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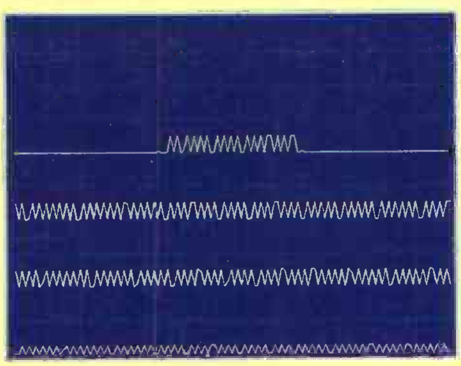

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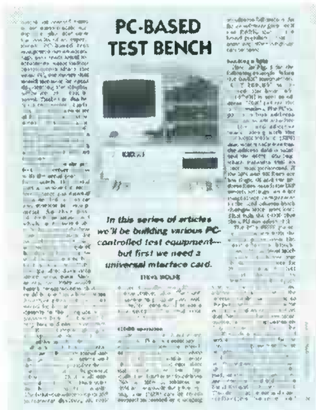

PC-BASED TEST BENCH

In this series of articles we'll be building various PC-controlled test equipment—but first we need a universal interface card.

STEVE WOLFE

PAGE 39

THE INSIDE STORY ON HARD-DISK STANDARDS

BYRON MILLER

Decisions, decisions, decisions. Here we sort out the differences between today's competing disk drive standards.

PAGE 63

AND MORE

ON THE COVER

If you're looking for a robot to serve you drinks, balance your checkbook, and cook your meals, dream on! If you're looking to learn about robotics by building a simple, inexpensive, and fun project, check out our Robot Bug. The free-roaming robot can sense and avoid obstacles to find a path through its environment. It has two switches—similar to an insect's antennas—that respond to a touch by causing the robot to stop, back up, and turn away from that side. Turn to page 33 for the details.

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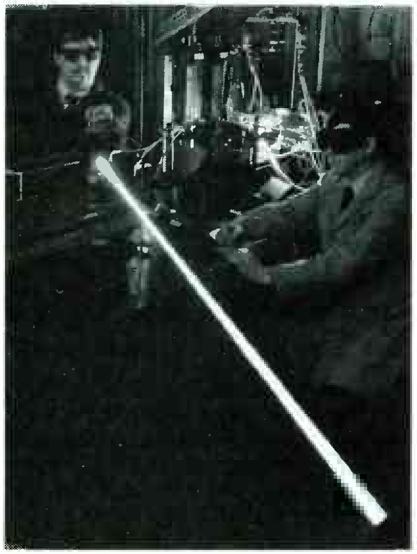
WHAT'S NEWS

A review of the latest happenings in electronics.

High-brightness green laser

A 52-watt green laser beam generated by researchers at the GE Research and Development Center in Schenectady, NY, more than doubles the previously published brightness record for green light produced with solid-state lasers. As used in optical physics, "brightness" refers to both power—the watts of photon energy put out by the beam—and beam quality—a measure of the beam's diameter and how much it diverges or spreads out.

To produce the high-brightness green beam, the GE researchers passed a 16-watt beam from a commercially available solid-state laser through a telescope and other optical elements, and then fed it into a specially built neodymium-doped yttrium-aluminum-garnet (Nd:YAG) face-pumped laser. That process amplified the beam to 92 watts while retaining the good beam quality. The 92-watt beam was then passed through a focusing lens and fed into a crystal of lithium triborate that acted as "frequency doubler"



GE SCIENTISTS HAVE GENERATED A 52-WATT GREEN LASER BEAM, more than doubling the previously published brightness record for this wavelength of light produced with solid-state lasers.

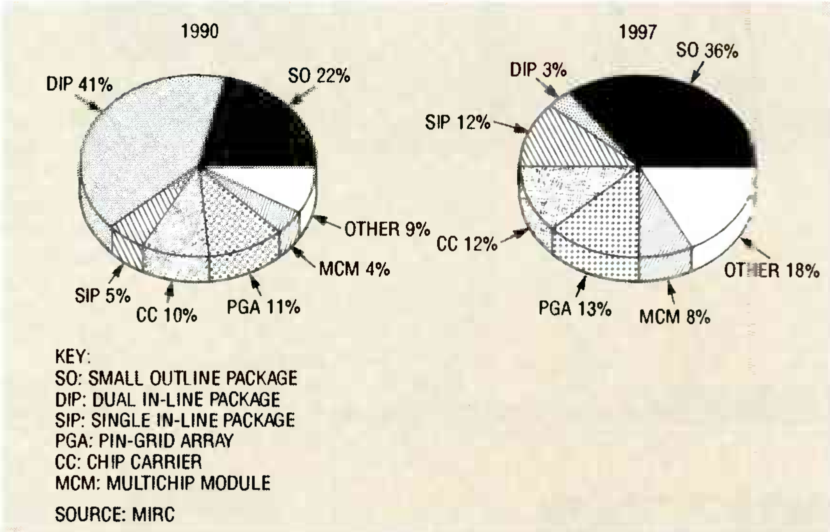


FIG. 1—The changing world market of IC component packaging is expected to change markedly between 1990 and 1997. Percentages shown indicate revenues by type of package.

and halved the beam's wavelength to 532 nanometers. That produced the 52-watt green beam in combination with an invisible infrared beam. The two beams were passed through a dispersing prism to separate them.

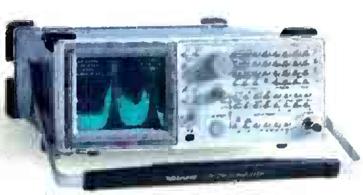
The research is part of GE's efforts to demonstrate new applications for its face-pumped laser technology, which is currently used in high-speed, high-precision metal cutting and drilling at GE's aircraft-engine manufacturing plants. The green beam, alone or in combination with infrared beams, is well absorbed by certain polymeric composites and might be suited for cutting and drilling them. Because seawater is essentially transparent to a green beam, the laser might be used in submarines for underwater detection and communications. With additional frequency conversions, the green beams can be shifted to wavelengths in the ultraviolet and deep ultraviolet regions that are used in laser surgery and other medical applications, without significant power loss. At present, only excimer lasers can approach such applications.

New IC packaging

According to a study recently released by *Market Intelligence*, strong growth in the IC component market—from $50 billion in 1991 to more than $106 billion in 1997—will be largely due to new packaging technologies. Surface-mount technology (SMT) surpassed through-hole technology as the leading electronic systems manufacturing technology for new designs in 1991. The shift from through-hole technology to other packaging technologies will be fueled by increased operating speeds and the need for higher pin counts.

As world consumption of dual-in-line packaged (DIP) IC's falls from 41% in 1990 to less than 3% by 1997, other technologies will fill the gap (Fig. 1). There is a clear trend toward specialized packaging by individual IC and application type, with the fastest growing packaging technologies expected to be small-outline (SO) packaging, multichip modules (MCM), and quad flat packs (QFP). The SO package is expected to gain the largest industry segment, rising from 22% in 1990 to 36% in 1997. **R-E**

YOU CAN ALWAYS SPOT THE TECHNICIAN WHO DOESN'T USE TEKTRONIX.



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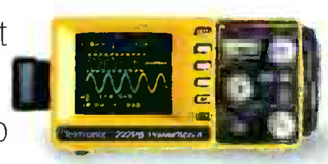

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **TV and X-rays.** Those of you who are at least 40 years old may remember the Great X-Ray Scare of the 1960's. Articles about the possibility of severe radiation exposure of TV viewers were widely published, and specific data on rats bred in the vicinity of network broadcasts allegedly showed mutations. Supermarkets sprouted "X-ray detection kits" to tell consumers whether their TV's were leaking excessive amounts of radiation.

Congress got in on the act and passed the nobly-titled "Radiation Control for Health and Safety Act of 1968." Among other things, that law was intended to limit radiation from TV sets to below the level of background radiation—certainly an admirable goal—and let parents permit their offspring to view TV with complete assurance that even if it would endanger their impressionable brains, it wouldn't hurt their bones and other vitals.

The U.S. Public Health Service promulgated rules to save the American people from X-ray zapping by color TV. Basically, those involved the use of special high-voltage hold-down circuits in TV sets to keep power supplies below the danger level, the addition of more shielding in picture tubes, and the development of testing procedures to make sure that no radiation developed within the TV sets. Among those test procedures were factory tests with all user and servicer controls set to produce maximum radiation, AC line voltage at 130 volts, and simulated failure of any component that could possibly cause excessive radiation.

In addition, dealers and distributors were required to keep the names and addresses of TV-set purchasers for the "useful life" of the set.

Almost immediately after the radiation rules went into effect, the TV industry went to solid-state circuits, eliminating the power tube that was classified as a major source of radiation. Despite the switch to solid state and the heavily leaded glass in picture tubes, the regulations weren't changed. Ten years ago, the Public Health Service proposed eliminating many of the unnecessary regulations, but nothing ever happened.

When we asked, nobody at the Public Health Service could remember the last time a consumer TV set was found to be radiating above the strict minimum. Nevertheless, the tentacles of the law reached out last year and nabbed a manufacturer—not for permitting excess radiation, but because of what the Public Health Service called improper test procedures. It impounded 30,000 sets made by that manufacturer. The manufacturer held up another 130,000 sets until everything was cleared up, losing most of the major Christmas selling season of 1991. Not one of the 160,000 sets was found to be radiating, but ... the law's the law, and inspectors visiting the factory found that the company wasn't following the right test procedures.

Asked the reason for the over-reaction, a Public Health Service official involved admitted candidly that it was because of the widespread criticism of the Food and Drug Administration for laxness in enforcing its regulations on testing drugs and such devices as silicon breast implants. Partly as a result of the ridiculous crackdown on the TV manufacturer, the EIA is now seeking a revision of the government's X-ray regulations for TV sets to avoid future problems.

• **Interactive TV.** Hewlett-Packard is the latest American data-processing name to say it will have a go at the TV industry. HP has announced that it will make home interactive terminals for the TV Answer two-way television system. TV Answer might roughly be described as the video version of Prodigy. Unlike many proposed pay-per-view systems, TV Answer isn't designed to charge the consumer more for using his or her TV, but it is intended to provide home shopping, educational, and polling services, including participation in game shows and the like.

The FCC recently allocated spectrum space to Interactive Video and Data Services (IVDS) at the request of TV Answer. TV Answer has a deal with Hughes Network Systems to install "very small aperture terminals" (VSAT's) for transmission to satellites in a cellular-type network. TV Answer expects to begin service about a year from now, if the FCC acts on its promise to choose the first allocations by lottery by the end of the year. HP says that its home terminals will cost about $700 at the start—"lower than the first VCR or the first CD player"—but concedes that prices could "decay rapidly."

• **Better, cheaper LCD's.** Can America solve the liquid-crystal display logjam? One company, In Focus Systems of Beaverton, OR, is betting that it can. In Focus says that it has developed a passive matrix LCD system that it believes can solve the problems posed by active matrix systems—low yields and high costs. In Focus is pushing a system called "Active Addressing," which it says solves the problems of passive matrix systems without the problems of going to active matrix. The system, in effect, takes the complexity out of the display and puts it in the electronic addressing system. Although In Focus products currently are designed for the commercial and industrial markets—particularly, computing—the company's new technology, not yet in production, could result in a major breakthrough for such video devices as flat-panel TV sets and projection TV's. **R-E**

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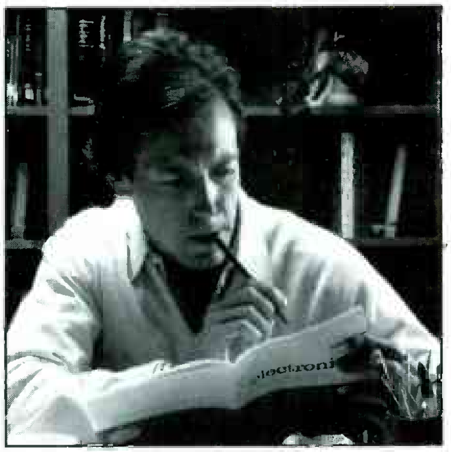

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TV SCRAMBLE

I've been tinkering with video signals, and I'm impressed at just how complex a video signal is. I'm amazed that cable companies can "scramble" and "descramble" the signal. I understand that each cable system has its own scrambling method. What exactly do they do to the video signal, and how can I determine what scrambling method my cable company uses?—G. Fischer, Deppee, NY

The fact that a video waveform is an extremely complex signal is exactly what makes scrambling possible. All the cable companies have to do is mess up just one part of the signal for the picture to become unviewable. Descrambling circuitry located in the box provided by your cable company is then used to restore the original signal.

I'd love to be able to tell you exactly what *your* cable company is doing, but there are many different ways to scramble video. The methods used by cable companies are constantly changing in order to keep one step ahead of the "illegal" descramblers that always show up.

In general, most scrambling methods involve some manipulation of the control portion on each line of video. And since the major player is the horizontal-sync signal (see Fig. 1), that's usually the one that gets messed up. If you take away the horizontal-sync signal, the TV won't be able to tell where each line ends. When that happens, the horizontal flyback in the TV will freewheel, and you'll most likely see the entire horizontal interval weaving down the center of your TV screen with the left part of the picture on the right side of the screen and the right part of the picture on the left.

Sometimes the picture portion of the video signal is inverted, so you'll see a negative image on the screen—or at least that's what you would see if they didn't also mess up the horizontal sync. To make matters even worse, the current trend in scrambling video is to do different combinations of these things on each frame of video. The information needed to decode the next frame of video is usually buried in one of the off-screen video lines present in the vertical interval.

We don't know just how many different methods are used by cable companies to scramble video, but we'd like to find out. We encourage all readers to take a few photos of the scrambled signal as it appears on an oscilloscope, or make some sketches of it, and send them in to us. If you know what scrambling method is being used, make a note of it. If you don't, we'll try to figure out what they're doing and get back to you with the answer.

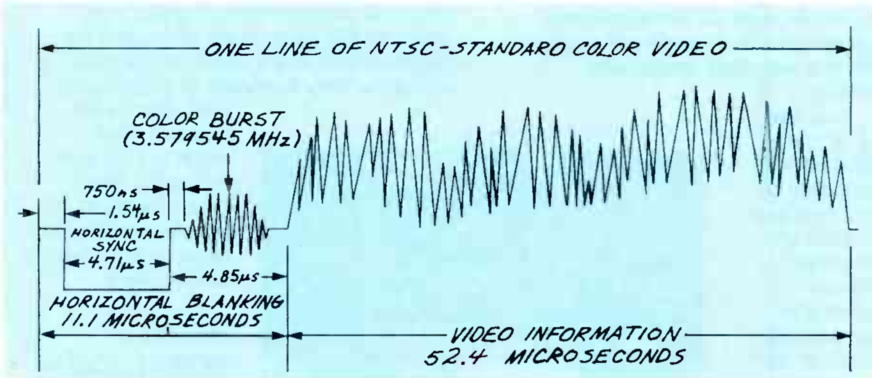


FIG. 1—A VIDEO WAVEFORM is an extremely complex signal. If you would like to know how your local cable company does their scrambling, take a few scope photos of the scrambled signal or make some sketches of it, and send them in to us.

60-HERTZ HUM

I live in an apartment and have a fairly elaborate audio system with speakers in every room. Recently, I moved the amplifiers to another part of the living room and since then I've been plagued with high levels of sixty-cycle hum. Is there anything I can do to get rid of the interference short of moving all the equipment back to where I originally had it?—B. Meredith, New York, NY

The problem of sixty-cycle hum is always hard to solve but the first thing you have to do is find out exactly where it's coming from and, as soon as you know that, you can start to deal with it. Until you know the source of the hum, anything you try to do is wasted effort.

Start by shorting out the inputs of your equipment, beginning with the power amps and working back to the tape decks, turntables, and so on down the line. If the hum disappears when a particular input has been shorted, disconnect whatever is feeding that input and see if the hum disappears. If it does, you've got a grounding problem in either the cable or the equipment feeding that input. If the hum remains, you've got a problem with the input or power supply circuitry in that piece of equipment, and that's where you should begin your search.

This wham-bam method of hum detection is great for locating faulty components, but it's also possible that all your stuff is in perfect condition and you're simply the victim of the friendly folks from your local power company. Unless you live deep in a cave, on the top of a remote mountain, or on an uninhabited moon of Neptune, you're spending your days surrounded by a

continued on page 15

LETTERS

Write to Letters, Radio-Electronics, 500-B Bi-County Blvd., Farmingdale, NY 11735

MONITOR TEST CORRECTIONS

Some errors appeared in our "Monitor Tester" article (**Radio Electronics**, January 1992). First, the two Schottky diodes in Fig. 1 (D2 and D3) were shown backward. Second, the input connection to IC1-c (pin 5) should jump two lines to the left to the "PSEUDO 3D EGA2" line instead of being connected to IC5 pin 12. Third, the intersection dot at J2 pin 1 should be removed—as it was shown, it wrongly grounded to output of IC1-d. And last, resistor R14 should be removed from the parts list.

SEEING THE LIGHT

I've been reading your great magazine for decades, and it's still as fascinating today as the day I discovered it. Recently, something happened that I feel must be shared with the other readers of **Radio-Electronics**.

Back at Christmas time a friend and I were standing in the light-bulb aisle of Builder's Square talking about the merits of different types of light bulbs. All of a sudden, without warning, he started telling me about the surge of power a light bulb uses to warm up, and how he leaves his lights on so that he doesn't waste electricity turning them on and off. I've heard that insane notion before, but this guy launches satellites into orbit for a living. I was absolutely flabbergasted that an actual rocket scientist believed an old wife's tale-like that.

Well, I asked him to explain, and he told me that the filament of a cold light bulb had a resistance close to zero, and therefore was effectively a short circuit when power was first applied. I replied that, while that might be true, the warm-up period is so short that it couldn't possibly pull more current than even a second of operation, let alone the minutes and possibly hours he was talking about. He disagreed, and, after all, he is an engineer!

So, forget the opinions. Here's an actual measurement. I stoked up my trusty Macintosh and set up my analog-to-digital converter to measure the current of a 100-watt GE soft white bulb (in my desk lamp) at 22,000 samples per second. Anything that was so short as to fall in between the samples would certainly not affect a power meter.

When first turned on, a 100-watt bulb pulls about 165 watts, but rapidly falls off to a nominal 100 watts in less than $^{9}/_{60}$ second. In fact, it falls to less than 150 watts in just $^{1}/_{60}$ second. That makes the average wattage for the first second only 103 watts, but by the end of the next second, the wattage has been stabilized at 100 watts for $^{50}/_{60}$ of a second.

My friend the rocket scientist told me in the light-bulb aisle that he leaves his lights on to the tune of 100 watts per second to save 3 watts for one second. In other words, he wastes 30 times more power in each extra second he leaves his lights on than were used to start them up. One extra minute's operation would consume 1800 times the power to turn them on, and an hour's would amount to a whopping 108,000 times the power to warm them up. No wonder it costs so much to run the space program!

If I were to figure in the inertia and internal friction of the power meter, I'm sure I would find that it would underread so short (and small) a change in power, reducing even those 3-watts. I wonder how I could measure that?

By the way, the same friend once told me that if you leave a car battery sitting on a concrete floor overnight it will go dead! But I've never actually checked on that. In light of all this, I have actually checked for the existence of satellites, and they *are* up there—amazing!

STEPHEN A. SCHLEICK
Livonia, MI

IN HOT PURSUIT OF TV TRIVIA

If Ephrim Zimbalist Jr. did indeed sit on his chief's desk and make conference calls around the country in 1958, as alleged in the "Speaker Mate" article (**Radio-Electronics**, January 1992), then he did so in the company of Roscoe, Rex, and Gerald Lloyd Kookson III. Thus, he was not in the role of of FBI agent Lewis Erskin, but in the role of chief private investigator Stuart Bailey on *77 Sunset Strip*. *The FBI* aired its first episode on September 19, 1965. I'm not a TV-trivia buff, but it would have been pretty difficult to stage chase scenes and traffic jams with about 500 identical 1965 Ford LTD's, as the director often did, when the program's sponsor was still making Edsels. "Kookie, lend me your comb!" Snap, snap.

MICHAEL W. TOLAND
Dover, NH

TRULY A TESLA COIL

In response to the letter titled "True Tesla Coil?" that appeared in the January issue, I would like to point out that the Solid-State Tesla Coil in question (**Radio-Electronics**, September 1991) *is* a true Tesla coil. I refer you to Tesla's lecture that was delivered before the Franklin Institute in February 1893. The text can be found in the book *The Inventions, Researches, and Writings of Nikola Tesla* by Thomas Commerford Martin (1894). That book is available in reprint.

On page 344, Fig. 184 shows a generator driving two different coils. One coil looks like a so-called Oudin configuration, and the other coil is directly connected with a single wire. The Solid-State Tesla Coil works on exactly the same principle that Tesla used to describe that figure! The generator in the diagram could, of course, be any source of alternating current. Tesla was limited to mechanical generators and capacitive discharges as sources for his alternating currents. I called my Tesla coil "solid-state" because it produces the same results that Tesla's coil produced, using his methods but introducing solid-state electronics.

Figures 180 and 181 from the same lecture also show his use of direct coupling. In fact, Tesla made many diagrams and wrote many descriptions on "open" circuits or those powered with "single wires." Tesla understood resonant phenomena very well, and I doubt that one could say the same for Oudin. Tesla has priority on direct coupling—or any other kind of coupling—not Oudin.
DUANE A. BYLUND

HAMFEST ALERT!

The Zero Beaters Amateur Radio Club will hold its 30th annual hamfest on Sunday July 19, 1992 at the Bernie H. Hillerman Park (Washington Fairgrounds) in Washington, Missouri, from 6 AM to 3 PM. There will be a flea market ($4-a-space parking fee for the flea-market), seminars, dealer displays, non-ham displays, and refreshments. VE exams will be given on a walk-in basis starting at 10 AM; bring your original license and a photocopy. Parking and admission are free. Talk in: 147.240 and 44.900 repeaters.
CRAIG BRUNE, N0MFD
Hamfest Chairman
Dutzow, MO

FUSE FIX

Some errors appeared in our Electronic Fuse article (**Radio-Electronics**, December, 1991). Pushbutton switch S3 and LED1 were shown incorrectly in Figures 1 and 2: S3 should normally be closed, and LED1 should be reversed. Also, the left side of R9 in Fig. 2 should be connected to the positive side of C5.

ASK R-E

continued from page 12

huge sixty-cycle electromagnetic field—and there's nothing you can do about it, short of packing up and moving into a cave.

The better your gear is, the more sensitive its inputs are, and, unfortunately, the better suited it is to picking up induced sixty-cycle hum from the power lines running in the walls of your apartment. Short of spending big bucks on transformers and other equipment, you should try shielding the cables in your system with aluminum foil. Just wrap them all individually and then try grounding the foil. Sometimes it works better if the foil is left unconnected to anything and other times it seems to be more effective when the foil is tied to a solid ground at one or both ends. Try both methods and see which one works out best for you.

I know this doesn't seem very scientific but it usually works. If you find some other easy and inexpensive way to solve the problem, I'd like to hear from you since a lot of people have exactly the same trouble. A lot of folks would be mighty happy if you did. Remember what they say: Build a better mousetrap and you'll catch a better mouse.

continued on page 78

EQUIPMENT REPORTS

Multidyne TS-8-MTS TV test-signal generator.

Track down TV video and audio problems quickly with the TS-8-MTS test-signal generator.

CIRCLE 10 ON FREE INFORMATION CARD

Troubleshooting modern TV's and computer monitors is usually tricky business. Sometimes an experienced troubleshooter can diagnose problems without using any special test equipment, but usually he needs the right tools for the job. The right tool for repairing or aligning video equipment is the TS-8-MTS test-signal generator from Multidyne Electronics, Inc. (12 Frost Creek Drive, Locust Valley, NY 11560. Phone 1-800-4-TV-TEST). It can generate eight different video test signals as well MTS stereo audio signals.

The TS-8-MTS has a composite video output on a BNC connector as well as an RF audio/video output that is switch-selectable between channels 3 and 4. An RGB colorbar output is available on a 9-pin D connector for testing computer monitors. Using a VIDEO-SELECT pushbutton you can switch the BNC and RF outputs between eight different video test patterns. Eight LED's indicate which pattern is selected. A switched horizontal or vertical trigger pulse is output on a BNC connector for triggering an oscilloscope.

All controls and outputs are located on the front panel of the unit so it's easy to use on your test bench. Housed in a sturdy metal case, the unit measures about 12 × 6 × 3 inches.

Video modes

The video section of the TS-8-MTS produces 8 digitally generated test signals. When the unit is first powered up, it outputs an SMPTE colorbar signal, which is split up, top to bottom, into three different groups of color bars. The test signal is used to check video gain, setup, hue, and saturation. Three black or gray bars on the bottom right of the screen make up the *pluge* portion of the signal, which is used to adjust the brightness of the picture. That is done by making the first two bars blend into each other. If all three bars are visible, the picture is too bright; if none of the three bars is visible, the picture is too dark.

Next is the multiburst signal where the video display is a series of vertical black and white bars ranging from thick to thin, left to right. The signal is used to check the video frequency response of a TV or VCR. The signal itself contains six sine-wave bursts that all have the same amplitude when initially generated. To check the frequency response of a TV, you would feed the signal into the TV and pick up the signal inside the set at a point just before it reaches the screen; the sine-wave bursts should still have the same amplitude when seen on an oscilloscope *after* the TV has processed the signal. The frequency response of a VCR can also be checked with this signal. All you do is record the signal on the VCR and check the output signal on an oscilloscope when playing back the tape.

The crosshatch, or convergence signal is next. The display is a grid with a dot in the center of each square. The signal is used to check and align the red, green, and blue color guns in a TV. When the grid-and-dot images from the three color guns are perfectly overlapped, the picture is fully converged. The grid can also be used to check vertical linearity. The horizontal bars should be equally spaced; crowding at either the top or bottom of the screen indicates a problem.

The NTC7 signal, or pulse-and-bar mode shows vertical blocks and bars on the screen. The test signal is used to measure short-time, line time, and field-time luminance distortions. The distortions can be seen on an oscilloscope as ringing, under-shoots, over-shoots, and tilt of various parts of the signal after it has been processed.

The stair-step signal consists of five steps in luminance from 0 to 100 IRE which is seen on a video display as a gray scale of five vertical bars. (IRE is the picture brightness level: 0 is black and 100 is white.) The signal is used with an oscilloscope to measure luminance nonlinearities.

The modulated stair-step signal is used to measure differential gain and phase. Differential gain is present when the chroma or color gain is affected by the luminance or black and white gain. Differential phase is present when chroma, color phase, or tint are affected by the luminance or black and white gain. The measurement can only be made with a video vector scope having differential gain and phase measuring capabilities.

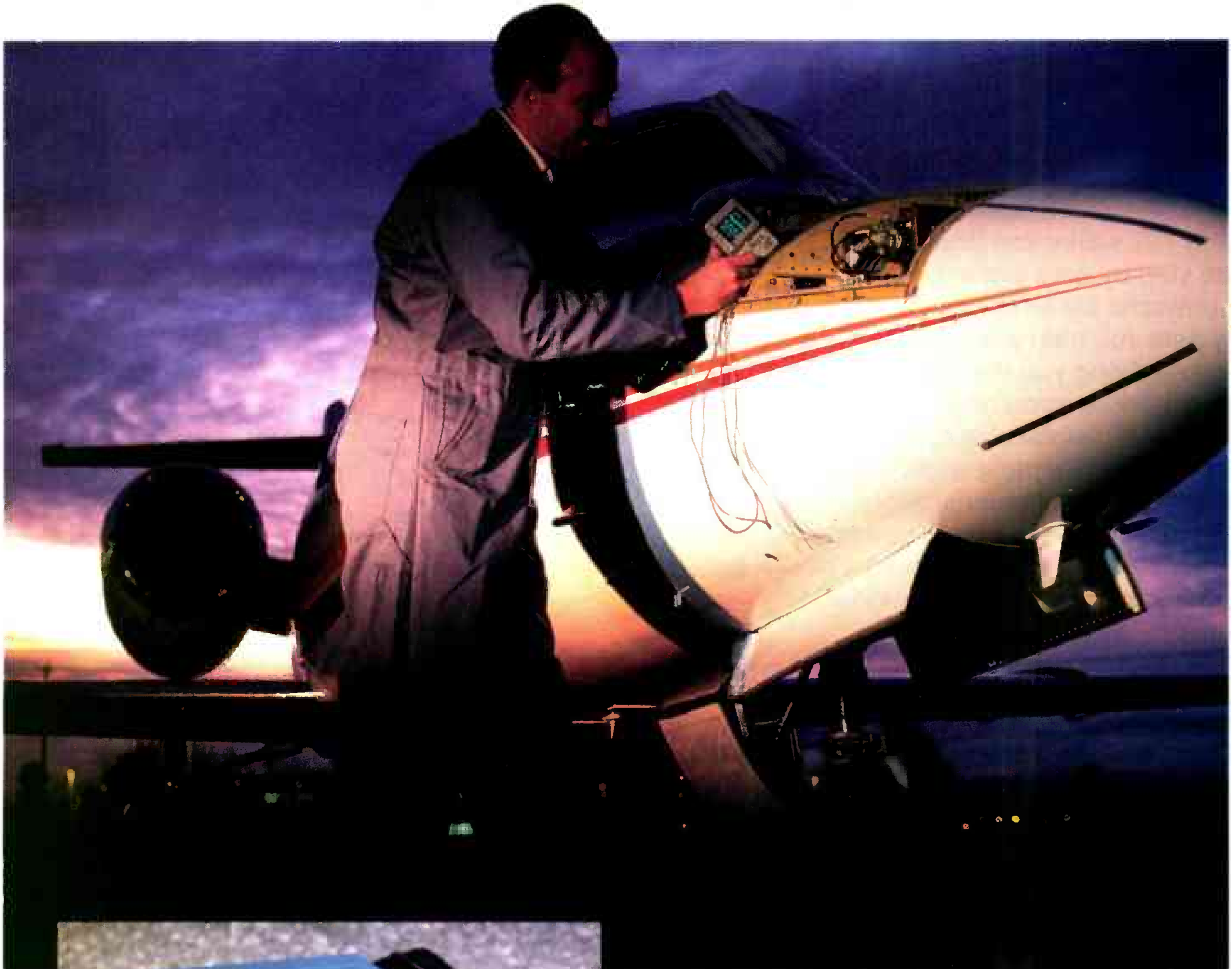
The red-field signal creates an entire video display of red to check for moire, color purity, and noise. The black burst signal can be used to measure color burst and setup amplitude.

Audio

In addition to video signals, the TS-8-MTS can generate an MTS stereo audio signal. Audio is present at the RF output and a separate phono-plug output. The audio can

continued on page 88

The new Tektronix 224 is as powerful as they come. And goes!



With this new 60 MHz digital oscilloscope, Tektronix takes handheld performance to an even higher plane! The 224 packs more power per pound than any other product and — with its on-board rechargeable batteries — goes wherever duty calls.

With its exclusive IsolatedChannel™ architecture, you can make two-channel floating measurements without the risk of shock or damage to delicate electronics. Such standards as Tek's sharp, bright CRT, rapid update rate and wide viewing angle make measuring fast and efficient. And the 224's familiar front panel and fully automated features keep it simple.

You get advanced capabilities like video line triggering and 10 MS/s digitizing per channel for excellent single-shot performance, plus time-correlated single-shot waveforms for easy comparison. With CAT200 software you can even control the 224 over phone lines from halfway round the world.

Call 1-800-426-2200 Ext. 83 to get the full story. We'll show you more of the 224 — and ways it's giving bench performance wings!

Tektronix
Test and Measurement

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No other training to troubleshoot computers

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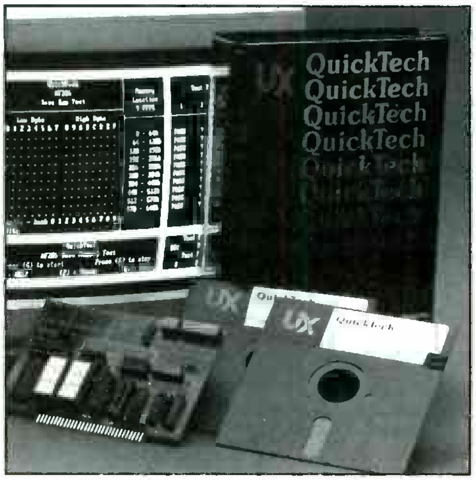
You start by assembling and testing your computer's 101-key "intelligent" keyboard, move on to test the circuitry of the main logic board, install the power supply and 1.2 meg high-density floppy disk drive, then interface your high-resolution monitor.

What's more, you now go on to install and test a powerful 40 meg IDE hard disk drive—today's most-wanted computer peripheral—included in your course to



dramatically increase your computer's data storage capacity while giving you lightning-quick data access. But that's not all!

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Your NRI training now includes a remarkable diagnostic package that allows you to quickly locate and correct defects in IBM XT, AT 80286/80386, and

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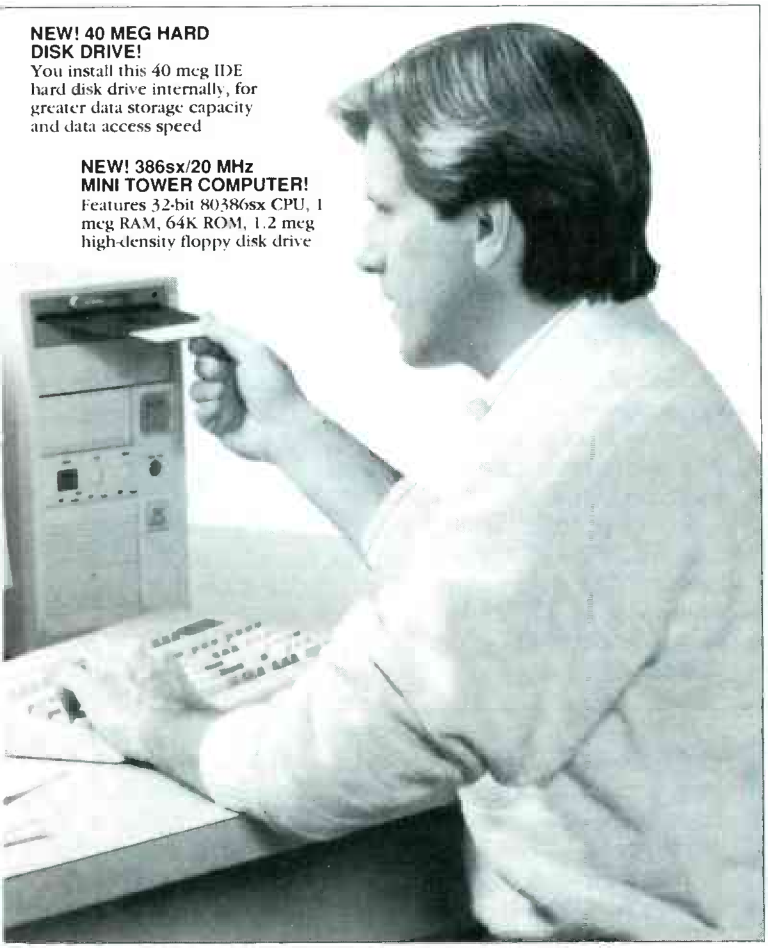

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NEW PRODUCTS

Use the Free Information Card for more details on these products.

PC BOARD PROTOTYPE KIT. *Multicore Solders'* patented *Copperset System* provides a simple way to form plated-through holes from drilled holes in printed-circuit boards quickly, reliably, and inexpensively. The portable system, intended for prototyping, modification, or repair, is packaged in a convenient kit containing the materials and tools needed to form 500 plated-through holes in each of three different diameters. The only additional tools required for formation of holes with 0.8-mm (0.031-inch), 1.0-mm (0.039-inch), and 1.2-mm (0.074-inch) diameters through standard 1.6-mm (0.062-inch) thick boards are a soldering iron and a desoldering tool. The *Copperset System* is based on thin solder wire rods that are plated with 25 to 30 microns of copper and a protective tin coat. According to Multicore, a plated-through hole can be formed with the kit in less than a minute at a cost of less than 20 cents a hole.

The *Copperset System* costs $289.—**Multicore Solders**, 1751 Jay Ell Drive, Richardson, TX 75081; Phone: 214-238-1224; Fax: 214-437-0288.

CIRCLE 15 ON FREE INFORMATION CARD

16-BIT PCM AUDIO DAC CHIP. The *AD1866* is the newest member of *Analog Device's* Soundport family. It is a complete stereo 16-bit PCM audio DAC that operates from a single +5-volt supply. The DAC is intended for automotive, portable and low-power digital audio playback systems. The *AD1866* requires very few external components to achieve its rated performance.

