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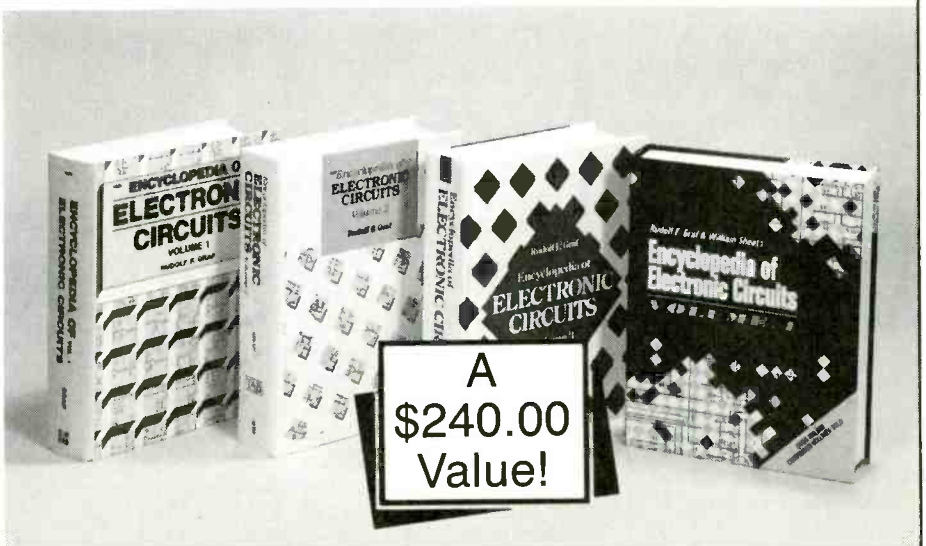

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Circuit design software has been around for about 20 years. Depending on how elaborate the software is, you can draw a schematic, breadboard the circuit, and design a foil pattern for a PC board, all without ever lifting a pencil. These software packages have traditionally been high-priced industrial applications that were too expensive for most hobbyists and small businesses. However, the last couple years have seen an influx of low-cost circuit-design software that's ideally suited for home use and small production work. Now the main problem is finding the program that's right for you. To take the risk and mystery out of shopping for this software, Electronics Now has scoured the market in search of circuit-design packages $350 and less. Turn to page 33 to find out which software package best suits your needs.

— TJ Byers

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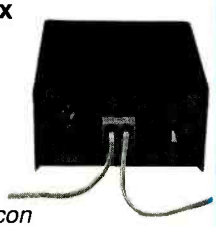

— James E. Cicon

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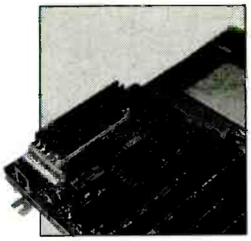

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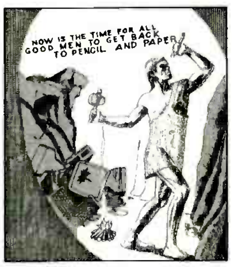

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WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

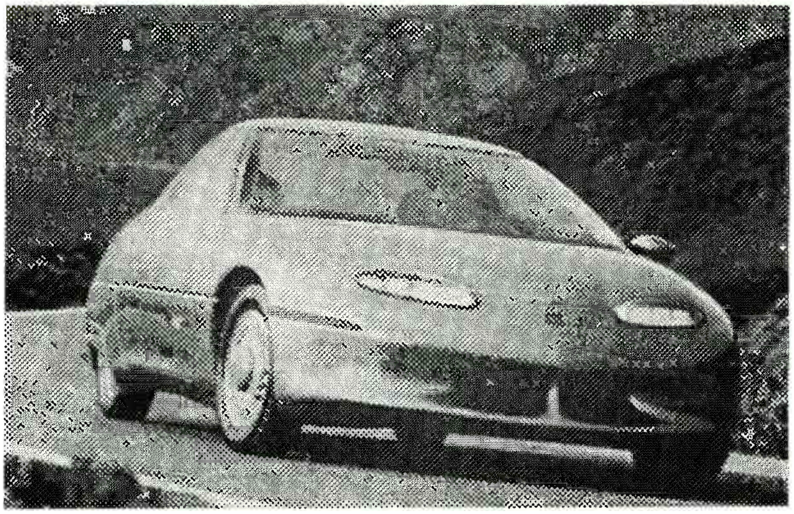
Lead vs. hydrocarbon emissions

The manufacturers of electric vehicles and the batteries for those vehicles recently took a bashing from a report issued by Carnegie Mellon University. The report suggested that the contaminants released by the production and recycling of the necessary lead-acid batteries for powering the cars posed more of a threat to the environment than the emissions from gasoline powered vehicles.

But now the Electric Vehicle Association of the Americas (EVAA) has stuck back by refuting Carnegie Mellon's methodology and findings. EVAA's 13-page technical brief entitled "Environmental Impacts of Lead-Acid Batteries in Electric Vehicles" declares that the Carnegie Mellon study was seriously flawed and led to misleading conclusions.

EVAA points out that crucial calculations in the report were based on incorrect technical data that was derived from General Motor's electric-powered Impact car. That mistake set off an alarming series of miscalculations and unsubstantiated "guesstimating," adding "Those inaccuracies were compounded by the study's presentation of conflicting data in text and charts."

The EVAA report goes on to state that the Carnegie Mellon study grossly exaggerated the projections of the electric vehicle population just to exaggerate their environmental impact. It said that the projection of 10 million electric cars is nearly 80 times the number of electric cars (127,000) needed to meet the EPA zero-emission-vehicle mandates by the year 2000, which now apply in three states.



THE GM IMPACT PROTOTYPE elctric vehicle.

The brief asserts that the existing inventory of lead-acid batteries for the 188 million cars, trucks, and buses now on the road in the U.S. dwarfs all reasonable projections of increases that would be related to electric vehicles. It reasoned that even if each of those 127,000 mandated electric cars were powered by 27 lead-acid batteries (the complement of an Impact), those 3.4 million batteries would only represent less than 2% of all the lead-acid batteries now in cars in this country.

The EVAA refutation declares that the Carnegie Mellon report failed to take into account the probability that future electric cars will include more advanced batteries that contain less lead than today's products, and that materials other than lead can be substituted for electrodes. Moreover, the brief said no mention was made of other possible forms of electrical storage for vehicles, such as fuel cells and flywheels.

To cap off its brief, EVAA zapped Carnegie Mellon for failing to recognize that most lead for car batteries is obtained from recycled lead products, and that modern lead recycling is essentially a closed-cycle, pollution-free process.

Smart cash cards proliferate

Many Europeans have become accustomed to paying for toll calls from public telephones with smart cards containing an embedded microprocessor that deducts value from the card as the caller speaks. The prepaid cards are purchased in local shops in various denominations, and they can be used as many times as it takes for the calling charges to equal the card's purchase price. This form of digital smart card has has now been upgraded

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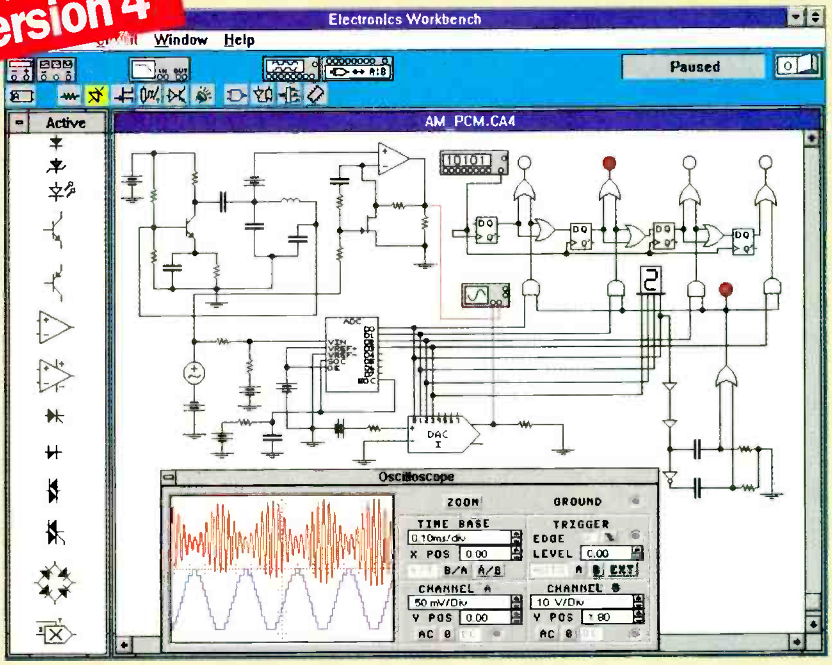

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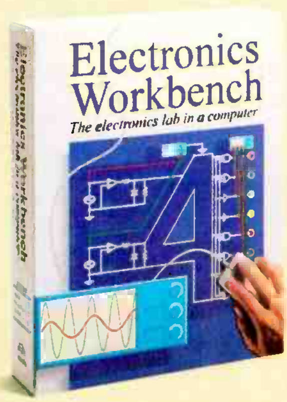

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CIRCLE 126 ON FREE INFORMATION CARD

VIDEO NEWS

WHATS NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

Recordable DVD

The battle over standards for the higher density CD—known in shorthand as the digital videodisc (DVD)—is intensifying, with both proponent groups calling for a single system, but neither willing to give an inch. As reported here (*Electronics Now*, August 1995), the two systems, developed by Sony/Philips and Toshiba/Time Warner are mutually incompatible, and both are being urged not only as the next generation of video disc but as extremely high-capacity CD-ROMs for computers. The two systems are identified as Multimedia CD (MMCD) and Super Density (SD), respectively.

Struggling to compensate for SD's endorsements by movie companies and consumer-electronics manufacturers, MMCD has been pushing for backing by computer companies, but at our press time had received the endorsement only of Gateway 2000, the big direct-marketing PC manufacturer. Now there is reliable information that the MMCD group will soon propose a recordable version of MMCD for introduction as early as 1997. The MMCD-R/E (for "record/erase") extension will use phase-change recording technology, with magneto-optical recording as an optional method. The SD group has already indicated that phase-change recordability is in its future.

Meanwhile, Thomson Consumer Electronics says that it plans to launch the video version of DVD at the May 1996 Consumer Electronics Show in Orlando under its RCA, GE, and ProScan brands. The company is forecasting sales of 2-million players in the first year of sales. Because of the decline in the value of yen, however, Thomson is now hedging its earlier prediction that they will retail at $499 from the start.

Sony's "Micromirror" projector

In a three-year project, Sony has built a prototype high-definition projection-TV system using the Digital Micromirror Display (DMD) technology developed by Texas Instruments. Although neither company is talking about the subject, it seems likely that Sony eventually will produce a line of Micromirror projection sets for industrial, commercial, and consumer use.

TI calls DMD a "digital light switch." Each DMD has an array of hundreds of thousands of aluminum mirrors fabricated on a silicon chip $^5/_8$-inch square. Each tiny mirror represents one pixel. When a voltage is applied to a mirror, it pivots slightly, reflecting light from an external light source through a projection lens onto a screen. When in the "off" state, light reflected from the mirror doesn't enter the lens. Projectors may use from one to three DMDs, with resolution as high as 1280×1024 pixels. The high-definition system built by Sony and was designed to represent the ultimate system—from which more simple systems could be devised.

Three other companies are preparing to produce non-consumer commercial versions of DMD projectors, to sell at $5000 and up. TI, however, is hoping that a consumer version can sell at around $2700, placing it at a popular projection-TV price.

The advantages of DMD, as summarized by TI, are as follows: DMDs can be fabricated on standard semiconductor production equipment. The system is all-digital and thus will be completely compatible with digital broadcasting, requiring no digital-to-analog conversion. It displays a complete frame at a time, without interlaced scan, thereby eliminating flicker. The picture is sharper and crisper, without blooming or color fringing characteristic of shadow mask tubes. The colors are mixed digitally for exact control and don't depend on phosphors. Brightness can be much greater than CRT-type projectors because an external light source is used. The system has square pixels for computer compatibility. Lower gain screens can be used, eliminating the directionality characteristic of CRT systems.

Consumer versions of DMD projectors could be available within two years, according to some manufacturers. The timing depends on the completion of accelerated life tests, which TI says have proven a five-year life span and should be able to guarantee the 10-year life span required by consumer products by this fall.

42-inch plasma TV

Last month we reported that Mitsubishi is planning to use plasma displays in its large-screen TVs as early as next year. Now Fujitsu is setting up a factory in Japan to

Continued on page 10

Q & A

READERS QUESTIONS, EDITORS ANSWERS

OP-AMP ANTENNA AMPLIFIER?

I have a long-wire antenna that I would like to share among several receivers. Given the wide bandwidth and high input impedance of FET-input-type op-amps (TL071/2/4 for example), could I use an op-amp as an impedance buffer for the broadcast band (535—1620 kHz) to fan out one antenna to feed the 50-ohm inputs of multiple receivers?—S. A. Jensen, Brooklyn, N.Y.

We were about to say "of course not" until we tried it! A few years ago, it would have been absurd to use an op-amp for RF signals—the frequency response would be inadequate and there would be too much noise. Today, however, there are good low-noise op-amps usable at frequencies of several megahertz. Figure 1 shows a circuit we breadboarded and tested.

