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Continuity Beeper	Yes		
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Volts/Division	1 mV/div to 100V/div		5 mV/div to 100V/div
Digital Delay or Pre-Trigger	By Number of Cycles, Events, Time, or Zoom Mode		By Time
Special Multimeter Modes	Min Max Average Record, Relative (zero), dBm, dBV, dBW, Audio Watts, % Scale, Frequency, Smoothing,™ Change Alert™		Frequency, Smoothing™ Change Alert™
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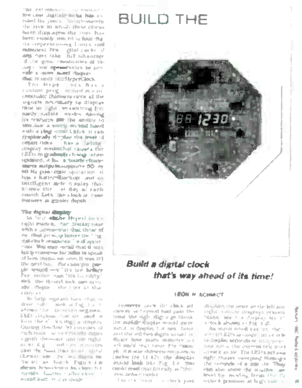

BUILD THE

Build a digital clock that's way ahead of its time!

PAGE 33

SCANNER CONVERTER

Upgrade your scanner to receive signals in the 800–900 or 900–1000 MHz bands!

PAGE 42

DEPARTMENTS

AND MORE

ON THE COVER

The 800-1000 MHz band of UHF frequencies contains many signals of interst to the shortwave and scanner enthusiast. However, many scanner can't receive those frequencies. Our scanner converter receives signals from 800-1000 MHz, and outputs them at 400-500 MHz. That allows you to monitor frequencies in the 800-1000 MHz range using your 400-500 MHz scanner. You can also use it to measure frequencies as high as 1000 MHz with a 500-MHz counter. To find out more about our converter, turn to page 42.

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WHAT'S NEWS

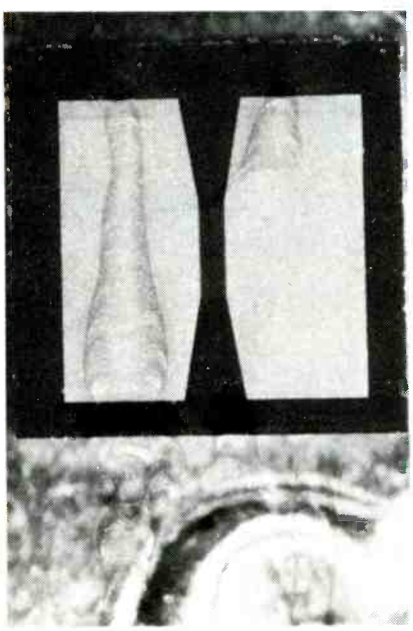
A review of the latest happenings in electronics.

Device for multiple automobile air bags

Researchers at Sandia National Laboratories (Albuquerque, NM) have invented a low-energy explosive igniter that could make it easier for automobile manufacturers to install multiple air bags in their vehicles. The device, called a semiconductor bridge or SCB, requires much less energy than the hot-wire igniters that are traditionally used in air-bag systems.

During the rapid deceleration caused by a crash, air bags are electrically ignited by a hot-wire device in an explosive cartridge. As the device heats, the sensitive explosive material burns. A hot gas is produced that enters the stowed air bag and ignites a gas-generating propellant, which then releases a burst of nitrogen gas that quickly inflates the bag. That entire process takes place in just thousandths of a second.

When designing air-bag systems, a worst-case scenario of an almost depleted battery is used. In such a case, one hot-wire igniter would consume nearly all of the battery's remaining voltage output—which means trouble for systems incorporating several air bags and explosively activated seat belts.



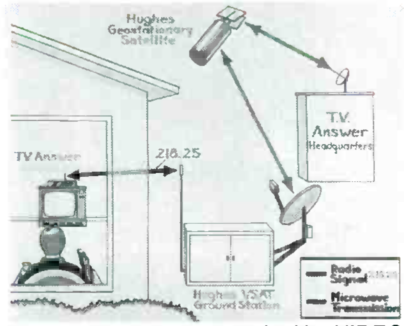
SANDIA'S SEMICONDUCTOR BRIDGE, which could be used in multiple air-bag systems, is shown resting on a penny. The penny's "C" letter give an Indication of the device's size.

The semiconductor bridge is about one one-hundredth the volume of a conventional hot wire, and can be heated much faster and with much less energy. Because SCB's are processed on a silicon wafer, the chip can incorporate extra circuitry for logic, timing, and safety.

Multimillion dollar interactive TV/satellite contract

The introduction of nationwide interactive television is a step closer with the signing of a multimillion contract between TV Answer, a pioneer in real-time wireless Interactive Video Data Service (IVDS) technology, and Hughes Network Systems, Inc. (HNS), manufacturer of interactive Very Small Aperture Terminals (VSAT's). Pending FCC approval, the TV Answer system would allow television viewer to use their TV's as communication devices to pay bills, order take-out food, shop for groceries, do banking transactions, and respond in real time to game shows, TV shopping shows, advertisements, polls, and interactive news and educational programs. In addition, it would serve as a universal remote control, and would provide on-screen TV schedules and VCR programming. The system would work with cable, satellite, and roof-top antenna systems and is expected to cost about $12.95 a month.

Similar in structure to a cellular phone network, the TV Answer network relies on individual cell sites to provide service to a market area consisting of a maximum of 10,000 households. Each cell site includes a VSAT two-way satellite dish earth-station that communicates with TV



TV ANSWER'S INTERACTIVE VIDEO DATA SERVICE would use Hughes Network Systems' satellite personal earth stations to provide direct transmission paths between remote cell sites and the hub station.

Answer Headquarters via a Hughes satellite, and a TV Answer radio receiver/transmitter that communicates with TV Answer home units. The data received via satellite is transformed at the cell site into a radio signal that is transmitted to each home unit. Viewer responses are relayed to the cell site and then back to headquarters in the same way. There the responses are processed and appropriate collection, billing, and ordering activities are performed.

The January 10, 1991 FCC Notice of Proposed Rulemaking proposed the allocation of ½-MHz of the radio spectrum—between 218.00 and 219.00 MHz, which is the frequency on which TV Answer's system operates—for an Interactive Video Data Service. The action is expected to be finalized, and technical standards and licensing procedures issued, by mid-1992.

Under the initial phase of the contract between HNS and TV Answer, HNS will build and install 1000 VSAT units for use in cell sites—enough to meet the projected first-year requirement. The initial phase includes a $2.1 million hub and network control system at TV Answer headquarters in Reston, VA. TV Answer estimates that a minimum of 10,000 VAST units will be needed to provide nationwide coverage for its technology. R-E

VIDEO NEWS

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

DAVID LACHENBRUCH

• Compact Disc-Interactive. Philips has launched its CD-I interactive audio-video multimedia system through 5000 stores, and first reports indicated that the players and discs were selling well. Philips changed its mind about brand name, and its first products were issued under the "Philips" instead of the "Magnavox" brand. The list price of the player was dropped to $1000 from $1400, but for all practical purposes, players are selling at about $800, and discs from $20 to $40. Using the theme, "the Imagination Machine," Philips plans major advertising campaigns for the system throughout 1992. This is the second multimedia CD system aimed at the general public via attachments to TV sets, the first being Commodore's CDTV (which stands for Commodore Dynamic Total Vision). Other manufacturers are competing with video and audio CD-ROM systems designed as computer peripherals.

• Zenith moves TV. The last major American-owned TV manufacturer will end color-TV manufacture in the United States sometime this year. Zenith Electronics announced that it will start phasing out final assembly of sets in its Springfield, MO plant when its union contract expires on March 22. The company, which has been losing money, explained that price erosion has continued in the TV industry and cost-cutting efforts haven't been sufficient, despite wage concessions by its union in Springfield.

Zenith will move final assembly of large-screen TV sets to its cabinet plant in Juarez, Mexico. Its 19- and 20-inch sets are already being assembled in Reynosa, Mexico. Some plastic molding and distribution operations will continue in Springfield. Zenith will continue to operate its large-picture-tube plant and headquarters in the Chicago. The only other American-owned TV assembler, Curtis Mathis Corporation, has a final assembly plant in Athens, TX. Although the remainder of TV manufacturers are foreign-owned, many of them continue to assemble their large-screen color TV's in the United States. The leaders are Thomson Consumer Electronics (French-owned), which assembles RCA and GE sets in Bloomington, IN, and Philips (Dutch), which produces Magnavox, Sylvania, and Philips sets in Greeneville, TN. Other final TV assembly is done in Huntsville, AL, by Goldstar (Korean); by Japanese manufacturers in Anaheim, CA; JVC in Elmwood Park, NJ; Mitsubishi in Santa Ana, CA and Braselton, GA; Orion in Princeton, IN; Sanyo in Forrest City, AR; Sharp in Memphis; Toshiba in Lebanon, TN; and Sony in San Diego and soon in New Stanton, PA.

• "Stereo" TV debate. As it promised more than a year ago (**Radio-Electronics**, March 1991), a company called dbx Technology Licensing has started a public-relations campaign to inform the public that if a television set doesn't conform with the FCC-backed stereo-TV system, it shouldn't be called "stereo TV." However, Thomson Consumer Electronics, manufacturer of RCA and GE brand sets, has challenged dbx, saying that some of its sets contain a new system called "XS" and qualify as stereo even though they don't use the dbx noise-reduction decoding technology that is officially part of the Multichannel TV System (MTS) stereo standard.

Although Thomson's higher-priced sets do use dbx decoding, Thomson says that the XS sound system, which uses phase shift to process the sound, qualifies as "stereo" even though little separation between left and right channels shows up in tests. dbx demonstrated test results that it says shows that some RCA and GE sets don't reconstruct the true sound transmitted by the TV stations. Thomson retorts that its XS system sounds better than dbx in lower-priced sets. In addition to Thomson, dbx Technology found that some Philips and some Sharp sets don't use dbx decoding in their stereo systems. Both of those companies, which use dbx in some of their sets, say they plan to add dbx across the board to all of their sets later this year. Since there is no official definition of "stereo," the dispute is expected to continue for some time. Stereo systems using various types of phase-shift techniques to enhance the "presence" effect include Q sound and SRS, the latter developed by Hughes Aircraft and being used tin some high-end sets by Sony and Thomson as an adjunct to MTS stereo. dbx says that's okay, some people may prefer processed sound, but officially MTS sound includes dbx encoding and decoding; therefore, saying that a set included "broadcast TV stereo" or "MTS stereo" is misleading.

• TV for computers. For years we've heard about the upcoming merger of TV and the computer. The CD-I system is one aspect of it—adding computer functions to the TV set. Moving in the opposite direction, IBM and others are adding TV functions to the computer. In March, IBM will offer a TV accessory for its PS/2 computers. That is an adaptor that permits the computer's keyboard to be used to select from among 70 TV channels as well as the other normal TV functions. Of course, other video devices may be input as well, including laserdisc players or VCR's. The TV picture may be viewed full-screen or inserted in a window—there's nothing like watching MTV while working on a spreadsheet! The IBM accessory will carry a list price of $495, which may be cheap for a computer add-on. But in TV-land, the same amount will be a 25-inch color TV set with a remote control. **R-E**

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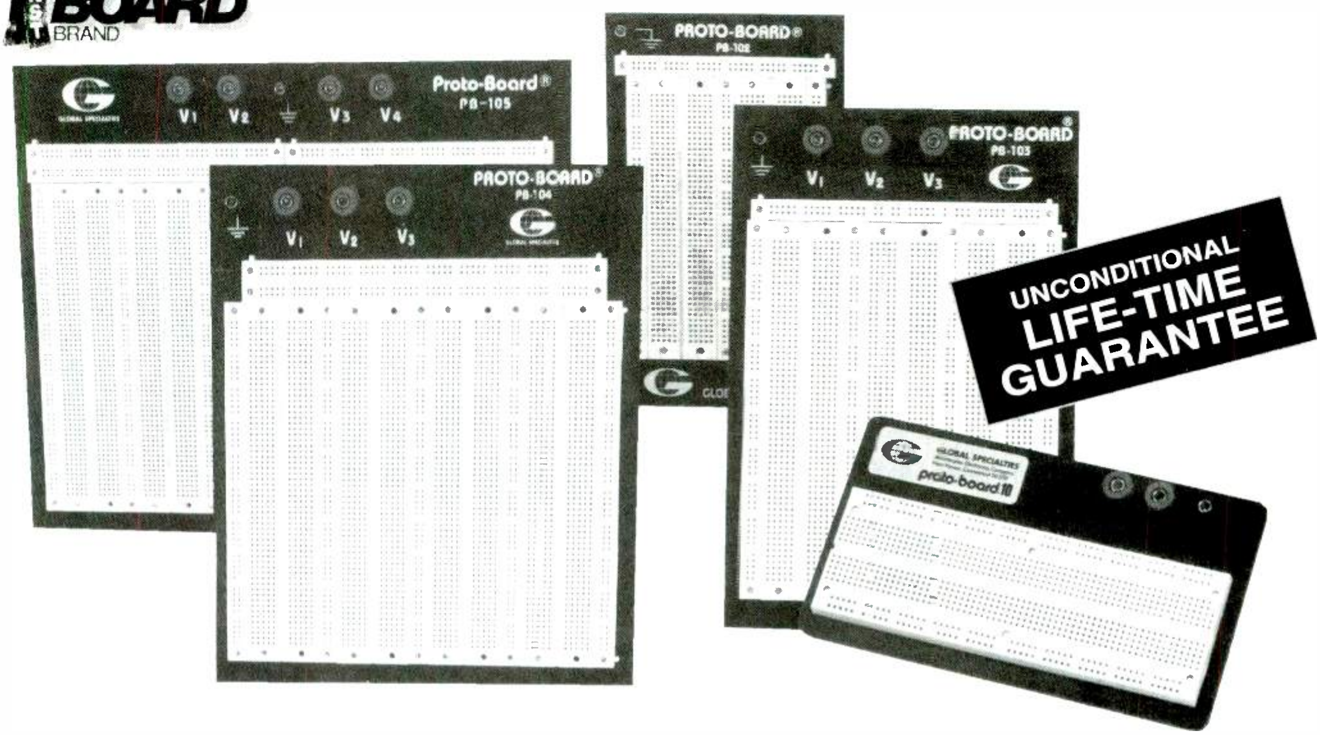

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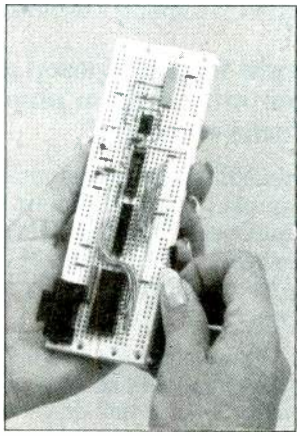

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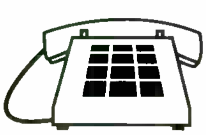

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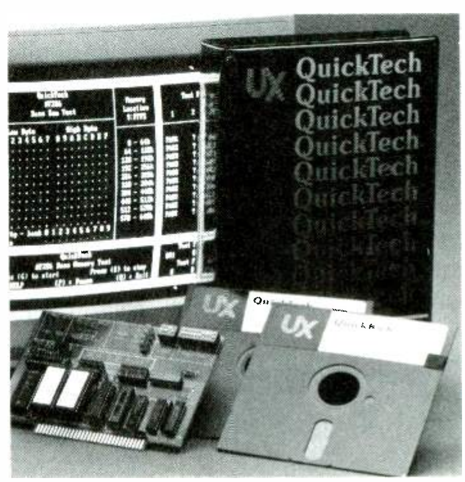

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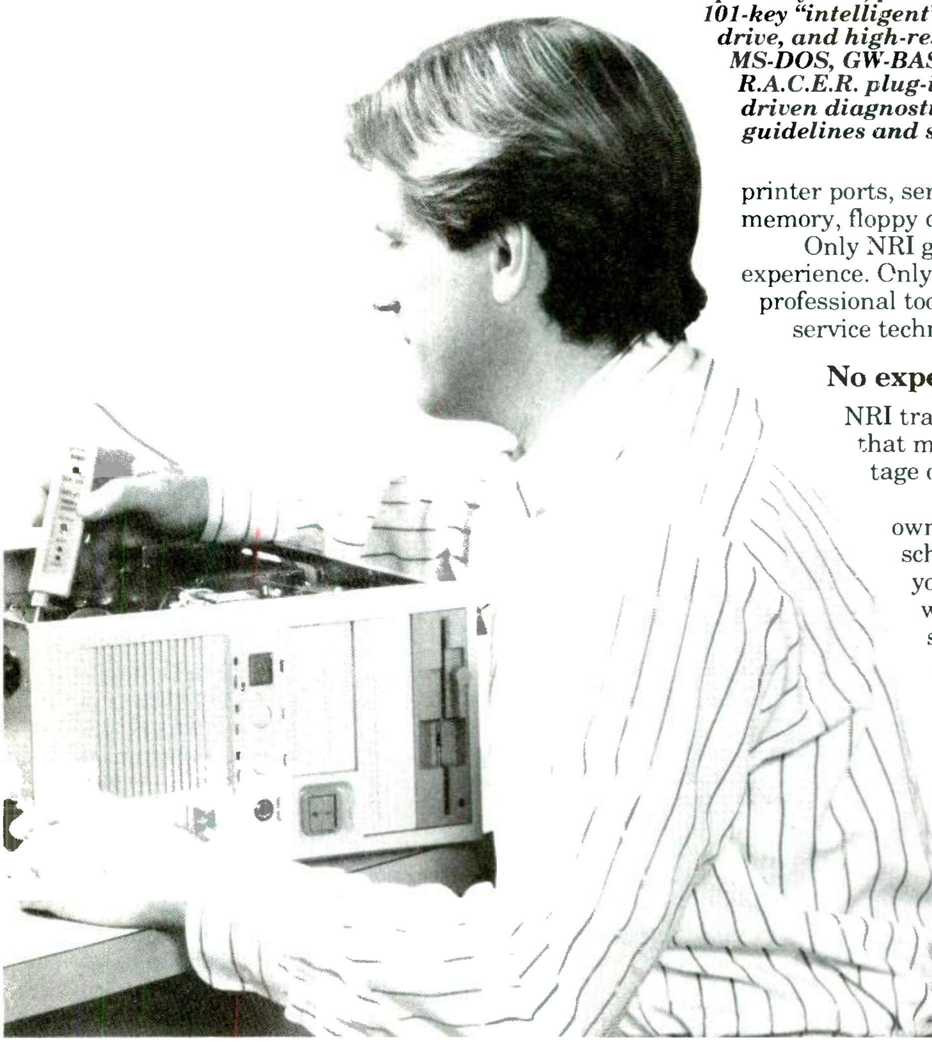

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MOTOR SPEED CONTROLLER

I have a electric model boat and I'd like to be able to control the speed of the motor. The circuit should be able to make the motor go from very slow to very fast without stalling. I've tried all sorts of things but haven't had any luck—particularly at low speed. The motor is powered by a 7.2-volt battery pack. Do you have any circuits that can help me?—A. Balsys, Howell, NJ

Electric boats aren't my thing but I would have imagined that they all had some way to vary the speed of the motors. Oh well, you live and learn.

Controlling the speed of a small DC motor is something I've talked about several times before but, judging from the number of times I get asked about it in letters and on the phone, it seems a lot of people are interested in the subject. There are several ways to get the job done and even some fairly inexpensive commercial products that will do it for you. In this case, particularly with such a low-voltage motor, there's an easy circuit you can build that will do the job and operate reliably for the life of the motor.

The circuit I'm referring to is shown in Fig. 1. Despite its apparent simplicity, the circuit will drive the motor over a range of speeds from dead slow to full ahead (that's boat talk, I think), without any stalling at even the lowest speeds. The reason it can do this is that the circuit works by controlling the duty cycle of the motor rather than, as in other controllers, the supply voltage.

Two of the inverters in the 4049 are set up as an oscillator whose frequency is roughly determined by:

$$F = 1/1.4RC$$

where R is the total value of the potentiometer. The two diodes isolate both the positive and negative halves of the output frequency and make the output waveform stick close to a 50-50 duty cycle all through its entire operating range.

The remaining inverters in the package are all ganged together in parallel to increase the output drive to the transistor. While you can use just about any inverter for the circuit, the 4049 is probably the best choice since it can handle more output current than other inverting gate chips. Just make sure you pay attention to the fact that the power pin on the 4049 is pin #1—a departure from the other IC's.

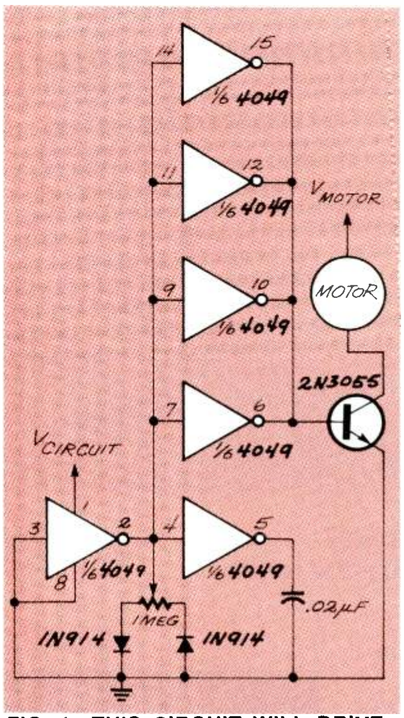


FIG. 1—THIS CIRCUIT WILL DRIVE a small DC motor over a wide range of speeds without stalling by controlling the duty cycle of the motor rather than the supply voltage.

Even though the schematic shows the supply voltage to the motor and the circuit on two separate lines, there's no reason why you can't use the 7.2-volt battery for both of them. The battery is supplying a perfect voltage for CMOS stuff like the 4049.

There's nothing critical about the layout of the circuit and you can build it using any technique you want. In actual fact, it's such a handy circuit you may want to generate a printed circuit board for it so you can easily use the circuit somewhere else.

WATCH THE SPEED LIMIT

I have an XT-compatible computer and, while it works perfectly, it's turning out to be much too slow for some of the newer software I want to use. Is it possible to speed up the computer by just changing the 14.1318-MHz crystal and are there limits as to how much of a speed increase this will give me?—F. Geeben, Hunter, IN

Before we get into this, I want to make sure you understand that any increase in speed you can get like this is going to be far outweighed by the amount of brain damage it takes to do it. The theory is great but the maximum speed of a motherboard, like an automotive engine, is a consequence of how it's designed. They both have red-line numbers.

At the most basic level, the parts on your motherboard were chosen to match the computer's original design specifications. The memory, I/O controller, interrupt controller, and DMA (Direct Memory Access) controller have maximum speed ratings and the ones in your computer were picked to match the speed of the board. The faster any chip's speed rating, the more expensive it is. I don't know who made your motherboard but it's a safe bet that the parts on it are only as fast as they have to be.

Changing the crystal changes the board's master clock and the more you step on the electronic accelerator, the closer you're going to get to the point where these chips first get flaky and finally fail completely. The point where that happens is determined by the speed rating stamped on the chips and the details of the design of your motherboard.

Memory chips have a maximum speed rating as well and it's usually stamped on the top of the IC right after the chip number. A suffix of 20 means 200 nanoseconds, 15 means 150 nanoseconds, and so on. If the only crystal on your motherboard is a 14.31818-MHz one, it's more than likely that your computer is running, like the original IBM PC, at a speed of 4.77 MHz. This means that your motherboard can operate with memory as slow as 200 nanoseconds. If that's what you have in your machine, you don't have much of a chance of upping the system speed and still maintain much in the way of reliability.

It's possible you can overcome these problems if the design of your motherboard incorporates enough wait states to do things like memory refresh and other housekeeping chores at an increased speed. But there's still another problem that has to be considered.

There are two clock frequencies at the expansion slots and most of the cards you plug into the motherboard are designed to expect the two clocks to be in a particular frequency range. Pin #B20 is known as the CLK and on your motherboard it's probably a buffered version of the 8088's clock frequency—4.77 MHz. That frequency can be higher, and you'll frequently find that it's as high up as 8 MHz.

The second frequency is the one that can cause you a problem. In the original PC (of which yours is a clone), pin #B30 was a buffered version of the crystal frequency—14.31818 MHz. That has remained a standard, even up to this day. Measure the frequency at that pin on the latest 33-MHz 486 motherboard and you'll find 14.31818 MHz. When you change the crystal on the board, you'll also be changing both frequencies at the expansion slots which can cause a problem with some cards that use the two clocks.

The biggest problem will come with floppy-disk controllers since they use those clocks for writing to the disk. Even if you somehow avoid the problem, it's a guaranteed fact that you'll have problems formatting disks.

Keeping all this stuff in mind, you can start experimenting with higher-frequency crystals to see how far you can go before you have major problems. My guess is that the most you'll be able to get is a 50% increase in speed. If you want to be able to format disks, you have to supply the computer with the original frequencies so don't get rid of the original crystal. Probably the easiest way to do that is to have both the crystals on the motherboard and use a switch to select one or the other.

We're talking about doing a good deal of work here and the possible rewards are really minimal. A 50% increase in speed may sound like a lot but you'll find that the practical effects are just not all that noticeable. A much better solution to the whole problem is to buy a new motherboard that's been designed from the ground up to run faster than the one you have now. **R-E**

LETTERS

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

VEHICLE GENERATORS AND REGULATORS

Radio-Electronics and its predecessor, *Radio-Craft*, have given me much pleasure for 50 years. Robert Grossblatt's articles have been favorites, but he fell off the track with his comment, "... (vehicle) generators and the regulators that control the current they produce are a really stupid charging system ..." (*Drawing Board*, **Radio-Electronics**, December 1991).

Low-cost, high-current silicon rectifiers that made the superior alternator available were not developed until after the transistor was invented in 1947. There happened to be a lot of high technology before that. Radio, TV, computers, and automobiles all pre-date the benefits brought by advanced solid-state devices. As I recall, submarines, Rolls Royce automobiles, and high-speed aircraft all used generators, and the electromechanical voltage regulators they required. I don't believe the word "stupid" characterizes that use.

I suspect the author was just trying to interject some lightness—which is all right with me—but his description of the operation of the older voltage regulator is incorrect.

The generator's field current was modulated by a voltage-sensing relay that inserted various values of resistance in the field circuit, not the output lead. The varying field current would then cause the output voltage to remain at the desired value. The relay was also designed to sense the ambient temperature and change the generator-charging voltage accordingly. The voltage regulator case usually contained a current-limiting relay to protect the generator from over-load, and a reverse-current relay to prevent the battery from discharging through the generator windings when the engine was not running.

These latter two functions were not needed in the alternator, but when they were first installed in new cars, there were no low-cost, high-current transistors developed that could operate at the high-temperatures in the engine compartment. So the same old electromechanical voltage regulator that had been used for 40 years was used again with the new alternator!

The rest of Mr. Grossblatt's article was well done and informative, as usual. I just didn't want to read your fine magazine for the next 50 years without contributing to its technical excellence!

GEORGE W. HAILS
Arlington Heights, IL

TESLA COIL IMPOSTORS

I have been tempted several times in the past to write to various magazines after the appearance of certain articles on the construction of Tesla coils. Don Lancaster's comments on the Tesla coil (*Hardware Hacker*, **Radio-Electronics**, October 1991) finally pushed me to fire up the word processor.

I agree that many "Tesla" coils are essentially nothing more than glorified step-up transformers. The Tesla coil, however, is *meant* to generate its high-frequency high voltage by taking advantage of the special properties of the resonant (quarter wavelength) transmission line (also known, somewhat esoterically, as the Ferranti effect). It can be shown that the voltage *amplitude* V, at the unloaded end of an ideal (i.e., lossless, uniform, etc.) quarter wavelength transmission line driven by a source of resonant voltage of *amplitude* V_S, and of impedance Z_S *at the resonant frequency* (assumed real for notational simplicity) is $V=(Z_O/Z_S)V_S$, where Z_0 is the characteristic impedance of the line. This is different in numerous ways from the standard voltage multiplication of a transformer, as it should be; these are quite distinct physical phenomena.

Although the physics of the transformer is pretty amazing, what is more impressive is that a wire (or, more properly, a transmission line) may itself act as a "transformer." A great experiment that shows this is the construction of a mock transmission line using discrete components to model (mock) the distributed parameters of a real transmission line.

In reality, a Tesla coil impostor is pretty easy to spot. It will suffer from a variety of maladies, some of which include improper magnetic coupling (making it a transformer instead of a propagating transmission line) and a marked insensitivity to resonant frequency tuning. Generally, even the most heinously constructed "Tesla coils" will generate hefty attention-grabbing sparks, but they are often missing the "magic and mystery" of the physics of the resonant line that makes it a true Tesla coil.

MATTHEW KLEJWA
Schaumburg, IL

HERE'S TO HOW-TO ARTICLES

I'm writing in response to Alex Funk's letter (**Radio-Electronics**, April 1991) titled "Mac-Hack Attack." It might be true that if you add up all the components required for a home-built computer system, the final price tag will come close to a dealer-bought system. However, there are quite a few people in this world who cannot afford to shell out over $1000 at one time, but who can afford to do it piece by piece. It's a lot easier to spend $25 or $50 at a time than it is to spend $1000.

And how can you put a price on your time when you are learning how to build something as useful as a computer system? How much is your time worth when you sit and watch television?

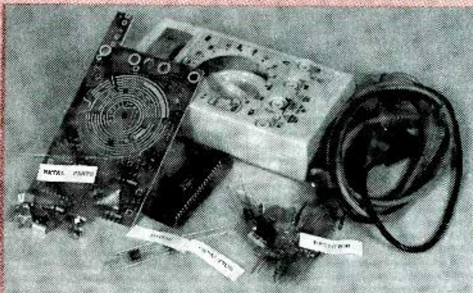
Please keep publishing those how-to articles!

JOHN CULLIVAN
Niles, OH

EQUIPMENT REPORTS

The Kelvin 100K Digital Multimeter

Most multimeters are ready to use right out of the box— but not the Kelvin 100K.



CIRCLE 10 ON FREE INFORMATION CARD

If we were to tell you that this review is about an inexpensive multimeter, you'd probably be inclined to turn to the next page. After all, multimeters are as common today as silicon chips, and the features found on inexpensive ones have been around for years. So what can we tell you about the *Kelvin 100K* digital multimeter that you couldn't already guess? The answer is that it's available as a kit.

The *Kelvin 100K* (Kelvin Electronics, 7 Fairchild Ave., Plainview, NY 11803) comes with a PC board and all parts that mount on it, a case with a backstand (that's always handy), a pair of test leads, an owner's manual, an assembly manual, an extra fuse, and even a 9-volt battery, all for $29.95. The *100K*'s features include a 3½-digit LCD; DC ranges of 2, 20, 200, and 1000 volts; AC ranges of 200 and 500 volts; resistance ranges of 200 ohms, 2K, 20K, 200K, and 2 megohms; and DC current ranges of 2 mA, 20 mA, 200 mA, and 10 amps. There's no provision for measuring AC current.

The *100K* also hosts a diode test, a low-battery indicator, and a battery test—a handy feature for a general-purpose multimeter. In the "battery test" mode, the meter will display the voltage of any 1.5-volt battery under a 100-mA load or the voltage of any 9-volt battery under a 6-mA load.

It's likely that not too many experienced kit builders will be interested in building the *100K*, mainly because they almost certainly already own a multimeter. However, the *100K* kit is perfect for any beginner in electronics or a child who's old enough to attempt soldering—especially a kid who's always playing with his dad's multimeter!

The assembly manual is particularly well-suited for a classroom environment, as it reads like an electronics lab manual; parts are installed a small group at a time, alternating with precautionary circuit checks, explanations of how each section of the circuit works, troubleshooting tips, and various quizzes on what has been covered so far.

Experienced kit builders may actually find the assembly manual somewhat irritating, because the sections in which components are installed are scattered throughout a lot of other explanatory paperwork. Remember though, that the kit is aimed at beginners. But this is where the kit's one flaw emerges: the assembly manual contains more than just a few typographical errors. A seasoned kit builder should be able to overcome these problems but they may be very confusing to the beginner. Let's go over the assembly manual and point out any problems we encountered.

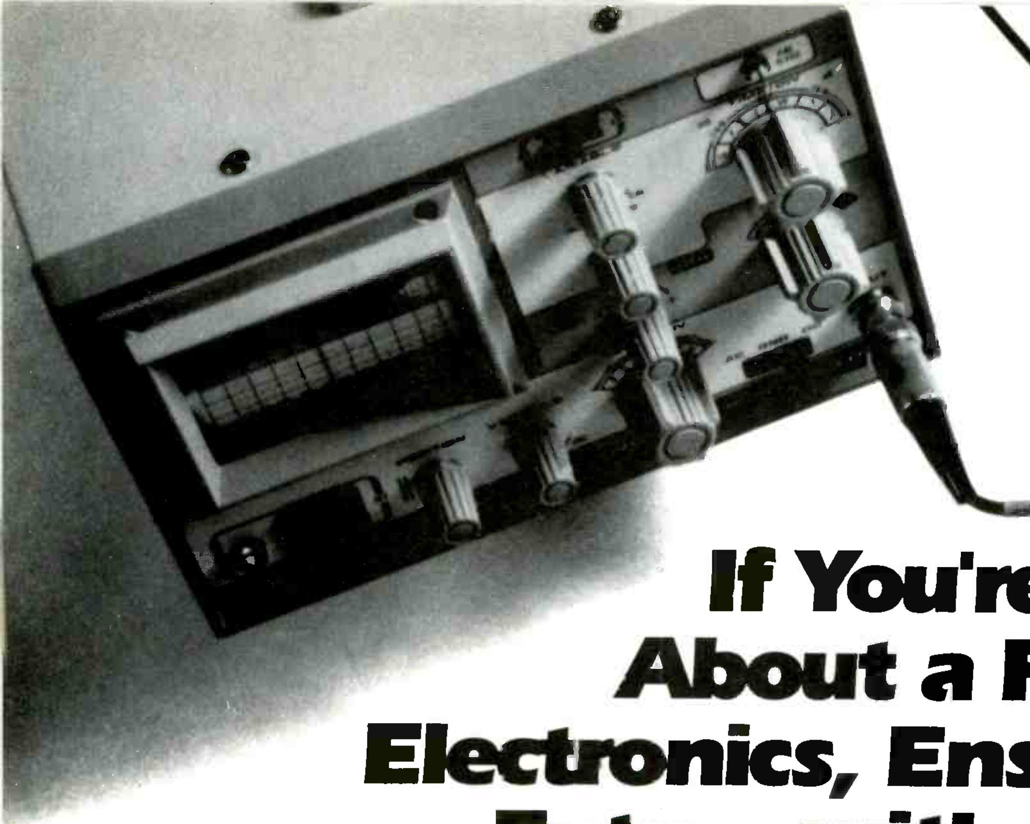
The manual starts out with an introduction to the meter and a table listing all of its specifications. A schematic of the meter's circuitry and a parts list follows. Diagrams of all of the parts are provided to help you quickly identify everything. A parts-placement diagram is next, although the PC board is silkscreened with all of the component designations as well. Also included are charts to help you identify resistor values by their color codes and capacitor values by their numbering. Pinout diagrams are provided, of the 3½-digit LCD, the 7106 A/D converter, and the quad XOR gate used in the meter. There's a brief discussion on proper soldering techniques and the proper handling of IC's. A list of all tools needed to build the meter is also given. Circuit theory is the last thing to be covered before the actual assembly of the board begins.

In the first assembly procedure, certain resistors and capacitors must be soldered to the PC board, and some might find this step confusing. You are instructed to install C14, 10 nF, and C16, 0.01 µF—but the two capacitors are actually the same value. And the fact that the parts list shows capacitors C14 and C16 to be "0.0 µF" only adds to the confusion.

Next you have to install the 40-pin 7106 IC so that the A/D circuitry can be tested out, which also requires the temporary installation of the battery clip, the LCD, and the rotary knob. The LCD and knob require a bit of sub-assembling before attaching them to the meter, and for some reason the sub-assembly instructions are found much farther on in the manual. The assembly diagram shows the back of the rotary knob as having six plastic tabs over which you are to snap on six metal contact clips—but the knob that came with our kit had seven tabs. After putting the clips on the six outermost tabs, the A/D section seemed to work just fine.

For the voltage-reference circuit,

continued on page 90



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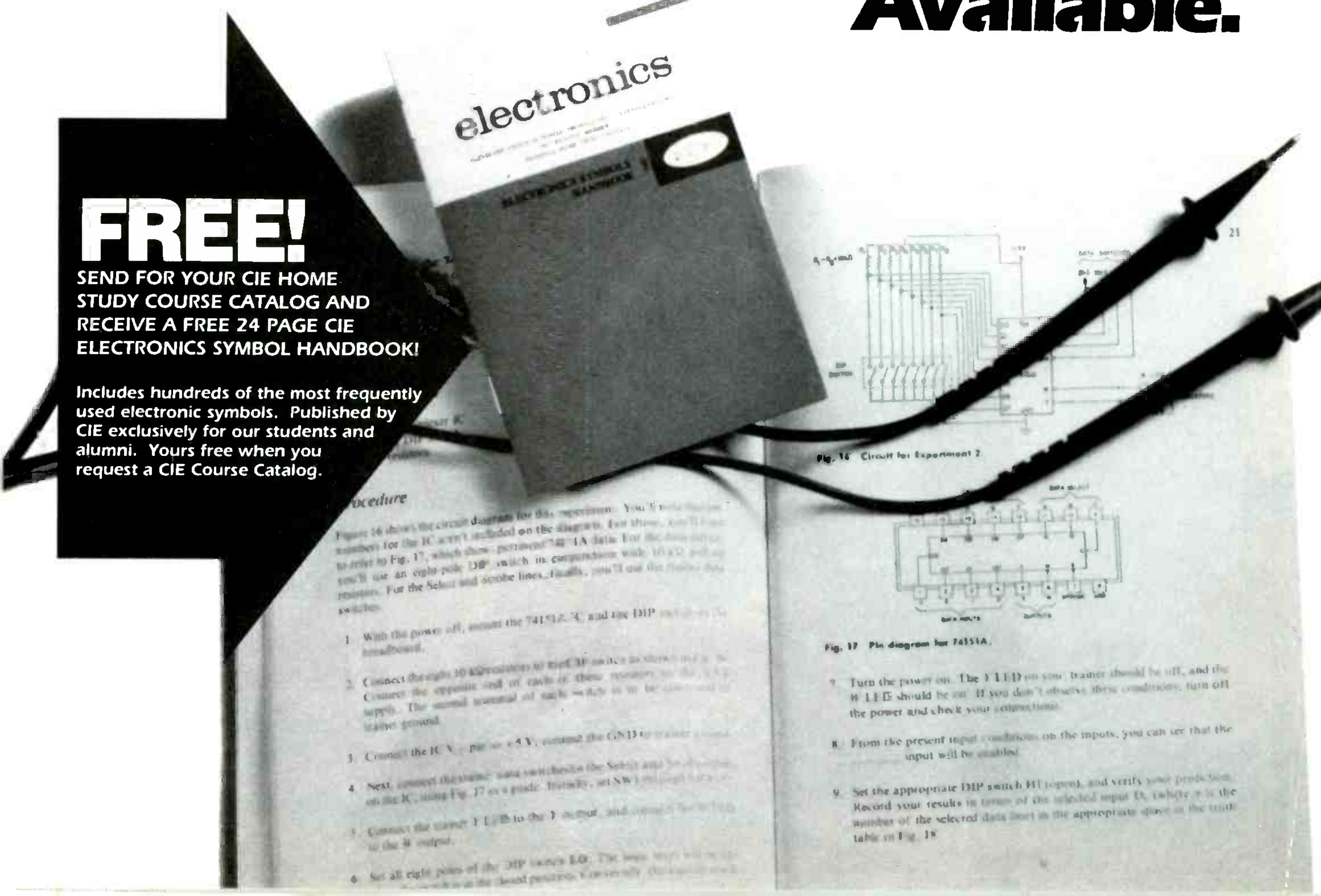

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DIGITAL MULTIMETER. The latest edition to Hewlett-Packard's line of digital multimeters is capable of measuring up to 1000 volts with 6½ digits of resolution and 1000 readings per second. By providing the capacity to go through 50-range/function changes per second, the *HP 34401A* has ten times the throughput of other digital multimeters in its class. The instrument offers basic 24-hour DC accuracy of 0.0015 percent, and the best AC accuracy and widest AC bandwidth in its class, according to Hewlett-Packard.

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Designed for system and bench applications, the *HP34401A* can be incorporated into existing systems with no changes in software, and includes such system DMM features as dB, null, diode test, and continuity. HP-IB and RS-232C interfaces are standard. In addition, it provides limit test, minimum/maximum testing results, storage of 512 readings, automatic-reading hold, auto-ranging, display updating, and almost instantaneous continuity readings.