The IC comprises two independent precision references, output amplifiers, and 16-bit converters. The DC-bias pins that position the output signal at 2.5 volts mid scale (1.5 to 3.5-volt swing) eliminate the need for any type of false-ground circuitry. An input clock rate of up to 16 MHz permits operation at two, four, eight, or sixteen times the sampling frequency (where the sampling frequency is 44.1 kHz) for each channel. Operating at eight times the sampling frequency, key specifications of the device are resolution of 16 bits, THD + N at 990.5 Hz and 0 dB) of 0.005 %, signal-to-noise ratio of 95 dB, channel separation of 115 dB, and power dissipation of 50 milliwatts. The *D1866* is compatible with all digital filter chips and it is packaged in 16-pin plastic DIP's or SOIC's.

The *AD1866* audio DAC IC is priced at $10.50 in hundreds quantities.—**Analog Devices Inc.**, 181 Ballardvale Street, Wilmington MA 01887; Phone 617-937-1428 for applications assistance; Fax 617-821-4273 for literature.

CIRCLE 16 ON FREE INFORMATION CARD

SMT SOLDER CREAMS. Innovative packaging alternatives are now available for *EPS Inc.'s* surface-mount solder creams. The *Flexpak* pouch, made of a tough, impregnable barrier laminate, is notched for easy opening to dispense exact amounts of solder cream. Stenciling and screening grades of solder cream are packaged in premeasured 50- and 150-gram *Flexpaks*, each supplied with a unique dispensing tool that empties the entire package, eliminating solder waste, preweighing, and contamination.

For manual or pulsed-air dispensing, SMT solder creams are also available in prepackaged *75- and 35-gram syringes/barrels* that provide consistent dot deposit control for SMT prototype and repair work. A "No-Drip" piston provides trouble-free dispensing and eliminates solder cream waste by wiping the barrel clean as it is emptied. In addition, ESP solder creams are available in *500-gram cartridges* for di-

CIRCLE 17 ON FREE INFORMATION CARD

rect mounting on screen printers, as well as in *500-gram jars* that feature a reusable inner seal to prevent the paste from "crusting" or drying out after the jar has been opened.

For pricing information, contact—**ESP Inc.**, 14 Blackstone Valley Place, Lincoln, RI 02865; Phone: 1-800-338-4353; Fax: 401-333-4954.

SOLDER REFLOW MODULE. The *Air-Vac PCBRM-12* solder reflow modules are intended primarily for repair work, but customers are finding them useful for soldering PC boards in small production runs. The modules are suitable for mounting leaded components on conventional PC boards. The *PCBRM-12* generates a restricted solder wave that matches the lead pattern of all multi-leaded through-hole components. The solder can be directed to limit component exposure to heat, and most components can be removed in about 5 seconds, regardless of the number of their leads. The module's high thermal capacity permits much lower operating temperatures than those of handheld or hot-air desoldering tools. According to *Air-Vac*, all leads will be evenly heated—even on multilayer PC boards. This feature eliminates the need for reheating and desoldering individual missed joints.

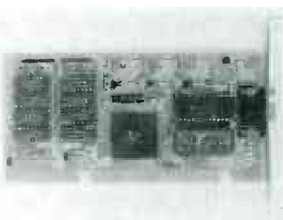
The user of the *PCBRM-12* is first in-

CIRCLE 18 ON FREE INFORMATION CARD

structed to select the proper "flow well" and matching hole-cleaning "hood" (corresponding to the lead pattern) before setting the temperature, flow rate, and cycle time. The PC board is then inserted into the unit's carrier arms with the component to be removed positioned over the flow well. When all solder joints are molten, the component can be lifted from the board and the holes can be cleaned of solder by a low-pressure air jet. A replacement component can be immediately inserted and soldered. Custom flow wells are available for selective tinning, soldering and desoldering of double-sided PC boards and subassemblies.

The *PCBRM-12* solder reflow module is list priced at $7300.—**Air-Vac Engineering Company, Inc.**, 100 Gulf Street, Milford, CT 06460; Phone: 203-874-2541; Fax: 203-783-1383.

8- OR 16-BIT VGA CARD. *JDR Microdevices' VGA card* should attract computer owners planning to upgrade their present systems in the future. They will be pleased to know that this VGA card can be transferred to a faster systems. Capable of operating in either 8- or 16-bit modes, the card can upgrade IBM compatible computers based on 8088 MPU as well as those with the 286, 386, and 486 MPU's. According to *JDR Microdevices*, advanced ASIC technology permitted them to minimize the number onboard components while providing the features found only in more expensive cards. This VGA card supports video monitor resolutions of 800 × 600 and 640 × 480 in 16 colors, and 320 × 200 in 256



CIRCLE 19 ON FREE INFORMATION CARD

colors. It provides automode switching for VGA, EGA, CGA, MDA, and HGC, and it supports both analog and multisync monitors. Software drivers for Windows 3.0, AutoCAD, Lotus 1-2-3, GEM, Ventura Publisher, and other programs are included in the purchase price.

The *VGA Card* costs $49.95.—**JDR Microdevices**, 2233 Samaritan Drive, San Jose, CA 95124; Phone: 800-538-5003; Fax: 408-559-0250.

ONE-PIECE TEST CENTER. Four of the most commonly used pieces of test equipment are combined in the *Tenma Test Center, Model 72-710*. The test center contains a 2-MHz sweep function generator, a 100-MHz frequency counter, a triple-output power supply, and a full-function autoranging digital multimeter. The frequency counter can stand in as a precision display for the sweep gener-

CIRCLE 20 ON FREE INFORMATION CARD

ator or it can be a standalone frequency counter. The power supply has three outputs. The first output provides variable voltage and current (0 to 5 volts DC and 0 to 0.5 amps). It has a three-digit LCD display that can be switched for voltage or current readout. The second and third outputs have fixed voltages of 5 volts DC at 2 amps and 15 volts DC at 1 amp, respectively. The *Model 72-710* has a one-year limited warranty and the purchase price includes test leads and an owner's manual.

The *Test Center 72-710* is list priced at $399.99.—**MCM Electronics**, 650 Congress Park Drive, Centerville, OH 45459-4072; Tel: 800-543-4330.

SURFACE-MOUNT INDUCTORS. These miniature inductors are designed for automatic surface-mount assembly. The *RL2515 Series* inductors from *Renco Electronics* feature molded plastic packages. Said to be impervious to moisture, they are suitable for soldering with either vapor-phase or infrared soldering systems. The series includes 35 standard values ranging from 0.15 μH to 100 μH with DC current ratings of 70 to 610 milliamps. These

CIRCLE 21 ON FREE INFORMATION CARD

inductors can be used as filters and as components in filter networks. The operating temperature range of the inductors is −25°C to +80°C.

The *RL2515 inductors can be supplied on tape and reel or in bulk quantities. They are priced at 25 cents each in 2500-piece quantities.*—**Renco Electronics Inc.**, 60 Jefryn Blvd. East, Deer Park, NY 11729; Phone: 516-586-5566.

PC-BUS POWER MONITOR CARD. Intended for computer-service personnel, *Wintek's PC-Bus Power Monitor Card* can detect power disturbances and identify substandard power supplies in PC, AT, and EISA computers. Pack-

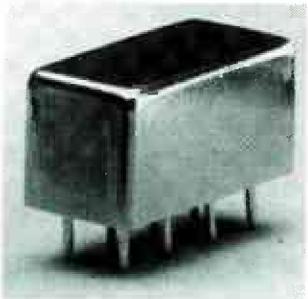
CIRCLE 22 ON FREE INFORMATION CARD

aged on an ISA short card, the power monitor can be plugged into an expansion slot. It then checks to confirm that all four supplies are within specifications, detects the presence of glitches or dropouts, and displays the information on an LED display. Many intermittent operation problems that appear to be caused by memory or disk faults are actually power supply problems. The *PC-Bus Power Monitor Card* is a handy tool for identifying or ruling out power-related problems in the field. According to *Wintek*, the *Power Monitor Card* is permits faster and easier power supply checking than a digital voltmeter or oscilloscope, especially when the faults are intermittent. By detecting a deteriorating power supply, system errors and catastrophic failures can be avoided.

The standard card provides a real-time indication of power quality and its memory stores momentary out-of-tolerance events. The enhanced version of the card includes an audible alarm and separate monitoring circuits to spot intermittent trouble with the system clock and dynamic-memory refresh signal.

The basic and enhanced *PC-Bus Power Monitor Cards* cost $195 and $249, respectively.—**Winteck Corporation**, 1801 South Street, Lafayette, IN 47904-2993; Phone: 800-742-6809; Fax: 317-448-4823.

I&Q MODULATOR. This modulator is intended for radar and communications applications. *Mini-Circuits' MIQA-70ML I&Q Modulator* offers −38dBc carrier and sideband rejection. Its third-harmonic suppression is −48dBc and its fifth harmonic rejection is −64dBc. This 50-ohm device operates over 66 to 73 MHz frequency range in both local oscillator and RF applications. It offers 10±1dBm local oscillator power over a −55 to 100°C temperature span.



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Conversion loss is specified at 5.1 dB. The modulator is housed in an EMI-shielded case that measures 0.8 × 0.31 ×0.4 inch.

The *MIQA-70ML* modulator is priced at $49.95 in quantities of 1 to 9.—**Mini-Circuits**, P.O. Box 350166, Brooklyn, NY 11235; Phone: 718-934-4500; Fax: 718-332-4661.

ANTI-THEFT VHF/UHF ANTENNA. A prominent external antenna on an automobile alerts thieves to the presence of expensive transceiver equipment within your car and attracts vandals. *The Stealth* antenna from *j•Com* is an internal antenna that disguises the presence of expensive transceivers in your car and offers no temptations for roving vandals. The antenna is made as a 0.003 inch thick etched copper serpentine on a gray shaded polymide substrate that measures 3.5 X 3.5 inches.

CIRCLE 24 ON FREE INFORMATION CARD

Its gray color permits it to blend almost invisibly behind the anti-glare band on the upper surface of an automobile windshield. According to *j•Com*, this inside-mounted antenna does not reduce transceiver performance. The etched-copper antenna is multipolarized to provide high gain regardless of signal polarization. That feature ensures good reception in rural as well as urban locations, and it provides a steady signal in your car when it is moving. Because *The Stealth* antenna could pass for a decal, it is also available with an optional printed warning symbol as a further deterrent to thieves. The antenna is said to have a low standing-wave ratio over its specified frequency band, and it does not require adjustment or tuning.

The Stealth is adheres to the inside of a windshield with the adhesive on its backing; no drilling, clips or suction cups are necessary. Because the antenna is mounted inside a vehicle, it is protected from the elements and need not be removed or retracted when entering garages with low-clearance entrances or car washes.

Standard and high-power models of *The Stealth* are available for mid-band operation at 146, 220, and 440 MHz. Standard models are rated for 50 watts of input power, and high-power models are rated for 110 watts. Sixteen feet of RG 58/U coaxial cable is included with each antenna.

The standard *Stealth Antenna* is priced at $59.95 and the high-power version is priced at $69.95.—**j•Com**, Box 194, Ben Lomand, CA 95005; Tel: 408-335-9120; Fax: 408-335-9121. **R-E**

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(Good-bye to imported instruments)

Ultravariable Pulse Generator
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Model 2001 $178.50

2MHz Sweep Function Generator
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- 50Ω output
- VCO input

Model 2002 $219.95

Digitally Synthesized Generator
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- Trigger, Sweep, Burst, Hop and Gate modes
- Internal/External Sweep
- Sine, Square, Triangle, Ramps
- Optional RS-485 communications port
- 16 programmable memories

Model 2003 $499.95

Compare the specifications and the prices of these four instruments with the competition. Then compare the labels. Global's say "Proudly Made in U.S.A.". Designed and manufactured in our Connecticut factory with the value and quality that Global is known for. The competitors, they look alike because they are. Different names on the front. The same label on the back. "Made in Taiwan".

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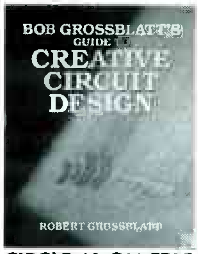
NEW LIT

Use The Free Information Card for fast response.

BOB GROSSBLATT'S GUIDE TO CREATIVE CIRCUIT DESIGN; by Robert Grossblatt. TAB Books, Division of McGraw-Hill Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-822-8138; $17.95.

If you read **Radio-Electronics** regularly, then you're familiar with Bob Grossblatt's columns and occasional feature stories. If you write to **Radio-Electronics** occasionally to request help with circuit-design problems, then you're one of the people credited with providing inspiration for this book.



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In its pages, Bob Grossblatt explains how to minimize your chances of running into such glitches—and how to work your way out of those that do arise—by following his common-sense approach to the design process. Working under the principle that the primary cause of such problems is not lack of knowledge but a poor design method, he presents a systematic approach that can be followed when prototyping any electronic circuit. To take your idea from concept to working project, the author explains, you must think it through and outline it in a notebook before you get into detailed planning (listing design criteria, choosing components, calculate component values, identifying alternatives, and setting operating parameters). Then you're ready to create block diagrams for your design. To keep from getting bogged down along the way, he continually emphasizes the importance of keeping an open mind about making changes in the original design, and persevering until you have a finished product, even if it's not as perfect as you would like.

Construction details for dozens of basic circuit "modules" that can be combined to form more complex—and quite useful—projects are presented, including a multi-voltage bench power supply, an audio preamplifier and amplifier, a fully buffered, 64K RAM system, a programmable home-control center, a VCR sync stabilizer, a battery back-up circuit with automatic switch-over, and a microprocessor-based waveform generator. Information on where to find components and technical literature, and how to set up an efficient workbench is included. To keep things from getting too heavy, troubleshooting hints, design tips and tricks, and Bob Grossblatt's own adages are included. Comments like "First make it work, then make it neat," "People make more mistakes than electrons," and "Versatility breeds complexity" are liberally sprinkled throughout the text.

RF/IF SIGNAL PROCESSING HANDBOOK; from Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; Phone: 718-934-4500; Fax: 718-332-4661; free.

Aimed at design engineers, this 718-page handbook is loaded with practical articles, answers to frequently asked questions, definitions of terms, convenient selection guides, and handy conversion charts. The comprehensive reference also includes hundreds of pages of fully detailed,

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computer-automated performance data (CAPD) specifications, and performance curves to eliminate guesswork during the design process. Components covered include frequency mixers, power splitter/combiners, amplifiers, I&Q modulators and demodulators, phase detectors, RF transformers, filters, switches, directional couplers, and attenuators.

HAWK PROGRAMMABLE ON-OFF CONTROLLERS/INDICATORS; from Simpson Electric Company, 853 Dundee Avenue, Elgin, IL 60120-3090; Phone: 708-697-2260; Fax: 708-697-2272.

Simpson's recently introduced Hawk series of digital on-off controllers and indicators is featured in this

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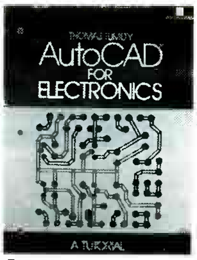
32-page, full-color catalog. Designed for start, stop, or limit control of a wide range of process variables, the controllers have broad applications in electrical, chemical, petrochemical, and other process industries. Models are available for AC and DC voltage current, 4–20-mA DC, 1–5V DC resistance, 3-wire potentiometer, frequency, and tachometer (rpm) inputs. Also featured are models for 2-, 3-, or 4-wire RTD inputs and J, K, R, or S thermocouples. Each Hawk series model is neatly packaged in a compact ⅛ DIN case. The catalog provides descriptions, technical notes, complete specifications, a glossary of terms, available accessories, and ordering information.

AUTOCAD FOR ELECTRONICS: A TUTORIAL; by Thomas Tumilty. Prentice Hall, Englewood Cliffs, NJ 07632; Phone: 201-592-2000; $43.00.

By demonstrating the step-by-step development of manufacturing drawings for a quad power supply and a multiwave function generator, this book—and the included diskette—show readers how to design electronics products



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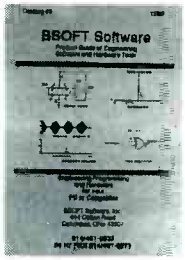
from scratch using AutoCAD. The text also demonstrates how a computer system works in the course of the product's development, how AutoCAD's commands are used, the technique for translating a hand-drawn sketch into a complete schematic/wiring diagram, and how to lay out a simple printed-circuit board. It also covers mechanical and electrical assembly methods, why components must be oriented in specific ways, universal drawing standards, etc. Practice exercises permit readers to improve their skills in dimensioning, text styles, and isometric and three-dimensional drawing. Concentrating on the basic commands that are used in all versions of AutoCAD, the book provids a knowledge of the fundamental concepts of computer-aided design and a foundation in AutoCAD from which the reader can go on to master more complex commands.

BSOFT SOFTWARE ENGINEERING TOOLS CATALOG #5; from BSOFT Software Inc., 444 Colton Road, Columbus, OH 43207-3902; Phone: 614-491-0832; Fax: 614-497-9971; free.

BSOFT's latest catalog offers low-cost, stand-alone engineering programs and hardware designed for engineers, technicians, and hobbyists using IBM-PC's or compatibles. Included are programs for drawing schematics, simulating logic-control circuits, FFT analysis, and circuit analysis. CAD programs for structural analysis, designing electronic circuits, and PC-board layout are also offered, along with PC bus board products for control and data acquisition. The 26-page booklet contains



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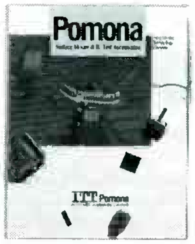
product descriptions, display printouts of schematics and waveforms, and ordering information.

SURFACE MOUNT & IC TEST ACCESSORIES; from ITT Pomona Electronics, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Phone: 714-469-2900; Fax: 714-629-3317; free.

Highlighted in this 14-page catalog are Pomona's complete lines of SMT/IC test accessories, kits, and



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probe sets. The booklet features DIP/SOIC, PLCC, QFP, and SMD Microtest clips and assemblies, miniature pincer and hooked test clips, standard hooked test clips, alligator test clips, coax cable assemblies, test lead kits, adapters, breakouts, and interfaces. Fifteen major product categories are presented. **R-E**

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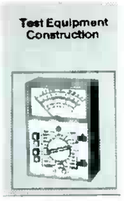

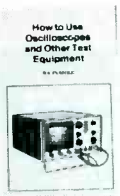

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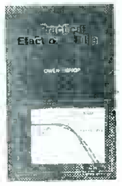

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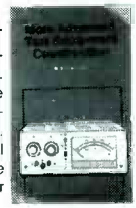

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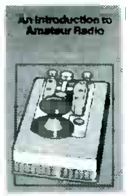

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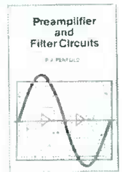

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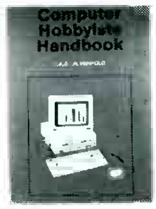

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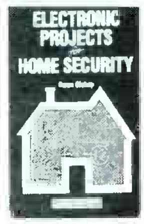

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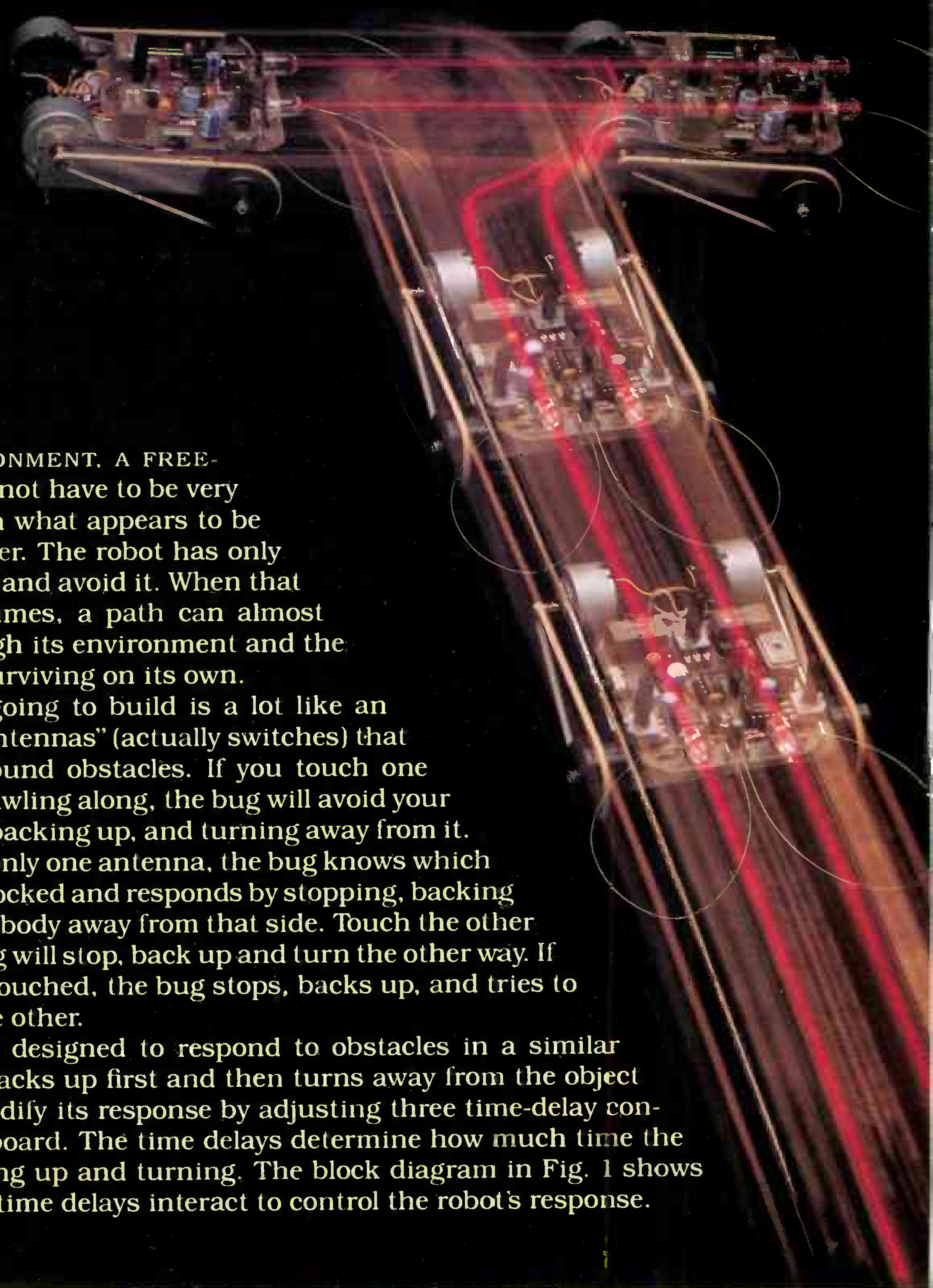


IN A SIMPLE ENVIRONMENT, A FREE-roaming robot does not have to be very smart to function in what appears to be an intelligent manner. The robot has only to sense an obstacle and avoid it. When that is repeated many times, a path can almost always found through its environment and the robot seems to be surviving on its own.

The robot we're going to build is a lot like an insect; it has two "antennas" (actually switches) that help it navigate around obstacles. If you touch one antenna of a bug crawling along, the bug will avoid your finger by stopping, backing up, and turning away from it. Because you touch only one antenna, the bug knows which side of his path is blocked and responds by stopping, backing up, and turning his body away from that side. Touch the other antenna and the bug will stop, back up and turn the other way. If both antennas are touched, the bug stops, backs up, and tries to go to one side or the other.

Our robot bug is designed to respond to obstacles in a similar manner. It always backs up first and then turns away from the object sensed. You can modify its response by adjusting three time-delay controls on its circuit board. The time delays determine how much time the robot spends backing up and turning. The block diagram in Fig. 1 shows how the adjustable time delays interact to control the robot's response.

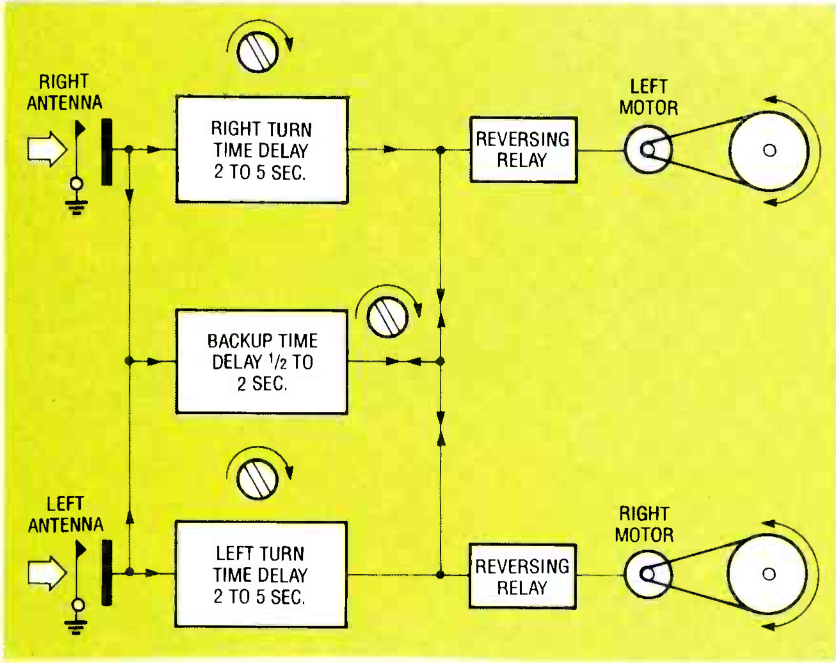


FIG. 1—THREE ADJUSTABLE TIME DELAYS interact to control the robot's movement.

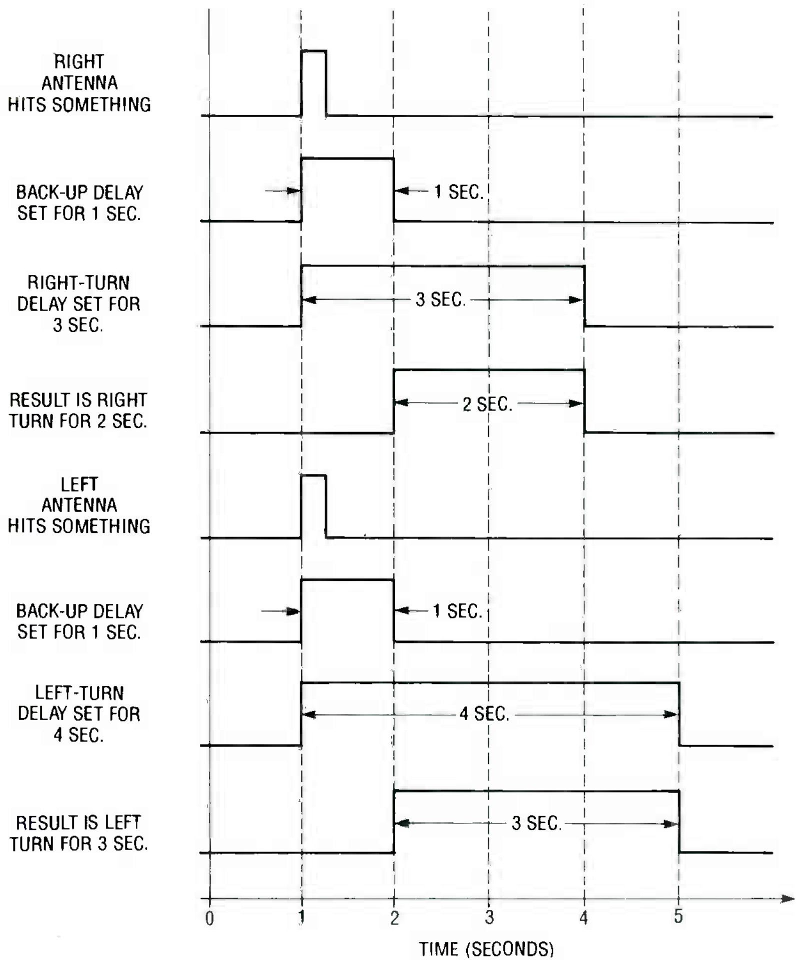


FIG. 2—TIMING DIAGRAM. Either antenna will reverse both motors and the robot backs up. When the back-up time is over, one of the motors continues in reverse, causing the robot to turn away from the object.

Three time-delay circuits share the control of two reversing relays. When the right antenna is triggered, it activates the back-up delay and the right-turn delay. When the left antenna is triggered, it activates the back-up delay and the left-turn delay. The back-up delay activates both reversing relays for a period of ½ to 2 seconds. During that time, the robot moves straight back, away from the obstacle. A turning delay (right or left) is set for period of 2 to 5 seconds. That keeps one motor in reverse after the other stops. If the left motor continues in reverse after the right motor stops, the robot turns to the left, and vice versa. The size of the turn depends on how long one motor continues in reverse after the other one stops. If both antennas are triggered, all three time delays are activated. The direction the robot turns is determined by whichever turn delay is longest.

The robot's control circuitry is based on simple "one-shots" that wait to receive a signal before turning on for a predetermined time. Three potentiometers let you adjust each one-shot separately. The timing diagram in Fig. 2 will help you visualize the different timing events. Either antenna (or both) will start the back-up one-shot which reverses both motors. One potentiometer sets the time that the robot spends going straight back. When the back-up time is over, one of the "turning" one-shots keeps one of the motors in reverse, causing the robot to turn away from the object. The direction of the turn is determined by the motor that stays in reverse; the size of the turn is determined by how long that motor stays in reverse after the back-up time is over.

Circuitry

As shown in Fig. 3, three one-shots (IC1, IC2, and IC3) control two relays (RY1 and RY2). The backup time delay is controlled by IC3, and is variable between ½ and 2 seconds via R20. The left- and right-turn delays are controlled by IC1 and IC2, respectively, and are variable be-

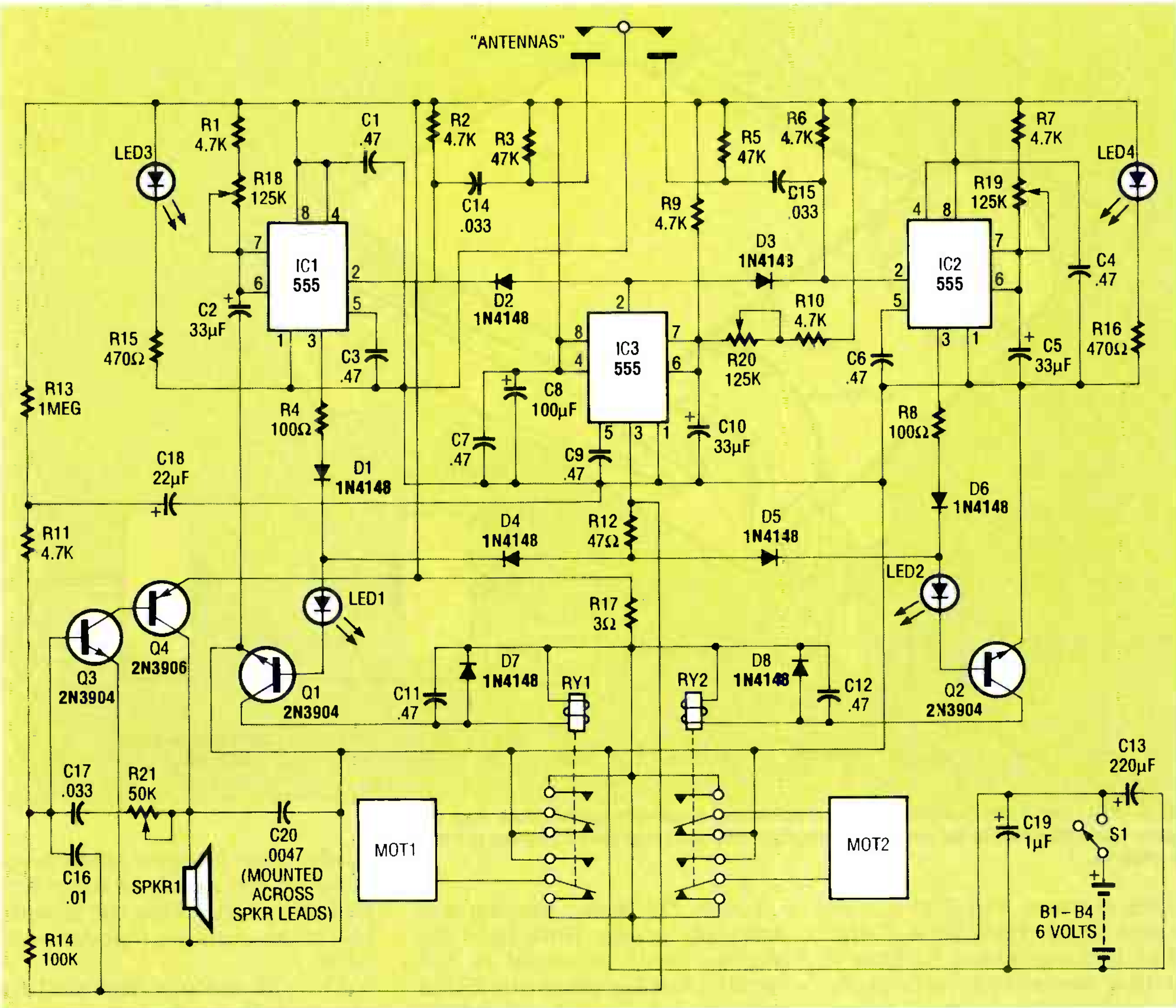


FIG. 3—THE BACKUP TIME DELAY is controlled by IC3, and variable between ½ and 2 seconds via R20. The left- and right-turn delays are controlled by IC1 and IC2, respectively, and variable between 2 and 5 seconds via R18 and R19.

ELECTRONIC PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R2, R6, R7, R9–R11—4700 ohms
R3, R5—47,000 ohms
R4, R8—100 ohms
R12—47 ohms
R13—1 megohm
R14—100,000 ohms
R15, R16—470 ohms
R17—3 ohms
R18–R20—125,000 ohms, potentiometer
R21—50,000 ohms, potentiometer
Capacitors
C1, C3, C4, C6, C7, C9, C11, C12—0.47 µF, monolythic
C2, C5, C10—33 µF, electrolytic
C8—100 µF, electrolytic
C13—220 µF, electrolytic
C14, C15, C17—0.033 µF, Mylar
C16—0.01 µF, Mylar
C18—22 µF, electrolytic
C19—1 µF, tantalum
Semiconductors
IC1–IC3—555 timer
D1–D8—1N4148 diode
Q1–Q3—2N3904 NPN transistor
Q4—2N3906 PNP transistor
LED1, LED2—red light-emitting diodes
LED3, LED4—jumbo round or rectangular light-emitting diodes
Other components
RY1, RY2—DPDT 5-volt relay
S1—SPST switch
SPKR1—Knowles electronics WO-360 speaker module or equivalent
Miscellaneous: IC sockets, PC board, two dual "AA" battery holders, all mechanical parts (see mechanical-parts list), wire, etc.

tween 2 and 5 seconds via R18 and R19.

To see how the 555 timers are used as one-shots, take a look at IC2 in the schematic. When a negative-going pulse is received from the right antenna at pin 2, the following timing cycle is started: pin 3 of IC2 goes high and turns on Q2 and RY2. At the same time, C5 charges through potentiometer R19. The charging time depends on the setting of the potentiometer. When C5 charges to approximately 4 volts, it begins to discharge through IC2. Pin 3 of IC2 returns to a low state and RY2 turns off. The one-shot now waits for the next pulse at pin 2. The circuit built around IC1 works in the same way.

