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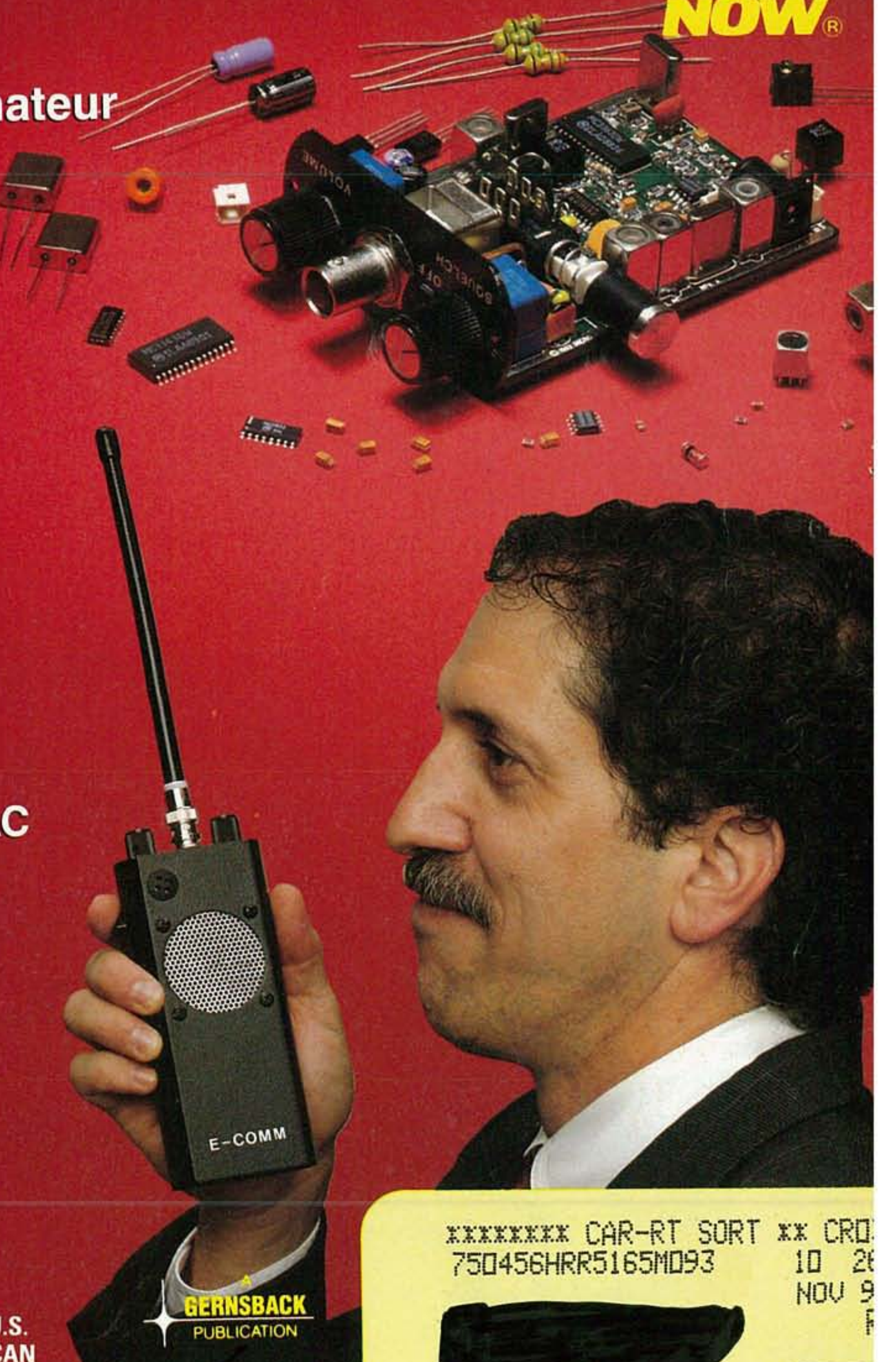

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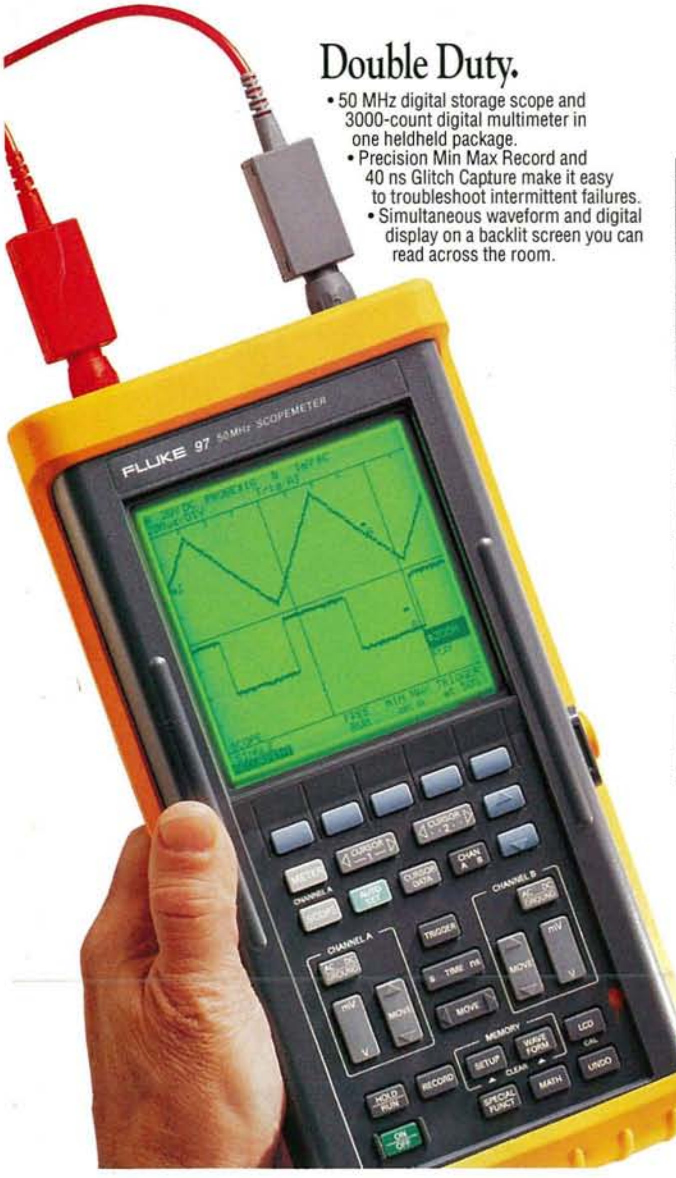

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Vol. 63 No. 10

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EDITORIAL

NOW'S THE TIME

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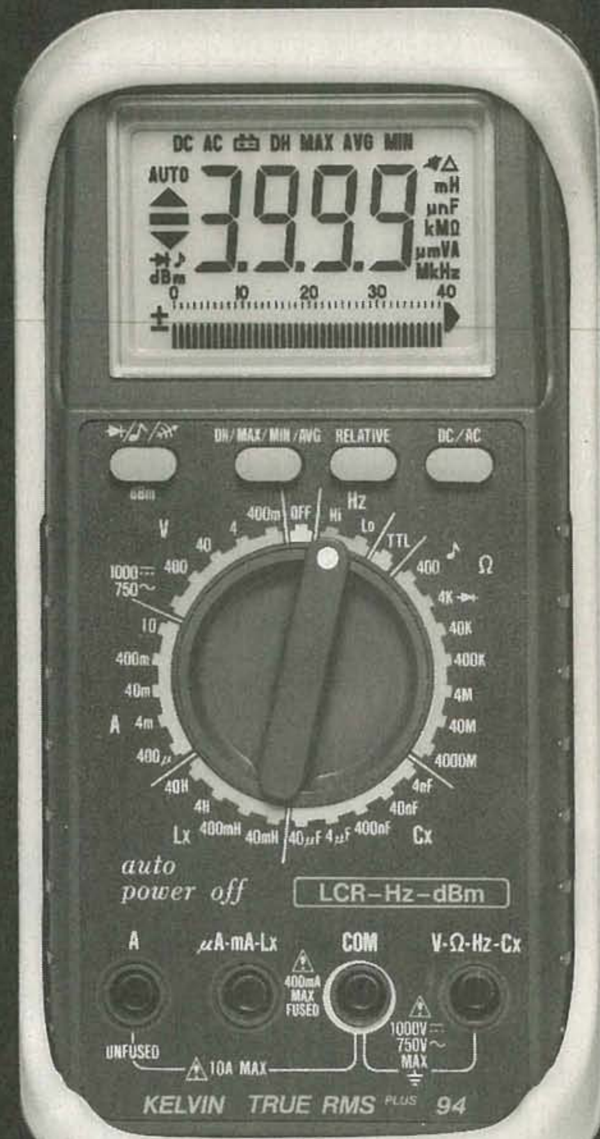

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WHAT'S NEWS

A review of the latest happenings in electronics.

64-megabyte memory chip

A computer memory chip jointly developed by engineers at IBM (Essex Junction, VT) and Siemens can store more than 64-million bits of data—four times the capacity of the most advanced memory chip in computers today.

The new dynamic random access memory (DRAM) chip can store the equivalent of about 6000 pages of double-spaced typewritten text, and can "read" more than 64-million bits on the chip in a fraction of a second. The chip measures 10.7mm by 18.1mm (approximately ⅜-inch by ¾-inch).

The chip was developed with an advanced CMOS technology process. Its smallest conductive traces are 0.4 micrometers wide, about one two-hundredth of the thickness of a human hair. The transistor' gate insulator, a nonconducting layer that separates conducting layers on the chip,measures only 10 nanometers in thickness.

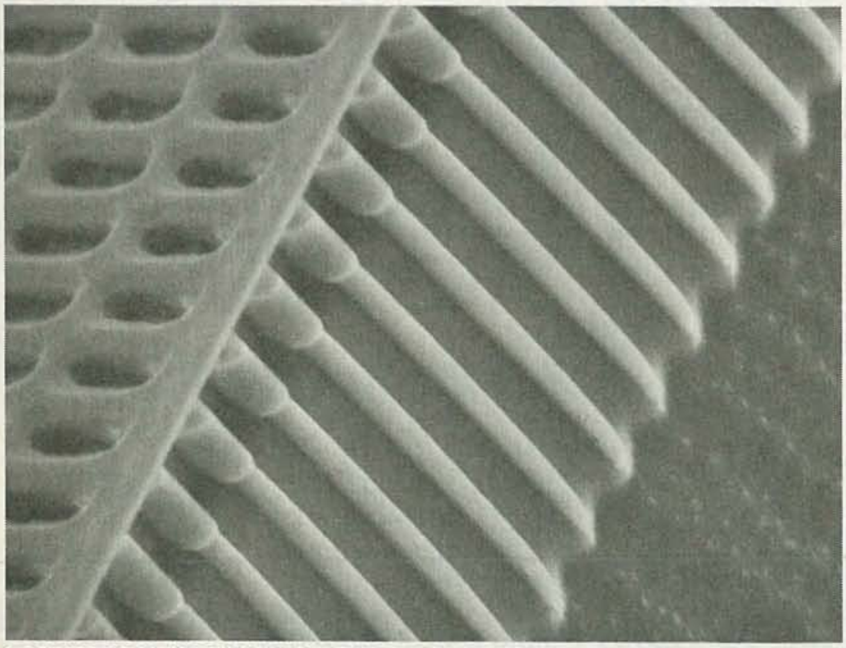
The electrical charges that make up each bit of information are stored in a buried-plate trench cell. A conductive region in this cell is diffused from the bottom part of the trench into the substrate. That region serves as the common buried-plate contact to all the cells. The trench's sidewalls are covered with an insulating material, and the trench is then filled with conductive silicon. Information is stored in the material inside the trench.

The entire trench area occupies only 1.5 square micrometers. The cell is so small that nearly one million of them can fit on the head of a pin.

The 64-megabit chip, which operates from a single 3.3-volt power supply, has borderless contacts that eliminate the necessity for providing a border around the metal that forms electrical contacts to specific areas of the chip.Borderless contacts reduce the area of the chip.

IBM and Siemens began their joint development on the chip in January 1990. Their goal is to have the chip ready for mass production by the middle of the decade.

In July IBM announced that it is joining with Siemens and Toshib develop 256-megabit DRAMS.



A SERIES OF MEMORY CELLS IN THE IBM/SIEMENS 64-million-bit computer memory chip as seen with an electron microscope.

Faster silicon circuits

Westinghouse Electr Corp.(Pittsburgh, PA) has receiv a government contract to deve silicon transistors that operate higher speeds than today's devic The new technology is expected extend the use of low-cost silic substrates into the higher-frequ cy regions of radar, cellular te phones, digital radio, and ultra-hi speed computing.

The $624,000 U.S. Navy F search Laboratory contract, wh extends through the end of 19 supports further development the silicon-on-insulator tec nology—called Microx. The te nology will be used for applicatic in which both microwave radio a digital functions are built into same monolithic chip.

Experimental microelectro chips fabricated from Microx ha operated at the microwave frequ cies of 30 GHZ and they are pected to achieve 40 GH smoothing the way to a new gene tion of low-cost, mixed function F digital silicon monolithic circu whose speeds are comparable those attained by gallium-arseni devices. Westinghouse believ these to be the highest frequenc ever reported for linear MOS silic transistors.

The key innovations are ion-i planted oxide layers produced wi in a high-resistivity substrate t resembles an insulator, combin with several advanced fabricati techniques. According to Mich C. Driver, manager of mic electronics at the Westinghou Science & Technology Center, crox can realize at least 10 decib of power gain at 10 GHz. This per mance,he said, coupled with t low cost typical of silicon MC technology, opens up a broad ran of applications. R

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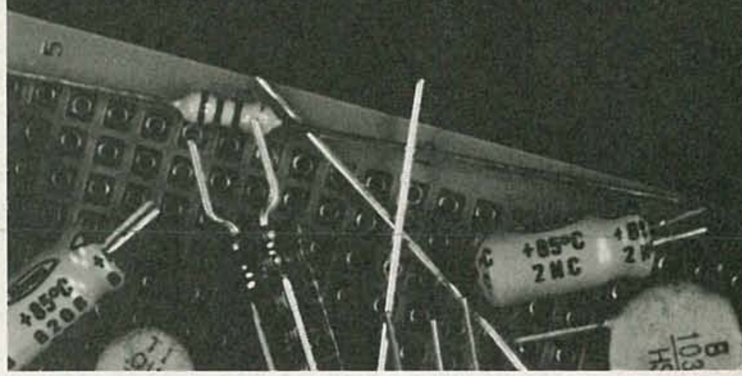

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VIDEO NEWS

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

DAVID LACHENBRUCH

• **Digital TV gains.** There has been a notable shift in the direction of the world HDTV winds in the last few months. Despite the fact that both Europe and Japan are theoretically committed to analog systems, the United States suddenly has assumed unquestioned leadership in the HDTV field. Progress here in digital HDTV—and proof that digital systems actually can work—has sent shock waves through Japanese and European television circles. Now, for the first time, engineers in both regions are looking seriously at digital systems, and predicting that their countries "ultimately" will go digital.

Japan. In Japan, where the analog MUSE Hi-Vision system is actually being broadcast by satellite for eight hours daily, engineers are beginning to forecast an eventual switch over to a digital compressed system. Japan's commercial broadcasters have always been slightly ill at ease over the publicly supported, non-commercial NHK network's espousal of Hi-Vision, but for direct satellite broadcast only. The Hi-Vision system is now almost 20 years old and it ignores some of the newer technologies employed in other HDTV systems. Prices of HDTV receivers have been coming down—but from the rarefied level of $30,000 to the still high $10,000—and sales have been extremely slow.

One manufacturer's view. Digital HDTV is "quite likely to be the wave of the future" in Japan, said Hiroyuki Mizuno in the keynote address to the International Conference on Consumer Electronics (ICCE) in June, the annual meeting of America's consumer-electronics engineers in Chicago. The statement is significant because Mizuno is executive vice president of Matsushita Electric, the world's largest producer of consumer electronics. Mizuno called the analog Hi-Vision system a "bird in the hand," giving the Japanese people and TV set manufacturers experience in high definition.

But Mizuno said digital HDTV will "inevitably fuse" the TV and the computer, making TV a "digital multimedia broadcast station which can process, store, create, and transmit video images." Conceding that "we are experiencing temporary technical difficulties" in supplying practically priced HDTV receivers and VCR's in Japan, he said that these problems eventually will be solved, but he didn't say whether the solution would be digital or analog.

Europe. Europe's Eureka project, designed to develop an HDTV system different from Japan's, envisions a two-stage move to HDTV. The first stage would be broadcasting in a widescreen improved system called D2-MAC, followed by a move to HD-MAC, a high-definition system. However, neither system is compatible with the existing PAL and SECAM broadcasts in Europe, and both systems were designed for direct satellite transmission. Europe's satellite broadcasters are having financial difficulties, and generally have refused to adopt MAC broadcasting,preferring to continue to use PAL, which is compatible with TV sets there. Despite tremendous pressure by TV manufacturers and proposals to issue large government subsidies for a changeover, MAC's adoption has been sluggish. Europe's broadcast authorities, with a nervous eye on the HDTV research in the United States, have been quietly working on digital systems for Europe. With the MAC structure coming under increasing criticism (for instance, it ignores terrestrial broadcasting, which produces 90% of the broadcast ad revenues in Europe and has more than 90% of the audience), demands for a change to digital terrestrial HDTV have been sounded more frequently in recent mont and research toward a digital s tem has come out of the closet a is being discussed openly.

Just a few years ago, it was po lar to say that the United States v far behind Japan and Europe HDTV. Today, it is accepted that d ital broadcasting is the wave of future, and that the United State in the vanguard. Officially, Jap might be very proud that it was f and that its system has been un development for 20 years—but t makes it a 20-year-old system, contrast to America's up-to-th minute approach to HDTV.

HDTV set availability. When HDTV receivers be widely availa in the United States? The Advanc Television Advisory Committ (ATAC) to the FCC recently set to get the answer, so it sent qu tionnaires to all major TV manuf turers serving the United Stat market—a total of 14. It received replies. ATAC specifically asked "time of general availability to co sumers from multiple sources" not for the time of shipment of "c set per showroom."

The replies indicated that HD sets would be plentiful 2½ to thr years after the FCC approves transmission system. That event tentatively scheduled for late 199 However, some respondents repl that sets could be available soon if manufacturers take a chance a start developing them as soon the advisory committee makes recommendation to the FCC. Th is expected in February 1993. A the survey showed that HDTV sy tem proponents that also manufa ture TV sets—Philips, Thomso and Zenith—might have a six- nine-month advantage over th competitors. Other manufacture that develop their own IC's mig have a three-month advantage ov those that buy chips from othe the survey revealed. **R**

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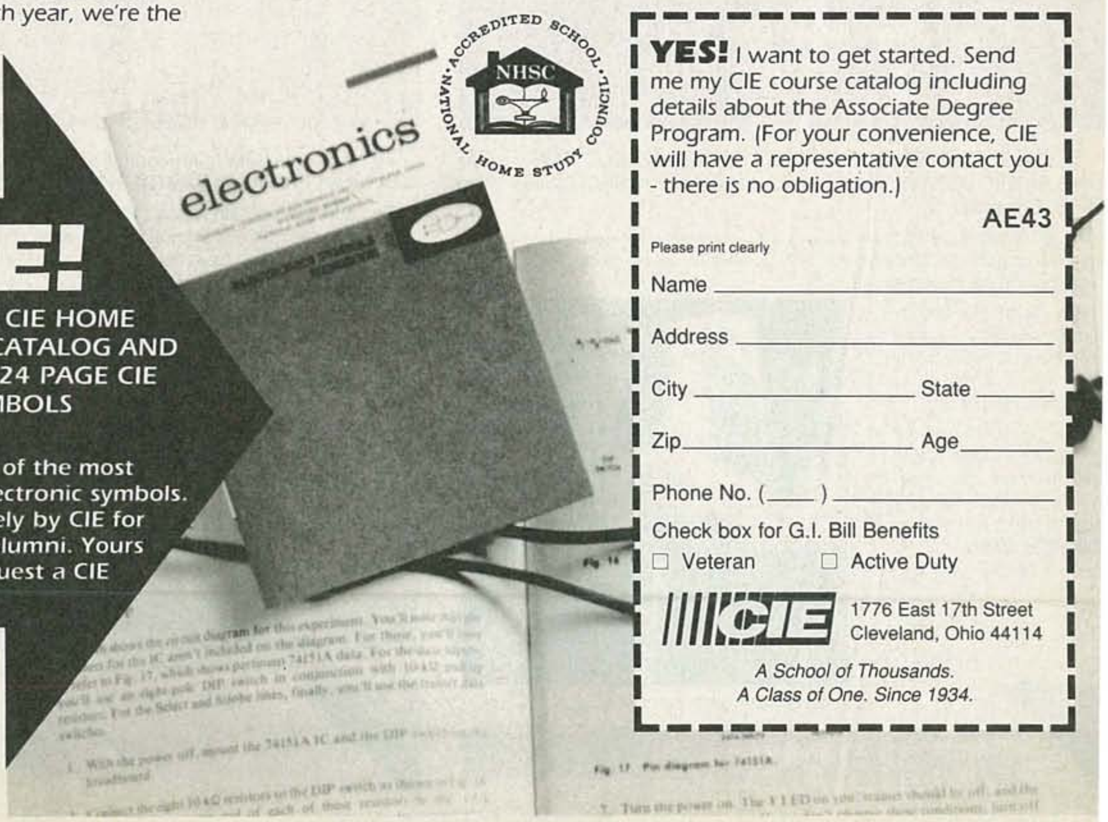

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Q & A

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LOCAL BUS

I've been hearing a lot about local-bus computers, but I can't seem to find a clear definition of exactly what they are and why they're supposed to be so terrific. Several computers in the mail-order advertisements tout the feature, and each one that does is quite a bit more expensive than similar ones without a local bus. Can you explain to me in simple terms what a local bus is, and whether it's worth the extra money?—F. Geeben, Anawana, NY

All the peripheral cards that plug into your computer, such as the video card and others, get their basic clock speed from a single pin on the bus. The clock speed comes from the master oscillator on the motherboard, which is usually the one that's clocking the microprocessor.

For reasons buried deep in the corporate vaults at IBM, the bus clock was usually limited to a maximum of 6 or 8 MHz—that was the speed of the last of the original AT's that had a standard bus. With the introduction of the PS/2 series of computers, IBM abandoned the old standard bus and began using the Microchannel Bus—a different thing altogether.

That change left the compatible and clone manufacturers in a bit of a quandary since they no longer had a developing standard from IBM. The original AT had a 16-bit bus because that was the internal bus size of the 80286 (the last microprocessor IBM used in the AT). IC's such a 386 and 486 are 32-bit m processors, but IBM's new 3 Microchannel Bus was a propri bus. The result was a lack accepted standard for a 32-bit

With the exception of IBM, puter manufacturers have rec agreed on the EISA (Extende dustry Standard Architecture bit bus that has shown up in a newer PC-compatibles. The sis of the local bus is similar.

While some cards that plug the slots at the back of the mo board have to run at speeds sl than the microprocessor, a others are perfectly happy to r microprocessor speeds. A goo ample of this is the video ada which can easily be designed t at speeds higher than those available with the standard bus clocks.

Along with the adoption of the EISA bus, the local bus is a system in which a separate bus is provided for certain peripheral cards that don't have to be limited to standard bus-clock speeds. The result is much faster operation, and for something such as video, the difference is astounding.

Deciding if something is worth spending money on is a personal decision, so I won't answer that part of your question. However, because this is a recent development, manufacturers are just starting to produce local-bus peripherals so you might want to wait and see what develops over the next few months and whether a standard takes hold.

AUDIO CROSSTALK

I've been getting a lot of crosstalk between audio channels and, after eliminating every other possibility, I've come to the conclusion that the signals are leaking through the power supply. There doesn't seem to be anything on the circuit boards to take care of the problem so I guess I'll have to do it myself. Could you tell me what the basic circuit setup is for power-supply decoupling?—A. MacDonnell, Mill Hill, NY

If you're sure that the power supply is the source of your problem, and it turns out that you're right, you can consider yourself lucky because it's easy to take care of.

The basic design for power-supply decoupling is shown in Fig. 2 and, as you can see, there isn't much to it. You can get a lot more involved when you're dealing with very high frequencies, but because you're only concerned with audio stuff, the layout in Fig. 2 will be fine.

The resistor values should be calculated by looking at the maximum current draw of the equipment and applying Ohm's law. Remember that the resistors will be carrying all the current needed by the circuit, so you should pay proper attention to their wattage as well. In general, as long as you're dealing only with line-level stuff, you can use quarter-watt resistors and everything will be OK.

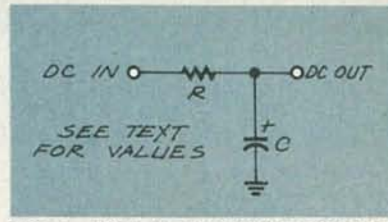

FIG. 1—POWER-SUPPLY DECOUPLING CIRCUITRY. These circuits can get a lot more complicated, but for audio frequencies, this is more than enough.

Once you calculate the needed resistance (supply voltage/maximum current), add another fifty percent to the value just to be on the safe side. Audio levels can vary all over the place, and if you're listening to something with a really wide dynamic range, too low a value on the resistor will cause the signal to clip.

There's nothing magical about the choice of the capacitor value either, and I've used everything from 10 to 100 μF without any noticeable difference. You would think that the circuit would call for a non-polarized

continued on page 15

LETTERS

Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 1173

EQUIPMENT REPORT UPDATE

Thank you for the wonderful *Equipment Report* on our CompuScope LITE IBM PC-based oscilloscope (**Electronics Now**, August 1992). We wholeheartedly agree with you that "PC-based instruments are the leading edge of growth for test and measurement." Gage has been a major contributor to the buildup of that industry for the past five years.

In the same article, three valid criticisms were made by your reviewer. Because those points have also been raised by some of our customers around the world, we have been working to solve the problems. In July 1992 we released a new software package called GageScope for our complete line of CompuScope cards.

First, we have drastically improved the hardware installation procedure. We have rewritten the entire documentation and software supplied with the CompuScope LITE card with special emphasis on installation. The 112-page manual has a 15-page section on board installation, full of examples and charts on how to configure a new I/O address even if the user does not know hexadecimal mathematics.

Second, to improve the description of the menus in the manual, we included a detailed description of each menu entry, as well as a 13-page tutorial that guides the user through the most often-used menu commands.

Finally, to satisfy the needs of more sophisticated customers, we offer other products: CompuScope 220, a 40-MHz card with up to 8 megabytes of memory, and CompuScope 250, which samples at 100 MHz. Our products are being used by major organizations such as NASA, IBM, Honeywell, and Motorola, and hundreds of smaller less well known companies and individual customers.

We think that, overall, your review was very positive about the importance of PC-based instruments in general, and CompuScope LITE in particular. We are very excited about our coverage in **Electronics Now**.

MUNEEB KHALID
Vice President
Gage Applied Sciences Inc.
Montreal, Quebec, Canada

SURFMAN DIODE REVERSAL

An error appeared in our SurfMan sound gernerator article (**Electronics Now**, August 1991). Diode D2 was incorrectly drawn reversed in the parts placement diagram, Fig. 2 on page 35. However, it is drawn correctly in the schematic, Fig. 1 on page 34.

IC SUBSTITUTION

Mr. Caristi is to be congratulated for his article "Digital Altimeter" (**Radio-Electronics**, May 1992).

There is one point that concerns me, however. IC3 gives a full-scale reading for a 100-millivolt input change (from 2.5 to 2.4 volts at pin 30), which is an effective sensitivity of 20 feet per millivolt. My concern is the choice of the LM324 as IC1. While it is a very useful chip indeed, it does not exhibit low off-set drift with temperature. Prospective constructors who think that shortcoming could be a problem might want to consider replacing the LM324 with four devices such as (which have impressively low

D.M. BRIDGEN
Reading, Berks., U.K.

CLASSIC VIDEO AMP RE-REVISITED

I enjoyed seeing my "Classic Video Amps Rev published in the June issue **dio-Electronics**. Thanks!

However, in the editing some errors crept in. The fi occurs in the second paragi page 60. The wording impli the 733 is the better choice in filters; that's not so. The 5 vides the greatest attenua the unwanted signal. I tried that the the 592 will provic voltage gain with a high imp across the gain control pin and G1B), the desired desigr tive at those points for tho nals. In fact, the 733 would b choice for this application b it provide a minimum 20-c oretical gain for the unwante signals.

Paragraph four implies t through D4 are forward bias odes D1 and D2 are reversed and D3 and D4 are not biase or only forward biased wl overvoltage signal is appliec circuit. That is necessary fc protection.

Also on page 60, Fig. 7 sh with a shorting bar across t wipers. That connection is rect. There should only be a lated mechanical connectior

On page 61, Q1 in Fig. 9 be a PNP device and it shc labeled 2N4959/2N3906 than 2N4959/2N3904. Also 9, Q3 should be a PNP devi ure 8 can be used to illustr proper configuration.

Overall, the article fulfills jective of stating that both t and 733 video amplifiers a recommended for new desi

EDGARDO PEREZ

Q&A

continued from page 13

capacitor, but my experience is that polarized capacitors work just as well. Remember that you're not dealing with high current and voltage levels here, and that gives you a considerable amount of leeway.

LINE-LEVEL DIFFERENCE

I've noticed that there's a considerable difference in the audio level that comes out of my CD, tuner, cassette player, and other equipment. When I switch my amplifier from one source to another I can often hear a dramatic difference in the levels. Is there some way to buffer those signals between the equipment and the inputs to my power amp so the levels presented to the amp are all the same?—D. Gould, Michigan City, IN

You can call them buffers, but as far as I can see, what you really need is a preamp on each line so you can adjust the level from each device before it gets to the power-amp inputs. A lot of the consumer audio equipment on the market really cheaps out when it comes to the output level. The cassette and CD players on my shelf, for example, are top of the line units, but neither of them has a convenient front panel control for adjusting the output level.

There are really three ways you can handle this problem. The first, and easiest, is simply to drop all the levels to that of the lowest one with simple resistor pads. Once you've done that, you can set the power-amp level and not have to change it every time you switch from one source to another.

The second way to deal with this involves a bit more work, but is not really all that difficult. Although there's no front-panel control for the output level, you can bet your new pair of white tennis shoes that there's a trimmer somewhere inside each of the players that sets the output level. Just get yourself a screwdriver, take the cover off, and start exploring. It's a good idea to have the service manual around when you do this, but most of the consumer audio stuff I've seen has the function of the trimmer silkscreened on the printed-circuit board.

The last approach to the problem is to build a bunch of preamps with line-level inputs and outputs. You can put them between the equipment and the power amp and adjust the levels that way. I'd do that only as a last resort. It's a lot more work because you'll need two preamps for each piece of equipment (assuming, of course, that you're dealing with stereo). Besides the extra work, I've never been convinced that it's a good thing to have more electronics on the line than the bare minimum required. That's because any extra electronics is a potential noise generator, and also a potential entryway for externally produced noise. **R-E**

The Checker Computer Monitor Tester

Get a quick go/no-go indication of computer monitor operation.

CIRCLE 10 ON FREE INFORMATION CARD

Computer monitors and standards have certainly changed dramatically in the last decade. We've moved from composite video monitors through the MDA, CGA, HGC (Hercules), EGA, VGA, and SVGA standards. And there are yet other standards in use, and more in the wings. One thing that hasn't changed, however, is that computers monitors eventually need service.

The Checker, a new product from Computer and Monitor Maintenance, Inc (6669 Peachtree Ind. Blvd, Suite B, Norcross, GA 30092) was designed with that in mind. though The Checker is a rather s ple service tool, it can make thi easier for any monitor repair tec cian, or for anyone who manage maintains computer equipmen an office environment.

The Checker is packaged in a r tangular plastic box that measu about 6 × 3½ × 1¼ inches. The f of the unit has a single control t serves as the power switch as v as an output-mode control. Two v eo connectors, one a nine-pin a the other a fifteen-pin connec are provided on one edge of device. The Checker can powered by a standard 9-volt b tery for portable operation; a w adapter is also provided to run unit from the AC lines.

The Checker provides three c

put modes: CGA (color graphics adapter), EGA (enhanced graphics adapter) and VGA (video graphics array). Only standard VGA resolution (640 × 480) is supported.

Using the Checker is straightforward: Turn the unit on, set the proper mode, and connect the monitor. In the CGA mode, you'll see two sets of color bars: high-intensity on the top half of the screen, low-intensity on the bottom. In EGA mode, three sets of color bars are presented. In VGA mode, the Checker generates a single set of eight color bars.

Even though the Checker is rather simple, we can come up with many uses for it. Around the **Electronics Now** offices, for example, we could use it for quick checks of monitor problems. When someone reports a monitor problem, the usual first check is to swap out the suspect monitor with one that is known to be good. (Of course if its the graphics card that is bad, then another swap is required.) That first step is basic, simple troubleshooting to narrow down the problem.

Unfortunately, that simple method has its own problems. First is the time and trouble to move heavy monitors around. Second is the limited space that is available at the computer—there's usually not enough room to work conveniently. The handheld Checker weighs less than a pound, and permits a monitor check to be done in just a minute or two.

For anyone who maintains an inventory of computer monitors, the Checker could also come in handy. Is the monitor that is to be installed for that new employee working? The Checker lets you find out *before* you haul a non-working monitor over to the installation site.

The Checker also has a place in professional service shops. It can be used, for example, to "burn in" a monitor without tying up special test equipment or a computer (with, of course, the correct graphics card installed.) When a customer comes in to pick up his monitor, the Checker makes an ideal way to demonstrate that the repair was successful and that the monitor is now working properly. It can also be used as an aid in setting vertical and horizontal size controls correctly.

The Checker does not support Hercules-type monochrome monitors. That's an unfortunate oversight in our opinion. Although such monitors are not popular sellers these days, there are an awful lot of older units in circulation, and older equipment is more likely to develop problems. We would also have preferred to see an SVGA (super VGA) mode and test patterns more useful than the non-standard color bars that are provided.

With a price of $229.95, the Checker is far too expensive for casual use. However, the speed and ease with which the Checker can provide a go/no-go indication would be welcome by anyone who spends a lot of time checking a lot of monitors. When you consider the amount of time that the device could potentially save, and the headaches it could help prevent, the Checker could prove to be a worthwhile purchase. **R-E**

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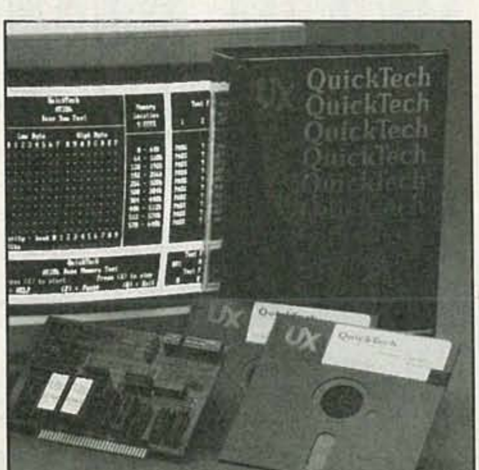

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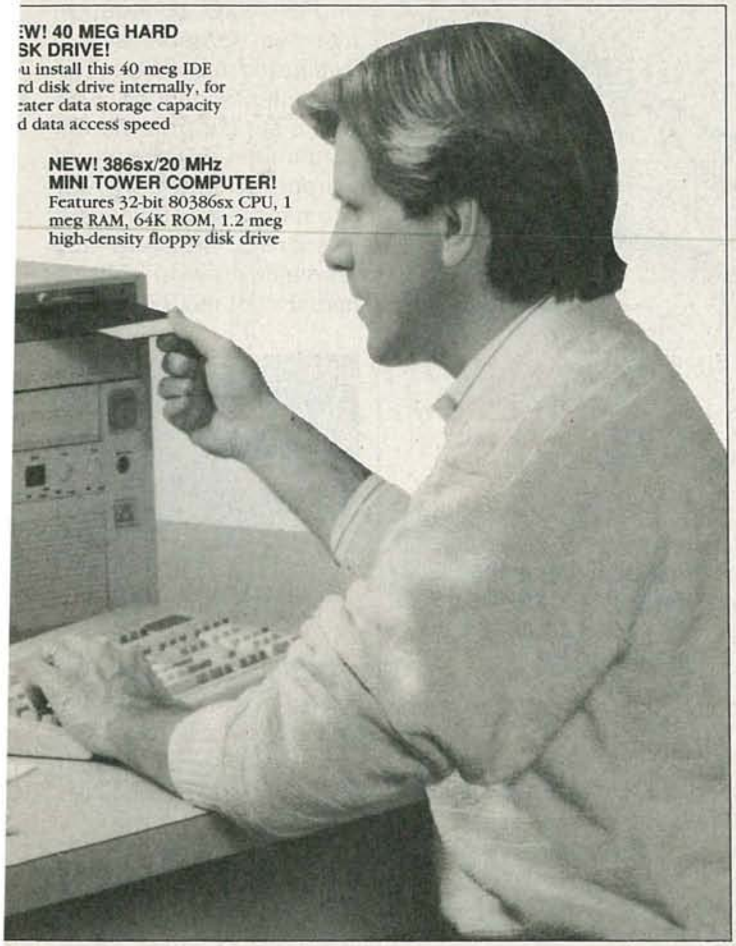

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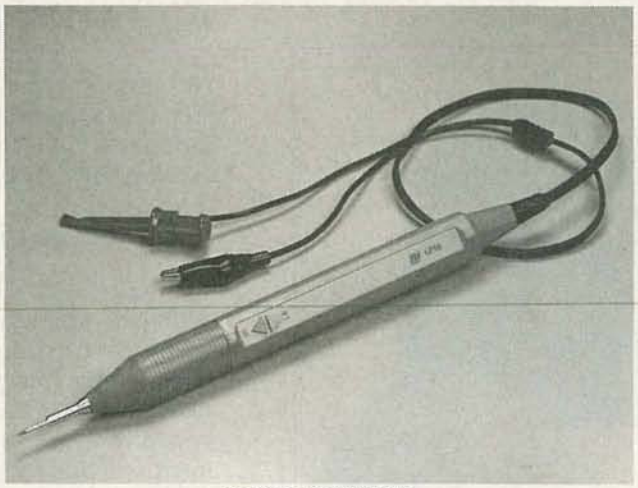
LOGIC PROBE. *Beckman Industrial's LP50* is an inexpensive, small 50-MHz logic probe that can detect pulses as short as 10 nanoseconds. The pen-sized logic probe is intended for troubleshooting high-speed, microprocessor-controlled circuits and the detection of extremely fast pulses. According to Beckman, the probe measures TTL, DTL, and RTL logic levels at frequencies up to 50 MHz.

The *LP50* is powered from the circuit under test through an alligator clip that provides a secure connection to circuit ground. The mini-hook clips onto the circuit's positive voltage points. When the probe tip is touched to the signal test point, the probe simultaneously lights an d LED and generates a tone to make it easy for the user to understand what is happening at the test point.



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The *LP50* logic probe is priced at $45.—**Beckman Industrial Corporation, 3883 Ruffin Road, San Diego, CA 92123-1898; Phone: 619-495-3218.**

CABLE/TV SIGNAL-LEVEL METER. *Leader Instruments' Model 951* RF signal-level meter is intended for broadcast and cable TV measurements. It features auto-channel search to measure the store level data for up to 32 channels. The LED bargraph display is arranged in groups of eight channels and it provides readout of the selected channel in dBmV or other user-selectable engineering units.

Autoranging is featured but manual ranging can be selected. The Model 951 also operates in the single-channel mode with a combination bargraph and digital readout of level in selected engineering units. The meter's operation can be programmed for video or sound-carrier levels of channels selected by the operator.

CIRCLE 17 ON FREE INFORMATION CARD

Frequency data for the USA and other countries are stored. Up to 32 channel readings can be stored. DC and AC voltages on the cable can also be read. The portable instrument measures 8⅜× 4¾× 7⅞-inches and it weighs 10½ pounds. Powered by D cells, it has an auto-off feature that extends operating time.

The Model 951 CATV/TV signal level meter has a price of $1695.—**Leader Instrument Corporation**, 380 Oser Avenue, Hauppauge, NY 11788; Phone: 1-800-645-5104 or 516-231-6900 in New York.

