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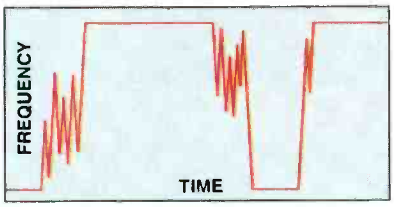

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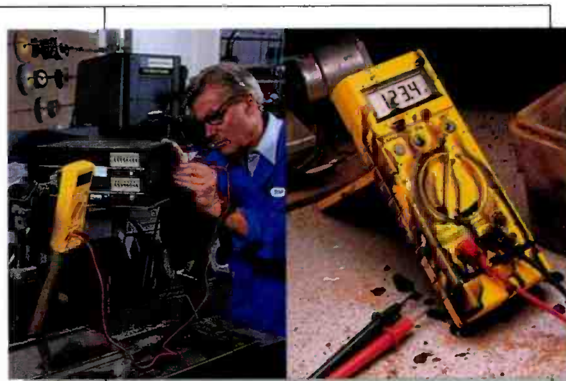

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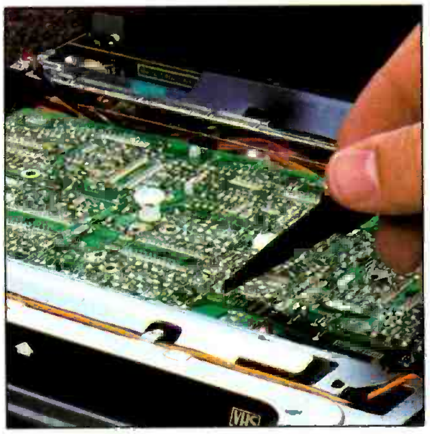

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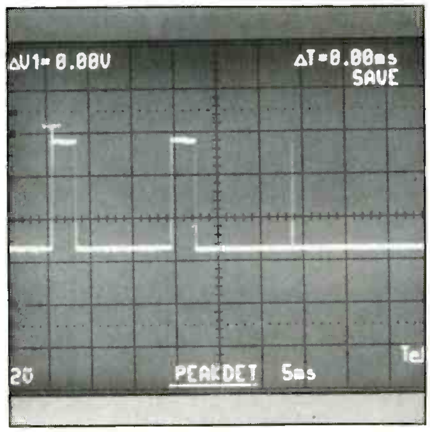

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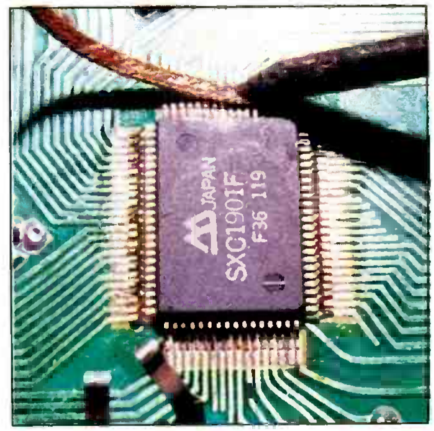

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FEATURES

DEPARTMENTS

ON THE COVER

Microprocessors are a fact of life in electronics servicing. You'll find them in VCRs, microwave ovens, TVs and even your own test equipment. Still, many servicers think microprocessors are difficult to service, probably because they believe microprocessors are much more complex than they really are. If there is one golden rule to correcting possible microprocessor problems, it's *remove the microprocessor only as a last resort.* (Photo courtesy of Sencore.)

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Hold that thought

Consumer electronics servicing has changed immensely over the years. Many of you no doubt remember the early days when servicing a TV ordinarily meant attacking it with a tube tester and a box of vacuum tubes. You would use a combination of circuit knowledge, component testing and substitution to get the unit back in working order.

Although the function of TV sets has not changed much, except for the addition of color to the picture, the circuitry has evolved tremendously. From vacuum tubes we changed to transistors, then to integrated circuits. Power supplies have changed, in general, from the old, inefficient, center-tapped transformer/2-diode supply to the transformerless full-wave bridge. Now, switching power supplies are being found in more and more TVs.

And in the interest of safety, both to consumers and the TVs themselves, the sets have been outfitted with start-up and shut-down circuits.

A little reflection will show that these changes are just the highlights. A lot of changes have been made.

The results of these changes have been a combination of vastly improved reliability, far better picture quality, increased efficiency, smaller size and weight, and a manyfold increase in the difficulty of diagnosis and servicing.

But this problem is not limited to consumer electronics servicing. Almost everything in this world—from cars to airplanes and from manufacturing to weapons systems—is becoming more complex as we ask them to do more, and do it more efficiently and faster.

A problem that has always existed is made worse by this increased complexity. Where do you find someone who has the expertise to diagnose these highly complex products? To make matters worse, after you have found an expert, when he leaves, whether because of retirement, a job change or death, all of the knowledge he has accumulated over the years leaves with him.

Again, this problem is not unique to consumer electronic servicing. It's also a problem in engineering, maintenance, medicine, law—in fact, in every skilled and learned profession in our increasingly complex world.

Fortunately, the computer, one of the factors that has contributed so much to the complexity of today's world, is also being brought to bear on this problem. A recent press release from the Diebold Group, management consultants, reports on some of the progress being made in the area of *expert systems*: computer programs that contain a combination of data and logic that are "...primarily applied to fully or partially automating the work of human 'experts' whose knowledge is difficult or impossible to capture using traditional programming tools. The key element in this area is the expert system's ability to represent knowledge as a set of decision rules, expressed in a form which is comparatively easy to code and maintain. Implementation of an expert system for end users often begins with a purchased 'shell,' which includes a 'knowledge interface' to accept the rules, and an 'inference engine' to execute their logic."

The implication of interest to consumer-electronics servicing technicians is that, in the near future, manufacturers (or independent information providers like Sams) should be able to provide computer programs that would help technicians diagnose problems in specific models of products or even in a broad spectrum of products, if the program is general enough. For those technicians who feel threatened by innovations that seem to automate diagnosis, the idea of expert systems should present no threat because the tech will still need a good degree of expertise simply to obtain and feed in enough information to operate the software.

Expert systems would seem to be one excellent way to provide the guidance and help technicians need in servicing today's complex consumer electronic products. Is anyone currently exploring this possibility?

Nils Conrad Persson

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News

U.S. electronics exports up 20%

U.S. exports of electronics rose 20% in 1987 over the 1986 figure, surpassing the growth rate of electronics imports for the first time since 1980, according to the Electronic Industries Association (EIA). Total U.S. exports of electronics products totaled more than $40 billion for 1987. Total imports, however, were almost $57.9 billion, 15% more than the $50.3 billion imported in 1986.

Anti-taping chip fails NBS report

The National Bureau of Standards (NBS) has released its report on the Copycode anti-taping chip. The report, which was requested by several Congressional committees studying the Copycode legislation, indicated that the chip failed each of the three major tests applied by the NBS study. According to the NBS, the system did not work as described, often failing to prevent taping and even giving false positives, which would prevent recording even when no encoding had been applied. The NBS also found that Copycode audibly distorted music and could be bypassed easily.

The report supported the objections of the Home Recording Rights Coalition (HRRC) to Congressional bills H.R. 1384 and S. 506, which would require Copycode. The report was financed by the HRRC and the recording industry, each contributing $75,000.

Copycode works by cutting a narrow notch in the upper mid-range frequencies of music on records, tapes, discs and FM broadcasts. An anti-taping IC would also be required in DAT recorders, shutting the device down any time this notch is detected.

EIA offers surface-mount information

The Electronic Industries Association (EIA) is offering a bibiliography and abstracts of more than 60 articles and publications on surface-mount technology. The articles, available through EIALINK (EIA's electronic information computer network), cover various aspects of soldering, circuit boards and inspection techniques. Hard copies will also be available.

ICCE plans technical program

The 1988 International Conference on Consumer Electronics (ICCE) will be held in Chicago, June 8-10. The technical conference, aimed at production designers, engineers and architects of future consumer electronic products, will feature 20 technical sessions and presentations of 125 papers. Panel discussion topics will include: "Trends in New Consumer Electronic Products," "Global Standards for Advanced TV" and "Magnetic vs. Optical Storage Techniques." Educational session topics covered will include: "Advanced TV Systems," "Principles of Digital Audio," "TV Distribution Systems With an Emphasis on Cable TV," and "Flat-panel Displays."

For more information, contact the conference's sponsor, the Consumer Electronics Society of the Institute of Electrical and Electronic Engineers (IEEE), at the David Sarnoff Research Center, Princeton, NJ 08540; 609-734-2531.

EIA/CEG publish pamphlets

As part of their salute to National Consumers' Week, April 24-30, the Electronic Industries Association's Consumer Electronics Group (EIA/CEG) has announced the publication of three free consumer education pamphlets. The "Consumers Should Know" series includes pamphlets on preventive maintenance and care products; choosing accessory products; and installing audio, TV, video systems and telephones. To request a pamphlet, send a self-addressed, number 10 envelope to the EIA at P.O. Box 19100, Washington, DC 20036. On the envelope, include the name of the pamphlet and appropriate postage for each ($0.25 for Care Products; $0.45 for Accessory Products; $0.65 for Hookup and Expansion).

SBCA establishes telephone hotlines

In an effort to promote home satellite-TV ownership and to educate and assist dealers and consumers, the Satellite Broadcasting and Communications Association (SBCA), assisted by General Instrument, has established two national, toll-free hotlines.

Two hotlines are available: a dealer hotline (800-356-3160) and a consumer hotline (800-533-4584). The hotlines may also be used to report (annoymously, if desired) individuals or companies involved in the manufacture, modification and sale of illegal descramblers.

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INTERTEC PUBLISHING CORPORATION

Isolating microprocessor-related problems

By Gregory D. Carey, CET

Many technicians think microprocessors are difficult to service. Why? Probably because they think of microprocessors as computers. Yet, most microprocessors are not used as computers. They are controllers. Controllers are found in VCRs, microwave ovens, TV receivers and most microprocessor-controlled test equipment. Knowing this can make servicing microprocessors a lot less fearsome.

Let's start with a practical piece of advice: Don't change the microprocessor too quickly. Time and time again, technicians admit that changing a microprocessor doesn't help a problem that looks like it might be caused by a bad micro. Microprocessors rarely fail. They are protected from static discharge and power-line surges by buffering transistors and ICs and by filtered power supplies. The best process is to leave the micro on your list of suspects, but be sure to investigate all the other likely culprits first.

There are five quick tests you can use to isolate most microprocessor-related problems. First, you need to understand how a microprocessor used as a controller differs from one used as a computer, so that you can see why microprocessor servicing has very little to do with computer servicing.

The computer vs. the controller

The biggest difference between a microprocessor used in a computer and one used as a controller deals with programming. A computer is re-programmed every time it is used, usually by reading information from a magnetic disk or tape. The controller has only one

Carey is an application engineer at Sencore.

program, which is entered at the factory. Compared to a computer, the controller lives a relatively boring life—playing the same program over and over. Any change in the internal program is caused by some mishap, resulting in a defective microprocessor.

Computers (whether desk-top personals or large mainframes) handle large volumes of assorted data. One batch may consist of numbers for a payroll; the next may be a document from a word processor. Controllers, by comparison, receive data that are repetitive and predictable. The inputs come from

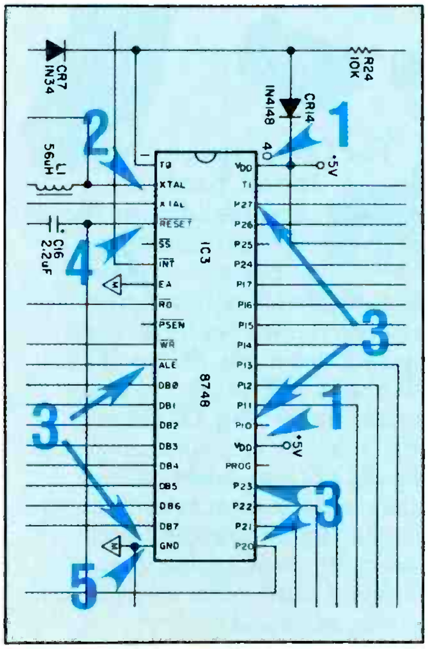

Figure 1. These five steps test the microprocessor's inputs and outputs in a logical sequence to determine whether a problem is outside the microprocessor.

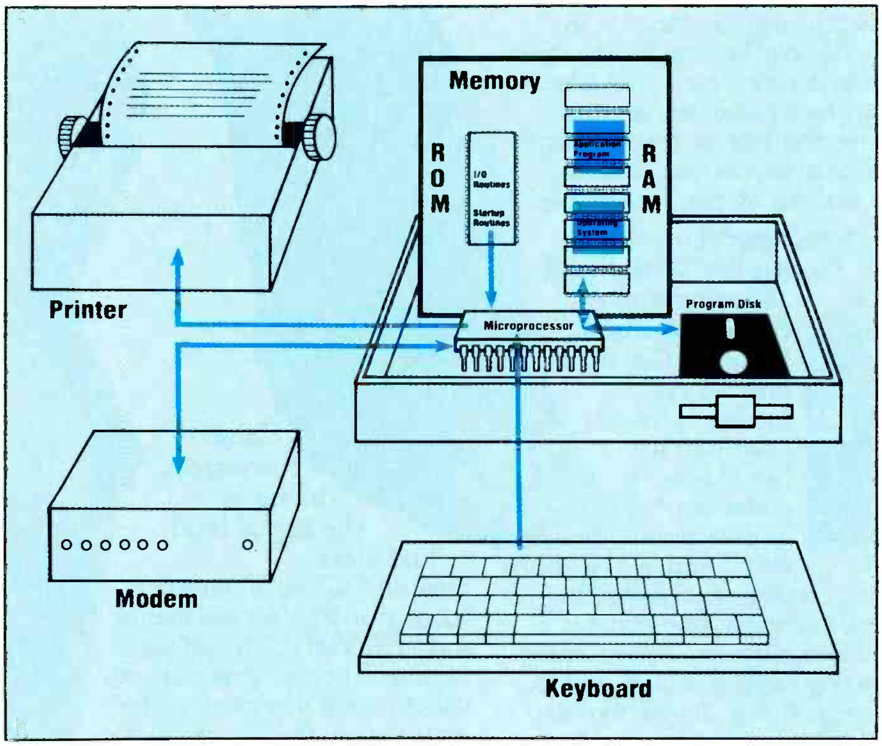

Figure 2. The microprocessor in a computer is reprogrammed every time it is turned on. It has many complex inputs and outputs, and banks of memory chips outside the microprocessor itself.

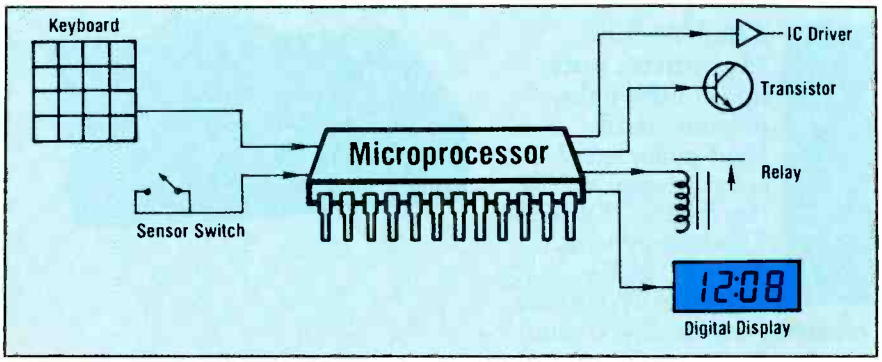

Figure 3. Most microprocessors are used as controllers, not computers. The controller has its program in permanent memory and works with simple input and output circuits.

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simple switches and sensors.

The microprocessor used in a computer connects to thousands or millions of bytes of external random-access memory (RAM), each byte consisting of eight memory locations. This RAM may require dozens of external memory chips. The controller only needs a small amount of memory, inside the microprocessor chip itself.

Finally, a computer has complex inputs and outputs. Inputs come from typewriter keyboards, disk drives or modems. Outputs feed printers, plotters, CRT displays or other computers. The controller only has inputs from a few switches or sensors. Its output feeds a few ICs, relays and a simple digital display.

Servicing controller-type microprocessors doesn't need to be any more complicated than servicing any integrated circuit. Because of the controller's limited environment, you don't need to know as much as you might think.

The simplified system

One of the biggest differences between servicing computers and controllers is that you don't have to worry about software problems in controllers. You don't need to know programming or ASCII codes. If you suspect a software problem, you have only one option: change the program chip.

Second, you don't have to sort through rows and rows of memory chips. This means you don't need a $20,000 logic analyzer or an 8-channel scope to view

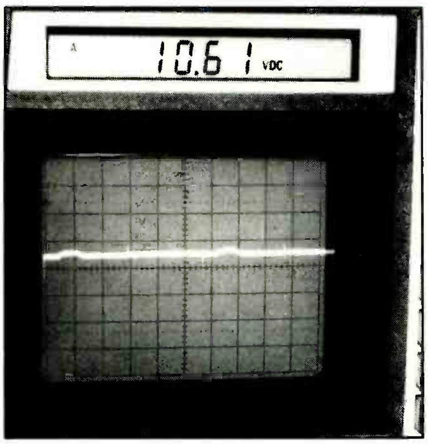


Figure 4. Check each power-supply pin for the correct dc level and for any noise or ripple. Here, the 11V supply for a CMOS microprocessor has the correct dc level and low ripple.

each byte of data separately to locate a defective memory location. If an internal memory location is defective, you have to change the microprocessor.

Finally, the controller has limited inputs and outputs, generally no more than eight of each. You can test each one separately to determine whether the problem is coming from inside the microprocessor or from an external component.

Once you stop worrying about software, memory and complicated interface systems, the microprocessor takes on a whole new look. You can find most problems by testing five standard components: the power supply, the clock, the input and output lines, the reset circuit and the grounds.

Testing the power supply

Always test the power supply(s) first, whether the problem is a totally dead

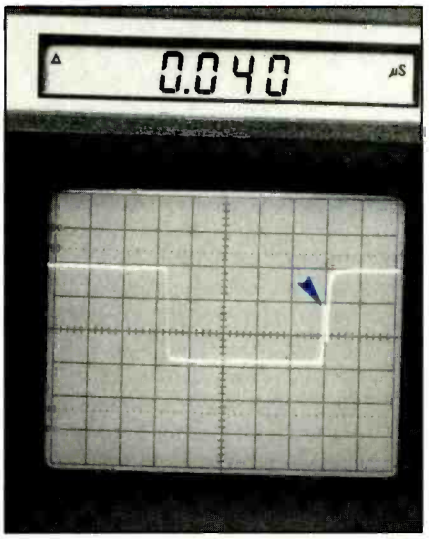


Figure 5. The clock signals must have the correct frequency and amplitude, and they must be free from glitches. This glitch causes the microprocessor to act as though it is defective.

micro or one with erratic operation. Start with the dc level. Use a digital voltmeter or the DCV function of a waveform analyzer to confirm the correct dc level. Your voltage should be within about 0.2V of the correct level.

Many microprocessors run at 5V because they use TTL logic. Some, however, may operate at voltages as high as 15V if they are the CMOS type. Be sure you check your schematic for the correct power-supply voltage.

Don't stop with dc voltage tests because noise often enters the microprocessor through the power supply, causing it to act erratically. Look at the CRT to see if the signal is clean. Measure the signal's actual value. You should see less than 0.1V of ripple.

You may see 60Hz ripple from a bad filter or regulator. You also may see

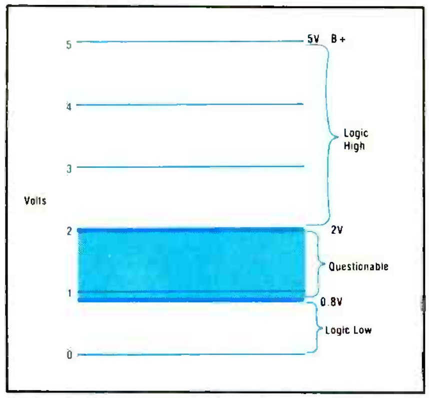


Figure 6. When testing logic inputs and outputs, remember that signals falling into the "questionable" area may cause intermittent operation.

high-frequency digital noise from a switching-type power supply or from another stage. This ripple can intermix with normal input signals. If so, suspect a bad filter choke or decoupling capacitor on the power supply line, or a bad IC on the same line that is loading the supply.

If the microprocessor has more than one power-supply pin, check each one in the same manner.

Testing the clock

A problem in the crystal-controlled clock can cause intermittent operation. Watch for the following conditions as you probe each of the microprocessor pins connected to the clock input pins. The "clock" pulses are usually generated by a crystal.

First, confirm that the clock is running at the correct frequency. The frequency must be measured to greater accuracy than is possible using a conventional oscilloscope, so you'll need a frequency counter or the frequency function of a waveform analyzer. If the frequency is incorrect, suspect a bad crystal.

Second, check the peak-to-peak amplitude of the clock output. Low amplitude may make the microprocessor miss some of the clock pulses. This makes the clock frequency seem to be

slow, even though the frequency test showed that it was correct. The results could be erratic operation of any function based on timing with another signal. Missed clock pulses caused by a low-amplitude signal could also cause the clock to keep incorrect time.

