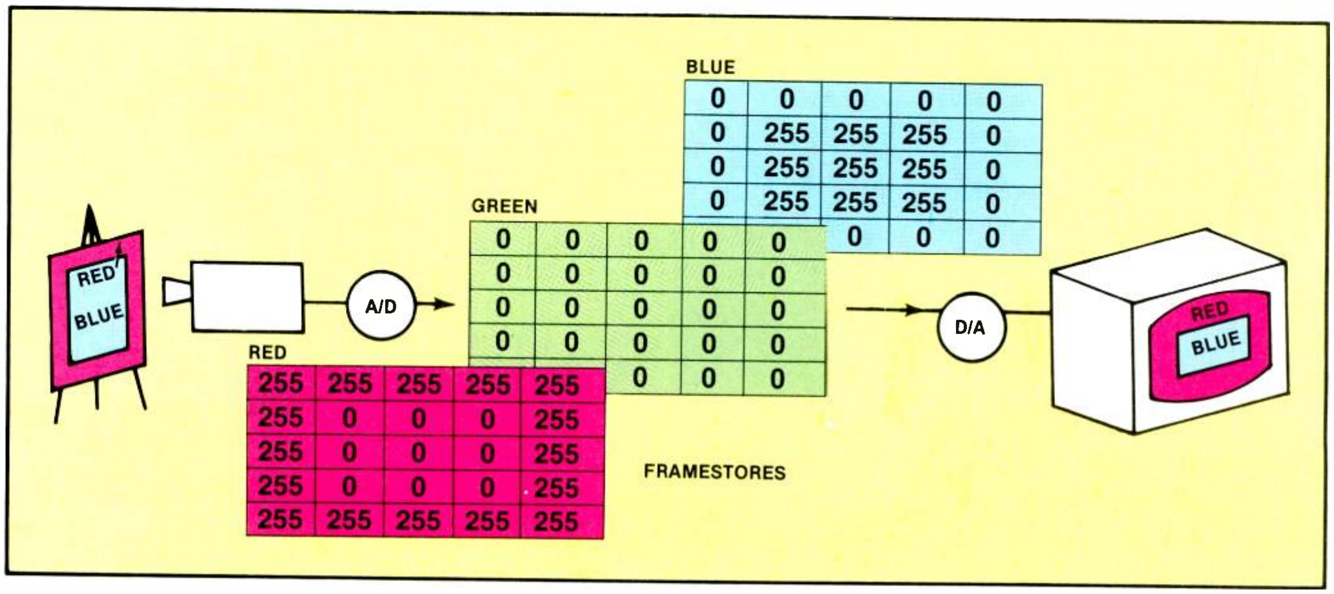

Figure 3. Three framestores, each with 8-bit capability, hold pixel color information in a full-color art system.

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Hum & Noise (0-4.2 mHz)	75	75	65	75	
(IRE WEIGHTING)	82				75
Frequency Response (dB to mHz)	±.1/5.5	±.1/5.5	±.1/5	±.1/5	±.1/5
Diff Gain (10-90%) 3.58	.1%	1%	.25%	1%	.1%
Diff Phase	.1°	*	.25°	.1°	.12°
AUDIO					
Crosstalk (dB/kHz) Audio to Audio	88/20	85/15	80/15	80/15	75/20
Hum & Noise (dB below out)/FILTER	-122/15k	-109/*	-92/15k	-104/15k	-109/15k
Freq Resp @ Max Out (dB/dBm)	±.1/30	±.2/24	±.1/24	±.1/24	±.2/24
Over Freq Range	20-20k	30-15k	20-20k	30-15k	30-15k
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full-color performance from a color-mapped architecture. Such systems, however, have fewer shades of red, green and blue available to recreate the subtleties of a full-color image. The result may appear as unnatural coloring.

For the user

What are the major implications of this fundamental difference in the systems to the user? With regard to what each type of system can do and how well it can do it, several functions can be compared.

•**Image scan-in.** As mentioned earlier, full-color systems reproduce images in all colors, while color-mapped systems cannot. Close observation may show stepping rather than a smooth gradation of color on the bit-mapped unit.

•**Anti-aliasing.** Aliasing is better known as the *jaggies*, or the stair-stepping along diagonals and curves of an image. Anti-aliasing is the ability to smooth those jagged edges. Full-color systems should do a better job of smoothing.

The color-mapped systems do not simultaneously display all possible shades necessary to smooth the edges. For example, a red colored region meeting a white colored region is shown expanded in Figure 4.

To reduce the jagged appearance, pixels identified by Xs should have some mixture of red and white (i.e., pink) so that the junction would appear smoother when viewed at normal size. This is a very simplistic example of anti-aliasing.

In reality, the junction represented in Figure 4 would require several shades of pink between red and white regions to effectively smooth the jagged edges. As you can imagine, a full-color image, with hundreds of principle color regions, could require thousands of intermediate shades to smooth all diagonals and curves in the picture.

Anti-aliasing is particularly important with cut-and-paste art. How natural the cut-and-pasted image appears depends upon the quality of anti-aliasing.

•**Color mixing.** In conventional art, such as oil painting, colors are combined in differing quantities to make other colors. Full-color systems provide the artist with that capability, without affecting other colors displayed on the system.

In color-mapped systems, the flexibility is impaired if the mixed color does not exist in the color map. A desired color must be created (on some systems in a way that resembles mixing). A new color may come at the expense of losing a color already in

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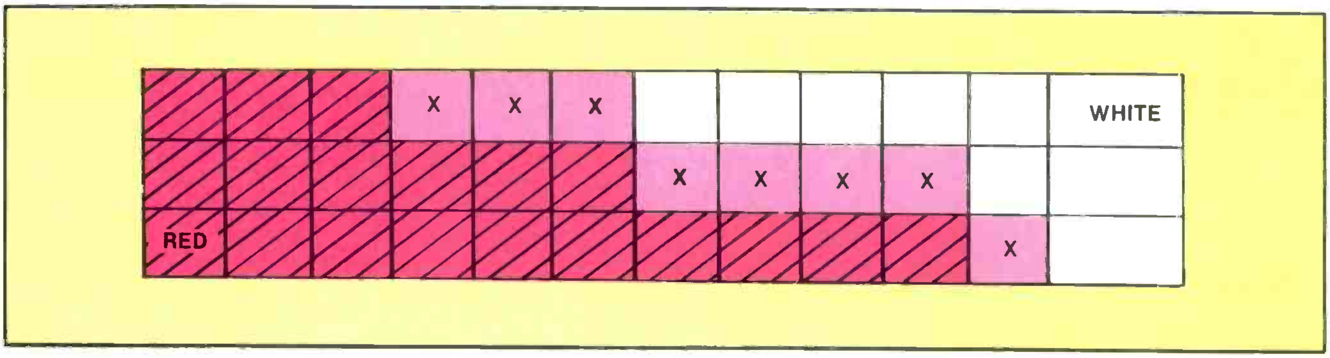


Figure 4. At the interface between red and white regions, anti-aliasing creates various shades of pink in those boxes (pixels) marked with Xs. The result is an apparent smooth edge between the red and white.

the map, which may be important to the overall image.

•**Transparency.** Artistic requirements may need transparent colors as well as opaque ones. A transparent color can combine with existing background colors on the screen to form a completely different set of shades.

The effect is similar to placing a tinted gel over a portion of the picture. Transparent colors may be used to duplicate conventional art tools, as in shaping, air brushing and the application of washes.

System control of transparency and color mixing often uses a pressure-sensitive stylus. The degree of transparency is varied with pressure. Such flexibility with transparent colors is possible, but unlikely on a color-mapped system.

•**Changing colors.** In this area, the color-mapped system has certain advantages over the full-color approach. If, on a color-mapped system, the artist wants to change the color of an object displayed on the screen, he merely changes the color in the table. In the process, all areas of the original color in the images are also changed.

With a full-color system, an object must be exactly and completely redrawn when a change in color is desired. Other similarly colored pixels remain unchanged, as the area of interest is altered.

•**Animation functions.** *Color cycling* is an animation technique in which the color map is altered quickly in cycles. Colors change in all or part of the images. The effect is analogous to a theater marquee, giving the illusion of motion by turning lights on and off in a defined manner. The technique relies on a color map to function. The full-color system is incapable of this type of animation.

In *history animation*, the system memorizes the creation of an image stroke by stroke. On command, the system reconstructs the image in real time, just as it was created originally. Such animation is independent of a system's architecture, but it is most commonly found on color-mapped systems.

Cell animation involves at least two framestores—one for the static background and one for the moving portions. The foreground framestore for the moving portions is reproduced in the foreground framestore as many times as there are cells.

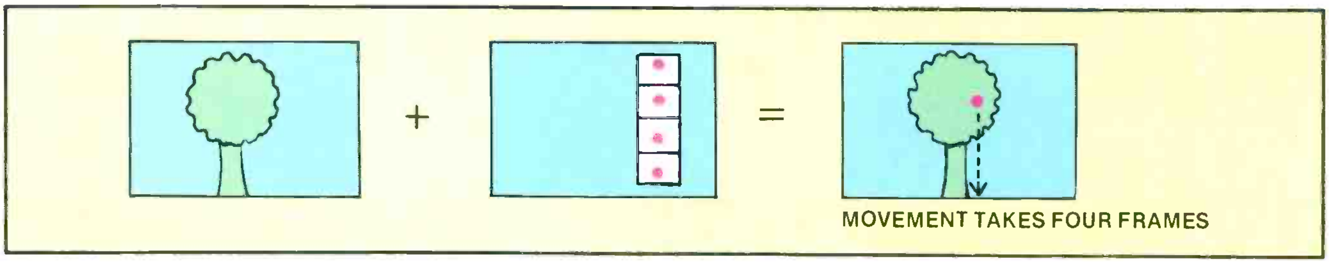


Figure 5. A fixed image in the background framestore will be mixed with a moving object in the foreground framestore to produce apparent motion for animation.

In Figure 5, the apple appears in different positions in each of the four foreground cells. As the foreground framestore cells are keyed into (or mixed over) the background, apparent motion results. This kind of animation is available in both types of graphic system.

Frame-by-frame animation is painstaking, but versatile. Two approaches are possible. The artist may create each frame manually. Alternatively, the operator designates certain key frames (pivotal points in time) of the animation and instructs the system to create the frames that go between the two end points.

After the frames are generated, the animation is recreated at real-time speed by the system. Also, images may be recorded, frame-by-frame, on videotape or film for real-time playback.

Any video art system can create frame-by-frame animation. Only more expensive computer animation/graphic systems create the in-between frames and play them back without first recording them sequentially on tape or film.

Future systems will no doubt be aided by automated control features to make this process less laborious. An example would be for the art system to control single frame VTR recording.

Best of both?

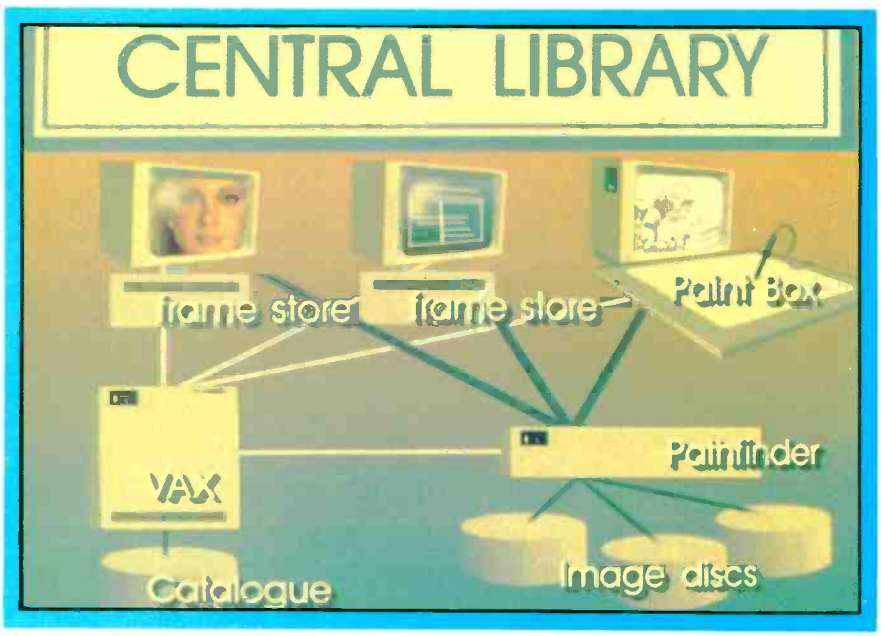
What about video art systems that combine the best of both worlds? There are color-mapped systems that can simulate many of the functions of a full-color system. Currently, no color-mapped systems can duplicate the image quality and color-mixing capability unique to full color designs.

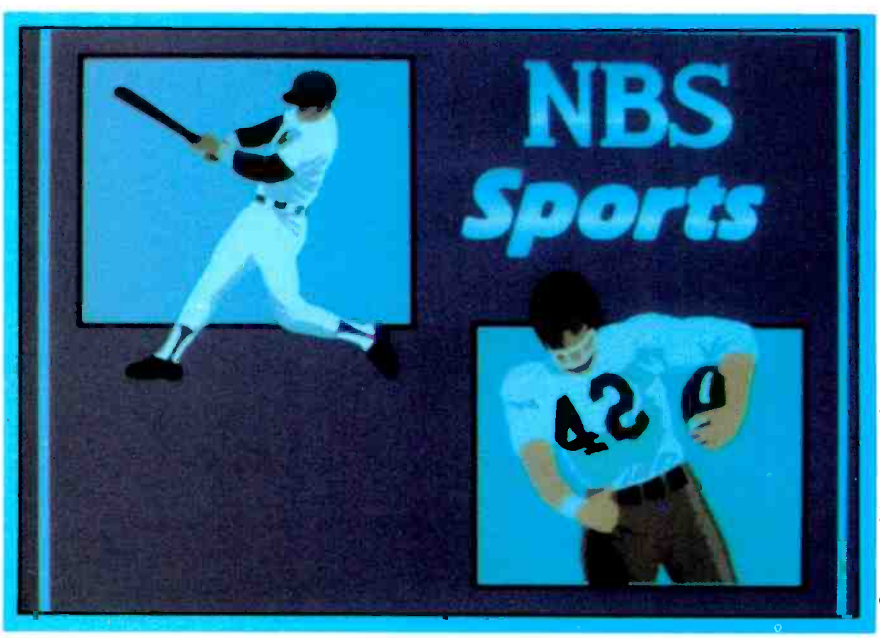
Making a selection

You must assess your needs to determine which type of system best serves the purpose. To that end, the following technical artistic features should be considered:

- **Geometrics.** Can the system generate geometric figures? Are size changes and shape skewing possible?
- **Color fills.** Is fill limited to regular shapes or can boundary floods of irregular shapes be performed? Can a monochrome image, scanned into the system, be filled?
- **Brushes.** What artist's brush forms are available? Can the user create his own? Can multi-color brushes be used?
- **Auto brushes.** Can the artist designate the path a brush should follow, then allowing the system to paint the path?
- **Object manipulation.** Once an object is placed on the screen, what can be done with it? Examples include justifying, skewing, rotation, inversion, size change and foreground priority.

Obviously, there are many other specifications and features that will come into the decision. However, this discussion of some of the differences in color-mapped and full-color graphics systems will be helpful in making your video art system purchase.





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The new three-quarter-inch EASTMAN Professional Video Tape gives your news crews the reliability needed to deliver the story accurately every time. With high signal-to-noise ratio and the lowest of dropouts. With consistency, cassette after cassette.

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Kodak

Circle (46) on Reply Card

Avoid a glitch in time: Inside TBCs

By Carl Bentz, technical editor

Television requires constant repetition. Each second, 29.97 complete images appear on the screen, each containing two fields of 262.5 lines, or a total of 525 lines. The lines of video occur regularly at a rate of 15,734.264/s with an error of ±0.0003% allowed.

NTSC color requires a reference subcarrier of 3.57954545MHz, with a tolerance of ±10Hz. Subcarrier drift may not exceed 0.1Hz/s. Figure 1 illustrates the signal tolerances.

In the studio, sync drives keep the video sources in time. Precise timing is essential for special effects or video mixing. Nonsynchronized signals produce bizarre color and luminance shifts, even within simple A-to-B fades. Studio cameras and electronic sources are driven from studio sync, so timing is relatively easy. For the complex electro-mechanical VTR, however, timing is a different story.

Today's VTRs are precise systems. Carefully machined parts and precision bearings reduce eccentric motions to a minimum. Still, mechanically induced errors plague VTR playbacks. Wow and flutter, speed variations, gyroscopic errors and physical changes of the tape produce video instabilities. These errors, all related to time, require correction before the video playback is broadcast.

As a helical scanning video head makes one pass across the tape, the head reads an entire TV field of 262.5 horizontal lines. Ideally, each line is 63.5μs long, and the repetition rate is constant.