KEYBOARD-CONTROLLED POWER SUPPLIES. *Kepco's DPS Series* of keyboard-controlled power supplies provide 75 watts of DC power in four ranges from 0 to125 volts. Eachpower supply is controlled by a keypad that commands a built-in microprocessor to set voltage, current limit, range, over voltage protection (OVP), displays, and over-current protection.

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DSP power supplies a priced at $429.—**Kepc Inc.**, 131-38 Sanford A nue, Flushing, NY 113 Phone: 718-461-7000; F 718-767-1102.

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The *SureTest Pro* tests seven outlet parameters: miswires and incorrect wiring, proper voltage and current capability, ground faults (6-milliampere trip current), ground/neutral voltage latch, ground/neutral short, and high ground impedance. The unit is plugged into an outlet, and LED indicators provide go/no-go readouts for all tests.

The *SureTest Pro* multifunction outlet tester (Part No. 413B200) is priced at $179.—**Jensen Tools Inc.**, 7815 South 46th Street, Phoenix, AZ 85044; Phone: 602-968-6231.

HEAVY-DUTY CABLE TEST CLIP. *ITT Pomona's Model 5784* test clip permits the probing of insulated wires or cables without stripping the insulation. It is intended for use in laboratories, auto service shops and factory maintenance facilities. The clip is said to assure positive electrical contact and true readings, and it provides safe high-voltage lead testing with operator protection of up to 1000 volts AC.

The spring-loaded test

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probe has a heavy-duty, stainless-steel needle point set within a clamp-type jaw, allowing the clip to pierce the insulation of a cable up to 0.14-inch (3.5mm) in diameter without damaging the insulation. The insulated tip assures that the desired wire or cable is safely and firmly grasped, and it avoids contact and shorts or grounding to adjacent machinery. A socket for a sheathed test lead connection is located in the plunger handle.

Model 5784 clips are priced at $12.30 each—**ITT Pomona Electronics**, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Phone: 714-469-2900; Fax: 714-629-3317.

SMT PROTOTYPING BOARD. The *SMT-1000* protoboard from *Precision Circuit Technologies* allows for the placement of more than one IC on the board. Measuring 2.9 × 4.75 inches, it permits the prototyping of circuits with many IC's.

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Each SMT pad is connected to a plated-through hole that interconnects it to other points on the board with wire links. Two power busses simplify power connections. Most of the board's part footprints will accommodate more than one part size. The SOIC-16's will accommodate 8-, 14-, or 16-pin SOIC's; the SOIC-20W will accommodate a 16-or 20-pin wide-body SOIC or an 8-, 14-, or 16-pin SOIC; and the SOIC-24W will accommodate a 16-, 20-, or 24-pin wide-body SOIC or an 8-, 14-, or 16-pin SOIC.

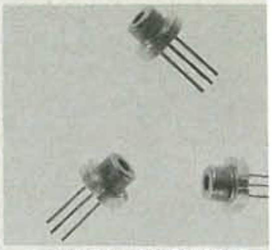
Two PLCC areas permit great selection of PLCC sizes (20- to 100-pin PLCC's). A small section with through-hole pads spaced at 0.1-inch is available for combinsed AMD and leaded assembly.

SMT-1000 protoboards are priced at $18.95 each.—Precision Circuit Technologies, 10378 Fairview Ave., Suite 152, Boise, ID 83704; Phone: 208-327-0300, Ext. 2200.

SELF-PULSATING LASER DIODE. The *RLD Series* of self-pulsating, single-longitudinal-mode, AlGaAs laser diodes from *Rohm Electronics* can, according to the manufacturer, reduce the cost of fiber-optic transmission in LAN's and WAN's. The double-heterostructure laser diodes can be modulated at frequencies of 1.2 GHz.

The high modulation frequencies are achieved through the low junction capacitance of the die's active area. They are manufactured by the molecular beam epitaxy (MBE) process which permits atomic-layer control in the growth of the structure. This, according to ROHM givers better control than is obtaine with either liquid-phase epitaxy (LPE) or metalorganic chemical vapor deposition (MOCVD).

RLD Series laser diodes typically operate at a threshold current of only 32 milliamperes, significantly lowering power consumption, increasing switching speed, and giving longer operating life. Recent accelerated life tests of the



CIRCLE 22 ON FREE INFORMATION CARD

laser diodes by ROHM one sample lot at 50° with a constant 3 milliw optical output showec mean time to failure 240,000 hours. This figı compares with the 20,0 hours typical for laser odes in compact and vid disk players.

RLD laser diodes ȧ priced below $30 each volume.—**Rohm Corpo tion**, address, Antioch, T

COMMUNICATIONS R CEIVER. According to manufacturer, the *Lo HF-150* communicatio receiver puts the entire dio spectrum from 30 k to 30 MHz at your fing tips. That gives the lister access to internatior shortwave bands, amate ship and aircraft banc and time signals. The tuni rate is variable according the rotation speed of t main tuning knob.

This rugged portable ceiver is made with sc hard alloy casings, me panels and machin parts. It measures or 7.3 × 3.2 × 6.3 inches a weighs only 2.9 pounds can be operated from AC to DC adaptor (sı plied), an external 10 15—volt DC source, eight internal nickel- ca mium rechargeable A cells for 150 milliampe drain.

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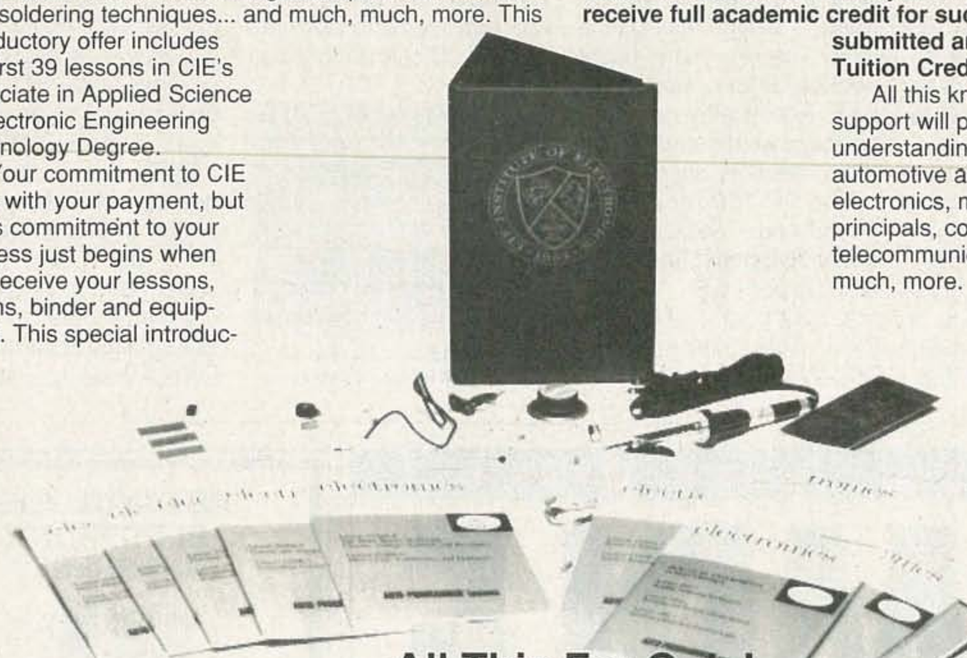

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system allows reception of selection of either synchronous lower sideband or synchronous upper sideband, and synchronous double sideband. That arrangement obtains the best reception from weak shortwave signals.

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The loudspeaker is internal. Provision is made for external connections to headphones, external loudspeaker, and output for a tape recording. The receiver can accept three different antennas: 600-ohm long wire, 50-ohm coaxial feed, or a high-impedance whip. The rear panel has a socket for an optional keypad, which allows direct frequency entry and instant direct memory access.

The *HF-150* receiver is priced under $600.—**Electronic Equipment Bank**, 323 Mill Street N.E., Vienna, VA 22180; Phone: 703-368-3270; Fax: 703-938-6911.

AUTORANGING DIGITAL MULTIMETERS. The *Tektronix DM2510* and *DM2510G* digital multimeters, designed for benchtop use, offer full programmability with 4½-digit accuracy, an integral power supply, and autoranging or manual operation. Functions provided by both units include voltage, current, or resistance measurement, true RMS AC voltage measurement (200-millivolts to 500-volt range), dB calculation, and

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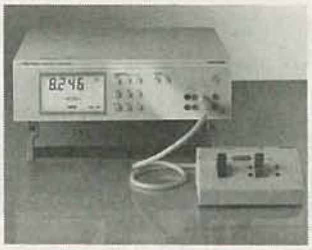
temperature measur ments.

The meters measure D volts from 200 millivolts 1000 volts with 0.03 basic DC voltage accura and DC amperes from 1 microamperes to 10 ar peres with 0.06% basic D amperes accuracy. Bo units are programmabl and the *DM2510G* offe full programmability with i IEEE-488.1 interface.

Front-panel keys simpli the selection of functic and range, and permit th setting of GPIB addres and termination parar eters. The TM2500 Serie DMM's can be stacked t gether with other produc in the Tektronix TM250 TM2500 Series to sav bench space. Besides d sign, manufacturing, ar service applications, Th DMM's are said to hav have broad applications in design manufacturing and service as well as training.

The *DM2510* is priced at $595 and *DM2510G* is priced at $695.—**Tektronix**, Test & Measurement Group, P.O. Box 1520, Pittsfield, MA 01202; Phone: 1-800-426-2200.



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AUTOMATIC RCL METER. *Fluke's PM 6303A* automatic RCL meter is said to determine the value, dimension, and equivalent circuit of passive components accurately over a wide range. The component is connected to the four-wire test fixture on the front panel of the instrument and the backlit LCD display shows the dominant component values with an accuracy of better than 0.25%. It also provides the user with an electrical dimension and one of the seven equivalent circuit diagrams.

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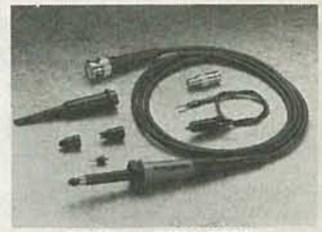
The *PM 6303A* automatic RCL meter, equipped with a four-wire test fixture, an operating manual, and a line cord, is priced at $1500.—**John Fluke Mfg. Co., Inc.**, P.O. Box 9090, M/S 250E, Everett, WA 98206-9090; Phone: 800-44-FLUKE.

RF DETECTOR OSCILLOSCOPE PROBE KIT. This kit is for an RF-detector oscilloscope probe with a bandwidth of 800-MHz. Intended for use with any oscilloscope having a 10-megohm input, *Pomona Electronics' Model 5815* kit contains interchangeable oscilloscope probes and accessories for the professional oscilloscope user. The RF detector oscilloscope probe kit is packaged in a reusable plastic case, and replacement parts are readily available. The probes' modular design permits maximum flexibility and interchangeability of tips and various types of interface connections.



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The *Model 5815* RF-detector oscilloscope probe kit is priced at $70.50.—**ITT Pomona Electronics**, 1500 East Ninth Street, P.O. Box 2767, Pomona, CA 91769; Phone: 714-469-2900; Fax: 714-629-3317. **R-E**

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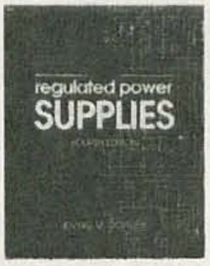

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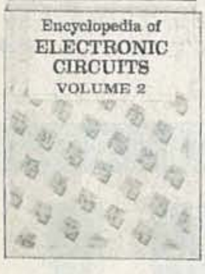

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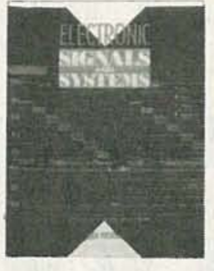

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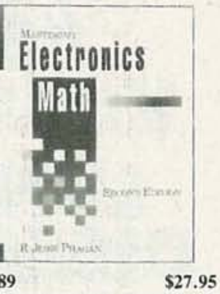

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Hundreds of schematics for up-to-date electronic circuits, straight from the drawing boards of industry leaders such as Motorola, Texas Instruments, General Electric, and National Semiconductor, are included in the 700-plus

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pages of this book. Tightly organized and extensively indexed, the book includes complete descriptions of automotive, audio, video, ultrasonic, alarm and security, and computer-related circuits. The book's index includes not only the circuits presented in Volume 4, but also those that appear in the first three volumes. The circuits are arranged in 104 chapters, with circuit titles listed at the beginning of each chapter for easy reference. Almost every circuit is accompanied by a brief written explanation; those who require more details can order the original sources, which are listed in the back of the book.

BUILD YOUR OWN SPECTRUM ANALYZER; by Murray (WA2PZO) and Bruce (WA2DRO) Barlowe. Science Workshop, Box 310, Bethpage, NY 11714; Phone: 516-731-7628; $24.95.

A spectrum analyzer is a valuable—and expensive—piece of test equipment with dozens of applications. But professional models, costing thousands of dollars, are beyond the means of most electronics hobbyists and many professionals. This book shows how to build the "Poor Man's Spectrum Analyzer" for a fraction of the cost. The instrument does "almost everything the professional models do," but requires "a little more effort and ingenuity" on the part of the user when it comes to making precise measurements. The analyzer can use almost any standard oscilloscope for its display. The Poor Man's Spectrum Analyzer is packaged as a kit, available separately.

The book includes a tutorial covering theory of operation, layout drawings and photographs, and magazine articles about the spectrum analyzer, reprinted from *Ham Radio* and *Communications Review*. In addition, it features a chapter titled "User Feedback" in which actual user modifications are presented and explained in detail. The final chapter includes copies of the instructions, schematics, and parts layouts for each of the modules used in the spectrum analyzer.

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MOBILE-ANTENNA WALL CHART; from The Antenna Specialists Co., 30500 Bruce Industrial Parkway, Cleveland, OH 44139-3996; Phone: 216-349-8400; Fax: 216-349-8407; free to dealers, distributors, service shops, RF-design labs, and service professionals.

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This full-color wall chart is intended to help readers choose the right mobile antenna for every vehicular installation requirement. The 54 × 38-inch chart presents pictures of almost 150 professional mobile-antenna models, grouped by frequency range from low-frequency band through 800 to 900 MHz. The antennas are cross-referenced to various vehicular mounting schemes, such as On-Glass, conversion mounts, ¾- and ⅜-inch hole mounts, trunk lid, magnetic, and other temporary mounts. The chart also presents antenna solutions for special applic tions including those motorcycles and railroac Each antenna is depicted a photograph with its co ponents identified by pa number.

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ditioning boards, as well PC-based frame grabber In addition to hardwa products, the catalog c fers high level languag (HLL) drivers, set-up ar demo routines, and inte faces to many third-par software packages. R

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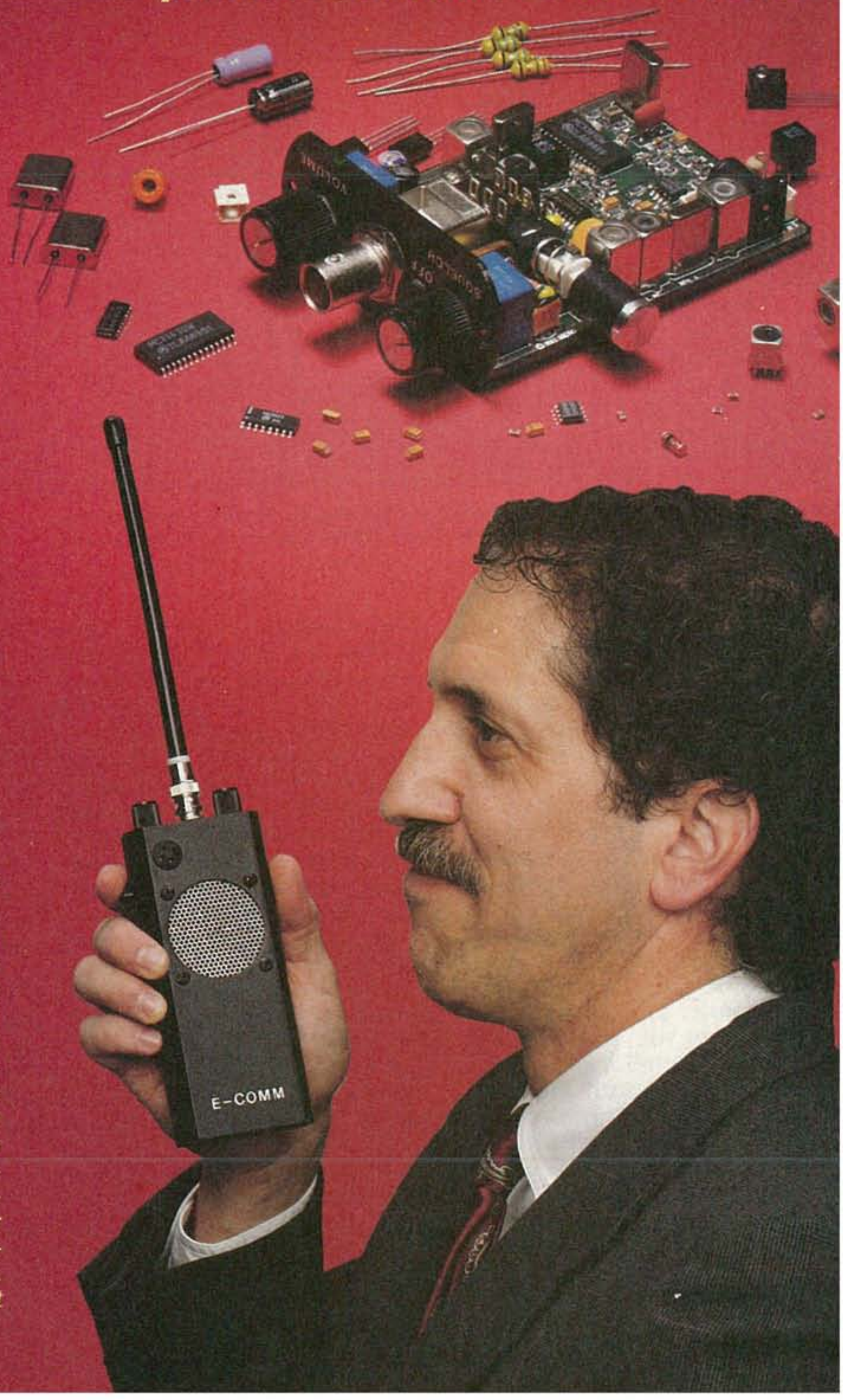
IF YOU EVER WANTED TO BUILD A small powerful handheld transceiver and, at the same time learn surface-mount technology (SMT), this is the project for you! The E-Comm frequency-modulated (FM) transceiver is housed in a rugged yet attractive aluminum case less than six inches long. It is one of the most unusual transmitter-receivers ever designed for its power level and operating frequency range. The case includes a rechargeable nickel-cadmium power pack that will save you the cost of periodically replacing eight AA alkaline cells.

The E-Comm receiver has a respectable 0.3-microvolt sensitivity (12-dB SINAD) for high quality reception, and its transmitter boasts at least a 90% efficiency. E-Comm owes its efficiency to its innovative Class-E final amplifier which exhibits high power gain. It offers a continuous output of 3 watts rms into a 50-ohm antenna or dummy load. The efficient receiver and the rechargeable power supply make it possible to keep E-Comm on the air in the *squelch* mode for 80 hours without recharging the power pack.

Intended for narrow-band FM, E-Comm has a usable carrier frequency range of 27 MHz to 32 MHz with only crystal and alignment changes. The subject of this article is a version designed for 27.145-MHz operation. With modifications to the transmit and receive filters (component value changes) operation up to 60 MHz is possible. This allows the transceiver to work both the six- and ten-meter amateur radio bands. Note: *This transceiver has not*



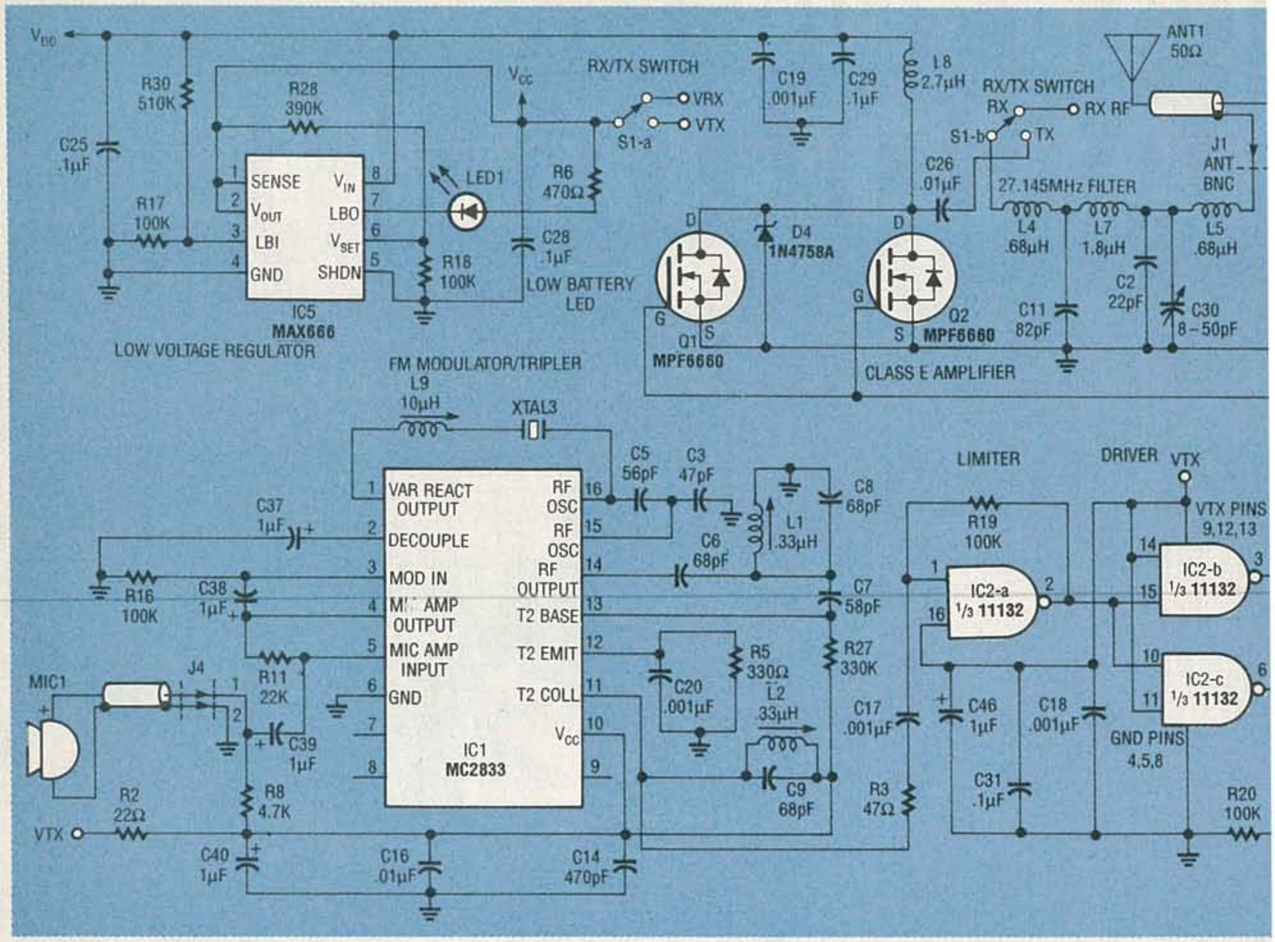


FIG. 1—SCHEMATIC SHOWING THE MODULATOR/TRIPLER, Class-E amplifier, limiter, driver and low-voltage regulator sections of the E-Comm transceiver. The key device is IC1, the FM transmitter chip.

been submitted for FCC approval, and its operation on certain frequencies may not be allowed and/or may require licensing.

The top panel controls of E-Comm include an ON-OFF switch, VOLUME and SQUELCH knobs and an LED power-pack status indicator. The removable flexible seven-inch antenna is coupled to the transceiver with a 50-ohm bayonet-style BNC connector plug. All the components except the battery pack, microphone, and speaker are mounted on the double-sided PC board. Extensive use of integrated circuits and surface-mounted components allows the circuitry to fit on a PC board that measures only 2.25 × 3.1 inches.

How it was designed

The transceiver has three main sections: transmitter, receiver, and power supply. (Refer to Figs. 1 and 2.) The transmitter is designed around Motorola's MC2833, a low-power FM transmitter IC whose pinout and functional block diagram are given in Fig. 3. The receiver is designed around Motorola's MC3363, a low-power, dual-conversion FM receiver IC whose pinout and block diagram are given in Fig. 4.

Received signals picked up by the antenna are preselected by the five-pole transmit bandpass filter consisting of inductors L4, L7, and L5 and capacitors C11, C2, and C30 as shown on the right side of Fig. 1. The received signal is then fed through the receive/transmit switch S1-b to an impedance-matching stage consisting of C10 and L3 shown on the left side of Fig. 2. That stage provides an additional two poles of preselection.

Diodes D1 and D2 prevent overloading and the possible (struction of the RF amplif transistor if it is subjected overdriving at the front er The preselected signal is th amplified by the IC3 (MC336 internal common-emitter l amplifier stage and fed to t first mixer stage on pin 1.

The RF amplifier provides gain of approximately 20 d The first local oscillator (L takes a third overtone from crystal, and drives the first m er through an internal casco amplifier. Downconversi makes the first LO frequen (the first IF frequency) 10.7 M greater than the carrier. For (ample, if a 27.145 MHz carr were present, the crystal f quency would be 27.145 M plus 10.7 MHz or 37.845 MH

The mixer is a doubly b anced multiplier that provic about 18 dB of conversion ga The output of the mixer is emitter-follower stage with output impedance of 330 ohi to match the ceramic filter. F

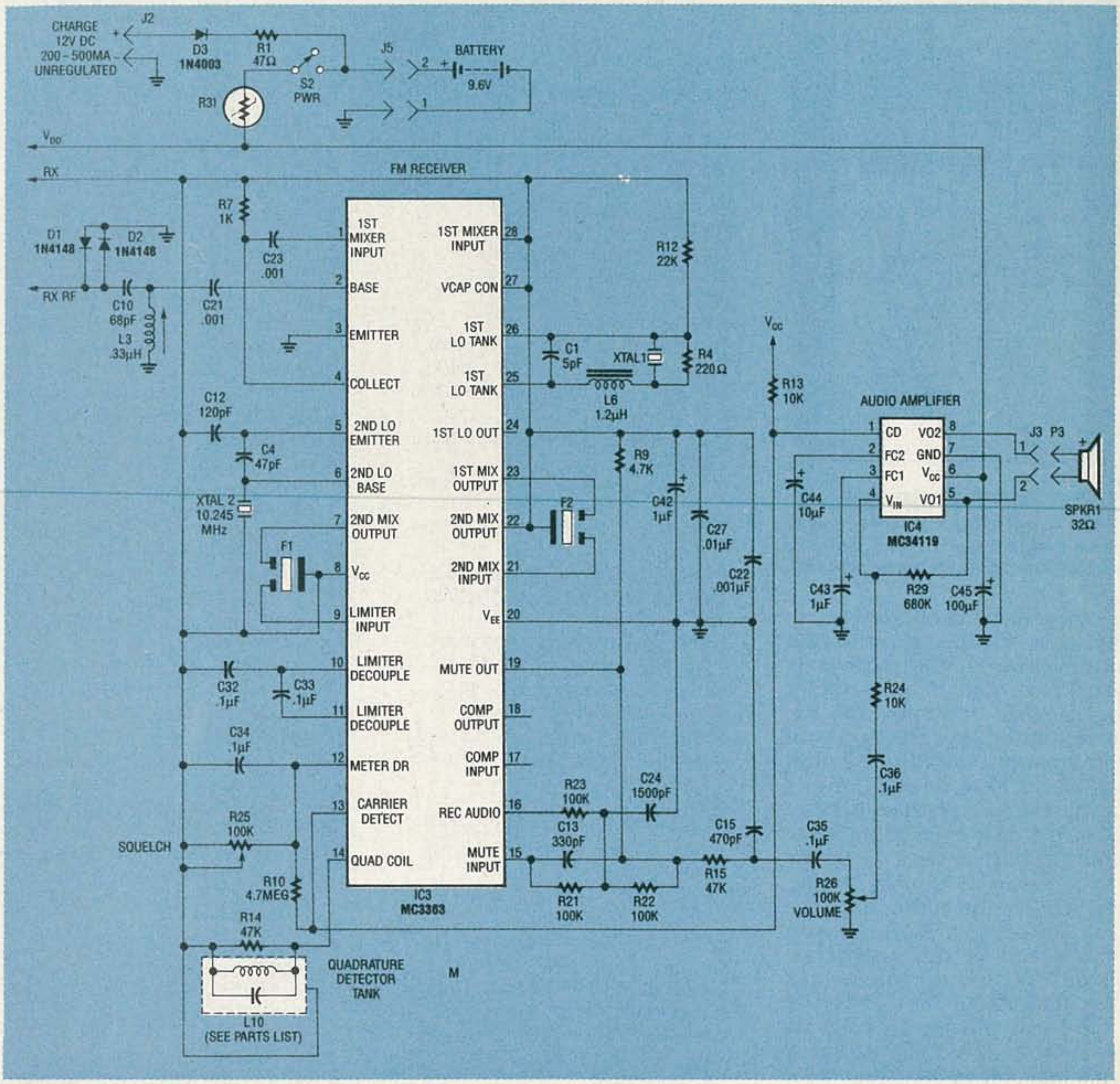


FIG.2—SCHEMATIC SHOWING FM RECEIVER, audio filter, and audio amplifier sections of the E-Comm transceiver. The key device here is IC3, the dual-conversion FM receiver chip.

ter F2, a 10.7-MHz ceramic bandpass filter, removes unwanted out-of-band harmonics from the output of the first mixer. The second mixer takes a signal from the 10.245-MHz fundamental mode crystal-controlled oscillator XTAL2 whose output is mixed with the 10.7-MHz first IF to generate the 455-kHz second IF with a conversion gain of approximately 21 dB.

The 455-KHz ceramic filter F1 (left side of IC3 in Fig. 2) provides narrow-band filtering for the limiter amplifiers within IC1, the MC2833 FM transmitter chip. The limiters clip the 455-kHz second IF signal to remove unwanted amplitude-modulated signals and feed the audio detector. A quadrature detector within IC3, the MC3363, detects the modulated signal. The parallel quadrature detector tank, L10, in the detector is tuned to 455 KHz.

The demodulated (audio) signal on pin 16 of the FM transmitter IC1 is then filtered by an active filter stage that includes an op-amp within IC3, the FM receiver chip in Fig.2. This active filter, connected at pins 15 and 19 of IC3 and consisting of capacitors C13, C24, and C15 and resistors R21, R22, R23, and R15, has a rolloff at 3 kHz

Squelch is performed by the carrier-detect function on pin 13 of the FM transmitter chip, IC1 in Fig. 1. Resistor R10 (between pins 12 and 13) provides hysteresis in the squelch circuit to prevent unwanted "break through." This squelch circuit is unusual; its output both enables and disables IC4, a Motorola MC34119D low-power audio amplifier with a CHIP DISABLE pin 1 (CD).

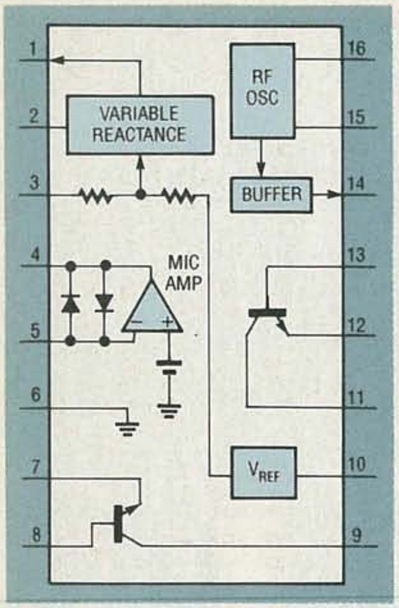


FIG. 3—PINOUT AND FUNCTIONAL block diagram for IC1, the Motorola MC2833 low-power FM transmitter chip.

Power consumption is reduced by disabling the audio amplifier when the receiver is squelched, and it is also kept low because it is run from the unregulated power supply in combination with the 32-ohm speaker. This arrangement holds receiver consumption down to only 7 milliamperes from the battery pack when the receiver is in the squelch mode. The gain of the audio amplifier is set by resistor R29 (between pins 4 and 5) and nearby resistor R24, and is expressed as (2 × R29/R24).

The transmitter is a 3-watt narrow-band FM Class E circuit with efficiency greater than 90%. The front end of the transmitter is based on IC1 (Fig. 1), the low-power FM transmitter chip. The voice signal is picked up by the microphone and fed to the MIC AMP INPUT on pin 5 of IC1. Resistor R11 (between pins 4 and 5) sets the gain of the amplifier, and the output of the amplifier drives the FM modulator.

A variable reactance in the modulator "bends" the frequency of the crystal-controlled oscillator. Because the crystal frequency cannot be deviated by more than a few kilohertz by the variable reactance circuit, a multiplication scheme derives the proper carrier and modulation frequencies. In the E-Comm, a crystal frequency equal to one-third of the carrier frequency was chosen. Inductor L9 (in series with XTAL3 between pins 1 and 16 of IC1) centers the oscillator frequency when no modulation is applie
The buffered output of the o
cillator on RF OUTPUT pin 14 the
feeds a tank circuit made up
inductor L1 and capacitor C
which is tuned to the third ha

PARTS LIST

Resistors (All 1206 SMD chip resistors are 1/8-watt, 5%, unless otherwise specified)
R1—47 ohms, 1/2-watt, 5%, radial-lead
R2—22 ohms, 1206, SMD
R3—47 ohms, 1206, SMD
R4—220 ohms, 1206, SMD
R5—330 ohms, 1206, SMD
R6—470 ohms, 1206, SMD
R7—1000 ohms, 1206, SMD
R8, R9—4700 ohms, 1206, SMD
R10—4.7 megohms, 1206, SMD
R11, R12—22,000 ohms, 1206 SMD
R13, R24—10,000 ohms, 1206 SMD
R14, R15—47,000 ohms, 1206 SMD
R16-R23—100,000 ohms, 1206 SMD
R25, R26—100,00 ohms potentiometer, Bourns 51CADD12A20, or equivalent
R27—330,000 ohms, 1206 SMD
R28—390,000 ohms, 1206 SMD
R29—680,000 ohms, 1206 SMT
R30—510,000 ohms, 1206 SMT
R31—current variable resistor, polymer-based, Raychem Polyswitch RXE040 or equivalent

Capacitors
C1—5 pF NPO 805 SMD ceramic, Tayio-Yuden UMK212CH0R5D-B or equivalent
C2—22 pF NPO ceramic disc, 100-volt, Panasonic ECC-F2A220JCE or equivalent
C3, C4—47 pF NPO 805 SMD ceramic, Tayio-Yuden UMK-212CG470K-B or equivalent
C5—56 pF NPO 805 SMD ceramic, Tayio-Yuden UMK212CG560K-B or equivalent
C6-C10—68 pF NPO 805 SMD ceramic, Tayio-Yuden UMK-212CG680K-B or equivalent
C11—82 pF NPO ceramic disc, 100-volt, Panasonic ECC-F2A820JCE or equivalent
C12—120 pF NPO 805 SMD ceramic, Tayio-Yuden UMK-212CG121K-B or equivalent
C13—330 pF NPO 805 SMD ceramic, Tayio-Yuden UMK-212CG331K-B or equivalent
C14, C15—470 pF NPO 805 SM ceramic, Tayio-Yuden UM 212CG471K-B or equivalent
C16, C26, C27—0.01µF Y5V 8(SMD ceramic, Tayio-Yude UMK212F103Z-B or equivalent
C17-C23—1000 pF NPO 805 SM ceramic, Tayio-Yude UMK212SL102K-B or equivale
C24—1500 pF X7R 805 SMD c ramic, Tayio-Yuden UMI 212B152K-B or equivalent
C25, C29, C31-C36—0.1µF Y5 805 SMD ceramic, Tayio-Yude UML212F104Z-B or equivalent
C28—designation not used
C30—8-50 pF trimmer capacit Sprague-GM GKG50011 (equivalent
C37-C40, C42, C43, C46— 1µ 1206 SMD tantalum, 16-volt
C41—designation not used
C44—10µF electrolytic, 16-volt, mm, Panasonic ECE-A1CGE1C or equivalent
C45—100µF electrolytic, 16-vol 6.3 mm, Panasonic ECE A1CGE101 or equivalent

Semiconductors
D1, D2—DL4148 switching diod 1206 SMD,
D3—DL4003 silicon rectifier, SM
D4—1N4758A 56-volt Zener dioc
LED1—HLMP-1503-101 (Hewlet Packard) green light-emitting d ode right-angle indicator (equivalent
Q1, Q2—MPF6660 power FE (Motorola) or equivalent
IC1—MC2833 (Motorola) low power FM transmitter systen SMD
IC2—74ACL11132 (Texas Instru ments) quad NAND gate, Schmi trigger, SMD or equivalent
IC3—MC3363DW (Motorola) low power dual-conversion FM re ceiver, SMD package
IC4—MC34119 (Motorola) low power audio amplifier, SMD
IC5—MAX666CSA (Maxim) vol age regulator, SMD package

Inductors
L1-L3—0.33 µH, adjustable coi Toko, 292KNAS-T1034Z c equivalent

PARTS LIST

L4, L5—0.68 μH, axial-leaded inductor, Taiyo-Yuden, LAL04NAR68M or equivalent
L6—1.2 μH SMD inductor, 2.5 × 3.2mm or equivalent
L7—1.8 μH axial-leaded inductor, Taiyo-Yuden LAL04NA1R8M or equivalent
L8—2.7 μH axial-leaded inductor, Taiyo-Yuden LAL04NA2R7M or equivalent
L9—10 μH adjustable inductor, Toko F292CNS-T1052Z or equivalent
L10—quad coil, Toko 5SVLC-0637BJT or equivalent

Switches
S1—DPDT pushbutton switch, (Schadow) F2UOA or equivalent
S2—SPDT slide switch, C&K, 1101M2S3AQE2 or equivalent

Connectors
J1—50-ohm BNC bayonet-style, PC-board-mount jack with two hex ring nuts
J2—charging jack, Cui Stack PJ-002A or equivalent
J3 to J5—sockets, 2-pin 2mm, Molex 53014-0210 with three 2-pin plugs, 2mm, Molex 51004-0200 and six pins, Molex 50011-8100 or equivalent

Crystals
XTAL1—37.845-MHz third-overtone crystal, Toyocom, HC-49 or equivalent
XTAL2—10.245-MHz parallel-mode crystal, 32 pF, Toyocom, HC-49 or equivalent
XTAL3—9.0483-MHz parallel-mode crystal, 32 pF, Toyocom, HC-49 or equivalent

Filters
F1—455-kHz ceramic filter, Murata CFUM455E or equivalent
F2—10.7-MHz ceramic filter, Toko SK107M5-A0-10 or equivalent

Other Components
MIC1—microphone, Panasonic WM-54BT or equivalent
SPKR1—speaker, 2-inch square, 32-ohm, Regal, SA-200 or equivalent
ANT1—flexible coil antenna with BNC bayonet-style plug.

Miscellaneous: PC board, custom-made battery pack with eight rechargeable nickel-cadmium AA cells, No. 24 AWG wire; one 120-volt AC to 12-volt DC adapter for charging the power pack; custom-made extruded case with bottom panel and silk-screened top panel; one custom made speaker grill; two knobs, Keystone, 8580 or equivalent with two hex ring nuts each; four No. 440 × 3/8-inch Philips-head screws, black; four No. 6-32 X 5/16-inch Philips-head screws, black; four No. 6-32 internal-tooth lock washers, four No. 6-32 hex nuts, one perforated hole plug, Hayco 2637 or equivalent; six-inch length of shielded wire; 12-inch length of No.24 AWG wire; fine solder wire; tools and accessories as specified in the text.

NOTE: The following parts are available from Micro Advancement Products, Inc., P.O. Box 8505, Hollywood, FL 33084 800-358-8545
- **Printed circuit board only—$12.00**
- **Kh with printed circuit board and all components—$97.00**
- **Enclosure including all hardware, microphone, speaker, knobs and transmit button—$38.00**
- **Battery pack—$17.95**
- **AC to DC adapter for charging power pack, wall outlet mount—$7.85**
- **Flexible "rubber ducky" seven-inch 27-MHz antenna with BNC bayonet-style plug—$17.95**
- **Complete kit for one E-Comm transceiver—$168.00**
- **Complete kit for two E-Comm transceivers—$297.00**
- **One E-Comm transceiver assembled and tested—$229.00**

Please add $4.95 for shipping and handling to all orders. Free frequency modification sheet and crystal list with each order.

monic of the oscillator.