In your situation, there are two problems to be solved: impedance matching and isolation. The impedance of a random-wire antenna at broadcast-band frequencies will be several kilohms, a poor match for the 50-ohm input of a receiver. Also, the inputs of multiple receivers can't be connected directly to a single antenna, or they'll detune each other.

The circuit solves both problems. The first op-amp overcomes the impedance mismatch, strengthening the signal greatly even though it has no voltage gain. The rest of the op-amps feed the signals to the separate receivers. We used a Texas Instruments TL054 op-amp, but the TL074 would work just as well. (Not the TL084, though.) No low-pass filter is needed because the gain of these op-amps drops off sharply above 2 or 3 MHz.

You may need to add some traps to cut out the signals of strong local stations as shown in the schematic. In fact, the overall noise level in your receiver will probably be lower after you add them, even if you weren't aware of a problem. You can make each trap out of any coil and capacitor that resonate at the desired frequency.

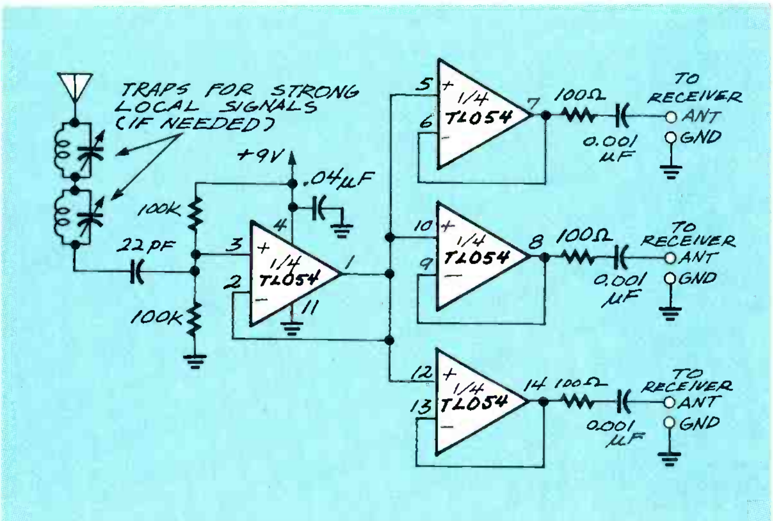

FIG. 1—TL054 OR TL074 HIGH-FREQUENCY OP-AMP distributes broadcast-band signals to several receivers.

CUSTOMIZED REMOTE CONTROL

I need a TV remote control for arthritic hands and fingers, one with larger buttons or rocker type volume and channel switches. Can you give me a diagram with the parts and values to construct one with just on-off, channel change, volume, and muting?—H. DeKeyser, Lake Elsinore, CA

Start by buying a universal remote control at a discount store. That will give you the ICs, LEDs, and other support circuitry ready-made. Then mount it in your own enclosure and hard-wire your own switches for the functions you need, and leave out all the rest.

This is an approach that hobbyists should consider for lots of projects—instead of building something from scratch, modify a readily available consumer item. It's cheaper!

CACHE MYSTERY

I recently installed 256K of external cache RAM in my Leading Edge computer and now, although I can still *boot DOS, Windows will not load. If I disable the cache, Windows will load properly. Do I have to set up Windows to recognize the cache or is there something wrong with my computer?—R. Van Workum, Laton, CA*

A Cache RAM is a small amount of special, fast memory into which the computer puts a copy of whatever it is reading from the real RAM. When executing a program, the CPU often reads the same small area of RAM repeatedly, and by fetching instructions from the cache instead of from RAM, it is able to run faster. Windows doesn't require any special setup to use a cache. In fact, software should not even be able to tell whether the cache exists.

The first thing you should do is replace the cache RAM chip; it's probably defective. If it checks out OK, and all your DOS applications run properly, the next step would be to start Windows with the command "win /b." That tells Windows to create a file called BOOTLOG.TXT describing every step it when through when starting up. That will at least tell you what part of Windows is running into the problem. You might be able to de-install a device driver to clear up the problem.

TRS-80 FOREVER?

Q *I have a Radio Shack TRS-80 Model III computer. It needs servicing, but I can't service it without the schematic diagrams. I asked Radio Shack and they replied, "We don't have those schematics, we threw them away a few years back." Where can I get them?—J. Reyes, Laredo, TX.*

Q *Last summer I bought a mostly working TRS-80 Model 4 for $10. I need some technical information in order to use it effectively. Are any TRS-80 user groups still in existence?—S. Fuesting, 911 Keller, Effingham, IL 62401.*

A Try calling Radio Shack's national support line at 1-800-THE-SHACK and/or Tandy National Parts at 1-800-322-3690. Also, schematics and service manuals for TRS-80 computers are available (for about $40 each) from Howard W. Sams & Co., 1-800-428-7267.

As for user groups, there's a thriving Tandy forum on the Internet in the newsgroup comp.sys.tandy. Also, we're publishing reader Fuesting's complete address so that TRS-80 Model 4 enthusiasts can contact him.

FLOATING A BATTERY

Q *I would like to have a circuit that will maintain a 12-volt automotive battery fully charged without overcharging it.—J. C. Farley, Landover, MD.*

A This is called float-charging. To float-charge a 12-volt lead-acid battery, all you need is an accurately regulated 13.8-volt power supply (such as Radio Shack's No. 22-120, or one of your own design).

You could connect the power supply directly to the battery, but it's safer to make the connection through a couple of 12-volt, 1-amp automotive

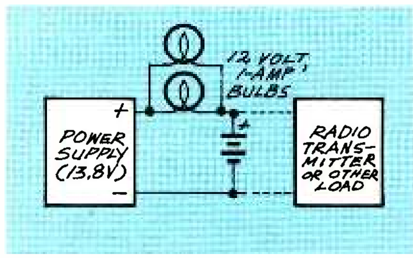

FIG. 2—LIGHT BULBS LIMIT CURRENT, float charging the battery without overloading the power supply.

light bulbs (see Fig. 2). The light bulbs serve as current limiters; they guarantee that no matter what happens, the power supply will never have to deliver more than 2 amps. Resistors can also serve as current limiters, but light bulbs are better because their resistance varies with current in a useful way. It's nearly zero at low current, but as the current through each bulb approaches 1 amp, the bulb lights up and the resistance increases. Thus, the bulb limits the current but doesn't waste energy when the current is low.

This setup is a good way to power a heavy load that operates intermittently, such as a ham radio transmitter. The battery delivers heavy current when necessary, and the power supply keeps the battery charged up. **EN**

WHAT'S NEWS

continued from page 4

from simply prepaying phone calls to the rank of a full fledged electronic cash card.

The telephone digital smart card is inserted into a slot in special public telephone that deducts value from the card. Fumbling for the right change to make the call is eliminated as is the aggravation of searching for additional coins to "feed the box" if the call exceeds the minimum toll. The cards are especially convenient for children and visually handicapped persons.

Now both American and European companies are expanding that concept into what have been called electronic "purse" cards for making all kinds of payments. The card's current value is digitally stored on the card itself. Store clerks will use a smart-card terminal to deduct the amount of each purchase.

Last July two large British banks, National Westminster and Midland, began testing Mondex, a card that "stores" cash. Mondex cards are favored by merchants for making small purchases because they do not have to install a telephone link to a central computer. This card's drawback is that, unlike a credit card, losing the card is like losing cash.

MasterCard International, Visa International, and Bank of America are also developing electronic cash cards. MasterCard's smart card combines electronic cash with existing credit or debit cards. Visa will test its cards at the Summer Olympics in Atlanta next year. Electronic Payment Services expects to test an electronic cash card in Delaware in automated teller machines next July.

The Microsoft Corporation plans to enter the electronic cash field. It is working with semiconductor manufacturers to develop a card for use by banks that would underwrite the payments programmed into the card. The card is intended to replace cash with digital money that would be stored on the card and then be spent for small purchases not unlike the prepaid meal tickets that were common a half century ago.

Industry's fastest 1-Mb SRAM

A high-speed CMOS memory IC from IBM makes it possible to access its contents in 2.5 nanoseconds (ns)—the time it takes a beam of light to travel a meter. This makes it the fastest 1-megabit synchronous static random-access memory (SRAM) in production. It is intended for PowerPCs and other high-performance RISC-based servers and workstations with speeds up to 200 MHz.

As central processing units (CPU) speed up, a workstation's memory must be able to keep pace in supplying it data. The advanced CMOS SRAMs permit workstation cache memories to match the speed of the CPU, significantly enhancing performance. Two 1-MB SRAMs can form a 256 Kbyte cache memory in a 200-MHz system.

The new IBM SRAMs provide enhanced data throughput in synchronous pipeline or flowthru operations, reduced signal noise with low-voltage TTL I/O level compatibility; and a self-timed late-write feature that allows consecutive read and write cycles. The 32 Kbit × 36 and 64 Kbit × 18 organizations minimize device count and optimize cache size.

ISCET receives White House recognition

President Clinton congratulated The International Society of Certified Electronics Technicians (ISCET) on its 25th anniversary. Founded in July of 1970, ISCET will celebrate its 25th anniversary at the National Professional Electronics Convention, July 31 to August 5, in Arlington, Virginia.

ISCET-certified technicians reside in all 50 states, and 41 territories and foreign countries. It is expected that the 40,000th technician will be certified before the end of 1995. The certification program has given consumers confidence that ISCET certified technicians have the knowledge, training, and experience needed to perform their service work reliably and professionally. EN

VIDEO NEWS

continued from page 6

make 42-inch thin plasma displays. The company plans to offer plasma TV sets in sizes from 20 to 100 inches diagonally starting in 1997, when Japan is scheduled to start commercial HDTV broadcasts, under its Fujitsu General brand in Japan. The company believes sets smaller than 20 inches will continue to use standard CRTs, while those bigger than 100 inches will be projection sets.

Fujitsu's factory will start producing 42-inch displays next year and plans to turn out 20,000 monthly to start. The company already sells 21-inch displays for monitors, and has sold some plasma TV sets, but sales are limited by current high prices—nearly 1,000,000 yen in Japan, the equivalent of almost $12,000.

Two-program VCR

Hitachi has introduced a VCR in Japan that can record two programs simultaneously. The recorder is compatible with standard VHS tapes in the single-program mode. For two-program recording, the deck records both programs side by side in a standard 58-micron helical track, using a 25-micron head to record one program and a 19-micron head for the other. The recorder has eight video heads and two stereo audio heads. Two models have been introduced in Japan—one permitting simultaneous playback of both programs, either side-by-side or picture-in-picture.

Hitachi hasn't indicated whether it will offer the two-program recorder in the U.S., but it has introduced two unique video-recording products here. A Hi8 camcorder has a detachable shirt pocket-sized camera head that is attached by cable to the unit's body and can be used up to 21 feet away. The camera head is waterproof, so it can be lowered from a boat for underwater photography, for example, while the main part of the camcorder remains high and dry on deck. The camcorder also includes a 4-inch LCD monitor. EN

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

DANGEROUS METER SHUNTS

The use of No. 20 copper wire to make a 50-ampere meter shunt, as suggested in the May 1995 "Q&A," is an invitation to disaster. It is likely that the shunt would vanish in a flash of blue vapor and the meter would be destroyed.

Calculated values of fusing current are only approximations, because the actual value is affected by such factors as ambient temperature, air circulation, variations in wire diameter, and heat conduction through the connecting leads.

The calculated fusing currents for No. 20 and No. 22 copper wire are 58.4 and 41.2 amperes, respectively, so substituting the smaller wire would certainly prove disastrous. Even if it didn't self destruct, the shunt would run so hot that the meter readings would be unreliable. Moreover, soldered connections would probably melt.

The 50-ampere load device whose current is to be measured would have, if it conformed to code, leads of No. 10 wire or larger—perhaps No. 8 or No. 6. The shunt should be of comparable size. The one-foot length of No. 10 copper would have the resistance of 0.001 ohm required by the example.

The shunt should be located near the load, and sturdy mechanical binding posts, rather than solder joints, would be more suitable for the load connections. The meter leads should be connected inboard of the current leads, as shown in Fig. 3 on page 10 of the May issue.

Only the distance between the meter leads is effective in calculating the length of the shunt. The meter leads can be standard products of any convenient length.

LEWIS F. GARBER
Duarte, CA

With regard to the May 1995 "Q&A," the response to Steve Baumfalk's question was misleading. A No. 20 wire shunt for carrying 50 amperes would be a dangerous mistake; that wire would burn out in seconds! A No. 20 copper wire should not be trusted to carry more than about 5 amperes.

The National Electrical Code, written to promote safe installations in house wiring, requires at least a No. 6 wire—and that is for conductors in conduits. But this emphasizes the differences in current-carrying ability between No. 6 and No. 20 wire.

I would obtain resistance wire, ribbon, rod, or a standard shunt modified for that value. Fasten the calculated length into solid blocks or lugs with separate take-offs for the meter leads. Then trim the calibration with a series resistor, perhaps even an adjustable resistor, and calibrate it against an ammeter of known accuracy.

DWIGHT EGGLESTON
Hendersonville, NC

STANDARD VALUE COMPONENTS ONLY

In the future, please do not specify non-standard values for components! I am referring to the Headphone Amplifier and Audio Chip described in the June 1995 "Q&A."

Forty years ago it was possible to find 0.04–µF or 0.05-µF capacitors in a radio or television set, but components have become more standardized since then. A 0.047–µF capacitor should be specified in those applications.