In practice, both line length and the rep rate may vary. Some lines occur early; others appear late. The image formed may exhibit a loss of horizontal and vertical hold.

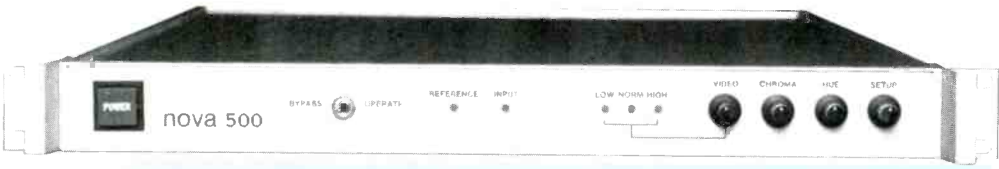
In addition to time errors, off-tape sync and burst may be noisy with poor pulse shapes. A monitor will display the picture, but the signal could prove unsatisfactory for studio production functions.

Removal of the timing errors is the purpose of a time base corrector. Signal repair comes from a *proc amp* section in the TBC. Together the two forms of correction produce a stable video signal from an unstable source.

The basic TBC

The basic time base corrector includes three major steps:

- An *input section* accepts a video signal with errors.
- The signal is digitized and the groups of bits are written to a *memory*.



When only TBC functions are required, a minimum of front panel controls is needed.

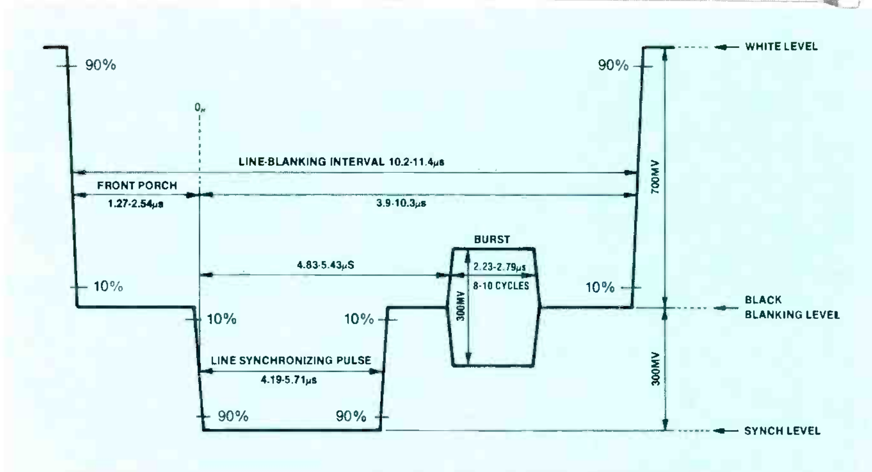
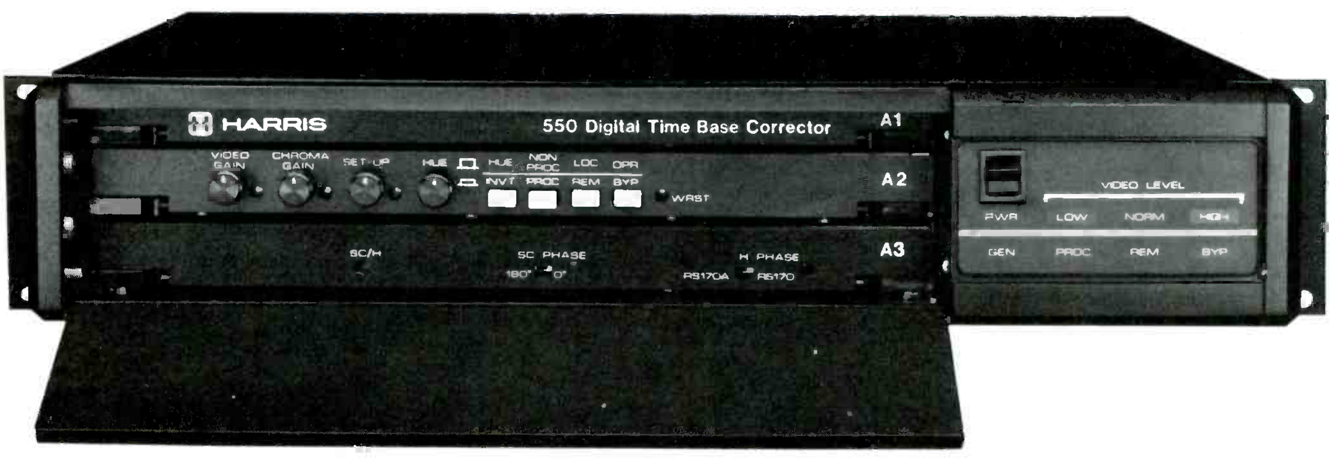


Figure 1. Tolerances allowed during the horizontal blanking interval for an NTSC signal.



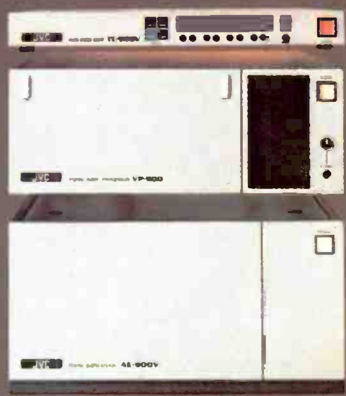
Added features require added controls.

JVC Digital Audio. The artist's editing system.

Digital audio editing takes on new speed, simplicity, and flexibility with JVC's 900 Mastering System. Anyone with a trained ear can learn to operate it in minutes and be assured of professional results of outstanding fidelity, accuracy, and clarity. And while sonic excellence is surely the 900's most persuasive feature, flexibility runs a close second; for not only will the 900 operate with ¾" VCR's, but with VHS cassettes, too, with total safety and confidence, making it ideal for mastering digital audio discs and the increasingly popular hi-fi video discs.

The DAS-900 consists of four principal components.

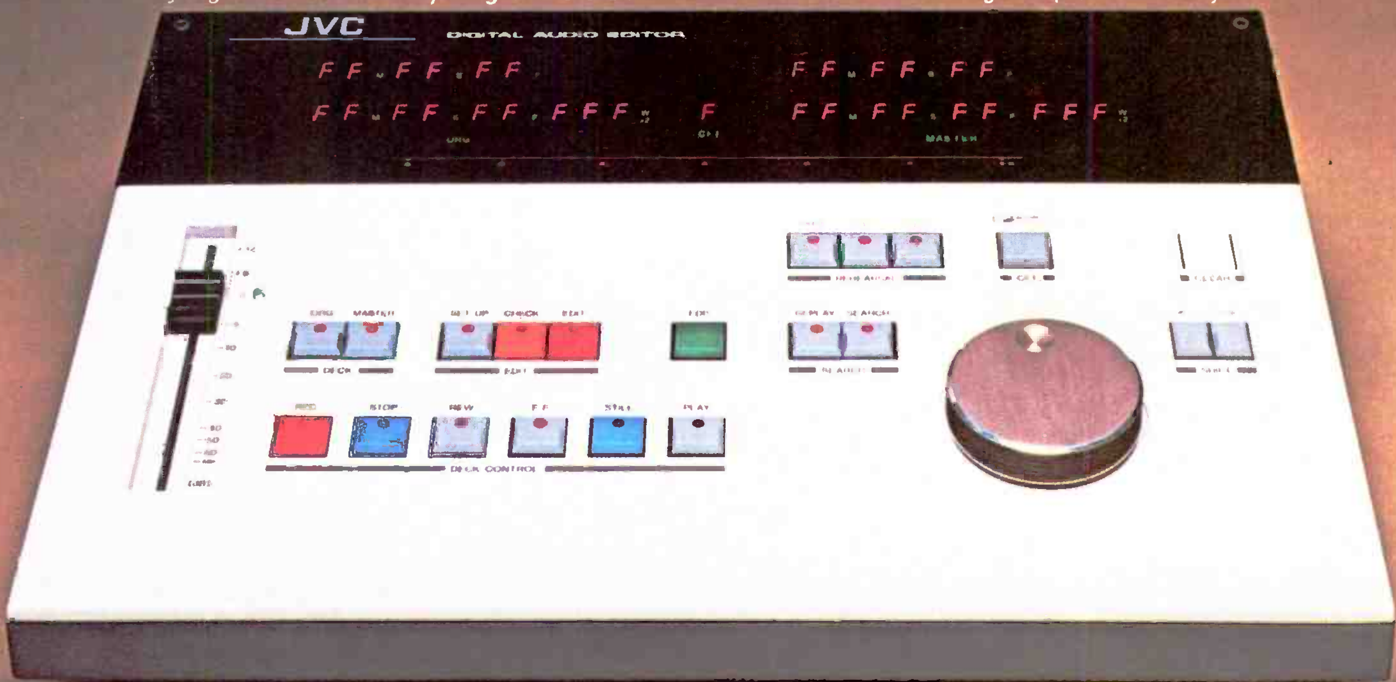
VP-900 Digital Audio Processor. Two-channel pulse count mode processor. Several 16-bit microprocessors make it compatible with other professional production equipment such as cutting lathes, synchronizers, and encoders. Dynamic range of more than 90 dB. Frequency response from 10 to 20,000 Hz (± 0.5 dB), and low recording bit rate of 3.087 Mbits/s at 44.1 kHz. Transformer-less analog I/O circuits further improve sound quality, and the analog-to-digital, digital-to-analog converter reduces distortion to less than 0.02 per cent, while an emphasis circuit improves signal-to-noise ratio. Logic circuit uses CMOS LSI chips for high reliability, compactness, light weight (48.6 lbs) and low power consumption.



Audio Editor Control Unit. Electronic governor for routing, coordinating, and executing all edit functions, both automatic and manual. All commands, from digital dubbing of original to master for continuous programs, to repetitive point-to-point manual cueing are regulated here.

TC-900V Time Code Unit. Actually two time code units in one, this unit reads and generates SMPTE standard time code and synchronizes the JVC exclusive BP (bi-parity) time code. Thus, the DAS-900 will operate effectively with both time codes; a necessity when the System is to be synchronized with video equipment.

AE-900V Digital Audio Editor. Simplicity itself to operate, this little number puts editing right in the hands of the artist, if need be. Precise to within microsecond accuracy, edit search can be carried out by manual cueing, automatic scan, or direct address. It will confirm cut-in, cut-out points independently by recalling signals stored in memory. Digital fade control for adjusting relative levels between original and master tape. Shift function for changing edit points backward or forward in 2-ms steps for super-fine adjustment. And variable-gradient cross-fading function for smooth continuity at the edit point, variable in 0, 10, 20, and 40 microsecond steps. Auto tape locate function enables the user to locate the desired address on the original tape, automatically.



For a demonstration of the DAS-900 Digital Audio System, a Spec Sheet, or JVC's complete catalogue, call, toll-free

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•When the time is right, an *output section* recalls the groups of bits and reconstitutes them into an analog form. A proc amp in the output section adds new burst and sync that coincide with local studio sync (Figure 2).

From incoming video, the input processor senses two parts of the signal, burst and sync. Off-tape burst is used to control a phase-locked oscillator (PLO). The oscillator runs nominally at 14.31818MHz, four times subcarrier, and determines the timing for sampling in the A/D converter. For any given line of video, the exact frequency may vary slightly from 14.31818MHz.

The input section also senses the leading edge of H-sync. From this point, a precise delay determines the *write start* point, where the A/D converter begins breaking the signal into bytes. The converter takes four samples during each cycle of subcarrier. When exactly 768 samples have been made, sampling stops for that line.

Memory control writes each group of bits into a buffer memory, as they are formed. Although video is serial in nature (as one line follows another one sample follows another), the eight bits of a sample move into memory in parallel (Figure 3). Each 8-bit sample goes into memory in sequence behind the previous sample, to wait until it is needed.

On the output side, when the *read start* point occurs, the first sample, from the write start point, is pulled from memory. Writing to memory followed the incoming video and for that reason probably happened at an uneven rate.

Reading, however, takes place every 69.8ns, precisely every ¼ cycle of output bursts. Any remaining vestige of time error is gone.

The output D/A converter changes the bits to an analog form and filters out all remnants of sampling (i.e., evidence that it was chopped into 256 discrete levels). New sync and burst complete the correction function.

Sync feedback

The secret of the TBC lies with the buffer memory and its capability for an uneven writing speed and a strictly regulated readout speed. But for the system to work, a sample must always be ready for readout. To assure that data are available, an advanced sync signal from the TBC drives the VTR servos. This forces the VTR to operate ahead of the TBC output.

Specifications for TBCs indicate that the memory capabilities of current models vary from two lines to 32 lines. This is the *correction window*. In theory, with the advanced sync feedback signal, the VTR keeps about half of the memory filled at all times. In other words, the time any particular sample stays in memory is approximately half of the memory capacity.

The DOC

On occasion, part of a line might be missing. Defects or dirt often result in momentary periods of no video read from the tape. Specks of black in the picture indicate such defects. *Drop out correction* repairs the signal by replacing missing video with information from an equivalent spot on a nearby line.

If information is taken from an adjacent line, the replaced video appears to be off color. In the NTSC signal, alternate horizontal lines of each field have a 180° shift in subcarrier. Thus

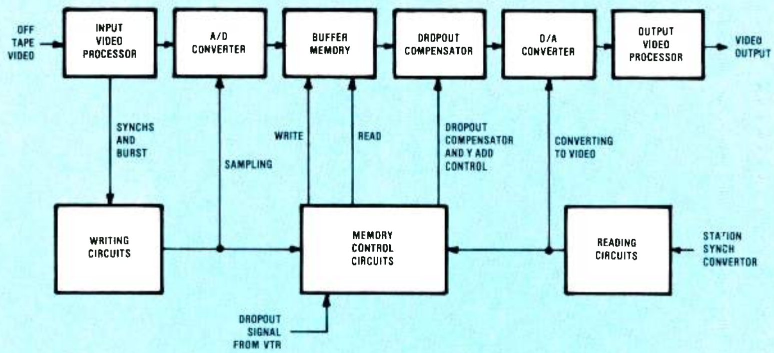
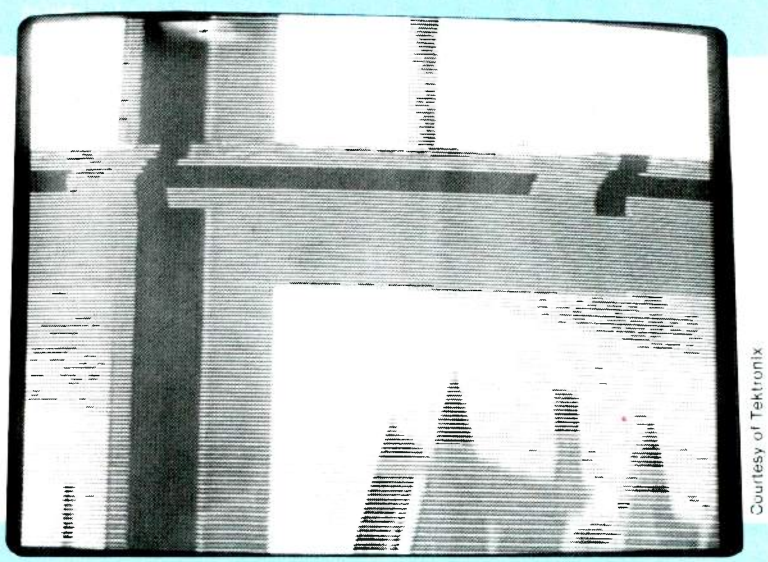


Figure 2. A generalized block diagram of a time base corrector.



Tension error, as shown in the vertical interval, from a VCR playback, is one of the corrections provided by a TBC.