The signal is multiplied by a factor of three to obtain the carrier frequency in this tank circuit. Both the carrier and the modulation signal are multiplied to obtain the 5-kHz deviation required by the receiver. Next the signal is passed through a tuned common-emitter amplifier to amplify and smooth the carrier.

Next the signal is clipped by the quad NAND Schmitt trigger, IC2, a 74AC11132 high-speed CMOS logic gate. Two sections of IC2 (IC2-b and IC2-c) provide drive to turn a parallel-connected pair of enhancement-mode MPF6660 power MOSFET's, Q1 and Q2, on and off. Class E operation is obtained with the fast switching as well as the low ON resistance of the power MOSFET's.

Theoretically, if no power were required by the switch for activation (driver power), and if it were lossless, E-Comm would be nearly 100% efficient. Although the FET's do not form a perfect switch, they offer several useful characteristics: The input power required to drive the FET's is very low (drawn principally in switching the gate input capacitance on and off at high speed (less than 6 nanoseconds), and their switching speed is very high.

Those characteristics give the transmitter an efficiency of about 90%, measured as the ratio of rms RF power (delivered to the 50-ohm load) to the DC supply. A five-pole filter matches

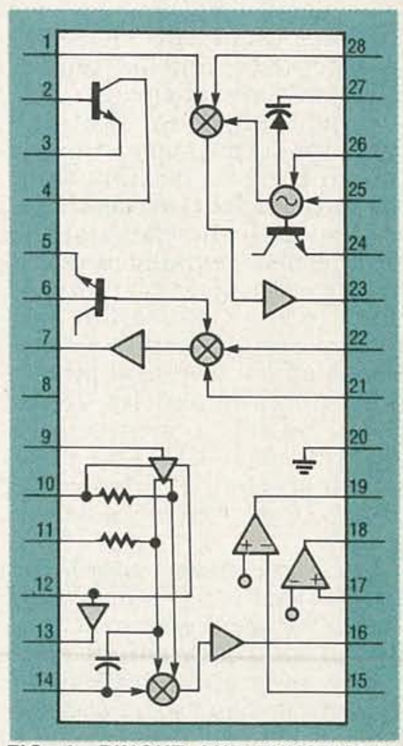


FIG. 4—PINOUT AND FUNCTIONAL block diagram for IC3, the Motorola MC3363DW low-power, dual-conversion FM receiver chip.

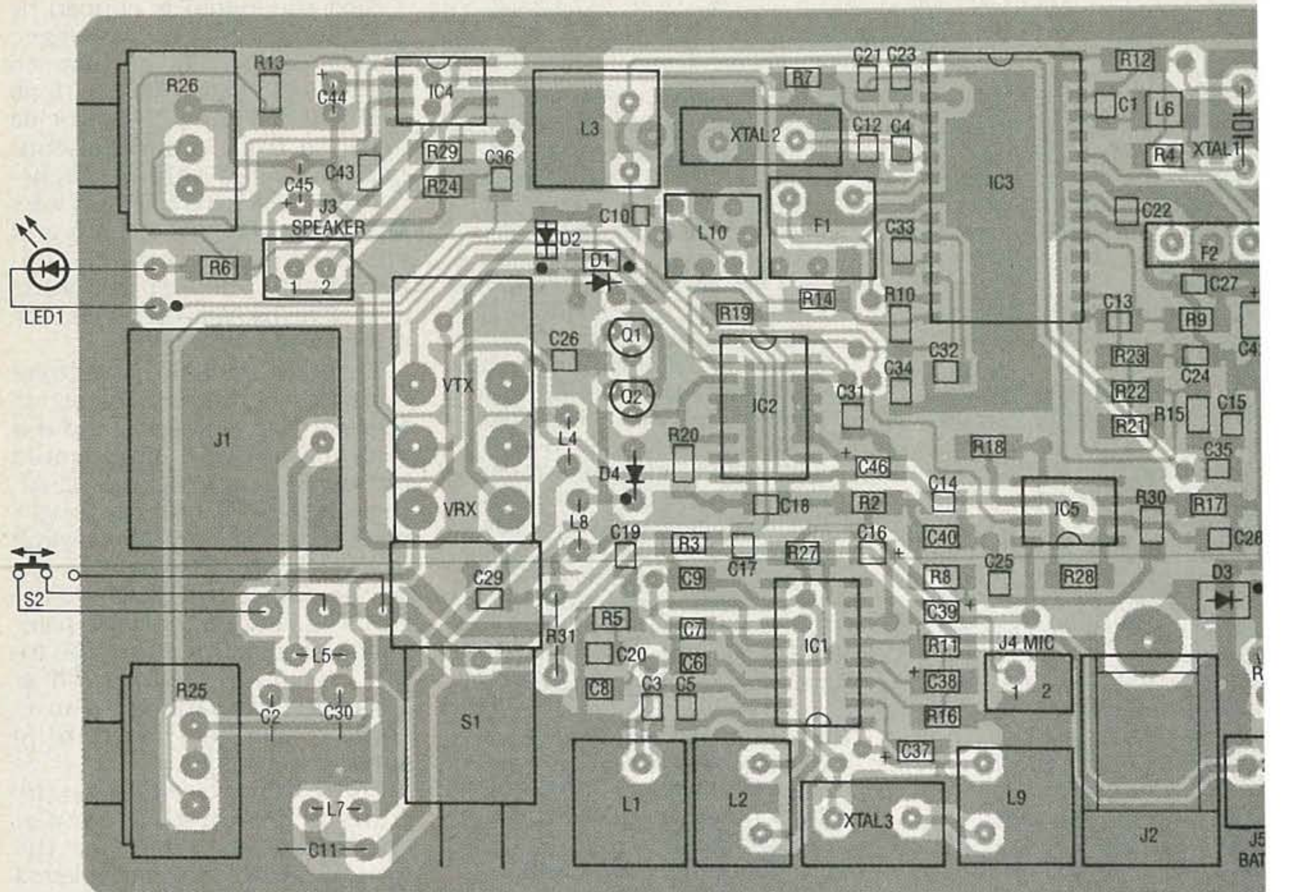


FIG. 5—PARTS PLACEMENT DIAGRAM for the E-Comm transceiver. Note radial leaded components C2, C11, R30 and F2. Axial leaded components R1, L4, L5, L7, L8 and D4 are vertically mounted.

the output of the MOSFET switches to the antenna impedance while also filtering.

Variable capacitor C30 fine tunes the output stage to match the antenna or dummy load. Notice that to obtain class E operation, both the load and the multiplier stages must be tuned in accordance with instructions in the Calibration and Tuneup section of this article. Mismatch and overload protection are provided by Zener clamp D4 (Fig.1, between Q1 and Q2) as well as the Polyswitch protective resistor R31 (Fig. 2, upper left) in the power supply.

The low-voltage regulator shown in Fig. 1 includes a CMOS voltage regulator IC5, a Maxim MAX666, which conserves power and provides two features: low quiescent current of about 15 microamperes and a built-in low-battery detect function. The regulated output is set by resistor R18 (pin 6) and R28 to be 6.4 volts. This voltage level was chosen to provide enough gate voltage to switch power MOSFET's Q1 and Q2 on hard without exceeding the maximum voltage specification of the quad NAND gate IC2.

The low-battery detect circuit is set by resistors R17 and R30 at LBI pin 3 of IC5 to about 8 volts. Because the voltage regulator is a CMOS device, high resistor values are placed in the feedback loops for further reduction of power consumption. Pin 7 of IC5 LBO has an open-drain output that drives the low-battery indicator LED1.

The receive/transmit switch S1-a turns the receive and transmit sections of the transceiver on and off for further power conservation. The power pack consists of eight AA nickel-cadmium rechargeable cells, each with a rating of 1.2 volts at 500 milliampere hours. The pack is charged through connector J2 (Fig. 1, upper left) by a 120-volt AC to 12-volt unre[g]lated DC adapter plugged i[n] the AC line.

Building the transceiver

Surface mount devices (SM[Ds]) were chosen for E-Comm [be]cause they permit the co[n]struction of a miniature tra[ns]ceiver, and their small com[po]nent dimensions help to k[eep] PC board traces short. The[re]fore, by building this tra[ns]ceiver you'll get a leg up on [the] whole process of surface-mou[nt] technology (SMT) because y[ou] will gain hands-on experie[nce] in picking and placing the mi[ni]ature components and [an] awareness of both the bene[fits] and drawback to SMT. Howe[ver,] *do not* attempt to construct t[his] transceiver unless you are [an] accomplished project builde[r.]

Transceiver assembly

Many SMD components [are] not marked with values or [mark]ings because of the limit space on their cases. This means that you must be extremely careful to avoid mixing up chip components before and during construction.

Specialized tools should be used in picking and placing SMD components. They should be suitable for grasping small, hard-to-handle parts. Recommended are stainless steel needle-point curved-end jeweler's tweezers for picking and placing small parts such as chip resistors, capacitors and diodes on the circuit board. Fine jeweler's pliers will be useful for straightening stub leads on surface-mount IC's.

Do all soldering with a fine-tipped 10- to 15-watt pencil-type soldering iron. A lighted magnifying glass will be helpful, preferably one that mounts on the edge of a bench. Use only high-quality fine (0.01- to 0.02-inch) diameter solder wire and a suitable liquid flux. Keep fine solder-removing braid on hand to correct any mistakes that you might make.

Anyone building E-Comm should be mentally prepared for the surprisingly small size of the SMD components and their close spacing. Working with SMD components calls for near professional quality soldering skills and a lot of patience. Set up for building E-Comm on a well lighted desk or bench and sit in a comfortable chair. Do not start this fine work unless you are rested and relaxed; mistakes can be costly and frustrating to correct!

Refer to the parts placement diagram, Fig. 5. Be sure to observe all conventions when mounting polarized components such as diodes and capacitors. Dots on the PC board denote polarity. Position all polarized capacitors so the positive lead is nearest the dot, and position all diodes and rectifiers so their cathodes are nearest the dot. Be sure to find the markers indicating pin 1 on all SMD packages. It is typically a white dot.

Do not attempt to build this circuit on any PC board except one that has been specifically designed for this circuit. Failure to observe this will result in a poor performing transceiver. A proper PC board for RF circuitry needs an adequate ground plane and short interconnects to prevent inadvertant oscillations, loss of sensitivity, and noise-related problems.

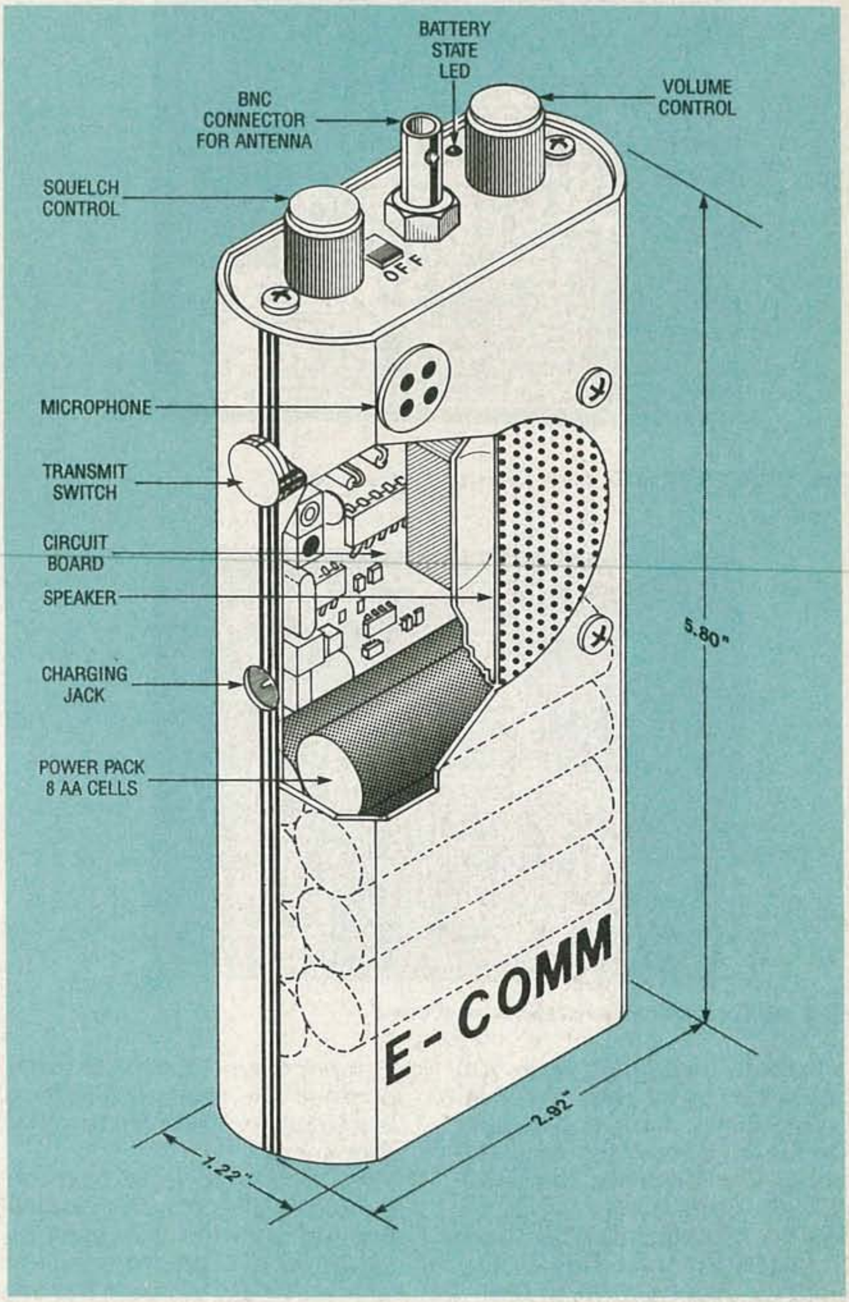
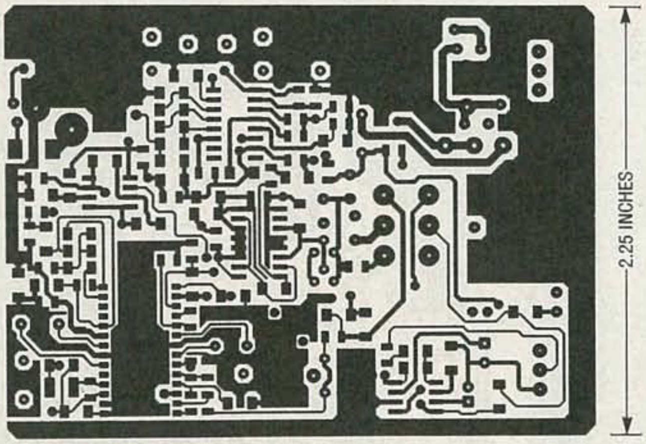


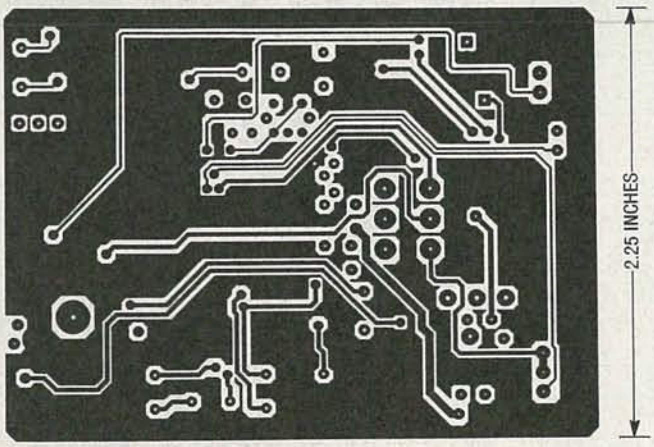
FIG. 6—CUTAWAY VIEW OF ASSEMBLED E-Comm TRANSCEIVER showing the positions of the controls and the locations of the microphone, speaker, loaded circuit board and power pack.

The accurate and effective mounting of SMD components requires a solder mask on the PCB because of the cramped lead spacing. A double-sided board with plated-through holes and solder mask is available from the source given in the Parts List. It can be purchased as a single item or as part of the options listed.

An orderly assembly procedure is recommended because of the cramped PC board layout and the mixture of small and large components on the board. Solder all surface-mount IC's to the board first. *This is the most time-consuming and tedious part of the project!*



COMPONENT SIDE of E-Comm transceiver circuit board



WIRE SIDE of E-Comm transceiver circuit board

In soldering SMD IC's, first tin one of the corner pads on the PC board. Then, with needle-nose tweezers, grasp the part and center it so the leads align with all of the pads. Solder the corner lead to the pad that has been tinned. Next solder the pin diagonally across from the first pin, making sure that the case is still centered on the pads. Before soldering the remaining pins, refer to Fig. 5 and verify that the IC is in the correct position; then double check to be sure that pin 1 is in the correct location.

Be careful not to apply too much solder at each pad, and try to avoid making inadvertant bridges with the molten solder between intended connections and adjacent pins. If bridging occurs, use a solder-removing braid and flux to remove it. Also avoid holding the soldering pencil at any connection point for more than the time requred to cause the molten solder to flow to prevent overheating the component.

The next step is to position and solder all SMD chip capacitors and resistors. *Install all resistors and capacitors of the same value at the same time to avoid mixing values!* Tin one pad of two-terminal components, place the component in the correct position, and hold it with tweezers while soldering it to the tinned pad. Next, solder the other end.

As in soldering the IC's, use only as much solder as is necessary to form a fillet between the component and the PC board pad. Be sure that the components are positioned flush against the board.

After all SMD components are mounted, clean the entire PC board with flux remover, and inspect all of the soldered connections with a magnifying glass all of the SMD soldering appea satisfactory, mount all of t leaded through-hole comp nents with the exception of ductor L8 and solder them position. (Inductor L8 is to installed after the multipli stages are aligned.)

Take care when soldering t connectors because their lea are off-centered. The axial-lea ed inductors and resistor R1 a mounted through holes. U the silkscreened pattern on t PC board as a guide. Be sure mount the switches and pote tiometers so they lie flu against the PC board.

Now assemble the batte pack, microphone and speak Assemble the connector plu for J3 to J5 by crimping a soldering them to the batte pack, microphone and speak wires. Solder two six-in lengths of insulated 26 AW wire to the speaker and tw them together. Next solder pi to the ends of the speaker wir being careful not to let sold flow into contact area. Th push the pins into the mati plastic plug housing. Each p should snap into place if it assembled correctly.

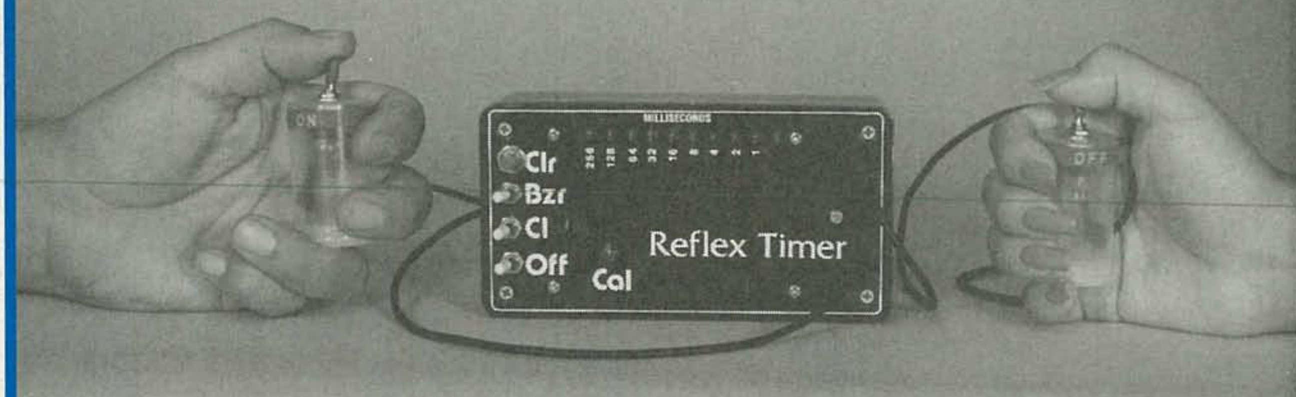
The assembly work on t battery pack subassembly limited to twisting the wir and attaching the connect plug. *Note that this connecto polarized and can only plug one way.* Verify that the batte connector polarity is correct b cause reversed polarity will d stroy the transceiver!

Solder a four-inch length shielded coaxial cable to the m crophone with the shield co nected to the negative side the microphone. Then conn the cable to the polarized co nector, again observing polari

Fasten the microphone in the plastic snap-in bushi with a room-temperature v canizing (RTV) silicone adh sive. *Mask the front surface the microphone with maski tape to prevent the entry of a adhesive in the microphone it could be ruined.* Be sure th the wire side of the micropho is flush with the back of t

continued on page

BUILD THIS
REFLEX TIMER



How fast are your reflexes? The reflex timer will show you.

DAN KENNEDY

HOW LONG DOES IT TAKE YOU TO close a switch after you hear a buzzer? When driving, how long does it take to hit the brakes after you see an obstacle? What we're really asking is, "How quick are your reflexes?" Our reflex timer will show you.

Testing your reflexes is a two-person job. To use it, one person secretly starts the timer, which sounds a buzzer. Upon hearing the buzzer, the person whose reflexes are being tested turns the timer off as fast as he can. (That also turns off the buzzer.) The person's reflex time can then be determined by observing a 10-LED display.

Figure 1 is a schematic diagram of the reflex timer, which consists of a 555 timer (IC1) and three 74LS193 4-bit binary counters (IC4–IC6). The 555 timer outputs a pulse about twice every millisecond, or 2000 times a second. The timer is secretly activated by S1 which then turns on piezo buzzer BZ1 via Q1, and connects the clock output from the 555 to the binary counters through one NAND gate (IC3-d), as shown in Fig. 2. The person being timed turns S2 off, which disconnects the 555 output from the counters and turns off the buzzer. Quad NAND gate IC2 is configured as two separate latches, also as shown in Fig. 2, to prevent the contacts of S1 and S2 from bouncing.

Depending on how long it takes the person to shut off the timer, a certain number of LED's light up. The numbers next to each illuminated LED (1, 2, 4, 8, 16, 32, etc.) are then added together to give the person's reflex time in milliseconds. If all the LED's are lit, the total elapsed time is 511 milliseconds or 0.511 seconds. The indicated time can be multiplied by a correction factor to give a more precise measurement, bu that's not necessary for relativ measurements or "contests" t determine who has the fastes reflexes. We'll talk more abou the correction factor later.

A 7805 voltage regulator (IC7 provides +5-volts DC for the ci cuit from a 9-volt battery. Tw 5.1K resistors (R1 and R2) and 0.047 μF capacitor (C1) give th 555 a clock frequency of approx imately 2000 Hz, or 2 cycles pe millisecond. Try using a few di ferent 0.047-μF capacitors fo C1 to get the frequency as clos to 200 Hz as possible. Closin switch S4 puts C2 (a 47 μF c pacitor) in parallel with C That slows down the timer demonstrate how a bina counter works. The number LED's will count the number times that LED1 turns on. Tl formula 1440/(R1+2R2)(gives the timer frequency in H

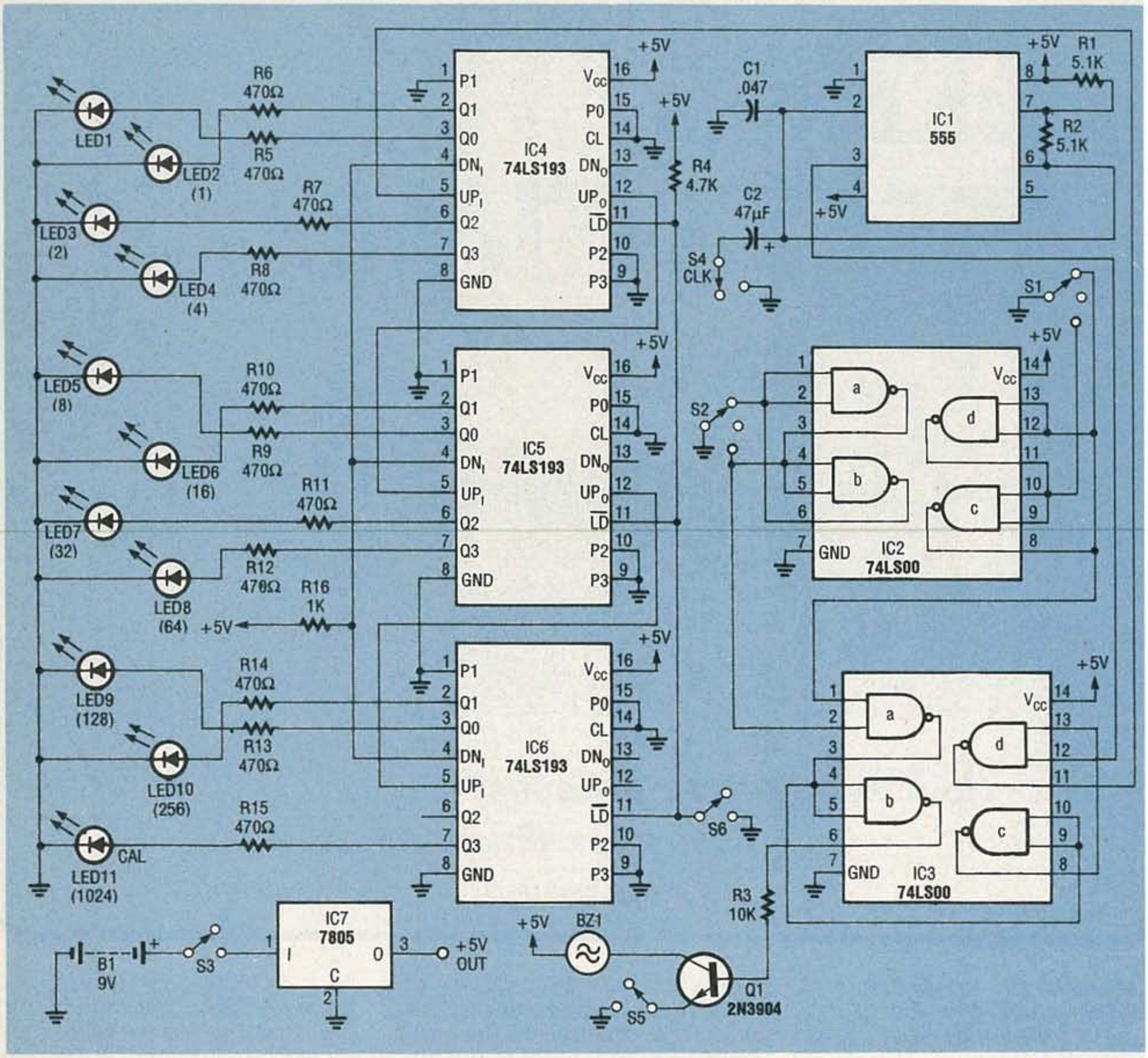


FIG. 1—SCHEMATIC OF THE REFLEX TIMER. It consists of a 555 timer and three 74LS193 4-bit binary counters.

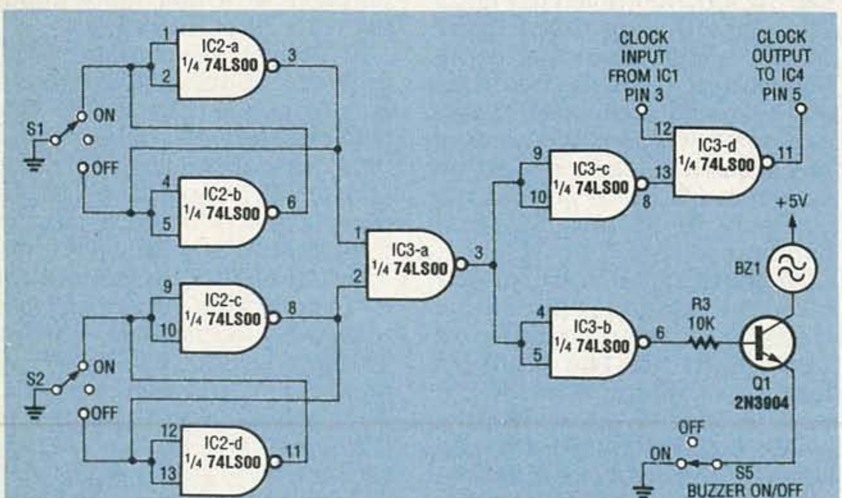
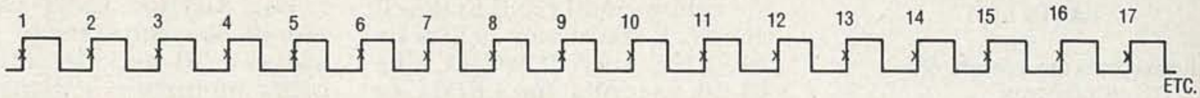


FIG. 2—QUAD NAND GATE IC2 is configured as two separate latches to prevent the contacts of S1 and S2 from bouncing. The clock output from the 555 is connected to the binary counters through one gate of IC3.

when R1 and R2 are in kilohr
and C1 is in microfarad
Switch S5 lets you turn off t
buzzer when demonstrating t
counters with the lower clo
speed.

The 74LS193 counters

The 74LS193 is a 4-bit u
down binary counter that ca
operate at clock speeds up to 2
MHz. Data input pins P0–
allow a 4-bit binary number
be loaded into the counter b
fore counting begins. The LOA
input ($\overline{LD}$, pin 11) must b
pulsed low to load the 4-b
number. Notice that the data i
puts (P0–P3) of all three counte
are grounded and that the LOA
pins are held at +5 vol
through R4. Momentarily clo



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Q0(1)	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Q1(2)	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
Q2(4)	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0
Q3(8)	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0

FIG. 3—WHEN ONE COUNTER FINISHES counting up to 15, it sends a carry pulse to the next counter. Here's how a counter responds to 17 clock cycles.

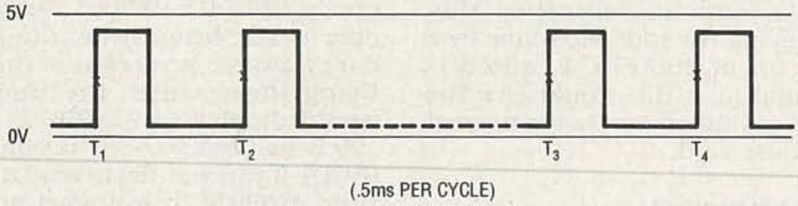


FIG. 4—THE COUNTERS ADVANCE one count on each low-to-high transition of the clock (point "X" on each rising edge).

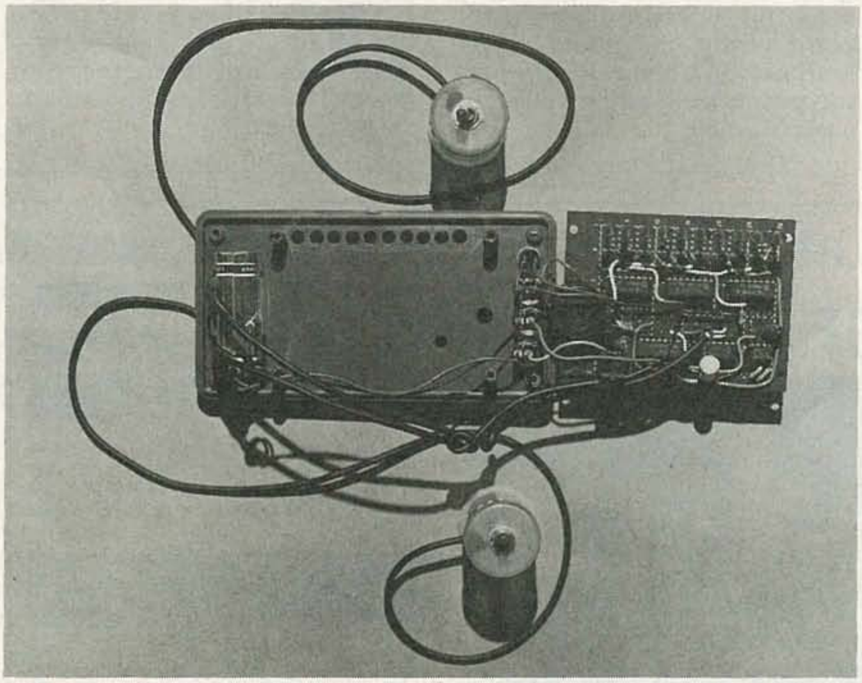


FIG. 5—THE REFLEX TIMER PROTOTYPE was built using perforated construction board and point-to-point wiring. Switches S1 and S2 are housed in plastic 35mm film canisters and connected to the main board with three-connector wire.

ing switch S6 grounds the $\overline{\text{LD}}$ pins and sets all three counters to zero. Although the CLEAR inputs (CL) are permanently grounded, pulsing them to +5 volts would also reset the circuit's counters.

The COUNT DOWN inputs (dn_I, pin 4) are held at +5 volts through R16. The clock signal from pin 3 of the 555 is applied to pin 5 on the first counter, IC4. When IC4 finishes counting up to 15, it sends a carry pulse from its UP_O (pin 12) to the count up input (UP_I, pin 5) of the second counter, IC5. Likewise, when the second counter reaches a count of 15, it sends a carry pulse from it UP_O pin to the third counter, IC6. Figure 3 shows how a counter responds to 17 clock cycles. A low-to-high transition triggers the counter. When a counter reaches 15, it starts counting again at zero.

Accuracy

Figure 4 shows the clock signal that is fed to the counters, which advance one count on each low-to-high transition of the clock (point "X" on each rising edge). We can start and stop the count anywhere in the clock cycle. Suppose we start at T_1 (just after a low-to-high transition); the timer will advance one count when T_2 is reached, which will correctly indicate 0.5 milliseconds have elapsed. However, we don't know exactly where in the clock cycle the timer will be started. Suppose the timer is started at T_2 and stopped at T_3. The timer would read 0.5 milliseconds more than the actual elapsed time because the timer started at T_2 and immediately registered one count.

A similar situation occurs at the stop time. If we start the timer at T_1 and stop at T_3 the count will be correct. But if we start the timer at T_1 and stop at T_4, the timer would read 0.5 milliseconds less than the actual elapsed time since we stopped the counters just before a low-to-high transition. That means that the accuracy of our timer is limited to ±0.5 milliseconds when we use a 2000-Hz clock. (That is also plus or minus the least significant bit (LSB) of our counters, which is the LED without a number next to it.

Another factor that determines the accuracy of the reflex timer is the clock frequency. If you have a frequency counter you can measure the clock output from IC1 directly. If a frequency counter is not available you can measure the clock frequency using a stopwatch and

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R2—5100 ohms
R3—10,000 ohms
R4—4700 ohms
R5–R15—470 ohms
R16—1000 ohms
Capacitors
C1—0.047 µF, ceramic
C2—47 µF, 10 volts, electrolytic
Semiconductors
IC1—555 timer
IC2, IC3—74LS00 quad NAND gate
IC4–IC6—74LS193 4-bit binary counter
IC7—LM7805 5-volt regulator
Q1—2N3904 NPN transistor
LED1—LED10—red LED
LED11—yellow LED
Other components
BZ1—Piezo buzzer
S1, S2—SPDT switch with center off
S3–S5—SPST switch
S6—SPST normally-open push-button switch
Miscellaneous: Perforated construction board, standoffs, project case, IC sockets, wire, solder, etc.

the calibration LED (LED11). If the clock frequency is exactly 2000 Hz, then it would take 40.96 seconds for LED11 to turn on twenty times. The author measured 41.5 seconds for LED11 to light twenty times. To calculate the frequency, multiply 2000 × 40.96/41.5; that comes to 1974 Hz. (A frequency counter measured it at 1979 Hz.) With a clock frequency of less than 2000 Hz, the indicated reflex time would be slightly less than the actual reflex time. Multiplying the indicated time by a factor of 2000/1974, which is equal to 1.013, would give the reflex time correct to the nearest millisecond.

Construction

No PC board is required to build the reflex timer. Instead you can use perforated construction board and point-to-point wiring. The photo in Fig. 5 shows how the author's prototype was built and installed in a plastic case.

The author used plas 35mm film canisters to hou switches S1 and S2, althou other mounting schemes c certainly be used. Three-cc ductor wire must be used connect S1 and S2 to the ma board.

It's a good idea to mount t IC's in sockets. That way y can easily exchange t 74LS193's with 74LS192's to s how a decade counter worl The 74LS192 has the same pi out as the 74LS193 but cour only to nine before generating carry pulse and repeatin Using those chips, the tim would display up to 399/2 199.5 in binary-coded decin (BCD). If you wanted to read t time directly in millisecon (from BCD) you would have change the clock frequency 1000 Hz.

The reflex timer is sure to be smash hit at your next party with it, you will be able to see f yourself who has the absolu fastest reflexes. F

CIRCLE 184 ON FREE INFORMATION CARD

PC-BASED TEST BENCH

The T1004 digital logic IC tester and identifier can handle 7400-, 5400-, and 4000-series IC's.

STEVE WOLFE

THIS MONTH WE CONTINUE our PC-based test-equipment series by building the T1004 digital logic IC tester and identifier. It is capable of testing 7400, 5400, and 4000 series IC's. In fact, the T1004 should be able to test any digital IC family that has the standard V_{CC} (+5V) and ground configuration (V_{CC} on the upper left corner of the IC package and ground on the lower right). On a 14-pin DIP that would mean that V_{CC} would be pin 14 and ground would be pin 7. The T1004 will accept 14-, 16-, 18-, 20-, 22-, and 24-pin DIP's.

The T1004 performs the following tests: Truth table, positive-going input threshold, negative-going input threshold, input hysteresis, output source capability under load, and an open-collector test. Additionally, the T1004 predicts (based on a best-guess analysis) what type of IC you are testing (HC, HCT, TTL, etc.). From now on, you'll find grab bags of unknown IC's very appealing because the T1004 has a feature that can help you identify those unknown digital IC's. If the IC being tested matches any of the IC's already in the IC database, the T1004 will find and display the names of those IC's. Running a complete test on one or all of those names will, in many cases, provide you with a comprehensive picture of the IC under test. The T1004 also lets you add IC's to the database. As we expand our IC support library we will make updated files available on the RE-BBS (515-293-2283, 1200/2400, 8N1).

General operation

Figure 1 shows the T1004 block diagram. The chip-select section is driven by the Front End section which we discussed in detail in our June 1992 issue; it selects and deselects every other section in the T1004. The reference-voltage section provides a 2.5-volt reference for the analog-to-digital converter (ADC) section and also for the digital-to-analog converter (DAC) section. The pull-up or pull-down section (PUPD) is capable of providing a 10-kilohm pull-up or a 200-ohm pull-down to any or all of the test-socket pins (except the V_{CC} pin).

The DAC section produces a voltage (in 20-millivolt steps between 0 and 5 volts) which is fed to the DAC multiplexer (MUX) section. The DAC MUX can apply the DAC voltage to one of pins 1 through 23 of the zero insertion force (ZIF) test socket. The DAC multiplexer can also disconnect the DAC voltage from the test socket. The ADC multiplexer can select a single voltage from one of pins 1 through 24 of the test socket and feed that voltage to the input of the ADC section. The socket-ground section supplies ground to one of six test-socket pins (pins 7–12) to connect the ground pin of the IC under test to ground.

Tests performed

- **Truth-table test**

During this description we'll use a 7432 quad 2-input OR gate as an example device. Because the 7432 is a 14-pin device, the socket-ground section grounds pin 7 of the test socket. The DAC section is disconnected from the socket. The device is looked up in the database and an input/output (I/O) mask is stored as three variables (or three 8-bit bytes). The I/O mask differentiates inputs from outputs. During subsequent testing, the I/O mask protects outputs from being inadvertently grounded. Next, a line of the truth table is read into the three variables from the data base. The portions of those three variables which correspond to inputs are sent to the IC under test via the PUPD section.

