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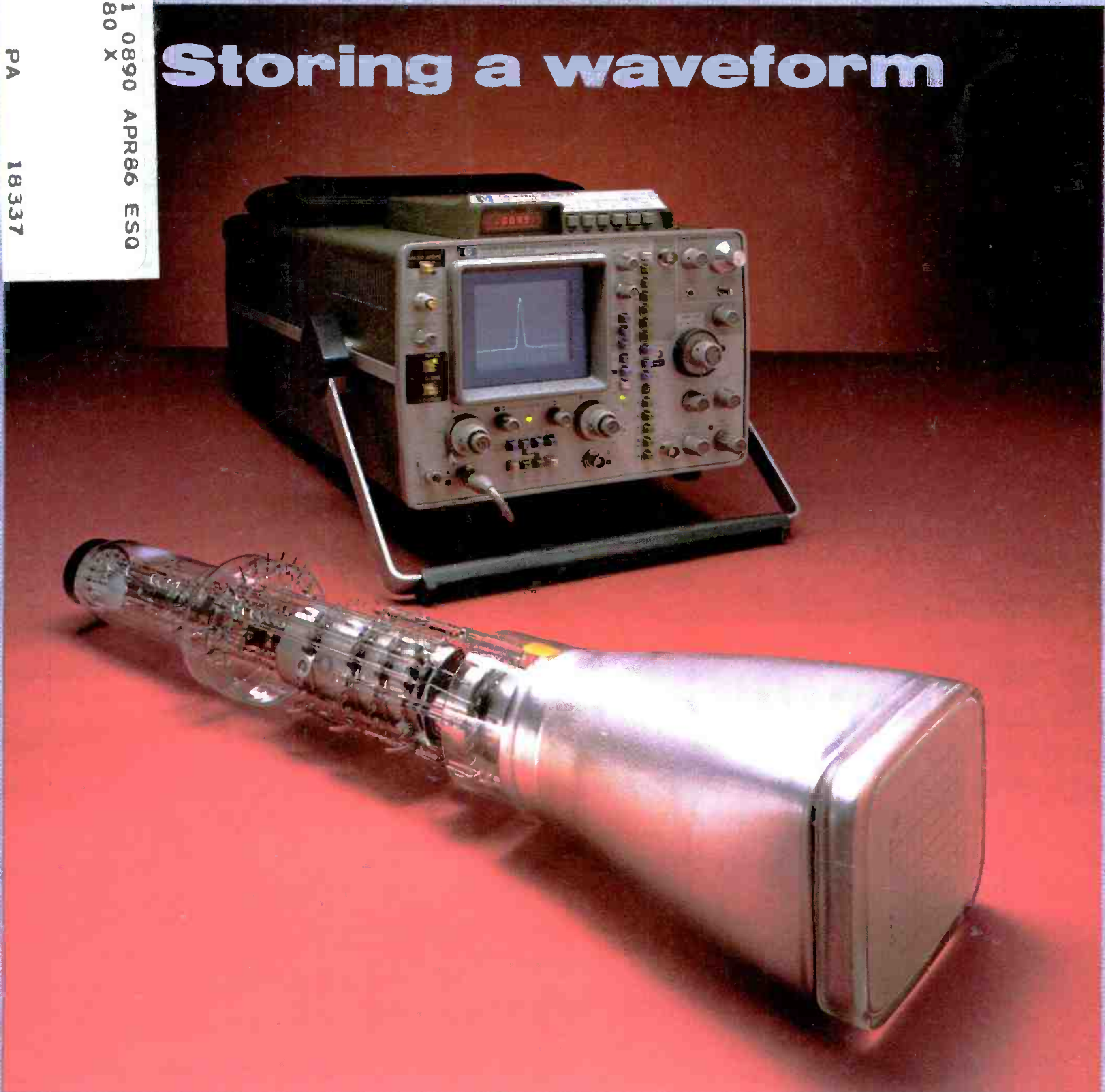

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The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

June 1982
Volume 2, No. 6

Storage CRTs in oscilloscopes are a popular solution to many measurement problems technicians encounter. See story on page 32. *(Photo courtesy of Hewlett Packard.)*

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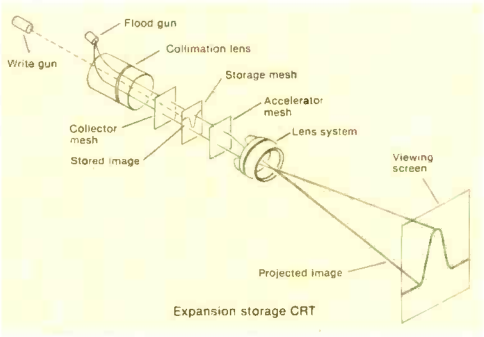

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DEPARTMENTS

Readers respond to projection TV article

When we published the article "How To Build a Giant Screen TV System," in the January 1982 issue of **ES&T**, we hoped that it would be of some interest to our readers. As it turns out, according to Bob Fischer, president of Projectapix, more than 1100 readers have already contacted his company to get further information. It is gratifying when an article strikes such a responsive chord among our readers. It helps us to know we're doing our job right at least some of the time.

But now we're curious. How many of the people who've inquired of Projectapix will actually order the materials for construction of a projection TV? What will be the experience of those who do so? If you are one of the readers who decide to try your hand at such a project, we are interested in learning about it. In fact, if we can get enough details about a build-it-yourself project, we might be able to turn it into an article. Let us hear from you!

In fact, we'd like to hear from any of you at any time. Letters are an important element in the development of thought and action here at **ES&T.** We receive quite a few letters from readers each month, commenting on the content and style of the magazine. Some of the content of these letters is complimentary, some of it is critical. But all of the letters are read – and heeded. After giving it a great deal of thought, we have decided to establish a regular department of *Letters to the Editor,* although we have not yet concluded that that's what we'll call it. This will give us a chance to let readers know what other readers are thinking. More than that, though, it will allow us to present valuable information that readers send in that might otherwise lie undiscovered, and we'll be able to give credit where it is due. On those occasions when we make an error and readers let us know, the *Letters* department will give us an opportunity to print the letters that pointed it out to us.

So keep those cards and letters coming. We love 'em, even when they hurt. But don't be surprised if you one day see your letter and your name printed in **ES&T.**

ELECTRONIC SCANNER

EIA/CEG urges orderly introduction of AM stereo

The Electronic Industries Association's Consumer Electronics Group (EIA/CEG) has expressed its concern that a recent decision by the Federal Communications Commission (FCC) permitting multiple AM stereo broadcasting formats will result in consumer confusion. The EIA/CEG is the national trade association for manufacturers of consumer electronics products.

"Even if some individual broadcasters begin using one of the proposed AM stereo systems permitted by the March 19, 1982, FCC Final Report and Order, no single system will prove viable until it receives widespread manufacturing support. We suggest, therefore, that consumers and press not simply jump at the first AM stereo receiver to appear just because it is there," noted Jack Wayman, senior vice president of EIA/CEG.

On April 26, broadcasters could begin transmitting AM stereo using any one of several systems, so long as they met FCC technical standards and had equipment-type approval. But, as Wayman emphasized, the successful history of U.S. broadcasting is due in no small part to the adoption of standardized technical formats.

"A marketplace determination is appropriate for choosing between products of the same type," Wayman commented, "but manufacturers and consumers alike are harmed if two stations in the same locality transmit AM stereocasts that can't be successfully decoded by the same receiver. Everyone remembers only too well the negative impact that multiple formats have had on other promising technologies, such as 4-channel sound. On the other hand, FM stereo developed rapidly in this country because manufacturers had a single standard, the position that EIA/CEG has urged for AM stereo since 1977 in its filings with the FCC."

Wayman was careful to point out that in no case will the introduction of AM stereo make existing radio equipment obsolete. But because the FCC ruling did not establish a single format, manufacturers of audio components must now arrive at their own *de facto* standard, which will take some time.

JEDEC CMOS logic committee develops new standard

The Joint Electron Device Engineering Council (JEDEC) JC-40.2 committee on CMOS logic standardization is working to provide the semiconductor industry with acceptable standard specifications for high speed silicon-gate logic devices.

A developmental specification

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for dc parameters was patterned around the emerging 54/74 HC specification. Companies represented at the meeting were RCA, Fairchild, GTE Microcircuits, Mitel Corporation, Motorola, National Semiconductor, Philips (Holland), Texas Instruments and Toshiba. All companies exhibited interest in the development of this specification. The tentative title for the developmental specification is "Standard Specification for 54/74 HC/HCT/HCU High-Speed Si-Gate CMOS Logic." HC specifications cover buffered CMOS compatible logic types, HCU specifications cover unbuffered CMOS compatible types and HCT specifications cover buffered TTL input compatible logic types.

The JEDEC Council and its supporting committee structure is the engineering standardizing body for solid-state products of the Electronic Industries Association's (EIA) Solid-State Products Division and the National Electrical Manufacturers Association's (NEMA) Power Semiconductor Division.

ETA to hold convention in July

The Electronics Technicians Association, International, will hold its fourth annual convention July 15 through 17 at Iowa State University, Ames, IA. Events include technician troubleshooting seminars, business training, personal development and employment clinics.

Any electronics technician may attend. For more information, contact convention chairman, Ron Crow, P.O. Box 1028, Ames, IA 50010, 1-515-294-5060.

ASSOCIATION NEWS

Dealers urge Congress to reverse court ruling

Video dealers' associations and more than 2000 individual dealers throughout the United States have called on their representatives in Congress to remedy last October's surprise ruling by the Ninth Circuit Court of Appeals that off-the-air home taping infringes copyright laws.

In testimony, personal visits, letters and telephone calls, the dealers are urging Congress to clarify the law so that it clearly exempts home recording from copyright infringement. At the same time, they are fighting off efforts by the movie industry to have Congress impose a royalty "tax" on video recorders and blank tapes.

Julius Kretzer, president of the National Association of Retail Dealers of America, whose 3600 members operate more than 10,000 retail outlets, testified at a Senate Judiciary Committee hearing last November, urging the Senate to pass a simple amendment to the copyright laws that would clearly exempt private, noncommercial taping. The amendment is known in the Senate as S. 1758. A similar bill in the House of Representatives is known as H.R. 4808. Further hearings are scheduled in April.

American Video Association President John Power, whose organization speaks for more than 400 video dealers, says the proposed royalty tax would be harmful to dealers as well as consumers.

Both associations have joined the recently formed Home Recording Rights Coalition in Washington, whose members also include the American Retail Federation, the National Retail Merchants Association, and Sears, Roebuck and Company. Other members include leading VCR and blank tape manufacturers and distributors.

The coalition opposes the royalty tax proposals and supports the passage of S. 1758 and H.R. 4808 to clearly exempt private, noncommercial taping from copyright infringement.

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Circle (7) on Reply Card

The FCC decision on March 4, 1982 to allow a free market approach to AM stereophonic radio broadcasting was met with mixed reaction – from delight to despair, according to an article in the April issue of *Broadcast Engineering* magazine. The FCC has declined to select a single, optimum system for AM stereo.

The FCC voted 6 to 1 to allow broadcasters to use any noninterfering system they desire, with only minimum technical guidelines. Commissioner Abbott Washburn cast the dissenting vote and spoke in favor of selecting a single system.

The failure of the FCC to decide on a single system, regardless of the technical reasons, may actually kill the future of AM stereo. If set manufacturers refuse to build appropriate sets to receive the AM stereo broadcasts and broadcasters cannot select and install an optimum system, the AM stereo industry may die because of signal incompatibility and the lack of suitable receivers.

On the other hand, the door is open now for the current proponents, plus all others who want to toss their hats into the ring, to do battle in the marketplace. Only time will show who dominates and if AM stereo will survive. The possibility exists that some foreign source, with strong government backing, could actually decide the AM stereo issue in the United States.

According to Bill Rhodes, editor of *Broadcast Engineering,* the decision was made by the FCC in large measure because budget limitations leave them without the technical resources needed to select a single, best AM stereo broadcasting scheme from among the five contenders.

The following pages describe the various technologies available, give a little of the history of the AM stereo decision process, and describe the reactions of some of the AM radio receiver manufacturers.

If the FCC decision does not mark the death of AM stereo, the result is almost certain to be chaos and confusion in the AM radio receiver marketplace. For the purchaser, there will be such questions as, "Do I want to buy AM stereo?" and "Which technology will eventually prevail?" For the radio servicer, it means it may be time to go out for more education.

AM stereo: To be or not to be?

By Dennis Ciapura,
group vice-president,
Telecommunications, Greater Media, East Brunswick, NJ

The battle to prove technical supremacy in the AM stereo arena has been as frustrating for broadcasters as it has been exciting. Proponents have raised so many serious questions about competing systems that one can't help but be at least a little skeptical about the claims of *all* of the proponents.

It's too early to predict the receiver marketplace, but a review of how each of the five proposed systems works is a good place to start the technical assessment.

The audio channels

All of the systems are similar to each other (and FM stereo) in that the left and right audio channels are converted into L + R and L – R equivalents for transmission. This is a natural outgrowth of the requirement that a normal mono receiver be able to detect a mono amplitude modulated carrier that is the summation of the left and right channels. Figure 1 is a greatly simplified block diagram that illustrates the general scheme employed by all five of the systems proposed thus far.

The systems begin to differ in the way in which the FM or PM of the carrier is accomplished. Don't be deceived into thinking that these systems are as similar in their performance characteristics as they are in their block diagrams though, because there are important differences.

Stereo generation

Figure 2 breaks the five pro-

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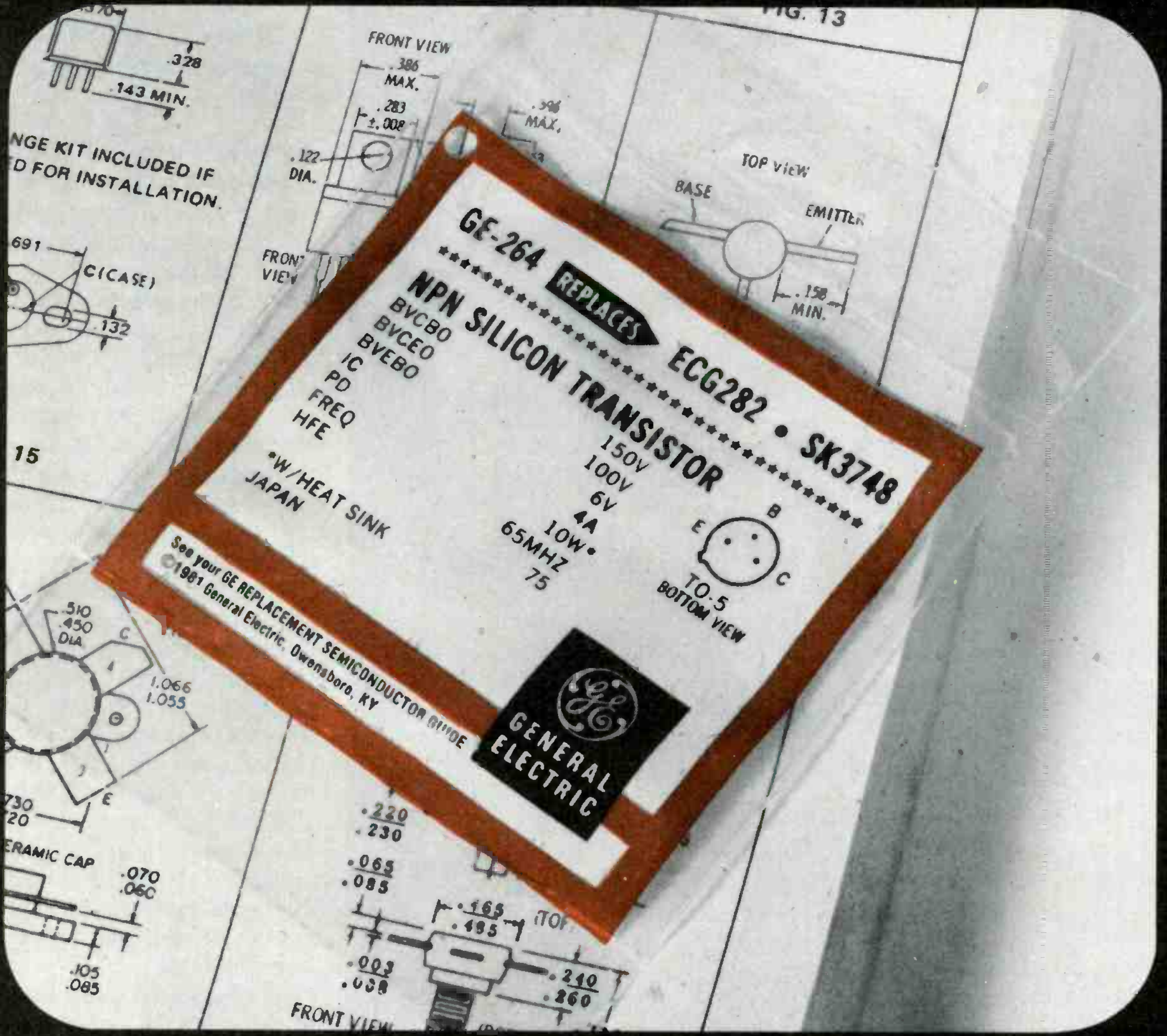

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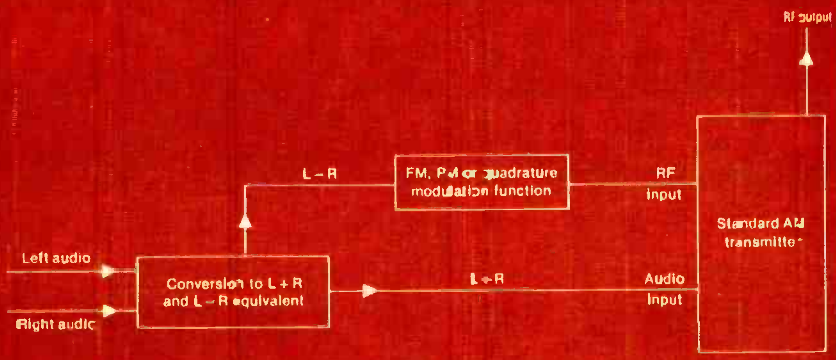

Figure 1. The basic stereo generation approach of the five systems presently proposed.

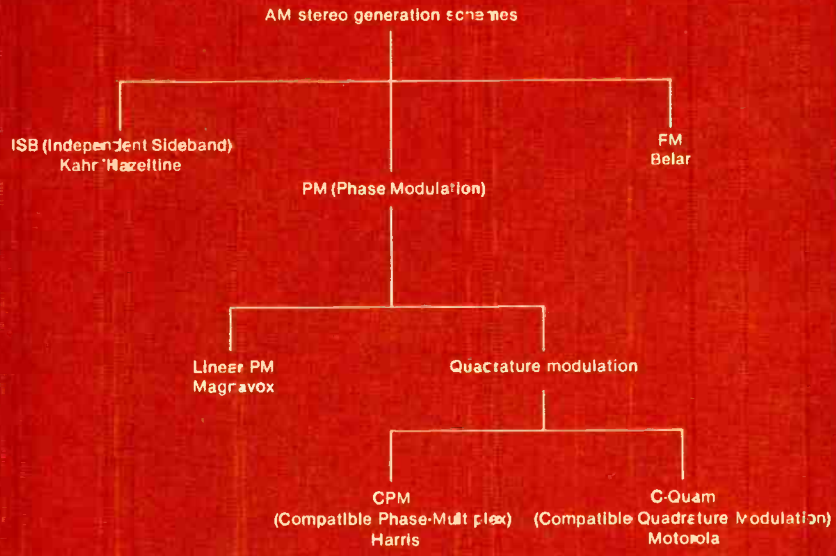

Figure 2 The AM stereo family tree.

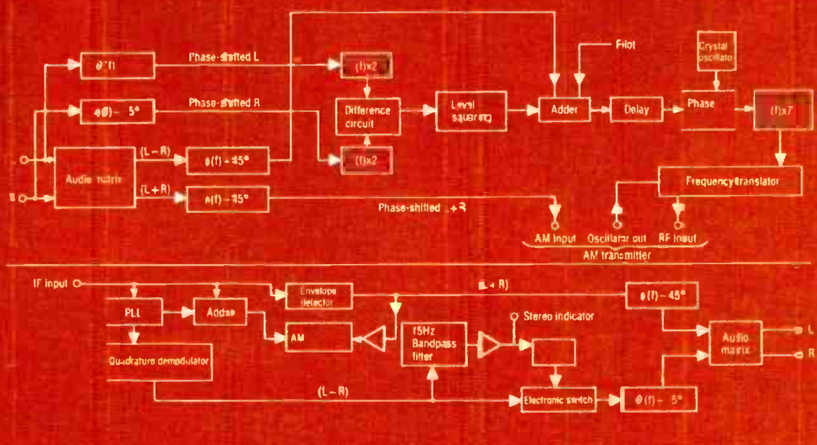

Figure 3. The Kahn ISB (Independent Sideband) system.

posed systems down by the method of stereo generation. Although all of the systems employ some sort of phase modulation; the Kahn system is unique in its independent sideband approach, which results in the left channel being carried on the lower sideband and the right on the upper one. This is the system that allows stereo reception with two mono receivers – one tuned a little low and the other a little high. The Belar approach is to frequency modulate the carrier with the stereo information, while Magnavox, Harris and Motorola phase modulate the carrier. The Harris and Motorola methods are similar in that they are modified quadrature modulation schemes, not unlike the method used to transmit two chroma signals on a single carrier.

Kahn: introduced more than 20 years ago and extensively air tested

Figure 3 shows a block diagram of the proposed encode and decode circuitry of the *Kahn* system. First introduced more than 20 years ago and extensively air-tested, the Kahn/Hazeltine ISB (Independent Sideband system), feeds its L+R output from the matrix into the transmitter's audio input to provide the required mono envelope modulation. A 45° phase lag is introduced, which, relative to the 45° degree lead in the L-R channel, spaces the L+R and L-R outputs of the matrix by a total of 90°. After summing and squaring, the second-order L-R components phase modulate a local oscillator, which drives a frequency multiplier chain and translator. The translator allows the station's transmitter oscillator to maintain carrier frequency control as usual. The second-order phase modulation generated by the phase shifted audio feeding the frequency doublers and different circuit serves to enhance the separation performance.

Reception is straightforward and consists of conventional envelope detection of the L+R, while carrier recovery and quadrature detection provides the L-R signal needed to complete decoding of the stereo channels in the matrix. Synchronous detection is also possible, if desired.

Overall, the system looks complex and is one of the more expensive schemes to implement*, but it

In the April 1982 issue of Broadcast Engineering, Kahn was quoted: "If it's handled right, receiver manufacturers will be convinced that this is the time to change the image of AM from a second-rate service to a quality service. It's a perfect time. There's no reason why the public should not be allowed a choice between quality AM and quality FM."

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Photograph of test bench taken at Orien-Tech, Inc. a factory authorized service center.

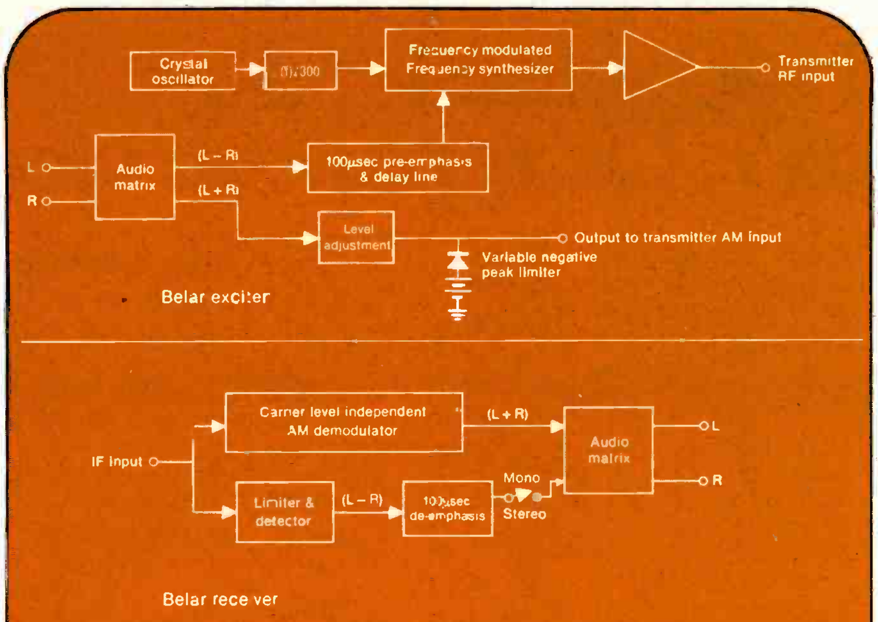


Figure 4. The Belar system.

