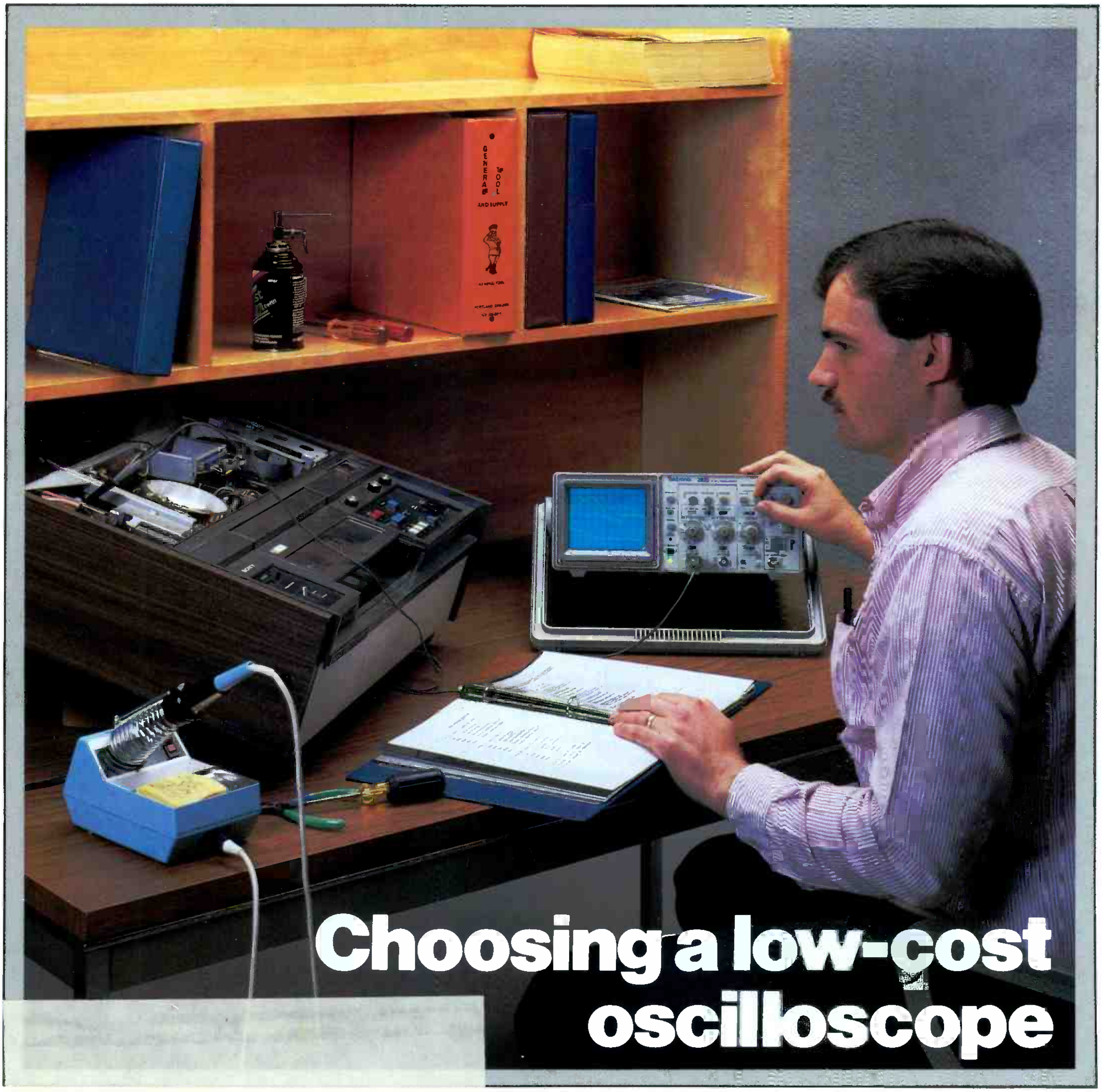
The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

JANUARY 1987/$2.25

MTS: TV sound in stereo, Part 1 • Digital circuits...enhance viewing

You have to buy test equipment. Or do you?



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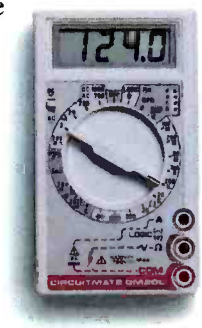
- hFE (NPN or PNP): 1 range (1000)
- DMM: Input Impedance—10 Megohms DCA/ACA-5 ranges (200μA to 2A)
- Ohms-8 ranges (200 ohms to 2000 Megohms)
- Continuity beeper



DM850 True RMS

- 4½ digits. DCV accuracy is .05% +3 digits
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- Frequency counter to 200KHz
- Data Hold display capability
- Continuity beeper
- Built-in bail
- Anti-skid pads
- Price: DM850 (True RMS)....$219.95* DM800 (Average)........$169.95*

DM25L Capacitance, Logic, hFE $89.95*

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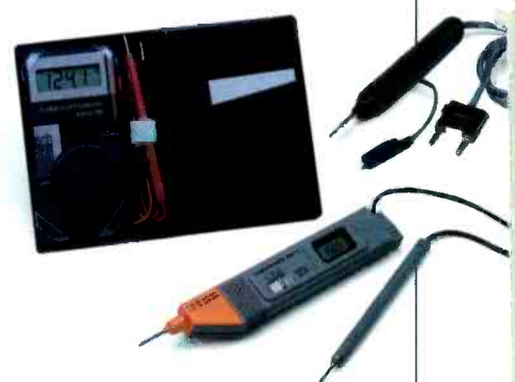
- Capacitance: 5 ranges (2nF to 20μF)
- hFE (NPN or PNP): 1 range (1000)
- Continuity beeper
- Built-in bail
- Anti-skid pads



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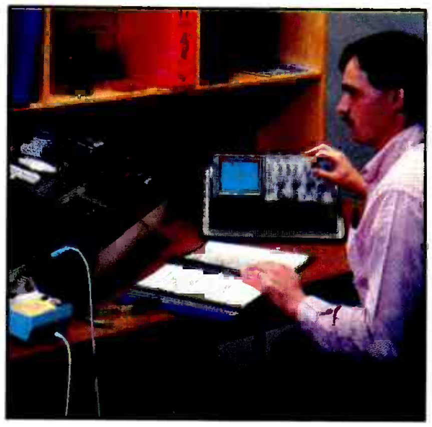

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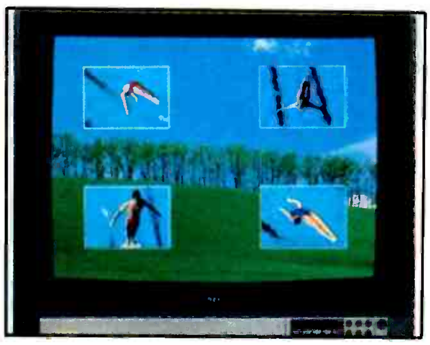
Beyond mere adequacy, today's oscilloscopes have a high performance-to-price ratio. *(Photo courtesy Tektronix)*



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The square-design picture tube and digital signal processing combine for viewing flexibility. *(Photo courtesy NEC)*

Departments:

Editorial

Will (electronic) wonders never cease?

Back in October last year, I had to rent a car to take a business trip. I wound up renting a van that had a computer on board. This was my first exposure to such sophisticated electronics in a car.

I had read about such units, of course, but that hadn't prepared me for this experience. As I was checking out the car before I got underway, I found above the windshield several buttons and a small screen. The agent at the rental agency just pointed out the computer controls but declined to explain how they worked. His attitude notwithstanding, I proceeded to experiment with the computer.

When I pressed the FUEL button, a number appeared that was obviously the number of gallons in the tank. No amount of pressing of the RESET button would change that number to zero as it did with most of the other numbers displayed. That made sense. There was another button marked DTE. That readout remained steady at about 380 even though I pressed the RESET button. It took a while before I figured out what that one was for.

Some of the other readouts were immediately self explanatory. One was marked AV FUEL ECONOMY or something like that, and displayed the overall fuel economy since the last time that value had been reset. MILES and MPH were simply repeats of the speedometer and trip odometer readings on the dashboard instruments. The AV MPH was one of my favorites. It showed my average speed from the start of the trip to the current instant.

There was one more button, and for me it was the most fascinating. It was marked INST FUEL ECON, or something similar. It told me what my fuel economy was at that instant in time. If I was laboring uphill, this readout showed me that my fuel economy had plummeted down to the low teens. If I was coasting downhill and had just taken my foot from the accelerator, my instantaneous fuel economy soared to around 50 miles per gallon. During most of the trip, I had the computer display this value.

The effect of knowing my fuel economy at any moment was uncanny. Even though this was a rented van and my company was paying for the gas, not me, I found myself striving to keep the fuel economy number high.

This experience drove home for me the incredible potential yet to be realized by the computer, and with only a small investment in effort and technology. If a driver can constantly be aware of the state of the car he's driving, why can't this information be made available about other electrical and mechanical equipment.

Take the home for example. Every home has a watthour meter and it's simplicity itself to read it periodically and so to keep track of the amount of power consumed. Still, when air-conditioning season comes to the warm parts of the country, people consume power to cool their homes and don't check the watthour meter. They have no idea what it's costing them until they're shocked by the bill. The same is true with the gas meter.

With sensors costing practically nothing these days, it really wouldn't be too hard for the utilities to make this information available to a central home computer where a computer exists. Programmed with the appropriate information, it should be no problem to keep the homeowner apprised of the number of kilowatt hours of electricity and the number of cubic feet of gas consumed, as well as the approximate cost in dollars and cents for a period of an hour, a day, a month or a year.

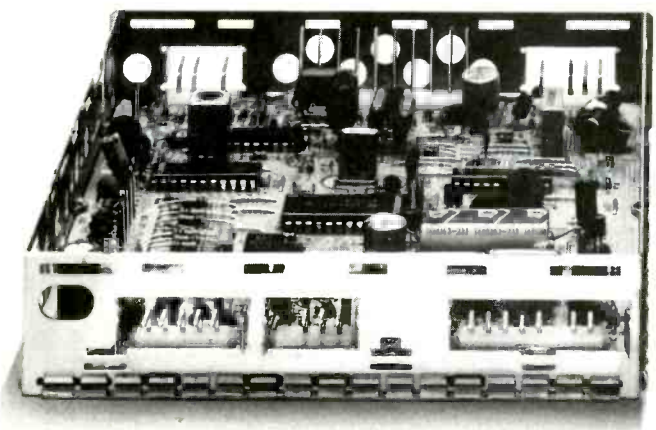
With the appropriate sensors and relays, it should be simple to use the computer as a load regulator so that if your home is beginning to use too much electricity, some preselected loads can be shed automatically.

We recently have witnessed a revolution in electronics as a result of the introduction of the computer and all manner of other solid-state electronic devices. A little thought about what has been achieved suggests that present achievements will pale by comparison to what is yet to come. Not very far in the future, if someone doesn't know about computers, he will not know about electronics.

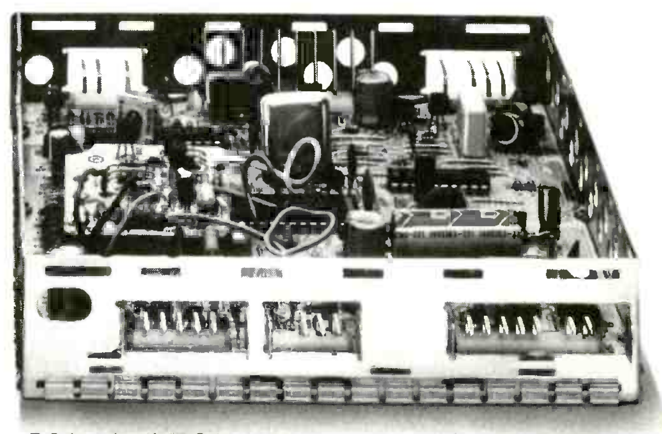
Oh, in case you're still wondering, the DTE display was for Distance to Empty. It was comforting to have that knowledge when making a long trip, on unfamiliar roads in an unfamiliar car. As it turned out, when I completed my trip I still had 70 miles to go before the tank was dry.

Nils Conrad Persson

Not all RCA modules are re-created equal.



Competitor's rebuilt RCA module



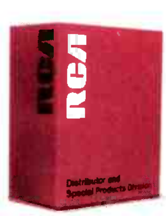
RCA rebuilt RCA module

Only modules rebuilt by RCA guarantee RCA quality.

Recently, one of our competitors slashed prices on their rebuilt RCA modules by up to 40%. Sounds good, until you review their products' performance. Then you'll wonder why they didn't do it sooner.

To demonstrate, we selected a random cross-section of their "bargain" boards for inspection. Using the same stringent testing methods RCA applies to its remanufactured boards, more than an incredible 70% of their rebuilt modules were rated unacceptable.

Some simply didn't work. Others lacked design updates, or had a wrong or missing component. The rest suffered from problems in workmanship, such as the use of wire to bridge broken circuit board etchings, which could affect both reliability and performance.



Which all goes to show, RCA modules remanufactured by RCA remain your best bet. Ours are re-created to perform as well as, if not better than, the RCA original. Each contains the latest design updates. And all are thoroughly tested, inspected, and covered by warranty.

Their rebuilt modules may cost less, but the quality just isn't equal. So do it right the first time. Insist on RCA. Because the quality and performance are built in.

RCA Distributor and Special Products Division

Circle (3) on Reply Card

News

HRRC to continue fighting VCR circuitry legislation

In the closing days of the 99th Congress, the motion picture industry sought legislative support for an anti-videotaping chip. The Motion Picture Association of America (MPAA) announced its intention to ask Congress to pass legislation that would modify VCR circuitry to prevent prerecorded cassette duplication.

At a Senate Judiciary Committee hearing, MPAA President Jack Valenti argued that the chip is necessary to prevent back-to-back copying of 70 million tapes each year. Charles Ferris, representing the Home Recording Rights Coalition (HRRC), opposed the anti-taping chip proposal, calling it a "ticking time bomb" that could be used by software manufacturers to take away the consumer's right to timeshift programs from commercial and cable television.

The Home Recording Rights Coalition, of which EIA is a major member, will continue its fight against any tampering with recording hardware or taxing of recorders when the MPAA asks the 100th Congress for legislation.

President Reagan vetoes TV efficiency standards bill

On October 15th, the Congress passed H.R. 5465. "The National Appliance Energy Conservation Act of 1986." The legislation would preclude any state or federal efficiency standard for television sets until 1992. President Reagan pocket-vetoed the legislation, however, thus preventing its enactment this year.

Present law requires the Department of Energy (DOE) to set an energy efficiency standard for TV sets and 12 other products. The bill would have mandated efficiency standards for most of these products, but would have left a TV set standard to the discretion of DOE after 1992.

Las Vegas gearing for CES

The Winter Consumer Electronics Show, Jan. 8 through Jan. 11, is expected to attract more than 100,000 trade attendees and approximately 1,400 exhibitors at the Las Vegas Convention Center, and Hilton, Riviera and Sahara Hotels. Like the summer counterpart in Chicago, the Winter CES is sponsored by the Electronics Industries Association (EIA) Consumer Electronics Group. Members of EIA include manufacturers of audio, video, home information and telephone products for the consumer.

CD Player sales to record high

When all the 1986 sales figures for compact disc players are tabulated, they should indicate a record sales year, according to a study by Venture Development Corporation (VDC), Natick, MA. If VDC's projection is accurate, compact disc player sales will have topped 1.5 million units during this past year, exceeding the projected sales of the more traditional, component turntables.

When introduced less than three years ago, CD players were considered an expensive novelty and, initially, less than 40,000 units a year were shipped, notes VDC. Also, CD players cost approximately $800 apiece when they were new on the market; they now sell for about $200. The study credits declining prices, effective promotion and the absence of competing formats with fueling market growth. Two additional factors are cited as important keys to the CD player's success: its demonstrable sound quality and its small size.

VDC further predicts that the availability of compact discs will continue to be a problem. ES&T

ELECTRONIC Servicing & Technology

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INTERTEC PUBLISHING CORPORATION

Feedback

Letter to Sam Wilson

Addressing the subject of gamma once again...

I remain unconvinced that h-parameters cannot be useful in follower circuits (determining input impedence, for example) but because we normally consider I_c to be equal to I_e when we calculate beta, we are actually approximating gamma anyway. Also, $h_{ic} = h_{ie}$, $h_{oc} = h_{oe}$ and, h_{rc} is almost equal to unity, so common collector h-parameters in addition to common emitter parameters would be redundant and would appear to serve no useful purpose.

I do believe, however, that the third set of transistor h-parameters serves a useful function as an educational aid and that its inclusion in textbooks is justified. In the study of electronics, it is often necessary to consider an impractical circuit to better illustrate the advantages and disadvantages of electrical phenomenon. A demonstration of impracticality is often the shortest road to understanding. How better to illustrate the advantages of feedback than to consider the circuit without feedback?

In the special case of reducing a transistor to a hybrid model and understanding the four parameters (h_i ,h_r ,h_f and h_o), we are severely limited in demonstrating their dynamic nature with respect to basing because there are only three possible transistor configurations. To disregard the common collector configuration would suggest a false either/or relationship, making an understanding of the total concept more difficult.

I have often been at odds with the manner in which some electronic concept has been presented only to later find myself in total agreement. An example that comes readily to mind is the concept of hole movement in semiconductors. It took a few years for me to come to terms with it but today it seems an essential concept when considering transistor operation. Still, I know good technicians who are much more knowledgeable than I and have been in the field for many, many years but still refuse to subscribe to the concept. Perhaps the concept of gamma has that same kind of effect.

Roy F. Graves C-29382
Soledad, CA

Yours was the first letter that mentioned the use of common-collector h parameters as an educational aid. I specifically like your statement: "The demonstration of impracticality is often the shortest road to understanding."

So, I am in agreement with you that those h parameters (or gamma) do not appear to be valuable in terms of amplifier design. They do, however, round out the 3-terminal possibilities and complete the h parameter set.

I know what you are saying about holes. The biggest problem was converting experienced technicians from dedicated electron flow to hole flow. I used all types of analogies like parking spaces and missing cue balls, but never found the universal magic words....

Sam Wilson

Technology

Automatic Focusing system uses video signal

Piezofocus, the new automatic focusing system by Matsushita that is based on the human eye, uses its video signal to focus on the sharpness of an object image. The focal state is changed cyclically to adjust the sharpness of an object image on an image sensor. To do this, Piezofocus uses the change in high frequency components that correspond to the sharpness level used to adjust the focus lens.

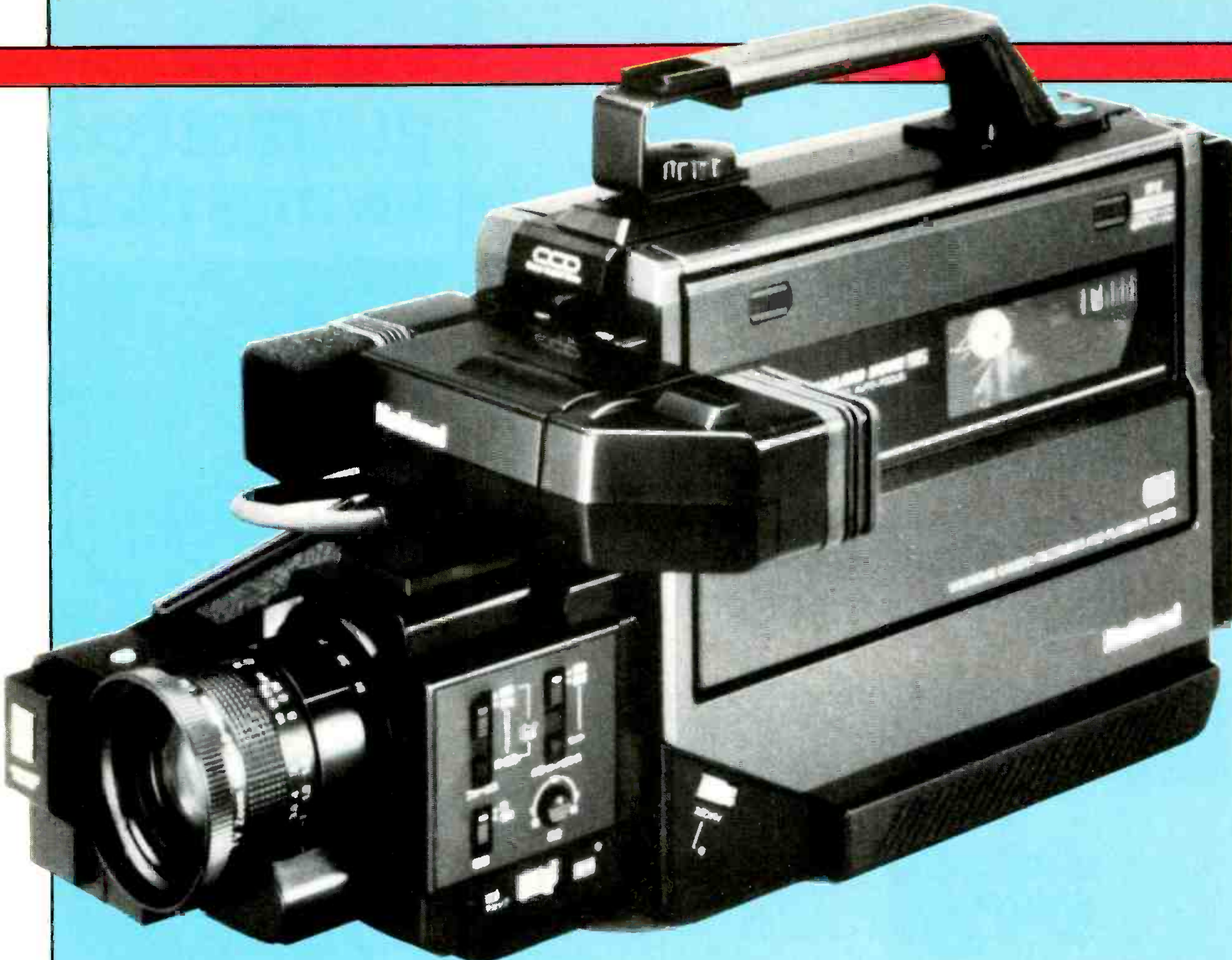
This approach to focusing a video camera has won a *Research & Development* magazine I-R 100 Award for excellence in industrial R&D for Matsushita Electric Industrial Company of Osaka, Japan, and its Central Research Laboratories.