TABLE 1— RESISTOR VALUES

5%	10%	20%
10	10	10
11		
12	12	
13		
15	15	15
16		
18	18	
20		
22	18	18
24		
27	27	
30		
33	33	33
36		
39	39	
43		
47	47	47
51		
56	56	
62		
68	68	68
75		
82	82	
91		

It is always useful to remind authors and readers (especially those now learning the basics of electronics), that resistors, capacitors, and most fixed inductors are available only in standard values.

As a rule, there are six standard values per decade for components with 20% tolerances, 12 standard values per decade for 10% components, and 24 standard values per decade for 5% tolerances.

Capacitor manufacture offers one exception to this rule. Just because a capacitor is marked 5%, you should not conclude that there are 23 other capacitor values per

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decade. Capacitor manufacturers confine themselves to six values per decade (and there are even exceptions to that rule deviation). This holds even if they offer a 10%, 5%, or even 2% tolerance.

Most capacitors are placed in RC circuits, and designers typically select the capacitor first before selecting a resistor that can be trimmed to the desired RC value. Thus, there is no demand for both capacitors and resistors in a full range of values.

Table 1 lists standard 5%, 10%, and 20% values. Remember that the table represents only one decade, meaning that 2.2-, 22-, and 220-ohm, 2.2-, 22-, and 220-kilohm, 2.2-megohm, etc. resistors are available. Potentiometers are typically available in only three values per decade: 10, 20, and 50.

You might be embarassed by asking for a 40-kilohm resistor at your local electronics retail store because you won't find one there.

DEAN HUSTER, INSTRUCTOR
Francis Tuttle Advanced Technology Center
Oklahoma City, OK

VARIABLE DUTY-CYCLE TIMER

In the June 1995 "Q&A" column, Jan Janowski asked for a variable duty-cycle timer with a fixed period of approximately 45 seconds. Q&A's answer implied that this was difficult for a single 555 IC timer.

The circuit shown in Fig. 1 gives an

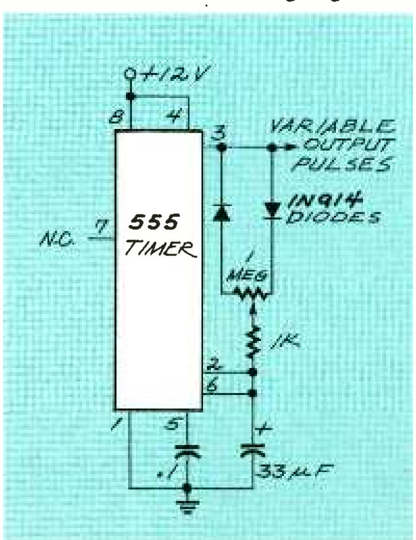

FIG 1—CYCLE TIMER

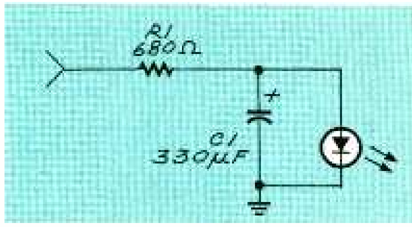

FIG 2 — TIMER LOAD

output that is identical to the one shown in the "Q&A "column, yet only one 555 is needed. Moreover, there are no annoying duty-cycle "jumps" near the 100% *on* setting.

To give the appearance of 100% on to 100% *off* operation as Jan requested, simply insert an integrator between the timer and the load. Figure 2 shows an LED as the load with a capacitor acting as an integrator to give the illusion of 100% *on* to 100% *off* operation. The load could also be a solid-state relay (AC or DC) controlling a high-power device.

Control a lamp that way if you want a flashing light. By reducing the values of the timing and integrating capacitors (to eliminate flicker), you can make a fancy light dimmer!

WILLIAM M. MILLER JR.
North Dartmouth, MA

EASY DOES IT

Larry Klein deserves a lot of praise for his simple cable tester design that appeared the April 1995 "Audio Update." Even with 29 years of experience in electronic servicing, I am still looking for ways to make my work easier.

I maintain an audio-visual system on a U.S. military base in Germany. The air conditioning system in the auditorium is quite loud, so I have difficulty hearing the beeper on my digital multimeter when I am testing cables. The beeper is just not loud enough to be heard over the background noise. This made it impossible for me to test a long cable by myself.

Mr. Klein's cable tester equipped with a Sonalert brand alarm produces a sound that is loud enough to overcome the background noise.

RICHARD J. MOLBY,
WB7NZG/DA1DB
HQ. USAREUR/7A, Germany

EN

EQUIPMENT REPORTS

SESCOM CT-6 CABLE TESTER KIT

This tester will verify that all of your cables are in good condition.

CIRCLE 15 ON FREE INFORMATION CARD

Let's say that you have spent the better part of the day setting up audio equipment for a band that will be playing in a few hours and you have found that some part of the system is not functioning properly.

Mentally you run through a checkoff list of what could be wrong. High up on that list is the condition of the interconnecting cables. Could there be a fault in one of them? Do you have time to check out all the cables to identify the fault before show time?

Any intermittent cables—audio, video, or RF—can cause trouble, and it doesn't matter if the system is for a professional show or for a home entertainment system. A cable with an intermittent fault might behave well when you set up the equipment initially, with the fault developing some time later on during the performance or video playback.

Testing each cable before it is connected can eliminate problems once it's installed in a system. But checking the integrity of a lot of cables can be time-consuming unless you have specialized test equipment that will simplify the task.

Easy cable tester

The CT-6 cable tester from Sescom, Inc. (2100 Ward Drive, Henderson, NV 89015, 800-634-3457, 702-565-4828) is a compact matchbox sized instrument that will make short work of testing all different kinds of cable. The top cover of the CT-6 contains a matrix of pairs of standard jacks including 3.5 mm mini stereo, RCA, F, BNC, XLR, $^1/_4$-inch stereo, and five-pin MIDI.

To test a cable, you plug each end of it into a matching jack on the tester and, depending on the configuration of the cable, up to three LEDs will light to indicate that there is continuity in the cable. Cables and their connectors should be wiggled and flexed while testing them to screen out any that might be making connections only when not subject to mechanical or thermal stress.

With the exception of the XLR jacks, where one is male and the other is female, all other jacks on the CT-6 are female. Thus any cables terminated with jacks will require an adapter. Unfortunately, if you want to test cables whose plugs or jacks don't match any of the connectors on the CT-6, you must purchase or make adapters for them. However, with satisfactory adapters, you can test unusual or uncommon cables with up to three conductors just as quickly and easily as standard cables.

The CT-6 tests cables with up to three conductors. (There are only three conducters in a five-pin MIDI cable.) The tester has a row of three momentary pushbutton switches on its top panel with an indicator LED built into each switch. The switches break connections between the two ends of a cable when pressed. The LED above each switch should turn off when the switch is pressed, indicating the discontinuity. If an LED doesn't turn off, this is an indication that there is a short circuit in the cable under test.

All of the jacks and plug are soldered directly to one of two PC boards within the CT-6. This makes building the tester easier and less time consuming. It also eliminates a lot of internal wiring that could cause of problems by themselves and this form of construction makes the CT-6 an extremely rugged unit for use in the field as well as on the lab bench.

The CT-6 is packaged in a rugged, modern, black-anodized aluminum case that measures only $5^1/_2 \times 3^3/_4 \times 2^1/_2$ inches. It is tough enough to stand up to a lot of abuse. The top panel is clearly labeled with silk-screened white lettering. The side panels of the case extend above the height of the top surfaces of the jacks to protect them in the event that a flat heavy object is dropped on it or if the instrument should accidentally fall to the floor. Four rubber feet on the bottom of the case prevent the unit from sliding around on the benchtop when it is being used.

Build it from a kit

A really attractive feature of the CT-6 cable tester is its low price of only $50 for a kit that includes the aluminum case. But building the kit should be fun and the results will be satisfactory even for relatively inexperienced hobbyists if they follow the directions carefully. The kit includes all of the components, circuit board, solder, and even a pair of fresh batteries. However if you don't have the time or would rather just purchase the cable tester complete, a fully assembled and tested CT-6 is priced slightly higher at $89.

To build the CT-6, you install the jacks and switches on two small PC boards and solder three small preformed jumper wires in place. The two boards are interconnected with a flexible multiconductor cable, which offers higher reliability than if individual wires were used to make the connections.

The PC boards mount securely to the front panel. A battery holder snaps into the back panel of the cable tester and two wires are solderd between it and one of the PC boards on the panel. The top and bottom panels then slide into a partially assembled case. Four slotted corner rails, which mount to the side panels with screws, hold the top, bottom, and side panels in place.

Our CT-6 should have worked immediately after we finished it, but it didn't. After investigation we noticed that an unused screw-on steel collar from one of the jacks was lodged inside another jack. It was only after checking and rechecking the boards for the usual solder shorts, and then peering inside each jack that the unwanted interference was noticed and removed. The moral of this story is that little details can sometimes trip up even the most experienced electronics hobbyists.

The CT-6 worked fine after that. We can't blame anyone but ourselves for not noticing the problem sooner. Even if the construction manual had included one of those boring boilerplate paragraphs "carefully inspect all the components before doing any assembly" we (like many other hobbyists) probably would have ignored it. But don't let our experience put you off building the CT-6!

How to use the CT-6

Pop the two AA cells into the holder in the back panel and it's ready for use. The instrument has no power switch. To test a cable, simply plug the cable into the appropriate jacks and that turns the CT-6 on. The number of LED lamps that will light depends on the construction of the cable under test, typically two or three conductors. The pushbutton below each LED on the panel should turn the LED off; if it doesn't turn off, suspect a short circuit. Flex the cable throughout its length to see if that has any effect on the integrity of the connection.

It is our view that those who regularly install cables in their daily work can avoid having to track down faulty ones by testing them first with the CT-6. It is clearly a useful addition to your bench tools or field repair kit. Considering the cabe testers reasonable price, exceptional versatility, and extreme durability, we strongly recommend the CT-6 as a test tool that will come in handy for many years to come. **EN**

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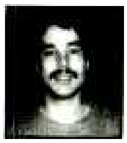

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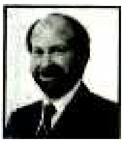

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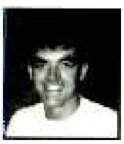

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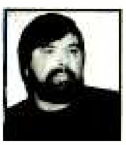

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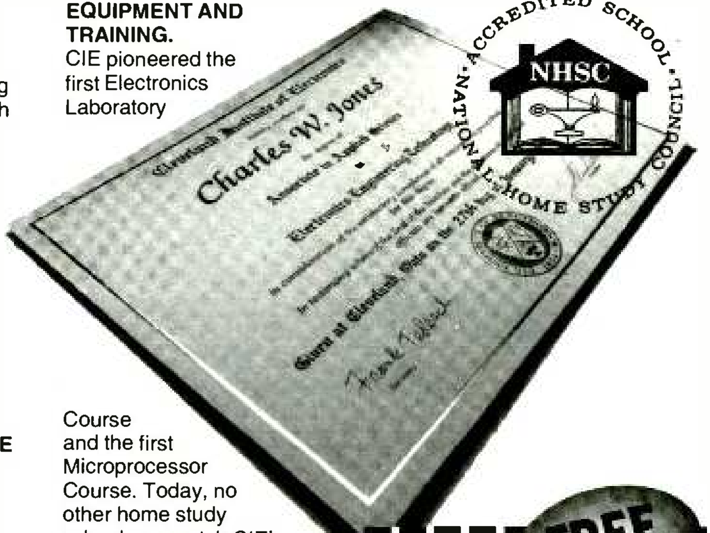

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CIRCLE 20 ON FREE INFORMATION CARD

A dome speaker system in the monitor produces sound that is directed to the front of the monitor through acoustic ducts and projected through micro-hole speaker grilles. Because the sound is projected very close to the CRT, sound localization is enhanced.

The monitor's icon-based, on-screen display menu permits picture size, geometry, and color to be customized. This permits the individual adjustment of the monitor's red and blue color guns. Color temperature adjustment permits screen image color to match the printed page. Proprietary coating reduces static electricity, screen glare, and reflections from the monitor for easier viewing

The speakers project only 1/4-inch on each side of the monitor. The high-sensitivity, unidirectional microphone, located in the center of the lower chassis, can voice-activate software and initiate video teleconferencing and audio-recording devices. Two jacks are provided for optional headphones and an additional microphone.

An auto-switching universal power supply permits the monitors to be powered from a 50 to 60-Hz source of 90 to 264-volt AC. The monitors conform to VGA, SVGA, XGA, Mac, and VESA standards, as well as the EPA's Energy Star guidelines. The monitors are certified for MPR II low magnetic radiation.

PanaMedia 15 monitors are priced at $599.00 and PanaMedia 17 monitors are priced at $999.00.