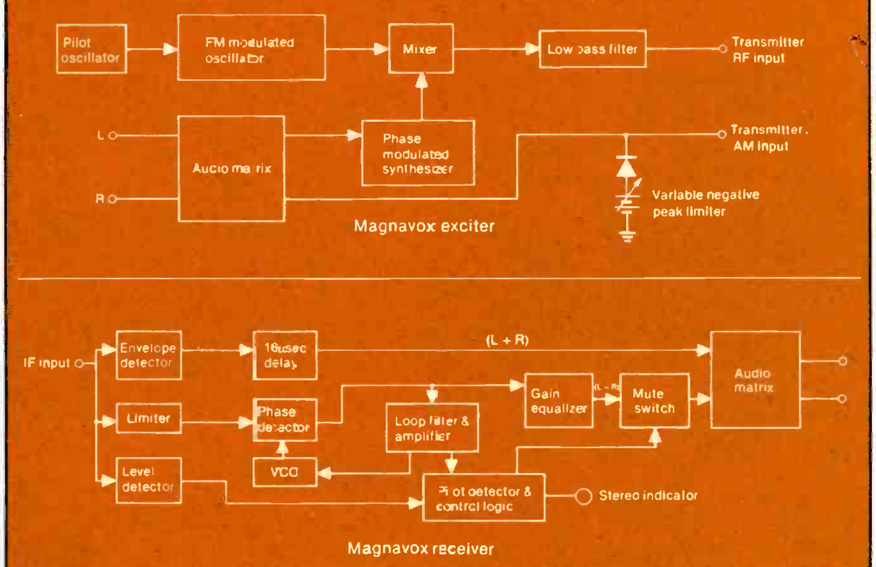


Figure 5. The Magnavox linear PM system.

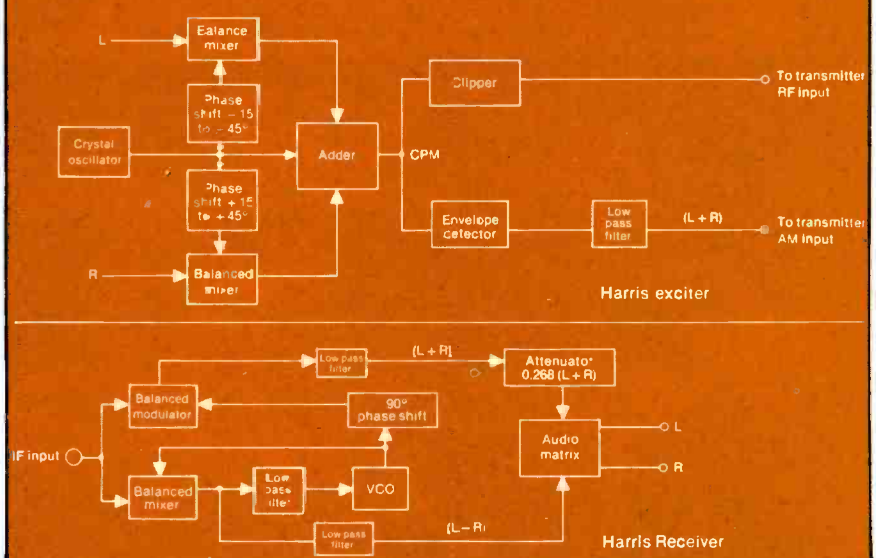


Figure 6. The Harris CPM (Compatible Phase Multiplex) system.

works. Over the years, Leonard Kahn has been able to successfully defend his system from aggressive detractors, and it has been improved along the way. The present form of the system features better stereo separation and a pilot lamp that was not part of the original proposal several years ago.

Belar: one of the less expensive to implement

The *Belar* AM/FM system is perhaps one of the easier ones to understand and is also one of the less expensive ones to implement. It starts with the ubiquitous audio matrix (see Figure 4), which produces a L+R to AM the transmitter and an L-R that frequency modulates the transmitter by ± 1.25kHz. The L-R path is pre-emphasized by 100μs to improve the L-R channel signal to noise, and a variable delay is incorporated to match the L+R delay through the transmitter's modulator. The negative peak limiter is required to prevent the FM detector in the receiver from generating a pop when the instantaneous signal-to-noise ratio of the carrier approaches unity as the carrier power approaches zero on the negative swing. Even a high-power transmitter will only be delivering a few dozen watts to the antenna at -95% modulation; at that instant the RF carrier that the receiver has to work with is not very much above the noise. You will see this same kind of negative limiter in some of the other AM stereo exciters as well, and in the case of Motorola, in its receivers.

The Belar receiver is almost a statement of the obvious, as you can see from the block diagram. Although the pilot injection and recovery points are not shown, a pilot will be included (as it will be in all five systems), and a 10Hz frequency is contemplated.

Magnavox: selected by the FCC in its first attempt to settle on a nationwide standard

Figure 5 illustrates the *Magnavox* AM/PM system operation. In this case, the L+R feeds the transmitter audio input as usual, while the L-R phase modulates the synthesizer output. This is mixed with the local oscillator output, which has been frequency modulated by the 5Hz pilot tone by ± 20Hz (at carrier frequency). The negative modulation limiter serves the same purpose here that it did in the Belar exciter.

The Magnavox receiver is also simple and readily understandable from the block diagram. L+R is recovered by conventional envelope detection, delay compensated and sent to the audio matrix. The PM signal is detected, leveled and sent along to the matrix to combine with the L+R to decode the left and right audio channels. The 5Hz FM component is detected and employed to illuminate the stereo indicator lamp.

It was the Magnavox system that the FCC selected in its first abortive attempt to settle on a nationwide standard among the five proposed systems in the spring of 1980.

Harris: ability to maintain stereo separation out of 15kHz

Harris calls its offering the Variable Compatible Phase Multiplex system, or V-CPM. Simple in concept, the Harris system amplitude modulates two RF carriers separated by 30° to 90° phase difference. The left channel modulates one of the signals while the right modulates the other (see Figure 6). As you can see, the two low-level carriers are added to produce the V-CPM signal, then reduced to their AM and PM components by envelope detection of the L+R, which feeds the transmitter audio input; the AM is stripped to recover the PM to feed the transmitter RF input. The complete composite signal looks similar to a normal mono with respect to the L+R components, and it is interesting to note that the output of the adder is the complete V-CPM signal, which could be fed directly to a high power linear amplifier.

Harris boasts of excellent bandwidth conservation with this method. Athough V-CPM is really a quadrature modulation scheme, varying the phase difference of the carriers from 30° to 90° prevents the generation of distortion in mono reception. The pilot tone is varied from 55 to 96Hz to enable the receiver circuitry to track this varying phase difference and provide normal stereo decoding. Although this means that the L-R frequency response can only extend down to about 200Hz, Harris points out that these long audio wavelengths make a negligible contribution to perceived stereo separation. One of the big advantages of the system is the ability to maintain stereo separation out of 15kHz, and it is these higher audio frequencies that are most directional. The Harris V-CPM system does not require a negative modulation limiter in either its exciter or receiver to prevent pops so, like the Kahn system, there is no modulation/distortion compromise to deal with.

The Harris receiver reverses the transmission encoding by generating unmodulated IF with the phase-locked loop to quadrature detect the L – R stereo difference information. After attenuating the L + R to match the L – R, both are fed to an audio matrix to recover the left and right audio channels. This is one of the more costly systems to implement.

Motorola: distortion in mono is prevented while the noise advantages of full quadrature operation are retained

The *Motorola* C-Quam (Compatible Quadrature Modulation) version of AM stereo will be recognized as a straightforward quadmod scheme, except a limiter strips off the AM to remove the incompatible sidebands that would cause IM distortion in a mono envelope detector. The L + R output of the matrix amplitude modulates the transmitter as usual, but the exciter RF output actually contains both L + R and L – R components. The C-Quam signal is actually generated by the transmitter itself as it amplitude modulates the phase-modulated RF carrier with the L + R input (See Figure 7.)

In the receiver, a gated envelope detector recovers the L + R while a quadrature detector arrangement employing synchronous detectors yields the L – R stereo signal. The system modulates the in-phase and quadrature components by the cosine of the modulation angle during transmission; this distortion in mono is prevented while the noise advantages of full quadrature operation are retained.

The Motorola C-Quam system exhibits good modulation noise characteristics up to the point where loss of carrier power during peak negative modulation generates a noise burst. As mentioned earlier, the Motorola receivers would probably employ a negative limiter if the exciters do not. Similar to some of the other systems, 95% seems to be the practical limit for negative peaks, but because the C-Quam system's angular phase modulation increases as instantaneous carrier level decreases, Motorola claims better depth of modulation than Magnavox and Belar. In any case, this is an area of considerable controversy among the proponents.

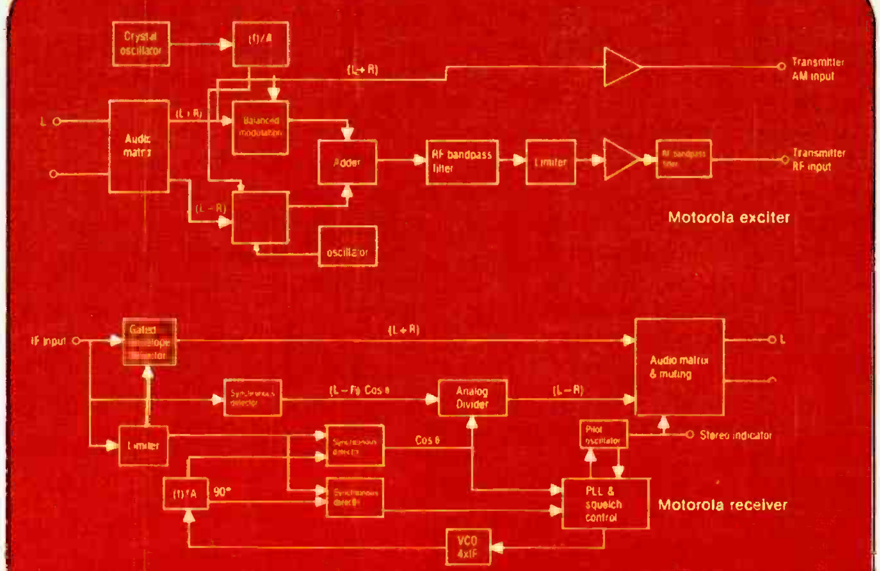


Figure 7. The Motorola C-Quam (Compatible Quadrature Modulation) system.

The differences

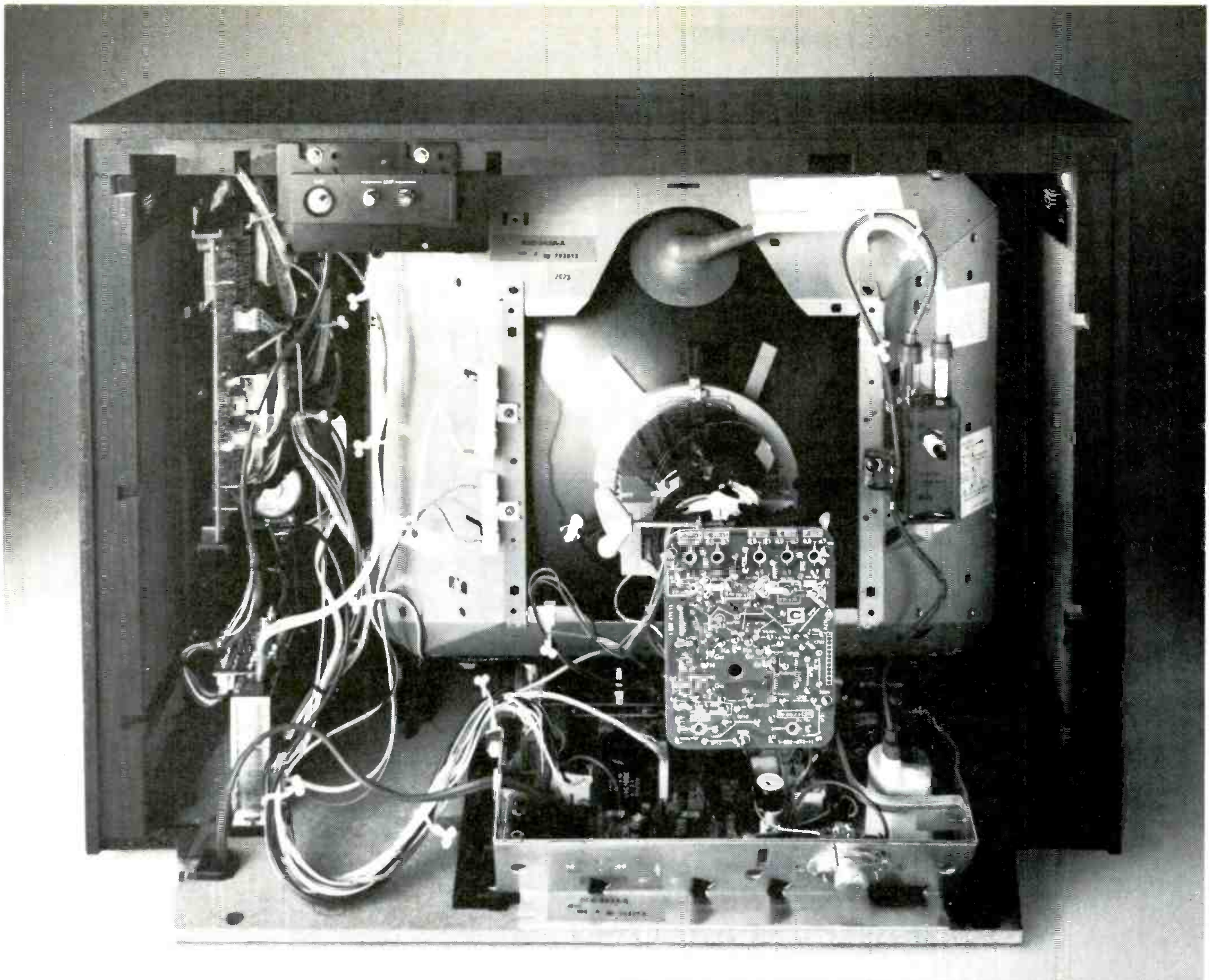
Although there are many similarities, there are also considerable differences among the five systems. As it stands, the best that we can do is to try to understand how each system works and consider what the proponents have said about each other.

Motorola has produced data showing that its system exhibits considerably less modulation noise than Belar, Harris and Magnavox, under certain conditions, such as left- or right-only modulation. It also shows Motorola *and* Harris to excel with left = right inputs, but the data give no figures for Kahn/Hazeltine. We would expect these results, considering the modified quadrature modulation schemes employed.

Harris has shown that its system has the smallest occupied bandwidth and is thus least affected by antenna system abberations. The FCC's Appendix E to its Report and Order readers like a glowing recommendation of the Harris system. It points out numerous advantages of the linear system and uses the Harris approach in comparison with the other systems to illustrate some of their weaknesses.

Kahn claims that the Belar, Magnavox and Motorola systems must clip negative modulation by 95% or less to prevent objectionable noise bursts. Whether the clipper is in the receiver or exciter is irrelevant; 0.5dB of clipping means either distortion generation or a reduction in modulation to avoid it.

Although the proponents of the less costly Belar and Magnavox systems stress the importance of low-cost implementation to encourage receiver proliferation, Kahn points to the importance of stable stereo imaging and robust performance under skywave conditions. Kahn/Hazeltine supports its claim with over 20,000hrs of field testing at broadcast stations.



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A long wait...

By Tina Thorpe, associate editor

The idea of broadcasting both FM and AM stereo became popular about 1952. Although most of the early systems were indeed broadcast over two separate channels, they were not practical for the segment of the audience that had one receiver because they would receive only one channel. These systems also required an uneconomical amount of spectrum space.

By the late '50s, about 20 systems had been proposed. Some were AM, some FM and some could be used with either method. The first compatible AM system was demonstrated at the 1959 National Association of Broadcasters (NAB) convention by Kahn Research Laboratories, and within a year, four stations outside the United States were using it. The Philco AM system and the Percival AM/FM system soon followed.

There was greater interest in FM than AM stereo among broadcasters, equipment manufacturers, trade associations and listening groups at this time, so in 1958 the Federal Communications Commission (FCC) asked interested persons to submit data and opinions on FM stereo. The commission was particularly concerned with performance standards, frequencies and transmission standards to be used and with compatible systems that would allow a listener with a monaural receiver to hear both channels.

On April 20, 1961, the FCC reported that they had chosen a composite GE-Zenith multiplex transmission system standard. Their report said, "We affirm at the threshold our conviction that there must be a single set of national standards governing FM stereophonic broadcasting."

During the development of FM stereo broadcasting, AM stereo took a back seat, but discussion of the AM systems continued for more than 20 years. In recent years, the interest in AM stereo has increased once more, and proponents asked the FCC for a decision.

At the 1981 NAB convention, the FCC reported their choice of the Magnavox system, but many broadcasters complained that this was not the best system for them. After much criticism, mostly from broadcasters, the FCC reconsidered and decided to allow a free-market approach.

Receiver conversion

The procedure for converting AM mono receivers to AM stereo receivers is simple and can be made in a service shop if the needed LSI chip is available. It costs about $100,000 to tool up to produce the chip circuitry, but they are inexpensive in quantities.

Several proponents have made plans for chips and two have begun work on them. National Semiconductor recently announced that they have manufactured chips for the Magnavox system and are ready to ship to manufacturers. Harris has also announced that they have launched a program to design and produce a chip for their system that will be available in three or four months.

Harris has also manufactured a prototype adapter to convert existing mono AM receivers to AM stereo.

"Some months ago we found out how easy it was to modify an existing car radio for an outboard adapter," said Dave Hershberger, inventor and principal engineer for the Harris linear AM stereo system. The company purchased seven car stereo receivers (Pioneer, Panasonic, Sony, Blaupunkt, Radio Shack, Alpine and Sanyo) and in a day and a half at a convention hotel, engineers modified the receivers to accept the Harris decoder box.

"The adapter box idea goes back to the days when FM radio became popular," Hershberger said. "Virtually all cars had AM radios and the inexpensive adapter was a way for the customer to receive FM quickly and easily. Once a receiver manufacturer has added an 8-wire 'pigtail,' the consumer can easily plug in the Harris adapter for AM stereo reception. We are certainly not in the car stereo adapter business. However, we will manufacture some prototypes and turn them over to receiver manufacturers, and provide engineering assistance for making the initial modifications." ES&T

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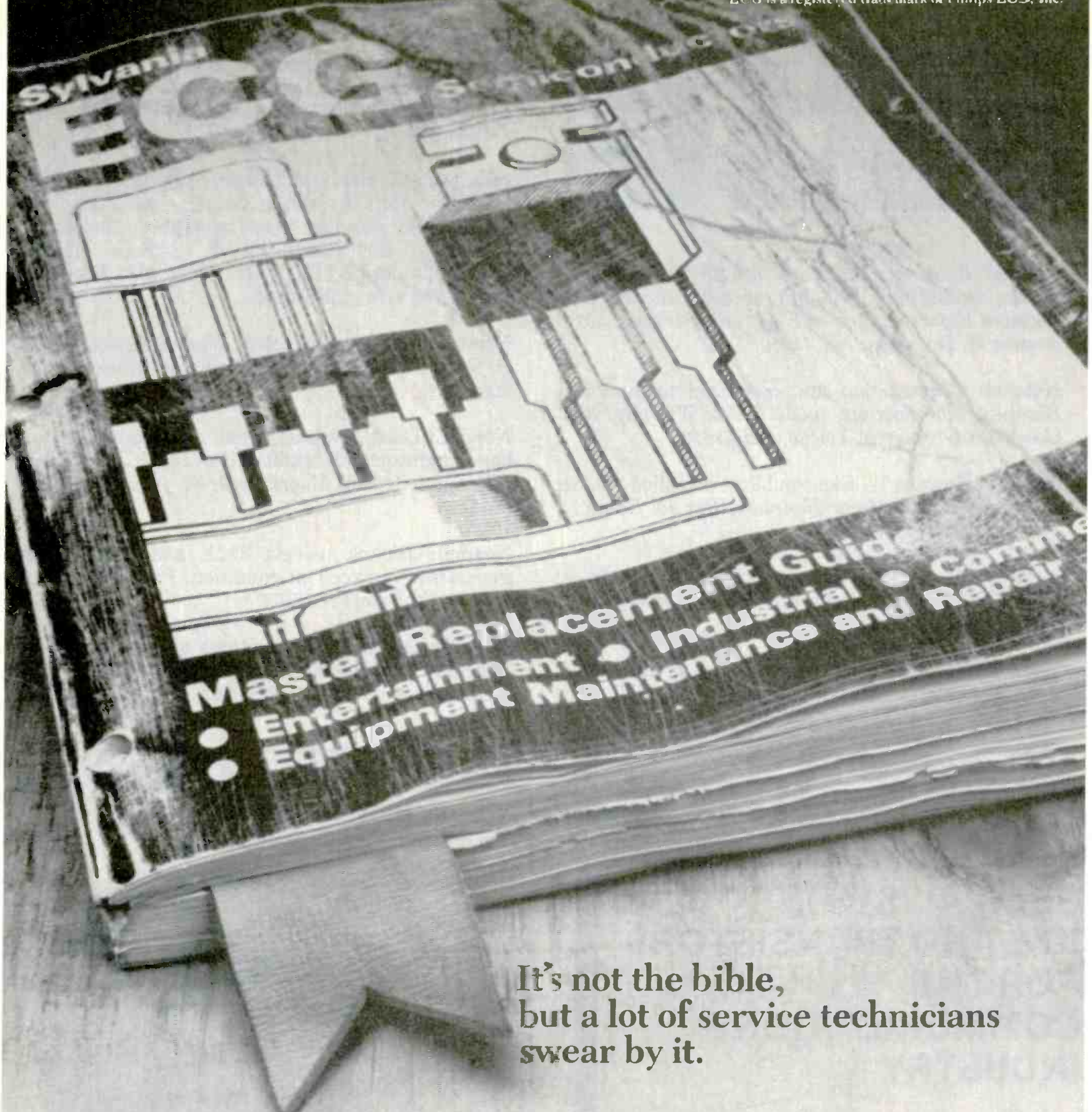

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Circle (13) on Reply Card

READERS' EXCHANGE

Needed: Schematic and parts list for an Eversonic stereo, model 90R. Will buy or copy and return. *Leonard Elgart, Educated Electronic Services, 3510 Avenue H, Brooklyn, NY 11210.*

Needed: Construction and operation manual for Heathkit tube checker, model TC-2. Will buy. *Bill Good, 218 Gramercy, Toledo, OH 43612.*

Needed: Howard W. Sams publication called "Color TV Guide Book." *Major Henricks, Box 96, Route 1, Fredericksburg, IN 47120.*

Needed: Sencore Big Henry multimeter. *Paulmer L. Williams, 112 S. Jefferson St., Lewisburg, WV 24901, 1-304-647-5414.*

Needed: Schematic and parts list for an automatic AM/FM cassette radio, model A8CS-052. Will take schematic only if necessary. All attempts have been futile; any conditions will be met to obtain. *Ardan Electronics, 33 Surrey Lane, East Northport, NY 11731.*

Needed: Schematic for Lincoln (Allied Radio) model L-124M AM/FM stereo tuner; schematic for Polytechnic standing wave amplifier, model 277; schematic for Electrophonic 8-track AM/FM receiver, model T-113C. *C.R. Wells, 2085 Barcelona Drive, Florissant, MO 63033.*

Needed: Four vacuum tubes, Western Electric #300 B. *Gary Thilgen, c/o Arts TV, 104 E. Main, Lowell, MI 49331.*

Needed: Used, low-cost, small or portable dot and bar generator with manual, if available. *E. Patrick Harrigan, 5165 S. Magellan Drive, New Berlin, WI 53151.*

Needed: Hickok models 292X and 295X signal generators in excellent condition. *Paul Capito, 637 W. 21st St. Erie, PA 16502.*

Needed: Operating instructions and schematic for Supreme Instrument Company (Greenwood, MS) Audolyer, model 562 precision signal generator, series E-200. Will pay for copies. *George M. Javor, 3119 E. Erie Ave., Lorain, OH 44052.*

For Sale: Sencore SM 152 sweep and marker generator, almost new, $275; Telequipment dual-trace D61 oscilloscope, $375. *G.L. Hallenbeck, 1711 Gessner, #120, Houston, TX 77080.*

For sale: RCA color bar/dot crosshatch generator, type WR-64B, new and in original carton. Complete with test leads and manual. Write for details; reasonable. *Bernard H. Serota, 2502 S. Phillip St., Philadelphia, PA 19148.*

For sale: Complete set of Tekfax circuit diagnoses. For sale or will trade for a DMM in Lima, OH area only. *Russell L. Landfair, 712 Eastern Ave., Lima, OH 45804.*

For sale: Tekfax, volumes 105, 106, 108, 109, 110, 111, 112, 113, 114, and numerous TV manuals by Tab and others. *Mike's Repair Service, P.O. Box 217, Aberdeen Proving Ground, MD 21005.*

For sale: Sencore model BE156 dc bias supply, $35; Mercury model 1000 dynamic mutual conductance tube tester, $90; Eico model 1140 series parallel R-C combination box, $35. *William Shevtchuk, 1 Lois Ave., Clifton, NJ 07014, 1-201-471-3798.*

For sale: Radio and TV test equipment tubes and parts. *Paulmer L. Williams, 112 S. Jefferson St., Lewisburg, WV 24901, 1-304-647-5414.*

For sale: 1953 Audel television service manual; two 9in b&w Sears televisions, model 5100 and model 7100, in one package and ready to ship out (not working); 1957 RCA color TV guide. *D.J. Aijala, 50 Fir Circle, Babbitt, MN 55706.*

For sale: Small model #806 mercury tube tester. Also an inventory of tubes for 50% off the 1974-75 list price, to be sold in one lot or in multiples of 25. Send for list with prices. *Fred W. Carn, Claysburg, PA 16625.*

For sale: B&K CRT checker, $35; Eico flyback tester, $25; hundreds of miscellaneous tubes for 80% off list price. *Temple TV, P.O. Box 782, Maywood, NJ 07607.*

For sale: B&L 747, $210 and Lectrotech BG-20, $110. *Miller, 10027 Calvin, Pittsburgh, PA 15235.*

ES&T

Circle (16) on Reply Card

Frederick L. Scott, service manager for DAC Data Systems, explains a function test that he is performing on a Z-89 microcomputer to Dorothy Cicchetti, company president. *(Photo courtesy of Thom O'Connor.)*

Keeping Zenith's computers on line

By Warren Thayer

Dorothy A. Cicchetti hangs up the telephone and glances at the immense regional wall maps that keep tabs on her three radio-dispatched service trucks. After finding the one nearest JFK International Airport, she reaches for the radio transmitter on her desk.