At this point the ADC multiplexer and ADC sections scan every test socket pin for the resultant voltage. Voltages found to be greater than 2.4 volts are converted to highs, and those less than 2.4 volts are converted to lows. The highs and lows are converted to three 8-bit bytes that are compared to the bytes that were read in from the truth table. If they match, the IC has

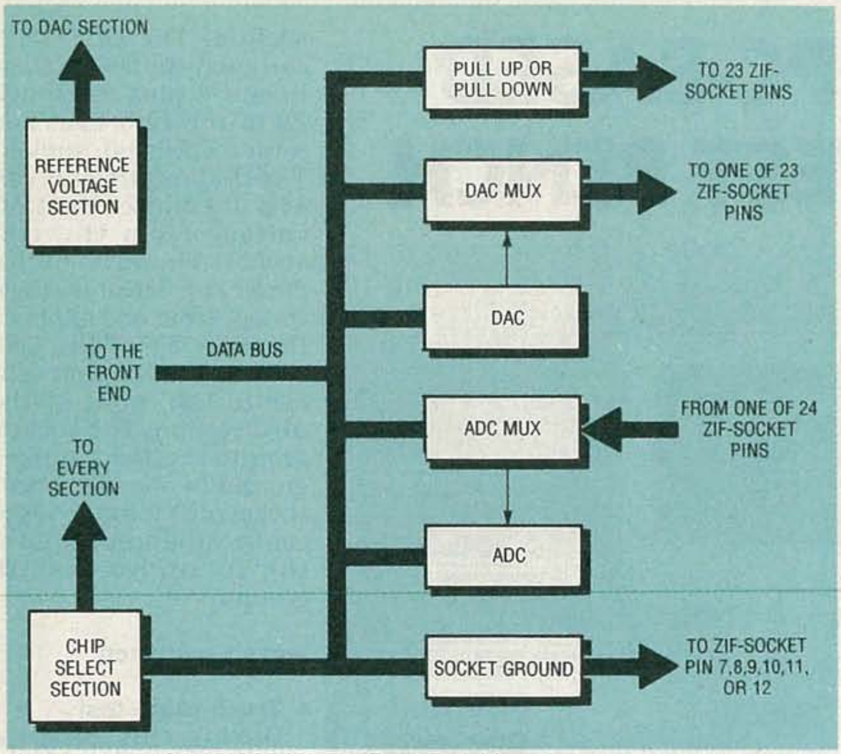


FIG. 1—T1004 BLOCK DIAGRAM. The Front End drives the chip-select section, which selects and deselects every other section in the T1004.

passed the first line of the truth table.

- **Low-to-high input test**

In this section three bytes are again sent to the test socket. The bytes are selected based on the following criteria: A known input pin on the IC under test is being held low. Additionally, when the pin being held low is taken high, a known output pin will change state. Working together, the DAC and DAC multiplexer sections take control of the input pin and slowly ramp its voltage from zero to the voltage level needed to cause the output pin to toggle. The voltage on the input pin is then read back and displayed on-screen next to the label "VT+:."

- **High-to-low input test**

In this section three bytes are again sent to the test socket. The bytes are selected based on the following criteria: A known input pin on the IC under test is being held high. Additionally, when the pin being held high is taken low, a known output pin will change state. The DAC and DAC multiplexer sections take control of the input pin and slowly ramp its voltage from +5 volts to the voltage level needed to cause the output pin to toggle. The voltage on the input pin is then read back and displayed next to the label "VT−:."

- **Hysteresis**

Input hysteresis is the difference between the trigger point of an input being taken high and the trigger point of the same input when it is taken low. IC's such as a 7414 intentionally have a large amount of hysteresis to give them increased noise immunity. The T1004 calculates the hysteresis and displays it on the screen next to the label "HYS:." The T1004 calculates hysteresis as follows:

(VT+) − (VT−) = (Hysteresis)

- **TTL input compatibility**

A TTL-compatible input must trigger when fed a voltage not larger than 2.4 volts. If VT+ is greater than 2.4 volts then the IC under test fails the test.

- **Output-load test**

The output-load test is performed by taking an output high and loading it with 200 ohms to ground for a very brief period. During the time that the load is present, the ADC reads the loaded voltage. This test will reveal weak or damaged gates, help to identify the gate type, and test for an open-collector condition.

Any of the tests describ above may be omitted from t testing procedure. The testi process is defined by a *scri* which is a set of test instru tions for a particular IC. Ea IC has its own script which TS or the end user writes to sui particular IC. IC scripts a compiled using a program su plied by TSW.

Script tutorial

IC's not presently support by the T1004 can be added the existing database by t user. Each script contains t IC's name, whether the IC is open-collector device, and truth-table informatio Scripts can be written usi any ASCII text editor.

The easiest way to create new script is to copy an existi script and edit it as neede Once a script has been create it can be compiled and added the appropriate database. Y can compile a script simply selecting that option from t software menu. You will asked to give the name of t script (example: S7400.TSW The compiler will then open t script and get the IC nan Next, it checks to see if the t get IC already exists in t database. If it already exis then the previous version of t IC script will not be overwritte

The delete function lets y remove any IC from tl database. If the target IC do not exist in the database, th the compiler will compile t target script file and add the sults to the database. The ori nal script is written in a fo that is easy for a person to f low. Once compiled, the scri takes on a more compact fo that can be used by the ma testing program. Scripts for 1 pin IC's must be located in t directory "\TSW\ICTES \D14\SCRIPTS." Similar scripts for 20-pin IC's must located in the directo "\TSW\ICTEST\D20\SCRIPTS and so on.

Take a look at Listing 1. T top line (TUTORIAL SCRI NUMBER 1) and the numbe down the left side (1–14) are r part of the script file. They ha been added for reference only, and should not appear in scripts that you write.

The symbols in the beginning of each line tell the software what kind of function is to be performed. A "?" tells the software that the two following variables are the IC's name and whether or not it is an open-collector device, respectively. A "#" tells the software that the letters "I," "O," "V," and "G" designate inputs, outputs, V_{CC}, and ground, respectively. "V" and "G" always represent V_{CC} and ground, respectively. The numbers "1" and "0" always represent a logic high and a logic low, respectively.

An "*" tells the software that following symbols designate the truth table of the IC under test, and that the data should be sent and the results should be read back. A "%" indicates that the following symbols designate the truth table of the IC under test, and that the data should be sent but not read back. A "/" tells the software that the following symbols designate the truth table used for the "low-to-high input threshold test" of the IC under test. A "|" says that the two following numeric variables designate the "low-to-high input threshold test" input and output pins, respectively. A "\" indicates that the following symbols designate the truth table used for the "high-to-low input threshold test" of the IC under test. A "-" means that the following symbols designate the truth table used for the "output load test" of the IC under test. An "=" means that the following numeric variable designates the "output load test" output pin.

Let's take a closer look at the script in Listing 1. Line (1) must contain three string variables separated by commas. The first variable in the line must be a "?" which tells the software that the next character is the name of the IC. The IC name can contain nine characters. In this case the name is "7400." The next character on line (1) tells the software whether or not the IC being tested is an open-collector part; "Y" for open-collector parts or "N" for parts without an open collector.

Line (2) represents the pin numbers of the IC being scripted. In this case the IC is a 14-pin package. Line (3) is the first line of the truth-table section. From that line the test software is able to determine whether to treat any given pin as an input or as an output. The line must be correct for the lines that follow to work correctly. If the IC being scripted has more than one input/output mode (a 74245, for example), you should give a new "#" line just prior to the IC's mode change. You can use as many "#" lines as needed, and you can use them in any section of the script. In this case pin 1 is an input, pin 2 is an input, and pin 3 is an output. Pins 4–6 follow the same pattern and pin 7 is ground. Pin 8 is an output, pin 9 is an input, and pin 10 is an input. Pins 11–13 follow the same pattern and pin 14 is V_{CC}. If you check your data book you will see that this accurately describes the I/O of a 7400.

LISTING 1
TUTORIAL SCRIPT NUMBER 1

```
     --------------------------------
               IC NAME
     --------------------------------
(1)  ?,7400,N

     --------------------------------
             PIN NUMBERS
     --------------------------------
(2)    0 0 0 0 0 0 0 0 0 1 1 1 1 1
       1 2 3 4 5 6 7 8 9 0 1 2 3 4

     --------------------------------
           MAIN TRUTH TABLE
     --------------------------------
(3)  #,I,I,O,I,I,O,G,O,I,I,O,I,I,V
(4)  *,0,0,1,0,0,1,G,1,0,0,1,0,0,V
(5)  *,0,1,1,0,1,1,G,1,0,1,1,0,1,V
(6)  *,1,0,1,1,0,1,G,1,1,0,1,1,0,V
(7)  *,1,1,0,1,1,0,G,0,1,1,0,1,1,V

     --------------------------------
        LOW TO HIGH INPUT TEST
     --------------------------------
(8)  /,1,0,1,1,0,1,G,1,1,0,1,1,0,V
(9)  |,2,3

     --------------------------------
        HIGH TO LOW INPUT TEST
     --------------------------------
(10) \,1,1,0,1,1,0,G,0,1,1,0,1,1,V
(11) |,2,3

     --------------------------------
        OUTPUT LOAD TEST
     --------------------------------
(12) -,0,0,1,0,0,1,G,1,0,0,1,0,0,V
(13) =,3

     --------------------------------
(14) TSW ELECTRONICS
     14 PIN IC TEST SCRIPT
     --------------------------------
```

Line (4) begins with an "*." That means that any "1"s and "0"s corresponding to inputs should be sent to the IC and that the "1"s and "0"s corresponding to outputs should be read back from the IC. If the "1"s and "0"s read back do not match the those predicted by the script then a fail condition exists. A 7400 is a quad 2-input NAND gate. The line tests all four gates at the same time. In line (4), pins 1, 2, 4, 5, 9, 10, 12, and 13 are all taken low. Each functioning NAND gate must respond by outputting a high. The results are read back and compared to the script. (Any error within the script will cause good IC's to fail the test). Lines (5) through (7) send and test the remaining truth-table conditions. An "*" can be used only in the truth-table section. Within that section, you can use as many "*" lines as you like.

Line (8) begins with a "/." That character causes the "low-to-high input test" (LHT) to be performed. The LHT is used to determine the voltage that an input considers a high, or logic-1. The "1"s and "0"s corresponding to inputs are sent to the IC. Line (9) contains the character "|," which precedes the input and output pins to be used during the test. In this example pin 2 is used as the inpu and pin 3 is used as the output When pin 2 is taken from low t high, pin 3 changes state. It i not important whether pin goes from high to low or low t high, but only that a change o state occurs. The T1004 increases the voltage present a pin 2 (in 20-millivolt steps) unt pin 3 changes states. The vol age on pin 2 is read back an displayed.

Lines (10) and (11) contain th character "\" and "|." They wor in the same way except that th input voltage is swept from hig to low. This test is used to dete mine VT−. Line (12) contain the character "-." That sends truth table that must produce high on one of the outputs. Th next line contains the charact "=," which tells the softwa which output pin is present high. We could have chosen a one of four outputs since they are all high. In this instance pin 3 is chosen, and loaded with 200 ohms to ground. The load test determines the sourcing capabilities of the gate, whether the part is open-collector or not, and provides clues that the software uses to predict the IC's family. The prediction of family or type should be considered a best guess (not absolute). Line (14) contains the text "TSW ELECTRONICS," which is there as an end-of-file marker for the compiler.

Listing 2 shows "TUTORIAL SCRIPT NUMBER 2." Line (1) indicates that the device is a 4040 and that it is not an open-collector device. Line (2) indicates that a 4040 is a 16-pin device. A 4040 is a 12-bit ripple counter. Line (3) indicates that pins 1–7 are outputs, pin 8 is ground, pin 9 is an output, pins 10 and 11 are inputs, pins 12–15 are outputs, and pin 16 is V_{CC}. Pin 10 is a falling-edge triggered clock input. Pin 11 is used to reset the counter, and is active only when high. Line (4) introduces the "%" command, which is similar to the "*" command, except that no test is performed; "%" should be used whenever you wish to send a byte to the IC without testing for a result.

In line (4) the RESET line (pin 11) and CLOCK line (pin 10) are taken high. On that same line all of the outputs are shown low, which is an accurate representation of the effect that a reset would have on the outputs. Because line (4) is a "%" line, we do not actually test the outputs. On line (5) the reset line is released. On line (6) the clock is taken low activating the first output line (Q0). Because line (6) uses an "*" instead of a "%," the outputs will be tested for accuracy. The "%" command allows you to configure a device before you begin to test it. It can be used in any section and as often as you like. In the low-to-high input test, it is used to reconfigure the 4040 before we sweep the input. In this case, we are using the RESET input to determine the low-to-high threshold (VT+).

The only pin that could be used for the high-to-low input test is the CLOCK pin. Because clock input pins require fast transition times, they are not suitable for use in threshold tests. For that reason, the high-to-low input test is omitted for the 4040 IC. You can omit any section except the "?" section and the "TSW ELECTRONICS" section. A "#" must precede truth-table, threshold, or output-load tests. It must appear at least once or as often as needed.

LISTING 2
TUTORIAL SCRIPT NUMBER 2

```
     ----------------------------------
                 IC NAME
     ----------------------------------
(1)  ?,4040,N

     ----------------------------------
               PIN NUMBERS
     ----------------------------------
(2)    0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
 ,     1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6

     ----------------------------------
             MAIN TRUTH TABLE
     ----------------------------------
(3)  #,O,O,O,O,O,O,O,G,O,I,I,O,O,O,O,V
(4)  %,0,0,0,0,0,0,0,G,0,1,1,0,0,0,0,V
(5)  %,0,0,0,0,0,0,0,G,0,1,0,0,0,0,0,V
(6)  *,0,0,0,0,0,0,0,G,1,0,0,0,0,0,0,V
(7)  *,0,0,0,0,0,0,0,G,1,1,0,0,0,0,0,V
(8)  *,0,0,0,0,0,0,1,G,0,0,0,0,0,0,0,V
(9)  *,0,0,0,0,0,0,1,G,0,1,0,0,0,0,0,V
(10) *,0,0,0,0,0,0,1,G,1,0,0,0,0,0,0,V
(11) *,0,0,0,0,0,0,1,G,1,1,0,0,0,0,0,V
(12) *,0,0,0,0,0,1,0,G,0,0,0,0,0,0,0,V
(13) *,0,0,0,0,0,1,0,G,0,1,0,0,0,0,0,V
(14) *,0,0,0,0,0,1,0,G,1,0,0,0,0,0,0,V
(15) *,0,0,0,0,0,1,0,G,1,1,0,0,0,0,0,V
(16) *,0,0,0,0,0,1,1,G,0,0,0,0,0,0,0,V
(17) *,0,0,0,0,0,1,1,G,0,1,0,0,0,0,0,V
(18) *,0,0,0,0,0,1,1,G,1,0,0,0,0,0,0,V
(19) *,0,0,0,0,0,1,1,G,1,1,0,0,0,0,0,V

     ----------------------------------
          LOW TO HIGH INPUT TEST
     ----------------------------------
(20) %,0,0,0,0,0,0,0,G,0,1,1,0,0,0,0,V
(21) %,0,0,0,0,0,0,0,G,0,1,0,0,0,0,0,V
(22) /,0,0,0,0,0,0,0,G,1,0,0,0,0,0,0,V
(23) |,11,9

     ----------------------------------
            OUTPUT LOAD TEST
     ----------------------------------
(24) %,0,0,0,0,0,0,0,G,0,1,1,0,0,0,0,V
(25) %,0,0,0,0,0,0,0,G,0,1,0,0,0,0,0,V
(26) -,0,0,0,0,0,0,0,G,1,0,0,0,0,0,0,V
(27) =,9

     ----------------------------------
(28) TSW ELECTRONICS
     16 PIN IC TEST SCRIPT
     ----------------------------------
```

Detailed operation

We will use BASIC as an example language. As we've seen with previous peripherals, the first step in controlling the T1004 is to establish a base address and select the desired peripheral. The first bit of code will be:

BAS = 768 : OUT BAS + 31,4

768 (hex 300) is the factory-preset base address of the I1000. As noted earlier, this address is DIP-switch selectable. Next, \ have an "OUT TO BAS + 31." / you may recall, that address reserved for peripheral sele tion. The T1004 has a unit, peripheral address of "4." Co sequently, if we send an "OL TO BAS + 31" with a data byte "4," the T1004 will be readi for full I/O operation.

The T1004 schematic h been split into two halves aı shown in Figs. 2 and 3. Addre lines A0–A4 (32 bytes) are us by the T1004 (or any other ŗ ripheral) to address its IC's, ar A0 is the LSB of the addre lines. (Lines A5–A9 are used the I1000 only.) The chip-sele section shown in Fig. (IC23–IC25) contains tv 74HCT138's (IC23 and IC2 Whenever their $\overline{G2A}$ and $\overline{G}$ lines are low and G1 is high, o of eight outputs will go low c pending on the address prese on the A, B, and C inputs. IC23 active when BEN is high, $\overline{SEND}$ low, and RD is low. IC24 is acti when BEN is high, $\overline{SEND}$ is lo and WR is low. All but one IC24's output lines drive tl load line of the 74HCT57 latches. Because the load line a 74HCT573 must see a high store data, IC25 inverts the a tive lows produced by IC24.

The voltage-reference sectio also in Fig. 2, is composed IC26, R21, R1, IC9-a, and IC9- Trimmer R21 is adjusted for 2 volts at TP1. That provides tl ADC section with a precise re erence voltage. The referen voltage also passes through IC b and used by the DAC sectio

An "OUT TO BAS + 7" will loa a data byte into IC15 (a latch DAC IC16, in combination wi IC17-a, will produce between and 5 volts which is propo tional to the byte stored in IC1 The voltage produced will be function of n × (5/255), where is equal to the number load into the latch (IC15). A 500-oh potentiometer (R22) is used set the full-scale output voltag If IC15 contains a value of 25 then R22 should be adjusted f 5 volts at IC17-a pin 1. The DA multiplexer section is con posed of IC18 through IC22. latch (IC18) used to hold tl DAC multiplexer address. Tl

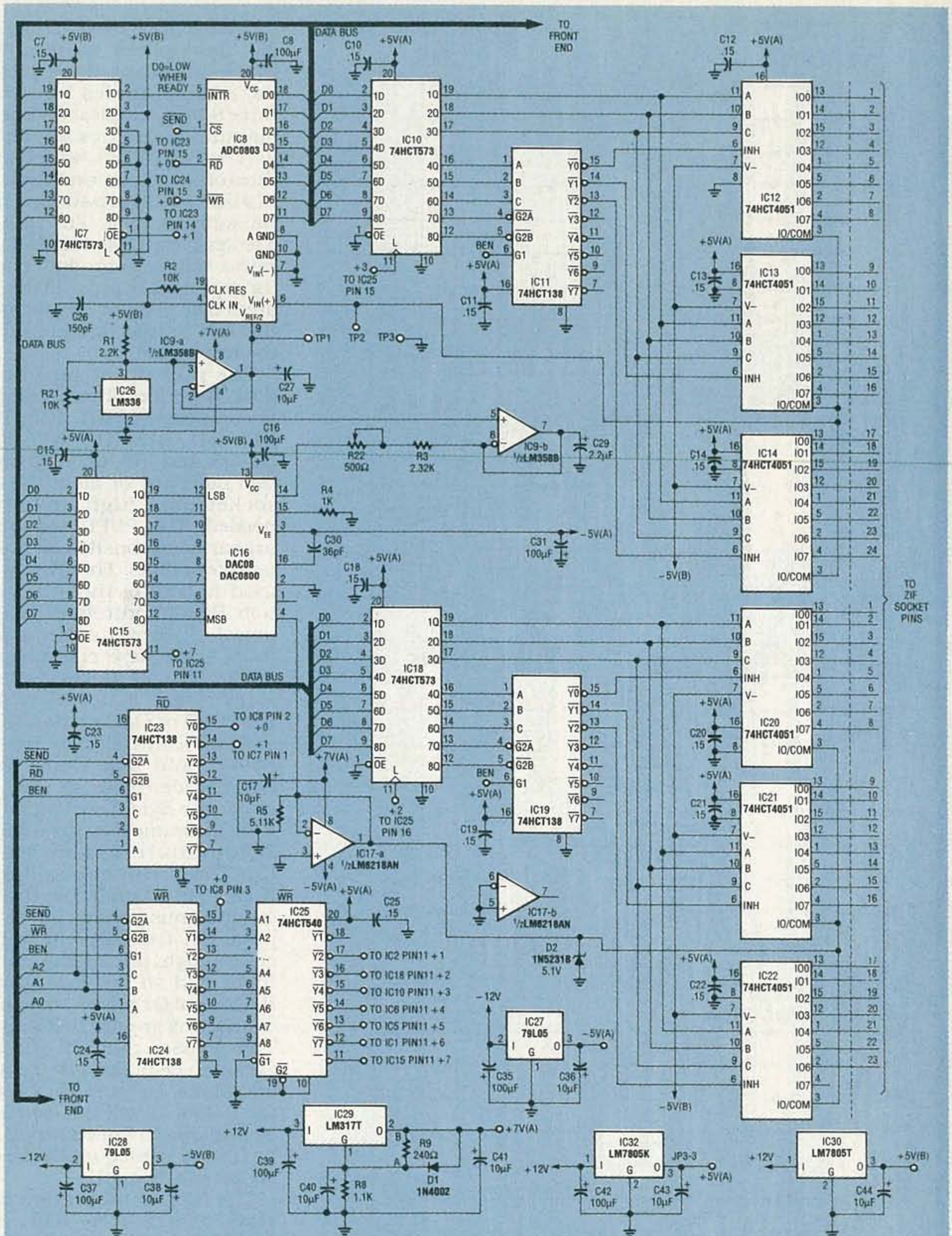


FIG. 2—IN THIS PORTION of the T1004 schematic, address lines A0–A4 are used to address IC's.

least significant three bits of the address are fed to each of three 8-bit multiplexers (74HCT4051). The remaining data lines are fed to IC19 (a 74HCT138), which activates only one of the multiplexer IC's (IC20–IC22). Assuming that the address byte sent to IC18 was less than 23, the DAC voltage is then passed through to the tes socket. If the address byte is 2: or greater, then the DAC voltag is disconnected from the tes socket.

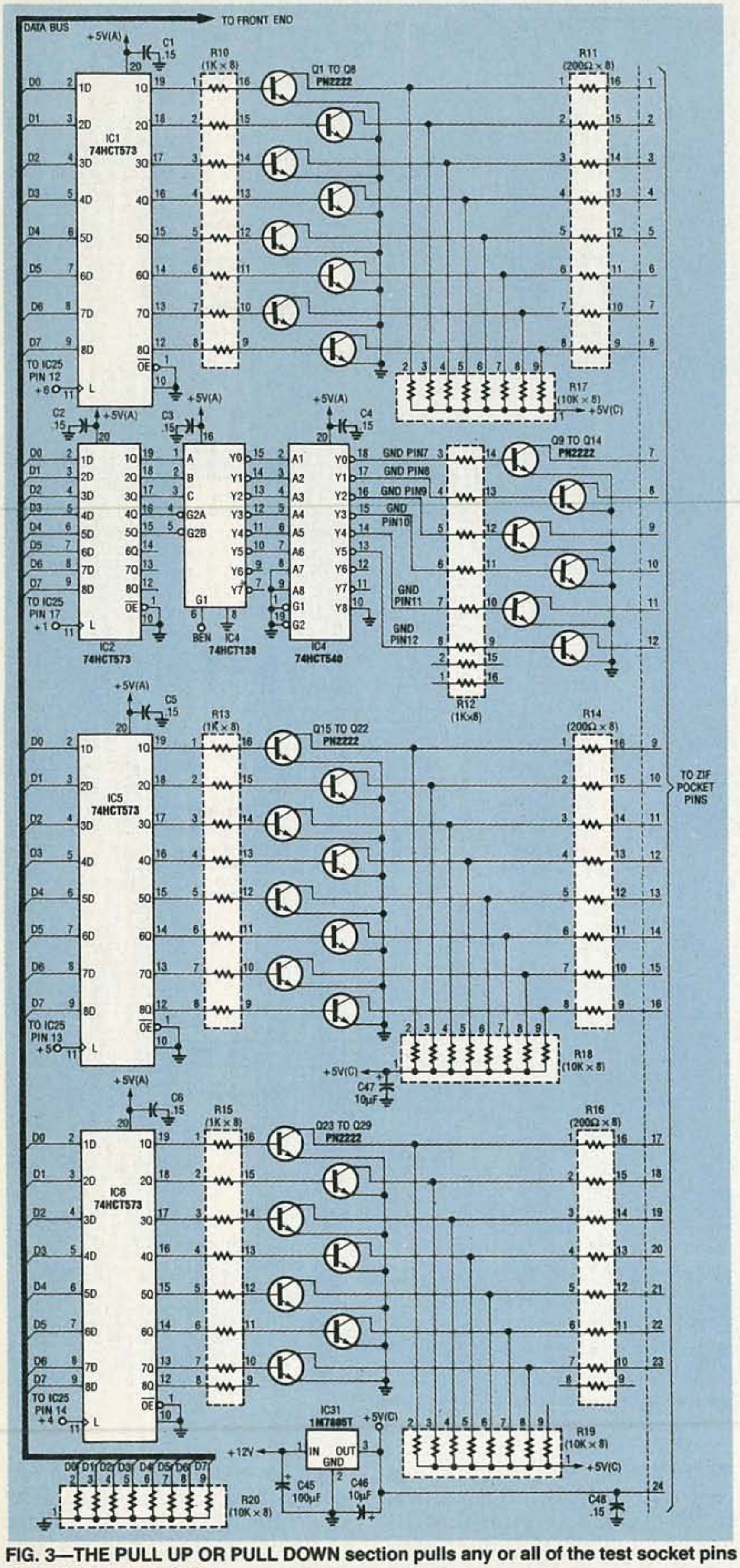


FIG. 3—THE PULL UP OR PULL DOWN section pulls any or all of the test socket pins high or low as needed.

Latch IC10 is used to hold th ADC multiplexer address. Th least-significant three bits the address are fed to each three 8-bit multiplexers. The r maining data lines are fed IC11, a 74HCT138, which act vates only one of the multiplex IC's (IC12–IC14). Assuming th the address byte sent to IC1 was less than 24, the ADC r ceives voltage from only one the test socket pins. If the a dress byte is 24 or greater, the the ADC is disconnected fro the test socket.

The pull up or pull dow (PUPD) section, shown in Fig. is composed of IC1, IC5, IC R10, R11, R13–R16, R17–R1 Q1–Q8, and Q15–Q29. This se tion pulls any or all of the te socket pins high or low a needed. The PUPD section primarily responsible for trut table functions. Three bytes a used to control the PUPD se tion. Byte-A controls test sock pins 1–8, Byte-B controls pi 9–16, and Byte-C controls pi 17–23. Pin 24 is reserved f V_{CC} only and is not affected b the PUPD or DAC sections. Th sections controlled by Byte- Byte-B, and Byte-C are fun tionally identical, so we'll d scribe the Byte-A section only.

We'll assume that the numb 85 (01010101) has been sent IC1. The OUTPUT ENABLE line o IC1 ($\overline{OE}$) is grounded so the "Q outputs must follow the "D" i puts. Pin 1 of DIP R10 will r ceive a high, pin 2 a low, pin 3 high, and so on. Resultantl the base of Q1 will be taken hig connecting ground to R11 pin That causes pin 1 of the te socket to be pulled low throug 200 ohms. Because the base Q2 is low, it will not conduc That allows R17 pin 3 to pull R pin 2, and subsequently the te socket pin 2, high.

The IC ground section co sists of IC2–IC4, R12, an Q9–Q14. Any byte latched in IC2 is passed directly to IC Byte values ranging from 0 to transition to a low one of IC3 output lines. IC4 inverts th signals which are then fe through R12 to the bases Q9–Q14. Only one line is activ at a time, thus ensuring th only one transistor is conducting at any given moment. Transistor Q9 is selected when driving a 14-pin device and Q14 would be used when driving a 24-pin device.

Regulator IC27 and its associated components produce −5 volts, which is used by the DAC (IC16). Regulator IC28 and its associated components produce −5 volts for the multiplexers (IC12–IC14 and IC20–IC22). Regulator IC29 and its associated components produce +7 volts, which the op-amps require in order to produce a full 5-volt output swing. Regulator IC31 and its associated components produce +5 volts for the IC being tested. Regulator IC30 and IC32 and their associated components produce +5 volts for all the remaining IC's. Regulator IC31 produces +5 volts and is dedicated to supplying V_{CC} to the test socket and +5 volts to the pull-up resistors R17–R19.

Construction

To build the T1004 peripheral, a PC board is recommended. You can either buy a PC board from the source mentioned in the Parts List or make your own from the foil patterns we've provided. Note that the parts for the Front End are contained on the T1004 board shown with a dark line around them in the Parts-Placement diagram of Fig. 4. There is a separate Parts List for the Front End, which was discussed in detail in the June issue. Do not confuse the two lists of parts, or where they go on the board. Also, for many of the capacitors, notice that there are three holes on the board, with two of them electrically the same. The holes accommodate capacitors with different lead spacing. Use whichever pair of holes on the printed-circuit board that best fits the capacitors you intend to use for the project.

One of the voltage regulators (IC32) is in a TO-3 case that must be mounted on the back panel of the T1004 case. Mount the regulator, along with an appropriate heatsink, on the back panel and hardwire it to the board. Figure 5 shows the com-

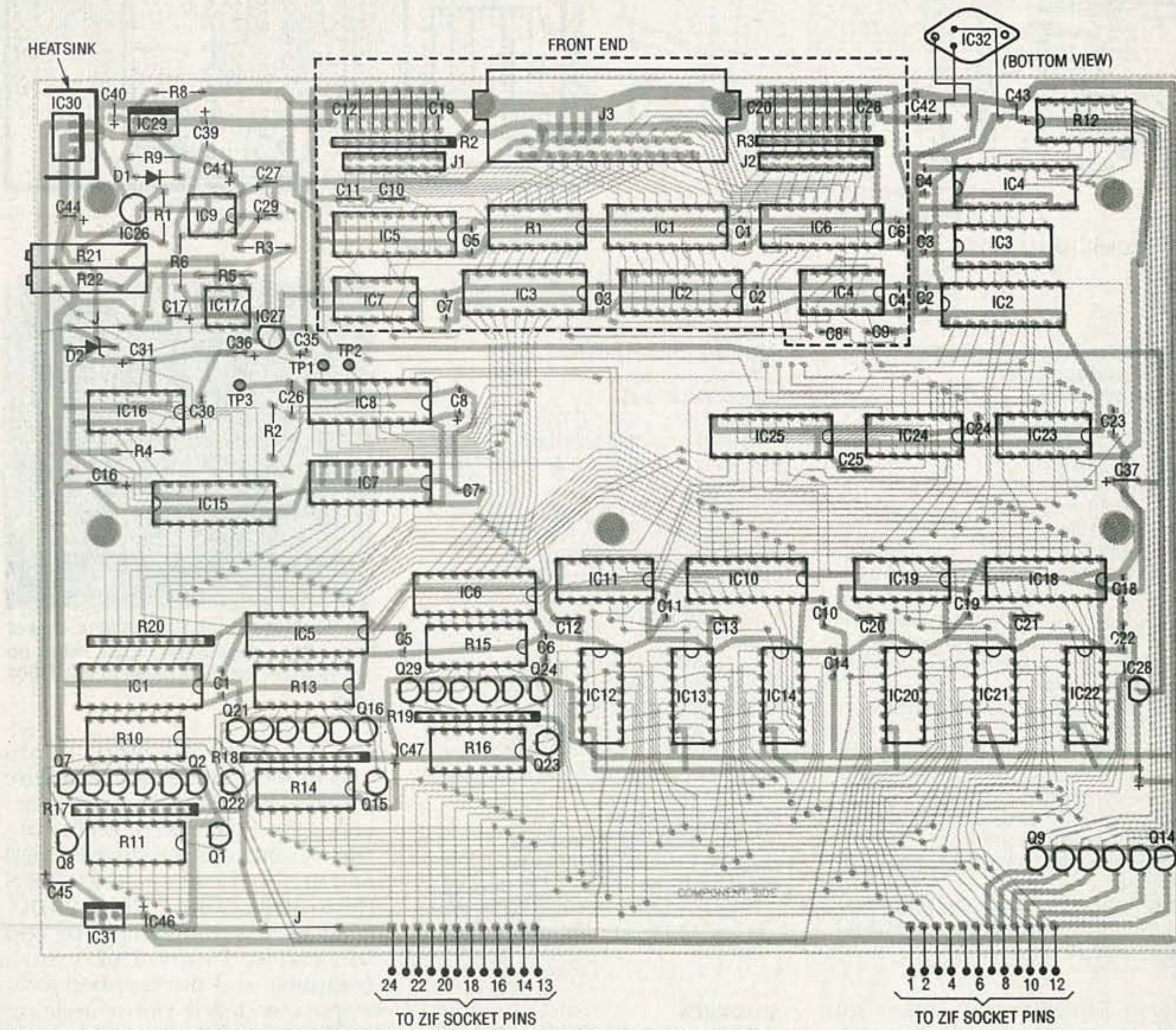
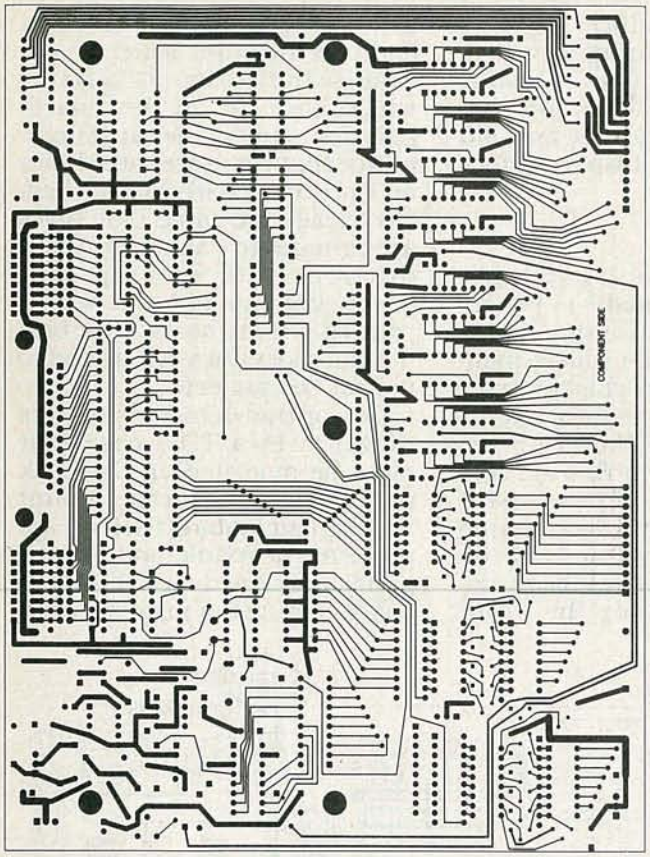
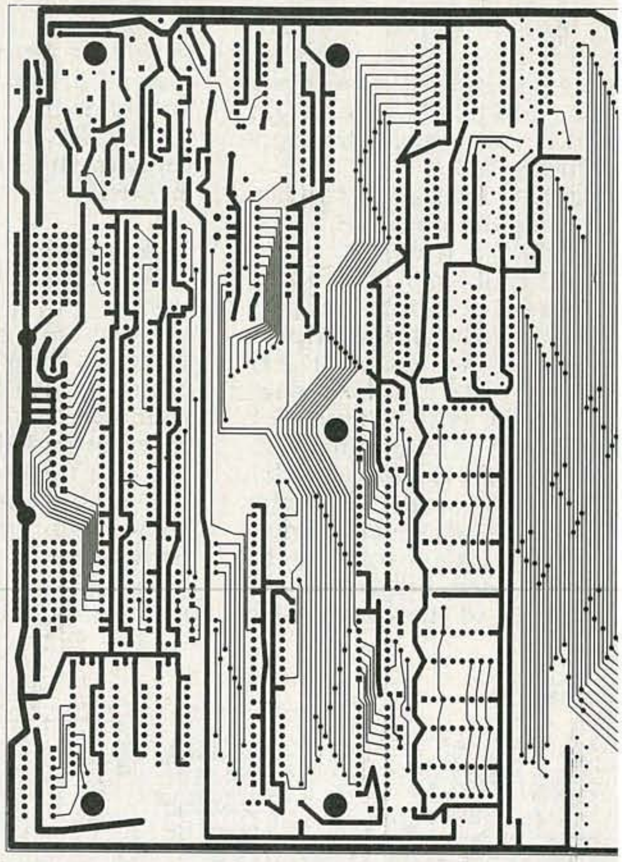


FIG. 4—PARTS-PLACEMENT DIAGRAM. The parts for the Front End are shown with a dark line around them. There is a separate Parts List for the Front End, so don't confuse the two lists of parts, or where they go on the board.



6^11/16 INCHES

T1004 COMPONENT SIDE.



6^11/16 INCHES

T1004 SOLDER SIDE.

T1004 PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—2200 ohms
R2—10,000 ohms
R3—2320 ohms, 1%
R4—1000 ohms
R5—5110 ohms, 1%
R6—2050 ohms, 1%
R8—1100 ohms
R9—240 ohms
R10, R12, R13, R15—1000 ohms, 16-pin DIP
R11, R14, R16—200 ohms, 16-pin DIP
R17–R20—10,000 ohms, 10-pin SIP
R21—10,000 ohms, multiturn trimmer potentiometer
R22—500 ohms, multiturn trimmer potentiometer

Capacitors
C1–C7, C10–C14, C18–C25, C48—0.15 µF, polystyrene
C8, C16, C31, C35, C37, C39, C42, C45—100 µF, electrolytic
C9, C15, C28, C32, C33, C34—not used
C17, C27, C36, C38, C40, C41, C43, C44, C46, C47—10 µF, electrolytic
C26—150 pF, mica
C29—2.2 µF, electrolytic
C30—36 pF, mica

Semiconductors
IC1, IC2, IC5, IC6, IC7, IC10, IC15, IC18—74HCT573 octal latch
IC3, IC11, IC19, IC23, IC24—74HCT138 demultiplexer
IC4, IC25—74HCT540 octal buffer
IC8—ADC0803 8-bit A/D converter
IC9—LM358 dual op-amp
IC12–IC14, IC20–IC22—74HCT4051 8-bit multiplexer
IC16—DAC0800 or DAC08 D/A converter
IC17—LM6218AN op-amp
IC26—LM336 voltage reference
IC27, IC28—79L05 voltage regulator
IC29—LM317T voltage regulator
IC30, IC31—LM7805T voltage regulator
IC32—UA7805K voltage regulator (TO-3 case)
D1—1N4002 diode
D2 1N5231 5.1-volt Zener diode
Q1–Q29—PN2222 NPN transistor

Miscellaneous: 24-pin ZIF socket, TO-220 heatsink, TO-3 heatsink, PC board, instrument case, wire, solder, etc.

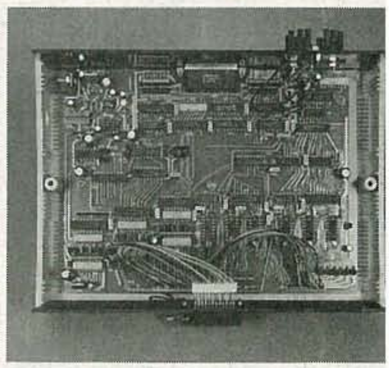


FIG. 5—THE COMPLETED T1004. One the voltage regulators, IC32, must b mounted on the back panel of the T10 case.

pleted T1004 board. When you use the T1004, position the IC's you want to test as shown in Fig. 6.