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CIRCLE 21 ON FREE INFORMATION CARD

Continued on page 29

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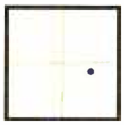

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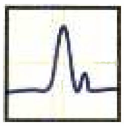
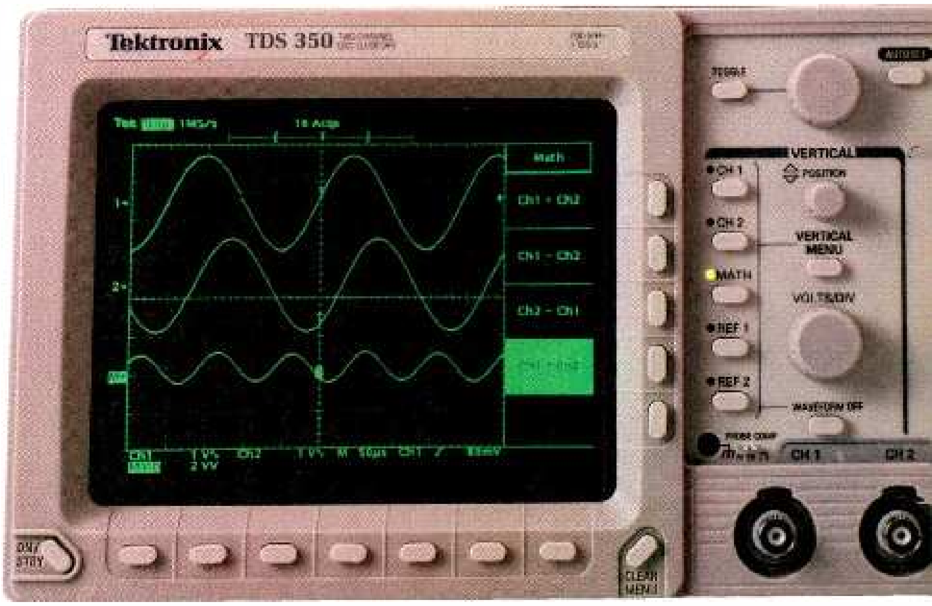


REAL LIFE CAPTURE. SINGLE EVENT CAPTURE USING DIGITAL REAL TIME. 500 MS/s 100 MHz DSO.



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Sweep Speeds	10 ns/div - 5 s/div	5 ns/div - 5 s/div	2.5 ns/div - 5 s/div
Channels	2	2	2
Vertical Sensitivity	2 mV - 10 V	2 mV - 10 V	2 mV - 10 V
Vertical Resolution	8 bits	8 bits	8 bits
Record Length	1K/channel	1K/channel	1K/channel
Standard Advanced Features	TV Line & Field Trigger, Roll Mode, Autoset, 21 Automatic Measurements, Peak Detect		
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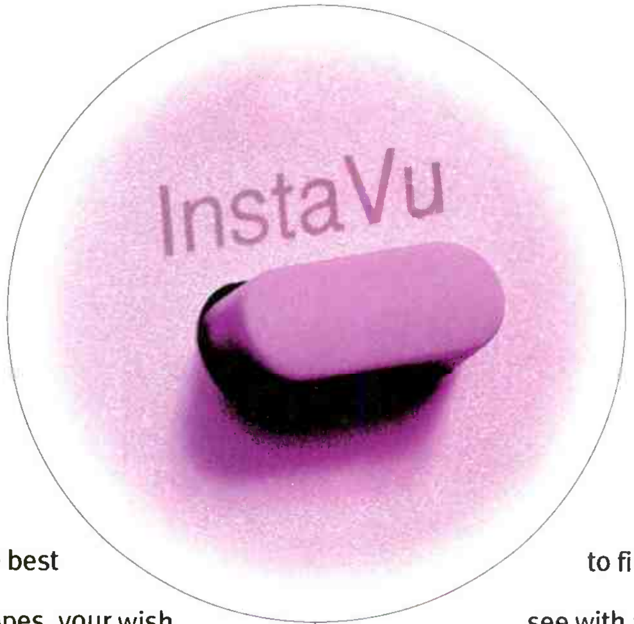

If you've ever dreamed of an instrument that combines the best of both analog and digital scopes, your wish has been granted. Tektronix TDS 700A TruCapture™ oscilloscopes are actually faster than the fastest analog scopes. Yet they give you the playback power of digital technology. All at the touch of a button.

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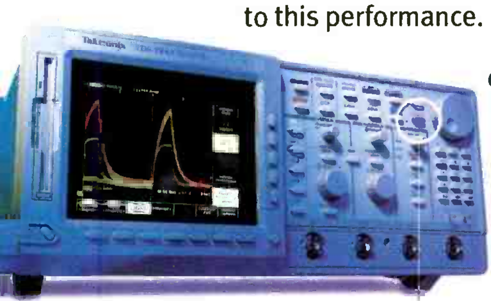

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All fieldpacks include a 300-ampere AC current clamp, a dual-temperature accessory with K-type thermocouples, test leads with removable tips, an alligator clip, and an extra set of long probe tips. The accessory heads measure temperature, AC current, DC microamperes, and relative humidity

When carried by its shoulder strap, access to any item in any pocket can be gained from the top. A zippered outside pocket can hold paperwork or a notebook computer. The inside pockets have clear plastic faces permitting their contents to be seen at a glance.

The HS24K14 fieldpack includes a heavy-duty HS24 "stick" meter and the DC microampere head. The HS24K15 adds the relative humidity head and the HB73K13 includes the heavy duty HB73 DMM. The HB73K14 includes the relative-humidity head.

The HS24 DMM has the 12 most popular measurement ranges for field use. The HB73 DMM adds 18 switch positions and measures current up to 20 amperes with a resolution down to 0.1 microampere.

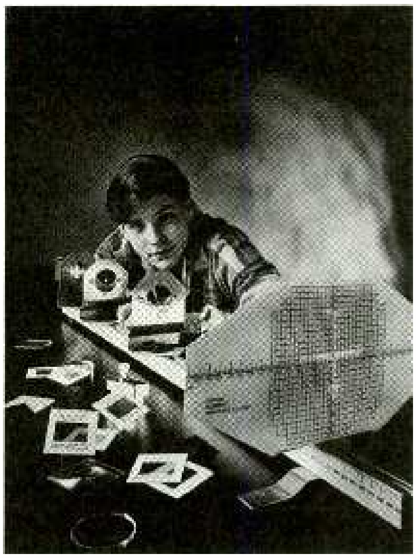
HS24K14 and HB73K13 fieldpacks are priced at $319.00, while the HS24K14 and HB73K14 fieldpacks are priced at $418.00

FIELDPIECE INSTRUMENTS, INC.
231 East Imperial Highway,
Suite 250
Fullerton, CA 92635
Phone: 714-992-1239
Fax: 714-992-6541

STUDENT OPTICAL BENCH.

THE ES STUDENT OPTICAL Bench from Edmund Scientific is a scientific teaching aid for demonstrating all the basic principles of light propagation. Experiments performed with the bench give students hands-on experience in building such basic optical instruments as telescopes, microscopes, and magnifiers in the classroom or at home.

The basic bench includes a multi T-slot meter beam with a stabilizing support and a full 1000-mm scale; a lamphouse with a bright filament bulb, socket, and DIN connector. In addition, it contains a 12-volt, 1.3-ampere wall outlet AC to DC adapter; two magnetic stainless-steel carriers to accommodate a 50-mm-diameter lens and/or a 50-mm square slide. Also included are a 6-inch high, 12-inch wide plastic screen with combined X-Y-mm scales and 5-mm grid pattern.



CIRCLE 22 ON FREE INFORMATION CARD

The kit, packaged in a compact case, also contains an assortment of 50-mm lenses and mirrors, 50-mm square slides (including filters), diffraction gratings, polarizers, slotted and round aperture plates, a diffuser, and an object slide. The instruction manual included describes nine experiments that introduce students to the concepts of geometrical optics, optical instruments, the polarization of light, and diffraction gratings.

The ES Student Optical Bench (Model 39,510) is priced at $250.00

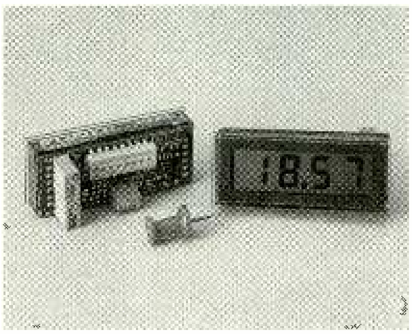
EDMUND SCIENTIFIC COMPANY
Department 15A1
C999 Edscorp Building
Barrington, NJ 08007-1380
Phone: 609-573-6886
Fax: 609-573-6295

DPM WITH LCD DISPLAY.

THE DMS-30LCD-4/20S 3-1/2-digit, digital panel meter from Datel is loop powered. It includes an eight-position DIP switch for selecting the DPM's input range, zero offset, and decimal-point location. No jumpers are required.

The DMS-30LCD-4/205 measures

2.2×0.93 inches and it has a behind the pane depth of less than 1 inch. Its LCD display has 0.4-inch high char-



CIRCLE 23 ON FREE INFORMATION CARD

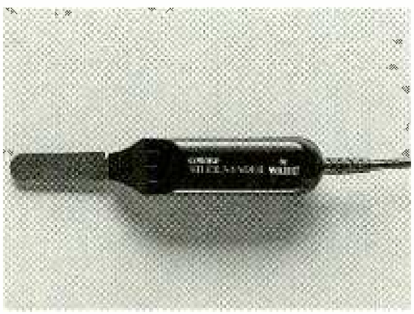
acters. The fully self-contained DPM is powered by a 4 to 20-milliampere current loop, so it requires no external power supply, bypass capacitors, or trimming potentiometers.

DMS-30LCD-4/205 DPM is priced at $74.00 in single units.

DATEL, INC.
11 Cabot Blvd.
Mansfield, MA 02048
Phone: 508-339-3000
Fax: 508-339-6356

FILER/SANDER.

THERE ARE TIMES WHEN electronic hobbyists and professionals must do some filing and sanding to build or repair circuitry or enclosures. Wahl's AC-powered Filer/Sander is a reciprocating tool for sanding and filing that relieves the user of the wrist stress during the repetitive motions of sanding and filing.



CIRCLE 24 ON FREE INFORMATION CARD

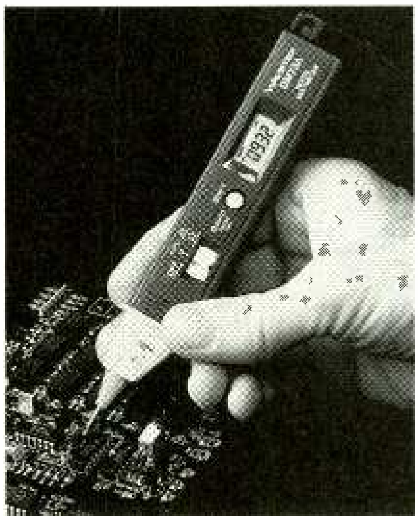
The filer/sander is suitable for working on material as soft as balsa wood, and as hard as metal, as well as all kinds of plastics. It provides easy access to hard-to-reach location on the projects. It is sold with 19 accessories in a combined storage and carrying case.

The Wahl filer/sander is priced at $78.95.

WAHL CLIPPER CORPORATION
P. O. Box 578
Sterling, IL 61081
Phone: 1-800-735-9245

PEN-STYLE DIGITAL MULTIMETER.

WAVETEK'S MODEL DM73A pen-style digital multimeter is designed for single-handed use. This allows the user to concentrate on making measurements, especially in restricted spaces. It has a 4200-count display that provides users with exceptional accuracy and resolution for set-



CIRCLE 25 ON FREE INFORMATION CARD

ting voltage levels.

The meter offers auto reading hold or probe hold which automatically freezes the reading on the display for later evaluation. The probe-hold feature is suitable for high-voltage troubleshooting and making readings of PC-board voltages. The reading record feature records maximum voltage and minimum resistance, permitting the tracking of variable voltage sources and general troubleshooting. The meter has a plug-in test lead with probe attached.

The Model DM73A pen-style DMM is priced at $69.95, and an optional leather carrying case (Model VC13A) with snap closures and belt loop is priced at $17.95.

WAVETEK CORPORATION
9145 Balboa Avenue
San Diego, CA 92123
Phone: 619-279-2200
Fax: 619-540-0325

WRIST WATERBED.

WAVECO'S WATERBED FOR Your Wrists is a bar shaped pillow filled with a high-viscosity fluid that conforms to the user's wrists while he or she is engaged in long-duration data entry on a computer keyboard. It is located on the desk or bench in

CIRCLE 26 ON FREE INFORMATION CARD

front of the keyboard where it will ease stress on the operator's wrists by supporting them properly.

The Waterbed For Your Wrists reduces or relieves discomforts likely to occur with prolonged computer keyboard operation. Its gel-filled cushion makes a comfortable wrist rest and the wrists are supported even while entering data. It is to be distinguished from conventional wrist rests that function only as wrist support platforms during periods of inactivity.

The gel conforms to the contour of the wrist and palms to maintain close contact regardless of the position of the user's hands and arms. That feature prevents the wrists from contacting any hard corners or edges on the desk or keyboard which can result in

Continued on page 130

Low-Cost Software For Electronics

New low-cost software lets you draw schematics, lay out PC boards, and breadboard circuits on your desktop PC.

TJ BYERS

THERE WAS A TIME, NOT too long ago, when making a printed circuit board required a drafting table, custom drawing templates, decals, hobby knife, plenty of Band-Aids, and a darkroom. And if you wanted to test and debug the circuit, there was the extra step of breadboarding. Thankfully, that era is all but a faded memory. Today you can draw a schematic, breadboard the circuit, and design a foil pattern for a PC board without ever lifting a pencil or getting your hands dirty. You can do it all with software that you can run on your personal computer.