The easy-to-use front panel was designed in response to extensive user testing, and a menu feature allows the user to easily modify secondary functions. An optional strap-on pouch can carry the power cord, interface cables, test probes, user and service manuals, and other accessories. The carrying handle and bumpers can be removed for rack installation.

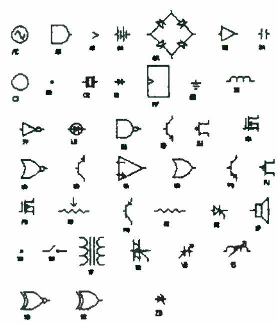
The *HP 34401A* digital multimeter has a U.S. list price of $995.—**Hewlett-Packard Company**, Loveland Instrument Division, P.O. Box 301, Loveland, CO 80539; Phone: 1-800-538-8787.

CABLE/TV SIGNAL LEVEL METER. Designed for measuring performance levels during system construction, installation, and maintenance, Leader Instruments' *Model 951* CATV signal-level meter can be used by the broadcast-TV, FM, MATV, and CATV industries. It has an auto-scanning feature that selects 32 channels encountered and displays measurement results that are auto-ranged and auto-scaled for storage to (or recall from) four groups of eight channel-bargraph data registers. Users can also select and store four memory-scans of picture and/or sound carriers, and measured results. Single- or multi-channel displays can be selected, using digital readouts and analog bargraph indications on a large, backlit, supertwisted LCD readout. The *Model 951* provides continuous frequency coverage from 48 to 870 MHz. It features EEPROM look-up tables for picture and sound carriers in broadcast VHF, UHF, and CATV standards of 16 countries. The battery-powered (8 "D"-size cells) unit measures 8.4 × 4.75 × 7.9 inches and weighs just 10.5 pounds. An optional RS-232 interface allows data to be downloaded to a printer or computer.


CIRCLE 17 ON FREE INFORMATION CARD

The *Model 951* Cable/TV signal-level meter costs $1695.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788; Phone: 1-800-645-5104 (in NY, 516-231-69000).

SCHEMATIC DRAWING SOFTWARE. Developed to help engineers, technicians, and hobbyists design and draw electronic circuits on-screen, *AutoSkem CAD Version 1.4* produces a high-quality printout, eliminating the rough hand-drawn sketch.


SYMBOLS

CIRCLE 18 ON FREE INFORMATION CARD

Drawings can be constructed using lines, text, and symbols. A software library of more than 50 predefined electronic symbols, logic gates, op-amps, transistors, diodes, coils, etc., is included. Users can create their own symbols and organize them into an unlimited number of libraries of up to 100 symbols each. Text can be rotated and scaled to five sizes before being placed in a drawing. Version 1.4 features improved graphics and drawing features for EGA and VGA systems; "rubber-banding" for drawing

straight or diagonal lines; the ability to save the drawing configuration file with all current program drawing configurations; improved mouse support; and internal high-resolution printer drivers for 9- and 24-pin dot matrix and HP LaserJet printers, and HP Pen Plotters. Parallel as well as serial interfaces are supported. The program requires an IBM PC, XT, AT, PS/2, or compatible computer running DOS 2.1 or higher; 384K RAM; and CGA, EGA, VGA, or Hercules graphics.

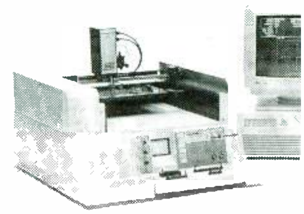
AutoSkem CAD Version 1.4 costs $49.—**BSOFT Software, Inc.**, 444 Colton Road, Columbus, OH 43207; Phone: 1-800-728-3805.

CARTOON-A-DAY PROGRAM. A PC-calendar program with a twist, the *Cartoon-A-Day Calendar Plus* from Individual Software offers DOS and Windows users a daily dose of whimsical humor in the form of the farcical drawing of nationally syndicated "Inside Out" cartoonist Kevin Pope. The daily cartoon can be added to personal calendars, printed correspondence, daily to-do lists, or schedules. The program displays (and prints) personal schedule information by the day, week, month, or year, and even keeps track of vacation time, personal plans, travel time, and holidays. It can also be used to create or update to-do lists. Both versions feature digital and analog clocks; the Windows version also features time-saving "Quick Memo" and "Quick Fax" functions that generate a memo or fax cover sheet that incorporates the daily computer right from their computer. The DOS version runs on any IBM-compatible PC with DOS 3.3 or higher and 512K of memory. The Windows version requires Windows 3.0 software.

CIRCLE 19 ON FREE INFORMATION CARD

The *Cartoon-A-Day Calendar Plus* program (for DOS or Windows) costs $29.95.—**Individual Software**, 5870 Stoneridge Drive, #1, Pleasonton, CA 94588; Phone: 1-800-822-3522.

ROBOTIC PROBE. Aimed at the electronic service industry, where low-volume boards, varying device technologies, and a wide range of repair problems exist, the *Prober RP388* is a computer-controlled, electro-mechanical probe that automates the testing process for components of various sizes and packaging, including surface-



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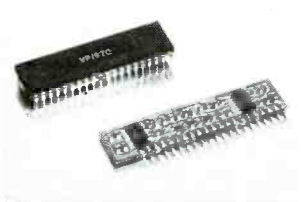
mount devices. According to Huntron Instruments, the robotic probe can set up and test any kind of component on a printed-circuit board faster than using a conventional "bed-of-nails" test system.

The *Prober RP388*, which requires the *5100DS* troubleshooting system for operation, consists of a precision electro-mechanical probe and a software-controlled video-imaging system. The probe can be driven to the test point with approximately ±4-mils accuracy, and the imaging system shows a detailed, real-time image of the board on the PC monitor. Establishing a test routine and troubleshooting is a three-step process using the combination of the *5100DS* and the *Prober RP388*: Teach the Prober the test-point locations; learn and store signatures of good components; and find faulty components by automatically comparing their signatures to the signatures stored on the PC hard drive. On average, a PCB with 39 surface-mount devices (14 to 20 pins per component) can be tested in less than 10 minutes.

The *Prober RP388* costs $23,000; the *5100DS* system required to operate it starts at $10,000.—**Huntron Instruments Inc.**, 15720 Mill Creek Blvd., Mill Creek, WA 98012; Phone: 800-426-2965 or 206-743-3171; Fax: 206-743-1360.

DIGITAL VOICE CHIP SET. Electech Electronics' *VCS-1870* allows circuit designers to easily add digitized voice to their designs. The set consists of the 40-pin DIP *VP-1870* voice-processing chip and the 21-pin *SF-700* filter module board. The chip features CVSD encoding at variable sampling rates for natural-sounding voice digitization. Its 8-bit bi-directional interfaces is compatible with most microprocessors. Digitized voice data is stored in external RAM or ROM. The *SF-700* is an active band-pass (300-Hz to 3.4-kHz) filter module with pre-amp for microphone or line input signals. Specially designed to work with the *VP-1870*, it provides good voice quality and high reliability with greatly reduced components count, board space, and power consumption. Operation requires a single 3- to 6-volt DC power supply.



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The *VCS-1870* digital voice chip set costs $16 in quantities of 1000.—**Electech Electronics**, 1262 East Katella Avenue, Anaheim, CA 92805; Phone: 714-385-1707; Fax: 714-385-1708.

DIGITAL MULTIMETERS. An enhanced line of low-cost, pocket-sized digital multimeters from Beckman Industrial include features ordinarily found only in more expensive units. For instance, *Models DM5XL*,

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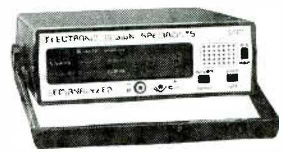
DM10XL and *DM10XL* each offer 10-amp current fusing to protect both the user and the meter, safety test leads with shrouded input plugs and text points, a warning beeper when the test leads are placed in the wrong input jacks, large LCD numerals, and increased battery life. All three meters measure DC voltage to 1000 volts, AC voltage (to 500 volts for the *DM5XL* and to 750 volts for the other two), resistance, and diode test, and have a continuity beeper. *Model DM10XL* adds a feature called the "Safety Tester," which detects and displays commonly encountered AC and DC voltage levels from 6 to 220 volts. This feature works even when the DMM battery is dead, ensuring that the user can always safely detect the presence of live voltage levels. *Model DM15XL* also adds a logic-measurement function that indicates the presence and polarity of TTL pulses up to 20 MHz.

Models DM5XL, DM10XL, and *DM15XL* digital multimeters cost $34.95, $44.95, and $59.95, respectively.—**Beckman Industrial Corporation**, 3883 Ruffin Road, San Diego, CA 92123-1898; Phone: 619-495-3218.

SEMIANALYZER SIGNAL TRACER. The *EDS-59C Semianalyzer II* from Electronic Design Specialists allows the technician to trace audio, video, digital, or FG signals to the problem area, while simultaneously monitoring DC voltages along the way on its 3½-digit voltmeter. Once the technician is in the suspected area, the instrument will check semiconductor devices in circuit and display the type, polarity, and condition of the device in plain English. Different tones beep to indicate various problems. The *Semianalyzer II* also checks Zener diodes for their proper voltages, as well as neons, LED's, and capacitors for leakage, noise, and voltage breakdown up to 175 volts DC using a built-in "Hi-Pot" tester. For repairing remote controls, an optional infrared detector probe is available. The *Semianalyzer II* comes with a three-year limited warranty and a 60-day money-back trial period. It is also available in kit form, without the 60-day trial period.



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The *Semianalyzer II* costs $399 fully assembled, and $299 in kit form, with cabinet.—**Electronic Design Specialists, Inc.**, 275 Rock Island Road, North Lauderdale, FL 33068; Phone or Fax: 305-720-4497. **R-E**

NEW LIT

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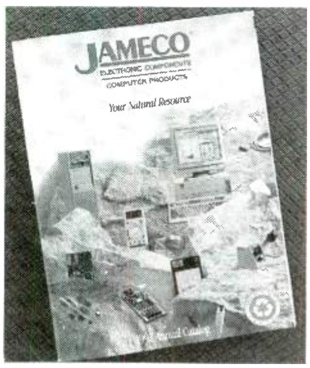
YOUR NATURAL RESOURCE: 1992 ANNUAL CATALOG; from Jameco Electronic Components and Computer Products, 1355 Shoreway Road, Belmont, CA 94002; Phone: 800-831-4242; Fax: 800-237-6948; free.

This year's catalog from Jameco, printed on recycled paper, carries the theme "Your Natural Resource." Intended as a complete source book for electronics hobbyists and computer enthusiasts, the 90-page, full-color catalog includes descriptions of more than 3000 products,



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from electronic components to test and measurement equipment, from cables to complete computer systems. Other features of the catalog include educational information and a RAM cross-reference guide. To further assist customers in making purchasing decisions, Jameco offers 24-hour toll-free order placement and toll-free fax and BBS service.

TECHNI-TOOL CATALOG 41; from Techni-Tool Inc., 5 Apollo Road, P.O. Box 368, Plymouth Meeting, PA 19462; Phone: 215-941-2400; Fax: 215-828-5623; free.

The 240 pages of this catalog are filled with an assortment of tools, tool kits, and test equipment that includes more than 18,000 items from 850 manufacturers. Electronics professionals and hobbyists will find items ranging from electro-mechanical and assembly devices to electronic, telecommunication, and field-service tool kits. Also featured are full lines of tools, equipment, and accessories for computer maintenance and for the fast-growing field of surface-mount technology. Static control and cleanroom items are included. Several new items are highlighted, including 100-MHz monolithic oscilloscope

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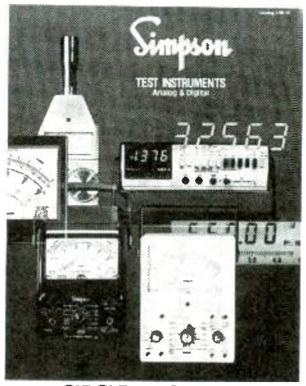
probes, the ESD heat gun, the Fluke 88 Automotive Meter, and the kit bag with conductive plastic cabinets for easy carrying of small electronic parts.

TEST INSTRUMENTS ANALOG & DIGITAL; from Simpson Electric Company, 853 Dundee Avenue, Elgin, IL 60120-3090; Phone: 708-697-2260; Fax: 708-697-2272; free.

This 44-page, four-color catalog features Simpson's lines of hand-held and benchtop multimeters,



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special function meters, clamp-on testers, and other specialized testers for electrical, electronic, and environmental applications. In addition to that equipment, the catalog covers special-function ohmmeters, voltmeters, and ammeters; insulation and temperature testers; testers for microwave and AC current leakage; and sound- and noise-measurement instruments and telephone-industry test sets. Capsule descriptions of each item, along with lists of features, ordering infor-

continued on page 87

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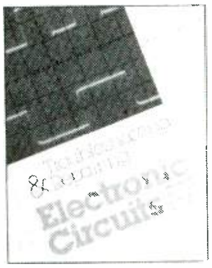

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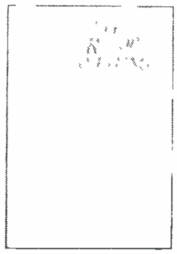

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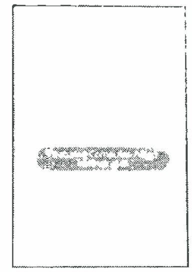

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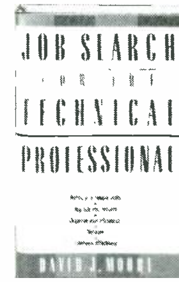

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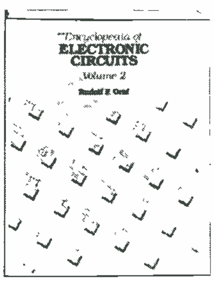

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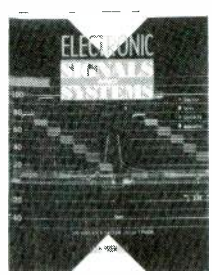

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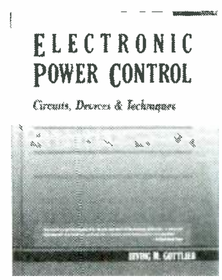

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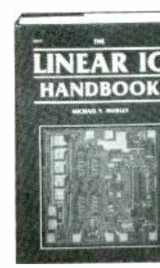

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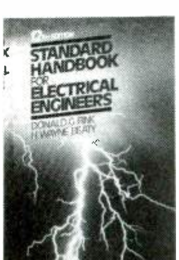

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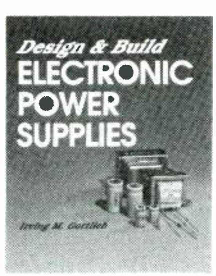

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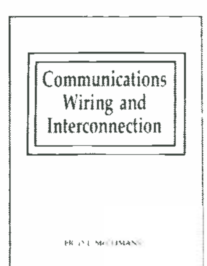

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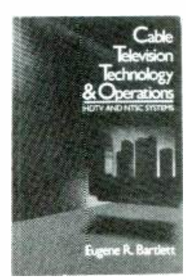

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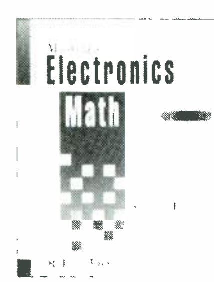

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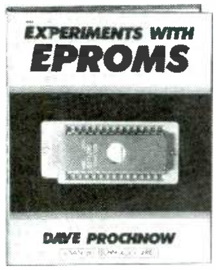

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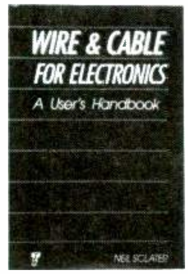

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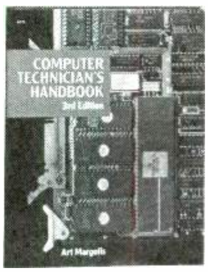

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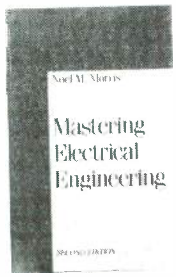

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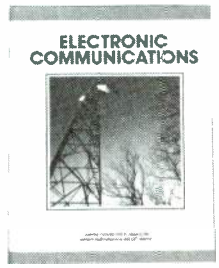

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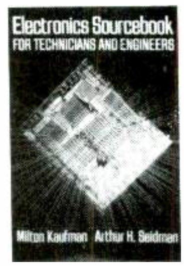

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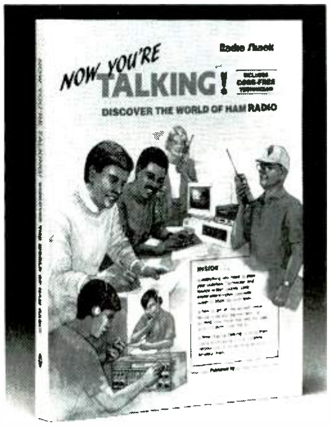

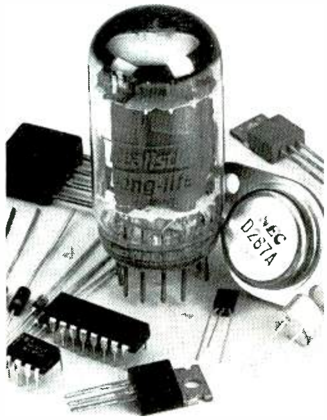

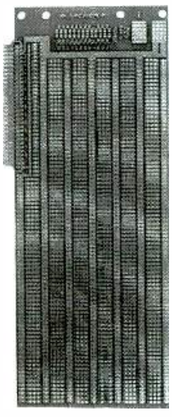

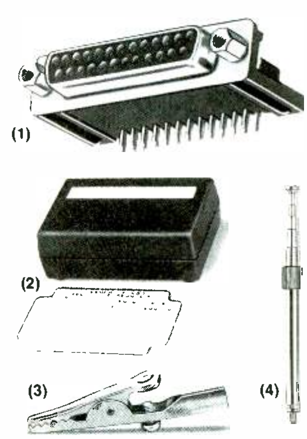

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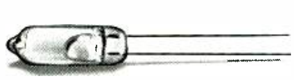

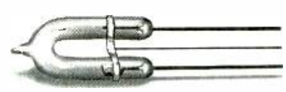

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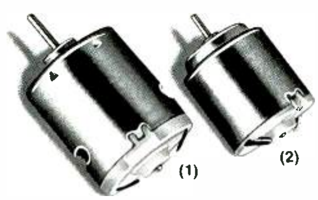

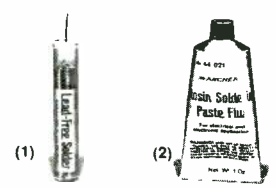

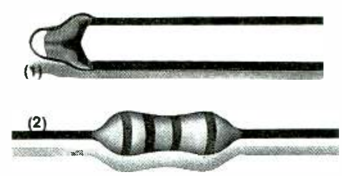

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THE TECHNOLOGY TO PRODUCE low-cost digital clocks has existed for years. Unfortunately, the style in which these clocks have displayed the time has been mostly limited to four digits (representing hours and minutes). Few digital clocks, if any, have taken full advantage of the great capabilities of today's microprocessors to provide a more novel display . . . that is until the HyperClock.

The HyperClock has a custom-programmed microcontroller that generates all the signals necessary to display time in eight eye-catching (yet easily readable) modes. Among its features are the ability to simulate a sweep second hand with a ring of 60 LED's; it can graphically display the level of ocean tides; it has a "fading" display mode that causes the LED's to gradually change when updated; it has a hourly chime/alarm output; supports 50- or 60-Hz powerline operation; it has a battery backup; and an intelligent date display that knows the last day of each month. Let's take a look at those features in greater depth.

The digital display

In four of the HyperClock's eight modes it can display time with a clever twist that those of you that grew up before the "digital-clock revolution" will appreciate. You may recall that it was fairly common for folks to speak of how many minutes it was till the next hour. For example, people would say "it's ten before five" rather than "it's four-fifty." Well, the HyperClock can actually "display" the time in that manner.

To help explain how that is done, take a look at Fig. 1-*a*; it shows the six seven-segment LED displays that are used to form the clock's digital display. During the first 30 minutes of each hour, the two middle digits signify the hour and the rightmost digits indicate minutes past the hour (like most digital clocks), and the two digits on the left are blank. Figure 1-*b* shows how eleven fourteen (or literally "fourteen *after* eleven") would look in this mode.

However, once the clock advances to beyond half-past the hour, the right digits go blank, the middle display would increment to display the next hour, and the left two digits would indicate how many minutes are left until that hour. For example, if it was thirteen minutes to twelve (or 11:47), the display would look like Fig. 1-*c*. You could read that literally as "thirteen *before* twelve."

On the hour, the clock just displays the hour, so the left and right minute displays remain blank (see the display for 12 o'clock shown in Fig. 1-*d*).

As mentioned earlier, there are 60 LED's arranged in a circle to display seconds or an approximation of the current tide level in your locale. The LED's act as a light chaser sweeping through the seconds of a minute. They can also show the relative tide level by moving from the 12 o'clock position at high tide to the 6 o'clock position at low tide. The timing of the tide-indicator mode is set to display two complete tide cycles in 24.51 hours just as it should. (For more on this subject see the sidebar entitled "A Bit About Tides.")

Fading-out the digits

The HyperClock also differs from other clocks in how it updates its display. In typical clocks, the display digits abruptly change as time passes. However, in four of HyperClock's eight modes when a digit must be updated, the LED segments representing its old value are dimmed as the segments for the new value become brighter. Likewise, each LED in the light chaser fades off rather than turns off. This animation is rather relaxing to watch.

These display effects are accomplished by a mixture of multiplexing and duty-cycle modulation. The seven-segment displays are all common-anode types, so each digit has its own anode-driver transistor. In typical multiplexed-display fashion, the cathodes of corresponding segments of each digit are connected together and share a common driver.

Like any other multiplexed display when the segment data for a digit is placed on the segment data lines, the anode driver for that digit is activated, and the seven-segment display lights to exhibit the appropriate digit. All the other digits are off at this time. After a short period of time (1.83 ms) the segments are turned off via the segment lines and the anode driver is deactivated. The anode driver for the next digit is then activated, the segment data for that digit is placed on the segment lines, and the process continues until all the digits have been lit. Since the human eye is too slow to see the digits turn on and off, it appears as though they are all on simultaneously. Multiplexing the digits in this fashion reduces the number of pins on the microcontroller needed to control the LED displays.

HyperClock's fading effect is created by modulating the duty

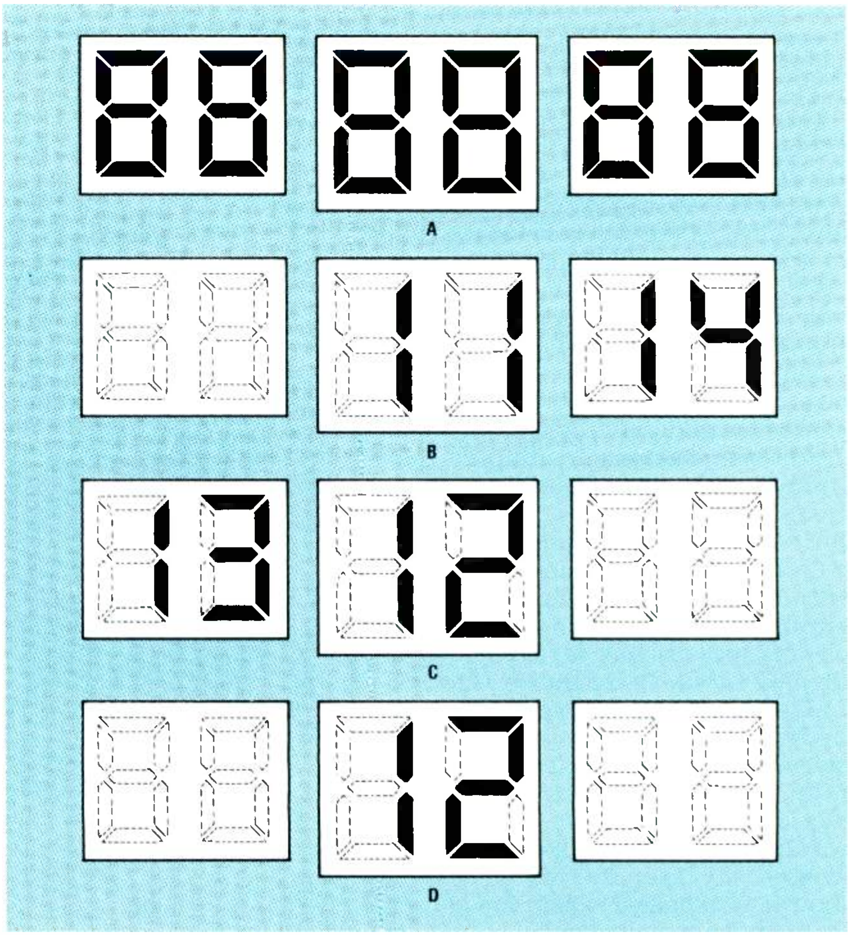


FIG. 1—HYPERCLOCK'S TIME DISPLAY (*a*) is unique in that it not only displays time normally (*b*), but it can indicate minutes left to the next hour (*c*), and blanks the minute displays on the hour (*d*).

cycle of the segment enable signals. When a seven-segment display is enabled, the segment data lines spend part of the time in states corresponding to the current digit to be displayed, and the rest of the time in states corresponding to the next or "future" digit that will be displayed. Each time the digit is enabled, the duty cycle will favor the future-digit data more and more, until only the new digit is displayed, and the process repeats each time the display must be updated.

The microcontroller

At the heart of the HyperClock is an Intel 8749 microcontroller. It is programmed to perform a variety of functions, namely: display multiplexing, timekeeping, receiving switch input, coordinating the hour and alarm chime, and initiating a power-fail mode that permits the time-keeping functions to continue while blanking the display to conserve backup-battery power.

The 8749 has 2K of EPROM, 128 bytes of RAM, 24 I/O pins, a programmable 8-bit timer, and an interrupt-control structure. The custom-program placed in the processor to create HyperClock's special effects extensively exercises all of the chip's features; Fig. 2 contains a simplified flow chart for the HyperClock program. The program is shown divided into two sections: an interrupt routine and a main loop.

The interrupt routine is mainly responsible for taking the segment data from the segment-data buffer in the microcontroller and placing it on the display-control lines in a multiplexed fashion. The interrupt that initiates the routine comes from the 8749's internal timer, which has been programmed to execute the interrupt every 1.83

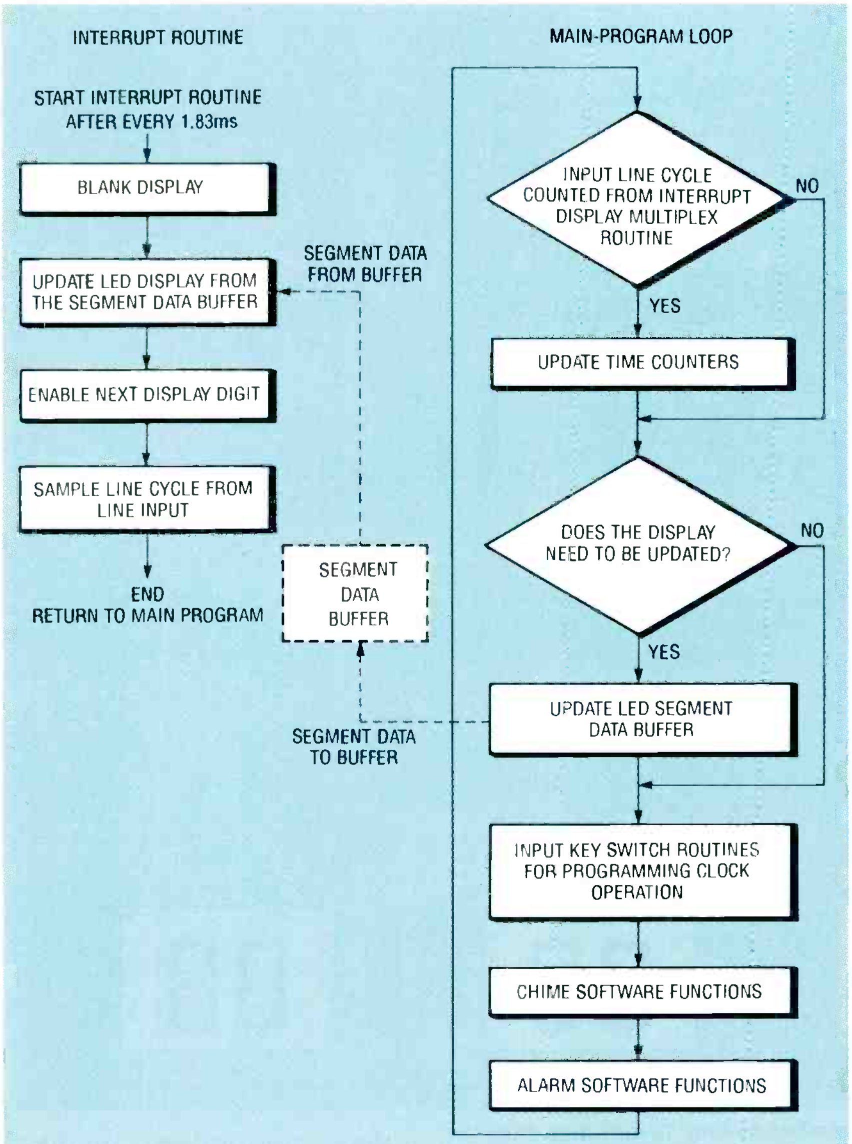


FIG. 2—HYPERCLOCK'S SOFTWARE can be broken down into two distinct code segments: a clock-scheduled interrupt routine, and a main-program loop.

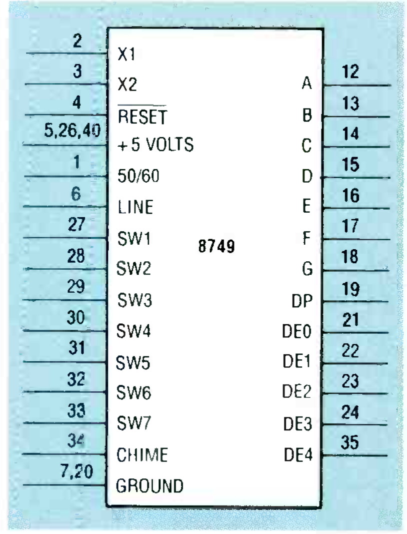


FIG. 3—THE PINS ON THE 8749 microcontroller are assigned various functions by the HyperClock program.

ms. Using an interrupt-program segment in this way allows the display's fading effect to appear gradual because the process of updating the display occurs at regular intervals. This routine is also responsible for checking a powerline-frequency input on the microcontroller to determine if a powerline cycle has passed. If so, it informs the main loop of the program.

The main loop keeps track of the number of cycles that pass so it knows when to update the segment-data buffer or initiate the alarm or chime. If no powerline cycles are detected, the main loop assumes AC power has been terminated and puts the clock in power-fail mode. In that mode it shuts off the display and allows the microcontroller to "invisibly" keep track of time via a 6-MHz crystal. The main loop also processes input from the clock's switches (we'll talk more about that later).

For all that goes on inside the microcontroller, the functions assigned to its pins by the HyperClock program (see Fig. 3) are relatively easy to understand. Let's take them one group at a time.

The pins labeled A through G and DP (pins 12–19) in Fig. 3 are the outputs for the display-segment data. They indirectly control the cathode drivers for the multiplexed display. Similarly, the outputs labeled DE0–DE4 (pins 21–24 and 35) control the anode drivers for the display via demultiplexer chips, which we'll discuss later.

The pins labeled S1–S7 (pins 27–34) are used as function-switch inputs. The switches connected to those inputs (DISPLAY MODE, DISPLAY DATE, DISPLAY ALARM, INCREMENT HOUR/MONTH/MODE, INCREMENT MINUTE/DAY, SNOOZE/TIDE ADVANCE, and ALARM TOGGLE, respectively) activate various chip functions by grounding those pins. A complete explanation of the switches' functions will be presented later.

Low-going pulses from the pin labeled CHIME (pin 34) activate the chime circuit, which is composed of discrete components. The microcontroller triggers the chime circuit with a 12.8-ms wide low-going pulse at one-second intervals. When not in alarm mode, the chime signals the hour by chiming an appropriate number of times, and signals each half-hour by chiming once.

When the microcontroller is in the "alarm" mode, the chime circuitry is used as an alarm annunciator. In this mode the clock does not chime on the hour and half hour. That permits you to use the HyperClock as an alarm clock without the chimes disturbing you until the appointed time.

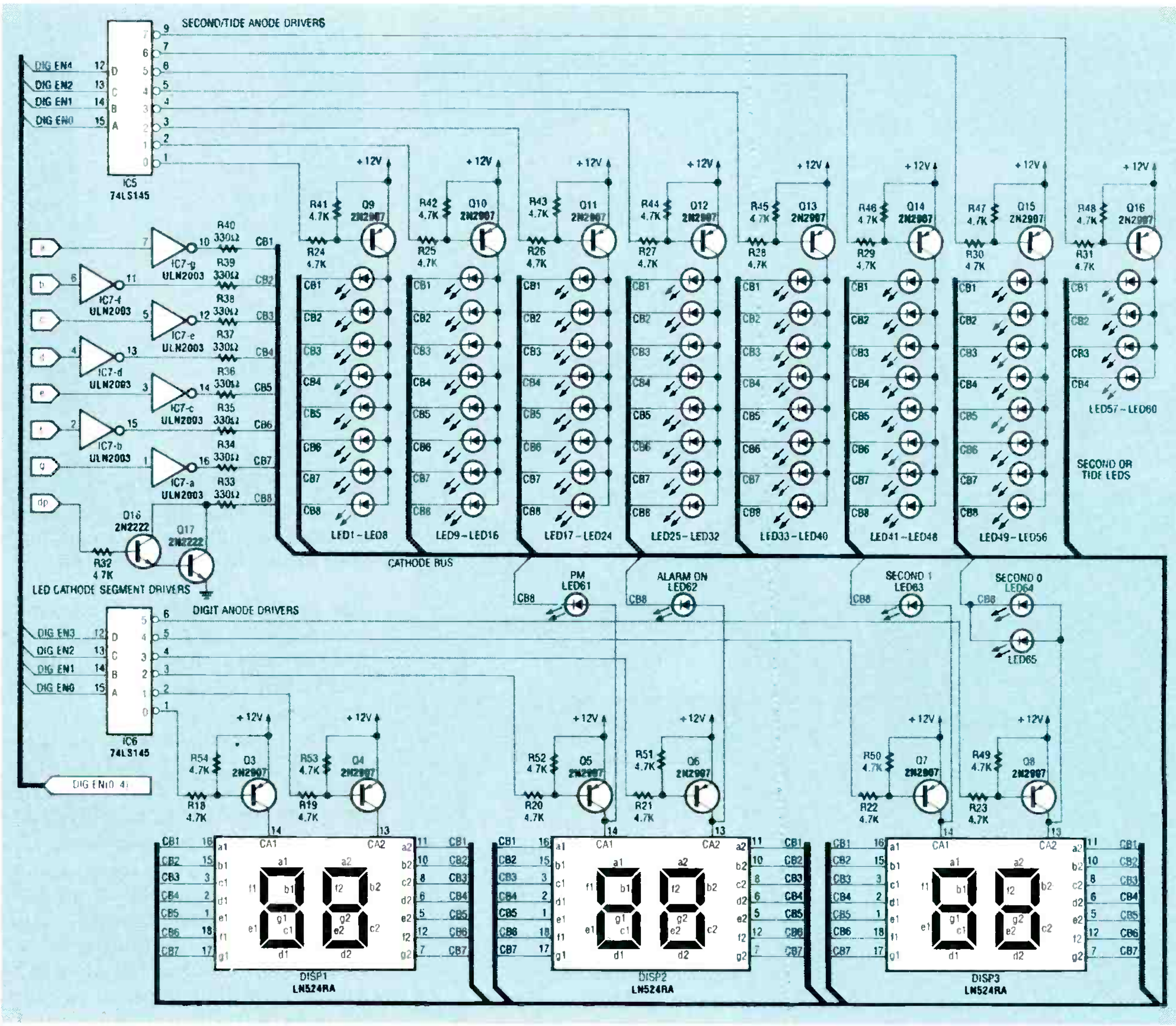


FIG. 4—THE HYPERCLOCK DISPLAY is controlled by only 13 data lines from the microcontroller.

The LINE input (pin 6) is used by the IC to accept a 50- or 60-Hz square wave. The square wave is used for time keeping and to detect AC-power failure as mentioned earlier. The 50Hz/60Hz input (pin 1), tells the 8749 what frequency to expect at the line input. If pin 6 is low, the 8749 assumes the line signal is at 60 Hz, but if that pin is high the 8749 prepares for 50-Hz operation.

As its name implies, the RESET input (pin 4) initializes the microcontroller. A low at that input will erase all modes and settings previously entered.

The X1 and X2 inputs (pins 2 and 3) need to be connected to the 6-MHz crystal, XTAL1, mentioned previously. Last, but certainly not least, are the 5-volt power inputs (pins 5, 26, and 40) and the grounds (pins 7 and 20). Those inputs of course, are self explanatory.

The display circuit

While the microcontroller does a great deal, the HyperClock requires some additional circuitry to make it a complete timepiece. For example, the microcontroller cannot provide nearly enough current to drive the LED display. For that reason additional anode and cathode drivers were included in the design. They are shown along with the other display components in Fig. 4.

The control signals for the LED cathodes originate from the A–G and DP pins of the microcontroller. The A–G signals are sent to a ULN2003 buffer/driver (IC7) which contains seven high-current drivers. Each output is capable of providing 500 mA of peak drive current. Since the ULN2003 contains only seven of the eight cathode drivers required, a Darlington driver was made out of two 2N2222 transistors to drive the DP line.

The DE0 through DE4 outputs generated by the microcontroller are decoded by two 74LS145 decoder/driver IC's (IC5 and IC6). Only one decoder output is driven low at any time. Each 74LS145 output supplies current to a 2N2907 drive transistor that sources current for the anodes of a group of LED's or a display digit.

Note that there are additional LED's to provide an AM/PM in-

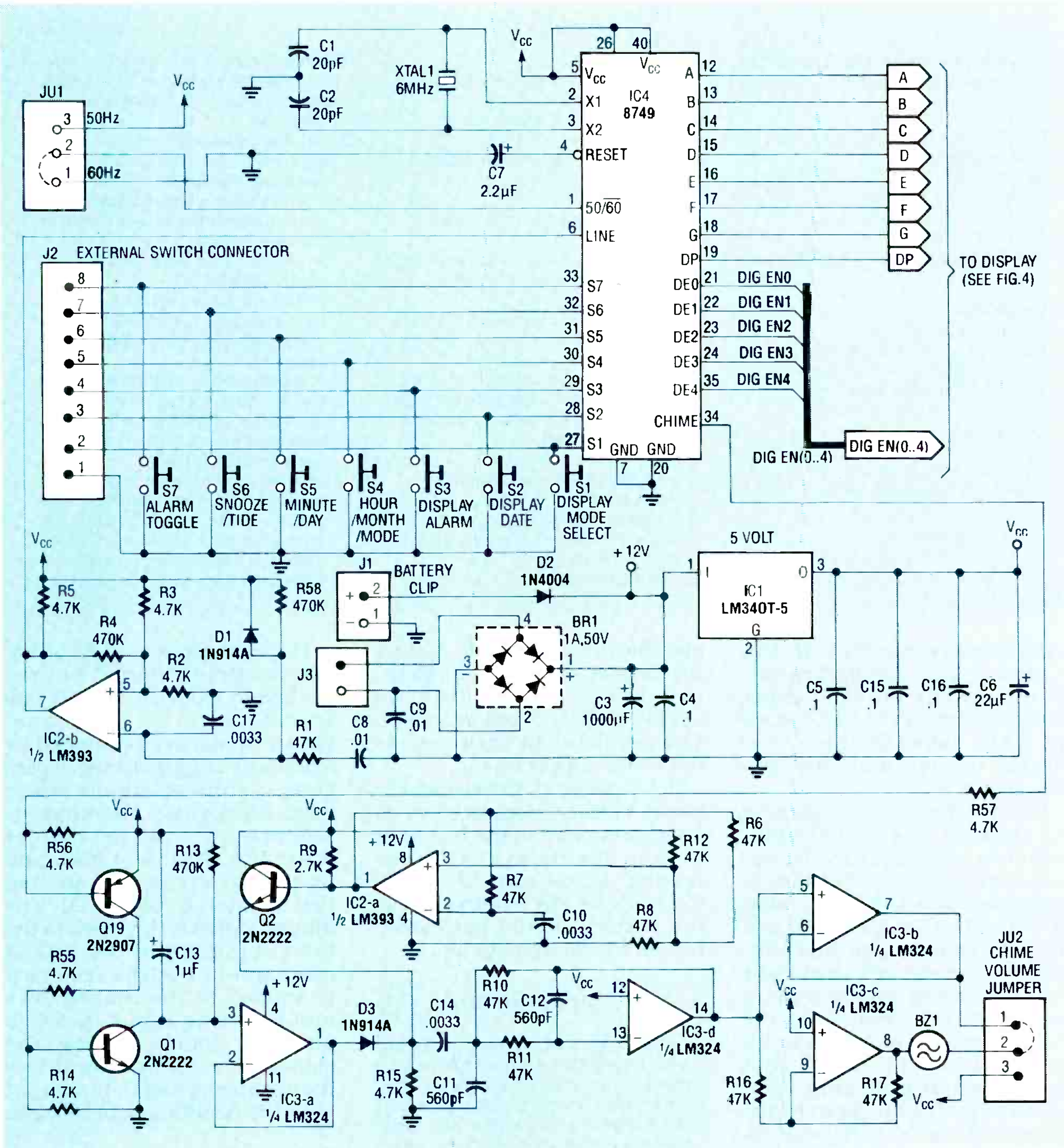


FIG. 5—THIS SCHEMATIC DIAGRAM FOR THE HYPERCLOCK circuit (less the display components) shows the support circuitry required by the microcontroller.

dication (LED61), tell you if the alarm-mode is active (LED62), and provide a winking second display (LED63 to LED65). That's all there is to the display circuit.