"Base calling one-two, come in one-two."

"One-two," responds the voice over the radio.

"Proceed to control tower at JFK. A Z-89 is down and in need of immediate technical support. Let us know when you arrive."

"Ten-four."

In 30 minutes, the truck is at JFK. In less than an hour, the Zenith Data Systems microcomputer is working again. It's all part of a busy day's work for Cicchetti, president of DAC Data Systems.

DAC, located in Flushing, NY, is one of more than 200 companies servicing Zenith Data Systems' microcomputers across the country. Like the other Zenith Data Systems authorized service centers, it repairs units in the customer's office while they are on the 90-day warranty and offers follow-on maintenance and repair agreements.

But DAC stands out as one of the stars in the computer repair field. Customers like the technical competency and the rapid service–a truck usually arrives within two to four hours, and always within a day.

Frederick L. Scott, DAC's systems engineer and service manager, said he and the two other technicians who work for DAC usually resolve the problem within a half hour after arriving at the site. There's no real pattern to the type of servicing required, he said, adding "No, I've never had a call where the only problem was that the unit wasn't plugged in."

The trucks carry enough spare parts to completely rebuild four of Zenith's Z-89 or Z-90 models.

Naturally, a complete rebuilding job is never necessary, but technicians find they never have to return to a site for lack of a needed part. Cicchetti noted that only twice since DAC was founded in August, 1980, has a unit had to be brought in to the Flushing headquarters.

DAC entered the computer repair field when the market had yet to develop, and Cicchetti conceded there was an element of risk involved. But she feels the risk was minimal for a variety of reasons.

First, she has been running CSI Electronics (which shares DAC's building) for almost 30 years, and is CSI's vice president and business administrator. For 22 years, CSI has dealt exclusively with Zenith home entertainment products.

"We knew Zenith extremely well. I'm a Zenith loyalist–I think they're great to work with. And CSI was good background for us. We knew the electronic repair business already, so we were used to the pressure," Cicchetti said.

She thinks 1982 will be a year of tremendous growth for DAC, and that several more technicians will have to be hired.

Service contracts are available on a monthly, quarterly or annual basis after the initial 90-day warranty period expires. Zenith Data Systems now offers a suggested service contract form nationwide that the service centers can use, and Cicchetti believes there will be substantial growth in this area because of business and professional use of desktop computers.

Looking back on her investment in DAC and computer service, Cicchetti said, "It's definitely been a rewarding experience in all ways. We were one of the first, and I know they say pioneers get arrows in their backs, but we haven't had many arrows. I honestly didn't really expect many."

ES&T

PHOTOFACTS

These Photofacts for TV receivers have been released by Howard W. Sams & Co. since the last report in ES&T.

GENERAL ELECTRIC
Chassis EM-D 2073-1

GOLD STAR
Chassis GL-X 2072-1

HITACHI
CT1914/18 2073-2
CT1911 2069-1
CT19X3/9X7/913/917 2074-1

PANASONIC
CT-3020A 2063-1
Chassis NMX-GLA 2065-1
Chassis 7A02-A 2074-2

JCPenney
685-1038E,F,-00,-10 (855-1798) 2061-1
685-1025,-00 (855-2960) 2067-1
685-1701F,-20 2068-1
685-4005F,-00 (855-2820) 2070-1

PHILCO
Chassis E34-1/4/5 2063-2

QUASAR
Chassis ADTS-/GTS-/YADTS-985 2070-2
Chassis ADTS-/TS-/YADTS-987 2072-2

SAMSUNG
CT-331AZ 2064-1
CT-501AZ 2066-1

SANYO
Chassis A2B-94NOO/01 2061-2
Chassis A2B-92NOO/01 2062-1

SEARS
564.44151150/4201150/4221150/4241150 2066-2
564.50384150 2068-2
564.42102150/51 2074-3

SHARP
C1985A 2071-1

TATUNG
13CFB 2057-2
19CFB 2059-1

TOSHIBA
Chassis TAC020/021/050 2054-1
Chassis TAC033/063 2058-2
Chassis TAC030/060 2050-3

WARDS
GGV12211B/220C 2053-3
GEN-11220A/250A 2064-2

ZENITH
N1990W5 2051-3
N1926W6 2054-2
SN2513W/21LE/23E/25M/
27DE/27P/31E/33PN/39X/
41X/43E/47PN/49E/51E/71P 2059-2
Chassis 9NB1X 2061-3
N1960P5,W5,X5,N1970LE5,
P5,N1992W6 2062-2
N2512W½/520LE/522E/524M/526DE/
526P/530E/532PN/588AR/592P 2064-3
N1312W4/320W4,N1740W4 2065-2
SN1961W5,X5/963W5/973P5/975P5 2067-2
N1908C5/912W6 2068-3
N1310W/314E/316M/318P/320PN,
N2502W/504E/506PN/508P/582E/584P 2069-2
SN1323W4/1743W,W4,SV3321E4 2071-2
N1924W6 2072-3

ES&T

Coming in

ELECTRONIC
Servicing & Technology

Noteworthy CB circuits. This look at three CB circuits covers two circuits used to incorporate special features and one that achieves amplitude modulation in a unique way.

BOOK REVIEWS

Editor's note: Periodically ***Electronic Servicing & Technology*** *presents reviews of books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publisher at the address given in each review rather than to us.*

Practical TV Troubleshooting Using a Video Analyzer, by Robert L. Goodman; Tab Books; 308 pages; $18.95.

The development of modular, super-circuit-board TV and video equipment, coupled with the proliferation of video devices for use in computer systems, video games, industrial applications and other technical equipment, has produced an increased demand for fast and efficient troubleshooting and repair service. This book is designed to make that job easier for technicians and service engineers dealing with all types of video devices. It's a compendium of all the technical information, operating instructions, and professional experience that has been developed on test and troubleshooting procedures for the Sencore video analyzer.

Loaded with shortcuts and practical techniques needed to help technicians and service engineers trail precise and minute digital and analog signals through a maze of "black boxes" and circuit panels, this book takes the guesswork out of the troubleshooting process and puts repair procedures into a scientific context that's consistent with the needs of modern technology. Readers will learn how to use each test signal as a quick means to finding the cause of specific problems, how to set up and perform each test, how to monitor the test signals, interpret the results and the techniques for repairing defects in each stage of typical video circuitry.

Published by Tab Books, Blue Ridge Summit, PA 17214.

How to Build Hidden, Limited-Space Antennas That Work, by Robert J. Traister; 308 pages; $9.95.

Here is help for hams, SWLs, CBers and anyone with a receiver or transmitter, but no place for large, conventional antennas. This how-to book shows the way to build a small-space antenna that will work just as well as bigger models, with projects for secret, hidden and limited-space antennas of all kinds and complete instructions plus detailed diagrams and schematics.

Topics include basic antenna principles – from voltage and current distribution to resonance, lumped constants, harmonics, ground systems, transmission lines standing waves, and all kinds of limited-space antenna applications. Special problems of the apartment dweller, even those living on the top floor of a high rise or in the sub-basement, are detailed, and solutions given.

Readers will learn how to wind coils and build shortened and hidden outdoor antennas, build indoor dipoles for hf work (including multi-bands), and devise antennas from existing structures (downspouts, fences, TV antennas or window screens). Projects include a suspended multiband vertical, a window antenna, an attic dipole and more.

Published by Tab Books, Blue Ridge Summit, PA 17214.

Speaking Pascal: A Computer Language Primer, by Kenneth Bowen; Hayden Book Company; 236 pages; $11.95.

This 10-chapter book is written in a non-mathematical language that requires no technical background or previous programming experience on the part of the reader.

After a brief introduction to the structure of computers and the problems of programming languages, the text explains various components of Pascal. Elementary and complex data types are covered along with the use of control structures, procedures and functions.

Bowen uses structured programming techniques to develop programs. In addition to exercises at the end of each chapter and numerous examples, an appendix is included on USCD Pascal.

Published by Hayden Book Company, 50 Essex St., Rochelle Park, NJ 07662.

49 Easy-to-Build Electronic Projects, by Robert M. Brown and Tom Kneitel; Tab Books; 112 pages; $9.95 hardbound, $5.95 paperback.

Anyone can dazzle family and friends with flashing lights, mysterious voices coming from the radio, sounds caused by just a move of the hands and dozens of other strange and novel effects. Or, readers can become ham radio operators, build AM radios, hi-fi amplifiers and other gadgets to make a music system sound better, and create devices to control lights, detect rainfall or even sense the presence of metal or radiation.

Only two types of the least expensive transistors are used, and the other parts are easy to come by. Tips in the book will help readers build up an inventory of inexpensive parts and show how to test salvaged parts to make sure they are good.

Complete, easy-to-follow instructions will guide readers through the construction phase, even if they're just getting into electronics project building.

Published by Tab Books, Blue Ridge Summit, PA 17214

ES&T

Circle (20) on Reply Card

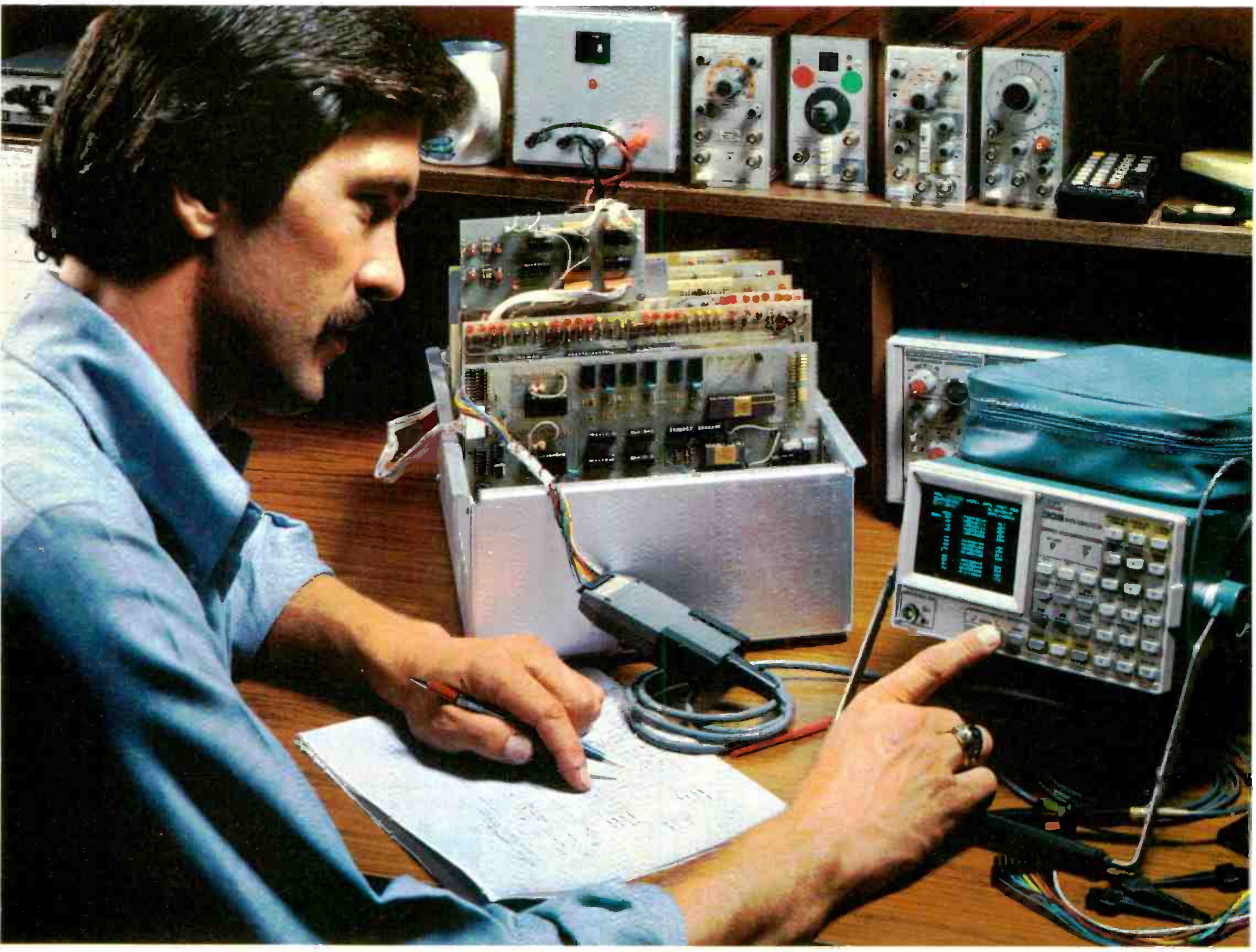
Circle (21) on Reply Card

In the last three to four years, microprocessors have come into their own in the electronics field. Microprocessors have had, and will continue to have, a large impact on digital instruments. In order to efficiently repair these newer and more complex instruments, the service technician will need the proper tools. The best tool for repairing digital systems is a logic analyzer.

Troubleshooting a complex digital system using an oscilloscope and/or a logic probe can be a frustrating and time-consuming experience. Even built-in diagnostic routines cannot prevent testing individual hardware circuitry or software data flow manually. When you have to get into the circuits, or even debug your software, you need a general-purpose logic-analysis tool.

Troubleshooting with a logic analyzer

By John Huber, Tektronix



Because of the microprocessor, new design innovations are turning digital systems into a serviceman's nightmare. Software, firmware, mnemonics, machine code—all of these concepts are being thrown at the service specialist who, just a few years ago, needed only an analog background and a rudimentary understanding of digital circuitry. How can the average service technician get along favorably in this new age of digital technology?

One way is through education. The service technician must be educated in the theory of digital systems and must know how to select and use the proper tools to test them. The primary service aid in digital systems troubleshooting is the logic analyzer. You will still need an oscilloscope and a multimeter for analog basics, but for use with complex digital circuitry, the logic analyzer is unsurpassed.

What is a logic analyzer?

Just a few years ago, the words *logic analyzer* immediately evoked in many people a picture of a big black box having many cables and switches. However, thanks to the microprocessor, logic analyzers have come a long way. Today's logic analyzer is keyboard controlled and has its own built-in CRT. It comes with high-impedance, quick-connect-disconnect probes.

Logic analyzers can be monolithic and used either as bench-top depot units or as lightweight portable packages to be carried into the field. They are available with a wide spectrum of frequencies, from 10MHz to 660MHz, enabling them to cover nearly all types of digital-system problems. They also can be clocked from an external source or clocked internally, which provides for synchronous or asynchronous operation, respectively.

The basic logic analyzer is made up of four different blocks (Figure 1). Block 1 is the data-acquisition section, which is the input port for all of the data to be stored by the logic analyzer. Block 2 is the memory section. The acquired data are loaded directly into random access memory for temporary storage. Block 3 is the display section. In this section, the acquired data, and possibly status information pertaining to the mode of operation, are displayed for the user. Block 4 is the control/trigger section. The control section consists of clocks, memory-control lines, and set-up parameters that enable logic analyzers to acquire data at the proper speed, load them correctly into memory, and properly display the acquired data. The trigger section controls the data being acquired and also determines exactly what data to store in memory for analysis. This section usually provides the most enhanced versatility because of its power to select data for analysis.

These four sections work together in the following manner: Data to be acquired are picked up from the system under test and loaded into memory until the trigger/control section halts data loading. The trigger/control section accomplishes this by recognizing either a particular data word or a block of the data being acquired. This section also regulates the display of the memory contents for troubleshooting the system under test. The display section is nothing more than a viewing section that allows the user to look at the data in different formats, that have been acquired.

Logic analyzer types

Four major types of logic analyzers are available: parallel timing, parallel state, serial state and signature analyzers. At least one of these logic analyzers is needed at each phase of a digital system's life cycle. The service technician needs *all* of these logic analyzer functions.

Why does a service technician need these specific functions? And what exactly does each one represent? Parallel timing is when multiple data signals are clocked

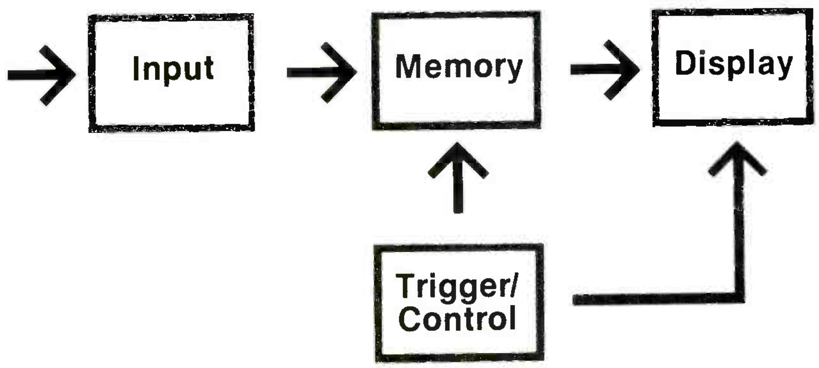


Figure 1. The basic logic analyzer.

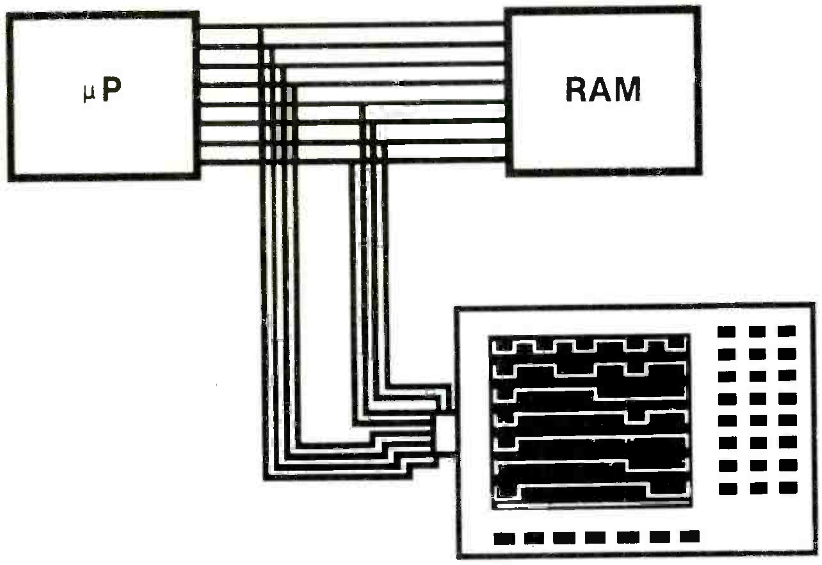


Figure 2. In a parallel timing logic analyzer, the data signals acquired from a parallel data bus are displayed so that they resemble a kind of data waveform.

into a logic analyzer at a set clock frequency or sample interval (Figure 2). These data signals are displayed as a pseudotiming waveform diagram. Psuedotiming is used because the timing relationships are based on the logic level of the signal during the sample interval. Timing diagrams are usually used for isolating hardware problems.

Parallel state is *also* a representation of parallel data signals clocked into a logic analyzer at a set sample interval (Figure 3). The data here are presented on the display as formatted binary words in hexadecimal, octal or binary form. The parallel-state mode is usually used for software and firmware debugging.

Serial state is a representation of data sampled via a single channel at a specified sample interval known as a baud rate (bits/second) (Figure 4). These data can be presented in hexadecimal, binary, ASCII or EBCDIC formats. The serial-state mode is used primarily for data-communications problems.

Signature analysis is a fairly new technique in logic analysis (Figure 5). This mode is based on a mathematical algorithm of polynomial division whereby a particular node in a digital circuit has its own repeatable "signature" based on the data flow through the node. In other words, a pin of a digital integrated circuit, when activated, has a specific pattern of 1s and 0s flowing through it. When read into a signature analyzer, this pattern becomes a unique 4-digit signature. This method is used with a signature table and needs additional signals (clock, start and stop) to be effective. Also, signature analysis must be designed into a system. Generally, it is impractical and expensive to try to incorporate signature analysis in a system already completed. Signature analysis can be used by anyone who can read and connect a probe to a node. It is primarily a hardware-troubleshooting tool.

If all of these four functions were combined into one instrument, you would have a data analyzer (Figure 6). Having these four functions in one package gives the service technician an ideal tool for digital-systems troubleshooting.

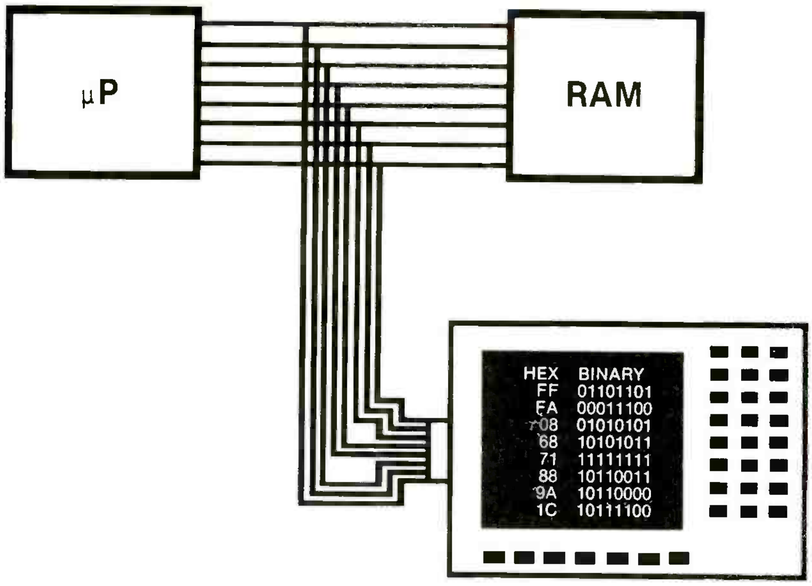


Figure 3. A parallel state logic analyzer displays the data it has acquired from a parallel data bus in the form of binary (or octal or hexadecimal) numbers.

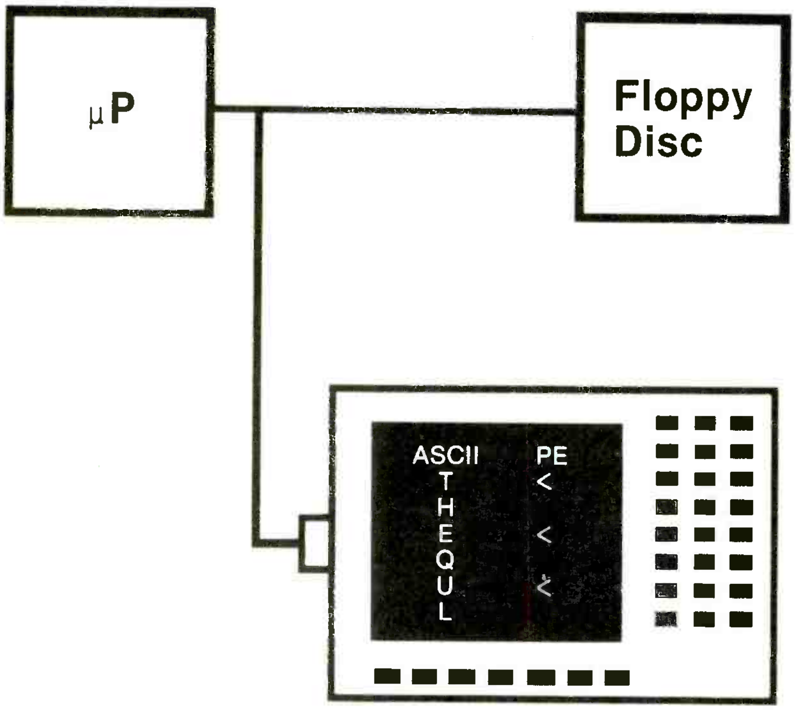


Figure 4. A serial state logic analyzer acquires a data signal from a single channel during a specified interval and displays it as a binary word.