Software

Each peripheral has its own software program to control its operation. All of the programs end up in one directory as yo add more peripherals. Softwa for the I1000 and the entire s ries of peripherals, includin the T1004, can be downloade from the RE-BB (516-293-2283, 1200/240 8N1) as a self-unarchiving z file called T1004.EXE. Bot compiled and uncompiled sof ware is included. Software is i cluded free with the purchase any peripheral from the sour that is mentioned in the Par

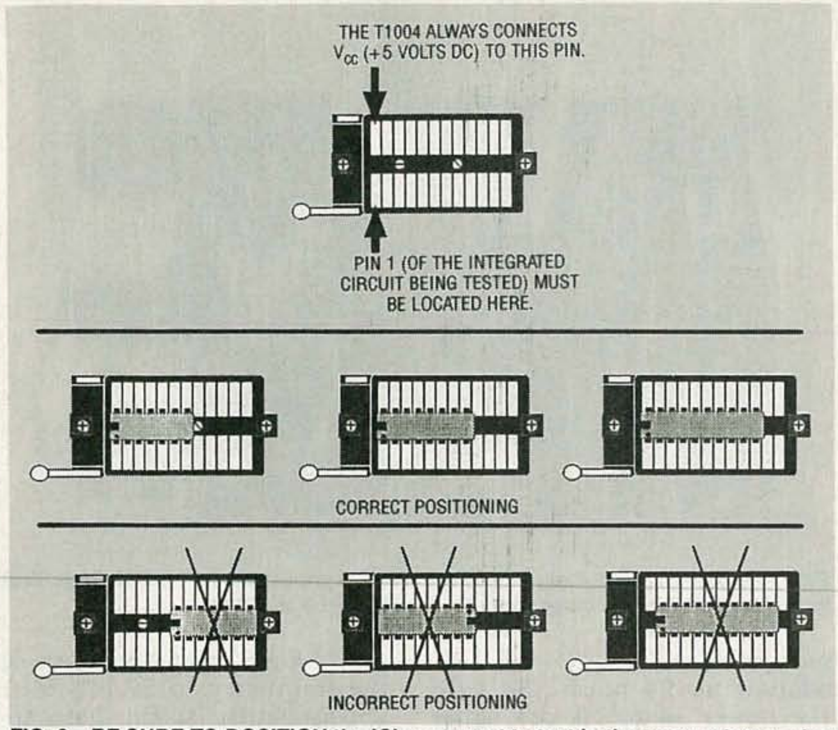


FIG. 6—BE SURE TO POSITION the IC's you want to test in the test socket as shown here.

FRONT-END PARTS LIST

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

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

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

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

Miscellaneous: 17 shorting blocks (for J1 and J2)

Note: The following items are available from TSW Electronics Corp., 2756 N. University Drive, Suite 168, Sunrise, FL 33322 (305) 748-3387:
- **I1000 kit—$65.00**
- **I1000 PC board only—$35.00**
- **I1000, assembled and tested—$77.00**
- **6-foot interface cable (DB-25-6)—$12.95**
- **T1001 kit (includes PC board, all listed parts, project case, and pre-assembled front and rear panels—$149.00**
- **T1001 PC board only—$49.00**
- **T1001, assembled and tested—$179.00**
- **T1001 software (included free with T1001 order)—$10.00**
- **Capacitor kit (unmeasured)—$21.00**
- **Capacitor kit (measured to within 1%)—$26.00**
- **T1003 kit (includes PC board, all listed parts, project case, and pre-assembled front and rear panels)—$159.00**
- **T1003 PC board only—$59.00**
- **T1003, assembled and tested—$189.00**
- **T1003 software (included free with T1003 order)—$10.00**
- **T1004 kit (includes PC board, all listed parts, project case, and pre-assembled front and rear panels)—$209.00**
- **T1004 PC board only—$79.00**
- **T1004, assembled and tested—$249.00**
- **T1004 software (included free with T1004 order)—$10.00**

Add $5.00 S&H to any order. Check or money order only.

List. (Software can also be purchased from that same supplier if you're not buying anything else from them and you have no way of downloading it from the RE-BBS.) With the T1004, you are on your way to automatic troubleshooting. **R-E**

HANDI TALKIE

continued from page 42

bushing to provide a gap between the top of the microphone and the holes in the face of the bushing. (that permits sound to enter unimpeded.)

It is recommended that the bushing be snapped into the extrusion before performing the microphone bonding step or the plastic snaps will interfere with the microphone.

Refer to the mechanical layout drawing Fig. 6 as a guide for mechanical assembly. Attach the front panel to the PC board. First attach hex ring nuts to the front of both SQUELCH potentiometer R25 and VOLUME potentiometer R26, and coaxial BNC connector J1. Be sure that the PC board abuts the front panel and is fastened with hex ring nuts on the outside of the threaded barrels of the potentiometers and BNC connector. *Avoid placing excessive torque on the potentiometers by holding the hex ring nuts behind the panel with pliers or wrench while tightening the front nuts with another wrench.*

To complete the assembly of the transceiver, place the speaker and grill inside the aluminum housing extrusion and fasten it with four No. 6-32 × 5/16-inch Philips-head screws, internal tooth lock washers, and nuts. Connect all cables to their proper jacks on the PC board, and slide the assembly into the housing. Depress the transmit switch S1 shaft so that it slides into the housing. *(The transmit switch button cannot be attached until the board is inserted in the extrusion.)*

Attach the end panels with No. 440 self-tapping screws. Slide the knobs on the 0.125-inch diameter squelch and volume potentiometer shafts (R25 and R26) and lock them in position with a 0.050-inch Allen wrench.

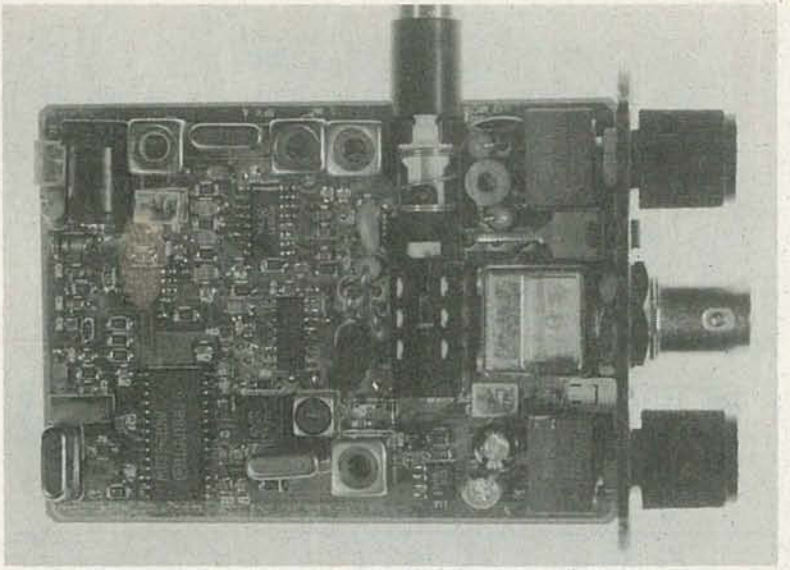


FIG. 7—COMPLETED E-Comm CIRCUIT BOARD shown actual size. Note vertica[lly] mounted axial-leaded components R1, L4, L5, L7, L8 and D4.

Calibration & troubleshooting

Charge the power cells by connecting them to the wall outlet-mounted AC to 12-volt DC adapter for 24 hours. *Be sure the power switch is* OFF *while the power pack is being charged.* The following test equipment is required to calibrate the E-Comm transceiver:

- Oscilloscope (one that is 50 MHz or faster)
- Frequency counter
- Digital multimeter
- Plastic coil-tuning sticks
- A 50-ohm dummy load

An FM-modulated RF source is helpful but is not a requirement for calibrating the transceiver. The 50-ohm dummy can be made by wiring ten 470-ohm resistors in parallel with short leads. *Be sure that inductor L8 is not* installed *before starting the procedure!*

First tune the transmitter. Note: *while adjusting the transmitter avoid touching any of the output circuit components because some high voltages are developed there.* Turn on the power switch and connect the oscilloscope leads to pin 1 of IC2, the quad-NAND Schmitt trigger and observe the waveforms while pressing the transmit switch. Tweak inductors L1 and then L2 until a clean sinusoidal waveform is observed. (The frequency should be about 27.145 MHz.)

Disconnect the oscilloscope and attach a frequency counter to pin 1 of IC2 through the high impedance input of the counter, and adjust inductor L9 to s[et] the frequency to 27.145 MH[z]. Reconnect the scope again an[d] fine tune inductors L1 and L2 [to] get the best looking wavefor[m]. The waveform amplitud[e] should be between 3 and 6 vol[ts] peak-to-peak. If the waveform [is] satisfactory, solder inductor L[8] into the circuit board and a[t]tach the 50-ohm dummy load [to] the BNC antenna jack.

Attach a current meter in se[ries] with the power pack or th[e] DC supply to adjust the final R[F] amplifier. Hook up the outpu[t] pin of J1 to the oscilloscope an[d] set it to 10 volts per divisio[n]. While observing the curren[t] meter, press the transmi[t] switch and look at the wave[form]. Quickly tweak capacito[r] C30 so that the current is les[s] than 400 milliamperes and th[e] output voltage across th[e] dummy load is about 35 vol[ts] peak-to-peak.

To obtain maximum efficien[cy], fine tune inductors L1 an[d] L2 and capacitor C30 to set th[e] output power as close as possi[]ble to the optimum value. Tha[t] value is expressed as (V_{out} pea[k] $\times$ 0.707)^2/50 divided by the in[]put power (V_{in} DC $\times$ I_{in} DC). (This is a "trial and error" ste[p] that calls for patience.) *Do no[t] try to set the output to max[]imum power!*

If the 400-milliampere max[]imum input current is exceed[ed]

continued on page 9[]

Differential Probe

WALTER DORFMAN*

A differential probe is an oscilloscope accessory that permits you to take measurements from two points in a circuit without reference to ground. That enables the oscilloscope to be safely grounded without the need for optoisolators or isolation transformers. The probe can also make accurate measurements of small signal differences even in the presence of very high common-mode voltage.

The probe, in effect, moves the input terminals from the front panel of the scope to the end of the probe. The inputs of a differential probe with appropriate input ratings can, for example, measure power semicondutor circuits because no reference to ground is needed. Both positive and negative sides of the balanced input offer high impedance to ground. High-impedance differential probes increase the input resistance and reduce the effective input capacitance of the oscilloscope.

The low-cost differential probe shown in Fig. 1 was designed primarily for industrial electronic maintenance applications where AC voltages up to 500 volts rms are present. Table 1 gives the leading specifications of that instrument. It has selectable attenuation ratios of 20:1 and 200:1.

Figure 3 is a simplified schematic of the differential probe showing how it is connected between the circuit under test and the scope. A built-in differential amplifier converts the high-voltage differential input signal to a low-voltage, single-ended output for a general purpose oscilloscope.

Electronic test labs that perform a wide variety of measurements are likely to own one or more differential probes. But until recently differential probes have been quite expensive (more than $2000). As a result, you might still see oscilloscopes "floated" above ground while tests of ungrounded circuits are made. While it is never recommended, it can be done safely only if low voltages, say 1 to 28 volts, are involved—and proper safety precautions are taken. Some use a battery-powered portable scope, others remove the ground pin from the scope's AC line plug or find other ways to "unground" the scope's chassis.

However, if one is to measure hundreds of volts in ungrounded circuits, the case of the oscilloscope and any metal parts touching that case are at a lethal potential. The scope operator could be electrocuted! That is why demand is increasing for low-cost, industrial-strength differential probes that can make accurate measurements safely on the factory floor with a conventional grounded general purpose oscilloscope.

Learn how to use the active differential probe to make measurements in ungrounded systems—safely

*Walter Dorfman is a Senior Electrical Engineer at Avex Probes, Inc.

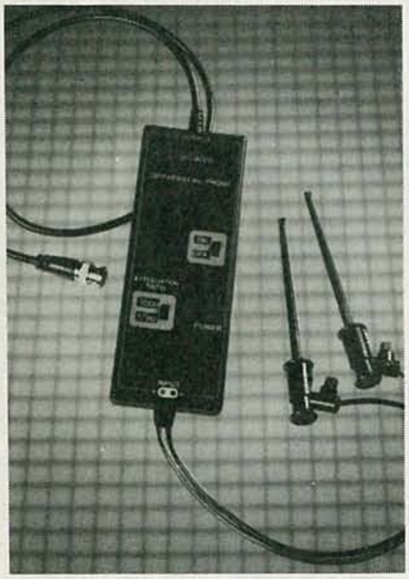


FIG. 1—API MODEL SI-900 ACTIVE DIFFERENTIAL PROBE suitable for making measurements to ± 1000 volts DC.

High-voltage application

The best way to explain the value of a differential probe in an industrial setting is to review a problem that occurred in an ungrounded closed-loop control system and that was solved in a safe and timely manner with the probe.

A conveyer belt in a manufacturing plant was exhibiting radical speed fluctuations; it would alternately slow almost to a halt and then speed up to a rate that endangered nearby personnel. Solving this control problem was important because, unless it was corrected promptly, the production line would be shut down.

Figure 3 is the schematic for the belt drive in a control system closed around a programmable logic controller (PLC). The belt-drive DC motor is driven by a single-phase, full-wave SCR bridge that is electrically isolated from the PLC by four isolating SCR gate trigger modules. The motor is electrically isolated from a tachometer that sends velocity signals back to the PLC, and both bridge and motor are electrically isolated from the 220-volt AC line by a 1:1 power isolation transformer.

When the belt was running, persons close to it could hear the sound of the drive motor change pitch as they observed the erratic belt speed. In attempting to trace the cause of the problem, the first step was to connect a conventional digital multimeter across the motor's armature terminals to verify that the belt speed changes corresponded with motor voltage changes. Then the conveyor belt was disconnected from the drive motor sheave to verify that the the motor's speed variations were not due to variations in belt loading.

Troubleshooting plan

A troubleshooting plan was formulated to rule out possible faults and isolate the cause to one or more of the system elements. Figure 3 shows that the PLC is referenced to Earth ground. But the rest of the circuit is isolated from ground to prevent a build-up of damaging or hazardous potentials, due to an insulation failure, within the motor-driven conveyor-belt system. An oscilloscope referenced and connected to Earth ground cannot make accurate measurements in a circuit that is not referenced to the same ground.

The maximum peak-to-peak voltage that could appear in the bridge is about 622 volts, based on the characteristics of a sine wave for 220-volt AC. (The rms voltage must be multiplied by a factor of 2.83 to obtain t peak-to-peak voltage.) Exa ination of the control diagr showed that differential m surement techniques w needed to make accurate a safe measurements of t "floating" system.

It would be necessary to che logic-level SCR gate sign riding on the 220-volt AC li Any differential probe suita for making those measu ments had to be capable of c celling the large peak-to-pe AC waveform, leaving only t desired logic-level signals, e mated at 3 and 12 volts DC, analysis.

The differential probe w first connected to Earth grou with the oscilloscope (BNC) c nector. Then the probe was c nected to the oscilloscope. this case, the internal pow supply was used so the pr could then be turned "on.

Knowing that voltages in cess of 622 volts AC peak- peak would be present, a pr attenuation range of 200:1 w selected. (Table 1 shows that the probe used, the maxim working voltage to ground a between inputs is 500 vo rms, and the maximum non- structive input is 700 volts rms or 1000 volts DC.)

The 622 volts is divided 200 to become a 3.11-volt s

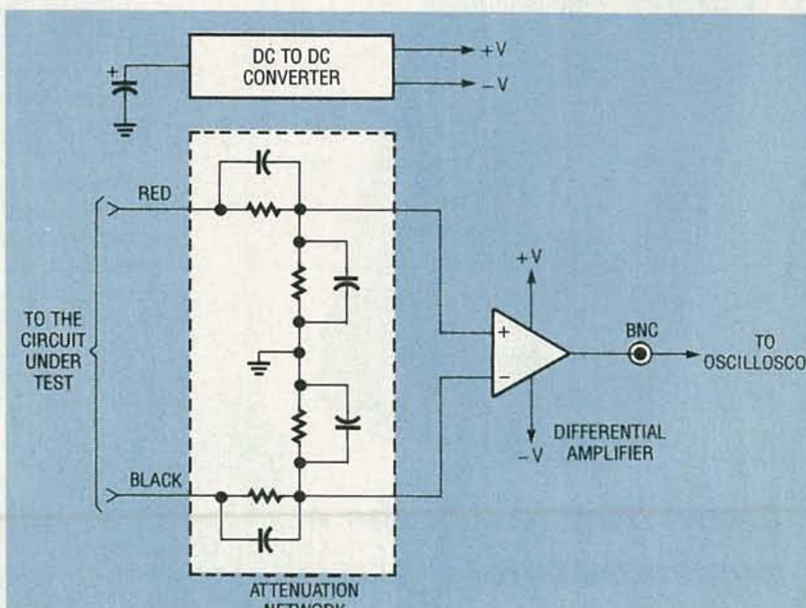


FIG. 2—A SCHEMATIC OF AN ACTIVE DIFFERENTIAL PROBE that can be interna powered by four 1.5-volt cells or an AC to DC converter.

TABLE 1—LEADING SPECS OF API PROBE

Bandwidth	DC to 15 MHz
Accuracy	±2% (nominal)
Attenuation ratio	20:1 and 200:1 (selectable)
Input resistance	2 Megohms
Input capacitance	25 pF (each side grounded)
Input range	±700 V DC + peak AC (200:1 attenuation) ±70 V DC + peak AC (200:1 or 20:1 attentuation)
Max. common mode input	500 V rms
Common mode rejection ratio	70 dB @ 1 kHz
Max. output	±3.5 V into 1 Megohm
Output offset	±5 mV (10°C to 40° C)
Power requirements	Four 1.5 V AA cells or 6 V DC, 50 m A adapter

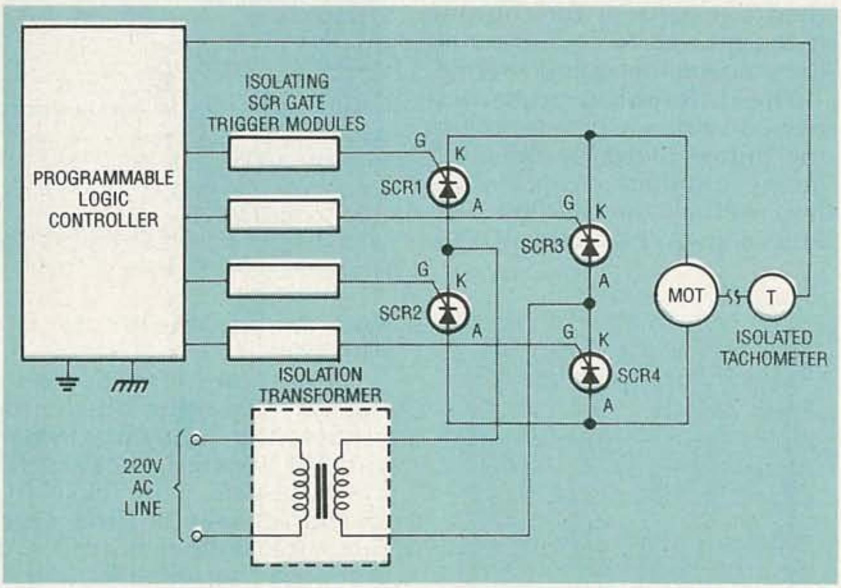


FIG. 3—A CONVEYOR BELT SPEED CONTROL system, isolated from Earth ground, includes a programmable logic controller (PLC), a full-wave, single-phase SCR bridge, DC motor with isolated tachometer, and four isolating SCR gate-triggering modules.

nal. (The displayed output voltage had to be kept within the ±3.5 volts limit of the probe.)

The two probe input leads were then carefully connected across the 220-volt AC line feeding the 1:1 isolation transformer. The oscilloscope displayed the 3.11-volts peak-to-peak sine wave shown in Fig. 4-a. The regularity of the scaled-down sine wave showed that there were no faults in the line voltage.

Both probes were moved to the secondary of the isolation transformer and a waveform essentially the same as the 622-volt peak-to-peak sine waveform of Fig. 4-a appeared; it is shown as Fig. 4-b. However, small distortions and amplitude changes were seen on the negative peaks, and they were in synch with motor-speed variations. The electrical noise in the waveform was believed to be due to the reflected loading effects of the motor's power and speed changes.

The differential probe leads were than connected across the motor's armature, and the periodic high-frequency oscillations shown in Fig. 4-c were seen. Their occurance matched the motor's speed variations. Next the probe was connected across the anode (+) and cathode (−) terminals of each of the four SCR's in the bridge, and their waveforms were observed.

As shown in Fig. 5, all the SCR's exhibited some waveform distortion, but one of them, Fig. 5-c exhibited more severe distortion than the others.

As the next step, the probe was connected across the gate (+) to cathode (−) terminals of each of the three SCR's that showed lower anode-to-cathode noise voltages. The differential probe successfully cancelled the 622 volts peak-to-peak AC on which the gate-to-cathode voltages were riding. The result was clean, normal gate trigger waveforms with nominal 3-volt peaks, as shown in Figs. 6-a, 6-b, and 6-d.

However, the remaining SCR's gate-to-cathode voltage waveform, Fig. 6-c, showed time-varying gate-trigger pulses. (It was the same SCR that had shown the highest anode-to-cathode jitter in Fig. 5-c.) Some pulses in Fig. 6-c started earlier and others start-

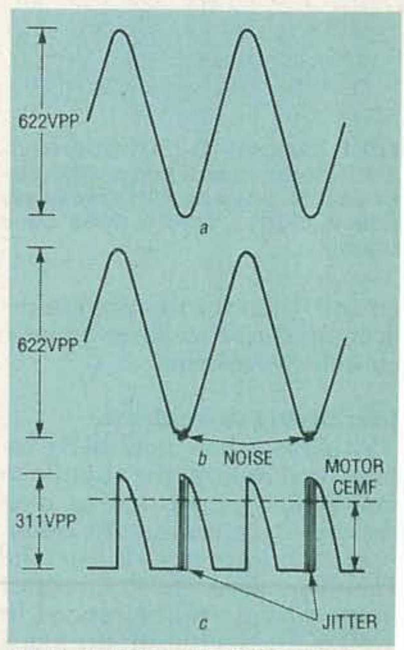


FIG. 4—VOLTAGE WAVEFORMS viewed at 220-volt AC input: transformer primary *a*, transformer secondary *b*, and motor armature (load) *c*.

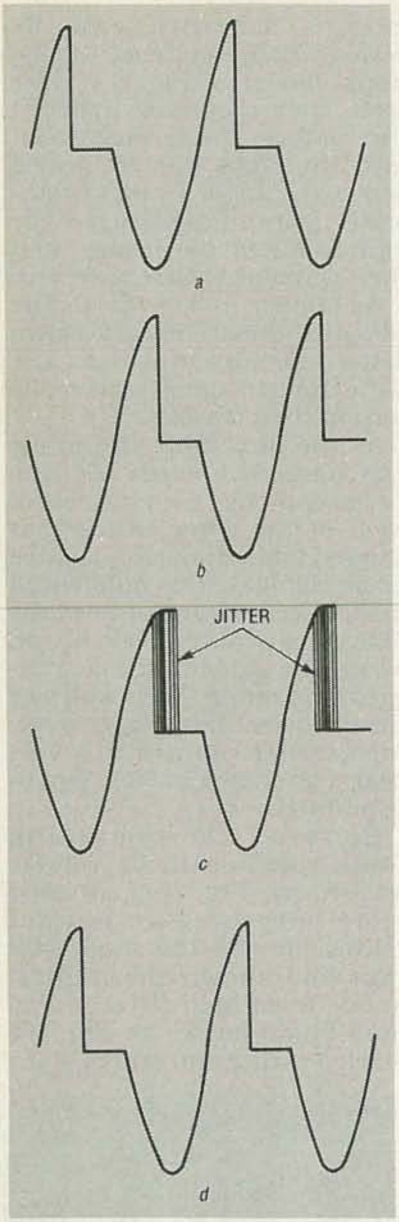


FIG. 5—ANODE-TO-CATHODE VOLTAGES viewed at each bridge SCR (triggered at 90° into a positive peak supply voltage): SCR1 *a*, SCR2 *b*, SCR3 *c*, and SCR4 *d*.

ed later than the nominal times seen for the other three gate-to-cathode waveforms.

Identifying the culprit

A pattern had now been established linking the trouble to one SCR channel. It was next decided to determine the quality of the output signals from the PLC. To observe the PLC output lines, which are referenced to system/Earth ground, the black (−) lead of the differential probe was connected to system ground. Because 12-volt logic signals were to be viewed, the differential probe's attenuator was switched to 20:1 (12 volts/20 = 0.6 volt), and the oscilloscope's vertical sensitivity of 0.1 volt/division was selected.

Three of the four 12-volt logic signals from the PLC to the SCR gate-trigger lines appeared normal, as shown in Fig. 6-e, 6-f, and 6-h. However, the Fig. 6-g waveform was distorted by low-level reflected noise that tracked with the motor's speed variations. It was the same SCR channel that had shown gate-to-cathode electrical noise in Fig. 5-c.

That finding narrowed the cause of the problem down to one SCR channel and it was thought to be either a faulty PLC-to-SCR gate isolating trigger module or a malfunctioning SCR. A new plug-in module was then substituted for the one that appeared to be faulty, and the problem was quickly solved.

The differential probe discussed in this article is sold in the United States by three different suppliers: Avex Probes Inc. (API) as the SI-9000; Test Probes, Inc.(TPI) as the ADF15, and Probe Master as t
PM4230.

For purposes of compariso
consider two other differenti
probes, the Tektronix P604
and the Hewlett-Packard H
1141A/1142A. The Tektron
system consists of three sep
rate cable-connected units:
probe head, an amplifier, and a
AC-line operated power supp
It has a common-mode rejectic
ratio (CMRR) of 10,000:1, an i
put resistance of 1 megohn
and an input capacitance of 1
picofarads. Its maximum ban
width is 100 MHz, and its ma
imum DC plus peak AC is ±25
volts.

The HP 1141A differenti
probe is a 1× FET differenti
probe with a 200-MHz ban
width and a CMRR of 3000:
The probe has an input resi
tance of 1 megohm and an inpu
capacitance of 7 picofarads.
must be used with the HP 1142
probe control and power mo
ule system. R

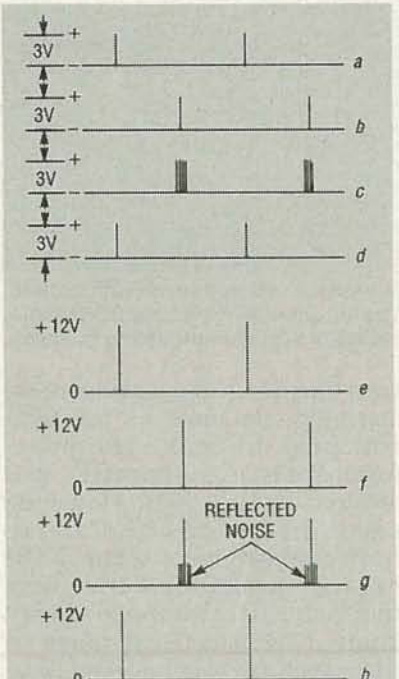


FIG. 6—GATE-TO-CATHODE VOLTAGES viewed at the input of gate terminals of SCR1 to SCR4 *a, b, c, and d*, and output signals from the PLC *a, b, c, and d*.

PROBE SUPPLIERS

Avex Probes Inc. (API)
PO Box 1026
Bensalem, PA 19020
215-638-3300
CIRCLE 316 ON FREE INFORMATION CA

Hewlett-Packard
PO Box 612350
San Jose, CA 95161-2350
800-452-4848
CIRCLE 317 ON FREE INFORMATION CA

ITT Pomona
1500 East Ninth St.
Pomona, CA 91769
714-469-2900
CIRCLE 318 ON FREE INFORMATION CA

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Beaverton, OR 97077
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Test Probes, Inc. (TPI)
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FROM NOTWORKING TO NETWORKING

Bring your knowledge to bear on several tough LAN case histories.

GARY McCLELLAN

PARTS 1 AND 2 OF THIS THREE-PART series on troubleshooting LAN's presented technical background on network technologies (in Part 1), and on tools and test equipment (in Part 2). This time we put our knowledge to work in diagnosing and solving network problems of varying difficulty.

In each case, we will describe the type of LAN, symptoms manifested, fault isolation techniques, use of test equipment, and repair methods. To follow the discussion, it is important to have at least a basic understanding of LAN technologies and test equipment as described in parts 1 and 2. So if you are unsure about anything discussed so far, reread those parts before continuing.

The computer ate my work!

This one happened at a local metal fabrication shop; the symptoms drove the company's finance people up the wall! That shop had five XT clones communicating with an IBM PC-AT file server via Ethernet. For a long time, the network had been reliable, but after several years of use, it began to run slower and slower whenever users ran order entry and accounting programs off the file server. Error messages began to appear, and sometimes users had to repeat the process. Troubleshooting began when several people in the order entry department complained of trashed data.

Several users were affected, so it seemed unlikely that their computers were at fault. That left the Ethernet backbone cable and the file server as suspects. The backbone cable could have been the problem, but it didn't seem likely. Then someone discovered that a seldom-used word-processing program ran fine, so we ruled out the possibility of cable fault. That left the file server and hard disk as a possible culprit.

That evening we shut down the network and ran a "disk doctor" program on the file server. Those programs are available from several sources, including Symantec (Norton Utilities), Central Point Software (PC Tools), and Gibson Research (SpinRite). What these programs do is perform a non-destructive low-level format of a disk drive. Typically, such programs work by reading a track of data from the drive, formatting that track, and rewriting the data. Any bad sectors detected along the way get mapped out, and the data gets moved elsewhere, if possible. Figure 1 shows a sample screen from the Calibrate utility included with versions 6.x of the Norton Utilities.

A related function often goes by the name of *disk defragmenting*, which attempts to group logically related segments of a file together physically in consecutive sectors of a disk. Doing so can dramatically increase the speed with which DOS reads files. A disk becomes fragmented because, when a file is erased, DOS subsequently adds the now-unused sectors to a pool of sectors that might subsequently be reused. A particular group of erased sectors might not contain enough space to hold an entire file, so DOS puts parts of the file in non-adjacent areas across the disk. The result is that when loading the program or data file, DOS sends the read/write head all over the surface of the disk, rather than lapping up sectors one by one. That jerky head motion can really slow things down. It is not unusual for overall operation to be speeded up by 10–20% or even more simply by "doctoring" the hard disk. Norton and Central Point both include disk defraggers as well.

Anyway, running a disk doctor program on the fabrication shop's server solved the problem. To avoid that type of problem, run a disk doctor program a minimum of every six months to catch bad cylinders and prevent data loss. If you encounter many bad cylinders, say 5% or more, you should replace that hard disk before a catastrophic failure occurs!

The dead PC

Many LAN problems go like this: A user cannot log onto th

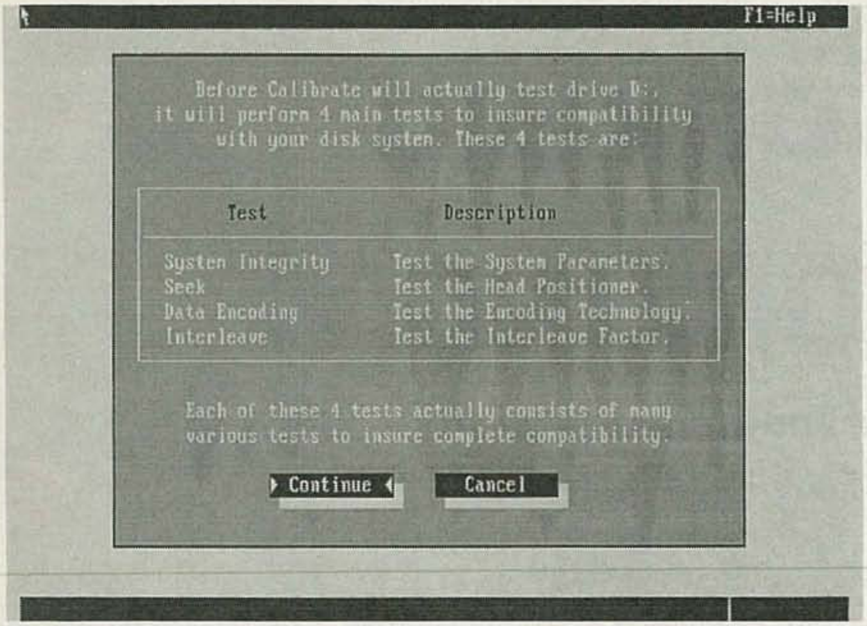


FIG. 1—SOMETIMES NETWORK FAULTS aren't network faults at all, but faults with hard-disk drives. In an MS-DOS environment, Norton's Calibrate utility can help to locate and lock out bad sectors.

network, or a PC suddenly drops offline—but other users remain unaffected. Following are two examples of this type of problem, along with corresponding solutions.

Example one occurred in a parts distributor's office. The LAN consisted of five clone PC's and a generic 80286 file server tied together via ARCnet. ARCnet operates over RG-58 thin coaxial cable that runs from computer to computer.

First, we tested the sick PC off-line and found it to be functional. That left the Network Interface Card (NIC) and LAN cabling as suspects. First we inspected the coax cables and they looked good. But a gentle tug on a loose BNC cable connector caused it to come off. Replacing the connector brought the computer back to life.

Generally speaking, connector faults are a major problem on LAN's. Most BNC connectors are crimp-on types, and if installed improperly, eventually they fail—but not before becoming intermittent and causing lots of grief! Connector problems usually develop several years after their initial installation; often they're caused by oxidation of contacts. For problem installations, we prefer soldered to crimp-on BNC connectors. They take 5 to 10 minutes longer to install, but are far more reliable.

Many connector problems are caused by users who accidentally damage cables by crushing them under chair legs, or dropping equipment on them. Our troubleshooting kit includes a collection of 10-foot cables which have coaxial BNC connectors, triple twisted-pair RJ-11 connectors, and quad twisted-pair RJ-45 connectors. The cables are for on-site substitution of questionable cables.

Example two in this category concerned a dead computer in a medical billing office. The company used five IBM PC's linked by telephone-type unshielded twisted pair (UTP) cabling into a Compaq 386 configured as a hub. The hub serves as both a file server and as a central point to which all cabling returns.

We tested the problem PC, and it appeared to be working. It just wouldn't log onto the network. We substituted a different drop cable between computer and wall outlet; the new cable worked for a while and then quit. Next we substituted a PC from the office of a vacationing user, but without success.

At that point the problem could have been anywhere, including the computer, its NI(the cable plugged into the wa outlet, or even the wiring bac to the hub.

First, we checked the old wa cable with the Paladi PatchCheck tester (discussed i the last article). PatchChec checks cables in seconds, if yo can access the modular plug on both ends. Pin 2 showed dim indication on the teste suggesting high resistance. W didn't know which end was bac so we replaced the connectors a both ends. The cable then tes ed good, so we reinstalled it an were able to log onto the ne work briefly. But then troubl developed again. On a hunch we pushed and held the modu lar connector in the wall outle The user could log onto the ne work and work normally—unt we let go of the connector. The the PC crashed. Replacing th wall outlet solved the problem

In general, most twisted-pai cable problems are caused b bad crimps or by users pullin individual strands out of th connectors. In the present case the initial installer used chea connectors that probably wer not crimped fully, which in tur caused resistance to increas over time. As for the wall outle close inspection showed tha the pins were partly covered by greenish film, probably cause by moisture in the wall corroc ing the faulty gold plating on th pins.

If you want to avoid a career i connector replacement yo should always use quality cabl and wall-socket connectors.

Warehouse madness

The problems described so fa represent roughly 80% of th faults you will encounter o computer LAN's. But there ar other kinds of problems tha will tax your troubleshootin abilities, and that also requir specialized test equipment. Ou next case is a good example.

A firm relocated to a ne headquarters 100 miles awa leaving behind a warehouse The new system used an IBI midrange computer (at head quarters) and CRT terminal and printers (in the ware house), all connected via modems and a dedicated telephone line. The purpose of this arrangement was to generate customer shipping orders. One day all the terminals and printers in the warehouse stopped cold. The data processing manager (DPM) of the company found that his equipment was not working properly, and he blamed the telephone line. The local telephone company checked its line and pronounced it good! So where was the problem?

One possibility was that the fault was somewhere in the warehouse, between the modem and the outside line connections. With permission, we inspected the modem wiring in the telephone cable closet. It looked good, but then we measured the line voltage with a DMM. It read zero! We had expected 2 to 10 millivolts of AC noise, typical on a terminated line. A quick resistance check showed 7 ohms. There was a short in the wiring!

We then spent several hours walking between modem and cable closet, disconnecting wiring, and eliminating various suspects. One look at the huge bundles of wiring on the wall of the building was enough to discourage fault finding by visual inspection!

The solution was to use a time domain reflectometer (TDR), which can locate faults along the cable. After making sure the outside telephone line and modem cable were still disconnected, we attached a MicroTest Cable Scanner handheld TDR to the line in the closet. The TDR indicated some irregularity about 70 feet away, which put the fault near the modem. Then we made another measurement near the modem end, and the cable scanner indicated a dead short.

Then we traced the wiring into a storage closet where the red and white twisted-pair cable ran through a hole in a steel riser and up the wall. Close inspection of the wires running through the hole revealed that a sharp edge had cut through the insulation and shorted the cable. Insulating the wires with electrical tape brought the network back on-line.

The problem of different organizations blaming each other for faults neither can trace is common, because most LAN's consist of different products from different vendors, including computers, terminals, printers, modems, NIC's, cables, and more. The solution is to learn about your LAN equipment and service it yourself, or find a trustworthy service firm that can do it for you.

NETWORK BACKGROUND

The following are reference materials, equipment suppliers, and network-related standards organizations.

References:

- *The Practical Guide to Local Area Networks,* Rowland Archer, Osborne-McGraw Hill. Good introduction to cable types, topologies, and access methods.
- *Networking IBM PC's,* Michael Durr, Que Corporation. Chapter 14 contains good overview of bridges, routers, and gateways.
- *LAN Magazine,* 600 Harrison Street, San Francisco, CA 94107 (415) 905-2200.

Suppliers:

- Black Box Corporation, P.O. Box 12800, Pittsburgh, PA 15241, (412) 746-5530.
- Cable Express Corporation, 500 East Brighton Avenue, Syracuse, NY 13210, (315) 476-3100.
- Contact East, 335 Willo Street South, North Andover, MD 01845, (508) 688-7829
- JDR Microdevices, 2233 Samaritan Drive, San Jose, CA 95124, (800) 538-5000.
- Jensen Tools, Inc., 7815 S. 46th Street, Phoenix, AZ 85044, (602) 968-6231.

Standards Organizations:

- American National Standards Institute, 1430 Broadway, New York, NY 10018, (212), 642-4900.
- IEEE Headquarters, 345 E. 47th Street, New York, NY 10017-2394, (212) 705-7900.

RESOURCES

The following are addresses of manufacturers whose products were discussed in this series of articles. Contact those companies for current pricing and more information.

- Paladin Corporation, 3543 Old Conejo Rd., Newbury Park, CA 92123, (800) 272-8665.
- MicroTest, Inc., 3519 E. Shea Blvd. Suite 134, Phoenix, AZ 85028, (800) 526-9675.
- *Radio Amateur's Handbook,* American Radio Relay League, Newington, CT 06111.
- Tektronix, Inc., Redmond Division, 625 S. E. Salmon Dr., Redmond, OR 97756, (800) 833-9200.
- AMP, Inc., P.O. Box 3608, Harrisburg, PA 17105, (717) 561-6168.
- Gibson Research, 22991 La Cadena Dr., Laguna Hills, CA 92653, (714) 830-2200
- Symantec Corp., Norton Utilities, 10201 Torre Ave., Cupertino, CA 95014-2132, (408) 253-9600.

Cloak and dagger

We saved the most fascinating LAN servicing case for last. After this case was resolved, someone must have answered some interesting questions about his late-night activities.

Here's what happened: A software development firm became highly distressed when several of its workstations performed intermittently in the middle of a rush project. The firm promptly called its regular service company, which in turn concluded that there was a bad cable connecting those machines and the rest of the LAN. The service company recommended tearing the old cable out of the wall and replacing it. After considering the cost of a new cable installation, the firm asked that it be repaired instead.

At this point we were called in to provide a second opinion. Wisely, the service company had bypassed the bad cable with a temporary one; thus we could test the bad cable without shutting down the LAN. This network used a series of high-end workstations tied together via an ARCnet system into a minicomputer. A 60- to 100-foot length of coaxial cable connected the LAN with the last two workstations in the chain. We knew that the cable between them and the LAN was at fault.

We started troubleshooting by making continuity checks on the wiring. Instead of an open circuit, our DMM showed 1(ohms between the shell and center conductor of one of the BNC connectors extending from the wall.