The remainder

The most noteworthy of the clock's remaining circuitry (shown in Fig. 5) is the chime circuit. When the microcontroller generates a low-going pulse on pin 34, it activates Q19. That transistor then provides sufficient current to drive Q1 into saturation.

With Q1 on, the negative side of C13 is effectively grounded, which causes it to charge. When Q1 is turned off, C13 discharges through a 470K resistor (R13). The resistor/capacitor combination has a time constant of 0.47 seconds. The exponentially decaying signal produced by the discharge is buffered through a unity-gain amplifier (IC3-a) to a 1N914 diode (D3).

The cathode of D3 is connected to the output of a 50% duty cycle 5-kHz square-wave oscillator consisting of IC2-a, R7, C10, and Q2. Transistor Q2 serves to provide a dynamic pull-up for that oscillator since the LM393 is an open-collector type comparator. The 5-kHz

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1, R6–R8, R10–R12, R16, R17—47,000 ohms
R2, R3, R5, R14, R15, R18–R32, R41–R57—4700 ohms
R4, R13, R58—470,000 ohms
R9—2700 ohms
R33–R40—330 ohms, ½-watt, 5%

Capacitors
C1, C2—20 pF ceramic
C3—1000 µF, 16 volts, electrolytic
C4, C5, C15, C16—0.1 µF, ceramic
C6—22 µF, 16 volts, electrolytic
C7—2.2 µF, 16 volts, electrolytic
C8, C9—0.01 µF, ceramic
C10, C14, C17—0.0033 µF, ceramic
C11, C12—560 pF, ceramic
C13—1 µF, 16 volts, tantalum

Semiconductors
IC1—LM340T-5 5-volt regulator
IC2—LM393 dual-comparator
IC3—LM324 quad-op-amp
IC4—8749 microcontroller with HyperClock program
IC5, IC6—74LS145 1-of-8 decoder/driver
IC7—ICLN2003 high-current driver
D1, D3—1N914A diode
D2—1N4001 diode
Q1, Q2, Q17, Q18—2N2222 NPN transistor
Q3–Q16, Q19—2N2907 PNP transistor
BR1—1-amp, 50 volts PIV bridge rectifier
DISP1, DISP3—Panasonic LN524RA or similar 7-segment display (for the smaller digits)
DISP2—Panasonic LN526RA or similar 7-segment display (for the larger digit)
LED1–LED65—light-emitting diodes

Other components
XTAL1—6-MHz crystal
T1—9-VAC 500-mA wall-mount transformer
BZ1—piezo transducer
S1–S7—miniature momentary-contact pushbutton switch
B1—9-volt battery

Miscellanious: T-220 style heatsink, PC board or perforated construction board, battery clip, shorting blocks, solder, etc.

Note: The following items are available from SkiTronix, P.O. 9685, Spokane, WA 99209:
- **A pre-programmed HyperClock 8749 microcontroller with firmware license—$10.00.**
- **An etched and drilled PC board—$25.00.**
- **The foil pattern artwork suitable for conversion to film—$3.00.**
- **Software on floppy disk—$5.00 postpaid**
- **A complete kit of parts including the PC board, programmed 8749 IC, LED's, displays, electronic components, and the wall-mount transformer—$70.00.**

A detailed drawing of the HyperClock wood case, will be supplied with all orders. Please include $3.00 for shipping and handling. Washington residents must include an additional 7.9% sales tax.

square wave present at the emitter of Q2 is clamped in amplitude by the buffered exponential waveform from IC3-a, so the 5-kHz signal decays in amplitude in step with the discharge of C13.

The decaying 5-kHz signal is fed through C14 to a second-order low-pass filter tuned to approximately 5 kHz. The filter is composed of a LM324 op-amp (IC3-d), C11, C12, C14, R10, and R11. It removes the high-frequency components contained in the decaying square wave to smooth it out. From there the signal is passed to two more op-amps (IC3-b and IC3-c) that form a push-pull amplifier, which provides the piezo transducer with a 10-volt peak-to-peak drive signal.

While the output signal is not exactly a pure sine wave, the audible result sounds pretty much like a small bell. If you feel the chime is too loud, you can eliminate half of the push-pull amplifier by jumpering one side of the transducer to the 5-volt supply, which is available via JU2.

The entire circuit receives power from a 9-VAC wall-mount transformer. The 9-VAC supply is fed to a full-wave bridge rectifier and filtered by C3 to act as an unregulated 12-volt DC supply. The 12-volt supply powers the display circuitry, op-amps, the comparators, and an LM340-5 (IC1) 5-volt regulator. The regulator in turn powers the 5-volt supply line.

If AC power is interrupted, a 9-volt battery connected to J1 sources current to the regulator to keep the HyperClock functioning. If you plan to unplug the clock for any length of time, the battery should be disconnected to conserve its life.

A BIT ABOUT TIDES

Predicting the tides in any given locale is not a simple job. Tides are affected by many cyclic astronomical forces: the declination in the orbits of the moon and sun relative to a point on the Earth, and the local geography of the coast line in the area in which you live, to name a few. HyperClock predicts the tidal levels from the most predominate of these forces, the moon. The moon requires 29.53 days to orbit Earth, and that combined with the 24-hour solar day causes a high and low tide in every 12 hour and 25.5 minute interval. HyperClock tracks the moons primary affect on the tide. You can find out about the level of local tides in your area from your newspaper or library. The information can be used to initially set the tide indication on your HyperClock to a low or high point. From then on the graphic display will be an aid in the determination of the relative level of the tides in your locality.

The line input (pin 6) of the microcontroller cannot be driven directly from the 12-VAC wall transformer. So the transformer signal is conditioned by a Schmitt-trigger circuit to generate a suitable square wave. First the signal's amplitude is reduced by a voltage divider consisting of R1 and R58, and its positive excursions are limited to about 5 volts by D1. The limited signal is then sent to the inverting input of the LM393 comparator. Positive feedback is applied to the comparator's non-inverting input by R4 to prevent it from generating false signals. The comparator drives the microcontroller's line input with the resulting square wave.

Construction

In order to build a HyperClock, you'll need a programmed 8749 microcontroller. A preprogrammed and tested microcontroller is available from the supplier mentioned in the parts list. The executable code to program an 8749 is available from the RE-BBS (516-293-2283, 1200/2400, 8N1), as a file called HYPER.HEX. The file is supplied in Intel's Hex format, which is directly compatible with most EPROM program-

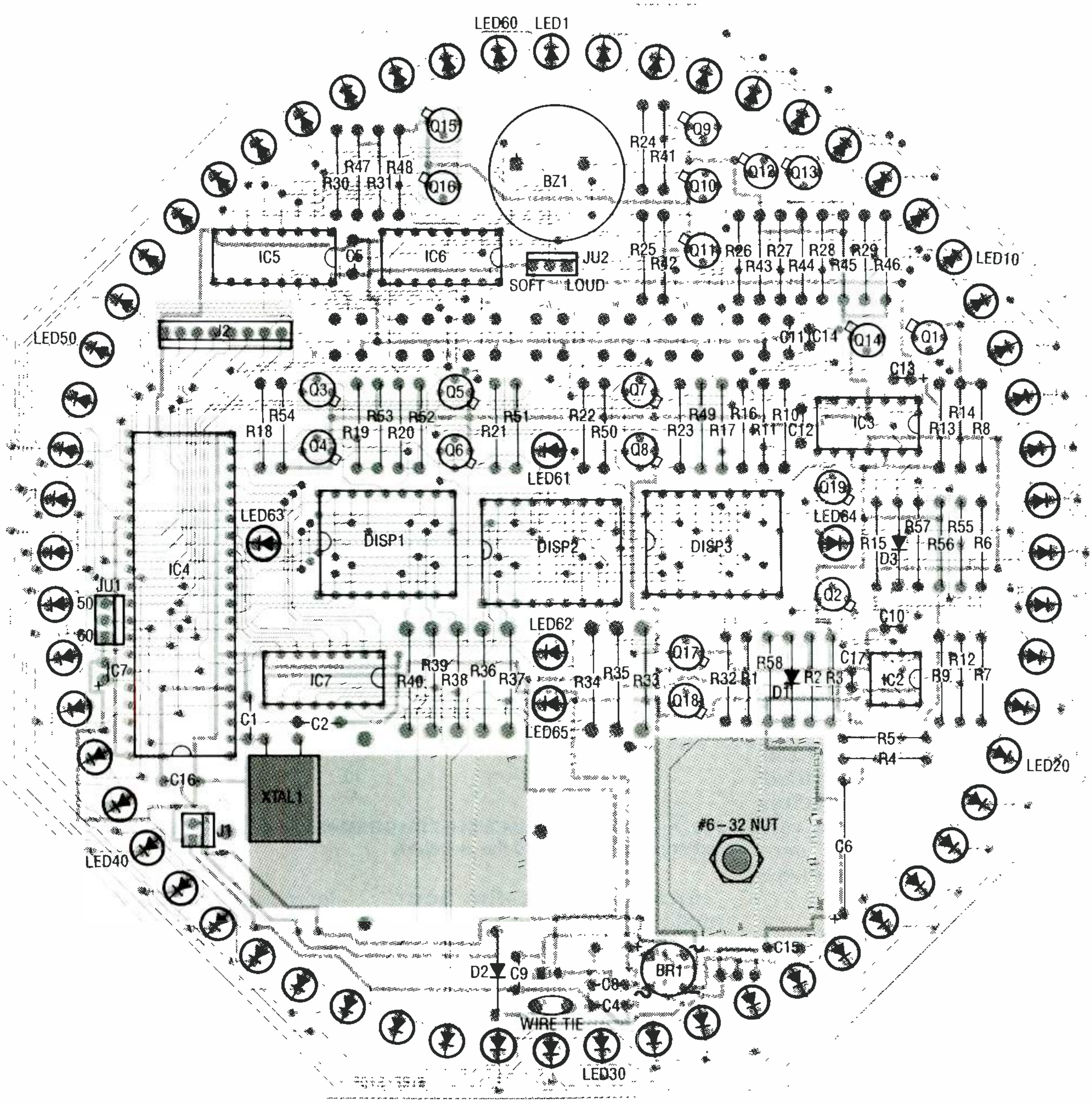


FIG. 6—DISPLAY-SIDE PARTS-PLACEMENT diagram can be used to locate most of the HyperClock's components.

mers. The software is also available on floppy disk from the source mentioned in the parts list.

A 6.5- × 6.5-inch octagon-shaped PC board is also available from that supplier to help you assemble a HyperClock of your own. If you wish, you can make your own double-sided printed-circuit board from the foil patterns included in this article or using artwork from the supplier listed in the parts list. Of course, you could even use a point-to-point wiring technique, so we'll discuss that briefly later on.

Figures 6 and 7 show the parts-placement diagrams for the HyperClock (6 shows the display side and 7 shows the solder side) for those of you that will use a PC board. All components, except for the wall-mount transformer, are shown mounted on the circuit board. Note that the switches can be placed on either side of the board, depending on the cabinet you wish to place the clock in. There are some additional connector pads on the board so you can run wires to the switches should your cabinet design require that they be located off the PC board. Figure 8 shows a completed HyperClock board.

The design readily lends itself to many different project cases. However, make sure that the cabinet you choose has some openings in the back to allow a little cool air to flow around the clock's 5-volt regulator and heat sink. If you like the case used for the prototype, you can build one out of a length of wood molding as the author did.

The PC board was designed to work with many different dual-digit displays, so you don't necessarily have to restrict yourself to the Panasonic units mentioned in the parts list. Just make sure that whatever you use is a pin-for-pin same-size replacement. If you do use the recommended units, be sure to raise the two minute displays up from the board so that their viewing surfaces are flush with that of the hour display.

Lastly, the PC board provides some holes for wire ties to hold the 9-volt battery and the wall-mount transformer leads. You should take advantage of them. Remember to install the 9-volt backup battery and connect JU1 and JU2 to select 50- or 60-Hz operation and the volume of the chime, respectively.

When you connect the clock to power it should come up at 12:30 AM and will be ready to accept the current time, alarm time, date, and the tide level if desired. If you run into any difficulty, you may find some of the troubleshooting tips provided in the following section useful. However, if all is well, you can proceed to the "operating" section to prepare the clock for use.

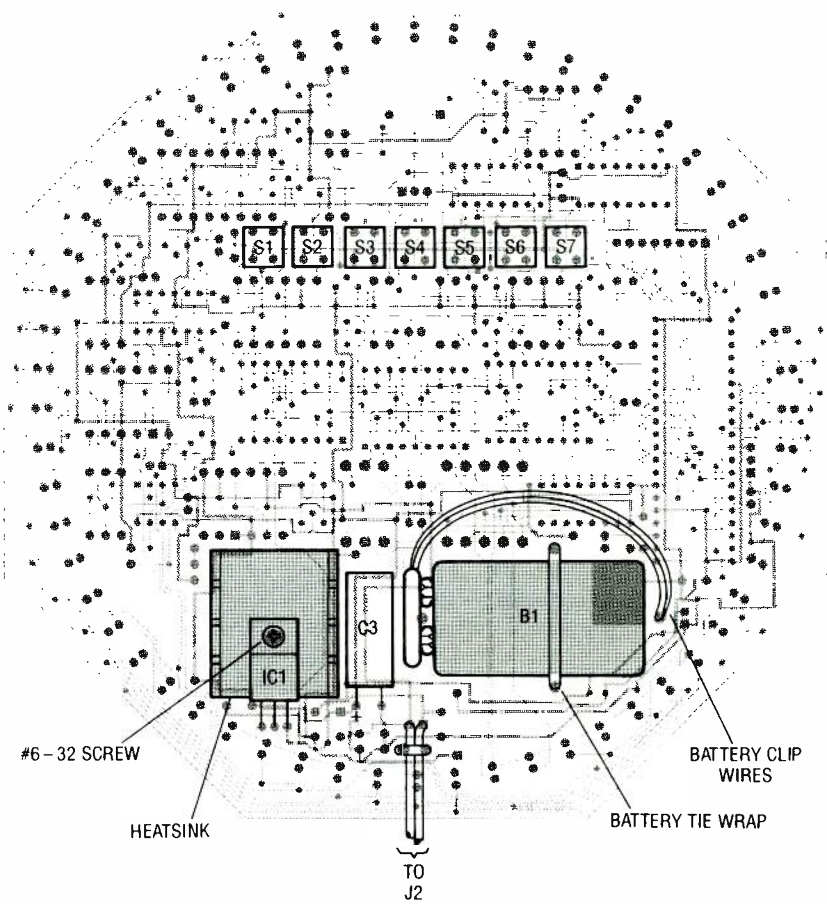


FIG. 7—THIS PARTS-PLACEMENT DIAGRAM should be used to position the regulator, battery, a capacitor, and the switches.

Point-to-point wiring

Working with perforated construction board and point-to-point wiring gives you the freedom to design your own display layout. One nice alternate design would be to place the 60 LED's in the form of a full cycle of a sine wave, especially if you set the clock to display the tide level.

An early prototype of the clock was built using wire wrap. Regardless of the wiring technique, you should invest in a large enough piece of perforated construction board (at least 6 × 6 inches) so that you can make your custom display with plenty of room to spare for all the support electronics.

Furthermore, when you are shopping for the hour and minute displays, select minute displays that are somehow distinctly different than the hour display. That will make the display more easily readable in the "minutes before the hour" mode.

It is also suggested that you don't place the display components on the same side of the board as the heatsink/regulator assembly, C3, and the 9-volt battery. Doing so would increase the profile of the display side of the board, forcing you to place the LED lens at an undesirable distance from the display components.

Aside from those suggestions, layout is not critical, so if you observe good construction and wiring techniques you should not have any problem getting the clock to function. However, if you should encounter some difficulty, the following hints ought to help:

- If no LED's are illuminated when you apply power, first check the unregulated supply for a minimum of 10 volts DC. While only 2 to 3 volts of overhead are required to operate the 5-volt regulator, at least 10 volts is required to drive the LED's sufficiently.
- If the power-supply circuitry is okay, check the wiring around the LM393 (IC2) from the bridge rectifier and going to IC4 pin 6; the microcontroller looks at that line and if there is no line frequency at that input, the clock will shut down the LED drivers (as we explained earlier).

Since most of the wiring in the clock runs between the LED drivers and the LED's, it is likely that you could have made an error in one or more of those connections. If you observe that any active LED segments do not form numbers, then you should check the connections from IC4 to IC7 and the corresponding connections to the cathodes of the LED displays. A mistake between IC4 to IC5 and IC6 will make the displayed digits and/or seconds appear out of order. An error in wiring from the outputs of the 74LS145's to the

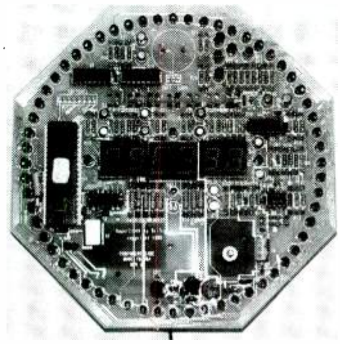
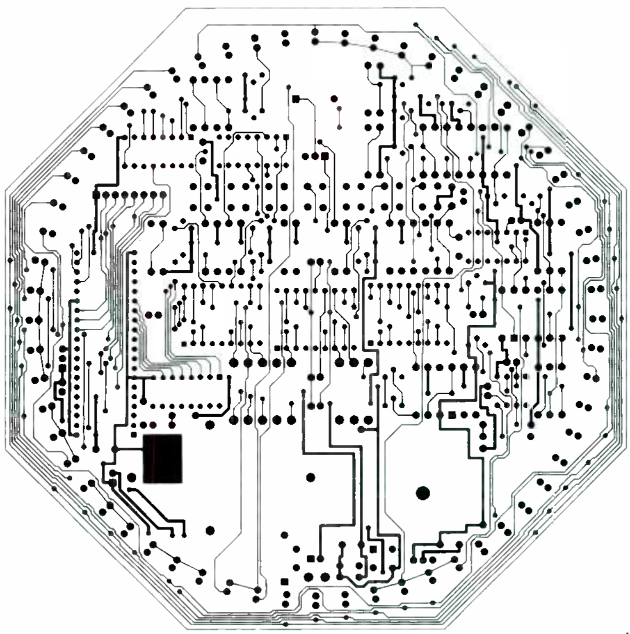


FIG. 8—A FINISHED HYPERCLOCK. The PC board makes assembly neat and straightforward.

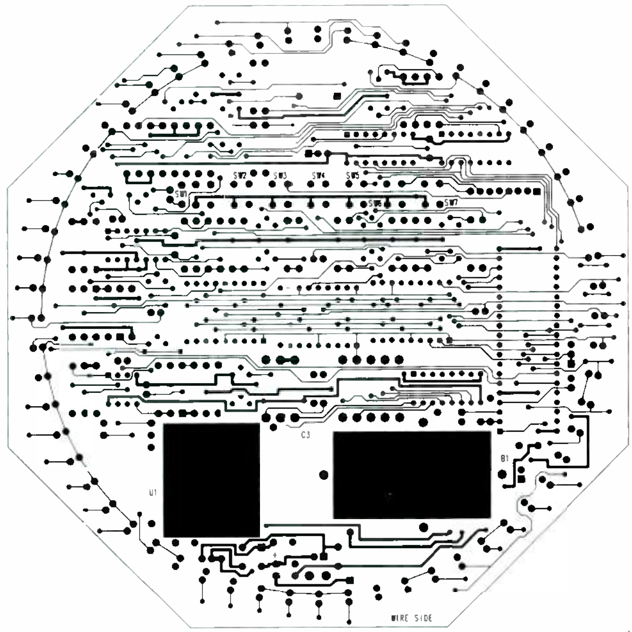
TABLE 1—MODES AND THEIR FEATURES

Feature	Mode							
	0	1	2	3	4	5	6	7
Fading Updates		•		•		•		•
Plain Updates	•		•		•		•	
Before-The-Hour Display			•	•			•	•
Plain Display	•	•			•	•		
Tide Light Chaser					•	•	•	•
Seconds Light Chaser	•	•	•	•				



8½ INCHES

THE DISPLAY-SIDE FOIL PATTERN can be used to generate one side of the clock's PC board.



8½ INCHES

THIS FOIL PATTERN can be used to generate the solder side of the clock's PC board.

driver transistors, which connect to the LED anodes, will cause the same effect.

Operation

The functions performed by S4 and S5 in the HyperClock depend on the state of the three display switches (S1 through S3). If none of the display switches are depressed, pressing S4 advances the current hour displayed and pressing S5 advances the minute display. That is how you set the time.

Pressing and holding down S1 (the Display-Mode button) causes the clock to display the number of the current operating mode, which can be altered by pressing S4 (S5 will do nothing). The various operating modes and the features they support are listed in Table 1.

If you depress and hold switch S2 (the Display-Date button) the current month and day are displayed. With that switch depressed, the month and day can be advanced by pressing S4 and S5, respectively.

Activating switch S3 will cause the clock to display the time the alarm is set for. By pressing S3 along with S4 you can alter the hour setting, and by pressing S3 and S5 simultaneously you can change the minute setting.

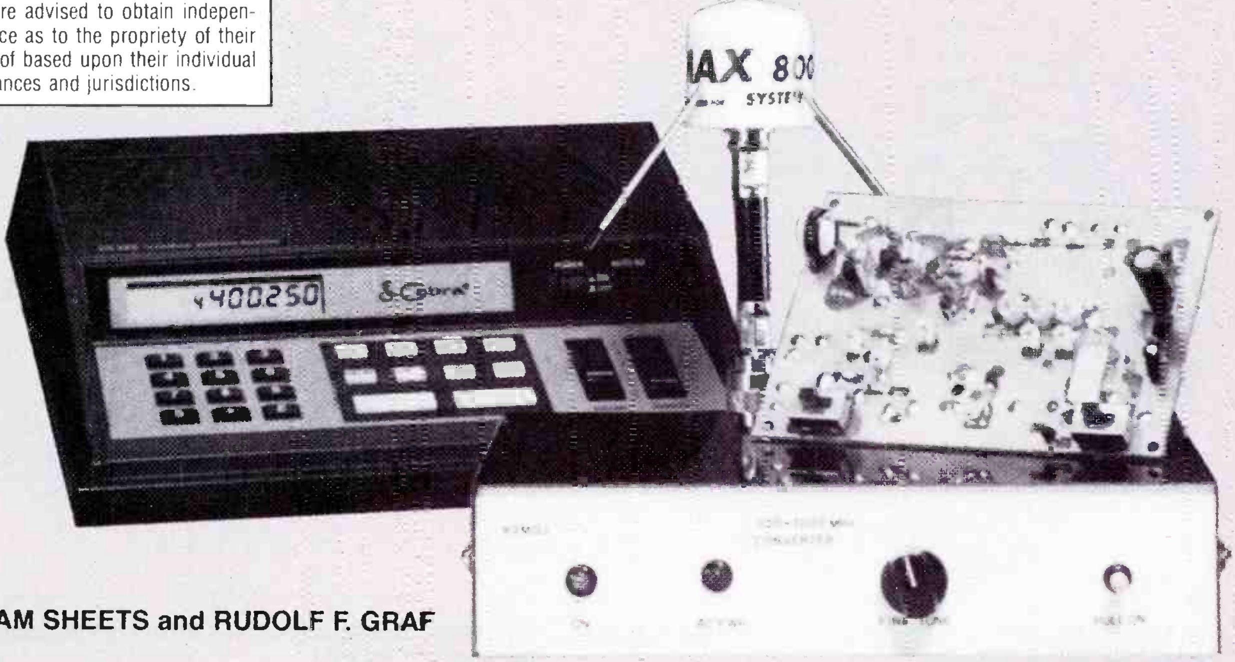
Moving on to the last two switches, the Alarm Toggle switch (S7) determines the state of the alarm and the hour chime of the clock. For example, on power-up the hour chime is enabled and the alarm is disabled. If S7 is pressed once, the alarm is turned on and the hour chime is disabled. Depressing the switch again will turn off both the alarm and the hourly chime.

The Snooze/Tide Switch (S6) has a dual purpose. If the HyperClock's alarm was armed and goes off, that button will silence the alarm for an additional ten minutes. You can forestall the alarm in this way as many times as you like. If the alarm is disabled, and the clock is in a mode that supports the tide-level display (modes 4 through 7), pressing S6 will advance the tide indication on the 60-LED display to set its position. **R-E**

SCANNER CONVERTER

WARNING!
Please note that unauthorized wire and electronic communications interception and interception of oral communications is illegal under Federal and State Law. In addition Federal Law renders illegal the intentional manufacturing, assembling, possessing, or selling any electronic, mechanical, or other device, knowing or having reason to know that the design of such device renders it primarily useful for the purpose of surreptitious interception or wire, oral, or electronic communications. Federal law imposes both civil and criminal penalties for violations of the applicable statutes. Thus, the use of the Scanner Converter described in this article is intended for and should be restricted to educational, scientific, and/or informational purposes. This is not intended to constitute legal advice and readers are advised to obtain independent advice as to the propriety of their use thereof based upon their individual circumstances and jurisdictions.

Upgrade your scanner to receive signals in the 800–900 or 900–1000 MHz bands!



WILLIAM SHEETS and RUDOLF F. GRAF

THE 800-1000 MHZ BAND OF FREquencies, lying in the portion of the radio spectrum known as the UHF band, has recently become populated with many signals of interest to the shortwave listener (SWL) and scanner hobbyist. Originally, the 800–890 MHz portion was allocated to UHF TV broadcasting. Lack of interest in these frequencies (formerly TV channels 70–83) and a pressing need for spectrum space was largely responsible for re-allocation. The portion of spectrum now includes business radio, public safety (police, fire, etc.) and general-purpose two-way radio. The lower portion is largely used by cellular mobile radio telephone services. The upper portion (above 900 MHz) is used for two-way radio, industrial radio, amateur radio, and miscellaneous purposes, such as wireless video and audio links, studio to transmitter (STL) links, and various Part 15 applications (low-power license-free uses), and even more! Figure 1 summarizes the current frequency allocations.

The frequencies are almost in the microwave region. Until recently, receivers for this band were scarce and usually special-purpose types. In the past few years, a number of communications receivers have been made available, covering from around 25 MHz or so up to over 1000 MHz. Some of the more expensive scanners cover portions of the 800–1000 MHz range, while others block out the bands.

Now you can build a converter that will allow the reception of signals from 800–1000 MHz on any scanner that covers frequencies in the 400–500 MHz range. The availability of high-performance transistors and Monolithic Microwave Integrated Circuits (MMIC's), together with very small components such as chip capacitors and prepackaged mixer assemblies, have made this feasible.

The antenna shown in the opening photograph is cut specifically for the 800-MHz band. It's available from the Cellular Security Group, 4 Gerring Road, Gloucester, MA 01930. Contact them directly for infor-

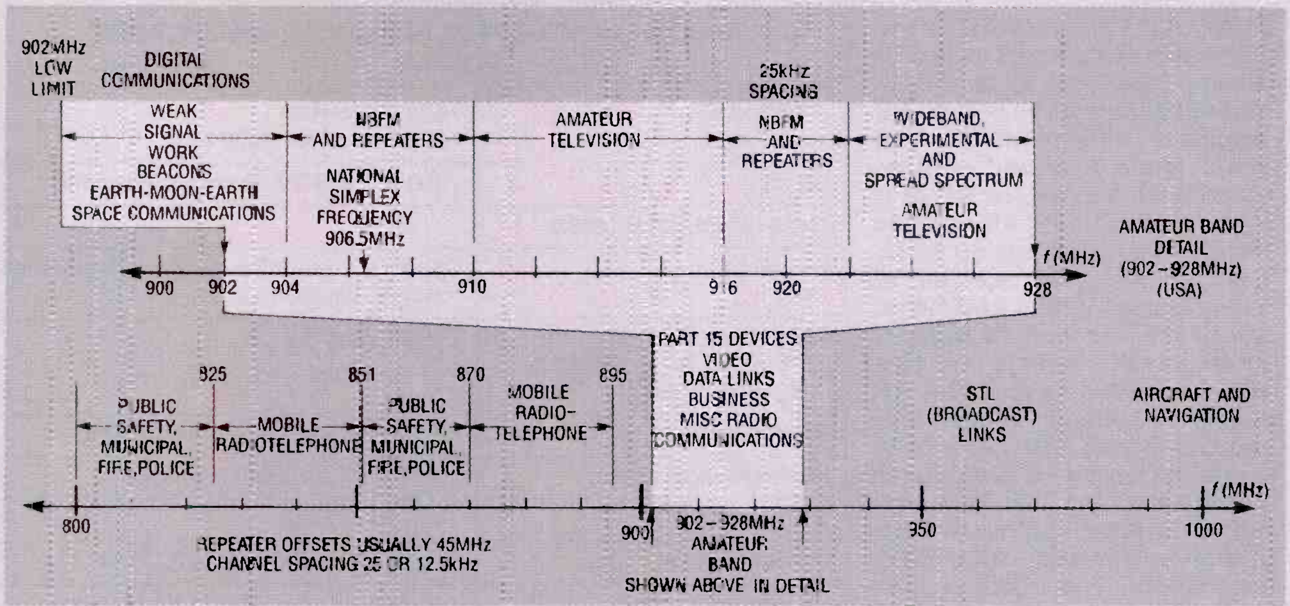


FIG. 1—THE 800–1000 MHZ UHF BAND has many signals of interest to the shortwave listener. Here is a summary of the current frequency allocations.

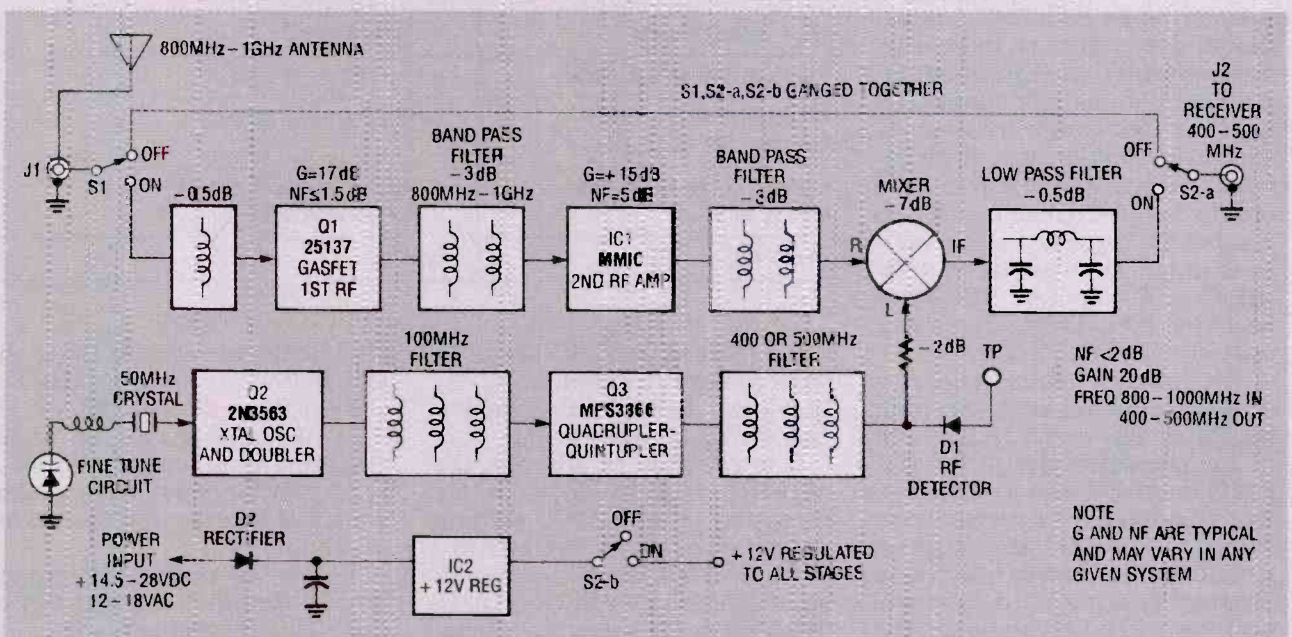


FIG. 2—BLOCK DIAGRAM. A GaAsFET feeds a double-tuned filter and a MMIC RF amplifier that feeds a second double-tuned filter. That feeds a double balanced mixer, or DBM. The DBM is also fed with a local oscillator signal of either 400-MHz or 500-MHz.

mation on that and other various UHF antennas.

The converter described in this article offers excellent performance (about 0.15 µV/12dB SINAD—signal-to-noise-and-distortion-ratio—sensitivity for standard 5-kHz FM), having an NF (noise figure) of about 2 dB, a gain of 20–25 dB, and an output frequency of 400–500 MHz. By simple tuning adjustment it can be set up for 800–900 or 900–1000 MHz ranges and optimized for any 30–40 MHz segment in the range. It will work well over the entire 100-MHz range if circuits are stagger-tuned, with only slightly reduced sensitivity. Applications of the converter are as follows:

1. Monitoring 800–900 or 900–1000 MHz ranges.
2. Amateur use for reception of 902–928 MHz band, downconverting to the 420–450 MHz range.
3. Reception of 902–928 MHz Amateur TV, using a standard TV receiver that covers UHF channels 20–23, and reception of wireless TV links operating in the 900-MHz range.
4. In conjunction with a 500-MHz counter, the measurement of frequencies in the 800–1000 MHz range.

Referring to the block diagram (Fig. 2), the converter uses a low-noise dual-gate

GaAsFET (gallium-arsenide field-effect transistor) as an RF preamplifier. That feeds a double-tuned filter and a second RF amplifier using a MMIC. The MMIC feeds a second double-tuned filter. The overall RF gain is about +27 to 30 dB and the bandwidth is around 30 MHz. That provides good rejection of out-of-band signals and helps minimize the feedthrough of unwanted signals in the 400–500 MHz range. The RF amplifier feeds a double balanced mixer, or DBM. The DBM is also fed with a local-oscillator signal of either 400-MHz (for 800–900 MHz conversion) or 500-MHz (for 900–1000 MHz conversion). The mixer output is therefore kept in the 400–500 MHz range covered by most scanners. The receiver should be suitable for the type of transmission to be received. A scanner is generally set to receive narrowband frequency modulation (NBFM) signals commonly used in this range in steps of 12.5 kHz, 25 kHz, etc. A TV receiver tuned to the lower UHF channels (14–23) can be used to receive TV signals in the 900-MHz range, such as amateur TV (ATV) and the new 900-MHz wireless video links. Converter output is at 50–75 ohms.

TABLE 1—800 TO 100-MHz CONVERTER SPECIFICATION

Freq Range RF Input IF Output	 400-500 MHz 800-900 or 900-1000 MHz
LO Freq	400 or 500 MHz, internally selectable
Noise Figure <2dB typical	
Sensitivity	gives 0.15 μ/12dBSINAD, 5 kHz deviation with typical scanner
Power Gain, RF to IF f^{IN} = 900 f^{out} = 500 MHz $R_S = R_L$ = 50 Ω	+22 dB typical
RF Bandwidth	40 MHz @ 3dB typical @ 900 MHz
Maximum Input Level	−40 dbm @ 1dB compression
Tuning Range	800-1000 MHz
Dynamic Range	Approx 90 dB (0.1 μc to 3000 μv)
Voltage and Current	+15-25 VDC @ 100mA, Neg ground or 12-16 VAC @ 300 mA peak, can be modified for +12 VDC regulated
Freq Control of L O	XTAL controlled .005%
Fine Tuning Range	±7 kHz typical
PC Board (finished) size	3½" × 5" × 1" high
RF to IF Feedthrough Isolation (IN-OUT) DB	>60 dB @ 400 MHz
Insertion Loss in dB with converter off	−1dB typical @ 400 MHz −0.3 dB typical @ 30 MHz
Switching	Built-in

The local oscillator (LO) is a 50-MHz crystal-based overtone oscillator. The second harmonic of the oscillator circuit (at 100 MHz) is used. A fine-tuning control is provided to compensate for any 800–1000 MHz signals not fitting the popular 12.5-kHz channel spacing used by many scanners. The LO can be shifted at least ±6 kHz to act as a fine-tuning control, if needed. Normally, the fine tuning is left set to center position.

The 100-MHz oscillator signal is fed to a multiplier stage using a UHF large-signal transistor as a quadrupler (×4) or a quintupler (×5) stage. The appropriate harmonic (4th or 5th) is selected by a triple tuned filter and the signal at 400 or 500 MHz is delivered to the mixer. The filter can select either signal depending on the setting of three variable capacitors. A diode detector samples the output of the filter so that a VOM can be used to align the filter simply by "peaking" the trimmer capacitors for maximum output.

It is possible to just use the 400-MHz signal. However, for reception of 900–1000 MHz, a receiver capable of tuning 500–600 MHz would be needed. Most scanners cover only up to 512 MHz or thereabouts. Therefore, the 500-MHz signal is necessary with these scanners for reception of frequencies over 912 MHz.

The converter board contains a switching network for switching the converter in or out. In the "out" position, the input jack, J1, simply connects to the output jack, J2, and all frequencies from DC to 550 MHz are passed. In this position, the DC line to the converter circuitry is also opened, thus disabling the converter.

The converter board also contains a rectifier and a regulator that delivers +12 volts DC to the converter circuitry. Either a +14.5- to +24-volt DC, or 12-volt AC supply can be used. Suitable supplies are either a wall transformer or one that mounts inside the converter case.

Referring to Fig. 3, let's go over a detailed description of the circuit. Signals enter J1 from the antenna and are routed to S1, a DPDT switch with only one side used. With S1 in the "off" position (converter off), signals from S1 are routed to S2-a, another DPDT switch. (Slide switches S1 and S2, although mounted at different locations on the PC board, are mechanically linked by an actuator rod assembly, so that correct switching is maintained.) Next, signals are routed through S2-a to low-pass filter L16-C15, and then to J2. The low-pass filter rejects signals above 600 MHz. A 50-ohm im-

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—100,000 ohms, ⅛-watt
R2—470,000 ohms, ⅛-watt
R3—180 ohms, ⅛-watt
R4—180 ohms
R5—390 ohms, ⅛-watt
R6—1000 ohms
R7—10,000 ohms, trimmer potentiometer with shaft
R8—10,000 ohms
R9—15,000 ohms
R10—3900 ohms
R11—330 ohms
R12—100 ohms
R13—15,000 ohms
R14—2200 ohms
R15—10 ohms, ⅛-watt
R16—47 ohms
R17—1 megohm
R18—15 ohms, ⅛-watt
R19—390 ohms, ⅛-watt
R20—10 ohms

Capacitors
C1, C8, C9, C13, C14—1–5 pF trimmer
C2–C7, C10–C12, C16, C28, C31—100 pF, 50 volts, chip
C15—5.6 pF NPO ±0.25 pF
C17—100 pF NPO, 5%
C18—39 pF NPO, 5%
C19—22 pF NPO, 5%
C20—2.2 pF NPO, ±0.25 pF
C21, C29—470 pF ±20%, disc
C22, C30, C32, C35, C36—0.01 µF, 50 volts, GMV disc
C23—33 pF NPO ±5%
C24—56 pF NPO ±5%
C25–C27—2–10 pF trimmer
C33—10 µF/16 volts, electrolytic
C34—470 µF/25 volts, electrolytic

Semiconductors
IC1—MAR-1 UHF amplifier
IC2—7812 +12-volt regulator
D1—MV2107 varactor diode
D2—HP5082-2800 hot carrier diode
D3—1N4007 rectifier diode
Q1—25137 dual-gate GaAsFET
Q2—2N3563 VHF NPN transistor
Q3—MPS3866 VHF NPN transistor
LED1—green light-emitting diode (optional)
LED2—red light-emitting diode (optional)

Inductors
L1–L5, L10–L12—part of PC-board etching
L6, L15—ferrite bead
L7—0.2–0.32 µH (9½ turns #22 enameled wire)
L8—0.05–0.1 µH (3½ turns #22 enameled wire)
L9—0.05–0.1 µH (3½ turns #22 enameled wire)
L13—1.0 µH RF choke
L14—ferrite bead on R20
L16—½-turn #22 enameled wire, ¼-inch diameter (see text)

Other components
J1, J2—female BNC connector
MOD1—MCL SBL-IX mixer module
S1, S2—DPDT PC-mount slide switch
XTAL1—50-MHz 3rd overtone crystal

Miscellaneous: PC board, small-diameter 50-ohm coaxial cable, project case, 14.5–24-volt DC or 12-volt AC 350-mA transformer (see text), hardware as required, brass rod or wire, 2¼-inch rubber grommets, line cord if required, solder, etc.