The backup time-delay circuit built around IC3 differs from the other two one-shots in that it has four diodes added; D2 and D3 at pin 2 and D4 and D5 at pin 3. The diodes serve as an "OR function," causing pin 2 to respond if either antenna

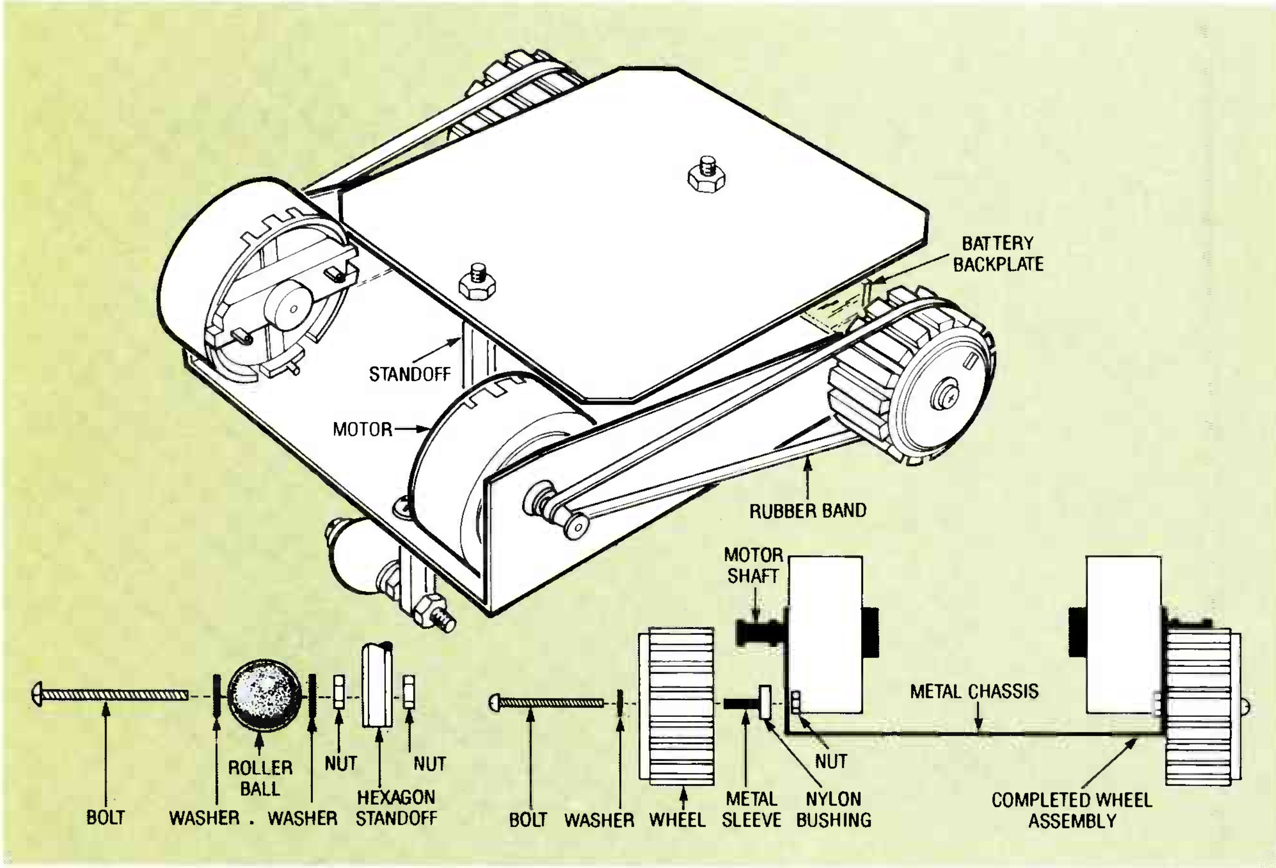


FIG. 4—FOLLOW THIS DIAGRAM as a mechanical assembly guide. Note that the motors come attached to the metal chassis plate, and can break lose if you flex or bend the chassis.

makes contact. Pin 3 of IC3 is controlled by the output of the other two one-shots; if either turning one-shot is activated, the backup delay, which takes precedence, is also activated.

Mechanical assembly

The robot is assembled in three steps. The first step is to assemble the mechanical parts, the second is to assemble the circuit board, and the third is to join the two sections together. The robot kit available from the source mentioned in the Parts List includes all of the mechanical parts. If you wish to build the robot without buying the kit, we've provided a list describing all of the mechanical parts. If you can't find the exact parts we've specified, it's very easy to improvise using similar parts. All the robot really needs is two independent drive wheels and one trailing wheel, mounted on a chassis with enough room to accommodate the two motors, two battery holders, and the PC board.

Follow Fig. 4 as a mechanical assembly guide. Note that the motors come attached to the metal chassis plate included with the kit. Do not pull on the motors as they can break lose, and do not flex or bend the chassis as it will make the wheel alignment more difficult. Start the mechanical assembly by pressing the metal wheel sleeves into the nylon bushings. Then assemble each front wheel onto the metal chassis as shown, using a screwdriver to tighten the bolt while holding the nut with pliers. You might want to put a small drop of oil on the bushings, but do not get any oil on the outside surface of the wheels where the rubber band attaches.

Turn the chassis over and attach the rear-wheel hexagon standoff as shown, and tighten it securely. Note the position of the hole through the standoff; it should be aligned parallel to the back edge of the chassis. Assemble the roller ball as shown onto the standoff. Again you might want to put a small drop of oil on the inside of the roller ball. After tightening the assembly, make sure the ball can still turn.

The DC motors included in the kit have one terminal marked with a white dot. If you're using motors with no polarity markings, make the electrical connections temporary. Later, when testing, if both wheels do not turn in the forward direction while the robot is free-running, simply reverse the leads to the motor(s) running in the wrong direction. For now, though, we'll assume you're using the motors included in the kit.

Solder a 3-inch red wire to each motor terminal marked with a white dot and solder a 3-inch black wire to the other two motor terminals. Put two "AA" cells in one of the battery holders and put a rubber band over the wheel and motor pulley on each side. Temporarily twist the battery-holder wires to the right motor wires—red to red and black to black—and make sure the wheel turns and the rubber

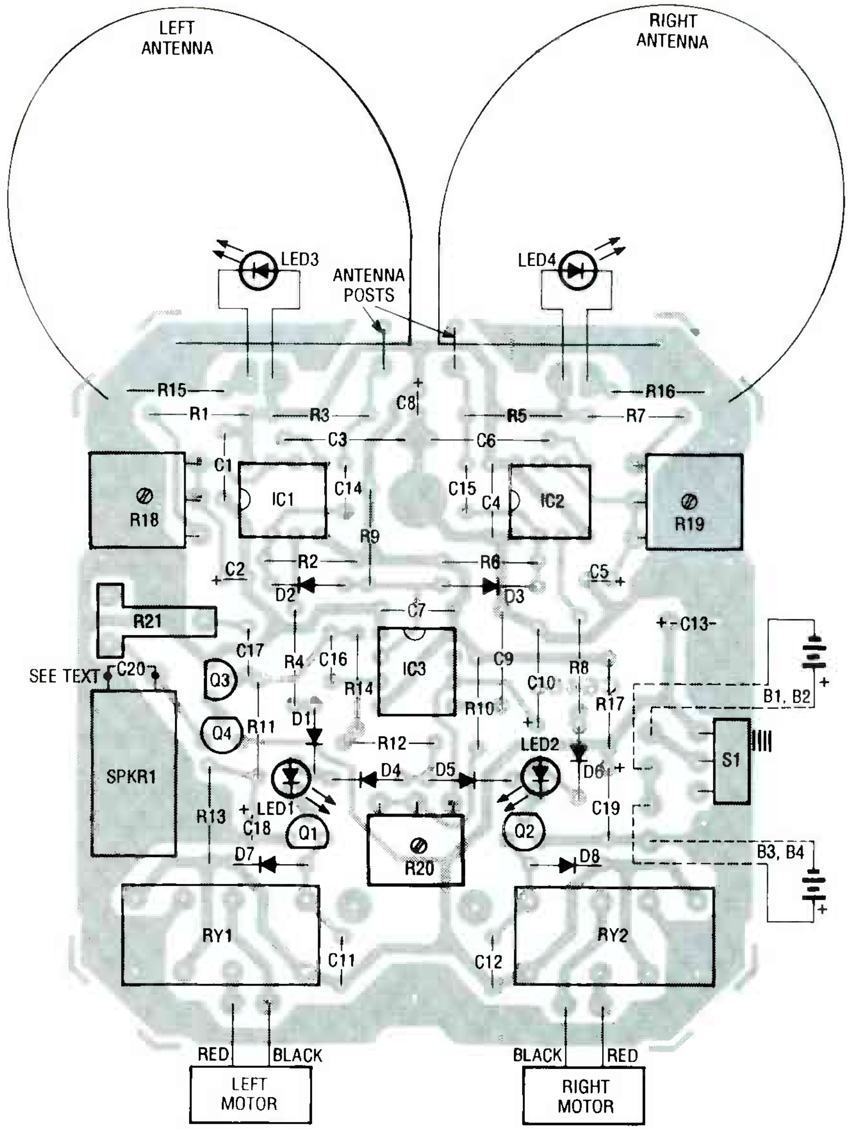


FIG. 5—PARTS-PLACEMENT DIAGRAM. Install LED3 and LED4 bent forward like headlights.

MECHANICAL PARTS LIST

- Metal chassis plate, approx. 3⅛ inches wide (after the sides are bent up at 90° angles) × 3½ inches long, drilled to accommodate all other hardware
- Two DC motors with shaft pulleys
- Two front wheels (the kit uses two plastic knobs, 1¼-inch outside diameter, with ¼-inch shaft hole)
- Two nylon or metal wheel sleeves, ¼-inch outside diameter, ⅛-inch inside diameter, 11/16-inch long
- Two nylon bushings, ½-inch outside diameter, ¼-inch inside diameter, ⅛-inch thick
- Two 1-inch wheel screws with a nut and washer for each
- One ⅝-inch diameter roller ball with hole drilled through the diameter
- One roller-ball axle screw with two nuts and two washers
- One 11/16-inch threaded hex standoff for the roller-ball assembly, cross-drilled on the bottom end
- One mounting screw for roller-ball standoff
- Two spring-wire antennas/feelers
- Two antenna posts
- Two 13/16-inch threaded hex standoffs and mounting screws for the PC board
- Rubber pads and adhesive-backed felt for the two battery holders
- Two rubber bands

Note: The following items are available from The Electronic Goldmine, PO Box 5408, Scottsdale, AZ 85261 (602) 451-9495: (Add $3.50 shipping/handling)

- **Complete robot kit (C6466, batteries not included)—$39.95**
- **PC board only—$10.00**

band stays in place.

If the rubber band comes off you must align the wheel by bending the chassis slightly. Run the motor again to see if the rubber band stays on. If it stays on, reverse the battery leads and check it again—you may have to readjust the wheel. (Never bend the chassis where the motors are attached and do not put any stress on the motors as they may come lose from their mounting.) When you finish aligning the right wheel, repeat the process for the left wheel.

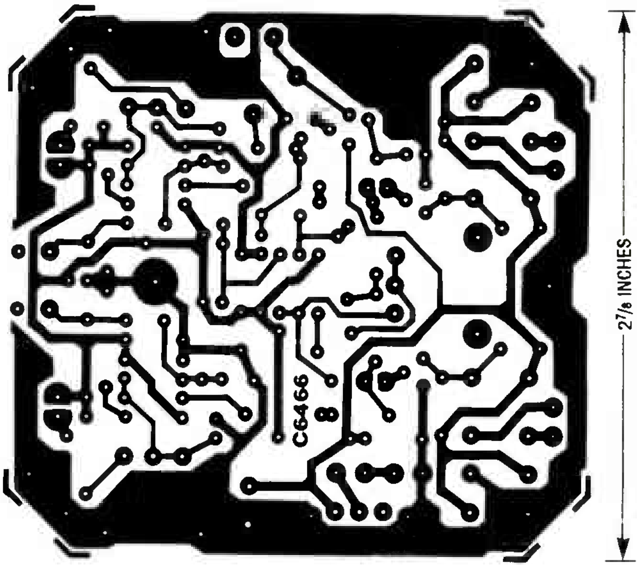
Two metal standoffs are installed on top of the chassis using bolts and washers through the bottom of the chassis. The bolts go up through the chassis, through the standoffs, through the PC board, and the board held down with the nuts as shown. But first we have to build the PC board.

Electronic assembly

Assemble the circuit board as shown in Fig. 5. Watch the polarity of the IC's, electrolytic capacitors, and diodes. Note that the leads of LED3 and LED4 should be bent at 90° angles so that they look like headlights when mounted on the board. It's a good idea to insulate the exposed portions of the headlight LED's. Install SPKR1 as shown. DO NOT attempt to remove the capacitor soldered across the speaker terminals; the leads of the capacitor are used to connect the speaker to the board.

Now install feeler wires as shown in Fig. 6. Each feeler is made from a length of spring wire, bent as shown in Fig. 6. Fit the straight portion of the left feeler wire at the point shown until it is flush with the board. Bend the other end around and insert it into the other hole as shown and solder that end. Repeat those steps for the right feeler wire.

Now make two feeler posts by bending wire as shown in Fig. 6. After bending, solder the posts to the board in place over the feelers. Adjust the straight part of each feeler wire so that it's centered under the post. Mak-



FOIL PATTERN FOR THE ROBOT shown actual size.

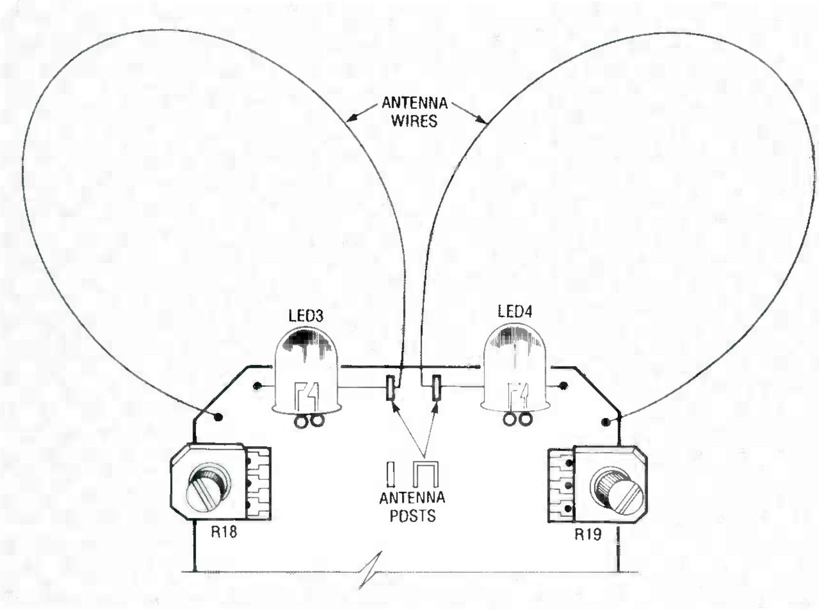


FIG. 6—THE FEELER WIRES are installed as shown here. The feeler posts are soldered to the board over the feelers. with the straight part of each feeler centered under the post.

ing sure the feeler is not touching the post, solder the straight end of the feeler to the board. The feelers must not touch any part of the posts after they're soldered in place; reheat the solder if necessary to reposition the feelers. Check the operation of the feeler by pushing on the circular part—the straight part of the feeler should hit the post. Figure 7 shows the finished robot.

Solder the battery-holder wires and the motor wires to the points shown in Fig. 5. Make sure S1 is in the "off" position and put four "AA" batteries in the holders. Hold the robot in your hand so that the wheels can spin freely, and turn on the power. Both wheels should be turning in the forward direction. If either wheel is turning in the wrong direction you'll have to reverse the leads going to that motor.

Set R18 and R19 fully clockwise and set R20 fully counterclockwise. With the motors running, bump the left antenna; LED1 should light and the

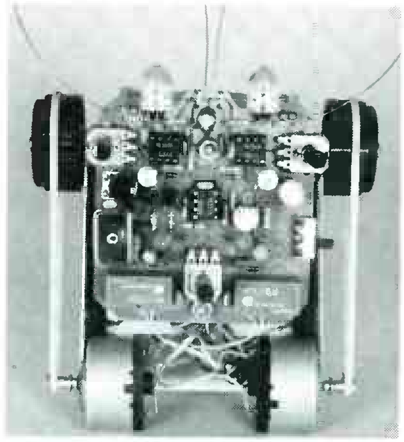


FIG. 7—HERE'S WHAT THE ROBOT'S board looks like close up. You can also see how the feelers work.

left wheel should reverse direction for a short period of time (LED2 will also light for just a second). Now bump the right antenna; LED2 should light up and the right wheel should change direction. Bump both antennas; LED1 and LED2 should light up and both wheels should change direction.

Final assembly

Install felt strips on the solder side of the PC board where the battery packs will come in contact with it. Lay the battery holders (with batteries installed) into chassis with the wires coming out on top near the motors. Set the board onto the standoffs and secure it with one nut on each standoff. Do not overtighten the nuts.

Operating tips

Find a large area and turn on the robot. The robot works best on a smooth, hard floor. It does not work well on carpeting, cement, dirt, or asphalt. The back up time delay should always be much shorter than either the left or right time delays. If the left or right delay is really long, the robot will make loops and other strange movements. In small spaces all time delays should be kept short and in larger spaces longer time delays work better. Make sure that the obstacles the robot encounters are solid all the way down to the floor. When the rubber bands get dirty from prolonged use, they will begin to slip. Replace them whenever necessary. **R-E**

PC-BASED TEST BENCH

In this series of articles we'll be building various PC-controlled test equipment—but first we need a universal interface card.

STEVE WOLFE

A PC IS THE PERFECT THING to use to accumulate, manipulate, plot, and store the results of an experiment. PC-based test equipment has an advantage over traditional instruments: since various instruments share the same PC, the money that would normally be spent duplicating the display, keyboard, etc., can be saved. That's the idea behind this series of articles. We'll build a number of PC-based test instruments, including a capacitance meter, a 100-MHz frequency counter, a logic IC tester/identifier, and an oscilloscope. We'll start this month with an interface card.

The search for the perfect PC interface begins with the serial port. Unfortunately, the serial port is too slow for transferring large quantities of data needed to control and monitor test equipment. Another possibility is the parallel port which can transfer 8 bits in 500 nanoseconds (best case). Unfortunately, the parallel port is not truly bidirectional. A couple of handshake lines can be used as data inputs, but that means converting fast parallel data into slower serial data. Also, several data lines would have to be sacrificed so that they could be used as address lines. Another possible solution would be to connect a circuit directly to the computer's expansion bus. That would be very fast and easy to program, but it would require giving up an expansion slot every time you added another device.

What's needed is a general-purpose, fully bidirectional parallel port that can select and drive different peripherals all connected to a single generic ribbon cable. That is all contained in the I1000 Data Interface that we'll build this month. The I1000 can address up to 256 peripheral devices, all connected in parallel, using 25-conductor ribbon cable. The I1000 is simple to program; an "out" or "write" command sends a byte, and an "in" or "read" command receives a byte.

I1000 operation

Each card in a PC has it's own address. That is necessary to ensure that information intended for a certain card is received only by that card, and to ensure that only one card can place data on the bus at a time. Typically, the I1000 is set to address 768 (hex 300)—an address that IBM left available for prototyping. The I1000 can be re-addressed as needed by changing an address DIP switch. As far as software goes, we'll use BASIC due to it's broad popularity, but almost any other language can be used.

Sending a byte

Refer to Fig. 1 for the following example. When the BASIC instruction, "OUT 768,85" is executed, the byte "85" (01010101) is sent to address "768" (where the I1000 resides). The PC expansion bus address lines A5–A9 are attached to the card-address block, along with the $\overline{\text{ADDRESS ENABLE}}$ ($\overline{\text{AEN}}$) line, which indicates that the address data is valid, and the $\overline{\text{WRITE}}$ ($\overline{\text{WR}}$) line, which indicates that an "out" was performed. If the $\overline{\text{AEN}}$ and $\overline{\text{WR}}$ lines are low (logic 0) and the address lines match the DIP switch settings, an 8-bit magnitude comparator in the card-address block changes state (goes low). That tells the I1000 that the CPU has selected it.

The PC's $\overline{\text{WRITE}}$ pulse, in conjunction with the $\overline{\text{ENABLE}}$ pulse from the card-address block, causes the address latch to store the address, and the data latch to store the PC bus data. At that point, the I1000 is finished using the expansion bus, and it places the data, address, and $\overline{\text{SEND}}$ pulse on the interface cable that is going to the peripheral. The $\overline{\text{SEND}}$ pulse is sent along as confirmation that the data and address information is valid. Approximately 750 nanoseconds later, the I1000 sends a 500-nanosecond peripheral $\overline{\text{WRITE}}$ pulse. By the time the $\overline{\text{WRITE}}$ pulse reaches the peripheral, the data, address, and $\overline{\text{SEND}}$ pulses have finished any ringing associated with parallel interfacing. Additionally, each of the signals mentioned are terminated and buffered on the I1000 and at the peripheral. That defeats any error and noise (reflection, bounce, and

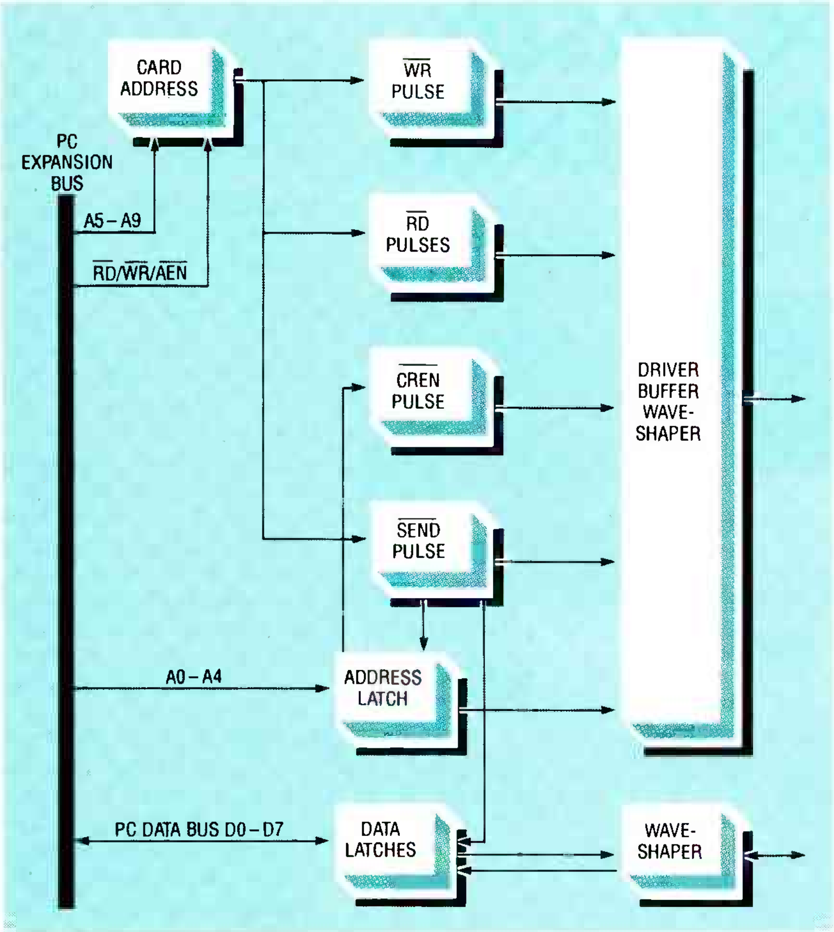


FIG. 1—I1000 BLOCK DIAGRAM. This interface will let your PC communicate with the test equipment we'll be working on in future articles.

crosstalk) problems commonly associated with parallel data transfer. The peripheral responds to the WRITE pulse by storing the data byte (D0–D7) within the location dictated by the address information (A0–A4) that it received.

Receiving a byte

For the following example, we will execute the line of BASIC: A=INP(768) : A=INP(768) : PRINT A. When the ADDRESS ENABLE (AEN) and the PC's READ (RD) lines are low, the card-address section once again goes low, and the send and address information is sent to the peripheral. A READ pulse is sent to the peripheral 500 nanoseconds later, which causes the peripheral to send the data back to the I1000. The data from the peripheral is stored in the I1000 250 nanoseconds later. The second input statement moves the data from the I1000 to the variable (A). Finally, the byte is displayed on the PC's monitor.

Control register enable

The I1000 has the ability to talk to 32 locations within 256 peripheral devices. That tremendous flexibility is accomplished through the use of the control register. When the I1000 is set to a base address of 768, it is actually active from 768 to 799, and covers 32 addressable bytes. If we say that the variable "bas" is equal to 768, then one I1000 can cover bas + 0 (768) to bas + 31 (799). Within the I1000, bas + 31 has been decoded to a single line. In other words, when an "out" is sent to bas + 31, the CREN line goes low.

When the CREN line goes low, any peripheral attached enters a comparator mode. While in that mode, each peripheral compares the information on the data bus with it's own hard-wired identification byte. If they match, that peripheral will attach itself to the data bus. In a peripheral where the bytes do not match, that peripheral will ignore or disconnect itself from the data bus. Once a peripheral has been called, it continues to be connected to the data bus until another bas + 31 activates a different peripheral.

Suppose peripheral 1 is an A/D converter with a unit address of 0 and peripheral 2 is a capacitance meter with a unit address of 4. An "out bas + 31,0" would select the A/D converter unit. The A/D would not actually do anything other than connect to the bus. After that, outs and ins to addresses between bas + 0 (768) and bas + 30 (798) would cause the A/D peripheral to perform it's job. An "out bas + 31,4" at this point would remove the A/D converter from the cable and connect the capacitance meter. Again, outs and ins in the range bas + 0 to bas + 30 would control the instrument selected.

Finally, an "out bas + 31,99" would disconnect both of the peripherals from the interface cable. That occurs because there is no device currently connected with a hard-wired identification byte of 99. The data bus is eight bits wide, so 256 (2^8) different peripherals can be addressed. Leaving bas + 31 for addressing different units, 31 addresses (0–30) remain for accessing IC's within each unit. The total number of locations accessible by one I1000 is 7936 (256 × 31).

Detailed operation

Take a look at the timing diagrams in Figs. 2 and 3 and the schematic in Fig. 4. A 74LS688 8-bit magnitude comparator (IC1) compares DIP switch S1's settings to the address present at address lines A5–A9 (P1, pins A22–A26). It also checks to see that WR and AEN are low. When those conditions are met, IC1 pin 19 goes low, telling the I1000 that it has been selected by the CPU. Address lines A0–A4 (P1 pins A27–A31) are connected to IC10, a 74LS573 address latch. When pin 19 of IC1 goes low, it causes pin 6 of IC2-b (a 74LS86) to go high, latching the address information into IC10. When

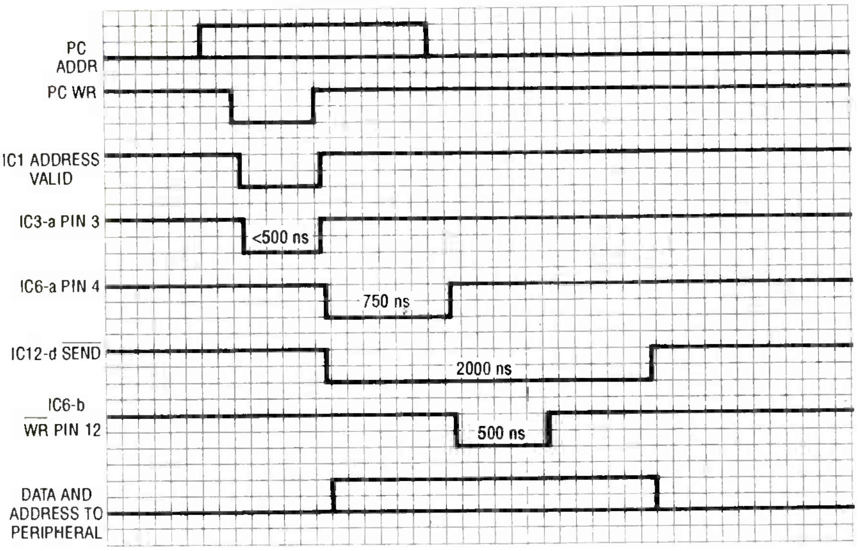


FIG. 2—I1000 WRITE, or "out" timing sequence.

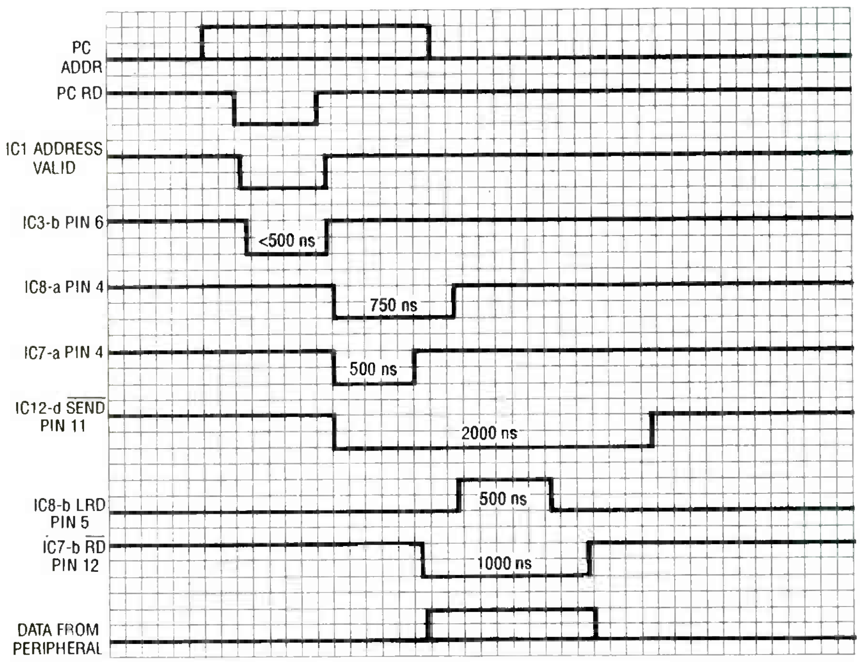


FIG. 3—I1000 READ, or "in" timing sequence.

the $\overline{\text{WR}}$ and $\overline{\text{EN}}$ pulses at the inputs of IC3-a (a 74LS32) go low, the output of IC3-a does the same. That causes the output of IC2-c to go high and moves D0–D7 data from the PC into data latch IC4.

Components IC6–IC9 (74HCT221's) are rising-edge triggered monostable multivibrators (one-shots) triggered by rising pulses. After approximately 500 nanoseconds, the $\overline{\text{WR}}$ and $\overline{\text{EN}}$ pulses return to their inactive high state and, as a result, the output of IC3-a returns to a high state. The rising edge produced by IC3-a triggers IC9-b and IC6-a. The $\overline{\text{WEND}}$ pulse, generated by IC9-a, when ANDed with the $\overline{\text{REND}}$ pulse, produces the $\overline{\text{SEND}}$ pulse. The $\overline{\text{SEND}}$ pulse tells the peripheral that the bus information is valid. The $\overline{\text{WEND}}$ and $\overline{\text{SEND}}$ pulses also enable IC10 and IC4, allowing A0–A4 and D0–D7 onto the peripheral buses.

At the same time IC9-b is triggered, IC6-a is triggered, producing a 750-nanosecond delay pulse. As IC6-a times out, it triggers IC6-b, which produces a 500-nanosecond $\overline{\text{WR}}$ pulse that is centered within the 2-µs $\overline{\text{SEND}}$ timing window. The $\overline{\text{WR}}$ and $\overline{\text{SEND}}$ pulses pass through IC13, a 74LS541 line driver/buffer. The $\overline{\text{WR}}$ pulse is reshaped by R9 and C30 to a waveform more suited to a long cable with inductive reactance. The $\overline{\text{SEND}}$ pulse is similarly reshaped by DIP resistor R10 (pins 6 and 11) and C27. During a $\overline{\text{WR}}$ operation, the data lines D0–D7 are conditioned by R11, R16, and C31–C38 on the way to the peripheral device. The address lines at the output of IC10 (A0–A4) are conditioned by R10 and C22–C26. Those address lines and the $\overline{\text{WEND}}$ pulse are applied to IC11, a 74LS138 demultiplexer. If $\overline{\text{WEND}}$ is low and the address is equal to the base address (768) plus thirty one (as discussed earlier), pin 7 of IC11 goes low producing the $\overline{\text{CREN}}$ pulse.

I1000 PARTS LIST

All resistors are ¼-watt, 1%, unless otherwise noted.

R1, R3, R5—1000 ohms, 5%
R2, R6—4320 ohms
R4—9090 ohms
R7, R8—20,000 ohms
R9—33 ohms
R10, R11—33 ohms, 16-pin DIP resistor
R12–R14—10,000 ohms, multiturn potentiometer
R15—4700 ohms, 10-pin SIP resistor
R16—2200 ohms, 10-pin SIP resistor

Capacitors

C1–C13—0.15 µF, 50 volts, monolythic or polystyrene
C14–C21—105 pF, 100 volts, dipped mica
C22–C29—1500 pF, 63 volts, polystyrene
C30—0.001 µF, 100 volts, ceramic disc
C31–C38—220 pF, 100 volts, ceramic disc
C39—100 µF, 25 volts, electrolytic
C40–C45—10 µF, 35 volts, electrolytic

Semiconductors

IC1—74LS688D 8-bit magnitude comparator
IC2—74LS86D quad 2-input XOR gate
IC3—74LS32D quad 2-input OR gate
IC4, IC5, IC10—74LS573D octal latch
IC6–IC9—74HCT221D dual one shot
IC11—74LS138D demultiplexer
IC12—74LS08D quad 2-input AND gate
IC13—74LS541D octal buffer

Other components

J1—Right-angle PC-mount female DB25 connector
S1—8-position DIP switch

Miscellaneous: I1000 PC board, PC mounting bracket and hardware with DB25 cutout, solder, etc.