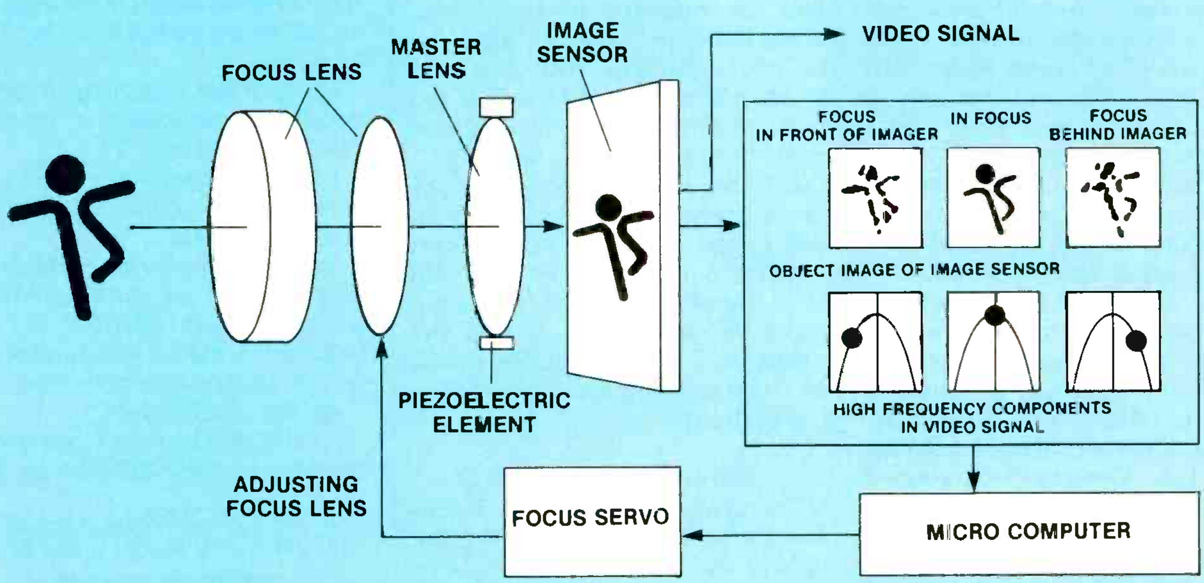
To date, conventional focusing systems adjust to the focus by measuring with infrared rays the distance between the camera and the object being videotaped. Infrared measuring accuracy can be impaired because of variations in degrees of light reflection, light may be reflected in the wrong direction, or objects may be beyond reflection. The size and location of the object as well as the position of the zoom lens also may contribute to errors in focusing.

Infrared systems consisting of an emitter and receiver tend to be bulky, and consume extra power, adding to the camera's cost and size. Piezofocus occupies only one-third the size, uses one-half the power, and costs about two-thirds as much as other automatic focusing systems.

Piezofocus operation

The master lens in the Piezofocus system is oscillated along the optical axis by a built-in piezoelectric element. This produces high frequency components in the video signals that contain a focus error signal. The error signal



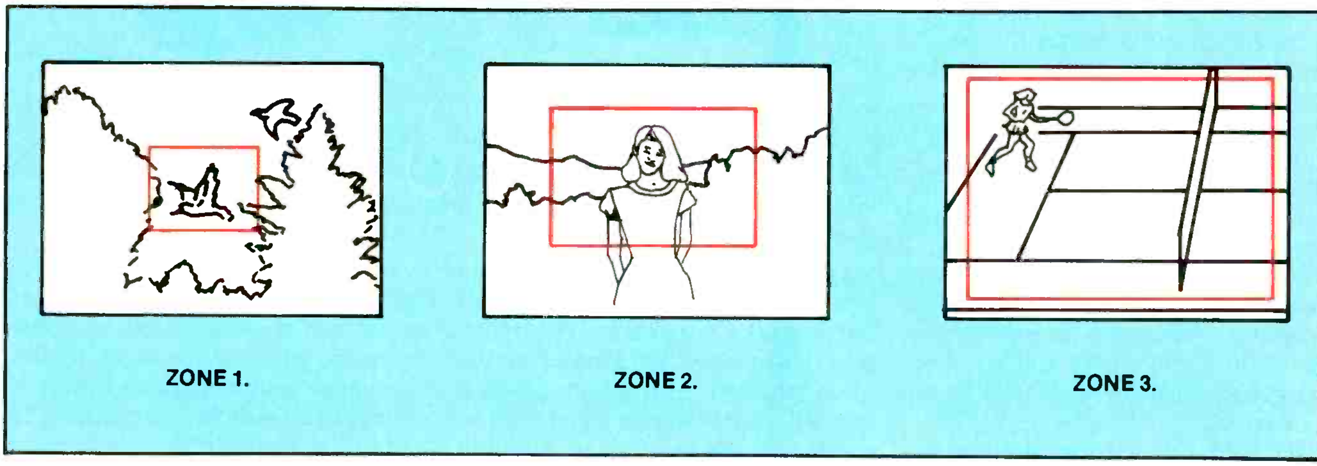


FOCUS LENS
MASTER LENS
IMAGE SENSOR
VIDEO SIGNAL
FOCUS IN FRONT OF IMAGER
IN FOCUS
FOCUS BEHIND IMAGER
OBJECT IMAGE OF IMAGE SENSOR
HIGH FREQUENCY COMPONENTS IN VIDEO SIGNAL
PIEZOELECTRIC ELEMENT
ADJUSTING FOCUS LENS
FOCUS SERVO
MICRO COMPUTER

represents the amount and direction of the focus deviation from the optimum in amplitude and sign. The Piezofocus video signal is used in controlling the focal lens servo system so the camera maintains optimum focus at all times.

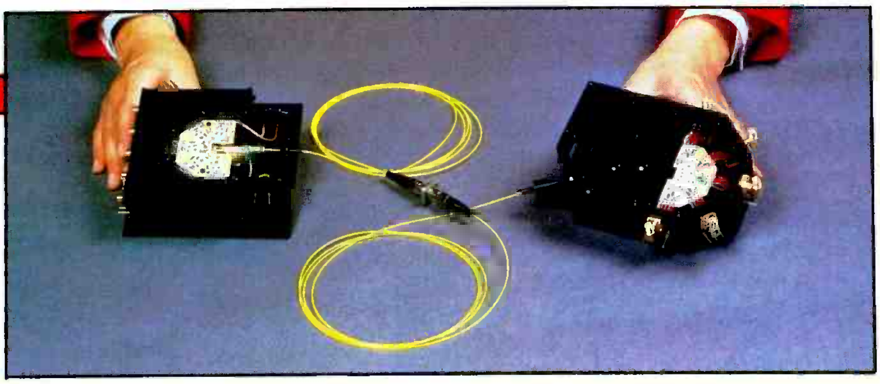
To operate the system, two new ICs and a microcomputer chip are used. The microcomputer always adjusts the condition of the system so that under any circumstances the video camera is brought into focus quickly. The system also has a focus zone function, called a *Magic Window*. This window, displayed on the viewfinder, allows the user to select three different focal zones to set the autofocus: Zone one can be used for close ups; zone two for medium shots; and zone three for distance.

Matsushita has installed Piezofocus systems in more than 100,000 of its NV-M3, F2, WV-3250 camera models.



(Diagram courtesy of Matshushita)

Fiber-optics system now can handle 1990's telecommunication capacity



(Photo courtesy of Toshiba Corporation)

In this photo, the optical transmitter (multiplexer) is on the left, and the optical receiver (demultiplexer), on the right.

Until this latest optical communications development by Toshiba, the high-capacity transmission of data forecast for the next decade would have been impossible to handle, even by today's fiber-optics systems wherein a single optical fiber has a communications capacity 1,000 times greater than non-optical means. With most such systems today, however, only light beams of a single wavelength can be conveyed in each single fiber, and a wavelength separation of 1,000Å is required.

Toshiba's new, integrated, next-generation demultiplexer can separate as many as *five* signals of differing wavelengths transmitted simultaneously from a single optical cable, with a wavelength separation of 50Å-1/20 of the current limitation. Each wavelength can be received accurately with little interference from adjacent waves.

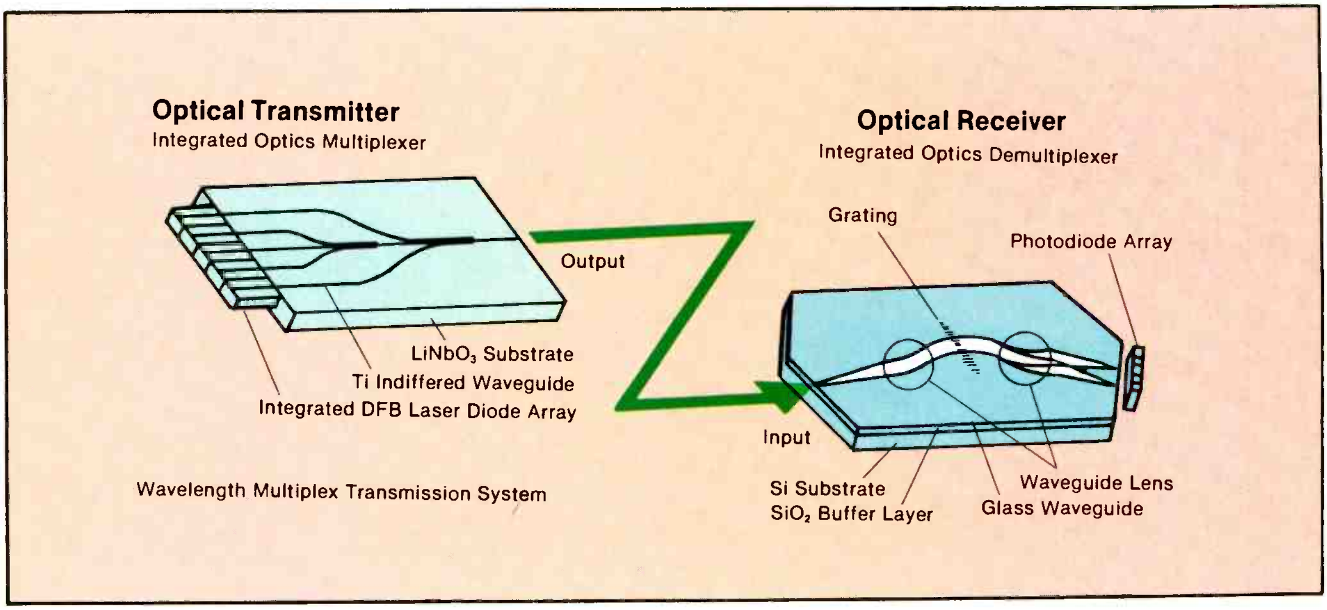
This demultiplexer has most of its key components integrated on a single crystal silicone substrate atop which a thin glass layer acts as a guide for lightwaves transmitted from the fiber cable. The multiple, multiplexed lightwaves strike a corrugated diffraction grating (etched on the silicon substrate) at a specific angle, and as a single signal.

Working like a prism, the grating separates the multiplexed signal back into the five different signals originally transmitted. This grating, with its minute grooves ($0.7\mu m$ wide and $0.3\mu m$ deep) is etched on the substrate at $1.5\mu m$ intervals—an achievement made possible only by sophisticated microlithography.

Besides developing this new receiver, Toshiba has improved the wavelength accuracy of the transmitter. Both have been incorporated into a system that has been operated at a data rate of 32Mb/s per beam to demonstrate the feasibility of full optical integration. An extended transmission capacity is planned.

The present research effort is part of a major research and development project on optical measurement and control systems, conducted under a program set up by the Ministry of International Trade and Industry's Agency of Industrial Science and Technology.

Figure 1. Key components, integrated on a single silicon substrate. Note the light waveguide.



(Diagram courtesy of Toshiba Corporation.)

★ RESEARCH
★ DEVELOPMENT
★ PROTOTYPING
★ PRODUCTION

Diehl Industries of Amarillo, Texas proudly announces the opening of a new and unique research, development, and proto typing division, for use by the nation's electronic industry.

WHAT MAKES IT SO UNIQUE

Traditionally, when a company or an individual has a new idea, mass confusion sets in, - - - and promptly takes control of the project.

The "electronics" for the original idea goes one direction (to R & D), while another "team" scrambles to develop the mechanicals for the case that will house the final product.

From "R & D" the artwork for PC boards must be generated, then sent to a PC board manufacturer, the mechanicals for the case must then be sent to a plastics manufacturer, once they are finished, the PC boards must then be sent to a "board stuffing" company, someone must then find the best price on component parts and hardware, someone else must coordinate the receiving of same, while yet another team s frantically trying to develop an operations manual for the final product (which must then be sent to a printer, who will ultimately have to send it out to a bindery to be bound, and turned into an actual book).

You guessed it! By the time all of the above comes back to home base, - - - nothing fits ★!✓$*
(just ask anyone who has tried it).

Diehl's new division has a unique advantage over tradition, in that all of the above is done under one roof.

Diehl's R&D Department can take a preliminary schematic (or just an idea without the schematic), design it, or refine it, bread board it, test it, turn it into working artwork for printed circuit production, then, using their own proto typing system, produce the original "trial" PC boards. Our R&D staff has immediate access to four, totally separate individual, full time, "in house" CAD systems (computer assisted design). In a "total design" project all four will become necessary.

"Auto CAD 86" will be used to generate shop drawings which will then be used by Diehl's Plastic Division.

Winteks "Hi-wire" will be used to generate the necessary schematics for use by Diehl's own in-house printing and bindery department along with the necessary text for same, which will be provided by Diehl's in-house technical writing staff.

Winteks "smart-work" will be used to generate artwork to produce PC boards. This same artwork is then given to Diehl's in-house camera and stripping dept. where it will be photographically reduced, and turned into working transparent positives, which will then be given to Diehl's in-house PC manufacturing division (once the R&D proto type boards have been approved).

Meanwhile, Winteks "drill" CAD System is used to generate the necessary "drilling" information for our Excellon "Mark III", four spindle, computerized drill which is just part of Diehls in-house PC board manfacturing division. Once our Excellon drill (which is based on an 8,000 lb. granite slab for accuracy) has completed the drilling operation (at 10,000 holes per hour × 12 boards at a time), the boards will go through our own in-house chemistry, then into one or more of our fourteen in-house electro platers for copper, tin-lead, nickel, or gold.

After being properly sized, the PC boards will then go to our in-house "board stuffing" department (which employs 20 full time stuffers). There it will be "stuffed", wave soldered, inspected, tested, then given to quality control for final inspection.

Meanwhile: Our purchasing dept. has been on the phone with every major supplier in the country fighting for the best possible price on the highest quality components. Our in-house printing and bindery division has produced the operation manuals from artwork that was provided by our own technical staff. Our in-house plastics division (which does some of the most sophisticated vacuum forming in the nation) has produced the cases into which the final product will be assembled. Our own in-house silk screening department has produced all necessary escutcheon plates and panels.

All of the necessary components are now ready for mass production by our own final assembly division. Because everything was done under one roof, and monitored by one project supervisor, - - - everything fits!

In adddition to the above, we also have our own in-house advertising agency and international marketing facilities.

The next time you have a "project" think about us,
- - - **we can make it happen!**

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Test your electronic knowledge

by Sam Wilson

1. A pure sine wave voltage is applied to the input terminal of the differentiating op-amp circuit in Figure 1. The output *waveshape* should be
A.) a sine wave.
B.) a triangular wave.
C.) short pulses.
D.) a square wave.

2. Figure 2 shows the distribution of signals in a television channel. Which of the following is correct?
A.) X is the I signal and Y is the Q signal.
B.) X is the Q signal and Y is the I signal.

3. A certain 12V power supply has an output voltage of 8V when it is delivering its full load current. As far as regulation is concerned, could this supply be replaced with a 12V supply having a percent regulation of 20%?
A.) Yes B.) No

4. Which of the following statements is correct?
A.) The VITS signal is located on the horizontal blanking pedestal.
B.) The VIRS signal is located on the horizontal blanking pedestal.
C.) Neither statement is correct.
D.) Both statements are correct.

5. At the alpha cutoff frequency, the emitter-to-collector current of a transistor
A.) is maximum for a common emitter amplifier.
B.) is zero for a common base amplifier.
C.) is 70.7% of maximum for a common emitter amplifier.
D.) None of these choices is correct.

6. Which of the waveforms in Figure 3 is best for a sawtooth qualitative test?
A.) The one shown in (a).
B.) The one shown in (b).
C.) The one shown in (c).
D.) The one shown in (d).

7. The track on a compact disc is about
A.) 800 feet long.
B.) 1,280 yards long.
C.) 2½ miles long.
D.) None of these choices is correct.

8. What is the name of the block marked 'x' in the phase-locked loop in Figure 4? ________________

9. Which of the following is a reason for using ECL logic in a bit-slice system?
A.) Low cost
B.) High speed
C.) TTL compatible
D.) Does not require interfacing

10. You are going to secure an antenna with guy wire. One of the guy wires will be attached to a point on the pole 40 feet above the base; and a point 30 feet out from the base. (See Figure 5.) Disregarding extra length for tying, what length should the guy wire be cut?
A.) 45'. C.) 55'.
B.) 50'. D.) 60'.

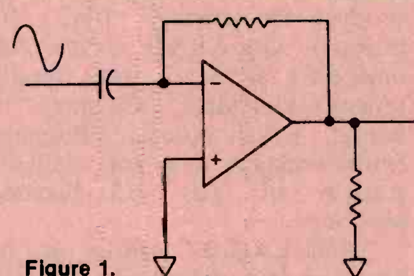
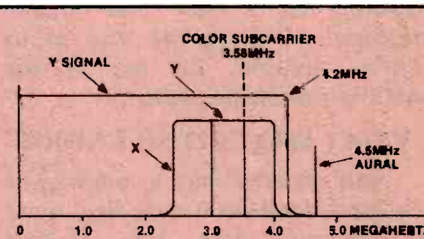


Figure 1.



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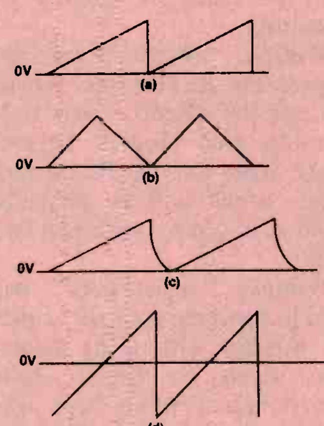

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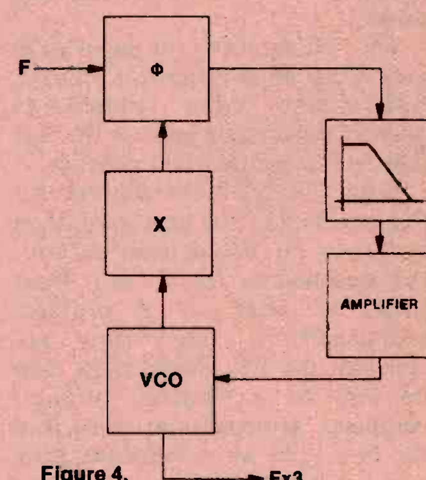

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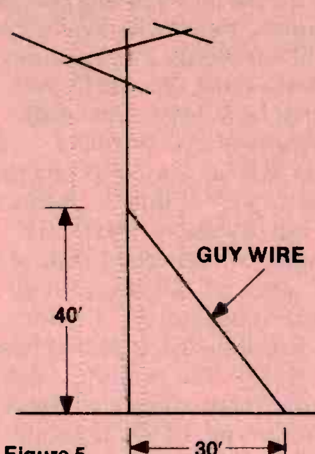


Figure 5.