Note: The following items are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804:
- **Converter kit including all parts except case and transformer —$67.50 + $3.50 S&H**
- **PC board only—$13.50 + $3.50 S&H**
- **Transformer—$9.50 + $3.50 S&H**

New York State residents must add appropriate sales tax.

pedance level is maintained through the converter in the "off" position to reduce VSWR (voltage standing-wave ratio) and line losses, so that a scanner connected to J2 has normal reception when the converter is switched off. Switch S2-b breaks the 12-volt supply line in this position to disable the converter circuitry.

In the converter "on" position, signals from J1 in the 800–1000 MHz range are fed through S1 to L1 (an inductor that is incorporated in the PC board etching and acts as a short circuit to lower-frequency signals) and C1, which are resonant at 900 MHz.

For matching purposes, at 900 MHz, C1 and L1 must form a resonant circuit as well as an impedance transformer to step up the 50-ohm impedance to somewhere between 800 and 1000 ohms. The input impedance of the gate of RF amplifier Q1 is about 1 to 2K or higher, and shunted by about 1 pF capacitance. The output impedance of Q1 is between 1000 and 2000 ohms with 0.5–1 pF shunt capacitance. The voltage gain of Q1 is about 7.5 from gate 1 to drain, or about 17.5 dB.

There is about 1.5 dB loss in the output-coupling network and about 0.5 dB loss in L1, so that a total of about 15 dB gain is observed. The device is rated at 1.1 dB noise figure, but allowing 1 dB (approximate) loss in L1 and S1, an actual NF of about 2 dB will be obtained. That is adequate since cable losses in the typical antenna system will be around 6 dB anyway.

Transistor Q1 is a dual-gate gallium arsenide field effect transistor (GaAsFET) biased to about 5–10 mA drain current; R3 provides a self bias for Q1. Chip capacitors C4 and C5 are RF-bypass capacitors soldered directly to the solder side of the PC board for low inductance. They are the only type of capacitor that provides reliable bypassing at 900 MHz. Resistors R1 and R2 bias gate 2 of Q1.

The drain of Q1 feeds double-tuned filter C8-L2 and C9-L3, and R4 feeds bias to the drain of Q1 Typically, the tuned circuits in this RF amplifier are tuned to 900 MHz with about 2.5 pF capacitance, and L1–L5 have an equivalent inductance of 0.012 microhenry, although these values are typical and cannot really be isolated or measured. Inductors L2 and L3 are printed on the PC board and are proportioned to give the desired coupling and inductance. Their layout is critical and cannot be changed.

The signal from L3 is coupled through chip-capacitor C10 to IC1, a monolithic microwave IC (MMIC) amplifier with 50-ohm input and output. Resistor R5 provides about 17 mA operating bias for IC1, which gives about 13 to 15 dB gain at 900 MHz. The output of IC1 is coupled via C12 to filter L4-C13 and L5-C14. The five tuned circuits in this

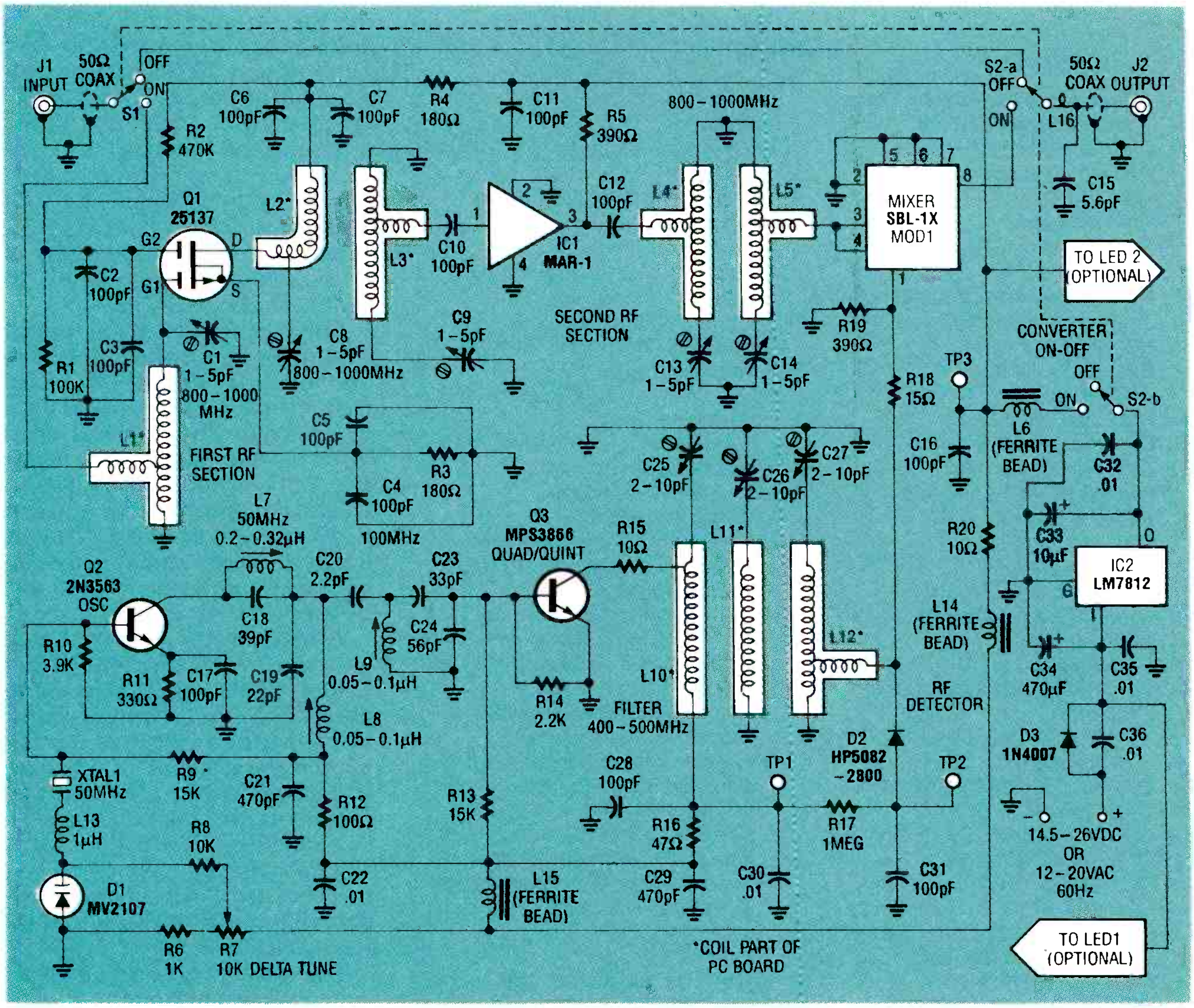


FIG. 3—CONVERTER SCHEMATIC. A 50-ohm impedance level is maintained through the converter with S1 in the "off" position so that a scanner connected to J2 still has normal reception. Switch S2-b breaks the 12-volt supply line in this position to disable the converter circuitry.

converter yield an overall RF bandwidth of 40 MHz at the 3 dB points. The signal from L5, about 28 to 30 dB stronger than the signal at J1, is applied to a mixer module (MOD1), an MCL SBL-IX, where it is mixed with the LO signal at 400–500 MHz. The IF output is then fed to S2-a, where it is connected to J2 via low-pass filter L16-C15.

An LO signal of either 400 or 500 MHz is required by mixer MOD1. It is generated as follows: Q2, a 2N3563, is configured as an overtone crystal oscillator. Emitter stabilization is provided by R11, and R9-R10 provide base bias. Resistor R12 supplies the collector voltage for Q2 through L7 and L8. Components L7 and C18 are nominally tuned to 50 MHz, the frequency of XTAL1. Components C19 and L8 form a resonant circuit at 100 MHz and therefore have a low impedance to 50-MHz signals. Bypass capacitor C21 RF grounds the bottom (cold end) of L8.

There exists a feedback capacitance (about 3 pF) between the collector and emitter of Q2. That, in conjunction with C17, forms an oscillator; the oscillation of Q2 would tend to take place at the resonant frequency of C18 (plus strays) and L7 (L7 is variable by means of a ferrite slug). The base of Q2 must be RF grounded, which can only occur at the series-resonant frequency of XTAL1, L13, and varactor-diode D1; D1 acts as a capacitor whose value can be varied via the applied DC voltage from potentiometer R7. Resistor R6 limits the lowest voltage to about 1 volt, and R8 provides RF isolation for D1. Varying R7 has the effect of varying the effective frequency of the crystal plus and minus 1000 Hz. When L7 is nominally tuned to 50 MHz, the crystal oscillator circuit produces a signal of 50.000 MHz. However, we need 100 MHz.

Since Q2 operates as class-C and produces harmonics, filter L8-C19 is tuned to 100 MHz. That transfers 2nd harmonic energy (6–10 dB below the fundamental 50 MHz) via coupling capacitor C20 to a second 100-

MHz tuned circuit (C23, C24, and L9). Capacitors C23 and C24 are chosen so as to match the oscillator to the base of frequency multiplier Q3, an MPS3866. That generates harmonics of 100 MHz in the base circuit of Q3. Capacitor C24 is chosen to have a low impedance at higher frequencies to encourage the flow of harmonic currents in the base circuit of Q3.

Inductors L10, L11, and L12 form a filter tuned to either 400 or 500 MHz by adjustment of C25, C26, and C27. There is sufficient tuning range to cover either 400 or 500 MHz. The filter is triple-tuned and L10, L11, L12, and their coupling coefficients are determined by the PC board layout which they are part of. RF energy at 400 (or 500) MHz is taken from a tap on L12 and fed to mixer MOD1.

Without the right test equipment, it would be difficult to align C25, C26 and C27. However, the problem is solved by diode detector D2, C31, and R17. Resistor R17 slightly forward biases D2 to produce about +0.2V at test point TP2.

When RF drive is applied from L12, a negative voltage is produced at TP2. When the triple-tuned filter is correctly tuned and Q3 is operating properly, about −0.3 volts is produced by D2, since about 300 millivolts of RF is present from L12. This, when added to the +0.2V bias on D2, produces −0.1V at TP2. Diode D2 is forward-biased to improve its sensitivity at low RF levels. Tuning of C25, C26, and C27 simply consists of monitoring the DC voltage at TP2, and obtaining the most negative voltage possible by peaking C25, C26, and C27.

Regulator IC2, a 7812, provides 12-volts DC power to the circuit; C32 and C33 and C34, C35 help stabilize IC2. Rectifier D3 acts as a protection device in case a negative DC voltage is applied to the circuit, and C36 reduces 60-Hz buzz caused by switching transients in D3. At least 14-volts DC is required across C34 for IC2 to function.

When we continue next time, we'll build the converter and show you how to align it. R-E

Will new standards bring of AM radio?

LEN FELDMAN

AM TRIES FOR

IT MAY COME AS SOMETHING OF A SURPRISE TO THOSE OF us who pay little attention to AM radio that this oldest of all broadcast services is due for some upgrading. After all, the FM radio service has been the preferred form of radio broadcasting in this country for at least two decades, now, and even FM radio may some day be obsoleted by digital audio broadcasting, or DAB. In fact, more than a dozen proposals for DAB are currently either on the drawing boards or have been demonstrated in prototypes. So why bother with AM radio at this late date?

The AM stereo debacle

Back in the mid-1980's, the Federal Communications Commission considered several systems for AM stereo broadcasting. Many AM broadcasters felt then that the reason for the decline of AM radio audience was the fact that FM could offer stereo whereas AM could not. Initially, the FCC selected one of some six systems, the Magnavox proposal, as a "standard." Faced with all sorts of threats of litigation by other proponents, the FCC reversed itself shortly thereafter and in effect, said, "let the marketplace decide." Since then, the field of proponents has narrowed down to two—the Motorola C-Quam system (by far the most popular) and the Kahn-Hazeltine system. Many experts maintain that by not coming down in favor of a specific system, the FCC has discouraged both manufacturers of receivers and AM radio broadcasters from moving to stereo.

With AM broadcasting audience on the decline for many years, manufacturers of high quality AM/FM tuners and receivers have paid little attention to the AM circuitry that they incorporate in their products. Figure 1 shows the actual frequency response measured for the AM section of a highly reputed AM/FM stereo receiver. No wonder listeners accustomed to playing digital compact discs and FM radios are "turned off" by this kind of AM reception! This "afterthought" approach by receiver manufacturers further exacerbated the problem. Another problem of AM has been adjacent channel interference—a problem that is particularly intense during evening listening. Many professionals blame the FCC for that problem as well, maintaining that the granting of broadcast licenses by the FCC has been a poorly administered "pork barrel" affair with little

back the good ol' days

A COMEBACK

attention paid to the technical problems that have inevitably resulted from an overcrowding of the broadcast band.

NRSC to the rescue!

As the AM broadcasters situation became worse and worse, the National Association of Broadcasters (NAB) and the Electronic Industries Association (EIA) finally decided to address some of the problems in what amounted to a major cooperative effort between organizations that, up until that time, had pretty well ignored each other. The two organizations formed a separate committee known as the National Radio Systems Committee, or NRSC. In a series of meetings, the NRSC came up with two standards recommendations, known as NRSC-1 and NRSC-2. A proposal to make NRSC-1 a national voluntary standard was issued in January 1990, and in March 1991, the EIA published the contents of NRSC-1 as an interim standard (EIA/IS-80) entitled "Audio Bandwidth and Distortion Recommendations for AM Broadcast Receivers." On a parallel track, the FCC issued a report and order on April 27, 1989 in which compliance with NRSC-1 was made mandatory as of June 30, 1990, while measurement of compliance with NRSC-2 was postponed until June 30, 1994. Both NRSC-1 and NRSC-2 were designed to address the problems of audio fidelity and interference mentioned above.

NRSC-1 and EIA/IS80

Let's take a look at the EIA Standard developed for receiver manufacturers first. Radio receivers that satisfy the technical requirements of this specification must have a frequency response of not less than 50 Hz to 7500 Hz, with limits of +1.5 dB and −3.0 dB, referred to 0 dB at 400 Hz. Since "opening up" the bandwidth to this extent might well increase interference from adjacent channels—especially in crowded metropolitan areas and during nighttime listening—receiver manufacturers may choose to offer a switch on their products that would, at the user's option, reduce bandwidth. As long as at least one of those switch positions results in the frequency response just stated, the receiver will be considered to comply with the new standard.

The second part of the NRSC standard deals with harmonic distortion. It states that receivers designed to satisfy the standard shall not exhibit more than two percent (2.0%) total harmonic distortion plus noise (THD + N) at all measured frequencies between 50 Hz and 7500 Hz. Two percent distortion may sound like a high number to those of us accustomed to the distortion levels of modern audio amplifiers and FM tuners, but, in fact, many current non-conforming AM tuners exhibit far higher distortion levels than that!—particularly at higher audio frequencies.

A third recommendation of the standard involves the incorporation of circuitry into AM receivers that attenuates 10.0-kHz adjacent-channel carrier frequencies by 30 dB, or 20 dB when the measurements are made with preemphasis characteristics inserted at the AM input of the RF test signal generator. To clarify that last point, we should note that in recent times, recognizing that AM radios had very poor high-frequency response, broadcasters began boosting the audio treble response of their transmission chains in an attempt to overcome the high frequency attenuation present in nearly all AM radios and tuners. Unfortunately, no two stations used the same boost of preemphasis characteristic. Furthermore, an overly extreme use of high-frequency preemphasis made the problems of interference between adjacent channels even worse. So, included in the NRSC-1 recommendation is a fixed preemphasis characteristic that AM radio broadcasters are required to use. The preemphasis characteristic, not unlike the one used by FM broadcasters in the U.S., is shown in Fig. 2.

Assuming that broadcasters conform (and as of this writing, well over half the AM broadcasters in the United States have embraced NRSC-1 standards), manufacturers of AM radios are expected to voluntarily incorporate standard, fixed deemphasis networks. In measuring the frequency response of an AM radio conforming to the new standards, a laboratory would expect to obtain a frequency response such as that shown by the dashed line in Fig. 3. The solid lines represent the allowable deviation or tolerance over the range from 50 Hz to 7.5 kHz. Results shown in Fig. 3 presuppose that the appropriate preemphasis network is installed between the audio generator and the amplitude modulation input terminals of the RF signal generator. If such a preemphasis network is not used in the test, results should be as shown in Fig. 4.

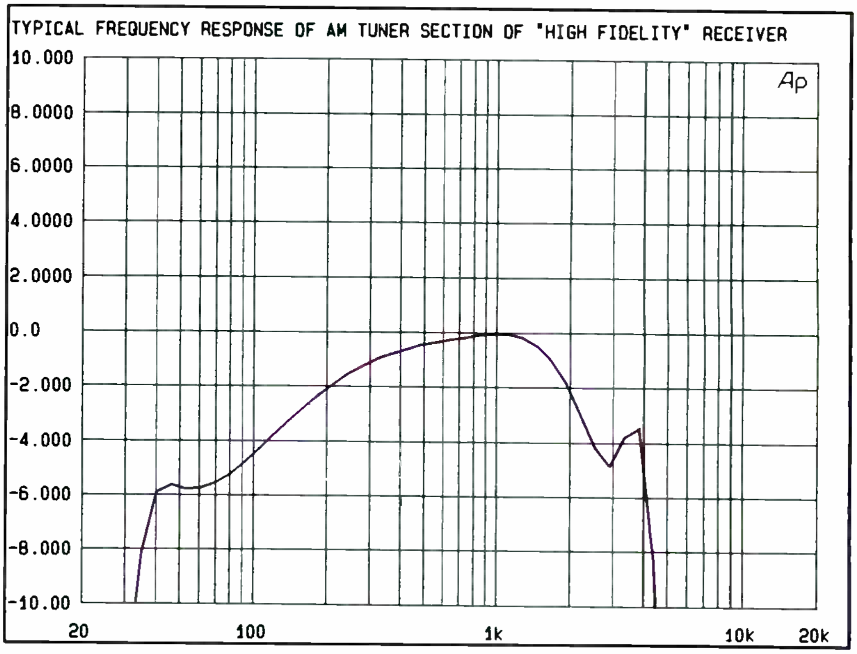


FIG. 1—AMPLITUDE VERSUS FREQUENCY. This is the response of the AM tuner section of a "hi-fi" AM/FM stereo receiver!

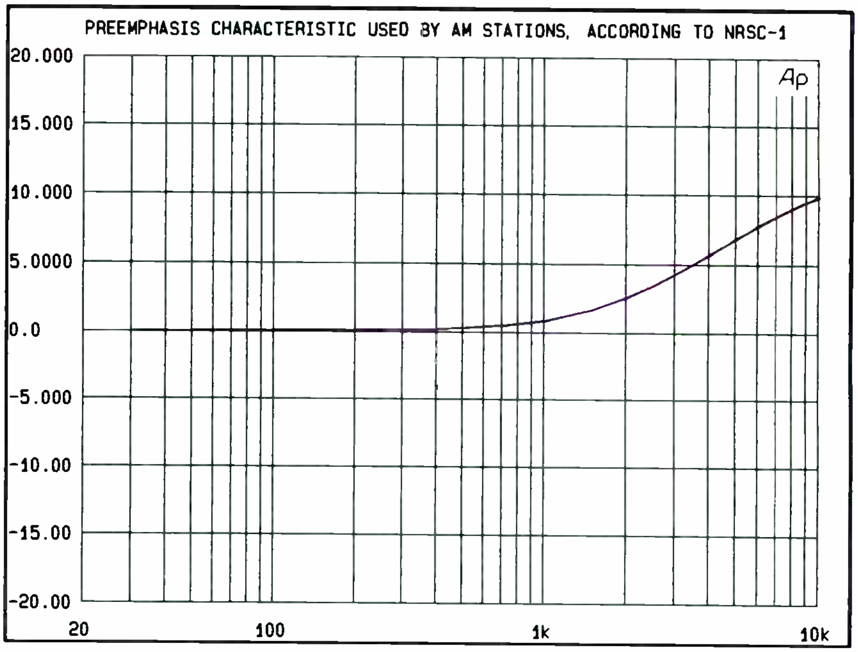


FIG. 2—BY STANDARDIZING THE PREEMPHASIS CHARACTERISTIC used by AM broadcasters, AM receiver manufacturers are able to incorporate standard deemphasis networks in their products to achieve the desired flat response to 7.5 kHz or better.

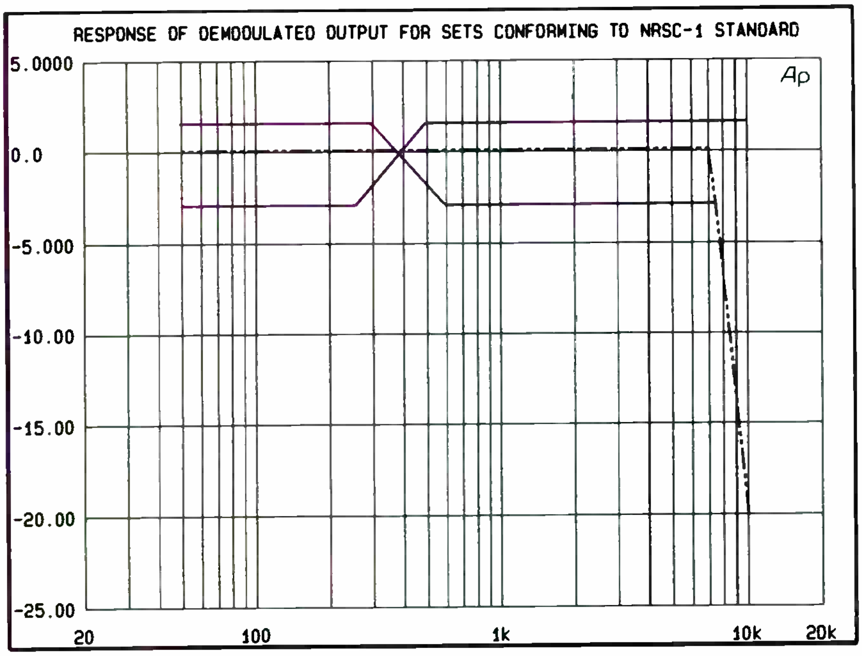


FIG. 3—FREQUENCY RESPONSE of AM circuitry that is required to conform to the NRSC-1 standard. The dashed line represents an ideal response, with the solid lines representing the tolerance limits. (Presumes preemphasis in the RF test generator.)

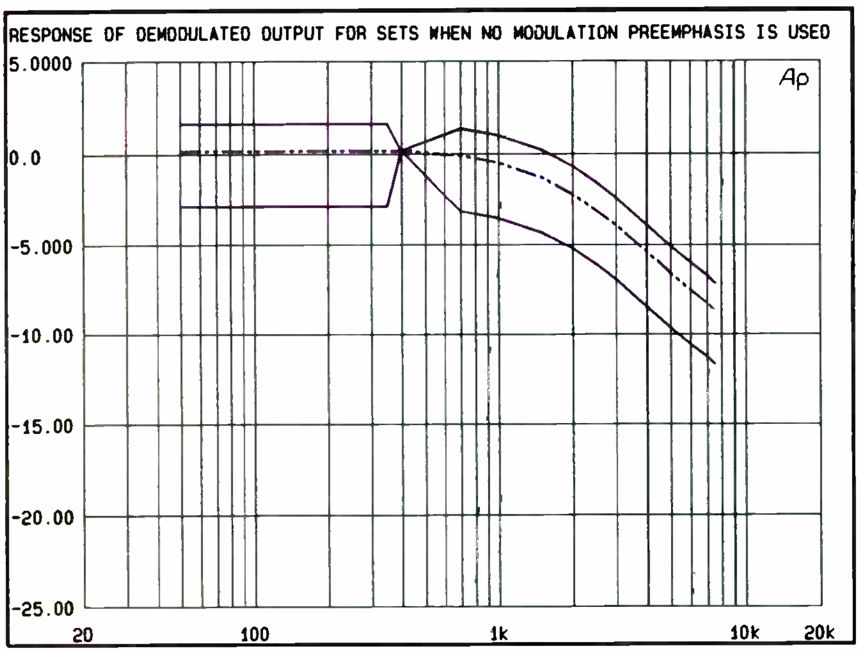


FIG. 4—FREQUENCY RESPONSE of AM circuitry that is required to conform to NRSC-1, with no preemphasis in the RF test generator.

FIG. 5—AMAX LOGOS will identify AM radios that meet the NRSC requirements.

NRSC-2 by 1994

During the interim period from June 1990 to June 1994, the FCC is going to presume that if a station conforms to NRSC-1, it is also in compliance with NRSC-2. The chief reason for the delay is the lack of appropriate, inexpensive test equipment needed to confirm compliance with all the provisions of NRSC-2. Those provisions mandate that. NRSC-2 deals primarily with attenuation of carrier emissions rather than indirectly with audio response and performance. According to the NRSC-2 rules, emissions between 10.2 kHz and 20 kHz removed from the carrier's fundamental RF frequency must be attenuated at least 25 dB below the unmodulated carrier level. Emissions between 20 kHz and 30 kHz away from the carrier frequency must be attenuated by at least 35 dB below the unmodulated carrier level. Emissions that are between 30 kHz and 60 kHz away from the carrier frequency must be attenuated by at least 5 + 1dB/kHz below the unmdodulated carrier level. (For example, emissions that are 50 kHz away from the carrier frequency would have to be attenuated by 5 + 50, or 55 dB relative to the level of the unmodulated carrier). Finally, emissions between 60 kHz and 75 kHz must be attenuated by at least 65 dB.

More breathing room

While the NRSC-1 and NRSC-2 provisions will certainly help alleviate some of the problems of interference between stations, it cannot do the whole job in view of the congestion of the AM band that now exists in some geographical areas. Accordingly, as of July 1, 1991, the FCC officially expanded the AM band by an additional 100 kHz. The band now extends from 535 kHz to 1705 kHz.

This additional spectrum space is expected to accommodate at least 200 AM stations, nationally. Rather than increase the number of licenses to broadcasters, however, it is expected that those stations causing the most severe interference will be asked to move up into the new frequencies. In order to retain their audiences, however, it is likely that those stations whose frequencies are reallocated to this new portion of the band will be allowed to "simulcast" on their existing frequencies for some time until a sufficient number of new AM radios are purchased by the listening public. Manufacturers (and particularly makers of car audio systems) have already incorporated the new swath of frequencies in their products and it turns out that the cost of doing so is minimal.

A new symbol of excellence

As these attempts to improve AM transmission and reception were being formulated, the NAB and the EIA came up with the idea that it would be nice to have some visible means of identification displayed on radios that meet the requirements of the new standards. After nearly two years of agonizing over the design of a symbol, the organizations have come up with a decal to be called the "AMAX" symbol, which stands for "AM Radio at its maximum potential." The certification logo could be affixed to radios that meet basic eligibility criteria including the equalization standards, variable bandwidth and other requirements described earlier. Two types of logos will be available. The second one, reading "AMAX Stereo," will be applied to improved AM radios that also have stereo capability. Illustrations of both logos appear in Fig. 5.

The "AMAX" program does not mandate a particular stereo AM format—only that the radio be capable of receiving and decoding *some* kind of AM stereo transmission. Of course, the decision to market AMAX certified radios is at the discretion of individual manufacturers, as is the decision to apply the "AMAX" or "AMAX Stereo" logo to the sets themselves. Interestingly, we recently learned that the latest Delco/Bose car audio radios, as installed in some 1992 model General Motors automobiles, do in fact meet the AMAX criteria but for reasons of aesthetics, the car maker elected not to apply the logo to the radios, at least for the present.

The NAB plans to publicize the logo through its member stations, who will be encouraged to develop promotional tie-ins with local audio retailers. NAB is also expected to unveil a major campaign by the time you read this, promoting enhanced AM radio to consumers. In addition to the improvements that we have already mentioned, eligibility of a radio to bear the AMAX symbol must also include provision for an external antenna, noise blanking for pulse-type interference and the expanded AM band.

Will improvements help?

While both the EIA and the NAB are enthusiastic about these attempts to improve AM, the question that remains is whether or not AM can attract enough of an audience to remain a major broadcasting format in the years ahead. Even though it is still uncertain whether or not the improvements in AM broadcasting and reception will attract new listeners to the band, the many improvements are certain to be welcomed with open arms by those who have been listening to AM for quite some time. While many AM broadcasters speak of a "level playing field" (against FM), the fact is that even with response extending to 7.5 kHz, sound quality cannot compare with the quality of FM, to which so many listeners have become accustomed.

Still, when you hear an AM broadcast that has extended frequency response of this kind, it's amazing how good it does sound when compared with the "typical" AM radio sound we have endured for many years. Perhaps AM radio can be given a new lease on life—even if it's only a temporary reprieve until digital audio broadasting (which some now prefer to call digital audio radio, or DAR) replaces both of our current modes of radio. R-E

MICHAEL A. LASHANSKY

SWEEP/FUNCTION GENERATOR

Let's build our benchtop function generator and frequency counter!

LAST MONTH WE INTRODUCED YOU to our professional-quality 2.5-MHz function generator and frequency counter that can read up to 150 MHz. This month we'll show you how to build, test, and properly use this essential test instrument.

Construction

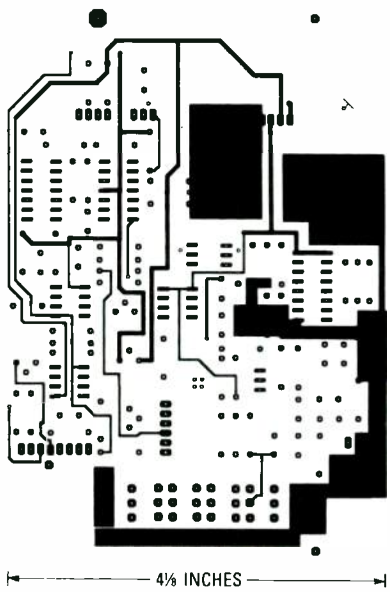
The function generator circuitry is mounted on three PC boards; the mother board, daughter board, and LED display board. The PC boards are available from the source mentioned in the parts list. Foil patterns are provided here if you wish to make your own boards, however the artwork was designed for nonplated holes. In places where it is impossible to solder both sides of a component, such as in the switch arrays, vias are provided for wire connections from one side of the board to the other. If you do make your own board you'll have to solder some wires from the top of the switch arrays to points on the board. That is not necessary if you use the boards supplied with the kit.

Figures 6 and 7 show internal photographs of the author's prototype. Solder all diodes and resistors first, followed by the capacitors and then the IC's. IC sockets are not required, but they may make life a lot easier in the event of trouble.

It's best to build and test functional blocks as you go rather than building the whole unit all at once. First, start by constructing all the cable assemblies as indicted in Fig. 8. Start with the power-supply section, and verify that the output voltages are correct. The AC power cord routes through a strain relief in the back panel and one side is soldered to the top of switch S15 (pole a). The other AC lead is soldered to the pad connected to fuse F1.

Next, build the triangle and square-wave generator sections. Those sections consist of components with the 1XX and 2XX component numbering scheme. A parts placement diagram of those sections, located on the main board, is shown in Fig. 9. You will need an oscilloscope to verify that a triangle wave of about two volts peak-to-peak is present at the gate of Q5, and a one-volt peak-to-peak square wave is present at the collector of Q6. If those two waveforms are not present, go back and check your solder joints and component orientations.

Potentiometers R125 and R126 set the symmetry of the waveform and should be adjusted to give a triangle wave with equal slopes. R129 sets the upper frequency limit and should be adjusted to give your desired high frequency for a given range. That is done with the course frequency-adjust potentiometer S101 in its maximum position. As a general guide set R129 for a maximum frequency of 2.5 MHz, with the 1-MHz range switch engaged. Potentiometer R223 sets the zero balance of the triangle wave and is adjusted to give a centered signal. Square-wave balance is achieved through potentiometers R224 and R225. You can now check the pulse output for TTL levels and a variable CMOS level. With the basic gen-



COMPONENT SIDE DAUGHTER BOARD foil pattern.

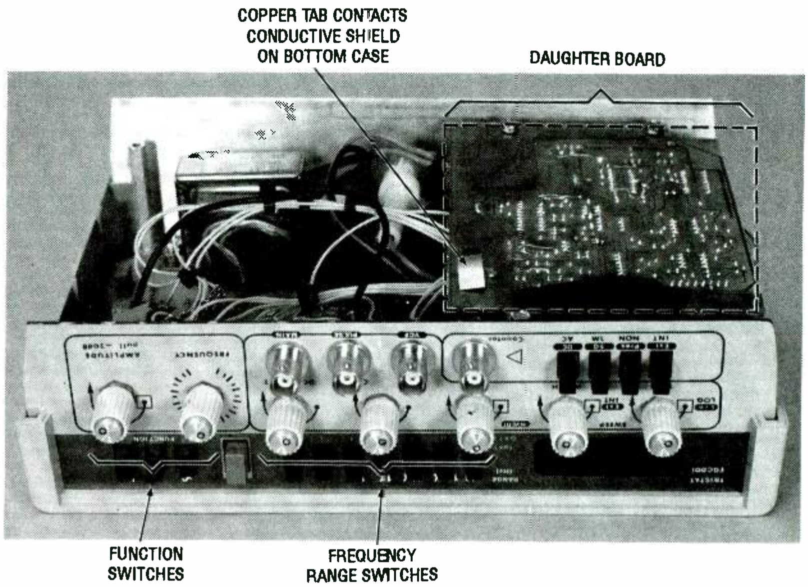
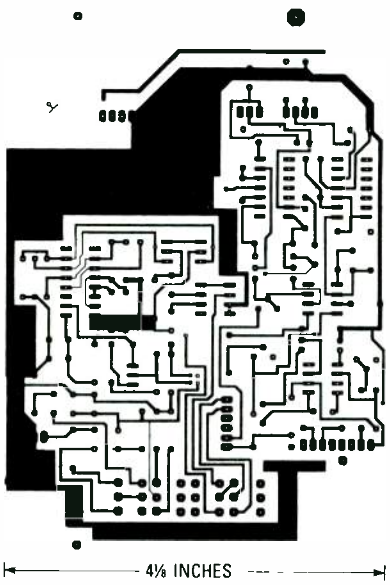


FIG. 6—INSIDE VIEW OF the author's prototype. A transparent red acrylic sheet was used for the front panel. A copper tab is soldered to the ground plane of the daughter board and contacts a 9½ by 3½-inch conductive shield, which is glued to the inside of the bottom case (not shown).



SOLDER SIDE DAUGHTER BOARD foil pattern.

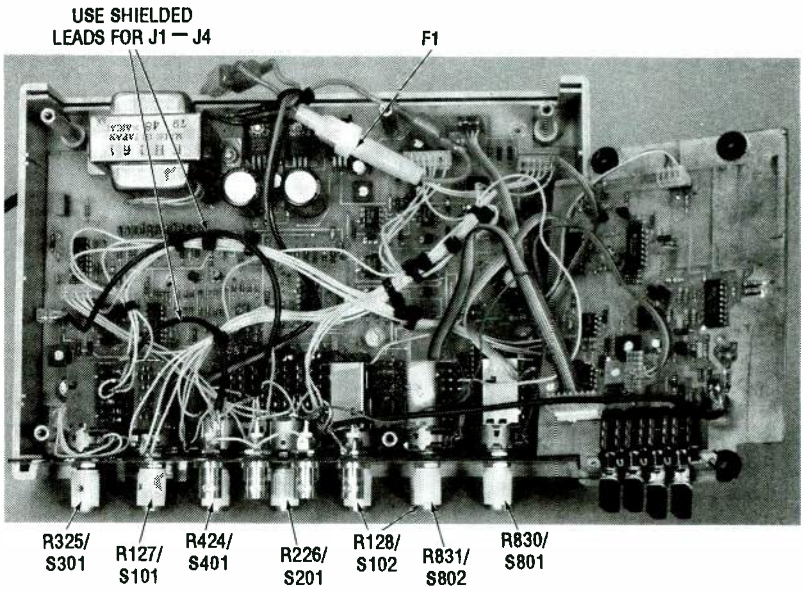


FIG. 7—INTERNAL PHOTO OF the author's prototype. Start construction by connecting all cable assemblies to switch-potentiometers mounted on the front panel.

erator now functioning, build the sine-shaper circuit (component numbers 3XX) and verify a sine wave at the output of IC9.

Adjust R323 for a two-volt peak-to-peak sine-wave output at IC9 pin 12. The amplitude of the square wave is controlled by R324, which should be set to give a clean square wave without any overshoot or rounding on the edges.

The output amplifier should be built next. That section uses the 4XX numbering scheme. Set to R423 to its center position and adjust it only if there is no output. Next, put your oscilloscope on DC coupling and observe the DC level of the output, adjust R422 until the output waveform is centered around zero. Verify the open-circuit signal swing of 20 volts peak-to-peak and the −20-dB attenuator switch.

The last work on the mother board is to build the frequency-counting section and to mount the display board. The six display LED's are soldered to the display board, which is connected to the motherboard by a 90-degree, 14-pin strip header. With the display and components in place, observe the display. Select the MHz range and make sure that all the digits are functioning. If not, go back and double check the circuit. Use a frequency counter or scope to calibrate the counter by adjusting C504 so that the display reading is the correct frequency selected.