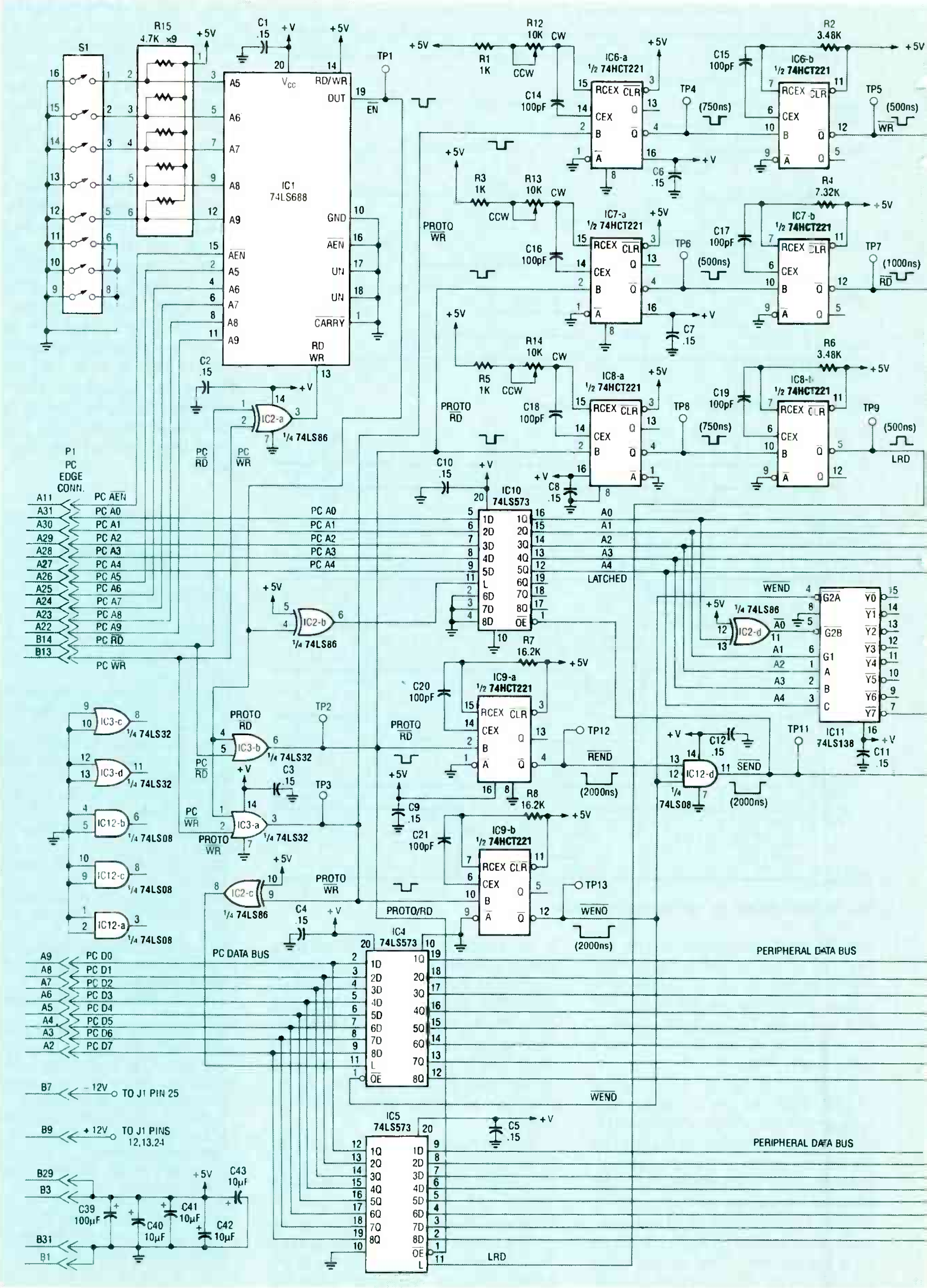
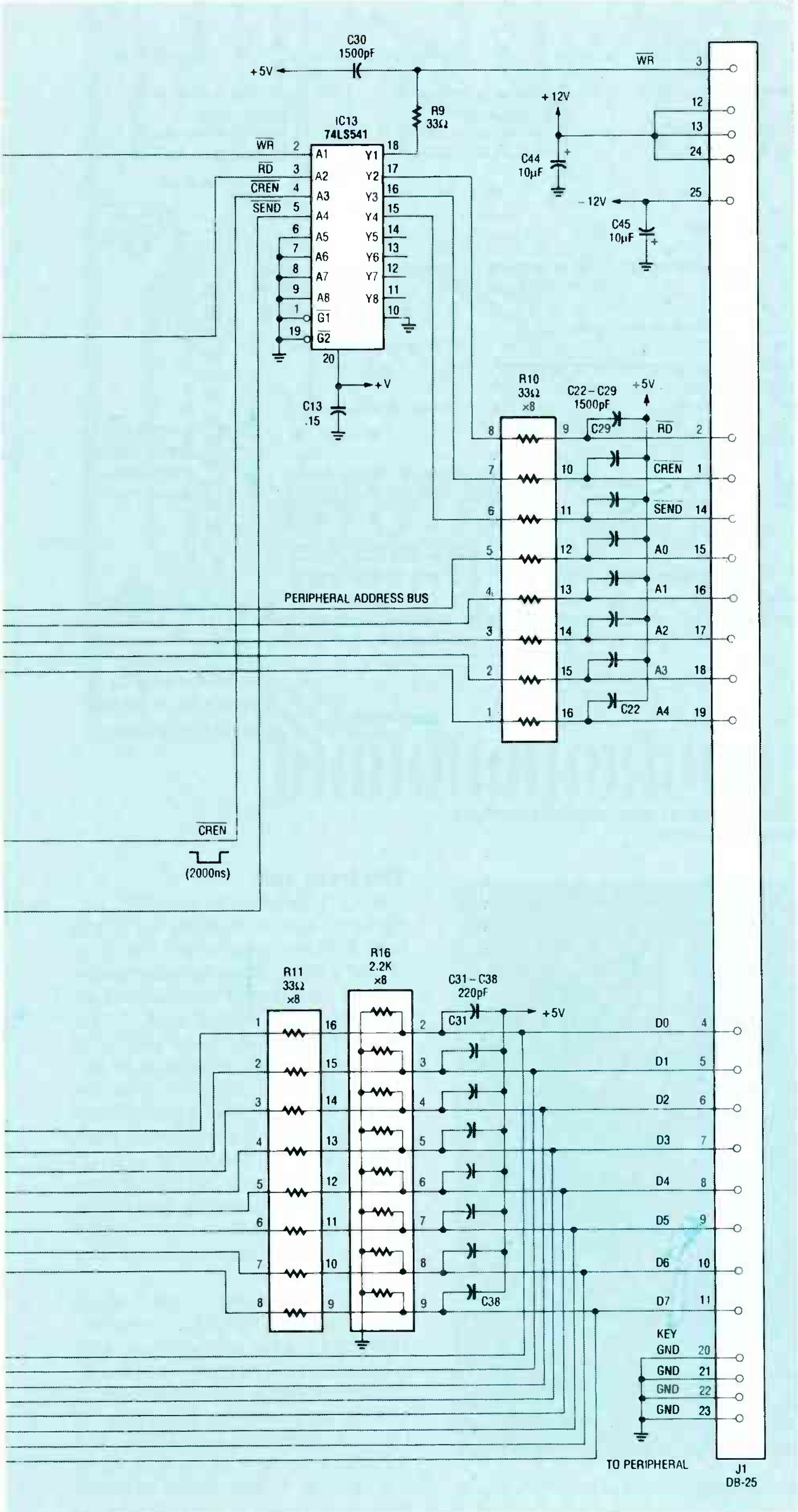


FIG. 4—I1000 SCHEMATIC. The I1000 can talk to 32 locations within 256 peripheral devices to provide tremendous flexibility.



Receiving a byte

When receiving a byte, IC1 operates the same as when it is sending except that the $\overline{\text{RD}}$ line goes low. The address data (A0–A4) is again stored in IC10. The $\overline{\text{RD}}$ and $\overline{\text{EN}}$ pulses go low, and as a result IC3-b transitions low. The PC then reads back the contents of IC5. (The information read back at this point is irrelevant, since information from the peripheral unit has not reached the I1000 yet.) As the $\overline{\text{RD}}$ and $\overline{\text{EN}}$ pulses end, a rising pulse edge occurs at IC3. That activates IC7-a, IC8-a, and IC9-a.

The $\overline{\text{REND}}$ pulse is produced by IC9-a, which, when it passes through IC12-d, becomes $\overline{\text{SEND}}$. A 500-nanosecond delay pulse is produced by IC7-a; as IC7-a times out, it triggers IC7-b, which produces a 1000-nanosecond $\overline{\text{RD}}$ pulse which is sent to the peripheral unit. (The $\overline{\text{SEND}}$ pulse and address information arrived at the peripheral 500 nanoseconds earlier.) Upon receiving the $\overline{\text{RD}}$ pulse, the peripheral sends the $\overline{\text{D0–D7}}$ data to the I1000 (IC8-a went active at the same time as IC7-a, and produced a delay pulse of 750 nanoseconds). As IC8-a times out, it triggers IC8-b to produce a 500-nanosecond latching pulse. The pulse controls the LATCH line of IC5 and stores the information sent by the peripheral during the (still active) 1000-nanosecond $\overline{\text{RD}}$ pulse. A second identical input statement will now cause IC3-b to go low. That again activates IC5 and returns valid data to the PC.

I1000 construction

To build the I1000 interface, you can either buy a PC board from the source mentioned in the Parts List or make one from the foil patterns we've provided. Install parts on the board as shown in Fig. 5. You will notice that for many of the capacitors, there are three holes on the board, with two of them electrically the same. Those two holes are for mounting capacitors of different sizes. Use the pair of holes that best fit the capacitors you use. Figure 6 shows a completed card.

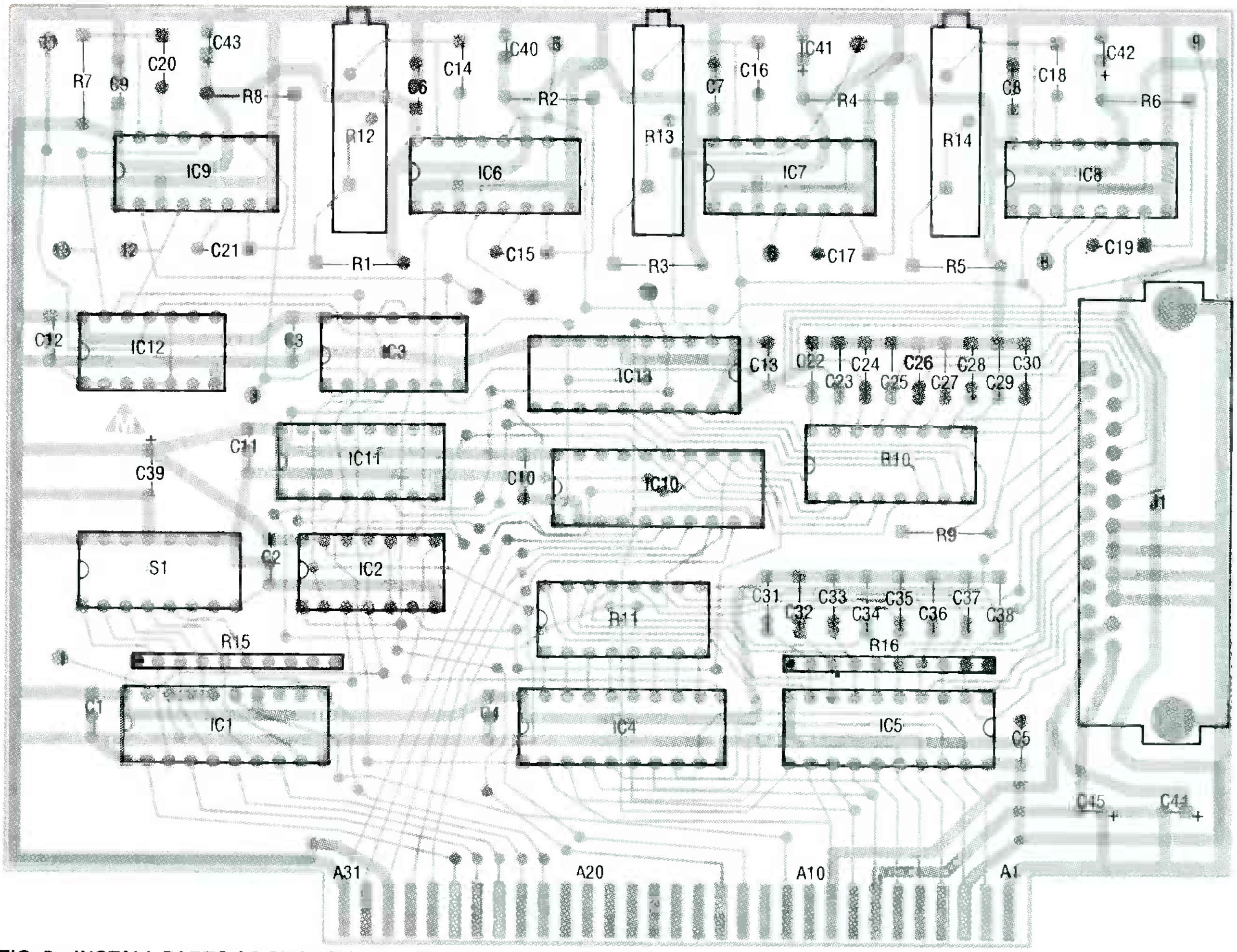


FIG. 5—INSTALL PARTS AS SHOWN HERE. For many of the capacitors there are three mounting holes to accommodate different-sized capacitors.

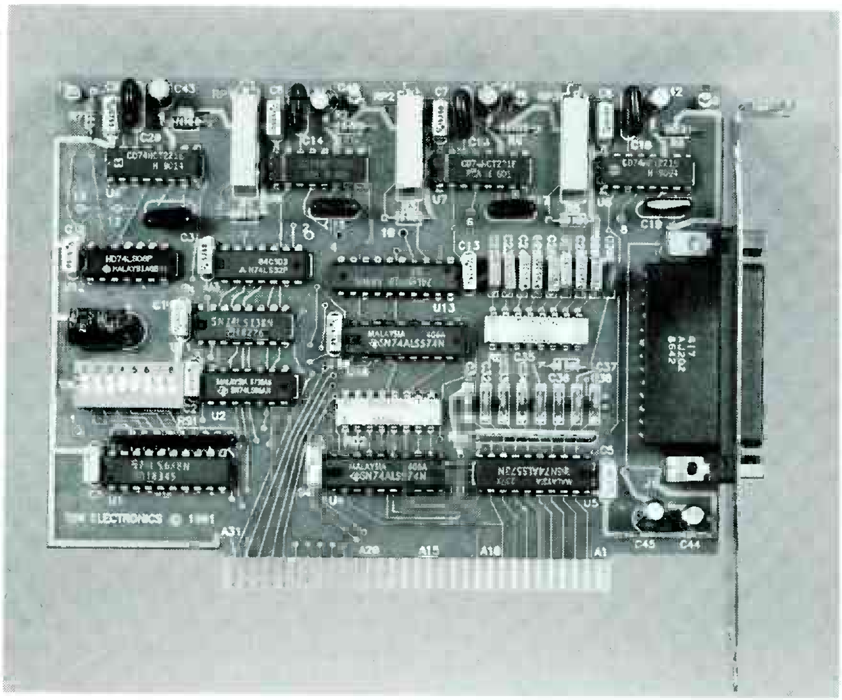


FIG. 6—COMPLETED INTERFACE CARD. This is installed in one of your PC's expansion slots.

The front end

Any I1000-compatible peripheral must contain an interface section to control the flow of data and clean up any noisy pulses. We'll call this interface section the "front end." The front end will be nearly identical for each I1000-compatible peripheral showcased in this series of articles. Each peripheral will contain its own front end, which will be included on the main PC board. Although we will not be discussing any of the PC peripherals this month, let's go over the operation of the front end now.

As shown in Fig. 7, each front end contains a data termination block and an address and handshake termination block. These sections are activated by inserting push-on jumpers. If the jumpers are removed, the termination section will be electrically inert. The I1000 is capable of addressing up to 256 (2^8)

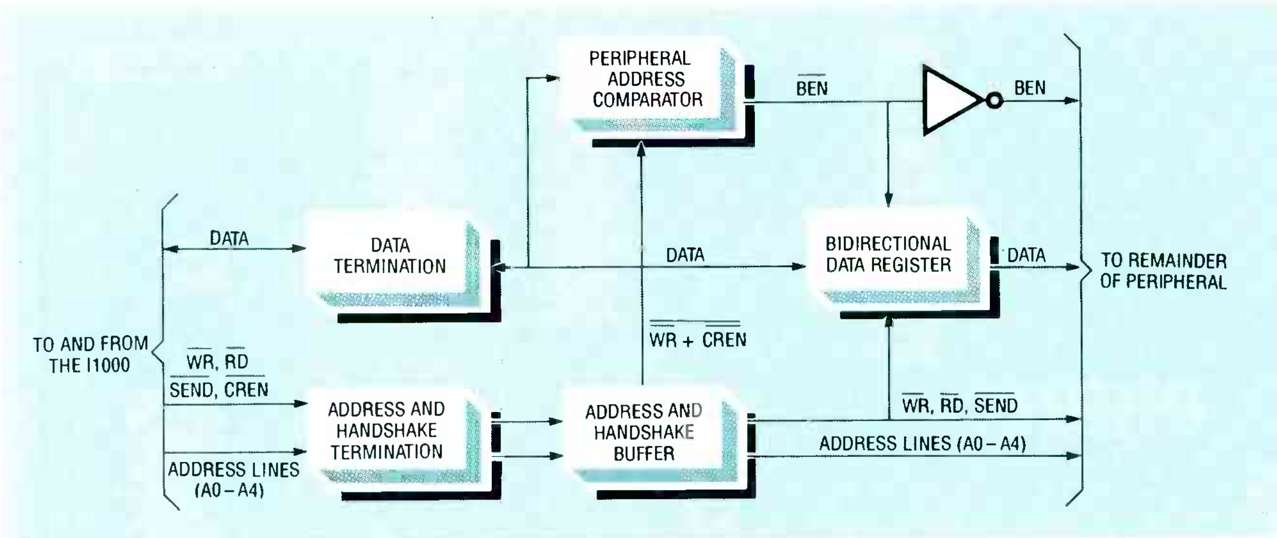
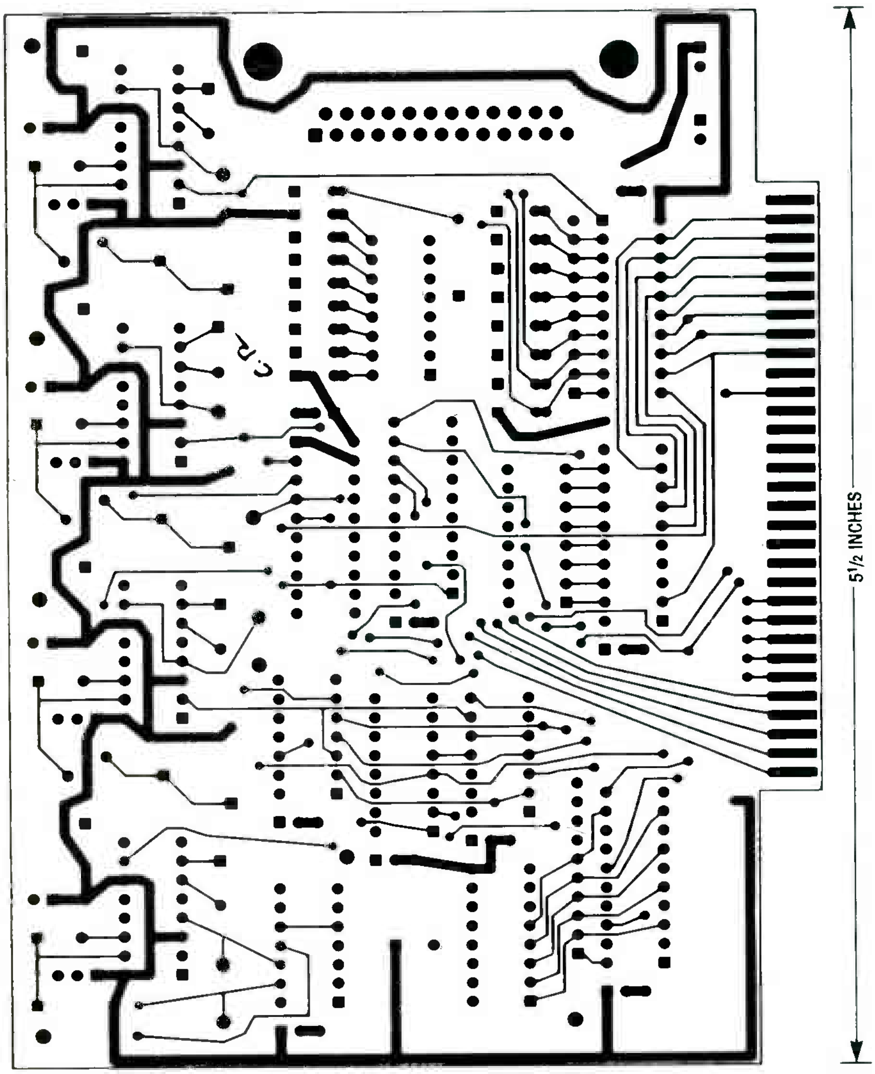


FIG. 7—ANY I1000-COMPATIBLE PERIPHERAL must contain an interface section to control the flow of data and clean up any noisy pulses. This front end will be nearly identical for all of the peripherals.



COMPONENT SIDE of the I1000 interface board.

peripherals. The DB-25 connectors on the rear of each peripheral are simply connected in parallel with one another. Termination of the data bus must occur at the most distant point on the bus and only at that point. If more than one peripheral were terminated at the same place, the termination impedance and its location would be altered, thus distorting the performance of the front ends.

After passing the active or inactive termination section, the data bus is attached to the Peripheral Address Comparator (PAC) and the Bidirectional Data Register (BDR). The PAC is responsible for activating a peripheral called by $\overline{\text{CREN}}$ as previously described. Each peripheral's PAC section contains its own unique address. If, during an active $\overline{\text{CREN}}$ pulse, the data on the bus matches the PAC address, the PAC section produces a low $\overline{\text{BOARD ENABLE}}$ handshake ($\overline{\text{BEN}}$). That signal and its complement (BEN) connect the remainder of the peripheral to the data bus and handshake lines ($\overline{\text{RD}}$, $\overline{\text{WR}}$, etc.).

The BDR is now capable of passing data to, and receiving data from, the main peripheral circuitry. The BDR is controlled by $\overline{\text{RD}}$, $\overline{\text{SEND}}$, and $\overline{\text{BEN}}$. Those lines tell the BDR the direction of data movement as well as the timing of that movement. After passing the active or inactive termination section, the address and handshake signals enter the address and handshake buffer. The signals are rounded by the termination sections to minimize crosstalk and other noise associated with fast rise and fall times. The address

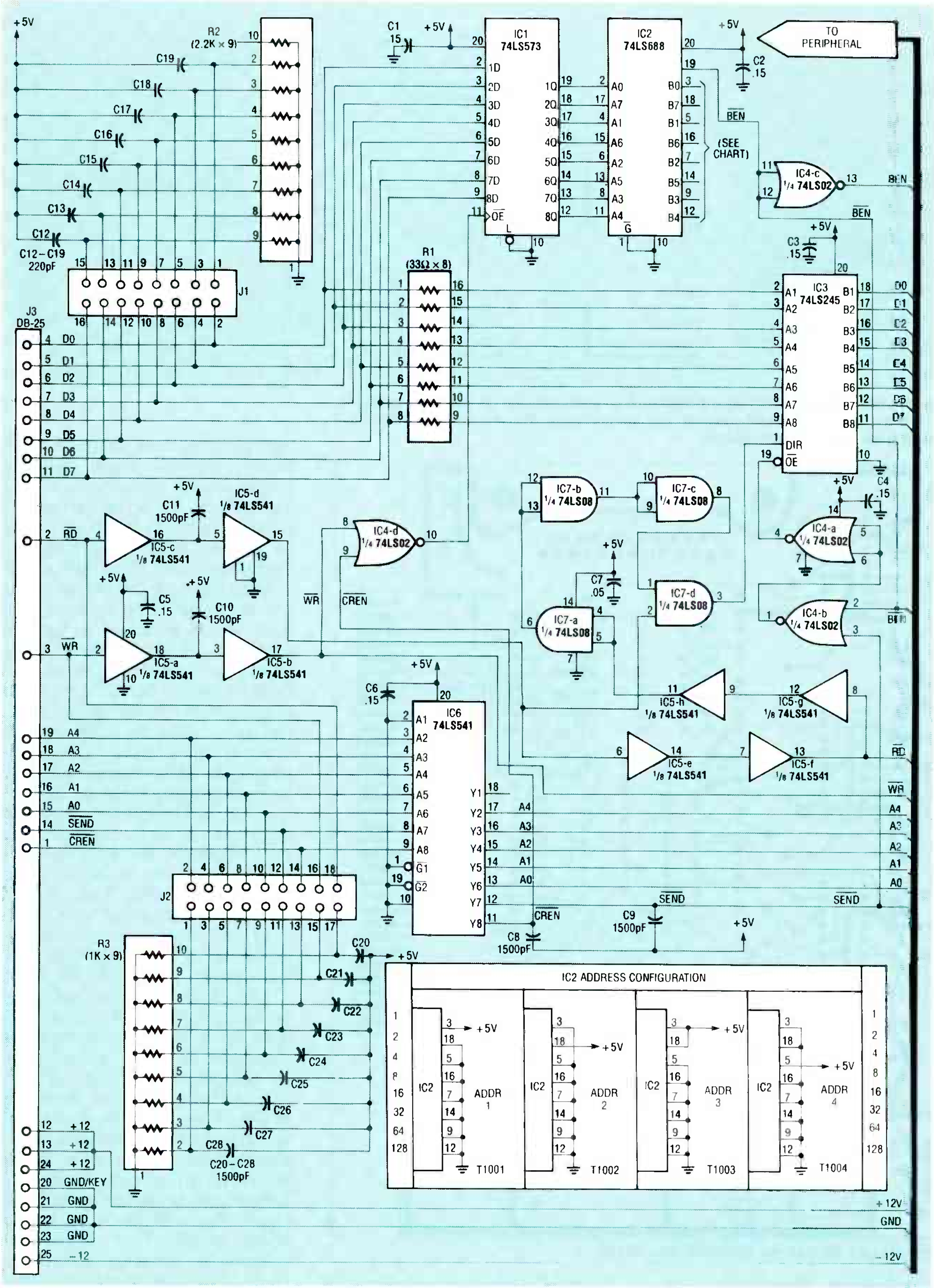
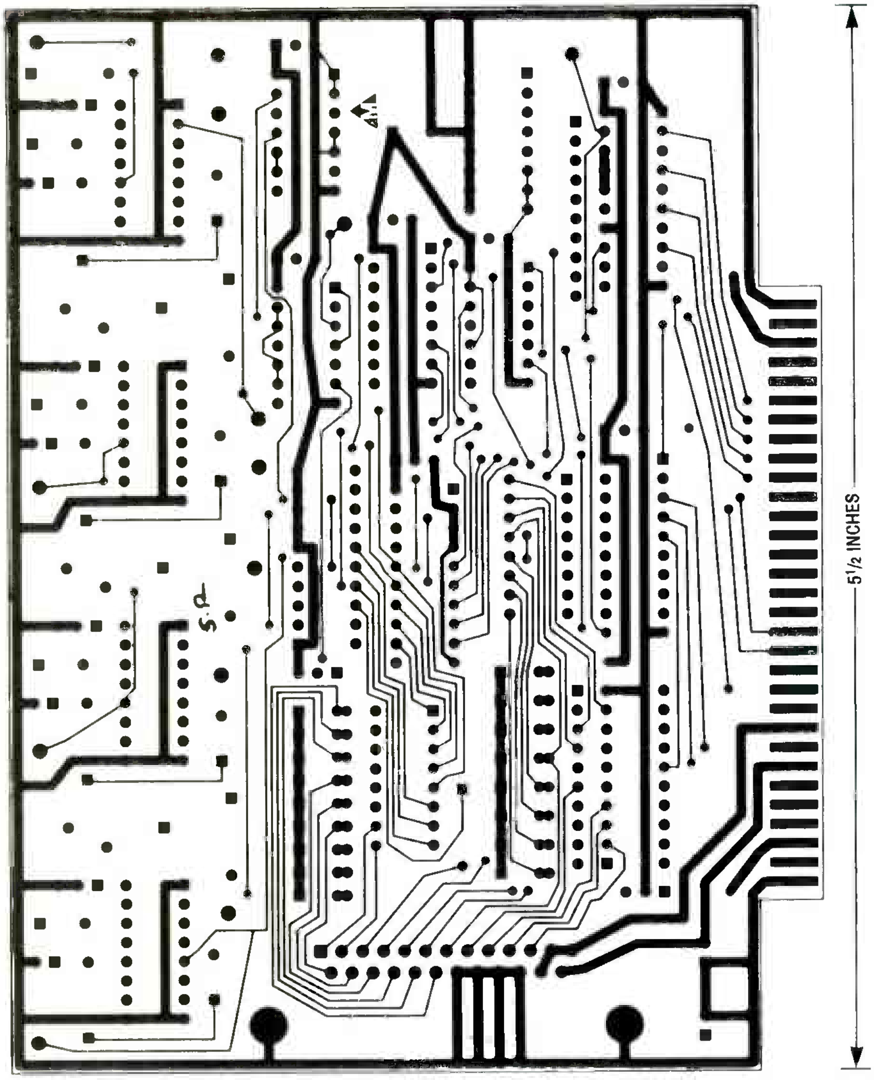


FIG. 8—FRONT-END SCHEMATIC. Each front end contains a data termination block and an address and handshake termination block that use push-on jumpers.



SOLDER SIDE of the I1000 interface board.

FRONT-END PARTS LIST

Resistors
R1—33 ohms, 16-pin DIP resistor
R2—2200 ohms, 10-pin SIP resistor
R3—1000 ohms, 10-pin SIP resistor

Capacitors
C1–C7—0.15 µF, 50 volts, monolythic or polystyrene
C8–C11, C20–C28—1500 pF, 63 volts, polystyrene
C12–C19—220 pF, 100 volts, ceramic disc

Semiconductors
IC1—74LS573D octal latch
IC2—74LS688D 8-bit magnitude comparator
IC3—74LS245D octal transceiver
IC4—74LS02D quad 2-input NOR gate
IC5, IC6—octal buffer
IC7—74LS08D quad 2-input AND gate

Other components
J1—16-pin male header
J2—18-pin male header
J3—Right-angle PC-mount male DB25 connector

Miscellaneous: 17 shorting blocks (for J1 and J2), solder, etc.

Note: The following items are available from TSW Electronics Corp., 2756 N. University Drive, Suite 168, Sunrise, FL 33322 (305) 748-3387:
- **I1000 kit—$65.00**
- **I1000 PC board only—$35.00**
- **I1000, assembled and tested—$77.00**
- **6-foot interface cable (DB-25-6)—$12.95**

Add $3.00 S&H for each order. Send check or money order only.

and handshake buffer restores the original fast rise and fall times of the signals.

Sending a byte

When describing software-related functions, we'll again use BASIC due its wide popularity and we'll assume the following initial conditions:

- The base address of the I1000 is 768 (hex 300).
- The front end of the peripheral has not been selected.
- The address of the peripheral is 4.

Refer to the front-end schematic in Fig. 8 and the following source code:

```
10 BAS = 768
20 OUT BAS + 31,4
30 OUT BAS + 2,170
```

Line 10 in that example assigns the address "768" to the variable "bas." Line 20 causes the $\overline{\text{SEND}}$ and $\overline{\text{CREN}}$ pulses at IC6 pins 8 and 9 to go low (refer to the timing diagrams in Figs. 2 and 3). If the shorting blocks have been installed at header J2, then the $\overline{\text{RD}}$, $\overline{\text{WR}}$, ADDRESS, $\overline{\text{SEND}}$, and $\overline{\text{CREN}}$ lines are all terminated. Line driver IC6 restores the original wave shape of any signals fed to it. The $\overline{\text{SEND}}$ and $\overline{\text{CREN}}$ pulses exit IC6 at pins 12 and 11. If the shorting blocks have been installed at J1, then the data lines D0–D7 are terminated. Either way, the data is fed to the input of latch IC1; IC3 is inactive at this time. At a time 750 nanoseconds later, the $\overline{\text{WR}}$ pulse enters IC5-a where it is reshaped. It is combined with the cleansed $\overline{\text{CREN}}$ pulse by IC4-d to produce the WR-CREN pulse.

The WR-CREN pulse latches the data (a binary 4) into IC1. The binary 4 appears at the output of IC1 and, subsequently, at the input of IC2, an 8-bit magnitude comparator. The magnitude comparator (IC2) compares the byte fed into it from IC1 with its hardwired address (see the IC2 address-configuration chart contained in Fig. 8). If the two bytes match, pin 19 of IC2 goes low ($\overline{\text{BEN}}$). $\overline{\text{BEN}}$ is then combined with $\overline{\text{SEND}}$ by IC4-b to produce the OUTPUT ENABLE control line signal ($\overline{\text{OE}}$) used by IC3, which transfers all the data to and from the peripheral.

When $\overline{\text{BEN}}$ is high, IC3 is inactive. The BEN line ($\overline{\text{BEN}}$'s compliment) is produced at IC4-c and enables or disables the chip-select section in the peripheral circuitry.

The $\overline{\text{BEN}}$ and BEN lines are the primary lines that determine whether a peripheral on the bus is active or dormant. The direction pin on IC3 (DIR) is controlled by the $\overline{\text{RD}}$ pulse. The $\overline{\text{RD}}$ pulse is high during a write operation, allowing data to flow from the I1000 side of IC3 to the peripheral side of IC3.

Line 20 in the software example activates the peripheral by causing $\overline{\text{BEN}}$ to transition low. Line 30 in the software example will not affect IC1 or IC2. As explained earlier, only an "out" to bas + 31 will activate $\overline{\text{CREN}}$. Line 30 will cause the following sequence of events: $\overline{\text{SEND}}$ will go low. The data (a decimal 170 in this case) will pass through IC3 to the peripheral circuitry. Address information (a decimal 2 in this case) will pass through IC6 to the peripheral circuitry. At a time 750 nanoseconds later, a 500-nanosecond $\overline{\text{WR}}$ pulse will pass through IC5 to the peripheral circuitry. The address is decoded by the chip-select circuit in the peripheral and the $\overline{\text{WR}}$ pulse is then routed to the addressed IC. Any "out" to an address between bas + 0 and bas + 30 will initiate the process commanded by line 30.

Termination

The termination sections are composed of J1, C12–C19, R2, J2, C20–C28, and R3. Those sections provide a termination impedance to ground as well as an R-C time constant. The termination impedance reduces the reflected signal caused by the inductive and resistive properties of the six-foot cable. The R-C time constant slows down the rise and fall times of the signal in the cable, thus reducing crosstalk. As stated earlier, the original transition times are subsequently restored.

Receiving a byte

As we describe how the front end end receives a byte from the I1000 interface, let's assume the following initial conditions:

- The base address of the I1000 is 768 (hex 300).
- The front end of the peripheral has been activated at an earlier time.

Next refer to the following source code:

```
40 A=INP(BAS+3)
50 A=INP(BAS+3)
60 PRINT A
```

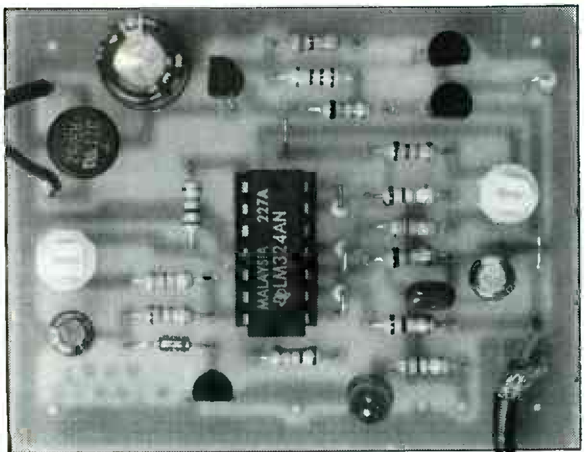
Lines 10–30 are assumed to have been executed previously. Therefore, our theoretical peripheral has already been selected (activated). Line 40 produces a read function as described earlier. The $\overline{\text{SEND}}$ pulse goes low. The address lines (A0–A4) function as they did during the write function. At a time 500 nanoseconds later, a 1-µs $\overline{\text{RD}}$ pulse is received by the front end. It is reshaped by IC5-c and IC5-d. The $\overline{\text{RD}}$ pulse passes through IC7-d to IC3 pin 1. The peripheral side of IC3 becomes an octal input while the I1000 side of IC3 becomes an octal output.

The $\overline{\text{RD}}$ pulse arrives at the read chip-select section of the peripheral circuitry. The $\overline{\text{RD}}$ pulse, in conjunction with the address lines, cause the target IC to place its byte onto the bus. The transmitted byte passes through IC3 to the I1000 where it is latched. A data bus directional delay (DBDD) is provided by IC5-e–IC5-h in combination with IC7-a–IC7-d.

The DBDD provides a delay after the read cycle has finished before returning IC3 to its normal "output" configuration. That prevents IC3's peripheral side from going into its low-impedance state before the IC that was just read is able to de-activate. Line 50 causes the byte latched in the I1000 to be sent to the PC where it is stored under the variable "A." Line 60 prints the value contained in variable "A" on the screen.

As mentioned before, there's no separate front end PC board; each peripheral contains its own front end. Next month you'll see the front-end parts installed on the first peripheral board we'll work on: the T1001. That peripheral contains a 100-MHz frequency counter for digital signals, a period event meter, and a capacitance meter covering 1 picofarad to 10,000 microfarads. Other PC-based test instruments that we will build in future articles, include a logic-IC tester/identifier, and an A/D-D/A peripheral that can also be used as a low-frequency 8-channel digital storage oscilloscope. R-E

electronic THERMOSTAT



This solid-state thermostat can replace those old mechanical units—at a cost of less than twenty dollars!

RODNEY A. KREUTER

THE MEASUREMENT AND CONTROL of temperature is one area in which electronics has had a great impact. From "set back" home thermostats to laboratory controllers with ±0.001-degree accuracy and digital fever thermometers, the use of electronics has all but eliminated mechanical systems.

Many methods are used for measuring and controlling temperature, including the expansion of mercury or alcohol, bi-metallic strips, thermistors, silicon sensors, and thermocouples. Each has its advantages and disadvantages.

The author was recently asked to design an inexpensive thermostat to replace some old bi-metallic-type thermostats. The new thermostat had to meet the ±5°C accuracy of the bi-metallic strips, have a −50 to +150°C range, and cost less than twenty dollars. A simple solid-state thermostat was the only solution.

Whether you're trying to keep a fish-tank temperature to within 1°C, maintain working temperature for PC-board etchant, shut down an overheated amplifier, or turn on cooling fans, you'll find that this simple solid-state thermostat will do the job. Note that this project is *only* a controller, so you must supply the heater (or cooler), a suitable relay, and a temperature-measuring device for calibration.

Looking around

Before anyone decides to design and build something, it pays to have a look around to see what's available on the market. First there's the Radio-Shack Thermometer/Controller. Total cost (with switches, etc.) is about twenty eight dollars. The temperature range is −40 to +50°C (−40 to +122°F), and it has a digital readout and temperature memory. So far so good—if the temperature range suits your needs. Maximum measurement speed is once per second. However, the real drawback is that if the temperature limit is exceeded, the output goes high for one minute; during that time period the temperature is not measured!