Circuit design software packages have been around for about 20 years. However, until recently, they were typically high-priced industrial applications that were out of the budget range of most hobbyists and many small businesses. The last couple years have seen an influx of low-cost circuit-design software that's ideally suited for home use and small-scale production work.

Because of the wide range of features available, finding the program that's right for you can be more of a chore than constructing a circuit board the old fashioned way! To take the risk and mystery out of shopping for these gems, *Electronics Now* scoured the market in search of circuit-design packages for schematic diagramming, PC board layout, and circuit simulation costing $350 and less. Then we tested them to see how they compared in price, features, and ease of use.

Before we get to the software-rendered artwork, take a look at Fig. 1. Shown is a diagram of the *Electronics Now* benchmark circuit as drawn by the *Electronics Now* art department. It can be used to compare the quality and aesthetics of the schematics drawn by the circuit design programs reviewed here.

The circuit, which is a functional sawtooth generator, was selected because it's simple enough to draw and construct, yet complex enough to be repre-

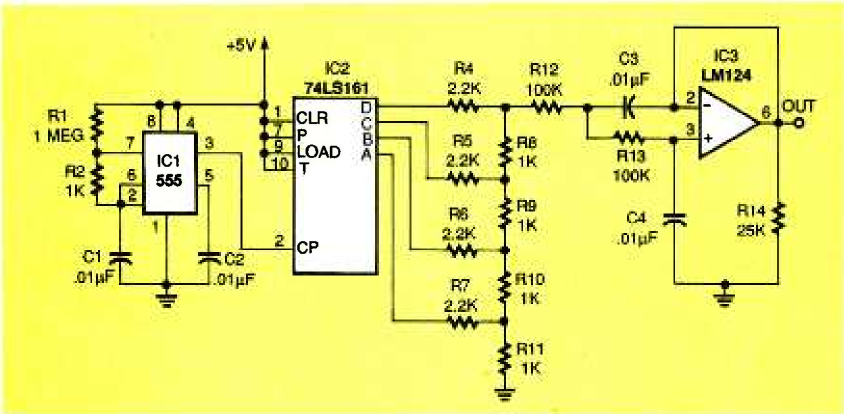


FIG. 1—THIS CIRCUIT WAS DRAWN by the *Electronics Now* art department. Compare it with the quality and aesthetics of the schematics drawn by the circuit design programs reviewed here.

sentative of the type of projects you're likely to tackle. For example, it consists of three ICs, a popular small project count, that are a mixture of analog and digital devices. While the parts are commonly available, they are diverse enough so that nearly half of the software packages didn't have all three "in stock" in their parts libraries. That provided an opportunity for testing their component library editors. When available, text in the form of descriptive headings (clock, waveform generator, and low-pass filter) was added to the drawing.

Schematic software

This article looks at 13 low-cost programs that let you draw schematics with your PC. The schematic is displayed on the screen using standard symbols stored in a component library. To draw a schematic, you select the desired components from a library menu or dialog box, then position them on the screen with a mouse or keyboard. Ideally, the library should contain all the devices you'll ever need. In practice, expect to create new parts on an as-needed basis with the component editor. Devices are wired together by drawing lines between the appropriate pins or their connecting intersections.

Changes to the schematic are made with a screen editor, which lets you add, delete, and move both wires and components. Editing tools can make those changes easier. The better

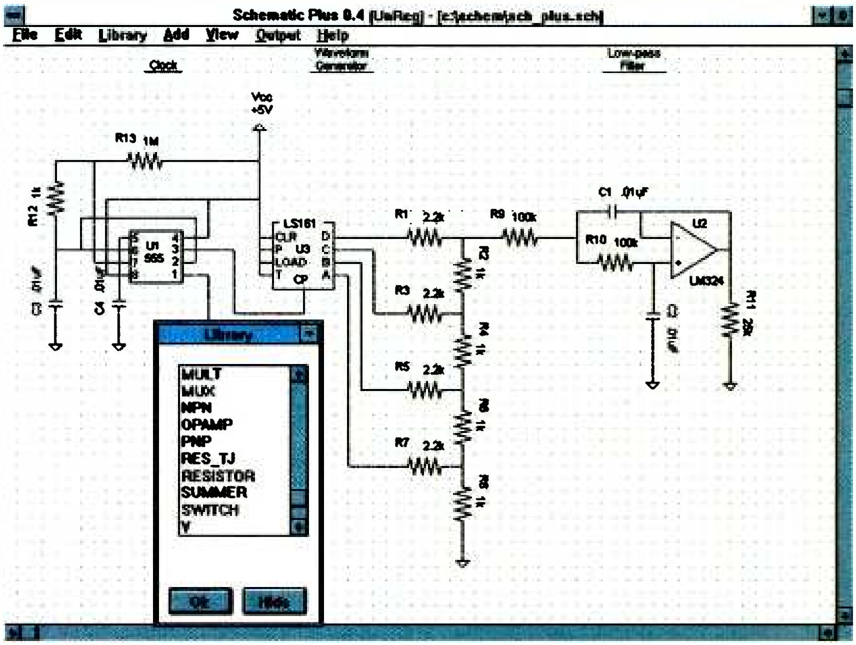


FIG. 2—DESPITE ITS LOW ASKING PRICE OF $20, Schematic Plus is quite flexible and easy to use. However, the library is limited to about a dozen components, so you'll have to create most of the devices yourself.

programs have a "rubberband" feature that lets the wires stretch and shrink as parts are moved on the screen, thereby maintaining their electrical connections. Without rubberbanding, only the device itself moves, forcing you to erase the old wires and redraw them. Other labor-saving features include *auto annotation*, which automatically assigns part references (R1, R2, etc.), and *on-the-fly zoom* or *auto scrolling* (called pan) for accurate placement of symbols on drawings that are larger than the screen.

There are two types of schematic diagram programs, those that just draw and those that produce netlists—a list of devices and their connections with each other. Six of the programs detailed here are draw-only. The remaining seven are schematic capture programs with netlist output for interface with PC board layout and/or circuit simulation software.

The programs are packaged in three different ways. A few, especially the schematic-draw programs, are stand-alone packages, which may or may not generate netlists. In some cases, the schematic draw software is bundled with companion PC board layout software, which has the look and feel of the schematic draw program, but has no link to the schematic. At the top of the line are integrated schematic capture and PC board layout programs that work interactively. The better schematic capture programs, both stand-alone and integrated, have design-verification features that check the circuit for short circuits, opens, and invalid connections (such as the output of a TTL gate tied to ground).

Schematic drawing

Schematic draw programs differ from schematic capture

Continued on page 137

RECYCLING MEMORY FOR YOUR PC

Save bucks by recycling DIP memories into SIMMs you can make yourself.

LEON W. SCHMIDT

YOU MIGHT BE SITTING ON A WINDfall of free and easily reusable semiconductor memory. For example, old motherboards, memory boards, and computer peripheral devices contain perfectly serviceable memory just waiting to be recovered. One problem is that today's personal computers no longer use DIP-packaged memory. If only the discarded devices could be recycled and put to use in the more modern single-in-line memory modules (SIMMs) required by the latest computers! As a matter of fact, they can, and this article will tell you how.

By following the techniques described, you can recycle old DIP-style DRAMs into 30-pin SIMM modules, at a cost of under $10 per megabyte (excluding the cost of memory). With new 1-megabyte SIMMs selling for around $40 apiece, the economics of recycling memory are obvious.

This article provides construction details on three DIP-to-SIMM conversion boards that can be used in four different configurations:

1. 256 kilobyte (KB or K) consisting of nine 256K × 1 DRAMs.

2. 256 kilobyte consisting of two 256K × 4 DRAMs and one 256K × 1 DRAM.

3. 1 megabyte (MB) consisting of nine MB × 1 DRAMs.

4. 1 megabyte consisting of two 1MB × 4 DRAMs and one 1MB × 1 DRAM.

The article provides background information on memory in general, construction details, and PC board patterns. Kits are available from the source listed in the Parts List. Figure 1 shows several standard SIMM modules along with the DIP/SIMM conversion modules for comparison.

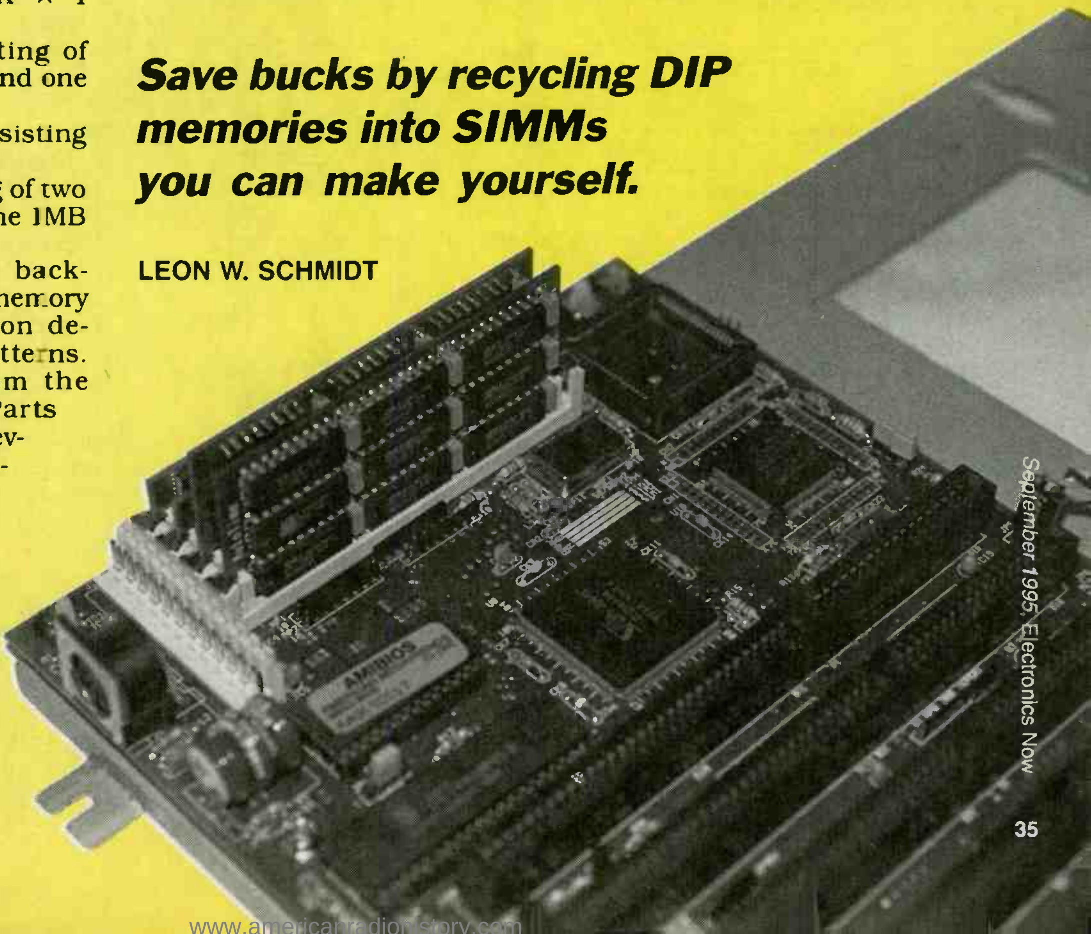
SIMM city

A SIMM is a module that houses multiple DRAM ICs organized into bus widths that are convenient for specific computer architectures. Standard manufactured SIMMs are available in 30- and 72-pin configurations. The 30-pin modules typically have data-bus widths of nine bits; the 72-pin modules have data-bus widths of 36 bits. The conversion boards described here have the popular 30-pin format.

Actually, 30-pin SIMMs are available in both eight- and nine-bit data-bus widths. Nine-bit modules are installed in most PCs, where the extra bit performs parity detection. To save money, some PCs (for example, some Compaq models) do not have the parity bit so they use 8-bit modules. Macintosh computers typically use the eight-bit format as well. The conversion boards described here will operate in either the eight- or nine-bit mode. To operate in the eight-bit mode, the parity checking IC is simply left out.

Generallly, 30-pin SIMMs hold a maximum of 16 megabytes; there are not enough address lines for more memory capacity. The boards discussed here can hold either 256K or 1MEG of memory.