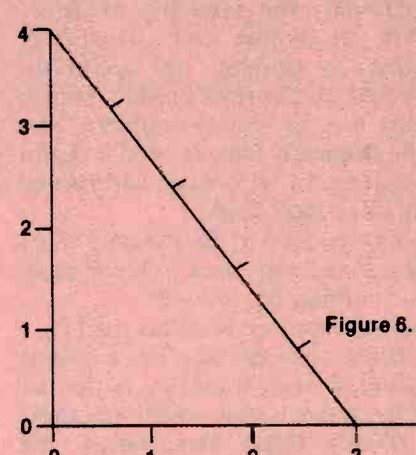


Figure 6.

Answers are on page 51

Digital circuits, squared corners enhance viewing on this TV

The DT-2680A digital television by NEC uses digital technology to enhance picture quality as well as to add features. Specifically, digital signal processing achieves horizontal resolution of 500 lines, through video inputs. Digital processing also enables the company to build in such features as picture-in-picture (PIP) and memory for three still pictures.

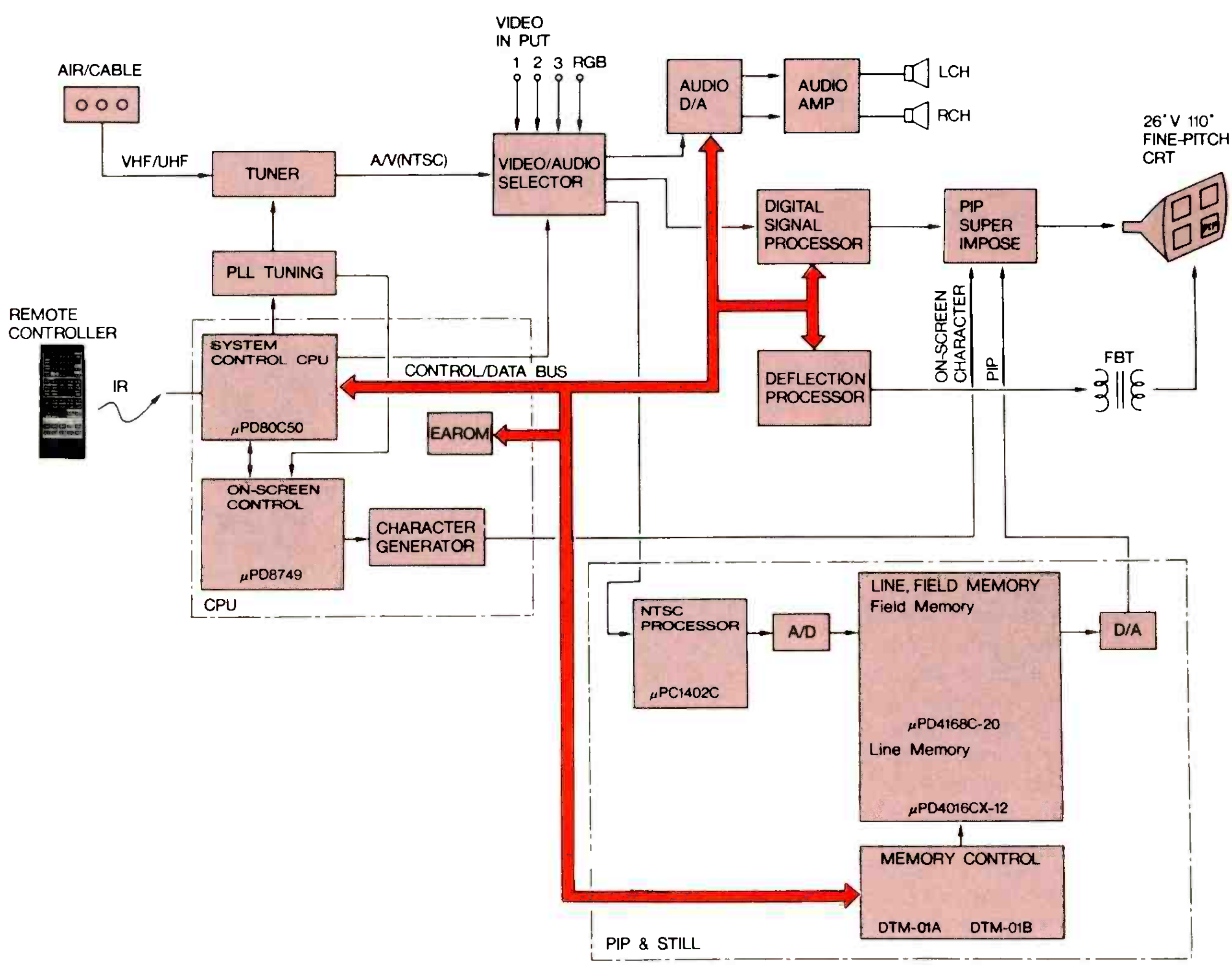
Picture quality

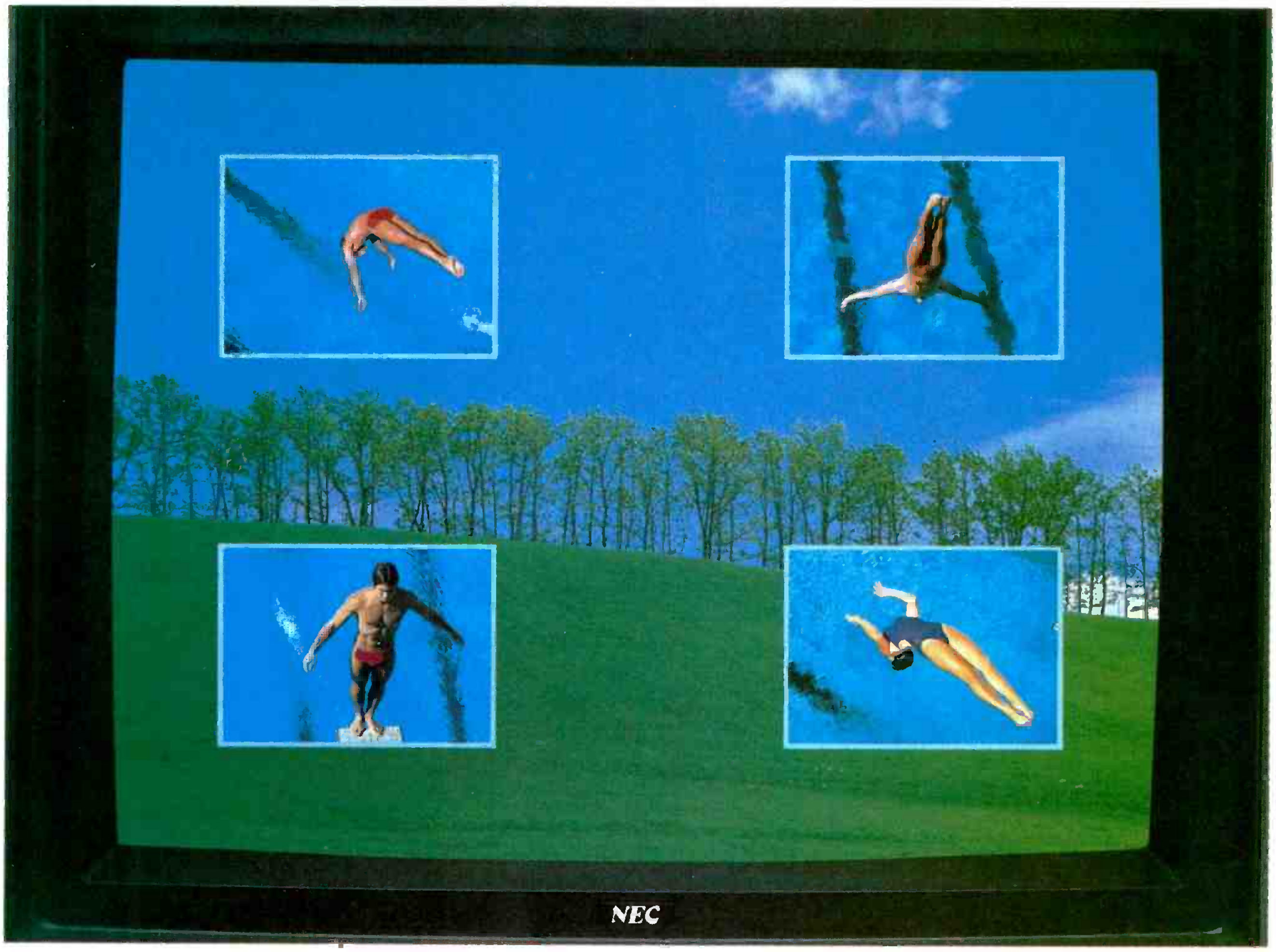
The DT-2680A uses a newly developed LSI for digital signal processing of video, chroma (with comb filter) and deflection control. Combined with precise in-line electron guns and a fine-pitch 26-inch screen, digital processing results in 500 lines of horizontal resolution (via video inputs).

This is the second receiver/monitor to use NEC's Square 90 26-inch picture tube. In comparison to conventional, spherical tubes, the Square 90 design reveals more picture information in the corners, reduces geometric distortion, and cuts down ambient light reflection. To reduce reflection further and assure deep, rich contrast, the screen uses a special dark glass.

Picture-in-picture

The DT-2680A can simultaneously display the station tuned in, plus moving pictures from any of three video inputs or color computer graphics from the set's RGB input. Initially, the TV picture occupies the entire 26-inch screen, while the external picture is displayed in an 8½-inch diagonal area in the lower right. The consumer can use the remote control to switch these pictures around, placing the external picture on the entire screen and the TV picture in





Simulated TV picture

the lower right.

This means computer owners can follow their stocks, VCR owners can check out a tape or tune in a second channel, all without interrupting their TV viewing.

Memory for three still pictures

The DT-2680A has the memory to store up to three different still pictures at a time. Pictures for memory are selected by remote control and displayed as 8½-inch diagonal inserts: No. 1 in the upper-right, No. 2 in the upper-left, and No. 3 in the lower-left quadrant of the screen.

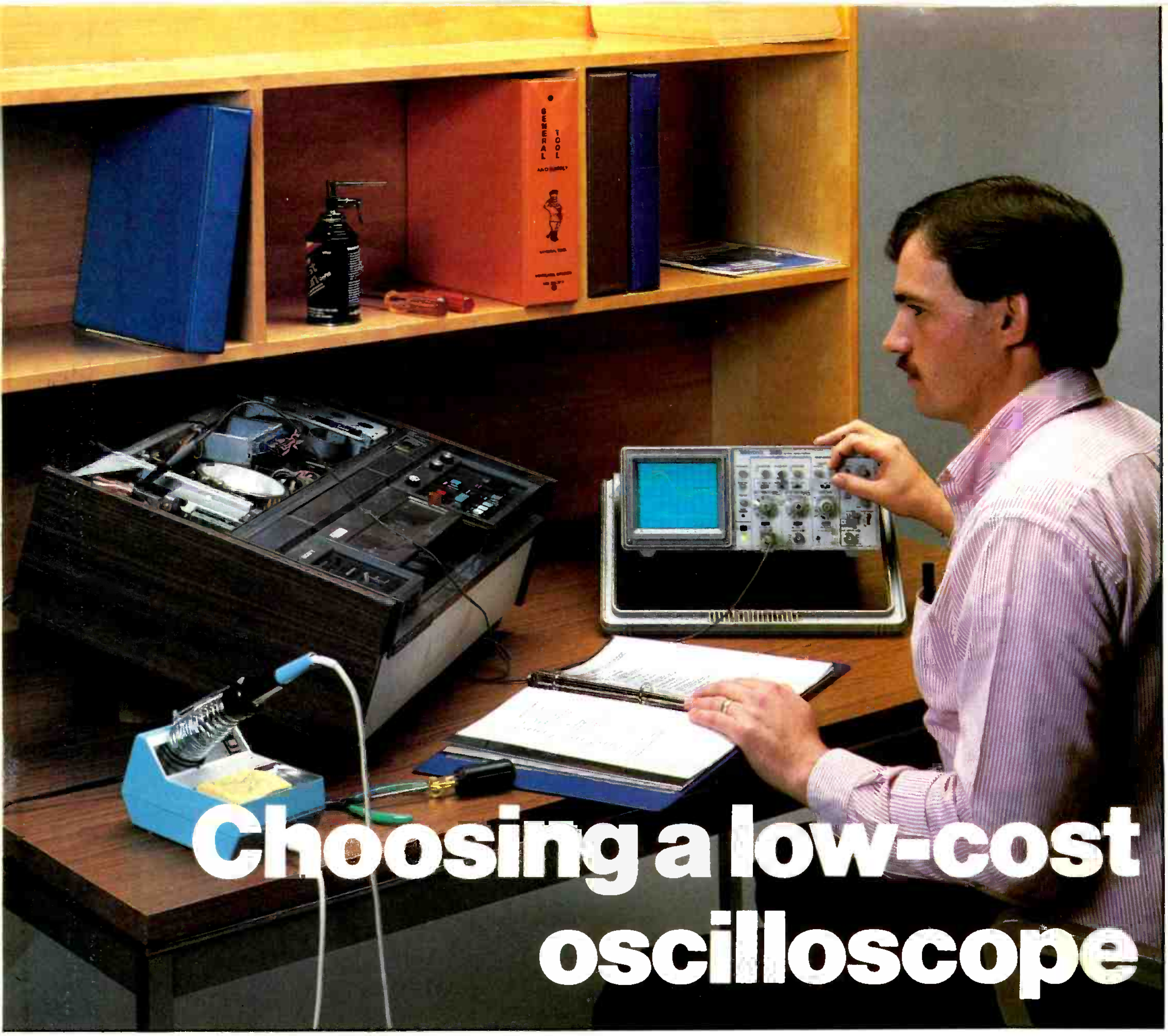
Connection and reception

The set has frequency synthesis tuning of 142 channels, including non-scrambled cable channels. Built-in MTS decoder, stereo amplifier and stereo speakers provide reception of TV stereo and second audio program (SAP). A special RF output and auxiliary antenna input permit connection of a pay-TV decoder box.

Three sets of line video inputs accept connections for VCRs, videodisc players, color cameras and home computers. An 8-pin RGB input enables the DT-2680A to display high-resolution computer graphics from IBM and NEC personal computers. Outputs include a monitor output that carries whatever is on-screen, a TV output that carries whatever channel the DT-2680A has tuned, external speaker outputs, fixed audio line outputs for recording, and variable audio-line outputs for volume-controlled connection to a high fidelity system.

Remote control feature

The set offers comprehensive remote control of functions including channel tuning, sleep timer, and a myriad of picture and sound adjustments. A variety of on-screen displays identify the channel and operating mode, and help the user make adjustments. Picture reset and sound reset functions return the controls to factory preset positions.



Choosing a low-cost oscilloscope

By Dave Herrington

There's an old axiom, "You get what you pay for."

The nice thing about electronics technology is that today you get far more for your dollar than was possible even a year ago. This is especially true of oscilloscopes. Choosing a low-cost scope today, doesn't have to mean giving up features to save money. The performance/price ratio has never been higher, particularly for scopes under $1,000.

For example, the new Tektronix 2225 scope starts with basic 50MHz, dual-channel capability. To this, add 500μV/div input sensitivity instead of the usual 2mV or even 5mV maximum sensitivity. This scope also provides high-frequency/low-frequency trigger reject along with normal, peak-to-peak automatic, single-sweep, and TV field/line triggering. There's even X5, X10 and X50 horizontal alternate magnification for simplifying measurements normally done with a dual-time-base oscilloscope.

A number of technologies have come together to make such features possible in low-cost scopes. In particular, engineering investment is much more effective with computer-aided design. Modern analog ICs have reduced part counts for quicker manufacturing (and higher reliability) while providing more features in a smaller package. And modular design features (Figure 1) have speeded assembly.

Advanced technology has built more scope for less money. But the question still remains: Will these new scopes do the job for you? How do they perform?

Table 1 lists some applications and related scope requirements. This is but a brief summary, however. Making a final scope selection still requires understanding the scope specifications and how far they can be pushed for any application. The alternative – if money is no object – is to buy the fastest scope on the market.

Bandwidth, rise time and sensitivity

In considering any scope for a given application, first look at its bandwidth, rise time and sensitivity characteristics. These are the

Herrington is product support specialist, Portable Test Instruments division, Tektronix, Beaverton, OR.

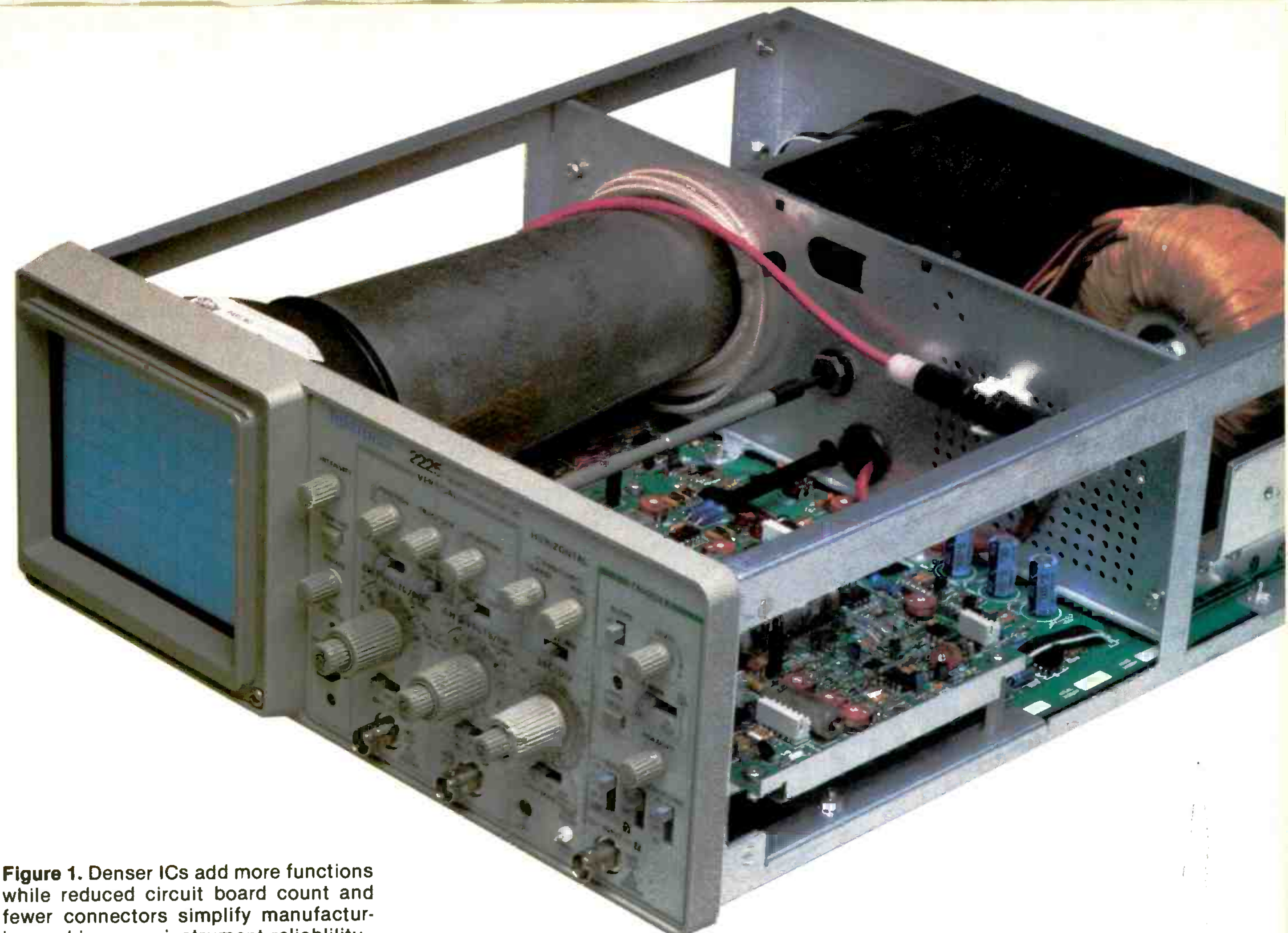


Figure 1. Denser ICs add more functions while reduced circuit board count and fewer connectors simplify manufacturing and increase instrument reliablility.