Last, use a scope CRT to examine the waveform for noise or extra "glitch" signals. These extra signals may cause the microprocessor to intermittently skip a program step, or they may cause the whole system to run too fast. The clock signal should be a clean sine or square wave.

Testing the input and output lines

Check each input pin for proper levels. Because the controller receives inputs from simple switches and circuits,

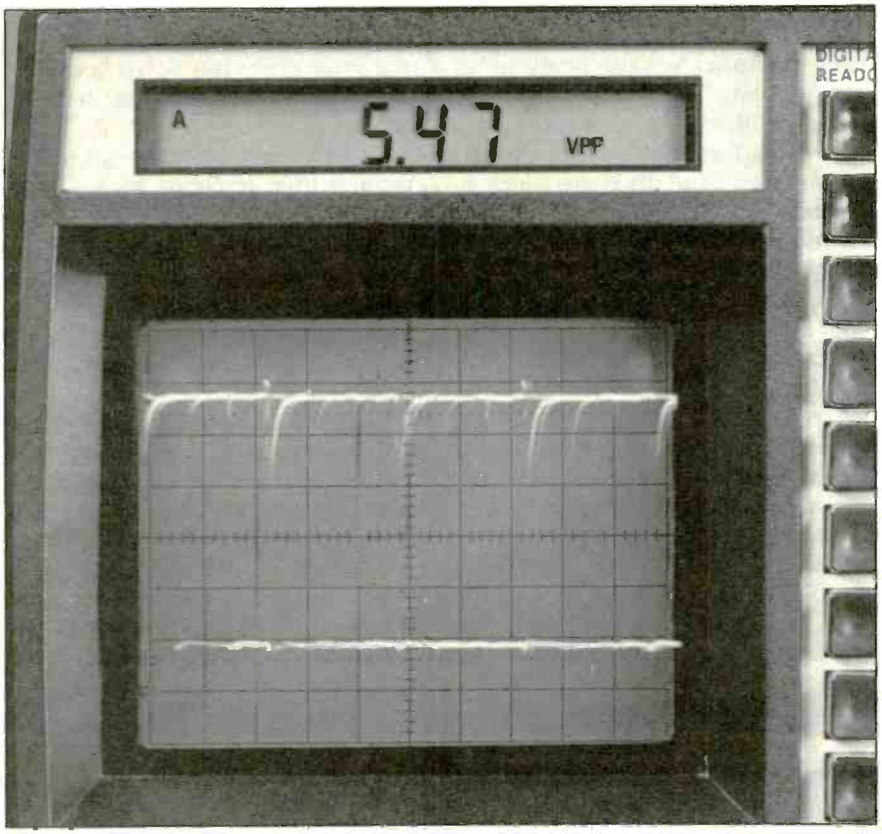


Figure 7. A toggling input or output pin may appear to be out of sync because of the changing data. Be sure that the pin is toggling and has the correct peak-to-peak level. Also, make sure the high or low levels don't fall into the questionable zone.

input problems often affect only one or two functions. Try every function controlled by the micro, and note which ones work correctly and which ones have trouble. Then, determine which input pins are associated with the bad functions. For example, one or two switches might provide an input to a single function and might not be used with any other of the micro's inputs.

Connect your scope or waveform analyzer probe to the pins associated with the questionable functions. Observe the trace as you cycle the input switches. Select dc coupling (or press the DCV button) and note the dc level with the switch contact both open and closed. Confirm that the level properly changes between the ONE and the ZERO logic level. Be sure that neither level falls into the "undefined" area between the two levels, or the micro may not be able to decide whether a high or low condition exists.

Check contact resistance or pull-up resistors if the levels are wrong. Watch for noise or glitches as the contacts close. These extra signals may cause the micro to interpret a single switch operation as two or more switch closures. Check the switch contacts, decoupling capacitors and switch buffer circuits to isolate noise conditions.

Next, test all output lines to be sure one isn't stuck at logic high or logic low. Touch your probe to each microprocessor output pin, one at a time. Don't worry that the signal shows a blur of lines, which looks like an out-of-sync condition. This blur results from the asynchronous (random) data coming from the micro.

Set the scope's input coupling switch to DC to confirm that the low points on the waveform are below the minimum level for a ZERO and that the high points are above the minimum level for a ONE. Suspect a bad pull-up resistor or IC outside the micro if the signals are falling between logic levels.

If the signal at a pin remains cemented to ground or to B+, look at the schematic to see when that pin is used. You might have to trace the pin to a relay or an IC to find out which function(s) it controls. Then, press a button or cycle a sensor to force the microprocessor into a function that uses this pin.

If the signal at the pin doesn't change, the microprocessor or an external circuit may be at fault. To find out, isolate the unchanging pin from the external circuits by carefully removing the solder

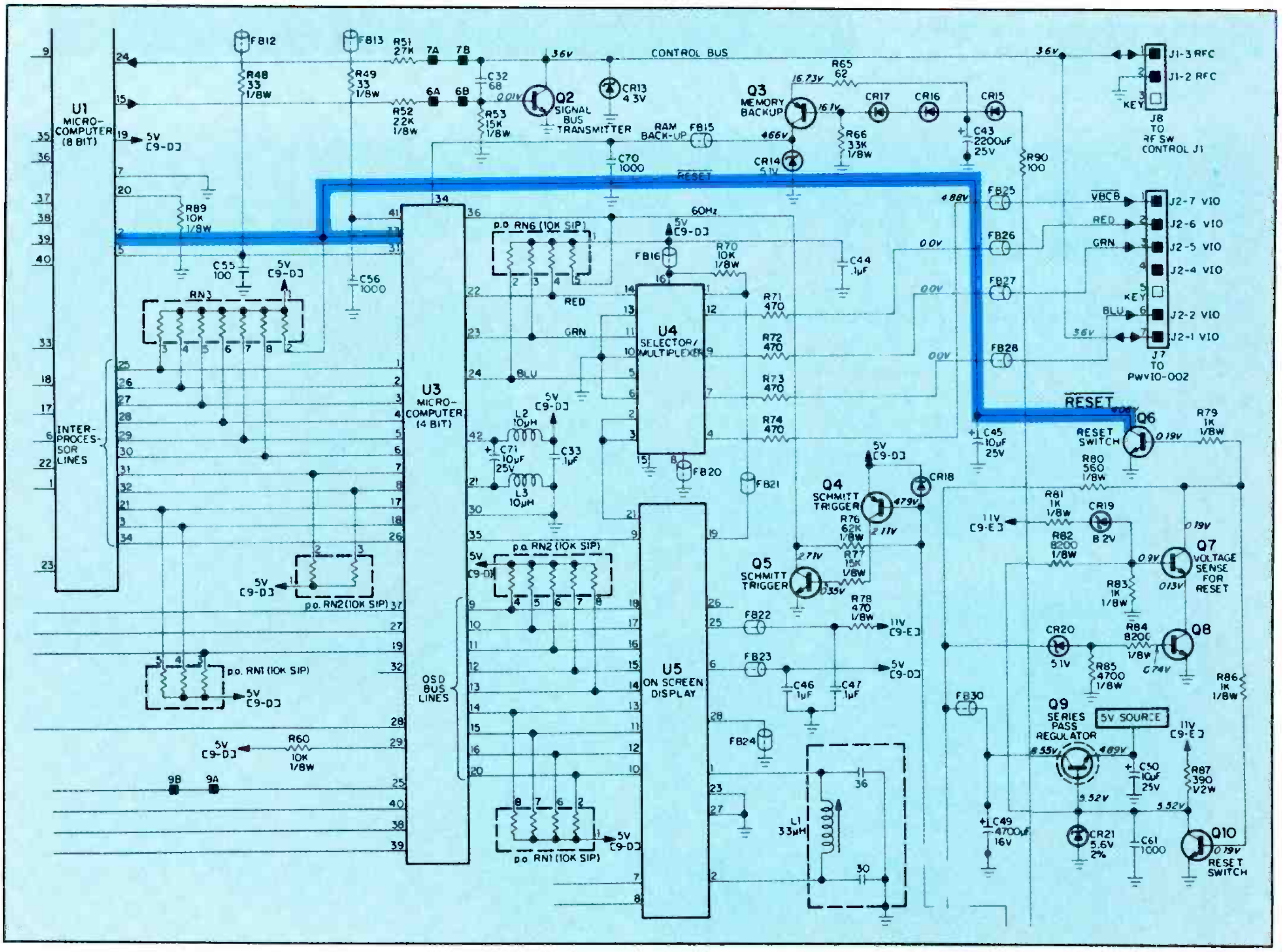


Figure 8. The reset circuits must fire when power is first applied. Here, a defective reset circuit would cause both of the tuner microprocessors to operate incorrectly.

between it and the foils on the PC board. DON'T DESOLDER THE OTHER PINS YET. Connect your scope probe to the isolated pin and again check for toggling. If the pin toggles with its load removed, the problem is probably outside the micro. An external component is holding the pin high or low. Isolate each component on that line, one at a time, until the line toggles. Then, replace the defective part.

If the pin remains stuck after being isolated, the problem is beginning to look more like a defective microprocessor. Don't unsolder the remaining legs, however, until you've performed the last two checks.

Testing the reset circuit

Microprocessors need an external reset pulse at turn-on. Without this reset pulse, the microprocessor starts in the middle of the program, resulting in totally unpredictable operation.

Use the CRT of your scope or waveform analyzer to check the reset pulse. Set the trigger SOURCE switch to channel A, the trigger MODE switch to NORM and the trigger LEVEL control to the center of its rotation.

Connect the device containing the microprocessor to an ac power strip that has a switch, so that you can turn the power off and on. Don't rely on the device's power switch because the microprocessor often receives power independent of the power switch. In fact, many "power" switches are simply microprocessor inputs and don't interrupt power.

Turn off the power and connect the channel A probe to the reset pin. The CRT should show no trace because the triggering circuits are in the NORMAL mode. Watch the CRT as you apply power to the system. If you see the trace flash across the CRT, you know a reset pulse occurred and triggered the sync circuits. By watching the trace carefully, you can even measure its pulse time. The time starts at the left edge of the CRT trace (switch to the AUTO triggering mode to find its starting point) and ends when the pulse on the CRT drops. Cycle the reset circuits several times to find the pulse width. If there is no trace or if the pulse is too narrow, repair the reset circuits.

Checking grounds

If you've confirmed that all the inputs are working correctly, the microprocessor is highly suspect. But don't unsolder it yet. First, check every grounded pin. Each pin should show 0Vdc and 0Vac. If any grounded pin has a signal on it, it is floating, which will cause the microprocessor to act as though it's bad. The presence of a signal tells you there is an open in the grounded path—either a broken PC foil or a bad solder connection. Repairing the bad ground will probably clear up your trouble.

You've already confirmed that all the inputs and outputs are normal, so if the grounds are good, you are ready to substitute the micro. ES&T

Using the logic analyzer

By David J. Blakemore

When a malfunctioning computer crosses your bench, the first thing you do is look at the symptoms and hope they immediately point you toward the problem. But what do you do if the symptoms point to several possible problems? Say you have a computer that turns on, spins the disk for a while, then stops. Is it the disk itself? Are the boot ROMs corrupted? Is it really running, but not listening to the keyboard or driving the CRT?

Fixing the problem isn't the hard part; the trick is finding out what the problem is. You need a tool that can help you locate the problem fast, so you can get this PC off your bench and go on to the next. One tool that can help speed up the detective process is the logic analyzer. A good analyzer is easy to use and will immediately help you find the source of the problem.

Using the analyzer

To use the logic analyzer, you simply clip its 8088 pod over the PC's microprocessor and capture some data. Again, imagine you are working on the PC with the trouble symptoms described above. You look to see where the code is executing and find that it is "off in the weeds" (the PC is at addresses where there is no sensible code). You set a trigger word and start the analyzer again, clipping a lead on the feed to the CRT and the keyboard.

The logic analyzer is especially useful with digital, non-repetitive signals.

The key to a logic analyzer's usefulness is that you can set it up to stop recording at a given place and see all the data leading up to that point. One of the most important features of an analyzer used in a servicing application is its triggering, which must be flexible and easy to use.

Blakemore is vice president of Arium Corporation.

But back to the bench. You need an easy way to find the problem, fast. You look at your latest set of collected data, and the timing lines from the keyboard interface wires suddenly say "bingo!" In normal operation, these lines should show no activity until you hit a key, but now they show transitions.

You see by looking at the code that the boot ROM loaded the BIOS properly from the disk, but then received garbage commands from the keyboard, sending the 8088 off into the wild blue yonder. You suspect noise on the keyboard interface lines. Upon further examination, you find that rough handling of the keyboard has caused some broken connections and that one of the lines is floating, generating the spurious inputs. So you fix it, and—voila!—it's time for coffee.

Choosing the best tool for the job

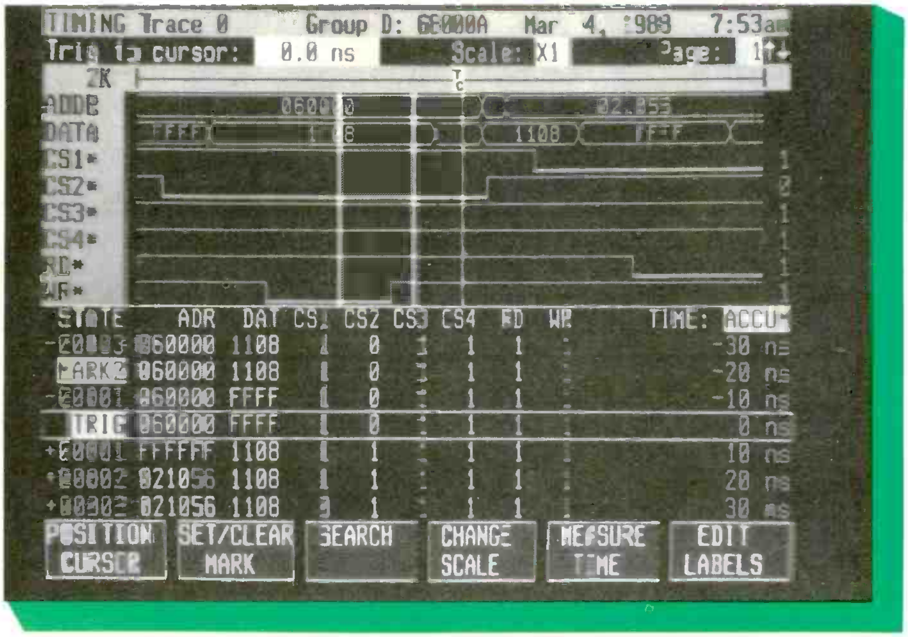
An oscilloscope is fine when you are dealing with repetitious signals, when the waveform itself is important and single-line, voltage-level triggering is adequate. But dealing with digital, non-repetitive signals requires a logic analyzer—when a symptom occurs just once, you have to be able to capture it. A logic analyzer permits complex, digital-word sequence triggering and provides long recording times.

Logic analyzers are becoming commonplace on the workbench. You need them everywhere now, because everything is digital and most equipment contains microprocessors. Analyzers are now less expensive and easier to use, yet they are offering more and more power.

The key features of a useful service-bench logic analyzer are:

- good triggering.
- non-volatile storage.
- high speeds on a few channels.
- wide widths for 16- and 32-bit microprocessors.

This sample screen shows a time-stamped state/timing split-screen display.



• light weight and small size (true portability).

• easy DIP-clip connections to target microprocessors.

• autocapture capability for continuous comparison when you are looking for intermittent failures.

An analyzer with good triggering will be able to set each trigger word to include external bits as well as status, address and data on microprocessors. It will have simple, standard sequences, such as "A then (B without C)", that are accessed by a single button. These predefined sequences will be augmented by user-defined sequences, which include multiple occurrences (such as "4 occurrences of A and B with D*") and Boolean combinations at the trigger words.

One final point: A good logic analyzer for the bench must also be priced low enough that you can afford to put it on your bench. You need to balance the features you want with the price you can afford. ES&T

Test your electronics knowledge

By Sam Wilson, CET

It is a good idea to review the basics every so often. Can you get 100% in this easy quiz?

1. Can you still name the six basic methods of generating a voltage?

2. A certain resistor has six color-code bands: orange, orange, orange, red, red, orange. When it is connected across an *exact* 5V supply, what is the maximum current that can flow if the resistor is in tolerance?

3. To remove a surface-mount transistor from a board, you must first remove the solder. Then, twist the transistor to break the epoxy holding it in place. To connect the transistor back to the board
A. put epoxy on the transistor only.
B. put epoxy on the board only.
C. put a small amount of epoxy on both the transistor and the board.
D. None of the above.

4. Can you add a resistor to the circuit of Figure A so that the lamps are operated at their rated values?

5. If it takes exactly 25ms for an oscilloscope to produce one trace, what frequency delivered to the vertical input will result in a display of four complete cycles?

6. The maximum amount of induced voltage across an inductor occurs when the maximum rate of current occurs. If the sine-wave current in Figure B is flowing through the inductor, the maximum amount of induced voltage occurs when the instantaneous current is at
A. point x.
B. point y.

7. What is a material that has a permanent electric field?

8. Is the following statement correct? "The power dissipated by a resistor equals $V^2 \div R$, so if you double the voltage across a resistor, its power rating will be four times greater."

9. Is the following statement correct? "The voltage rating of a fuse tells what voltage must be across the fuse to make it blow."

10. Is the following statement correct? "The impedance of the circuit in Figure C is fixed, so doubling the applied voltage (V) will double the current and double the voltage drop across L_1."

Wilson is the electronics theory consultant for **ES&T**.

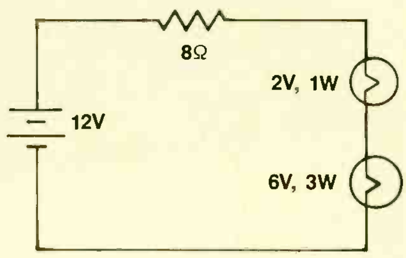


FIGURE A

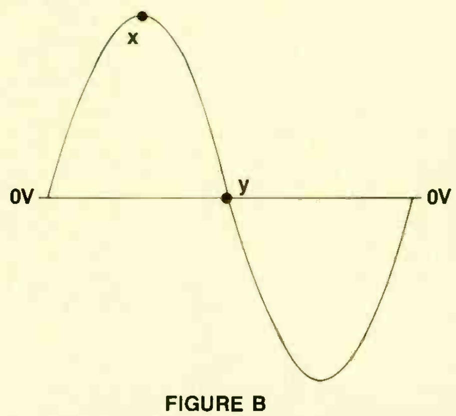


FIGURE B

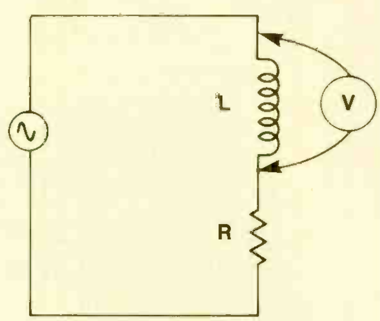


FIGURE C

Answers are on page 51.

Test accessory catalog

E-Z Hook has introduced a 116-page catalog of electronic test accessories. The catalog includes specifications, configuration diagrams and application examples for more than 12,000 product styles and sizes. Included are a miniaturized, E-Z Micro Double Gripper test connector, test lead interfaces, BNC and DB coaxial test cables, and type N series connectors and cable assemblies.

Circle (125) on Reply Card

Electronic equipment catalog

Anasco has released a catalog of laboratory and service test equipment. The catalog provides technical specifications on more than 400 items, including multimeters, oscilloscopes, circuit analyzers, calibrators, power-control equipment, signal generators, counter/timers and more. The company also provides free telephone consulting to help customers choose the right equipment.

Circle (126) on Reply Card

Test instrument catalog

The *B&K-Precision Division* of Maxtec International has released the BK-88, a 68-page electronic test instrument catalog covering analog and digital storage oscilloscopes, IC testers, DMMs, signal and function generators, digital test instruments and more. The catalog provides complete performance and mechanical specifications in both detailed listings and summary comparison charts, and offers accessories for the instruments described.

Circle (127) on Reply Card

Computer/data comm catalog

Electro Standards Laboratory is offering a product catalog describing the company's line of computer accessories and data communication products. The catalog features RS-232 breakout boxes, cable adaptors, line drivers, modem eliminators, surge protectors, computer and printer switches, data cables, bulk data cable, PC cables and twin-axial interface products.

Circle (128) on Reply Card

Benchtop accessory catalog

The PM-57, 8-page catalog from *Desco Industries* describes the company's line of benchtop accessories for the electronic workbench. Another catalog, PM-56, shows the company's other line of products for controlling electrostatic discharge.

Circle (129) on Reply Card

Fiber-optic/digital instruments catalog

Intelco Corporation has published its Telecommunication Test Instrument Handbook and Catalog for 1988. The catalog shows the company's line of fiber-optic test equipment, including optical power meters, attenuators, laser and LED source sets, and loss sets. T1, RS-232 and V.35 hand-held BER analyzers are also covered.

Circle (130) on Reply Card

ES&T

The digital storage oscilloscope:

Providing the competitive edge

By Brad Harris

Today's consumer electronics products are significantly more complex than they were even a few years ago, largely due to the ever-increasing power of electronics components and design. This complexity brings to the service technician both new challenges and a need for advanced tools to troubleshoot, calibrate and service electronic products. One such tool rapidly gaining popularity is the digital storage oscilloscope, or DSO.