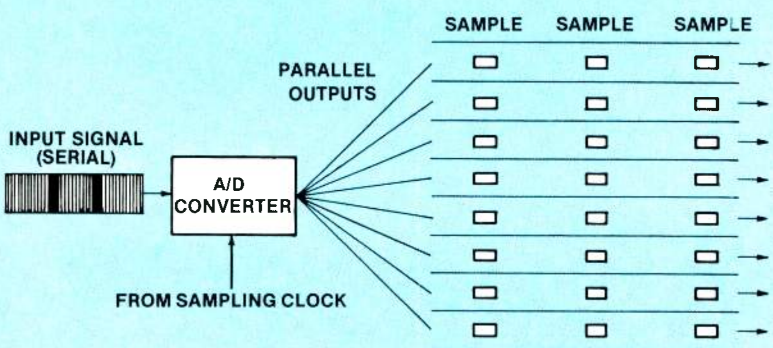
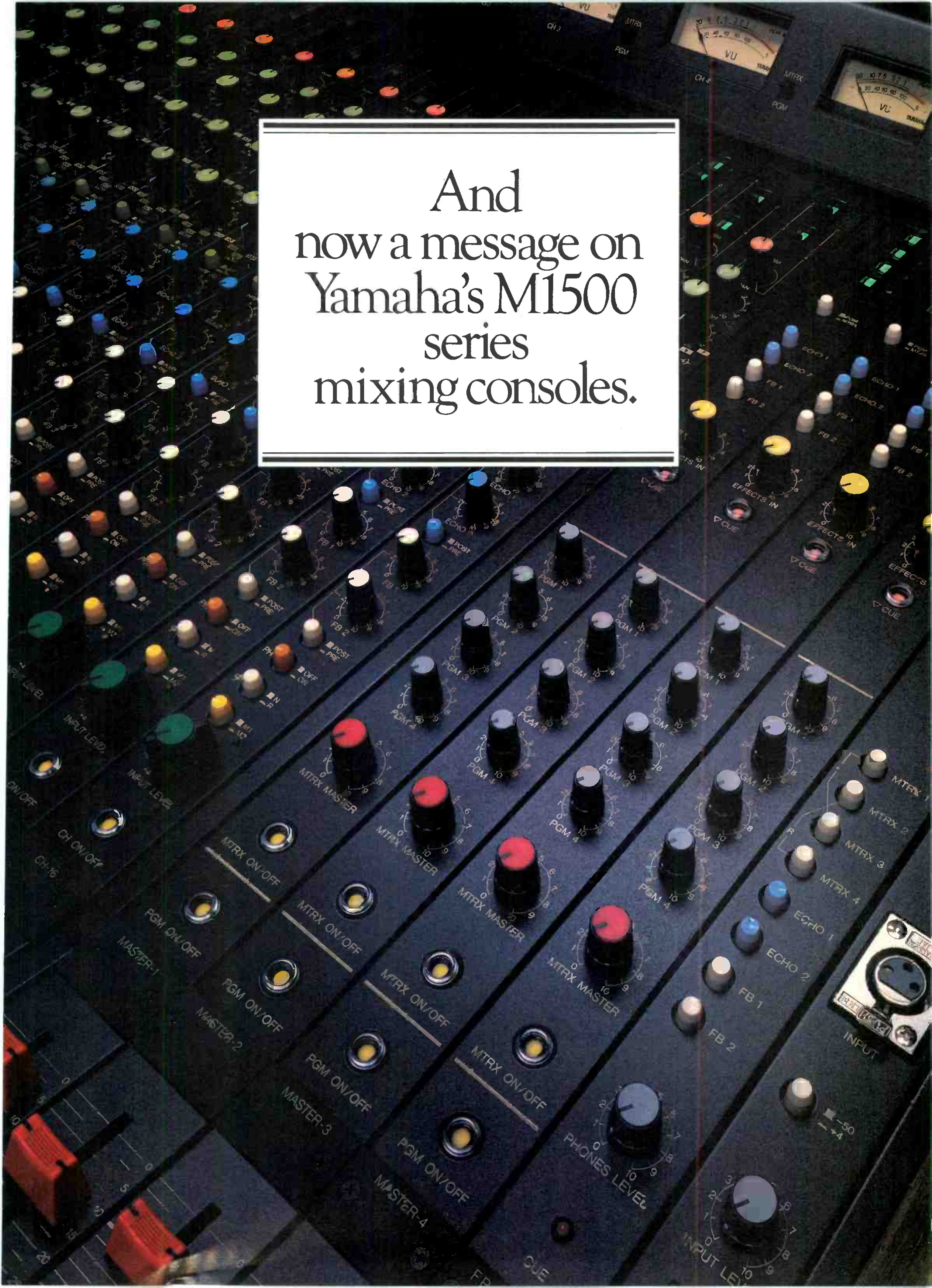


Figure 3. The analog signal, arriving at the A/D converter, is broken into samples. The eight bits (1s or 0s) in each sample travel in parallel to a memory location.


And
now a message on
Yamaha's M1500
series
mixing consoles.

M1516A

GENERAL SPECIFICATIONS

FREQUENCY RESPONSE +0, −3dB, 20Hz to 20kHz; +0, −0.5dB, 30Hz to 15kHz.

TOTAL HARMONIC DISTORTION (THD)*
Less than 0.5% @+10dB, 20Hz to 20kHz. Less than 0.1% @+20dB, 50Hz to 20kHz.

HUM AND NOISE* (20Hz to 20kHz, 150Ω source, Input Selector set at "−60")
- −128dBm Equivalent Input Noise (EIN);
- −95dB residual output noise with all Faders down.
- −73dB PROGRAM OUT (77dB S/N); Master Fader at nominal level & all Input Faders down.
- −64dB PROGRAM OUT (68dB S/N); Master Fader and one Input Fader at nominal level.
- −73dB MATRIX OUT; Matrix Mix and Master controls at maximum, one PGM Master Fader at nominal level, and all Input Faders down.
- −64dB MATRIX OUT (68dB S/N); Matrix Mix and Master controls at maximum, one PGM Master Fader and one Input Fader at nominal level.
- −70dB FB or ECHO OUT; Master level control at nominal level and all FB or ECHO mix controls at minimum level. (Pre/Post Sw. @ PRE.)
- −64dB FB or ECHO OUT (68dB S/N); Master level control and one FB or ECHO mix control at nominal level. (Pre/Post Sw. @ PRE.)

MAXIMUM VOLTAGE GAIN (Input Selectors set at "−60" where applicable)
PROGRAM & MATRIX 84dB; Channel In to the corresponding output. EFFECTS 20dB; Effects In to PGM Out.
FB & ECHO 94dB; Channel In to FB/ECHO Out. SUB IN 10dB; Sub In to PGM Out.

EQUALIZATION (±15dB maximum)
LOW: 50, 100, 200, 350, 500Hz, shelving. HIGH MID: 1.2, 2, 3.5, 5.7kHz, peaking.
LOW MID: 250, 350, 500, 700, 1000Hz, peaking. HIGH: 10kHz, shelving.

HIGH PASS FILTER 18dB/octave rolloff below 80Hz.

PHANTOM POWER For remote powering of condenser microphones, +40V DC can be switched on via a rear panel Master phantom power switch. When an individual Input Phantom switch is also On, voltage is applied to pins 2 and 3 of that input's balanced XLR connector.

DIMENSIONS/WEIGHT M1516A 34" W x 36 1/2" D x 14 1/2" H 147 lbs. M1524 55 3/4" W x 36 3/4" D x 14 1/2" H 213 lbs.
M1532 55 3/4" W x 36 3/4" D x 14 1/2" H 231 lbs.

*Measured with a 6dB/octave filter @12.47kHz; equivalent to a 20kHz filter with infinite dB/octave attenuation.

The specs shown are for the 16-channel M1516A console. When you need the same outstanding performance but more channels, there's the 24-channel M1524 and the 32-channel M1532. All three mixers have remote rack-mounted power supplies and are ideal for just about any fixed or portable sound reinforcement or broadcast application.

Of course, all three M1500 consoles have legendary Yamaha quality, reliability and craftsmanship. Which explains why you see Yamaha mixers wherever you look. Studios. Concert halls. Clubs. Theatres. Churches. We could go on, but you get the message.

For more information, write: Yamaha International Corporation, Combo Products Division, P.O. Box 6600, Buena Park, CA 90622. In Canada, Yamaha Canada Music Ltd., 135 Milner Ave., Scarborough, Ont. M1S 3R1.

YAMAHA

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the nearest, best probable match to the missing video is on the second line after the dropout.

In an image with much vertical detail, the 2-line discrepancy could prove unacceptable. In such cases, luminance from the line after the error and chroma from the second line are used. This approach is possible only in TBCs with separated luminance and chroma.

The separation is usually done by comb filtering in the input section, and parallel paths are provided for the two components through the correction process. While the complexity is increased with extra control and memory, the operation is similar to what has been described.

Non-standard VTR speeds

Standard play speed in Type C VTRs specifies a linear tape motion of 9.646 ± 0.047ips. Many of today's video machines may operate at other tape speeds for slow or fast motion. Locked images are possible from -1x to + 3x play speed, forward as well as reverse, and still motion. This implies a new problem.

Non-standard speeds mean that the video track on the tape no longer appears at the same angle across the tape at which it was written. The normal video head cannot read the video track properly.

Attempts to do so result in dropouts as the head traces part of one track, then the guard band between tracks and finally the next track. The solution is called *automatic scan* or *dynamic tracking*.

Auto scan tracking requires a head that moves at right angles to the video track. The mechanism for this places the video head chip on a piezo-electric mounting system. (See "Piezo-electric?", page 88.) In normal play, the head moves transversely only enough to keep the gap centered on the track it is reading.

As the linear tape speed varies, the head begins to move at right angles to keep the gap centered over the video track. If the linear speed is doubled, it would logically be only a short time until the entire TBC memory is filled to overflow.

For faster-than-normal operation, the dynamic tracking system causes the playback head to skip every other video field on the tape. For slower motion, the head will be instructed to trace each video track more than once.

With a different tape speed, the time length of each line is different. Each must still be digitized at a rate of four samples/cycle of subcarrier.

However, the apparent burst frequency is not longer 3.579545MHz, because the change in tape speed means an apparent change in off-tape burst. The input circuit of the TBC phase-locks to the new frequency to drive the sampling circuit at four times the new input burst frequency.

As with normal tape speeds, the output circuit of the TBC still clocks video out in step with the local sync generator. By skipping field on the tape, the output appears to present faster motion. If fields are read more than once, output video motion is slower.

Still-frame operation creates another condition. The head continues to read the same video field. NTSC requires that alternate fields have a half-line offset and subcarrier is reversed by 180° in each field.

The TBC is signaled by the VTR

How many samples per line?

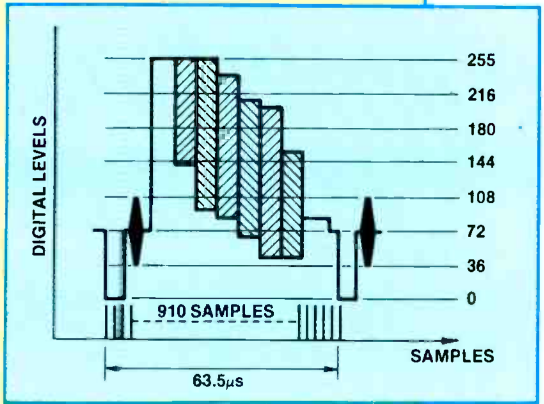
If you make a few calculations, you can determine how many samples occur along a video line. In one second, there are 3,579,545.45 cycles of color subcarrier. During the same second, 15,734.264 horizontal scan lines are traced on the screen.

The formula for the number of cycles of subcarrier in the time required for one TV line is:

• Cycles = Subcarrier (in Hz)/ Line rate = 227.5Hz.

If sampling is at four times the subcarrier, 14.31818MHz, then exactly 910 samples are possible.

Actually, some of the video line is not sampled. Horizontal sync and burst intervals will be replaced at the output of the TBC by standard sync from the local generator. Of the 63.555μs line, only about 53.64μs carries image information. The difference of 9.91μs is equivalent to 142 samples of 69.8ns.



Sampling a television line at 4fsc for NTSC.

Not all TBC systems use a 4x sampling clock. Some NTSC products use 3x, or 10.7386MHz. In PAL, both 3x and 4x subcarrier are used.

A trend in TBC and synchronizer products includes some production effects.

Systems may include front panel adjustments for horizontal and vertical sync timing, as well as selection of operating modes.

motion control circuit of this new condition and makes the compensation for the half-line offset in video.

Frame synchronizers

Video from the remote truck or from a satellite relay will not be in sync with studio signals. If a news segment calls for chroma-key or split screen between remote and local video, the two signals must be locked together. A frame synchronizer is called for.

Some synchronizers include a TBC card to handle any type of incoming video. Most, however, require that the nonsynchronous signal is in a standard format, just offset by some amount of time from local sync.

Essentially, the principle is the same as time base correction. The signal is digitized, placed in memory, delayed until timing relationships are correct and clocked from the memory as a stable video source.

The main difference between the TBC and frame synchronizer is in the size of the memory. While the TBC may have from two to 32 lines of memory, the synchronizer must be able to hold a complete frame of 525 lines. The added capacity does provide new capabilities.

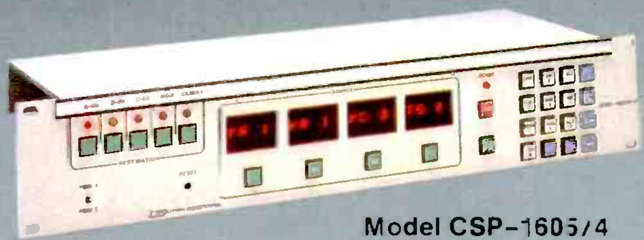
To freeze a frame, for example, input sampling is stopped. The readout continues to operate with what is held in the memory. This is an advantage both for production purposes and for emergencies. If the video input should fail, switches allow a selection of the last good frame or black.

The ability to control write and read clocks on a frame synchronizer leads to the standards converter. The input and output of the frame synchronizer are closely related, with only a fixed time offset between them. Changing from NTSC to PAL, however, introduces different parameters between the input and output. Lines of video may need to be created through interpolation of stored data. In other cases, data may need to be dropped.

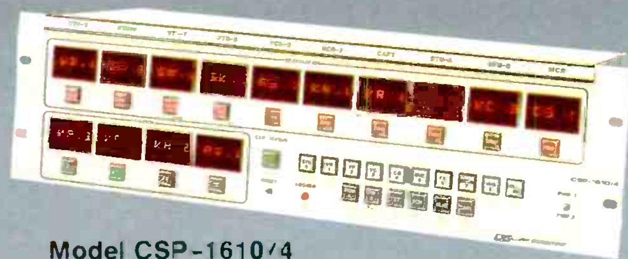
Beyond synchronizers

The capability to store a full frame of video with independent control of the writing and reading functions

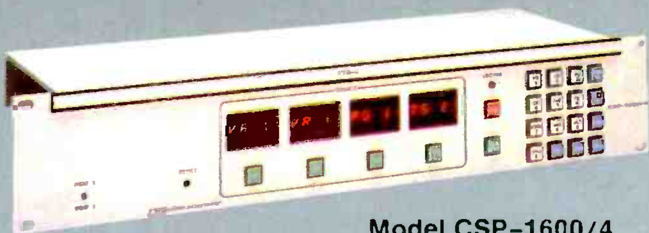
FOUR-LEVEL ROUTER CONTROLS
from
UTAH SCIENTIFIC



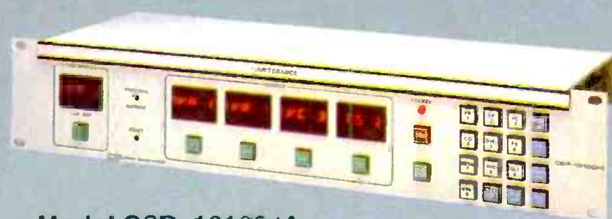
Model CSP-1605/4
Controls Five or Ten Busses



Model CSP-1610/4
Controls Ten or Twenty Busses



Model CSP-1600/4
Controls One or Two Busses



Model CSP-16160/4
Full Matrix Controller and Diagnostic Panel

This new series of microprocessor-based panels has been designed by Utah Scientific to meet the needs of the broadcast and teleproduction industries for individual control of source selection on multiple switching matrices (levels).

Each panel includes four alphanumeric displays to indicate either current *Status* (steady display) or a *Preset* source selection (flashing display) on each switching level. An alternate-action *Clear* button associated with each display plus an *All Clear* button permits toggling the displays between *Preset* and *Status* modes.

The touchpad features sixteen *group name* selections (beware of panels allowing for only ten) which, with either one or two *numeral* keystrokes, accommodates up to 1600 possible source names. Each panel can be provided with a *Program Select* switch that doubles the number of controlled busses at no extra charge.

Multi-bus panels provide instantaneous statusing of all four levels each time a new destination is identified. Instantaneous confirmation of changed status is also provided each time a new Take Command is entered.

The model CSP-16160/4 panel is specially programmed for maintenance/diagnostic duties as well as for full matrix control. It operates in either *alphanumeric* (source and destination names) or *numeric* (matrix input and output numbers) modes and can perform various diagnostic routines to permit rapid isolation of system faults.

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Circle (50) on Reply Card

Piezo-electric?

Various materials exhibit an unusual coupling between elastic and dielectric energy. Crystals for frequency control are good examples. A small bias voltage placed across a carefully formed piece of quartz oscillates. The frequency of oscillation is determined by the material's dimensions and the means in which it was cut from a larger quartz crystal.

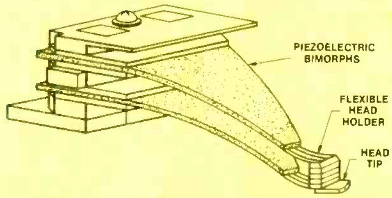
The effect is bidirectional. If a piece of quartz is placed under stress, a voltage develops across its surfaces. This is the concept involved in a crystal or ceramic phonograph pickup. Stress created by the stylus tracking the phono grooves is translated into electrical voltages, which are then amplified for the speakers.