Oscilloscope Applications Summary

	Bandwidth	Rise Time	Other Key Features
1. TV/Video	12.5MHz	28ns	TV Frame and Line Triggering
2. Digital	50MHz	7ns	Dual Channels, Alternate Horiz. Mag.
3. Audio	175kHz	---	500μV Sensitivity
4. Electro-mechanical	5-10MHz	35ns	Single Sweep, HF/LF Reject Trigger
5. Robotics	5-10MHz	35ns	Single Sweep, HF/LF Reject Trigger, 500μV Sensitivity
6. Power Supplies	175kHz	--	500 μV Sensitivity

Notes:

1. Based on 0.14μS sync pulse rise time requirements. At least 50MHz needed for IF sections.
2. Covers most consumer digital systems (e.g. personal computers).
3. Does not cover digital recording; 500μV sensitivity for microphone, tape head measurements.
4. Based on rise time/switching requirements.
5. Same as 4; high sensitivity for low amplitude sensor waveforms.
6. Bandwidth determined by supply switching rates; 500μV sensitivity for low-level ripple measurements.

Measurement capabilities such as rise time and bandwidth and special features that you need to have in an oscilloscope depend on what you intend to measure with it. This table indicates some possible applications, but technicians' needs vary.

may be easier to deal with in the single-shot mode. In this mode, a single display sweep is triggered when the signal occurs. The scope trigger is then manually rearmed for the next signal. Typically, low-speed single-shot signals, such as a relay or switch closure, can be viewed directly on screen. Faster transients usually must be captured with single-shot CRT photography or more expensive digital storage technology.

TV frame and line triggering modes (Figure 3) are less commonly found on low-cost scopes. As their name implies, these modes allow synchronous triggering on TV display frames or scan lines. Naturally, this is an important feature for TV servicing, but it is becoming increasingly important for general use because more and more products are using raster scan displays: video terminals, video games and personal computers are a few common examples.

In cases where signals are low level, any of the above modes can have trouble locking in on the signal for a stable display. This is usually because of noise, which is a common problem in most low-level measurements. Power supply ripple, 60Hz from lighting and general random noise are the usual culprits. Their presence disrupts trigger stability by obscuring the desired trigger point.

In the past, many low-level measurements had to be made in shielded rooms or with some kind of shield cage constructed on the bench. Now, however, low-frequency and high-frequency reject modes are extending standard scope triggering to much lower level signals (Figure 4). These modes reject unwanted bands of noise from the triggering pick off of the signal being measured.

When 60-cycle or other low-frequency interference is the problem, use low-frequency reject to obtain stable triggering. For other trigger jitter problems, high-frequency reject is usually the solution.

But not all low-cost scopes provide all of these triggering modes. Although a scope may meet basic bandwidth and sensitivity requirements, lack of a convenient

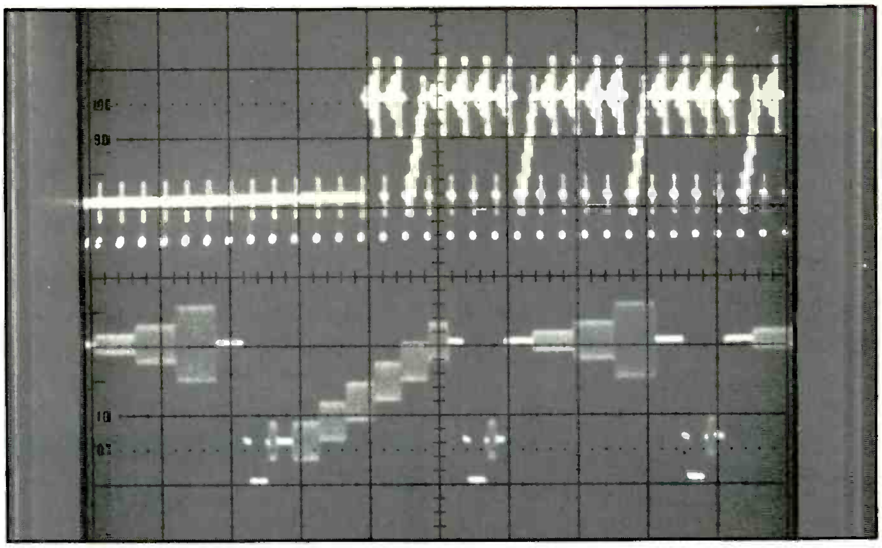


Figure 3. The ability to synchronously trigger on a TV frame or a scan line is an important scope feature in a world that is becoming increasingly video oriented.

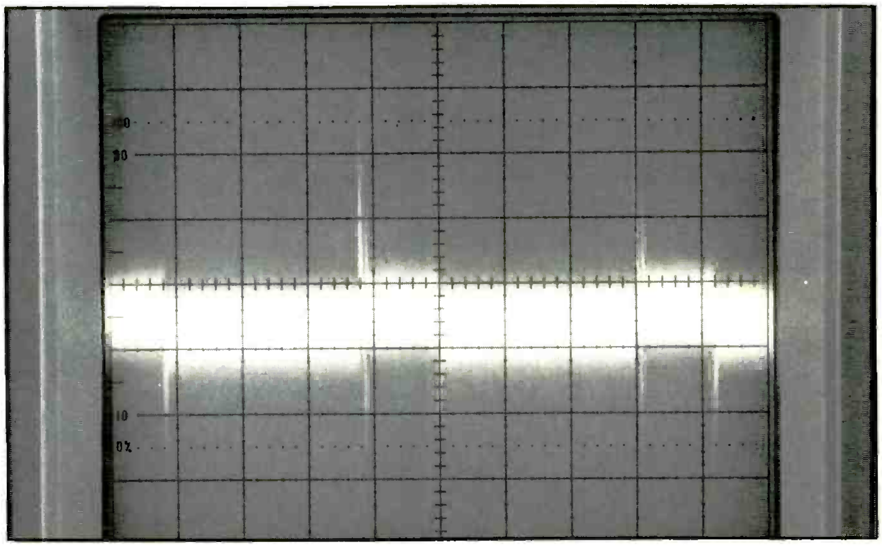


Figure 4. High sensitivity input (500μV/div) and *high-frequency* reject triggering provide large, stable displays of low-level signals.

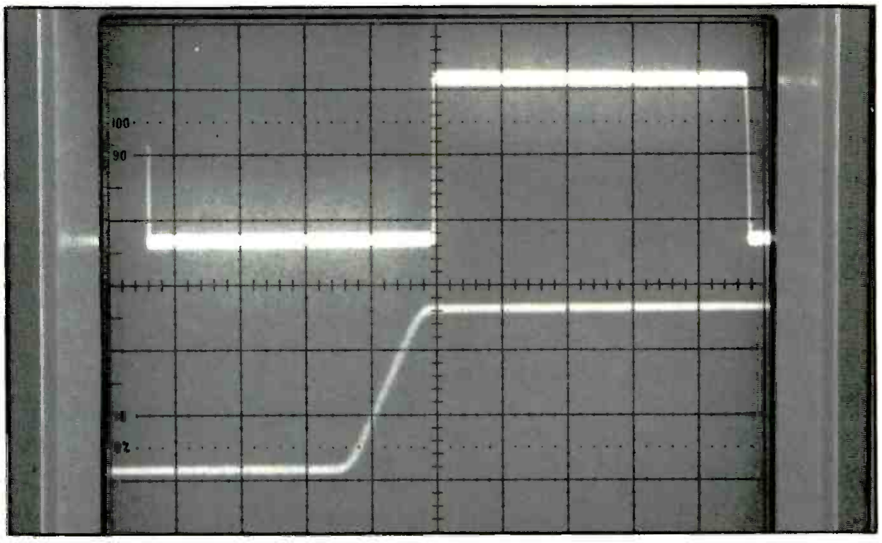


Figure 5. Alternate horizontal magnification allows zooming in on transition details without the complexity or expense of dual time base or delaying time base features.

triggering system can make the measurement process unnecessarily difficult. In short, a wide range of triggering features can multiply the scope's value several fold simply by the convenience and time savings they provide.

Horizontal alternate magnification

After bandwidth, rise time, sensitivity and triggering considerations are resolved, the next considerations are the number and types of additional features included in the scope's price. For example, number of input channels can be an important additional feature.

In reality, most measurements can be made with a single-channel oscilloscope. However, dual input channels expand capability and convenience. One channel can be used to observe the input to a signal stage, and the other used to observe the output simultaneously. This makes comparisons and level adjustments much easier because both signals are displayed. Also a single probe does not have to be switched back and forth between circuit input and output.

If two channels are good, might not three or four channels be even better?

Certainly – if you really need to look at three or four signals simultaneously. But how often does that need arise in day-to-day measurements? How often could the job be just as easily done with two channels? And is the extra price of additional channels really worth it? In walking through advanced engineering areas, it is surprising how often you see just one or two probes attached to an expensive 4-channel scope.

Dual time bases or delaying time bases are more likely additional features of usefulness. Although they are useful for high resolution time measurements, dual or delaying time bases do add to scope cost. They are also typically advanced features that are not always easy to understand or use.

Alternate horizontal magnification, on the other hand, is a simpler and easier-to-use feature. It is also a feature that can make the most of measurements associated with dual-time base or delayed sweep features, and without the additional cost.

Using this feature is basically a matter of pressing a button for the amount of expansion desired. One or two expansion factors such as X5 or X10 are typical for most scopes. However, on the Tektronix 2225, three factors are provided: X5, X10 and X50 expansion.

With all of the different low-cost scopes on the market today and the variety of features available, there is certainly plenty to think about before spending your money. The nice thing about the newer models, though, is they usually provide all of the features, plus some you may not expect. Moreover, thanks to modern engineering and manufacturing technology, they are able to do it at about the same price as older, less capable scope models.

Circle (135) on Reply Card ES&T

You have to buy test equipment OR DO YOU?

By Jack Cunningham

A decision to acquire test equipment is not always a choice between buying and not buying. This is particularly true when budgets are stretched. It's also true when the need is immediate or short-term. But it's especially true when you're not sure as to just what instrument will be the right tool for the job. At those times, it might be better to rent.

People who buy, build, install or repair electronic equipment do not have unlimited budgets and instrumentation is expensive. Few businesses can afford to purchase all of the instruments they would like to have. Additionally, the rapid progress of technology increases the risk of obsolescence. Even if you had an unlimited capital budget, you might have a difficult time keeping pace with the regular introduction of new and better products.

When choosing the right instrument, you must weigh many variables. For instance, how much does the equipment cost? How soon is it needed and for how long? How many functions can it perform? And will a new, better model be available before the current model receives its first scratch.

As all of these questions are important in deciding whether to acquire a given instrument, they are equally important in trying to decide how to acquire that instrument, particularly when the variety of test equipment available – in relation to the number of test functions required – can be enormous.

For such users, access to rental equipment also makes it possible to avoid premature commitments to undefined requirements. You can minimize these risks by making a thorough evaluation of the alternatives. Some important benefits of choosing the rental option are discussed in this article.

The benefits of renting

Virtually all types of test equipment are available from rental companies. For example, the current U.S. Instrument Rentals catalog lists everything from digital multimeters, analyzers and oscilloscopes to data communications, microwave test sets and logic analyzers. Also in inventory is a variety of power supplies, meters and generators. A single phone call provides immediate access to a wide range of test equipment.

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

Try before you buy

Given the high price tags of most test equipment, it is critical that the instrumentation is right for the job. Rental permits you to try, risk free and at a low cost, individual instruments before opting for purchase. Renting also enables users to do hands-on testing of comparable equipment. That's something that can't be obtained through spec sheets and catalogs. The chance of acquiring the wrong equipment for the job is virtually eliminated.

Cost allocation and tax savings

With rental, specific equipment costs can be isolated and assigned directly to individual projects. In this way, special equipment costs can be directly borne by the group or individual that specifically benefits from its use. And, because rental payments are currently considered operating expenses, the full value of those payments can be deducted from income for tax purposes. Purchased equipment must be capitalized over a number of years as a charge against future earnings.

Making it work

Rental companies maintain permanent stocks of all kinds of instruments in their inventory centers. In most cases, these locations are combined warehouses and metrology labs. These facilities not only store, they also provide personnel to calibrate, maintain, and if necessary, rebuild equipment to meet manufacturers' specifications. Warehouse and calibration activities are integrated to provide immediate availability of ready-to-use equipment.

Test instruments can be rented for terms as short as one week or as long as several years. Typically, instruments are rented for three to eight months. During this time the rental user need not worry about problems related to maintenance or service. Most rental companies will replace a malfunctioning piece of equipment with an identical one – at no cost to the customer.

At the end of the rental term, equipment can be returned, renewed, upgraded or purchased outright. Many rental companies offer equity build-up plans. These plans allow a customer to accrue equity in an instrument while it is being rented. This accrued equity then can be applied to the equipment purchase, if the customer decides to buy it. Or a predetermined portion of the equity can be swapped and used to buy or lease a completely different instrument.

Rental companies are also in a position to offer excellent opportunities to purchase test equipment outright. Both new and used instruments can be purchased directly from a rental company's inventory, with warranty protection and immediate delivery. In this sense, even those who prefer to purchase can benefit from the rental alternative in the test equipment marketplace.

Prospective buyers should ask themselves these few questions before deciding to purchase an instrument. Do I have an immediate need for this instrument? Is the instrument still in a dynamic phase of its development or in danger of becoming obsolete? Could my capital funds be more productively

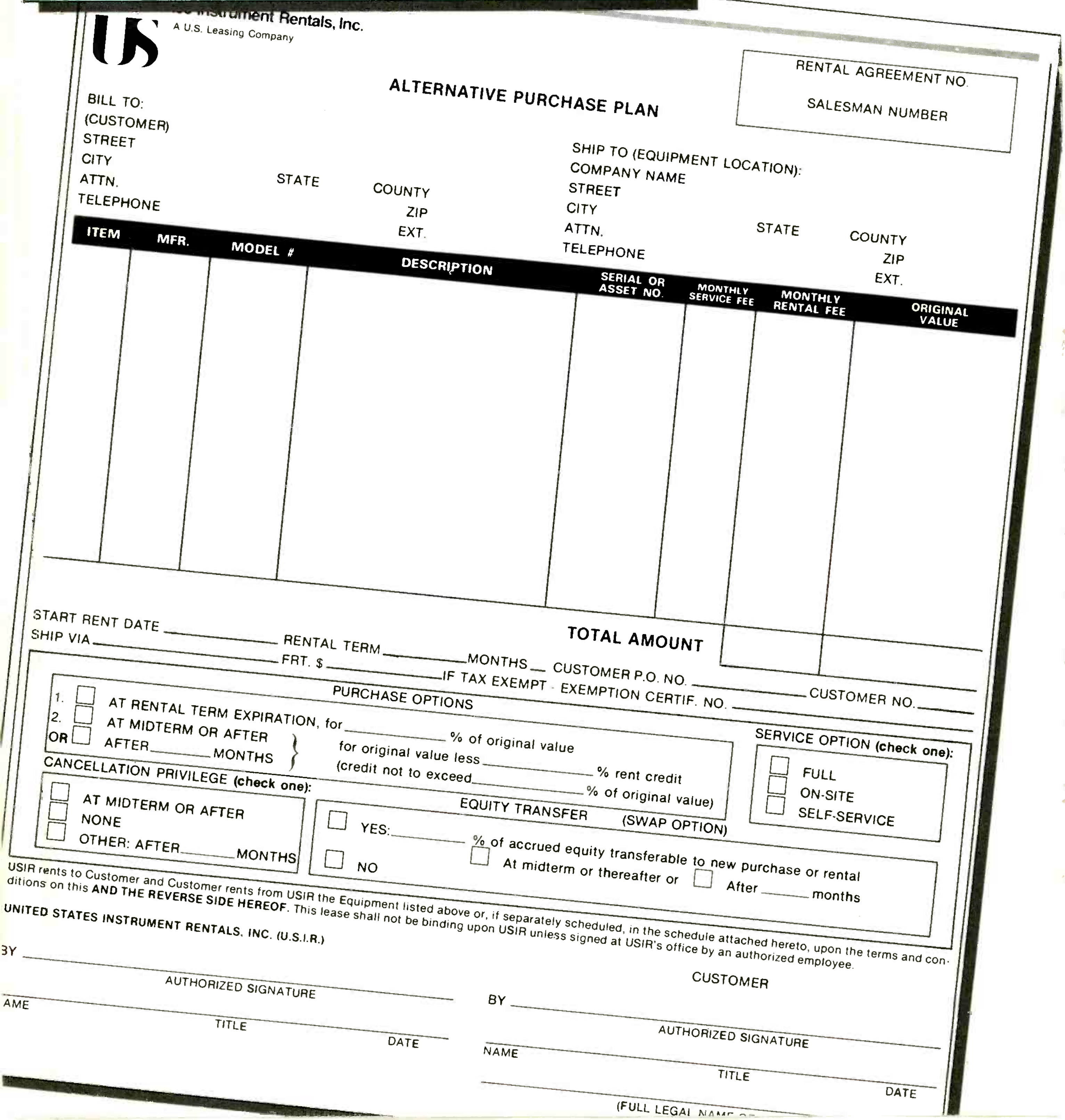
How much? How long?

OK! But what will it cost, and what's the minimum rental period?

The following figures are very rough, just to get you into the ballpark of what it might cost to rent a piece of test equipment. Depending on what you rent and for how long, actual cost could be very different from this.

The average rental period for a piece of test equipment rented by U.S. Instrument Rentals is three to eight months. Some equipment may, however, be rented for as little as a few weeks. The monthly rental cost is ordinarily in the range of 8% to 10% of the purchase price of the unit. There also will be shipping costs and any applicable taxes.

spent on something else at this time? Is there reason to believe this product will not be needed full time or long term? If the answer to any or all of these questions is yes, prospective buyers should seriously consider the merits of rental as a means of meeting instrumentation needs. ES&T



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SALESMAN NUMBER

ALTERNATIVE PURCHASE PLAN

BILL TO:
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SHIP TO (EQUIPMENT LOCATION):
COMPANY NAME
STREET
CITY
ATTN. STATE COUNTY
TELEPHONE ZIP EXT.

ITEM	MFR.	MODEL #	DESCRIPTION	SERIAL OR ASSET NO.	MONTHLY SERVICE FEE	MONTHLY RENTAL FEE	ORIGINAL VALUE

START RENT DATE ______
SHIP VIA ______ RENTAL TERM ______ MONTHS __ TOTAL AMOUNT
FRT. $ ______ CUSTOMER P.O. NO. ______ CUSTOMER NO. ______
IF TAX EXEMPT - EXEMPTION CERTIF. NO. ______

PURCHASE OPTIONS
1. ☐ AT RENTAL TERM EXPIRATION, for ______ % of original value
2. ☐ AT MIDTERM OR AFTER
OR ☐ AFTER ______ MONTHS
for original value less ______ % rent credit
(credit not to exceed ______ % of original value)

SERVICE OPTION (check one):
☐ FULL
☐ ON-SITE
☐ SELF-SERVICE

CANCELLATION PRIVILEGE (check one):
☐ AT MIDTERM OR AFTER
☐ NONE
☐ OTHER: AFTER ______ MONTHS

EQUITY TRANSFER (SWAP OPTION)
☐ YES: ______ % of accrued equity transferable to new purchase or rental
☐ NO
☐ At midterm or thereafter or ☐ After ______ months

USIR rents to Customer and Customer rents from USIR the Equipment listed above or, if separately scheduled, in the schedule attached hereto, upon the terms and conditions on this **AND THE REVERSE SIDE HEREOF**. This lease shall not be binding upon USIR unless signed at USIR's office by an authorized employee.

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Books

Troubleshooting and Repair of Microprocessor-Based Equipment, by John D. Lenk; Howard W. Sams, 250 pages, $21.95, softbound.

In this manual, Howard W. Sams & Company, a division of Macmillan, provides a simplified, practical system for diagnosing, isolating and locating faults in microprocessor circuits. Although the book concentrates on the basic approach to troubleshooting, numerous, effective shortcuts (tricks?) are included. The following subjects are covered: microprocessor test equipment; problems in troubleshooting microprocessors; troubleshooting the gate and IC; stimulus-response testing; Vcc and ground shorts from unexpected causes; flip-flop troubleshooting; register troubleshooting; current flow analysis; wired-AND and wired-OR troubleshooting; using the logic analyzer; step-by-step procedure for troubleshooting the VCR.

Published by Howard W. Sams & Company, 4300 W. 62nd St., Indianapolis, IN 46268; 317-298-5409.

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More than 60 books and videotapes are available for purchase from a bookstore of electronic communications organized by MFC, a producer of filters for the communications industry. Selections offer theoretical and hands-on problem solving information in six electronic communications markets that include satellite and cable television, mobile and general communications, local area networks and amateur radio. Among publications are the "Avoidance and Suppression of Terrestrial Interference" (ASTI) handbook, and its video counterpart, "The ASTI Guide to TI," both written and produced by this company.