There was definitely a short in the cable. But where was it located? Our initial response was to confirm the service compa

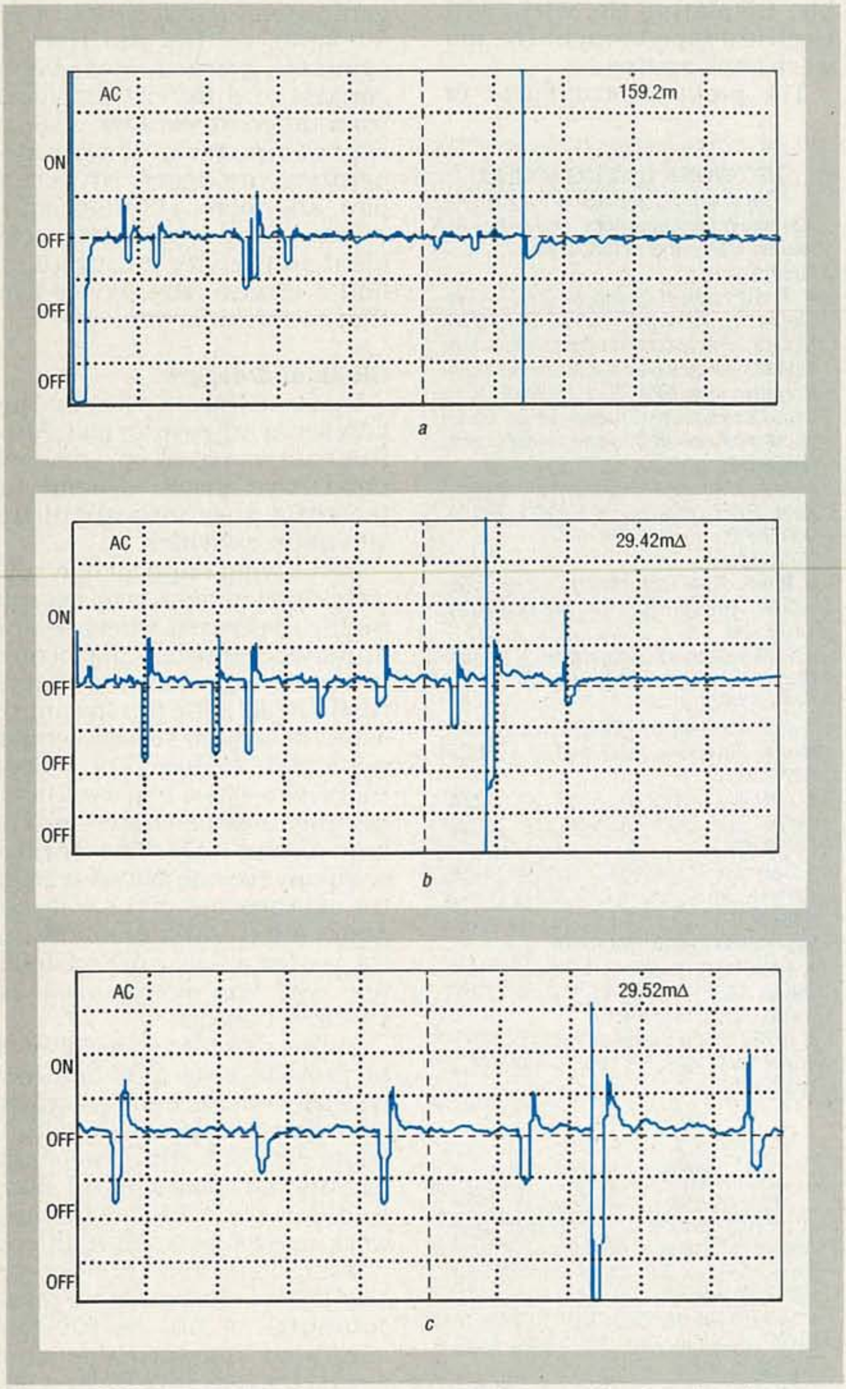


FIG. 2—A GOOD ETHERNET CABLE appears like this on a time domain reflectometer (TDR), which shows impedance vs. distance. The vertical line in *a* marks the end of the cable. In *b*, the vertical line represents a bad cable tap. The TDR can "zoom" into the display, and *c* shows an expanded view of the bad tap.

ny's assessment, and to recommend tearing out the old cable. However, we first decided to do some troubleshooting.

We rented a Tektronix model 1502C analog TDR from a local instrument rental company. (Rental is recommended anytime you need an expensive piece of equipment for just a few days.) We chose this premiere TDR because it displays minor faults that digital TDR's often miss. In the past we have located rusty connectors, loose connectors, and watersoaked cable sections with the 1502C, all of which were missed by a digital TDR. The down side of an analog TDR is that it requires more skill to use.

The 1502C displays distan vs. impedance on an L screen. The display show along the entire length of cable, a continuous "snapsh of impedance, which in our ca was supposed to be about ohms. Shorts cause the trace drop to 0 ohms, and ope cause the trace to rise off display. In operation, you lo for suspect drops and ris read the distance directly off display, and start troublesho ing at the specified locati Figure 2 shows several exa ples of TDR displays.

After connecting the TDR the cable, we checked the d play, which showed the pected 50-ohms, but with sharp drop about 29 feet away company manager, who h been looking over o shoulders, suggested that check the ceiling. We lifted c ing panels and located the ble. Since we had no idea distance in the ceiling space, guessed at the location and spected cable for some distan each way from our access poi Above a service closet we fou the culprit. Someone had slic the cable open and crud spliced another cable to it.

Upon closer inspection, noticed that the added cal was pulled taut, causi strands from the uninsulat connections to touch. That, turn, reduced signal levels the workstations, causing int mittent problems. With exci ment, we traced the seco cable into a closet where found a computer and a prin hidden behind a row of shelv

We showed our findings to t manager. He said he wou watch the closet and determi the identity of the eavesdropp A week later he called the servi company and had them remo the splice and replace it with crimp-on BNC connector and barrel adapter. Later we hea that the computer had been moved from the closet, but t manager would not say wheth he had caught the guilty p son. If it hadn't been for t short, we might never have d covered that illegal tap!

THE 555: A VERSATILE OSCILLATOR

Learn how to build the 555 IC into oscillator circuits whose frequency you c change so they'll wail, warble, and honk.

RAY M. MARSTON

THIS ARTICLE LOOKS AT THE VERsatile 555 monolithic integrated timing circuit as an astable multivibrator, the flip-side of its capabilities as a monostable multivibrator in time-delay circuits. A recent article (September R-E, pg. 58) explored the role of the 555 in the monostable mode.

Now you'll find out how to build many different kinds of circuits with the 555 configured as a self-triggering oscillator. You will want to build the circuits that can generate a variety of square or rectangular waveforms, wail like a police car, imitate the jarring he-haw sound of European emergency vehicles, or reproduce the Klaxon alarm of the Star Treks' starship Enterprise.

The last article on the 555 as a monostable multivibrator included a functional block diagram and an electrical schematic of the chip. You might want to refer back to those figures if you want more detailed information about how the 555 is organized. Figure 1 is a pinout diagram of the 555 as packaged in the most common 8-pin DIP. It was pointed out in the last article that, although a mature device, the 555 remains one of the most popular IC's available today.

At least five major semiconductor firms in the U.S. and Japan make the 555. There is also a dual version, the 556, that has two identical 555's on a single chip. The device is usually packaged in a 14-pin DIP. A quad version, the 558, has four indentical 555's on a single chip, and it is packaged in a 16-pin DIP. The alternate source suppliers usually include the numerals 55, 56 or 58 in their own designations for those devices.

The 555 occupies a strange position in the universe of integrated circuits. Classed as a linear IC because it can be triggered either by linear or digital signals, its output is always digital—in the form of rectangular or square waves or pulses.

The 555 in a *monostable* multivibrator circuit (also called a timer, time delay, or one-shot) generates a fixed-length output pulse for each trigger pulse at its input. This can be demonstrated with the circuit in Fig. 2. By contrast, the 555 in an *astable* multivibrator circuit is shown in Fig. 3. It has no stable output states and no external trigger is necessary to start circuit oscillation; it is said to be self-triggering. This circuit configuration is also called an *oscillator, signal generator, pulse generator,* or a *rectangle-wave generator.*

FIG. 1—PINOUT DIAGRAM OF THE 555.

As long as power is applied to the astable circuit, the output continually switches back and forth between the high and low states at a regular rate or frequency. The time in the high state (pulse width) and the time in the low state (space length) depend on the selection of external resistors and capacitors. Because of its relatively high output, the 555 in an astable circuit can drive LED's, speakers, and meters directly.

Astable operation

In the monostable multivibrator circuit in Fig. 2, OUTPUT pin 3, DISCHARGE pin 7, and THRESHOLD pin 6 are held low when the circuit is quiescent. A monostable timing period can be started by driving TRIGGER pin 2 low with pushbutton switch S1. That causes OUTPUT pin 3 to switch high, while DISCHARGE pin 7 is released and free to follow the voltage across C1. Voltage rises exponentially through R1 toward the supply

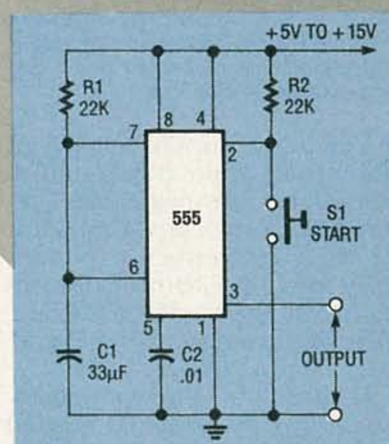


FIG. 2—MONOSTABLE MULTI VIBRATOR TIMING CIRCUIT based o the 555.

voltage. Eventually the voltag at pin 7 rises to two-thirds o the supply voltage, and mono stable action ceases with pins 3

6 and 7 grounded by the internal circuitry of the 555.

Examine the astable circuit shown in Fig. 3-a. In this circuit TRIGGER pin 2 is shorted to THRESHOLD pin 6, and timing resistor R2 is wired between pin 2 and DISCHARGE pin 7. When power is applied to the circuit, capacitor C1 charges exponentially (as it did in Fig. 1) through resistors R1 and R2 until the voltage on C1 reaches two-

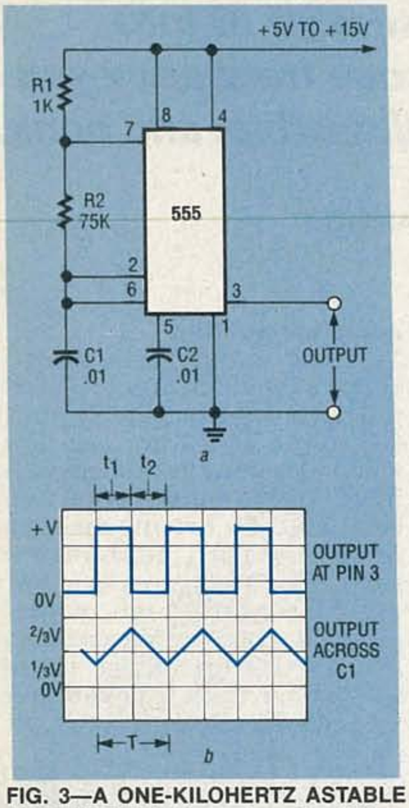


FIG. 3—A ONE-KILOHERTZ ASTABLE MULTIVIBRATOR based on the 555, *a*, and waveforms at output pin 3 and across C1 are shown in *b*.

thirds of the supply voltage. At that time, monostable action ceases and DISCHARGE pin 7 returns to its low state. Capacitor C1 then discharges exponentially into pin 7 through R2 until the voltage on C1 falls to one-third of the supply voltage, and TRIGGER pin 2 is activated.

At that time, a new monostable timing sequence is started and C1 recharges to two-thirds of the supply voltage through resistors R1 and R2. The whole sequence then repeats itself over and over with C1 alternately charging to two-thirds of the supply voltage through R1 and R2, and then discharging to one-third of that voltage through R2 only.

Notice that in Fig. 3-a, the value of R2 is very large with respect to the value of R1. It turns out that the oscillation frequency of the circuit is largely determined by the values of R2 and C2. Figure 3-b shows the nearly symmetrical square output waveform that appears between OUTPUT pin 3 and ground while a nearly linear triangle waveform is simultaneously generated across C1.

The graph of Fig. 4 shows the relationship between the free-running frequency of the circuit in Fig. 3-a and the capacitance values of C1 with the range of R2 values shown on the diagonal lines. In this graph the contribution of resistor R1 is neglected because it is a fraction of the R2 value.

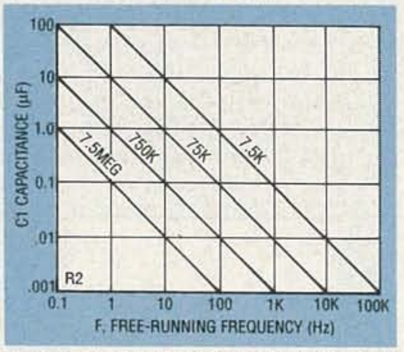


FIG. 4—THE FREE-RUNNING FREQUENCY OF OSCILLATOR in Fig. 3 as a function of capacitance values for C1 and the resistance value of R2 (when large with respect to R1).

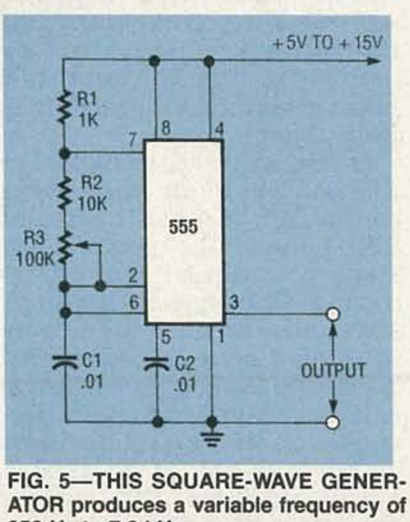


FIG. 5—THIS SQUARE-WAVE GENERATOR produces a variable frequency of 650 Hz to 7.2 kHz.

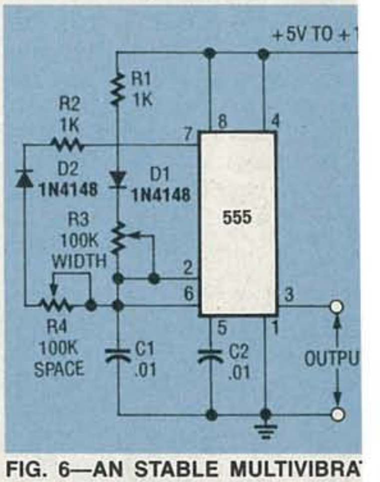


FIG. 6—AN STABLE MULTIVIBRA with independent pulse width and sp periods variable from 7 to 750 micr conds.

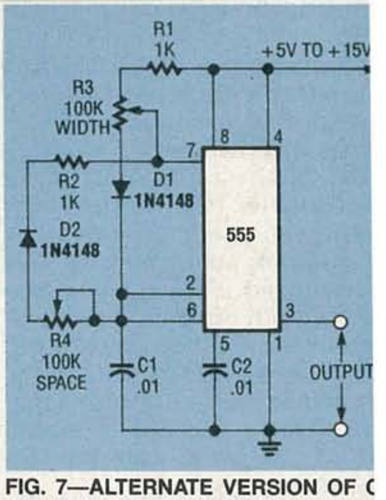


FIG. 7—ALTERNATE VERSION OF CILLATOR shown in Fig. 6.

The values of R1 and R2 c be varied from 1 kilohm up tens of megohms. Resistor can, however, have a significa effect on the total circuit cu rent consumption because p 7 is essentially grounded duri half of the oscillation cycle. T duty cycle or pulse width-space ratio of the circuit can preset at a nonsymmetrical v ue, if desired, by the choice of and R2 values.

The high time (pulse widt and low time (space length) this circuit must be calculat separately. The pulse width c culation includes the values the timing capacitor C1 ar both timing resistors R1 ar R2. By contrast, the spa length formula includes or the values of timing capacit C1 and resistor R2.

Refer to Fig. 3-b. Pulse width (or time to charge capacitor C1 is:

$t_1 = 0.7\ C1\ (R1 + R2)$

Space length or time to discharge capacitor C1 is:

$t_2 = 0.7\ C1R2$

The total cycle time is:

$T = t_1 + t_2$

The ratio of pulse width to the total cycle time is the *duty cycle*. In a 555-based oscillator, the duty cycle is defined by the relative values of the two timing resistors R1 and R2:

Duty cycle = R2/(R1 + 2R2)

Frequency in hertz (Hz) is the reciprocal of total cycle time: F = 1/T.

The circuit in Fig. 3-a can be modified in many different ways. Figure 5, for example, shows how it can be made into a variable-frequency square-wave generator by replacing R2 with a fixed resistor and potentiometer in series. The frequency can be varied over a range of about 650 Hz to 7.2 kHz with the values of the resistor and potentiometer R3 shown. If required, the frequency span can be further increased by switch-selecting alternative values of C1.

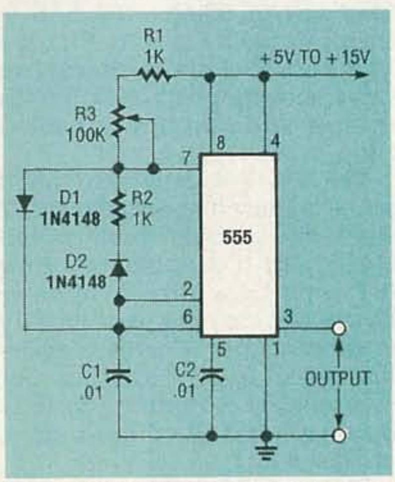


FIG. 8—A 1.2 kHz OSCILLATOR with a duty cycle variable from 1 to 99%.

Width-space control

The circuit in Fig. 3-a can generate a fixed-frequency output waveform with any desired pulse width-to-space length ratio by selecting the appropriate values for R1 and R2. In each operating cycle, C1 alternately charges through R1 and R2, and discharges only through R2. For example, if R1 and R2 have equal values, the circuit will generate a 2:1 width-to-space ratio.

The width-to-space periods can be independently controlled with either the Figs. 6 or 7. In Fig. 6, C1 alternately charges through R1, diode D1, and potentiometer R3, and it discharges through potentiometer R4, diode D2, and R2. In Fig. 7, C1 alternately charges through R1, potentiometer R3, and diode D1, and it discharges through potentiometer R4, diode D2, and R2. In both Fig. 6 and 7 circuits, R2 protects the 555 if potentiometer R4 is shorted.

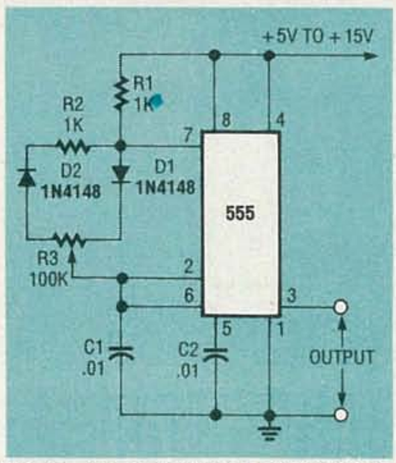


FIG. 9—AN ALTERNATE VERSION OF OSCILLATOR shown in Fig. 8.

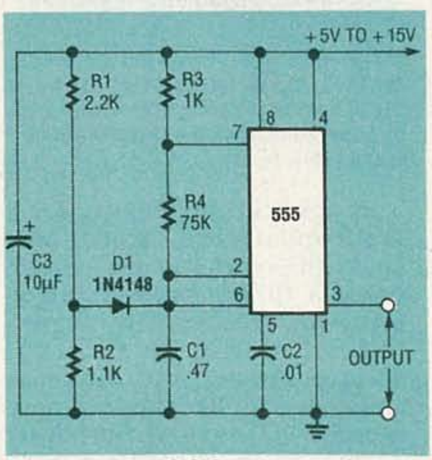


FIG. 10—A PRECISION LOW-FREQUENCY OSCILLATOR with a frequency of about 20 Hz.

In the circuits of Figs. 6 and 7, the width-to-space periods can be independently varied over about a 100:1 range, enabling the width-to-space ratio to be varied from 100:1 to 1:100. The oscillation frequency varies as the ratio is altered.

Figures 8 and 9 show alternate ways of connecting the 555 in the astable mode so that the width-to-space ratio can be varied without altering the oscillating frequency. In those circuits, the pulse width period automatically increases as the space length period decreases, and vice versa. Therefore, the total period of each operating cycle is constant. In those circuits, the feature of interest is the duty cycle. In Figs. 8 and 9, the duty cycle can be varied from 1% to 99% with potentiometer R3.

In the circuit of Fig. 8, C1 alternately charges through R1, the upper half of R3, and D1, and it discharges through D2, R2, and the lower half of potentiometer R3. In Fig. 9, C1 alternately charges through R1 and D1 and the right-hand half of potentiometer R3, and it discharges through the left-hand half potentiometer R3, D2, and

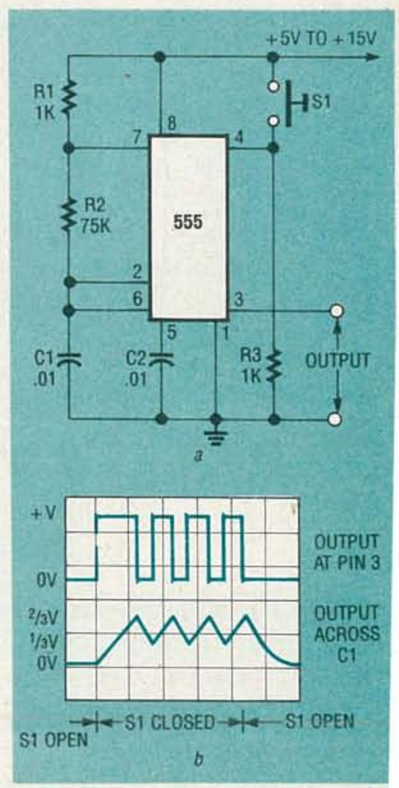


FIG. 11—GATED 1-kHz OSCILLATOR o fering "press-to-turn-on" operatio ***a,CFHB and waveforms at output of pi and across C1, b.***

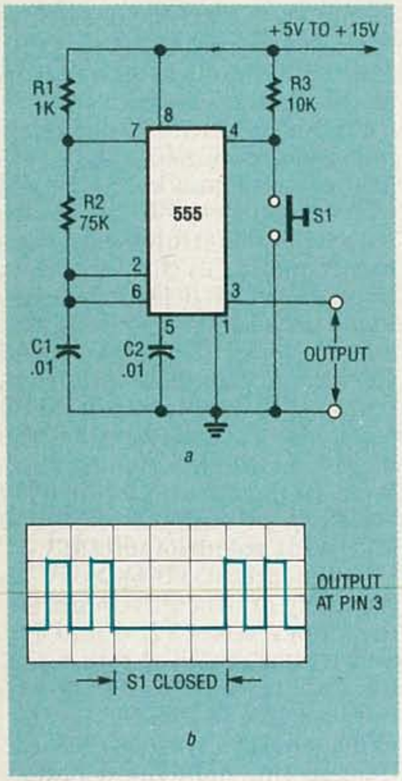


FIG. 12—GATED 1-kHz OSCILLATOR offering "press-to-turn-off" operation, *a*, and waveforms at output of pin 3 and across C1, *b*.

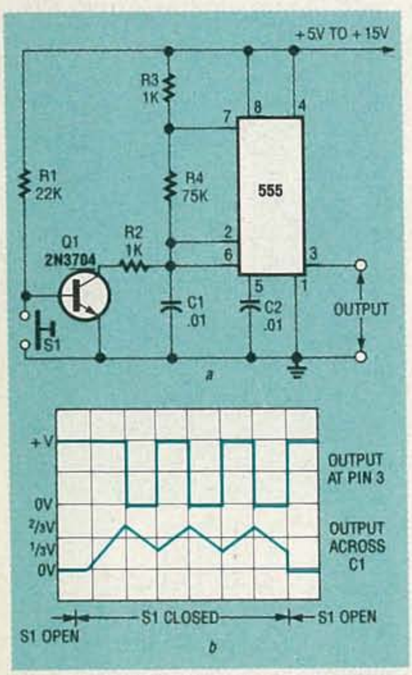


FIG. 13—ALTERNATIVE GATED 1-kHz OSCILLATOR offering "press-to-turn-on" operation, *a*, and waveforms at output of pin 3 and across C1, *b*.

R2. Both circuits oscillate at about 1.2 kHz with the value of C1 shown.

Precision astable circuit

In the description of astable multivibrator operation given earlier in this article, it was stated that in the first half cycle of oscillation timing capacitor C1 charges from zero volts to two-thirds of the supply voltage, but in all subsequent half-cycles it either discharges from two-thirds to one-third of the supply voltage or charges from one-third to two-thirds of that voltage. Consequently, the first half cycle of oscillation has a far longer period than all subsequent half cycles.

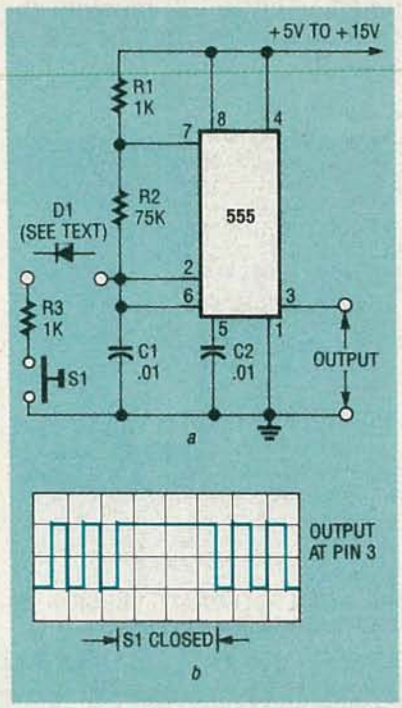


FIG. 14—ALTERNATIVE GATED 1-kHz OSCILLATOR offering "press-to-turn-off" operation, 1a and waveforms at output of pin 3, *b*.

In applications calling for a low-frequency clock signal, this large differential in period can cause a timing problem. However, this problem can be averted by adding an external voltage divider and diode as shown in Fig. 10. Those components bias C1 to a point slightly below one-third of the supply voltage (rather than zero volts) at the moment of switch-on. Here, R1 rapidly charges C1 to one-third of the supply voltage through D1 at switch-on, and all of the C1 charge is subsequently controlled by R3 and/or R4 only.

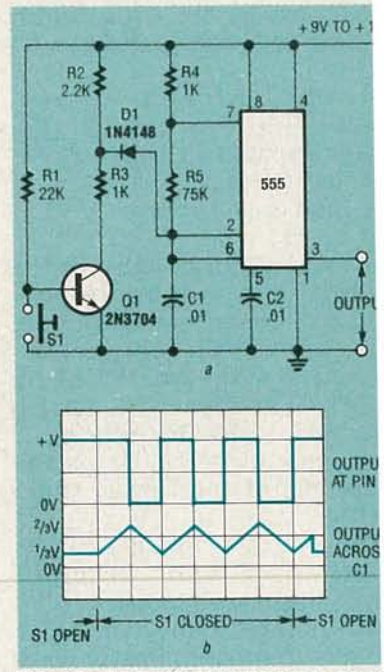


FIG. 15—PRECISION VERSION OF T OSCILLATOR in Fig. 13, *a*, and wa forms at output of pin 3 and across C1

Astable gating

The 555 in the astable mul vibrator mode can be triggere ON and OFF in many differe ways with either an ele tromechanical switch or electronic signal. The most pc ular way to trigger the 555 through RESET pin 4. Figur 11-a and 12-a show alternati ways of triggering the 555 wi this pin and pushbutton swit S1.

The 555 is organized so that pin 4 is biased above about 0 volts, the astable mode is e abled. But if it is biased belc 0.7 volts by a current great than 0.1 milliampere (l grounding pin 4 with a res tance less than 7 kilohms, f example) the astable mode disabled, and the 555's outp is biased low.

For example, the circuit Fig. 11-a is normally turned by R3, but it can be turned on closing pushbutton switch S which biases pin 4 high. Figu 12-a shows an astable circu that is normally on, but it ca be turned off by closing pus button switch S1, which shor pin 4 to ground. The circuits Figs. 11 and 12 can also be tri gered by applying suitable ele tronic signals directly to thei

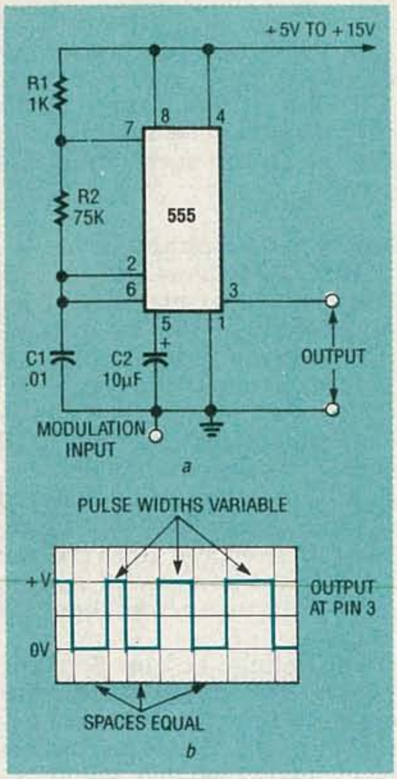


FIG. 16—CIRCUIT FOR APPLYING AC-COUPLED FM or PPM to a 555 configured as an oscillator, a, and waveforms at output of pin 3, *b*.

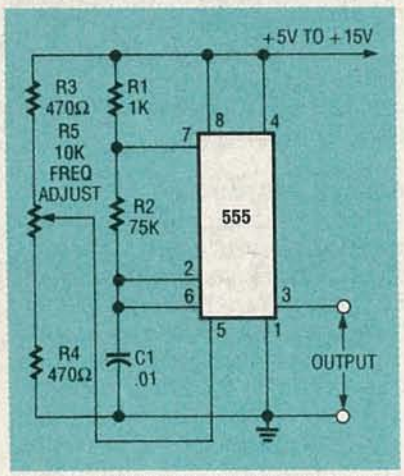


FIG. 17—CIRCUIT FOR APPLYING A DC-COUPLED FM or PPM to a 555 configured as an oscillator.

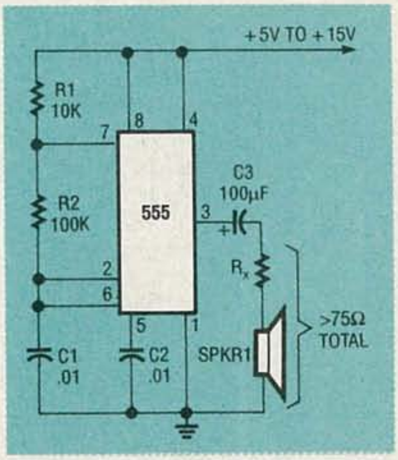


FIG. 18—CIRCUIT GENERATES 800-Hz MONOTONE ALARM that operates from 750-milliwatts.

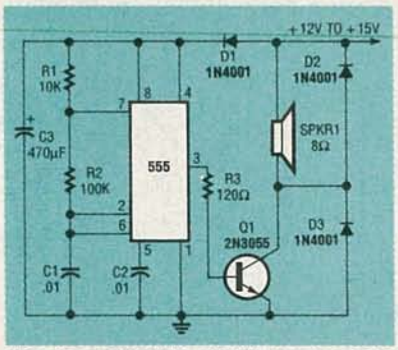


FIG. 19—CIRCUIT GENERATES 800-Hz MONOSTABLE ALARM.

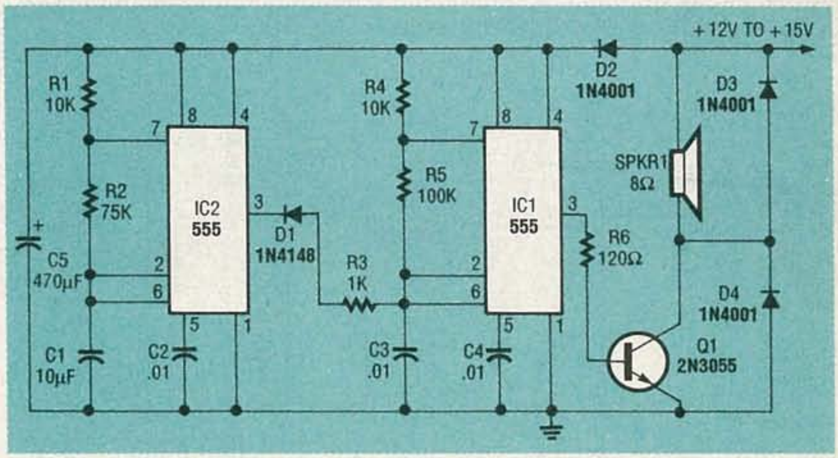


FIG. 20—CIRCUIT GENERATES 800-Hz PULSED-TONE ALARM.

RESET pins.

In Fig. 11-b, the precise circuit waveforms at OUTPUT pin 3 and across C1 are shown. It can be seen that the duration of the first half-cycle of oscillation is considerably longer than the succeeding half cycles because of the time for C1 to charge to two-thirds of the supply voltage. Also, note that when the astable mode is turned off, the C1 voltage decays slowly to zero; the output at OUTPUT pin 3 is zero volts in the OFF condition. The waveform characteristics of Fig. 12-a are similar as shown in Fig. 12-b.

Figure 13-a shows an alternative method for triggering the 555 in the astable mode. Here transistor Q1 is normally biased ON by R1, so it acts like a closed switch, which pulls the junction of C1 and R4 close to zero volts through R2 preventing oscillation. When pushbutton switch S1 is closed, Q1 is biased off, and the astable circuit is free to oscillate normally.

Refer to Fig. 13-b for the waveforms of the circuit in Fig. 13-a. When the astable response is triggered on, the first half cycle is again considerably longer than in succeeding half cycles, and that the voltage on C1 decays rapidly to nearly zero volts when the trigger is off. Also notice that OUTPUT pin 3 is high in the OFF state.

Figure 14 shows how the circuit in Fig. 13-a can be modified to give *press-to-turn-off* oscillation simply by replacing Q1 with a pushbutton switch. A digital signal can trigger this circuit if a diode is connected as shown in the diagram and the pushbutton S1 is deleted. With S1 removed, the circuit will be turned off when the input signal voltage is reduced below one-third of the supply voltage. The waveform is shown in Fig. 14-b.

Finally, to complete this look at triggering techniques, Fig. 15-a shows how the Fig. 13-a circuit can be modified so that the duration of its first half-cycle is almost equal to that of all succeeding half-cycles, thus giving precision operation. In the Fig. 15-a circuit, when pushbutton switch S1 is open, Q1 is saturated, so the voltage divider made up of R2 and R3 pulls the junction of R5 and C1 to slightly below one-third of the supply

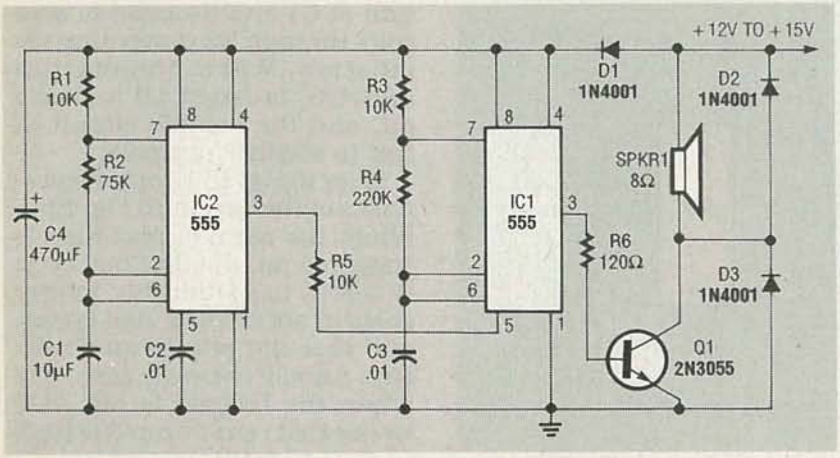


FIG. 21—CIRCUIT GENERATES WARBLE ALARM of European emergency vehicles.

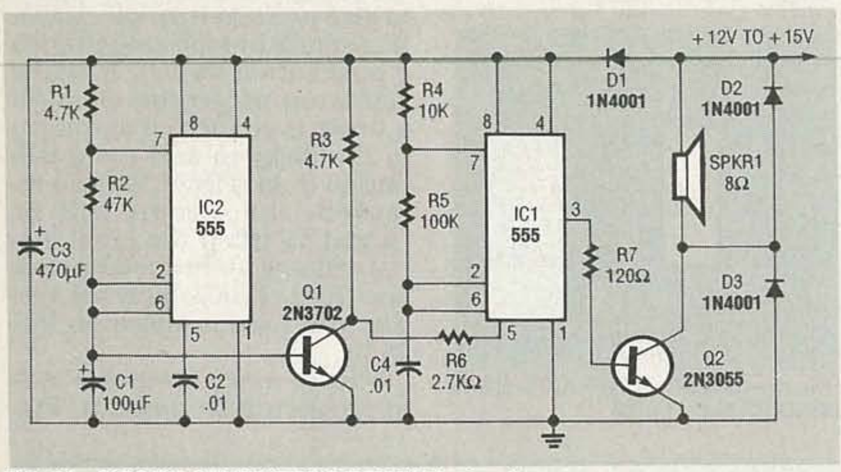


FIG. 22—CIRCUIT GENERATES SIREN WAIL of police cars.

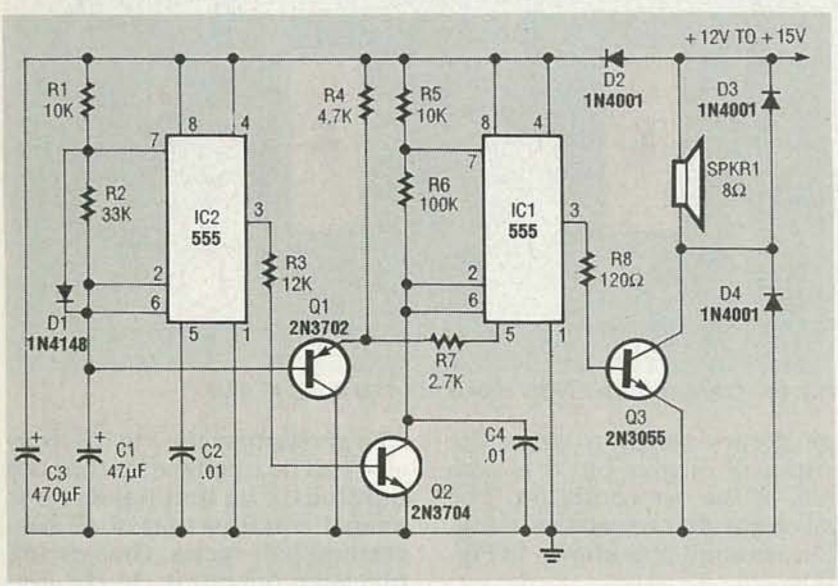


FIG. 23.—CIRCUIT GENERATES PENETRATING ALARM of Star Trek spaceship.

voltage through diode D1, thus turning the circuit off. When S1 is closed, Q1 turns off, D1 is reverse biased through R2, and the circuit is then free to oscillate normally.

Notice in Fig. 15-b that when S1 is first closed, C1 starts to charge from an initial valu almost a third of the supply v age rather than from zero vo Therefore, the duration of initial half cycle is similar that of all the succeeding h cycles.

Modulation techniques

All of the 555 astable circu reviewed so far can be freque or pulse-position modula (FM or PPM) by feeding a su able modulation signal t CONTROL VOLTAGE pin 5, which connected to part of the inter voltage divider chain of the 5 The AC modulation signal is to pin 5 through a blocking pacitor, as in Fig. 16-a, or DC modulation signal can fed directly to pin 5, as shown Fig. 17.

The voltage on pin 5 of t Fig. 15-a circuit alters the wic of the pulses in each timing cle of the 555, but it has alm no effect on the space duratic The signal at pin 5 changes t PPM pulse width position, fecting the total cycle period it also influences the output f quency, as shown in Fig. 16 In so doing, pin 3 provides a f quency-modulated sign Those characteristics of the 5 are useful for generating spec waveforms.

Alarms and sirens

Some of the most popular a plications for the 555 organiz as an astable multivibrator a as waveform generators f loudspeakers. They can pr duce alarm and siren sounc Figures 18 to 23 show differe ways to create those sounds. of the circuits in those figur are triggered by making breaking their supply-volta connections.

Figure 18 shows an 800-H monotone alarm-call generat circuit, which can be power by any 5- to 15-volt DC supp The speaker SPKR1 can ha any impedance value. Not however, that R_X must be wir in series with any speak whose total impedances is le than 75 ohms. Select a resist to give a total series resistan with the speaker of 75 ohm

continued on page 9

JAMES MELTON

250 WATT POWER INVERTER

Power small appliances from your car or any other 12-volt source with our 250-watt inverter.