Where to use a logic analyzer

Just because a logic analyzer has multiple channels that are ideal for microprocessor data and address-bus problems does not mean this is the only application. Any instrument that contains combinational or sequential digital circuitry can be repaired or debugged using a logic analyzer. Just remember, the logic analyzer was not designed to service *only* microprocessor-controlled instruments but *any* digital instruments. A logic analyzer can be used to troubleshoot any digital system from a basic counter to an IBM computer.

That's a big statement to make about the addition of a logic analyzer. Let's take a look at how

and why this is true. There are four major reasons:

1) multiple input channels,
2) triggering complexity,
3) memory size (depth/channel) and number, and
4) display features.

The multiple input channels tell how different input signals can be sampled and stored simultaneously. A minimum of eight channels for 8-bit microprocessors and basic digital circuitry is necessary, and at least 64 channels should be used for IBM-type computer systems.

The types of complex triggering available will enable the most elusive digital problems to be resolved. These will range from simple word-recognition triggers to sequential and nested triggering schemes to allow analysis of the complex, innermost circuitry of digital systems.

The memory size tells you how many samples of the input signals you can store for analysis, and the number of memories (preferably the same size) allows special features such as comparing data, glitch-triggering storage and "babysitting." Babysitting is a mode of operation in which the logic analyzer continuously makes an acquisition, compares it with known good data and stops when a difference is found.

The display features let you manipulate the data samples stored in memory to allow pinpointing of problem areas in either the hardware or the software of the digital system under repair. For example, there is a search feature for finding certain words or patterns in the memory and a cursor feature for decoding words or inputs from a timing diagram.

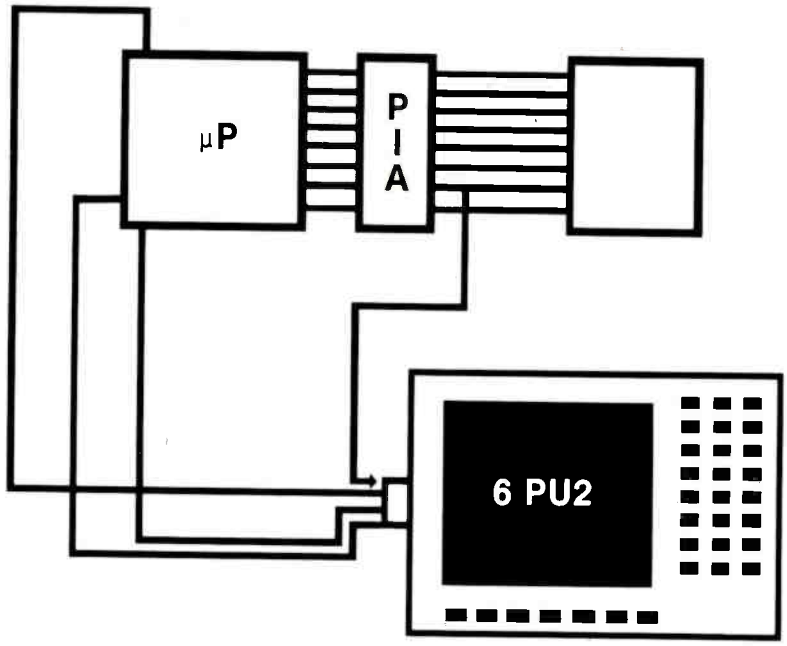


Figure 5. Signature analysis takes advantage of the fact that any pin of a digital integrated circuit has a specific pattern of ones and zeroes flowing through it.

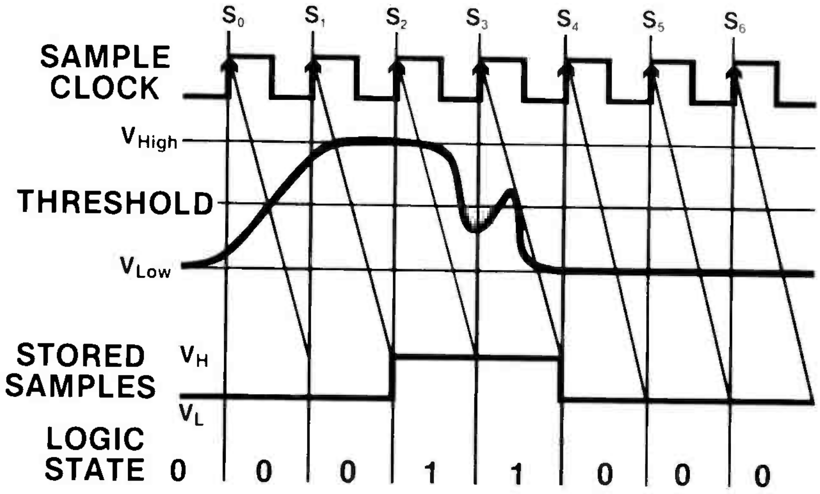


Figure 6. The ones and zeroes displayed by a logic analyzer are logic-level indications of the level of the input signal when the analyzer clock signal edge occurred.

Using the logic analyzer

Nearly anyone can learn to use one of today's logic analyzers. There is a 4-item checklist to go through when using a logic analyzer:

1) Connect the probes to the appropriate points of the system under test.
2) Set up the logic analyzer (on some models this can be time consuming) for the proper mode, entry format, data-trigger positioning, display logic, trigger word, external triggering, delay (if any), sample interval and qualifier inputs.
3) Press "start" to get the data coming into the logic analyzer. This enables it to find the trigger event or word-recognizer word you specified.
4) Analyze the data you have acquired in conjunction with the trigger and other specifications you have supplied. These data have been acquired and stored based on your specifications, so you can interpret them. Even if you have a timing diagram, the cursor will tell you where you are in reference to your trigger word and will even decode those timing waveforms into readable words of 1s and 0s or some other code.

Remember to use all of the available features of the logic analyzer to help you analyze your problem quickly and effectively. The main problem for most people when first using a logic analyzer is "What does all the stuff on the screen mean?" As is true with any new equipment, you need to have some hands-on training to understand it.

Interpreting the data

When it comes to analyzing the data stored in memory, problems begin to arise. Incorrect interpretation of the displayed data can cause time to be wasted looking for a non-existent problem.

Let's look at a typical asynchronous timing-diagram display and analyze what is displayed. One of the first things to be aware of is that the data being displayed are not *real*-time data. This goes back to logic analyzer basics (Figure 5A).

Because the data being loaded into the memory are being *sampled,* the 1s and 0s being stored are only logic-level indications related to where the input level was when the active clock edge occurred. This means that if your input pulse was above the threshold (a logical high) and your sample interval setting was very narrow (in relation to your input signal), then each edge of the clock would store 1s into the logic-analyzer memory until the input signal went below the threshold (a logical low). When the input signals change from high to low rapidly, you need to select a sample interval much narrower (at least five times) than the narrowest input signal to enable you to catch all transitions of the input. By properly selecting the sample interval, you see each input transition.

One thing to remember here is that when sampling asychronously, you are using the internal clock of the logic analyzer, which puts a physical limitation on the types of hardware you can analyze. When using a logic analyzer for asynchronous analysis, the maximum clock frequency must be five times faster than the fastest signal input. For example, a 50MHz logic analyzer will give you the capability to effectively troubleshoot a digital system that runs at 10MHz. This mode is usually used for hardware debugging.

For synchronous analysis you need only to match the clock speed of the logic analyzer to the digital system's clock, allowing data to be stored in step with the system clock. The synchronous mode is usually used with software problems, where it allows monitoring the flow of instruction for the digital systems. By capturing the system-instruction sequences, you can isolate incorrect instructions.

When using serial analyzers, you enter a different acquisition scheme. Serial data are clocked into the analyzer, either synchronously or asychronously, one bit at a time (Figure 7). These bits are normally formatted in groups of five, six, seven or eight and presented as a state-table display. The state table contains the serial data decoded into hexadecimal, binary, ASCII or possibly EBCDIC.

Serial-data interpretation is basically a verification that sent data were received correctly. With the data already decoded (in the state table), you can follow the data flow from start to finish. If there is an error you can see it immediately.

Signature-analyzer data displays are the simplest to interpret. The signature itself is meaningless. Signature analysis can enable troubleshooting to the component level if the proper steps are taken to provide the documentation and the necessary diagnostic procedures.

When using signature analysis, you simply acquire a signature at a node and compare it with the proper signature in the signature-table listing. If it's correct, you go to a different node. If the signature is incorrect, you move to verify the signatures for the inputs to the bad node.

Summing it up

Troubleshooting digital systems will continue to be a necessary part of the service technician's function. Using a logic analyzer, complex digital system problems can be diagnosed and repaired more efficiently. Efficiency in a service department means less downtime for the customer, coverage of more calls per day and a better service reputation for your company.

You should now have a basic understanding of logic analyzer types, how to use them and where to use them. Also, you should understand that a logic analyzer is a versatile troubleshooting tool, easy to use and effective in resolving digital problems. With a minimum amount of training, a service technician can learn to interpret and analyze digital-system problems using logic analysis. To be even more effective, service technicians can use a logic analyzer in conjunction with a multimeter and an oscilloscope to give them an arsenal of problem-solving equipment.

A final word of caution: Be certain to choose the correct type of logic analyzer for your particular application. And, above all, plan for future needs. For the service world, digital systems will continue to get more complex, and the proper tools will get the job done more effectively and efficiently.

ES&T

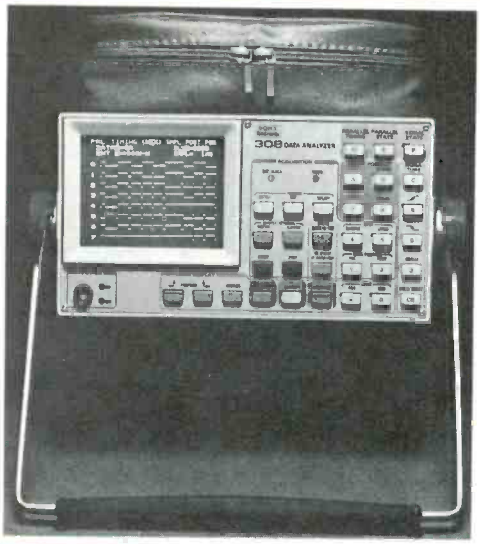


Figure 7. The logic analyzer bears a resemblance to its analog counterpart, the oscilloscope.

DATA

SYNCHRONOUS 0110110111101110111011101110
— A clock is supplied with the data to synchronize the transmitter with the receiver.

ASYNCHRONOUS — The data is sent in groups at a predetermined rate but framed with a start bit and stop bit (or bits).

Figure 8. Serial data are clocked into a serial analyzer either synchronously or asynchronously, one bit at a time.

CALENDAR OF EVENTS

June

6-9
Summer CES '82, McCormick Place, Chicago, IL. Contact Consumer Electronics Shows, Two Illinois Center, Suite 1607, 233 North Michigan Ave., Chicago, IL 60601, 1-312-861-1040.

7-10
National Computer Conference '82, Astro Arena, Houston, TX. For more information call 1-703-558-3600.

August

2-7
Joint convention of National Electronic Service Dealers Association, International Society of Certified Electronic Technicians, The Texas Electronics Association, the Louisiana Electronic Service Dealers Association and Television Service Association of Arkansas at the Hilton in New Orleans, LA. Contact The National Electronic Service Dealers Association, 2708 W. Berry St., Ft. Worth, TX 76109, 1-817-921-9061.

24-25
Indycon '82 microcomputer and electronic components conference, Indianapolis Convention Center. Sponsored jointly by Institute of Electrical and Electronic Engineers, Electronic Representatives Association and the National Electronic Dealers Association. Contact F. Schechter, Show Manager, 8326 Trace Circle, Indianapolis, In 46260, 1-317-875-7711.

26-29
National Association of Television & Electronic Servicers of America (NATESA) Annual Convention, Indian Lakes Resort, Bloomingdale, IL. Contact Frank J. Moch, 5930 S. Pulaski Road, Chicago, IL 60629, 1-312-582-6350.

September

14-16
Wescon '82, Anaheim Convention Center, Anaheim, CA. For more information call 1-800-421-6816.

14-16
Mini/Micro Computer Conference and Exhibition, Disneyland Hotel, Anaheim, CA. Contact Electronic Conventions, 999 N. Sepulveda Blvd., El Segundo, CA 90245, 1-800-421-6816 (in California, 1-213-772-2965).

Storing a waveform

By Michael Gasparian and Charles Donovan, product marketing engineers, Hewlett Packard.

Storage oscilloscopes are becoming increasingly popular as a solution to the variety of measurement problems encountered daily. Without a background knowledge of the technologies involved in storing a signal, however, a storage oscilloscope can be frustrating to operate. With this in mind, this article will review the primary methods of storing a waveform – the technology and physics behind variable persistence/storage oscilloscopes and digital oscilloscopes.

The storage CRT

Although each CRT manufacturer uses a different design, some elements are common to all storage CRTs. The diagram in Figure 1 highlights the key elements necessary to review the storage process.

Write gun: a triode electron gun consisting of a filament, cathode, and grid. The grid voltage is varied with the oscilloscope's intensity control, and the difference between grid and cathode voltage sets beam intensity.

Deflection plates: These plates, horizontal and vertical, transfer input signal information to the write beam for any point in time.

Flood gun(s): emit a cloud of slow-moving electrons.

Collector mesh: a fine wire mesh, usually kept at a voltage that will collect excess electrons.

Collimator: creates a voltage field that shapes the flood gun electrons into a uniform cloud.

Storage mesh/dielectric layer: The storage mesh is a fine wire mesh, analogous to a screen door. The dielectric material is deposited on the storage mesh and is where storage actually takes place.

Phosphor/aluminum backing: The phosphor is a chemical coating that covers the faceplate of the CRT. Phosphor emits photon energy (light) when bombarded (excited) by electrons. This photon energy, called luminescence, consists of the energy at the time of the excitation and a continued emission after the excitation is removed. This "afterglow" is known as persistence and is used in characterizing phosphors. Most oscilloscopes use P-31 phosphor, which emits a green-colored light that reaches a 10% persistence level (10% of original light output) in 38μs. The aluminum backing permits a high voltage potential to be applied to the phosphor and serves to accelerate electrons to the surface.

Storing an image

A stored image results when the electron beam interacts with the storage dielectric material. A signal is stored in the dielectric layer on the storage mesh. Storing a signal requires differentiation between the areas of the storage surface that are struck by write-beam electrons and those that are not.

Imagine three high-velocity write-beam electrons striking the storage dielectric surface with enough energy to jar three electrons loose. The charge on the surface remains constant, and the net effect of the interaction is zero. However, if three electrons with more energy than the first three strike the dielectric matter or the same three strike a different dielectric, the three striking the surface might dislodge six others. In this example, the interaction creates a highly localized net positive charge. This phenomenon, called the secondary emission principle, is defined as the average number of secondary electrons emitted from a bombarded material as a function of a primary electron energy; that is, write-beam electrons. (See Figure 2.)

In a storage CRT, primary electrons from the write beam possess a large amount of energy, resulting in a secondary emission ratio of approximately 5:10. It is important to remember that the write-gun electrons, via the secondary emission ratio, create a highly localized net positive charge wherever the write beam strikes the storage surface. The amount of positive charge is a function of how fast the write beam is moving (the slew rate). Written and unwritten areas can be easily differentiated by their potential on the storage surface (written, positive; unwritten, neutral).

Projecting the stored image

After an image has been written on the storage mesh, it must be projected to the phosphor so that it is visible on the CRT faceplate. The stored image is projected to the phosphor by low velocity flood-gun electrons reacting differently to written and unwritten areas.

The flood guns emit slow-moving electrons, which are shaped into a uniform cloud by the collimator. These electrons are accelerated

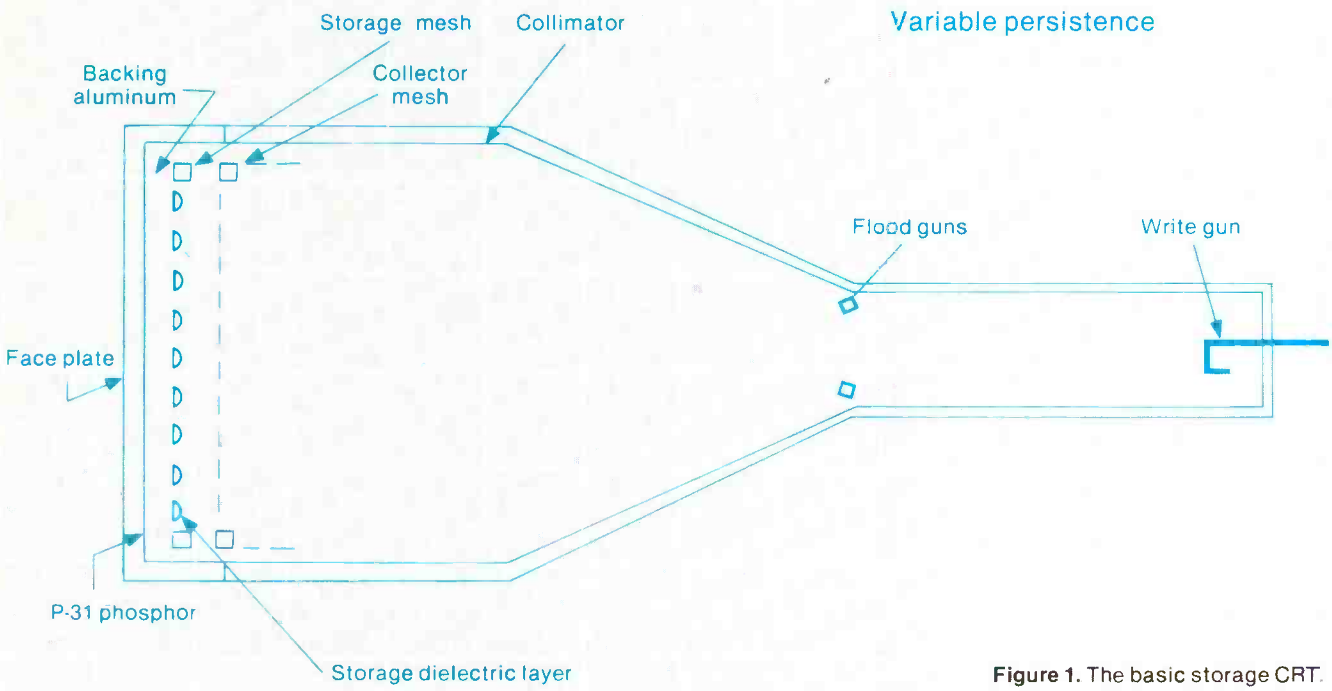


Figure 1. The basic storage CRT.

toward the storage surface. Approximately 30% pass through the collector mesh, where they interact with the electric fields associated with written and unwritten areas. The electric fields of written areas permit electrons to penetrate the storage mesh, while the electric fields of the unwritten areas repel these flood gun electrons back to the collector mesh (Figure 3).

The flood gun electrons that pass through the storage surface see the high voltage (≈10 to 20kV) of the aluminized phosphor and are accelerated to the phosphor. Striking the phospher with high energy, these electrons excite the phosphor and produce a photon emission, which displays the stored trace.

Erasing the image

The erase cycle is both the initial and final phase of the storage process. Initially, this cycle erases any previously stored image and then sets the sensitivity of the storage surface to accept new information from the write beam.

Erasure starts with a high voltage on the entire storage mesh. This high voltage is capacitively coupled to the dielectric layer. This attracts flood gun elec-

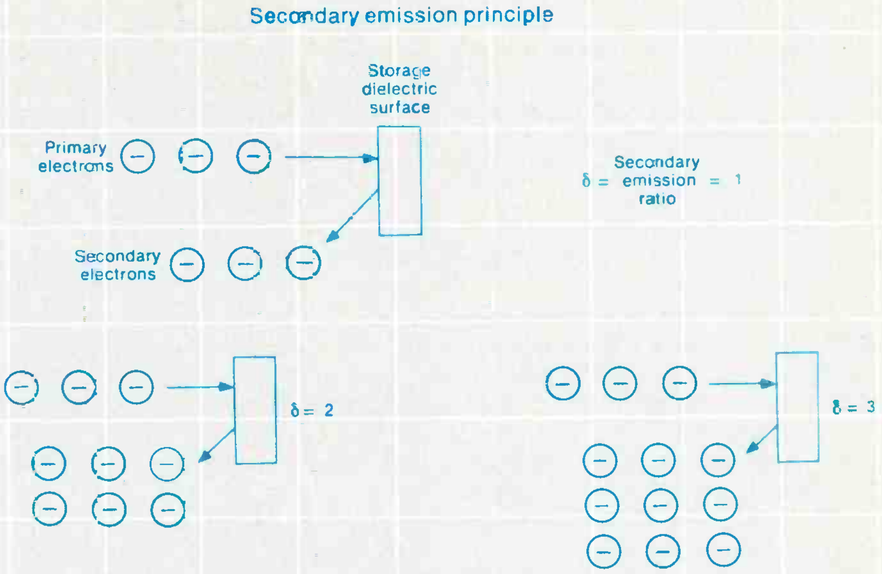


Figure 2. The secondary-emission ratio (δ) is defined as the average number of secondary electrons emitted from a bombarded material as a function of primary-electron energy.

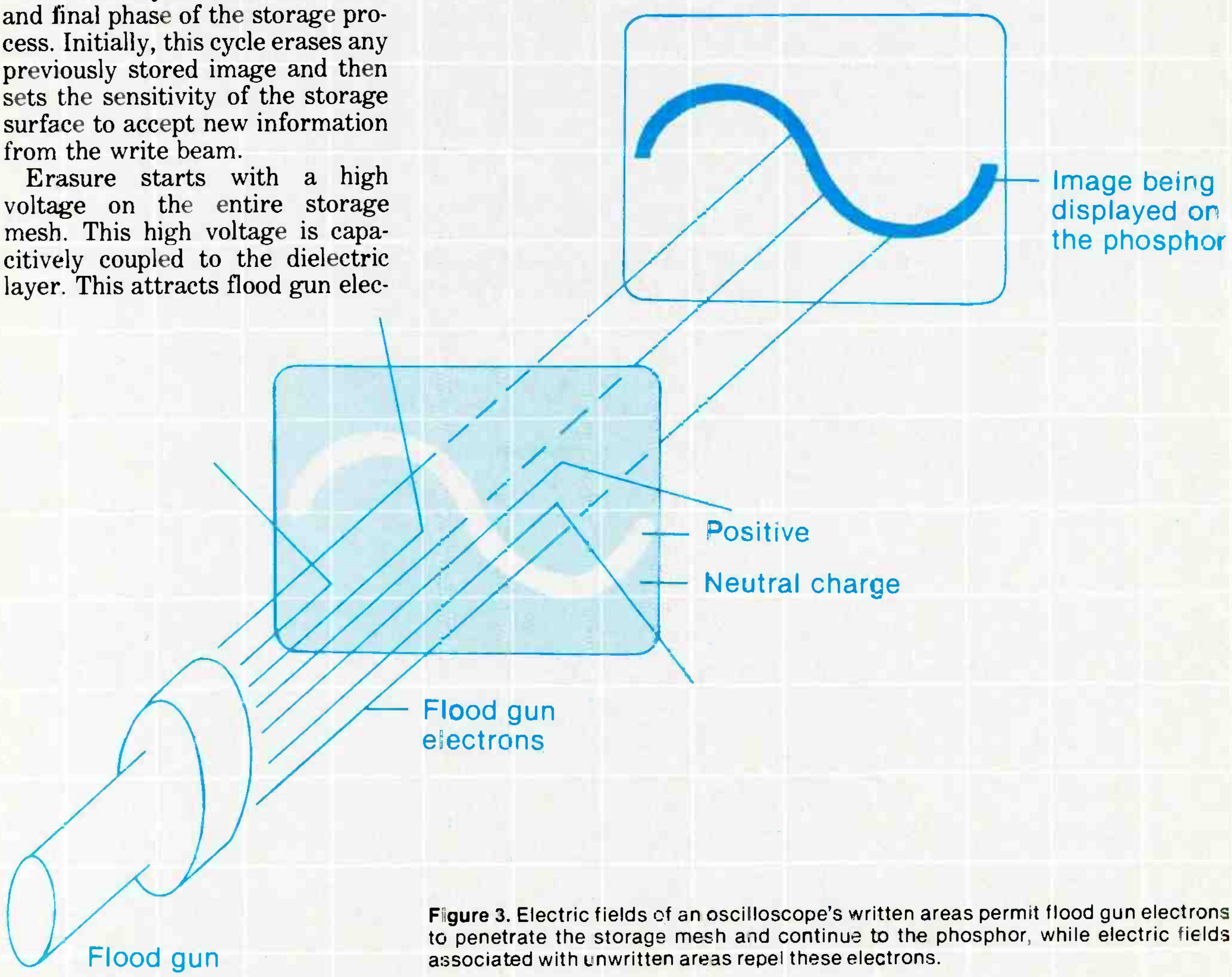


Figure 3. Electric fields of an oscilloscope's written areas permit flood gun electrons to penetrate the storage mesh and continue to the phosphor, while electric fields associated with unwritten areas repel these electrons.

trons and permits them to pass through the entire storage surface to the aluminized phosphor. Next, the storage surface returns to a nominal voltage and prepares to write new information. The sensitivity of the mesh is established with the brightness control, which regulates the base voltage on the storage mesh.