Contact Microwave Filter Company, 6743 Kinne St., East Syracuse, NY 13057; 800-448-1666, or NY, HI, AK, Canada residents call collect, 315-437-3953.

PART 1

MTS

TV sound in stereo

By Bert Huneault

A new dimension came to North American television in 1984: stereophonic sound. Do you know how it works yet? Although many technicians probably studied the principles of FM multiplex stereo a long time ago (it's been around for 25 years), how many still remember those fundamentals?

This article is designed to familiarize readers with the basics of the new *multichannel television sound* (MTS), the TV stereo sound system that really has gotten off the ground in the last year or so.

To set the stage for MTS, we should first review the basics of FM stereo. This stroll down memory lane should benefit oldtimers as well as newcomers to the field, because the new TV stereo sound is based on, and is really an extension of, the standard stereo system used in FM broadcasting.

FM multiplex stereo

To broadcast in stereo, an FM station must transmit left-channel and right-channel audio information simultaneously, in such a way as to allow the two channels to be ultimately separated in receivers. This calls for *multiplexing* techniques. Multiplexing (MPX) means interleaving or simultaneously transmitting two or more messages on a single channel; MPX is thus a modulation method that combines two or more signals into a single wave from which the signals (left and right audio) can be individually recovered in a receiver.

Two carriers are involved in FM MPX broadcasting: the station's main RF carrier (VHF), and a much lower frequency subcarrier. One of the two channels of audio intelligence *frequency-modulates* the station's main carrier directly. The other audio signal *amplitude-modulates* the subcarrier, resulting in AM sidebands; these sidebands are then used to frequency-modulate the station's main carrier. Sound confusing? What follows will clear it up.

Now, you would think that the two channels of audio intelligence that actually modulate the carrier and subcarrier consist only of the left and right audio signals, wouldn't you? Not so; that would be too logical. But there is a reason why it can't be accomplished so simply: compatibility with monophonic FM receivers.

L + R and L − R audio

When the Federal Communications Commission (FCC) authorized standards for multiplex stereo broadcasting back in 1961, it decreed, in its wisdom, that FM stereo broadcasts should be compatible with existing monophonic receivers. That put a bit of a fly in the ointment, but as it turned out, it was no big deal. Broadcast equipment designers solved the compatibility problem by simply combining the left and right audio signals in a matrix circuit that produces two different outputs: a left plus right (L + R) signal and a left minus right (L − R) signal. L + R audio is sometimes referred to as the *monophonic signal* because it satisfies the requirements of mono receivers. L − R audio is often called the *stereo signal* because, when added to L + R in a stereo receiver, it makes possible the recovery of separate left and right audio signals, thus reproducing the stereo effect.

What's in that bag of tricks called the *matrix*? Essentially, it consists of a combiner circuit that contains a couple of adders and a phase inverter. (See Figure 1.)

The signal voltage from the left microphone is added to that from the right microphone in an L + R adder, resulting in the monophonic (L + R) audio signal. Also, the signal from the right microphone is phase-inverted into a − R signal and then combined with the L signal in an L − R adder, resulting in the stereo (L − R) signal. Note that both L + R and L − R are still *audio* signals as they exit from the matrix. These are the two signals that actually modulate the station's carrier and subcarrier. Filtering (not shown in Figure 1) limits these audio signals to a frequency range of 50Hz to 15,000Hz.

Stereo transmitter

Next, let's get down to brass tacks and see how modulation is achieved, and discuss the role the subcarrier plays in this scheme. (See Figure 2.)

Note that the L + R signal from the matrix goes directly to the RF transmitter, where it frequency-modulates the station's carrier. But the L – R audio signal doesn't take such a direct route. Instead, it amplitude-modulates a 38kHz subcarrier in a balanced modulator, and the resulting L – R AM sidebands are then fed to the transmitter where they also frequency-modulate the RF carrier. The 38kHz subcarrier is a continuous wave generated by a 19kHz oscillator and a frequency doubler.

Now, a word about those AM sidebands. Because the modulator circuit is of the *balanced* type, the 38kHz subcarrier gets suppressed, and the only signals emerging from the modulator are AM double sidebands ranging up to 15kHz on both sides of the suppressed 38kHz frequency, occupying the spectrum between 23kHz and 53kHz. This is referred to as AM double sideband suppressed-carrier (DSBSC) modulation. It is essential to recognize that no 38kHz subcarrier accompanies these L – R sidebands into the FM transmitter; the missing subcarrier will have to be reckoned with

Take another look at Figure 2. Note the 19kHz pilot signal that also feeds the FM transmitter; this is a sample of the unmodulated (continuous wave) signal generated by the 19kHz oscillator. As we'll see later, this pilot signal plays a vital role

So, we have several distinct signals applied to the transmitter, and each of them frequency-modulates the station's VHF carrier at its own specific rate. Obviously, this keeps the FM carrier quite busy, deviating all over the place! Let's take a specific example: Suppose a 2,000Hz musical note is played into the L and R microphones. This results in a 2kHz L + R audio signal and the following pair of L – R side frequencies: 36kHz and 40kHz (38 – 2 = 36; 38 + 2 = 40). These signals, as well as the 19kHz pilot, cause the station's FM carrier to deviate at four different rates; the amount of carrier deviation is determined by the amplitudes of these modulating signals (maximum deviation allowed: ±75kHz).

Thus the L + R audio signal forces the station carrier to deviate 2,000 times per second; the pilot signal makes it deviate 19,000 times per second; the L – R lower sideband causes it to deviate 36,000 times per second; and the L – R upper sideband creates 40,000 deviations per second, all going on simultaneously.

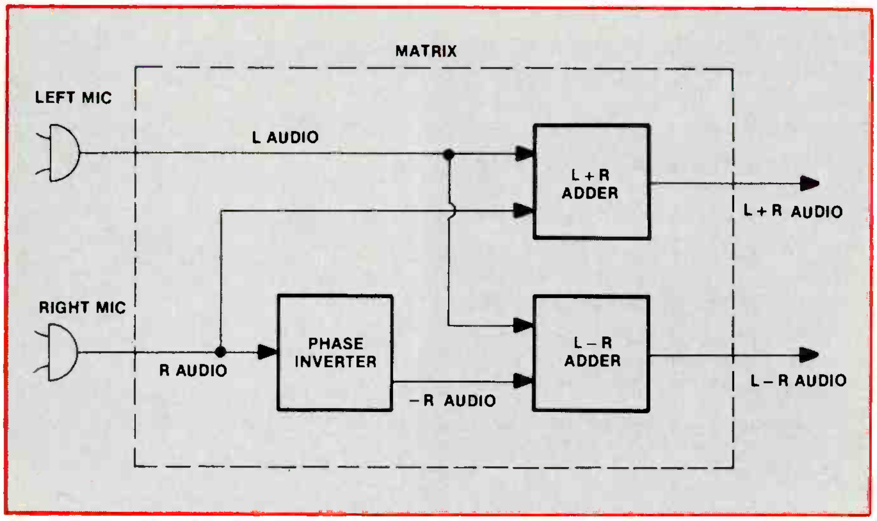


Figure 1. The matrix outputs L + R and L – R audio signals.

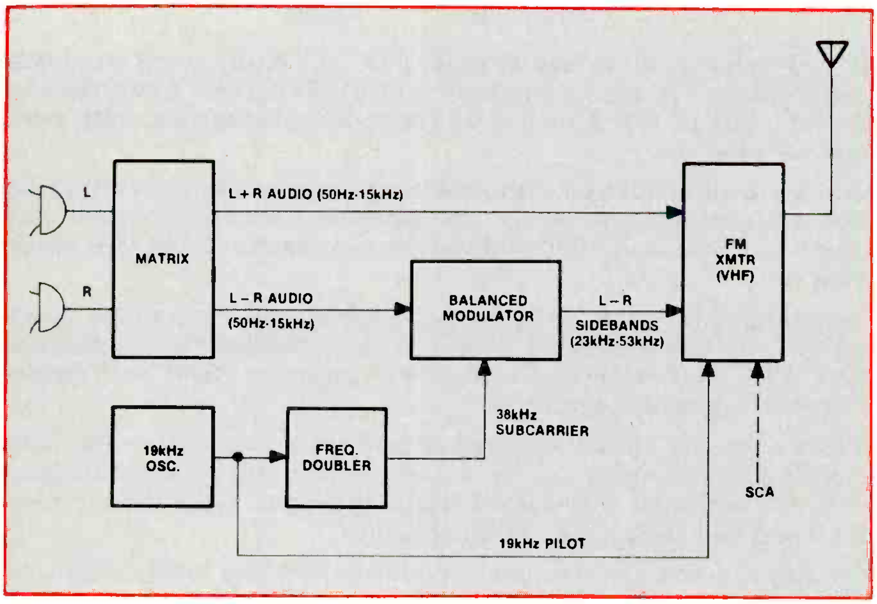


Figure 2. Simplified block diagram of FM stereo transmitter.

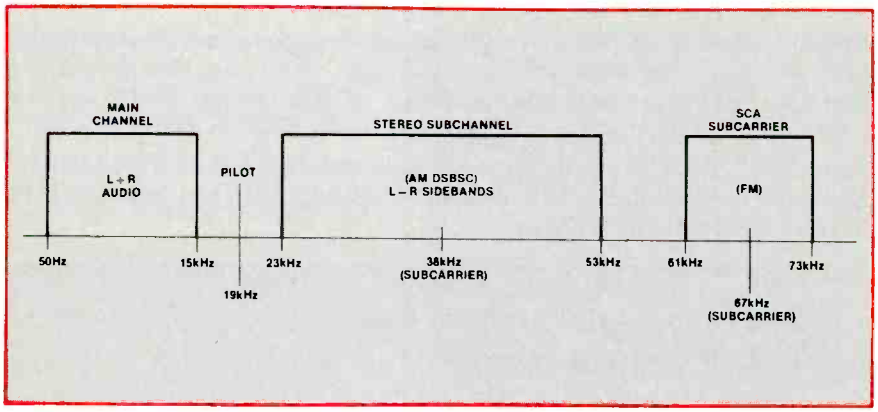


Figure 3. Composite stereo signal baseband.

Loudspeaker analogy

If you have any difficulty visualizing an RF carrier that simultaneously swings in frequency 2,000, 19,000, 36,000 and 40,000 times per second, the following analogy might help. Think of a loudspeaker with an audio input signal consisting of two musical tones: a 100Hz bass note and a 5,000Hz treble note. These two ac currents cause the voice coil to vibrate at two different rates simultaneously: while the speaker cone wobbles back and forth at a relatively slow rate of 100 swings per second, it also wobbles at a much faster rate of 5,000 vibrations per second, reproducing both tones simultaneously.

The RF carrier of our FM stereo station follows the same scenario: while its frequency wobbles back and forth at a relatively slow rate of 2,000 swings per second due to the L + R signal, it also deviates at a much faster rate of 19,000 swings per second due to the pilot signal; and at 36,000 and 40,000 deviations per second due to the L – R sidebands. Therefore, at any given moment, the instantaneous carrier frequency is actually the net result (resultant vector) of all those different modulation rates acting upon it. The FM carrier thus undergoes complex deviations, just as a loudspeaker cone experiences complex vibrations while reproducing music or speech.

The end product is an FM signal that contains modulation representing the total *composite stereo signal*, whose baseband frequency spectrum is illustrated in Figure 3.

SCA signal

As shown in Figure 3, the composite stereo baseband also includes an optional subchannel with a subcarrier frequency of 67kHz. This subsidiary communication authorization (SCA) subcarrier is *frequency-modulated* (typical deviation: ±6kHz) and may be used by some FM stations to transmit privileged information, control signals, or background music (storecasting). Ordinary FM stereo receivers reject this signal.

Pre-emphasis

A final word about the L+R audio signal at the FM transmitter: the higher audio frequencies are pre-emphasized in order to obtain a better signal-to-noise ratio in transmission; the treble boost is achieved by means of a high-pass filter with a time constant of 75μs. This doctoring up of the audio signal will have to be offset in FM receivers in order to restore the natural balance of bass and treble tones.

An interesting comparison

Until now, while you were reading the article, did you by any chance get a sense of *deja vu* even if you had never studied FM MPX stereo before? Did you perhaps get the feeling that all this jazz about subcarrier modulation is already familiar in connection with color TV? If so, you're right. Before we leave the subject of composite stereo signal generation and transmission, let's make a quick comparison between the block diagram of an FM stereo transmitter (Figure 2) and that of a color TV picture transmitter (Figure 4).

Note the striking similarity between the two systems. In the color TV transmitter diagram, the camera feeds three video signals (red, green and blue) to the matrix; this is analogous to the L and R audio signals from the two microphones in Figure 2. In Figure 4, the matrix mixes the three color signals in various proportions and outputs three different video signals. The luminance (Y) signal, which contains brightness (B&W) information, goes directly to the RF transmitter where it amplitude-modulates the picture carrier; this is like the L+R audio signal that directly modulates the FM transmitter in Figure 2. The I and Q color video signals produced by the matrix are applied to the balanced modulator, where they amplitude-modulate a 3.58MHz subcarrier, producing chroma sidebands on either side of the suppressed 3.58MHz subcarrier frequency (this is a *two-phase* AM DSBSC modulation system because there are two modulating signals, I and Q). These AM sidebands then modulate the RF transmitter, just like the L−R sidebands did in Figure 2. And, finally, a sample of a 3.58MHz c.w. (continuous wave) signal (color burst) is fed to the transmitter where it also modulates the picture carrier, just like the 19kHz pilot signal in Figure 2.

The similarities between the two systems are remarkable. As a matter of fact, it looks like the engineers who designed the FM MPX stereo system stole a page right out of the NTSC color TV handbook.

FM MPX stereo receiver

Now that we understand the make-up of the composite stereo signal, let's shift our attention to the stereo receiver and see how the various ingredients (L+R audio, 19kHz pilot and L−R sidebands) fit together. Figure 5 is a highly simplified block diagram of such a receiver.

As expected, the composite stereo signal is recovered after demodulation of the IF signal by the FM detector. The signal is then applied to a *stereo decoder* circuit, which may consist of a single IC or distinct circuits with discrete components. Separate L and R audio signals emerge from this decoder. After de-emphasis by 75μs time constant low-pass filters (in order to compensate for pre-emphasis at the transmitter), the two signals are amplified and fed to separate L and R loudspeakers, thus reproducing the stereo effect.

What's in that black box labeled *stereo decoder*? Various circuit

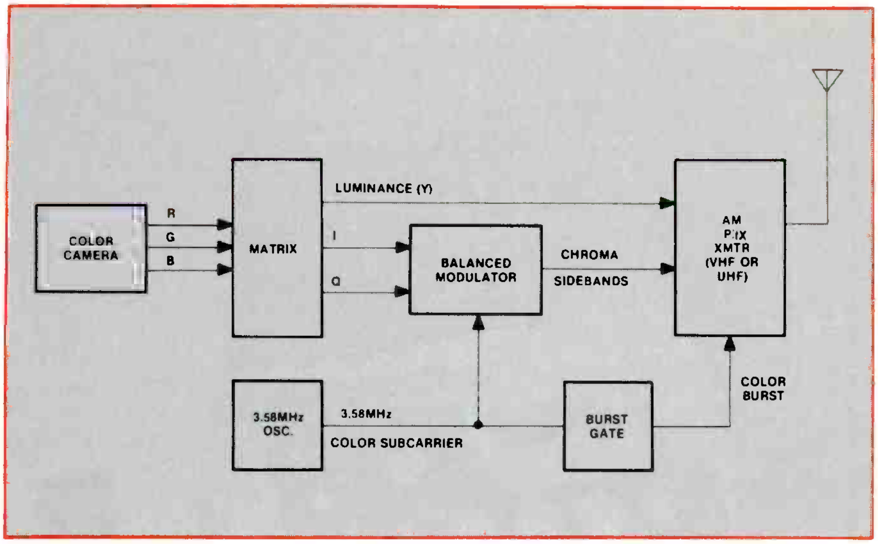


Figure 4. Simplified block diagram of color TV transmitter.

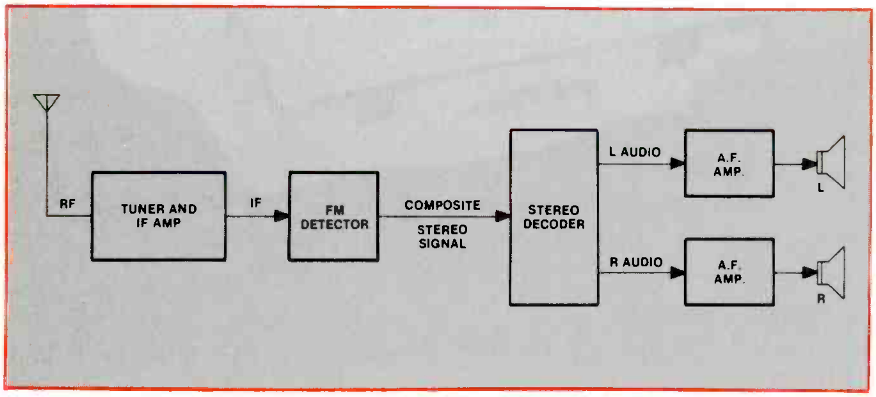


Figure 5. Simplified block diagram of stereo receiver.

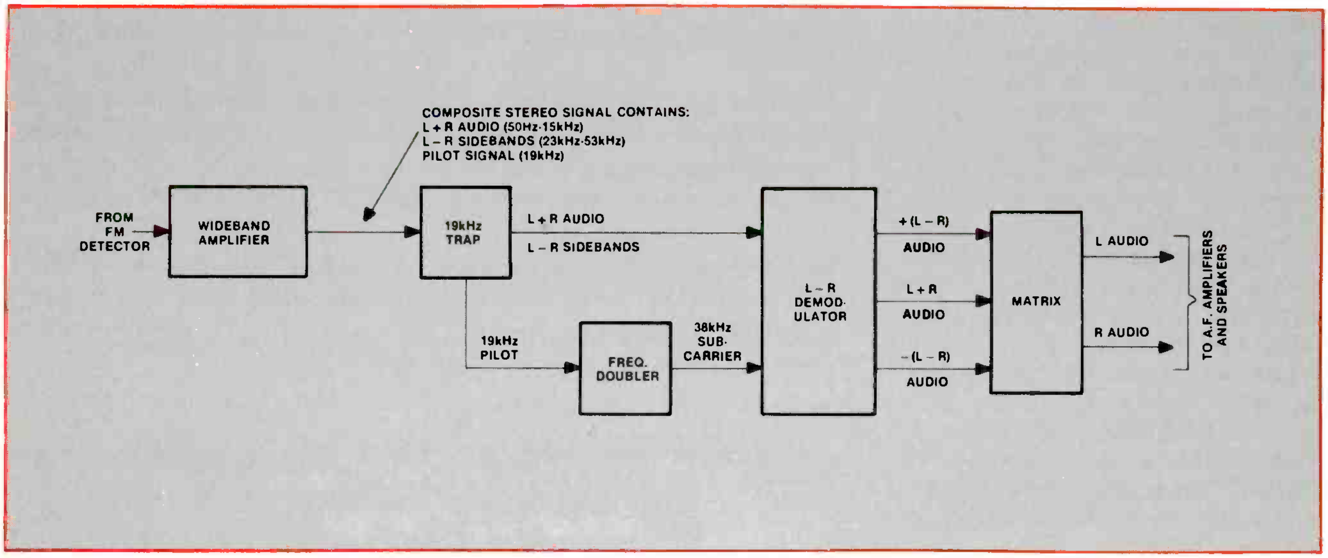


Figure 6. Block diagram of one type of stereo doubler.

designs are possible, including PLLs (phase-locked loops), but the decoder block diagram shown in Figure 6 illustrates one widely-used method of reconstituting left and right audio from the composite stereo signal.

After passing through a wideband amplifier with a notched response at 67kHz (to reject SCA signals), the composite stereo signal runs into a trap. This 19kHz tuned circuit allows the 50Hz-to-15kHz L+R audio and the 23kHz-to-53kHz L – R double sidebands to pass through, on their way to the demodulator, but the 19kHz pilot signal is extracted and sidetracked to a frequency doubler, resulting in a subcarrier with the same frequency and phase as the 38kHz subcarrier back at the transmitter. This is essential for proper demodulation of the L – R sidebands. Recall that the subcarrier was suppressed by the balanced modulator in the stereo transmitter, thus the missing subcarrier has to be regenerated in the decoder.