The daughter board, which holds the counter input amplifier and sweep generator is as-

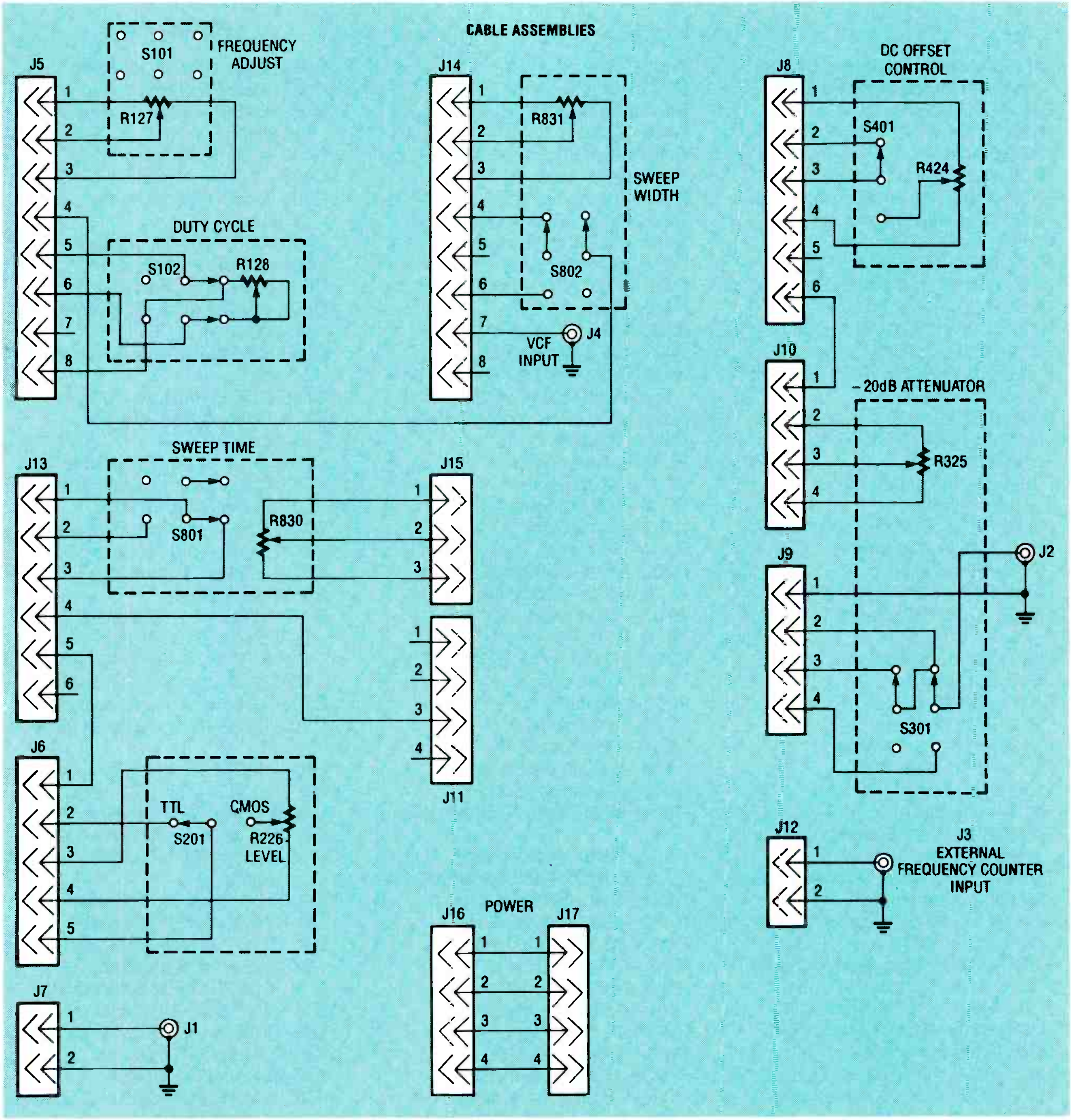


FIG. 8—CABLE ASSEMBLIES show the potentiometers that are connected to each of the function switches.

sembled next. That parts-placement diagram is shown in Fig. 10. The frequency-counter input circuit must be tested with an external signal or by selecting the external-signal source function and jumping the generator output to the counter input. Testing consists of verifying the operation of the switches, S11–S14 and the input amplifier.

The input amplifier can be tested by varying the amplitude of an input signal from about 25 millivolts to 50 volts peak-to-peak (if no test signal is available, use the generator itself) and observing the frequency reading on the display. The frequency should remain the same for all amplitude conditions. When selecting the prescale function, the display should shift two decimal places to the right if working correctly.

All the boards were designed to use transistors with an emitter-collector-base pin arrangement, and the rectangular pads are configured to accept that. If you choose to use the alternate transistors indicated in the parts list, they are American made, and use an emitter-base-collector pin arrangement. When the substitutes are used, a small circular pad is placed between the emitter and collector of the rectangular pads. This circular pad is used for the base pin and the collectors and emitters remain connected to the rectangular pads.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise indicated.
R101—2700 ohms, 1%
R102, R104, R105, R109, R111—100,000 ohms, 1%
R106—33,200 ohms, 1%
R107, R108, R110—1000 ohms, 1%
R112, R114—3010 ohms, 1%
R113—49,900 ohms, 1%
R115, R120—4990 ohms, 1%
R116, R121—7150 ohms, 1%
R117, R122—348 ohms, 1%
R118, R123—75,000 ohms, 1%
R119, R124—750,000 ohms, 1%
R125, R126, R826, R827—10,000 ohms, potentiometer
R127, R128—5000 ohms, potentiometer (part of S101 and S102, respectively)
R129, R825—20,000 ohms, potentiometer
R201, R210, R220—10,000 ohms
R202, R222—470 ohms
R203—390 ohms
R204, R206, R219–1000 ohms
R205, R216, R217—2700 ohms, 1%
R207, R208—4020 ohms, 1%
R209—511 ohms
R211—30,000 ohms
R212—2000 ohms
R213, R214—13,000 ohms
R215—910 ohms, 1%
R218—7500 ohms
R221—47 ohms
R223, R828—5000 ohms, potentiometer
R224, R225, R228, R229—2000 ohms, potentiometer
R226—10,000 ohms, potentiometer (part of S201)
R227—4700 ohms, potentiometer
R301—49,900 ohms, 1%
R302, R303—11,300 ohms, 1%
R304, R306—12,100 ohms, 1%
R305—309 ohms, 1%
R307—200 ohms, 1%
R308, R309—24,900 ohms, 1%
R310—127 ohms, 1%
R311—63.4 ohms, 1%
R312, R313, R320—1000 ohms
R314—5100 ohms
R315—680 ohms
R316—150 ohms
R317—6800 ohms
R318, R319—10,500 ohms, 1%
R321—2000 ohms
R322—12 ohms
R323, R324—1000 ohms, potentiometer
R325—5000 ohms, potentiometer (part of S301)
R401, R402, R503, R504—10,000 ohms
R403, R404—22,000 ohms
R405—170 ohms, 1%
R406—12,000 ohms
R407—1200 ohms
R408—2000
R409—18,200 ohms 1%
R410—270 ohms, 1%
R411—100 ohms, 1%
R412, R414, R502—3000 ohms
R413—24,3000 ohms, 1%
R415, R418—47 ohms, 1W
R416, R417—7.5 ohms
R419—50 ohms, ½W
R420—499 ohms, ½W
R421—56.2 ohms, 1%
R422, R424—10,000 ohms, potentiometer (R424 is part of S401)
R423—200 ohms, potentiometer
R501—100,000
R505—10 megohms
R701—10,000 ohms
R702—100,000 ohms
R703—1 megohm
R704—50 ohms
R705, R718—150 ohms
R706, R712—220 ohms
R707—470 ohms
R708, R715—51 ohms
R709–R711, R713, R714, R716, R717—510 ohms
R719—36 ohms
R720—1000 ohms
R801—7500 ohms, 1%
R802—33,000 ohms, 1%
R803—33 ohms, 1%
R804, R805, R807—5100 ohms, 1%
R806, R810, R816, R817, R819, R820, R822—10,000 ohms, 1%
R808—510,000 ohms, 1%
R809—2200 ohms, 1%
R811—22,000 ohms, 1%
R812—2400 ohms, 1%
R813—100 ohms, 1%
R815—150,000 ohms, 1%
R818—15,500 ohms, 1%
R821—2000 ohms, 1%
R823—15,000 ohms, 1%
R824—18,000 ohms, 1%
R830, R831—5000 ohms, potentiometer (part of S801 and S802, respectively)

Capacitors
C101, C102, C204, C205—0.1 μF ceramic
C103, C203—100 pF, ceramic
C104—0.001 μF, Mylar
C105—0.01 μF, Mylar
C106—0.1 μF, Mylar
C107—1 μF, Mylar
C108, C504—15–60 pF, variable capacitor
C201—68 pF, ceramic
C202—0.047 μF, ceramic
C301, C303—0.1 μF, ceramic
C302, C304, C502—39 pF, ceramic
C305, C401—4.7 pF, ceramic
C307—15 pF, ceramic
C308, C408—5–35 pF, variable capacitor
C402—120 pF, ceramic
C403—2.2 pF, ceramic
C404, C406—6.8 μF, tantalum, 20 volts
C405, C407—0.047 μF, ceramic
C501—33 pF, ceramic
C503—10 pF, ceramic
C601, C602—1000 μF, electrolytic, 50 volts
C603, C604—100 μF, electrolytic, 50 volts
C605—1 μF, tantalum, 20 volts
C701, C704–C706—0.1 μF, ceramic
C702, C707—100 pF, ceramic
C703 10u tantalum 16 volts C801—22 μF, tantalum, 16 volts
C802, C803—220 pF, ceramic
C804, C805—100 pF, ceramic
C806—500 pF, ceramic

Semiconductors
D101–D108, D201–D204, D206–D226, D301–D312, D315–D318, D401, D402, D701, D702, D801—1N4148 diode
D205—1N751, 5.1-volt Zener diode
D313, D314–1N746, 3.3-volt Zener diode
BR1—W02M bridge diode
Q1, Q4, Q12, Q13, Q21—2SC1815 or MPSA05 NPN transistor
Q2, Q3, Q6, Q7, Q11, Q19, Q20—2SA1015 or 2N4403 PNP transistor
Q5, Q17—2N4416, N-channel FET
Q8—2N3904, NPN transistor
Q9, Q10, Q14—2SC1923 or MPSH34, NPN transistor
Q15—2N2219, NPN transistor
Q16—2N2905, PNP transistor
Q18—PN5139, PNP transistor
IC1, IC2—LM741, op-amp
IC3, IC4—LM308, op-amp
IC5, IC6, IC20—CA3086, NPN transistor IC (Harris)
IC7—7420, dual 4-input AND gate
IC8—4011, quad NAND gate
IC9—CA3030, op-amp
IC10—4066, CMOS quad bilateral switch
IC11—7216B, frequency counter and LED driver (Intersil)
IC12—7815, +15-volt voltage regulator
IC13—7805, +5-volt voltage regulator
IC14—7915, −15-volt voltage regulator
IC15—MC10116, ECL triple-line receiver with Schmitt trigger (Motorola)

IC16—SP8629, prescaler (Plessy)
IC17—LM324, quad op-amp
IC18—MC1458, dual op-amp
IC19—CA3140, op-amp (Harris)
SR801—1000 ohms, thermistor
DISP1–DISP6—common-cathode LED (FND357)

Other components

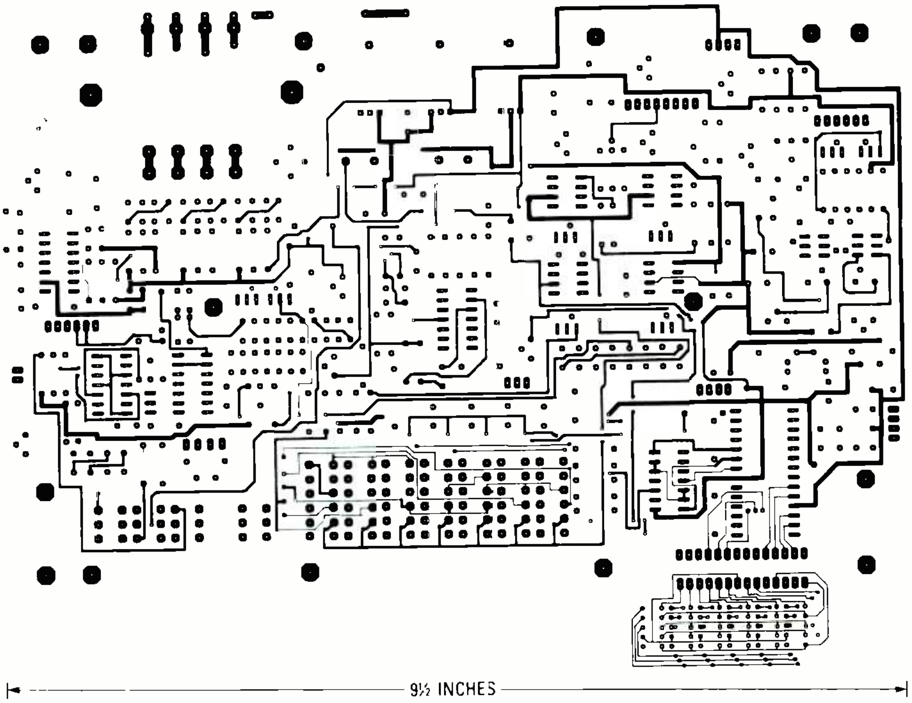
S1–S7—4PDT-D switch
S8—DPDT switch
S9–S11—DPDT-D switch
S12–S14—DPDT-I switch
S15—DPDT on/off switch
S101—DTDP switch used with R127 (5K potentiometer)
S102—DTDP switch used with R128 (5K potentiometer)
S201—SPDT switch used with R226 (10K potentiometer)
S301—DPDT switch used with R325 (5K potentiometer)
S401—SPDT switch used with R424 (10K potentiometer)
S801—DPDT switch used with R830 (5K potentiometer)
S802—DPDT switch used with R831 (5K potentiometer)
J1–J4—BNC connector
J5, J14—8-position female/male, 0.1-inch centers
J6—5-position female/male, 0.1-inch centers
J7, J12—2-position female/male
J8, J13—6-position female/male
J9–J11, J15, J16—4-position female/male, 0.1-inch centers
XTAL1—10-MHz AT/CUT crystal
T1—115/40 volts AC, 0.5-amp transformer
F1—0.5-amp fuse

Miscellaneous: Case (CTP-1 by Global Specialties), three 1.75-inch standoffs, four 2-inch standoffs, two T0-5 heatsinks, three T0-220 heatsinks, three PC boards, internal wiring, fuseholder, 3-conductor 18-gauge power-supply cord, and strain relief.

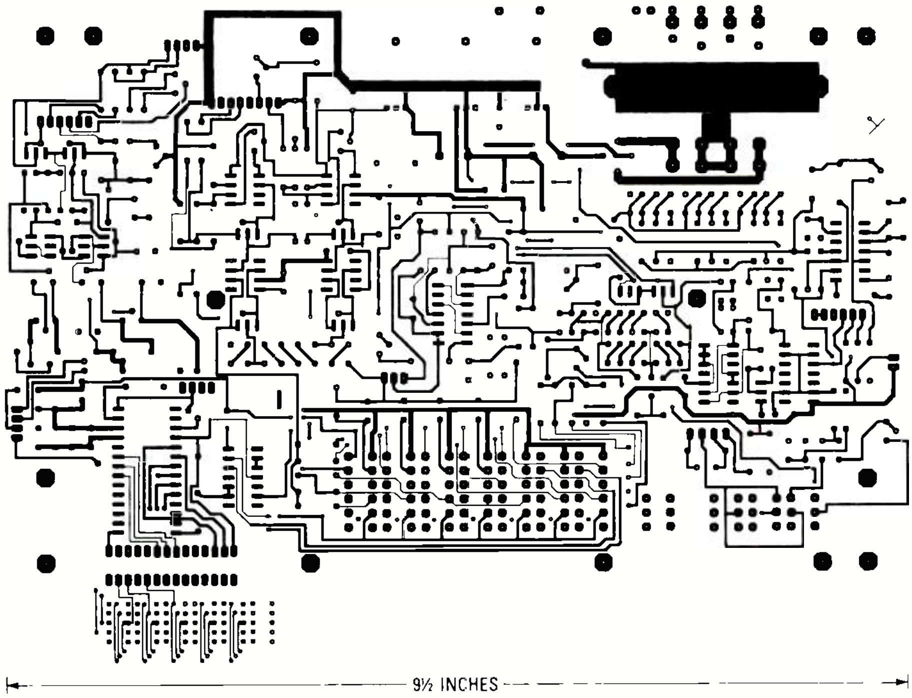
Note: The following items are available from Tristat Electronics, Inc., 66A Brockington Cres., Nepean, Ontario, Canada, K2G 5L1, (613) 228-7223:

- **A set of three etched and drilled PC boards—$76.**
- **All components without the PC board and case—$250.**
- **Complete kit of all parts (unfinished front panel)—$300.**
- **Cut and silk-screened front panel—$10.**

Add $17 for shipping and handling. Send check or money order only.



COMPONENT SIDE FOIL pattern of the mother board.



SOLDER SIDE FOIL PATTERN of the mother board.

The sweep generator is built next. If you're using the boards supplied with the kit, mount potentiometers R825–R828 to the solder side of the board. That will make adjustments easier when the unit is assembled. If you're making your own boards, place the potentiometers on the component side and make your adjustments before the board is connected to the mother board.

Once again you'll need an oscilloscope to verify proper alignment. Set R828 to its midpoint,

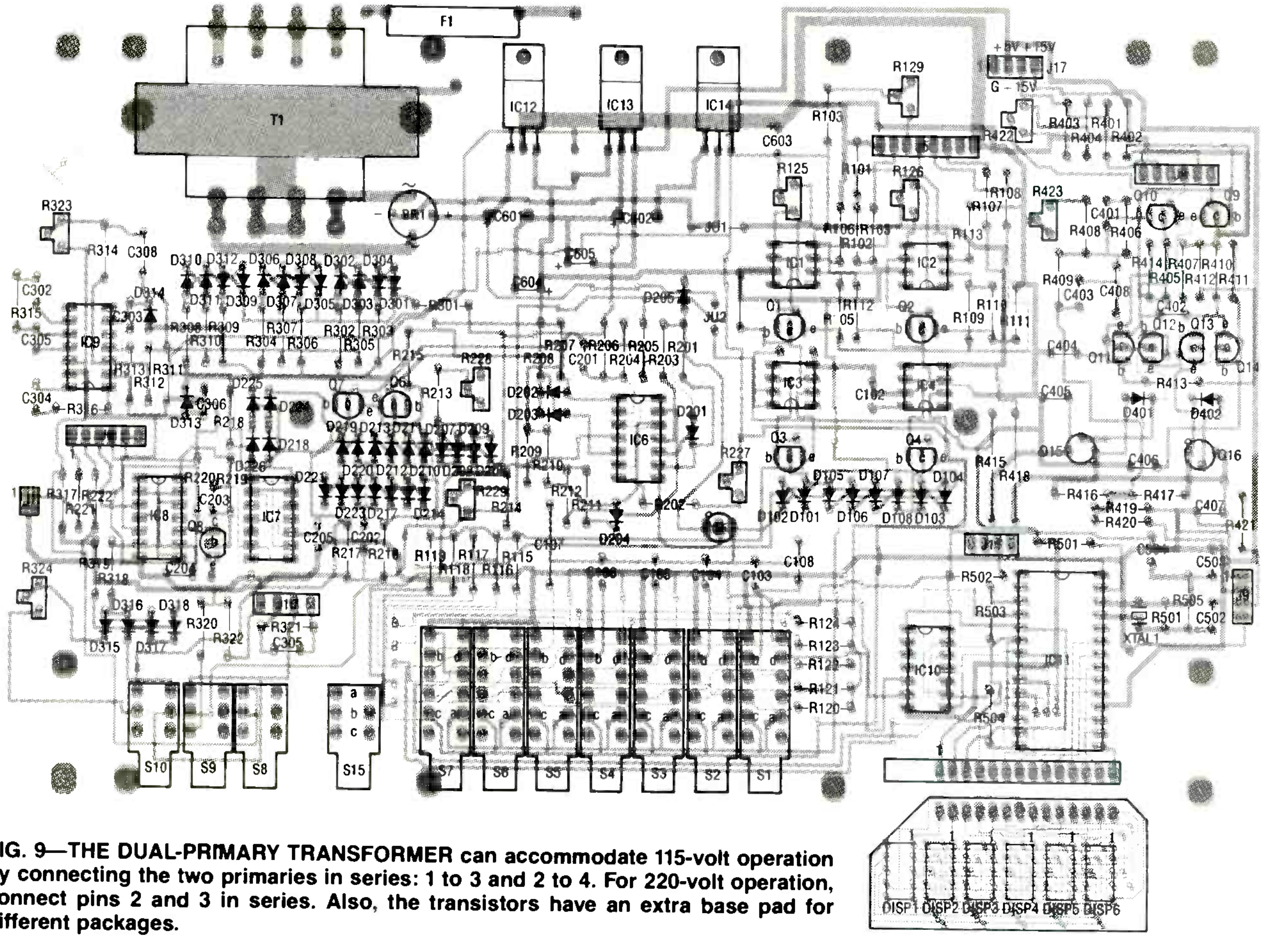


FIG. 9—THE DUAL-PRIMARY TRANSFORMER can accommodate 115-volt operation by connecting the two primaries in series: 1 to 3 and 2 to 4. For 220-volt operation, connect pins 2 and 3 in series. Also, the transistors have an extra base pad for different packages.

and adjust R825 to give a good log output (when selected) and a linear output. Adjust R826 to achieve a good input signal to IC19 pin 2 and R827 will set the maximum sweep width. If a scope is not available, most potentiometers can be set to their center position and adjustments can be made by observing the LED display with the counter set to the internal-count mode.

If everything is working properly, you can install the completed boards into the case. The top of the case uses four 2-inch standoffs. The front and back panels supplied with the case are of 0.065-inch aluminum and are not recommended for use as a front panel. A complete cut and silk-screened panel is available from the source mentioned in the parts list, or you can make your own using transparent red acrylic. Secure the mother board in place (top half of case) and finally install the daughter board uses three 1¾-inch standoffs. You're now ready to power up and use your combination function generator and frequency counter.

Using your unit

Table 1 shows a complete list

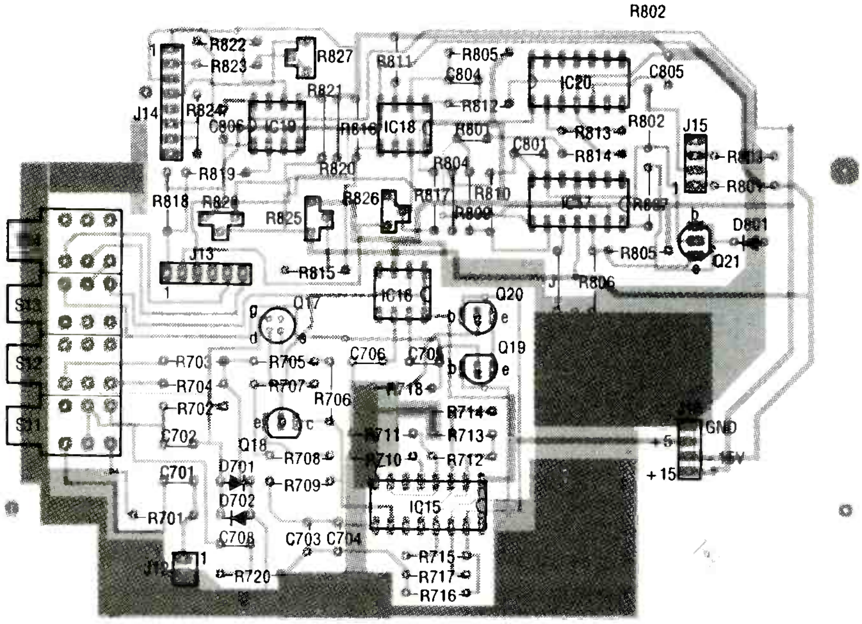


FIG. 10—PARTS PLACEMENT OF DAUGHTER BOARD holds the input amplifier and sweep generator circuit.

TABLE 1—FUNCTION GENERATOR SPECIFICATIONS

FUNCTION	MIN	MAX	UNITS
Sine Wave	0.1	2.5 Mega	Hz
Triangle Wave	0.1	2.5 Mega	Hz
Square Wave	0.1	2.5 Mega	Hz
Pulse	0.1	2.5 Mega	Hz
Amplitude			
Main Output	3.0	20	Vp-p
−20dB	0.5	6	Vp-p
TTL Pulse	50	5	Vp
CMOS Pulse	0.5	15	Vp
Duty Cycle	10	90	%
DC Offset	−10	+10	VDC
Sweep Generator			
Sweep Width	1	1000	X Initial Freq.
Sweep Time	1	20	Seconds
Frequency Counter			
Input Sensitivity	20	100	Vp-p
Input Range	0.1	150 Mega	Hz
Input Impedance	50	1 Mega	Ohms
Gates Times	.01	10	Seconds
Error	±LSD		
Stability	50ppm/°C		

of functions and specifications of the unit.

The square wave output is in phase with the sine wave and the triangle wave, but is 180 degrees out phase with the TTL and CMOS pulse outputs. That feature is useful for creating a two-phase clocking system if you happen to be working with digital equipment. The unit is calibrated to give a frequency range of 0.1 Hz to 2.5 MHz. The upper frequency limit can be extended by adjusting variable capacitor C108 and/or R129. With the component values that we have given, the upper frequency limit can reach as high as 4 MHz.

Changing the values of the timing resistors R115–R119 and R120–R124 will produce output frequencies as determined by the formula 1/RC. That method will achieve a maximum sinewave output of 10 MHz with an amplitude of 1 volt peak-to-peak above 2 MHz. **R-E**

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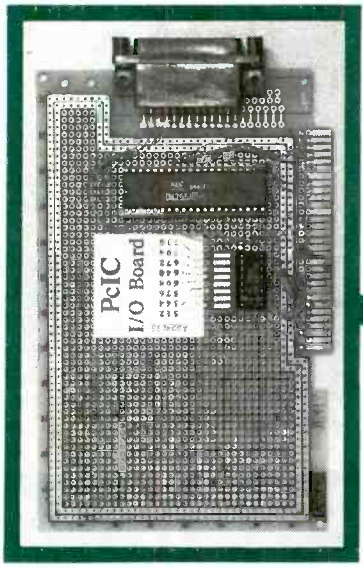
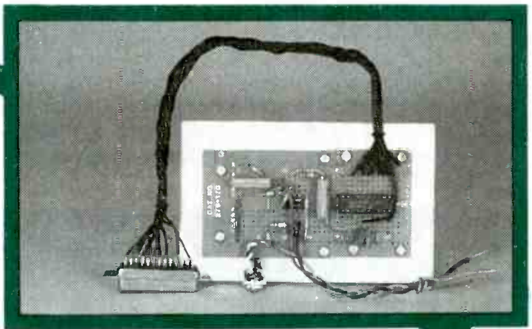
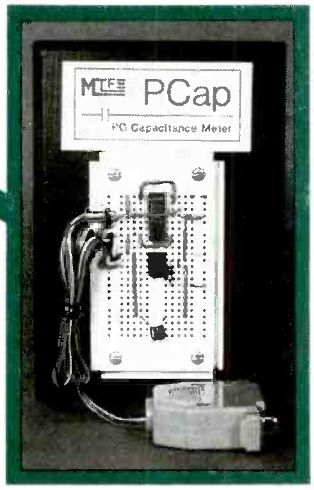
EXPERIMENTING WITH ADC FOR YOUR PC





JAMES J. BARBARELLO



Add a variety of analog inputs to the PC-based analog-to-digital convertor.

PC-BASED TEST INSTRUMENTATION has turned out to be a popular topic among readers. We continue this ongoing series by interfacing new sensing devices (a linear displacement transducer, a piezoelectric transducer, and a microphone) to the analog-to-digital converter (ADC) discussed in the January 1992 issue. If you're just getting started with this series, here's a brief review of progress thus far.

Quick review

The heart of the system is a PC I/O expander called the PC IO that adds 24 lines of digital I/O by means of an 8255 Parallel Input/Output (PIO), all on a single 8-bit expansion card. In the January 1992 installment, we added an outboard analog-to-digital converter (ADC), based on an ADC0804. The ADC allows you to measure and capture any 0–5 volt analog signal (e.g., temperature, displacement, and audio). The circuit includes a variable-gain amplifier for low-level inputs, and a DC-offset adjustment for inputs with unwanted DC components. A temperature probe shown in that article was built around the base-collector junction of a silicon transistor. With the proper settings for amplification and DC offset, a several-hundred millivolt change over a 100°reeC temperature range produced a digital output spread over the full input range of the ADC0804.

In general, an A/D converter and a PC can provide very low-cost solutions to measurement problems that would ordinarily require costly test equipment. Following are some ideas, practical circuits, and software for interfacing other types of devices. These ideas cover the three most common types of sensing: mechanical, electrical, and acoustic.

Mechanical sensing

As an example of mechanical sensing, the author and a friend were contracted to measure the displacement, impact force, and velocity of electromechanical rappers used in the pollution-control industry. Factory smokestacks have environmental controls that contain huge, electrostatically charged metal plates. As the smoke goes up the smokestack, it passes by those plates; the plates "pull" the suspended particles to them, removing pollution that would otherwise be released to the outside air. Particles accumulate on the plates, and eventually have to be removed. To "clean" the plates, rappers (like giant solenoids) provide quick, hard jolts to the plates, breaking trapped particles free in huge sheets that fall to the bottom of the smokestack. Our task was to determine the characteristics of existing commercial rappers, and then determine whether our customer's rapper could be made better than the competition's.

Our test instrumentation consisted of an 8-bit A/D converter hooked up to a computer, and fed by a rectilinear potenti-

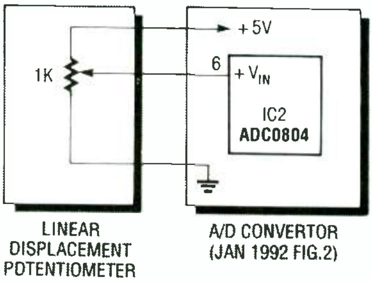


FIG. 1—INTERFACE A LINEAR displacement transducer to the PC IO as shown here. The wiper of the LDT drives the ADC0804 directly, so remember to disconnect the op-amp output (pin 7) from the ADC's input. (The original circuit was shown in Fig. 2 in the January 1992 installment.)

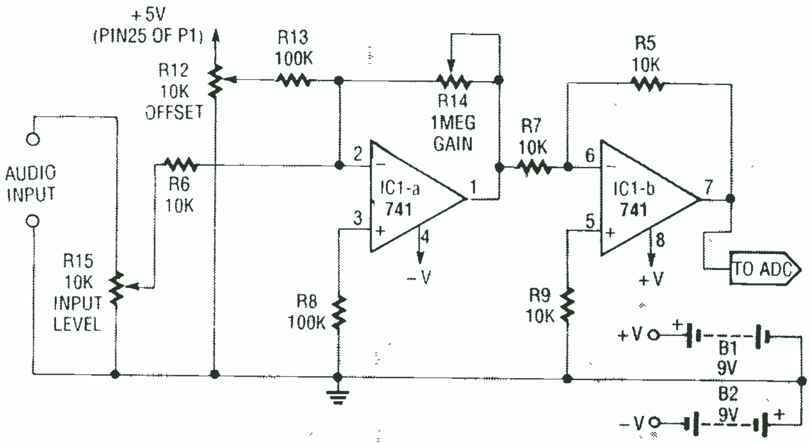


FIG. 3—INTERFACE AN AUDIO SOURCE as shown here. The nonsequential part numbers occur to keep numbering consistent with the original circuit.

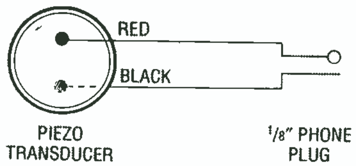


FIG. 2—INTERFACE A PIEZOELECTRIC transducer as shown here. Make sure the red lead goes to the tip and the black lead to the ring of the plug. Also, to avoid feeding DC voltage into the transducer, disconnect the J1 end of R1.

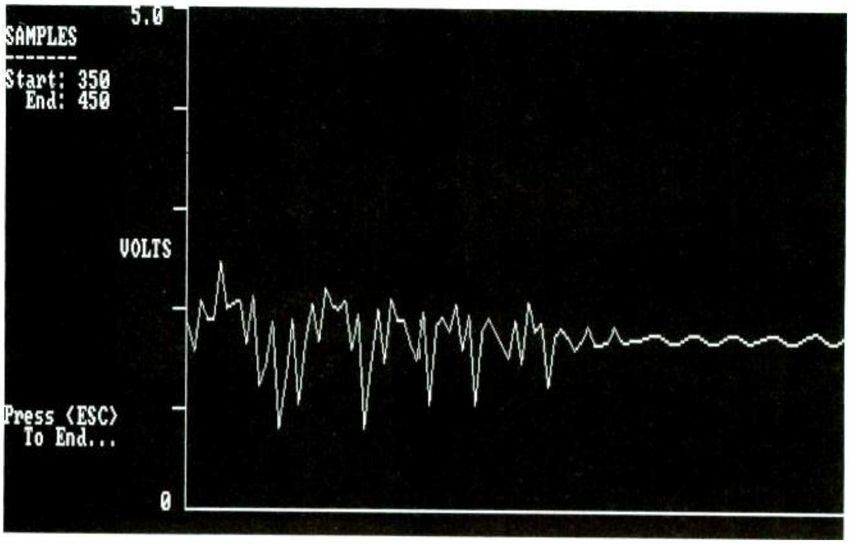


FIG. 4—GRAPHICAL OUTPUT from GRAFDATA.BAS (Listing 2), which allows you to display as many as 1000 data points captured by ADC.BAS (Listing 1).

ometer (also called a linear displacement transducer, or LDT). LDT's are precision potentiometers that move linearly, rather than circularly. Even at surplus prices, LDT's aren't cheap ($20–$50), but they do a great job. Figure 2 in the January 1992 issue shows the complete ADC circuit; we simply supplied it with the input shown here in Fig. 1. Note that we power the LDT directly with a 5-volt DC supply, so neither amplification nor DC offset were required. Instead, we drive the ADC0804 (IC2) directly, as shown in the figure.

If you use this type of arrangement, be sure to disconnect the op-amp's output (pin 7) from the ADC's input (pin 6). In addition, make sure the potentiometer has a resistance of at least 1K, so as not to draw too much current from your PC's power supply. Also, the mechanical linkage between the LDT and the rapper must be firm so there is little or no slippage at the speeds encountered. Otherwise, the potentiometer will not give a true indication of displacement. This type of setup would also be useful for measuring the movement of solenoids, pistons, cams, and similar devices.

Using that circuit, we obtained a series of outputs that showed exactly how the rapper's plunger moved a quarter of a second after it triggered. Eight bits of digital data made it easy to calculate the rate of change of displacement (velocity), as well as the maximum displacement. We determined impact force using strain gages.

The only problem we had was in determining just when to read the LDT's resistance. The solution turned out to be straightforward, as we'll see momentarily.

Electrical sensing

The temperature probe developed last time is one example of electrical sensing. Another good sensing device is piezoelectric material, available in both film and crystal form. An inexpensive source of piezoelectric crystal is Radio Shack's Piezo Transducer (273-073). Simply break open the plastic case, and you have a circular piezoelectric transducer with red and black leads. When flexed in any way, the transducer produces a voltage that varies proportionally to the amount of flexing.

A piezo transducer can be used to measure force of impact, or the amount of bending and flexing. Figure 2 shows how to connect a piezo transducer to

LISTING 1

```
1 REM*************************************************
2 REM** ADC.BAS - V910803 - JJ Barbarello *
3 REM** Capture/Store Analog Data with PcA/D-MATE *
4 REM*************************************************
10 CLS : DEFINT A, X: DIM A(1000): GOSUB 370: LOCATE 1, 23
20 PRINT "PcA/D DATA COLLECTION SYSTEM": LOCATE 2, 1: PRINT
STRING$(79, 220)
30 LOCATE 5, 1: PRINT SPACE$(79); : LOCATE 5, 10
40 LINE INPUT "Enter Time (0-3600 seconds) between samples...";
interval$
50 interval = VAL(interval$)
60 IF interval < 0 OR interval > 3600 THEN BEEP: GOTO 30
70 LOCATE 7, 10: PRINT "Press <Enter> to begin, or <Esc> to
abort...";
80 GOSUB 350: IF A$ = CHR$(27) THEN CLOSE : END
90 LOCATE 5, 10: PRINT SPACE$(60): LOCATE 7, 10: PRINT SPACE$(60)
100 LOCATE 10, 22: PRINT "DIGITAL DATA (0-255) ": LOCATE 12, 19
110 IF interval > 0 THEN PRINT "SECONDS BETWEEN SAMPLES: "; interval
120 LOCATE 13, 29: PRINT "SAMPLE NUMBER: "
130 LOCATE 16, 20: PRINT "Press <Esc> to End Sampling...";
140 acount = 1: xsample = 1
150 told = VAL(MID$(TIME$, 4, 2)) * 60 + VAL(RIGHT$(TIME$, 2))
160 IF interval = 0 THEN GOTO 210
170 T = VAL(MID$(TIME$, 4, 2)) * 60 + VAL(RIGHT$(TIME$, 2))
180 IF T = 0 AND (told - T > interval) THEN told = told - 3600
190 IF INKEY$ = CHR$(27) THEN GOTO 260
200 IF T - told > 0 THEN told = told + interval ELSE GOTO 170
210 OUT ADD + 2, 0: OUT ADD + 2, 1
220 x = INP(ADD): LOCATE 10, 44: PRINT USING "###"; x
230 LOCATE 13, 44: PRINT xsample; : xsample = xsample + 1
240 IF acount < 1001 THEN A(acount) = x: acount = acount + 1
250 IF INKEY$ <> CHR$(27) THEN GOTO 160
260 BEEP: LOCATE 16, 15
270 PRINT "Press <Enter> to save data, <Esc> for no save...";
280 GOSUB 350: IF ASC(A$) = 27 THEN CLS : END
290 LOCATE 16, 15
300 LINE INPUT "Enter File Name To Save Data  ex: TEST01.ADD)..."; f$
310 OPEN "r", 1, f$, 2: FIELD 1, 2 AS d1$
320 LOCATE 18, 20: PRINT "Saving Data...";
330 FOR i = 1 TO acount: LSET d1$ = MKI$(A(i) : PUT 1, LOF(1) / 2 +
1: NEXT
340 PRINT "Done.  Press ANY key."; : A$ = INPUT$(1): CLOSE : CLS :
END
350 A$ = INKEY$: IF A$ = "" THEN GOTO 350
360 IF ASC(A$) = 13 OR ASC(A$) = 27 THEN RETURN ELSE BEEP: GOTO 350
370 OPEN "R", 1, "HWADDRES.DAT", 4: FIELD 1, 4 AS A$
380 GET 1, 1: ADD = VAL(A$): CLOSE : DEF SEG = 64: OUT ADD + 3, 146:
RETURN
1 REM** GRAFDATA.BAS
2 REM** Graph PcA/D-Mate .ADD File Data (Requires Graphics Monitor)
3 REM** V910802 - JJ Barbarello
4 REM**
10 CLEAR : DEFINT I-J, Y: KEY OFF: CLS
20 COLOR 0, 7: LOCATE 3, 27: PRINT " GRAPH PcA/D-MATE DATA "; : COLOR
7, 0
30 LOCATE 10, 20: INPUT "Enter File Name (ex: TEST1.ADD)..."; DFN$
40 OPEN "R", 1, DFN$, 2: FIELD 1, 2 AS D$: IF LOF(1) > 0 THEN GOTO 80
50 CLOSE : KILL DFN$: BEEP: LOCATE 25, 13
60 PRINT "That File Doesn't exist.  Press ANY key to try again...";
70 A$ = INPUT$(1): CLS : GOTO 20
80 LOCATE 21, 34: COLOR 16, 7: PRINT " Reading data "; : COLOR 7, 0
90 DIM I((LOF(1) / 2) + 3)
100 FOR I = 1 TO LOF(1) / 2: GET 1, I: I(I) = 190 - CVI(D$): NEXT
110 LOCATE 21, 34: PRINT SPACE$(20)
120 LOCATE 12, 20: PRINT "File Has"; LOF(1) / 2; "Samples."
130 LOCATE 14, 20: INPUT "Enter Start Sample To View..."; ISTART
140 LOCATE 15, 20: INPUT "Enter End Sample To View"; IFIN
150 IF IFIN - ISTART > 1000 THEN IFIN = ISTART + 999
160 I(I) = I(I - 1): I(I + 1) = I(I): I(I + 2) = I(I + 1)
170 YINC = 500 / (IFIN - ISTART)
180 IF (IFIN - ISTART) > 499 THEN istp = 2 ELSE istp = 1
190 SCREEN 2: LOCATE 2, 1: PRINT "SAMPLES": LOCATE 3, 1: PRINT "-----
--"
200 LOCATE 4, 1: PRINT "Start:"; ISTART: LOCATE 5, 3: PRINT "End:";
IFIN
210 LOCATE 20, 1: PRINT "Press <ESC>": LOCATE 21, 3: PRINT "To
End..."
220 LINE (138, 0)-(138, 190): LINE (138, 190)-(639, 190): J = 139
230 FOR I = 0 TO 152 STEP 38: LINE (128, I)-(137, I): NEXT
240 LOCATE 1, 13: PRINT "5.0": LOCATE 24, 16: PRINT "0";
250 LOCATE 12, 12: PRINT "VOLTS";
260 FOR I = ISTART TO IFIN STEP istp
270 LINE (J, I(I))-(J + YINC, I(I + istp)): J = J + YINC: NEXT I
280 A$ = INKEY$: IF A$ = "" THEN 280
290 IF ASC(A$) = 27 THEN SCREEN 0: END ELSE BEEP: GOTO 280
```

our circuit. We want only the voltage generated by the piezo sensor, so disconnect the J1 end of R1, shown in Fig. 2 last time (R1 provided +5-volts DC to the temperature probe). With no input signal, adjust R11 for maximum gain, and R12 so output is about 2.5-volts DC. (The latter setting allows the piezo voltage to vary from that quiescent level.) You might also want to adjust the value of R3 so that the piezo sensor produces maximum indication at its maximum output.