In a VTR designed for still-frame or slow-motion modes, the video head is mounted in a cantalevered arrangement that involves a piezo-electric crystal. When the machine is in standard play mode, the head traces out normal tracks across the tape. Tracking servos alter capstan and head drum speeds to keep the video head centered in the narrow band of information recorded on the tape.

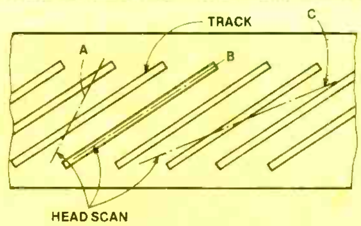
When altered speeds are used, a dc control voltages, related to the speed, is developed. The voltage, when applied across the piezo-electric crystal holding the head, changes its shape (oscillates) and moves the head up and down.

By this mechanism, the head is aided in tracing out the video tracks that have essentially changed with the effective change in tape speed.

Actually, some control voltage may be applied to the crystal material even during normal play speed to aid in maintaining the best possible tracking. The primary activity of the crystal material, however, occurs when forward or reverse speeds other than normal play and stop motion are desired.



A generalized structure of a VTR video head for dynamic tracking. Use of two piezo-electric parts keeps the head tip surface aligned properly with the tape surface.



In normal play, the video head traces track B to reproduce the video signal. As tape motion is increased or decreased for non-standard speeds, the tracks may appear as in A or C. A voltage applied to a head mount causes the scan path to take the new direction of A or C.

gives rise to other production tools. Digital effects systems and free-form graphics units both use some of the sample principles of frame synchronization. Both present much more complex control problems, however (Figure 4).

In the effects system, correct video is constantly clocked into and out of memory. By using more than one memory, more than one image may be stored. By reading selectively from the multiple memory planes, parts of each image are combined in the output.

Control for such systems is handled by a computer. The computer does the high speed calculations necessary for the desired effect and talks to the memory control system. Memory control handles the rearrangement of complete bytes of data within the frame buffer memory.

Effects systems may depend upon additional memory to store effects instructions. Designated function or soft programmable keys on the control panel allow one key access to the effects programs.

Graphics systems require a different control plan. With a frame of video held in the memory, the control computer gives the operator access to the memory. System software allows stored pixels to be duplicated, altered and replaced.

Individual bits may be changed from 1s to 0s, for example, to change the color of an individual pixel. Limitations appear to be the imagination of software engineers who program the control systems.

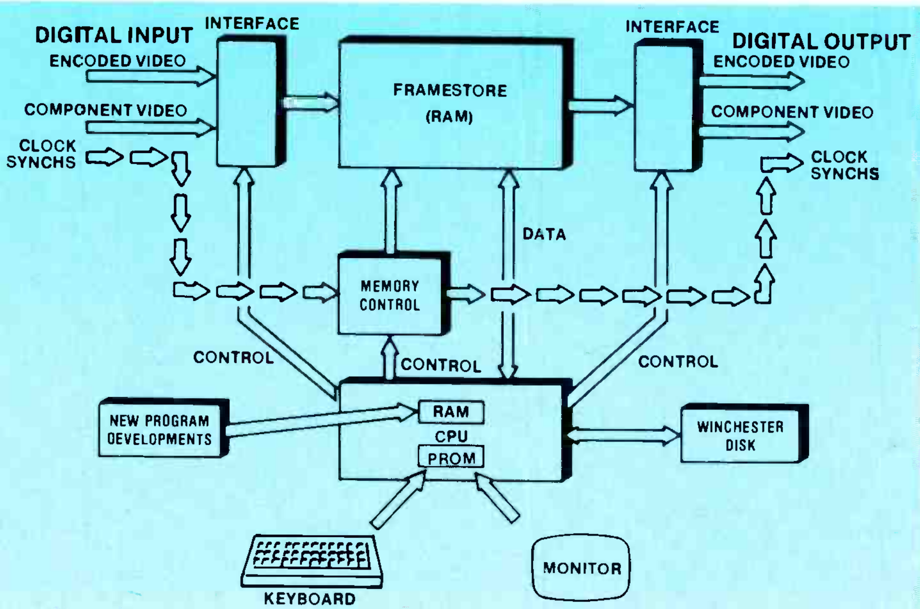


Figure 4. Centered on a large RAM storage area, the image processing system includes control of the data in memory. In this diagram, instructions for the desired effects are provided through a keyboard to the computer CPU, to the memory control and finally to the frame-store.

Constant time

Television requires constant repetition and accurate timing. Time base correction achieves the necessary constancy through memory buffering and controlled data writing and reading.

The evolution of those principles with the marriage of computer control has produced a series of video production tools for both on-line and off-line uses. Creative use of these tools revolves around control of the time-related parameters of the video signal.

Yet one factor remains true for TV. Time must remain constant.

Audio time base correction

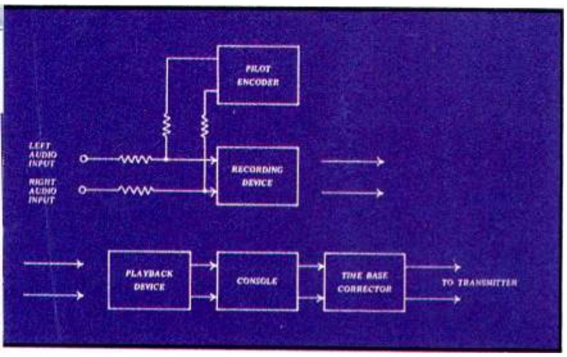


Figure 1. Block diagram of the basic ATBC pilot encoder and corrector system.

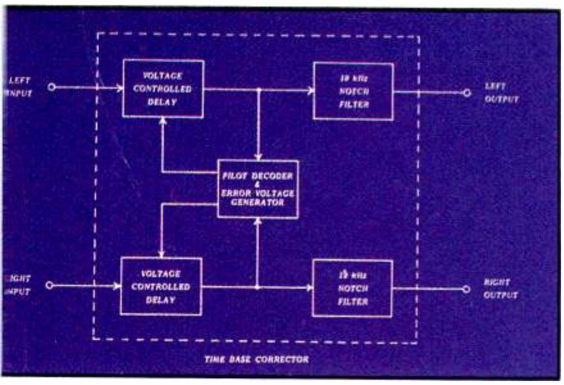


Figure 2. Block diagram of the ATBC corrector unit.

By John Pate, staff engineer,
WSM Radio, Nashville, TN

Using stereo cartridges has become widespread in FM radio stations. Because of the movement toward AM stereo and multichannel TV sound, the use of stereo carts will continue to increase. The best carts and cart machines available today are the results of more than a quarter-century of technical evolution. Their performance, in many respects, is equal to the best reel-to-reel tape machines.

If you compare the best cart equipment available and the original machines introduced at the 1959 NAB, the advances that have been made become strikingly apparent.

However, equally apparent is the similarity that still exists between the machines.

For each generation of cart machines to be compatible with the previous generation, the basic design of the tape cartridge has remained unchanged. It is still a center-pull, endless-loop, external pinch roller tape cartridge of the same basic specifications that was introduced 26 years ago.

Here lies a problem. The achievable mechanical tolerances of this tape packaging system are simply not good enough to ensure that the stereo interchannel delay error will consistently be low enough to preclude some degree of mono-sum high frequency loss.

Several years ago, WSM started a project to find a solution to the problem of stereo interchannel delay error in carts without producing objectionable side effects. The idea was to build an *audio time base corrector* (ATBC).

Time base correction is not new. Television has used TBCs for many years. For a time base error corrector to work, however, it must have a recorded time reference signal. In video applications, the horizontal sync pulses serve this purpose well. In audio applications, however, there is no signal. Therefore, we developed an ATBC *pilot signal*.

In our system, we proposed to build an ATBC pilot encoder that would generate an inaudible pilot signal, which would be inserted at a low level with the audio on the regular left and right channels of our cart machines. The pilot encoder would be located in the production room where the carts were recorded (Figure 1).

As these carts were later played back on the air, the pilot signal would travel along with the audio from the playback machines, through the air console and down the program line. Inserted in the program line before the limiter would be the ATBC.

Its function would be to make the necessary time base correction by extracting and reading the information contained in the inaudible pilot signal. When the pilot signal was not present, the ATBC would go into a non-correcting state.

This system would provide many obvious advantages. First, only one correction device would be needed for an entire system, regardless of how many tape machines or air studios were in use. The pilot encoder (one required for each production room) would be simple, inexpensive and automatic. Our existing carts and cart machines could be used without modification.

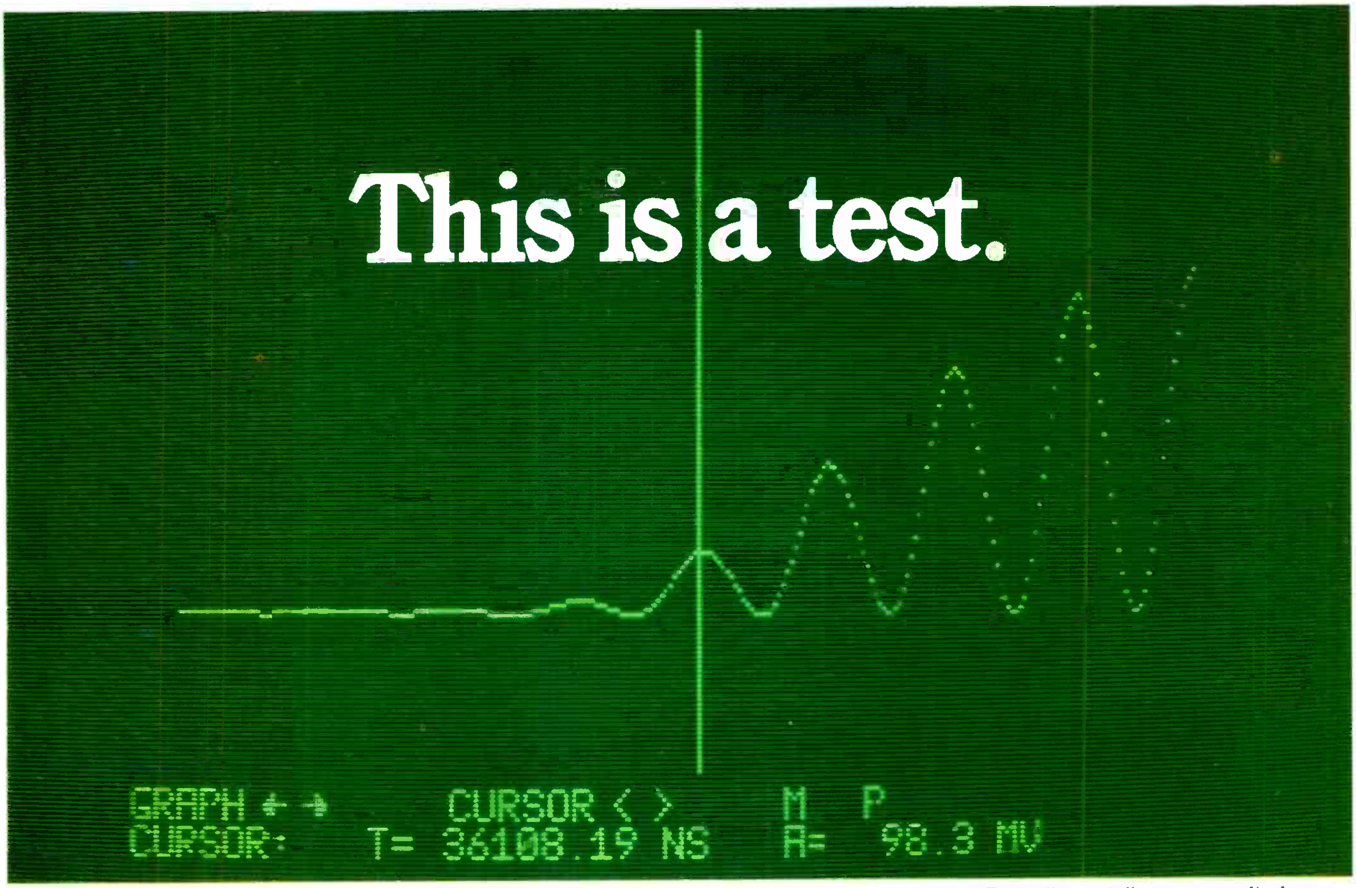
Installation of the system would be simple and its operation would be automatic. Pilot encoded carts could be phased into the system because the ATBC would automatically distinguish which carts were encoded and which ones were not.

Building the ATBC

The first step in the project was to test our concept for the pilot signal. We had to determine whether its use would cause any undesirable side effects. Our goal was a pilot signal that could be easily recorded on any cart machine and convey the necessary time reference information to the corrector, which was to be located in the program line. The pilot also had to be inaudible, not interfere with the operation of any other equipment and not degrade the quality of the recorded audio.

After considerable testing, we

This is a test.



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decided on the following specifications for the pilot signal: a 19kHz sine wave, 60% double sideband amplitude modulated by a 300Hz sine wave, injected into the program audio at a level 27dB below 0VU. This may sound rather complicated, but it is really quite simple to generate.

The first pilot encoder was a 1.5" x 6" module that plugged into our production console. It had two buttons labeled *pilot on* and *pilot off*, and a red LED that came on when the pilot was on.

Remote control connections were also provided for the module, which allowed the pilot to be automatically turned on when the cart machine's *record preset* button was pushed, and turned off when the record cart machine's *secondary cue* button was pushed. In this way, any number of pilot-encoded carts could be played sequentially without pilot overlap.

Performance tests on the pilot tone signal indicated that our goals had been met. We could detect no change in distortion, headroom, S/N ratio, frequency response or separation. In addition, the pilot was inaudible and did not have any detectable effect on the air console, switcher, distribution amplifiers, processing gear or FM stereo generator. Because the pilot was injected at a low level, it didn't even show up on the VU meters.

Now that we had determined that the presence of the pilot signal didn't cause anything *bad* to happen, we began construction of the ATBC itself to learn if the pilot could cause something good to happen. Our concept of the ATBC was to use two short (in the millisecond range) voltage controlled delay lines, one inserted in each channel (Figure 2).

Circuits were included that extracted the pilot signal as it reached the outputs of the delay lines. The 300Hz modulation of the pilot was detected in each channel and compared. One of the voltage controlled delay lines were then either increased or decreased, as necessary, until the 300Hz AM signals were in perfect phase. In this way, all delay errors were corrected, regardless of their source.

Rather than design and construct our own delay lines, we obtained a pair of Deltalab DL-3 digital delay lines and modified them for an external clock input. The remainder of the ATBC was built in our engineering shop.

Ready to go

When the ATBC was completed, the initial results were exciting. The output of a cart machine was connected to the input of the ATBC and the output of the ATBC was connected to an oscilloscope set up for a Lissajous display.

The scope showed the familiar diagonal line of an in-phase Lissajous pattern when reproducing an 8kHz tone that had been recorded along with the pilot tone. The playback azimuth screw was then moved about an eighth of a turn and the pattern instantly jumped through a full circle to a diagonal line in the opposite direction, indicating a 180° phase shift.

But then an amazing thing happened. The line gradually opened back up into a circle and then closed again to a perfect in-phase line. About two seconds after the deliberate misadjustment of the azimuth screw, the ATBC had made a complete delay correction. The delay error correction meter on the front panel was reading 62μs, which agreed with what we observed on the oscilloscope.

More tests and refinements were made on the bench, and soon the unit was put into operation on the air. By that time, a large number of carts had been encoded with the pilot. Instantly, our mono-sum problems were gone. Now, all carts sounded as bright on

mono receivers as they did on stereo receivers.

The most surprising thing we learned was the extent of the problem we had just solved. As the cart played through the ATBC, the amount of delay correction could be read directly on the meter. More than ⅔ of the carts we were playing exceeded 17μs delay error (3dB mono sum loss at 15kHz). Some were off as much as 100μs. This occurred in spite of the fact that WSM has always used top-quality, well-maintained cartridge equipment.

Our normal maintenance procedure had been to remove each playback machine every eight to 12 weeks and, among other things, check stereo phase against a reference cart. We would typically see a 0 to 60° (at 15.8kHz) change over this period. We had assumed, incorrectly, that the vast majority of the carts we played back on the air fell within this range.

The *delay error correction* meter on the ATBC revealed, however, that the problem was much worse. The difference was apparently due to the control room carts being played more often and handled more roughly than our reference cart.

Flutter correction

After several weeks of testing, the ATBC was removed from service for the installation of the second portion of the time base correction circuitry. The goal of this modification was to eliminate flutter, another time base error. Because the pilot signal originates from a crystal oscillator, its carrier frequency is stable.

Circuits were added to the ATBC that measured the frequency modulated content of the 19kHz pilot carrier at the output of the delay lines. The frequency modulated component correlates to flutter and is used to generate a signal which is fed back to the control input of the delay lines.