The L – R sidebands can now heterodyne with the reinserted 38kHz subcarrier in the L – R demodulator, thus recovering the L – R audio signal. Because the demodulator actually contains two opposite-polarity detectors, a pair of L – R signals emerge from the demodulator circuitry: positive (L – R) audio, and negative (L – R) audio. As for the L+R signal, it doesn't need to be demodulated because it already is an audio signal; it simply passes right through the demodulator and is applied, along with the (L – R) audio signals to a matrix circuit that adds them together. (L+R) added to +(L – R) produces 2L (left channel signal only) and (L+R) added to –(L – R) yields 2R (right channel signal only). So we've gone full circle, with the original left and right audio signals having been individually recovered in the receiver. They are then fed to separate audio amplifiers and loudspeakers, to reproduce sound in full stereo.

The conclusion of this article next month will provide a detailed discussion of Multichannel Television Sound (MTS), the new electronic baby of the mid-eighties. You'll be pleasantly surprised at the similarities between TV stereo sound and conventional FM broadcast stereo. ES&T

What do you know about electronics?

Digitizing sound

One way to learn about components is to study them in various circuit applications. In the previous issue I gave several applications of the Hall Effect through the courtesy of F. W. Bell Inc., Columbus, Ohio.

Figure 1 shows another of Bell's interesting applications. In this case the Hall device is used in a *multiplier* circuit. There are two input currents. One of them (Ia) establishes flux in the soft iron circuit. The second (Ib) is the current that flows normally through the Hall device.

The output voltage (Vo) is directly proportional to the product of Ia and Ib. This circuit is called an *analog multiplier*.

From time to time, I will show other applications of Hall devices.

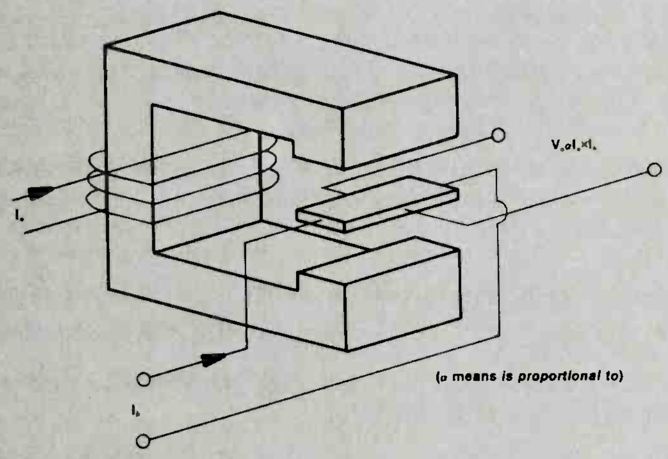


Figure 1.

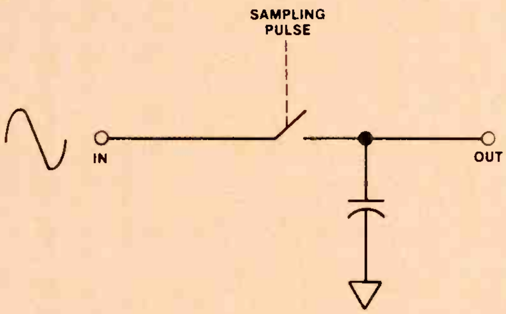


Figure 2.

Although the compact disc represents state-of-the-art electronics, there is practically no new circuitry or theory involved. The concept of pulse code modulation (PCM) was known in the communications field years before it was applied to audio discs. Memories are not new. The diode laser has been with us for many years.

In fact, the compact disc is an advance in technology that was made by taking already-existing circuitry and putting it to work. The exception is the disc. Video discs have used the same basic concept for years. However, putting an hour or more of music on a disc that is only about 4¾ inches in diameter required a considerable amount of innovation.

This is not to detract from the technological advance of the CD system. It is one thing to have all of the circuits and components available, and quite another thing to get them put together into a workable system. That is probably the greatest accomplishment of compact disc technology.

This article will discuss some of the circuits in compact disc systems. As mentioned before, they are not new, but it may have been some years since these concepts have come to your attention. This will be a good way to review state-of-the-art electronics. The circuits are used in just about every field of electronics. So if you're not that much interested in compact discs, don't go away; these circuits apply to your field too.

The concept

Music consists of sound of continuously variable frequencies and amplitudes. Until the compact disc was introduced, analog methods were used for recording music, so there was a direct relationship between the sound being recorded and the shape of the grooves in the disc or the magnetic fields on the tape. The compact disc consists of digital numbers that represent the recorded sound.

Continued on page 52

Answers to the Quiz

By Sam Wilson   Questions are on page 14

1. A. The output of a differentiating circuit is proportional to the rate of change of the input signal. The output is a cosine wave. It has the same *waveshape* as a sine wave.
2. A. It is important to understand the TV signal in order to understand how a TV receiver works.
3. A. Yes. The substitute supply also must be able to deliver the required current. Other factors also may be important in the selection of a power supply.

$$\% \text{ Regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

V_{NL} = no load V V_{FL} = full load V

The *lower* the percent regulation, the better the supply regulation. Use this equation and you will see that the substitute supply has a lower (better) percent regulation.
4. C. The VIRS and VITS signals are both located on the *vertical* blanking pedestal. They are useful testing signals.
5. D. The alpha cutoff *frequency* cannot be a *current* value. The alpha cutoff frequency is that *frequency* at which alpha drops to 70.7% of the value at 1kHz. Remember that alpha is a common-base gain; beta is a common-emitter gain.
6. D. The test signal should have both positive and negative peaks so that clipping (if present) can be observed.
7. D. Putting that much track on a 4¾-inch disc is, by itself, a great technical achievement. Making a laser follow the track is another great achievement. Neither of these technical aspects of the compact disc represents a very recent achievement.
8. The block is a divide-by-three circuit. It must divide the 3 x f output by 3 so the signal will match the f input at the phase comparator.
9. B. The advantage of a bit slice over a microprocessor system is speed. To obtain the best possible speed, the ECL family is a logical choice.
10. B. There is no calculation required. This problem involves the 3-4-5 triangle. Any time two sides of a right triangle are in a 3 to 4 ratio, the hypotenuse is in a 5 relationship. Examples: 3-4-5, (Figure 6), 30-40-50, 300-400-500, etc.

Literature

The 56-page full color product catalog includes descriptions of **Pace's** "CRAFT-100A" removal-and-replacement system for surface mount components, rework-and-repair systems, desoldering systems, function accessories, work materials, tools and aids.

The new catalog has information on motion picture/video training courses, "Basic Soldering" (now available in 11 languages) and "Rework and Repair for Electronics."

This company also provides a repair support program, including documented solutions to specific repair problems with customized repair instructions and instructor courses.

Circle (125) on Reply Card

The 1987 **Hand Tool Industries** catalog is the first issue to combine with the hand tool product line the electronic tool kits of **Hi-Tech Tool Supply**.

The catalog features a new line of 15 electronic tool kits, in 80 different case models. In addition, the new catalog pictures and describes hundreds of hand tools, ranging from simple probes and alignment tools to complete sets of Xcelite screwdrivers, Easco wrenches and Klein pliers in vinyl and Cordura pouches. Test equipment of well-known manufacturers is included.

Circle (126) on Reply Card

Services for diagnosing terrestrial interference (TI) at a proposed or operating TVRO site are described in a new catalog, "InfoTek/86," from **Microwave Filter Company**.

The services help pinpoint the interference type affecting the site and assist in determining whether the problem can be solved with natural or artificial shielding, or by inserting filters in the system.

Described are area maps of 4GHz towers by state, reports providing frequency, polarization of carriers transmitted along paths and potentially affected TVRO channels, area maps of 4GHz networks near a specific TVRO site and a computerized satellite tracking program that prints the longitude, azimuth and elevation for every satellite within a viewing arc when exact latitude and longitude are inserted in the program.

Other services covered include a one day TI seminar that will train installers and operators to diagnose a wide variety of interference symptoms and provide solutions; Field Service, a team of experts that will arrive onsite to analyze and solve interference problems and The Fast Filter Rescue.

Circle (127) on Reply Card

International Data Sciences announces its "Data Communications Products" catalog. This 24-page catalog describes IDS' complete line of hand-held test sets, data traps and data comm testers, test sets and printers, modems, data switches, modular switching devices, and the recently introduced 5000 Series Network of test equipment. The variety of data communications products could be useful in the formation and maintenance of large and small networks.

Circle (128) on Reply Card

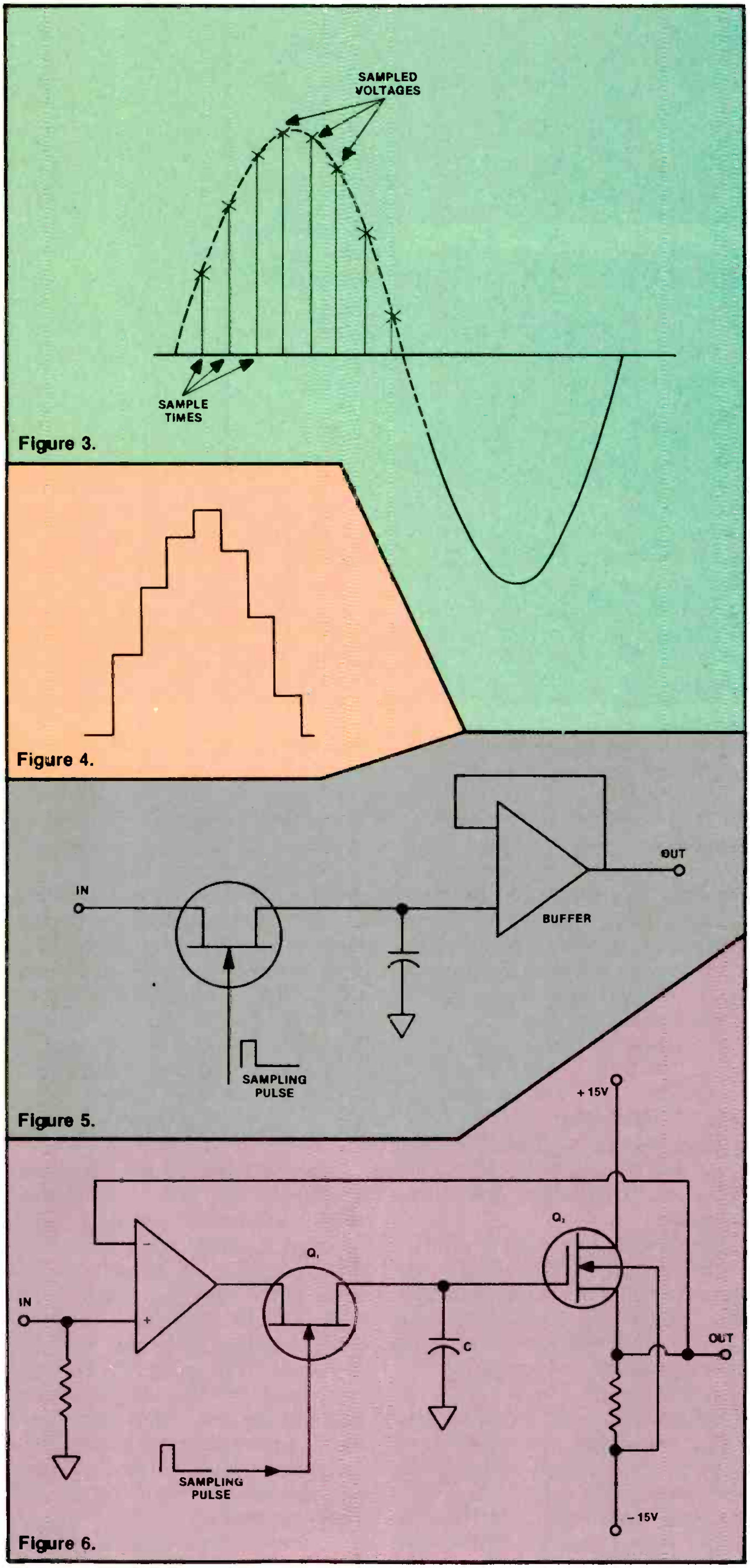


Figure 3.

Figure 4.

Figure 5.

Figure 6.

Digitizing

Continued from page 50

How do you go from an audio signal to a bunch of numbers that represent the signal? That is a good place to start this discussion.

The sample-and-hold circuit

The sample-and-hold circuit is an important part of the analog-to-digital conversion of the audio signal. It is shown in simplified form in Figure 2. In this case, an input sine wave is to be sampled. The sampling pulse turns the switch *on* and *off* very rapidly in even time segments called *sampling times.*

Because the voltage across the capacitor at any instant will be equal to the input voltage, it follows that the output will be a point-to-point representation of the sine wave. This is illustrated in Figure 3.

The capacitor holds the output voltage until the next sampling pulse arrives, so the actual output waveform for the circuit looks like the one shown in Figure 4.

As you can see, this waveform has the general shape of the sine wave half-cycle. A basic problem with the sample and hold in Figure 2 (in addition to the fact that it is impossible to operate a switch quickly enough to get logical samples) is in the fact that the capacitor may discharge a small amount between the sampling pulses. That is undesirable because it means the output is no longer a faithful representation of the input amplitude for a particular instant of time.

A greatly improved sample-and-hold circuit is shown in Figure 5. Here, the sampling pulse saturates the JFET at the instant the input signal is to be sampled, charging the capacitor to the instantaneous value. At the end of the sampling pulse, the JFET becomes a high impedance. Also, the operational amplifier input will be a high impedance if it has an FET input circuit. So the capacitor is isolated and the output of the buffer amplifier is directly proportional to the capacitor voltage.

Figure 6 shows another example of a sample-and-hold circuit. In this case the input signal is to an operational amplifier that is stabilized by feedback from the output of the circuit. Q1 is a JFET that delivers the sampled signal to the capacitor, and, Q2, a MOSFET, acts as a buffer between the capacitor and the outside world.

There are many other versions of sample-and-hold circuits, all of them having the same purpose: to sample an analog input signal and deliver an output voltage that is proportional to the amplitude of the input signal at some particular instant of time.

Sampling errors–It should be obvious that the outputs of the sample-and-hold circuit must be a good representation of the input signal and also that a large number of samples are required over a period of time so that no part of the input signal is lost. Take for example the condition in Figure 7. The sampling points are shown, but note at the point where the arrow is, there is a period where the signal goes through a change but is not sampled.

At first, you might think that an infinite number of samples would have to be taken to get a fair representation of an analog signal representing music. Actually, some mathematical geniuses named Shannon and Nyquist spent some time mulling over this problem, and they proved without doubt that you could exactly reproduce the analog signal, provided that your sampling rate is at least twice as high as the highest frequency component of the analog signal. So if the highest frequency you are going to record is 20,000Hz, the sampling rate must be at least 40,000Hz.

In practice, the sampling rate in the compact disc system is about 41,000 samples per second.

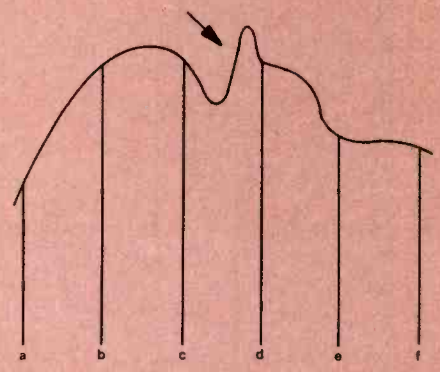


Figure 7.

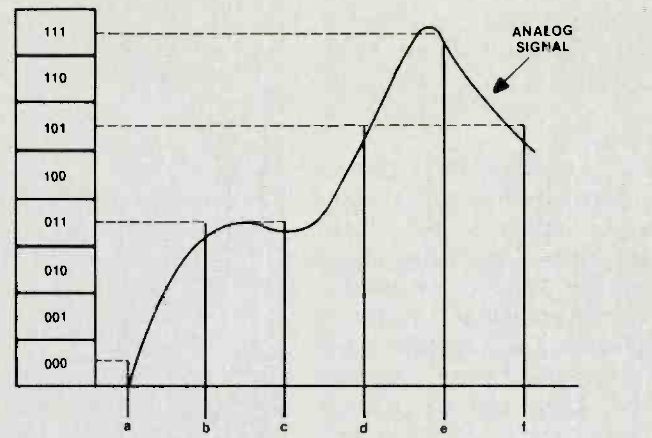


Figure 8.

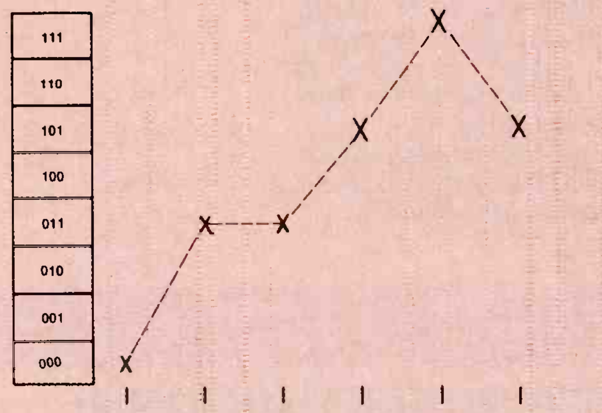


Figure 9.

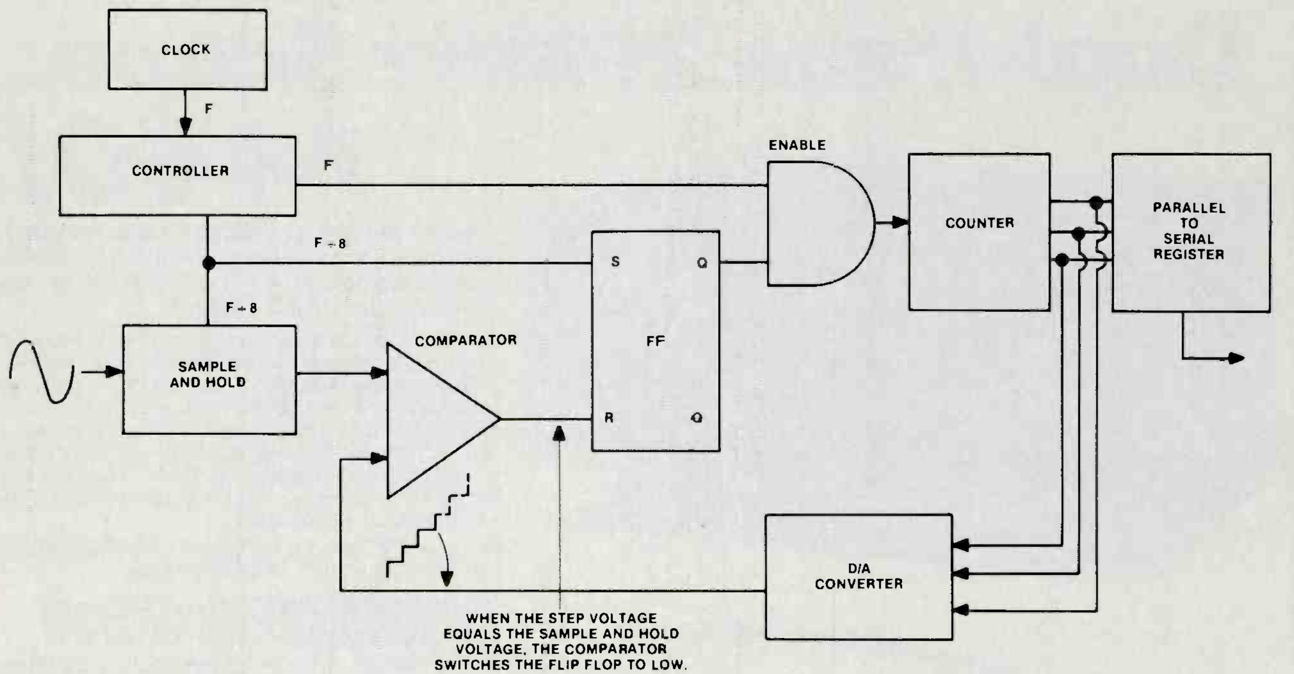


Figure 10.

Converting a signal to a number

The output of a sample-and-hold circuit represents the instantaneous voltage at the time the sample was taken. The next step is to convert these voltage values into binary numbers. I am going to use a limited binary count so that we don't get bogged down with large numbers when we are trying to understand basic digitizing. In practice, the amplitude of the analog wave is resolved into a great many more values requiring much larger binary numbers.

Consider the analog signal in Figure 8. Samples are taken of this signal at points *a* through *f*. In other words these represent the sample-and-hold voltages. The amplitudes may be represented by one of eight binary values. At sample point *a*, the nearest binary number is 000. At *b* and *c*, the same binary number (011) represents the two voltages for the samples taken. At points *d* and *f*, the binary representation is 101. Finally, at *e*, the highest point, the binary representation is 111.

If you would take these signals in order, the analog signal can now be represented by the binary numbers as shown in Table 1.

Table 1.