Several factors have contributed to the growing acceptance of DSOs. First, prices have fallen significantly since the days when the DSO was confined to the domain of the research and development lab. As digital storage technology has matured, portable DSOs have become more cost effective. Second, the built-in features of a DSO are becoming better known in the service industry, largely because the benefits of simplified measurements and more efficient service procedures are giving companies a key competitive edge. Finally, the DSO has become more familiar and easier to use, making it a useful tool for the novice as well as the more experienced servicer.

DSOs offer many capabilities not available with traditional non-storage technology. These capabilities include capturing single-shot or transient events; enhancing the waveform display for troubleshooting or calibrating; displaying events that occur before a trigger event; and applying advanced waveform processing techniques to servicing tasks. Combined with conventional analog features, these capabilities can boost your productivity while enhancing your accuracy and efficiency.

Capturing a transient

A fundamental benefit of digital storage is that it allows you to capture a transient or single-shot event. For example, you can easily capture a waveform, which might appear as a single blink on the trace of an analog oscilloscope, and either freeze it on-screen for detailed analysis or store it in digital memory for comparison to newly acquired data. Or you could examine a transient, such as a power-line surge caused by a motor

Harris is product marketing manager of the Portable Test Instruments Division of Tektronix.

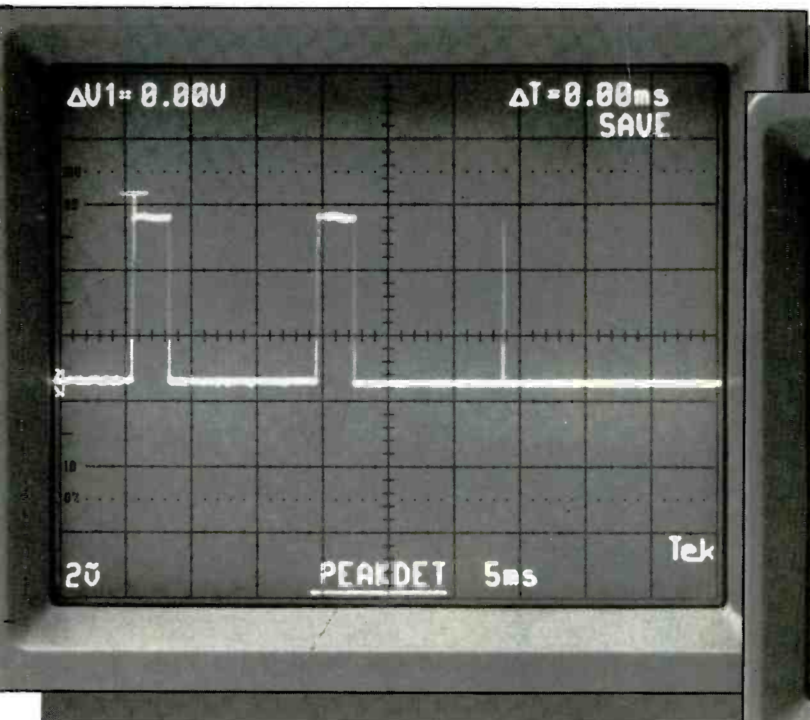
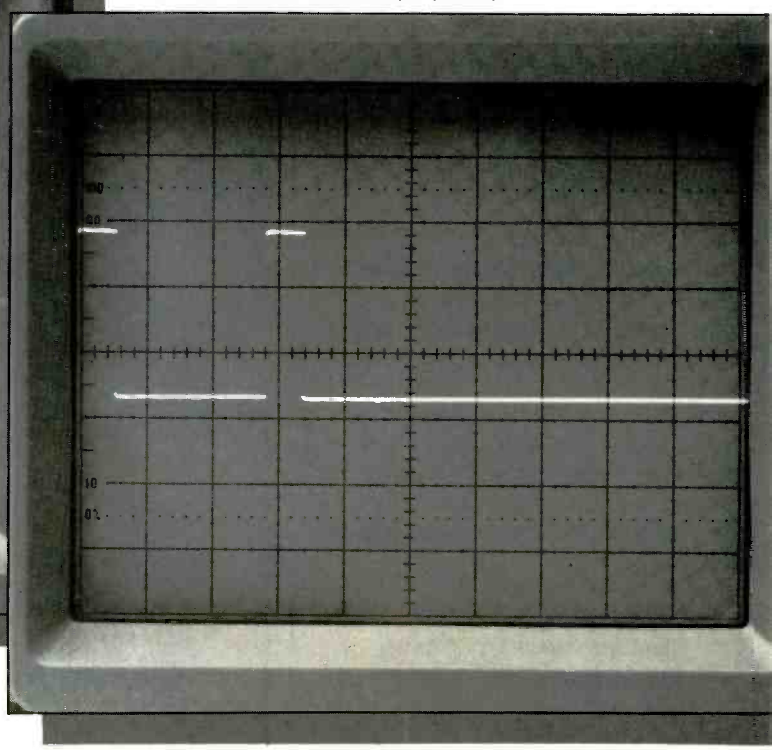
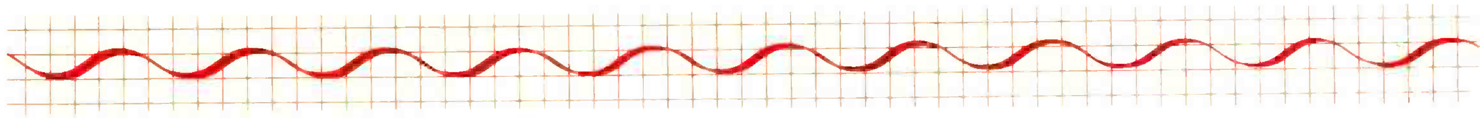


Figure 1. A DSO with peak detection (shown on the left) is capable of capturing and displaying narrow spikes that are often missed with a standard analog oscilloscope (below).





switching on or off, without continuously cycling the motor.

Searching for glitches caused by circuit crosstalk or electromechanical interference is also simplified. A narrow spike common with such glitches is all but invisible on a standard analog display, but a DSO is capable of displaying even narrow pulses with the same intensity as typical frequency events or pulse widths.

With a digital storage scope, it's also easy to monitor a problem circuit to catch an elusive glitch. For example, you can set up a DSO in babysitting mode and leave it unattended while it waits for a trigger event. When a glitch occurs, the DSO captures the event and stores it in memory.

Trace quality

Reducing eye fatigue is especially valuable in applications requiring low-repetition signals, such as the familiar *cats eye* pattern used for head radial alignment in disk-drive repair. A stable display of such signals also results in faster, more reliable measurements.

The display capabilities of a DSO are excellent for displaying low-repetition signals. A 60Hz line frequency, for example, can be difficult to view for extended periods of time on a conventional oscilloscope. Because of the signal's low repetition rate, the conventional oscilloscope's display tends to blink or flicker, quickly leading to operator fatigue as the trace is constantly redrawn across the CRT. The DSO, however, first digitizes the low-repetition signal, updates it from memory and displays a clear, stable, flicker-free waveform.

Reference memory

Adding one or more reference memories to a DSO further enhances the value of waveform storage. For example, you can store a previously acquired waveform in one memory location and the current acquisition in another. What's more, both the reference waveform and the current waveform can be displayed simultaneously on-screen for rapid comparison.

This feature is especially useful during repetitive testing or calibration of a device to a standard waveform pattern. For instance, when evaluating the performance of a stepper motor, you can use your DSO's reference memory to acquire and retain a waveform from a functioning stepper motor. Then compare waveforms from subsequent motors being tested against the reference waveform. You can even reposition the reference waveform directly on top of the current acquisition to highlight differences.

You can extend the value of reference memories by providing non-volatile, battery-backed memory for retaining waveforms even after the DSO's power is switched off. Using a battery allows you to carry standard waveforms to different field sites or capture unfamiliar waveforms on-site and bring them back to the service center for further analysis.

Pre-trigger information

Another feature unique to digital storage technology is the capability to acquire and display pre-trigger data. An analog oscilloscope initiates a trace at the trigger point only; a typical DSO also can be set to display events leading up to a trigger point.

Pre-trigger viewing in a DSO is possible because the scope is constantly sampling the voltage value of an input signal. Thus, the trigger does not need to start the recording; it serves only as a reference point. Pre-trigger data is available because the scope reserves some portion of the waveform record for events occurring before this reference point.

This feature is especially valuable in power-supply testing. Just set the DSO to trigger at the power supply's stable output voltage, then arm it for a single sweep, with 75% of the waveform record being reserved for pre-trigger data. When you switch on the power supply, the DSO captures rise time data during power-up as part of the pre-trigger information, along with the subsequent ripple exhibited after the trigger point as the output voltage stabilizes.

Viewing pre-trigger data also provides an easy way to find the cause of a recurring circuit glitch. The glitch becomes the trigger event. The DSO captures information leading up to that point and displays it on-screen for analysis.

Signal processing

Signal processing capabilities provide a means for transforming raw waveform data into valuable information. In general, signal processing can be divided into two areas: enhancement of signal capture and subsequent data extraction.

One common method of enhancing signal capture, for example, is waveform averaging. By averaging together multiple waveform acquisitions, you can eliminate unwanted random noise riding on top of a repetitive signal, thus obtaining more precise and accurate measurements.

Record keeping

Finally, many DSOs offer the capability to document waveforms by interfacing with an external device via standard communication protocols. Options, which include GPIB or RS-232 interfacing, allow waveforms to be transferred to another device such as a printer or a personal computer.

With this capability, you can document waveforms in hard copy or retain them in standard PC memory media such as a floppy disk. You might even

create a library of standard waveforms used in servicing various equipment. The appropriate waveform can be downloaded to the DSO's reference memory when needed. You also can maintain a complete service record for a particular unit being serviced without using analog plotters or CRT cameras. In addition, preprogrammed test routines can be saved in a controller's memory, then recalled as part of a standard test procedure and sent to the DSO for execution.

The DSO's interfacing capabilities make teleservicing possible. With a telephone modem, a service technician in the field can gain access to a central waveform database. The technician could also transmit the waveforms encountered to the main servicing facility, enlisting the diagnostic assistance of other technicians.

Digital storage technology

The principal difference between a DSO and its analog counterpart is the addition of a *digitizer*, or analog-to-digital (A/D) converter. The digitizer transforms an analog signal into discrete voltage values over time, then stores these values in memory as a digital record of the waveform. This process consists of two steps: *sampling* and *quantizing*. A waveform is sampled to obtain a voltage value of the input signal at sample points equally spaced in time. Quantizing then transforms the voltage value into a binary number for storage.

The resolution for transforming continuous values into discrete values is determined by the number of *bits* (from binary digit) available to the A/D converter. A 2-bit converter, for example, would have four (2^2) discrete amplitude levels available to describe a signal at any given time. (For example, for a full scale of 0V to 10V, levels would range from 0 to 2.5, 2.5 to 5.0, etc.) The higher the number of bits available to the digitizer, the greater the subdivisions of a full vertical scale. For example, an 8-bit digitizer has 256 levels, while a 10-bit digitizer has 1,024 levels (or 1/100th of a division).

Although a higher number of bits allows greater discrimination between voltage values, the accuracy of your DSO measurement may be limited by other factors, including the accuracy of the vertical amplifier. Thus, the accuracy of a DSO is normally specified consistent with its analog counterpart (typically 2% to 4%). The usefulness of a high number of bits available to the digitizer also may be limited by screen resolution or cursor measurement accuracy. For instance, the resolution of a CRT screen is limited by its spot size, which typically ranges from 1/25 to 1/50 of a division.

Horizontal resolution

Waveform record length also has an impact on signal detail. Generally, the more samples recorded during a given unit of time, the greater the horizontal resolution. Longer record length provides the advantage of capturing an entire waveform event while maintaining the time resolution needed for detailed analysis.

For example, a transient waveform often displays a fast rise time, requiring a fast time-base setting for reasonable sampling resolution (lots of samples per unit of time). Yet, without adequate record length, such a fast sweep setting may result in a record duration that is too short to capture the entire transient. Conversely, slowing the sweep speed in order to display the whole signal may result in inadequate resolution for the fast-rising edge. The solution is a longer record length.

Some DSOs offer the flexibility of varying the record length for each application. This capability, however, involves a tradeoff—resolution vs. record update rate. The tradeoff exists because as more samples are taken, the time required to fill the record and display it on-screen becomes longer.

Sampling rate

The *sample rate*, or frequency at which a sample is taken, is the final factor in determining the level of detail of a digitized waveform. The sampling rate (also known as the *digitizing rate*) is usually expressed in terms of the maximum number of samples that can be taken in one second by the A/D converter (for example, 10 megasamples per second, or 10MS/s).

Another way to express sampling rate is by the *sampling interval*, or period of time between sample points. Sample interval is the inverse of frequency. (For example, at 10MS/s, the digitizer is sampling every 100ns.)

In order to relate sampling rate to a bandwidth specification, you need to understand the method of sampling being used. There are two different sampling techniques: *real-time sampling* and *equivalent-time sampling*.

In real-time sampling, all samples are

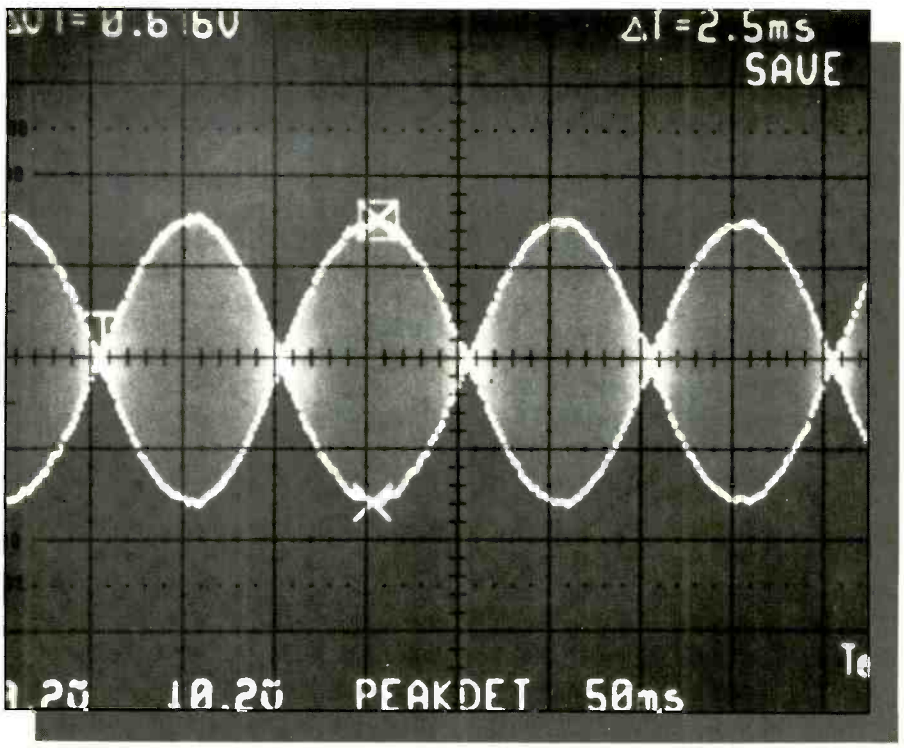


Figure 2. The DSO provides a stable, flicker-free display for displaying low-repetition signals. In this example, a head radial-alignment waveform (cat's eye) is displayed for on-screen amplitude measurements.

taken sequentially over a single acquisition of the waveform, as in capturing a single-shot event. Because there is only one sweep of the waveform, all samples must be taken in real time. This limits the useful storage bandwidth for single acquisitions to two factors: the number of samples that can be taken during a single sweep and the number of samples required to characterize a given waveform.

Theoretically, a sine wave can be characterized by only two points (according to Nyquist theory). Thus, real-time sampling is capable of capturing a single-shot waveform with frequency components as fast as half the sample rate.

In reality, however, you need more data points per cycle to adequately define or measure the transition parameters of a more complex waveform. Therefore, the useful storage bandwidth is typically considered at a rate that can capture six to 10 samples or more per waveform cycle. For example, a DSO with a 20MS/s sampling rate would have a useful bandwidth of 2MHz if 10 data points per cycle were expected to characterize the waveform.

Another sampling technique, equivalent-time sampling, extends the useful storage bandwidth of a DSO. With repetitive waveforms only, a full complement of sample points can be built up over several sweeps of the waveform. During each sweep, a small portion of the waveform detail is captured. This process repeats until a full record is available to reconstruct the complete waveform. Equivalent-time sampling can generally extend a DSO's useful frequency range to match the analog input bandwidth of the oscilloscope.

Actual sampling rate vs. time setting

Although a DSO is specified by its maximum sampling rate, the actual rate used in acquiring a given waveform is usually dependent on the time-per-division setting of the oscilloscope. The record length defines a finite number of sample points available for a given acquisition. The DSO must, therefore, adjust its sampling rate to fill a given record over the period of time set by the sweep speed.

To determine the sampling rate for a given sweep speed, you simply divide the number of *displayed points per division* into the *sweep rate per division*. For example, a DSO with a 1K display record length has 100 sample points per division. Dividing this value by the sweep rate per division gives you the sampling frequency (subject to the maximum rate of the digitizer clock). With a 1s/division sweep rate, the sampling rate would be 100 samples per second (or a 10ms sampling period). At 5μs/division, the sampling rate increases to 20MS/s (100 points/division divided by 5μs/division), or 50ns between sample points. By adding more points to the displayed record length, the actual sampling rate increases. (For example, with 400 points per division, a 1s/division sweep setting would result in 400 samples per second, or 2.5ms per sample point).

Two additional features can modify the actual sample rate. The first is the use of an external clock for pacing the digitizing rate. With the internal digitizing clock disabled, the digitizer will be paced at a rate you define. The source of the external clocking signal could be linked to a trigger event, causing the DSO to take a sample at each turn of a motor, for example.

The second method of modifying the actual sample rate is known as *peak detection* or *glitch capture mode*.

Peak detection

Peak detection allows the digitizer to sample at the DSO's full digitizing rate, regardless of the time-base setting. The minimum and maximum values found between each normal sample interval (as defined by the time-base setting) are retained in memory. You can use these minimum and maximum values to reconstruct the waveform display using a special algorithm that recreates a smooth display along with any captured glitches.

Peak detection allows the DSO to capture glitches even at its slowest sweep speed. Regardless of the time-base set-

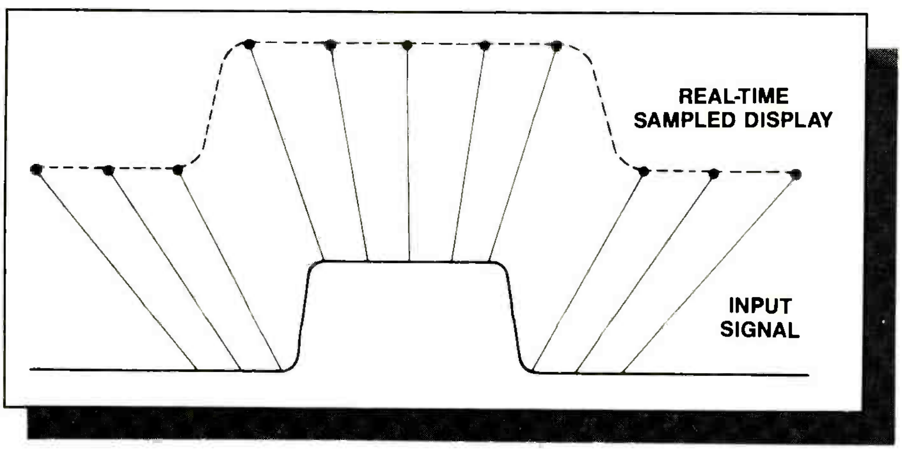


Figure 3. In real-time sampling, each point is displayed as it really occurs in time. Only one complete sweep is needed to display the input waveform.

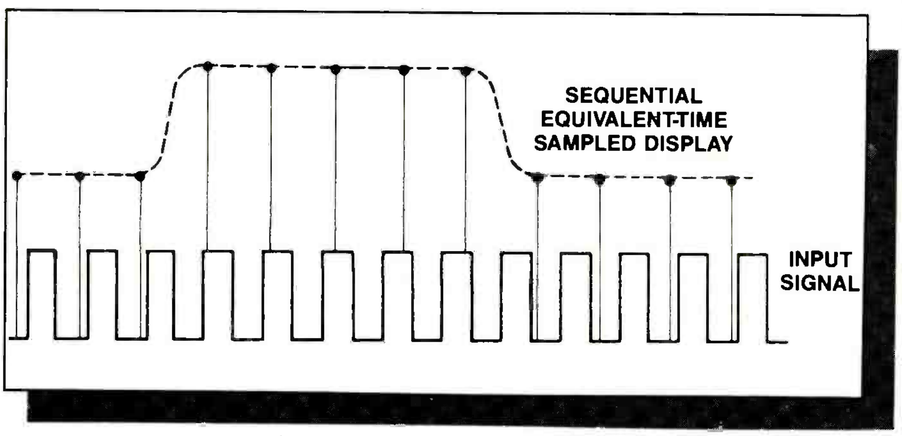


Figure 4. In equivalent-time sampling, successive samples of the signal to be captured are taken over many stable waveform repetitions. The signal is reconstructed from the samples.

ting, peak detection enables the DSO to place samples on narrow pulses discovered by sampling at its fastest rate. For example, a digitizer capable of sampling at 10MS/s can detect excursions as narrow as 100ns, even when viewing a 50s event. Without peak detection, such glitches can easily fall between samples and be missed entirely.