Thirty-pin SIMMs are 3.5 inches long and less than an inch tall. To accommodate the larger ICs, the boards discussed here are slightly taller. The nine-IC boards are 1.5 inches tall, and the three-IC boards are 0.8



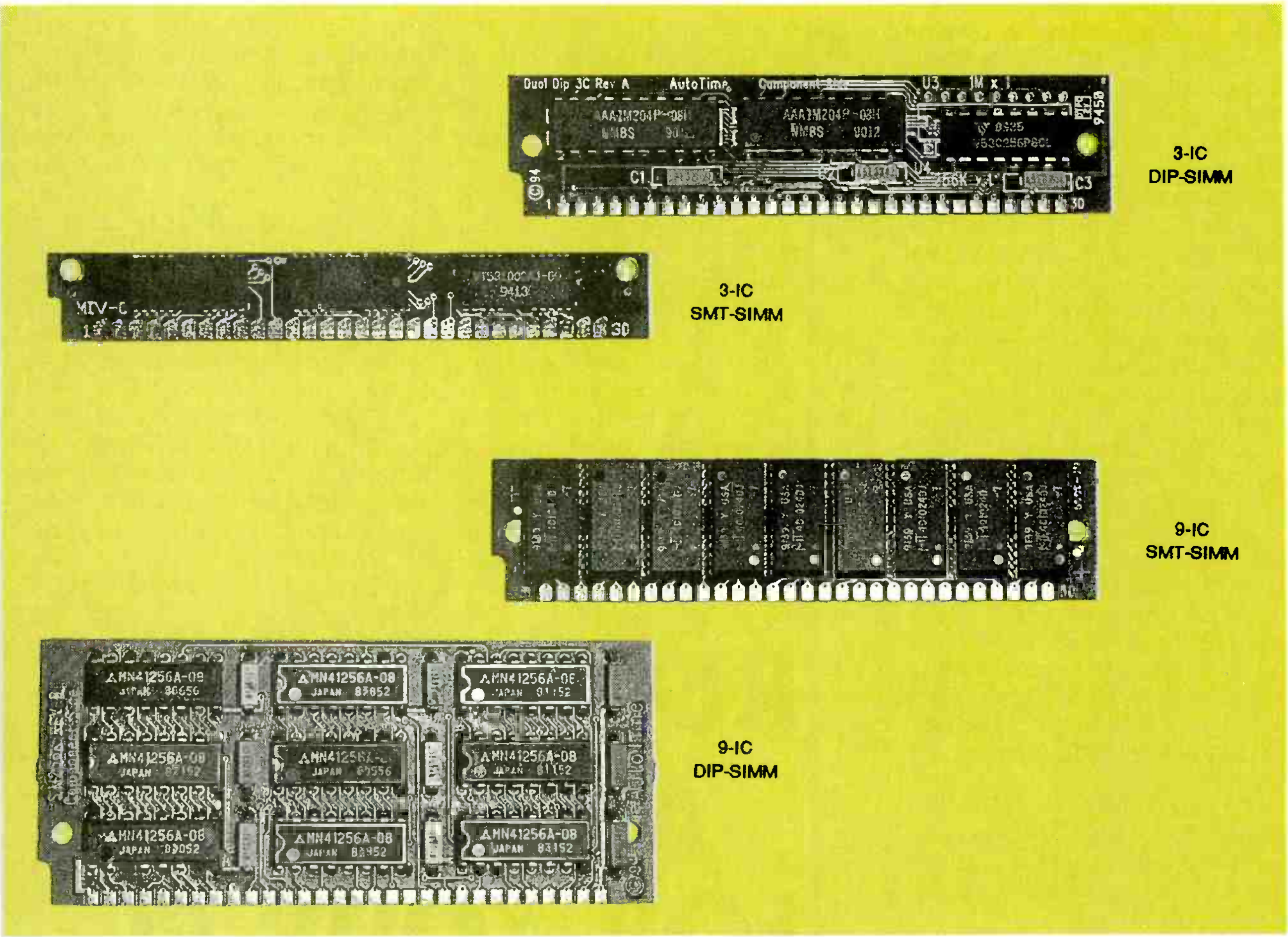
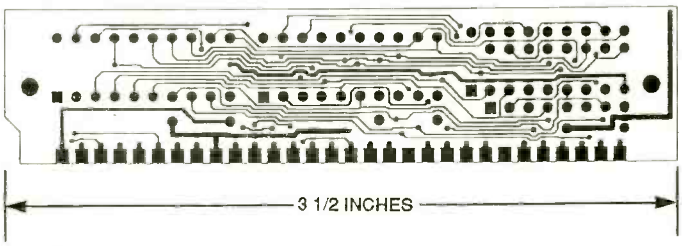
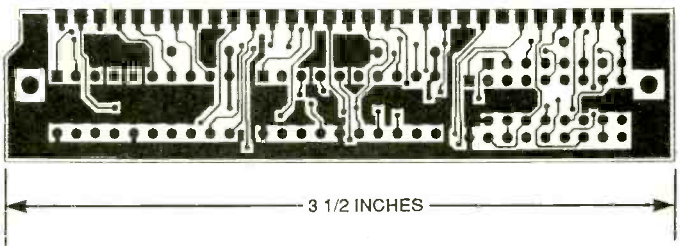


FIG. 1—DIP TO SIMM CONVERSION BOARDS are slightly taller than factory-made SIMM-only counterparts.



COMPONENT SIDE of the 256-kilobyte/1-megabyte board.



SOLDER SIDE of the 256-kilobyte/1-megabyte board.

inch tall. Before committing to this project, be sure that the host motherboard can accept the larger modules. You'll find it easier to work with motherboards that have their SIMM sockets mounted directly behind the keyboard connector.

A SIMM connects all address lines to all ICs in parallel. In addition, a SIMM parallels the control signals: row-address strobe ($\overline{RAS}$), column-address strobe ($\overline{CAS}$), and write enable ($\overline{WE}$). The data lines (D0–D7) come out separately, as does the parity data bit and its $\overline{CAS}$.

Figure 2 is the schematic of the 256K/1MEG combination board, Fig. 3 is the schematic of the 1MEG nine-chip board, and Fig. 4 is the schematic of the 256K, nine-chip combination board.

A DRAM stores a bit of data as a charge on a tiny capacitor. Each DRAM contains an array of storage capacitors. Access to any particular bit in the array is determined by the row and column indexes of that bit. Those indexes are set by the address lines. In addition, the state of the $\overline{WE}$ line determines whether data is written to or read from a DRAM: a CPU reads data from a DRAM when $\overline{WE}$ is high, and writes to it when $\overline{WE}$ is low. DRAMs also have separate input (DI) and output (DO) pins.

Over time, the charge stored

Continued on page 149

CARBON MONOXIDE DETECTOR

An early warning of the presence of carbon monoxide can save your life.

ROBERT GAFFIGAN Jr.

CARBON MONOXIDE, AN ODORLESS and colorless gas, is a naturally occurring byproduct of combustion. Carbon monoxide, or CO, is inert except for its strong tendency to combine with hemoglobin in the blood. Hemoglobin's affinity for carbon monoxide is 300 times that of oxygen. As a result, lethal levels of the gas in blood can be reached within minutes of exposure. The data in Table 1 make it very clear that an early warning of CO concentrations in the air can save lives.

This article describes a portable CO detector that can be carried to the job site or used in a tent, camper, boat, motel room, or anywhere else CO buildup could be a danger. The idea for this article came from a 1966 patent. The patent has since expired, but the method for detecting CO is still viable using 90's technology. The patent was based on a chemical-type CO detector that changed color with exposure to the gas. The detector described in the patent sensed a transmittance change through a CO-sensitive reactant. The 1960's technology depended on a photodetector to detect the transmittance change, but the photodetector's output voltage drifted with temperature. Moreover, the device was power hungry, which precluded battery operation.

The scheme described in this article to detect CO is based on a changing reflection coefficient of the reagent, rather than a transmittance change through the reagent. The reflection coefficient or reflectivity of an opaque surface is defined by the ratio of the light reflected from the surface to the total incident light, and the value is always less than unity.

The reflection coefficient can refer to a specular reflection or a diffuse reflection (see Fig. 1-*a*). In general, the coefficient varies with the angle of incidence, with the wavelength of the light, and the surface material. In the circuit presented here, the angle of incidence is held constant and the wavelength of the light (in the infrared range) is constant; the only variable is the surface.

A cross section of the surface of the CO reagent is shown in Fig. 1-*b*. Incident light enters the reagent particle film. Some of the light is reflected specularly and some is reflected diffusely, scattered by the reagent particles. If the reagent darkens due to the presence of carbon monoxide, the light reflected from it will decrease. The circuit senses this reduction in reflected light.

The CO detector uses an inexpensive chemical carbon monoxide detector card that is sold under the trade names "GAS ALERT plus" and "heads up!" as the sensor element. These sensors darken to a gray or black color when exposed to CO. The cards are a little over two inches square and have a light yellow colored reagent located in their centers (see Fig. 2). This project uses an optical sensor to con-

TABLE 1
CONCENTRATION OF CARBON MONOXIDE

Percent	Parts per million	Results
0.02	200 PPM	Slight headache within 2-3 hours
0.04	400 PPM	Frontal headache within 1-2 hours
0.08	800 PPM	Dizziness, nausea and convulsions within 45 minutes. Insensible within 2 hours.
0.16	1600 PPM	Headache, dizziness and nausea within 20 minutes, death within 2 hours.
0.32	3200 PPM	Headache, dizziness and nausea within 5 to 10 minutes, death within 30 min.
0.65	6400 PPM	Headache, dizziness in 1 - 2 minutes, death in 10 - 15 minutes.
1.28	12,800 PPM	Death in 1 - 3 minutes.

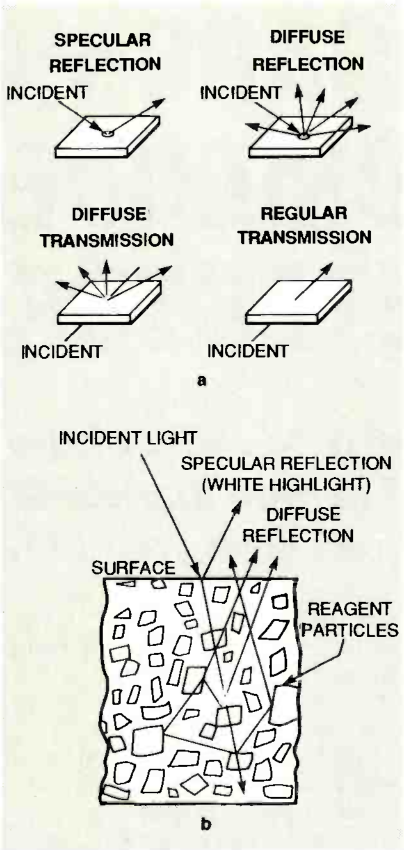


FIG. 1—A REFLECTION COEFFICIENT can refer to a specular reflection or a diffuse reflection (*a*). The coefficient varies with the angle of incidence, with the wavelength of the light, and the surface material. A cross section of the surface of the CO reagent is shown in *b*.

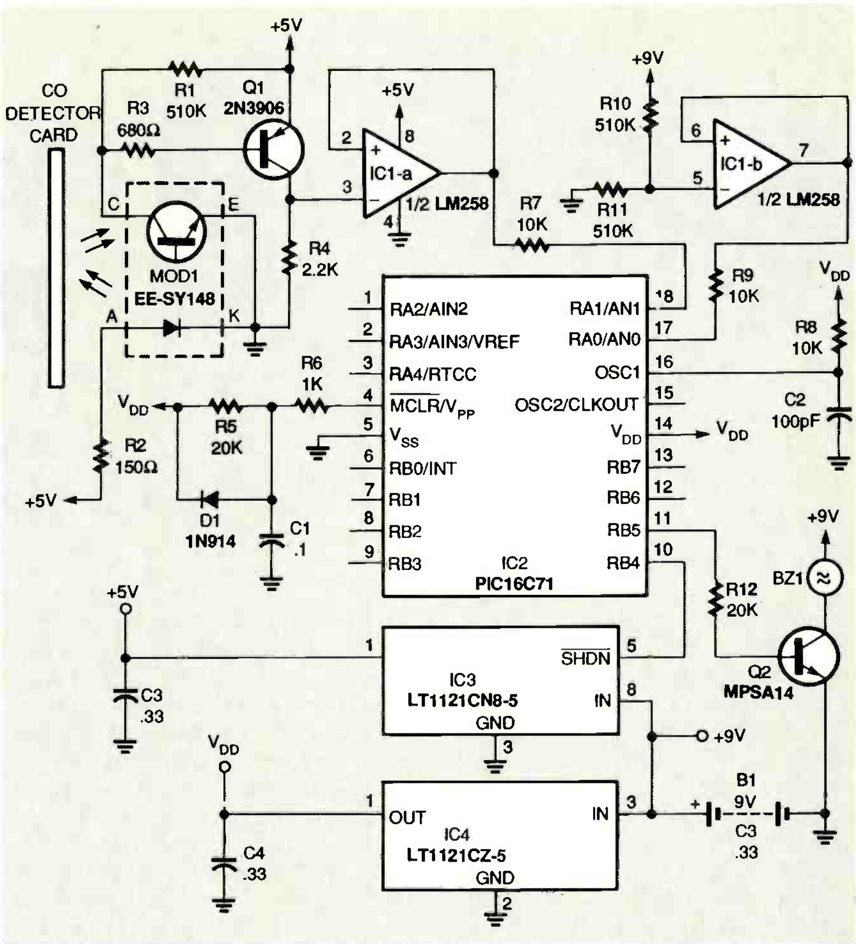


FIG. 3—CO DETECTOR SCHEMATIC. The circuit uses a focused optical sensor to transmit light to the CO reagent, and then it senses the amount of light reflected.

FIG. 2—THE CO DETECTOR uses an inexpensive chemical carbon monoxide detector card. The sensor darkens to a gray or black color when exposed to carbon monoxide.

stantly monitor the card for discoloration, and it sounds an alarm if any darkening occurs.