Binary Number	000	011	011	101	111	101
Sample Point	*a*	*b*	*c*	*d*	*e*	*f*

It is important to note that the sample voltage is always represented by the *nearest* binary number. In Figure 9, the points are connected together with a broken line to show that the numbers taken at the related sampling points give a fair representation of the original wave. If a greater number of digital values had been available, the stored numbers would more closely represent the exact waveform.

Figure 10 represents a method of converting the sample-and-hold output to a binary number. This is a simplified diagram but it shows the essential steps.

To start with, a clock with an output frequency of f delivers a signal to a controller. That signal also is delivered out of the controller to one input of an ENABLE.

You will remember than an ENABLE is an AND circuit connected so that it either will pass a signal or reject it. Here, the clock pulse is the signal to be passed.

When the output (Q) of the flip flop is at a logic 1, the clock signal will pass to the counter; when the output of Q is at logic 0, the signal is disabled and the counter can no longer count pulses.

The pulses that are delivered to the counter cause it to increment one step for each pulse. The counter has only three outputs so the maximum binary number is 111 representing decimal number 7. Because zeros also count, there are a total of eight counts. Therefore, a maximum of eight pulses could pass through the ENABLE for one sampling time.

At the end of that sampling time, the divide-by-8 out of the controller delivers a sampling pulse to the sample-and-hold circuit and a new voltage is delivered to the comparator.

The output of the counter goes to a digital/analog converter that produces a step voltage. Each step represents one binary count. So there will be a maximum of eight steps when the counter goes from 000 to 111.

In the comparator, the output of the sample-and-hold circuit is matched with the steps. *The first step that exceeds the output of the sample-and-hold* circuit results in an output from the comparator that switches the flip flop to a low condition. That, in turn, causes the ENABLE to stop the flow of the clock pulses and the counter stops.

Note that the counter stops at a count that represents the point where the step voltage equals the sample-and-hold voltage. So the counter output will be a binary number somewhere between 000 and 111 that represents the output of the sample and hold.

The output of the counter, in addition to going to the D/A converter, also goes to a parallel-to-serial register. It produces a series of output pulses that represent the binary number. At the end of eight counts the flip flop is always switched high and the ENABLE again begins to deliver pulses to the counter.

We will talk about this parallel-to-serial register later. It must have a clock input pulse (not shown) in order to step the binary counts to the outside world.

This simple analog-to-digital converter is used to represent the relatively simple method of converting the sample-and-hold output voltage to a binary number.

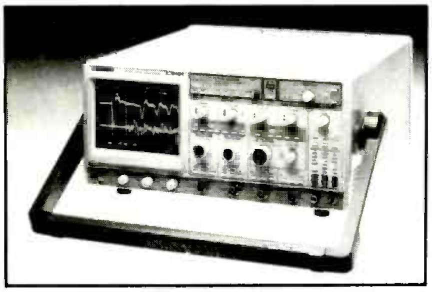
I will continue with circuits in compact disc systems in the next article.

Circle (22) on Reply Card

Products

Digital storage scope

Kikusui International (KIK) announces a price-competitive, 4-channel, dual-time base, digital storage oscilloscope. The COM 7101 features a 50ms/sec sampling rate, digitizing of 100MHz repetitive signals, 20MHz transient capture, full CRT readout, and familiar front panel control. Included as



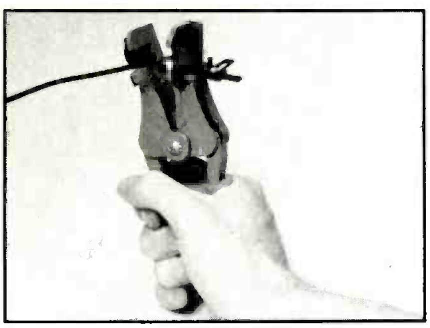
standard equipment, the 7101's built-in, bi-directional GPIB interface bus provides full front panel control and I/O of all CRT data.

Circle (75) on Reply Card

Wire and cable stripper

The Eraser Company announces the availability of a new precision die blade automatic hand-held wire and cable stripper, the model B.

The model B is a lightweight, automatic hand tool for stripping insulation from stranded, solid, coaxial and multicore wires and cables of sizes between 8 AWG and 18 AWG. Most insulation types



can be stripped, including PVC, polyethylene, nylon, and some PTFE and Teflon type insulations. Wires are cleanly stripped, with no risk of nicking, cutting or deforming the conductors.

Hardened steel, precision ground die blades are activated by a single squeeze of the tool handles. The blades cut the insulation cleanly, and the slug is automatically removed. The die blades and clamps for slug removal cycle in such a manner that the stripped end of the wire is not crushed or damaged on the return cycle of the tool.

Circle (76) on Reply Card

Super-compact digital multimeter

The model 2030 shirt-pocket-sized digital multimeter from *Triplett Corporation*, a *Penril Company*, provides four functions and 19 microprocessor-controlled ranges for workshop or in-field consumer power testing of electrical/electronic devices. It is designed for use by the home workshop do-it-yourselfer and electronics hobbyist, as well as the technician.

The 3.5 digit LCD display includes automatic polarity indication. Autoranging, low battery indication and overload protection are also provided.

Circle (77) on Reply Card

Static dissipative bench mat

The 8000 series soft bench mats from *Desco Industries* feature a computer grey color that is designed to reduce eye strain and fatigue. The mats are made from CompoStat material with a volume resistivity of $10^8\Omega$/cm. This material will provide a static decay time of less than .10 second. All Desco mats come individually packaged with illustrated instructions for proper grounding. Each mat includes a Desco 9860 screw-on mat ground snap. Mats also are available with a 10 foot grounding cord. Samples of the mat material are available.

Circle (78) on Reply Card ES&T

Multichannel TV sound (MTS)

It's taken a while, but multichannel TV sound (MTS) is a reality, at least in a few parts of the country. Once again, an audio development is intimately connected with video, but this time, the technology comes from the former. While CD, 8mm PCM, and VCR hi-fi were developed from video applications, MTS adapted its technology from FM stereo and tape noise-reduction systems.

MTS carves four information channels out of the 120kHz audio baseband of a TV channel, hence the term *multichannel*, instead of merely *stereo*. Here's the layout.

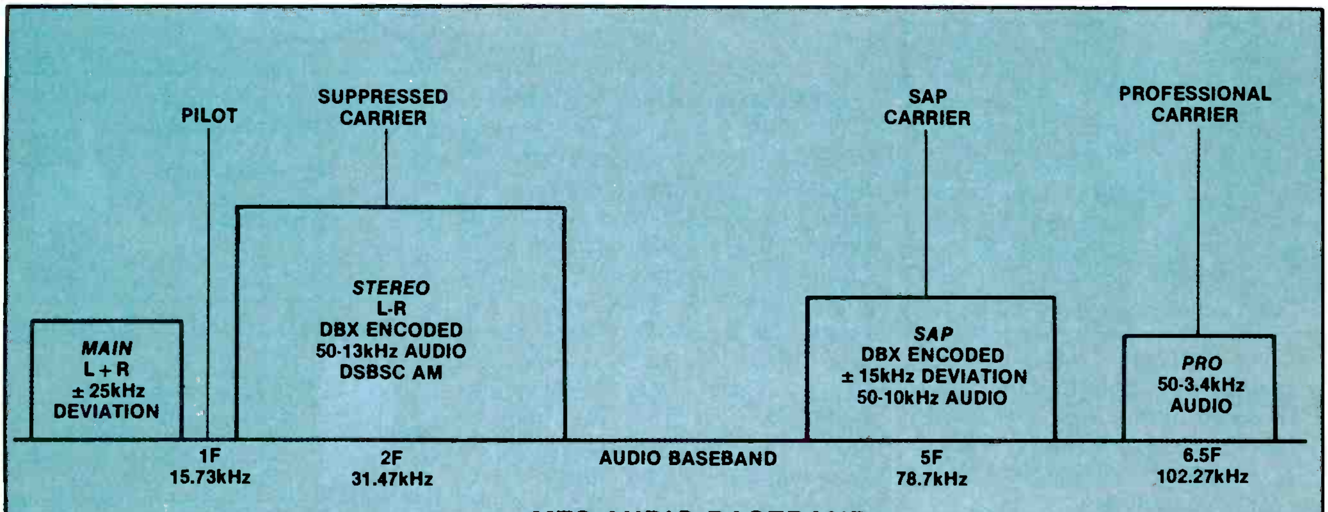
- *Main (L+R)* – Good old mono information, with a couple of kilohertz sliced off the top end to make room for the MTS pilot, at 15.734kHz (the horizontal scan rate). Deviation is ±25kHz, with a pre-emphasis of 75µs.
- *Stereo (L–R)* – Double sideband, suppressed carrier AM, just like FM MPX. The audio bandwidth restricted to about 13kHz. The suppressed carrier's frequency is 31.47kHz, twice the horizontal scanning rate (Fh), which also happens to be the stereo pilot in this system. To reduce noise, DBX compansion is used.
- *SAP* – This channel may contain the soundtrack in a second language, or whatever the broadcaster wishes. It's FM, with an audio passband of 50Hz to 10kHz, centered on a carrier of 78.67kHz (5Fh). It uses the same type of noise reduction as the L–R information.
- *Professional* – Used for voice, data, control or other subsidiary services, this channel has a bandwidth of 3kHz for voice, 1.5kHz for data.

The good news is that the stereo effect greatly enhances enjoyment of TV programs that make use of it, notwithstanding the bad news – a frequency response shamed by cassette decks of the mid '70s. In order to cram SAP and the professional channel into the spectrum, designers parked the stereo pilot too low in the band to allow the complete top octave of audio to be transmitted. Of course, it's understandable that the pilot must be a multiple of the horizontal frequency to minimize the possibility of beats, but the audiophile might wish they had chosen a pilot of 2Fh, and retained the original bandwidth of the mono channel.

Noise reduction

As we all have learned in technical training, the broader the bandwidth of a signal, the more noise that is present. Since MTS stereo uses triple the space of a mono signal, it follows that its unprocessed S/N ratio will be inferior to mono. This is true also of FM stereo, but is exaggerated in MTS, due to the narrower deviation of a modulated TV audio signal. To overcome this problem, noise reduction is used, in the L–R and SAP channels.

If you've serviced many tape decks, you're probably familiar with a system of compression/expansion (compansion) developed by a company called dbx. It's a double-ended system that requires reduction of dynamic range (compression) on the transmitter end, and reconstruction of it (expansion) at the receiver. In the process, the signal is essentially transmitted above the noise floor. When received, the low amplitude signals, which had been boosted, are reduced to proper levels. In the process, the noise gets reduced as well. This is called *wideband*



MTS AUDIO BASEBAND

companion. To further improve performance, a second process, *spectral* companding, is used. Basically, it varies the pre-emphasis of high frequencies, depending on the amount of signal that is present in that band. If the signal is rich in high end material, it will tend to mask the noise, so less pre/de-emphasis is needed. When treble material is lacking, pre/de-emphasis is boosted to improve S/N ratio.

To summarize, dbx MTS noise reduction improves S/N ratio in two ways. First, it uses wideband compansion to keep the overall signal level high, and above the noise floor. Second, it varies pre/de-emphasis to keep high frequency noise in line.

Test equipment

We all love the new technology, but what kind of test gear will we need to service it? Well, in this case, we have to commit some of our capital to an MTS generator. At least two companies are meeting the need: B&K, with its model 2009, rumored to sell for about $400, and RE Instruments, whose RE540 is scheduled for release this November. As soon as I've had a chance to mess with one or both of these units, I'll report back to you with the results.

Quirks

MTS is where FM MPX was 20 years ago. During such a transition period, "bugs" are inevitable, and MTS has its share. First of all, only a few stations are transmitting it. The ones that don't sometimes cause the stereo indicator on sets to flicker. Remember that in the "old days," the mono channel extended up to 15kHz, which is within 5% of the new MTS pilot, so a program rich in high frequencies tends to trigger the stereo light falsely, usually resulting in a customer complaint.

Some complain of relatively poor separation between left and right channels. I don't believe this is a fault of the system. It arises from two factors. First, some of the program material, even on stereo stations, is monophonic. Second, the FCC has recently ruled that broadcasters may leave the stereo pilot *on* at all times. I can tell you that most stereo broadcasts produce a respectable looking X-Y display on a scope, so separation is quite good. When MTS generators are in wider use, the truth will out.

ES&T

Video Corner

By Conrad Persson

Just a tape recorder?

The home VCR burst onto the consumer electronics scene along with a flurry of other new products: laser video discs, audio compact discs, personal computers, personally-owned phones, and more. Little wonder, that the technical marvelousness of the consumer VCR has been obscured within a cloud of hype, hoopla and information about all these electronics technology luminaries.

The modern consumer VCR is truly a marvel; it is a system, rather than simply a product, with several complex interacting subsystems, controlled by an intricate computer-based control system. If VCRs seem to be complex to service, they are.

Let's take a look at the overall block diagram of a VCR (Figure 1). There's a whole lot going on in there. There are signal processing circuits, tuning, manipulating and recording the TV signal. There are the drive circuits transporting the tape and controlling the motion of the video head cylinder. There's the tape loading mechanism. All these subsystems are intricately interrelated and controlled by the system control circuits, which consist of one or more microcomputers.

And you thought this was just a tape recorder!

That's the reason for this column, which will be a regular monthly feature of ***ES&T***. In it, we will be bringing you articles that describe the operation of some of these complex circuits and their interrelationships, maintenance guides, cleaning and lubrication, tips on troubleshooting and remedying faults.

This installment contains the overall block diagram of a modern consumer VCR and a top-level troubleshooting chart, which provides the first steps in logical VCR troubleshooting. Over the next three months, we will be concentrating on the control circuits, based on material provided by GE. In February, we'll feature an *Introduction to system and servo control;* March will concentrate on *System control diagnosis* and April will feature *Servo control circuits.*

Proper servicing of VCRs, as with servicing any other product, begins with becoming thoroughly familiar with the subsystems and components, and thoroughly understanding the features and normal operation of the unit. This familiarity will enhance troubleshooting ability. For example, grasp of the circuits that connect to the signal input/output jacks, as shown in Figure 1, will suggest that in

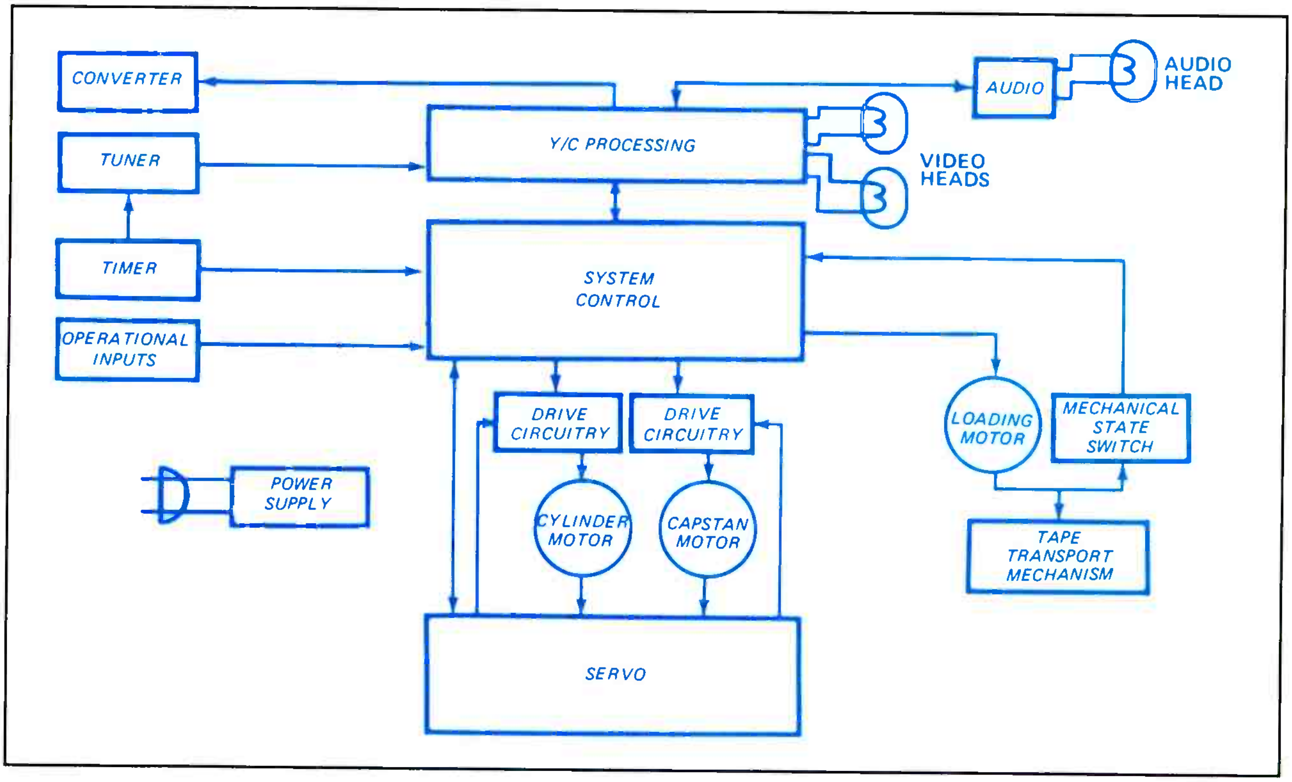


Figure 1. As the overall block diagram shows, a consumer VCR is not a simple product, but a system consisting of several complex subsystems all controlled by a system-control section. If you plan to service one of these units, you should have a pretty good idea of what's going on inside.

most VCRs, using these jacks will allow you to bypass the tuner, IF and RF converter stages, and thus confirm or absolve them as causes of the problem.

This understanding of VCR operation will enable you to interpret symptoms so you can zero in on specific areas before you begin troubleshooting. For example, in the servo system, malfunctions in the cylinder servo system will affect only the picture, while the capstan servo stages (which pull the tape through the transport path) will cause changes in both picture and sound. But watch out, life's never quite that simple. Video tapes with high-fidelity audio have the audio track recorded along with the video on the helical track as well as on the standard audio track. You have to be sure you know which track you're listening to. Another fly in the ointment is that, as remote a coincidence as it may be, both servo systems *could* fail or lose a common reference input at the same time.

No one ever said that electronics servicing was going to be easy. And the relatively innocuous appearance of the average VCR really doesn't prepare a technician for the complexities that lurk inside. But a logical approach to troubleshooting and the right kind of information can help simplify the complexities and bring VCR troubleshooting within the capabilities of mere humans. With this column we plan to help make this happen.

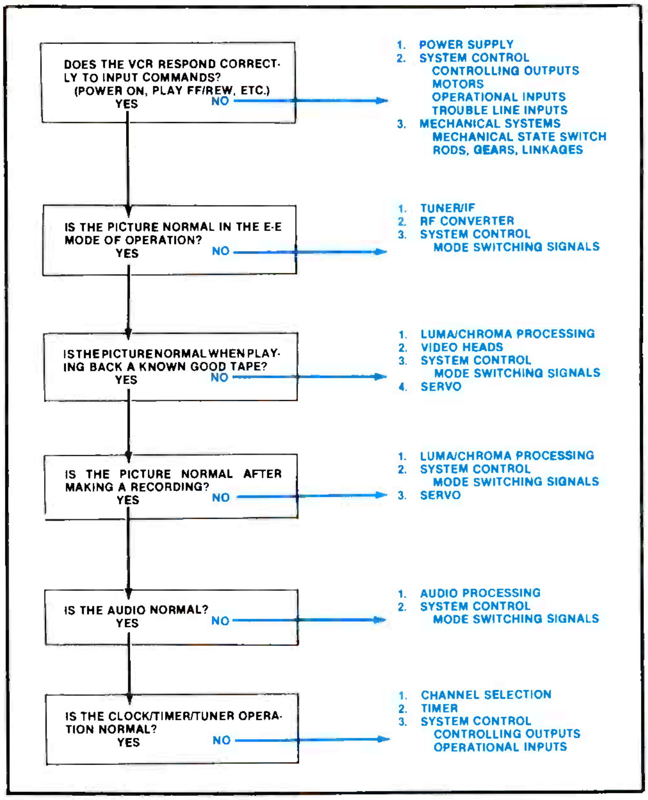


Figure 2. A logical troubleshooting approach will help isolate a problem to a specific area of the VCR. ES&T

Computer Corner — By Conrad Persson

When is a computer not a computer?

Hardware and software available from a number of vendors, such as this system from Virtual CAT, can turn a personal computer into a piece of test equipment.

The earliest electronic computer was just that: a computer. It was designed to compute trajectories of artillery shells to aid the war effort.