Once this circuit was completed, we tested it on a 3-deck cart machine. At the output of the cart machine we measured 0.12% weighted flutter, but at the output of the ATBC we measured just 0.034% weighted flutter. Spectral analysis indicated that the 7.5Hz component of the flutter (induced by the capstan) was reduced by approximately 20dB.

When the ATBC was put back in the program line, the changes were immediately apparent. It was impossible to listen over the air and tell the difference between music from discs and music from carts. At the following (1981) NAB convention, I gave a paper on the subject of audio time base correction to a small but interested group of broadcasters and manufacturers.

It had been interesting to note the progress of carts and cart machines since the ATBC was developed at WSM. In 1985, the carts themselves still seem to be the greater problem in terms of phase error. Although WSM continues to use the best available carts and cart machines, a check of the delay error correction meter on the ATBC reveals that not much progress has been made in reducing long-term stereo phase error for carts in everyday use.

The system today

The original ATBC has now been partially recanabalized and is in storage at our transmitter. It has been replaced by a more refined and technically sophisticated unit with delay lines using the latest 16-bit A/D technology and RAM storage. The latest version of the ATBC consumes only 5¼ inches of rack space, compared to 12¼ inches for the original unit.

The ATBC has put in tens of thousands of hours of service. It has also been successfully tested at other stations. The audio time base corrector is an idea whose time has come. ▮

Troubleshooting

The 1/2-wavelenth PA cavity

By Clarence Daugherty, senior broadcast technology instructor, Harris, Quincy, IL,
and Jerry Whitaker, editor

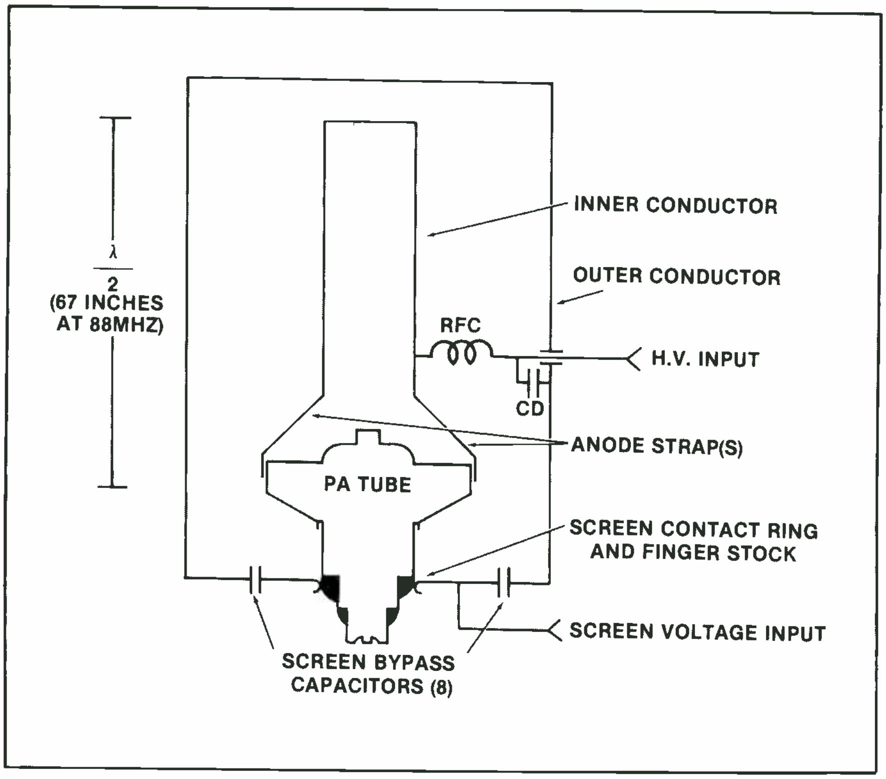


Figure 1. The ½-wavelength PA cavity in its basic form.

The ½-wavelength PA cavity has been used extensively in FM transmitting equipment. The design can take a number of forms, but the underlying theory of operation remains.

The design of a basic ½-wavelength PA cavity is shown in Figure 1. The tube's anode and a silver-plated brass pipe serve as the *inner conductor* of the ½-wave transmission line, and the cavity box serves as the *outer conductor*. The transmission line is open at the far end and repeats this condition at the plate of the tube. The line is, in effect, a parallel resonant circuit for the PA tube.

The physical height of the circuit shown in Figure 1 (67 inches) was calculated to operate at 88MHz. To allow adequate clearance at the top of the transmission line and space for input circuitry at the bottom of the assembly, the complete cavity box would have to be almost eight feet tall. This is too large for any practical transmitter.

Figure 2, page 108, shows RF voltages, current and impedance for the inner conductor of the transmission line and the anode of the tube. The load impedance at the plate is many thousands of ohms. The RF current is, therefore, extremely small and the RF voltage is extremely large. In the application of such a circuit, arcing would become a problem. The high plate impedance would also make amplifier operation inefficient.

Figure 2 also shows an area between the anode and the ¼-wavelength location where the impedance of the circuit is 600Ω to 800Ω. This value is ideal for the anode of the PA tube. To achieve this plate impedance, the inner conductor must be less than a full ½-wavelength. The physically fore-

Continued on page 104

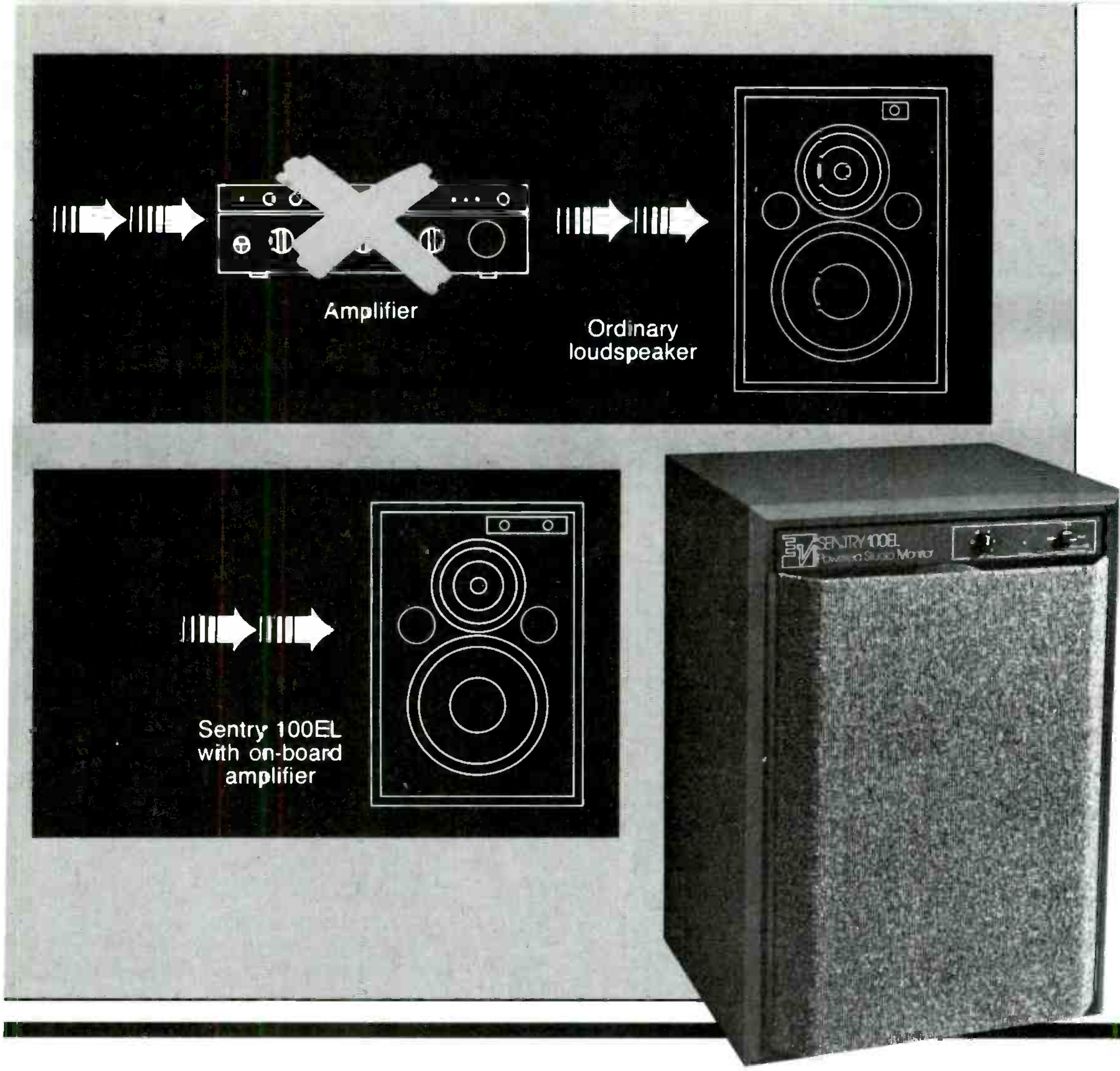
Troubleshooting suggestions

We continue last month's discussion of transmitter plate supply overload problems. Occasional plate trip-offs (one or two a month) generally are not cause for concern. Most of these occurrences can be attributed to power line transients.

More frequent trip-offs, however, require a closer inspection of the transmission system. For discussion purposes, we assume the plate supply overload occurs frequently enough to make continued operation of the transmitter difficult.

Repair work on a transmitter that is experiencing high voltage

Continued on page 98



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Continued from page 96

trip-off problems begins with a series of preliminary troubleshooting steps, including:

- Switch the transmitter to local control.
- Switch off the automatic recycle circuit (so that the transmitter will not restart after a fault).
- Determine the exact fault condition and failure history.
- Check all low voltage systems for proper operation.
- Inspect the internal circuitry for any obvious signs of failure.
- Check to see if the problem is caused by an antenna or transmission line failure.
- Determine whether the overload is RF- or dc-based.
- Examine the fault sensor circuit to determine within what limits component checking will be needed.
- Substitute a spare PA tube for the original tube if tests show the possibility of tube failure.
- Check for short circuits using an ohmmeter in suspected areas of the power supply.

These preliminary steps were discussed in previous "Troubleshooting" columns.

If the plate overload trip-off is dc-based, cannot be corrected using the previously listed procedures and occurs only at elevated voltages, it may be necessary for you to use the process of elimination to repair the system.

Process of elimination

This troubleshooting method involves isolating various portions of the circuit—one section at a time—until you find the defective component. However, special precautions are required:

- Never touch anything inside the transmitter without first removing all ac power and then discharging all filter capacitors with the grounding stick.
- Whenever you disconnect a wire, temporarily wrap it with electrical tape and secure it so that it will not arc-over to ground or another component when power is applied.
- Never perform this type of troubleshooting work unless another person is with you.
- Analyze each planned test before it is conducted. Every test in the troubleshooting process requires time, and so steps should be arranged to provide you with the greatest amount of information about the problem.
- Check with the transmitter manufacturer to find out what testing procedures the company recommends. Ask what special precautions should be taken.

Troubleshooting the high voltage plate supply is usually done under the following conditions: exciter off, plate and screen voltages for *all previous stages* off, PA screen voltage off. Individual transmitters may require different procedures. Check with the manufacturer first.

The figure on page 100 shows a diagram of a transmitter high voltage power supply. Begin the troubleshooting process by breaking the circuit at point A. If the overload condition persists, the failure is caused by a problem in the power supply itself, not in the PA compartment.

If, on the other hand, the overload condition disappears, a failure in the feedthrough capacitor (C1), decoupling capacitors (C2, C3) or blocking capacitor (C4) is indicated.

If a problem is indicated in the PA compartment, reconnect the high voltage supply line at point A and break the circuit at point B. A return of the overload problem would indicate a failure in one of the decoupling capacitors or feedthrough capacitor.

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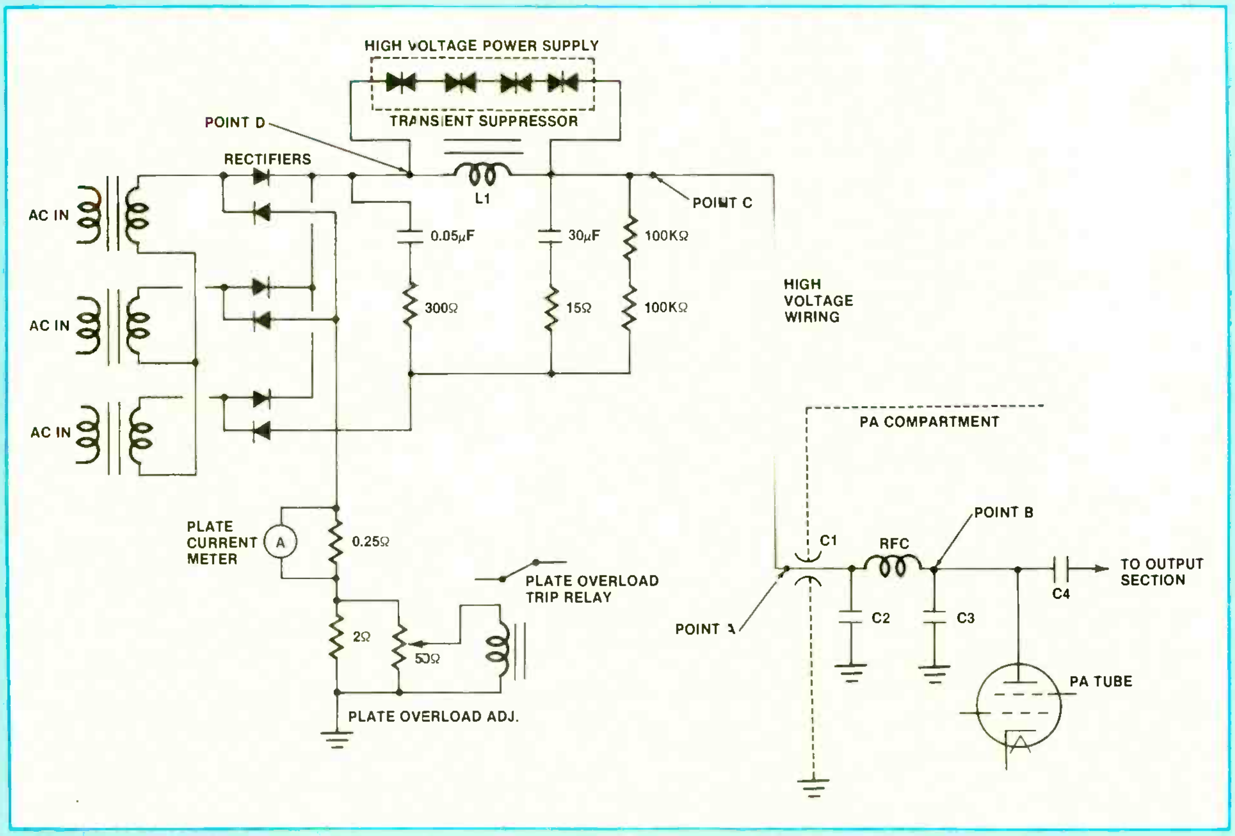

A common broadcast transmitter high voltage 3-phase power supply circuit.

In order to avoid unnecessary effort and time in troubleshooting, use the process of elimination to identify *sections* of the circuit to be examined. If, for example, the test at point A had indicated the problem was not in the load, but in the power supply, a logical spot to perform the next test would be at point C (for long high voltage cable runs). This test would identify or eliminate the interconnecting cable as a cause of the fault condition.

If the cable run from the high voltage supply to the PA compartment is short, point D might be the next logical point to check. Breaking the connection at the input to the power supply filter assembly allows the rectifiers and interconnecting cables to be checked.

Components protected by transient suppression devices (as shown above L1) should be considered a part of the component they are designed to protect. If a choke is removed from the circuit for testing, its protective device should also be removed. Failure to remove both connections could damage the protective device.

To avoid creating a new problem while trying to correct the original failure, break the circuit in only one point at a time. Also, study the possible adverse effects of each planned step in the process. Disconnecting certain components from the circuit may cause overvoltages or power supply ripple that may damage other components in the transmitter. Consult the manufacturer to be sure.

Safety considerations

Perform any troubleshooting work on a transmitter with extreme care. Transmitter high voltages can be lethal. Such work should be performed only when a second engineer is with you.

Perform work inside the transmitter only after all ac power has been removed and after all capacitors have been discharged using the grounding stick provided with the transmitter. Remove primary power from the unit by tripping the appropriate power distribution circuit breakers in the transmitter building. Do not rely on internal contactors or SCRs to remove all dangerous ac.

Be familiar with first aid treatment for electrical shock and burns. Always keep a first aid kit on hand at the transmitter site.

Do not defeat protective interlock circuits. Although defeating an access panel interlock switch may save work time, the consequences can be tragic.