DO YOU EVER NEED TO POWER 120-volt ac equipment when there is no AC outlet available? Our affordable power inverter was designed to supply up to 250 watts to power line-operated equipment a a fraction of the cost of commercially built units.

The inverter described here has been used to power flood lamps, soldering irons (both resistance and transformer types), fans, televisions, and portable computers. It has even powered an air pump for the author's asthmatic son. The inverter will power almost any device that runs on 120 volts AC. Some motorized devices won't work well, however. A variable-speed drill may work, but only at one speed. Fans and other purely inductive loads seem to run at about ⅔ normal speed with the inverter. Synchronous motors will run at normal speed but will be a little "noisy."

Power FET's to the rescue

Power FET (field effect transistor) devices have gotten more versatile over the last few years and, at the same time, the prices for them have plummeted. Nothing can match a FET in its ease of interfacing with logic signals, and for the ease in which it can work in parallel with similar devices without the need for any extra components. To parallel the FET's, all you have to do is tie the source leads together. When the they get warm, FET's exhibit a positive temperature characteristic, which means as the temperature goes up, so does the resistance; as the resistance goes up, the current through the device is lowered. That makes FET's self-limiting when working in parallel.

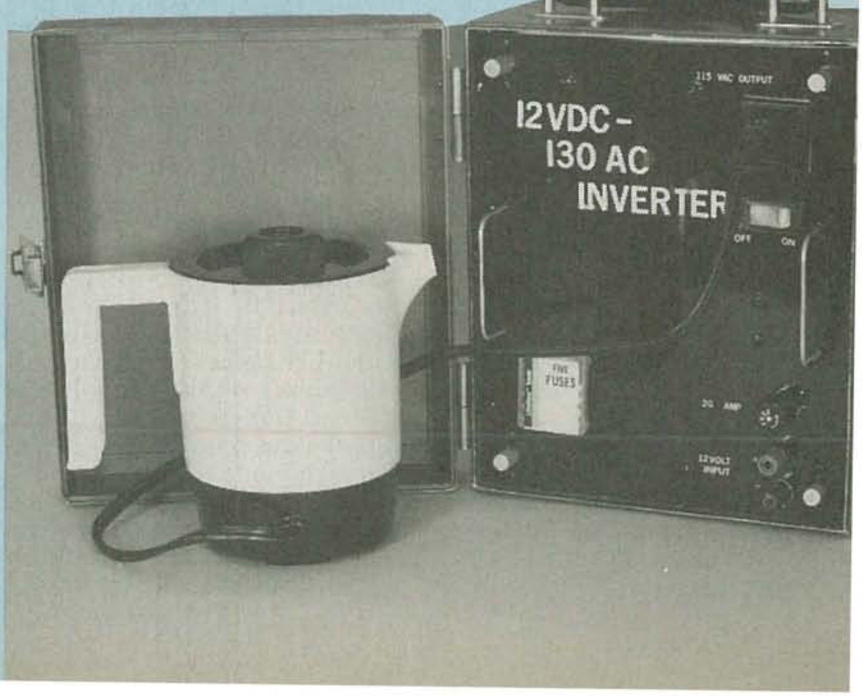
FET's are now being produced with power ratings that can often make parallel operation unnecessary. The ratings for the IRFZ30's that are used in this project are amazing: they can handle a 30-amp load with 50 volts across the source-drain leads and 75-watt power dissipation, all in a TO-220AB plastic package—for less than two bucks each when purchased in small quantities.

Operation

Figure 1 shows the schematic of the inverter. A 555 timer, IC1, along with R3, R2, and C2, generates a 120-Hz (± 2 Hz) signal, as set by the value of potentiometer R3.

The output of IC1 at pin 3 is fed to the CLOCK input of a CD4013BE dual D-type flip-flop, IC2-a, which is wired to divide the input frequency by two; that generatea the 60-Hz clocking for the FET array (Q1–Q6). The output from flip-flop IC2-a at pin 1 has a 50% duty cycle, which is necessary for the output transformer. The flip-flop also provides an inverted output ($\overline{Q}$, pin 2), which saves us from having to add additional components to invert the Q output. The second half of IC2 (IC2-b) is not used, so all of its input pins are grounded.

The Q and $\overline{Q}$ outputs from IC2-a are each fed, via R5 and R4, to three inputs of IC3, a CMOS CD4050BE hex buffer. Each group of three buffer outputs drives one bank of FET's in the power stage.



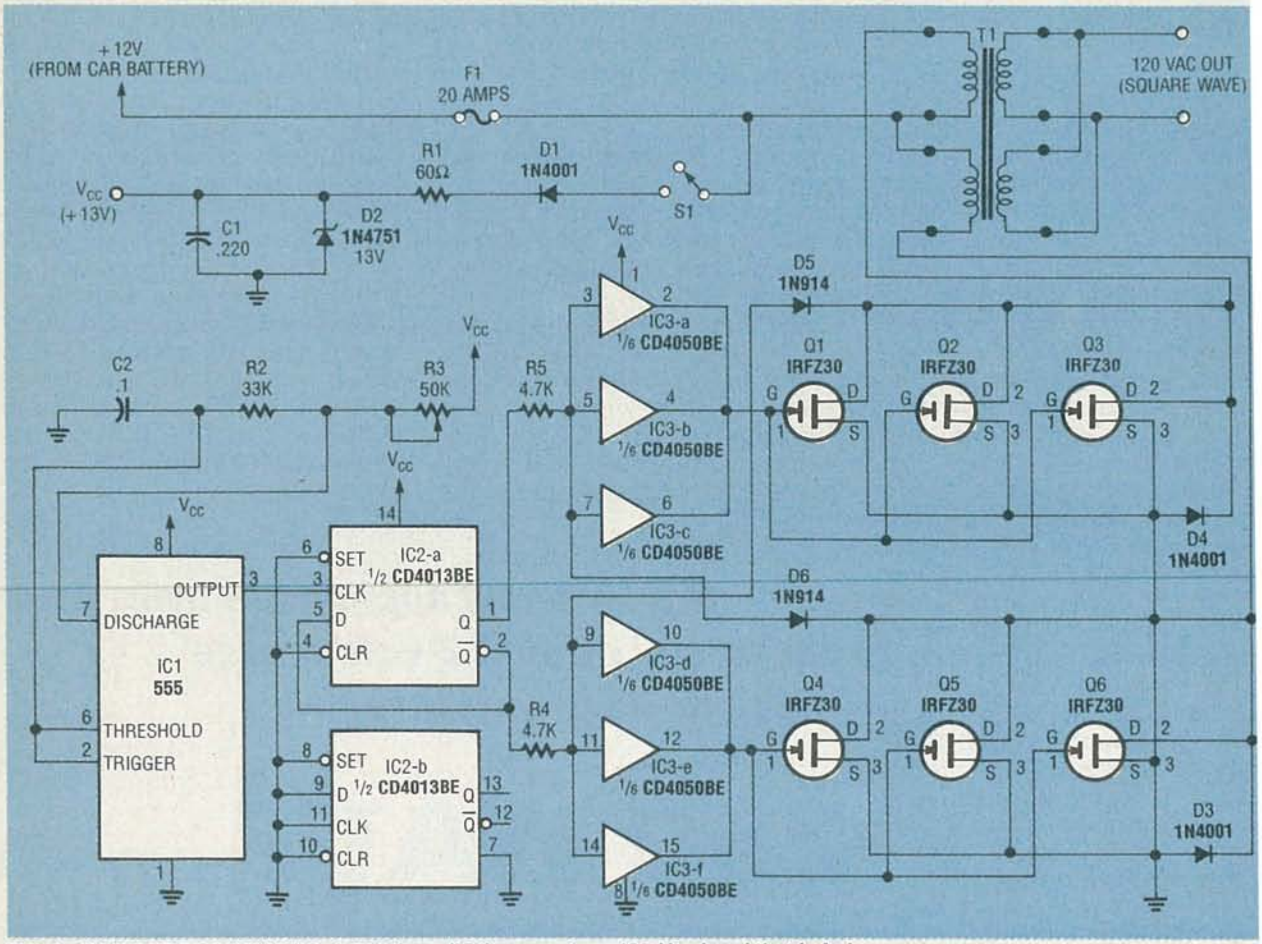


FIG. 1—INVERTER SCHEMATIC. A 555 timer (IC1) generates a 120-Hz signal that is fed to a CD4013BE flip-flop (IC2-a) which divides the input frequency by two to generate a 60-Hz clocking frequency for the FET array (Q1–Q6).

The inputs to the buffers are also controlled by D5 and D6, which are connected to the drains of the FET's so that the array that is turned-on essentially has control of the drivers of the opposite array. When one side is turned on and its drain is at ground potential, the other side cannot turn on because the input to the buffer for that array is also being held at ground. It stays that way until the controlling array has completely turned off and the drain voltage has gone above about 6 volts. That is necessary because the turn-off time for a FET is longer than its turn-on time. If the diodes were eliminated, both arrays of FET's would be turned on simultaneously during each transistion, which creates tremendous spikes on the battery, the equipment tied to the output of the inverter, and to the FET's themselves.

The FET array can be made as big or as little as your application requires. The author needed at least 250 watts, and used two IRFZ30's in parallel for each array. However, to play it safe, use three in parallel (or however many you need) for each array as we've shown in the schematic. Diodes D4 and D3 dampen inductive kickback from the transformer winding that would likely cause overheating and premature transistor breakdown.

Power-supply conditioning circuitry (D1, R1, D2, and C1) eliminates spikes, overloads, and other noise from a car's 12-volt supply. Even though the 555 can handle up to a 15-volt supply, power-supply spikes will surely damage it.

If the transformer you use has a center tap, the center tap must be connected to the 12-volt line and the two 12-volt windings must be connected to the dra of their respective driving tra sistors. The author usec Jefferson buck/boost trai former that's normally used reduce or increase the line vo age for AC devices. If you going to buy a transformer, y can use any center-tap 24-v or dual-winding 12-volt trai former. It is important to us transformer that can supply t ammount of current that yo application requires.

Construction

Some of the componen mount on a small PC board, f which we've provided the f pattern. The parts-placeme diagram is shown in Fig. 2. V recommend that you use soc ets for the IC's. After solderin all components on the boar apply 12 volts and measure t frequency on the pads mark J4 and J2. Adjust R3 for a rea

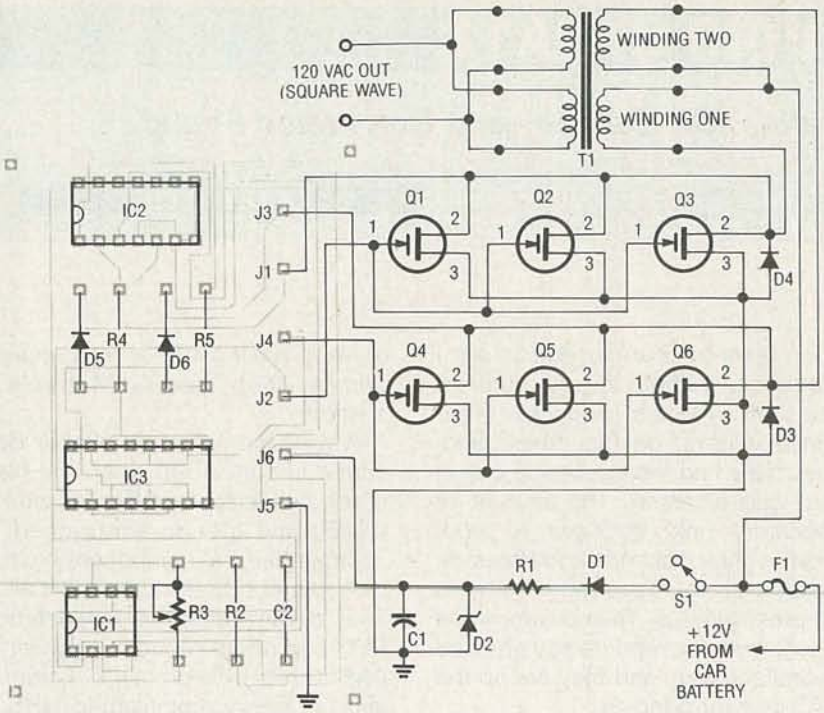


FIG. 2—MOST OF THE COMPONENTS mount on a small PC board. The off-board components can be mounted on a terminal strip or perforated construction board.

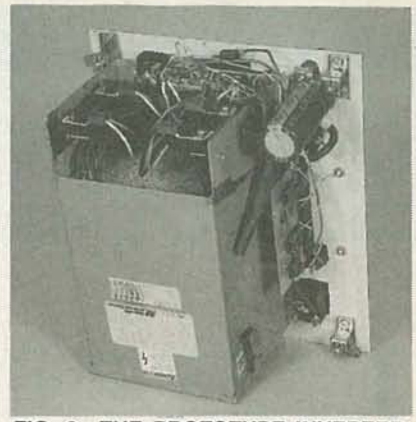


FIG. 3—THE PROTOTYPE INVERTER. The author used a car cigarette lighter plug on the end of the power-input lead and an AC outlet for plugging appliances into.

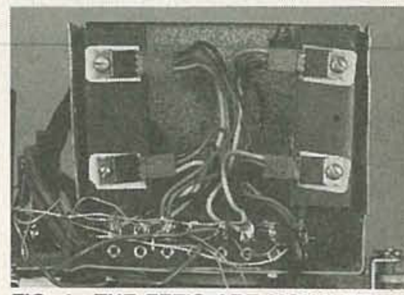
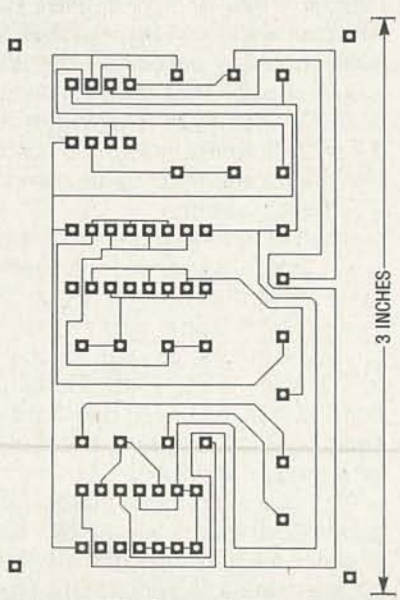


FIG. 4—THE FET'S ARE MOUNTED on metal plates used as heatsinks. If the heatsink is at ground potential, insulate the FET's from the heatsink.

ing of 60 Hz, and make sure the voltage is very close to ½ of the supply voltage on each pad. That tells you that your duty cycle is 50%.

Now connect the rest of the components. The small off-board components can be mounted on a terminal strip. However, be sure to mount the FET's on a heatsink. If the heatsink is at ground potential, also be sure to insulate the FET's from it.



FOIL PATTERN for the inverter board.

PARTS LIST

All resistors are ⅛-watt, 5%, unless otherwise noted.

R1—60 ohms, 1 watt, 10%
R2—33,000 ohms
R3—50,000 ohms, 10-turn potentiometer
R4, R5—4700 ohms

Capacitors

C1—220 µF, 35 volts, electrolytic
C2—0.1 µF, 50 volts, ceramic disk

Semiconductors

IC1—LM555 timer
IC2—CD4013BE CMOS dual D-type flip-flop
IC3—CD4050BE CMOS hex buffer
D1, D3, D4—1N4001 diode
D2—1N4751 13-volt Zener diode
D5, D6—1N914 diode
Q1–Q6—IRFZ30 30-amp, 60-volt FET

Other components

T1—Jefferson #216-1121 buck/boost transformer (contact WW Granger, Inc., 1250 Busch Pkwy, Buffalo Grove, IL 60015, 708-459-5445) or other 12- or 24-volt center-tapped transformer (see text)
S1—SPST switch
F1—20-amp fuse (or use value according to desired output current and transformer used)

Miscellaneous: fuse holder, cabinet, mounting hardware, AC outlet, car cigarette lighter plug, wire, solder, etc.

The author used a car cigarette lighter plug on the end of the power-input lead, but you are free to use alligator clips or whatever is most convenient for you. A standard AC outlet was mounted on the front panel of the unit. The prototype was installed in an old, rugged metal case, but you can use whatever you have on hand. Figure 3 shows the prototype inverter and how everything is assembled. Figure 4 shows a close-up view of the FET's and how they are mounted on metal plates used as heatsinks.

Operation

To operate the unit, plug the input power into your cigarette lighter socket, turn on the power switch, and turn on the appliance that's plugged into the inverter. When you are not using the inverter, be sure to turn it off, since the transformer will draw about 2 amps even with no load. That will drain your car battery fairly quickly! R-E

AUDIO UPDATE

Syndicated Reviewers, AM Stereo, and Consumer Fraud

LARRY KLEIN

I've frequently been distressed by the writings of the syndicated audio columnists, the pundits whose opinions appear weekly in large and small local newspapers. I've met many of them over the years and, by and large, they are nice people, but I just don't like the job they do. What's wrong? Several things.

I feel strongly that a writer should not express his opinion in print on the audio qualities of a borrowed product listened to under uncontrolled conditions in a home environment. Such home evaluations without lab test backup are, in general, untrustworthy. They actually tell you far more about the writer's mood, health, and relationship with the manufacturer than they do about the product. This is not to say that some of the recommended products aren't topnotch, but the reader has no way—sound unheard—of confirming the reviewer's opinions.

Am I being too harsh in my judgment? I think not. The temptation to say nice things about a product becomes intense when a writer has been personally wined, dined, junketed, and brainwashed by a company's public relations agency.

I can say that in the 35 years or so that I've been writing about audio I've kept my skirts relatively clean. Despite temptations to do otherwise, I have never confused my subjective opinions with objective facts and never praised a hi-fi component in print without a lab test backup. I should admit that as the technical director of the world's largest circulation audio magazine, I found it easy to be holier than almost anybody. I regularly received such manufacturer-supplied perks as all-expense-paid annual trips to audio shows and factories in Japan, Europe, and elsewhere, and all the long-term-loan audio equipment I could use without extolling the virtues of anyone's products. Freelance writers, on the other hand, inevitably find themselves in a *quid pro quo* situation. The amount of laudatory "ink" they give to products in their columns correlates directly with the frequency of invites to press junkets. Their columns and comments are reprinted by gratified manufacturers, and they are on the "A" lists for goodies.

Once I left *Stereo Review* for the freelance life, my invitations slowly dwindled as the various PR agencies became aware of my new unexalted status. I could have reversed the situation somewhat by taking the same product review route as my syndicated contemporaries, but I chose not to do so. In any case, to reaffirm my point: Be careful before committing your dollars on the basis of any opinions unsupported by laboratory testing. It's just too easy to be mislead.

AM stereo

Remember AM stereo? It's an idea that won't die—but won't come fully to life either. Perhaps a dozen years ago, when AM stereo was first introduced as a new broadcast technology, I wrote that because of the lack of consumer interest the format would probably never fly. The letters of disagreement that subsequently reached my desk were mostly from station owners, broadcast engineers, and companies with investments in AM-stereo technology.

For years there was no visible progress on the AM-stereo front, possibly because the FCC in its wisdom (ha!) decided to let the competing formats fight it out in the marketplace. True, there was an occasional press release telling of this or that company's home or car receiver's having AM-stereo rec
tion facilities, usually Motoro
system.

A mini breakthrough almost
curred in June 1990 when the
tional Association of Broadcast
(NAB) and Denon announce
"comprehensive component brc
cast monitor tuner that does it a
The "all" included the now-defu
FMX FM noise-reduction syste
AM stereo (Motorola's C-Qua
and the newly promulgated NR
AM standard. The new standarc
cluded an extension of the AM t
ing range (520 to 1710 kHz), a p
emphasis/de-emphasis curve,
a wider, tightly specified audio ba
width. The tuner was promised
"early 1991."

I recently called the Denon te
nical rep to ask what, if anyth
had happened to the tuner. He fa
me a copy of a press release da
May 1992 announcing a revis
tuner that no longer had FMX
did have AMAX, which seems to
the NRSC parameters under a n
name (See **Radio-Electroni**
February 1992 for more details).
AM bandwidth can be switched
wide or narrow, providing either
broadest audio-frequency respo
or the lowest noise. Helping to
duce AM impulse noise is a no
blanking circuit from Sprague/A
gro Microsystems.

I found the tuner's technical s
sheet, which was printed in Jap
to be somewhat puzzling. The au
frequency response of the
tuner set to wide is given as 50
to 7.5 kHz, +1.5 -3 dB. Certa
that's better than what one find
most AM/FM receivers, but it f
far short of CD quality.

The claim has been made t
good AM stereo is frequently in
tinguishable from FM. That may
be, given the aging ears of the c

continued on page

HARDWARE HACKER

Histogram equalization, alternate action latches, gamma curve correction, digital image processing, and semiconductor IC houses.

DON LANCASTER

Stop the presses. *Murata* has just announced a *Gyrostar* piezo gyroscope. Which, if it is as great as it looks, could easily become *the* hacker component of the decade. All I've got on this so far is that brief note in the June 8th *Design News* and a promise for more technical information. Needless to say, the hacker potential of a $5 navigation gyro would be truly revolutionary.

Be sure to stay tuned on this one.

Things are also starting to happen fast and furious on that direct-toner printed circuit board front. Since my last report, the new water-soluble decal-based *Toner Transfer System* offered by *DynaArt* has been further improved. The new *Printed Circuit Board Transfer Film* from *Techniks* looks even more promising.

What Techniks did was take their old differential transfer system and add a new blue polymeric release coating. The polymeric release coating can dramatically improve the transfer; it actually becomes an important part of your resist pattern.

Faster than light?

Every week or so I get at least one letter or helpline call from people who feel they have clearly broken some physical law. Maybe they have proof that the speed of light is not a constant. Or that those three laws of thermodynamics just do not apply to them. Or that perpetual motion can be possible using magnetic repulsion. Or they have tapped the zero point scalar energy from the fabric of space. Or that their latest pet theory proves the cold-fusion process.

Usually, they'll also complain that they've sent their theory everywhere and have gotten no replies. Or that they are getting ignored because they are outsiders.

Very often, their inquiries will be self-defeating. How? They will include totally irrelevant religious or political contexts. Or they'll be super secretive. Or written and submitted in such a way that they scream "Hey, kick me, for I'm not even computer literate."

If it likes water, looks like a duck, and quacks like a duck...

But consider who is receiving those letters. Based on past experience, the editors or the publishers *know* that the probability is 0.99+ that the lab work (if any) is just plain wrong. Or, more typically, *not even wrong*. And 0.99+ that the sendee is clearly a few chips shy of a full board. Why *should* they believe you?

The sad thing is that needle in the haystack. I'm going to be generous and claim that one letter in 500 in fact *does* have the germ of a new theory or a developable product or a fresh look at a solvable problem. And, yes, newer ideas often will get ignored or vehemently attacked.

What can you really do if you have genuinely beaten those overwhelming odds and your controversial idea is in fact both new and for real?

There are two possible routes you could take to get your ideas accepted. The first or *real science* method is to *thoroughly try and prove that you are wrong*. Be sure to use lots of careful research, especially through *Dialog* and those *UMI* reprints. Be certain to subscribe to *all* of the relevant insider trade journals and go out of your way to study the scholarly publications in the field. Learn all the lingo. Attend conferences and trade shows. Find a patient and knowledgeable industry insider that is willing to look at your idea and comment honestly on it.

Be absolutely certain that you have a simple experiment that can be independently duplicated and verified by disinterested outsiders.

Hire some competent engineering or physical science consultants to study and add credibility to all your claims. Take enough college and university level courses to make sure you do thoroughly understand at least the fundamentals of the field—along with the needed math to back it up.

And finally, present the ideas clearly identified as a possible new theory in some professional context totally free of religious, political, o any conspiracy mumbo jumbo.

The second route is to publish via a *pseudoscience* press. There are quite a few underground and alternate life publications that welcome material of this type. Every now and then, *Whole Earth Review* gives yo a list and rundown of all the maga zines of that genre. Let me know you want to see a resource sideba on those.

One leading bookstore that doe specialize in selling and distributin pseudoscience topics is *High Ene gy Enterprises*. Many of their offe ings are utterly fascinating. Thos folks also sponsor several year forums where controversia pseudoscience topics are strong encouraged.

Several *very* important tips whe publishing your own pseudoscienc tracts: Be sure to use cut-and-pas Xerox-of-a-Xerox and lots of poor printed sloppy layouts. Smeared i on cheap paper is a must. Free quote obscure rural newspapers

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

your prime data sources. Include illegible artwork. Extensively refer to unheard-of and unavailable journals. Use plenty of irrelevant inference and innuendo.

Use only 20–200 year old references, especially in any rapidly changing field. Misquote and drop some big names, even if totally out of context and they never heard of you. "Billions and billions of Carl Sagan's ago..." *Never* offer any succinct and easily verified experiment.

Always use ten words where one will do. Make all of your paragraphs unbearably wide and long. Then run them all together in haphazard order. *Never* come right out and state your key points. Work Tesla in somehow, and be sure to include plenty of obscure religious and/or political references. Show how your theory is now being suppressed by a federal conspiracy headed by the Trilateral Commission and secretly funded through both the WCTU and the SPCA.

Ignore all the personal computers entirely. They are only a passing fad that never will catch on. Finally, do not ever, under any circumstances, use any new desktop publishing tools and techniques.

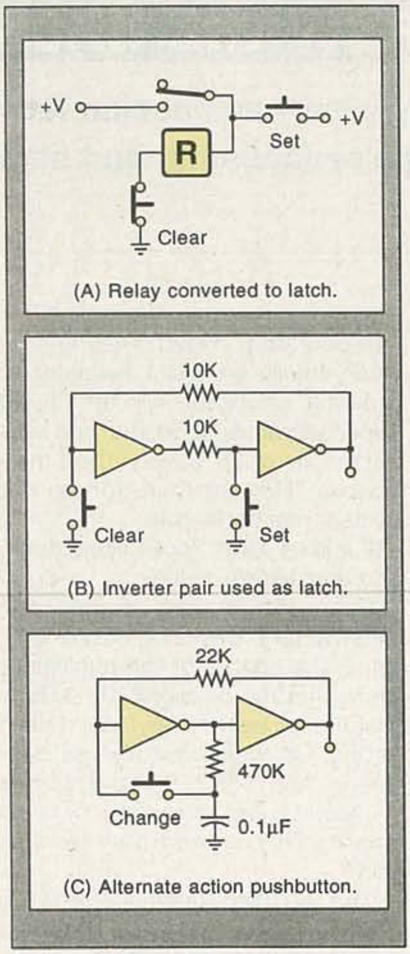


FIG. 1—SOME SIMPLE LATCHES and alternate action circuits.

Alternate action switches

I got a helpline call the other day asking for a circuit to convert any old ordinary relay into an alternate-action on-off device. Well, as the caller has found out on his own, that gets a little trickier than it sounds.

Figure 1-*a* shows how to convert a regular relay into a latching relay. Press normally open button A and your relay pulls in. The pull in closes a relay contact that *holds* the relay engaged. To reset the relay, press normally closed button B. The relay drops out, opening its latching contact. This is a simple example of a *latch*, or a *set-reset* flip-flop.

In Fig. 1-*b* we've used a pair of digital logic inverters instead. An inverter outputs a one for any zero input and vice versa. Assume the left inverter happens to be outputting a one. The right inverter sees this one as an input, and output zero. The zero in turn reach around and holds the left inverte its present state. We are t latched and stable. Press butto to set your latch. Press button E clear your latch.

It turns out that any alternate-tion circuit has to consist of distinct storage elements. One for "Where am I?" and one is "Where was I?" If you don't prov two storage devices, you will into major reliability, oscillation, preferred state hassles.

In most integrated circuits, two needed storage elements done with a *pair* of separate latch One is called the *master* flip-fl The other is the *slave* flip-flop. Of they are combined into a sin more complex logic block, formin *type-D clocked flip-flop* or so similar device.

Check carefully, and you will ev find that the button on a retracta ball-point pen consists of two d tinct storage devices.

The simplest alternate-acti pushbutton I know of appears in F 1-*c*. The "Where am I?" stora consists of that pair of back-to-ba inverters. The "Where was I?" st age is the capacitor.

Here's how it works: Some b time after that latch changes, t capacitor will charge up to hold t

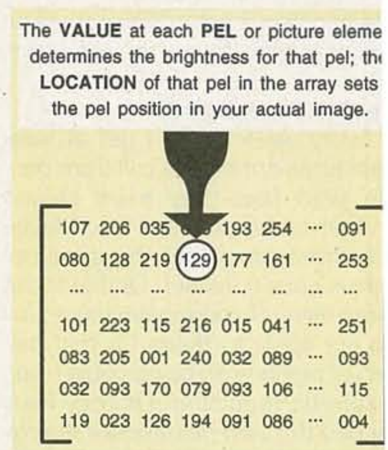


FIG. 2—A DIGITAL IMAGE is nothing b an array of numbers. Digital image pr cessing takes those numbers and places them with other numbe following a rule or set of rules. Wh there is a stunning variety of uses digital image processing tricks a techniques, two of the most importa involve gamma correction and hist gram equalization.

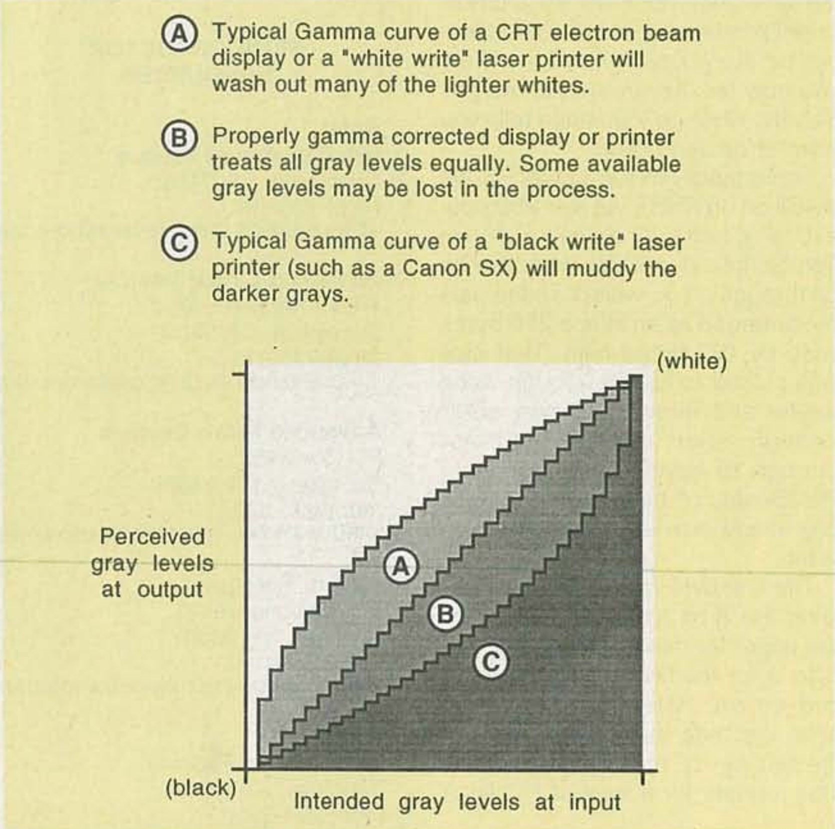


FIG. 3—THE GAMMA CURVE for any display or printer relates how the brightness levels are viewer perceived compared to how they are input. A non-linear gamma either "muddies the lows" or "washes out the highs." Gamma correction attempts to make each gray equally significant to the end viewer.

"Where was I?" one or zero. Pressing the button forces the "Where was I?" value back onto the input of the first inverter, and the latch quickly flips.

That happens because the charge on a capacitor cannot change immediately. Thus, at the instant the switch is closed, the capacitor acts as a very low impedance which "force feeds" its value to the inverter input. As soon as the inverters flip, positive feedback reinforces and holds the new value.

Releasing the button will let the "Where am I?" pair of inverters work normally. A short interval later, the capacitor will charge up (or down) to its new "Where was I?" value, and the cycle can repeat.

The circuit can also be used as a relay driver. It's the fastest and best way I know of to make a mechanical relay reliably alternate its states. While any old CMOS gates could be used, my favorite here would be a 74HC13 hex Schmidt trigger. Much more technical information on counters, latches, and state alternation appears in my *CMOS Cookbook*.

Digital image processing

I never cease to be amazed at how stunningly versatile that PostScript general-purpose language is. I've recently used PostScript to create a group of rapid, easy, and fun digital image processing tools. The tools and a few test images to go with them have been posted to my *GEnie* PSRT RoundTable as IMAGEKIT.PS.

What I'd like to do here is give you a brief introduction to digital image processing. We'll limit ourselves to high-quality gray-scale images.

We will also try to zero in on doing both a *gamma correction* and a *histogram equalization*. Those are both highly important and little understood crucial uses for serious digital image processing. Fail to understand either one and your images will all end up as disasters waiting to happen.

We'll first note that good old silver halide "slopping-in-the-slush" photo work is both incredibly versatile and highly forgiving—besides having an enormous dynamic range.

Instead, electronic digital displays, printers, and any photosetters *demand* data which is always "right on." If anything misses at all, you will get lousy to useless results. That's why digital image processing has become so important. And so hackable.

Hmmm. To do some digital image processing, you have to start with a digital image. You can borrow one of mine off of *GEnie* PSRT, or grab one from a scanner, off a satellite, a fax machine, or a video-capture board. Such a digital image is made up of *picture elements*, or *pels*. Note that a pel may or may not be the same size as the final *pixel* on your output device. A pel is simply the *minimum resolvable data value* found in your numbers within the digital image.

In a gray scale image, a pel gets defined by three parameters. The pel *luminance* value will tell you how *bright* this tiny portion of your scene will be. Its *X position* value will tell you how far *over* in the picture this pel sits, while its *Y position* tells you how far *up and down*.

Ferinstance, in the LENA.PS file #463 on up PSRT, we use 256 possible grays (ranging from PostScript's 0 = black smoothly up on through a 1 = white). These pels are arranged as an image 256 bytes wide by 192 bytes high. That size was picked to be big enough to be useful and interesting, yet small enough, short enough, and fast enough to have lots of fun with. PostScript, of course, can handle any image size and resolution you want.

The first byte in your data file contains the 8-bit luminance value for the upper lefthand pel. The second byte is for the next pel to the right, and so on. After 256 horizontal pels, the data starts over again at the left pel of the next line down. This repeats for a total of 192 lines

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or 49152 bytes. Or 48K for short.

As Fig. 2 shows us, digital image processing simply consists of taking this large array of digital bytes and then creating a second array of new digital bytes. The bytes in the second array are related to the bytes in the first array by some rule or set of rules. And your processed new image should somehow be "better" for whatever you are trying to do.

For instance, we might just take each individual data value and make it larger. That would brighten your display and give you *lighter* values. Make each data value smaller, and you will instead *darken* your display, favoring darker values.

Should there be any defect in the picture, you can "retouch" by looking at adjacent pel values and working out some type of average. Carried to extremes, this sort of digital image processing can remove telephone poles from pictures, rearrange trees, and literally leap tall buildings with a single bound.

A digital image processing *anti-aliasing* trick lets you remove the jaggies from black and white lines. For anti-aliasing, gray values should get substituted equal to the expected average value at each pel. From any reasonable viewing distance, your jaggies will magically disappear.

Calculating new pel values based upon values of neighbor pels opens up all sorts of powerful digital image processing opportunities. Ferinstance, if you average or low-pass filter against nearby pels, you can soften or *soft focus* your image. If you emphasize differences, you can crispen or *sharpen* your final image. Carried to extremes, a crispening or sharpening becomes *edge detection*, where only outlines remain. A magic algorithm called a *Laplacian* is often used for high-quality edge detection.

What if your original picture is out of focus or blurry? Well, you can go to a rather fancy *Fourier* or wavelet transform into a *transform plane*

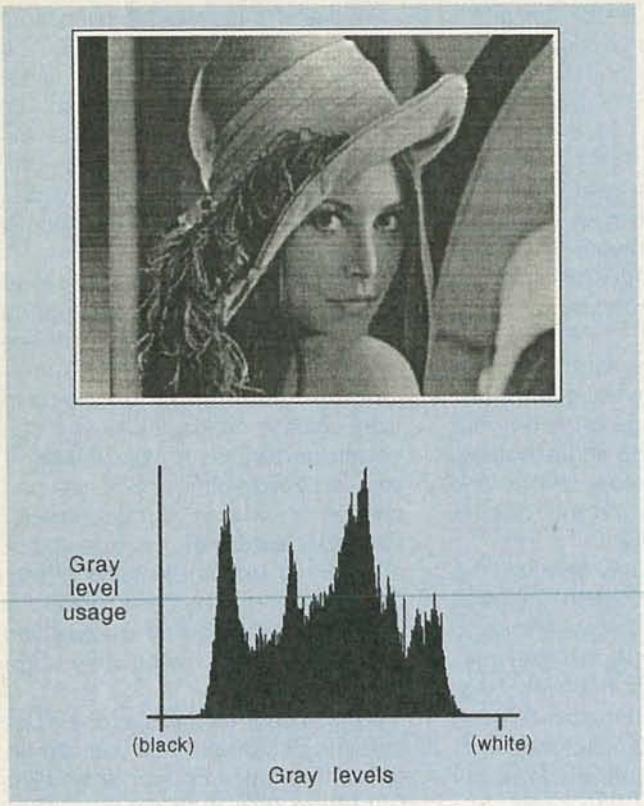

FIG. 4—THIS STOCK "LENA" DIGITAL IMAGE appears rather "weak" or "low in contrast." A glance at the histogram clearly shows why. There are no dark blacks, no lighter whites, and the few remaining grays cluster around the two peaks.

FIG. 5—HISTOGRAM EQUALIZED "LENA" DIGITAL IMAGE much higher contrast. The histogram shows all gray values a full use. A full histogram equalization is the equivalent perfect photo darkroom "dodge and burn."

and extract a *deblurring function*. Which can cancel out much (but not all) of such things as camera motion. And perform such tricks as reading those license plates on speeding cars.

There are now zillions of exciting techniques which use digital image processing. We may look at some of these in future columns. But the first of the two techniques I feel are by far the most important involves...

Gamma correction

The eye acts as a log, rather than a linear device. And deep down inside, most display schemes are also quite nonlinear. As Fig. 3 shows us, the *Gamma* curve for any imaging system relates how the *expected* input gray levels actually *appear* to your eye at the output.

The process of "fixing" a gamma curve is called *Gamma Correction*. On a video display, nonlinearities are *purposely* introduced to attempt to cancel out such nonlinearities as the square law response of most electron beams to a control voltage. In color work, the strengths of each individual beam are also carefully adjusted to make each color appear to be equally bright. Even if the color phosphors used have different sensitivities. As does your eye.

If at all possible, you want to do your gamma correction in some way that does *not* cut into the number of grays you have available. But if it simply can't be helped, digital image processing can be applied to gamma correct your display. It can do that by redefining gray levels, trading off a lot of nonlinear grays for fewer and more linear ones.

All of today's laser printers have inherently nonlinear gamma curves. This happens because a round dot is used which has to be *larger* than the intended square pixel it is supposed to completely and flawlessly cover. Thus, in a *black write* system (such as the Canon SX) where the laser places down black dots, typical gray levels usually end up *darker* than you asked for.

The *PhotoGrade* system used on the Apple *LaserWriter G* uses digital image processing to trade off its gray levels for a more linear gamma. We saw some details on *PhotoGrade* halftoning process month. At 106 DPI, Apple's F toGrade system has 128 gray le available. A total of 61 of these often used for gamma correct The gamma correction redefi lots of really dark grays and a fe the mid range grays. The net re is the remaining 67 distinct and Gamma corrected grays.

The PhotoGrade system of you three calibration options. options compensate for your ticular choice of toner, density tings, humidity, and so on. C calibration, a coarse and a finer tone square are put down for ty gray levels. This is done for t different pages. You then pick page you like the best. The inte code does a predefined Gar correction for you.

Additional details on PhotoG processing appear in my *G* PSRT #451 LASGCAL.PS and in #388 LASGNOTE.TXT. A quite handy is a #R023 *LaserWriter IIg Printers Devel Notes* from APDA.

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Histograms

Those photo darkroom technicians and artists have lots of secret tricks they use to explore the incredible dynamic range of photo film. By lengthening or shortening all their exposures, they can make all of their prints darker or lighter. By printing on a "soft" paper, they can reduce their dynamic range and contrast. Or increase it by using a "hard" paper. Or eliminate it entirely with a "litho" photo paper.