National Semiconductor has been making a number of temperature sensor/controllers for at least 15 years. The LM3911 (−25 to +85°C) and the LM35 (−55 to +150°C) are two examples. They are easy to work with, but they are more difficult to find and ones with a large temperature range aren't exactly cheap.

Sensors are also made by Linear Technology (the LM134 with a −55 to +125°C range) and Analog Devices (the AD590 with a −55 to +150°C range) as well as dozens of others. The only catch, besides availability, is that they are precision sensors meant to measure as well as control temperature. They are also quite expensive.

Complete controllers are also made by other companies such as Omega, but the cost is about the same as a cheap personal computer. That is due partly to super accuracy and digital temperature readout.

Rollin' your own

When so many people are making temperature sensor/controllers, why build one from scratch? There are two basic reasons:

- Commonly available parts can be used.
- You can control such parameters as accuracy and temperature measurement bandwidth.

Theory of operation

If a constant current is passed through an ordinary silicon diode, the voltage across the diode will be a function of temperature. There are more accurate ways to measure and control temperature, but at twenty for a dollar you can't beat the price, and control accuracy of ±0.5°C is typical.

The actual voltage across the diode with 1 milliamp of current passing through it is about 0.75 volt at −50°C and 0.35 volt at 150°C. That works out to about 2 millivolts per °C. Although a controller could be made to work at that level, a little amplification makes things much simpler.

The schematic of the controller is shown in Fig. 1. Transistors Q1 and Q2 make up the 1-milliamp constant-current source for the temperature-sensing diode, D1. The base-emitter junction of Q1 is used to temperature-compensate the base-emitter drop of Q2. The 1.25-volt reference of the LM317 regulator appears across resistor R4, keeping the emitter current (and therefore the collector current) of Q2 constant at about 1 milliamp. The actual amount of current isn't nearly as critical as the fact that the current remains constant.

Differential amplifier IC1-a serves two purposes. The first is to subtract a DC voltage from the temperature-sensing diode D1. That's necessary so that a DC amplifier can be used to amplify the signal from D1 without saturating. The signal is also inverted by IC1-a so that an increase in temperature produces an increase in voltage.

Op-amp IC1-b is configured with a gain of 11 (1+R11/R10). That makes the job of comparator IC1-d easier.

The temperature set point is controlled by resistor R15 and buffered by IC1-c. Note that by changing the values of R14 and R16 you can restrict the control range, making it easy to vary the set point in very fine steps. Using the values shown, control is adjustable from about −50 to

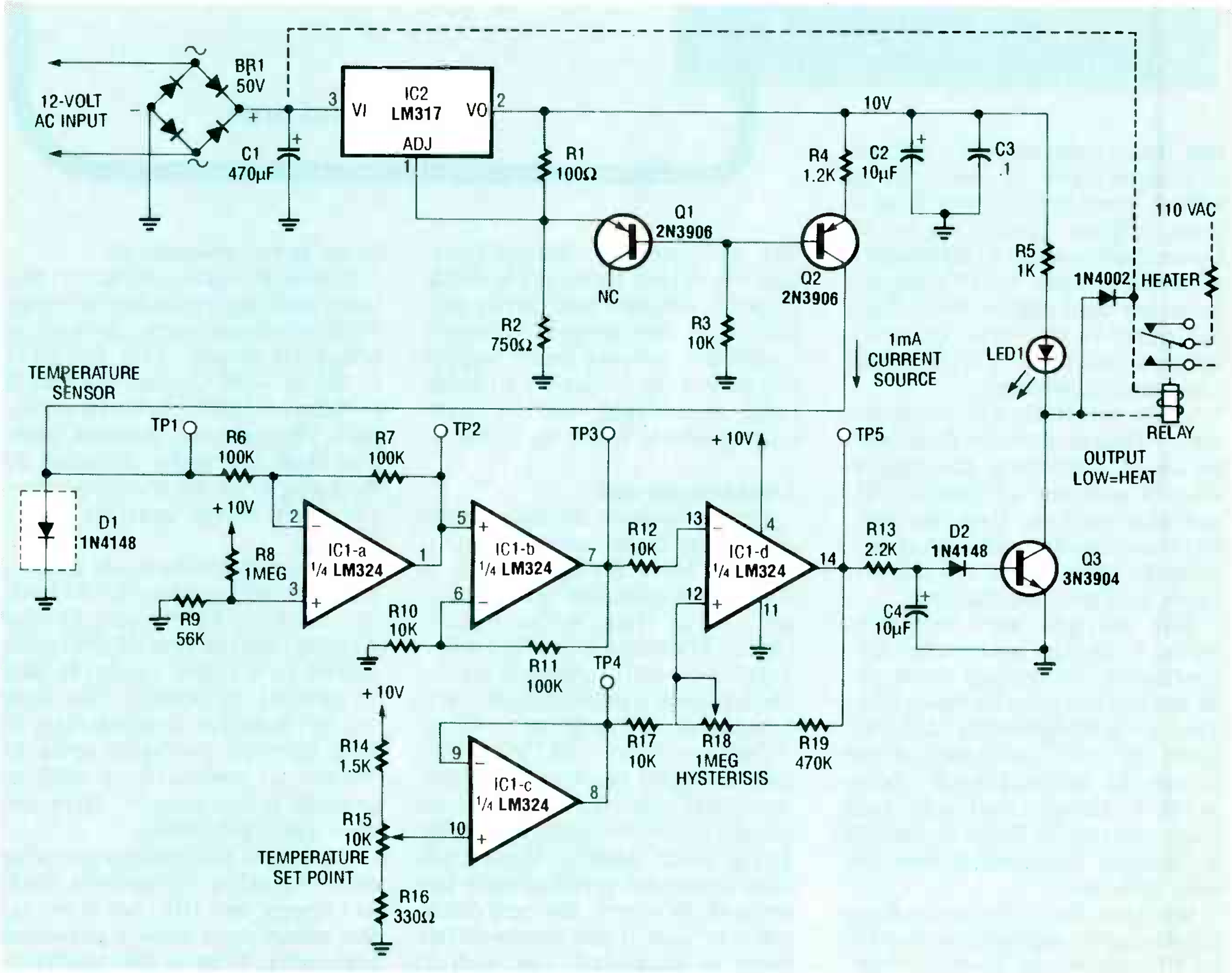


FIG. 1—CONTROLLER SCHEMATIC. If a constant-current is applied to a diode (D1 in this case), the voltage across the diode will be a function of temperature.

+150°C. With that much range, a small movement of a single-turn potentiometer will produce a large change in the set point. A ten-turn potentiometer would be a better choice for a large-range thermostat. Table 1 shows recommended values for R14, R15, and R16 for smaller temperature ranges.

Comparator IC1-d compares the set-point voltage with the output voltage of IC1-c. If the voltage at TP3 is greater than TP4, the output of the comparator will be low, thus shutting off transistor Q3. If more heat is needed, the voltage at TP3 will be less than TP4 and the comparator output will go high, turning on Q3.

Resistors R18 and R19 provide some hysteresis. Providing a small amount of hysteresis in a comparator ensures a smooth transition from one state to the other. Although it limits the accuracy somewhat, the benefits far outweigh the disadvantages. Without hysteresis, the output of the comparator would dither, or oscillate from one state to the other when the inputs are about equal. Imagine ordering an oil-burning furnace to turn on and off a thousand times a second!

The amount of hysteresis can be controlled by resistors R18 and R19. Decreasing R18 will increase the hysteresis and cause a greater temperature variation in the controller. For example, using the highest resistance, the temperature window might be 0.5°C. At the lowest, it might be 3°C.

The output of the controller can control a conventional or solid-state relay. A solid-state relay is preferable since its reliability is much greater than that of a conventional relay. (If you'd like to build your own solid-state relay, see **Radio-Electronics**, May 1992.) Any relay rated from five to twelve volts will work if you connect it to the positive side of C1 through the appropriate resistor. That resistor value can be obtained by dividing the voltage drop required by the current consumed by the relay. If a conventional relay is used, a snubbing diode such as a 1N4002 should be used to protect Q3 when the relay turns off.

Construction

Any method of construction can be used since there is nothing critical about the circuit layout, but it will be easier using a PC board made from the foil pattern we've provided or one purchased from the source mentioned in the Parts List. *Do not* substitute another regulator for the LM317. In addition to providing a regulated voltage, the LM317's 1.25-volt reference is used to operate the constant-current source for diode D1. Figure 2 shows the parts-placement diagram.

Twelve-volts AC can be supplied from just about any transformer since only a few milliamps are required—not counting the relay current. Relay current of up to 100 milliamps can be handled by Q3.

The temperature probe can be made of metal or glass. The diode is so small that it can be put into standard glass tubing and sealed with RTV (room-temperature vulcanizing) silicone. Coating the diode with RTV sil-

TABLE 1—RESISTOR VALUES

Temperature Range (Degrees C)	R14	R15	R16
−50 to −30	10K	1K	330Ω
−30 to −10	9.1K	1K	1.2K
−10 to 15	8.2K	1K	2.2K
15 to 35	7.5K	1K	3.3K
35 to 55	6.2K	1K	4.3K
55 to 75	5.1K	1K	5.1K
75 to 95	4.3K	1K	6.2K
95 to 115	3.3K	1K	6.8K
115 to 135	2.2K	1K	8.2K
135 to 155	1.2K	1K	9.1K

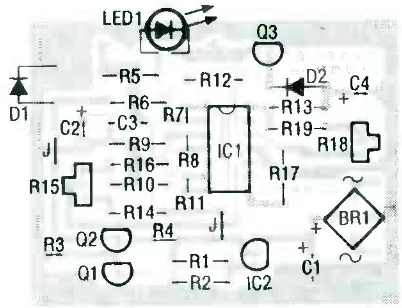
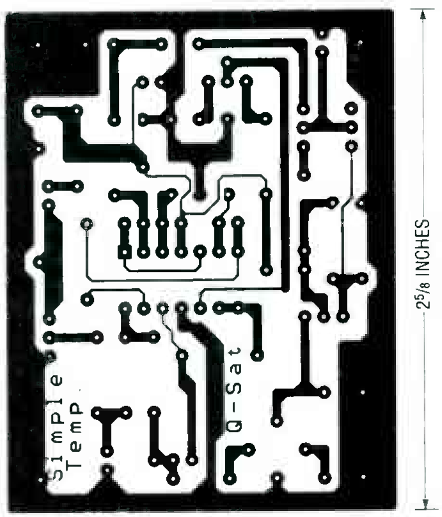


FIG. 2—PARTS-PLACEMENT DIAGRAM. Any method of construction can be used, but it's best to use a PC board. You can make one from the foil pattern we've provided or buy one from the source mentioned in the Parts List.

FIG. 3—THE TEMPERATURE-SENSING diode can be sealed in a length of glass tubing and sealed with RTV silicone. You must use a shielded cable between the probe and the measuring circuit.



FOIL PATTERN for the solid-state thermostat shown actual size.

icone might also work although the thermal time constant would probably increase using that method. You must use a shielded cable between the probe and the measuring circuit. Figure 3 is a close-up view of the probe assembly with the diode installed in a length of glass-tubing.

The printed circuit board is designed to accept two different trim potentiometers, hence the four holes instead of three. If you must adjust the temperature often, you might opt to run wires from the PCB to standard-type potentiometers. Figure 4 shows the author's completed prototype.

Testing

You should first test the 1-milliamp current source. If the voltage across R4 measures about 1.2, you're in business. Placing a milliammeter in series with D1 can confirm that.

For the purposes of testing, it's handy to replace D1 with a 1K potentiometer. Since a constant current of 1 milliamp is flowing through the resistor, a voltage from 0 to 1 volt can be obtained depending on its setting. Of course that range is too much since the diode voltage varies only from about 0.8 volt at −50°C to about 0.3 volt at +150°C.

First measure the voltage from pin 3 of IC1 to ground. It should be about 0.55 volt. Using the 1K potentiometer, adjust TP1 for the voltages shown in Table 2, and make sure the TP2 and TP3 voltages agree with Table 2 for each voltage at TP1. Next check the temperature set-point range. Measure the voltage from TP4 to ground; with the potentiometer set at the extreme counterclockwise position, TP4 should be about 0.31 volt. Clockwise, it should be about 8.88 volts.

If the testing works out, you're ready for the real test. With R15 set counterclockwise and the temperature-sensing diode at room temperature, LED1 (and Q3) should be off. Turn R15 slowly clockwise until the LED comes on. Now heat the diode with a soldering iron or match; the LED should go off. If everything is allright, the final step is to calibrate the controller with an accurate temperature-measuring device. R-E

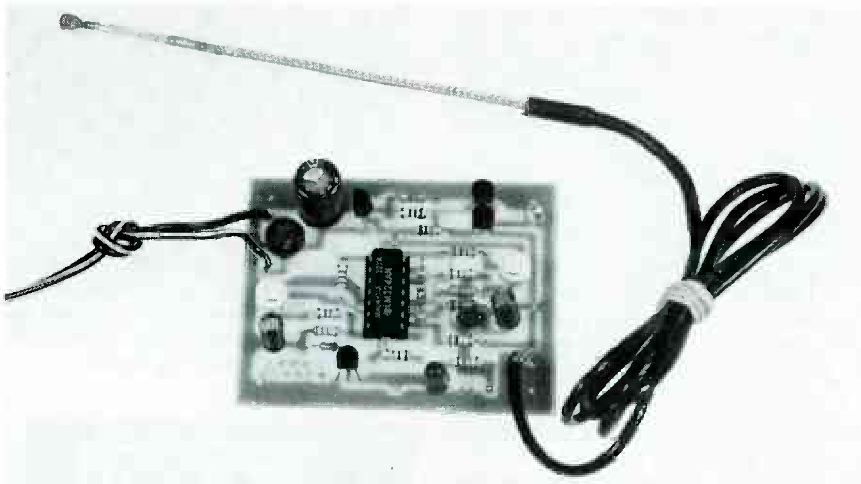


FIG. 4—THE AUTHOR'S PROTOTYPE. If you will need to adjust the temperature often, run wires from the PCB to standard-type potentiometers.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—100 ohms
R2—750 ohms
R3, R10, R12, R17—10,000 ohms
R4—1200 ohms
R5—1000 ohms
R6, R7, R11—100,000 ohms
R8—1 megohm
R9—56,000 ohms
R13—2200 ohms
R14—1500 ohms (see text)
R15—10,000-ohm potentiometer (see text)
R16—330 ohms (see text)
R18—1-megohm potentiometer
R19—470,000 ohms

Capacitors
C1—470 µF, 25 volts, electrolytic
C2, C4—10 µF, 16 volts, electrolytic
C3—0.1 µF, Mylar

Semiconductors
IC1—LM324 quad op-amp
IC2—LM317L voltage regulator
D1, D2—1N4148 diode
LED1—light-emitting diode, any color
Q1, Q2—2N3906 PNP transistor
Q3—3N3904 NPN transistor
BR1—50-volt bridge rectifier

Miscellaneous: 12-volt AC power supply, PC board, glass or other similar tube for temperature probe, RTV cement, wire, solder, etc.

Note: The following items are available from Q-Sat, PO Box 110, Boalsburg, PA 16827:
- **PC board (Temp-PCB)—$7.00 postpaid**
- **All parts (including PC board) except 12-volt transformer (Temp-KIT)—$18.00 postpaid**

Pennsylvania residents please add 6% sales tax.

TABLE 2—TEST-POINT VOLTAGES

Approximate Temperature (°C)	TP1	TP2	TP3
	0.300	0.766	8.38
150	0.350	0.717	7.84
	0.400	0.665	7.28
	0.450	0.616	6.74
	0.500	0.566	6.81
50	0.550	0.515	5.63
	0.600	0.465	5.08
	0.650	0.415	4.54
	0.700	0.364	3.97
	0.750	0.315	3.43
−50	0.800	0.263	2.87
	0.850	0.212	2.31

EDGARDO PEREZ

CLASSIC VIDEO AMPS *Revisited*

Learn to put mature high performance video amplifiers to work in your latest video and RF circuits.

BANDWIDTHS OF THE LATEST MONOlithic video amplifiers have now reached 600 megahertz. That performance has been achieved in differential two-stage video amplifier IC's because of recently introduced vertically integrated PNP structures. These new products have pre-empted earlier, more mature video amplifiers, including the 592 and 733, from many new designs.

Nevertheless, the 592 and 733, introduced in the early 1970's for such applications as tape- or disk-memory read amplifiers remain versatile devices. Leading-edge video amps in their day, they offered typical differential voltage gains of 400 and adjustable pass bands. Moreover, neither required frequency compensation. The typical bandwidth of the 592 is 90 megahertz while that of the 733 is 120 megahertz. Risetime on the 733 is 2.5 nanoseconds, and typical propagation delay time is 3.6 nanoseconds.

Originally developed by Fairchild as the µA592 and µ733, the parts were second sourced by IC suppliers including Motorola, National Semiconductor, Signetics, Texas Instruments, and VTC Inc. They were redesignated by those manufacturers with their prefixes such as MC1733, LM592, SE592, TL592, and VA592.

After making them for many years Motorola and National Semiconductor recently bowed out, but Signetics, TI, and VTC have confirmed that they are still producing one or both of those video amps. Both devices are available in a variety of packages including plastic and ceramic DIP's, and metal cans.

Although their performance has been superseded by newer video amps, the characteristics of the 592 and 733 remain attractive. They might no longer be at the forefront of video amplifier IC technology but they are definitely not obsolete! What's more, maturity has brought about a steady decline in pricing. Bargain prices as low as 25 cents apiece have been reported, but you can expect to pay from 70 to 90 cents for a plastic-DIP version from your distributor.

There are slight differences in performance between the 592 which was introduced in about 1974, and the 733 which was introduced a few years later. For most of the circuits in this article the 592 and 733 are pin-for-pin interchangeable. Figure 1 is the schematic of the 592, with an inset showing the circuit differences in the 733. (The 592 has two transistors in its first-stage differential amplifier (Q11 and Q12) while the 733 has only one (Q11).

Designers use both of these video amps in the differential output mode for DC applications, or with AC coupling for single-ended output. In place of external feedback to control gain, the video amps have built-in internal local feedback for operation in the open-loop mode only. Because they include only NPN transistors (as shown in Fig. 1), the outputs are always 2.4 to 3.4 volts above ground when both inputs are grounded.

Construction guidelines

You can take advantage of the low prices for these devices in your next RF- or video-circuit design if you are willing to follow some basic rules for designing and building radio-frequency circuits. So before you start to build anything, let's take time to review those guidelines.

- Use only passive components that are stable at radio frequencies. For example, use only car-

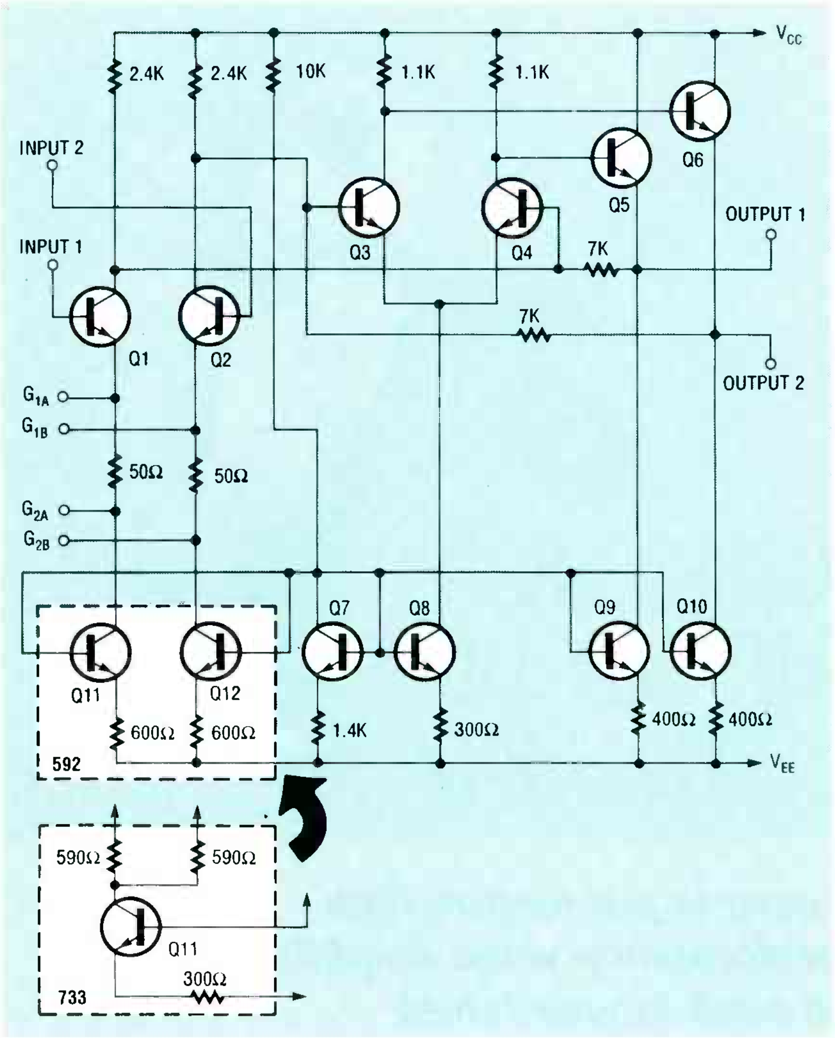


FIG. 1—SCHEMATIC FOR THE 592 with an inset showing the differences in the 733. Transistor Q11 and three related resistors replace transistors Q11 and Q12 and two emitter resistors.

bon-composition or non-inductive metal-film resistors. For small capacitance values, use only silvered-mica (rather than foil and mica), ceramic, and mylar-film capacitors. For large capacitance values, use solid or foil tantalum capacitors in place of aluminum electrolytics.

- Keep all traces on your PC boards short and wide to minimize both stray inductance and stray signal coupling from the input to the output. That precaution preserves the system bandwidth and eliminates possible circuit oscillation.
- Keep capacitance and resistor values as small as possible to minimize all unwanted time constants. High capacitance and resistance values could also cause oscillation or reduce bandwidth. This is especially true for feedback resistors. The use of resistors with values of less than 2 K is a good point of departure in resistor selection.
- Use a ground plane to keep return resistances as low as possible. Avoid point-to-point wiring but if you must use that construction technique, be sure to return all ground leads to one and *only* one point to reduce the possibility of ground loops. In circuits where large stray noise signals could show up, suitable input shielding is required.
- Each power supply lead of the video amplifier should be properly bypassed to ground with a capacitor located as close to the video-amp as possible. A 10-ohm resistor ahead of the capacitor will also help to decouple the power supply from the amplifier. In addition, if you have a problem decoupling the power supply from the video amp, try a radio-frequency choke (RFC) in place of the resistor, or slide a few ferrite beads on the resistor's leads.
- Keep the input resistance as low as possible to reduce the effects of input noise currents.

Communications applications

Both monolithic video amps will give you access to the emitters of their first differential amplifier stages (as shown in Fig. 1) via gain-select pins G_{1A}, G_{1B}, G_{2A}, and G_{2B}. By placing a variable potentiometer between the G_{1A} and G_{1B} pins (pins 4 and 11 on the DIP), you can adjust differential voltage gain over a range of 250 to 600.

With the addition of frequency-dependent components, these IC's can function as video-band active filters or RF amplifiers. Figure 3 illustrates five possible filter configurations. The components are placed across the G_{1A} and G_{1B} pins (4 and 11 on the DIP) for the out-

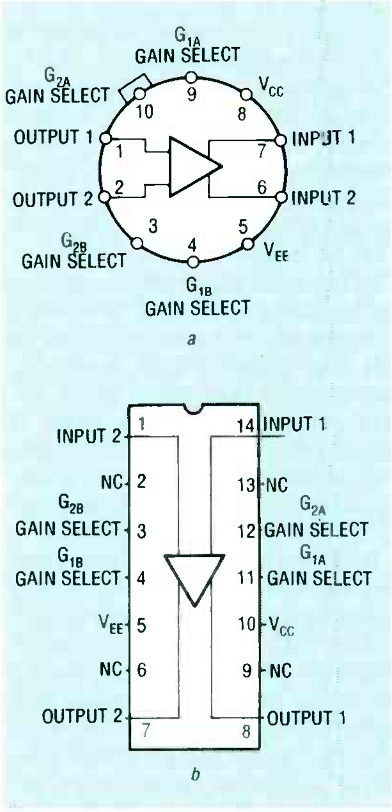


FIG. 2—TOP VIEWS OF 592 and 733 packages: (*a*) metal can and (*b*) ceramic and plastic DIP.

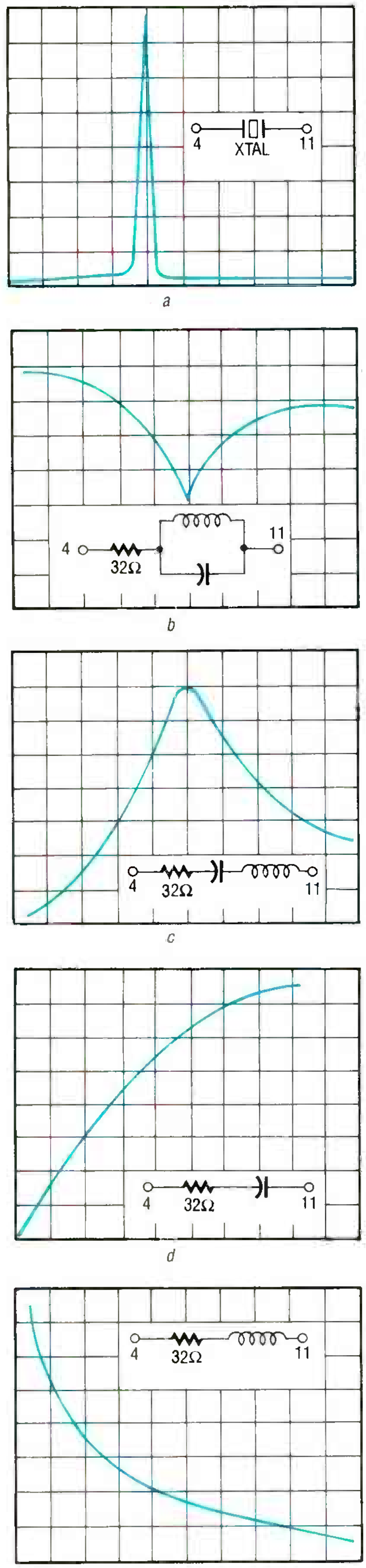


FIG. 3—**ACTIVE FILTER** using the 733 and 592: (*a*) crystal, (*b*) notch, (*c*) bandpass, (*d*) high-pass and, (*e*) low-pass.

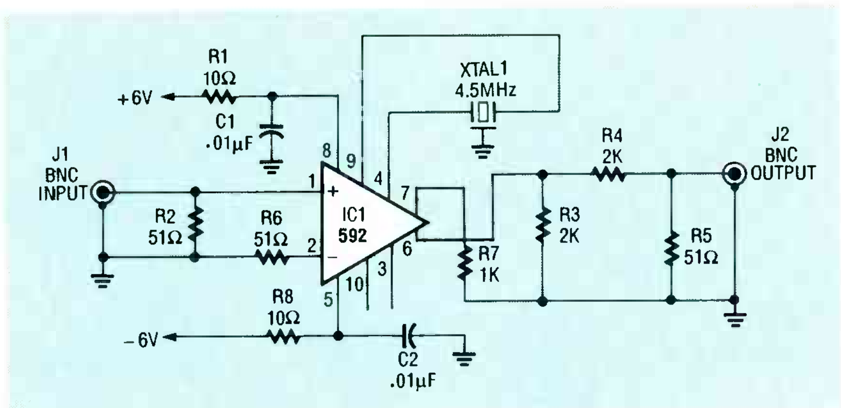


FIG. 4—**A 4.5-MHz AMPLIFIER** based on the 592 video amp.

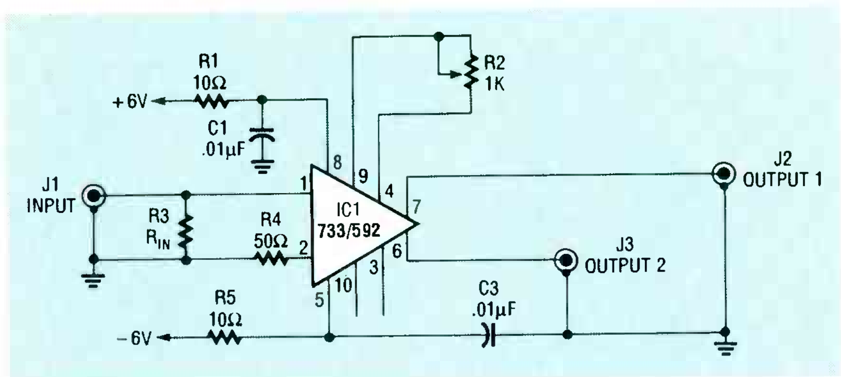


FIG. 5—**A GENERAL PURPOSE PREAMPLIFIER** based on either the 592 or 733 video amps.

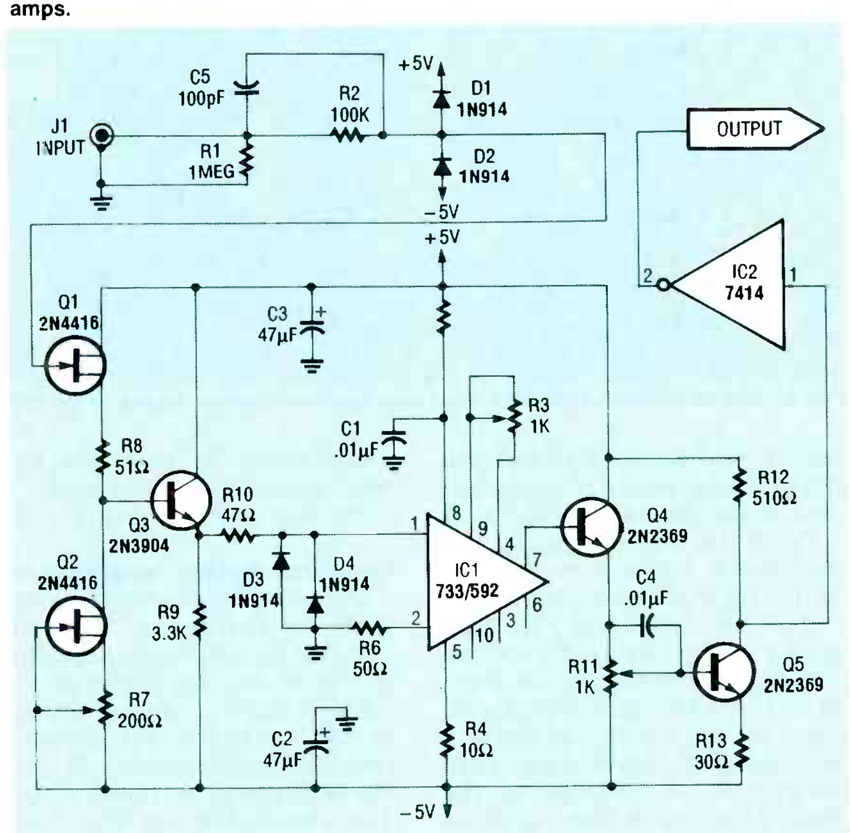


FIG. 6—**FREQUENCY COUNTER** based on either the 592 or 733 video amps.

put responses.

In Fig. 4, the addition of a 4.5-MHz ceramic filter between pins 4 and 9 of the 592 converts the circuit into an audio intermediate-frequency amplifier that is

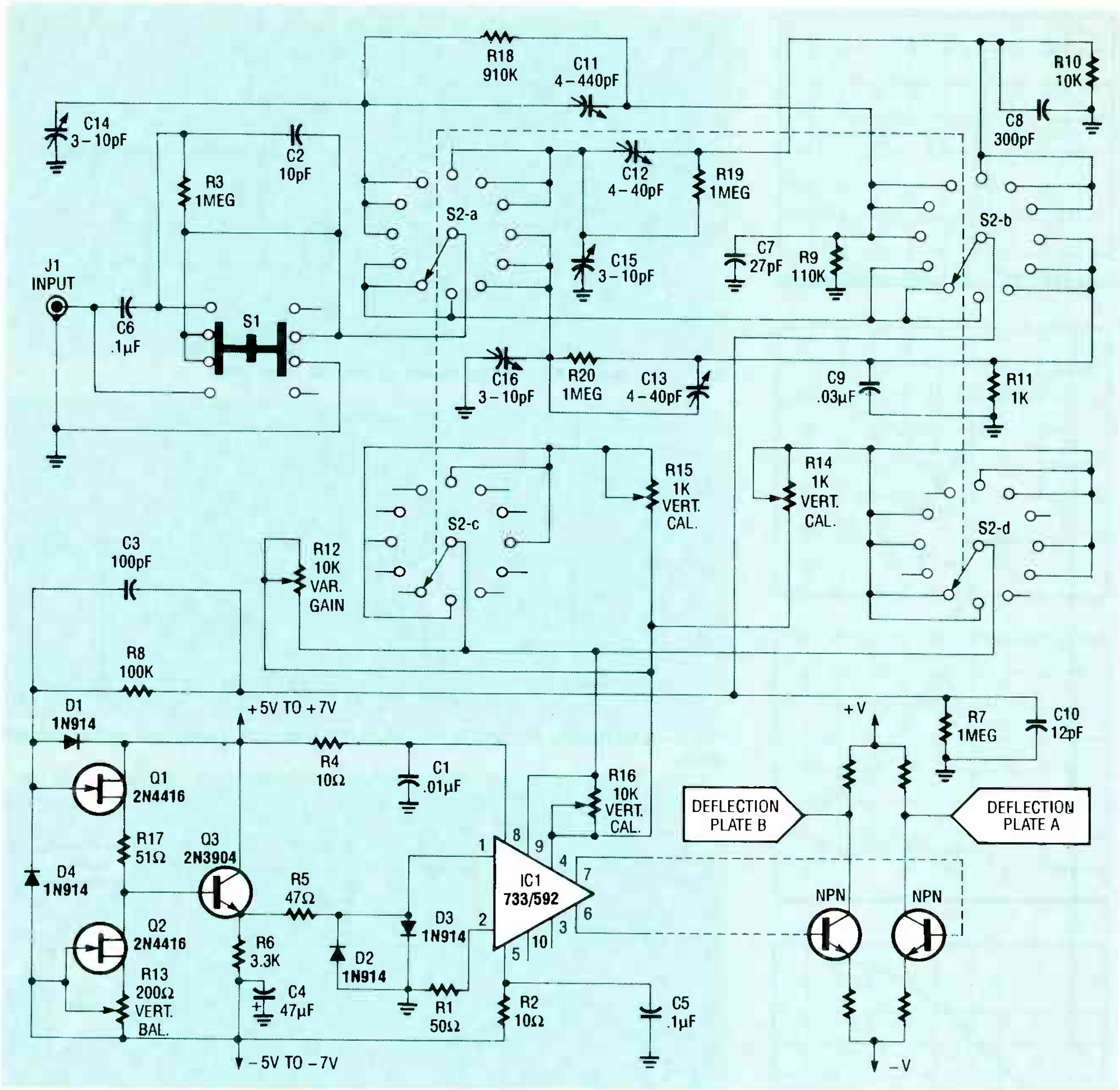


FIG. 7—OSCILLOSCOPE PREAMPLIFIER with input conditioning based on the 592 or 733 video amps.

suitable for use with TV signals. Many variations are possible. You could also place passive filters on the input, output, and gain-control pins for even better signal rejection and separation.

The 592, like the 733, permits you to control gain with an external impedance value. However, the 733's differential voltage gain (A_{vd}) can be as low as 8 with all gain- select pins open, an option not available on the 592. Thus, in a filter application, the unwanted signal will have a theoretical voltage gain of 20 dB minimum, making the 592 unsuitable for that application. However, the video amps can usually be interchanged with minimal or no modifications to your basic design.

Instrumentation applications

Because these amplifiers are wide-band devices, they are suitable for use as preamplifiers in meter and oscilloscope circuits. Figure 5 shows a basic general-purpose instrumentation preamplifier that will operate at frequencies down to DC. The preamplifier in Fig. 5 will work with either the 592 or 733. You can set resistor R3 (R_{IN}) to meet your requirements up to a maximum of a few hundred ohms. This design is limited, however, by its inherent low input impedance and high output impedance.