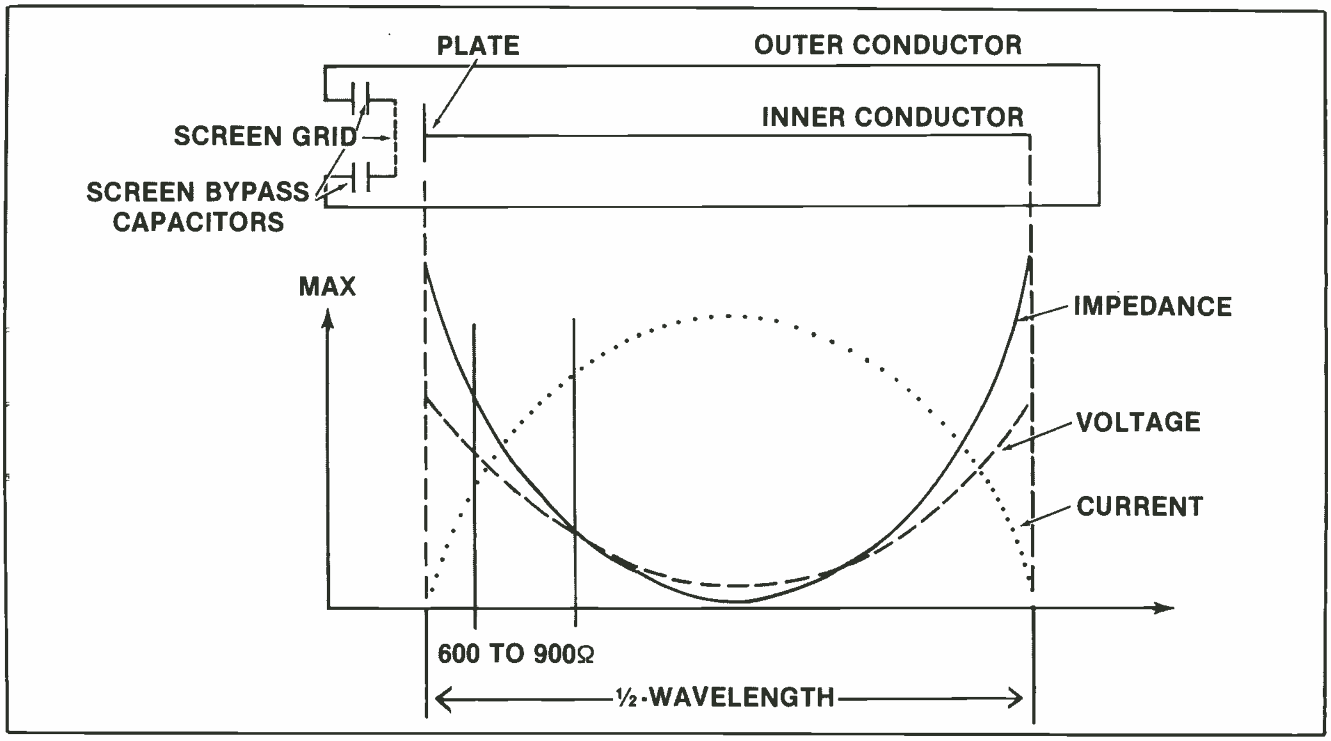

Figure 2. The distribution of RF voltage, current and impedance along the inner conductor of a ½-wavelength cavity.

shortened transmission line circuit must, however, be *electrically resonated* (lengthed) to ½-wavelength for proper operation.

If the line length were changed to operate at a different frequency, the plate impedance would also change because of the new distribution of RF voltage and current on the new length of line. The problem of frequency change, therefore, is twofold: The length of the line must be adjusted for resonance, and the plate impedance of the tube must be kept constant for good efficiency.

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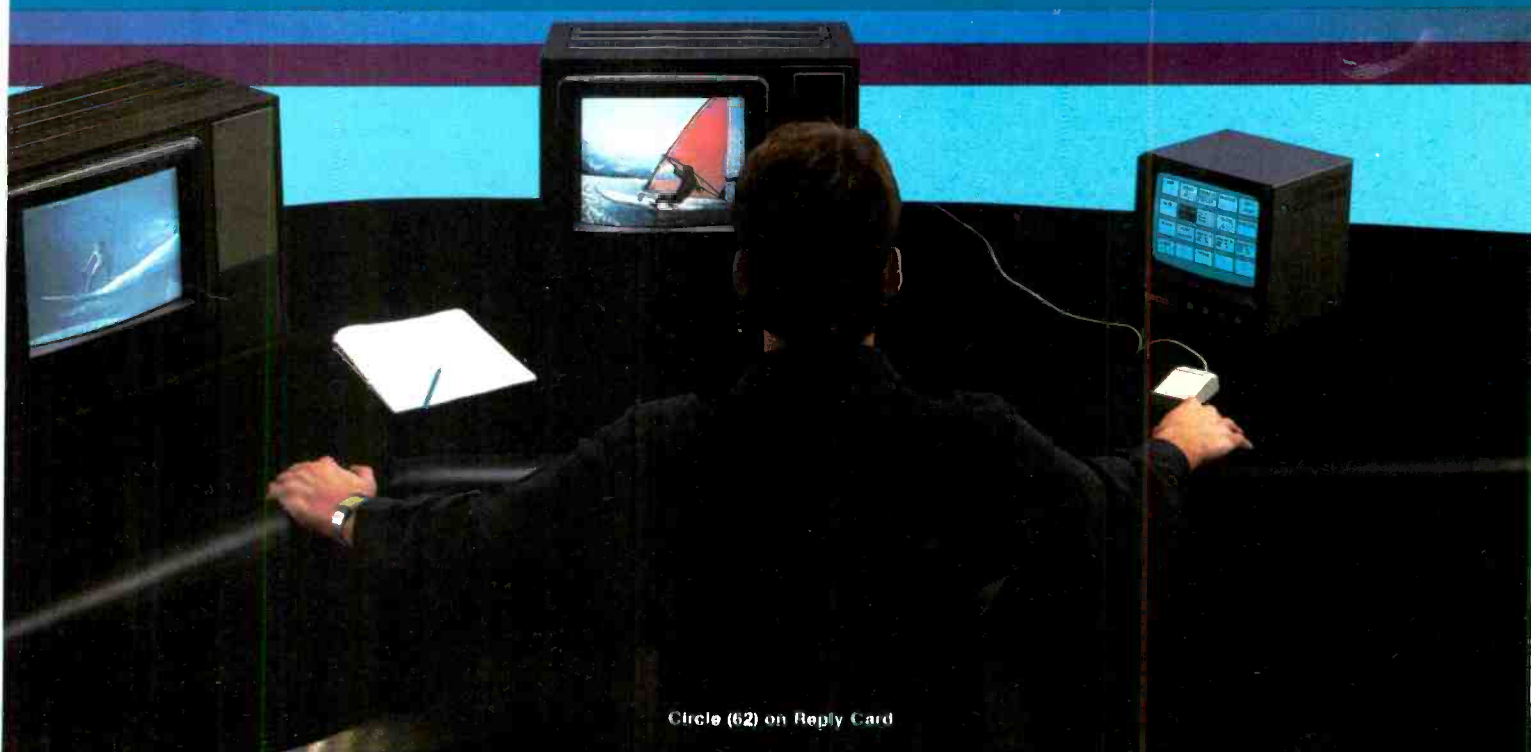

Circle (62) on Reply Card

A practical cavity

To accommodate operation of the transmitter at different frequencies while keeping the plate impedance constant, two forms of coarse tuning and one form of fine tuning are built into the ½-wave PA cavity.

Figure 3 shows the tube and its plate line (inner conductor). The inner conductor is U-shaped to reduce the cavity height.

With the movable section (the *plate tune control*) fully extended, the inner conductor measures 38 inches and the anode strap measures seven inches. The RF path from the anode strap to the inside of the tube plate (along the surface because of the *skin effect*) is estimated to be about eight inches. This makes the inner conductor's maximum length about 53 inches.

This is too short to be a ½-wavelength at any FM frequency. The full length of a ½-wave line is 54.7 inches at 108MHz and 67.1 inches at 88MHz.

The coarse tuning and fine tuning provisions of the cavity, coupled with the PA tube's output capacity, resonate the plate line to the exact operating frequency. In effect, they electrically lengthen the physically foreshortened line. This process, along with proper loading, determines the plate impedance and, therefore, the efficiency.

Lengthening the plate line

The output capacity of the tube is the first element that electrically lengthens the plate line. A ½-wave transmission line that is too short offers a high impedance that is both resistive and inductive. The tube's output capacity resonates this inductance. The detrimental effects of the tube's output capacity are eliminated.

Another element that will electrically lengthen the line is the stray capacitance between the movable section (plate tune) and the cavity box (the outer conductor).

The anode strap and the cavity inner conductor rotary section provide two methods of coarse frequency adjustment for resonance.

The anode strap (shown in Figure 3) has less of a cross-section than the inner conductor of the transmission line. It, therefore, has more inductance than an equal length of the inner conductor. The anode coupling strap acts as a series inductance and electrically lengthens the plate circuit.

At low frequencies, one narrow anode strap is used. At mid-FM frequencies, one wide strap is used. The wide strap exhibits less inductance than the narrow strap and does not electrically lengthen the plate circuit as much.

At the upper end of the FM band, two anode straps are used. The parallel arrangement lowers the total inductance of the strap connection and electrically lengthens the plate circuit only a small amount.

There are two ways to view the action of the rotary section in the plate circuit. It can—in effect—be thought of as either a variable capacitor or a variable inductor.

Variable capacitor theory

The main portion of the plate resonant line and the rotary section can be thought of as a single transmission line with an expanded conductor area, regardless of the rotor position.

The capacity of the rotary section is greatest when the assembly is closest to the cavity box (outer conductor). It is least when the assembly is furthest from the outer conductor. This shunt capacity electrically lengthens the line and lowers the resonant frequency. The amount of frequency change depends on the position of the rotary section.

Variable inductor theory

The main section of the plate resonant line, together with the rotary section, can also be thought of as a

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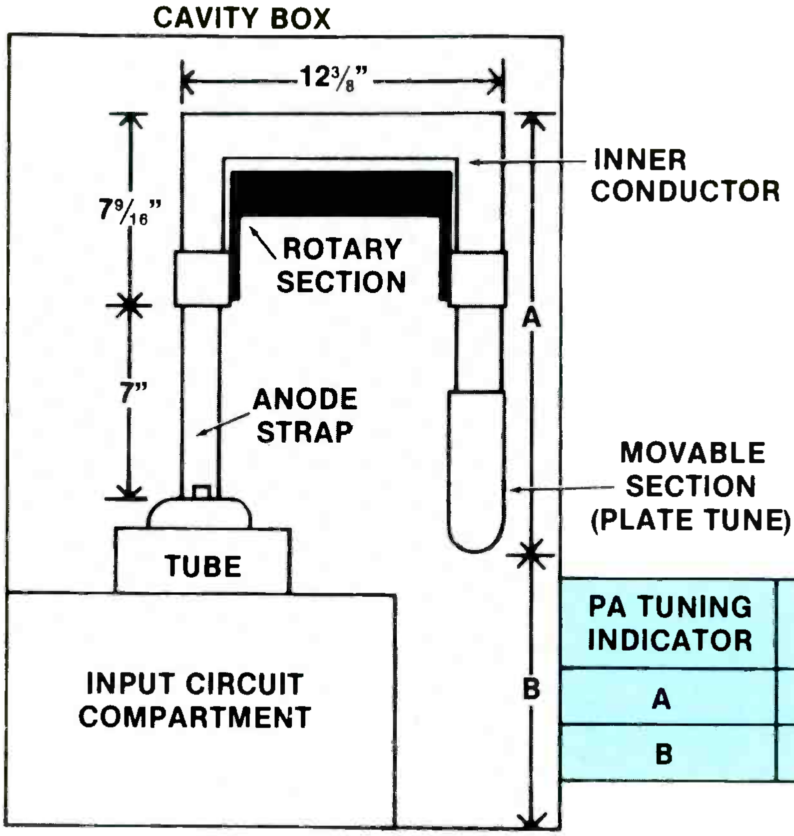

PA TUNING INDICATOR	000	MAX
A	18 1/16	13¾
B	8 1/16	12⅜

Figure 3. The configuration of a practical ½-wavelength PA cavity.

parallel inductance.

RF current flows in the same direction through the transmission line and the rotary section. The magnetic fields of the two paths, therefcre, add.

When the rotary section is at minimum height, the magnetic coupling between the main section of the transmission line and the rotary assembly is maximum. Because of the relatively large mutual inductance provided by this close coupling, the total inductance of these parallel inductors increases. This electrically lengthens the transmission line and lowers the resonant frequency. The concept is illustrated in Figure 4(a).

When the rotary section is at minimum height, the magnetic coupling between the two parts of the inner


THE "THIRD" TRACK
FEATURED ACTOR: A810 TC
TAPE FORMAT: 1/4"
AUDIO TRACKS: 2 (STEREO OR 2 TRACK)
CODE TRACK: THE "THIRD" TRACK
CODE FORMAT: SMPTE/EBU
CROSSTALK CODE-AUDIO: >90dB
OFFSET: ZERO
OFFSET COMPENSATION: µP-CONTROLLED DELAY LINE
COINCIDENCE: EXTREMELY PRECISE

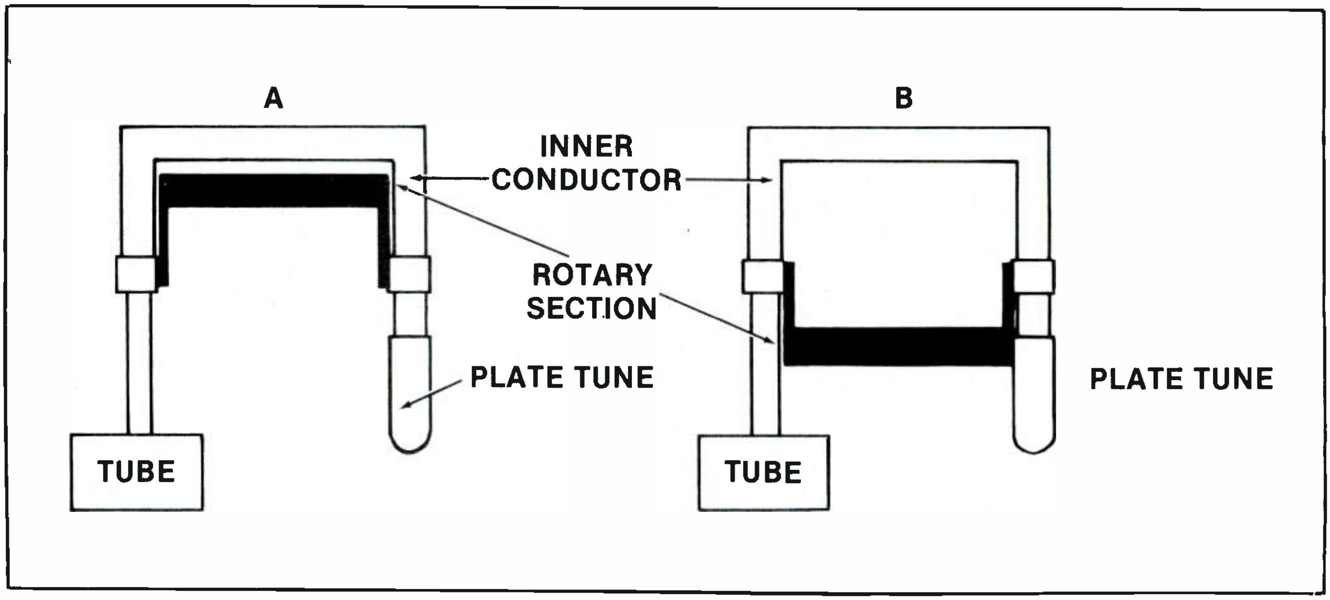

Figure 4. Using the cavity's movable section to adjust for resonance. Diagram (A) shows the rotary section at maximum height and (B) shows the rotary section at minimum height.

conductor is minimum. This reduced coupling lowers the mutual inductance, which lowers the total inductance of the parallel combination. The reduced inductance allows operation at a higher resonant frequency. This condition is illustrated in Figure 4(b).

The rotary section provides an infinite number of coarse settings for the various operating frequencies.

Plate tuning

The movable plate tune assembly is located at the end of the inner plate transmission line. It can be moved up and down to change the physical length of the inner conductor by about 4 11/16 inches. This assembly is linked to the front panel plate tuning knob, providing a fine adjustment for cavity resonance.

March's "Troubleshooting" will continue the discussion of the ½-wavelength PA cavity.