One method of peak detection provides for even greater troubleshooting efficiency. Known as *peak-accumulation* or *envelope mode*, this approach accumulates and displays the maximum and minimum excursions of a waveform for a given point in time. This approach builds an envelope of activity that can reveal infrequent noise spikes, long-term amplitude or time drift, and pulse jitter extremes. Figure 5 illustrates the advantage of peak accumulation when variations in data pulse width are monitored.

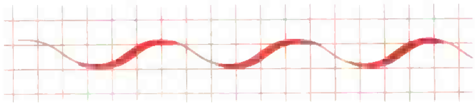
Once you've reviewed the basic DSO specifications, the next task is to decide which features are most beneficial to your application. Will you require capturing and displaying glitches that occur between normal sample intervals? How many reference memory locations will you need? Do you need point-selectable pre-trigger data? How much post-acquisition waveform processing do you need?

Choosing a DSO

When selecting a DSO, you should determine what type of signals you normally measure—are they repetitive or transient, and how frequently do they occur? As described earlier, these factors affect the storage bandwidth and sampling methods required.

You should also consider what level of signal detail you need. Are you seeking accurate waveform parametric data, or are you merely comparing against a visual standard (for example, when calibrating)? Remember, signal detail is determined by the number of digitizer bits, the record length and the sample rate.

Once you've reviewed the basic DSO specifications, the next task is to decide which features are most beneficial to your application. Will you require capturing and displaying glitches that occur between normal sample intervals? In this case, peak detection will be a valuable feature. How many reference memory locations will you need, and should they be battery-backed? Do you need point-selectable pre-trigger data? How much post-acquisition waveform



processing do you require? Would you benefit from interfacing over a built-in communications port to a plotter, a printer or an external controller such as a PC?

Features common to conventional oscilloscopes also should be included in your purchase criteria. Will you need,

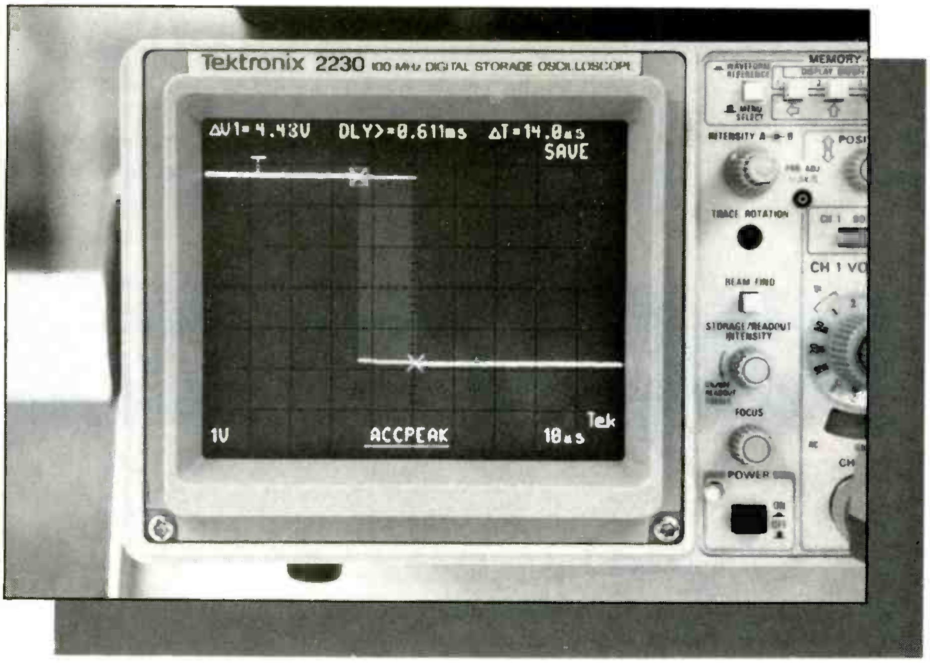


Figure 5. Accumulate peak-detect mode reveals signal excursions over time—in this case, variations of data pulse width.

for example, analog capabilities along with digital advantages to display complex waveforms in real time? Are measurement cursors or advanced signal-processing features valuable for your application? How portable is the unit? Is it rugged enough to withstand the rigors of service applications? Is the unit third-party certified for safe and reliable operation? What are the anticipated after-purchase costs (length of warranty, reliability and after-sale support)? Finally, how simple is the oscilloscope to learn and operate?

By carefully considering all of these factors, you can significantly simplify the task of selecting a DSO for your application. Understanding how you use an oscilloscope today and how you anticipate using it in the future is the first step. Considering the advantages of digital storage technology—enhanced productivity and improved accuracy—is the next step. ES&T

Books/Photofact

Editor's Note: Please direct inquiries to the addresses given beneath each book write-up rather than to ES&T.

Understanding Data Communications, 2nd Edition, by Gilbert Held; Howard W. Sams & Company; 304 pages; $17.95.

This book combines a general overview of data communications with detailed explanations of specific technologies. It includes all features of the Understanding series plus review questions and answers at the end of each chapter. Asynchronous and synchronous modems, network design and management and digital multiplexing are emphasized. V.22bis and Packetized Ensemble Protocol modems are also covered.

Howard W. Sams, 4300 W. 62nd St., Indianapolis, IN 46268; 800-428-SAMS.

Crash Course in Electronics Technology, by Louis E. Frenzel, Jr.; Howard W. Sams & Company; 400 pages; $21.95.

The third book in the Crash Course series, this book is a tutorial to help hobbyists, technicians, students and laypersons learn basics of electricity and electronics. In a step-by-step, self-paced, self-instructional format, electricity is introduced and followed by a discussion of circuit basics and electronic devices. The book then presents a discussion of electronic communication, controls, motors, test equipment and troubleshooting with illustrations and examples.

Howard W. Sams, 4300 W. 62nd St., Indianapolis, IN 46268; 800-428-SAMS.

PHOTOFACT

EMERSON
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QUASAR
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SEARS
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TEKNIKA
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2583-1 . . . . FH202, TF2085 (CH. ECC-2111)

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2584-2 . . . . CF2047, CX2047C
2585-2 . . . . CX2077, CX2077C

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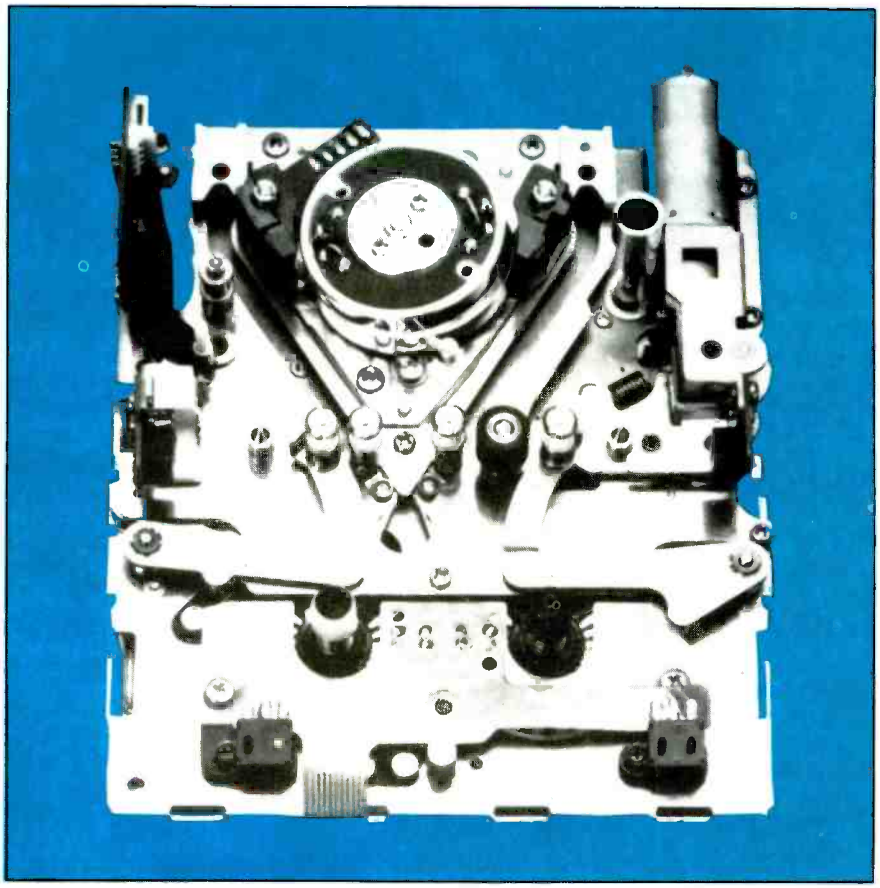
2583-2 . . . . C1308S, C3338W, V3308W

ES&T

Audiotape gets rapid transit



The F.A.S.T. R-DAT tape-transport mechanism uses a symmetrical link-arm mechanism that rides in precision V grooves. The link-arm loader allows playback within 2 seconds of receiving the command. A half-load position allows tape search at speeds almost 400 times greater than real time (twice the speed of conventional transports).

Nakamichi Corporation has announced an R-DAT tape-transport mechanism that provides more precise tape guidance and higher search speeds.

The mechanism, called F.A.S.T. (for fast-access stationary tape guide-transport), can perform a tape search at almost 400 times real time, or twice the speed provided by conventional transports. A half-load position allows the faster search speed with less tape damage than a conventional mechanism with full-load search.

The mechanism also differs from conventional transports by using a symmetrical link-arm mechanism that rides in precision V grooves. The link-arm loader also provides faster startup. Playback begins less than 2 seconds after the command is given.

A primary difference between the F.A.S.T. mechanism and conventional R-DAT designs is the use of stationary tape guides at both sides of the head drum. In other transports, the position of the tape against the head drum is determined by inclined pins that ride on the tape-loading arms. Because the pins move the arms, the precise position of the tape cannot be ensured from one loading operation to the next. In the F.A.S.T. mechanism, precision slot guides are mounted to the chassis in a fixed relationship to the head drum, ensuring a stable tape path.

The mechanism is compatible with DAT Conference Standards and can be used in DIN-sized mobile DAT players as well as in home decks. Nakamichi will use the mechanism in an upcoming line of DAT decks. The company also has entered into an arrangement with a leading Japanese supplier to provide the transport to other tape-deck manufacturers.

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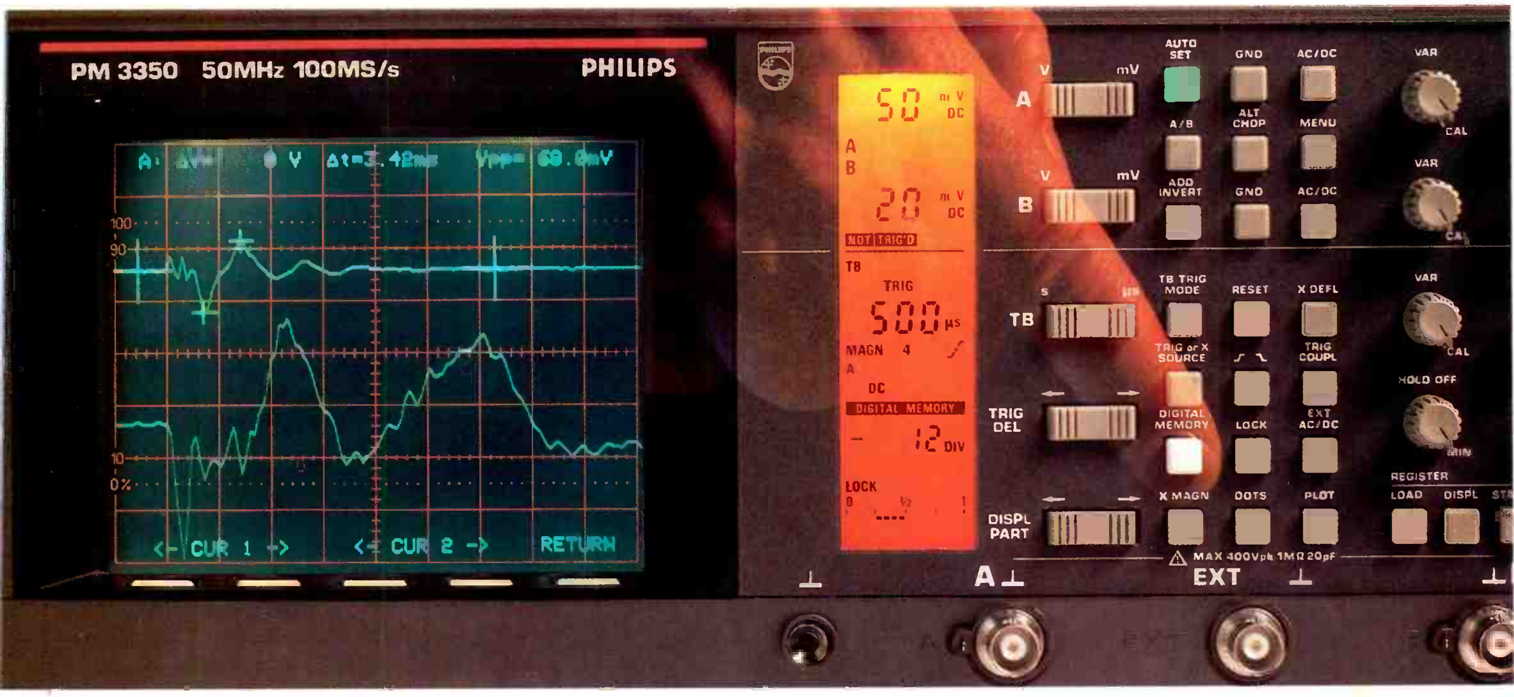

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Circle (10) on Reply Card

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Repair that digital DMM

By Victor Meeldijk

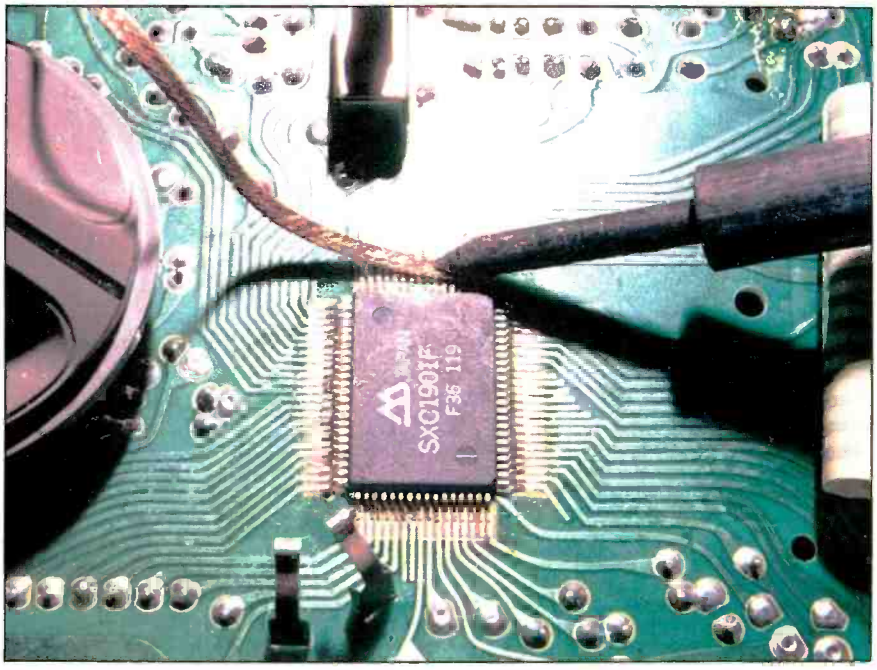
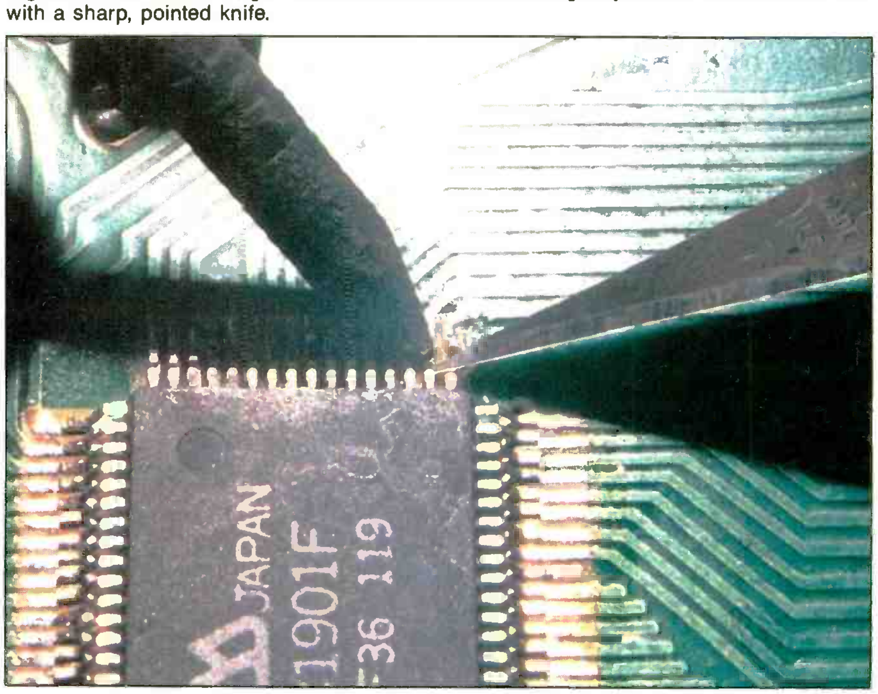


Figure 1. Desoldering braid is used to replace the 80-pin, surface-mount IC. A grounded soldering iron and a wrist strap prevent ESD to the static-sensitive IC.

Figure 2. After desoldering, each connection is heated and gently lifted from the circuit card with a sharp, pointed knife.



Before you throw away that multimeter, try to repair it. This actual case history of the diagnosis and repair of a Radio Shack Micronta LCD digital multimeter (model 22-192) also illustrates practices that should be followed with any repair.

The DMM came back from the calibration house with this notation: "Meter will not zero in the ohms-adjust range, reads 30.7Ω, defective IC, not economic to repair." Having had a previous experience where the repair was actually easier and cheaper than was estimated, I decided to attempt an evaluation/repair.

The first step, confirming the failure symptoms, showed that with the leads shorted, the meter reading was in the range of 150Ω.

I opened the unit, taking care to observe static sensitivity handling procedures (with a table mat and a wrist strap), and examined the circuit. No parts appeared to be missing, but a few solder connections had been resoldered (with flux residue left on the board), and a ground trace to some circuitry had been cut. After cleaning the flux and repairing the cut trace, I took some measurements on the defective DMM and on an identical unit that functioned properly. (See Table 1 for the values read during those tests.)

The results of those measurements seemed to indicate that the problem was isolated to the resistance section of the DMM, although the calibration of the voltage section needed adjustment. The next step was to check the precision resistors used in the resistance measurement section. Using the values indicated on the schematic (Figure 1) and the resistor color bands, I obtained the results shown in Table 2.

Next, the OVX-OVS sections and the surge absorber were checked. The results are tabulated in Table 3.

Meeldijk is reliability/maintainability engineering manager at Diagnostic/Retrieval Systems.

The readings for TR_1 were not identical for the defective and control-unit DMMs, which could still indicate a defective IC. I needed to conduct more tests to be sure.

As is the case when most multimeters are tested, resistance measurements are actually made by measuring the voltage drop across the device under test. In the case of this DMM, resistance is measured by applying a known constant current to the unknown resistance and measuring the resultant voltage drop. The voltage divider components were, therefore, the next logical components to check. For the results of these tests, see Table 4.

Using the range-hold switch, I checked the current/voltages available at each resistance range. (These values are listed in the owner's manual.) See Table 5 for the results of these tests.

Replacing the IC

These results were again inconclusive and did not pinpoint any discrete component as being defective. At this point, I determined, by a process of elimination, that the IC was defective. I ordered a new part (number MX-5227) from Tandy National Parts. A service manual (part number MS-2200192) was also available.

To replace the 80-pin, surface-mount IC, I used desoldering braid on all the solder connections (see Figure 1), applying heat with a grounded-tip soldering iron to prevent possible electrostatic discharge damage. Each connection was then heated and lifted with a sharp, pointed hobby knife (Figure 2).

After removing the IC, I aligned the new part with the PC card traces and held it down with a finger. I then made solder connections to each corner of the device in order to hold the IC's alignment while all the other solder connections were made.