Circuit operation

This circuit, shown in Fig. 3, has a focused optical sensor to transmit light to the CO reagent, and then it senses the amount of light reflected. The reagent for CO detection darkens from a light yellow color when exposed to CO. According to the card's manufacturer, a concentration as low as 100 parts per million (ppm) will darken the detector after 15 to 45 minutes. A concentration of 600 ppm will darken it in one to two minutes. The reagent will return to its original color when the air freshens, usually after about 10 minutes. The time it takes for the reagent to return to its original color depends on the concentration of CO to which it was exposed.

The "brain" of the CO detector circuit is a PIC16C71 microcontroller (IC2) that contains a built-in four-channel analog-to-digital converter. Other than the microcontroller, the main component of this circuit is MOD1, an Omron EE-SY148 optical reflector module. The module directs infrared light to the CO reagent and then receives the light reflected back to it. When CO is present, the reagent will darken, thus reducing the reflectivity. The reduction is sensed by the microcontroller which then turns on buzzer BZ1.

Ideally, the reflectivity of the CO reagent should not change in fresh air, but because of the scheme used to bias the optical reflector (resistors R1–R4 and Q1), the reflector becomes very sensitive to temperature variations. Moreover, each detector reagent card has different shaped particles that are orientated differently. That causes the light hitting the reagent to scatter differently so that each card can have a slightly different reflectivity. The microcontroller has an automatic calibration routine that takes reflectivity and temperature

Continued on page 153

OVER/UNDER VOLTAGE PROTECTOR

This simple protective device can prevent costly damage to appliances that are always turned on.

RON TIPTON

THIS PROJECT WAS DESIGNED IN RESPONSE to a "power line incident" in which a car or truck knocked down a telephone pole and short circuited a couple of the power lines. The line voltage rose to more than 150 volts over a significant part of the service area for at least 30 minutes. The next morning, many fax machines and PCs that had been left on were found "dead." This article describes a device that provides transient as well as under- and over-voltage protection for a fraction of the cost of an uninterruptable power supply (UPS).

The heart of the unit is a normally open solid-state relay that is held closed by the output of a window-type voltage comparator. If the comparator's input voltage goes outside the window for even a brief period, the relay opens and disconnects the load. Power stays disconnected until a reset button is pushed. If the line voltage is still too low or too high when the reset button is pushed, the load will again be disconnected immediately. A brief power outage of a tenth second or less will not disconnect power.

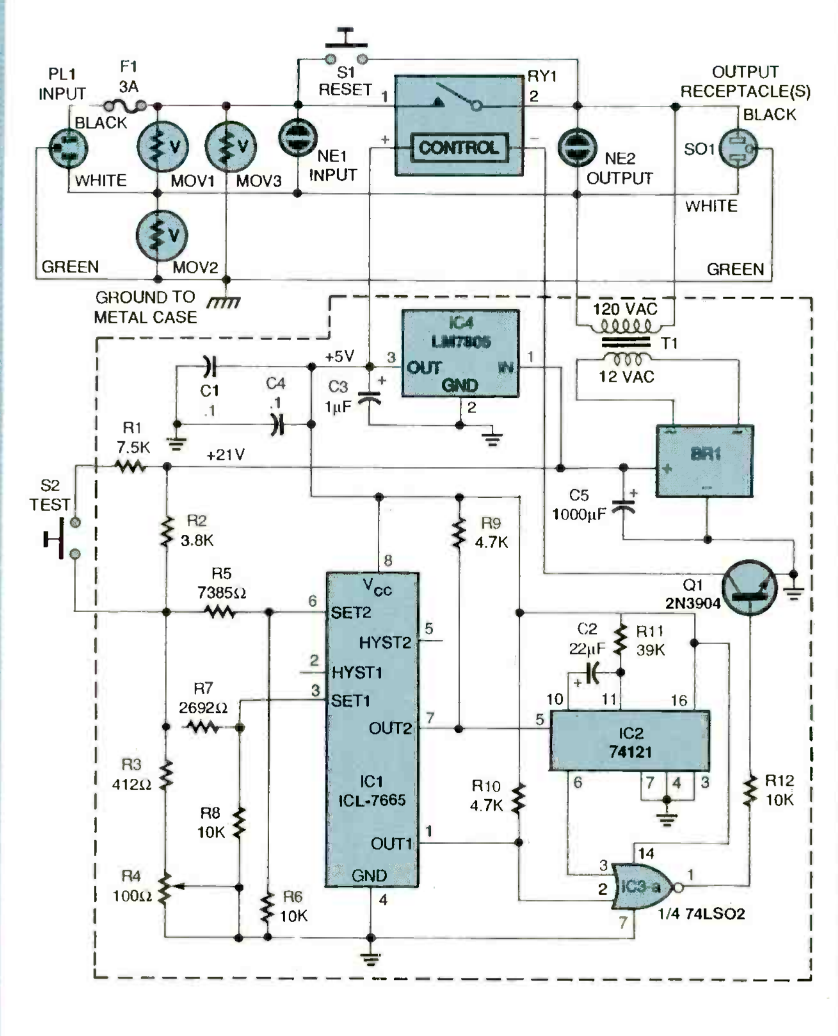


FIG. 1—SCHEMATIC OF THE PROTECTOR CIRCUIT. The ICL7665 over/under voltage detector monitors the line voltage and disconnects the load if the input voltage goes below 95 volts or above 130 volts.

How it works

A schematic of the circuit is shown in Fig. 1. The ICL7665

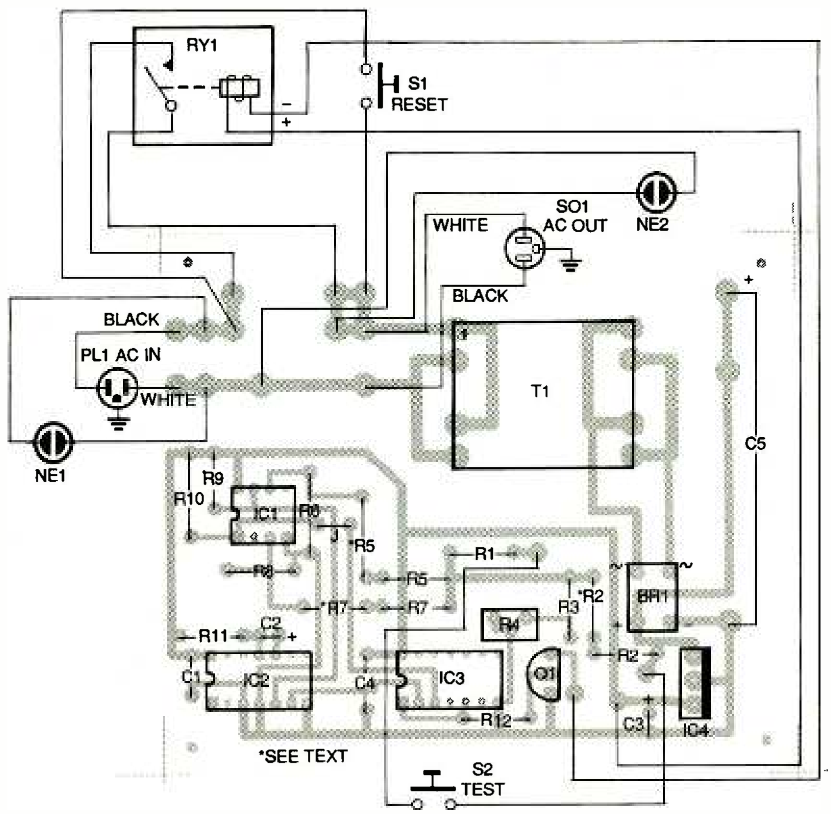
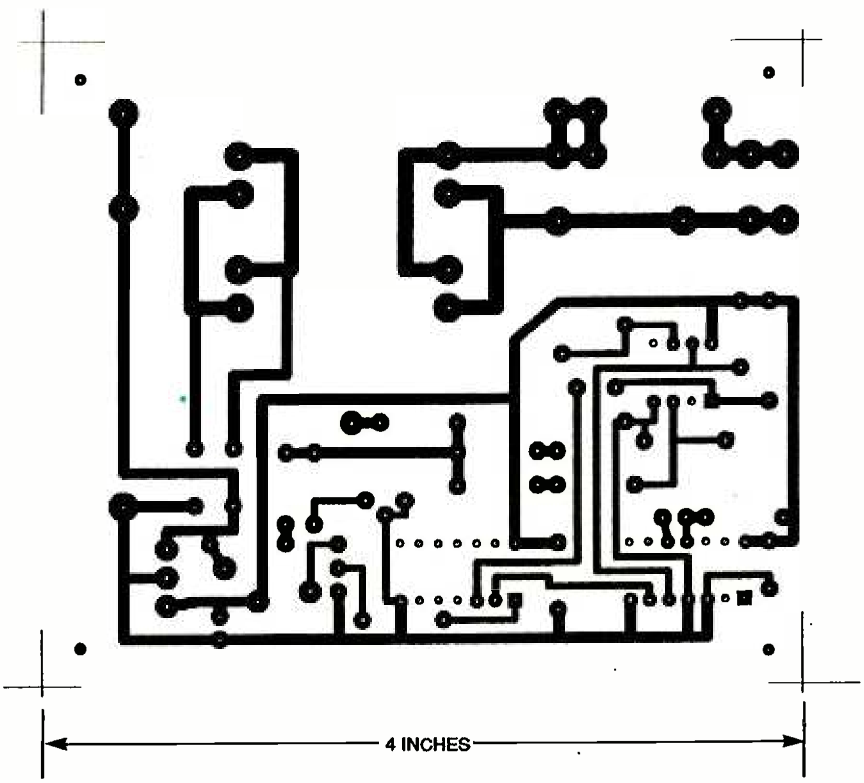


FIG. 2—PARTS-PLACEMENT DIAGRAM. Only one jumper wire is required in the position marked "J." The PC board is designed to accept a series pair of resistors for R2, R5, and R7 to make it easier to find a pair of 1% resistors that will combine to make the correct value.



VOLTAGE PROTECTOR FOIL PATTERN.

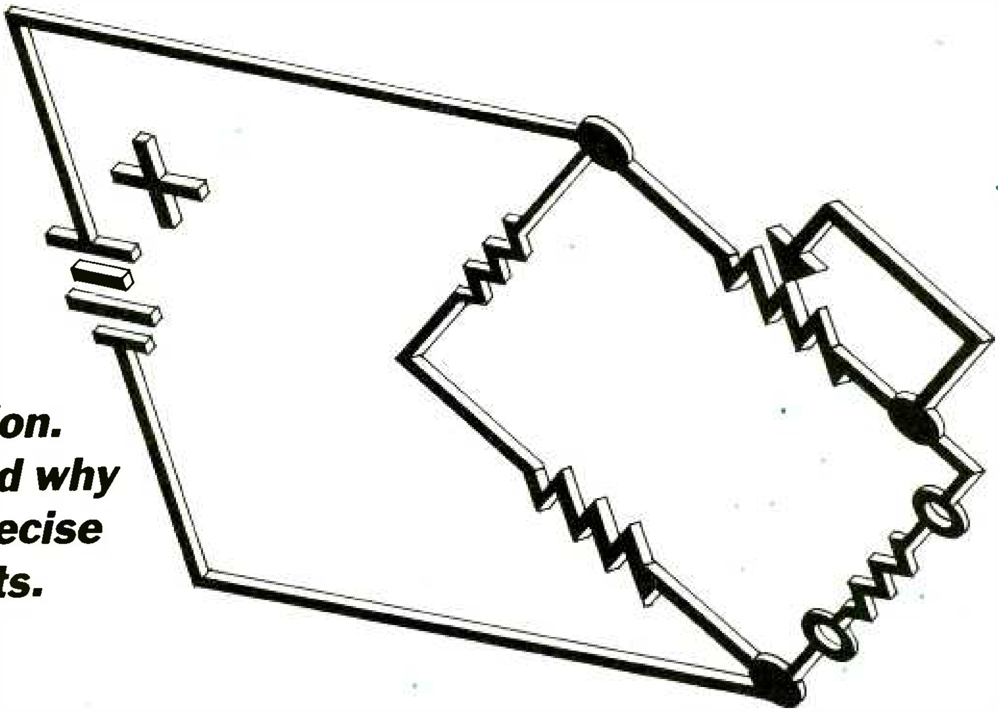
over/under voltage detector manufactured by Maxim (IC1) monitors the line voltage and disconnects the load if the input voltage goes below 95 volts or above 130 volts. The ICL7665 incorporates a pair of comparators and a voltage reference into a single 8-pin DIP. The IC's switch points are accurately set when the chip is manufactured, and its outputs will drive TTL loads directly.

The over/under voltage detector (IC1) monitors the filtered, unregulated DC voltage developed across C5 which changes with the input line voltage. The input voltage levels to IC1 are set by resistors R2 through R8. Both comparators in IC1 change state at 1.3 volts, but the under-voltage output has a built-in inverter which provides a window comparator. As long as the voltage at pin 3 is above 1.3 volts and the voltage at pin 6 is lower than 1.3 volts, both outputs (pins 1 and 7) are low and RY1 is turned on and its contacts are closed. The resistor values for R2 through R8 were carefully chosen to set the voltage levels at which the circuit turns on and off. The math used to determine the resistor values is explained in the sidebar "Calculating Resistor Values." One-percent metal-film resistors must be used for this network. Average line voltage varies from different locations. Trimmer potentiometer R4 provides a small adjustment range so you can set the window's center for your particular line voltage.