Figure 6 shows an improvement on the circuit in Fig. 5 making it suitable as a preamplifier for a frequency counter preamplifier. An FET buffer Q1 has been placed on the input of the 592 or 733, and the input impedance has been increased to 1 Megohm with R1. Input protection is provided by forward-biased diodes D1 to D4 which prevent input signals from overdriving the amplifier. Diodes D3 and D4 also keep the video-amp's outputs from saturating with increased switching fre-

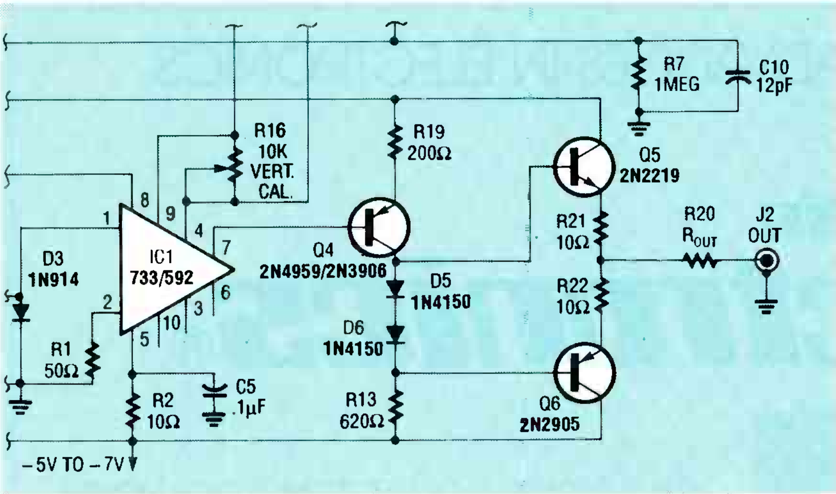


FIG. 8—SECTION OF PREAMPLIFIER circuit of Fig. 7 showing additional output compensation.

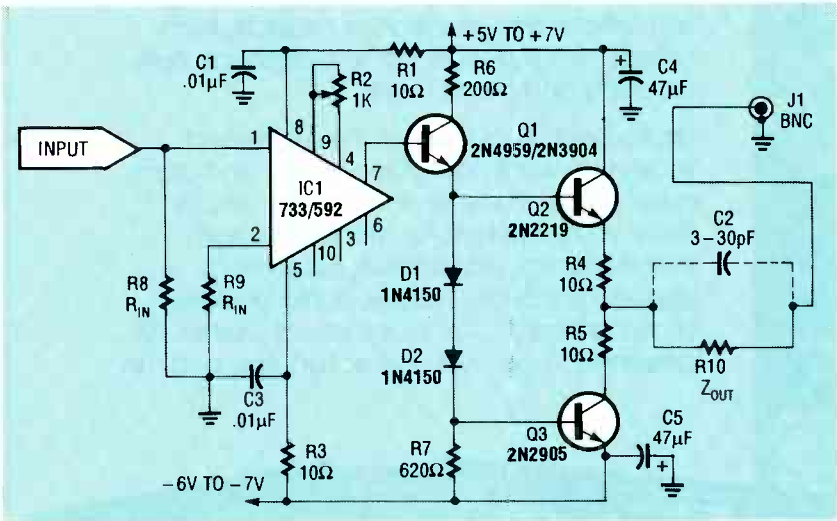


FIG. 9—GENERAL PURPOSE OUTPUT amplifier based on either the 592 or 733 video amps.

quency. The FET buffer has a bandwidth of 100 MHz so it will not restrict the bandwidth of the video amp.

For interfacing the preamplifier to TTL devices such as those found in a TTL frequency counter, the circuit in Fig. 6 also has an output buffer and TTL translator made up of Q4, Q5, and a 7414 inverter. Those will operate to 45 MHz with the gain of the 592 or 733 set to 10. (The gain pins of the 733 are left open.) To obtain measurable gain from the 592, an emitter resistor of the proper value must be placed across the gain-select inputs G_{1A} and G_{1B} (pins 4 and 11 of the DIP). Alternatively, a 1K potentiometer can be adjusted for the desired gain.

If you want to design your own oscilloscope, modify the circuit in Fig. 6 to those shown in Figs. 7 or 8. Both are oscilloscope preamplifier circuits that will operate at frequencies up to 10 MHz. In those preamplifiers more elaborate input circuits and gain- switching arrangements can produce the standard 1-2-5 calibrated oscilloscope steps with a range from 10 millivolts per division to 5 volts per division.

Figure 7 shows a method for coupling the preamplifier to an oscilloscope's vertical deflection amplifier for DC measurement without concern for the DC offset which occurs at the outputs. In that way, the equal offset at both outputs of the video amp are nulled by the common-mode rejection ratio (CMRR) inherent in the vertical-deflection differential amplifier. Capacitors C3 to C5 are input- compensation capacitors that can be adjusted with a square-wave input after the preamplifier has been completed and tested. Trimmer capacitors C14 through C16 compensate a ten-power magnification probe so that it will respond the same way to all input attenuators.

The circuit in Fig. 8 shows a modification of Fig. 7. It permits the video amp to be used in a single-output mode by eliminating the DC offset. A voltage-shifter arrangement around Q4 performs that function. With the related components shown, the output of Q4's collector is zero volts. To maintain the bandwidth of the video amp, a buffer configuration made up of Q5 and Q6 isolates the load from the high impedance of Q4's collector. The buffer will drive a 50-ohm load to 20 MHz at about 3 volts peak-to-peak. This characteristic makes it possible to couple the preamplifier to the front end of an oscilloscope near the attenuators so that the vertical amplifier can be driven through a coaxial cable.

Before placing either video-amp IC in the circuits of Fig. 6, 7 or 8, adjust the 200-ohm offset potentiometer (R7, R13, or R17, respectively) so that the voltage at the emitter of Q3 (a 2N3904) is zero. That moves the video-amplifier's output into a "ballpark" operating region.

In the frequency-counter preamplifier circuit Fig. 6, the offset potentiometer R7 and the 1K trimmer R11 at Q4's emitter will vary the threshold point of Q5, so both must be adjusted to obtain the best switching speed and bandwidth.

For communications purposes, the circuit shown in Fig. 8 can be modified once again to that shown in Fig. 9, a DC-to-20-MHz line driver. That type of general-purpose amplifier can be a variable-gain video distribution amplifier or even a broad-band local-area network (LAN) line driver. R-E

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5REF8

THE INSIDE STORY

ON HARD-DISK STANDARDS

BYRON MILLER

Decisions, decisions, decisions. Here we sort out the differences between today's competing disk drive standards.

THERE IS A BATTLE RAGING. IT IS A battle to assume the role of standard bearer for the PC hard-disk drive interface. The venerable ST-506 served the PC industry well during its first decade, but as we move off into the 90's with increasing reliance on high-performance 386, 486, and 586 systems, users demand ever-greater speed, capacity, and ease-of-use.

Three technologies—ESDI, IDE, and SCSI—are vying to become the next standard. But how does a person choose among them? In this article we will examine the basic ideas and history behind each, compare and contrast their strengths and weaknesses, and point out situations where each would be useful.

Background

Because each of the three new drive-interface standards represents, in some way, a response to the ST-506, let's begin with a little history and background on that standard.

Properly speaking, the ST-506 was the model number of a hard-disk drive that Seagate Technology introduced in 1980. The capacity of that drive was a whopping five megabytes! Several years later, Seagate introduced a 10-megabyte monster (the ST-412) with a similar electrical interface, and a new feature called *buffered seeking* that allowed the drive to "collect" sequential seek commands and then move the read/write head across the surface of the disk in one quick, smooth motion. These drives recorded data on the disk platters using modified frequency modulation (MFM).

The combination of recording method and electrical interface limited the maximum rate at which data could be transferred to and from the drive to five megabits per second (5 Mbps). By encoding the data on the drive in the run-length limited (RLL) format, designers could increase data transfer rate by 50% to 7.5 Mbps; capacity also increased by 50%.

The market continued to demand greater performance, so by spring of 1983, an ad hoc committee formed and produced the first draft of a specification for a new drive interface, what later became known as the Enhanced Small Device Interface (ESDI). By 1986, ESDI became a proposed ANSI standard, and early in 1990, it became officially recognized as ANSI X3.170-1990.

Development of the Intelligent Drive Electronics (IDE) interface began in 1984 when Compaq got together with Western Digital to develop an ST-506 controller that mounted directly on a hard-disk drive. The following year Compaq worked with Imprimis (now a part of Seagate) to integrate Western Digital circuitry on a Wren disk drive. Soon Compaq shipped the first PC with an IDE drive; other manufacturers followed suit shortly thereafter. The appeal of IDE is that it eliminates one PC board and most of the interface electronics required between a system bus and a hard disk, thereby significantly lowering cost. Today, IDE has pretty much displaced ST-506 as the standard drive interface for desktop PC's.

The Small Computer System Interface (SCSI) traces back to the Shugart Associates System Interface (SASI), which was developed by the same company (Shugart Associates) and the same designer (Al Shugart) that developed the ST-506. In fact, Shugart developed SASI around the same time as the original ST-506. From the beginning, the SASI interface was designed to be more general than the specialized interfaces heretofore developed for personal computer peripherals. Rather than using specialized signals to control various low-level hardware functions, SASI/SCSI included from the beginning a general-purpose 8-bit parallel bus and several control signals. The hope was (and still is) that a general-purpose bus would attract designers of various types of peripherals.

SASI supported several important features, including daisy-chaining drives and issuing high-level commands via a command block. Vendors quickly adopted SASI and began to add features and functionality, e.g., support for Write Once Read Many (WORM) drives and other types of devices. Similarly, vendors increased the maximum number of devices from two to seven. They also added the ability to service several devices at once. After some evolution, the SASI interface became so popular that in 1986 the X3T9.2 ANSI working group adopted it as standard ANSI X3.131-1986, or SCSI-1 for short. An enhanced version, SCSI-2, was finalized in 1990; it provides for wider bus widths and other performance-enhancing features.

With that background in mind, let's now look at each type of interface in more detail.

ESDI basics

ESDI is a disk-controller interface that is like an enhanced ST-506. For one, ESDI uses a similar cable and connector scheme: a 34-conductor control cable that is daisy-chained from drive to drive, and a separate 20-conductor data cable for each drive. ESDI controllers typically support only two drives, even though the specification allows a maximum of seven.

The signals on ESDI and ST-506 cables are similar but by no means identical, so you cannot run an ESDI drive on an ST-506 controller, nor an ST-506 drive on an ESDI controller. Electrically, all signals are TTL compatible; the maximum length of an ESDI drive cable is nine feet. Table 1 compares signals from both of those systems.

Another similarity between ESDI and ST-506 is that ESDI is a device-level interface. In other words, its control signals direct low-level actions such as selecting a drive head and moving it to a desired track on the disk. As we'll see, SCSI and IDE devices contain high-level interfaces in which the operating system issues commands like, "Give me a block of data, as quickly as you can, and don't bother me with the details!"

The biggest difference between ESDI and ST-506 drives is the data transfer rate, which for basic ESDI drives runs at twice the ST-506 rate (10 Mbps), and which reaches its maximum at 24 Mbps.

As for disk format, ESDI drives typically put about 34 sectors on a track (versus 17 for a standard ST-506 drive), and they run with a 1:1 interleave.

In operation on a PC, most ESDI controllers emulate standard ST-506 controllers (e.g., the ubiquitous WD1003), so no additional software drivers are required. IDE drives also emulate the WD1003, but SCSI drives always require external software drivers.

IDE

The IDE interface strongly resembles the AT I/O expansion bus, as shown in Table 2. There are some important differences, and there is some inconsistency in the way different manufacturers use some signals. For example, IOREADY can appear on pin 21, 27, or both, depending on the disk drive manufacturer. Many new system boards contain a built-in IDE interface, so

TABLE 1—ESDI AND ST-506 SIGNALS

ESDI Signal	ST-506 Signal	Pin No.
Head select	Reserved	2
Head select	Head select	4
Write gate	Write gate	6
Config/status data	Seek complete	8
Xfer Ack	Track 0	10
Attention	Write Fault	12
Head select	Head select	14
Sector	Pin 7 on data cable	16
Head select	Head select	18
Index	Index	20
Ready	Ready	22
Xfer request	Step	24
Drive select	Drive select	26
Drive select	Drive select	28
Drive select	Drive select	30
Read gage	Drive select	32
Command data	Direction in	34

TABLE 2—IDE AT 1/0 BUS SIGNALS

IDE signal	AT I/O signal	Description
CS1FX-	N/A	Chip select for ST-506 compatible I/O
CS3FX	N/A	Chip select for ST-506 compatible I/O
DA0-DA2	SA0-SA2	Drive address bus lines
DASP	N/A	Drive Active I Drive one percent
DD0-DD15	SD0-SD15	Drive data bus
DIOR-	-IOR	Drive I/Q read
DIOW-	-IOW	Drive I/Q write
DMACK-	-DACKx	DMAWQ acknowledge
DMARQ	DRQx	DMA request
INTRQ	IRQ14	Drive interrupt
IOCS16-	-I/OCS16	Drive 16-bit I/O
IORDY	IOCHRDY	I/O channel ready
PDIAG-	N/A	Passed diagnostics
RESED-	RESET	Reset; on AT bus is opposite polarity.
SPSYNC	N/A	Spindle sync. Produces clock for slave drives.

there's no need to waste an expansion slot on a disk controller. Inexpensive IDE adapter cards are also available for older systems. If you're not buying a preconfigured system, you must ensure compatibility between your intended controller and drive(s). Electrically, an IDE drive connects to the controller with a 40-conductor ribbon cable.

Like ESDI, the IDE interface emulates a standard IBM hard-disk controller, and an IDE drive masquerades as one with a corresponding value in the host system's BIOS drive table. Internally, an IDE drive typically has 34 sectors per track, although *translation* can make it appear to have 17, to match a BIOS table value. In addition, IDE drives usually operate at a 1:1 interleave. You cannot change interleave, perform a low-level format, or run low-level disk utilities, for example the Norton Utility, Calibrate.

The controller electronics reside at standard disk-drive I/O port addresses (1F0–1F7 and 3F0–3F7), and respond to all standard commands (format track, read sector, write sector, etc.), as well as enhanced commands that allow more efficient operation. For example, commands C4 and C5 allow the system to read and write multiple sectors, respectively. However, most AT BIOS's do not yet support the enhanced disk-drive commands.

The IDE interface has evolved rapidly since 1984, occasionally with different vendors creating incompatible enhancements. Hence, in 1988 a Common Access Method (CAM) committee formed to define standards. By spring of 1989, the committee had produced a draft of an AT Attachment (ATA) interface standard. That document has evolved quite a bit over the years, and it is now well on its way to becoming an ANSI standard, by way of the X3T9.2 working group.

Like the ST-506, the IDE standard allows a maximum of two devices on its shared bus. Drive 0 functions as the master, and drive 1 as the slave. Maximum cable length is only 18 inches, so the drives must be situated close together.

SCSI

SCSI is an intelligent system-level interface that, in theory, can connect through a common parallel 8-bit bus a variety of devices, including disk drives, optical scanners, printers, tape drives, network adapters, and various types of optical drives. It is an unfortunate fact of life that in practice, you'd probably end up installing a different SCSI host adapter for each type of device in your system. *(My main system currently has three SCSI adapters: hard disk, CD-ROM, and Bernoulli Box.—Editor)* And it is difficult if not impossible to use a SCSI device intended for one system (e.g., a DOS-based PC) on another (e.g., a Macintosh) system.

The SCSI bus consists of eight data bits, a parity bit, nine

TABLE 3—SCSI BUS SIGNALS

Signal(s)	Explanation
DB0-7	8-bit bidirectional parallel data bus
DBP	Data bus parity line (optional)
ATN	Attention, used to send message to target when it has control of the bus
BSY	Busy indicates that the bus is unavailable for use
ACK	Acknowledge, used by initiator for handshaking
RST	Reset, used to initiate a bus free phase
MSG	Driven by target to indicate that current transfer is a message
SEL	Used by initiator to select target before command execution. Also used by target to reconnect when the reselection phase is implemented.
C/D	Control/Data, used during information transfer phases to transfer commands, status, messages, and data over the bus.
REQ	Request by target during information transfer phases. Handshakes with ACK to envelop data.
I/O	Input/Output determines direction of transfer during information transfer phases.

control lines, and a line for terminator power, as shown in Table 3. The bus can be driven with either single-ended or differential line drivers. In both cases, the bus has a total of 50 lines. A single-ended system alternates grounds with signals; in a differential system, even and odd pins form differential signal pairs. Maximum cable length is six meters for single-ended and 25 meters for differential systems. SCSI devices on PC's and Macintoshes usually follow the single-ended standard.

A host device issues a command to a SCSI device via a 6-byte *command descriptor block*, which specifies an op code, a logical unit number and block address, a length control byte, and a control byte. The control byte has a feature that allows multiple SCSI commands to be sent in a single block. Every SCSI command returns a status byte, each bit of which has a specific meaning (good, busy, etc.).

Most devices currently on the market adhere to the SCSI-1 standards. However, many new devices conform to SCSI-2, which offers much greater potential performance. Whereas SCSI-1 allows a maximum of 4 million transfers per second, SCSI-2 allows 10. In addition, SCSI-2 increases maximum bus width from the 8-bit SCSI-1 standard to an optional 16 or 32 bits. The X3T9.2 committee completed the SCSI-2 specification in August 1990; after editorial polishing, it should be published sometime in 1992. (The committee has also begun work on another standard, SCSI-3.—*Editor*)

SCSI can communicate with several different devices simultaneously. For example, an SCSI host can disconnect from a target device after issuing a command, connect to a different target device, give it a command, disconnect from it, and then reconnect back to the original device. By contrast, IDE operates in a master/slave mode in which the interface can issue only a single command at a time.

To use an SCSI device in a PC requires BIOS-level software drivers, typically added through adapter-based EPROM or a device driver loaded at boot time. The Macintosh has a built-in SCSI Manager.

SCSI compatibility is still a problem. Although electrically identical, SCSI peripherals from different vendors may be dissimilar. In other words, an SCSI drive from vendor A may work fine with a given SCSI adapter, while an SCSI drive from vendor B does not. That is due to variations in interpretation and implementation of the SCSI command set. Hundreds of commands are available, some of which work differently with different types of devices. For example, one form of the write command can be used for writing to a Direct Access Device (DAD) and another for a Sequential Access Device (SAD). One vendor can interpret a disk drive as a DAD where another would interpret it as a SAD. Sending a SAD write command to a DAD device will not work. In response to that dilemma, the CAM committee has defined a standard subset of SCSI commands that performs basic functions (read, write, etc.). The resulting eleven commands are known as the Common Command Set (CCS), and are part of the SCSI-2 standard.

Compare and contrast

Like ST-506, ESDI is an unintelligent device-level interface that transfers data serially from drive to controller, which compiles serial bits into 8-, 16-, or 32-bit chunks of data and presents them to the host. IDE and SCSI devices, by contrast, build up data bytes on the drive and present them to the system in 8-, 16-, or 32-bit chunks. The advantages are several: less-expensive controllers and adapters, less cabling required, more reliable performance, and higher performance.

IDE drives (even with an adapter, if required) typically cost less than SCSI and ESDI drives of comparable capacity and performance. However, a given system can hold a maximum of two IDE drives, whereas seven SCSI devices can be handled directly, and theoretically thousands indirectly. ESDI controllers typically allow only two drives, and there is no pretense of supporting other types of devices.

Both IDE and SCSI drives suffer from various types of compatibility problems that make system integration trickier than it should be.

Recommendations

Selecting a drive interface depends on your performance needs, capacity needs, budget, and future system migration plans. If cost is the main determinant, you'll probably want to go with IDE. If performance is paramount, ESDI or SCSI will be your choice. Remember that performance you don't need right now may become necessary in the future. Sometimes a little added expense turns out to be a good investment. If you need a really large drive, ESDI or SCSI will also be required. If you hope to share a single interface card among multiple peripherals, SCSI may eventually help you realize that goal. **R-E**

FOR MORE INFORMATION

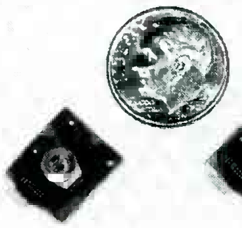
For more information on disk-drive technologies, see these excellent articles (published in *Byte* magazine): "The Evolution of ESDI," June 1990; "The IDE Hard Disk Drive Interface," March 1991; "The SCSI Bus, Part 1," February 1990; "The SCSI Bus, Part 2," March 1990.

For detailed technical information on ANSI standards and technical committee, contact the American National Standards Institute, 1430 Broadway, New York, NY 10018. (212) 642-4900.

For printed copies of ANSI specifications, contact Global Engineering Documents, 2805 McGaw Avenue, Irvine, CA 92714. (800) 854-7179, (714) 261-1455.

Electronic copies (including working drafts) of SCSI and many related standards are available from the SCSI BBS, (316) 636-8700. 300–9600 bps, 8N1.

For product information, contact Conner Peripherals Inc. 2221 Old Oakland Road. San Jose, CA 95131; Micropolis Corp. 21211 Nordhoff Street Chatsworth, CA 91311; Seagate Technology Inc. 920 Disk Drive Scotts Valley CA 95066-4544.—*Editor*



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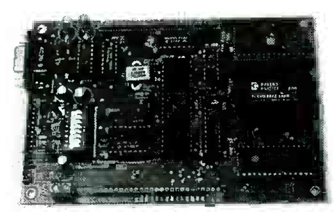

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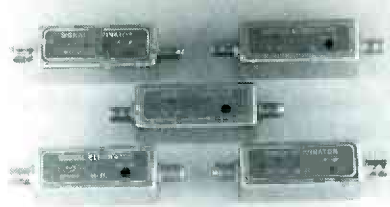

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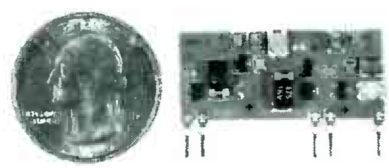

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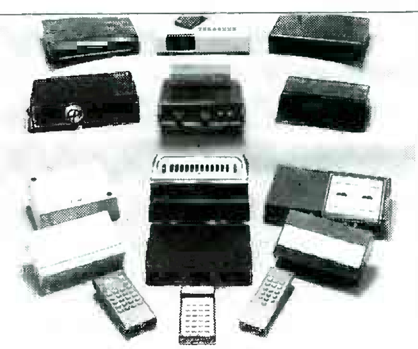

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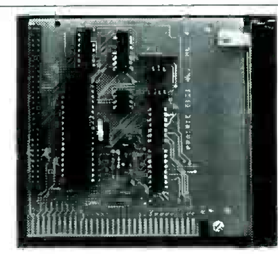

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HARDWARE HACKER

Super Nintendo update, FM stereo broadcasters, Ockham's razor revisited, DYS and other resources, and CD-to-car-radio adapters.

DON LANCASTER

Let's start off with an update to those Nintendo interface circuits we looked into back in April. For those of you who came in late, you will find a special connector at the rear of the *Super Nintendo* machines that lets you connect them to stereo amplifiers, headphones, RGB monitors, *Super VHS* recorders, and bunches more.

We looked at the connector in some detail, and we saw several useful and low-cost interface circuits. And we found that *Redmond Cable* offers all sorts of custom and stock video-game interface kits.

But after some further testing, the RGB SYNC line on a *Super Nintendo* connector pin 3 is not quite what it appears to be. As Fig. 1 shows you, the pin *looks* like it should be both CMOS- and TTL-compatible, but it is not. You can't pull it up fully for CMOS, and there isn't enough current-sinking capability for much of TTL. Some (but not all) RGB monitors will refuse to lock to the output.

The problem is that the output does not come from a "real" logic gate. It apparently arrives from an emitter follower that has a weak pull-down resistor. And a low supply voltage.

There seem to be several simple workarounds you can try. The easiest is to add the external 680-ohm resistor shown in Fig. 1. That should give you enough current sinking for typical LSTTL inputs. Use a scope to verify your levels. There is even a place for the resistor on the circuit board we looked at in April.

Otherwise, you should be able to directly interface to any low-cost but rare 74HCT CMOS logic. Or you can use the sync stripper circuit we saw in April as a substitute, deriving your sync from the composite NTSC video instead.

Finally, next month we might look at a simple *sync amplifier* which also will be needed for an upcoming new *Neo-Geo* interface. It should also work and is based on adding feedback to a 4049 inverter to make it into a simple AC amplifier. Stay tuned.

Ockham's razor

See, I even got the spelling correct. William of Ockham was a fourteenth century English philosopher. Paraphrased, Ockham's really big thing in life was that "The simplest possible explanation is usually the best and probably also the most correct." And *Ockham's razor* can be your ongoing process of slicing away and reducing everything to its bare (but still quite correct) essentials.

Very few engineering design courses ever mention Ockham. But his razor should be the very center of virtually *all* engineering design, *all* analysis, development, debugging, and repair. So, I thought I'd use Ockham's razor as an excuse to simplify the few loose helpline odds and ends that I've been meaning to comment on anyway.

Cold fusion. Ockham's razor says they had their chance to get their act together, and they blew it. Yes, strange amounts of heat can apparently be produced in highly unusual lab circumstances. No, such rather mundane reasons as hydrogen fires, mixed-gas fuel cells, or an embrittlement stress relief have not been totally ruled out. And no, I have not seen so much as one credible and reproducible shred of evidence that anything atomic is in fact coming down. Barring any new developments, cold fusion seems to be on hold. And it probably remains a sucker bet for hackers at this time.

Pseudo radio astronomy. Several years back, a "radio astronomy" receiver appeared in **Radio-Electronics** that seemed to be responding to extragalactic signals in a circuit that was vastly simpler than those used by far more credible researchers. I've often been asked for my comments, so Ockham says the circuit was just a simple analog thermometer that was measuring the temperature drift of the offset voltage of a 741 op-amp. When the sun set, so did

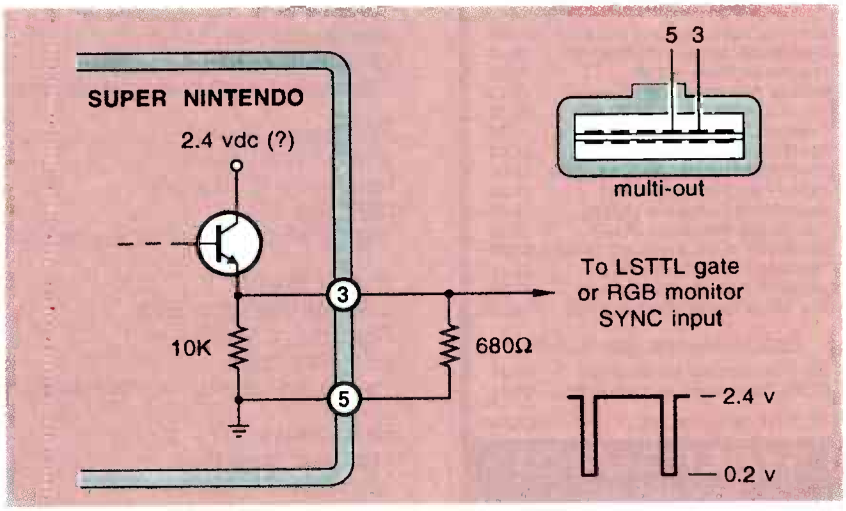

FIG. 1—THE SUPER NINTENDO RGB SYNC output only looks like it is TTL or CMOS compatible. Add the external resistor shown for an LSTTL interface.

the 741. And the circuit capacitors that mysteriously acquired charge are no mystery at all. The effect is known as *bounceback* and has to do with lateral charge migration in a dielectric.

Utility linemen do learn all about bounceback in lecture one of day one in lineman's school. And there is a very simple way to spot any utility lineman who knows all about bounceback: they are still alive.

Now, the circuit might or might not have been receiving the extra-galatic signals. But the temperature drift and bounceback effects clearly would have been many millions to many billions of times larger. Thus there would be no way to tell until all of those first-order effects have been carefully and painstakingly removed from the circuit.

The Newman motor. The Newman motor is (or was) a perpetual-motion machine that still seems to eke out a meager existence on late-night talk shows. This one-time media circus has been around for a decade or so. Yet, for some strange reason, working models still remain few and far between. Now, *if* we're going to grant the true believers that something weird was in fact going on, then Ockham's razor reduces it down to "sparks *may* lengthen battery life."

That *might* bear further looking into as a hacker topic. An ordinary flashlight cell does not yield all of its chemical energy whenever it "runs down." Clearly, if so much as a tiny scrap of the zinc case remains, then recoverable chemical energy might still remain—at least in theory. Instead, a cell will *polarize* and thus raise its series resistance to the

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
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DYS AND OTHER RESOURCES

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point where it can no longer deliver useful power.

What if you *recycle* a fraction of the power back *into* the cell as a high-current pulse? Let's say we put in ten amps for ten milliseconds per second for every continuous one amp out. Could that partially delay the increase of cell resistance by slowing down the polarization process? Or maybe just warm the cell up to a more optimum power delivery point?

Note that electroplaters do this all the time. They occasionally *reverse* the plating process and purposely *unplate* for a while. That improves the smoothness, and does other good things to the finish.

The obvious questions to ask here are "Does energy recycling help us at all?," "What are the optimum recycle pulse strengths and best duty cycles?," "Does any higher-frequency AC help?," and, of course, "Even if all these effects do significantly improve life, are the economics there?"

Let's have your thoughts on this. Cell energy recycling does look like a reasonable and legitimate research topic. But as a warning, if you're going to experiment, keep your target carbon-zinc cells in a suitable "bomb shelter." And be careful.

Microcontrollers. The breakeven point between using and not using a CPU and RAM-ROM-I/O architecture in any hacker project was passed a decade ago. Ockham's razor says that it's now ridiculously faster, cheaper, and far better to include a microprocessor these days, rather than foolishly trying to leave one out.

Yet, I get all of these strange calls for projects that require such things as keyboards, displays, fancy timing, strange sensors, and minuscule markets. All of which could be done insanely faster and cheaper by first making a model with a $30 Commodore 64 from a yard sale and then, if really needed, working out a one- or two-chip RAM-ROM-I/O solution.

Besides lots of really great microcontroller projects found right here in **Radio-Electronics**, you'll find lots of others over in Steve Ciarcia's *Circuit Cellar Ink*. And I do offer my *Micro Cookbook I* and *Micro Cookbook II* that can get you started on many of the fundamentals.

NAMES AND NUMBERS

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Wireless broadcasters

One of the less pleasant recent hacker surprises is that most low-cost FM wireless broadcaster circuits flat out will no longer work. Older analog FM radios could be tuned anywhere across the entire band and had a very strong AFC or *automatic frequency control* circuit that would lock onto a non-standard signal and track it anywhere. But nearly all of today's digitally synthesized FM receivers (especially most car radios) absolutely *demand* that the transmitted signal be precisely locked onto one of the FM broadcast channels.

Designing any high-quality FM transmitter that is both ultra-stable and able to be rapidly and linearly frequency modulated gets tricky fast because you are asking for a circuit that both will and will not change its frequency. The "technically correct" high-end solution is to use an indirect circuit known as the *frequency lock loop*. The average output frequency from your transmitter gets divided down with a counter and compared against a crystal reference. An error signal is then derived phase-lock-loop style and used with varactor diodes to continuously force your transmitter back onto the correct frequency.

Hams have long chosen a simpler technique called *crystal pulling*. Your average crystal is *slightly* sensitive to reactive loading in a circuit. The rule of thumb is that you can pull a plain old crystal around *one-tenth percent*. But crystal pulling is usually highly nonlinear.

To pick up enough deviation, hams would start off with a low-frequency crystal and then multiply up into their final 145 megahertz—or whatever frequency range. Typical hams rarely concern themselves with any wide-deviation broadcast-quality audio. In fact, they are not allowed to do so.

Apparently both *Sony* and *Pioneer* have figured out how to linearly pull a special third-overtone HF crystal to *directly* let you do a full CD-quality FM stereo transmitter that is precisely locked onto the correct frequency. Sony's product is called the XA-7A, and Pioneer's is the CD-FM-1. While the intended use of those units is to let you conveniently add a CD player to your car radio, either one will apparently make up most of the critical circuitry for an excellent and very high-quality FM stereo wireless broadcaster. Dealer cost for the units is in the $42 range, and they seem to be easy and fun to hack. They offer both on-channel lock and near-broadcast quality. We will look at the *Pioneer* CD-FM-1 here.

Obvious uses for a short-range FM broadcaster include "Please buy my house" messages for drive-bys; baby sitting or handicapped monitoring; and cord-free audio for a teacher, a public speaker, or a video actor. But there are also zillions of non-obvious uses, including such things as getting data onto or off of a rotating shaft, and short-range rocket telemetry.

Limited-range and limited-power FM broadcasters are now generally allowed by the FCC, while the more powerful units have to meet specific licensing and certain type-approval requirements. More details on getting and meeting FCC specs appear in our *Hardware Hacker III* reprints. Both the unmodified *Sony* and *Pioneer* seem to have been created with full FCC compliance code in mind.

I could also see several *wired* or *semi-wireless* broadcaster applications that might use twin lead to route high-quality audio all over your plant or whatever. With wires, you could easily go several hundred feet without running afoul of FCC specifications, all the while avoiding the hum and noise problems of using "real" audio. And a whole new world of point-of-sight light-modulated FM data links is also newly opened up.

In their intended use, you unplug your car radio antenna, plug in the CD-FM-1, and then reconnect your antenna. A DIN-8 connector goes to your CD player, and the usual red wire goes to your +12-volt battery.

When your CD is turned on, its audio appears at 88.1 on your FM dial. All other stations are muted. That quickly and conveniently lets you use your existing car audio system without needing anything fancy in the way of rework or switches.

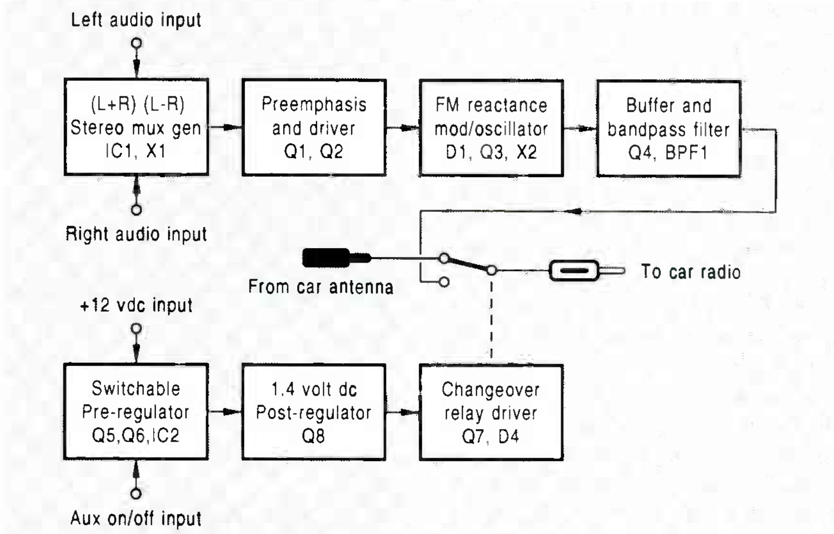


FIG. 2—MOST LOW-END FM WIRELESS BROADCASTERS simply will no longer work because nearly all the newer synthesized receivers now *demand* precisely on-channel stations. The Pioneer CD-FM-1 (block diagram shown here) generates exact-frequency stereo FM signals. The CD-FM-1 is easily made wireless.

A block diagram of this matchbox-sized module appears in Fig. 2, while an approximate and unofficial schematic is shown in Fig. 3. Because of the surface-mount parts used, certain component values are based only on my estimates. The exact circuit shown also might not be fully accurate.

At first glance, the circuit seems deceptively simple. But if you flip the board over, you'll find nearly a dozen more surface-mount semiconductors on the foil side. It is obvious that bunches of time and effort went into the design.

As with any circuit, you usually want to start off with your power distribution. The twelve volts from the car battery turned off and on by an auxiliary (AUX) logic signal. The power is applied only when your CD is to be used. The power switching is via input-switching field-effect transistor Q5 and series power driver Q6. Driver Q6 is followed by a two-volt regulator IC2, which in turn is followed by a *dynamic regulator* or *capacitance multiplier* at Q8. The post-regulator will obviously introduce a temperature drift that might or might not be intentional.

Several refinements in the supply switching include Zener diode D2 to prevent turn-on with a weak battery or during cranking. The network R27-C30 gives a slight turnoff delay to eliminate clicks or thumps.