Variable persistence

Variable persistence was designed to match input signals and persistence characteristics over a wide range of conditions. Ideally, the best trace display could be obtained by interchanging phosphors to compensate for sweep speeds, repetition rates and other signal characteristics. Because this is hardly practical, an artificial method of changing persistence was developed. The technical aspects of variable persistence are directly related to the storage process outlined. Basically, the interaction of the persistence, intensity and brightness controls dictate the perceived persistence of the phosphor.

The principle behind variable persistence is relatively simple. Imagine a stored image being projected to the phosphor by the flood-gun electrons. As long as that image remains stored, it continues to be displayed on the CRT faceplate. When the stored image is slowly erased, the image on the phosphor slowly fades away. This process generates persistence depending on the rate of erasure.

Erasure occurs with miniature erase pulses that slowly erase the stored image, rather than one large, standard erase pulse. By varying the frequency of these pulses, different persistence characteristics are achieved.

The higher the frequency, the faster the erase process; the lower the frequency, the slower the process and the longer the persistence. (In Hewlett-Packard's variable persistence oscilloscopes, when the persistence control is set for minimum, a 1kHz pulse train creates a persistance of approximately 100ms.)

Variable persistence is useful in a variety of applications. Flicker can occur when the input signal repetition rate is below approximately 30Hz or a sweep speed of 2ms/div or less is selected. Either solution is annoying to view and difficult to measure. Variable persistence quickly "integrates up" the waveform from a flickering display or trace too dim to see to a bright display. Second, variable persistence usually amplifies the light on low repetition rate signals at fast sweep speeds. With a conventional CRT, these fast sweep speeds produce low light output and frequently require a viewing hood. In many applications, variable persistence is used when capturing infrequent transitions that might occur in digital systems or components (Figure 4).

Storage oscilloscopes are commonly used to capture elusive transients that occur infrequently–either single-shot or with a low repetition rate. One key specification, which measures how fast the signal can move and still be viewed, is called stored writing speed. This measures how fast the write beam can move (for only one sweep) and still create enough positive charge, via the secondary emission ratio, on the storage surface so that the flood guns can project the image to the phosphor. It is important to understand that the primary limitation of a storage oscilloscope is the storage mesh and its sensitivity. In most cases, the bandwidth of the oscilloscope exceeds the signal frequency it can capture. Therefore, the signal fidelity of the display is accurate, but viewing a display is questionable. This is quite different from the limiting factor in digital storage technology.

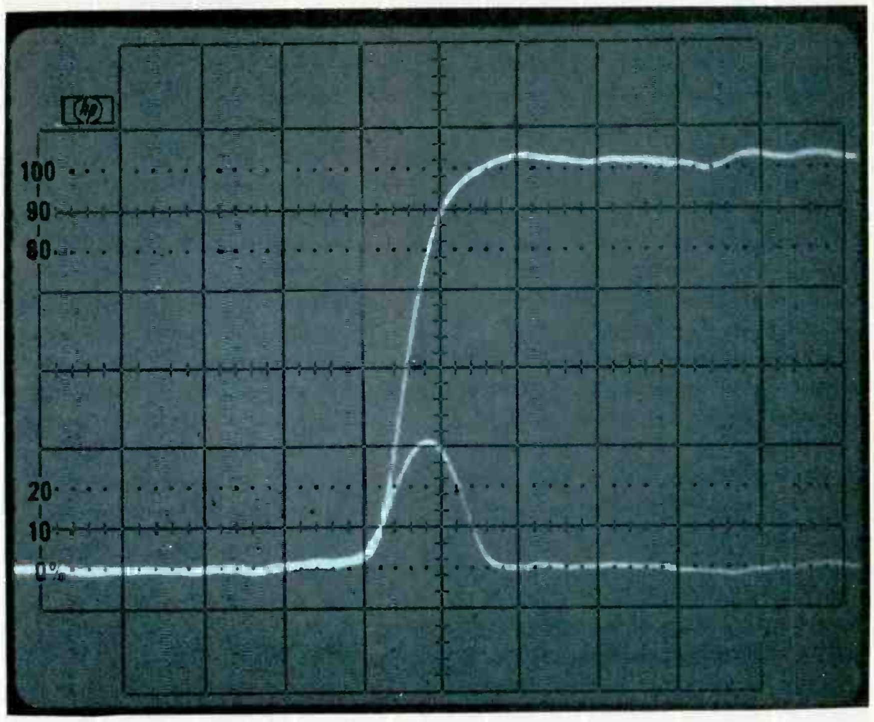


Figure 4. The variable persistence mode of Hewlett Packard's 1727A (275MHz) can easily capture setup and hold violations in an ECL 10k D flip-flop.

Fast writing speed

Two techniques are currently used to achieve fast writing speeds: expansion storage and transfer storage.

Expansion storage creates fast writing speed by combining a miniature precision storage mesh with an electronic lens system that magnifies and projects the stored image. The storage mesh is approximately one-fifth the size of the viewing screen and is sandwiched between the collector and accelerator meshes directly in front of the deflection plates (Figure 5). Any image written on the storage mesh is magnified by a static-electric field crossover lens system and is projected to the viewing screen.

A simple analogy explains the basic principles of expansion storage. Imagine a boy who smears mud on a window pane (storage mesh) with his finger (write beam). That night, someone shines a flashlight (flood gun) onto the small pane. Light (flood gun electrons) passes into the room only where the mud was etched away. On the inside of the room, the etched image is magnified (static-electric field lens system) and displayed as a large object on the wall (phosphor).

Transfer storage achieves fast writing speed by using two meshes adjacent to the CRT phosphor. The write beam traces an image on the first mesh, an extremely sensitive mesh optimized for writing speed. This is usually called the fast mesh because it can capture fast write-beam slew rates. The high sensitivity of this mesh does not allow a store time of more than a few seconds. Therefore, after the image is captured on the fast mesh, it is transferred to the second mesh, where it can be displayed for a longer time.

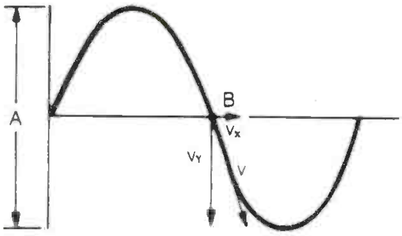
This method of storage offers fast stored writing speeds and long storage times in the single-shot mode. The method of capture and display is to write on the fast mesh, transfer what is written to the bistable mesh, erase the image on the fast mesh, and reset to sweep again. Because the minimum time between sweeps is approximately one second, some applications are difficult with this method.

Digital storage

Digital storage, or digitizing, is the process of sampling a waveform at equally spaced, discrete points in time and then converting the sampled analog voltages into digital values (Figure 6). This process is accomplished by an analog-to-digital converter (ADC). Using this technique, waveforms can be

A stored writing-speed specification defines the maximum beam velocity that can be captured and displayed on a single-shot basis. To simplify comparisons between oscilloscopes, it is convenient to express writing speed in cm/μs rather than div/μs. This eliminates the need to know the division size. Also, all writing-speed measurements should be made using a viewing hood to avoid variations in writing speeds due to different ambient light conditions. To determine if a storage oscilloscope can capture a specific single-shot signal, calculate the maximum signal spot velocity and compare it with the writing speed specification. A method for calculating the maximum spot velocity of both a single-shot sine wave and transition time of a pulse follows.

Convert writing speed in cm/μs to div/μs by dividing the graticule division size in centimeters into the cm/μs writing speed. For example, for a model with 0.72cm/div graticule markings and a 2000cm/μs stored writing speed, 2000÷0.72 equals a stored writing speed of 2778div/μs.



When a beam writes a sine wave, the vector spot velocity (V) is composed of both the vertical (V_y) and horizontal (V_x) component, which are related as:

$$|V| = \sqrt{V_y^2 + V_x^2}$$

Vertical displacement (y) is defined as:

$$y = \frac{A}{2}\sin(2\pi ft)$$

and therefore:

$$\frac{dy}{dt} = V_y = A\pi f\cos(2\pi ft)$$

Maximum vertical spot velocity occurs at point B where: $\cos(2\pi ft) = 1$, therefore: $V_y\ max = A\pi f$

Horizontal spot velocity (V_x) is constant and equals 1/time base setting in divisions per microsecond.

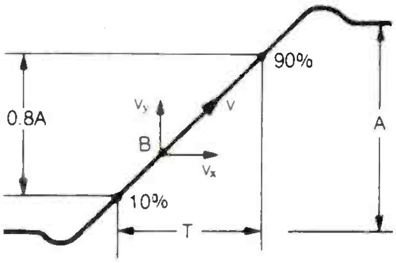
Therefore, when f is in MHz:

$$V_{max} = \sqrt{(A\pi f)^2 + \left(\frac{1}{\mu s/div}\right)^2}$$

When several cycles (approximately 10) are displayed on screen, the horizontal spot velocity component is small with respect to the vertical component and can be neglected.

In this situation:

$$V_{max} \approx A\pi f$$



Assuming that the maximum spot velocity equals the average velocity between the 10% and 90% points, then $V_y = 0.8A/T$, where T = observed pulse rise time.

For most oscilloscopes:

$$T_{observed} = \sqrt{t_{pulse}^2 + t_{scope}^2}$$

Horizontal spot velocity is constant and equals 1/time base setting in divisions per microsecond.

$$V_{max} = \sqrt{\left(\frac{0.8A}{T_{observed}}\right)^2 + \left(\frac{1}{\mu s/div}\right)^2}$$

When $V_y \gg V_x$:

$$V_{max} \approx \frac{0.8A}{T\ observed}$$

Table 1 is a quick reference guide showing the writing speeds associated with several frequencies, amplitudes and sweep speeds.

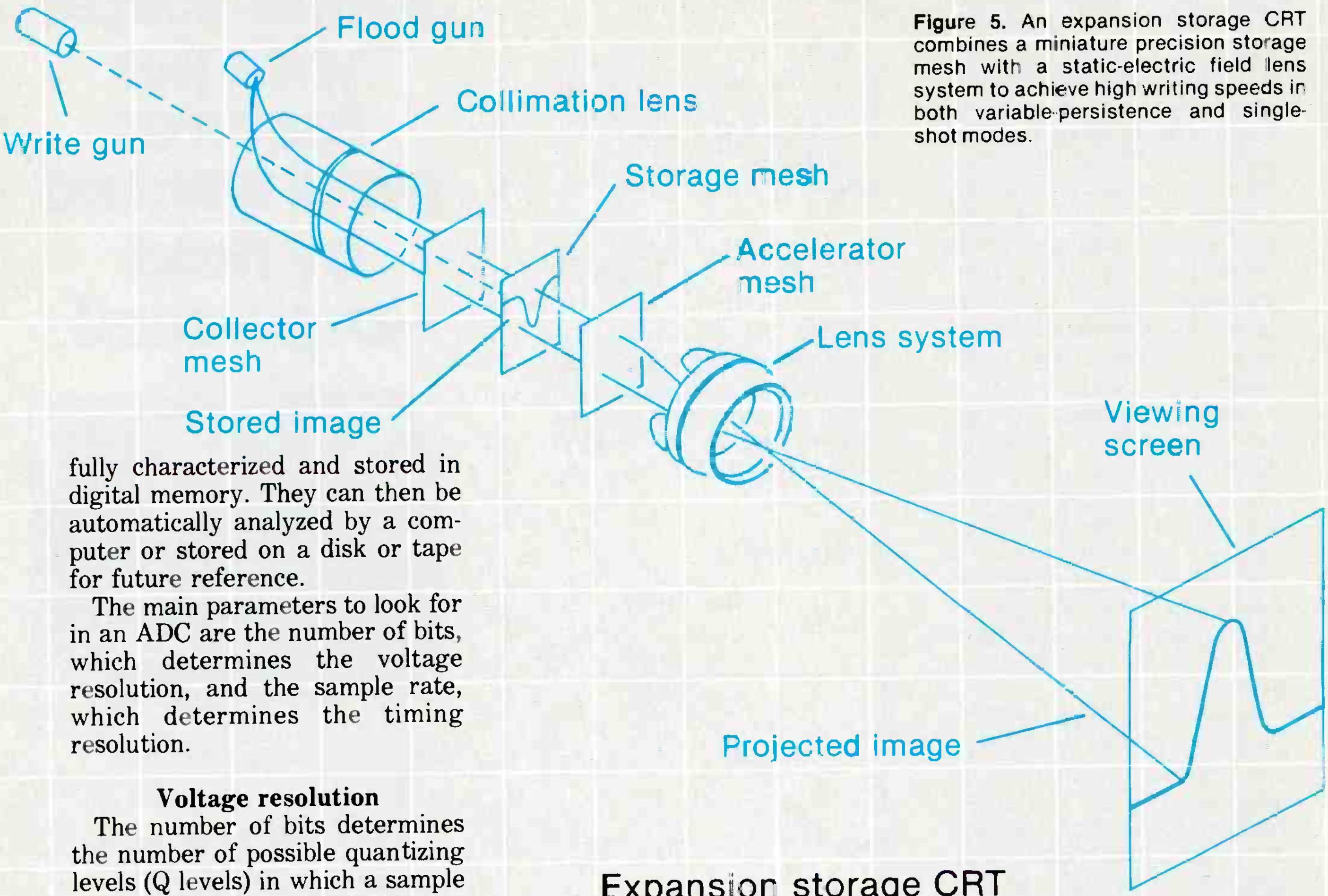


Figure 5. An expansion storage CRT combines a miniature precision storage mesh with a static-electric field lens system to achieve high writing speeds in both variable-persistence and single-shot modes.

fully characterized and stored in digital memory. They can then be automatically analyzed by a computer or stored on a disk or tape for future reference.

The main parameters to look for in an ADC are the number of bits, which determines the voltage resolution, and the sample rate, which determines the timing resolution.

Voltage resolution

The number of bits determines the number of possible quantizing levels (Q levels) in which a sample can fall. Because an n-bit digitizer has 2^n Q levels, the smallest voltage that can be detected (Q) times the number of Q levels gives the full scale voltage window (Figure 7).

Because the smallest level that can be detected is Q, there is always the possibility of an error of $\pm\frac{1}{2}Q$ (Figure 8). This error shows up as noise on a digitized waveform and can be expressed as a signal-to-noise ratio (SNR). The SNR is the largest signal that can be digitized over the sample error. This relationship is expressed as:

$$SNR = 2\ \log_{10}\left(\frac{Q2^n}{Q}\right) = 6n + 1.8db$$

Therefore, in an 8-bit ideal ADC, where the only error is the quantization error of $\pm\frac{1}{2}Q$, the SNR = 49.8db. This is a measure of the quality of an ADC. As the frequency of a signal increases, the SNR of most ADCs degrades because the least significant bit (LSB) or bits of the ADC lose their ability to change rapidly enough to represent the signal accurately. This causes the effective resolution of the ADC to go down, and an 8-bit ADC may behave like a 6-bit ADC.

The SNR is specified on some new ADCs as an equivalent number of bits for a range of frequencies. This is measured by digitizing a sine wave and calculating the SNR using either a Fourier transform or a technique called the sine wave curve fit. After the SNR is known, the equivalent bits can be calculated with the formula:

$$EB = \frac{SNR - 1.8}{6}$$

Table I

The stored writing speed needed to capture any signal can be calculated and compared with oscilloscope specifications. This table, using the formulas presented, provides general information on the stored writing speed required to capture single-shot sine waves of a specific frequency and amplitude.

Frequency	20MHz	100MHz	275MHz
Amplitude	3cm	5.4cm	2.2cm
Sweep speed	20ns/div	5ns/div	1ns/div
Required writing speed	195cm/µs	1702cm/µs	2000cm/µs

Time resolution

An ADC's sample rate determines the maximum frequency it can detect, as well as its time resolution. Nyquist's sampling theory says that one half the sample rate is the maximum frequency that the ADC can detect. This provides two points on each period of the waveform (Figure 9). For example, an ADC with a sample rate of 10MS/s (megasamples per second) can measure a frequency of up to 5MHz. This does not say that sufficient amplitude information will be available to measure the peak-to-peak voltage, only that the frequency can be detected.

A good benchmark to use is that 10 points are needed on the period of a waveform to obtain useful amplitude and frequency information. This is because a square wave is often the waveform being acquired. A square wave is a summation of odd harmonics with the formula:

$$f(t) = \sum_{l=1}^{\infty} Cn \sin(nt)$$

where CN = 0 for n even, $Cn = \frac{4}{\pi n}$

for n odd, and t = period of the square wave.

Therefore, the fifth harmonic, which will have two points per period, is approximately 20% of the amplitude of the fundamental frequency.

Although 10 points per period is a good rule of thumb, it is by no means an absolute measurement criterion. For example, if you want to use the data to perform a rise-

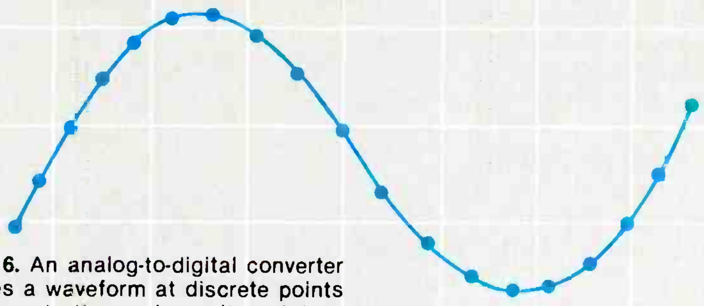


Figure 6. An analog-to-digital converter samples a waveform at discrete points and converts the analog voltage into a digital value.

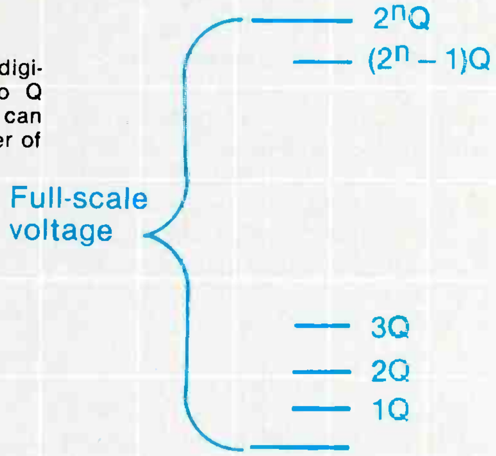


Figure 7. The possible values of a digitized point are broken down into Q levels. The largest signal level that can be digitized is 2^n where n = number of bits.

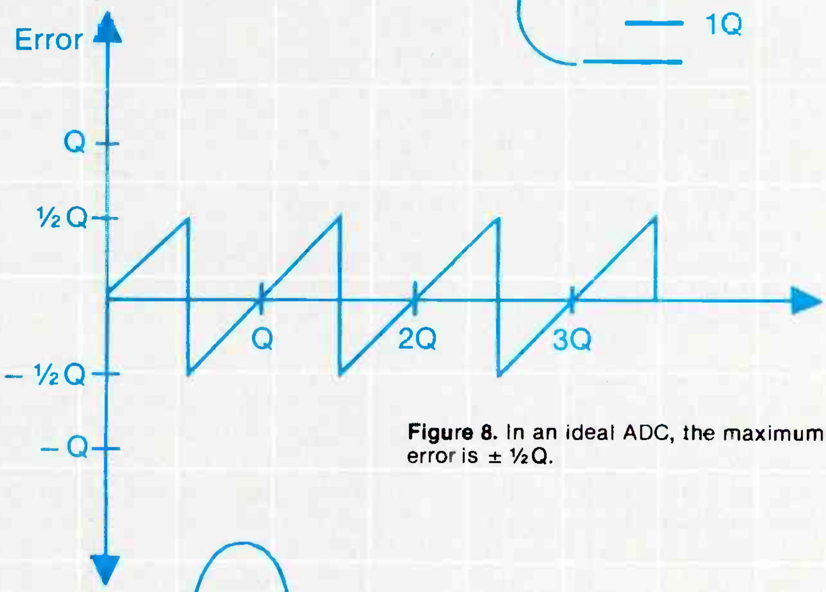


Figure 8. In an ideal ADC, the maximum error is ± ½Q.

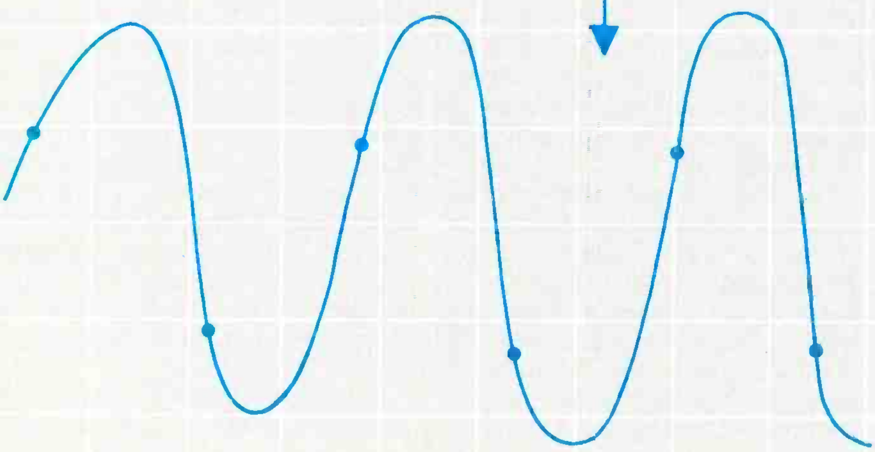


Figure 9. Using the Nyquist criterion of two points per period only allows the frequency of the waveform to be measured, but very little amplitude information is obtained.

time measurement, then you should have at least 10 points just on the rising edge, and the period of the waveform will not matter.

Interpolation

Some digital storage instruments use interpolation to increase the useful digital storage bandwidth with a fixed sample rate. One method that is widely used is vector or pulse interpolation in which lines are drawn between the digitized points. Although the lines do not add information about the waveform, they do help the operator determine the wave shape. A similar method is sine interpolation in which the digitized points are connected with a sinusoidal function. Sine interpolation increases the useful digital storage bandwidth from 10 points per period to 2.5 points per period, but it works only if the waveform is sinusoidal.

Aliasing

Aliasing is a potential problem when using digital storage. Aliasing occurs when the frequency of the sampled waveform is greater than one half the sample rate. The frequency increment greater than a multiple of one half the sample rate is aliased into the data. For instance, when a 110Hz sine wave is sampled at a 100Hz rate, the data will show a 10Hz sine wave (Figure 10).

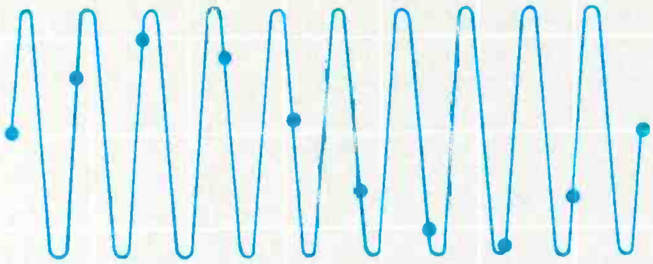


Figure 10. When a signal of 100Hz is sampled at a 100Hz rate, 10Hz is aliased into the data.

This is sometimes known as a beat frequency. For example, when tuning an instrument, a reference note is played and the instrument is tuned to eliminate the beat or aliased frequency, which is the difference between the two notes.

ADC techniques

Several different techniques are used to convert the analog signal into digital values in digital oscilloscopes. The two most popular of these are successive approximation and flash conversion.