After the IC was replaced, I again tested the DMM. The resistance reading with leads shorted together was 177.7Ω;

Table 1.
DMM measurements

Condition	Defective unit	Control (functioning) unit
kΩ-open circuit	1.000 blinking	same
kΩ-short leads	153.4Ω to 153.6Ω	1.2Ω to 1.3Ω
kΩ-short leads, ohm-adjust on	150.2Ω to 150.3Ω	0.00Ω
Diode continuity on	0.15Ω, buzzer sounds	0.00Ω, buzzer sounds
Diode continuity on, ohm-adjust on	0.00Ω, buzzer muted	0.00Ω, buzzer sounds
dcv range, used 1.5V battery	1.586V	1.426V
ac voltage, to wall outlet	133.2V	126.5V

Table 2.
Precision resistor checks

Reference des.	Schematic	Measured
R_6	1.64MΩ	1.64MΩ
R_7	164kΩ	163.5kΩ
R_8	16.4kΩ	16.43kΩ
R_9	1.64kΩ	1.646kΩ
R_{10}	164Ω	162.6Ω

Table 3.
OVX-OVS section/surge absorber checks

Reference des.	Schematic	Measured
R_{12}	100kΩ	100.3kΩ
R_{13}	100kΩ	100.3kΩ
C_1	0.22μf	Checked by replacement—no effect
SA	—	Checked by removal—no effect
R_{14}	5kΩ	4.99kΩ
R_{15}	100kΩ	100.1kΩ
TR_1	—	Defective unit: E=−0.19V B=1.52V C=0V Control unit: E=0V B=1.38V C=0V

Table 4.
Voltage divider checks

Reference des.	Schematic	Measured
R_2	1.11MΩ	1.1MΩ
R_3	101kΩ	100.6kΩ
R_4	10kΩ	10.01kΩ
R_5	1kΩ	1.000kΩ
C_7	0.01μf	Tested by removal—No effect on shorted-lead measurement.

Table 5.
Current/voltage for resistance ranges*

Range	Spec. value	Defective unit	Control unit
200Ω	1.5V/1.4mA	1.556V/1.136mA	1.43V/1.202mA
2kΩ	0.65V/160μA	0.655V/150μA	0.649V/145μA
20kΩ	0.65V/30μA	0.665V/30μA	0.658V/30μA
200kΩ	0.65V/4μA	0.666V/3μA	0.659V/3μA to 4μA
2,000kΩ	0.65V/0.4μA	0.666V/0.000μA	0.659V/0.000μA

*Readings shown as open/short-circuit values

with ohm adjustment, the reading was 170.2Ω.

During this checkout, I put the spare fuse into the meter. The resistance value went to 200Ω. I didn't consider this reading significant because it was taken the next day, and some other component drift was suspected. Later information, however, proved that this change of resistance reading was, in fact, significant and should have been investigated. (How many times have you said to yourself, "But it *looked* OK"?)

Knowing that there was a defective component still in the circuit, I tried spraying coolant to isolate the problem part. I found that capacitor C_4 was sensitive to the cold: The short-circuit resistance reading went to as low as 8.9Ω when this part was cold. With C_4 replaced with a new Mylar capacitor, the resistance reading was 108.3Ω (99.9Ω with the ohm-adjust on).

At this point, the old IC was swapped back for comparison purposes and readings of 91.2Ω and 89.9Ω were obtained. The service manual does not explain the operation of the C_4-C_5 section of the meter, so I contacted Tandy Service for further details.

Although the company could not provide details on this section (this meter was designed by an engineering staff in Japan), the symptoms were known to be related to a batch of defective 0.315A fuses that had a resistance of about 100Ω instead of the specified 1Ω to 2Ω. The actual measurement for the DVM fuse was 93.4Ω (115Ω for the spare fuse).

Circle (12) on Reply Card

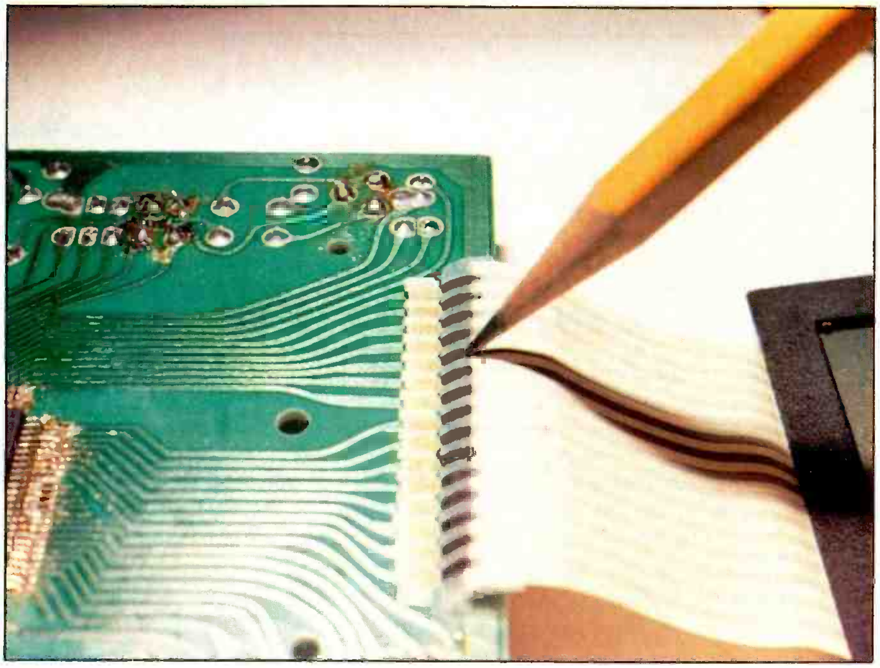


Figure 3. A lead pencil can be used to repair LCD traces.

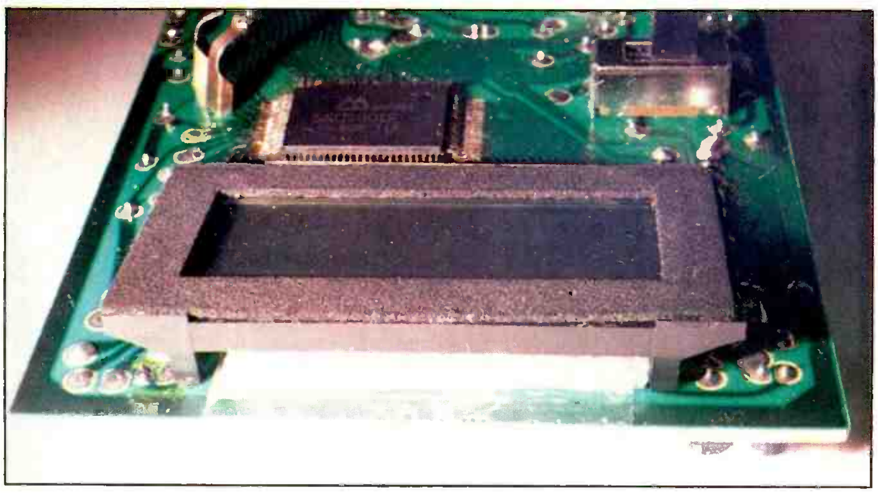


Figure 4. Foam placed between the LCD display and the display connector tape will enhance connections to the PC card when the display is screwed down.

Replacing the original with a good fuse resulted in a shorted test-lead reading of 1.1Ω (0.00Ω with the ohm-adjust on).

During final repairs, I encountered problems with the display and with other meter functions. The display/connector tape separated from the printed-circuit card, and some traces opened in the connector tape. I repaired the connections by rubbing them with a lead pencil (Figure 3). Proper connections to the PC card were enhanced by foam material between the display and the connection tape. The foam would press on the PC-card connections when the display was screwed to the PC card (Figure 4).

Cold solder joints and solder bridges resulted in missing display segments. I used the repair manual to pinpoint the problem connections. I also encountered two other problems on the way to completing this repair. The first was the ac current/ac voltage ranges, which did not read zero with the test leads shorted. This was caused by a solder bridge in the ac/dc converter section. The second problem was voltage overranges that occurred when more than 20V (ac or dc) was measured. These overranges were caused by an open circuit in the voltage divider network.

Troubleshooting techniques

In this repair, as in any repair attempt, the following steps should be performed:

1. Determine the circumstances surrounding the problem. Did it fail after a power surge or brownout, was it dropped, etc.
2. Confirm the failure symptoms.
3. Visually examine the unit for previous repair attempts, missing parts, cut connections, solder flux or parts tacked in place.
4. Determine the possible areas where the problem may be coming from. (Did the visual examination reveal any charred circuit areas?) Check out each circuit section. Use manufacturer service data/schematics when available. If possible, compare test readings against a known-good unit.
5. Always investigate each anomalous condition. For example, I could have saved time if I had investigated the change in the meter reading when the spare fuse was installed.
6. After repairs are attempted, check all unit functions to verify that a new problem has not surfaced.
7. If problems persist, contact the manufacturer for assistance.
8. Keep notes of all your efforts during the repair. They may be useful for reference during the current repair and during future repairs if the same problem is seen again. ES&T

SYMCURE/ Troubleshooting Tips guidelines

ES&T is now paying $60 per page (six different cases of symptoms and their solutions) for accepted Symcure submissions.

The term *Symcure* is a contraction of two words: symptom/cure. Problems that are published in the Symcure department are those that have occurred more than once.

This is the kind of problem you can solve without even a second thought because you've already seen so many of that particular brand and model of set with those symptoms; in almost every case, it will be the same component that fails or the same solder joint that opens.

It is preferred that you submit six or seven symptoms and cures for a single TV model.

ES&T is also paying $25 per item for accepted Troubleshooting Tips.

A Troubleshooting Tip describes a procedure used to diagnose, isolate and correct an actual instance of a specific problem in a specific piece of equipment. Its value, however, lies in the general methods described.

A good Troubleshooting Tip has the following elements:

- It should be a relatively uncommon problem.
- The diagnosis and repair should not be obvious and should present something of a challenge to a competent technician.
- It should include a detailed, step-by-step description of why you suspected the cause of the problem and how you confirmed your suspicions—anything that caused you to follow a false trail also should be included.
- It should describe how the repair was performed and any precautions about the possibility of damage to the set or injury to the servicer.

For Symcures and Troubleshooting Tips, please also include:

- the manufacturer's name;
- the model and chassis number;
- the Sams Photofact number; and
- a sketch of the schematic area where the fault was found. (Include a major component such as a transformer or transistor to provide a landmark for the **ES&T** staff.)

What do you know about electronics?

Hall-controlled motors

By Sam Wilson, CET

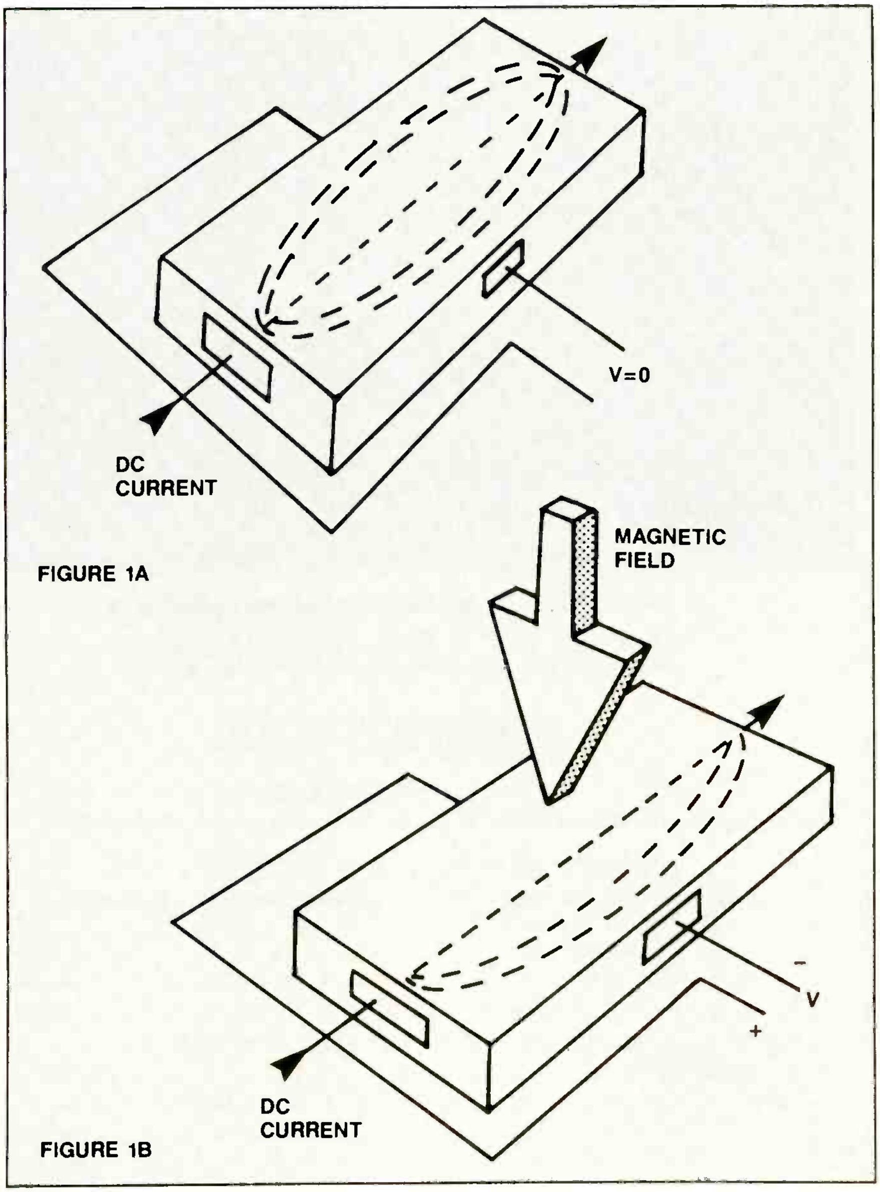


Figure 1. In the Hall device shown in Figure 1A, an electron current is flowing through a small semiconductor slab. The broken lines show that the electrons spread out because like charges repel. When a transverse magnetic field is introduced, as represented in Figure 1B, the electrons crowd to one side.

In previous articles, I discussed the Hall effect. I also discussed the phase-locked loop (PLL). Now I'll put those subjects together to show how motor speed can be controlled using those two concepts.

It's been a while since those subjects were covered, so I'll start with a short technical review.

Basic theories

The basic concept of the Hall device is shown in Figure 1. In Figure 1A, an electron current is flowing through a small semiconductor slab. The broken lines show that the electronics spread out because like charges repel. There is no output voltage because the electrons are equally distributed between the dc electrodes.

When a transverse magnetic field is introduced, as represented in Figure 1B, the electrons crowd to one side. This effect is similar to electron deflection in a picture tube.

In reality, the flow of the electrons is somewhat more complicated than shown in the illustration. When an electron moves through a magnetic field, its magnetic field reacts with the external magnetic field to produce a corkscrew motion. This motion occurs because the force on the electron is the vector sum of the forces produced by the motion of the electron and the magnetic resultant force.

Showing the corkscrew motion in the illustration of Figure 1A would make it unnecessarily complicated. Anyway, the overall result would be the same—a crowding of the electrons on one edge. The overall result is a dc voltage at the output of the Hall device.

Wilson is the electronics theory consultant for ES&T.

Figure 2 illustrates the basic idea behind the PLL. Two frequencies are introduced to the frequency and phase comparator (∅). One is a fixed frequency (f_1) from a precise frequency generator. The second frequency (f_2) comes from a voltage-controlled oscillator (VCO).

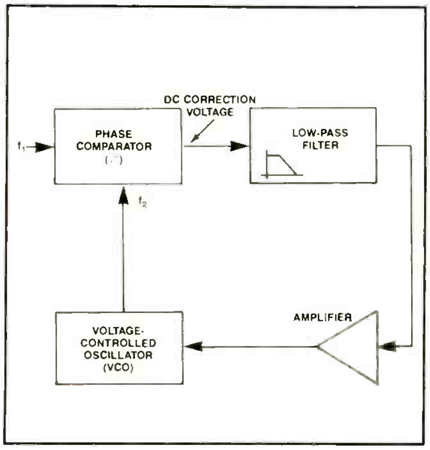


Figure 2. In a PLL, two frequencies (f_1 and f_2) are introduced to the frequency and phase comparator (∅). If the two input signals are not the same, a positive or negative correction voltage appears at the output of the comparator.

If the two input signals are the same in frequency and phase, the output correction voltage is 0V. When the frequencies are not the same, a positive or negative correction voltage appears at the output of the comparator.

The low-pass filter eliminates both f_1 and f_2, so only the dc correction voltage is delivered to the amplifier. This dc amplifier is optional, so you won't see it in every drawing of a PLL.

The correction voltage is delivered to the voltage-controlled oscillator. If f_1 equals f_2, the correction voltage is 0V (because there is no need for correction). Of course, the 0V correction voltage makes no change in oscillator frequency. If f_1 is not equal to f_2, the dc correction voltage will change the VCO frequency until those frequencies match. The result is that the VCO output frequency is locked to the reference frequency.

Combining the theories

In Figure 3, a Hall-controlled motor has been introduced into the loop in place of the VCO. This device consists of a dc motor mechanically connected to a rotating drum with two permanent magnets (M_1 and M_2) attached 180° from each other.

When a permanent magnet passes close to one of the Hall devices (H_1 or H_1), a pulse of voltage occurs at the output. Because of the way the magnets and Hall devices are positioned, there are four pulses out of the OR circuit for each 360° rotation of the drum. So, if the drum speed is 900RPM, the output of the OR circuit is:

$$\frac{900 \text{ revolutions}}{\text{minute}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} \times \frac{4 \text{ pulses}}{\text{rev.}} = 60 \frac{\text{pulses}}{\text{second}}$$

The amplifier delivers a dc voltage to operate the dc motor. In the equation above, the frequency of the pulses delivered to the phase comparator would be 60 pulses/second if the motor speed is correct.

If the motor speed is too fast or too slow, there will be a positive or negative correction voltage delivered to the am-

plifier. That correction voltage, in turn, will result in a change of motor speed until the motor turns at exactly 900RPM.

If a divide-by-two circuit is added to the circuit, as shown by the colored lines, the motor speed will double. The reason is that it is necessary to get 120 pulses per second out of the OR circuit. Then, when the 120 pulses/second are divided by 2, the resulting 60 pulses/second will match f_1.

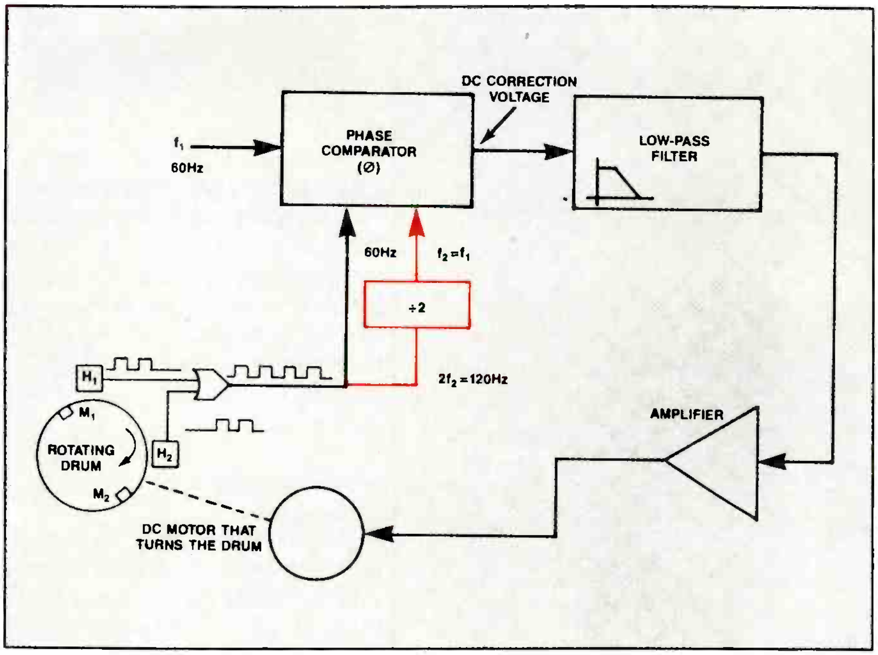


Figure 3. A Hall-controlled motor can be introduced into the loop in place of the VCO. If the motor speed is too fast or too slow, there will be a positive or negative correction voltage delivered to the amplifier. That, in turn, will result in a change of motor speed. The motor speed can be doubled by a divide-by-two circuit, shown by the colored lines.