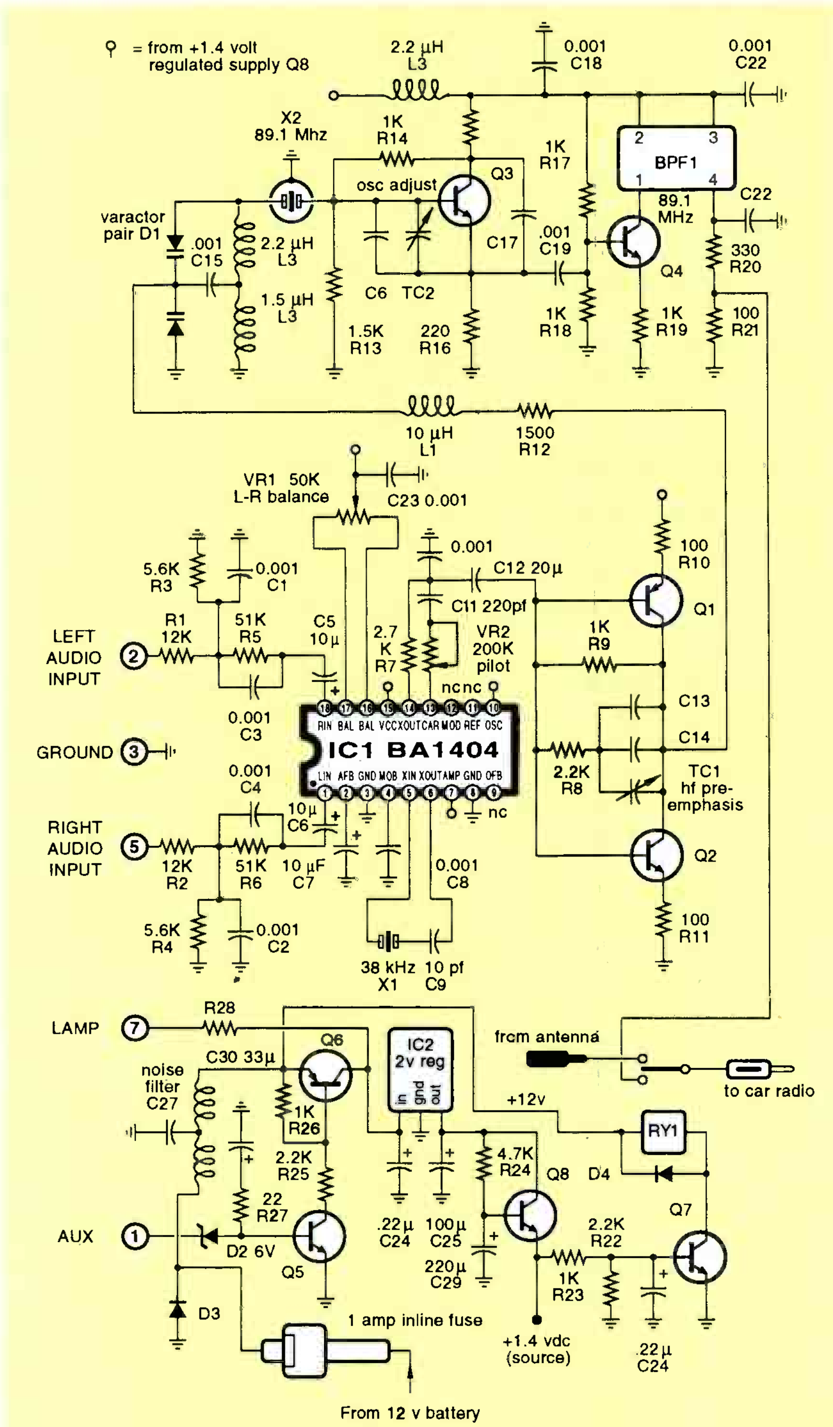
Except for that switchover relay, the rest of the circuit runs on the dynamically regulated 1.4-volt supply. Theoretically, a single AA cell could be used instead.

The heart of the circuit is the great *Rohm* BA-1404 FM stereo broadcaster chip that we have looked at in the *Hardware Hacker II* reprints. Only this time, the internal RF transmitter circuitry is *not* used and gets very carefully deactivated. A 38-kHz signal (X1) is needed to modulate the incoming audio and to create the 19-kHz pilot signal. Control VR1 adjusts your balance, and VR2 sets the 19-kilohertz pilot level.

The multiplexed audio output is added to the pilot and routed to a combination driver and pre-emphasis network via Q1 and Q2. The amount of high-frequency pre-emphasis is adjusted by TC1.

The linear and broadband "crystal puller" is an interesting reactance modulator scheme using a pair of varactor diodes at D1. A simplified circuit of the modulator appears in Fig. 4. What you've got is a crystal in series with the parallel resonant circuit "A," which is, in turn, in series with a second resonant circuit "B."

Tank "A" is tuned well *below* the crystal's parallel resonance and will normally appear as a high *inductive* reactance. Tank "B" is tuned *above* the crystal parallel resonance and will appear as a *capacitive* reactance. In the absence of any audio



WARNING: Be sure to current limit the AUX input with an external 1K resistor!

FIG. 3—APPROXIMATE SCHEMATIC of the Pioneer CD-FM-1. While intended as a CD-audio-to-car-radio adaptor, this module can easily become a highly stable and on-channel FM stereo wireless broadcaster. Applying +12 volts to the AUX input activates the module.

modulation, the reactances will cancel, and the series combination of the crystal and the two tanks becomes a high-impedance open circuit.

Those varactor diodes act as electronically variable capacitances that raise or lower the tank frequencies. On positive modulation swings, both tanks *increase* their resonant frequencies; on negative swings frequencies decrease.

The final result is a reactance frequency modulator whose resonant frequency is set by the crystal but it is rapidly shiftable either way by the multiplexed audio. Usually a frequency change varies as the *square root* of a capacitance change. But, because a *pair* of varactor diode capacitors is changing, the resonant frequency changes *linearly* with the modulation input.

At any rate, Q3 is a *Pierce*-style oscillator that can oscillate at the frequency determined by the highest impedance sum of the crystal's third overtone resonance and the reactance modulator tanks. A frequency of 88.1 megahertz is used in my particular sample, with a final trim given by TC2.

The fundamental crystal frequency is way down at 29.7 megahertz, but the oscillator tries its best to run at 88.1. The resultant waveform thus has some uneven subharmonic lumps.

It is very important to keep the loading on any FM oscillator constant, especially when using an overtone crystal. So, a buffer and driver transistor follows at Q4. That in turn drives a special bandpass filter (probably a surface acoustical wave, or a SAW device) to eliminate any subharmonics and out-of-band harmonics. Only the crystal's third overtone at a frequency of 88.1 MHz is allowed through the filter.

Even with the attenuation through the bandpass filter, the output signal is still too strong to directly couple into an FM receiver's antenna, so it is further attenuated by R20 and R21.

Recall that the supply power is turned on only when you want to listen to your CD player. When the 1.4-volt DC supply voltage is present, relay-driver Q4 and spike-suppressor D4 pull in the relay, connecting the RF-converted CD audio directly to your auto-radio antenna input. At the same time the antenna is disconnected to prevent any back radiation or unintentional broadcasting. You do, of course, also have to pushbutton select 88.1 MHz on your car radio to listen to the CD audio.

Once again, this description is for the FM-CD-1. The XA-7A uses a somewhat different circuit that we might look at in a future column if there's enough interest.

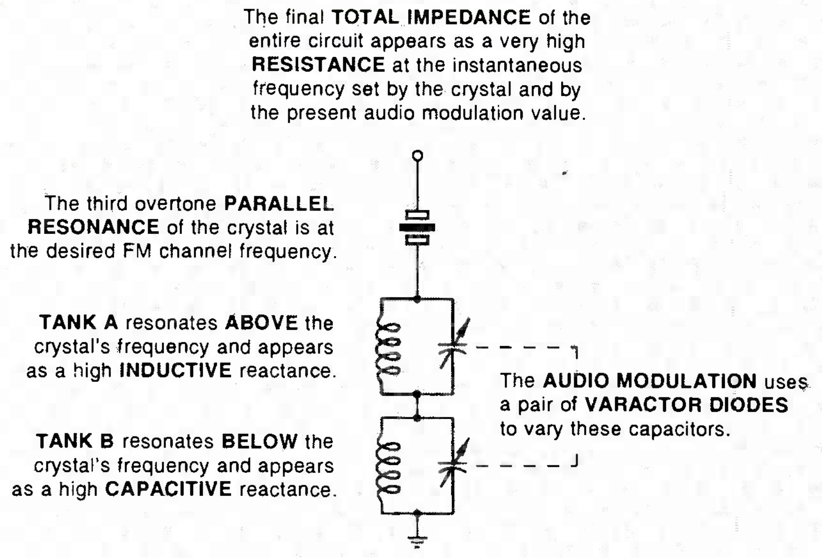


FIG. 4—SIMPLIFIED SCHEMATIC of the linear reactance modulator.

Hacking the CD-FM-1

In the absence of a CD player, the CD-FM-1 can be activated by connecting the AUX input to the +12-volt supply. Your left and right audio inputs are normally at "line" level; additional gain will be needed for most microphones. Any and all audio connections must be shielded.

The antenna changeover relay might be optionally defeated by shorting R23. Supply current is 30 milliamps with the relay active and 17 milliamps with it defeated. Another four milliamps can be saved by disconnecting the AUX input and shorting the collector to emitter on Q6. Nearly another milliamp can be saved by removing R22. The remaining power needed by the "useful" part of the circuit is then 1.4 volts at eleven milliamps, or something around fifteen milliwatts.

With those power reductions, you could probably substitute an ordinary 9-volt transistor battery for your 12-volt supply. But be sure to turn the power off when you are not using the transmitter.

Theoretically, you might want to replace the dynamic regulator Q8 and substitute a single AA cell instead. A bypass capacitor or two would also be a good idea if you try that. One way or another, though, you can easily get the circuit down into the millipower range but not the micropower range.

A possible antenna takeoff point for any low-level direct-broadcasting experiments seems to be the collector of Q4. Figure 5 shows how to route a 30-inch antenna wire through a grommet in the case. I got a 50-foot useful range with a good car radio that way. Be sure to insulate the wire tip to prevent possible shorting of the DC supply or damaging of the filter. A far cleaner but weaker takeoff point would be the pin-4 filter output.

While the BA1404 supply voltage can be raised as high as 3 volts, doing so may change the performance of the reactance modulator.

The best way to increase the range is to improve the antenna on your receiver. Be sure to connect a good receiving antenna and disconnect any cable connections. Experiment with the antenna orientation; vertical might be best for car radios and horizontal might work out better for a home hi-fi.

The range can also be improved by placing a ground plane, such as a grounded cookie sheet (or preferably something bigger), under your transmitter. That could give you a hemi pattern with double field strength.

A directional receiving antenna, such as a correctly cut Yagi, can also dramatically improve your range.

Note that lower power plus good antenna matching and orientation will give you vastly more range than will high power and poor or improperly aligned antennas.

While there is that extra booster amplifier remaining unused in the BA1404, it might be tricky to access and still have it remain stable. An external boost circuit could also be built using a 2N918 transistor or something similar. That would best be done in a separately shielded and a properly decoupled box. *Do not, under any circumstances, attempt to amplify the unfiltered output.* Doing so will create unacceptably strong outband signals especially at 29.7 megahertz.

What can you get away with in the way of increased power? Any boost at all gets you into a legal gray area. But, as a practical matter, if your DC input power to your boost stage is under 50 milliwatts, and if nobody complains, and if your total useful range is well under a hundred feet, and if you use the transmitter yourself rather than selling it to someone else, you can probably get away without any serious problems or hassles.

On the other hand, using one of these as a predriver to broadcast heavy metal to your entire college campus is a very big no-no.

Another contest or two

This CD-FM-1 is one of the most hackable projects to come down the pike in a long, long time. For here we have all of the compact and millipower core circuitry needed for one very high-quality and quite stable FM stereo (or mono) broadcaster all in one place and ready to go—with the nasty stuff fully debugged. And one that works with synthesized auto receivers.

For our first contest this month, just tell me about a new or unusual use for a short-range and high-quality FM stereo or a mono wireless transmitter. Or show me a variation on the circuits we just looked at.

There will be all of those usual *Incredible Secret Money Machine II* book prizes going to the dozen or so best entries. In addition there will be an all-expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

Be sure to send your written entries directly to me here at *Synergetics* per the help box, rather than on over to **Radio-Electronics** editorial.

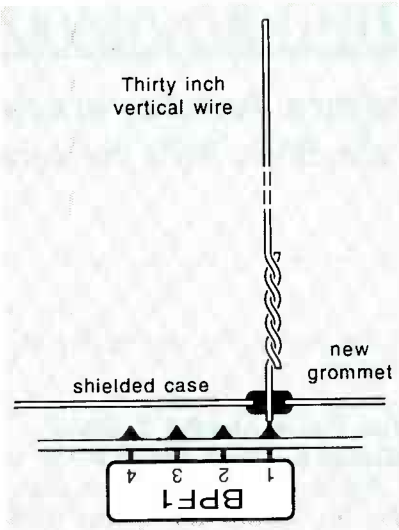


FIG. 5—AN ANTENNA CAN BE ADDED as shown to the CD-FM-1 for your initial short-range FM broadcasting experiments. Be sure to insulate the far end of your coupling gimmick. Experiment to get the best length and orientation.

DYS resources

I thought we'd do something a tad unusual for our resource sidebar this month. There's a group of direct-mail outfits that I will call DYS, short for *Distressed Yuppy Surplus*. All these folks specialize mostly in overpriced toys for the non-technical types. But every once in a while, an electronic gem or two shows up at a really unbeatable price. Or a useful tool. Or a great idea.

An example or two: Those "meals in minutes" food vacuum-packaging machines seemed to bomb out as a Yuppy prize. Their intended use was to package single-portion leftovers so they can be frozen, boiled, or nuked. And they are great for just that. But at $29 each via DYS, they also make very effective software and book vacuum-packing machines. Be sure to get the type that has the little electric pump with it. Plain old *Baggies* work just fine with them.

Those automated bread machines also bombed at retail. This happened because far too many females viewed them as an outright threat and they throw both the machine and whoever gave it to them out of their houses. So I got one via DYS. Around here these days, any bread that is even twenty minutes old is considered "stale," and even the birds won't touch it.

You do have to be selective. For instance, a CPM computer is pretty much worthless at any price, as is any laser printer that does not speak real PostScript or, for that matter any teletext receiver with no teletext to receive.

My three favorite DYS sources are *Dak*, *Comb*, and *Damark*. But every once in a while, a good solution to a technical problem can even be found in such unlikely sources as *Taylor Gifts* or *Harriet Carter*.

I thought I had a lot more of these DYS catalogs than I could find at column deadline time. Is *JS&A* still around? They invented DYS in the first place. How about the *Sharper Image* folks? So why don't you tell me about the rest of them?

As a second contest, just tell me about any non-obvious direct-mail resource that can be used to get ideas and solve hacking and other technical problems. Include a sample copy if you are able to.

I've also added a great heaping bunch of other unusual direct-mail sources to our sidebar. While several of these are clearly not DYS, they do offer very interesting and very useful catalogs. And every hacker should definitely know about them.

New tech lit

From *Analog Devices*, the fat new *Data Book Volume 10* on their analog integrated circuits. From *WSI*, there's a new *Programmable Peripherals Design and Applications Handbook* that includes lots of free demo software. From *Intel*, you can get their new *PLD shell Plus* programmable logic design and its supervision software. It is free on a professional request.

Assorted free samples of *Kydex* thermoplastic sheets are obtainable from *Kleerdex*. This stuff looks great for custom thermoformed cases and enclosures. There's lots of colors, thicknesses, and surface finishes. And free tactile dome keyswitch samples are available through *Snaptron*. Finally, *Avery Dennison* now has test-fixture samples of their *FasTape UHA* super-strong clear adhesives.

A reminder that I still have lots of book-on-demand bound reprint

continued on page 88

AUDIO UPDATE

Testing the testers: Another exceptional paper from the 91st AES convention

LARRY KLEIN

Conventional listening tests have always been problematical for dedicated audiophiles. By "conventional," I mean tests posing as scientific with such methods as double-blind techniques, careful controls, statistical analysis, and instant switching with precise level equalization. The editors of *The Absolute Sound, Stereophile*, and other non-mainstream audio publications believe that those techniques obscure the sound quality differences that they hear so easily when listening under relaxed conditions. i.e., where an audio component is listened to for hours, days, or even weeks to evaluate its sound quality, and then its sound is compared to that of a reference component under similar listening conditions. If quality differences heard during this long-term audiophile testing fail to appear under the tightly controlled "quick-switch" procedures, then, in their view, the purportedly rigorous scientific procedures (espoused by people such as myself) must be somehow flawed and thus terribly misleading.

Incidentally, it's worth pointing out that the contention between the two opposing camps seldom is reduced to determining which of two amplifiers sounds better. Instead, the argument is usually about whether properly operating modern amplifiers sound alike or different.

If, as claimed by most audiophiles, carefully performed switching tests based on double-blind techniques (in which neither the tester nor the listener know the identity of the components being compared) are of dubious value, it's important that those involved in new-product and new-technology evaluations know that their tools are flawed. David L. Clark, of ABX fame, discusses these matters and more in the Audio Engineering Society preprint.

Ten Years of ABX Testing [David L. Clark (3167 K-1)]

About ten years ago, David Clark and his associates invented the ABX switch, a sophisticated component that enables a listener to do double-blind listening evaluations without the need for a second or third party to handle the random switching involved. The ABX switch automatically charts a listener's judgment about whether component A or B is the same as X, which might be A or B in a given trial series. At the end of the test series, the number of correct decisions is given.

When it became available, Clark and his associates thought that the ABX comparator would be a powerful tool for determining, once and for all, whether small differences in components such as power amplifiers are audible and commonly heard. However, the debate raged on as though the ABX device were never invented. When the ABX comparator confirmed that audiophile listeners consistently fail to identify components on a basis of sounds that they thought they heard, the audiophiles were not embarrassed. Most convinced themselves that they heard those differences clearly under normal, not test, listening conditions.

Audiophiles offered two explanations for their failure to discern acoustic differences during ABX testing: (1) The switching relays and connectors used in the ABX switch introduce artifacts that somehow mask the differences, and (2) short-term, quick-switched listening does not permit differences that are readily apparent on typical long-term audiophile testing. In other words, the stress induced by a rigorous test de-sensitizes the listener and impairs his ability to hear differences that are apparent under more relaxed circumstances.

Clark set out to test the reality of the explanations and excuses. Two audiophile societies participated: The Audiophile Society (TAS), consisting mostly of true believers in high-end audio equipment and Clark's group, the Southeastern Michigan Woofer and Tweeter Marching Society (SMWTMS) who tended to be rationalists.

The test consisted of the insertion/non-insertion of a black box non-linear circuit that injected 2.5% harmonic distortion into the signal path. Two sets of tests were planned for each group. One employed the ABX switch for the typical quick-switch procedures preferred by the "scientific" audio group, while the other called for the long-term listening preferred by the high-end, everything-sounds-different crowd.

As might have been predicted, the "golden ears" of the TAS group refused to have the signal passed through the ABX comparator, and instead used a much slower, manually plugged 16-trial comparison test with a very expensive high-end system familiar to most of them. The SMWTMS group listened in an unfamiliar room to an unfamiliar sound system.

Double-blind black boxes

The second part of the test attempted to set up the long-term, relaxed listening situation favored by high-end audiophiles. Ten sealed black boxes were distributed double-blind to at least 16 members of each group. Half of the boxes contained the distortion circuit; the others were simply bypass circuits. Participants were instructed to patch their black boxes into the tape loops of their home preamplifiers and listen for as long as necessary to decide whether or not the black box was neutral.

No one in either group was able to distinguish the distorting box from the non-distorting box reliably in long-term listening on a home system. Moreover, no one in the TAS group could identify reliably the distorting black box in the manually patched series of relatively quick trials. However, with the ABX comparator, the SMWTMS group was able to differentiate between the distorting and non-distorting black boxes within 45 minutes. And they went on to perform just as well with the black box at even lower distortion levels!

This, to my mind, constitutes an ultimate rebuttal to those who claim that long-term listening is required for detecting differences, and that instant switching with boxes such as the ABX comparator somehow masks acoustic differences. To repeat: the Audiophile Society failed to detect the 2.5% total harmonic distortion (THD) under its preferred listening conditions. By contrast, the SMWTMS group, using the ABX switch, detected the distortion quickly and, later, at even lower levels.

Those who have been involved with ABX testing agree that the reason for the high sensitivity of the ABX procedure is the ease and speed of the comparison, which enables one to focus on the detection task. Dependence on one's memory of what one thinks one heard—interrupted by juggling cables while switching components—obviously does *not* make for reliability in evaluating components, despite audiophile claims to the contrary.

Final note

People I consider to be fuzzy-minded, non-technical elitists are not the only ones who believe that rigorous double-blind testing obscures small audible differences under non-test conditions. When Clark was chairman of an AES Workshop on Esoteric Audio in 1988, he asked the audience to indicate by a show of hands whether they believed that different modern gain-matched power amplifiers sounded different from each other. (It was assumed that all of the amplifiers would measure up well in conventional testing, and be operated within their ratings.)

Approximately 70% of the AES audience indicated that they thought the amplifiers would probably sound different! Along with Clark, I find that result disheartening, especially in light of all the carefully controlled tests and studies that have failed to show that such audible differences exist. **R-E**

ASK R-E

continued from page 15

ANALOG SWITCH LOSS

I'm building a circuit that uses a 4066 CMOS analog switch to select between various audio sources. Everything works fine but I notice that there's some loss in signal level through the switch. According to the data books, a closed 4066 switch acts like a 75-ohm resistor and, since that is a characteristic of the IC, I'd guess there's no way around it. Or is there?—W. Meredith, Elkins, WV

Analog switches are neat devices that allow digital circuits to control the flow of analog signals. When these IC's first appeared on the market they were immediate hits. But you're right, there is an internal loss.

While there's no way to pop the cover off the IC and do a bit of creative microsurgery to cut down the signal loss, there are some more conventional alternatives that can help. After all, the losses are due to routing signals through transistors as opposed to mechanical contacts.

The most obvious answer is to put a simple amplifier after the switch, which is what I would do if faced with your problem. A one-transistor or op-amp circuit doesn't cost much nor does it take a lot of board space. An added benefit is that you'll be able to adjust the overall gain to any level you want. And since you're dealing with audio, it's not much of a job to tailor the amp's characteristics to match whatever equipment the circuit has to feed.

If you're not using all the switches in the IC, there's no reason why you can't use two or more switches in parallel. The apparent resistance will drop in the standard reciprocal-addition pattern used for calculating the equivalent resistance of parallel resistors. You can never reduce the resistance to zero but you might be able to get it down low enough to make the problem unimportant.

Your last alternative is to use a different IC. Some of the more expensive analog switches designed for video and other high-frequency applications have a lower inherent signal loss but they're much harder to get in single quantities. A less expensive and more available choice would be something like the 4016, the father of the 4066. That earlier chip has a higher internal resistance (about 300 ohms), but does a better job of preventing signal leakage. Anyone who stocks the 4066 would probably stock the 4016 as well.

FM ANTENNA

I'm having a lot of trouble getting good FM reception in my home. No matter what kind of antenna I try or where I put it in the room, the reception is garbled and distorted. I live only a few miles from the main transmitting antenna so I know it's not a problem with the level of the signal. I'm thinking of getting one of those devices I've seen advertised that turn my electrical wiring into an antenna. Do they really work?—L. Lasky, New York, NY

I thought those phony baloney contraptions disappeared along with more important things like the Rosicrucians (AMORC everyone) and White Cloverine Brand Salve. The answer is a definite no. Few things in life are for sure but the fact that those antennas are a waste of time is something you can bet on.

The reason you're getting such terrible reception is because of multipath reception. The signal from the transmitter bounces around off the metal in buildings and you're getting several delayed versions of the same signal. If you had the same problem with TV reception you'd be talking about ghosting. And the way to solve the problem is to follow the same route you would with ghosting: increase the signal strength.

I've seen lots of devices that purport to eliminate multipath FM reception but I've never run across one that delivered what was promised in the ads. The bottom line is that if you have excessive signal reflection and the reflections are strong enough, you're going to have poor reception. FM antenna amplifiers—the ones that go in front of the antenna inputs—can solve problems caused by a weak signal but they can't do anything with multipath reception. As they say, garbage in, garbage out.

Until someone out there can show me otherwise, all you can do is try to get cable FM service, or put your antenna somewhere that it has a clear shot at the transmitter's antenna. That would be out a nearby window if you're up high enough, or out on the roof if you're not. **R-E**

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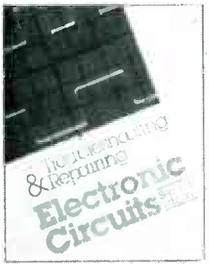

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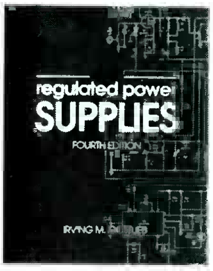

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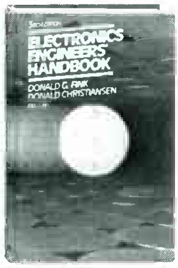

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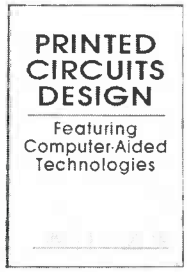

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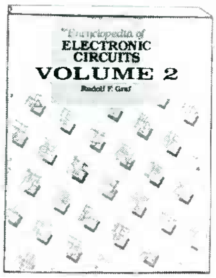

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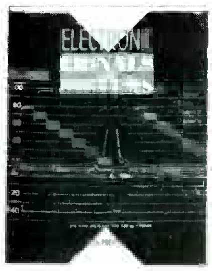

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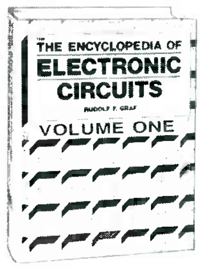

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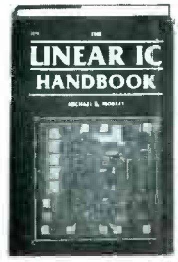

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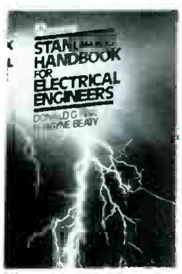

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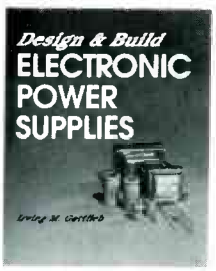

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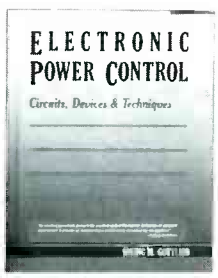

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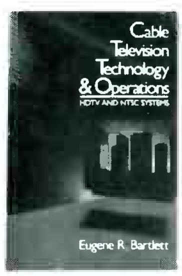

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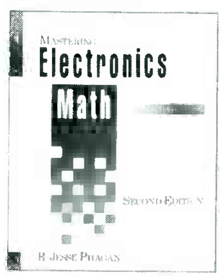

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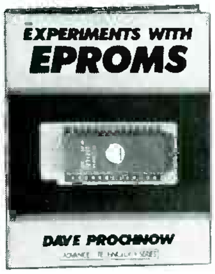

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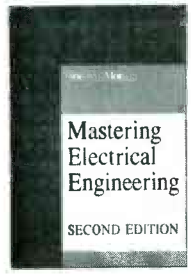

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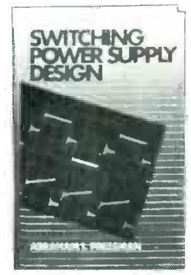

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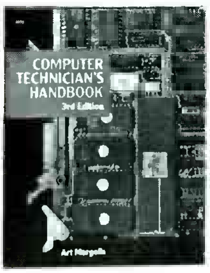

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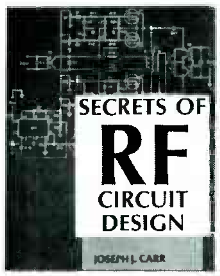

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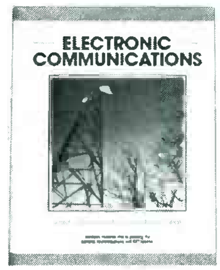

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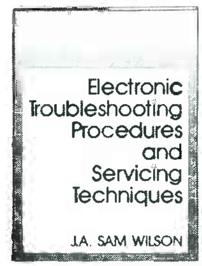

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Windows 3.1, OS/2 2.0

JEFF HOLTZMAN

Windows 3.1 is destined to be an extremely popular upgrade to Microsoft's already popular graphical operating environment. It is an incremental upgrade that fixes many small problems and adds several significant new features. I wish Microsoft had gone further with some things, but there is enough new and improved here to capture a heck of a lot of user interest (and dollars). This report is based on the "final" beta (3.1.061d, shown in Fig. 1); some features might vary slightly in the finished product (due out by the time you read this).

Win31 contains five major areas of improvement: higher reliability, Object Linking and Embedding (OLE), the TrueType font system, a new File Manager with "drag-n-drop" file management, and lots of small user-interface enhancements. Let's discuss each in turn.

Improved reliability is first on the minds of many (including yours truly). Put simply, Win31 is not as robust as OS/2, but it's better than Win30. When a program crashes, it usually brings up a dialog box stating where the fault occurred, and allows you to terminate the application without rebooting or corrupting Windows' internal memory-management scheme. I say *usually* because (at least in the beta), it's still not 100% reliable.

A related feature is Ctrl-Alt-Delete trapping: You can't simply reboot at any time. If you press Ctrl-Alt-Delete, a text-mode screen pops up advising you to press the key combination again if you really want to reboot, to press Esc if you'd really rather not reboot, or press Enter to terminate the current application. The purpose of the latter is to terminate hung applications. If an application hangs, you can "reset" just that session and return to Windows. (DESQview has had that feature for years; it's about time Windows got it as well!)

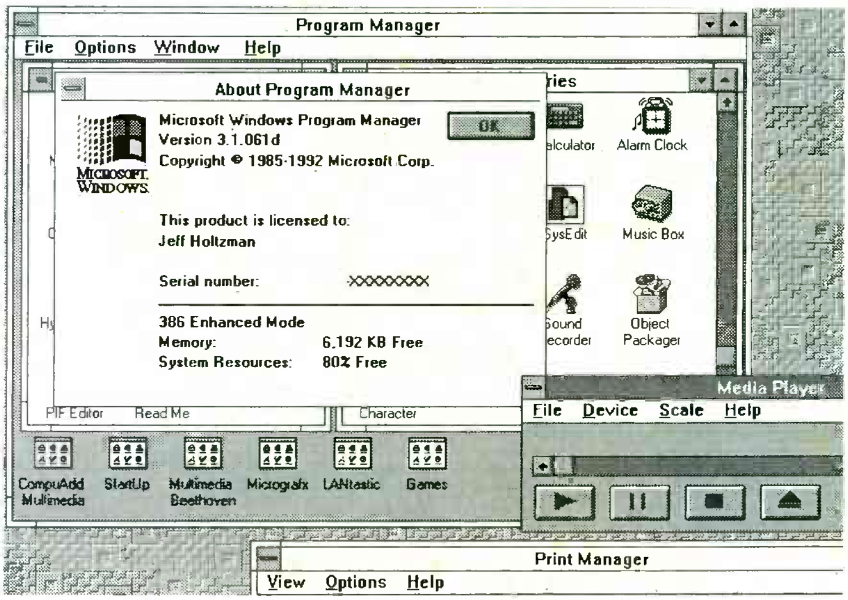

FIG. 1—WINDOWS 3.1 contains improved reliability, object linking and embedding, and lots of small improvements that together add up to another run-away success for Microsoft.

OLE

Object Linking and Embedding (OLE) provides the most interesting and far-ranging enhancements to Windows. Recent versions of various Windows applications (Excel, WinWord, Ami, PowerPoint) have been getting smarter and smarter about how they integrate data from other applications. For example, you might want to include an Excel worksheet in a budget statement, or include an Excel graph of data collected as part of a school report. In the old way of doing things, you would leave a big hole in your document, print the worksheet or graph separately, then paste the printout physically into the document. Savvy Windows users have, for several years, eliminated the physical cut and paste, instead doing so through the Windows clipboard. However, doing so has limitations. What if the Excel data changes? Then you must delete the version in the document and "paste" in a new one.

A better way is to set up a "link" between the Excel data and the word-processor document. The link allows you to work on both document and data separately, perhaps with separate users performing different tasks. The word processor watches over the link; when it detects new or changed data, it updates the document with a new copy of the spreadsheet.

An embedded object is quite different, and there is much confusion floating around about this point. An embedded object exists only in the main document, not in a separate file. That means that only one user can get at an embedded object at a time.

Let's back up a couple of steps. What does Microsoft mean by the term *object?*

In the Windows scheme of things, an object is a chunk of data. It could be a cell in a spreadsheet, a range in a spreadsheet, or the entire spreadsheet. It could be a paragraph of text or a whole document. It could be a bit-mapped image created in a paint program. It could be a sound file containing voice annotations to a document. The point is that it could be just about anything; the "document" containing such an object does not need to know how to display it or print it.

Object linking and embedding doesn't happen in a vacuum; applications must be "OLE-aware." There are two types of OLE-aware applications: OLE servers, which provide objects that can be linked to or embedded in other documents, and OLE clients, which can accept objects supplied by an OLE server. A given application can be a client, a server, or both. In Win31, PaintBrush and the Sound Recorder (only available with multimedia hardware) are OLE servers; CardFile and Write are OLE clients. Current versions of Excel and Word for Windows can function in both roles. (The next version of Word is rumored to have extensive built-in OLE capabilities.)

Whereas a linked object exists in a separate file, an embedded object exists only in the primary file. You edit an embedded object by double-clicking on it, which causes the corresponding application to load with that data. After you edit the data, you close the second application, which inserts an updated copy of the object in the document.

What about applications (DOS programs, for example) that are not (and may never be) OLE-aware? Win31 includes a special program called the Object Packager. What it does is link an application and its data file to an icon that you embed in an OLE client. The type of application and data is irrelevant; all that appears in the OLE document is the icon. To access the "packaged" data, you double-click the icon. Windows then executes the corresponding application.

The iconic representation has some interesting ramifications. Hard-copy and on-line versions of OLE documents differ. The hard-copy version will contain only the iconic representation, not the actual data. The irony is that the on-line version will be richer than the hard-copy version, not the other way around. The implication is that you'll need a computer to get at all the information contained in the OLE document. As computer hardware continues its evolution toward rich, standardized multimedia capabilities, this will become the rule rather than the exception.

The whole OLE procedure is awkward, time-consuming, and distracting. In the current way of doing things, a whole new application launches in a separate window that takes you out of the context of your document. Ideally, when you selected an embedded object, the menus and tool palettes of the current application would change to reflect available capabilities. Then you would have the feeling that it was your document that mattered, not the computer applications used to create it. OLE represents the first cut at that type of transparent editing capability.

TrueType

Microsoft's answer to Adobe Type Manager (as well as similar products from BitStream and others) is called TrueType. TT provides built-in device-independent scalable fonts. Device-independent means that, within the resolution of the device, fonts will appear identical on any supported video display or printer. With font support built into the operating system, documents can easily be ported among different machines without loss of formatting information.

Win31 includes four typefaces corresponding to Helvetica, Times, Courier, and Symbol. These fonts are rendered quickly and are quite good looking; Adobe might be in for trouble on that count. Professional desktop publishers will likely still prefer ATM and Adobe Type 1 PostScript fonts, but run-of-the-mill users probably won't care what's under the hood as long as it works. And even in this beta, it does. I've already seen lots of public-domain TT typefaces floating around on the telecommunications services. Win31's ability to work with both TrueType and PostScript Type 1 fonts was unclear as of this writing.

It's important to understand that TrueType is no substitute for PostScript. PostScript is a robust language for describing both fonts and complex page layouts; TrueType covers only the font portion. Microsoft has a related technology, TrueImage, that attempts to make up for the deficiency. However, few laser-printer manufacturers and even fewer application programs support either TrueImage or TrueType. The point is that PostScript is well-supported, hence is likely to be with us for a long time.

Other improvements

File manager is incrementally faster and easier to use. Using the Multiple Document Interface (MDI), it allows you to open multiple windows into various drives, and then to copy and move files among them. Drag-n-drop allows you to select a file from the file manager, then drag it to another application to move, copy, or print the file. Moving and copying work fairly well; the print feature is not so elegant. For example, if you drag FILE.TXT to the Print Manager, it in turn launches NOTEPAD.EXE, which does the actual printing. You can drop the file icon on either the minimized PrintMan icon, or on the open PrintMan window. The idea behind this capability is great, but the implementation is awkward. If I drag something to the printer icon, I just want it to start printing while I go on about my business. Instead, the dropped-on application takes over the screen and keyboard until printing is done. For this capability to work smoothly, applications vendors are going to have to cooperate, i.e., provide DDE-accessible print modules that do their thing in the background, without disturbing the user. FileMan also provides a "backdoor" capability for adding new functions; already there are shareware packages that do so. FileMan is much better than in previous incarnations, but I would have a hard time giving up the Norton Desktop for Windows.