The slower, but usually more accurate, of the two methods is successive approximation. With this method, a digital to analog (DAC), a comparator and decision logic perform the conversion (Figure 11). The DAC produces an analog voltage that is compared to the input. The DAC starts out with the most significant bit (MSB) turned on and the rest of the bits turned off. The input voltage and the DAC voltage are compared to determine if the MSB should stay on or be turned off. Each bit is checked in this manner until the LSB is checked.

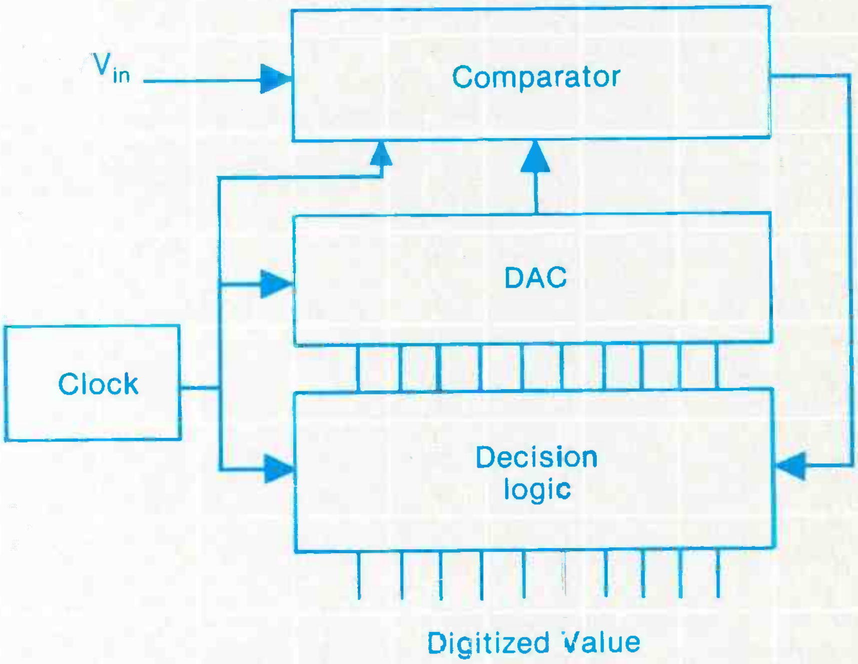


Figure 11. A successive approximation ADC utilizes a DAC comparator and decision logic to make the conversion.

The input signal must remain constant during the conversion process or serious errors can occur, especially if the change in the input signal affects whether the MSB is turned on or off. To eliminate this potential source of error, a sample-and-hold circuit is often placed before the ADC. This circuit samples the input voltage and holds it while the ADC performs the conversion.

To do this, a sample pulse generator turns on a diode bridge by providing very narrow pulses (Figure 12). The bridge is turned on for a short period of time known as the aperture time, which charges the hold capacitor with a percentage of the input voltage. This voltage is then integrated onto a second capacitor for a predetermined period of time, which charges the integrating capacitor to the input voltage. The input voltage is then held on the integrating capacitor while the conversion is performed.

A drawback of the successive approximation ADC is that one clock

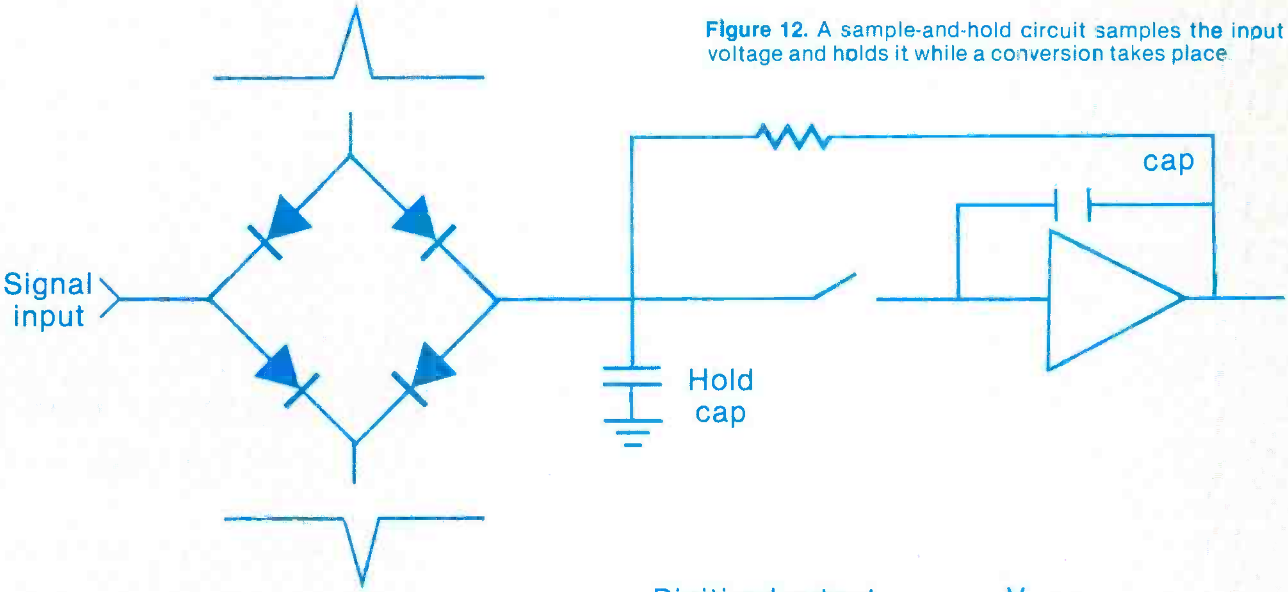


Figure 12. A sample-and-hold circuit samples the input voltage and holds it while a conversion takes place.

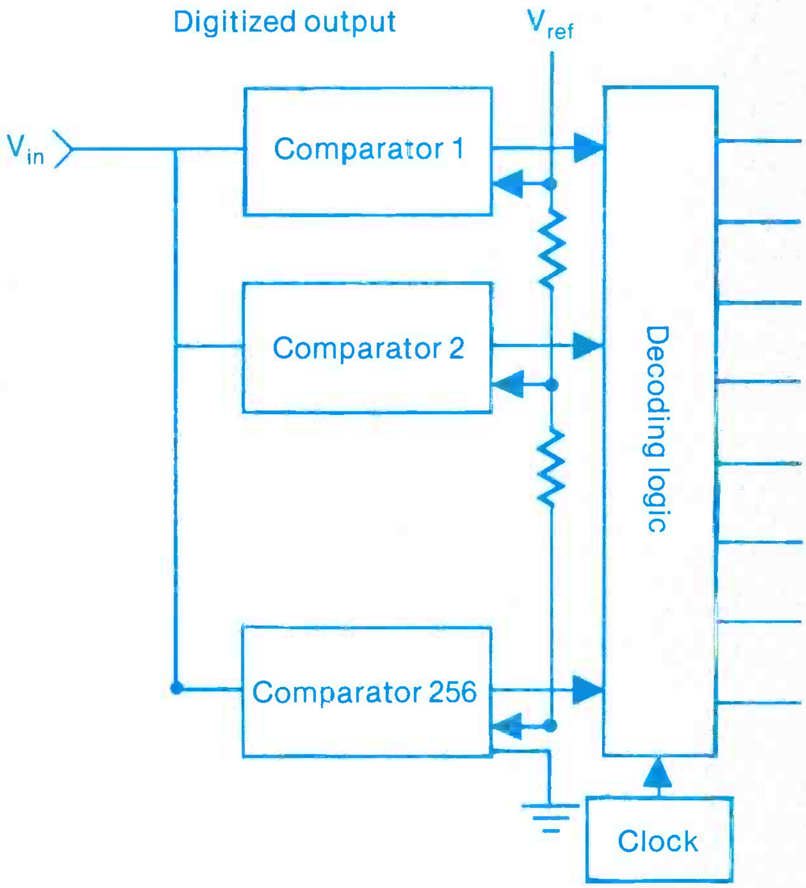


Figure 13. The flash converter utilizes a row of comparators in parallel to perform a conversion in one clock period.

pulse is required for every bit to perform a sample conversion. A 10-bit converter requires ten clock pulses to perform a conversion. An obvious way to increase the speed of the conversion process is to reduce the number of clock pulses required. The flash converter does this by performing a conversion in only one clock pulse.

The flash converter applies the input signal to a row of comparators (Figure 13). The number of comparators is the same as the number of Q levels plus an overrange comparator. The outputs of the comparators are constantly turning on and off as the input signal changes. A conversion is made when the comparator output levels are clocked into a row of flip-flops. The output of the flip-flops is then decoded into an output value. Because the conversion is made on the clock edge, a sample-and-hold circuit is not necessary.

There are two factors that limit how fast a flash converter can be clocked. First, the amount of capacitance in the comparators limits how fast they can turn on and off; second, the amount of decoding logic on the output of the comparators limits how fast an output value can be obtained.

Digital oscilloscopes

A digital oscilloscope uses an ADC to store the analog signal so that it can be displayed or analyzed at any time (Figure 14). For this reason, a digital oscilloscope can provide a number of features not available on an analog oscilloscope. Digital oscilloscopes can use two methods to clock the ADC: continuous sampling for single-shot events or repetitive sampling for higher frequency, repetitive events.

Single-shot storage

To store a single-shot event, the digital oscilloscope continuously samples and digitizes the input

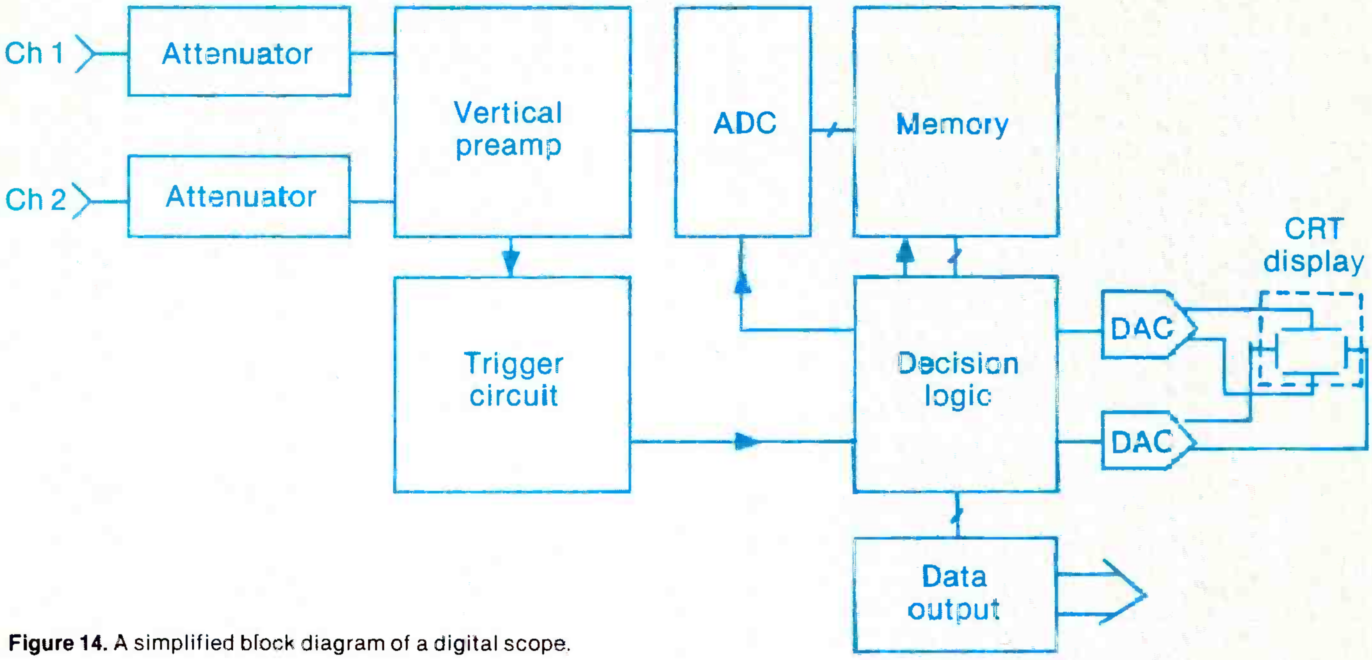


Figure 14. A simplified block diagram of a digital scope.

signal and stores it by continuously writing into memory until a trigger event occurs. When the trigger event occurs, the oscilloscope can either stop storing data or continue to store data for a specified period of time. This allows you to store data before or after the trigger event.

Suppose you want to see what happens before an SCR fires. You can set up a digital oscilloscope to fill 50% of the memory before the trigger event and 50% after the trigger event. In this way, the oscilloscope will display what caused the SCR to fire and what happened when it did.

Repetitive sampling

In repetitive sampling, a high frequency waveform can be stored by a relatively low frequency ADC. This is done by using a sample-and-hold circuit to hold onto the sampled voltage while the ADC takes as much time as it needs to make the conversion. The key to this method is that the signal being stored must be periodic; it must not change from one period to the next.

The signal is stored by sampling one point each time the oscilloscope is triggered. On the first trigger event, the sample is taken immediately after the trigger is received. On the next trigger event, the sample is taken a period of time (the sample interval) after the trigger event. On the third trigger event, the sample is delayed two sample intervals, on the fourth sweep three intervals, etc. (Figure 15), until the number of points desired are acquired. The effective sample rate is then 1/sample interval and the rules of

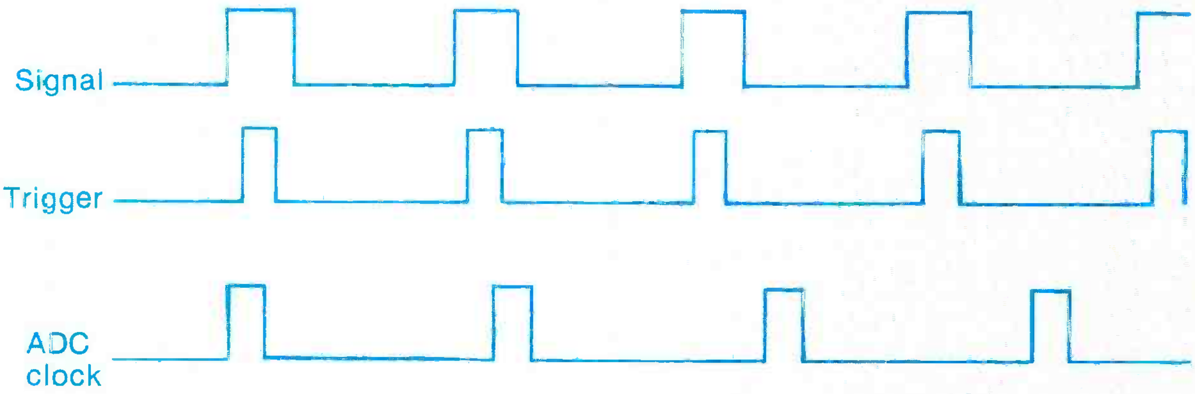


Figure 15. To characterize the waveform, a repetitive sampler takes a sample a specified delay time after each trigger event.

Table II

	Advantages	Disadvantages
Analog	•cost-effective solution for storage of high frequency transients •no sample rate limitations (aliasing) •high signal fidelity (no interpolation needed)	•brightness is a function of many variables •limited store time and view time
Digital	•unlimited store time •waveform can be automatically analyzed by a computer •pretrigger information •more accurate at low frequencies •fewer controls	•price •bandwidth limited by sample rate in single-shot applications

useful digital storage bandwidth and aliasing still apply.

Conclusions

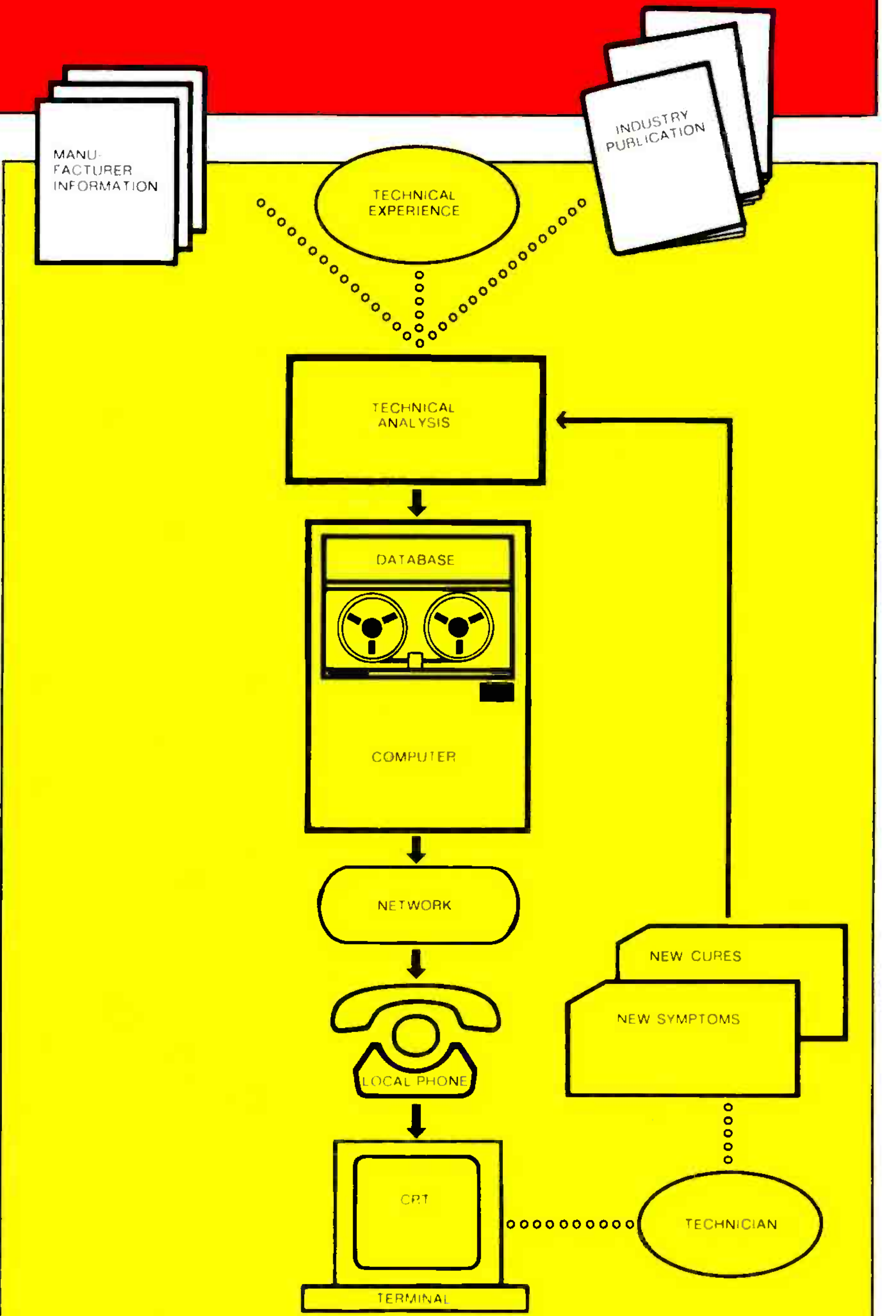
Analog storage has now been in the marketplace for over 20 years and has evolved over the years to its current high level of technology. Digital storage, on the other hand, has been on the market for approximately nine years and has only begun to make significant advances. In the last three years, the lower costs of memory and the greater availability of high speed logic have allowed digital storage to make significant measurement contributions. However, digital storage has not yet reached the storage bandwidth possible with analog storage for a reasonable price. The primary advantages and disadvantages of analog and digital storage are listed in Table 2.

ES&T

Troubleshooting at your fingertips

With Primefax, technicians can call up the troubleshooting experience of others around the country.

By Nils Conrad Persson, editor



A computerized diagnostic system provides the technician with suggested cures to specific problems. The experience of system users modifies the database to keep information current.

The process of solving a problem or curing an ailment often consists largely of comparing the symptoms with items of information filed away in the memory of the problem solver. The greater the number of items of information the problem solver holds for that particular problem, and the more logical the sequence of comparisons of symptoms to data, the greater the chance of success in solving the problem.

This is true in diagnosing medical problems, in preparing a legal brief or in troubleshooting an electronic device such as a TV. And although it is frustrating, it isn't unusual for one person to exhaust his knowledge and have to call on someone else who has more experience with that particular type of problem. Then the consultant, having just the right bit of information at the tip of his memory, immediately suggests a cure and the problem is solved.

Jessee Wheeless and George Hearn are experienced electronic servicers who have been through the troubleshooting process many times. Faced with the limitations of their own memories' ability to store and retrieve information, and knowing how helpful calling upon resources such as other technicians, manufacturers' literature and magazine articles can be, they developed the concept of using a computer to store this information. Their brainchild, called Primefax, (4825 Fredericksburg Rd., San Antonio, TX 78229 is expected to be operational this month.

The Primefax database is developed from manufacturers' information, industry technical data, actual technical experience and key people in the industry, according to Wheeless. This information is then analyzed to fit into a symptom/cure probability format and becomes the Primefax database. As feedback on successful cures returns from the technicians, the database is altered to provide the most probable cures to any given problem on a listed set. At the moment, the database includes listings for all the major brands of color sets dating back 10 or 12 years.

Listings include all Admiral, Curtis Mathis, General Electric, Magnavox, Panasonic, Philco, Quasar, RCA, Sony, Sylvania and Zenith color TV sets and many videocassette recorders.

The technician using the system simply identifies the set in the Primefax index by manufacturer, model or chassis number, and a run number (when one exists). He then enters the Primefax index number and the symptom, and the computer will list from one to 10 solutions based on the highest probability of an effective solution to the problem. The Primefax computer will even make suggestions recommended by the manufacturer to improve the set's reliability or picture quality.

Although these 6500 listings currently account for about 75% of all sets being repaired today, the company is constantly adding listings for other manufacturers.

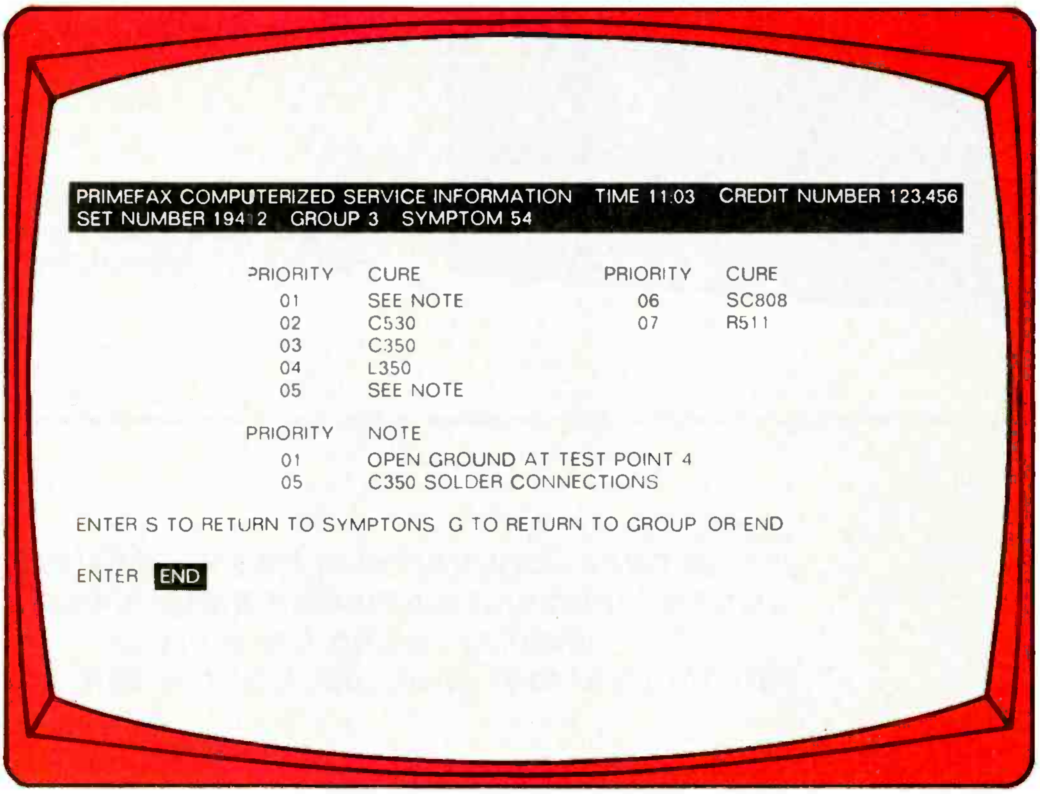
The cost to the repair shop for this service will be a one-time $100 installation fee, then $15 per week and $5 per inquiry (minus a $1 rebate for reporting the successful cure). The $15 weekly/$5 inquiry charges are the total charges for the system, including the terminal, terminal-generated phone calls and databank solutions, without any franchise or membership fees.