The unique Calrec Soundfield Microphone MK IV

THE FEATURES

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- ☐ **Variable stereo capsule angle and polar pattern in POST PRODUCTION, off tape.**
- ☐ **Variable zoom, both forwards and backwards, in POST PRODUCTION, off tape.**
- ☐ **The only truly coincident stereo microphone in the world.**
- ☐ **Very low noise performance for the digital era.**
- ☐ **Separate outputs for Ambisonic surround sound.**
- ☐ **Level frequency response both on- and off-axis.**
- ☐ **The most accurate polar patterns in the world.**
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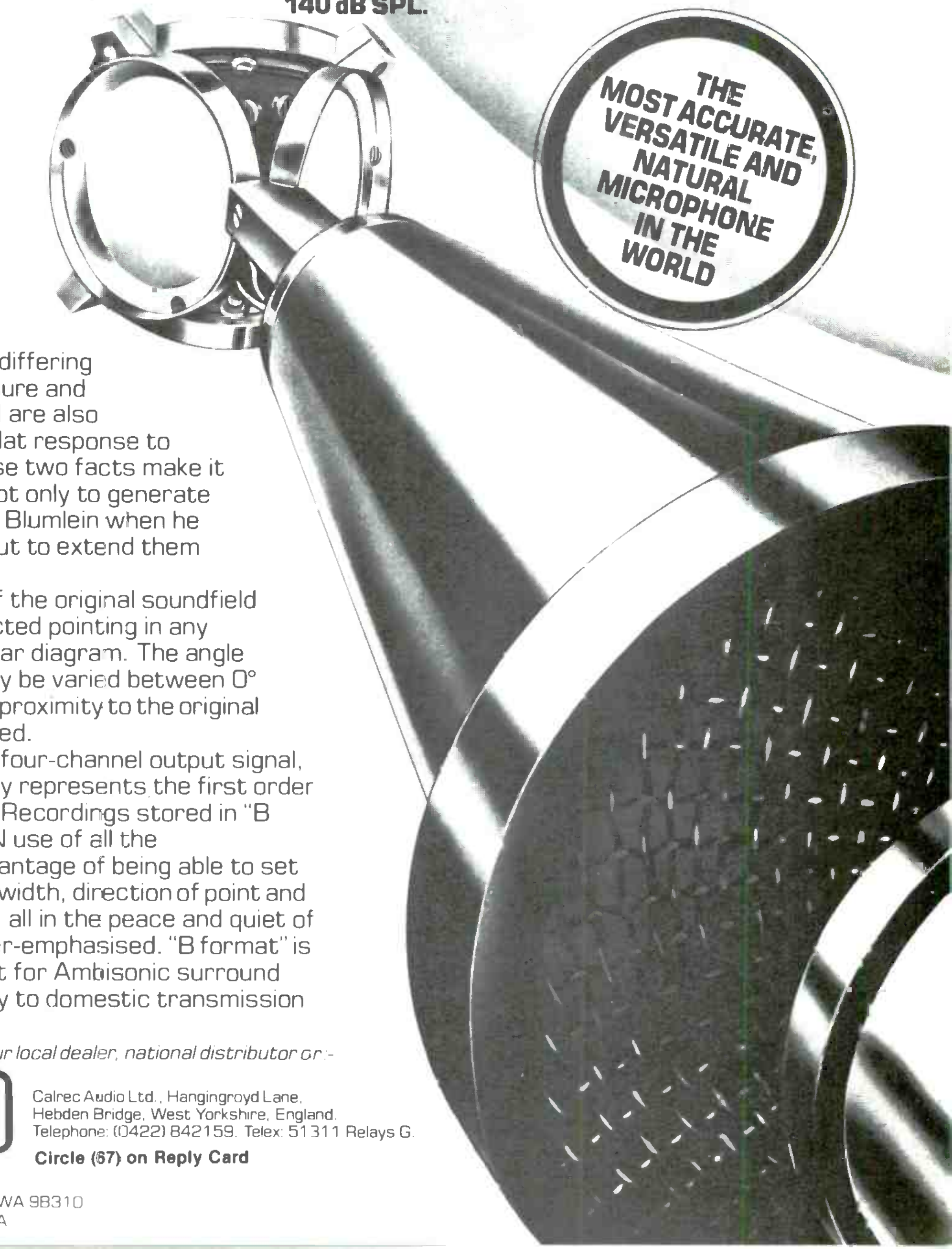

THE FACTS

The spherical three-dimensional pick-up of the Soundfield Microphone is such that the phase errors introduced by the capsule spacing in normal microphones are effectively eliminated and the resulting stereo output of the control unit has virtually perfect image placement at all frequencies. The differing frequency responses of the pressure and gradient components of the signal are also corrected, thus giving an equally flat response to both on- and off-axis sounds. These two facts make it possible, for the first time ever, not only to generate exactly signals envisaged by A. D. Blumlein when he first proposed the M/S system, but to extend them into three dimensions.

This spherical representation of the original soundfield allows a stereo signal to be extracted pointing in any direction and of any first order polar diagram. The angle between the two microphones may be varied between 0° (mono) and 180° and the apparent proximity to the original sound sources may also be adjusted.

The control unit also provides a four-channel output signal, known as "B format," which exactly represents the first order characteristics of the soundfield. Recordings stored in "B format" allow the POST SESSION use of all the aforementioned controls. The advantage of being able to set such critical parameters as image width, direction of point and tilt, polar patterns and distance – all in the peace and quiet of the dubbing studio – cannot be over-emphasised. "B format" is also the professional signal format for Ambisonic surround sound and may be encoded directly to domestic transmission and consumption formats.

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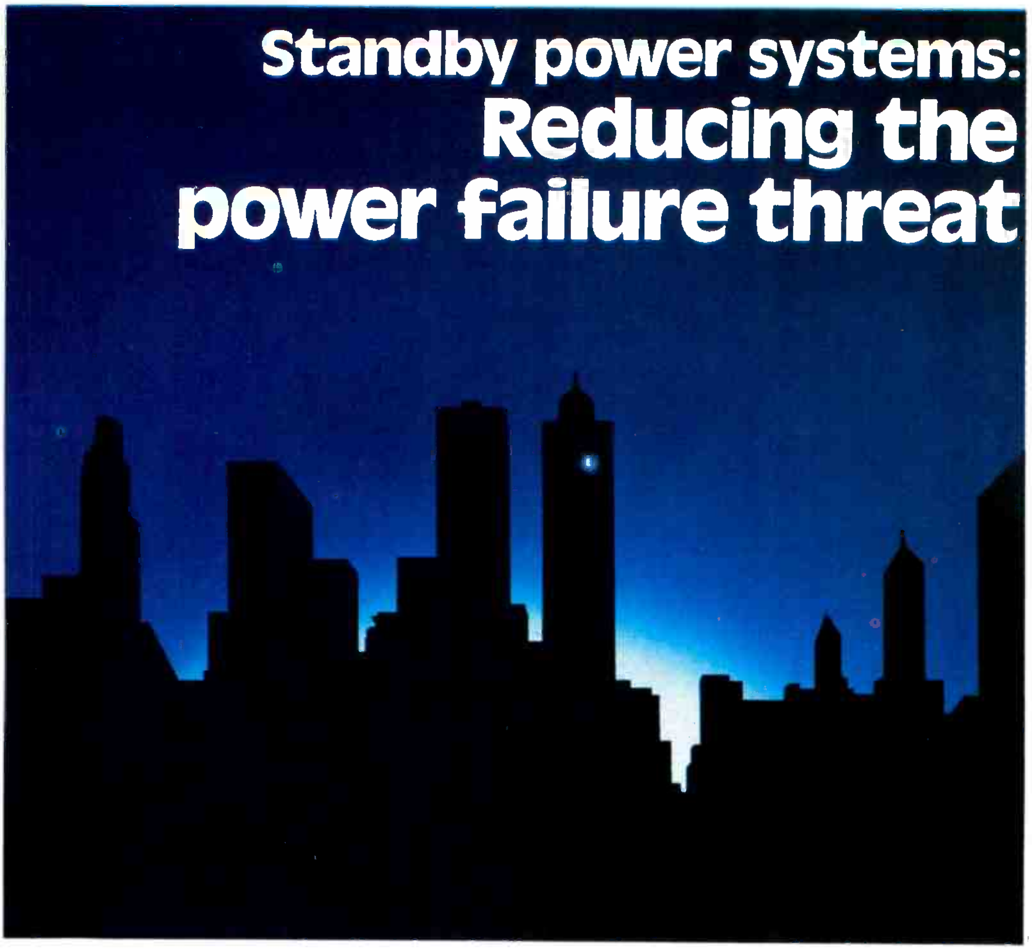
Standby power systems: Reducing the power failure threat



Courtesy of Topaz

By Jerry Whitaker, editor

When most people discuss utility company power problems, they immediately think of blackouts. The lights go out and everything stops. Blackouts, however, rarely occur in most areas of the country and are generally short in duration. Studies have shown that 50% of all blackouts last six seconds or less, and another 35% are less than 11 minutes long. These power failure figures are not usually cause for concern to commercial users, except to broadcasters.

A station that is off the air for 11 minutes—or even five minutes—will suffer a drastic audience loss than can take hours (or perhaps days) to rebuild. Coupled with this threat is the possibility of extended power service loss because of storms. Many broadcast transmitting sites are located in remote, rural areas or on mountain tops. Neither of these locations are well known for their power reliability. It is not uncommon in mountainous areas for utility company service to be down for several days after a major storm. Few broadcasters are willing to take such risks with their air signal, and choose to install standby power systems at appropriate points in the transmission chain.

The cost of standby power for a broadcast facility (particularly high-power radio or TV) can be substantial, and an examination of the possible alternatives should be conducted before any decision on standby equipment is made. Management should clearly define the direct and indirect costs, and weigh them appropriately.

This cost-vs-risk analysis should include the standby power system equipment purchase and installation price, the exposure of the transmission system to utility company power failure, the alternative transmission methods available to the station and the direct and indirect costs of lost air time because of blackouts.

Standby system options

The classic standby power system using an engine-generator is shown in Figure 1. An automatic transfer switch monitors the ac voltage coming from the utility company line for any power failure conditions. Upon detection of an outage for a predetermined period of time (generally one to 10 seconds), the standby generator starts. Once up to speed, the load is transferred from the utility to the local generator. Upon return of the utility feed, the load is switched back and the generator stops. This basic type of system is widely used in the broadcast industry and provides economical protection against prolonged power outages (five minutes or more).

In metropolitan centers, two utility company power drops can be brought into a facility as a means of providing a source of standby power. As shown in Figure 2, two separate utility company service drops—from separate power distribution systems—are brought into the plant and an automatic transfer switch changes the load to the back-up line in the event of a main line failure.

This *dual feeder* system has an advantage over the auxiliary diesel arrangement, shown in Figure 1, in that the power transfer from main to standby can be made in less than a second. Time delays are involved in the diesel generator system, which limit its usefulness to power failures lasting more than several minutes.

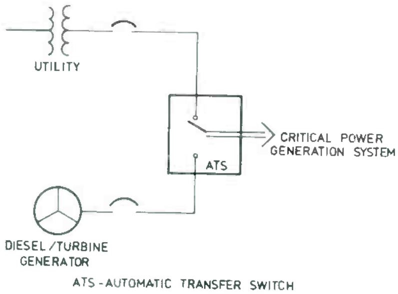


Figure 1. The classic standby power system using an engine-generator unit. This system protects a facility from prolonged utility company power failures.

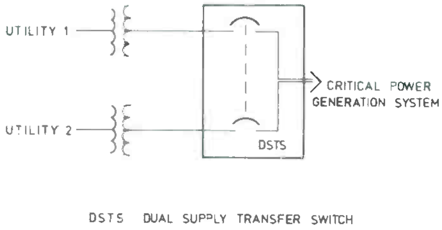


Figure 2. The dual feeder system of ac power loss protection. An automatic monitoring system switches the load from the main utility line of the standby line during a power disruption.

The dual feeder system of protection is based on the assumption that each of the service drops brought into the facility is routed via a different path. The likelihood of a failure on both power lines simultaneously is remote. The dual feed system will not, however, protect against the occasional area-wide power failure.

The dual feeder system is primarily limited to urban areas. Rural or mountainous regions are not generally equipped for redundant utility company operation. Even in urban areas, the cost of bringing a second power line into a broadcast facility can be high, particularly if special lines must be installed for the feed.

Figure 3 illustrates the use of a backup diesel generator for both emergency power and *peak power shaving* applications. Commercial power customers often realize substantial savings on utility company bills by reducing their energy demand during certain hours of the day. Figure 3 shows the use of an automatic overlap transfer switch to change the load from the utility company system to the local diesel generator.

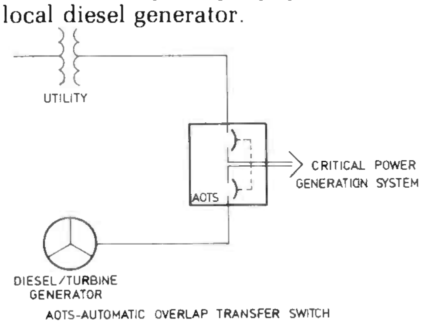


Figure 3. Using a diesel generator for emergency power and peak power shaving applications. The automatic overlap transfer switch changes the load from the utility feed to the generator instantly so there is no disruption of normal operation.

This changeover is accomplished by a special transfer system that does not disturb the load equipment operation. This application of a standby generator provides financial returns to the station regardless of whether the generator is ever needed to carry the load through a commercial power failure.

Advanced system protection

A more sophisticated power control system is shown in Figure 4, where a dual utility supply is used to feed a motor-generator unit (MGU) to provide clean, undisturbed ac power to the load. The MGU will smooth over the transition from the main utility feed to the standby, often making a commercial power failure unnoticed by station personnel. An MGU will typically give up to ½ second of power-fail ride-through, more than enough time to accomplish a transfer from one utility feed to the other.

This principle is further refined in the application shown in Figure 5, where a diesel generator has been added to the ac power supply system. With the automatic overlap transfer

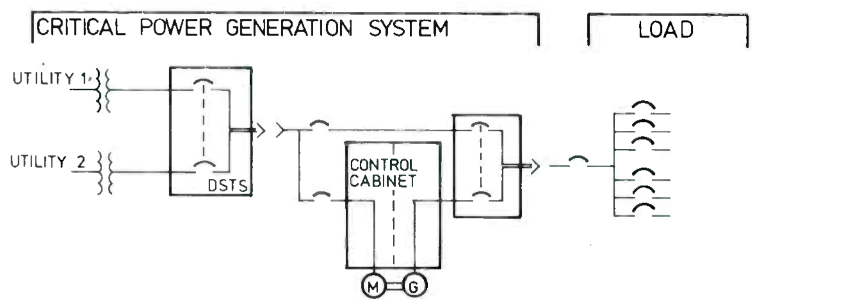


Figure 4. The dual feeder standby power system using a motor-generator unit to provide power-fail ride-through and transient disturbance protection. Switching circuits allow the MGU to be bypassed, if desired.

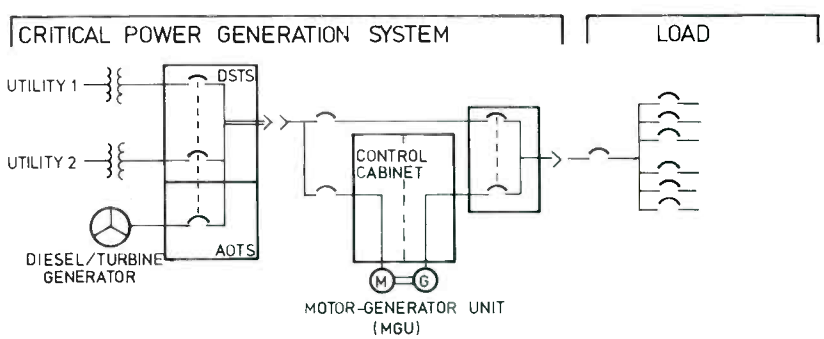


Figure 5. A premium power supply backup and conditioning system using dual utility company feeds, a diesel generator and a motor-generator unit. This arrangement would be used for critical loads that require a steady supply of clean ac.

switch shown at the generator output, this system can also be used for peak demand power shaving.

Other considerations

The generator rating for a standby power system should be chosen carefully, keeping in mind any anticipated growth of the broadcast plant. It is good practice to install a standby power system rated for at least 25% greater output than the peak facility load. This headroom gives a margin of safety for the standby equipment and allows future expansion of the facility without worrying about overloading the system.

A station seeking standby power capabilities should also consider the possibility of protecting key pieces of equipment in an installation against power failures with small, dedicated, uninterruptible power systems (UPS). Small UPS units are available with built-in battery supplies for microcomputer systems and other hardware used by broadcasters.

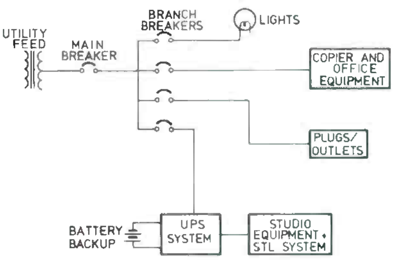


Figure 6. An application of the "critical load" power bus concept. In the event of a power failure, all equipment necessary for continued operation would be powered by the UPS equipment. Noncritical loads would be dropped until commercial ac returned.