As with Microsoft's recent release of Word for Windows 2.0, there are lots of small user-interface improvements that together add up to a much more pleasant computing experience. To name a few, ProgMan and FileMan save settings much quicker when exiting; high-speed support for many super-VGA cards is built-in; full mouse support for DOS apps running in a window; faster switching among applications; a large collection of application icons; built-in screen savers; built-in multimedia support, built-in tutorial on Windows operations; a Startup group in ProgMan (the visual equivalent of the LOAD= and RUN= lines in WIN.INI); better support for COM3 and COM4 serial I/O; variable size fonts for windowed DOS sessions.

In prior versions of Windows, you could press Alt-Tab to cycle through all open applications. Win31 includes a "smart" version in which you press and hold Alt; subsequent presses of Tab cycle through a window that lists each running application, complete with icon and title. When you reach the one you want, release Tab and you switch to it. Simple but elegant.

Win31 includes an updated version of Microsoft's disk caching program SmartDrv. SmartDrv 4.0 hooks in at the DOS level, hence is able to cache more types of devices. The program now includes the ability to cache both reads and writes. In addition, the final version should have its own Ctrl-Alt-Delete trap which will help ensure that cached writes actually are written to disk before the system resets.

In conclusion, Win31 sports many small improvements and several indicators of great things to come. Windows is still not perfect, but it's a whole lot better. The detailed attention paid to improved user interaction echoes similar improvements in the recent release of Word for Windows 2.0. This type of user focus is what would-be competitors had better pay attention to.

OS/2 2.0 update

Flash: I just received beta version 6.304, which now allows Windows and OS/2 windows on the screen simultaneously. My initial impression is highly favorable. Choosing between OS/2 and Windows is no longer as easy as it once was. More next time.

Multimedia update

As soon as things settle down on the system software front, I will get back to my promise to provide an in-depth look at CompuAdd's multimedia upgrade kit, which puts a CD-ROM, sound card, and optional AM/FM and TV tuners in your PC. You've gotta see it to believe it! **R-E**

"Let me guess: The computer never goes down up here!"

HARDWARE HACKER

continued from page 75

sets available on pretty near all of my recent columns. Included are *Ask the Guru* I, II, and III, *Hardware Hacker* II and III, *LaserWriter Secrets*, and *Blatant Opportunist*. Write or call me for more details.

I've just posted my printed-circuit layout package up to *GEnie* PSRT as our file #401 PRINCRCT.PS. It lets you do ultra-fancy PC layouts using nothing but your very favorite word processor or editor. And please note that all my *Ask the Guru* and *LaserWriter Corner* columns continue to be electronically published, also on *GEnie* PSRT-on time, full length, and uncensored. I have also updated all my book-on-demand publishing secrets as #410 BOOKDEMD.PS.

As usual, we have gathered most of the sources together into either our *Names and Numbers* or our *DYS Resources* sidebars. **R-E**

EQUIPMENT REPORTS

continued from page 16

be switched between the frequencies of 300 Hz, 1 kHz, 3 kHz, and 8 kHz, and the output level can be switched between 0 and −6 dB. Stereo-pilot and SAP (Second Audio Program) signals can be switched on and off, and stereo-sum and -difference signals (L + R and L − R) are also individually available. With the four audio output signals from the TS-8-MTS, all sections of a TV's decoding circuitry can be checked.

The TS-8-MTS is a versatile piece of test equipment, and at $895 it's also competitively priced. It's a worthwhile investment for anyone who regularly works on TV's and VCR's—or someone considering getting into servicing. The generator is intended for troubleshooting and aligning video equipment but it would be great if stores had them to demonstrate the quality of the next TV set you are about to buy! **R-E**

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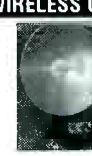

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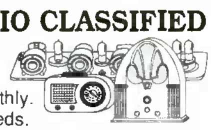

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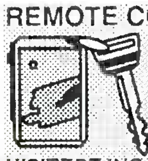

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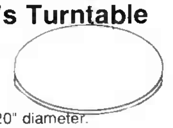

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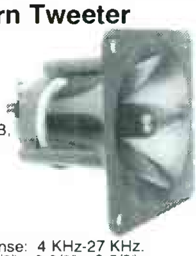

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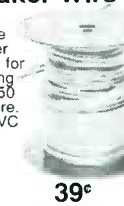
12 Ga. Speaker Wire



Extra large gauge speaker wire for use with very high power stereo systems and for use in extremely long cable runs. Over 250 strands of 36 ga. wire. Extra thick, clear PVC insulation. **Please order in multiples of 5 feet.**

#RH-100-151 **39¢** (per foot)

BBC 12" Dual Voice Coil Subwoofer

Super quality Italian made cast frame dual voice coil subwoofer. Paper cone with foam surround. 2" dual voice coil. fs= 45 Hz. Frequency response: 45-4KHz. Sensitivity: 96.69 1W/1M. VAS= 3.73 cu ft., QTS= .338. BBC #SW321/F8. Net weight: 9 lbs.

#RH-294-130 $139.90 (1-3) **$128.60** (4-up)

8 Ga. In-Line Fuse Holder

Screw together Bakelite fuse holder with 8 ga. wire. For use with AGU type fuses or regular AGC fuses when spring spacer is used. 50 amp max at 12 volts.

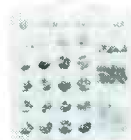
#RH-070-800 $3.20 (1-9) **$2.75** (10-up)

High Voltage Cap Kit

This 85 piece kit contains a selection of 250, 350, and 450 volt electrolytic capacitors. 5 pieces each of 1, 2.2, 3.3, 4.7, 6.8, 10, 22uf and 2 pieces each of 33, and 47uf, 250V radial caps. 5 pieces each of 1, 2.2, 3.3, 4.7, 10uf and 2 pieces each of 22, 33uf, 350V radial caps. 5 pieces each of 1, 2.2, 4.7uf and 2 pieces of 10uf, 450V radial caps. Over $62.00 wholesale cost if purchased individually. Net weight: 1 lb.

#RH-020-950 **$49.95** Kit

VCR Parts Assortment



Convenient assortment of clips, washers, springs, and screws. 10 pieces each of 4 sizes of "E" clips, 10 pieces of 2 sizes of retaining rings, 10 pieces of 14 sizes of washers, 2 each of 8 sizes of tension and compression springs and 24 assorted screws. Total of 246 pieces.

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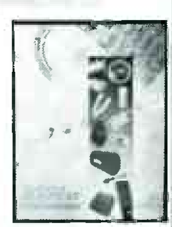

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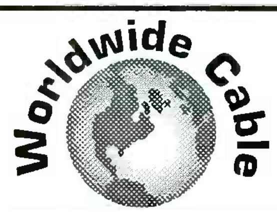

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LASER DIODES

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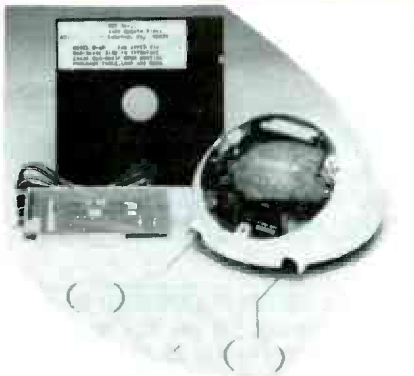
LS9220	TOSHIBA	660nm	3 mW	85 mA	2.5 V	129.99	123.49	111.14
LS9200	TOSHIBA	670nm	3 mW	85 mA	2.3 V	49.99	47.99	43.19
LS9201	TOSHIBA	670nm	5 mW	80 mA	2.4 V	59.99	56.99	51.29
LS9211	TOSHIBA	670nm	5 mW	50 mA	2.3 V	69.99	66.49	59.84
LS9215	TOSHIBA	670nm	10 mW	45 mA	2.4 V	109.99	104.49	94.04
LS3200	NEC	670nm	3 mW	85 mA	2.2 V	59.99	56.99	51.29
LS022	SHARP	780nm	5 mW	65 mA	1.75 V	19.99	18.99	17.09
SB1053	PHILLIPS	820nm	10 mW	90 mA	2.2 V	10.99	10.44	9.40

WAO II PROGRAMMABLE ROBOTIC KIT

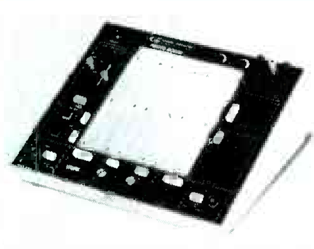


The pen mechanism included with the robot allows it to draw. In addition to drawing straight lines, it can also accurately draw circles, and even draw out words and short phrases. WAO II comes with 128 x 4 bits RAM and 2K ROM, and is programmed directly via the keypad attached to it. With its built-in connector port, WAO II is ready to communicate with your computer. With the optional interface kit, you can connect WAO II to an Apple II, IIe, or II+ computer. Editing and transfering of any movement program, as well as saving and loading a program can be performed by the interface kit. The kit includes software, cable, card, and instructions. The programming language is BASIC.

- Power Source - 3 AA batteries (not included)

STOCK #	DESCRIPTION	1-9	10-24	25+
MV961	*WAO II Programmable Robotic Kit*	79.99	75.99	68.39
WIIAP	*Interface Kit For Apple II, IIE, II+*	39.99	37.99	34.19

PROTOBOARD DESIGN STATION



- The total design workstation - including expanded instrumentation, breadboard and power supply.
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- 8 TTL compatible LED indicators, switches
- Pulsers
- Potentiometers
- Audio experimentation speaker
- Multiple features in one complete test instrument saves hundreds of dollars needed for individual units
- Unlimited lifetime guarantee on bread-board sockets
- **Fixed DC output**
  +5 VDC @ 1.0 amp, ripple - 5 mV
- **Variable DC output**
  +5 - to +15 VDC @ 0.5 amp, ripple - 5 mV
- **Variable DC output**
  -5 - to -15 VDC @ 0.5 amp, ripple - 5 mV
- **Frequency generator**
  frequency range: 0.1 Hz to 100 KHz in 6 ranges
  output voltage: 0 to ± 10V (20 Vp-p)
  output impedance: 600 (except TTL)
  output current: 10mA max., short circuit protected
  output waveforms: sine, square, triange, TTL
  sine wave: distortion 3% (10 Hz to 100 KHz)
  TTL pulse: rise and fall time 25ns drive 20 TTL loads
  Square wave: rise and fall time ± 1.5 s
- **Logic indicators**
  8 LED's, active high, 1.4 volt (nominal) threshold, inputs protected to ± 20 volts
- **Debounced pushbuttons (pulsers)**
  2 push-button operated, open-collector output pulsers, each with 1 normally-open, 1 normally-closed output. Each output can sink up to 250 mA
- **Potentiometers**
  1 - 1K , 1 10K , all leads available and uncommitted
- **BNC connectors**
  2 BNC connectors pin available and uncommitted shell connected to ground
- **Speaker**
  0.25 W, 8 Ω
- **Breadboarding area**
  2520 uncommitted tie points
- **Dimensions**
  11.5" long x 16" wide x 6.5" high
- **Input**
  3 wire AC line input (117 V, 60 Hz typical)
- **Weight**
  7 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PB503	*Protoboard Design Station*	299.99	284.99	256.49

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The Panavise PV505 1/4 ton manual IDC bench assembly press is a rugged, practical installation tool designed for low volume, mass termination of various IDC connectors on flat ribbon cable.

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- Additional accessories below
- Size - 10" W x 8.75" D x 9" H
- Weight - 5.5 lbs.

STOCK #	DESCRIPTION	1-9	10-24	25+
PV505	*Panavise Bench Assembly Press*	149.99	142.49	128.24

COLLIMATING PEN

A low power collimator pen containing a MOVPE grown gain GaAlAs laser. This collimator pen delivers a maximum CW output power of 2.5 mW at 820 nm.

The operating voltage of 2.2-2.5v @ 90-150mA is designed for lower power applications such as data retrieval, telemetry, alignment, etc

The non-hermetic stainless steel case is specifically designed for easy alignment in an optical read or write system, and consists of a lens and a laser diode. The lens system collimates the diverging laser light .18 mrad. The wavefront quality is diffraction limited

The housing is circular and precision manufactured measuring 11.0 mm in diameter and 27.0 mm long. Data sheet included.

As with all special buy items, quantity is limited to stock on hand

STOCK #	DESCRIPTION	1-9	10-24	25+
SB1052	*Infra-Red Collimator Pen*	49.99	47 49	42.74

LASER DIODE MODULE

The LDM 135 integrated assembly consisting of a laser diode, collimating optics and drive electronics within a single compact housing. Produces a bright red dot at 660-685 nm. It is supplied complete with leads for connection to a DC power supply from 3 to 5.25 V

Though pre-set to produce a parallel beam, the focal length can readily be adjusted to focus the beam to a spot.

Sturdy, small and self-contained, the LDM135 is a precision device designed for a wide range of applications. 0.64" diam. x 2" long.

STOCK #	DESCRIPTION	1-9	10-24	25+
LDM135-.5	*.5 mW Laser Diode Module*	179 99	170.99	153.89
LDM135-1	*1 mW Laser Diode Module*	189.99	180 49	162.44
LDM135-2	*2 mW Laser Diode Module*	199.99	189.99	170.99
LDM135-3	*3 mW Laser Diode Module*	209.99	199 49	179.54

COLLIMATING LENS

This economical collimating lens assembly consists of a black anodized aluminum barrel that acts as a heat sink, and a glass lens with a focal point of 7.5 mm. Designed to fit standard 9mm laser diodes, this assembly will fit all the above laser diodes. Simply place diode in the lens assembly, adjust beam to desired focus, then set with adhesive.

STOCK #	DESCRIPTION	1-9	10-24	25+
LSLENS	*Collimating Lens Assembly*	24.99	23.74	21.37

DUAL MODE LASER POINTER

New slimline laser pointer is only ½" in diameter x 6¼" long and weighs under 2 oz., 670 nm @ less than 1 mW produces a 6 mm beam. 2 switches, one for continuous mode, and one for pulse mode (red dot flashes rapidly). 2 AAA batteries provide 8+ hours of use. 1 year warranty.

STOCK #	DESCRIPTION	1-9	10-24	25+
LP35	*Dual Mode Laser Pointer*	199.99	189 99	170 99

He-Ne TUBES

New, tested 632nm He-Ne laser tubes ranging from .5mW to 3mW (our choice). Perfect for hobbyists for home projects. Because of the variety we purchase we cannot guarantee specific outputs will be available at time of order. All units are new, tested, and guaranteed to function at manufacturers specifications.

STOCK #	DESCRIPTION	1-9	10-24	25+
LT1001	*He-He Laser Tube*	69.99	66.49	59.84

POWER SUPPLY

- Input: 115/230V
- Output: +5v @ 3.75A
  +12v @ 1.5A
  -12v @ .4A
- Size: 7" L x 5¼" W x 2½" H

STOCK #	PRICE
PS1003	$19.99

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STOCK #	PRICE
YO1	$43.99

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STOCK #	PRICE
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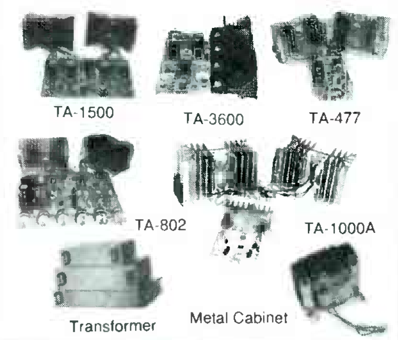

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TA-28MK2	Digital Voice Memo ▲▲	30 00	
TA-50A/B	Multi-Purpose Melody Generator ▲	12 84	17 20
TA-50C	Multi-Purpose Melody Generator (Melody such as Happy Birthday Wedding March etc) ▲	13.65	18 71
TA-120MK2	35W Class 'A' Main Power Mono Amp ▲▲	31 50	42 80
TA-300	30W Multi-Purpose Single Channel Amp ▲	20 00	29 00
SM 302	60W +60W Stereo Power Amplifier (with Mic input case & transfomer included) ▲▲★	73 00	85 00
TA-323A	30W + 30W Stereo Pre-main Amp ▲	31 50	42 80
TA-377A	State of the Art Fully Complementary Systemmetrical Fet Pre-Amp ▲▲▲	59 95	75 00
TA-400	40W Solid State Mono Amp ▲	28 00	34 93
TA 477	120W Mosfet Power Mono Amp ▲▲	68 00	85.00
SM-720	120W +120W AC/DC Stereo HI-FI & Pre-Main Amp (case & transfomer included) ▲▲★	75 00	89.00
TA 800MK2	120W + 120W Low Tim Pre-Main Stereo Power Amp ▲▲	63 92	73 95
TA-802	80W + 80W Pure DC Stereo Main Power Amp ▲▲	45 94	59 72
TA-1000A	100W Dynamic Class 'A' Main Power Mono Amp ▲▲	50 00	65 00
TA-1500	100W +100W New Class 'A' DC Stereo Pre Main Amp ▲▲▲	73 70	95 81
TA 2200	DC Fet Super Class 'A' Pre-Amp ▲▲▲	47 70	58 24
TA-2500	HQ Pre-Amp w/10 band graphic equalizer ★		78 00
TA-2800	BI-FET IC Pre Amp w/3 way tone control ▲▲	48 90	63 57
TA-3000	Stereo Simulator (For Mono TV or Any Mono Source) ▲▲	27 00	38.50
TA 3600	300W HQ Hi-Fi Power Mono Amp ▲▲▲	85 00	110 00
SM-222	7 Band Stereo HI-FI Graphic Equalizer ▲▲▲	26 80	38 80
SM 328	4 Channel Professional Color Light Controller ★		165.00
SM 333	Audio/Video Surround Sound Processor (case & transformer included) ▲▲▲★	73 00	85 00
SM-666	Dynamic Noise Reduction ▲	26.00	34 00
SM-888	Universal Audio/Video KARAOKE Mixer Pre-Amp ★		155 00
MISCELLANEOUS		**KIT**	**ASSEMB.**
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TY-7	Electronic Touch Switch ▲	8 20	10 20
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TY-11A	Multi-Functional Control Switch ▲	6 19	8 79
TY-12A	Digital Clock w/Timer ▲	17 95	26.00
TY-13	Color Led Audio Level Meter ▲	20 15	26 20
TY-14	Electronic Shock ▲	8 25	
TY-18	High precision Sound Control Switch ▲	10 22	14.50
TY-20	V Shape color Led Level Meter ▲▲	21 45	25.00
TY-23B	3 Channel Color Light Controller ★		73 00
TY-25	Stereo Loudspeaker Protector ▲	14.85	20 85
TY 35	FM Wireless Microphone ▲	11 25	
TY-36	AC/DC Quartz digital Clock ▲	19 00	26 20
TY-38	Sound/Touch Control Switch ▲	12 00	15 50
TY-41MK5	Infrared Remote Control Unit(case,transmitter & receiver included) ▲▲▲	25 00	38 00
TY-42	Bar/Dot Level Meter ▲▲	24 15	33 81
TY-43	3½ Digital Panel Meter ▲	29 00	38 00
TY 45	20 Steps Bar/Dot Audio Level Display ▲▲	38 45	46 14
TY 47	Superior Electronic Roulette ▲▲	19 46	27 24
#016	10 000u/f 80V Capacitor (Suggeted for TA 3600 TA-477 TA-1000A& TA-802)		23 00
#017	8 200u/f 50V Capacitor (Suggeted for TA-802 TA 120MK2)		13 00
#021	NOBEL (Single)Variable Resistor (Suggested for TA-3600, TA-477, TA-1000A & TA-120MK2)		12 00
#022	ALPS (Dual)Variable Resistor (Suggested for TA-377A TA-2200 & TA 802)		22 00
REGULATORS		**KIT**	**ASSEMB.**
TR-355A	0-15V 5A Regulated DC Power Supply (case transformer not included) ▲	15.65	21.76
TR-355B	0-30V 3A Regulated DC Power Supply (case transformer not included) ▲	15 65	21.76
TR-503	0-50V 3A Regulated DC Power Supply w/Short Circuit & Overload Protection (case transformer not included) ▲▲	16 75	23.65
DIGITAL METERS AND COUNTERS		**KIT**	**ASSEMB.**
SM 43	3½ Multi-Functional Led D P M (w/ABS plastic case) ▲▲	34 50	43 00
SM-48	4½ Hi-Precision D P M ▲▲▲	38 00	48 00
SM 48A	4½ Hi-Precision D P M (w/ABS plastic case) ▲▲▲	41 20	52 00
SM-49	3½ Multi-Functional LCD D M P (w/Hold Function) ▲▲	36 00	44 50
SM-100	150 MC Digital Frequency Counter ▲▲▲	79 00	90 00

METAL CABINETS WITH ALUMINUM PANEL

MODEL	H" X W" X D	MATCHING	PRICE
LG-1273	3" 12" 7"	TA-2800, TA-377A, TA-2200	23 85
LG 1684	4" 16" 8"	TA-323A TA-377A, TA-2200	28 50
LG 1924	4" 19" 11½	TA-802 TA-1500, TA120MK 2, TA-800 MK2 TA-1000A	34 50
LG-1925	5" 19" 11½	TA-477 TA-800MK2 TA-1500 TA-1000A TA-3600	38 00
LG-1983	2¾" 19" 8"	TA-377A TA-2800 TA-2200 TA-120MK2	30 50

POWER TRANSFORMERS

MODEL	DESCRIPTION	MATCHING	PRICE
#001	28V x 2 6A to 30V x 2 6A	TA 800MK2 TA-802, TA-1000A TA-1500	28 00
#002	36V x 2 3A	TR-503 TA-323A, TA-400, TA-300 TA-377A	23 00
#003	40V x 2 6A	TA-477	30 00
#004	24V x 2 6A	TA-120MK2	23.00
#005	26V x 2 3A	TR-355B	17 00
#006	18V x 2 5A	TR-355A	17 00
#007	53V x 2 8A	TA-3600	45 00

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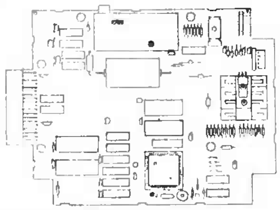
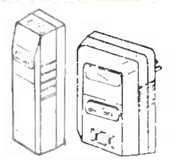
PC BOARD WITH RF MODULATOR (and lots of other parts)

We recently received a load of these PC boards which contain, among other things, a RF modulator. With a little desoldering you should be able to liberate a working unit from the board. Also contains a 7805T voltage regulator with a couple of heatsinks, 20 ICs, capacitors, resistors, diodes and connectors. No hook-up information available on the modulator. CAT# VMB-1

$2.75 each



INFRARED Remote A.C. SWITCH



This infrared remote control device lets you turn on/off lamps, appliances or other 120 Vac devices using an IR transmitter similar to the one on your TV or VCR. Originally designed for use with a hydromassage unit, these transmitters and receivers will apparently operate most A.C. devices with 2 prong non-polarized plugs. Not recommended for use with heaters. Requires a 9 volt battery (not included).

CAT# RC-1

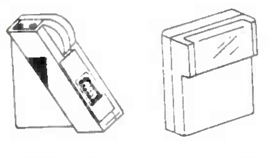
$9.95 each

2 for $17.00

A.C. Line Cord

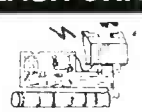
6' Black A.C. power cords. SPT-1 insulation. Polarized plug. Hanked.
CAT# LCAC-7 2 for $1.00 • 100 for $45.00 • 1000 for $400.00

Wireless Remote Control FOR NINTENDO™



CAMERICA "Freedom Connection" ™ Turns your wired Nintendo™ control paddle into a remote control unit. Infrared remote like those used on TV's and VCR's eliminates messy wires. Allows players more mobility. Two players can use one remote unit except on games where they play simultaneously. In those games two "Freedom Connections" units are required. A well-known national discount toy chain sells these for more than twice our price. Operates on 4 AAA batteries (not included). CAT# IR-1 $9.95

FLASH UNITS



NEW compact flash assemblies from a camera manufacturer. Operates on 3 Vdc. Measures 2 1/2" X 1 1/4". Ideal for use as a strobe, warning light or attention getter. Includes a hook-up diagram.
CAT# FSH-1 $3.75 each
10 for $35.00 • 100 for $325.00

L.E.D.'s

Surface mount LED chip.

Clear when off, green when lit. Very tiny - whole unit is 0.115" X 0.055" X 0.05" thick. 1mm (0.04") lens diameter. Gold-plated mounting surfaces for superior conductivity.
CAT# SMLED-2 10 for $2.00
100 for $18.00
1000 for $140.00

Standard JUMBO

Diffused T 1-3/4 size (5 mm)

RED CAT# LED-1
10 for $1.50 • 100 for $13.00
GREEN CAT# LED-2
10 for $2.00 • 100 for $17.00
YELLOW CAT# LED-3
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FLASHING LED

W/ built in flashing circuit
5 volt operation. T 1-3/4 (5mm)

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YELLOW 75¢ each
CAT# LED-4Y 10 for $7.00

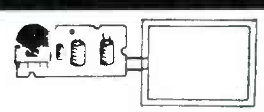
LED HOLDER

Two piece holder.
CAT# HLED
10 for 65¢

D.C. Wall Transformers (120 Vac INPUT)

Volts	Amps	Plug Style	Center	Cat#	Price
4 Vdc	70 ma.	2.5mm co-ax	negative	DCTX-470	$2.00
6 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-632	$2.75
8.3 Vdc	10 ma.	battery snap		DCTX-8310	$1.50
9 Vdc	300 ma.	2.1 mm co-ax	positive	DCTX-932	$3.00
9 Vdc	1 Amp	2.1 mm co-ax	negative	DCTX-910	$5.00
12 Vdc	100 ma.	2.1mm co-ax	negative	DCTX-1210	$2.50
12 Vdc	500 ma	2.1mm co-ax	negative	DCTX-125	$4.50
12 Vdc	1 Amp	none		DCTX-121	$6.50
14 Vdc	700 ma.	1.3mm co-ax	negative	DCTX-1470	$5.25
15 Vdc	400 ma.	2.5mm co-ax	negative	DCTX-1540	$4.50

ELECTROLUMINESCENT BACKLIGHTS



At last! A low cost electroluminescent glow strip and inverter. These brand-new units were designed to backlight small LCD TVs made by the Citizen Watch company. The inverter circuit changes 3 or 6 Vdc to approximately 100 Vac, the voltage required to light the glowstrip. Luminescent surface area is 1.7" X 2.25". The strip is a salmon color in its off state, and glows white when energized. The circuit board is 2.2" X 1". Glow strip and circuitry can be removed easily from plastic housing. Ideal for special lighting effects.
Citizen# 91TA operates on 3 Vdc
CAT# BLU-91
Citizen# 92TA operates on 3-6 Vdc
CAT# BLU-92
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GI Clare # PRMA-1A05B.
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500 ohm coil. U.L. listed.
Diode protected.
CAT# DRLY-57 $1.50 each

12 Vdc - S.P.S.T.

Gordos# 846A-412
575 ohm coil. Sealed.
Internal clamping diode.
CAT# DRLY-12 $1.25 each

24 Vdc - S.P.D.T.

GI Clare # PRMA 1C24
2,150 ohm coil.
10 vA switching power.
CAT# DRLY-1C24 $1.00 ea.

48Vdc - S.P.D.T.

Aromat # DS1E-A-DC48V
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2 amp contacts.
CAT# RLY-788 $1.00 each

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Sprague # UGN3075LT
Operates on 4.5 - 24 Volts
Can sink 10 ma. With suitable output pull up, can be used directly with bi-polar or CMOS logic circuits. Especially suited for electronic commutation in brushless D.C. motors using multiple ring magnets. Very tiny surface mount package 0.175" X 0.09"X 0.06" thick.
CAT # HESW-5 2 for $1.00
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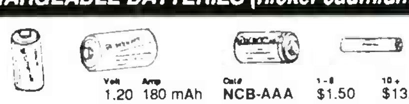
LARGE QUANTITIES AVAILABLE

RECHARGEABLE BATTERIES (nickel-cadmium)



Size	Volt	Amp	Cat#	1-9	10+
AAA	1.20	180 mAh	NCB-AAA	$1.50	$13.50
AA	1.20	500 mAh	NCB-AA	$2.00	$18.50
AA w/ Solder Tabs	1.20	500 mAh	NCB-SAA	$2.20	$20.00
Sub C w/ Solder Tabs	1.20	1200 mAh	NCB-SC	$4.25	$40.00
C	1.20	1200 mAh	NCB-C	$4.25	$40.00
C Heavy Duty	1.25	1800 mAh	HDNCB-C	$5.25	$42.50
D	1.20	1200 mAh	NCB-D	$4.50	$42.50
D Heavy Duty	1.25	4000 mAh	HDNCB-D	$7.00	$65.00

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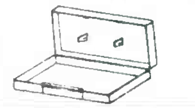

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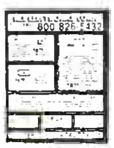

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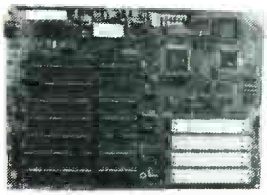
Jameco 80386SX Motherboard



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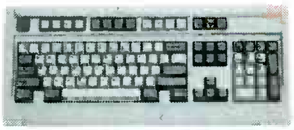

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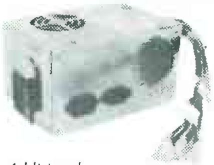
- Built-in fan
- Size: 6.5"L x 5.88"W x 6"H
- One-year Warranty



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Part No.	1-9	10+
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74LS02	.25	.15
74LS04	.25	.15
74LS08	.29	.19
74LS14	.39	.29
74LS30	.25	.15
74LS32	.25	.15
74LS74	.29	.19
74LS76	.39	.29
74LS86	.25	.15
74LS112	.35	.25
74LS123	.39	.29
74LS138	.39	.29
74LS175	.39	.29
74LS193	.59	.49
74LS244	.69	.59
74LS245	.69	.59
74LS373	.69	.59
74LS374	.69	.59

Linear ICs*

Part No.	1-9	10+
TL082CP	$.59	$.49
LM317T	.65	.55
LM324N	.35	.29
LM336Z	1.05	.95
LM339N	.39	.35
NE555V	.29	.25
LM556N	.49	.39
LM723CN	.49	.39
LM741CN	.29	.25
LM1458N	.35	.29
LM1488N	.45	.39
LM1489N	.45	.39
ULN2003A	.69	.59
LM3914N	1.95	1.75
NE5532	1.19	1.09
7805T	.45	.41
7812T	.45	.41

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Part No.	Function	Price
41256-120	256K DIP	120ns......$1.69
41256-150	256K DIP	150ns........1.59
511000P-80	1MB DIP	80n...........5.99
511000P-10	1MB DIP	100ns........5.49
41256A9B-80	256K SIMM	80ns........16.95
421000A9A-80	1MB SIPP	80ns........54.95
421000A9B-60	1MB SIMM	60ns........64.95
421000A9B-70	1MB SIMM	70ns.......59.95
421000A9B-80	1MB SIMM	80ns......54.95

Miscellaneous Components*

Potentiometers

Values available (insert ohms into space marked "XX"):
500Ω, 1K, 5K, 10K, 20K, 50K, 100K, 1MEG

43PXX	3/4 Watt,15 Turn	$.99
63PXX	1/2 Watt, 1 Turn	.89

Transistors And Diodes

PN2222	$.12	1N751	$.15
PN2907	.12	C106B1	.65
1N4004	.10	2N4401	.15
2N2222A	.25	1N4148	.07
1N4735	.25	2N3055	.69
2N3904	.12	1N270	.25

Switches

JMT123	SPDT, On-On (Toggle)	$1.15
206-8	SPST, 16-pin (DIP)	1.09
MPC121	SPDT, On-Off-On (Toggle)	1.19
MS102	SPST, Momentary (Push-Button)	.39

**Additional components available*

Connectors

Part No.	Description	Price
DB25P	Male, 25-pin	$.65
DB25S	Female, 25-pin	.75
DB25H	Hood	.39
DB25MH	Metal Hood	1.35

LEDs

XC209R	T1, (Red)	$.14
XC556G	T1 3/4, (Green)	.16
XC556R	T1 3/4, (Red)	.12
XC556Y	T1 3/4, (Yellow)	.16

IC Sockets

Low Profile		Wire Wrap(Gold) Level #2	
8LP	$.10	8WW	$.49
14LP	.11	14WW	.69
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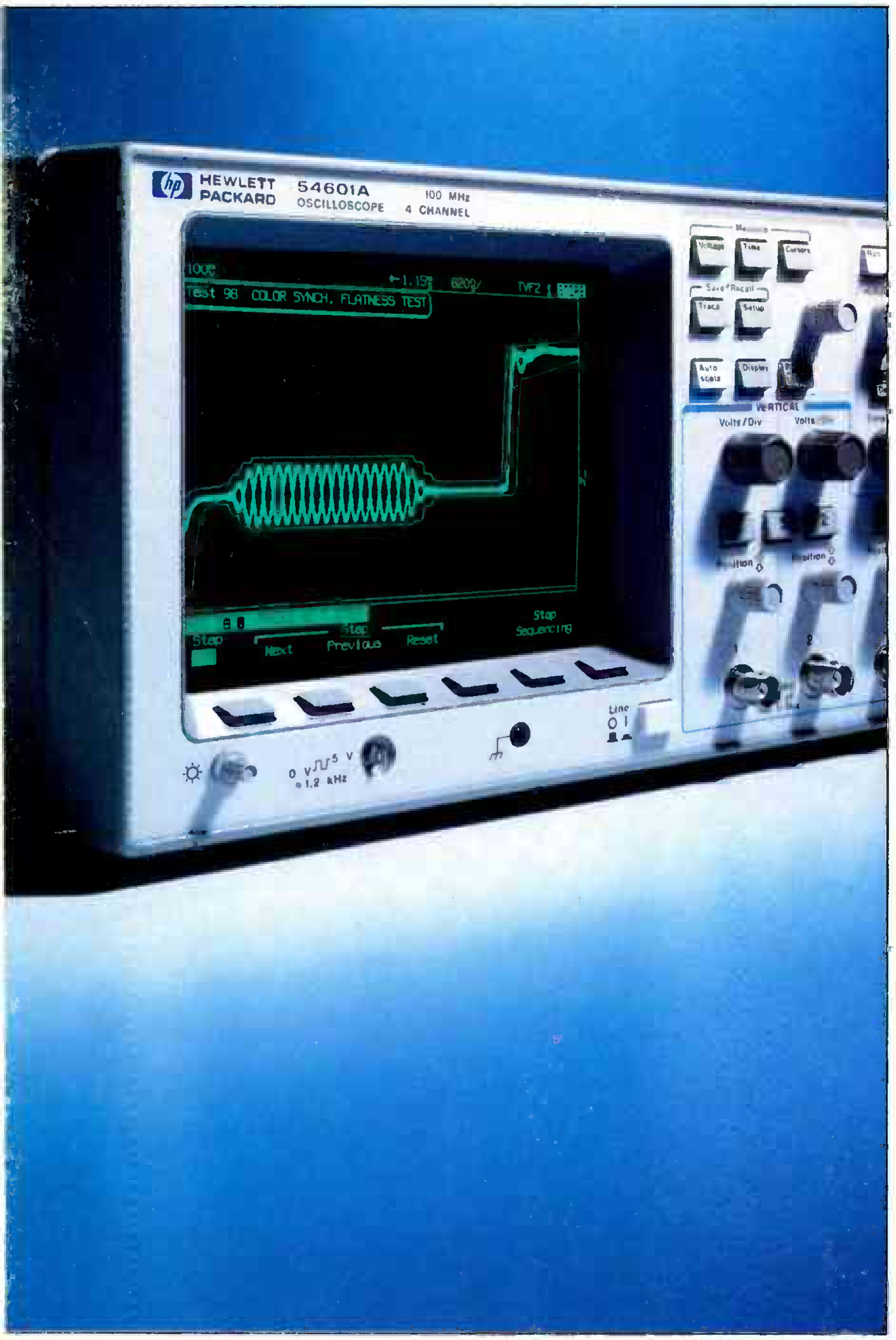

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