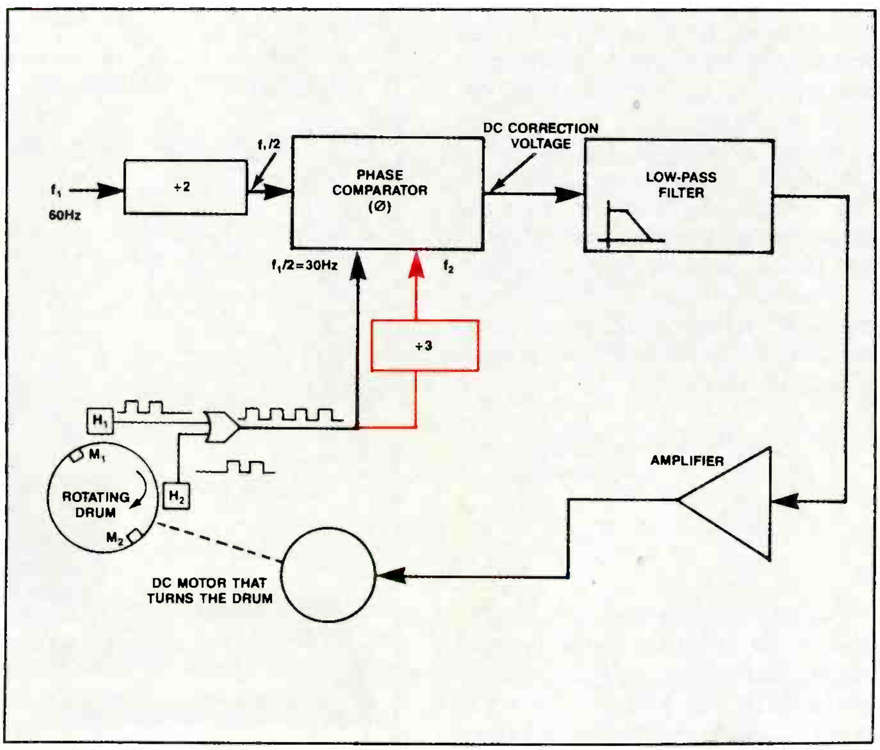


Figure 4. If a divide-by-two circuit is added at the input the motor speed will be reduced to half the value given for Figure 3. If a divide-by-two circuit is used at f_1 and a divide-by-three circuit is used at f_2 (see the colored lines), the motor speed with be 3/2 the original value.

If a divide-by-two circuit is added at the input, as shown in Figure 4, the motor speed will be reduced to half the value given for Figure 3. At half speed, the output of the OR circuit is 30 pulses/second in order to match the input (f_1/f_2) to the phase comparator.

If a divide-by-two circuit is used at f_1 and a divide-by-three circuit is used at f_2 (see the colored lines), the motor speed will be 3/2 the original value, or (3/2)900=1,350RPM.

Programmable dividers also can be used to get a wide range of speeds. A microprocessor can be used to set the programmable dividers. That way, the Hall-controlled motor speed is set by a microprocessor keyboard.

Another way to measure transformer imbalance?

Delbert S. Shafer of Warren, OH, has written to tell me about another way to determine imbalance in circuits. He adjusts the pot until the lamp filaments just barely glow. This is useful on pulses as short as one cycle (16ms). He uses this lamp on SCR-controlled resistance heating and motor-speed controls, the output of PA systems, the output of full-wave rectifiers (to see if one leg is leaking) and triac-controlled equipment. (His circuit is shown in Figure 5.)

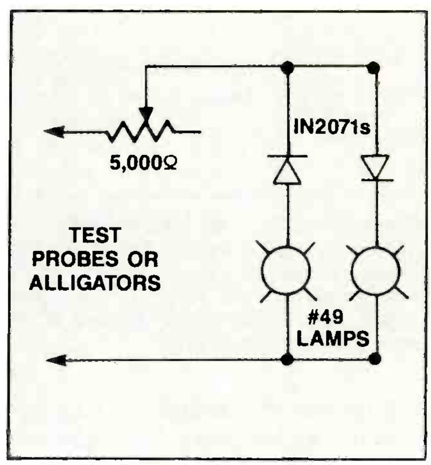


Figure 5. This figure shows another way to determine imbalance in circuits. The pot is adjusted until the lamp filaments just barely glow. This is useful on pulses as short as one cycle (16ms).

If any other readers have ideas for home-built test equipment and troubleshooting ideas, send them in so we can share them. ES&T

Quiz answers

Questions are on page 18.

1. In any order:
Electrostatic: A voltage can be generated by rubbing two dissimilar insulating materials together.

Chemical: A voltage can be created by immersing two dissimilar conductors (or semiconductors) in an acid or alkaline solution.

Heat (thermal): A voltage is generated when the junction of two dissimilar metals is heated.

Light: A voltage can be generated when certain materials are exposed to light.

Pressure (piezoelectric): Some crystalline materials generate a voltage when under pressure.

Electromechanical: Voltage is generated any time a conductor is moved through a magnetic field.

2. 0.0015321A. The resistance value is $3.33k\Omega \pm 2\%$. Maximum current flows when the resistance is at its lowest allowable value. (The question asks for the maximum current, not the current you can measure. The answer is OK for calculator accuracy.)

3. D—None of the above. For two reasons: The manufacturers say you should not return components to the board, and you should *never* epoxy a component to a board. (The epoxy is used during the *manufacturing* procedure.)

4. No. Both lamps are operating at their rated value. If the resistor can dissipate the required power, the circuit is OK as is.

5. 160Hz. One cycle will be displayed if the input frequency is 40Hz. (That's 1/0.025 seconds.) You need a frequency that is four times higher to display four cycles in the same amount of time.

6. B—point y. The greatest rate of change of current occurs as the sinewave current passes through zero.

7. An electret. It is the dual of a permanent magnet that has a permanent magnetic field.

8. No. The power *rating* is set by the manufacturer.

9. No. A fuse is blown by current, not voltage.

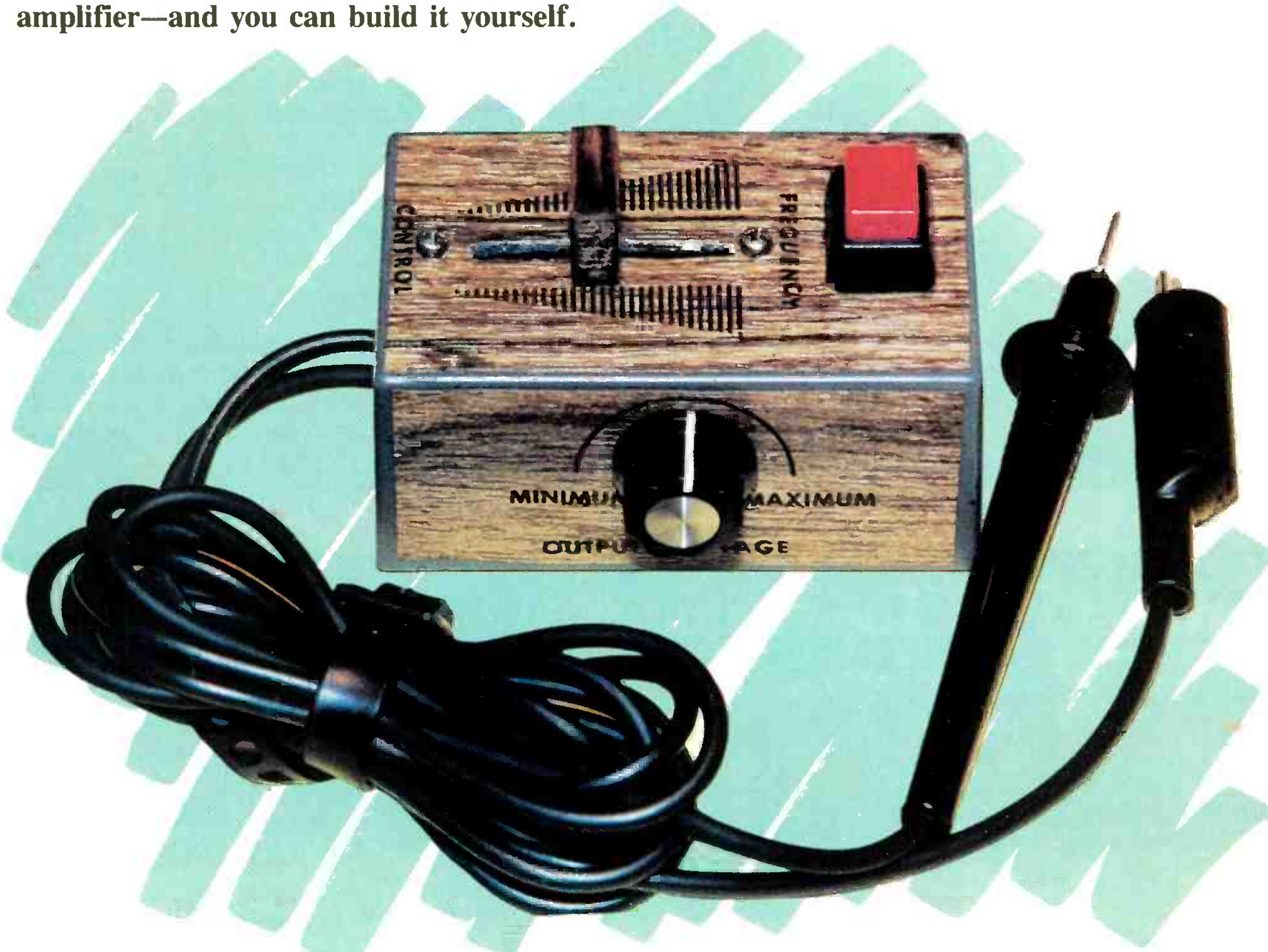
10. Yes. The voltage across L is equal to IX_L. If you double the current, you will double the voltage as long as X_L does not change.

ES&T

A build-it-yourself signal injector

By Gregory D. Lettera

This handy little gadget can help you track down a defective amplifier—and you can build it yourself.



If you need a simple tool for tracking down defective amplifiers, try out this square-wave signal injector. It's smaller than a pen or matchbox enclosure, and it's portable, which makes it ideal for bench or field work.

This simple multivibrator circuit has an approximate frequency range of 1kHz to 10kHz with a maximum output of about 1.4V peak-to-peak. The amplitude can be reduced by varying R_4 (see Figure 1).

The waveform (see Figure 2) is rich in harmonics. That gives it a wide frequency spectrum. The duty cycle can be changed by varying the resistance ratio at R_1. The frequency range can be altered by reducing or increasing the resistance value of R_2 and the capacitance value of C_1.

R_3 sets the probe to 600Ω of output resistance. Isolation protection can be increased by using a ceramic capacitor of 0.1μF. However, this change in capacitance will alter the rise time of the square-wave form and reduce the harmonic content.

The multivibrator is flexible and inexpensive to build. I built mine for less than $6 using parts from a local electronics supply house.

Lettera is an electronics lab technician at the New England Institute of Technology.

Parts and specifications:

IC = LM 3909
V_1 = 1.5V battery (AA)
C_1 = 0.15μF at 5V Wdc
R_1 = 10kΩ potentiometer (0.25W)
R_2 = 10kΩ potentiometer (0.25W)
R_3 = 600Ω (0.25W)
R_4 = 10kΩ potentiometer (0.25W)
Frequency range = 1kHz to 10kHz
Harmonic spectrum = 1kHz to 11kHz
Output voltage = 1.4V to 0V

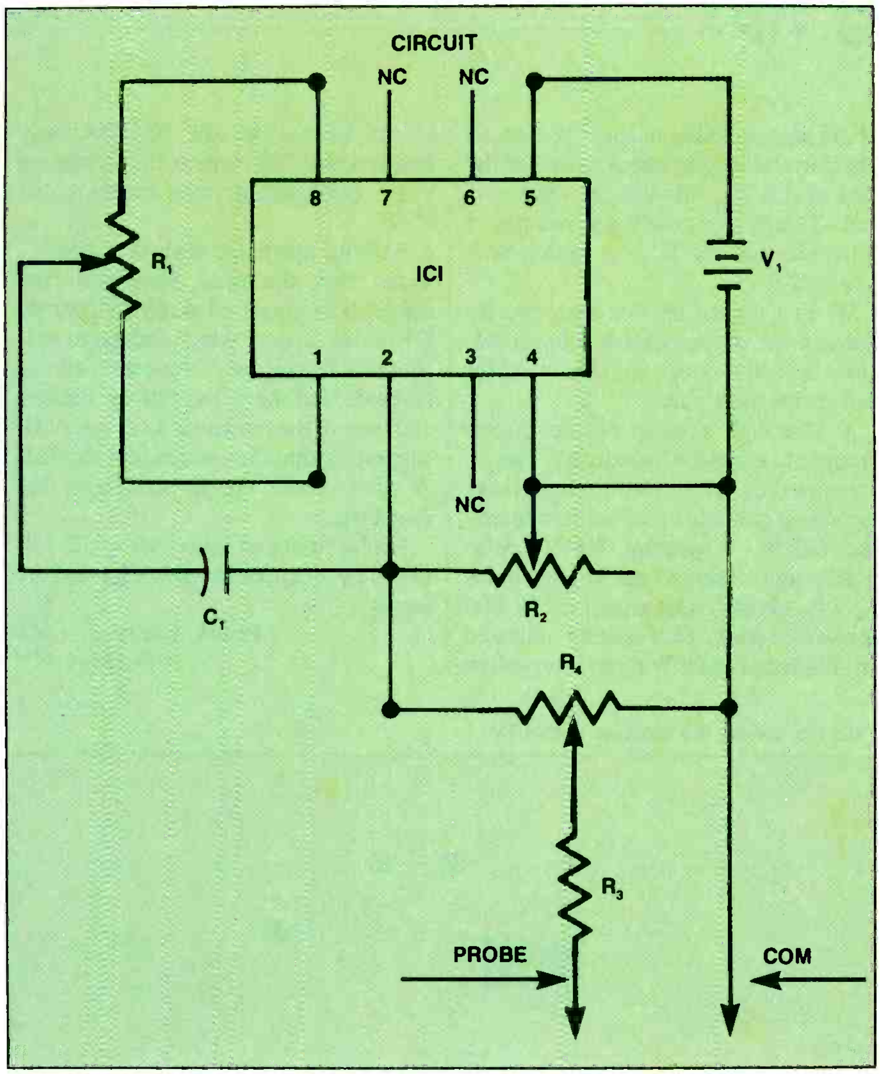


Figure 1. This simple, square-wave signal injector can help you track down defective amplifiers.

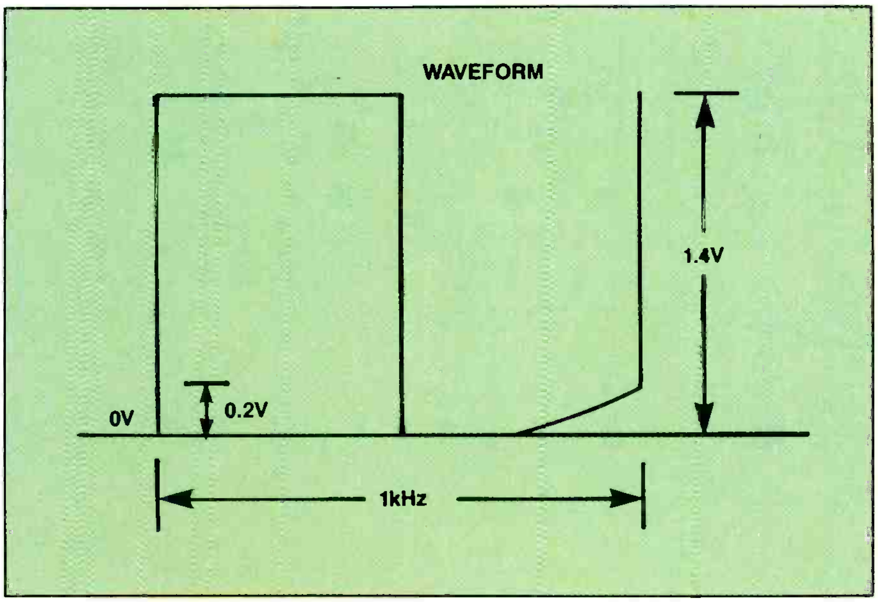


Figure 2. The waveform produced is rich in harmonics, with a wide frequency spectrum.

ES&T

Troubleshooting tips

Dark screen
RCA CTC 110
(Photofact 2033)

The problem with this TV was that the screen was black, but still had good sound. When I turned on the set, I heard the normal rushing sound that indicates high voltage is present. Turning up the screen control revealed that there was a blank raster with full deflection.

This symptom pointed to a problem in the video circuit. Because the heart of the video circuit in this set is U701, the luma/chroma IC (see Figure 1), I decided to scope the inputs to U701 (Y-pin 27 and C-pin 3). The signals at these points were normal. Next, I checked the output waveforms at pins 20, 21 and 22. There was no video at these points, so I performed voltage checks at all of the pins of this IC. All voltages were normal. This set of conditions led me to conclude that the IC was faulty, so I replaced it.

When I turned the set back on, instead of the proper picture I expected, I saw the same symptoms the set exhibited in the first place.

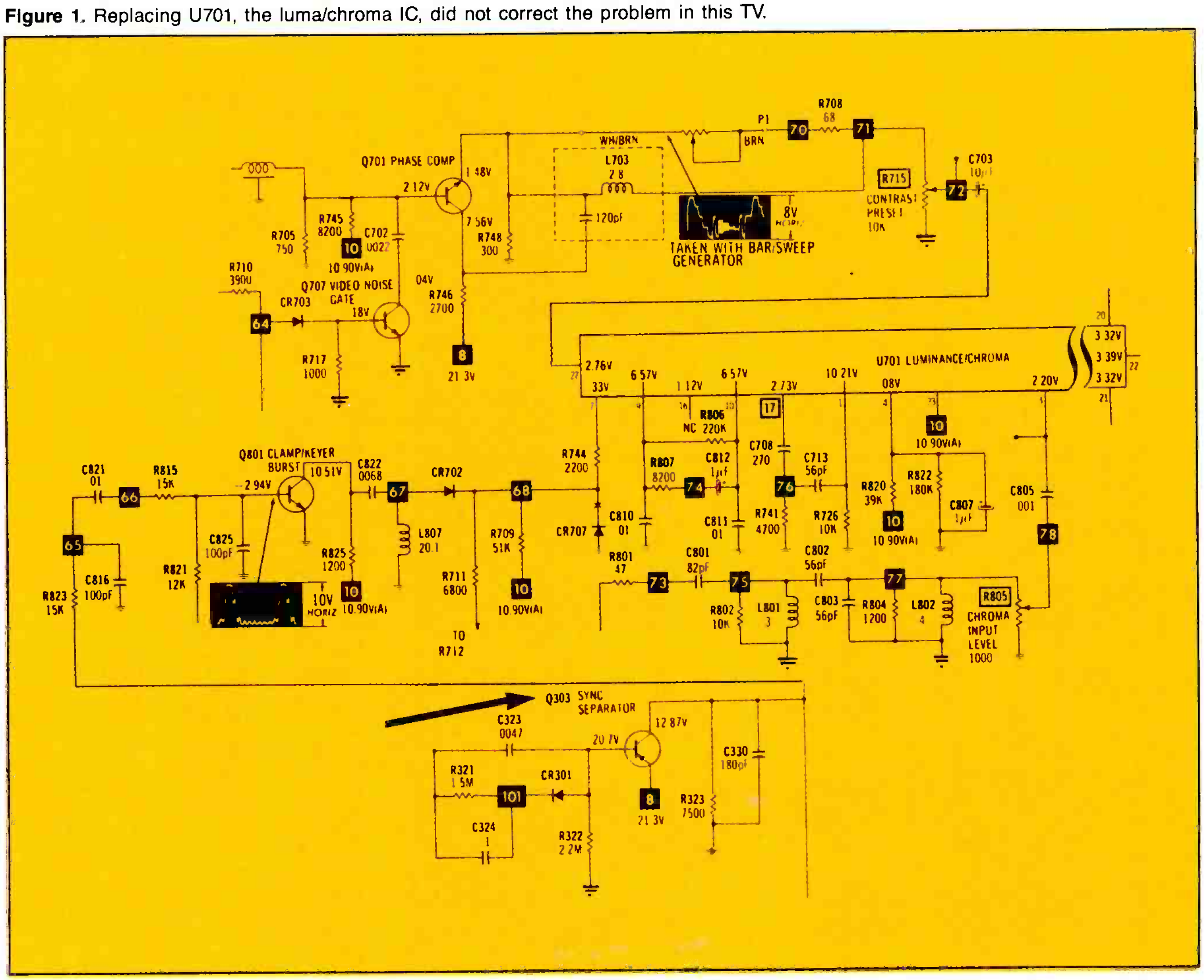
A thorough review of the circuit brought to mind the "sandcastle" waveform used by RCA. This timing/blanking signal is made up of vertical blanking (R710), horizontal IHVT pulse (R712) and a horizontal keying pulse (Q801). Scoping this signal at TP 806 showed no peak. This reading indicated an absence of sync. Without this portion of the sandcastle, the IC effectively blanked the CRT screen by preventing video information from reaching the CRT.

Probing upstream with the scope, I found that the sync waveform that should have appeared at the collector of Q303 was absent, which led me to suspect that transistor. Voltmeter readings revealed that the voltage at the emitter and base of the transistor were identical, suggesting that this device was shorted. A curve tracer check confirmed that diagnosis.

Replacement of transistor Q303 followed by a proper setup completed the repair.

Frank Comisso, CET
Buffalo, NY

Figure 1. Replacing U701, the luma/chroma IC, did not correct the problem in this TV.



VCR stays in PAUSE/STILL
GE VCR Model 9-7115

The customer who brought in this VCR complained that when a cassette was inserted into the VCR and the play button was pressed, the tape would load, but the unit would immediately go into the PAUSE/STILL mode. Pressing the PAUSE/STILL button had no effect. SCAN FORWARD and REVERSE worked normally, but when those buttons were released, the VCR went right back to PAUSE STILL.

I suspected problems on the timer/operation board and proceeded to check the input lines related to PAUSE/STILL operation. Even after the data 6 and scan 4 ports of IC7501 were isolated, the problem remained. I convinced myself that the culprit had to be the timer microprocessor. Well, 64 desoldered and soldered pins later, the new IC gave me no change of symptoms.