If economics prohibit the installation of a system-wide standby power system (using generator or solid-state UPS technology), the engineer should consider establishing a "critical load bus" that is connected to a UPS system or automatic transfer generator unit. This separate power supply would be used to provide ac to critical loads, thus keeping the protected systems up and running (Figure 6). Unnecessary loads would be dropped in the event of a power failure. A standby system built on the "critical load" principle can be a cost-effective answer to the power failure threat.

FCC Update

Continued from page 8

law requires the commission to promulgate regulations authorizing franchising authorities to regulate basic cable rates for systems that are not subject to "effective competition." One possible way of defining effective competition is in terms of the availability of off-air signals.

For instance, a system located in a community receiving four Grade B TV services, including three network services, could be considered to have a sufficient number of obviate the need for rate regulation.

Congress has also directed the commission to establish procedural standards for rate regulaton in instances when systems do not have effective competition. The commission is proposing rules that would require formal public notice of rate proceedings, an opportunity for interested parties to make their views known, and issurance of a formal statement once a decision on rate matters is made.

With respect to the substance of rate-making decisions, the commission proposes to require that rates be set according to a "comparable rate" method. With this method, rates would be made equal to levels in comparable unregulated markets.

Continued from page 64

above, below and on both sides of the one being quantized. The resulting level closely resembles the actual video, minus noise. Such an integration process eliminates much of the noise, which being random in nature does not come through normal averaging processes well.

•**Differentiation**—A blurred picture sharpened by enhancing the real edges in the video signal. This is the opposite of integration or averaging. Mathematical differentiation can sharpen a picture blurred from the mechanics of a quantization system. With the concept of neighborhoods, orthogonal differentiation finds a mathematical derivative that relates the greatest change in gray level near any given pixel and uses that derivative during quantization to effect more sharpness. This is superior to edge enhancement based on peaking circuits.

•**Aliasing**—The sampling process that often introduces unwanted signals as a byproduct. These spurious signals, called *aliasing* frequencies, must be removed through precise comb filters. Circuits to remove spurious frequencies are called anti-aliasing circuits.

•**Look-up table**—Pertinent data held in arrays of random access memory (RAM) or read-only memory (ROM). As a program is executed, a key is used to determine where to look up data in the array. Information for D/A processing may include special contouring, grey level treatments and color effects, in addition to words representing the video image. Such tables are typically dynamically addressed RAM, but special conditions may involve non-volatile ROM devices.

•**Digital filtering**—Signal filtering accomplished by a microcomputer. This is preferred to physical filters, which may hard limit signal bandwidths. Digital filtering, a result of recent advances in very large-scale integration (VLSI) ICs, is particularly useful when constraints or limits of a filtering circuit must change on a line-by-line or pixel-by-pixel basis, because of changing video or changing degrees of quantization with changes in picture detail.

•**Fourier analysis**—A branch of mathematics, developed by French mathematician Fourier, that applies to signal analysis. A Fourier series allows any complex waveform to be examined as a fundamental frequency plus a finite number of harmonics as sine and cosine functions. Fourier analysis is extensively used in digital video system designs where speed and limited bandwidths become critical.

people

Richard M. Wolfe has been named vice president of technology for Satcorp, New York. He will review innovations and trends in audio, video and satellite technology, with an emphasis on high-definition video applications, to determine their potential for investment or development. Wolfe is the former president of the Wolfe family radio and TV stations in Columbus, OH and Indianapolis. Also, **John Brady Jr.** has been elected vice president of finance and administration, and chief financial officer, and **David Saltman** has been named vice president of planning and development. Saltman is responsible for the development and review of new business opportunities in communications and pay television.

Gould, Rolling Meadows, IL, announces that **Michael S. Bernath** has been named president and general manager of the company's Programmable Control Division. Andover, MA, and **George M. Gordon** has been named president and general manager of the Systems Protection Division, Horsham, PA, succeeding Bernath.

Steve Russell, former director of operations for Walt Disney Telecommunications, has been named general plant manager of VCA Duplicating's facility in Naperville, IL. Russell will be responsible for all plant operations.

Jerry Ford, chairman of the board and chief executive officer of Lenco, Jackson, MO, announces the appointment of **Mark A. Hill** as assistant sales manager for Lenco's Electronics Division. Hill was a trust officer for Mercantile Trust Company N.A., the lead bank of Mercantile Bancorporation, St. Louis.

Michael Crall has joined Uniden Satellite Technology, Huntington Beach, CA, as regional sales manager. Crall will be responsible for overseeing all sales activities in the western region for Uniden's advanced line of TV receive-only satellite (TVRO) equipment. Crall was a former marketing representative with B. Eliot Suied Organization in California.

A. Franz Witte III has joined the Ampex Magnetic Tape division, Redwood City, CA, as manager of market research and planning. He will create and implement division market analysis programs and develop models for future division growth.

(Dennis) Ray Kirchhoefer has joined Electro-Voice, Buchanan, MI, as engineering product manager/microphones, responsible for defining and developing new microphone products and product line concepts.

Robert Dupras has been appointed acting regional distribution manager for the Burbank, CA, regional distribution center of Agfa-Gevaert, Teterboro, NJ. He previously was office manager of the Burbank office.

Panasonic Industrial's audio-video systems group has appointed **Tom Nagai** to assistant general manager of product management. He will be responsible for product planning, line business management, training and technical support for Panasonic's professional audio-visual product line.

Richard G. Canfield has been named director of operations at CMX/Orrox, Santa Clara, CA.

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EQUIPMENT

Shook Electronic Enterprises, San Antonio, TX, has delivered a new radio mobile van to the Voice of America, Washington, DC. Work began on Sept. 4, and the van was delivered on Jan. 18. The 27-foot Airstream van has lead-lined walls to block noise and is equipped to handle most broadcast applications, from interviews to live concerts. It is equipped to transmit through telephone lines, standard broadcast radio lines or by satellite.

KMSP-TV, Minneapolis/St. Paul, has purchased a 70kW transmitting system and a circularly polarized antenna from **RCA Broadcast Systems,** Gibbsboro, NJ. It will be the first station in that market to switch to circularly polarized broadcasting when installed this spring.

KUSA-AM, St. Louis, has become the first station to transmit in AM stereo using the AX-10 AM stereo exciter, from **Broadcast Electronics,** Quincy, IL. The model, developed under license from Motorola, was granted FCC-type acceptance in November.

A.F. Associates, a New York video systems integrator, has purchased 20 **Ampex** VPR-6 VTRs. The VPR-6 also has been selected by the Swiss PTT to equip the Swiss Broadcasting Corporation. Eight VTRs with digital TBC will be shipped.

M/A-Com, Germantown, MD, has announced the receipt of three contracts from India. The Indian government has ordered digital speech interpolation equipment for the INSAT system and a supply of 4.8kbps burst demodulators for the Indian Meterological Department. M/A-Com is also providing two low-cost earth stations for the Electronics Corporation of India.

Comsat World Systems Division has purchased an Intelsat Standard "E" satellite earth station from Satellite Transmission Systems, a subsidiary of **California Microwave,** Sunnyvale, CA.

KERA-TV, Dallas, has purchased two **Larcan** 30kW VHF TV transmitters. KATV, Little Rock, AK, has purchased a TEC-IV exciter from the company. KHET, Honolulu, and KMEB, Maui, Hawaii, have purchased 30kW and 5kW VHF TV transmitters.

Private Satellite Networks has ordered three transportable satellite terminals from **GEC McMichael,** Slough, England. The New York company specializes in teleconferencing via communications satellites.

Elicon, Brea, CA, will ship a computer-controlled camera system to Beijing Film Studios in the Peoples Republic of China. The studio will use it to film "Star Wars"-type special effects as well as live shots.

Lake Systems, Newton, MA, is building a stereo TV station for WKSV-TV, Marlboro, MA, with studios in Framingham, MA. The station is planning a 24-hour music video format with live broadcasts from the master control room.

CORPORATE DATA

Wiltron, Mountain View, CA, announces the opening of its New England regional office at Woburn, MA. Tom Kilbourne, Northeastern regional sales manager, is the office manager. He is assisted by three sales engineers, Ed Macomber, Len Doiron and Dan Gabriner.

Marconi Communications Systems, Chelmsford, England, has announced the appointment of Comark Communications, Southwick, MA, as the sole distributor of Marconi's broadcasting transmitter products for the United States and Central and South America. Comark will also provide engineering, service and spare parts support.

Tektronix, Beaverton, OR, has authorized Allied Broadcast Equipment, Richmond, IN, to distribute a group of products, including the TM503, 506 and 515 mainframe power supply modules, the AA501 distortion analyzer and the SG505 audio oscillator.

Logitek has added two broadcast suppliers to its domestic dealer network: Bradley Broadcast Sales, Rockville, MD and Keating Technical Services, Tarzana, CA. Two new sales offices also opened by Videomedia, Sunnyvale, CA, will carry Logitek products. The offices are in Salt Lake City and Colorado Springs, CO.

Acrodyne Industries, Blue Bell, PA, has been purchased from its parent company, Whittaker, Los Angeles.

new products

Wireless microphone

The T-36 wireless microphone, from *Cetec Vega*, uses the Electro-Voice BK-1 "Black Knight" condenser element and windscreen. It is a companion to the company's R-31/DII receiver. It operates on any crystal-controlled frequency between 150MHz and 216MHz, at a range of up to 1000 feet.

Circle (458) on Reply Card

Camera batteries

Telecommunications Devices has video/camera replacement batteries designed for use in Sony BP90-A applications. Rechargeable, the packs come in 120- and 90-minute operating time units, providing 12V at 4A. The TD-120 and TD-90 packs come with cable and plug.

Circle (459) on Reply Card

Coax attenuator series

A series of 33 broadband attenuators with six continuous power ratings from 2W to 75W is available from *Bird Electronic*. They are bidirectional and come with male/female BNC connectors.

Circle (460) on Reply Card

Wireless intercom headphones

Two-channel FM wireless intercom headphones, by *R-Columbia*, provide 2-way intercommunication up to 150 yards. The TR-50/PRO has channel selection to choose between two non-interfering networks operating in the same area. Five channels are available.

Circle (461) on Reply Card

Condenser microphone

Shure Brothers has introduced the SM91 unidirectional condenser microphone, designed for surface-mounted applications where a unidirectional pickup pattern is desirable. The half-cardioid pickup pattern (with the cardioid in the hemisphere above the mounting surface) results in less reverberation and muddiness than omnidirectional surface-mounts.

Circle (462) on Reply Card

Signal generator

Fluke's 6060A synthesized signal generator is a general-purpose unit that tests a variety of RF receivers, filters, ampliers and mixers. It covers a frequency range of 0.1MHz to 1050MHz, selectable with 10Hz resolution. Typical switching speed is less than 100ms.

Circle (463) on Reply Card

Frequency counter

A frequency counter, from *VIZ Test Equipment*, is capable of measurements from 5Hz to 1GHz. It has eight LED displays with lead-zero blanking along with discrete LEDs as annunciators. A switchable low-pass filter allows the user to include or reject low-frequency components of high-frequency signals.

Circle (464) on Reply Card

Belt pack

The QB-1 belt pack, from *Communications-Applied Technology*, is an 8.4V/1.4Ah NiCd battery pack for use with the Cetec Vega Q System. It allows the unmodified Cetec Vega system to operate from a signal master control switch, and eliminates the interconnect wire between transmitter and receiver.

Circle (465) on Reply Card

Wire markers

Flexy Markers, from *Datak*, are wire markers that allow you to accomplish three marking tasks without letting go of the applicator tab. The first part is a terminal marker, and the two remaining pieces will mark wires as small as 0.040". The adhesive initially allows repositioning; after six hours, bonding increases.

Circle (466) on Reply Card

Signal generators

Marconi Instruments has launched the 2018/2919A signal generators, which enhance the 2018/2019 units. The units combine their predecessors' features and adds full phase modulation facilities, AM, FM, variable-level AF output and auxiliary FM input. Also included is a choice of optional external-reference frequencies.

Circle (467) on Reply Card

Industrial videodisc player

Sony Video Communications' LDP-180 is a laser videodisc player for the institutional and industrial markets. The front-loading, diode laser player is designed for Level I and Level III video applications. It may be used as a source player for a video editing, or for playing back images in an automatic programming sequence.

Circle (468) on Reply Card

Character generator

Micro-Tek introduces the Mycro-Vision Ernie, a low-cost character generator with gen-lock and system-to-system communications. Similar to the company's Mycro-Vision Max, the new unit has several new capabilities as a titler or telecommunications device. It can operate as a stand-alone device, generating an RS-170A composite video signal.

Circle (469) on Reply Card

Film accessory

ARRI-VAFE from *Arriflex* interfaces a small TV camera to the film camera to produce a videotape of the shoot. The film is imprinted with time code data that matches time code recorded on tape. After the editing decision is done with tape, time code numbers simplify cutting of original film material.

Circle (471) on Reply Card

Still store

The *Harris* Iris C image storage system with Iris Composition System places a wide range of effects with still storage into a small package for the production van. Nine effects sequences may be stored in Archive Modules for repeated use.

Circle (472) on Reply Card

Multichannel sound

The *Tektronix* 1450-1 TV demodulator is upgraded with a wide bandwidth audio section compatible with BTSC multichannel sound. For those who already have a 1450-1 demodulator, an upgrade kit called a 1450F20 will be offered in March.

Circle (473) on Reply Card

Zoom lens

A zoom lens for ½-inch format cameras, from *Fujinon*, zooms 13.3X with no loss of aperture. The S14x6.6ERM, designed for ENG use, maintains an f1.4 aperture from 6.6mm to 87mm. The basic range is 6.6mm to 92mm, and is doubled with the extender. Minimum object distance is 0.08mm.

Circle (474) on Reply Card

Metal cleaner

Cramolin, from *Caig Laboratories*, is an anti-oxidizing solution that cleans, preserves and lubricates all metal surfaces, including gold. It forms a protective layer that adheres to the metal to maintain conductivity. It can be used on switches, potentiometers, relays, PCB connectors, batteries and faders.

Circle (475) on Reply Card

TV remote system

A microprocessor-controlled TV camera system, from *Evershed Power Optics*, has 14 control functions. The camera control processor's memory can store 500 shots and can control shot-to-shot changes, including fades.

Circle (476) on Reply Card

M-format adapter

Panasonic's RS-422 serial interface increases the compatibility of M-format. It allows for multisource or interformat editing by interfacing AU-300Bs with 1-inch and ¾-inch VTRs in a single configuration. The unit can also provide ¾-inch or 1-inch to M-format direct control.

Circle (477) on Reply Card

Battery charger

Christie Electric introduces CASP, for battery charger, analyzer, sequencer and power supply. It can charge batteries in 20 minutes, will analyze and recondition them and can be turned into a 0-to-50V, 350W-programmable dc power supply. It can process six intermixed batteries at once.

Circle (478) on Reply Card

Blower

AMCO Engineering's BRDSPM is a dual-scroll blower with variable speed control. A panel-mounted unit, it can provide from 325-425 standard cubic feet per minute. The speech interference level is 51dB at low flow and 55dB at maximum flow.

Circle (479) on Reply Card

ESD switch

ITT Schadow's Digitast switch protects equipment from electro static discharge, from 15kV to ± 2kV. Pin spacing is 0.100.

Circle (480) on Reply Card

LED indicator

A multipurpose LED indicator card, from *Modular Devices*, can monitor audio signals. It allows switch selection of VU or peak reading as well as setting OVU indications from -2dB to + 12dB. The unit has a 19-segment LED indicator board, balanced or unbalanced inputs and a high impedance input.

Circle (481) on Reply Card

PC repair kit

The CIR-KIT, from *Pace*, will repair or replace lifted, damaged or missing lands, plated-through holes, conductors and edge connectors on PC assemblies. Included are more than 30 sizes of eyelets, tracks plated to mil specs and in sheets of various pad diameters and track widths, abrasive stick and a setting tool.

Circle (482) on Reply Card

Replacement semiconductors

TRW replacement semiconductors for Gates TE3 exciters are available from *Calvert Electronics*. Individual semiconductors can be replaced instead of replacing the entire exciter board.

Circle (483) on Reply Card

Stereo processor

The MSP-126 multitap stereo processor, from *Ursa Major*, performs several stereo processing functions, including stereo synthesis from mono sources, image manipulation, ambience simulation and individual and cluster repeats. It can be used for music, film and video applications.

Circle (484) on Reply Card

Character generator

Laird Telemedia's 1500 is a TV broadcast character generator, with a character resolution of 35ns, 65,536 resident colors, 70-font library, and a dual disk drive system. It also has auto centering, italics and proportional spacing.

Circle (485) on Reply Card

Stereo generator

The FMT615 stereo generator, from *Leaming Industries*, is for CATV and satellite communications applications. The principle application is for use in CATV operations that incorporate the M/A-COM Linkabit Videocipher System for HBO, Cinemax, Showtime and TMC.

Circle (486) on Reply Card

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high
DUBNER

RANGE
INPUT
HP FILTER
WBS