Even more sneaky is *dodging* and *burning*. With dodging, you put your moving and out-of-focus hand or a *dodging paddle* between the enlarger and the area being printed. That *holds back* your light in a selected area and makes that area *lighter* than normal. Which lets you pull details out of any dark or "muddy" areas of your negative.

With burning, you hold an opaque mask having a small, ragged, out of focus, and rapidly moving hole in it between your enlarger and the print paper. Burning lets you darken your highlights and extract details from underexposed areas.

By now, most of you have seen those spectacular Navajo slot canyon photos. Most any southwest calendar should include at least one example. And *Arizona Highways* will be happy to sell you bunches of them. These incredible prints carry dodging and burning to an extreme, using multiple exposures and twenty or more very precisely aligned dodging masks to bring out the subtleties of color and texture.

Digital image processing can be used to imitate these darkroom tricks. And getting things right on gets even more important with digital images, because you will always be *severely* limited by both the dynamic range and laser resolution.

The first step in correcting a digital image is to find out what was wrong with it in the first place. To do this, you run a *histogram*. A histogram is simply a vote on how many of the grays get used how often. Figure 4 shows us the stock and well-known *Lena* digital image, which should appear slightly "weak" or low in contrast.

That histogram underneath Lena clearly shows us why. Those lightest and darkest grays are not used at all. And most of the rest fill two clearly defined peaks.

A digital image processing method known as *histogram equalization* will let you perform a magic dodging and burning that can often dramatically improve your results. In Fig. 5 you see a much higher contrast and greatly improved Lena with lots more "snap."

To do your histogram equalization, you try to spread all of your pels around such that *each gray gets used nearly as often as any other*. You can then selectively replace each pel with a lighter or a darker gray, adjusting your accumulated sum to spread out the total number of pels per gray.

In short, you'll do an absolutely perfect dodge and burn.

For instance, if you have 49152 pels in your image and use 256 gray levels, you redefine your grays to get about 192 or so pels per gray level. A simple accumulated running average does the job for you. Full code details in my digital image tools on *GEnie* PSRT, especially IMAGEKIT.PS. As you can see in Fig. 5, nearly all of those available grays are fully and uniformly used.

By doing a histogram equalization, you can print "auto shopper" quality images on any unenhanced 300 DPI laser printer.

Figures 4 and 5 are available as PSRT files #463 LENA.PS and my #468 LENAHIST.PS.

Semiconductor chip houses

I have been meaning to do some resource sidebars that give you most integrated circuit manufacturers, or at least the more hacker-friendly ones. Since there's so many of them, we'll need several sidebars to do the job right. So, *Actel* through *Fujitsu* will appear this month, and I'll show you the rest of them as we get to them.

Some data books are free. Others have "optional" pricing depending on whether the sales person likes you or whether any of the covered chips are currently being promoted. For others, just about everybody has to pay the going rate.

Your best bet is to first request a short form catalog, a price list, and their technical literature and application note index. These are all usually both free and immediately available.

Be sure to use your laser-printed letterhead or a professional sounding telephone request.

New tech lit

Data books include the *Optoelectronic Products Catalog* from *Quality Technologies*. This used to be the old *GE/Harris* opto line.

Advanced Linear Devices has a *Product Databook* on linear timers, op-amps, and comparators.

From *Signetics/Philips*, there's a new data book on *CMOS Sequencer Solutions*. And from *Hitachi*, there's a *Semiconductor Devices for Communications* data book. Included are lots of telco and cellular radio devices.

Our two brand new labor-of-love newsletters include *WeatherSat Ink* and the *Geo-Monitor*. The first is on weather satellite image reception; the second on earthquake monitoring and prediction.

Over in our neat mechanic[al] department, a free sample of machined plastic is availabl[e] *KMC*. And an incredible c[atalog] from *Outwater Plastics*. Thes[e] are laboring under the delusi[on] they are now in the store [fixtures] fixtures business. In reality, t[hey] fer lots of useful new electron[ic] prototyping hardware at unbe[lievable] prices. Not to mention off-t[he] ideas. They even stock Grecia[n] for writing odes on.

For *the* two key books o[n] the fundamentals of digita[l inte]grated circuits, try my *C[MOS] Cookbook* and *TTL Cookbo[ok]* ther by themselves or as part *Lancaster Classics Library*.

As usual, we've gathered m[ost] the resources mentioned to[gether] into either the *Names & Numb[ers]* the *Integrated Circuit Ma[nufac]turers* sidebars. Check thes[e] *before* you use our no-charge nical helpline or call for you hacker secrets brochure.

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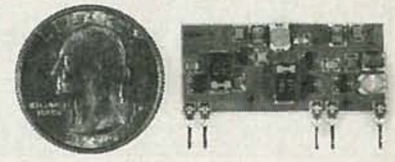

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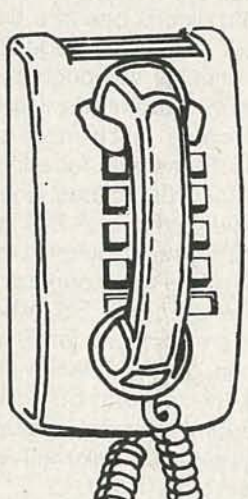

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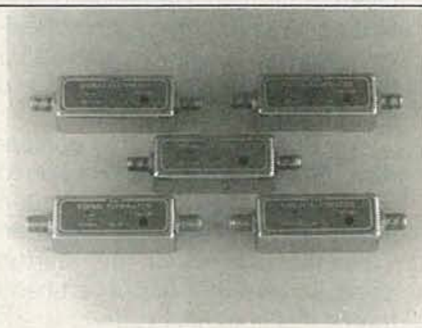

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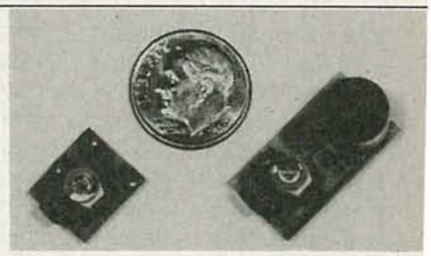

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Let's see what's involved in descrambling a SSAVI signal.

ROBERT GROSSBLATT

Fooling around with the simple video stuff we've been building is a nice alternative to hanging around on street corners, but it's not really all that terrific if your ultimate goal is to figure out what to do with the junk that shows up on certain channels on your TV. Suppressed sync is the Model-T version of video scrambling, and you can bet your bottom dollar that things have gotten a lot more complicated. Enter the digital age.

Since the suppressed-sync scrambling system was so simple, it wasn't long before people with only moderate electronic skills figured out what was being done and how to beat it. Even the simple stuff we put together over the last couple of months could—with some minor additions—do the job. As the cable business grew, so did the complexity of their scrambling methods.

As I told you when we first started out on this trip into cable video land, ripping the video signal apart is easy—putting it back together successfully is something else entirely. The amount of messing up that's done to the standard video signal is directly proportional to the cost. More intense scrambling is more expensive. Cable operators have to balance their degree of security against the cost of the equipment. Also, the larger the customer base, the less expensive the scrambling system has to be. In New York City (and other large areas), the cable companies have a lot of subscribers, each of whom needs a cable box. The more boxes the cable company has to buy (they don't make them themselves), the more money it has to keep tied up in its inventory.

The old suppressed-sync system was a one-way deal. If you got a box that could descramble one channel, it could descramble any channel. Which channels would be unscrambled was determined by one of the wafers on the channel selector dial. A position would be either jumped or open, which was a major cable company headache for two reasons. The first was that they had to open the boxes and solder or cut traces to configure the box for a given customer. The second was that some enterprising people realized what was going on, opened up their cable boxes, and reconfigured it themselves.

The only way the cable companies could guard against that was to use screws with oddball shaped heads to hold the box together. When that didn't work, they started using screws that had a left-hand thread. But enough history.

What the cable companies needed was a way to talk to each of the boxes individually, while they were in customer's homes. Making such addressable boxes also meant that several scrambling methods could be used; the boxes could be told which method was in use at any one time. Since that information could be sent to the box during the vertical blanking interval (while the beam was off the screen), the cable operator could change the scrambling method from field to field—up to sixty times a second. The boxes could also keep a serial numl an EPROM or some other st device, which meant that b could be addressed individuall the descrambling circuitry cou turned on and off for separate nels from the main cable com office. The cable companies it.

Understanding that kind of s a bit more difficult than the old pressed-sync system, but i take the pieces one at a time gets cut down to manageable sized chunks. Although the company's scrambling delivery tem became much more sop cated, it was still faced wit same cost restrictions when i to decide which of the ava scrambling techniques to use

One of the most popular ch was the so called SSAVI sy That's an acronym for Sync pression Active Video Inversi allows the video to be deliver your doorstep in one of four fla

- Suppressed horizontal syn normal video (Fig. 1).
- Suppressed horizontal syn inverted video (Fig. 2).
- Normal sync and suppresse eo (Fig. 3).
- Normal sync and normal (we can forget this one).

Before we get into the nitty of the SSAVI system, there

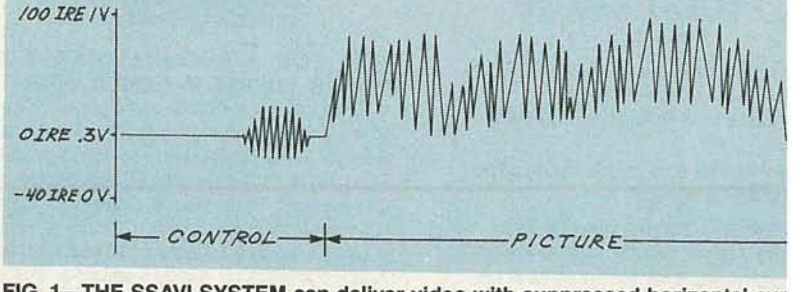

FIG. 1—THE SSAVI SYSTEM can deliver video with suppressed horizontal syr normal video.

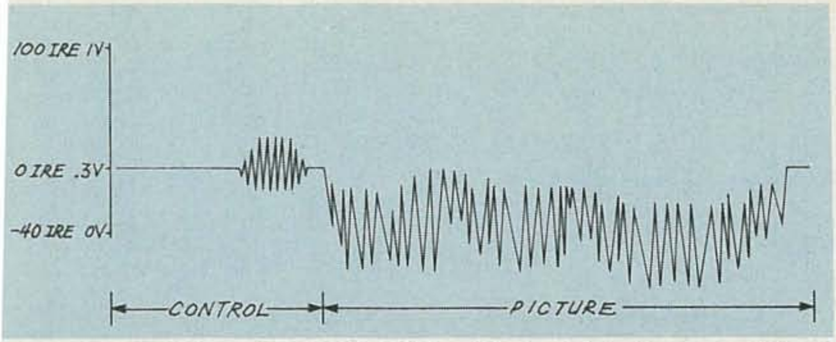

FIG. 2—SUPPRESSED HORIZONTAL SYNC and inverted video is also possible with the SSAVI system.

few basic things you should know, because they tell you some interesting things about how the system works.

The first is that horizontal sync is never inverted—even if the picture is inverted. This means that any circuit designed to descramble it has to separate the two basic parts of the video line (control and picture first). We have to be able to turn the picture right side up (if needed) without inverting the control section as well.

The SSAVI system seems even more complex when you realize that the job of separating control and picture has to be done on lines that might very well have no horizontal sync pulse that can be used as a reference mark. In the older suppressed-sync system, the sync could be recovered from the gating signal that was buried in the audio; with the SSAVI system, there's nothing like that available.

The key to regenerating the video signal is based on the fact that all aspects of it are tied together in a strict mathematical relationship. If you can locate one part of the signal, you can determine where everything else has to be.

The broad picture for a descrambler, therefore, is to design a circuit that can identify one part of the signal, and then use the repetition of that signal as a reference for restoring the rest of the video. You should realize by now that we're talking about a phase-locked loop, or PLL. Even if the identifiable component of the video occurs only once a field (or even once a frame), that's still often enough to control the frequency of a voltage-controlled oscillator, or VCO, and lock the PLL to the received video.

This isn't as strange as it might seem. In a normal video signal, the reference for color is the burst signal that follows horizontal sync. The colorburst signal lasts only a bit longer than 2 microseconds, but it's used as a reference for the whole video line, which is about 63 microseconds long. As far as color correction is concerned, that means there's no real reference signal available for more than 95% of the line! The color phase for the rest of the

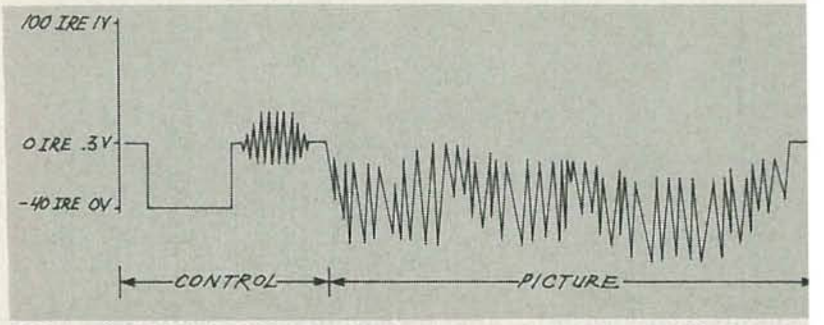

FIG. 3—HERE'S WHAT NORMAL SYNC and suppressed video look like.

line is based on the stand-alone 3.58-MHz generator that's a normal part of the TV set.

Building a SSAVI descrambler isn't as easy as building one to take care of suppressed sync, but it's not as difficult as you might think. Before we start to work out the details of the circuitry, we have to draw up a comprehensive list of exactly what we want the circuit to do. A circuit designed to descramble the SSAVI system needs the following basic features:

- A means of knowing if the picture will be normal or inverted.
- The ability to generate horizontal sync pulses.
- A way to identify a definite point in the received video.
- A circuit to place horizontal sync pulses at the right point.

Some SSAVI systems also play games with the audio, but the methods used to hide the audio have been around for a long time. The audio is usually buried on a subcarrier that's related, in some mathematical way, to the IF component of the TV signal. We'll get into that briefly when we take care of restoring the picture.

Although we'll be working out the details of the circuitry next time, you should already have some ideas of what it has to be like. The SSAVI system uses digital signals for security and access rights—the stuff that cable executives lie awake all night thinking about (instead of less-important things such as improving picture quality, increasing channel services, and widening the audio bandwidth. Because the first step in handling SSAVI scrambled signals is to locate a known point in the signal, we'll be using counters and other standard digital logic to keep track of where everything is supposed to be. That's right peop most of the guts of a SSAVI scrambler are made of the sa standard digital stuff we've be using in this column since the beg ning.

In the future we'll take apar typical frame of SSAVI-encod video and see how we can pu back together again correctly. not as complicated as you think a to tell you the truth, I wouldn't b bit surprised if a bunch of you re ers beat me to it. In the meantin to help you appreciate what's volved in scrambling a video sigr next month we'll work on some cuitry that will scramble a perfe good video signal.

COMPUTER CONNECTIONS

Miniature multimedia machines.

JEFF HOLTZMAN

Apple has indeed announced a second miniature multimedia machine (MMM), as rumored here last month. Newton, the first MMM, will be designed and produced in conjunction with Sharp Electronics, and is more computer than gadget. Sweet Pea, the second, will be designed and produced in conjunction with Toshiba, and is more gadget than computer. Whereas Apple has publicly shown the hand-wired Newton prototype, Sweet Pea appears to exist only at the conceptual level. Nonetheless, the implications and technology behind Sweet Pea are enormous.

Newton has no keyboard, but uses a stylus for input. Connectivity to other Newtons, and to PC's and Macs, is also strong. The point is to service students, executives, factory workers, and others who need on-the-go computing that integrates smoothly and cleanly with desktop systems and networks.

Sweet Pea, on the other hand, appears to be aimed squarely at the consumer market, in particular, a segment that some are calling by the awkward term *infotainment*, which attempts to combine learning and entertainment. Sweet Pea will play specially prepared CD's containing text, graphics, audio, and video. According to one Toshiba official, it may connect to a TV set for home use, or it may be portable. It should hit the shelves in summer of 1993, and should be priced under $1000.

The software technologies behind Sweet Pea are mighty interesting. Kaleida, the joint venture in multimedia between IBM and Apple, will supply these technologies. One is called Script X; it is an authoring language that developers can use to create multimedia titles that will run on multiple platforms, including Intel and Motorola CPU's, and RISC devices. It will also run on special operating systems used by MMM's. In fact, Kaleida is developing one such operating system, the Consumer Operating System (COS) that will, of course, support Script X. Script X is also slated to support Apple's multimedia standard, QuickTime.

Apple has signed deals with Warner New Media and Paramount Communications to supply titles; Claris, Apple's software subsidiary, will also develop new titles.

Kaleida got off to a slow start, and has been partially eclipsed by other more immediately apparent benefits of the historic 1991 accords between IBM and Apple. However, the recent appointment of a board of directors, along with Nat Goldhaber as head of Kaleida, not to mention the Sweet Pea technology announcements, all indicate that Kaleida is likely to be the vortex of some fascinating and industry-shaking new developments.

Less technologically advanced, but likely to have some market impact, are new pen-based pocket organizers that will be introduced by Sharp and a joint effort between Tandy and Casio. At an estimated $300, the Tandy/Casio unit aims to undercut initial pricing on Newton and Sweet Pea devices. The Tandy/Casio will use the GeoWorks graphical environment, will have built-in handwriting recognition, and will have a PCMCIA slot for memory and telecommunications. Look for it sometime in 1993. The Sharp unit adds pen input to the Wizard line, and includes an extensive pushbutton/menu-based interface. Pricing was unclear as of press time; the device is scheduled for release this year. Also scheduled from Sharp is an 8088-based palmtop that should sell for about $1000.

Microsoft is hankering after this market as well. Lately there has been discussion about a CD-ROM based machine that would run a ROM-based subset of Windows, connect to a TV set, and provide *infotainment*. Apparently designed to compete in the video-game market, the device is currently going by the name *Wintendo*.

Upheaval in the PC business

In the beginning was the PC, which meant an 8088 and one or two 360K floppies. Then came the XT, which added a hard disk and bumped memory up to 640K. Next came the AT, which added a full 16-bit processor and peripheral interface. Then came the 386, which brought 32-bit processing and unheard-of performance. For a good four or five years, the boundaries between those four divisions were clear. However, in the past two years, the introduction of new CPU's by both Intel and its rivals has almost completely obliterated those bounds. Now there is a smooth spectrum of often overlapping price/performance choices ranging from lowly 386SX's to 50-MHz 80486DX's. It's nearly impossible to keep in mind all the variations among CPU's, including speed, bus width, power management, cache size, math coprocessor, and system support components. Choosing a complete system is no longer a choice among four well-defined categories.

Against that backdrop, manufacturers find it difficult to make their offerings stand out. In the past year, intense price wars have forced system costs to absurdly low levels. At first, the price wars were conducted almost exclusively among clone manufacturers, but Compaq recently joined the fray, IBM has promised to do so by this fall, and second-tier suppliers like Dell have already retaliated. One industry analyst has stated that there are some 500 PC suppliers, of which 450 shouldn't exist. Another analyst suggests that within a few years, the vendor base will be reduced to a dozen multinational corporations that supply 95% of industry needs.

Another trend is that toward increasingly dense integration, both at the chip and the system level. For example, the original PC used 16K DRAM's. Today's standard is 4 megabits, an increase of 256 times. Back then, system logic was built from hundreds of discrete TTL components. Today, three or four VLSI IC's do the same job. At the system level, many motherboards today contain built-in serial and parallel ports, hard- and floppy-disk controllers, and expansive memory—16 megabytes or more. By contrast, original IBM motherboards seldom held more than 512K of memory, and contained nothing but the required system logic.

Together, price wars and the larger trend of increasing integration lead to the necessity of *product differentiation*, or some means of making your product stand out in the customer's mind from that of your competitor. Price cutting is one way, but it can only go so far. The other way is to add features, and that's what we'll start seeing this fall.

Look for systems with built-in networking and sound capabilities. Look for systems from IBM and others with preinstalled operating system software (OS/2, DOS/Windows). Look for systems with tons of bundled applications. Look for creative marketing schemes. (For example, DAK, a mail-order house, now gives away a 386DX/33 with purchase of $1500 worth of software—and quality stuff at that, including current versions of Windows, Word for Windows, Norton Desktop, Adobe Type Manager, Paradox, and more). Look for preassembled networks supporting anywhere from 2 to 250 users. Look for hard-drive upgrades from Seagate and others with preinstalled software (Windows). Look for laser-printer upgrades that include RAM with font and emulation cartridges. Look for operating systems (Windows and OS/2) to include more and more features traditionally assumed to be part of the applications realm, e.g., networking and E-mail.

The following are several trends to watch:

CPU Wars

Intel continues to try to fend off attacks on its 386 business—AMD expects to take 50% of the mar by the end of this year—but b AMD and Cyrix are mounting r offensives on the 486. Cyrix wil troduce 25-, 33-, and 40-MHz sions of its 486 clone at about the price Intel charges. Meanwh AMD plans similar introductio but a recent legal setback co stall its efforts. IIT is also enter the race; the company stated cently that it is developing a clone with integrated video disp and image compression hardwa paralleling Intel's efforts to comb an X86 CPU with IBM's XGA gra ics and Intel's own Digital Video teractive (DVI), a digital system compressing and playing back eo on standard PC's. Timely in duction of the latter could be breakthrough PC-based multime has been waiting for.

Intel's P5 (sometimes known the 586, although reports indic that Intel is searching for a n name) contains two CPU's, a 4 compatible unit, and a Reduced struction Set Computing (RIS unit. What's the value of stickin RISC chip in a PC? On the ot hand, what would be the value sticking a 486 in a workstation (r mally powered by a RISC chip)? PC, let the 486 do PC things (DC Windows, OS/2), and let the RI unit run the video system or a de cated compression/decompr sion unit. In a workstation, let RISC unit do Unix things, and let 486 provide PC compatibility.

Power Play

Power consumption is becom a hot topic not only among nc book PC vendors, but among de top system vendors as we Consumers demand longer batt life from their notebooks—a m mum of eight or ten hours. Deskt vendors need to cut power c sumption for reasons of energy c servation. Significantly reduci energy consumption by comput would save $1 billion per year, p reduce CO_2 emissions by the eq alent of 5 million automobiles dur the same period. Achieving the reductions is not wishful thinking recently formed industry/gove ment coalition that includes EPA, Apple, Compaq, DEC,

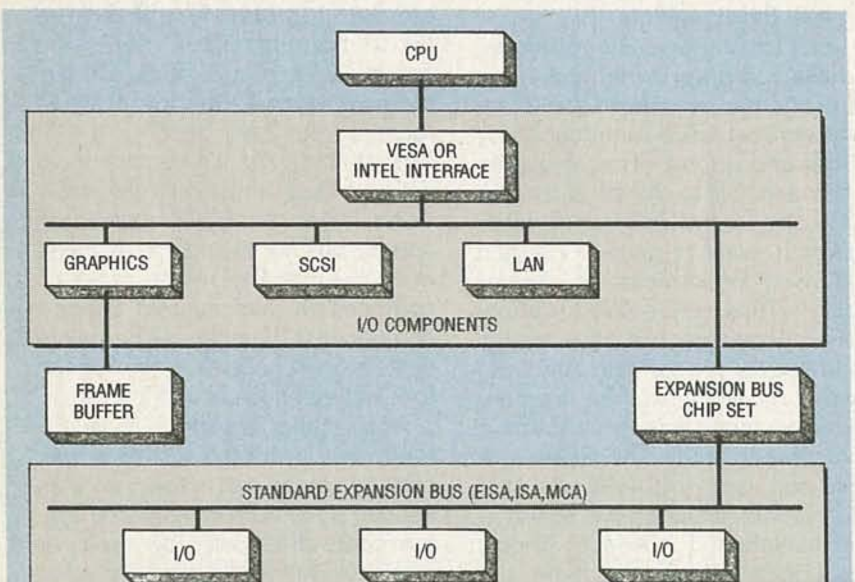

FIG. 1—LOCAL BUS ARCHITECTURES supplied by Intel and the Video Electronics Standards Association (VESA) promise to provide a high-bandwidth channel between the CPU and fast peripherals including video and network adapters, and mass-storage interfaces.

IBM, NCR, Zenith, and other manufacturers announced a set of design parameters centered around several types of "sleep" modes and 3.3-volt system components. The goal is to reduce power consumption of the average PC to 30 watts.

AMD is promoting 3-volt system design guidelines, and it says that a complete PC chip set will be available this summer, with product introductions (probably centered around notebooks) scheduled for fall COMDEX. To support this burgeoning market, Intel has announced a 3.3-volt version of the 386SL that includes a fully static CPU, cache controller, bus and memory controllers, that can interface with both 3.3- and 5-volt peripherals. Cirrus Logic has introduced a dual-voltage video controller.

Just Add Water

Networking is not yet fully pervasive. However, new chip designs promise low-cost system additions that will further spread the ability to link up. One study shows steady growth in units shipped per year during the period 1989 (2.2 million) through 1995 (6.7 million). AMD has introduced a single-IC Ethernet adapter that (along with similar devices from National, SMC, and others) is going to further increase the availability and use of networks. The chip will be a built-in component on many new motherboards; several influential PC systems houses (Apple, Compaq, Dell, HP, Northgate) have already introduced (or will shortly) systems with built-in network adapters. Couple that with increasingly aggressive marketing by Novell, plus built-in network capabilities of the next version of Windows—and you've got instant networking.

The Magic Bus

Windows and OS/2 demand fast, high-performance computers. As clock speed increases, getting data in and out of the CPU becomes more critical to maximizing system performance. Our trusty old system buses (ISA, EISA, MCA) simply aren't up to the task. In recent months, computer manufacturers have added a local bus that provides a direct path between the CPU and some other component, usually a special video adapter. So far, however, these efforts have been hampered by a lack of standards.

In response, Intel and an industry consortium called the Video Electronics Standards Association (VESA) have each devised its own local bus standard (see Fig. 1). Some published reports have claimed that the two standards will compete with each other; however, Intel officials have stated publicly that the two efforts are complementary. Both share throughputs in the 120–130 megabytes-per-second range. The VESA spec includes a connector design (based on a Micro Channel bus connector) that the Intel spec currently lacks. On the other hand, the Intel spec includes a special interface IC that helps isolate the CPU from I/O subsystems—and that presumably allows for transparent CPU upgrades via the company's OverDrive technology. Due to bus-timing and signal-reflection issues, local bus slots will most likely be limited to three, e.g., one each for video, network, and hard-disk control; the latter could be a SCSI host adapter for connecting multiple devices. The regular expansion bus would then be limited to slow-speed devices.

In short, the next few years will see many PC vendors dropping out; the ones that remain will be fighting tooth and nail to establish their products with increasingly dense integration of hardware and software components. Price wars are already raging; feature wars are just about to break out. This is going to be one heck of an interesting battle. **R-E**

HANDI TALKIE

continued from page 60

ed, variable Polyswitch resistor R30 could trip and/or the output power MOSFET's could overheat.

When using the flexible "rubber ducky" antenna, it might be necessary to fine tune capacitor C30, taking care to keep the antenna away from people or large metal objects.

After tuning the transmitter, set up the receiver. Turn the power ON and set the SQUELCH control fully counterclockwise (OFF). With the 32-ohm speaker connected, increase the volume until the background noise is audible. Using the oscillocope, look at the output from RECOVERED AUDIO pin 16 of the FM receiver chip IC3, and adjust inductor L10 so that the signal reaches a maximum level.

If an FM-modulated RF source is avaliable, connect it to the antenna jack and set it to a 1 microvolt output level. Set the audio signal to 1 kHz and the deviation to 4 kHz. Adjust L10 for a symetric waveform on pin 16 of IC3. The tone should be audible in the speaker. Set the input level to 0.3 microvolts and adjust L3 for minimum noise level. (This adjustment is optional.)

The range of the transceiver with the specified antenna is one to three miles, depending on background noise and the proximity of buildings or geographical obstructions. The range can be increased with a citizen band (CB) base station antenna, or if its transmission frequency is set for the 10-meter amateur radio band and a suitable antenna for that frequency range is connected.

To change the transceiver's frequency from 25 MHz to 31 MHz, change crystals 1 and 3 (XTAL1 and XTAL3) and tune the transceiver according to the instructions given earlier. (See the Parts List for the crystal specs.) To operate the transceiver outside of the 25-MHz to 31-MHz bands, the transmit filter as well as the multiplier components must be changed. **R-E**

VERSATILE OSCILLATOR

continued from page 74

That resistance value will keep the peak speaker currents within the 200-milliampere output limit of the 555. The output power of this alarm circuit depends on speaker impedance and supply voltage, but it can be as high as 750 milliwatts with a 75-ohm speaker and a 15-volt supply. Notice that C3 ia an electrolytic capacitor.

Figure 19 shows how the output power of the circuit in Fig. 18 can be boosted to several watts with buffer transistor Q1. The resulting high speaker output current can introduce a significant ripple voltage to the power source. Diode D1 and electrolytic capacitor C3 protect the 555 from the effects of that ripple. Diodes D2 and D3 clamp the inductive switching spikes from the speaker and protect Q1 against damage. The circuits in Figs. 20 to 23 have a similar output stages.

Figure 20 shows how a pair of 555's organized as astable multivibrators form an 800-Hz pulsed-tone alarm generator. In this circuit IC1 is wired as a 500-Hz alarm generator, and IC2 is wired as a 1-Hz oscillator that triggers IC1 on and off through diode D1 once per second, thus generating the pulse-tone alarm.

The circuit in Fig. 21 generates the penetrating two-tone "he-haw" sound of European emergency vehicles. Here, IC1 is also wired as an alarm generator, and IC2 is wired as a 1-Hz oscillator. But in this case the output of IC2 frequency modulates IC1 through resistor R5. The output frequency of IC1 alternates symmetrically between 500 Hz and 440 Hz in one-second alternating cycles.

Figure 22 shows a circuit that generates the wailing noise of a police siren. Here IC2 is wired as a low-frequency oscillator with a cycle period of about 6 seconds. The slowly varying *ramp* waveform of IC2, buffered by emitter follower transistor Q1, frequency modulates alarm generator IC1 through resistor R6. In this circuit IC1 has a natural ce frequency of about 500 Hz. alarm output signal starts low frequency, rises for tl seconds to a high freque then decays over a perioc three seconds to a low-frequ cy before repeating itself as l as power is applied.

Finally, the circuit in Fig. generates an alarm that si lates the "Red Alert" that is o heard in the Star Trek TV ser The sound starts at a low quency and rises to a high quency in about 1.15 secor ceases for about 0.35 secor and then starts rising ag from a low frequency. H again, the sound pattern peats as long as power is app to the circuit.

The 555 labeled IC2 is w as a non-symmetrical oscilla Capacitor C1 alternat charges through R1 and di D1, and discharges through The result is a rapidly rising slowly falling "sawtooth" wa form across C1. After buffer by Q1, this waveform freque modulates pin 5 of IC1 throu R7, causing the output frequ cy of IC1 to rise slowly dur the decay part of the sawto waveform and to colla rapidly during the rising pa the sawtooth waveform.

The rectangular waveforn pin 3 of IC2 turns IC1 through common-emitter a plifier Q2 during the de phase of the alarm. Therefo only the rising parts of sound pattern are heard wh sound very much like the S Trek Red Alert.

The outputs of most of the cuits in this article have b taken from *output* pin 3, many of the figures ha shown triangular wavefor developed across the timing pacitor (e.g. Figs. 3b, 11b, and 15b). There might be oc sions when you will find th sawtooth (or ramp) wa useful. You can obtain a s tooth by tapping the cha voltage across the timing ca itor. By charging the capac with a constant-current sou instead of a simple resistar the ramp can be made quite ear.

AUDIO UPDATE

continued from page 78

sical-music audience and the poor audio quality of most FM broadcasts. In any case, the question remains: Is the listening public really interested in AM stereo?

I don't relish raining on anyone's parade, but I suspect that (to mix a metaphor) the AM-stereo bandwagon will never get off the ground.

The AMAX logo will identity AM receivers that meet the NRSC requirements.

Consumer fraud?

One of the panel discussions at last fall's Audio Engineering Society convention was titled "New Cable Designs: Innovation or Consumer Fraud?" The organizer of the event was strongly anti-cable and had stacked the panel accordingly. One of the surprising guests was Wilfredo Lopez, a non-audio person from the New York City Department of Consumer Affairs. He presented his department's view about what constituted fraudulent advertising, and suggested that most audio components are "blind" items, meaning that the average consumer is not in a position to judge the validity of advertising claims. Deceptive practices include "false implications of quality or characteristics of the item." Mr. Lopez went on to say that if his agency finds stores trying to sell a speaker cable that is heavier but not better—but they are nevertheless claiming it is—it might take action against them.

I would caution Mr. Lopez to tread carefully. In any area where consumers are being sold "dreams"—products that purport to make them slimmer, younger, more beautiful, or their equipment better-sounding—they don't want to be told that they are being deluded. For example, the cosmetic industry would seem ripe for such an investigation with its cellulite removal creams, skin rejuvenators and other such products. Is it a defense or justification for the manufacturer to say that the consumer "thinks" the product works, notwithstanding objective evidence to the contrary?

In truth, it had never occurred to me that the absurd claims made by many high-end cable and accesso
manufacturers could be legally
fined as fraudulent. In the years t
I've been dealing with audio equ
ment claims, I never became v
upset by the sometimes technica
off-the-wall—or at least unprover
pronouncements of the vario
manufacturers. As a matter of fac
even had a hand in writing some a
and technical papers for varic
companies promulgating th
sometimes strange technologi
points of view.

Because the literature was aim
at a high-end audience, I felt no g
at providing the kind of nonser
they loved to hear. After all, I
tionalized, it wasn't as though
outrageously priced equipment v
depriving anyone's wife and child
of food.

My ultimate conscience-clear
maneuver was to editorialize un
my own name against some of
properties (ultra-wide bandwid
olefin cable insulation, dual-pov
supplies, etc.) that I had extolled
the ads. In any case, I took (and
take) none of this very seriou
and I regarded my jabs and jibes
audiophile nonsense as editoria
interesting but not really powe
blows for truth, justice, and
American Way.

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TUBES, new, up to 90% off, SASE, **KIRBY,** 298 West Carmel Drive, Carmel, IN 46032.

T.V. notch filters, phone recording equipment, brochure $1.00. **MICRO THinc.** Box 63/6025, Margate, FL 33063. (305) 752-9202.

SPEAKER repair. All makes — models. Stereo & professional. Kits available. Refoaming $18.00. **ATLANTA AUDIO LABS,** 1 (800) 568-6971.

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( ) ____________________

Special Category: $25.00

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16 ($49.60)	17 ($52.70)	18 ($55.80)	19 ($58.90)	20 ($62.00)
21 ($65.10)	22 ($68.20)	23 ($71.30)	24 ($74.40)	25 ($77.50)
26 ($80.60)	27 ($83.70)	28 ($86.80)	29 ($89.90)	30 ($93.00)
31 ($96.10)	32 ($99.20)	33 ($102.30)	34 ($105.40)	35 ($108.50)

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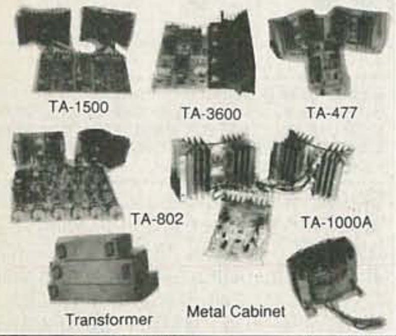

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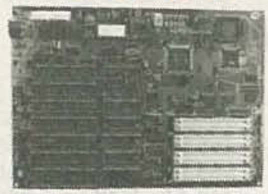

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38421	2N4401	TO-92 case	.15
36038	1N4148	DO-35 case	.07
38308	2N3055	TO-3 case	.69

Switches

Part No.	Product No.	Description	Price
21936	JMT123	SPDT, on-on (toggle)	$1.15
38842	206-8	SPST, 16-pin (DIP)	1.09
26622	MS102	SPST, momentary (push-button)	.39

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Memory

Part No.	Product No.	Function	
41398	41256-120	256K DIP	120ns
42251	511000P-80	1MB DIP	80ns
41523	41256A9B-80	256K SIMM	80ns
41718	421000A9A-80	1MB SIPP	80ns
41769	421000A9B-80	1MB SIMM	80ns

LEDs

Part No.	Product No.	Description	Price
34761	XC556G	T1 3/4, (Green)	$.16
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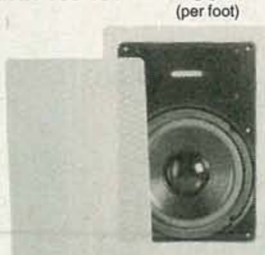

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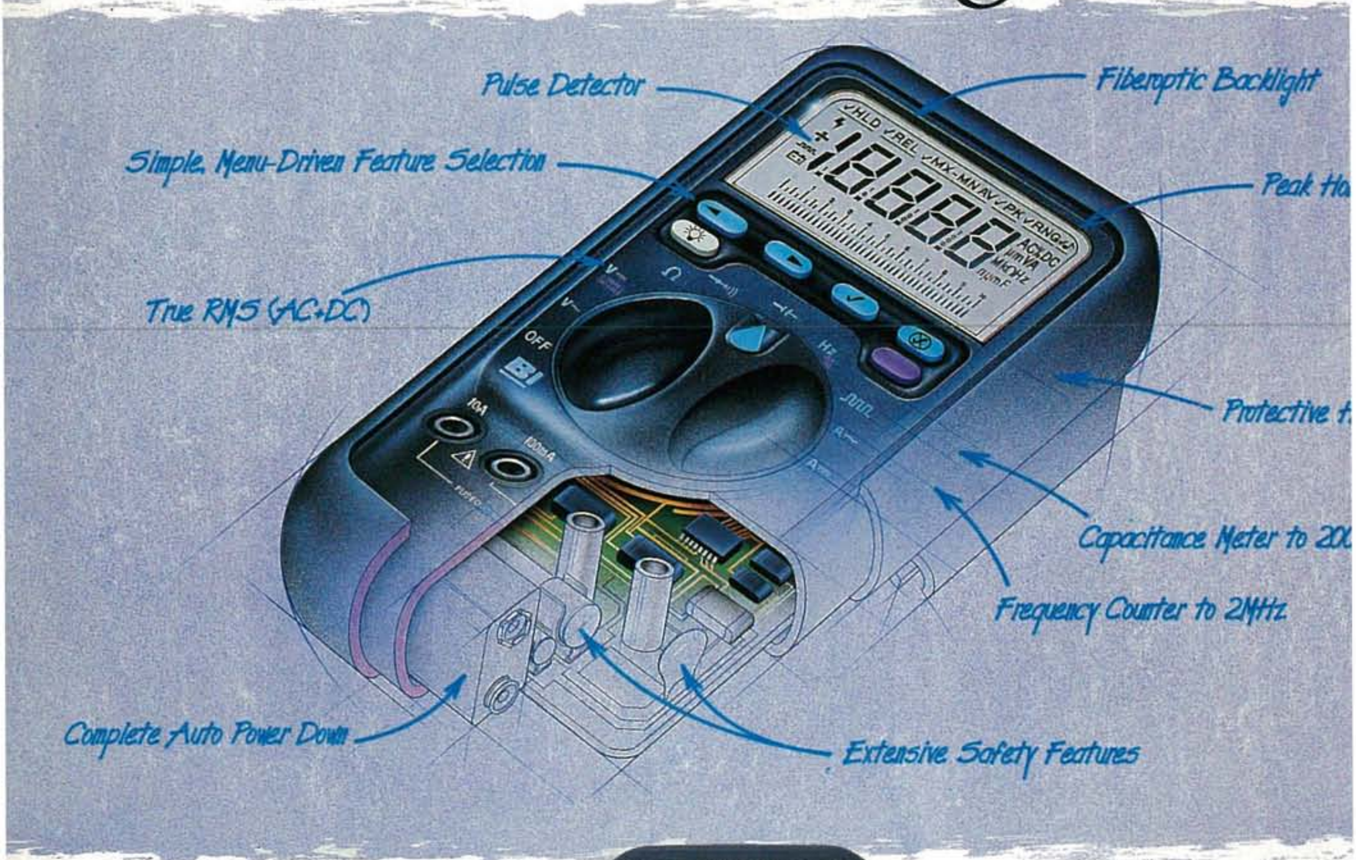

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