The computer and its communications system are as important to the total effectiveness as the database and program, according to company officials. They point out that the concept of computerized service information is not new, but it was not until recently that computer capacities and computer-based communications systems would make the concept a reality. The system is such that the technician deals directly with the main computer and does not need to dial a telephone number to access the computer.

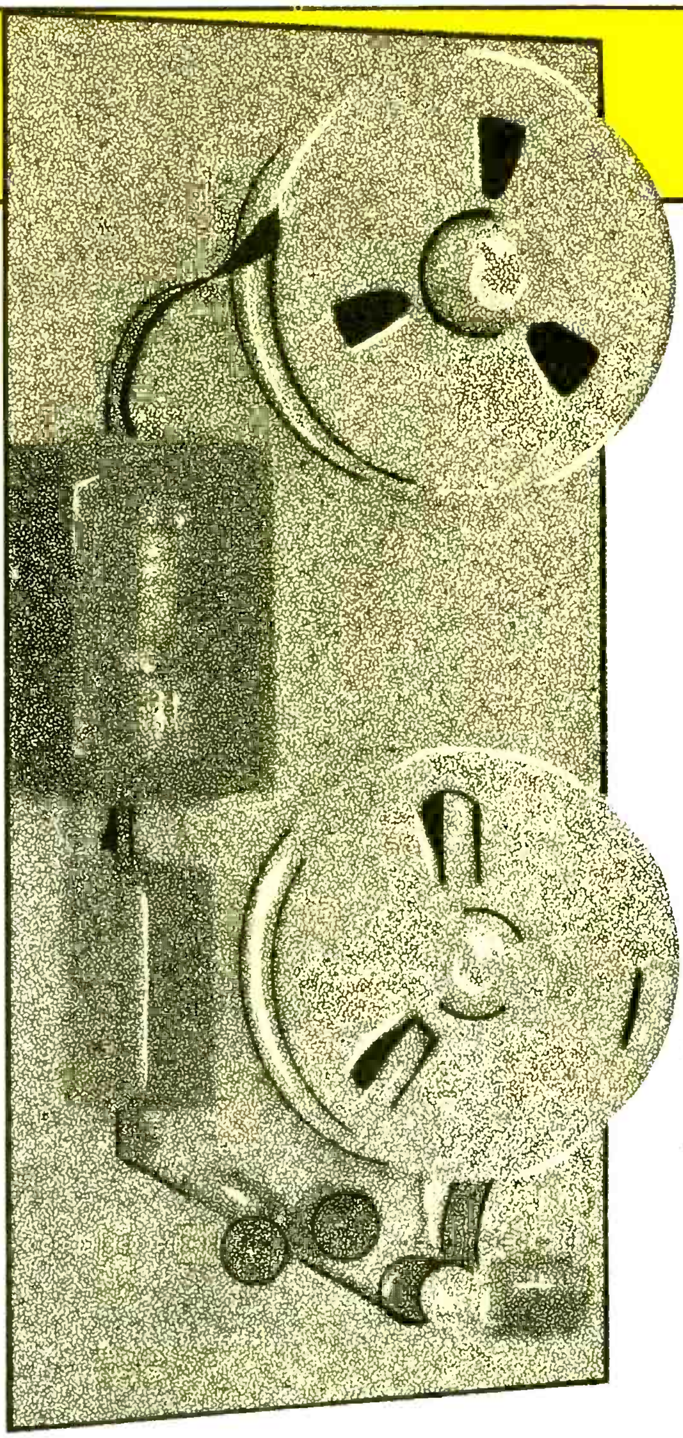
Primefax uses one of the nation's largest computer utility companies, CompuServe, to provide communications, programming and the storage of the database. CompuServe, owned by H&R Block, is located in Columbus, OH.

The system is being marketed through a regional system of distribution by established electronic parts distributors. Sales and service are based on the regional level so that there is rapid response to the individual shop's needs. If a computer terminal malfunctions, the local distributor can make rapid repair or replacement.

ES&T



The data terminal screen shows suggested cures to symptoms, ranked by priority. A priority system is based on a combination of actual experiences and logical failure analysis.



The Ampex Museum of Magnetic Recording

By Peter Hammar, curator,
Ampex Museum of Magnetic
Recording, Redwood City, CA

Ampex Corporation in Redwood City, CA, is now building a permanent historic equipment display telling the story of an industry that dates back to the 19th century.

The three bright, young digital engineers had just noticed the Webster-Chicago wire recorder recently on display with other historic equipment at Ampex Corporation's Redwood City, CA, campus.

"Hey, what's that?" one of them asked me.

"A 1948 wire recorder," I answered.

"What's a wire recorder?" they asked.

"A wire recorder," I said, "is an analog 10kHz audio recording device that uses a homogeneous recording medium of 18-8 stainless steel wire, amplified in a circuit utilizing sort of 'hot FET devices,' each in an evacuated glass case."

Intrigued, the engineers recorded a segment of wire. The quality of the playback of this early ac bias magnetic recording surprised the leaders of the *digital revolution.*

Then the wire broke. "What now?" they asked.

"Tie the wire with a square knot," I answered. "Hold it tight and heat the knot with a match to take the temper out of the knotted wire." Imagine their surprise when they could not hear the splice upon playback!

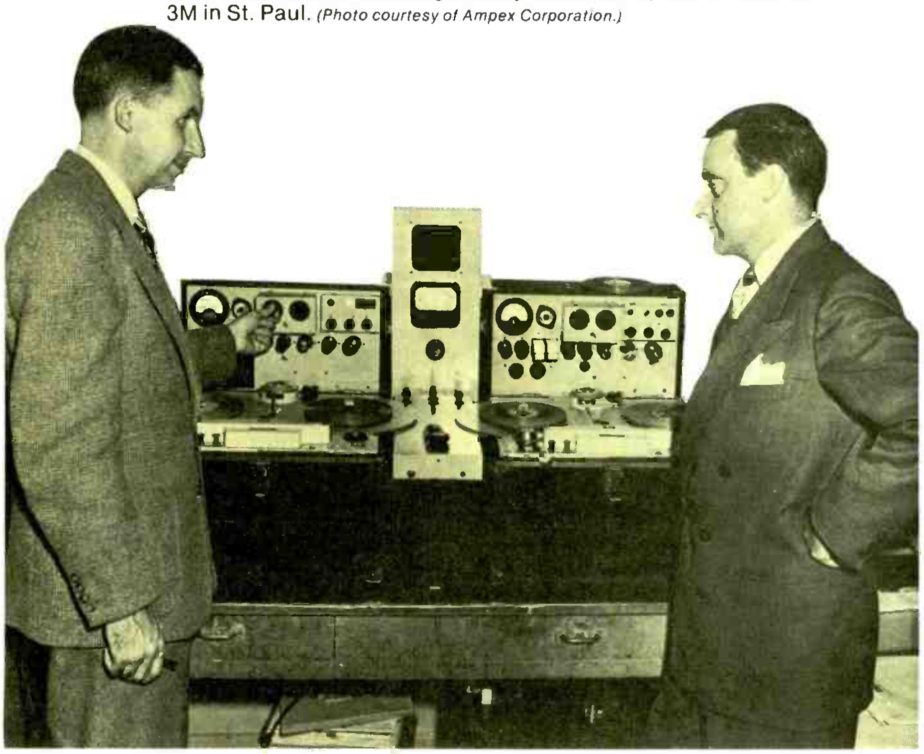
For the next hour, early magnetic recording was the talk of the Ampex digital engineering department. Wire recording, Valdemar Poulsen's 1898 invention, which was perfected by Marvin Cameras in 1940, had captured the imagination of our next generation of electrical inventors.

Looking back on this industry's history is a great, and sometimes new experience for many of us. People are amazed to hear that many of today's *modern* electronic technologies were patented before 1940, including metal, sputter, non-ferrous oxide tapes, helical and transverse scan recording of audio and video signals, color television and FM multiplexing. You name it, Grandpa probably already thought of it before a lot of today's broadcasters were even born.

Electronics nostalgia – finding out where we've come from – is growing. You can visit many fine public and private museums of broadcast and recording technology in California, New York, Texas and other places around the country. Yet the history of the one technology that has revolutionized our lives more than any other – magnetic recording – has not been treated by most technical museums as a separate story worth telling.

Ampex's Harold Lindsay is shown checking out a model 200 in late 1947. Note the Dumont scopes to his right, as well as the Altec intermodulation analyzers and Hewlett Packard VTVMs and signal generators. *(Photo courtesy of Ampex Corporation.)*

Jack Mullin (left) with Murdo McKenzie (right), Bing Crosby's technical producer in 1947, demonstrates the two AEG Magnetophon K-4s that Mullin brought back from Germany in 1945. Tape recording was to make a big difference in Bing's radio career. After heading Crosby Electronics, Mullin went to 3M in St. Paul. *(Photo courtesy of Ampex Corporation.)*



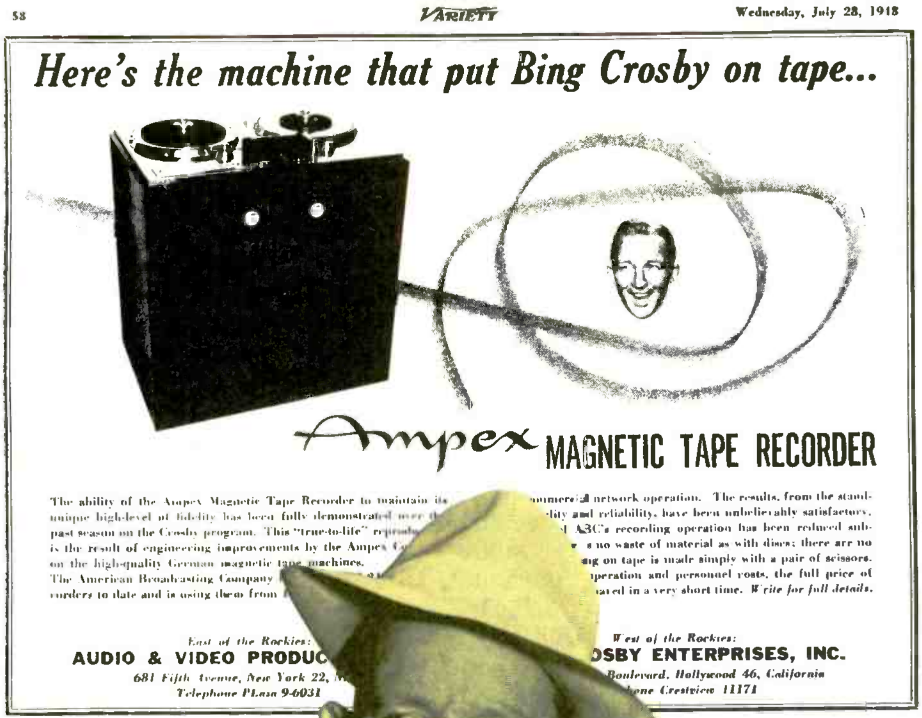
Tennessee Ernie Ford stands with an Ampex model 300 at Capitol Records around 1950. The model 300 appeared in mid-1949, setting design standards for the professional recording industry. *(Photo courtesy of Ampex Corporation.)*

Ampex model 300s were in use at ABC around 1950. In the early days of tape, broadcasters provided their own meter panels. Note the blank covers over the 300's meter panels. *(Photo courtesy of Ampex Corporation.)*

It was magnetic recording that changed radio, and then television, from a *live* medium with limited production values to today's almost boundless programming that tape *editing* makes possible.

Imagine a world without tape–everything on television and radio live or on kinescopes or uneditable transcription discs; computers driven by mountains of punch cards; and instrumentation recorders spilling out miles of strip charts. That was the scenario I discussed with Ampex's Harold Lindsay two years ago, when we first talked about the idea of a museum dedicated to the history of magnetic recording. Lindsay was the primary designer of the 1947 Ampex model 200, America's first commercially successful professional tape recorder.

What would have happened if anything had prevented Lindsay, or his friend Jack Mullin (later with 3M), from introducing Hollywood and American broadcasters to audio tape recording after World War II? The Germans–AEG, BASF and Grundig, along with head-makers Woelke and Bogen–would probably have entered and dominated the American broadcast market by the early 1950s.



An early advertisement in *Variety* magazine on July 28, 1948, publicized Ampex's first recorder, the model 200. Designed by Harold Lindsay and Myron Stolaroff, the model 200 was America's first commercially successful professional tape recorder. Although Ampex built only 112 units, the model 200 showed broadcasters that tape was a practical alternative to transcription discs. *(Courtesy of Ampex Corporation. Photo by permission.)*

Bing Crosby uses an Ampex model 600 in 1954. Crosby Enterprises remained Ampex's West Coast representative until 1957. The model 600 shared the professional market primarily with Magnecord, famous for its PT-6 model that appeared in the late '40s just after the Ampex model 200. *(Photo courtesy of Ampex Corporation.)*

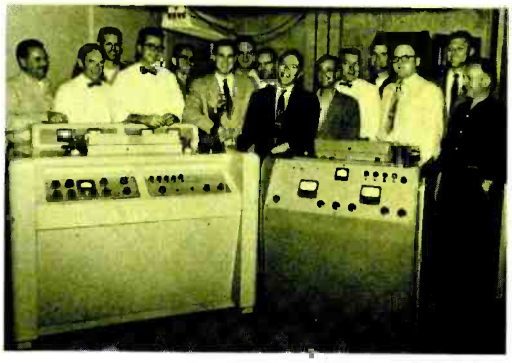
Many people had heard about the German Magnetophons, the world's first high fidelity magnetic tape recorders developed in the 1930s. Mullin, however, was the first to put it all together in the United States in 1946, using two Magnetophons he had "Americanized" to show broadcast engineers what a difference hi-fi tape could make to program editing and broadcast time-delay.

It was Lindsay's model 200 that proved to American broadcasters that tape recorders in the studio could be rugged, reliable, more practical, and of higher quality than the disc recording lathes in use in 1947.

Anyone wanting to start a technical museum of industry-wide scope 15 years ago would have applied for government grants, along with local university and municipal support. Two years ago, with the necessary government belt-tightening of the 1980s clearly ahead, I opted instead for business support from Ampex Corporation. Along with artists and public broadcasters, museums are finding new support among US corporations making *cultural investments.* Industry is stepping in where government is getting out.

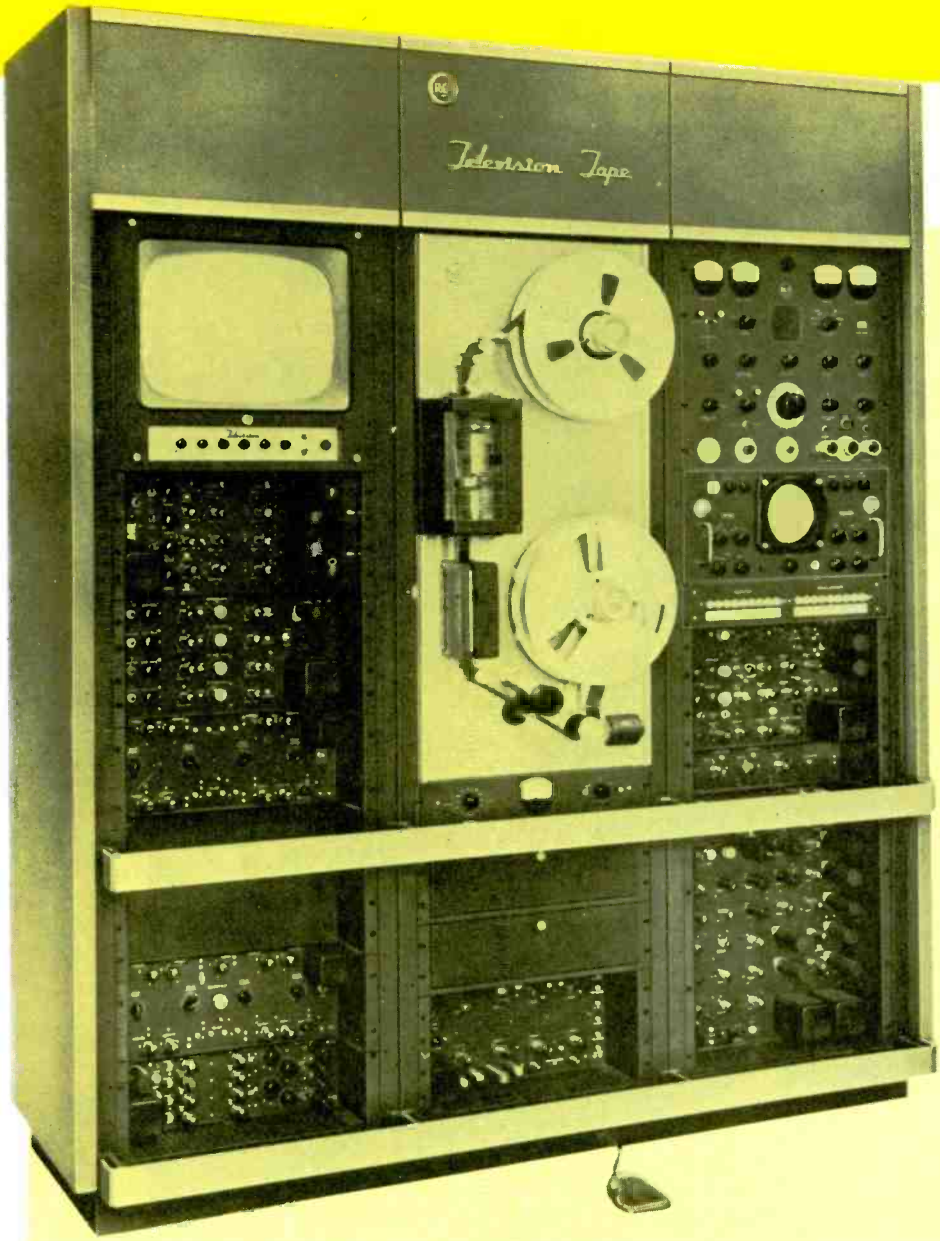
As a pioneer in the professional magnetic recording industry, Ampex is in a unique position to tell its story, while being able to give tremendous credit to all the other firms that have made modern tape recording possible. AEG-Telefunken, BASF, 3M, Orradio, RCA, Fairchild, NBC, ABC and CBS are some of the companies that, along with Ampex, have made modern tape recording what it is today.

Opening in the spring of 1982, the Ampex Museum of Magnetic Recording in Redwood City will tell an amazing story. From magnetic recording's inception in 1898 as a wire recorder, to the AEG/BASF perfection of modern tape before World War II, to the Mullin-Lindsay story, to video, to computer drives, to instrumenta-



The six members of the original VTR R&D team are included in this 1957 photo of the VR-1000 group: leader Charles Ginsburg (9th from left, in dark suit), Charles Anderson (4th from right), Ray Dolby (6th from left), Shelby Henderson (3rd from left), Alex Maxey (4th from left), Fred Pfost (8th from left). Machines shown are the Mark III (right) and Mark IV prototypes. *(Photo courtesy of Ampex Corporation.)*

The unveiling of the first practical videotape recorder was at the NARTB (now NAB) convention in Chicago in April 1956. Shown is the Mark IV prototype of the Ampex VR-1000. Ampex and RCA later traded information on video heads, signal processing and color. RCA developed its first VTR in 1956, calling it TRT-1A. *(Photo courtesy of Ampex Corporation.)*



The RCA TR-22 VTR, the first commercially successful transistorized VTR, appeared in 1961. Transistorization reduced maintenance and increased stability. *(Photo courtesy of RCA.)*

tion recording, the road to today's high-performance, high-band tape recorders was strewn with rocks – big ones. The Ampex Museum will take visitors down that road.

At 2200 square feet, the Ampex Museum will not be a mammoth exhibit, but it will be the first of its kind, dedicated exclusively to magnetic recording. For maximum credibility, the museum details the industry history as a whole, with Ampex's part in that story seen in its proper perspective over the last 35 years.

Besides Ampex recorders, the museum will feature AEG, RCA, 3M and Sony products. Due to limited space, however, visitors will learn about most companies' *firsts* via closed-circuit television. Each of the 22 historic *stations* will show visitors a mini-documentary of that era, as well as a sample piece of equipment. The video programming portion of the museum provides the depth that will make this a total-industry show, rather than a 1-company show.

Among the more than 40 machines on display, the collection will include two Poulsen Telegraphones; WW II-era wire recorders, including Armour and Webster-Chicago; a 1936 AEG Magnetophon FT-2, the oldest magnetic recorder known to exist in this country; the Ampex model 200 serial #3, the first professional recorder to be delivered to a U.S. network, ABC, in 1948 (serials #1

The RCA TRT-1A VTR was developed in 1957-58. Ampex and RCA swapped technical information that got RCA into the transverse scan VTR market, while providing Ampex with valuable color know-how. *(Photo courtesy of RCA.)*

and #2 first went to Jack Mullin at the Crosby show); samples of BASF, 3M, Orradio (later Ampex), Audio Devices and Reeves tapes; and the VPX-1000 serial #4 videotape recorder, the first commercially-produced VTR to be delivered to a US network, CBS, Hollywood, in 1956 (serials #1-3 were demo/test units, made after the Mark IV prototype shown in Chicago at National Association of Radio and Television Broadcasters (NARTB) in the same year).

Why bother spending money to capture the past when we have got so many other future concerns in our business? Because the past gives us hope for the future. We can learn from our mistakes and successes. When Poulsen's Telegraphone wire recorder bombed in the American marketplace in 1905, industry wags at that time pronounced magnetic recording dead. Today, the recording and broadcasting industries are holding their breaths waiting for other technological shoes to drop: digital audio and video recording, digital broadcasting, wideband video and stereo TV, among others.

Those shoes *will* drop. Valdemar Poulsen, the father of magnetic recording, could have told us that.

The author invites you to participate in the Museum Project. If you have old equipment, new information, or are just interested in the museum, contact him in care of Ampex, 401 Broadway, MS 1-14 Redwood City, CA 94063; 415-367-3127.

ES&T

NEW PRODUCTS

Training seminars

Integrated Circuit Engineering Corporation is offering a variety of training seminars and workshops for 1982. The topics include LSI design alternatives, gate array design, MOS digital circuit design, bipolar linear circuit design, basic IC technology, IC fabrication, failure analysis of ICs and advanced IC processing.

Circle (85) on Reply Card

Earth station packages

Winegard Company is offering four complete, commercial-quality earth station packages ranging in list price from $7995 to $10,600. Each package includes two LNAs, 24-channel tunable receiver, polar mount, dual-polarized feed and segmented fiberglass antenna.

Combination packages of 10-foot and 12-foot antennas and 120° and 100° LNAs are available.

Circle (86) on Reply Card

5½-digit DMM

Data Precision announces the availability of a new 5½-digit multimeter series, its models 2590 and 2590R. These instruments, with 0.007% 1-year dc accuracy, measure not only dc volts, ac volts and resistance, but measure dc and ac current as well, all to 5-digit

resolution. Designed for bench-type use, these instruments provide manual ranging and manual function control only.

Circle (87) on Reply Card

Digital power meter

A single power meter capable of flat coverage of the 10MHz to 140GHz frequency range, has just

been introduced by *Anritsu America*. Anritsu America supplies the United States with fiber-optic and electronic measurement instruments for telecommunications equipment and systems, as well as general purpose test equipment.

The unit, known as the Anritsu ML83A digital power meter, is accurate for −60dBm to +20dBm. Frequency or sensitivity ranges are changed by plugging in a selection of sensors. These sensors come in standard N-type RF connectors and a wide range of waveguide flanges.

Circle (88) on Reply Card

Oscilloscopes

Tektronix has introduced the new performance/price standard in oscilloscopes, the 2200 series. The first two oscilloscopes in the 2200 series are designed to meet the growing needs in the low- to mid-performance general purpose portable oscilloscope market. According to John Gragg, product marketing manager for the 2200 series, "This new series offers increased performance at a lower cost. The instruments meet the needs of the customer base, which has grown rapidly due to the proliferation of microprocessors into all segments of industry."

The 2213 and 2215 are dual-trace, delayed-sweep instruments achieving 60MHz at 20mV to 10V and 50MHz at 2, 5 and 10mV settings. The maximum sweep speed is 5ns/div.

Circle (89) on Reply Card

Anti-static TV screen treatment

Bib Audio/Video Products has announced new packaging to their Videophile Edition range, the VE-15A Anti-Static TV Screen Treatment Kit.

The Bib VE-15A's anti-static fluid retards the attraction of airborne contaminants to TV screens

and big screen mirrors by preventing static build-up. Accumulated smudges and fingerprints are also removed from the TV screen, ensuring optimum viewing enjoyment.

Circle (90) on Reply Card

Flat pocket television

Sony Corporation has announced that it has developed a revolutionary flat pocket television, which employs a newly developed cathode ray tube only 16.5mm thick.