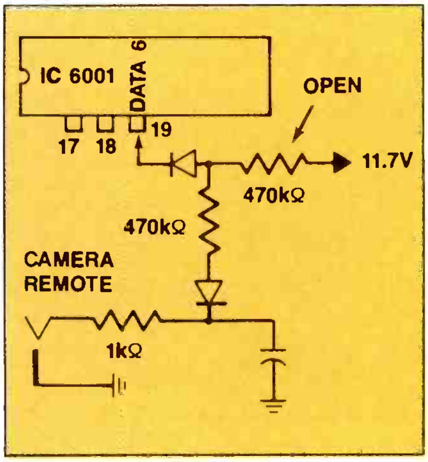


Figure 1. An open R6024 caused the voltage at pin 19 to be so low that the unit went into PAUSE mode.

I discussed the problem with a fellow technician, who casually mentioned that this mode of operation sounded like the operation of camcorders when they are loaded for recording. Bingo! Something clicked, and I realized that I had completely overlooked the camera remote line. Checking pin 19 (see Figure 1), I found that the data 6 line of the main micro, IC6001, showed about 1.8V. Normal voltage at that port is 3.1V. After desoldering pin 19, I turned the unit on and it played normally. Something was causing the voltage at that pin to be low enough to put the unit in PAUSE.

A few multimeter checks at points in the vicinity of Pin 19 revealed an open 470kΩ R6024, which feeds B+ to pin 19. Replacement of this resistor restored normal operation.

Ronald J. Patch
Bismark, ND

ES&T

PC diagnostic board

The Blue-Magic diagnostic board plugs into any slot of a PC and displays located errors on the monitor. The board can be purchased alone or with a portable printer. Exercise and monitoring operations, including self test, are carried out without keyboarding. The board tests BIOS read-only memory; the 8253 programmable interval timer (all three channels); the 8237 DMA chip (all four channels); the 8259 programmable interrupt controller (all eight channels); all lines of the 8255 PIO controller as three 8-bit ports; all RAM of the motherboard and installed memory cards; the keyboard-interface circuitry on the motherboard; and LPT1, LPT2, COM1 and COM2 and their support circuitry on the motherboard.

Circle (75) on Reply Card

Voltage detector

The model VH-600 Volt-Hound noncontact voltage detector from *A.W. Sperry Instruments* detects 100Vac to 600Vac with repect to ground. If the tip is placed near a live wire, the unit gives audible and visual indications. The hand-held unit weighs 1 ounce.

Circle (76) on Reply Card

Vision aid

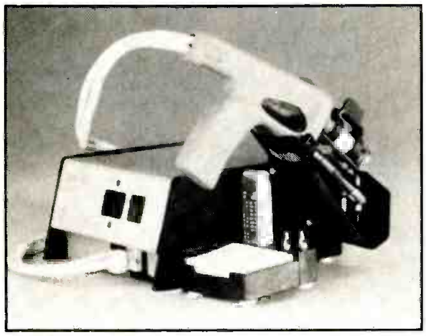
The Stereoptic Magnifier vision aid from *Edroy Products* provides up to 48 square inches of distortion-free, illuminated viewing area and maintains complete depth of field through all focal

distances. The base provides stability in extending the lens assembly up to 19 inches from the rear of the base and up to 13 inches high. The lens angle is adjustable. Two models are available, each with one or two lenses and with or without a lamp.

Circle (77) on Reply Card

Desoldering stations

Plato Products has introduced three products that meet DOD standards. The V-985 and V-185SF fully grounded desoldering stations meet military and



navy specifications for transient voltage of 2mV peak-to-peak. The V-985 shop air model is a spike-free station equipped with circuitry to prevent transient voltages at the tip. The V-185SF, a spike-free station with an internal generator, features a quick-cleaning solder collector and non-clogging tip and conduit.

Plato has also introduced permanently static-dissipative products that meet DOD and Mil specs. These products include flux and liquid dispensers, lead cutters and desoldering wick in a variety of sizes.

Circle (78) on Reply Card

Wire-wrapping gun

The OK-730 hand-held, air logic wire-wrapping gun from *O.K. Industries* has a triggerless "thumb sensor" that eliminates muscle fatigue. The gun is used with the ALC-730 Air Logic Control Unit. A small amount of air is released constantly through the thumb-controlled air hole. When the thumb blocks the hole, the air flow switches to engage the air motor and rotate the standard bit and sleeve.

Circle (79) on Reply Card

Delayed-sweep scope

The *Phillips* PM 3070 100MHz, delayed-sweep oscilloscope is a dual timebase model that has full cursor measurement capabilities in the time and amplitude axes. The scope features automatic display set-ups, two input channels and a third channel (Triggerview). A zoom function allows a section of the measured signal to be pinpointed by the cursors and expanded to the width of the screen. Measurement calculations automatically include the probefactors, magnifier and timebase used.

Circle (80) on Reply Card

Wire locator

The model 50B wire locator from *Contact East* is designed to locate the path and depth of buried telephone and service wire and to locate the end of a cut or open wire. It operates on dead and active lines and will locate conductors 3-foot deep. The unit includes a lightweight, solid-state transmitter and a receiver.

Circle (81) on Reply Card

Write-protect device

Director Technologies has introduced the Disk Defender, a hardware write-protect device for fixed Winchester disks. The circuit board plugs into any IBM XT, AT or compatible. The device permits protection of a portion of the disk while allowing operation of full read and write functions on the rest of the disk. A control box provides full or partial protection. The device is transparent to and operates independently of software and can be used with multiple operating systems on one disk.

Circle (82) on Reply Card

PC maintenance and repair kit

The JTK-39C "Blue Max" maintenance and repair kit from *Jensen* is designed for PC workstation assembly, cable repair, routine removal and installation of circuit boards and disk drives. The kit includes a selection of

tools, a soldering iron, a hex key set, insertion/extraction and IC inserter tools, a pen light, an adjusting tool and more. The case has room for an optional probe meter.

Circle (83) on Reply Card

Anti-static cleaner

Staticide anti-static cleaner from *ACL* cleans and controls static electricity on table tops, anti-static mats and work stations. It leaves no film, is non-abrasive and non-flammable.

Circle (84) on Reply Card

Foam swabs

The PURSWAB line of textured foam swabs has been introduced by *Hardwood Products*. The swabs are available with foam or foam-over-cotton tips with polypropylene or wood shafts. A variety of sizes and shapes are available.

Circle (85) on Reply Card

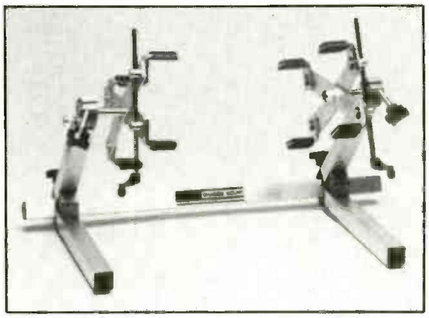
Computer carrying case

Chicago Case Company has introduced a foam-lined carrying case for transporting lap-top computers and portable printers. The case is made of polyethylene and features a removable top with a compact brief case for paper storage.

Circle (86) on Reply Card

Chassis holders/mounts

PanaVise Products has introduced two chassis holder/mounts for load capacities of more than 100 pounds and width



capacities of up to 18 inches. The devices are made of 1¼-inch square aluminum alloy tubing and allow a pivot-center height of 9 inches from the work surface. For safety, a positive lock detent is visible while the chassis heads are rotated, and a visual indicator shows when the safety latch is engaged. The all-metal friction brakes allow for either left- or right-hand operation.

Circle (87) on Reply Card

Industrial test lead set

John Fluke Mfg. has introduced the TL20 industrial test lead set. The set features heat-resistant test leads and interchangeable alligator clips (with retractable jaws) and stainless steel, needle-point test probes. The leads are 1.6m long. The shrouded banana plug connectors provide twice the standard number of contacts.

Circle (88) on Reply Card

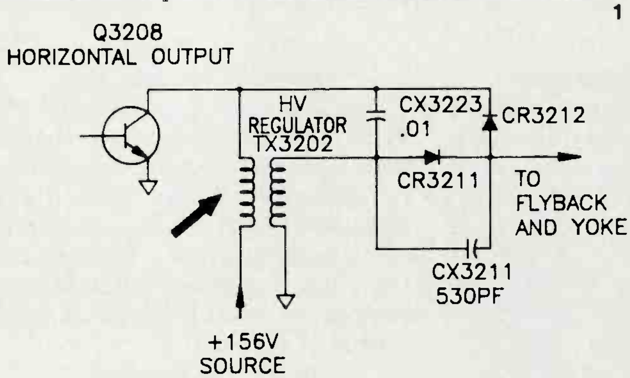
Software system

Micro Design has introduced Ensemble, a software program designed for small field-service organizations. This scaled-down version of the Concert system features call handling and technician dispatch; invoicing of service calls; inventory of parts ordered and received with multi-location tracking; contract administration; report management; and a database for service engineer, customer, vendor, equipment and parts.

Circle (89) on Reply Card

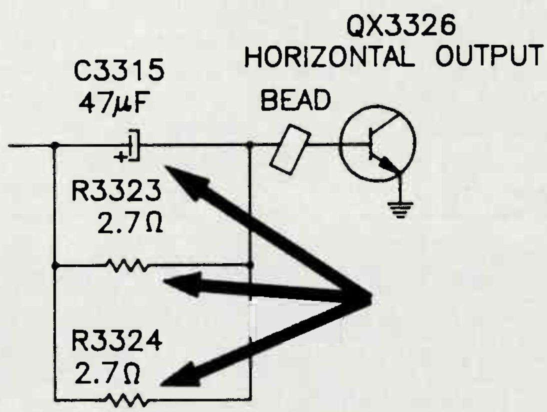
Continued on page 59.

1



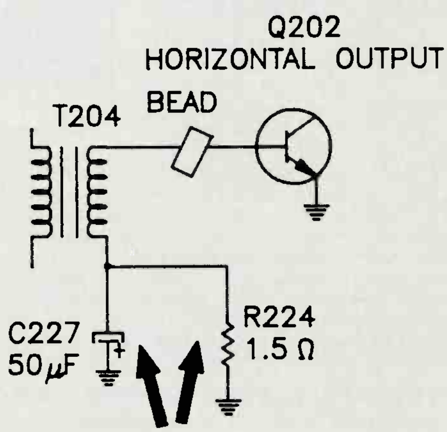
Chassis—Zenith Z1310A
PHOTOFACT—2265-2
Symptom—Intermittent high voltage or no HV.
Cure—Check for a bad connection at TX3202 (on heat sink). Resolder.

2



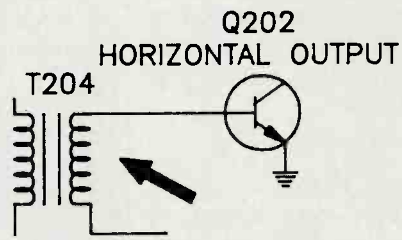
Chassis—Zenith SM1961W
PHOTOFACT—2021-2
Symptom—High voltage is excessive, and QX3326's life is too short.
Cure—Check C3315; replace it if it is leaky or has changed in capacitance. Also, check R3323 and R3324; replace if either has increased in resistance or opened.

3



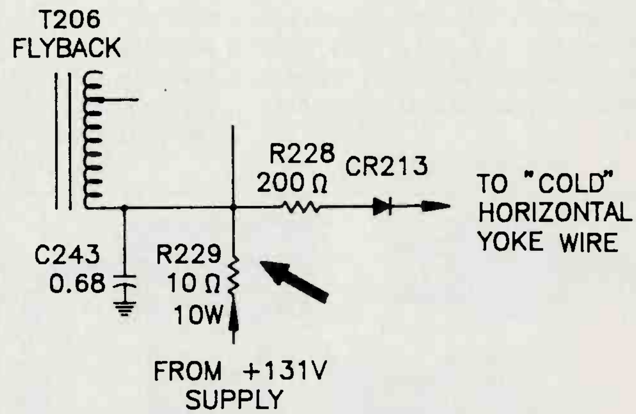
Chassis—Zenith 23HC45
PHOTOFACT—1637-2
Symptom—Narrow picture and low high voltage.
Cure—Check C227; replace it if it is leaky or open. Check R224; replace it if the resistance has changed.

4



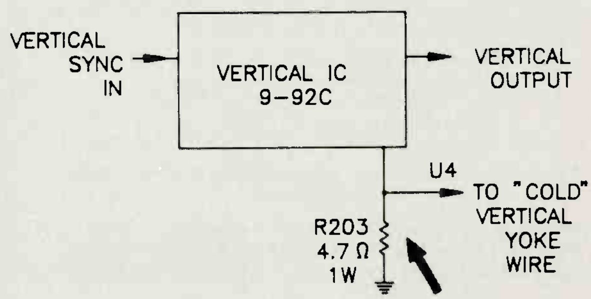
Chassis—Zenith 23HC45
PHOTOFACT—1637-2
Symptom—The HV is zero, and the Q202 has no drive. A new 9-90 module provided no improvement.
Cure—Check T204; replace it if a primary or secondary winding is open.

5



Chassis—Zenith 23HC45
PHOTOFACT—1637-2
Symptom—High voltage is zero; Q202 collector has 0Vdc.
Cure—Check R229; replace it if it is open or has increased in resistance.

6



Chassis—Zenith 23HC45
PHOTOFACT—1637-2
Symptom—Insufficient height; a new 9-92C vertical module did not help.
Cure—Check R203; replace it if it has increased in resistance.

LCR meter

The LM22A hand-held LCR meter from *Beckman Industrial* measures capacitance (eight ranges, from 19pF to 1,999μF), inductance (seven ranges, from 19μH to 199.9H), resistance (seven ranges, from 1Ω to 19.99MΩ) and dissipation. Basic accuracy for dissipation readings varies from 1% ±2 counts in the majority of user ranges, to 2% and 3% in the extreme low and high L and C ranges. The meter has a 9V battery and runs on ac power.

Circle (90) on Reply Card

Gold oscilloscope probe

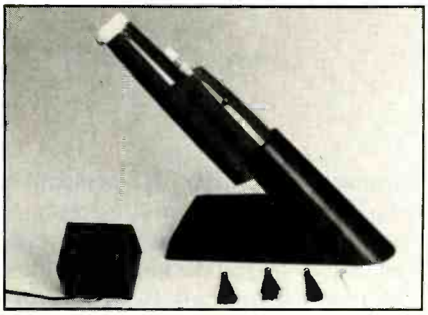
The 4900 series gold oscilloscope probe from *Probe Master* includes 15 accessories with gold-plated probe tips and other interconnect points, which provide better contacts for low-level analog signals and high-speed digital data. A variety of models are available from 35MHz to 300MHz, with fixed or switched attenuation.

Circle (91) on Reply Card

Cleaning tools

The Eraser Company has introduced two cleaning tools. The CP154 fiberglass rotary cleaning and burnishing brush has a 4-inch OD, a ½-inch face width and a ¾-inch bore diameter. Several brushes may be stacked together on a spindle or mandrel to produce a wide-face brush.

The model ECT-1 portable, hand-held



rotary cleaning tool comes with fiberglass, stainless steel, brass and nylon brushes.

Circle (92) on Reply Card

Break-out box

The model 232BOB break-out box from *B&B Electronics* allows you to test and rewire RS-232 interfaces. It opens signal lines, monitors signals and rewires lines using the jumpers included. The box incorporates nine 2-color LEDs that indicate high input, low signal or open line. It includes 24 switches that allow any RS-232 line to be opened, except for pin 1. Lines may be rewired to any configuration using the 20 jumper wires included.

Circle (93) on Reply Card

Line-voltage monitor

TEP has introduced the model 2200, a plug-in, 115V line-voltage monitor. By leaving the monitor plugged into any wall outlet, you can tell the exact line voltage and avoid using certain appliances during low-voltage periods. The monitor features a color-coded dial and records voltage from 95Vac to 135Vac.

Circle (94) on Reply Card

ES&T

Circle (23) on Reply Card

Audio Corner

Setting up a shop log--by computer

By Kirk Vistain

Computers—about half the techs I talk to are scared silly of them; the other half loves to mess with them. You can't get away from them. Like it or not, they are everywhere. That should be a clue. They are versatile, useful machines that can be put to work on the service bench as well as anywhere else.

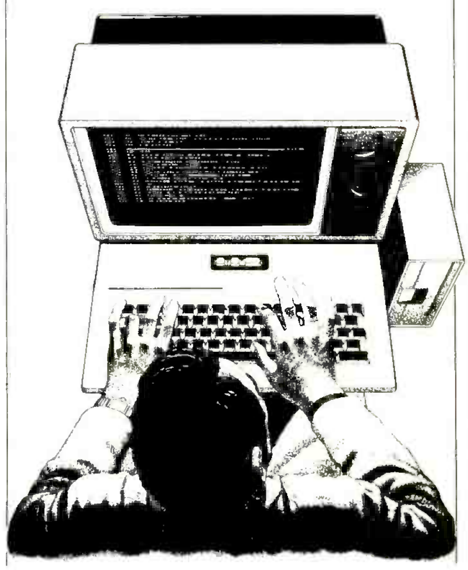
There are many kinds of computers in the home entertainment electronics servicing industry. The vast majority are dedicated processors in VCRs, stereo receivers, cassette decks and other products. A large number also inhabit the innards of test equipment, the most obvious example being the digital multimeter (DMM). They are programmed to do one particular task. Usually the program instructions are *burned* into the chip. Users cannot alter them. They are the "computers" that engender most of the negative feeling because they seem to make troubleshooting more difficult.

For example, manufacturers commonly upgrade the code (program instructions) in their microcontrollers during the production cycle of a particular model family. This means that early and late units may contain micros with different programs. The result may be that the same failure causes different symptoms in units whose only obvious difference is the serial number. This is not good for people who rely on symptomology to pinpoint defects, but it's something important for them to keep in mind.

The PC in the shop

Personal computers (PCs) are a different matter altogether. They are user-programmable. They are also very inexpensive. An 8MHz, XT-compatible with 20Mbytes of hard-drive storage costs less than a typical oscilloscope, and much less than the virtually useless distortion analyzer most audio manufacturers require as part of your warranty authorization. Yet a PC, coupled with your own determination to keep track of repairs, tips, hints and bulletins, can boost your shop's productivity significantly.

Given the state of current technology, the PC works best as a database handler, a sort of substitute for an individual's memory. The concept of automated testing, at least in our industry, is impractical at the moment. Each manufacturer does things differently as far as board layout goes, so the machines used to test boards during mass production won't work for us. Most shops don't see enough of one given model or design to make a dedicated board tester practical.



I've often wanted to use a PC to monitor communications between the microcontroller and its various slaves and coprocessors, to help isolate the defective section. Unfortunately, this usage seems impractical. Once again, there is little standardization among manufacturers. On top of that, it is virtually impossible to consistently get information such as signal protocol, the meaning of control codes, etc., out of manufacturers. This is true even if you happen to work for one of them.

Given these obstacles, the database route makes the most sense to me. It doesn't need to be anything complicated. Many good, inexpensive database programs are available for IBM PCs and clones. The newest ones are relatively easy to use. Certainly anyone with the skill to service CD players or VCRs should be able to set up a useful data file in a matter of hours. After that, you need to regularly enter repair results, preferably each day. You'll grumble at first as your fingers fumble over the keyboard, but after a while, you'll get used to it.

There have been attempts to put this kind of information on mainframe computers, accessible over telephone lines to anyone with a modem and a terminal. They haven't proven to be popular. First of all, starting the terminal, calling up and logging on are time consuming. Most people won't bother to do it regularly. This type of system might be more popular if it allowed mass download of all or part of the database to the user's computer, enabling easy local access in the future.

Setting up a shop database

By using information generated with-

Vistain is the audio consultant for **ES&T**.

in your own shop, if there's information about a fix you don't understand, you can always go back and get more details from them. You can also examine their testing techniques to further verify the information. Even a medium-size repair facility will generate much good data over a period of several months. If it services a wide spectrum of products, the resulting database will be fairly representative of field experience in general. A more specialized shop will end up with a more focused database, uncluttered by extraneous makes and models. Either way, the shop is preserving one of its most valuable, but intangible, assets—experience. When a technician leaves the establishment, a certain amount of his expertise will remain. If one's own memory is a bit clouded, as happens to us all from time to time, go over to the computer and punch in a make, model and problem. Five minutes spent doing some research may salvage the repair (maybe the day) for you.

A repair database should contain at least the following items:

- make
- model
- symptom
- cure

A more involved database might add these:

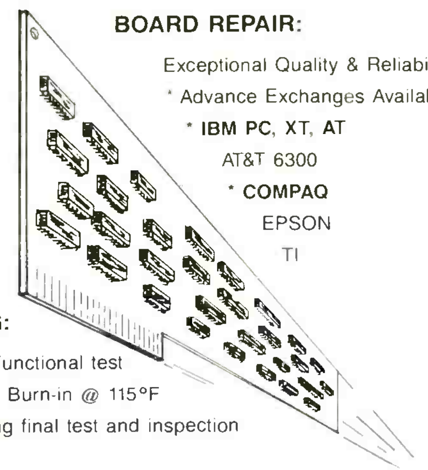
- failure code
- repair code
- serial number (to track manufacturing run-dependent trouble)
- defective parts (greatly adds to complexity)
- originator (makes it easier to check validity and ask questions later)

The best way to handle implementing the database would be as part of an integrated package that computerizes the shop's invoicing, accounting and parts inventory. It seems to me that any shop with more than three technicians ought to be giving some thought to a system like this.