This wondrous machine has evolved to such a degree that even its own mother (if it had a mother) wouldn't recognize it. And yet, unfortunately (I think), we still call it a computer. We label as computers today's descendents of that first computer even though they process information, process words, play games, compose songs, in short process just about any kind of information that can be converted into digital form, in just about any way that anyone can think of to process it in. They don't just compute.

One example of the versatility of today's computers is personal computer-based test equipment. By connecting the appropriate electronic module or adding in the appropriate printed-circuit board and loading the appropriate software, a home computer can be turned into a multimeter, a function generator, a timer/counter or an oscilloscope.

There are a number of manufacturers of such systems: Rapid Systems, Hewlett-Packard, Summation, Virtual Instrument and Vistar, to name a few.

The Virtual CAT (Computer Aided Testing) by Virtual Instrument Corporation is one example of this generation of personal computer-based test equipment. It will turn an IBM PC, AT, XT or compatible into a full function 4½ digit digital multimeter, a 10MHz timer/counter, and a 100MHz function generator. The front panels of these instruments are displayed simultaneously on the personal computer's CRT. Front panel controls are activated by keyboard command or mouse. Measured values appear as they would on a standard instrument display.

According to the manufacturer, these instruments are comparable in performance to many popular bench top stand-alones.

The instruments may be used individually or in combination to perform tests. No programming is necessary. Because of its instrument-to-instrument interaction, the Virtual CAT can conduct tests, store, recall and print out results. Several options are available and near-future plans call for the introduction of additional instruments and accessories.

Specifications

These specifications show the capabilities of the IBM PC as a piece of test equipment with the Virtual CAT installed.

FUNCTION GENERATOR

Waveforms:	Sine, Triangle, Square
Modes:	Continuous, Sweep, N-burst
Outputs:	
Waveforms:	± 10V into 50 Ω
Dc offset:	± 10V into 50 Ω
Sweep Range:	.1 to 1,000 sweeps/sec
Waveform Characteristics:	
Frequency Range:	.01 to 10MHz
Frequency Resolution:	.01Hz lowest scale to 10kHz on highest
Frequency Accuracy:	<±4%
Sine Distortion:	<1% .01Hz to 1MHz, <3% 1MHz to 10MHz
Triangle Linearity:	Better than 97% linear.
Operational Modes:	
Burst Modes:	N-burst frequency range — 8MHz max. Sends out "N" number of bursts. Single burst mode — 2 to 65,535 full cycle increments.
Continuous Mode:	Limited to .01 to 10MHz. Amplitude and dc offset limited to ± 10V.
Linear Sweep Mode:	User sets start/stop frequencies on panel thumbwheels. Rate limited by start/stop frequencies.
Logarithmic Sweep Mode:	A continuous logarithmic sweep defined in the same manner as the linear mode.

Table 1. *(continues on adjacent page)*

UNIVERSAL COUNTER/TIMER

Frequency	
Overall	10Hz to 100MHz
Channel A Direct:	10MHz
With Prescaler	100MHz
Sensitivity:	
Channel A/B:	50mV rms, ac coupling 75mV rms
Period:	
Range:	100ns to 10s where N = 1
Resolution:	100ns
Pulse Width:	
Periods Averaged:	1, 10, 100 or 1,000
Sensitivity:	25mV rms
Time Intervals:	
A--->B:	250ns to 10s
Resolution:	100ns
Ratio:	
Channel A:	10Hz to 10MHz
Channel B:	10Hz to 2.5MHz
Event Count:	
Maximum Total:	100MHz
General:	
Display Digits:	8
Clock:	10MHz
Sample Rates:	250ms/reading

DIGITAL MULTIMETER

Voltage:	
Range:	200mV to 200V full scale in 4 ranges
Resolution:	0.01mV to 10mV
Accuracy:	dc, + 0.1% reading, ac (30-1kHz) + 1% of reading. Both ± 1 digit
Current:	
Range:	2mA to 2A in 4 ranges
Resolution:	0.0001mA to 0.1mA
Resistance:	
Range:	200 Ω to 20M Ω in 6 ranges
Resolution:	0.01 Ω to 1k Ω
Accuracy:	200 Ω to 200M Ω at 1% of reading ± 1 digit
dB:	
True RMS, Autoranging:	– 30 to 48dBM
General:	
Display:	4½ Digits
Maximum Meas. Rate:	2.5 readings/sec
Input Impedance:	10M ohms all ranges
Normal Mode Rejection Ratio:	>50dB at 50/60Hz
Common Mode Rejection Ratio:	>50dB from DC to 60Hz
Isolation Voltage Rating:	>600V peak between input and ground.

Table 1. is continued from page 62.

ES&T

Readers' Exchange

Needed: Schematic for Motorola auto radio FM210A. Will buy or copy and return. *C.T. Cooper, R.D. 4, Box 482A, Dover, DE 19901; 302-674-1636.*

Needed: Complete service information for Uniden model Ex6000B cordless telephone. Will buy or copy and return. *Fred MacKenzie, 519 SW 6th Ave., Hallandale, FL 33009; 305-458-3824.*

Wanted: Sencore VA48 or VA62 video analyzer; course material for NRI VCR training course. Send postcard with phone number and price. *Jerry Polasek, 1511 Elmscott Drive, Sugar Land, TX 77478; 713-757-3406, days; 713-494-1291 after 6 p.m., or weekends.*

For Sale: New receiving and transmitting tubes in original cartons, 80% off list price. S.a.s.e. with wanted list. Shipping cost is 25¢ per tube. Heathkit model 1G-57A post marker/sweep generator with manual and all cables, perfect condition, $99. *Walter G. Dowdy, 1243 Marlin Place, Tracy, CA 95376.*

For Sale: Hewlett-Packard 1712 oscilloscope, 200MHz, 2-channel, delayed sweep, main, delayed or mixed time base, new H.P. probes, excellent condition, asking $600. *Denny's TV, 2725 Eden Lane, Rapid City, SD 57701; 605-342-8852.*

For Sale: B&K 1077B TV analyst, $200; B&K 466 CRT tester/rejuvenator, $150; Heathkit IM-18 VTVM, $30. All in good condition, manuals included. All prices plus shipping. *Dwayne Talley, Route 4, Box 221, Arab, AL 35016; 205-586-8502 after 5:00 p.m.*

Wanted: Heathkit EF-2, "How to Understand and Use Your Oscilloscope"–theory and application of oscilloscope, including experimental chassis with parts and text. Will pay for entire course, plus postage. *Sidney R. Creacey, 1358 Turquoise Ave., Mentone, CA 92359.*

For Sale: EICO resistor-capacitor bridge analyzer, model 950B, good working condition, $40; Sams Photofact folders Nos. 69 through 496, $1 each, or all 275 sets for $175, s.a.s.e. for complete list; Sams record changer service manuals, CM-2 through CM-9, RC-11, RC-12, $2.50 each, or all 10 manuals for $20; Philco wideband oscilloscope amplifier, model 8300, $10. All prices plus shipping. *John Brouzakis, 247 Davidson Drive, Charleroi, PA 15022; 412-483-3072.*

Wanted: Tripler for Panasonic color TV, model CT-915, chassis No. NMXP3B. Number on tripler is ECX-B 1070B. State price. *M.X. Romando, P.O. Box 895, Floral Park, NY 11002.*

Needed: Service manual/schematic for Simpson model 85, 6-band, ship-to-shore, 2-way radio, manufactured by Pearce-Simpson, Miami. Company out of business. **Wanted:** Vintage radio station transcription turntable, preferably RCA type 70-D or 70-C with 78/33 ⅓ speeds only. Built during the 1930s/'40s. I will appreciate any information leading to the purchase of this equipment. *Kenneth L. Mixon, 401 E. San Pedro Ave., Perry, FL 32347; 904-584-2116.*

Needed: Rider's schematic for Victor RCA table model 125, cathedral; power transformer for this same model. I will buy the single or section of this schematic. Also need #80 tube in A-1 condition. *Jos. A. Gontarz, JAG's Radio & TV, 14 Rudolph Road, Forestville, CT; 203-583-7532.*

Wanted: Manual, or copies of pages relating to Starkit tube and transistor tester, model 12-22A. State price (if copies, will pay extra above copying cost). The tester was made in Canada, but may be same as Hickok tester. *Donald W. Marshall, P.O. Box 70, Chester, Nova Scotia, Canada BOJ 1JO.*

Wanted: Diagram for ECA TV, model No. E1800 (12" B&W). *Jiranek TV, Farmington, IA 52626.*

Wanted: Schematic or service manual for FM signal generator, model 100W, New London Instrument Corporation, New London, CT. State price. *Joseph M. Mockus, 12683 W. Hawaii Ave, Lakewood, CO 80228.*

Needed: Knight RF generator and signal tracer with manuals. **Wanted:** Supremes manuals–TV1, 2, 11 and R1; Sams TR-82. *C.T. Huth, 229 Melmore St. Tiffin, OH 44883.*

For Sale: B&K equipment–1077B, $250; 283 bench DVM, $50; 801 capacitor-analyst, $50; 707 and 667 tube testers and extensions, all $100. Keithley 4.5 digit bench DVM, $125; 0-140Vac Variac, $50; Sencore VA48, $750; Tektronix 503 scope and chart, $275. Many other items; offers considered. *E. Garay, 2436 Pocatello, Rowland Heights, CA 91748; 818-913-1590.*

Wanted: Weller solder station, WTCPL; dual-trace scope, working or non-working. *Ron King, 551 E. North Ave., Flora, IL 62839; 618-662-2531.*

For Sale: Bell & Howell ABR-917 dual lens microfiche reader, $150. *Charles R. Woodward, Woody's TV Service, 3133 8th St., Meridian, MS 39301; 601-482-3995.*

Wanted: Schematic or service manual for Allied radio stereophonic receiver, model 498. Will buy or will copy and return. *John Takish, 3415-173rd Place, Lansing, IL 60438; 312-895-3118.*

For Sale: Sencore CR161 picture tube tester and restorer with 11 sockets (other sockets available from Sencore), complete with manual and set-up chart, $85; B&K sweep-marker/generator, model 415, complete with manual, $125. *M.B. Danish, P.O. Box 217, Aberdeen Proving Ground, MD 21005; 301-272-4984, evenings.*

For Sale: Flybacks and yokes for older televisions. If interested, write for listing. *Glennon E. Swoboda, 402 East Brook, O'Fallon, MO 63366.*

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These Photofact folders for TV receivers have been released by Howard W. Sams since ES&T's last report.

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SHARP
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ATTENTION: Sylvania remote control motor for hospital televisions no. 23-99-383 for sale. With exchange $39.00, without exchange $47.00. Kinirral Electronics, 68-26 64th Place, Glendale, N.Y. 11385. Tel. (718) 366-3859. 1-86-4t

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VIDEO/AUDIO technician needed. Top pay and benefits for well trained and experienced technicians who are expert with consumer TV and audio equipment. Training by manufacturers such as: Sony, Hitachi, RCA, Panasonic, etc. are necessary for job experience. Write or call: Atlantic Electronics, Inc., 1881 NE 26th St., Ft. Lauderdale, FL 33305, 305-564-8274 (10 AM 6:30 PM). Ask for Dave or Joe. 06-86-tfn

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Void after May 1, 1987

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- FF☐ **Operations Management** Such as Service Manager, Operations Manager, Production Manager, Customer Service Manager, Marketing/Sales Manager, Purchasing Manager, Credit/Accounts Manager and Other Operations/Administrative Personnel
- GG☐ **Engineering/Technical & Other Personnel** Such as Engineer, Technician, Field Service Engineer, Specialist, Engineering Associate and Other Engineering And Technical Support Personnel
- KK☐ **Other** ____________

▶ Check the number of Service Technicians employed at your facility.
- A☐ 1-5
- B☐ 6-10
- C☐ 11-25
- D☐ 26-50
- E☐ Over 50
- F☐ Not applicable

▶ **Check the statement that best describes your role in the purchase of major electronics servicing equipment and servicing components, accessories and services.**
- 1☐ Make final decision to buy a specific make or model.
- 2☐ Recommend make or model to be purchased.
- 3☐ Have no part in specifying or buying.

SUBSCRIBE NOW!

- ☐ 1 Year – 12 issues **ONLY $18.00**
- ☐ 2 Years – 24 issues **ONLY $30.00**
- ☐ 3 Years – 36 issues **ONLY $38.00**

Your Biggest Savings!

Please check preferred order
(Allow 6-8 weeks for delivery of first issue)

Note: Outside U.S.A. rates are: ☐ 1 Year $22 ☐ 2 Years $34 ☐ 3 Years $44

- ☐ Payment enclosed
- ☐ Charge to my VISA/MASTERCARD
- ☐ Bill me later

CHARGE TO MY: (Please check one) ☐ MASTERCARD ☐ VISA
ACCOUNT NUMBER
INTERBANK NUMBER
CARD EXPIRES MO. YR.
MASTER CHARGE ONLY (4 digits above your name)

Signature required ____________ Date ____________

Electronic Servicing & Technology

READER SERVICE INFORMATION AND SUBSCRIPTION SERVICE CARD

For issue of January 1987
Void after May 1, 1987

FOR FASTER ACTION!
I have an immediate interest in the items I've indicated here.
Please have a salesperson call me. ☐☐☐☐ RJ7

For more information on products or services mentioned in this issue, simply circle the appropriate numbers below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

Please print
Name ____________ Title ____________
Company Name ____________
Address ____________
City ____________ State ____________ Zip ____________

SAVE TIME Use peel-off address label from cover for faster service

BUSINESS TELEPHONE: AREA CODE ( ) NUMBER ____________
Signature ____________ Date ____________

Please check one box under each ▶ to expedite your request for information.

▶ Type of Business
- 21☐ Consumer Electronics Equipment Independent or Franchised Service Business
- 22☐ Retailer With Consumer Electronics Equipment Service Department
- 23☐ Electronics Equipment Field Service Organization
- 24☐ Service, Installation or Operation of Electronics Equipment In Industrial Or Commercial Facility
- 33☐ Engineering Of Electronics Equipment In Industrial Or Commercial Facility
- 35☐ Wholesaler, Jobber, Distributor
- 37☐ Electronics Equipment Or Components Manufacturer
- 38☐ Government and Military: Federal, State, Municipal
- 09 Education
  - (a)☐ College, Library, School, Including Instructors
  - (b)☐ Student
- 30☐ Other ____________

▶ Position
- EE☐ **Company Management** Such as General Manager, Owner, Partner, President, Vice President, Director And Other Corporate Personnel
- FF☐ **Operations Management** Such as Service Manager, Operations Manager, Production Manager, Customer Service Manager, Marketing/Sales Manager, Purchasing Manager, Credit/Accounts Manager and Other Operations/Administrative Personnel
- GG☐ **Engineering/Technical & Other Personnel** Such as Engineer, Technician, Field Service Engineer, Specialist, Engineering Associate and Other Engineering And Technical Support Personnel
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ACCOUNT NUMBER
INTERBANK NUMBER
CARD EXPIRES MO. YR.
MASTER CHARGE ONLY (4 digits above your name)

Signature required ____________ Date ____________

Tell us what you think about this issue?

What was the most interesting article in this issue?

List the subjects you want to read about most?

Which one advertisement in this issue was of most interest to you?
Advertiser's name ______________________

Circle No. __________

PLACE FIRST CLASS POSTAGE HERE

ELECTRONIC
Servicing & Technology

Product Information
P.O. Box 12951
Overland Park, KS 66212-0951

Tell us what you think about this issue?

What was the most interesting article in this issue?

List the subjects you want to read about most?

Which one advertisement in this issue was of most interest to you?
Advertiser's name ______________________

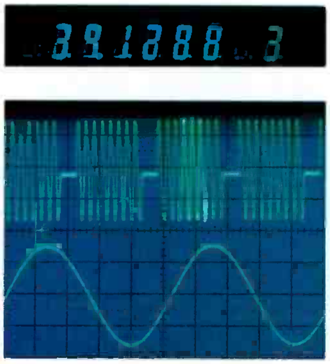
Circle No. __________

PLACE FIRST CLASS POSTAGE HERE

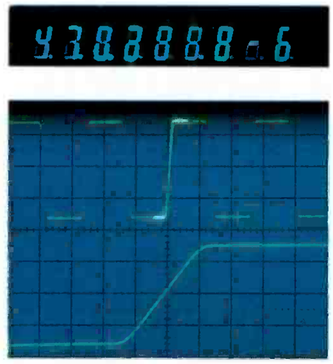
ELECTRONIC
Servicing & Technology

Product Information
P.O. Box 12951
Overland Park, KS 66212-0951

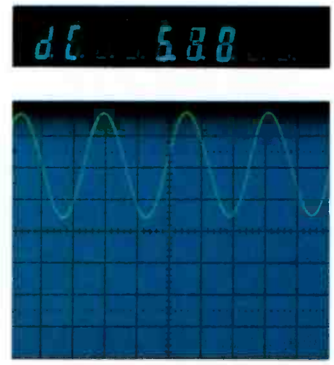
NOW GET SCOPE, COUNTER AND DMM INPUT ALL AT ONCE THROUGH ONE PROBE!



Gated frequency measurement. B sweep triggering during the intensified portion of the A sweep. Intensified portion frequency is measured with the counter/timer/ DMM.



Delay time measurement. Delay time from the start of A sweep to the start of the B sweep is measured with *crystal accuracy.*



Channel 1 dc volts measurement. The average dc component of a waveform is measured directly through channel 1 with direct digital fluorescent readout.

The Tek 2236 combines 100 MHz, dual timebase scope capability with counter/timer/DMM functions integrated into its vertical, horizontal and trigger systems. For the same effort it takes to display a waveform you can obtain digital readout of frequency, period, width, totalized events, delay time and Δ-time to accuracies of 0.001%.

The same probe is used to provide input for the CRT display and the digital measurement system, resulting in easy set-up, greater measurement confidence and reduced circuit loading. Probe tip volts can also be measured through the Ch 1 input.

Precision measurements at the touch of a button. Auto-ranging frequency, period, width and gated measurements are push-button-simple. And the 2236 offers an independent floating 5000 count, auto-ranging multimeter with side inputs for DC voltage measurements to 0.1%.

A built-in, auto-ranging ohmmeter provides resistance measurements from 0.01 Ω to 2GΩ—as well as audible continuity. Automatic diode/junction detection and operator prompts serve to simplify set-up and enhance confidence in your measurements.

Bandwidth	100 MHz
No of Channels	2 + Trig. View
Max. Sweep Speed	5 ns/div
Digital Readout Features	Direct Ch 1 Voltage Meas. 0.5% DC; 2.0% AC RMS Resistance: .01Ω to 200 MegΩ Continuity/Temp: Audible/C° or F° Totalizing Counter: —1 counts to 8,000,000 Direct Freq. Meas: 100 MHz to 0.001% acc. Period, Width Meas: 10 ns with 10 ps max. resolution
Timing Meas. Accuracy	.001% (delay and Δ-time with readout)
Trigger Modes	P-P Auto, Norm, TV Field, TV Line, Single Sweep
Weight	7.3 kg (16.2 lb)
Price	$2650
Warranty	3-year including CRT (plus optional service plans to 5 years)

The 2236: scope, counter, timer, DMM plus a 3-year warranty —all for just $2,650. Contact your nearest distributor or call Tek toll-free. Technical personnel on our direct-line will answer your questions and expedite delivery. Orders include probes, 30-day free trial and service worldwide.

Call Tek direct:
1-800-433-2323 for video tape or literature,
1-800-426-2200 for application assistance or ordering information.

In Oregon, call collect:
1-627-2200

Tektronix®
COMMITTED TO EXCELLENCE

Circle (2) on Reply Card

Start the New Year right by selling Zenith Video/Audio Accessories to the same people whose electronic products you now service.

Like all Zenith products, Zenith Audio/Video Accessories are made to the same uncompromising quality and performance standards that have earned Zenith a reputation unsurpassed in consumer electronics.

And it goes without saying that the better known and the more respected a product's name the easier, faster, and the more profitably you can sell it across the counter ...or while you're out of the shop on a service call.

To learn how it's done, how other service techs just like you are cashing in on the selling power of the Zenith name, call your Zenith distributor's Accessory Sales Manager now.

Everything you need is there at your Zenith distributor's place – the help and encouragement of an experienced Zenith Accessory Sales Manager...the selling power of the Zenith name on video and audio accessories...and the overall support of your Zenith distributor's dedicated personnel.

With easy access to this wealth of know-how, you should have no trouble turning some 6, 7 or 8 feet of your floor space into a very respectable profit center. With Zenith Electronic Accessories, of course.

Call your Zenith distributor's Accessory Sales Manager now or write direct for the name of the Zenith distributor serving your area.

Call or write now, today!

ZENITH®

The quality goes in before the name goes on.®

Zenith Service, Parts & Accessories • Department 30 • 11000 Seymour Avenue, Franklin Park, Illinois 60131 • A Division of Zenith Electronics Corporation