To test the circuit, use a piece of masking tape to secure the piezo sensor to a flat surface, making sure you aren't flexing it. Tap the surface firmly and note the response. In actual use, you would mount the sensor using a clamping device or flexible adhesive. This type of device is useful for measuring applied impact, oscillation after impact, or amount of flex or bend.

Acoustic sensing

You've probably seen audio signals displayed on an oscilloscope. Now imagine "freezing" those signals—i.e., storing them in digital form. Scientists capture digitized audio in this way to study the sounds that whales, birds, and other animals make. In digitized form, it's easy to compare and contrast different sounds to determine which have similar characteristics, or to look at other factors that wouldn't otherwise be obvious.

To accommodate a microphone input, we modified the ADC circuit as shown in Fig. 3. The changes allow us to increase the gain of IC1-a to a maximum of 100, and to attenuate high-level inputs. Gain is determined by the ratio R14/R6 $= 10^6/10^4 = 10^2 = 100$. If the part numbering in Fig. 3 seems strange, it's because we tried to stay consistent with the main circuit shown in Fig. 2 in January. Note that in the January version, R6 was 100K; here we decreased its value to 10K. Also, we no longer use R1–R4.

In operation, first set R12 to mid-value. Then adjust R14 for maximum range, as described last time. Last, readjust R12 as necessary to set the quiescent level to about 2.5-volts DC. For example, a microphone might provide a maximum output

LISTING 2

```
1 REM** GRAFDATA.BAS
2 REM** Graph PcA/D-Mate .ADD File Data (Requires Graphics Monitor)
3 REM** V910802 - JJ Barbarello
4 REM**
10 CLEAR : DEFINT I-J, Y: KEY OFF: CLS
20 COLOR 0, 7: LOCATE 3, 27: PRINT " GRAPH PcA/D-MATE DATA "; : COLOR
7, 0
30 LOCATE 10, 20: INPUT "Enter File Name (ex: TEST1.ADD)..."; DFN$
40 OPEN "R", 1, DFN$, 2: FIELD 1, 2 AS D$: IF LOF(1) > 0 THEN GOTO 80
50 CLOSE : KILL DFN$: BEEP: LOCATE 25, 13
60 PRINT "That File Doesn't exist.  Press ANY key to try again...";
70 A$ = INPUT$(1): CLS : GOTO 20
80 LOCATE 21, 34: COLOR 16, 7: PRINT " Reading data "; : COLOR 7, 0
90 DIM I((LOF(1) / 2) + 3)
100 FOR I = 1 TO LOF(1) / 2: GET 1, I: I(I) = 190 - CVI(D$): NEXT
110 LOCATE 21, 34: PRINT SPACE$(20)
120 LOCATE 12, 20: PRINT "File Has"; LOF(1) / 2; "Samples."
130 LOCATE 14, 20: INPUT "Enter Start Sample To View..."; ISTART
140 LOCATE 15, 20: INPUT "Enter End Sample To View"; IFIN
150 IF IFIN - ISTART > 1000 THEN IFIN = ISTART + 999
160 I(I) = I(I - 1): I(I + 1) = I(I): I(I + 2) = I(I + 1)
170 YINC = 500 / (IFIN - ISTART)
180 IF (IFIN - ISTART) > 499 THEN ISTP = 2 ELSE ISTP = 1
190 SCREEN 2: LOCATE 2, 1: PRINT "SAMPLES": LOCATE 3, 1: PRINT "-----
--"
200 LOCATE 4, 1: PRINT "Start:"; ISTART: LOCATE 5, 3: PRINT "End:";
IFIN
210 LOCATE 20, 1: PRINT "Press <ESC>": LOCATE 21, 3: PRINT "To
End..."
220 LINE (138, 0)-(138, 190): LINE (138, 190)-(639, 190): J = 139
230 FOR I = 0 TO 152 STEP 38: LINE (128, I)-(137, I): NEXT
240 LOCATE 1, 13: PRINT "5.0": LOCATE 24, 16: PRINT "0";
250 LOCATE 12, 12: PRINT "VOLTS";
260 FOR I = ISTART TO IFIN STEP ISTP
270 LINE (J, I(I))-(J + YINC, I(I + ISTP)): J = J + YINC: NEXT I
280 A$ = INKEY$: IF A$ = "" THEN 280
290 IF ASC(A$) = 27 THEN SCREEN 0: END ELSE BEEP: GOTO 280
```

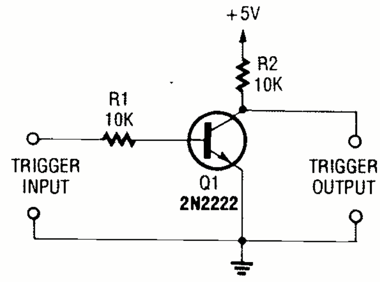


FIG. 5—DIGITAL TRIGGER CIRCUIT allows the PC IO to start reading data based on the appearance of a predetermined signal. Connect this circuit between that signal and an unused PC IO input, and modify the software accordingly.

voltage of 0.5. Adjust R14 so the maximum is about 4.0 volts. Then readjust R12 so the no-signal (quiescent) value is about 2.5-volts DC. Now you'll get the best resolution from the circuit.

Software

We wrote two programs for data capture and display. Listing 1 shows the capture program (ADC.BAS), and Listing 2 the display program (GRAFDATA.BAS)—both are available on the RE-BBS (516-293-3000, 1200/2400, 8N1) as a file called PCADMAT2.LST. Figure 4 shows sample output from GRAFDATA. Enhanced versions of both programs are available on disk from the author for a nominal fee; see the sidebar for details.

ADC.BAS is a general-purpose data capture and storage utility. To use it, you must create a data file called HWADDRES.DAT in the same directory as the program. The file contains the decimal address of the PC IO card. You can create the file with any text editor or word processor capable of storing text in ASCII format. Assuming your card is set to the default address (640), create a one-line file that contains "640D" (without the quotes) followed by a carriage return.

Connect the ADC circuit to your PC and run ADC.BAS. It initializes the PC IO card, then asks you for the interval (in seconds) to wait between samples. If you want continuous samples (with no delay), enter 0. Otherwise, you can enter any number between 1 and 3600 (one hour). When you press Enter, sampling begins.

The program displays three pieces of information: current data (line 100), time between samples (line 110), and current sample number (line 120). Press Esc at any time to end sampling (line 130).

Lines 150–200 take care of interval timing. The sampling program showed last time used a timing loop that was system-dependent; the current version reads the system clock, hence is system-independent. Sampling takes place in lines 210–250; as many as 1000 samples are saved in array A.

When you press Esc to end sampling, execution continues at line 270. If you press Esc again, data is abandoned and the program ends. If you press Enter, the program requests a file name for storing the data. Specify the complete file name, including any path and extension (e.g., C:\SUB1\TEST01.ADD.) If you don't specify a complete path, the file will be stored in the current directory. If the file already exists, current data will be appended to the end of the file.

GRAFDATA.BAS allows you to plot your data on-screen. When you run the program, it asks you to specify a data file. As with ADC.BAS, specify the full file path if the file is not in the cur-

(Continued on page 76)

WORKING WITH LED'S

We continue our survey of optoelectronic principles and systems, with an in-depth look at practical LED chaser and bar-graph displays.

RAY MARSTON

LAST MONTH, WE BEGAN INTRODUCing the general subject of optoelectronics, and we examined light-emitting diodes (LED's) and several practical LED flashers in detail. In this article, we'll examine several practical LED chaser (or sequencer), dot, and bar-graph displays.

Chaser principles

One of the most popular LED displays is known as a chaser, also called a sequencer. That's when an IC drives an LED array, so that each LED (or small groups thereof) turns on and off in a fixed, periodic sequence, that appears as a ripple of light running along a chain. The LED's don't necessarily have to be arranged linearly, and can be placed in any desired geometric pattern, to alter the visual effect.

The most popular CMOS IC which is used for that purpose is the CD4017B, which is a decade counter/divider IC with 10 decoded outputs, each capable of directly driving an LED display. If desired, the outputs can be coupled back to the IC control terminals to make the device count to (or divide by) any number from 2–9, and either stop or recycle.

The CD4017B is easily cascaded for use in multi-decade frequency division, or for use in counters with any number of decoded outputs. It's extremely versatile, and it can easily be used in a chaser or sequencer LED display of any desired length.

Figure 1 shows the pinouts of a CD4017B, with decoded outputs in arithmetic order. Figure 2 is its timing diagram; the CD4017B is a 5-stage Johnson counter with CLOCK, RESET, and CLOCK INHIBIT inputs. The counters are advanced with each positive-going clock pulse, when the CLOCK INHIBIT and RESET inputs are low. At any time, nine of the 10 decoded outputs are low, while the remaining one is high.

The 10 outputs go high sequentially in step with the clock, with the selected output staying high for one full clock cycle. The CARRY OUT goes high for one clock cycle out of every 10 clock cycles, and it can be used to ripple-count more CD4017B's in a multi-decade counting application. The counting cycle is inhibited by setting CLOCK INHIBIT high. A high on the RESET input clears the counter, and sets the "0"-output high.

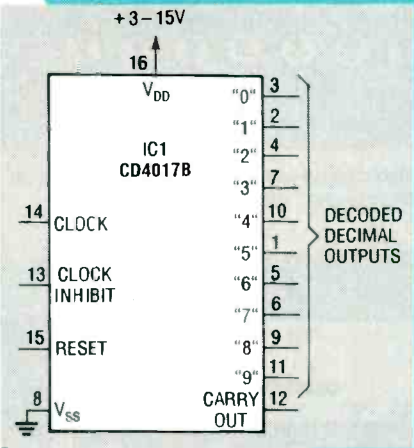


FIG. 1—PINOUTS OF THE CD4017B decade counter/divider, with its decoded outputs shown in ascending arithmetic order. The clock is inhibited by a high on pin 13, and the counter is reset by a high on pin 15 and advances on a positive-going clock transition.

CD4017B chaser circuits

Figure 3 shows a practical CD4017B 10-LED chaser, with IC1, a 555 astable multivibrator, which is used as a variable-speed clock generator. The CD4017B becomes a decade counter by grounding pins 13 (CLOCK INHIBIT) and 15 (RESET). The visual display will appear as a moving dot sweeping from left to right (or from LED's "0"–"9") in 10 steps, as the outputs go high and turn the LED's on sequentially. They can either be arranged in a straight line, or configured circularly, so that the dot appears to rotate.

The LED's shown in Fig. 3 aren't current-limited. Manufacturers don't give a maximum short-circuit current for the CD4017B, but practical experience dictates a value somewhere between 10–15 milliamps. The maximum dissipation per output on some data sheets is 100 milliwatts, so up to 7 volts DC can be developed safely across a CD4017B output stage at maximum current.

Each LED is connected between output and ground, and can have a maximum supply of 9 volts DC, for a 2-volt DC drop across each LED that's lit. Above 9 volts DC, use the version shown in Fig. 4, which contains a current-limiting resistor, and is capable of being used with supplies up to 12 volts DC.

Figure 5 shows a possible equivalent of the circuit in Fig. 4, that uses a 15-volt DC supply, that also illustrates a major design flaw. When one LED is on, the anodes of the others are grounded, so R1 reverse-biases them. Due to low LED reverse-voltage ratings, you'll often find that an LED that's off will act like a Zener diode at about 5

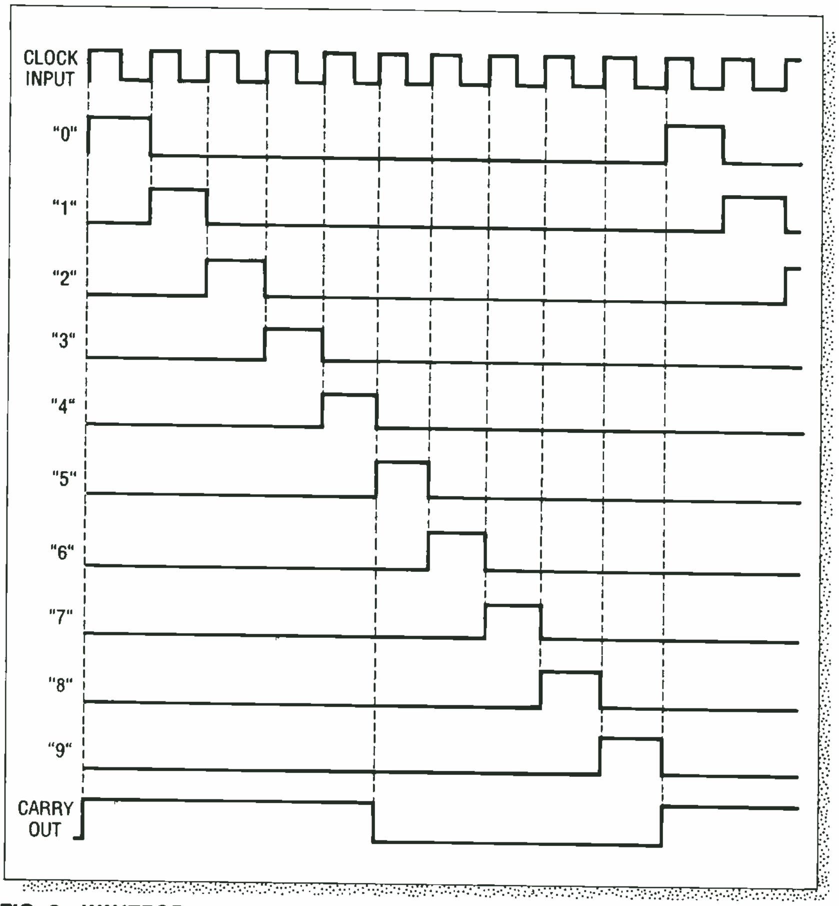


FIG. 2—WAVEFORM TIMING DIAGRAM OF THE CD4017B, with its RESET and CLOCK INHIBIT terminals (pins 13 and 15) grounded.

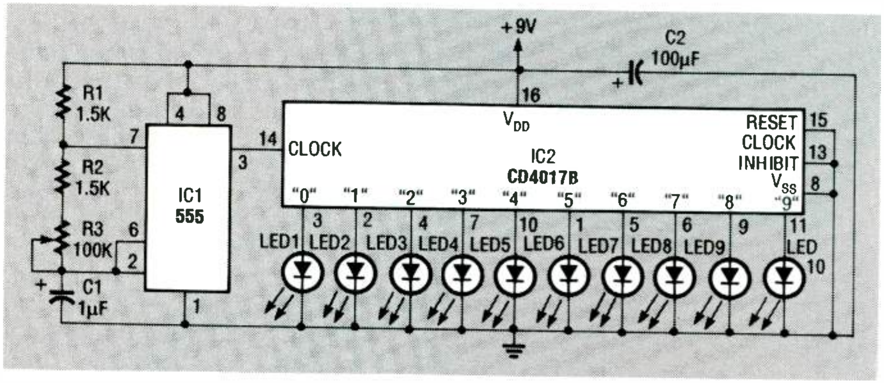


FIG. 3—A 10-LED CHASER OR SEQUENCER that can be used with supply voltages up to only 9 volts DC, and which produces a "moving-dot" display.

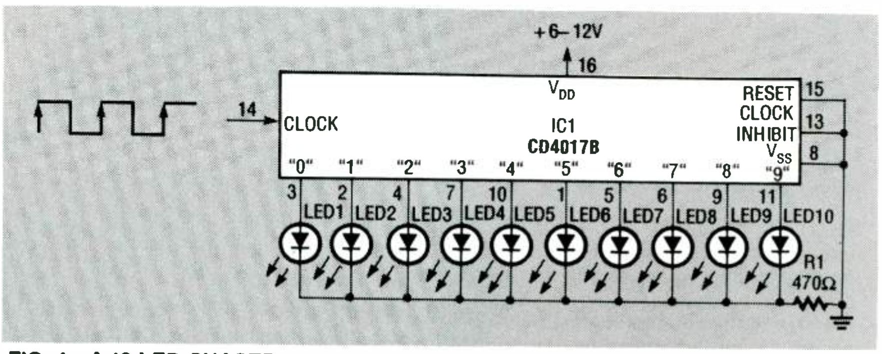


FIG. 4—A 10-LED CHASER, WHICH USES up to a 12-volt DC supply.

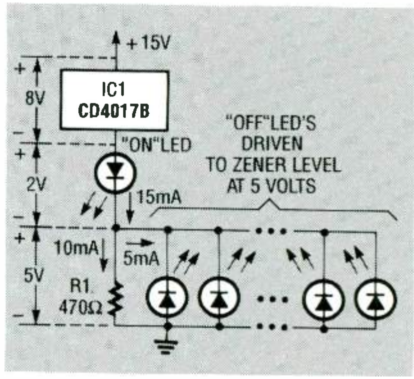


FIG. 5—A POSSIBLE EQUIVALENT to Fig. 4, which uses up to a 15- volt-DC supply.

volts DC, and possibly destroying a CD4017B output stage.

When a CD4017B drives LED's in moving-dot mode, they can be connected directly to the IC outputs if supply values are no more than 9 volts DC. For higher supplies, you'll need current-limiting resistors. Several such display circuits are shown in Figs. 6–12.

Alternative LED displays

The output stages of the CD4017B can either source or sink currents equally well. Fig 6 shows IC2 used in sink-mode in a moving-hole LED display; nine of the 10 LED's are on at any given time, while one turns off sequentially. If the LED's are arranged circularly, they seem to rotate. Since all LED's except one are on at a time, they all need current-limiting resistors.

Moving-dot displays are much more popular than the moving-hole variety. The type shown in Fig. 3 can be designed to use fewer LED's just by omitting the unwanted ones, but then the dot moves intermittently or scans, since IC2 takes 10 clock steps per sequence, and all the LED's will be off during the unwanted steps.

If a continuously-moving display with fewer than 10 LED's is needed, connect the first unused CD4017B output to pin 15 (RESET), as indicated in the 4-LED version shown in Fig. 7. To achieve an intermittent display using a controlled number of off steps, just connect the desired unwanted output to pin 15 (RESET). Or, in other words, move the connection going to pin 10 of IC2 to pin 9. In that type of an intermittent display, the LED's will light for four cycles, go blank for four cycles, and the sequence then repeats.

Figure 8 shows a visually attractive 4-LED, 5-step sequencer. Initially, all four LED's are on, and then turn off sequentially until they're all off in the fifth step, as shown in the accompanying table. The LED's are effectively in series, and the basic circuit can't drive over four LED's.

Figure 9 shows another version; here, the CD4017B does a 10-step sequence, with LED 1 on from steps "0"–"3," LED 2 on for "4"–"6," LED 3 on for "7" and "8," and LED 4 on for step "9." The display will accelerate from LED 1–LED 4, not just sweeping smoothly from one LED to the next, and the cycle then repeats ad infinitum.

Figure 10 shows such a circuit modified to produce an intermittent display, where the visual acceleration occurs for 10 clock cycles, the LED's all blank for 20 cycles, and then the counting cycle repeats. When IC2 is in a ÷10 mode as shown in Figs. 9 and 10, pin 12 (CARRY OUT) produces an output each time IC2 does a decade count, which is used to clock IC3 (which is connected in ÷3 mode), with its "0" output fed to Q1.

For the first 10 cycles of a sequence, the "0" output of IC3 is high, and Q1 is biased on, so IC2 acts as shown in Fig. 9, with the LED's turning on sequentially through Q1. After the 10th clock pulse, the "0" output of IC3 goes low, turning Q1 off; the LED's can no longer light, but IC2 keeps counting. After the 30th clock pulse, the "0" output of IC3 again goes high and turns Q1 on, reenabling the display.

Figure 11 is a simple multiplexed display, where IC3 and Q3 enable or disable a bank of LED's. Figure 11 is yet another example of a multiplexed display, which uses three lines of six intermittently-sequenced LED's. They're each sequentially enabled via IC3 and individual gating transistors, only one line at a time; if you want, you can expand this version still further to control a 10-line, 100-LED, matrix display.

Figure 12 shows a 4-bank, 5-step, 20-LED chaser; the four LED's are in series in each of the five CD4017B outputs, so four LED's are lit at any one time. Each lit LED drops about 2 volts

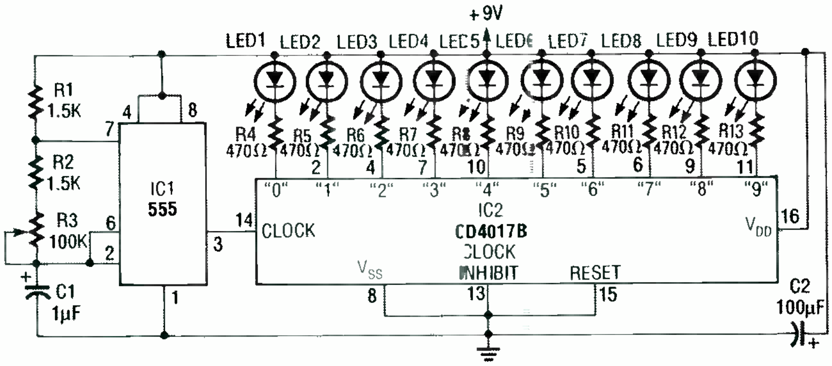


FIG. 6—A 10-LED "MOVING-HOLE" DISPLAY.

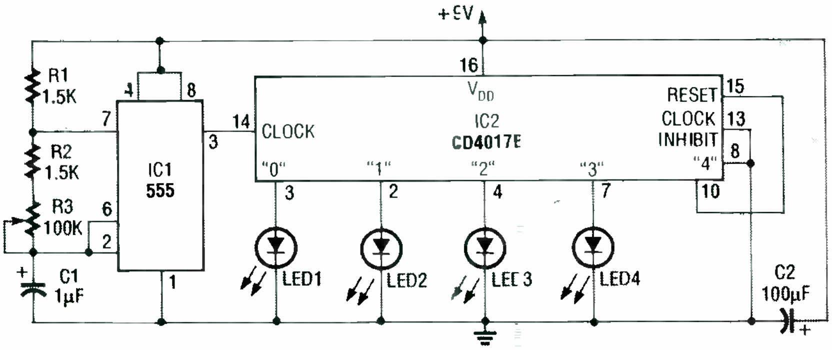
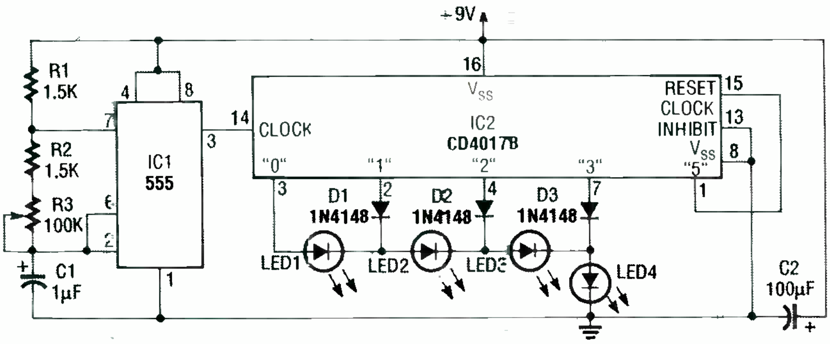


FIG. 7—A 4-LED CONTINUOUS "MOVING-DOT" DISPLAY. To get an intermittent "moving-dot" display using a 50% "blanking" period, just change pin 10 (or output "4") to pin 9 (or output "8").



STEP NUMBER	1	2	3	4	5	6
LED1	ON	OFF	OFF	OFF	OFF	ON
LED2	ON	ON	OFF	OFF	OFF	ON
LED3	ON	ON	ON	OFF	OFF	ON
LED4	ON	ON	ON	ON	OFF	ON

FIG. 8—A 4-LED, 5-STEP SEQUENTIAL TURN-OFF DISPLAY.

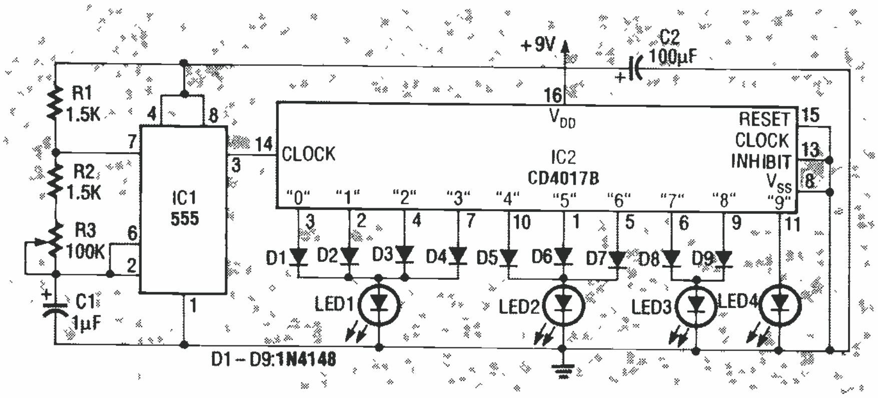


FIG. 9—A 4-LED CONTINUOUS "ACCELERATOR" DISPLAY, where the pattern of the dots appears to accelerate from left to right.

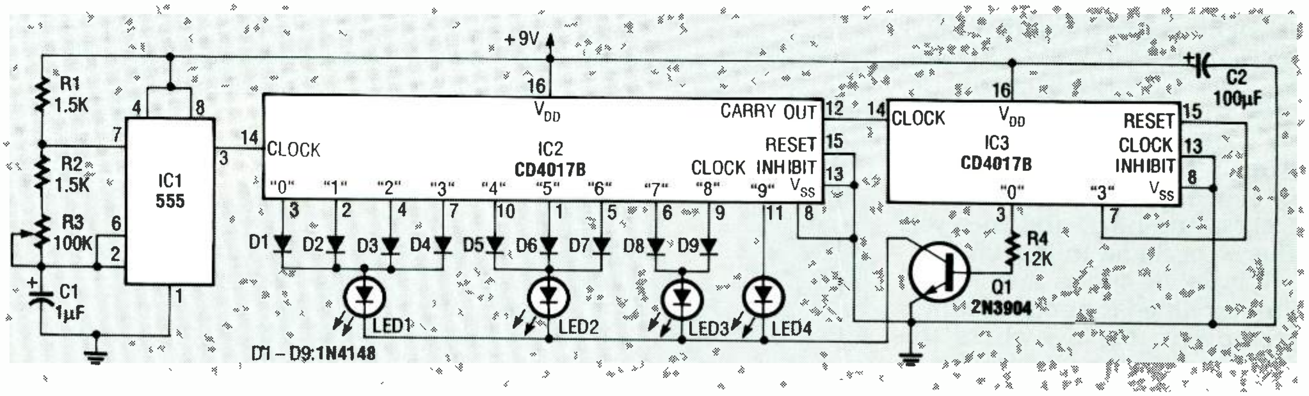


FIG. 10—A 4-LED INTERMITTENT "ACCELERATOR" DISPLAY, where the "acceleration" occurs for 10 out of every 30 clock steps.

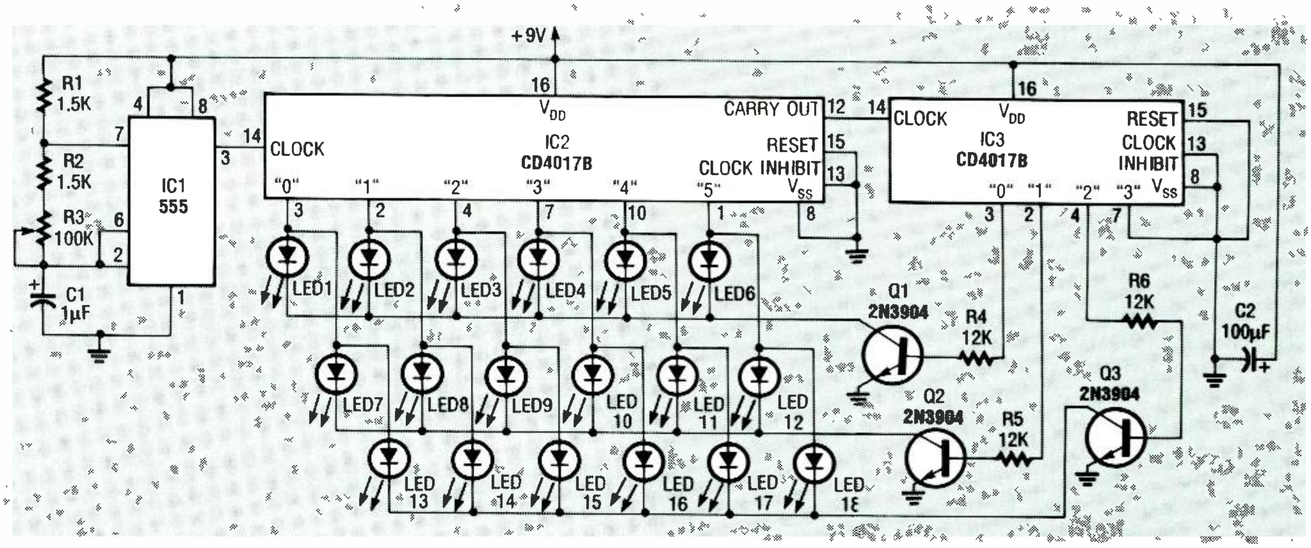


FIG. 11—A MULTIPLEXED 6-LED × 3-LINE MOVING-DOT DISPLAY, in which the dot moves intermittently along the lines.

DC; that's 8 volts DC for each LED bank that's on, so the supply voltage must be greater than that for the circuit to work. A greater number of LED's can be used in each LED bank if the supply voltage is correspondingly increased to handle the added load.

Bar-graph displays

Another multi-LED indicator circuit is the analog version, which drives a chain of linearly-spaced LED's. The number of LED's that are lit is proportional to the voltage applied to the LED-driver, so the circuit acts like an analog voltmeter. You can use the LED's as either a bar- or dot-graph display. In a bar-graph display, the input value is indicated by the total number of LED's that are lit. In the dot display, the input value is indicated by the relative position of just one lit LED.

Special IC's are available for building LED analog displays, the most useful examples being the U2X7B family from AEG, and the LM3914 family from National Semiconductors. The U2X7B family consists of simple, dedicated devices, which can be usefully cascaded to drive up to 10 LED's in bar-graph mode only, the members being the U237B, U247B, U257B, and U267B. The LM3914 family is more complex and versatile by comparison, and are easily cascaded to drive up to 100 LED's in either bar-graph or dot-graph mode. Both varieties of IC's are considered to be bar-graph drivers.

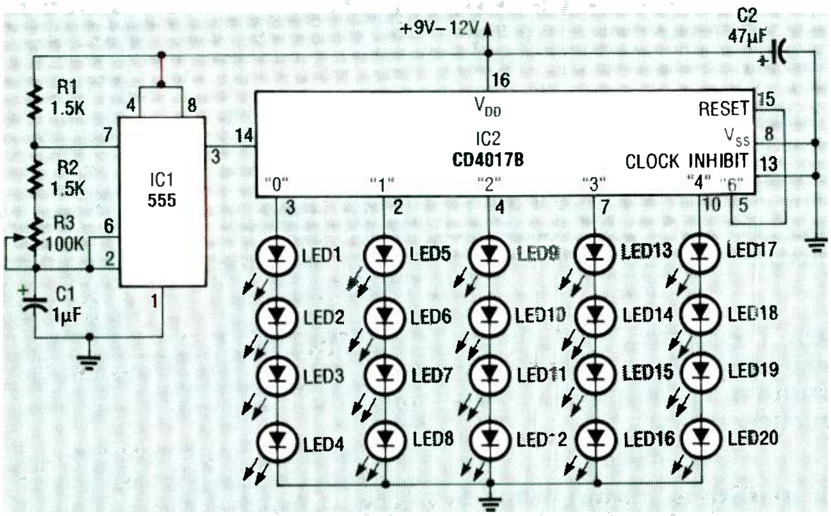


FIG. 12—A 4-BLANK 5-STEP 20-LED CHASER, for use with a supply above 9 volts DC.

TABLE 3—U237 IC FAMILY MAJOR SPECIFICATIONS

Parameter	Minimum	Typical	Maximum
Supply voltage	8V	12V	25V
Input voltage	—	—	5V
Input current	—	—	0.5 mA
Max supply current	—	25 mA	30 mA
Power dissipation (at 60°C)	—	—	690 mW
Step tolerance	−30 mV	—	30 mV
Step hysteresis	—	5 mV	10 mV
Input resistance	—	100 K	—
Output saturation voltage	—	—	1V

TABLE 1—U2X7B INTERNAL TRANSISTOR STATES AT VARIOUS INPUT VOLTAGES

V_{IN},V	Q1	Q2	Q3	Q4	Q5
1.0	Off	Off	Off	Off	Off
0.8	Off	Off	Off	Off	On
0.6	Off	Off	Off	On	On
0.4	Off	Off	On	On	On
0.2	Off	On	On	On	On
0.0	On	On	On	On	On

IC-driven bar-graph displays are inexpensive, superior alternatives to analog meters. They don't stick, they're fast, and they're unaffected by both vibration and attitude. Their scales can have any desired shape, they can have mixed LED colors to highlight special sections, and they can be equipped with over-range detectors that are activated by the drivers to either sound an alarm, flash the display, or both.

The linearity of such a bar- or dot-graph meter is considerably better than that of most analog meters, and is generally about 0.5%. The resolution depends on the number of LED's that are used; a 10-LED version has adequate resolution for most hobbyist purposes.

Basics of the U2X7B IC family

The AEG U2X7B IC family is composed of four different 8-pin DIP's, each capable of driving five LED's. The U237B and U247B pair produce a linear display, and are used together when driving 10 LED's. The U257B and U267B pair produce a logarithmic display, and are also used together when driving 10 LED's. All four IC's in the family use the same internal circuitry, in block diagram form, as shown in Fig. 13.

All four IC's contain five Schmitt voltage comparators with unique thresholds feeding into transistor switches. The thresholds are fixed by the tapping points on voltage divider R1–R6, which is powered using a built-in voltage regulator: each comparator input is connected to pin 7.

All four IC's also contain an internal 20-milliamp constant-current source, and the five external LED's go in series between it and ground (pin 1), as shown. Groups of LED's are turned on or off using the individual switching transistors. If Q3 is turned on, it sinks 20 milliamps via LED's 1 and 2, so they turn on, and LED's 3–5 turn off.

The U2X7B family has step voltages spaced at 200-millivolt DC intervals, and Table 1 lists the states of its five internal transistors at various input voltages. At 0 volts DC input, all five transistors are switched on, so Q1 sinks the full 20 milliamps, and all five LED's are off. At 200 millivolts DC, Q1 turns off but all other transistors are on, so Q2 sinks the 20 milliamps via LED 1, driving LED 1 on and turning all others off.

TABLE 2—U237B INTERNAL STEP VOLTAGES

Device	Step 1	Step 2	Step 3	Step 4	Step 5
U237B	200 mV	400 mV	600 mV	800 mV	1.00 V
U247B	100 mV	300 mV	500 mV	700 mV	900 mV
U257B	0.18V/ −15 dBW	0.53V/ −6 dBW	0.84V/ −1.5 dBW	1.19V/ +1.5 dBW	2.0V/ +6 dBW
U267B	0.1V/ −20 dBW	0.32V/ −10 dBW	0.71V/ −3 dBW	1.0V/ 0 dBW	1.41V/ +3 dBW

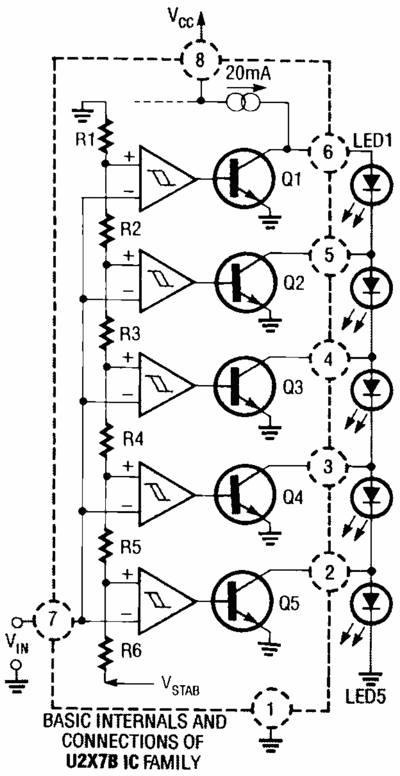


FIG. 13—BLOCK DIAGRAM OF a U2X7B bar-graph driver, showing the basic external connections.

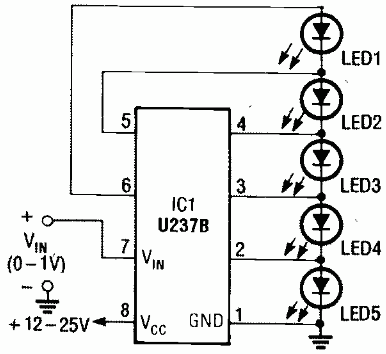


FIG. 14—A 0–1-VOLT DC, 5-LED, linear-scale bar-graph meter using a U237B.

With an input of 1 volt DC, all transistors are off, the 20 milliamps go to ground via the LED's, so all five LED's are on. The IC current is independent of the number of LED's turned on, so minimal RF interference (RFI) is produced as it switches transistors and LED's.

The four IC's in the U2X7B family differ only with regard to their step voltages, which are fixed by R1–R6 as shown in Table 2, and the values for which are also given in dBW (or dB relative to a watt). The linear-scale U237B and U247B pair of IC's can be used to make a 10-LED, 1-volt DC linear meter. The logarithmic-scale U257B and U267B pair of IC's can be used to make a 10-LED logarithmic meter with a full-scale value of 2.0 volts DC, or +6 dBW.

The reason for the correspondence between those two values is justified as follows. Since

$$P = E^2/R,$$

where P is power, E is voltage, and R is resistance, then the assumption, for purposes of convenience, is that:

$$R = 1 \text{ ohm.}$$

If so, then to convert voltages on the logarithmic-scale meter into a quantity *proportional* to power (and *not* into power itself), just square the voltage indicated, take the $\log_{10}$ of the result, and multiply by 10. If E has the unit of volts (as opposed to some fractional or multiple unit, like millivolts, for exam-

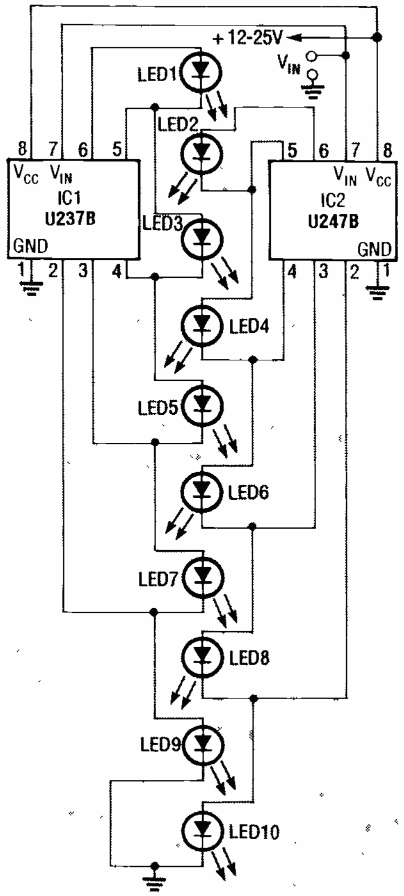


FIG. 15—A 0–1-VOLT DC, 10-LED, linear-scale bar-graph meter using a U237B and a U247B connected as a pair.

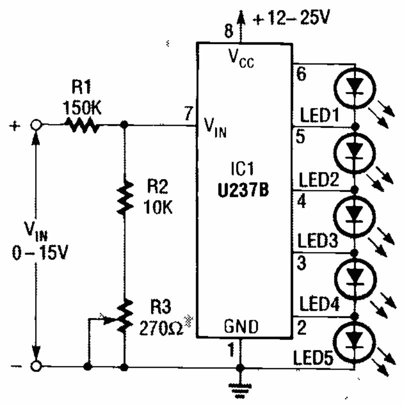


FIG. 16—METHOD OF REDUCING the sensitivity of the bar-graph meter shown in Fig. 14, for use in a 0–15-volt DC, 5-LED, linear-scale, bar-graph meter using a U237B.

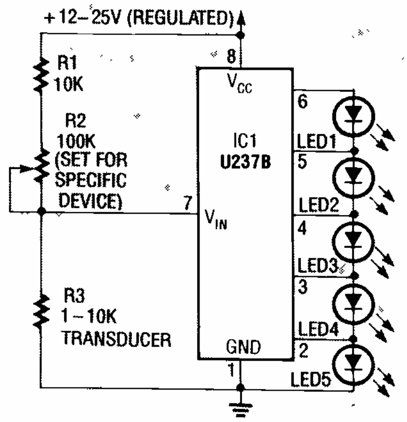


FIG. 17—SIMPLE USE OF A transducer to show the value of a physical quantity.

ple), then P has the units of watts, and the units in dB are called dBV, since they're expressed relative to a fixed value of potential.