Still, even a 1-man shop will benefit greatly from a properly maintained and used repair database. As I've mentioned before, a database is within the reach of anyone who can afford to be a warranty station. Give it some thought.

If any of you are interested, leave me a message on Compuserve (72356,1355) or Genie (K.VISTAIN). You can download and try out a simple, dedicated database handler I developed for IBM PCs and 100% compatibles.

By the way, if any of you have come up with ways to use the power of the PC for servicing, please write in and share them with us. ES&T



Interfacing computers to the analog world--Part I

By Joseph J. Carr, CET

Editor's note: The next several installments of Computer Corner will discuss one of the most important aspects of the computer when used as a controller: how analog information from the outside world is converted to digital information that the computer can manipulate, and how the digital results of computer operations are converted back into analog information that can be used or interpreted by the world outside of the computer.

This first installment gives an overview of digital-to-analog conversion and its converse, analog-to-digital conversion.

Digital computers and the analog world speak fundamentally different electronic languages. Interfacing these two diverse worlds requires electronic translators to reconcile their language differences. In the next few installments of Computer Corner, we will examine the basic forms of data converter and real-world interfaces available to effect that translation. These devices were traditionally used in instrumentation applications, but they now also turn up in microprocessor-controlled digital audio, VCR and professional video equipment, among other consumer and industrial applications. There is also at least one data converter in your digital multimeter (DMM), and there may be one in your oscilloscope, if it has numerical readout capability.

Carr, an electronics engineer, is a frequent contributor to **ES&T** and has published a number of books on electronics.

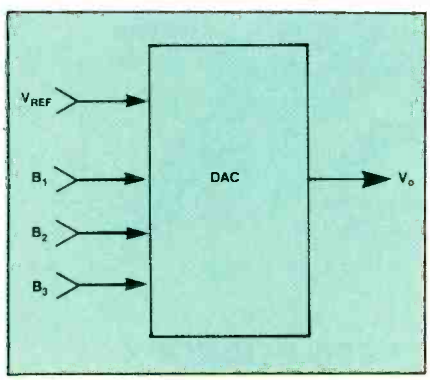


Figure 1. A DAC converts a binary digital word to an equivalent current or voltage. In this 3-bit DAC, the three parallel, digital input lines form a 3-bit binary number; each line represents one digit of the 3-bit (3-digit) number.

Table 1.

Binary numbers in a 3-bit system

Binary input	Decimal
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

The data converter does one of two jobs: It either converts a binary digital word to an equivalent current or voltage, or it converts an analog current or voltage to an equivalent binary word. The former are called *digital-to-analog converters* (DACs); the latter are called *analog-to-digital converters* (A/D or ADC).

Digital to analog

Figure 1 shows a 3-bit DAC. (Real-world DACs are typically 6 to 32 bits, but a 3-bit version is used here to keep the discussion simple.) The three parallel digital input lines form a 3-bit binary number; each line represents one digit of the 3-bit (3-digit) number (or *word*, in digital terminology).

Each line can take only one of two possible states: 0 or 1. In TTL-logic systems, the 0 is represented by 0V, while the 1 is represented by a positive voltage between +2.4V and +5V (if CMOS logic is used, other voltage combinations are possible). Table I shows all eight possible binary numbers in a 3-bit system, along with their decimal equivalents. Of course, longer binary words will count to higher decimal values. (For example, a 4-bit binary word counts to decimal 15.)

Figure 2 shows the transfer function (output vs. input) graph for a 3-bit DAC. The vertical axis shows the output voltage, while the horizontal axis shows the input binary words (with their decimal equivalents in parentheses for clarity). For simplicity's sake, assume a maximum V_o of +7V. Notice in Figure 2 that V_o increases a specific amount each time the input word increments one digit. This amount is called the 1-LSB voltage (LSB means the *least-significant bit*, or the rightmost digit in any number). This voltage is the minimum

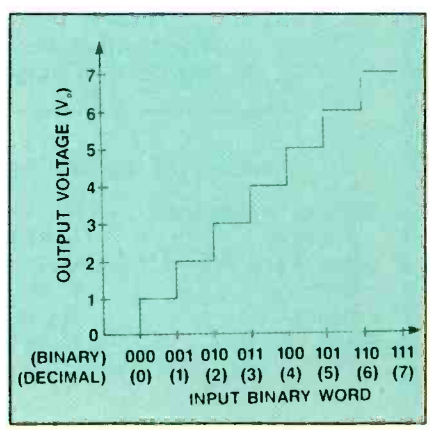


Figure 2. This transfer function (output vs. input) graph for a 3-bit DAC shows that V_o increases a specific amount each time the input word increments one digit. This amount, called the 1-LSB voltage, is the minimum amount that V_o changes when the least significant bit flips from 0 to 1 or from 1 to 0.

amount that V_o changes when the least significant bit flips from 0 to 1 or from 1 to 0.

The output of the DAC for any given input binary word is found from the following:

$$V_o = (V_{ref}) \times (A/2^N)$$

where V_o is the output voltage, V_{ref} is the reference input voltage, N is the number of bits in the binary input word (three in Figure 1), and A is the decimal value of the actual applied input word.

If V_{ref} is +8Vdc, then the maximum value of V_o (when A=111=decimal 7) is:

$V_o = (+8Vdc) \times (7/2^3)$,
$V_o = (+8Vdc) \times (7/8)$
$V_o = +7Vdc$

The 1-LSB voltage (when A=001=1) in this case is 1V.

Analog to digital

The A/D converter (also called an ADC) does the opposite of the DAC: It converts an analog voltage or current to an equivalent binary word that can be input directly to a computer or other digital device. A block diagram is shown in Figure 3. The transfer function is the same as in Figure 2 with vertical and horizontal axes swapped.

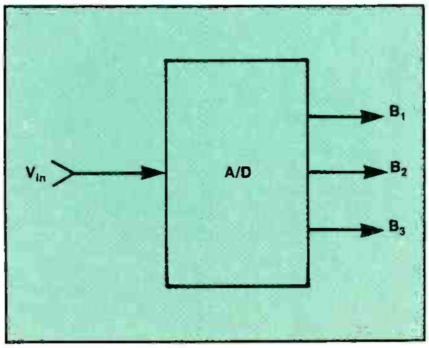


Figure 3. An ADC converts an analog voltage or current to an equivalent binary word that can be input directly to a computer or other digital device.

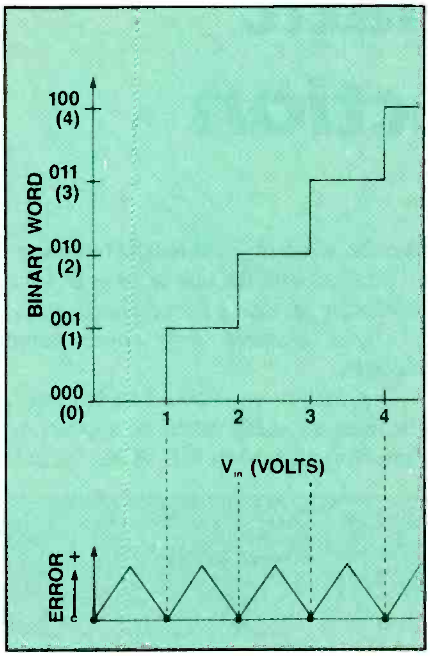


Figure 4. In analog-to-digital conversion, a quantization error exists because the binary word representing an analog voltage (or current) can take on only certain specific values even though the analog signal can take on any value between limits. This causes the staircase shape in Figure 4A. The amount of error slides up and down in a sawtooth form (Figure 4B) from zero to a maximum at the midpoints between voltage points.

A fact of life when using ADCs is that a certain quantization error exists. Figure 4 shows this effect in detail. The quantization error exists because the binary word representing an analog voltage (or current) can take on only certain specific values even though the analog signal can take on any value between limits. This causes the staircase shape of Figure 4. For example, When V_{in}=2V, the output word is 010 (or 2 in decimal). The error in this case is zero. But at 1.51V and 2.49V input, the same 010 output exists, resulting in about a ½V error. The amount of error slides up and down in a sawtooth form from zero to a maximum at the midpoints between voltage points. Of course, the smaller the 1-LSB voltage, the smaller the quantization error.

Next month, we'll consider some electronic circuit schemes for achieving digital-to-analog conversion. ES&T

The automatic search function

By the ES&T staff

Adapted from the GE technical Training Manual "VCRs and Video Cameras, 1984 Line."

Some of the more sophisticated VCRs have so many features, it's a wonder that the manufacturers can cram them all into such a small package. Of course, unless the servicing technician is intimately familiar with the unit or has all of the necessary servicing data on hand, some of these features may cause some chagrin.

One feature you should be aware of, the memory index function, appears on some top-of-the-line GE VCRs, including the 1VCR4016. This feature makes it possible for the computer to automatically detect the starting position of a recording. Different from the conventional memory counter, this circuit uses the full erase head to record an index signal on the tape at intervals of one second near the part of the tape where the

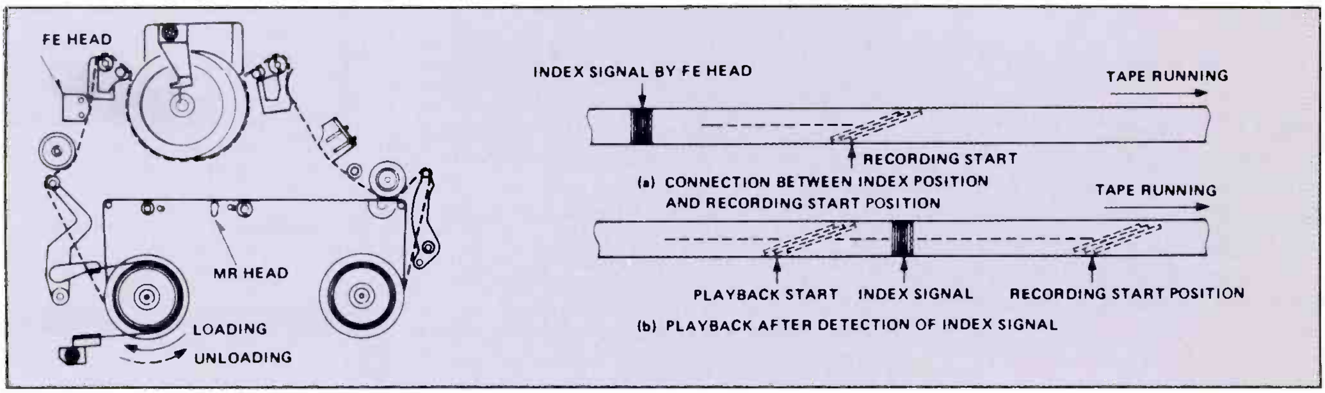


Figure 1. The full erase head records the index signals on the tape at intervals of one second. Because the full erase head is installed in a different position from the cylinder head, the index signals are recorded apart from the position where the recording of the video signal starts.

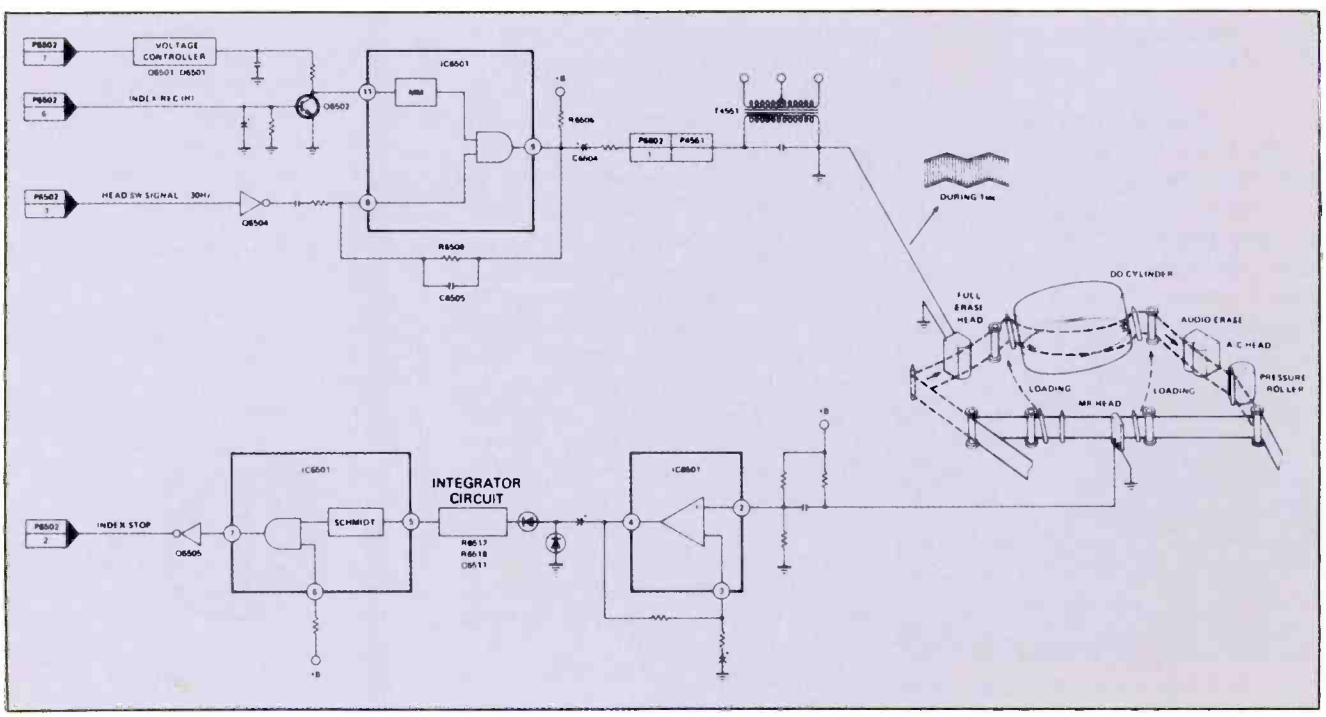


Figure 2. This schematic shows the circuitry used to apply the index signal to the full erase head and extract it from the tape with the special magnetic-resistance (MR) head.

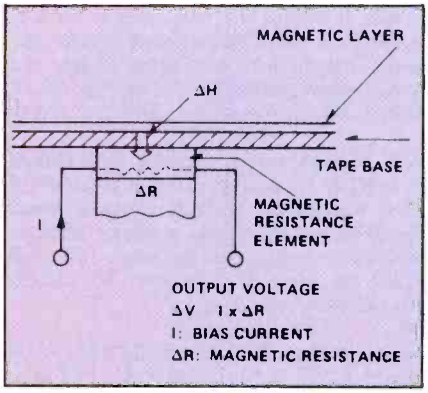


Figure 3. The magnetic resistance effect of the MR head uses the principle in which the magnetic resistivity (ΔR) reduces its effect in response to the intensity of the magnetism (ΔH) that is applied to the videotape.

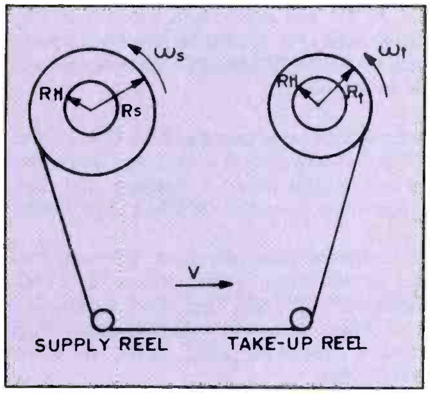


Figure 4. To compute the tape time remaining, an IC performs some complex calculations based on the parameters from the take-up and supply reels.

program recording starts. This enables the circuit to memorize the starting position of the picture on the tape. A magnetic-resistance (MR) head detects the index signal during the fast-forward mode so that the unit automatically stops. In this way, the starting position of the picture on the tape is detected.

When the REC/PLAY button is pressed and loading is completed, the full erase head starts to record the index signals on the tape at intervals of one second each. The index signal is composed of a 30Hz ac bias, which does not adversely affect the video track on the tape. Because the full erase head is installed in a different position from the cylinder head, the index signals are recorded apart from the position where the recording of the video signal starts, as shown in Figure 1.

The circuitry used to apply the index signal to the full erase head and extract it from the tape with the special MR head is shown in Figure 2. Details of the MR head are shown in Figure 3. It uses the principle in which the magnetic resistivity (ΔR) reduces its effect in response to the intensity of the magnetism (ΔH) that is applied to the video tape. Thus, with a constant bias current flow (I) in the MR head, a constant output voltage (ΔV), corresponding to the magnetic resistivity (ΔH), is obtained.

If that's not fancy enough for you, some of these units not only display the tape counter information, but also tell you in 5-minute intervals how much recording time is left on a tape (with an accuracy of plus or minus two minutes). The complex calculations required to determine this information are performed in a counter mode and remaining-tape time-display microprocessor, and are based on information sensed about the parameters listed in Table 1. (See Figure 4.)

Table 1.

Parameters for the time-remaining function

Rh: Radius of the tape hub
Rs: Radius of the supply reel
Rt: Radius of the takeup reel
Ws: Angular velocity of the supply reel
Wt: Angular velocity of the takeup reel
V: Tape speed
L: Total tape length
Ps: Number of supply reel rotations
Pt: Number of takeup reel rotations

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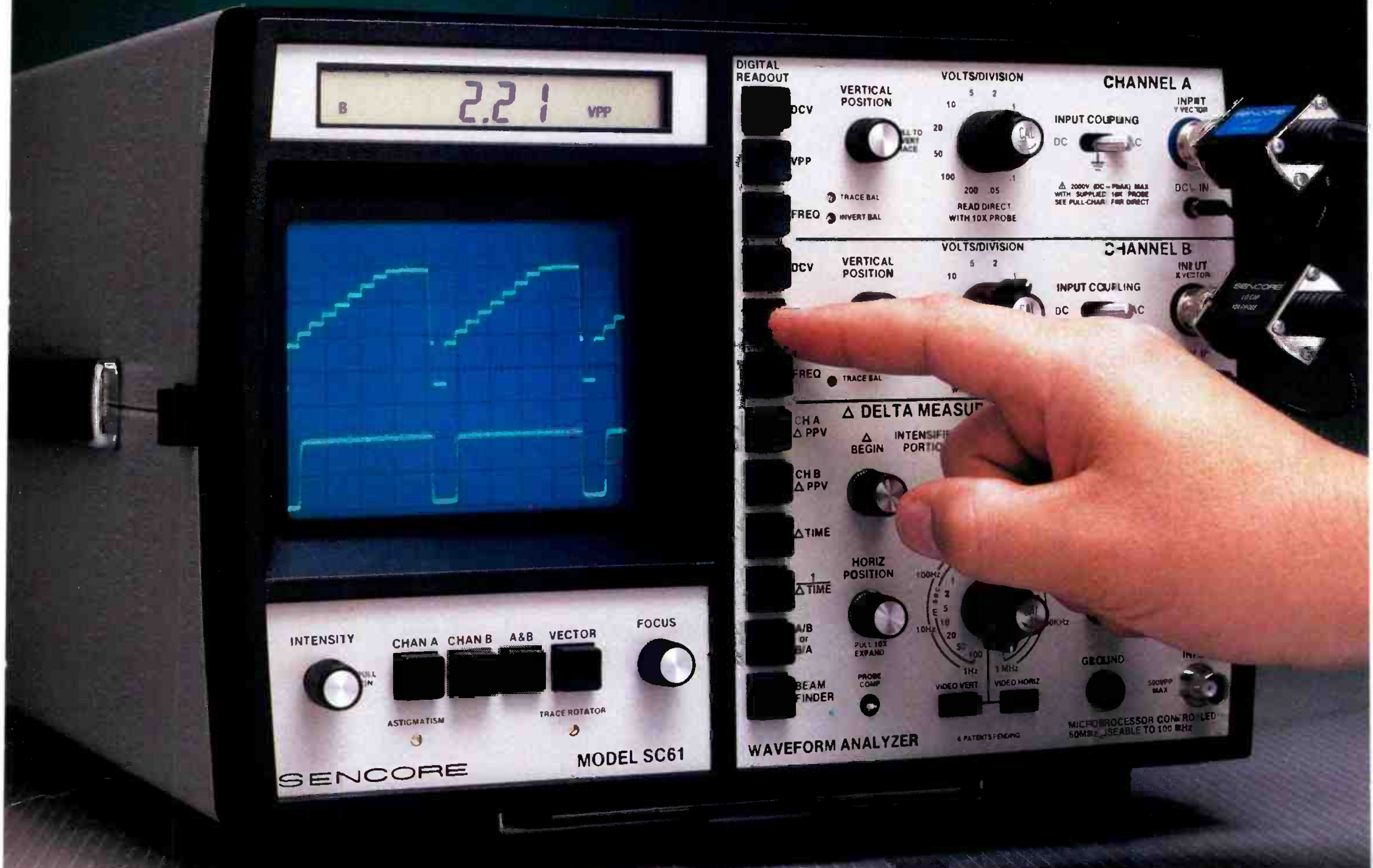

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