Called the "FD Tube" (Flat Display Tube), the new picture tube is shaped like a miniature paddle and allows the flat TV to be only 33mm thick. The FD-200 will be marketed in Japan from late

February of this year, but no marketing date has been announced for the United States.

Circle (45) on Reply Card

Terminal/printer maintenance kit

Jensen Tools has developed a new tool kit for the servicing, maintenance and repair of ter-

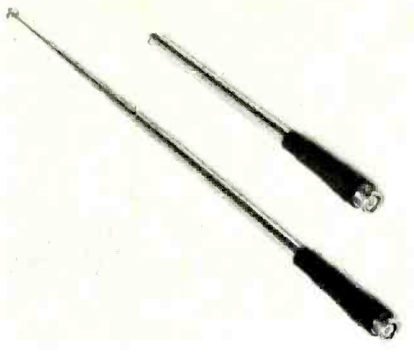
minals, printers and small computer systems.

Designated the JTK-65, the kit contains more than 40 tools, including screwdrivers, nutdrivers, hex keys, miniature box wrenches, soldering equipment and more.

Circle (49) on Reply Card

Telescoping antenna

Centurion has added a new model to their line of telescoping antennas. It is a full length 5/8 wave radiator providing increased effi-



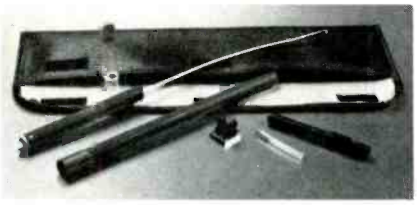
ciency and range for hand-held radios.

Designated style F, the new antenna for VHF frequency bands from 118-174MHz is fitted with a BNC connector.

Circle (46) on Reply Card

Visual tool

Bend-A-Light, developed by *L & W Enterprises,* was designed to meet the need for a light to get into holes, cracks and cavities encountered by everyone involved in building, repairing or servicing



complicated machines and devices.

The tool is high-intensity, optically focused light on a 10-inch flexible shaft that can be bent and rebent to fit into any 1/4-inch hole or crack for inspection, retrieval of parts, or repair. The pinpoint of light cannot reflect back into the eyes and is effective up to 50 feet. Two AA batteries supply the necessary power.

Circle (48) on Reply Card

Talking multimeter

A multimeter that voices its readings is now available from *Arthur H. Thomas Company.* The circuit analyzer allows voltage, current and resistance to be measured and reported without looking at a display. The operator is free to concentrate on the more critical parts of the job, such as locating the probes of the multimeter or placing a sensor in a high-temperature location, and electric shocks, accidental shorts and blown integrated circuits are avoided.

Ideal for testing of high-density LSI chips and high voltage cir-

cuits, this multimeter is an analog input instrument adaptable to particular needs. The battery-powered multimeter is accurate to ±0.1% ±1 LSD on dc voltage and speaks every seven seconds or on the press of a button.

Circle (44) on Reply Card

Tone remote tester

The CLT 500 tone remote tester brings a new dimension to servicing 2-way, radio-tone, remote-control systems. It is the second in a series of specialized communications test equipment produced by *Industrial Electronics Service Company.*

The tester automatically duplicates the tone burst functions

of remote-control consoles with a choice of guard-tone frequency and 11 standard function tones. An adjustable duration guard-tone feature provides the ability to identify control-circuit timing problems and allows matching of tone burst delays in certain systems. Continuous function tones and guard tone are provided for testing and alignment of control circuits. The continuous tones are also used to measure communications line loss and frequency response.

Circle (50) on Reply Card

Waveform analyzer

T. G. Branden Corporation has introduced an integrated hardware/software system with built-in disk storage for waveform analysis of time and frequency domain data that weighs less than 25 pounds.

Based on a 16-bit microprocessor, the Smartscope II is a complete system for the acquisition, storage, analysis, processing and display of waveforms in the time and frequency domains. Front panel knobs, controls and switches are replaced with a calculator-style

keypad. Menu selections and screen prompts provide an easy-to-understand operator interface. Stored test setups and programs on diskette can be run by nontechnical personnel.

Circle (30) on Reply Card

Temperature indicators

Solder Absorbing Technology has expanded its line of 1-shot thermosensitive temperature indicators, which, when applied to any piece of equipment can measure and document operating temperatures.

These irreversible temperature indicators offer precise visual proof that a specific temperature has been exceeded, particularly in inaccessible, hazardous areas. You just apply them and forget them until you inspect them.

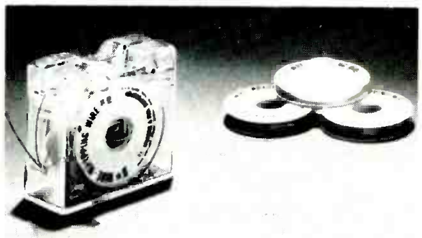
The labels are self adhesive and measure only 0.3mm thick, so the

sensitive white triangle turns irreversibly black when the surface reaches the specific temperature level of that triangle, and is accurate to +1%.

Circle (32) on Reply Card

Wire dispenser

The WD-30-TRI dispenser from *OK Machine and Tool* holds three colors of wire and features a built-in cutting and stripping mechanism. The refillable dispenser holds 50 feet each of red, white and blue Kynar-insulated, silver-plated



solid-copper wire. To operate the cut/strip mechanism, the wire is first drawn out to the desired length. Then a built-in plunger cuts the length free from the roll while a gentle pull through the stripping blade removes the insulation.

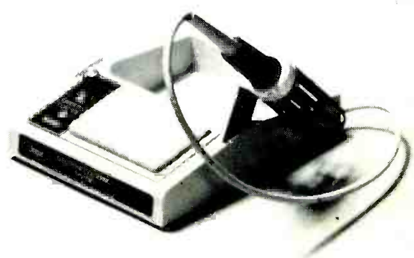
Circle (33) on Reply Card

Variable-temperature solder system

A temperature-controlled soldering system with variable temperature control has been introduced by the *Ungar Division of Eldon Industries*. A rotary control on the base enables the user to vary the temperature in 50-degree increments from 400 to 800°F.

Although the unit is low enough in price to make temperature-controlled soldering feasible for hobbyists and do-it-yourselfers, the System 9100 has features previously developed for the "Electronic System 9000" for high-technology industrial use.

The iron holder can be changed quickly to the left or right side of the stand, and any of five Ungar soldering iron tips can be used.



The system is electrically conductive from the tip to a grounded wall plug to prevent static electricity damage to microcircuits.

Circle (34) on Reply Card

Modular electronic teaching system

A self-contained, portable electronics teaching "laboratory in a briefcase" that features plug-in modules is now available from *Thornton Associates*. The system consists of a modular design frame (MDF-100) power supply bus with built-in analog multimeter, breadboard module (BBM-100) with solderless breadboard, function generator (FGM-100), digital voltmeter (DVM-100) and decade resistance module (DRM-100). Because the modules plug in, students spend less time setting up and more time learning. Each module is on a separate card, so students can work on their own modules.

Circle (35) on Reply Card

Log amplifier

Leader Instruments Corporation recently introduced a new linear/logarithmic amplifier designed primarily to detect audio signals and eliminate the need for computations of voltage levels to relative dB levels, normally asso-

ciated with swept frequency measurements. The unit is compatible with most low frequency sweep generators.

The LPA-1305 is used to convert a linear frequency response envelope to a logarithmic dc output, enabling relative dB values to be measured directly from a linear scale, such as an oscilloscope graticule. After setting the amplifier's attenuator controls, a standard linear scale may be calibrated to equal increments of dB values.

Circle (36) on Reply Card

Oscilloscope calibrator

As soon as it is installed, the new *Fluke* 7410A automated oscilloscope calibration system can accurately calibrate oscilloscopes, probes, plug-ins, amplifiers and calibration fixtures manufactured by all major manufacturers. An outgrowth of the Fluke 7405A multimeter calibration system, the 7410A relies on sophisticated software procedures and integrated

IEEE-488 instrumentation.

The system comes complete with Fluke's comprehensive applications software designed to make generating calibrations procedures easy. Virtually a "soft keyboard," 1720A shows the operator pre-programmed procedure steps while sensing single touch responses through a switch-matrix overlay.

Circle (37) on Reply Card

Programmable signal generator

A new programmable FM/AM signal generator, model 1021, is available from *Boonton Electronics.* It is a companion instrument to the current model 1020 but with wider frequency that extends from 150kHz to 1.08GHz. The generator features high RF output levels, low distortion and wideband FM and AM, and true phase modulation. The value of all functions can be entered via the keyboard, and most can also be incremented in preset or user-defined steps using the up/down keys or a rotary control.

Circle (38) on Reply Card

Multi-tester

A. W. Sperry Instruments has announced the introduction of its new SP-170 portable, electrical

ac/dc multi-tester. The unit features a 21-position selector switch with an *off* position, full-view window, easy-reading 2-color scale, fuse protection on all ranges except 10Adc, safety-designed front panel and a simplified polarity selector switch. Sensitivity is 20KΩ/Vdc and 5KΩ/Vac.

Circle (95) on Reply Card

Analog panel meters

Weston Instruments has introduced a new line of analog panel meters. The mechanism used in these series 8500 meters uses only precision parts that snap or

Circle (27) on Reply Card

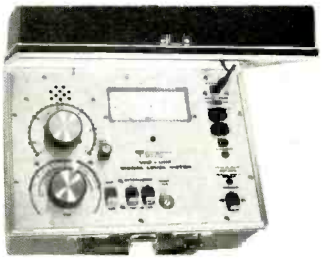
lock together, without the use of solder or cements.

The self-shielding Cormag mechanism is provided with a taut-band suspension. Each band is automatically welded for distributed stress, to a dual-cantilevered support that provides resistance to shock and vibration. A tough plastic pointer ends the possibility of a bent pointer resulting from overload conditions.

Circle (39) on Reply Card

Field strength meter

Blonder-Tongue Laboratories has a solid-state UHF/VHF field



strength meter for professional installers and technicians. Designated FSM-8, the meter operates on any of three different battery combinations. The battery pack is located in the cover and batteries can be changed without removing the meter. The FSM-8 reads directly in dBmV and has a digital delay circuit to automatically shut off the meter at a preset interval.

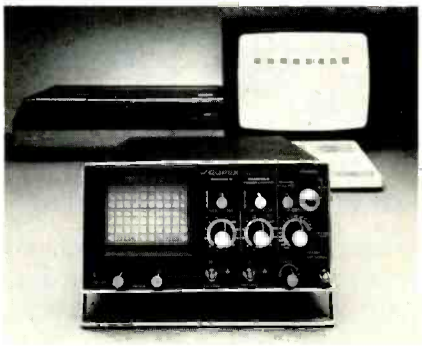
Circle (40) on Reply Card

Oscilloscope

Scopex Instruments Limited, a British independent oscilloscope manufacturer, has come up with the 14D10V.

This oscilloscope with a TV line selector has been developed primarily for the videocassette/videodisc/TV service market, although it will also be useful to the radio and TV laboratories of colleges and universities.

The main feature is the facility to trigger onto a video color



waveform via an active TV sync separator and then select any line on the waveform to enable easy and accurate alignment of the VCR, VHS, BETA and videodisc recorders.

Circle (51) on Reply Card

Soft wiring tool

A wiring aid molded from nylon is now available from *Desco Industries.* The model 618 nylon forming tool is designed for manipulating wires and component leads without damage. The nylon material is tough and flexible enough to wear well, yet soft enough to prevent damage to wire insulations or component leads.

Circle (41) on Reply Card

Voltage spike protector

Radio Shack, a division of Tandy Corporation, offers protection against potentially damaging power line voltage surges. The Archer voltage spike protector (61-2790) absorbs voltage transients associated with power line surges, yet does not interrupt the

normal current flow. This helps protect components within computers, televisions, stereos and other electronic equipment.

Circle (42) on Reply Card

Dip squeezers

The multi-function Klatch dip squeezers DS299, from *Edsyn*, is a versatile hand tool suited not only

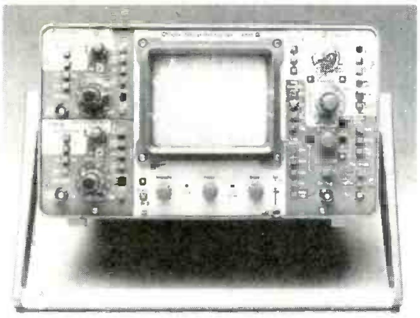
for dip IC removal and insertion, but for discrete parts handling, lead straightening, wire bundle holding and many other applications where items must be temporarily held in place for soldering or other work. Its unique handle can slide up or down along the gripper shafts to change the gripper opening, allowing for the firmest grip.

Circle (43) on Reply Card

Digital storage scope

A new digital storage oscilloscope, the DSO4200, joins the extensive line of portable, dual-trace DSOs offered by *Gould, Instruments Division.*

Special features include maximum sensitivity of 100μV/cm, high vertical and horizontal resolution (0.1% and 0.025% respectively) via a 10-bit x 4k store, the ability to select portions of stored waveforms in overlapping 1k segments and expand them up to X10 vertically and X50 horizontally for detailed examination, and a dual-scope trigger window permit-



ting triggering on signals crossing either a positive or negative threshold.

Circle (91) on Reply Card

IC extraction tools

Micro Electronic Systems has developed two extraction tools to add to their family of insertion and extraction tools. The units feature a locking member and finger pulls to enable the user to extract an IC from sockets that have high insertion and extraction force. The tools lift from the sides of the IC for security and only require 0.1in clearance. The units are designated P/N 203L for 24/28 pin ICs and P/N 206L for 36/40 pin ICs.

Circle (47) on Reply Card

ES&T

Circle (28) on Reply Card

Circle (29) on Reply Card

NEW LITERATURE

The Engineering Department of the **Electronic Industries Association** has announced the availability of RS-204-C, "Minimum Standards for Land Mobile Communication, FM or PM Receivers, 25-947MHz." This standard details definitions and methods of measurement of the characteristics of FM or PM land mobile receivers in fixed or vehicular installations. This standard is intended to promote compatibility of these receivers with the systems in which they will operate.

The document was revised to incorporate the technical content of IEC Recommendation 489-3, "Methods of Measurement for Radio Equipment Used in Mobile Services," (1979), into the familiar format of RS-204.

Circle (60) on Reply Card

A comprehensive IF system for FM receivers, type ULN-3889A, is described in **Sprague Engineering** bulletin 27102.62. This integrated circuit is an improved version of the Sprague type ULN-2289A.

A combination of tuning-error muting and signal-level muting gives the type ULN-3889A versatility in applications ranging from signal-seeking and scanning duty in automotive and communications equipment to quiet performance in standard FM broadcast radios.

Circle (61) on Reply Card

The complete **Audio-Technica** 800-series line of microphones and related accessories is presented in a new 4-color, 24-page catalog.

Pictured and described are A-T studio electrets, studio dynamics and remote-powered special-purpose electrets (including two new line gradient microphones, of which one is remote powered). Home recording/A-V dynamics and electrets are also shown. An array of microphone cables, windscreens, line matching transformers, stand clamps, shock mounts, desk stands and power supplies concludes the display.

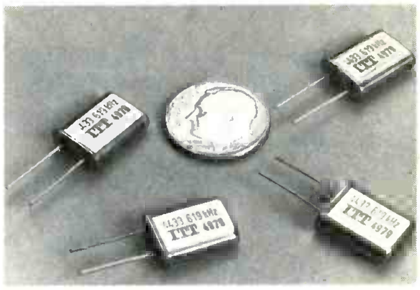
Circle (64) on Reply Card

The **UXL Corporation** has announced publication of its full-line catalog featuring TeleMatic test jig systems, Polaris dual range test probes and Magna Sound public address systems. An 8-page Adapter Selection Guide, which provides set-up information for hundreds of chassis is also included, making it a powerful distributor sales tool.

Circle (63) on Reply Card

An 8-page catalog featuring quartz crystals for use in the color television, telephone equipment, automotive and instrumentation markets has been published by **ITT Components.**

Catalog QC-1 describes the microprocessor-type quartz crys-



tals in the HC-18/RW holder (hermetically sealed through resistance welding), covering a frequency spectrum from 3 to 10MHz.

Circle (62) on Reply Card

The **Electronic Representatives Association** has announced publication of the 1981-82 "Electronics Industry Manufacturers Representatives Locator." This annual directory carries within its pages information about member companies and their top-level management personnel, home office and branch locations, number of employees, type of products represented, territories covered and services offered to principals.

Circle (65) on Reply Card

Speco has published new literature on their PA amplifier line. The catalog sheet, #PA82, contains information on Speco's 30, 60 and 120W PA amplifier.

Circle (67) on Reply Card

The 129-page 1982 edition of the **Mouser Electronics** catalog offers more than 10,000 items. It serves as a guide for engineers, purchasing agents or anyone needing quick access to up-to-date product data and pricing of standard stocked industrial electronic components.

Circle (68) on Reply Card

The **Bluffton Products** new catalog features a variety of electrical instruments for voltage, current, resistance, watts, power factor, watt-hour, phase and frequency. It also includes instruments for temperature, humidity, r/min, elapsed time, electronic circuits, air, light, gas, residual magnetism, water corrosion and batteries.

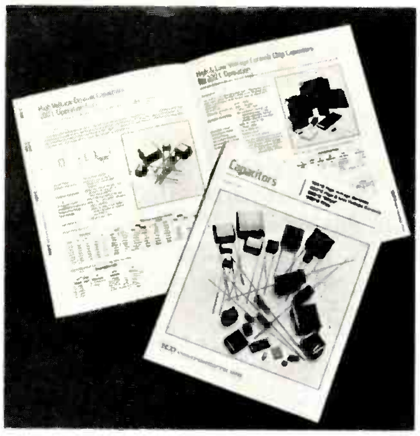
Circle (69) on Reply Card

A 1982 edition of RCA's SK Solid-State Replacement Guide, featuring 1800 RCA solid-state replacement devices that replace 178,000 domestic and foreign types, is now available.

Included in the 495-page guide is complete information on RCA replacement transistors, rectifiers, thyristors, integrated circuits and high voltage triplers. A dual numbering system lists the RCA SK number along with the stock number used by Philips ECG, REN and TM, which facilitates correct identification of the proper solid-state replacement in this one publication.

Circle (70) on Reply Card

A 10-page, tab-indexed catalog of capacitors, recently published by **KD Components,** contains



everything the prospective user needs to know about KD's 125° to 300°C high- and low-voltage ceramic, chip and mica capacitors.

The booklet is illustrated by photos, diagrams and a variety of size/capacitance/voltage tables. One section is devoted exclusively to a series of easy-to-read performance curves.

Circle (66) on Reply Card

A 6-page applications note from **EIP Microwave** provides an in-depth, clear understanding of considerations in the selection of frequency counters for communications applications. The emphasis is on specifications and features available in counters today, what they mean and why they are important for specific applications. Applications discussed include VHF/UHF radio, point-to-point microwave, satellite communications and others.

Circle (73) on Reply Card

Franzus Company has published a brochure, *Foreign electricity is no deep dark secret,* which explains the conversions necessary for using American electrical products overseas. The publication also describes the Franzus products available for making the needed conversions.

Circle (72) on Reply Card

A new, expanded catalog of rental test instruments has been published by the **General Electric Company.**

The Quick-rental instrument

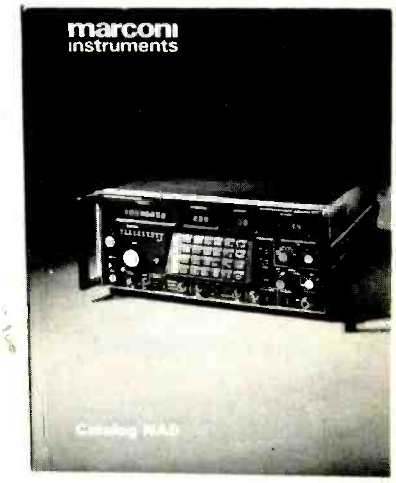
catalog features 80 pages of test and measurement instruments from leading manufacturers. All equipment is fully calibrated to manufacturer's specifications and is ready for delivery. Quick-rental instruments are offered through the nationwide service network of GE's Instrumentation and Communication Equipment Service Department.

Circle (71) on Reply Card

This control knob catalog, from **Alco Electronic Products**, graphically illustrates the series, and includes full dimensions and quantity pricing to allow a full determination of whether the product fits your applications. The specialization is toward instrumentation and the most recent entry is a variety of torque knobs.

Circle (74) on Reply Card

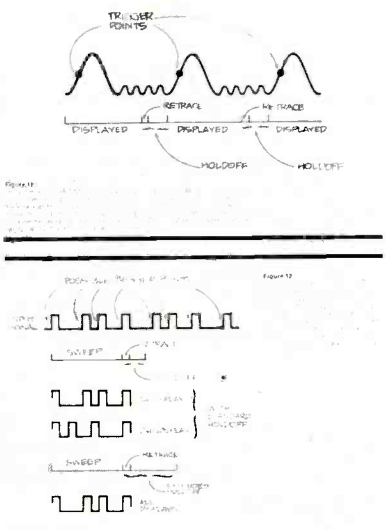
The latest full-line instrumentation catalog from **Marconi** is of particular interest to signal generator users, as it includes complete details of both the new cavity-tuned 2017 generator and the 2018/2019 synthesizers.



Circle (75) on Reply Card

Oscilloscope primer

The XYZs of using a a scope is the title of a new primer on oscilloscope technology from Tektronix. This 36-page primer is divided into two parts. Part I includes chapters covering scopes, controls and probes; part II includes techniques of measurements with scopes.



Chapter titles include: the display system, the vertical system, the horizontal system, the trigger system, all about probes, waveforms, safety, getting started, measurement techniques and scope performance. A 2-page index makes it easy to locate topics of interest.

Figures include 34 graphics and scope traces to illustrate this primer. One of these graphics is reproduced here to illustrate the type of graphic and caption included to communication scope usage.

If you would like a free copy of this scope primer, circle 80 on the reader service card and we will pass your request along to Tektronix. ES&T

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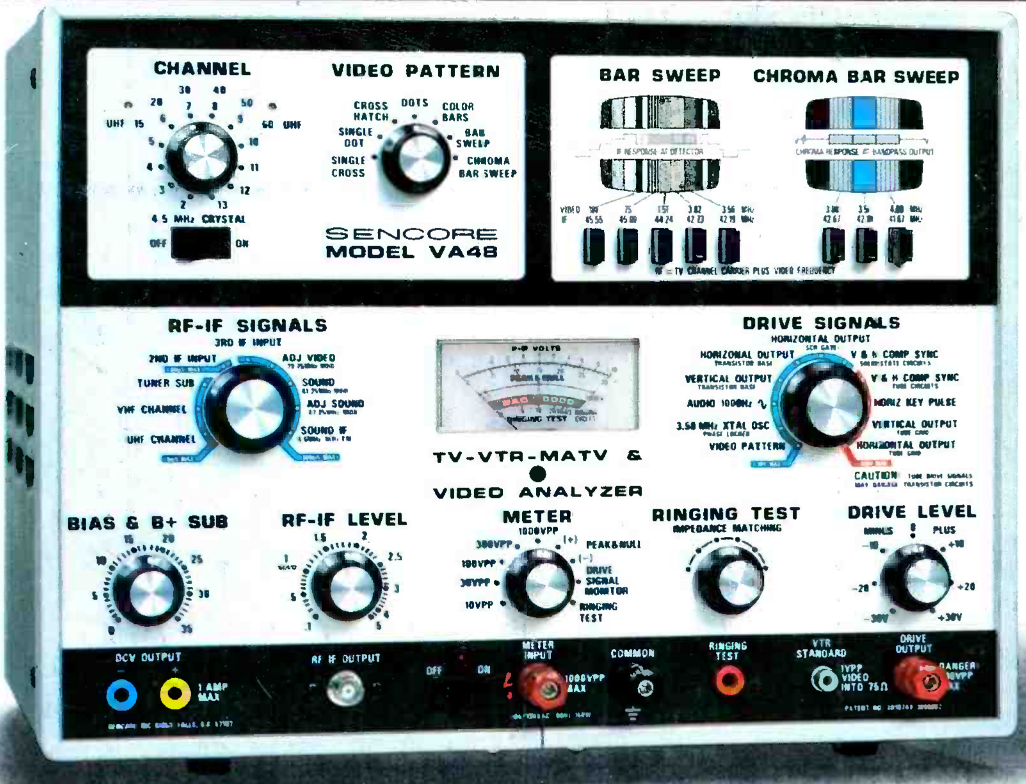

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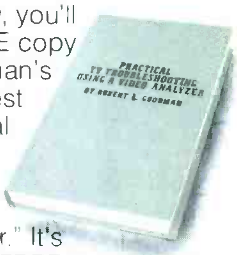

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