Likewise, if you wanted to express dB in terms of power, then the proper terminology would be dBW, or a similar unit for any fractional unit of power. The number of dBV is always double the number of dBW, since taking the $\log_{10}$ of both sides of the power relation gives

$$\begin{aligned}\log(P) &= \log(E^2/R),\\ &= 2 \times \log(E) + \log(R),\\ &= 2 \times \log(E) + \log(1),\\ &= 2 \times \log(E).\end{aligned}$$

For that reason,

$$1 \text{ dBW} = 2 \text{ dBV.}$$

For example, in Table 2, for the U267B and step 5, the entry given is 1.41 volts DC, or +3 dBW. On squaring that, you get

2 volts^2, so 10 times its $\log_{10}$ is +3 dBW, and doubling that gives +6 dBW. Of course, when ever you take the logarithm of a quantity like voltage or power, you always operate on the numerical part alone, and ignore the units. If you ever hear of an audio or noise level that's expressed in dB alone, with no unit appended to indicate "dB with comparison to what," such a specification is nonsense.

To express an amplitude in dB relative to a unit of potential or power with a multi-letter abbreviation, just append the whole unit, like dBmV for dB relative to a millivolt. Sometimes, the term dBm is used as an abbreviation for dBmW, or dB relative to a milliwatt.

Table 3 lists the specifications of the U2X7B family. When driving five red LED's, each with a 2-volt DC forward drop, the minimum supply value required must be 12 volts DC. Different-colored LED's with different forward drops can be used together, if the supply voltage is adequate.

Although the IC input impedance is typically 100K, the IC becomes unstable if the source impedance is above 20K. It should ideally be kept under 10K; if it's not, place a 0.01-µF capacitor between pins 1 and 7 for added stability.

Practical U2X7B circuits

Figures 14–19 show practical U2X7B-family circuits; in all of them, the supply is 12–25 volts DC, but you'll have to remember the constraints previously mentioned. Figure 14 shows a 0–1-volt DC, 5-LED, linear-scale meter using a U2X7B, and Fig. 15 shows a U237B and U247B pair used in a 0–1-volt DC, 10-LED, linear-scale meter. The latter circuit operates each IC as shown in Fig. 14, with supply voltages that are appropriate to five LED's, but their input terminals are tied together, and the LED's are alternated, to achieve a 10-LED display.

Figure 16 shows how the full-scale sensitivity of the meter is reduced by feeding the input to IC1 via R1-R2-R3, using a ratio of 15:1, and giving full-scale sensitivity of 15 volts DC. Figures 17 and 18 show how the circuit shown in Fig. 14 can be used to display a physical quantity like light intensity or heat, as represented by the analog resistance R3 of a transducer. In both, the transducer is fed by a constant-current source, so the input voltage to IC1 is directly proportional to the transducer resistance.

As shown in Fig. 17, constant transducer current is derived from regulated supply via R1-R2, since regulated supply voltage is large relative to the 1-volt DC full-scale meter sensitivity. By contrast, as shown in Fig. 18, constant current is ensured via D1-Q1. Finally, Fig. 19 shows the U267B used in a 5-LED logarithmic audio-level meter. A 10-LED meter can be made using a U257B and U267B pair as shown in Fig. 15. R-E

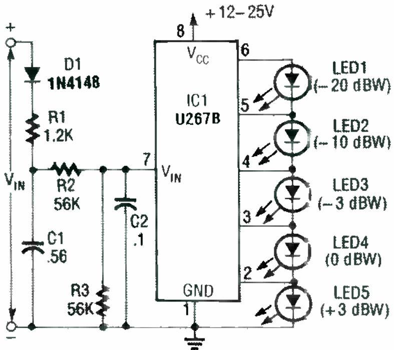


FIG. 19—A 5-LED LOG-SCALE audio-level meter; a 10-LED version is made using a U257B and U267B pair, in a fashion similar to the version shown in Fig. 15.

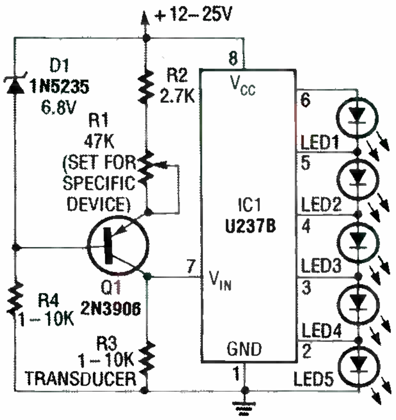


FIG. 18—AN ALTERNATIVE USE of a transducer to show the value of a physical quantity.

ADC FOR YOUR PC

continued from page 68

rent directory. If the file exists, the program then tells you how many samples it contains, and asks start and stop points for the plot; the maximum number is 1000.

The program (line 170) scales the graph to produce the widest possible graph; lines 220–270 graph the data. Press Esc to terminate the program. To "magnify" a limited portion of the data set, run the program again, and enter appropriate start and end values (e.g., 350 and 450). You can print your graphs by running the DOS program GRAPHICS.COM before GRAFDATA.BAS. When the desired graph appears on the screen, press PrintScrn. (You must have a compatible printer in order to print out any of the graphs.)

Triggered sampling

Now with the software under our belt, it's time to finish the "rapper" story begun earlier. The rapper was triggered by an electronic control circuit. We tried to trigger sampling by hand, but it was impossible to tell when the rapper was about to energize, and reaction time was too slow and unsure for accurate triggering. Our solution was to create a trigger input. We tapped a digital signal from the control circuit that changed just before the rapper triggered.

The ADC circuit uses only 8 of the 24 input lines on the PC IO. What we did is use bit 0 of port B as a trigger input. Then by adding a single line of code, we could trip on either a low-to-high signal:

```
145 IF (INP(ADD + 1) AND 1) = 0 THEN
    GOTO 145
```

or a high-to-low signal:

```
145 IF (INP(ADD + 1) AND 1) = 1 THEN
    GOTO 145
```

If you want to add a slight delay between the trigger and the start of sampling:

```
146 FOR I = 1 TO DELAYTIME : NEXT
```

However, the delay time in this case would vary with the speed of your PC. In addition, make sure the trigger signal is TTL-compatible (logic low = 0V, and logic high = 5V). If it isn't, or you want to buffer the trigger signal from your system, you can use the circuit of Figure 5. Remember, this circuit inverts the incoming trigger signal, so a positive-going trigger will be negative-going when it exits the buffer circuit. Adjust added line 145 accordingly.

Conclusions

The analog world of nature is not so distant from the digital world of computers. Simple circuitry can allow your PC to function as a digital eye, ear, or hand on the external world. The circuits and software shown here are only the beginning. **R-E**

HARDWARE HACKER

Caller ID update, new wavelet shareware, perpetual motion again, common lab test pitfalls, and Lumeloid and Lepcon films.

DON LANCASTER

Wavelets. We have got lots of wavelets. You getcher wavelets here. As we've discovered a number of times before, wavelets are a stunning new math concept that is profoundly changing virtually all the advanced electronic topics. A failure to learn wavelets *now* is the same as volunteering for early retirement.

We've already seen that *Jones and Bartlett* has published THE great new wavelets book, and that the *Ultrawave Explorer* from the *Aware* folks is definately one fine commercial wavelet study and development program.

But the big news is that I've just posted full working PC shareware copies of the *Wavelet Packet Library* from *Digital Diagnostics* on *GEnie* PSRT as #365 WAVELET.PS.

Those of you into satellite dishes and microwave electronics are now probably familiar with *Smith Charts*, a handy graphical method of doing things like impedance matching and tuning. I have written a PostScript Smith Chart generator that lets you instantly create all your own Smith charts in any quantity, any size, any-resolution, and any where in your publication. Check *GEnie* PSRT #367 SMITHCHT.PS for several freeware samples. Your downloading cost on this is around twenty one cents.

Perpetual motion again

I get an average of three to five helpline calls a week on "free energy" and other perpetual-motion topics. As we have seen in the past, perpetual motion is definitely real as a historic and ongoing societal phenomenon. We have also seen that two ongoing sources of perpetual-motion books, videos, and papers are *High Energy Research* and *Lindsay Publications*.

Now, I personally feel that looking for any free-energy systems is rather dumb. First, because the desirability of any free energy ranks somewhere between Herpes and AIDS. Why? Because this would obviously hasten the already ongoing entropic heat death of the planet. If someone does in fact find a free-energy system, they should be spanked and sent to bed without any supper. Or, better yet, chopped up and fed to the cows.

Second, because the odds of your accomplishing anything that's even remotely useful involving free energy are stupendously low. Third, because your credibility starts out as less than zero and quickly plummets. Owing to previous scams, the "not even wrong" research, and the "few-chips-shy-of-a-full-board" guilt by association.

And, finally, because there's so much better to be doing. We're sitting on the greatest mountain of new hardware hacking chips, tools, info, and concepts anywhere ever. Stuff that's crying for hacker use, and stuff that is nearly certain to result in lots of interesting and profitable things. Why should you ignore the obvious?

Several of the recent callers were making measurements that were just plain wrong. Since I am one of the world's foremost experts in gathering incorrect, misleading, or meaningless lab data, I thought we might briefly focus on a few of the ways that casual measurements may not end up what they appear to be.

In general, you'll *always* want to assume that *all* meter pointers and, especially, *all* of your digital numeric displays are lying through their teeth. Or, if they are giving you a correct reading, the odds are overwhelming that the *meaning* and the underlying *reasons* for that reading are not at all what you had in mind.

Oscilloscopes do a far better job than the meters or digital displays at showing you what is really coming down. Even here, an uncompensated probe, the wrong setting, improper sync, an invisible glitch, any outband signals, or just a ground clip that is slightly too long can cause you wildly incorrect results.

It is only when the same tests are run over and over again by different people under different circumstances that you can even remotely begin to trust your instruments. Even when repeated, that trust should only apply to the *exact* measuring conditions.

A ferinstance: Figure 1 shows you a seemingly simple method to measure AC power. You connect your new motors-and-magnets perpetual motion machine load to the AC power line through an ammeter and then separately measure the line voltage. Since power equals volts times amps, you just multiply your two readings together and you'll have the input power. Right?

Wrong. Dead wrong.

Let's temporarily forget about any noise, spikes, back-EMF effects, harmonics, and non-linearities that are certain to be present with your new motors-and-magnets load. Assume a pure sine-wave voltage and a similar current waveform. You have to take the *phase* of the current into account. You would get a zero phase shift

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with a purely resistive load. In a purely inductive load the voltage would *lead* the current by 90 degrees. In a purely capacitive load, the voltage will *lag* the current by 90 degrees.

Good old *ELI THE ICE MAN*. The voltage is ahead of the current in the eLi's L inductor; the current is ahead of the voltage in his iCe capacitor.

And if you have any purely active load such as another generator, your current could end up phased by 180 degrees. Sourcing, not sinking.

Your actual power will end up as the voltage times the current times the cosine of the phase angle between the two. If your voltmeter reads 110 and your ammeter reads 4, your actual circuit power will be 440 watts to a purely resistive load, ZERO to any purely inductive or capacitive load, and MINUS 440 watts to any purely active load. Or anything between, depending upon your phase angle.

Why is the power zero to a purely inductive load? Because of the phase angle. A math freak will tell you the full cycle cross product of a sine and its cosine is zero. Intuitively, on the first quarter cycle, you have positive voltage and current. On your next quarter cycle, you will have positive voltage and negative current. On the next, negative voltage and negative current. And finally, negative voltage and positive current. Add them all up and average them all out and you end up with zero real power.

Yes, you will get lots of back-and-forth reactive power that can give you real fits. And hack off your electric utility. But your net real power into a pure inductive or capacitive load is precisely zero.

Thus, as far as power goes, all the voltmeter and ammeter readings are *totally meaningless*. And they are even less so in the presence of noise, back EMF's, sparking, or harmonics.

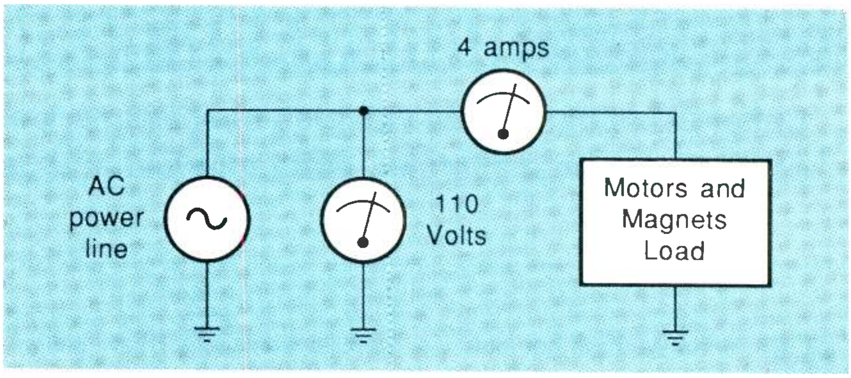

FIG. 1—WHAT IS THE REAL POWER being consumed in this test circuit? There's no way to tell with the setup shown. But you can safely bet that it is probably not anywhere near 440 watts

Measuring real power

So how do you measure real and reactive power? The trick is that you have to multiply the *instantaneous* voltage and current together. Then you sum to find the total power.

The power of any arbitrary waveform is equal to the DC continuous power that would give you exactly the same amount of total heating in a purely resistive load.

You can do this measurement with a real *wattmeter*, or by measuring the rotational speed and direction of a *watthour meter*. The wattmeters and watthour meters are often available through *Fair Radio Sales* or *Herbach and Rademan*.

Electronically, you can use a multiplier chip or a special RMS power-calculating circuit. *Analog Devices* is one leader in low-cost power chips of this type.

Or graphically, you can take plots of all the exact voltage and current waveforms, split them up into time slices so narrow that the voltage or current does not change much, multiply the results of those slices and then sum the results.

Note that you *must* multiply first and then add. Never vice versa.

But you still do have to be careful. Nonlinearities, pulses, harmonics, motor back-EMF effects, and noise require special treatment. And most power measurement schemes have a *crest factor* limit which ruins their accuracy on strong but narrow pulses. Especially things like spikes and glitches.

For these reasons, it is extremely difficult to accurately measure your input power to a motors-and-mag-

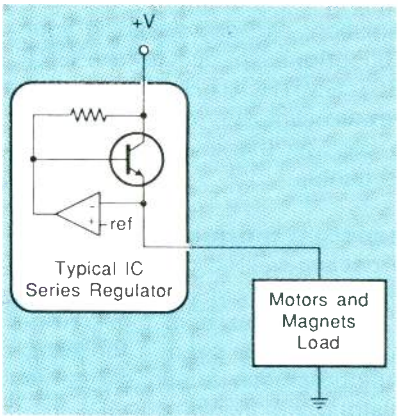

FIG. 2—WHEN IS A REGULATOR not a regulator? Any time that your load tries to source (rather than sink) power, a typical IC voltage regulator will shut down or else become unstable. There is no current path to ground.

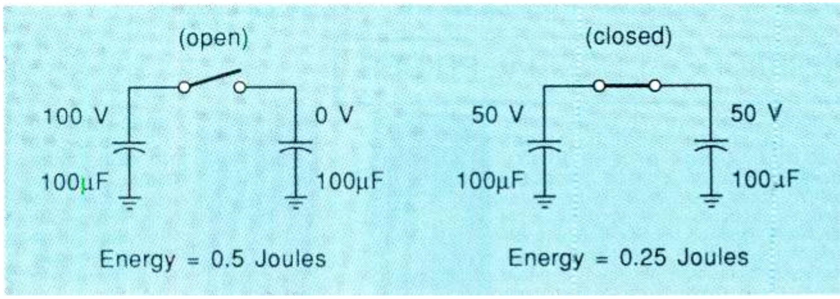

FIG. 3—QUICKLY CLOSE THE PERFECT AND LOSSLESS SWITCH. And half of your circuit energy will vanish without a trace. Where did the energy go?

nets perpetual motion machine. If you do not know *exactly* what you are doing, all your results are *guaranteed* to be wildly wrong. And so, of course, will be all of your conclusions.

Figure 2 shows you a second measurement pitfall that the recent callers have all decided to ignore. A voltage regulator is always a voltage regulator, right?

Wrong. Dead wrong.

Most popular voltage regulators are only capable of *sourcing* current. If the *load* starts *sourcing* any power even briefly, there is no place for the current to go, and the regulator either shuts down or starts oscillating.

Thus, if you have a motors-and-magnets load, there could be times when the back-EMF effects, spikes, commutator noise, or whatever, will try to *source* power back *into* your supposed power source.

Put in another way, typical power supplies and most regulators have wildly different impedances between when they source and sink power.

Note that any normally connected Zener diode will behave precisely the opposite—they are great power sinks but poor sources.

An output filter capacitor on your regulator is essential for grabbing and smoothing out high-frequency load sourcing variations.

Beyond proper output filtering, two ways around load sourcing effects are to hang enough of a resistive load on your regulator that the regulator will always output a net sourcing current. Most batteries are usually capable of sourcing and sinking any reasonable amount of current.

Figure 3 shows you yet another way to go astray. All bets are off if there is any sparking or arcing. It is physically impossible to instantly change the voltage across a circuit capacitor or the current through an inductor. The usual result when you try this is sparking or arcing.

Take a 100-microfarad capacitor and charge it up to 100 volts. Your energy in any capacitor is...

$$E = 0.5CV^2$$

or, in this case, 0.5 Joules of stored energy. Now, you close your lossless switch so you have two capacitors in parallel. The voltage must, of course, drop in half, since the same charge is now spread across twice your plate area. And by the same formula, you now have only 0.25 Joules of stored energy.

Question: Where did the rest of your energy go? If you have a non-lossless switch of resistance R, the answer is easy. In the process of charging the second capacitor, the extra energy got burned up in your resistor as heat during charging. But go through the charging math, and you'll find that the loss of half the stored energy is a constant which is *totally independent* of the value of R!

If R equals zero, then you have to get a spark and radiated energy. But you still lose half of it, regardless of how good the switch is.

Thus, if there is any sparking or arcing whatsoever in your machine, your readings are once again *absolutely certain* to be wrong.

Always think carefully about your measurements and how they could be wrong or misleading.

Lumeloid and Lepcon films

We sure had a bunch of helpline calls over the new materials stuff I announced a column or two back and in our *Hardware Hacker III* reprints. I've picked up some more

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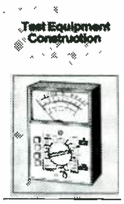

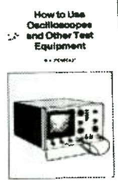

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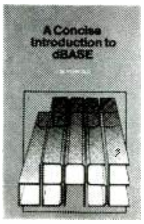

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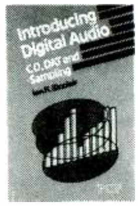

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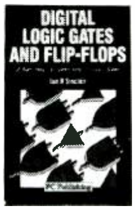

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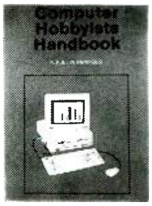

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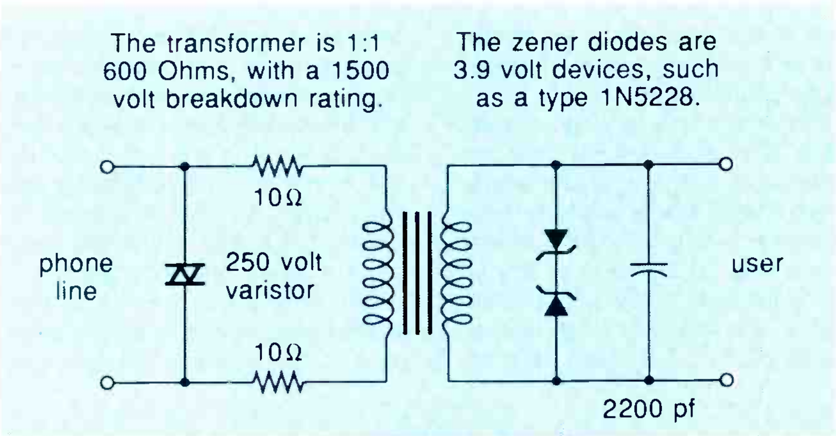

FIG. 4—A FCC PART 68 INTERFACE is required any time you connect any circuit of your own to the phone line. While this interface can be both simple and cheap, the required submission and approval process is not.

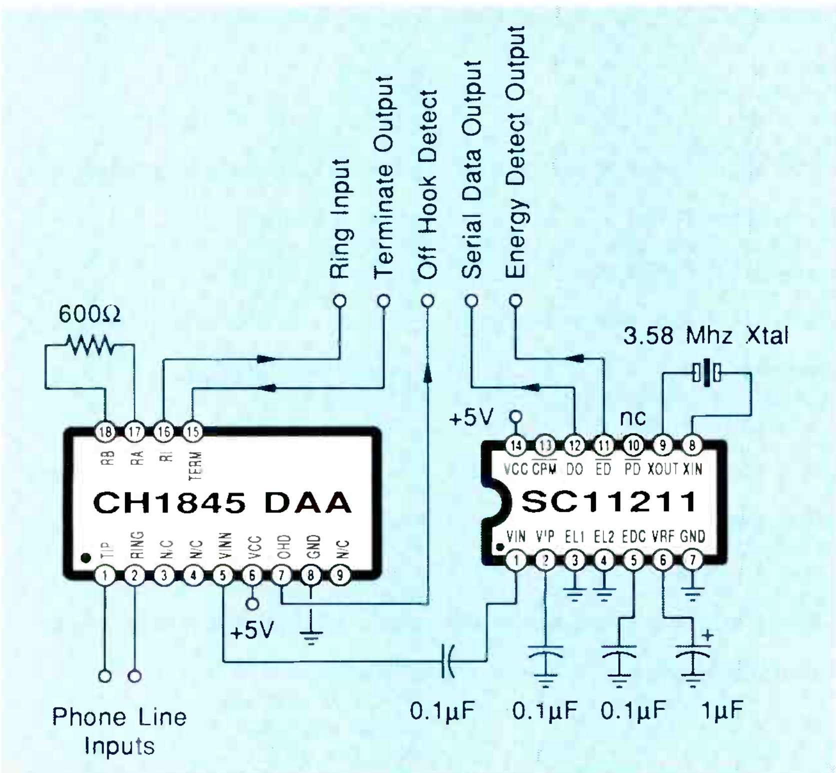

FIG. 5—PRE-APPROVED PART 68 INTERFACE HYBRIDS are available, but they are rather expensive. Here is a caller-ID circuit that uses the Cermetek CH1845 DAA interface and the Sierra SC11211 caller ID chip.

info, and have summarized where to go for more in our *Lumeloid and Lepcon Solar Resources* sidebar.

Let's start off with the bottom line: Yes, this looks like it someday could be real. Maybe. At least in the lab. No, you cannot yet buy the stuff by the yard through your local *K-Mart* fabric department and staple it to your roof. Yes, this is a great topic for a school paper or a science fair. And an incredible emerging research area.

On the other hand, *working prototypes do not yet exist*. And there are just enough "penny stock" and "media hype" aspects to all this that I have lowered my rating from "solar breakthrough" to "an interesting potential solar development." But you could judge for yourself, just by picking up on the resources in our sidebar.

The key individual behind all this

is one Alvin Marks and his company of *Advanced Research Development*. Their OTC pink sheet stock is traded under the name *Phototherm*. This is strictly an unregistered blue sky security, and trading remains illegal in Massachusetts, the issuing state.

Marks is a credible, experienced, and independent researcher with a long history of successful energy, optical-film, and pollution-control developments. Among other things, he developed the cheap glasses once used for 3-D movies.

And EPRI, that ultra-conservative *Electric Power Research Institute* electric utility consortium has seen fit to fund Marks with a modest research grant. Albeit a paltry one by EPRI standards. Coffee money.

The two key patents that are involved in this are #4,445,050 *Device for Conversion of Light Power into Electric Power*, and #4,574,161 *An Ordered Dipolar Light-Electric Power Converter*.

There is very little .published to date. And *all* of it is single sourced. None appears to be peer reviewed or critiqued. A collection of reprints is now available free on request from Advanced Research Development. One original paper has shown up as *Lumeloid Solar Plastic Films and Lepcon Submicron Dipolar Antennae on Glass*, from the 1990 *International New Energy Technology* symposium published by the *Planetary Association for Clean Energy*, located in Ottowa, Canada.

As we've seen a number of times in the past, you can quickly research any technical topic by using the *Dialog Information Service* at your local library, and then can get any reprint by using either interlibrary loan or the *UMI* reprint service.

So what is the big deal here and how does it work? Your traditional methods of generating electricity from the sun are seriously flawed. The old mirrors-and-boilers method involves a thermodynamic cycle with a *Carnot* thermodynamic efficiency limit around 35 percent. Besides not downsizing very well. Silicon solar cells at a theoretical 26 percent are even less efficient. It seems that they can only accept "whole lumps" of quantum energy, and have to throw the rest away as heat. And, before Marks, any photosynthesis scheme was well under six percent efficient.

Efficiency is everything in solar power. On a good day, you have one incoming kilowatt per square meter to work with. Say a nickel an hour "avoided cost" income for a perfect conversion. Or two cents a day allowing for night and weather. Naturally, your bottom-line efficiency will usually be much less than your theoretical. Let your efficiency drop too low and there's no way that solar can be competitive. Get under the bottom-line efficiency of seven percent or so, and you will *never* be able to pay for your installation and land, owing to the time value of money. The longer it runs, the more it costs you for the financing.

But, alternatively, the nickel-per-kilowatt-hour incoming solar energy on a 2200 square foot house roof

NAMES AND NUMBERS

Analog Devices
One Technology Way
Norwood, MA 02062
(617) 329-4700
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Aware
One Memorial Drive
Cambridge, MA 02142
(617) 577-1700
CIRCLE 302 ON FREE INFORMATION CARD

Bennet LaserBrite
720 Fourth Street, SW
Rochester, MN 55902
(507) 280-9101
CIRCLE 303 ON FREE INFORMATION CARD

Cermetek
1308 Borregas Avenue
Sunnyvale, CA 94089
(408) 752-5000
CIRCLE 304 ON FREE INFORMATION CARD

Dallas Semiconductor
4401 Beltwood Parkway South
Dallas, TX 75244
(214) 450-0400
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Digital Diagnostics
1025 Sherman Avenue
Hamden, CT 06514
(203) 288-9444
CIRCLE 306 ON FREE INFORMATION CARD

Direct Imaging
2 Technology Drive
West Lebanon, NH 03784
(603) 298-8383
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Hughes
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NewTek
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Topeka, KS 66603
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Serpac
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Covina, CA 91723
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Sierra Semiconductor
2075 North Capitol Avenue
San Jose, CA 95132
(408) 263-9300
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Cypress, CA 90630
(714) 229-4175
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adds up to over $3000 a year. Which is lots more than usually gets used underneath as electricity. So efficient solar electric conversion could completely blow away coal, nuclear, and even most hydro.

Marks has developed two different solar-to-electric systems that seem to have rather high theoretical efficiencies.

Radio waves are electromagnetic. Solar energy is electromagnetic. The main difference between orange light (at 600 nanometers) and television channel two (6 meters) is a 10,000:1 size factor. Those light wavelengths may seem tiny, but we are starting to routinely handle *submicron* distances in integrated-circuit manufacturing.

There's this thing called a *crystal set* that you might have heard of. Just shove some electromagnetic energy into an antenna, rectify it somehow, and out comes DC power. These days, we call the same thing a *rectenna*. So why not use light waves instead of radio waves?

An antenna is any subsystem for converting radiated electromagnetic energy into conducted wire electromagnetic energy. Or vice versa. As a transmitter, if your antenna is now properly *matched* to the rest of your circuit, nearly all of your input energy will get radiated. And, since most antennas are linear and reciprocal devices, if you input any electromagnetic energy well inside of the antenna's *effective area*, nearly all of it will get converted into conducted electricity. So, a properly matched antenna can be 100 percent efficient. And a rectifier nearly so.

Now, an optical antenna is trivial. Just make it any old color so long as it is black. Even a black felt tip pen will do. The trick lies in rectifying and gathering all the received solar electromagnetic electricity, rather than burning it up as heat.

The *Lepcon* panel is the older of Marks' two new developments. In a Lepcon panel, tiny rectenna elements are created on glass using more or less conventional but very advanced microlithography. These are basically a conductive channel ending with a metal barrier diode. The photons in the incoming solar

LUMELOID & LEPCON SOLAR RESOURCES

Key Patents:
#4,445,050—Device for Conversion of Light Power into Electric Power.
#4,574,161—An ordered Dipolar Light-Electric Power Converter.

Key Paper:
Lumeloid Solar Plastic Film and Lepcon Submicron Dipolar Antennae on Glass. 1990 International New Energy Technology Symposium. pages 201-210. From Planetary Association for Clean Energy below.

Key Info Packet:
From Advanced Research Development below.

Key Players:

Advanced Research Development
359R Main Street
Athol, MA 01331
(508) 249-4696
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Dialog
3460 Hillview Avenue
Palo Alto, CA 94304
(415) 858-2700
CIRCLE 320 ON FREE INFORMATION CARD

Electric Power Research Inst.
PO Box 10412
Palo Alto, CA 94303
(415) 855-2000
CIRCLE 321 ON FREE INFORMATION CARD

Home Power
PO Box 130
Hornbrook, CA 96044
(916) 475-3179
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Planetary Assoc Clean Energy
191 Promenade du portage, #600
Hull PQ, CANADA J8X 2K6
(819) 777-9696
CIRCLE 323 ON FREE INFORMATION CARD

UMI
300 North Zeeb Road
Ann Arbor, MI 48106
(800) 521-3044
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energy are used to accelerate electrons, which jump the barrier diode to become a DC current. Unlike a traditional solar cell, there are no "whole lumps only" quantum effects involved, and nearly all of the available energy gets converted.

The antenna/rectifier combination only works with one polarization of light. It converts the one polarization with up to a theoretical 80 percent efficiency, and passes the remainder on through. You could put a second Lumeloid panel underneath that is oriented 90 degrees from the first to convert the other polarization.

Or, you could use a sneaky trick consisting of a *quarter wave plate* and a mirror to rotate your rejected polarization by 90 degrees and shove it back *up* through the original film. Your combined efficiency ends up around a theoretical 72 percent.

The projected costs of the Lepcon process is around $250 per panel, and the panels should last 25 years.

The *Lumeloid* film process uses chemicals instead of very expensive microlithography. The chemical techniques in theory lend themselves to low-cost and high-volume production. The chemicals attempt to mimic the first half of the long photosynthesis process. A rather long chain carbon molecule, such as polyacetylene, is attached to some electron donor acceptor complex, such as porphyrin and quinone.

The long chain molecule acts as a conductive antenna, changing the input optical energy into electron energy. The tunneling gap effect between the large donor and small acceptor rings acts as a rectifying diode for DC conversion.

For all this to work, the molecules have to be carefully oriented while the sheet is being created. Mark's work has centered on suitable bulk processes to do the orientation in a low-cost and high-volume process. Projected costs are five dollars per meter and three cents per watt.

At present, the Lumeloid films are only expected to last a year in strong sunlight. Once again, Lepcon panels use conventional microlithography on glass, while Lumeloid use oriented films that mimic photosynthesis.

Interestingly, the Lumeloid process is totally reversible. You can input electricity and get light out as well. Which could lead to new lighting and display technologies.

For any of this to become real, we will need working prototype panels, credible third party research, and the proper peer review. My "usual suspects" of *Science*, *Nature*, *Science News*, and the technology page of the *Wall Street Journal* have been suspiciously silent to date.

My own feelings are that short and open circuits in production panels are going to lead to the very same type of yield problems that have held back and restricted development of large area flat-panel TV displays.

Because of the lack of even lab prototypes, their efficiency and cost projections at this time would appear totally meaningless.

Caller ID update

Time sure does fly when you are having fun. As a result, I've gotten hopelessly far behind on a bunch of potentially great projects here. So my caller-ID project may take a while.

Caller ID should be available in most parts of the country very soon. The controversy is dying down, since the benefits so totally and ludicrously outweigh any potential problems. To see what dozens of others are now thinking about caller ID, you might want to check #2239 CALLERID.CAP on the *GEnie* RADIO RoundTable.

If for no other use, the convenience of having a no-charge, no-hassle list of everyone that called you while you were out is just flat out wonderful.

Motorola has just announced a brand new MC145447 caller ID chip. Free sample kits are available. This one is supposed to include internal ring detection. But, as near as I can tell so far, the chip of choice remains the *Sierra* SC11211.

An FCC Part 68 interface is shown in Fig. 4. Which is what normally has to go between you and the phone company. Key points include an exceptionally well-balanced transformer with a 1500-volt isolation capability. While such an interface is fairly cheap and simple, getting the needed approval is not.

Several companies now offer some ready-to-go Part 68 interfaces. These are priced well above what you could build your own for. But they come pre-approved, eliminating most legal hassles. *Dallas Semiconductor* and *Cermetek* are two typical sources. An interface between the new Cermetek CH1845 and the Sierra SC11211 caller ID chip is shown in Fig. 5.

Both *Cermetek* and *Sierra* have free caller-ID ap notes available.

As we've seen before, a number of ready-to-use caller-ID products are available from *Hello Direct*.

New tech lit

From *Sony*, a new *Laser Diode Guidebook*. And from *Hughes*, a free brochure on their *Nonvolatile Serial Programmable Devices*.

The Best of Analog Dialogue is a three decade compilation of the very best in analog linear integrated circuit design info. From the company *Analog Devices*.

In a startling development, *real thermography* is now available for toner-based desktop publishing. One new source is *Bennet LaserBrite*. You spray on chemical A to soften your toner, dust on powder B, and then apply heat from desklamp C. Presto. Instant raised letters. Even Braille.

Free stuff this month: A video on a high-end printed circuit prototyping system from *Direct Imaging*. A free video on the *Toaster*, the low-cost broadcast-quality video production system from *NewTek*. And a great new sample A-42 plastic electronic case from *Serpac*.

A reminder that I do have a full collection of reprints available. These include *Hardware Hacker II & III*, my *Ask the Guru I & II & III*, the *Blatant Opportunist I*, *LaserWriter Secrets*, and our brand new *Book-on-Demand Resource Kit*. Just give me a call on our no-charge tech helpline (per the box) for more details. Or call me at my *Synergetics*.

You can also reach me via *GEnie* PSRT (800) 638-9636. Besides that wavelet freeware and the Smith Chart package, you'll find lots of *Hardware Hacker* and *Midnight Engineering* hard-to-find resource stuff. **R-E**

More from the mail bag

LARRY KLEIN

Last month, I answered several hi-fi questions from readers, but ran out of room before getting to them all. This month, we'll get to the bottom of the mail bag.

Overpriced signals?

I'm appalled by the proliferation of signal processors—particularly equalizers—in the audio market place. What ever happened to the notion that a hi-fi system should be a "straight wire with gain"?
A.T.
McAlester, OK

The idea is alive and well, but beset by philosophical confusions. While the concept has validity for, say, power amplifiers, it really can't be applied to the entire recording-reproduction chain. Straight-wire-with-gain audiophiles—for whom tone controls of any kind are anathema—appear to assume that whatever signal comes out of their carefully chosen disc player or tape machine somehow perfectly embodies an original performance. Anyone naive enough to harbor such a belief has, at best, a *very* unclear notion as to how sound is recorded and reproduced.

Assuming that you had a perfect stereo recording of the sound field (at a specific location) of a live musical event—and all the electromechanical and electronic elements in your playback system were perfect—your speakers would still have the task of replicating the acoustics of a concert hall within the comparatively cramped space of a conventional listening room. In short, the chances of *exactly* duplicating an original live sound field in your listening room are about zero.

Given the aberrations in frequency balance, noise level, and dynamic range likely to be introduced, plus the loss of rear ambience and reflections, I see nothing wrong with using signal processors to help minimize, ameliorate, or eliminate the various ill effects. I've long since given up any hope of reproducing the precise sound of any original musical performance in my home. But when I achieve *plausible* reproduction, then I'm satisfied that I've achieved *high*, if not *absolute*, fidelity.

System imbalance

After a long struggle to find the reason for my having to operate the balance control on my preamplifier at the 3-o'clock position, I traced the difficulty to my speakers. What would account for the fact that a readjustment of the midrange control on one of my speakers cured the problem?
J.W.
Freeport, TX

The frequencies that contribute to the perception of "loudness" are mostly in the midrange. (You can confirm this for yourself by noting the small effect on the overall loudness of music produced by the outermost controls of a ten-band equalizer.) Hence, any control that boosts or cuts the mid-frequencies in a speaker system will also necessarily influence its relative "efficiency" or loudness.

Alcoholic anxiety

Some tape-cleaner ads seem to say that alcohol may be injurious to the insides of recorders. But magazines seem to recommend alcohol as a cleanser. Which information is correct?
N.W.
Covington, LA

You should avoid solutions sold as "rubbing alcohols" because they are likely to include a skin lubricant (usually glycerin) that could be transferred to the tape and the pinch roller. Ask your pharmacy for isopropyl alcohol in "NF" purity; that will work fine for heads, pinch rollers, and for general internal cleaning of your machine.

Costly repairs

My receiver recently went dead in one channel, and I brought it to a local authorized service center. They charged me $75 to repair a unit that cost $300 when new. My friends have had similar experiences. Are the repair-shop owners trying to get rich at our expense—and why don't the manufacturers do something about it?
K.U.
Boston, MA

We live in a time when very complex electronic devices are manufactured by automated machinery controlled by computers. That is the reason why you can buy a digital watch or a pocket AM/FM radio for well under $10. But the elimination or reduction of the expensive hand-labor element in many of today's electronic devices is of no help when the device needs repair. The repair process continues to be labor intensive, and it involves skilled, expensive labor at that. In short, although electronic products are built by the most sophisticated automated techniques available to the 20th century, they are repaired one at a time by the equivalent of an 18th-century handicraft approach. As you have found, that's not cheap!

Slam damage

I've noticed that when I close the trunk lid the cones of the woofers installed in my car's rear deck seem to jump forward. Can the woofers be damaged by my slamming the trunk shut?
E.C.
Chicago, IL

Possibly, but not probably. The variables in the situation are the ruggedness of the woofer-cone suspensions, the size and air leakage of the trunk, and the velocity of the slam. To determine whether there is a potential problem, watch the woofer cone (with its protective grille removed, if possible) during a typical slam. If the forced outward excursion exceeds a quarter inch or so, it might be best to close your trunk a bit more gently in the future. However, I expect that the better manufacturers of the larger car stereo speakers, who knew where they would be mounted, have designed their cone suspensions to withstand large pneumatic shocks.

FM bandwidth

What is the purpose of a narrow/broad bandwidth switch on an FM tuner?
R.A.
Bay Shore, NY

As far as I know, the only justification for a narrow-band switch is the rare case when a listener is located between two transmitters of comparable strength that are adjacent to each other on the FM dial. In any case, a rotatable directional antenna will probably be of more help in separating the two stations than the tuner's ability to narrow its IF bandwidth. The narrow bandwidth setting may be helpful if the conflicting stations are in approximately the same direction, or possibly when there are severe noise conditions.

Off-frequency FM

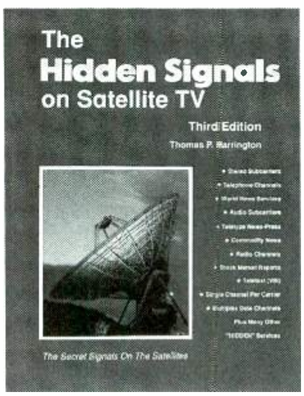
Many of the rock stations in my area advertise themselves as being located at, for example, "100 on the FM dial." But my digital tuner won't tune to even numbers; It sets itself for 99.9 or 100.1. Does something need adjustment?
R.P.
San Diego, CA

Yes—the thinking of those who like to reduce all communication to the short, punchy, and simple-minded. In the U.S., all broadcast stations are assigned odd-numbered operating frequencies, 2-megahertz apart. Even if you could tune to 100 MHz, you wouldn't find anything there but a lot of noise and distortion. But, come to think of it, that may be pretty close to what some stations are really broadcasting!

NEW LITERATURE

continued from page 27

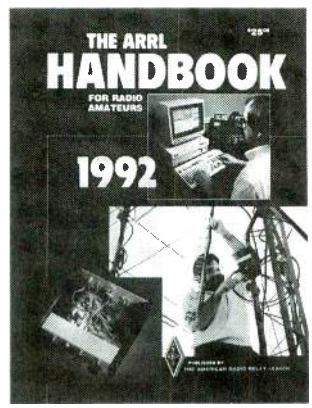
mation, complete specifications, and operating range data, are provided for more than 50 models. A five page summary of specifications and ranges is organized by instrument type to help the reader make model-by-model comparisons. Besides being chock full of test instruments, the catalog describes protective cases that are tailored for individual models, and a complete line of accessory test probes, cables, and test lead kits.



CIRCLE 37 ON FREE INFORMATION CARD

THE HIDDEN SIGNALS ON SATELLITE TV: THIRD EDITION; by Thomas P. Harrington. Universal Electronics, Inc., 4555 Groves Road, Suite 13, Columbus, OH 43232; Phone: 614-866-4605; $19.95, plus $3.00 shipping and handling.

Everyone knows that you can pick up video signals with a satellite dish, and most satellite owners know that they can also receive audio channels on receivers equipped with tunable audio subcarrier sections. However, not many people are aware of the variety of non-video and data services that are also carried on satellites. Those services include audio news, stereo subcarriers, telephone systems, world news and press services, teletext, single-channel-per-carrier (SCPC) systems, stock market reports, financial news services, and business data channels. This book covers all phases of this expanding side of the satellite business. Beginning with an explanation of the transmission and reception of satellite signals, the book goes on to provide details about each of the systems transmitting hidden signals. It describes each system and how it works, explaining who uses it and how the reader can receive it. The book also includes glossaries of data-communications and satellite-system terms.



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THE ARRL HANDBOOK FOR RADIO AMATEURS 1992; Edited by Charles L. Hutchinson, K8CH and Joel P. Kleinman, N1BKE. American Radio Relay League, 225 Main Street, Newington, CT 06111; $25.00.

Everything you ever wanted to know about amateur radio—and then some—can be found in the more than 1100 pages of this book. Aimed at hams, technicians, and engineers, the book provides a thorough introduction to the basics of amateur radio, including electrical fundamentals, the techniques and terminology of radio design, and the basics of solid-state and vacuum-tube sets. A comprehensive section on radio principles covers power supplies, audio and video communications, digital basics, modulation and demodulation, RF oscillators and synthesizers, principles of radio transmitting and receiving, transceivers, repeaters, amplifiers, antennas, and transmission lines. Modulation methods for voice, digital, and image communica-

continued on page 102

Our long-lost discussion on digital scopes.

ROBERT GROSSBLATT

Well, it's been a while coming but, at long last, we're finally back to talking about digital scopes. There have been some interruptions in the meantime but that's the way life is—it sometimes interferes with living. This subject got put on hold for a bit because of the business of voltage regulators. Sorry about that but, even if you don't have any particular interest in cars or motorcycles, all that information should be put away for future reference. You never know.

Just to refresh all our memories, we had been talking about the things to be considered in designing a circuit that would serve as the beginnings of a digital scope. All scopes, even the one we're going to design, have certain basic things in common and any project you have in mind that involves scope design has to start out life around these fundamentals. Your ultimate goal may be to construct something that's bigger, faster, or (to use my favorite phrase), "feature rich," but no matter what you have in mind, when you're just getting started it makes sense to approach things from the beginning.

The design criteria for the scope we are going to be putting together are the following:

1. The scope will have a maximum bandwidth of at least 1 MHz.
2. There will be eight selectable sweep speeds.
3. There will be eight selectable gain levels.
4. There will also be a variable gain control.
5. The display will be in a twenty-by-twenty matrix.

The block diagram of the scope we're talking about is shown in Fig. 1. While you're looking at it keep in mind that, even though we're only talking about a demonstration circuit, the basic structure is the same for every scope there is. Once you go through the design of a simple scope, it'll be much easier to understand the workings of more complex ones.

There are all sorts of interesting things that can be done with the scope we're building and there's no reason whatsoever why you can't take the basic circuit and add anything you want to it. But we're getting ahead of ourselves.

One of the major players in the accuracy of a digital scope is the timebase. Ordinarily, in a simple scope such as ours, the timebase is an RC-type circuit that gives you. . . well, RC-type accuracy. But just because we're not building the world's most complex scope, there's no reason why we have to settle for so-so accuracy. Whenever you want accurate timekeeping, the answer is a crystal-based circuit, and that's what we'll use here.

There's no shortage of circuits when it comes to building a crystal oscillator, and the schematic shown in Fig. 2 is as good as any. If you need frequencies up in the many megahertz or even the gigahertz range, you'd have to devote a lot of time to this part of the scope, but since we're keeping everything to under one measly megahertz, this schematic is a simple answer to the problem.

I've picked one megahertz for the basic crystal frequency because it's a nice even number to work with and 1-MHz crystals are readily available. You shouldn't have any trouble getting the 4049's to work at 1 MHz—even if you're only operating the circuit at 5 volts. If you have any problems, up the voltage to 9 volts or so (working with CMOS stuff is great!), and that should take care of the problem.

Should you want or need to stay down at 5 volts and you find that the

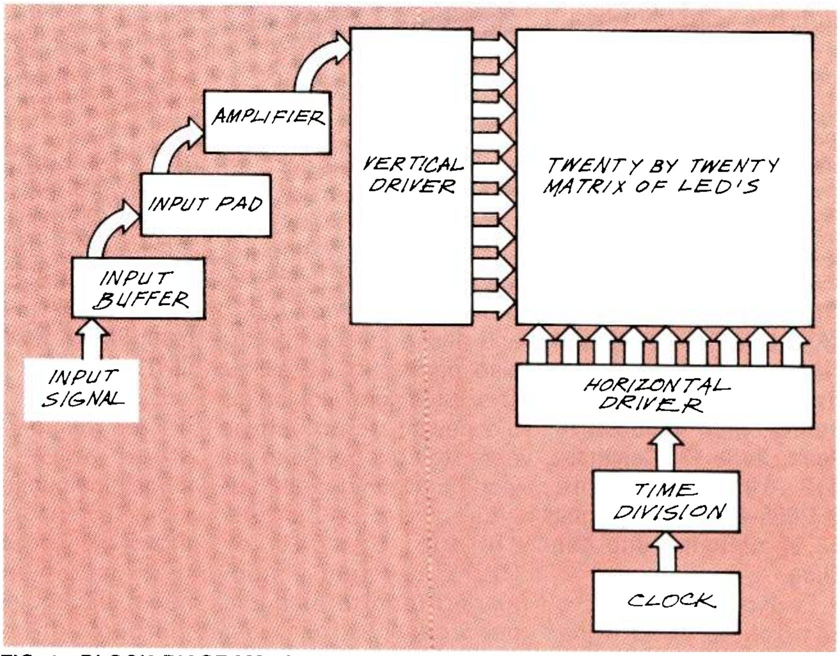

FIG. 1—BLOCK DIAGRAM of our oscilloscope. The basic structure is the same for every scope there is.

oscillator isn't self-starting at that voltage, use an equivalent high-speed CMOS part like the 74HCT4049. Most of the mail-order houses carry the 74HCT family and you'll find that they're all faster than the 4000 series and just as reliable. Just about the only restriction you'll have is that 74HCT parts have the same voltage restrictions as TTL. They want a supply voltage of 5 volts and going any higher than that is a sure way to cook the chip.

Once we have the timebase circuit working properly, the next step is to do some straightforward frequency division to generate all the sweep speeds we need. First, however, we should decide what those sweep speeds are going to be and, even before that, we have to work out how the horizontal part of the display is going to be conceptually organized.

Our display is going to be, as we specified, a twenty-by-twenty LED matrix. There are twenty columns of LED's and each column is going to be enabled in turn for a particular length of time. When we refer to the sweep speed, we have to distinguish whether we're talking about how long it takes to sweep across the entire twenty columns or how long each of the twenty columns is enabled.

If you look at the sweep-speed settings on a standard oscilloscope, you'll see that it's marked in seconds/division. Since our display is made up of separate columns, we can translate that into seconds per column. Therefore, we'll arrange our sweep speeds around the time each column is enabled, and not how long it takes to cycle through all the columns. That is important to keep in mind because we want to be able to get a rough idea of frequency when we're viewing a waveform on the scope, and the standard way of doing that is to count the number of divisions covered by a complete cycle. Since each division relates to a particular amount of time, you can estimate the period and calculate the frequency of whatever waveform is being displayed.

Standard oscilloscopes use a 5-2-1 counting sequence for dividing the sweep frequency. That means, at a basic level, that it takes the trace five, two, or one second (or some fraction of a second) to cover each division. The maximum sweep speed we can reasonably expect to have is about 10 microseconds since there are certain limitations to LED intensity, construction methods, and so on. It's possible to do a lot better, but the stuff you have to worry about has nothing to do with the basic design of the scope itself.

The lowest sweep speed that makes sense for the scope we're working on is about a tenth of a second per column. The major factor here is that when you get much slower than this, it gets increasingly hard to visualize the waveform on LED's. Remember that the scope will be enabling one column at a time and only one LED in each column will be lit. If the sweep speed is too slow, the eye won't be fooled into seeing several of the columns lit at the same time.

Once we get the circuit working, you can experiment with the range of sweep speeds and see what the outside limits are. The top limit is a function of electronics but the bottom is determined by considering the persistence of the retina and other biological factors. If you want to drop the sweep speed to one second per division because you have a particular need to do that it's relatively simple to set the elec-

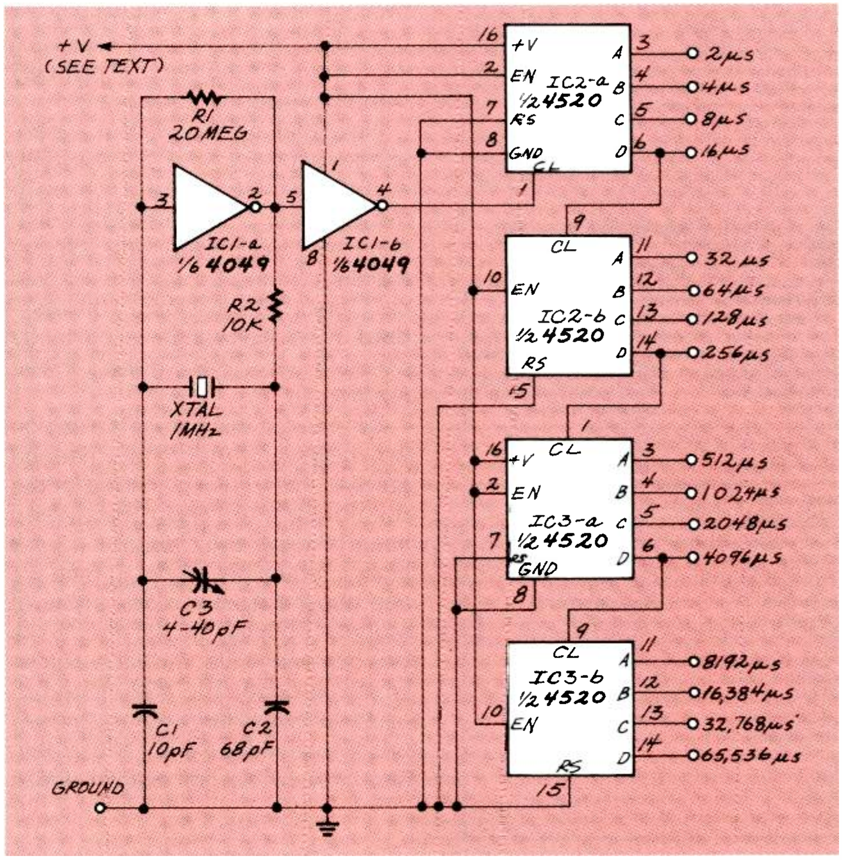

FIG. 3—THE 4520 DUAL SYNCHRONOUS BINARY COUNTER will provide us with a series of frequencies that are accurate enough for the kind of circuit we're designing.

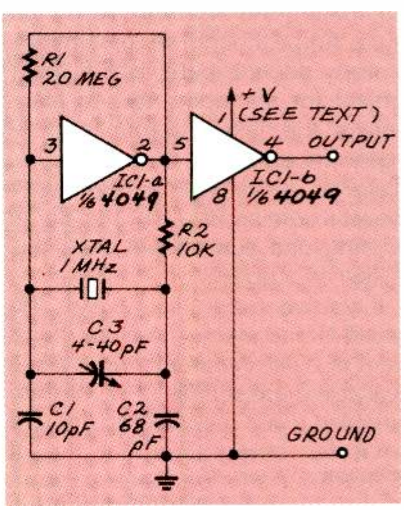

FIG. 2—A CRYSTAL OSCILLATOR for our scope. For frequencies below 1 MHz, this schematic is a simple solution.

tronics to do it. The best way to get an idea of what it would be like is to sit in front of a real scope and play with the sweep-speed control.

Now that we know the sweep-speed range—from a low of a tenth of a second (10 Hz) to a top of 10 microseconds (100 kHz) per division—we can decide what the remaining six sweep speeds should be. Generating divisions in the standard 1-2-5 sequence is certainly possible but it's also a pain in the neck to do.

We can cut this part of the design way down and reduce the needed parts to a bare minimum if we let the relationship between the sweep speeds follow the standard 1-2-4-8 binary sequence. By doing that, we can choose from a wide variety of standard binary counters and, as you can see in Fig. 3, that's exactly what I've done. The 4520 is a dual synchronous binary counter and will provide us with a series of frequencies that, while not exactly whole numbers, are close enough for the kind of circuit we're designing.

Remember that the resolution of the scope we're building isn't all that great in the first place.

Feeding a standard CMOS part like the 4520 with a clock as high as 1-MHz is an iffy business—especially, as we discussed a while ago, if you're running off a supply that's down in the range of only five volts or so. If you have such a problem, the ways to get around it are the same as the ones we talked about earlier; you can either raise the supply voltage or use 74HCT4520's instead of the standard 4520.

The two 4520's in the circuit give you a choice of sixteen clock frequencies (seventeen if you count the basic crystal frequency), so you have lots of sweep-speed choices. When we get together next time, we'll finish the horizontal circuit and go through the design of the vertical amps and driver circuit as well. **R-E**

EQUIPMENT REPORT

continued from page 16

the manual says to install C40, a 22 pF, 16-volt electrolytic, but the actual part, as shown in the parts list, is 22 μF. Also, a spring must be installed to the left of the 7106 IC to ground a metallic shield in the back of the meter housing; the instruction manual does not clearly show where the spring goes.

Other problems included R43, one of four 1-megohm resistors to be installed, but the parts list shows only three 1-megohm resistors and R43 as 100K—also, the 100K resistor was missing from our kit. Resistor R7 is said to be installed as 900K but the parts list shows it to be 898 ohms and that's what was included in our kit. Likewise with R8; it's installed as 100K but listed and included as 100 ohms. Another 100-ohm resistor, RX, was not among the parts included in our kit, but they did include an unnecessary 75K resistor—perhaps it was intended to be close enough in value to R43. Resistors R09 and R17 are to be installed as 9 ohms each but listed as 8.98 ohms. Neither of the two remaining resistors were color-coded for 8.98 ohms, but they measured about 12 ohms. Close enough we decided, and the meter seems to work just fine.

You never know exactly what's inside something until you take it apart, so you can't help but be familiar with the basic insides of any multimeter once you build the *100K*. The finished *100K* is a sturdy, capable meter, and certainly worth its price. And although we feel that it's a pretty decent meter and a great project for someone new to electronics, the help of someone more experienced might be necessary. However, we've already pointed out the kit's sore spots so if you plan on building one you should save this review as a guide.

If you've read this review and would like to own a *100K* but don't want to build it yourself, the *100K* is available preassembled. And the assembled *100K* multimeter actually costs ten dollars less than the kit ($19.95). That's because it costs more to package the unit in pieces, and the kit includes a 47-page assembly manual. **R-E**

COMPUTER CONNECTIONS

Pen-Based Computing

JEFF HOLTZMAN

Pen-based computing is one of this year's hot topics. At first glance, this new class of device seems to be more gadget than computer. On closer examination, however, it looks more like a glimpse of the future.

As with many hot topics in today's computer world, pen-based computing got its start at Xerox PARC (Palo Alto Research Center), a research division of the corporation mostly famous for photocopying, but whose basic research has fueled much of the personal computer revolution—but that's another story.

In 1968, a fellow by the name of Alan Kay, now a researcher at Apple, put together a cardboard model of something he called the Dynabook. Kay didn't call it a computer; he intended to suggest something far larger, more grandiose, more connected, and more accessible than any mere data-processing machine. The original design called for a notebook with a megapixel screen, multiple CPU's, and wired and wireless networking. Since then Kay realized that the hardware alone was not enough; a user-friendly (Macintosh-like) user interface would also be required. Even more important, a cooperating system of software "agents" would assist the user in gathering information and performing routine tasks. Agents are not yet ready for prime-time. User interfaces have evolved considerably since 1968, but still have a long way to go. Perhaps not surprisingly, as in most areas of the computer business, the greatest strides have been made in hardware.

Since portable computers, laptop computers, and notebook computers first started to appear, several companies have released suboptimal designs bearing the title Dynabook; however, it is only the very latest generation of pen-based machines that even dignify the concept. NCR released the first of this new breed in the spring of 1991; fall COMDEX in Las Vegas saw the release of a spate of new machines by other vendors. This first generation of commercial machines illustrates several points: (1) The Dynabook concept is valid, but (2) current hardware and software have not fully achieved the vision; even so (3) there is a light at the end of the tunnel.

Hardware and software

The typical pen-based machine is about the same size as a notebook PC (8.5" × 11" × 2", less than five pounds). The current generation typically has a 286 or 386SX processor, a few megabytes of memory, a floppy drive, possibly a hard drive, and a slot or two for special credit-card sized memory cards (these cards have now been standardized; more in a future installment). Usually there's no keyboard, although there are "convertible" units that allow both keyboard and pen input. Some units, such as Grid's GridPad RF (shown in Fig. 1), allow wireless connection to standard networks. Overall, the most interesting thing about pen-based machines is that the screen is used for both input and output. Using a special stylus, you draw, write, and edit directly on the display surface—it's like an intelligent Etch-A-Sketch, one that allows you to store and recall text and graphics. It's what some call a *direct-manipulation environment* (DME).

If there's no keyboard, how do you use the thing? There are three basic approaches. The first simply glues a pen-input interface on familiar operating environments (DOS or Windows). The second creates a rich new environment (GO's PenPoint operating system). The third creates a limited new environment, one that restrains cost and power in service of specialized applications.

Microsoft, as might be expected,

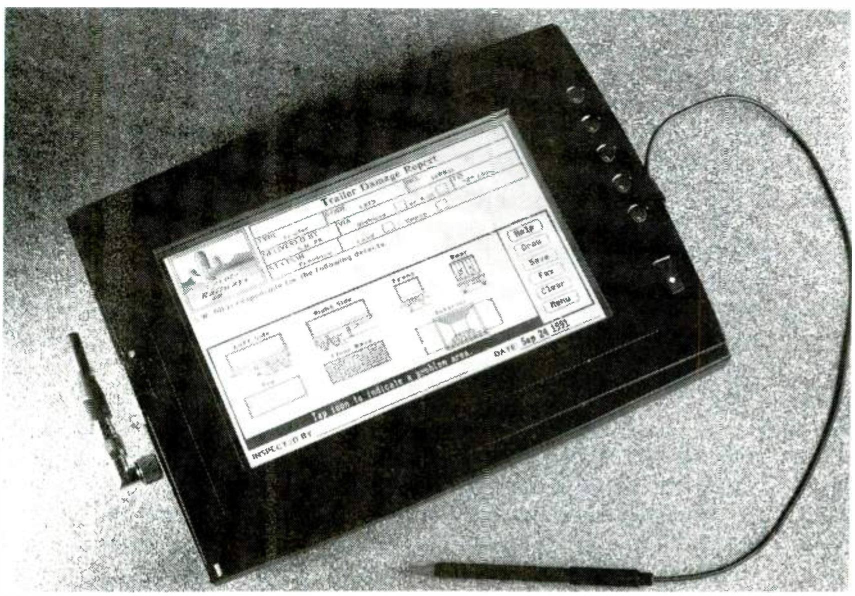

FIG. 1—THIS PEN-BASED PC from GRiD features wireless RF connectivity to Novell networks.

has adopted the first course. The company has defined a set of pen-oriented extensions to the Windows environment, called Windows for Pen Computing (WPC). This environment is scheduled to be released in the first quarter of 1992, right after Windows 3.1. WPC has already garnered support from some three dozen hardware vendors, including AST, Dell, Grid/Tandy, NCR, Zenith, Sharp, Sony, Toshiba, Tusk, Momenta, NEC, Samsung, Sanyo, and many more. Currently Grid owns more than 50% of the market, but in five years that's expected to drop to about 10% of the current level, with Sony, Toshiba, and Sharp accounting for about 36%, and IBM and Apple together for about 30%. Hundreds of software developers have also shown support for WPC.

A company called GO Corporation has pursued the second option with a product called PenPoint, the chief competitor to WPC. PenPoint has not achieved as much support as WPC (yet), but the support it has achieved is quite meaningful. IBM, for instance, has licensed PenPoint, and has shown it running on a to-be-released pen machine. Apple is evaluating use of PenPoint versus its own internally developed pen-based operating system for a soon-to-be-released pen machine.

Although extending an already popular environment has some advantages, some feel that a whole new way of looking at things is required. This new paradigm returns to square one in the process of thinking about how people can best interact with a computer. For example, the select-do paradigm (e.g., select text, press Delete) of Windows may not make sense in a direct-manipulation environment. In a DME you might simply draw a line through unwanted text. It's more direct, more natural, more efficient, more comprehensible by computer novices. This is the tack taken by PenPoint.

A related area is compound documents, documents that include text, graphics, possibly other media. Windows is just about to the point where building compound documents is reliable and efficient. By contrast, PenPoint has been built from the ground up to support Embedded Document Architecture (EDA). With EDA, you just grab something and start working on it. If it's text, a text-editing window pops up; if it's graphics, sizing/shaping handles appear. This focus on the document, rather than the applications used to produce it, is what will make pen PC's attractive to novices, and to the those of us tired of fighting the battle for integration.

Deferred I/O is another interesting capability of PenPoint. It allows you to "send" documents to other people, regardless whether you're plugged into the company network or riding a camel in Riyadh. If the hardware can't physically send the file when you make your request, it adds it to a queue and sends it when the required resources become available. Likewise with modem output, fax output, and printer output.

Gesture	Meaning
•	Places the insertion point or selects where you tap the pen.
—	Selects all characters under the line.
	Extends the selection to the location where you draw the gesture.
	Deletes the current selection or the character to the right of the insertion point.
	Deletes words or objects underneath the gesture.
\	Backspaces and deletes the character to the left of the insertion point. (Optional)
	Inserts space at the insertion point. (Optional; can also be positional)
	Inserts a new line (Return) at the insertion point. (Optional; can also be positional)
	Inserts a Tab at the insertion point. (Optional; can also be positional)
✓	Places the checked word or selection in the Edit Text dialog box.
	Cuts the selection and places it on the Clipboard.
	Copies the selection and places it on the Clipboard.
∧	Pastes the contents of the Clipboard at the insertion point. (Optional; can also be positional)
	Reverses the previous action.

a

Gesture		Meaning
Tap	▪	Select/Invoke
Press-hold	⊙	Initiate drag (move, wipe-through)
Tap-hold	▪⊙	Initiate drag (copy)
Flick (four directions)	|	Scroll/Browse
Cross out	X	Delete
Scratch out		Delete
Circle	O	Edit
Check	✓	Options
Caret	∧	Insert
Brackets	[ ]	Select object, adjust selection
Pigtail (vertical)		Delete character
Down-right	L	Insert space

b

FIG. 2—PEN-BASED GESTURES differ between Microsoft's Windows for Pen Computing (*a*) and GO Corp.'s PenPoint (*b*).

Gestures

Both PenPoint and WPC make use of *gestures*, pen motions that signal an intent to do something, and depending on the operation, the data to which it is done (e.g., striking a line of text). Gestures come in several sizes and shapes, depending on the system; and specific gestures tend to be inconsistent from system to system, as shown in Fig. 2-a (WPC) and Fig. 2-b (PenPoint). (This is equivalent to the once-heated argument about whether the Delete key should work on characters to the right or left of the cursor. The vast majority of users simply didn't care, as long as usage was consistent from program to program.)

PenPoint demonstrations are extremely compelling. But Microsoft is Microsoft, and Windows is Windows. Does PenPoint have a chance? It's simply too soon to tell. The Windows juggernaut is rapidly crushing everything in its path; GO is working hard on data portability, so there's a good chance it will at least survive. In any case, most hardware vendors are playing it safe and supporting both operating systems. Phoenix has even released a dual-mode BIOS that provides low-level support for both.

Theoretically, anything that runs under Windows should run under WPC. PenPoint is in a more precarious position regarding applications; however, WordPerfect and Lotus are converting and developing applications, and several other companies are developing new applications, including telecommunication, word processor, spreadsheet, network interface, outliner, PIM, and more.

Some developers are targeting applications for both environments. Slate is one interesting example. The company has introduced a product called PenBook that allows you to take any file in PostScript format and convert it for use in a pen environment. The software allows you to build a table of contents and link specific pages to it. It also indexes the text. Rather than 45 pounds of manuals, imagine being able to take a notebook with all relevant service information on a house call, and instantly locate the desired information with a few taps and flicks of the pen. There's potential here.

Who cares?

Companies marketing pen products see two initial focii: highly mobile personnel (e.g., doctors and nurses, delivery people, sales people, insurance sales people and adjustors, etc.) and professionals who travel a lot.

Mobile usage is already happening. For example, a major pharmaceutical company recently purchased 1000 pen units from Grid for on-site sales; the San Jose Police Department is evaluating use of Grid machines to reduce paperwork

Some industry veterans feel that pen computing is just another overhyped technology, with little mainstream application. More informed sources, those with a little historical perspective, see the potential. It will take a few years, but by the end of the decade, most of us will be carrying "pentops" and wondering how we ever got along without them.

News bits

Last time I talked about the significant effect that multimedia will be having on the computer industry, the publishing industry, and society in general. At the time, I wondered how IBM planned to get involved. Shortly after my deadline, Big Blue announced a wide variety of products and services under the banner **"Ultimedia."** The software (discussed last time) is in some ways the most interesting part of the announcement; however, there are some interesting hardware goodies as well, including a device that lets you broadcast and receive televisions signals across a token-ring network simultaneously with normal network traffic, thereby setting the stage for real-time video-conferencing. IBM also co-released with Intel a $2000 NTSC video board, called the ActionMedia II, that allows playback of digitally recorded video. (A $900 add-on allows digital recording.) The basic technology is Intel's DVI (Digital Video Interactive); the board, though it may sound expensive, is about half the cost of the previous version, occupies half as much space, and reportedly provides about twice the performance. In addition, the company released a rather weird multimedia PC (the M57SLC) that includes a high-performance CD-ROM drive, XGA graphics, 16-bit audio capture/playback, and a souped-up 386SX processor that sounds like a 486SX crammed into a 16-bit package.

After years of promises, Philips finally unleashed its **CD-I** (Compact Disc Interactive) technology on the consumer market under the name Imagination Machine. It costs in the neighborhood of $800, but does only one thing. Conversely, you can upgrade your PC with a CD-ROM drive and a slew of useful software for that amount of money, have change in your pocket, and have a general-purpose tool that's truly only limited by your imagination. I think Philips' marketeers inadvertently hit on the right name, but for the wrong reason. The only imagination is in the amount of sales CD-I will generate.

On the software front, IBM has delayed release of a fully functional (i.e., Windows compatible) version of **OS/2 2.0** until the end of the first quarter of 1992. In the meantime, Microsoft will sell another couple million copies of Windows. However, Microsoft also slipped its ship date for Windows 3.1 until the first quarter of 1992, but has publicly shown a fairly robust version of **Windows NT** (New Technology), betas of which will be shipping to developers by the time you read this. Digital Research released **DR-DOS 6.0,** the major addition to which is RAM-based task switching and some utilities. It seems like a good product, and three or four years ago would have been a great competitor to DESQview. **R-E**

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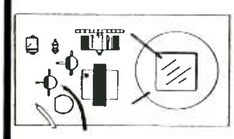

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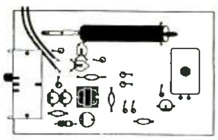

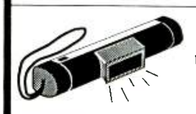

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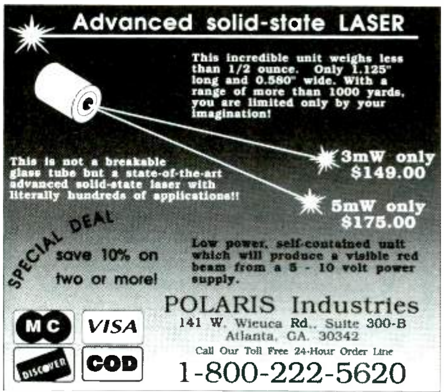

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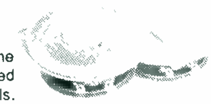

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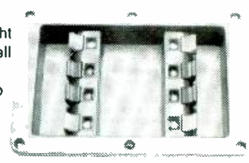

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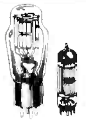

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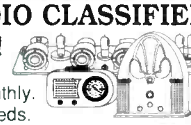

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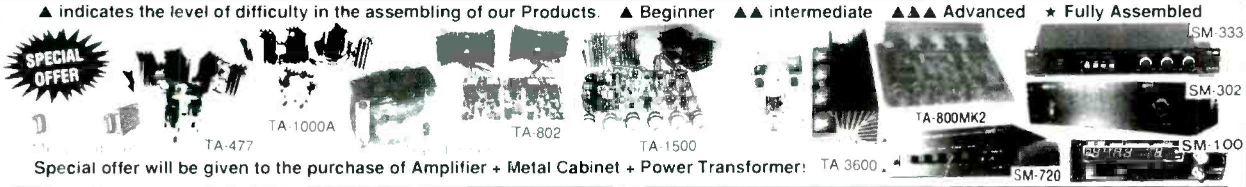

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SB3220	31.49	30.49	9.5 x 8.3 x 1.2	7	700	4	2,520	4

ACTIVE COMPONENTS

MICROS

Order #	Price
6242	8.95
6502	2.95
6522A	3.75
6821	1.75
6845	2.45
8080A	2.75
8085A	2.95
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8237A5	4.15
8250	5.75
8251A	2.25
8253-5	2.25
8255A5	2.75
8275	18.95

DRAMS

Order #	Price	Desc.
MK4027N2	.75	4x1
4116-20	.85	16x1
4416-12	2.95	16x4
4164-10	1.95	64x1
4164-15	1.55	64x1
4164-20	1.25	64x1
41464-12	2.75	64x4
41256-80	2.75	256x1
41256-12	2.15	256x1
51258-80	4.95	256x1
514256-10	6.95	256x4
514258-80	9.95	256x4
511000-80	7.25	1Mx1
511000-10	6.95	1Mx1
511001-80	8.25	1Mx1

STATIC RAMS

Order #	Price
2101	1.65
2114L25	1.39
2147-3	3.75
6116LP3	2.75
6116-3	2.25
6264LP10	4.95
6264LP15	3.95
6264-10	4.75
6264-15	3.75
62256LP10	6.75
62256LP15	6.25
628128LP8	34.95
628128LP10	32.95

EPROMS

Order #	Price	Prog.
2708	4.75	25V
2716	3.45	25V
2732	3.95	25V
2732A25	3.45	21V
2732B45	4.25	12.5V
2764-25	3.75	21V
2764A25	3.25	12.5V
27C64A15	3.95	12.5V
27128A25	3.95	12.5V
27256-25	4.75	12.5V
27C512-15	6.95	12.5V
27C010-15	9.95	12.5V
27C020-15	24.95	12.5V

LINEAR

Order #	Price
MAX232CPE	4.55
LM311N	.49
LM324N	.35
LM339N	.39
LM555CN	.29
LM741CN	.29
LM1488N	.45
LM1489N	.45

LINEAR

Order #	Price	Description
CA3161E	1.95	Decoder Driver
CA3162E	6.25	Converter
78L05	.35	5V Pos. Reg. TO-92
7805K	1.25	5V Pos. Reg. TO-3
7805T	.45	5V Pos. Reg. TO-220
7812T	.45	5V Pos. Reg. TO-220
79L05	.29	5V Neg. Reg. TO-92
7905T	.49	5V Neg. Reg. TO-220

MEMORY MODULES–SIMMS

Order #	Price	Organization	Speed
256x9-80	19.95	262,144x9	80ns
1x9-80	57.00	1,048,576x9	80ns
4x9-80	210.00	4,194,304x9	80ns

ZILOG DATABOOKS*

Z80 CPU Technical Manual

This 338 page manual contains the architecture, pin description, timing, instruction set, instruction description, interrupt response and hardware/software implementation examples of the Z80 CPU.

Order # **Z29** 9.95 Z80 CPU Technical Manual .... Weight: 1 lb.

Intelligent Peripheral Controllers

Over 700 pages of data sheets, application notes and technical information on Zilog's intelligent peripheral controllers. The part numbers contained in this book are Z8400, Z84C00, Z84C01, Z8410/C10, Z8420/C20, Z8430/C30, Z8440/1/2/4, Z84C40/1/2/3/4, Z84C50, Z8470, Z84C90, Z84011/C11, Z84013/15, Z84C13/C15, Z80180, Z80181 and Z280.

Order # **Z2480** 13.95 Intelligent Peripheral Controllers .... Weight: 2 lbs.

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Over 700 pages of data sheets and other technical information on Zilog's Data Communications ICs. Part numbers contained in this book are the Z16C30/31/33/35/50, Z5380, Z85230, Z80C30, Z85C30, Z8030, Z8530, Z80181, Z84013, Z84015, Z84C13, Z84C15, Z8440, Z84C40 and Z85C80. Also included are application notes.

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Microcontrollers

Over 1300 pages of data sheets, application notes and technical information on Zilog's microcontrollers. The part numbers contained in this book are Z8600/01/02/03/04/11/12/13/71/81/82/91, Z8800/01/20/22, Z86C00/C06/C08/C09/C10/C12/C19/C20/C21/C27/C30/C40/C50/C61/C62/C89/C90/C91/C93/C94/C96/C97, Z86E08/E19/E21/E30/E40, Z88C00, Z86127, Z86128, Z765A, Z5380 and Z53C80.

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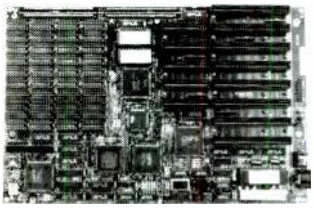
Jameco 80386SX Motherboard



- 16MHz processing speed
- Baby motherboard (8.5"x13")
- Zero or one wait state operation
- Supports up to 8MB of RAM
- Intel 80387SX/compatible math coprocessor socket
- AMI BIOS
- Six 16-bit and two 8-bit expansion bus slots
- One-year Warranty

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This keyboard features 12 function keys, separate cursor and numeric keys.

- IBM PC/XT/AT and compatible computers
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Integrated Circuits*

Part No.	1-9	10+
7400	$.29	$.19
7402	.29	.19
7404	.29	.19
7406	.35	.25
7407	.35	.25
7408	.35	.25
7410	.29	.19
7417	.35	.25
7420	.29	.19
7432	.35	.25
7447	.89	.79
7474	.39	.29
7476	.45	.35
7486	.45	.35
7489	2.95	2.75
7490	.59	.49
74121	.49	.39
74192	.79	.69
74193	.79	.69

Linear ICs*

Part No.	1-9	10+
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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

** Call for a complete listing of ICs*

Dynamic RAMs

Part No.	Description	Price
4164-100	100ns, 64K x 1	$1.89
4164-120	120ns, 64K x 1	1.69
4164-150	150ns, 64K x 1	1.49
41256-60	60ns, 256K x 1	2.49
41256-80	80ns, 256K x 1	2.19
41256-100	100ns, 256K x 1	1.95
41256-120	120ns, 256K x 1	1.79
41256-150	150ns, 256K x 1	1.69
511000P-80	80ns, 1MB x 1	5.99
511000P-10	100ns, 1MB x 1	5.49

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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28LP	.22	28WW	1.39
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NEW LITERATURE

continued from page 87

tions are described, along with some special modulation techniques. Radio frequencies, propagation, and space communications are covered.

Almost half of the book focuses on construction and maintenance of ham equipment, and getting on the air. It provides practical advice about construction techniques, test equipment, measurements, troubleshooting and repair. Instructions are provided for building your own power supplies; audio and video equipment; modems; HF, VHF, UHF, and microwave equipment; antennas; and accessories. PC board patterns are included, as are parts lists. Tips are provided about how to assemble a station, monitoring and direction finding, and coping with interference.

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The 64 pages of this catalog are filled with products

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from major manufacturers, including power-protection gear from Triplett; test equipment from Beckman, Leader, B&K, Soar, Global Specialties, Hitachi, Kenwood, Simpson, and Vector Viz; Pace soldering/desoldering and surface-mount rework and repair equipment; programmers from Logical, C.S.T., and American Reliance; and Print's own custom tool kits and cases. New to this catalog are service monitors and radio test equipment from Helper; Landmark PC-troubleshooting gear; AEMC test equipment and power-demand analyzers; Ungar soldering irons, Fieldpiece field-service equipment; static-detection meters from Staticide; and spectrum analyzers from Avcom, Penntek, and B&K. **R-E**

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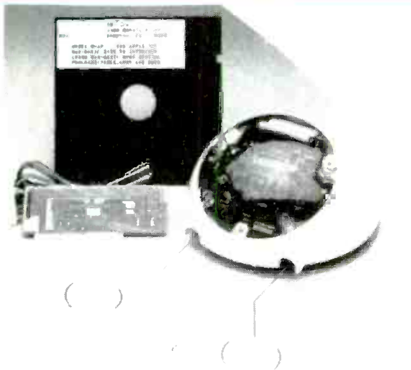
LASER DIODES

STOCK #	MFG.	WAVE-LENGTH	OUTPUT POWER	OPER. CURR.	OPER. VOLT.	1-24	25-99	100+
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

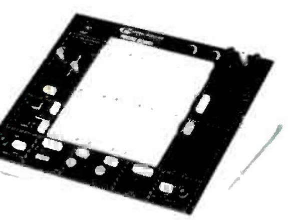


The pen mechanism included with the robot allows it to draw. In addition to drawing straight lines, it can also accurately draw circles, and even draw out words and short phrases. WAO II comes with 128 x 4 bits RAM and 2K ROM, and is programmed directly via the keypad attached to it. With its built-in 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

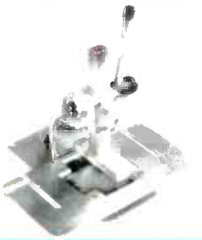
PROTOBOARD DESIGN STATION



- The total design workstation - including expanded instrumentation, breadboard and power supply.
- Ideal for analog, digital and micro-processor circuits
- 8 logic probe circuits
- Function generator with continuously variable size, square, triangle wave forms, plus TTL pulses
- Triple power supply offers fixed 5 VDC supply plus 2 variable outputs - +5 - 15 VDC and -5 - 15 VDC
- 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

IDC BENCH ASSEMBLY PRESS



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.

- Assembly base & standard platen included
- Base plate & platen may be rotated 90° for maximum versatility
- Base plates & cutting accessories are quickly changed without any tools required
- 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 " in diameter x 6" 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.

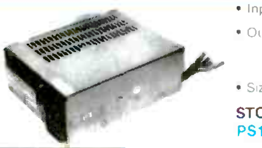
STOCK #	DESCRIPTION	1-9	10-24	25+
LP35	*Dual Mode Laser Pointer*	199.99	189.99	170.99

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 5" W x 2" H

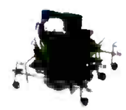
STOCK #	PRICE
PS1003	$19.99

ROBOTIC ARM KIT

Robots were once confined to science fiction movies. Today, whether they're performing dangerous tasks or putting together complex products, robotics are finding their way into more and more industries. The Robotic Arm Kit is an educational kit that teaches basic robotic arm fundamentals as well as testing your own motor skills. Command it to perform simple tasks.

STOCK #	PRICE
YO1	$43.99

AVOIDER ROBOT KIT



An intelligent robot that knows how to avoid hitting walls. This robot emits an infra-red beam which detects an obstacle in front and then automatically turns left and continues on.

STOCK #	PRICE
MV912	$43.99

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