When IC1 detects an over-voltage at pin 3, it immediately opens the relay by sending a high output to pin 2 of NOR gate IC3-a which, in turn, turns off Q1. When IC1 detects an over-voltage at pin 6, the output at pin 7 goes high. That high does not turn the solid-state relay off directly. If it did, the energy stored in capacitor C5 would decrease slightly, which would make the circuit "think" that the input voltage has gone back within the desired window. Then RY1 would turn back on even though a voltage outside the trip point might be present.

Continued on page 143

The bridge circuit holds an honored place in the history of electronic instrumentation. Learn how and why they make precise measurements.



BRIDGE CIRCUITS

RAY MARSTON

A BRIDGE CIRCUIT IS AN INSTRUMENT for making *comparison measurements*. These circuits are widely used to measure resistance, inductance, capacitance, and impedance. They have four sections or arms connected in series to form a diamond. An AC or DC voltage source is connected between one pair of opposite junctions, and an indicating meter or output circuit is connected between the other pair of opposite junctions.

Bridge circuits operate on a *null-indication* principle. When the bridge is balanced, the output is zero. Consequently, the indication is independent of the calibration of the indicating device. For this reason, accurate measurments can be made with bridges. Bridge circuits can also control other circuits. When functioning as controls, one arm of the bridge contains a resistive element that is sensitive to such physical variables as temperature or pressure.

Bridge circuits are classical electrical measuring instruments predating electronics as a field distinguished from classical electrical engineering. Until about 25 years ago, bridge circuits were the only practical instruments for making many kinds of precise measurements.

However, in many applications they have been displaced by digital multimeters that contain provisions for making comparable measurements. Nevertheless, the availability of low-cost digital multimeters and capacitance meters (sometimes combined in one instrument) does not negate the value of the basic bridge circuit.

The Wheatstone bridge

The Wheatstone bridge is the best known bridge circuit and the one most widely taught in electronics courses. It consists of two parallel resistance branches with each branch containing two series elements, typically resistors. A DC voltage source is connected across a diamond-shaped network to provide a source of current through the network. A *null detector*, originally a simple galvanometer, is connected between the parallel branches to detect a condition of balance.

The circuit shown in Fig. 1 was first invented by S.H. Christie in 1833. However, its value was not recognized until 1847 when Sir Charles Whetstone described how it could make accurate electrical measurements. As a result of his insights and demonstrations, the bridge came to be known as the Wheatstone bridge.

The Wheatstone bridge has probably been in use longer than any other electrical measuring instrument. Although still an accurate and reliable instrument, it is not as convenient to use as the new digital multimeters. Nevertheless, 0.1% accuracy is commonly obtainable with the Wheatstone bridge. This compares with the 3% to 5% error expected in resistance measurements made with analog ohmmeters. Accuracy on digital multimeters will depend on the meter's

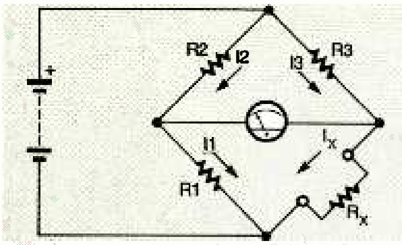


FIG. 1—ORIGINAL WHEATSTONE bridge as demonstrated by Sir Charles Wheatstone in 1843.

TABLE 1
RESPONSE OF 6-RANGE WHEATSTONE BRIDGE

Switch S1 Range	Bridge Range (Ohms)	Resistor R1 Value (Ohms)	R1/R2 Ratio (Nominal)	Bridge Null Sensitivity
1	0-10	10	1/1000	3.0 %
2	0-100	100	1/100	0.3 %
3	0-1k	1k	1/10	0.03 %
4	0-10k	10k	1/1	0.003 %
5	0-100k	100k	10/1	0.03 %
6	0-1MEG	1MEG	100/1	0.3 %

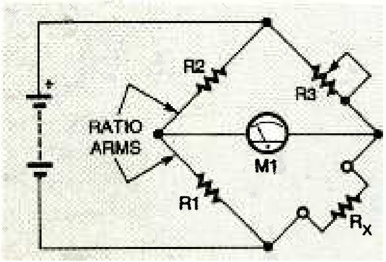


FIG. 2—CONTEMPORARY VERSION of the Wheatstone bridge.

characteristics, such as DC voltage accuracy and resolution.

When making measurements with a Wheatstone bridge to determine the value of an unknown resistor (R_X) one of the remaining resistors is varied until the current through the null detector decreases to zero. The bridge is then in a balanced condition. This means that the voltage across resistor R3 is equal to the voltage drop across the unknown resistor R_X and the two divider resistors R1 and R2 are passing equal voltages. As a result, the following is true:

(1) $I1 \times R1 = I_X \times R_X$

At balance the voltage drops across R2 and R3 are equal so:

(2) $I2 \times R2 = I3 \times R3$

Because no current flows through the galvanometer G when the bridge is balanced, it follows that:

(3) $I2 = I1$ and $I3 = I_X$

Substituting I2 for I1 and I3 for I_X in equation 1 yields the following equation:

(4) $I2 \times R1 = I3 \times R_X$

Dividing equation 2 by equation 4, yields.

(5) $R2/R1 = R3/R_X$

This can be rewritten as:

(6) $R2 \times R_X = R3 \times R1$

Equation 6 states the conditions of balance of a Wheatstone bridge and is useful for computing the value of an unknown resistor, once balance has been achieved.

Dividing both sides by R1 yields the most common Wheatstone bridge equation:

$R_X = R3 \times R1/R2$

An important feature of the original Wheatstone bridge was its very high null sensitivity. Thus, if the bridge is energized from 10-volt DC, 5 volts is developed across all resistors at balance, and the galvanometer remains centered. A shift of only 0.1% will then give a 5 millivolt reading on a calibrated moving-coil analog meter. By installing a simple null-detecting DC amplifier, this circuit can have a *null sensitivity* factor (i.e., percentage out-of-balance detection value) of about 0.003%.

However, the major drawback of this 1847 bridge is that R3 must have a large resistive range if it is to balance all possible values of R_X. In 1848, the German-born engineer Wilhelm von Siemens, overcame this drawback by introducing the modifications, as shown in Fig.2

The bridge can be further modified as shown in Fig. 3 by giving R2 a fixed value and making R1 switch-selectable. This version is based on a 1970 version, high-accuracy laboratory measuring instrument.

The circuit in Fig. 3 can measure DC resistances from near-zero to 1 megohm in six switch-selected decade ranges. Resistor R3 is a calibrated 10-kilohm variable potentiometer that controls the sensitivity of the balance-detecting center-zero meter. The value of RL limits its bridge current to a few milliamperes. Table 1 lists the major weakness of this 1970 Wheatstone bridge—its null sensitivity (which is proportional to the R_X test voltage) degrades in proportion to the R1/R2 ratio's divergence from unity.

Consequently, the sensitivity is nominally 0.003% on the 10-kilohm range where the R1/R2 ratio is 1/1, but it degrades to

Continued on page 145

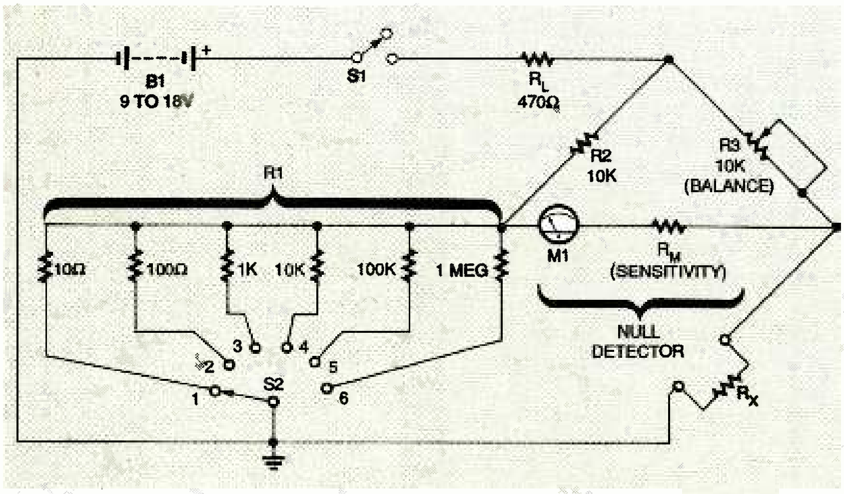
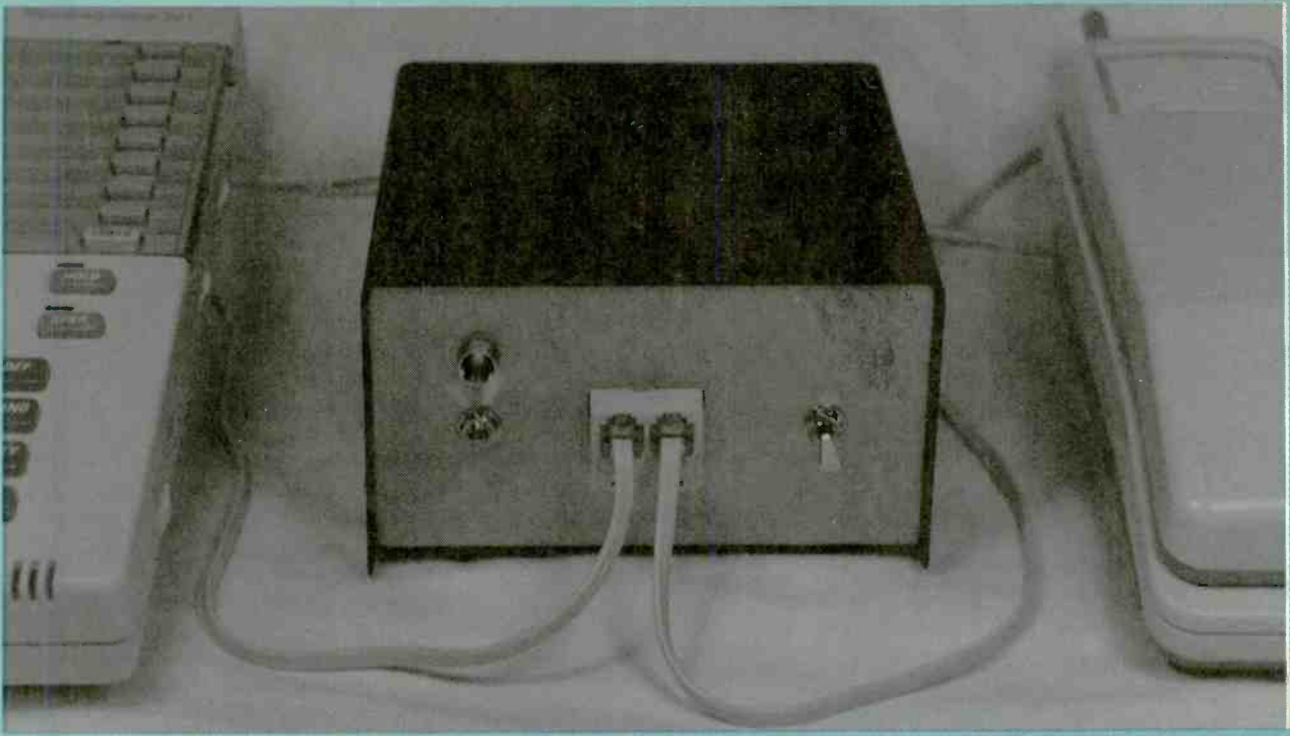


FIG. 3—WHEATSTONE BRIDGE with six DC measuring ranges.



TELCO IN A BOX

Simulate a telephone line with the Telephone Company in a Box.

JAMES E. CICON

YOU JUST BOUGHT A BRAND NEW ANswering machine and you want to test it out. You set it up, connect it to the telephone line, and then just sit there looking at it. You want to see and hear it work, so you drive to a pay telephone and call your home number—nothing happens. Then you rush back home, decide to read the user's manual to find the problem, and then rush back to the telephone booth to test it again.

Now suppose that instead of an answering machine, you have some old telephones lying around in your house that don't work any more. To test those telephones completely, they must be connected to your telephone line and then someone must call you. Perhaps you have a modem or a fax machine that you would like to test but don't want to pay your local copy shop $1 a page.

These hypothetical examples are some of reasons why you will want to build a Telephone Company in a Box, or TCB for short, the subject of this article. It will solve all of the problems posed in these scenarios, cheaply and quickly. All of the components needed to build this project are readily available. You will not need a PC board, nor will you be required to program a microprocessor or microcontroller.

The telephone company

To understand how the TCB works, it is helpful to know what happens on your telephone line when an outgoing call is made or an incoming call is received. When a telephone handset is on-hook, the telephone line voltage is about 50 volts DC. When a handset is off-hook, the telephone line is loaded and the voltage drops to about 7 volts DC; this voltage is detected by the telephone company's central office equipment as an off-hook condition. The central office then provides a dial tone and the equipment waits for you to start dialing. When you dial a telephone number, the central-office equipment halts the dial tone, waits to receive a valid dialed number, and then makes a connection between your telephone and the number you dialed.

When the telephone company's central office equipment has a call for you, it rings your telephone by pulsing the 50-volt DC line voltage on and off at about 20 Hz for a short period of time, then it pauses, pulses again, pauses again, and so on. This produces the ring-ring-ring effect that informs you that there is an incoming call. When

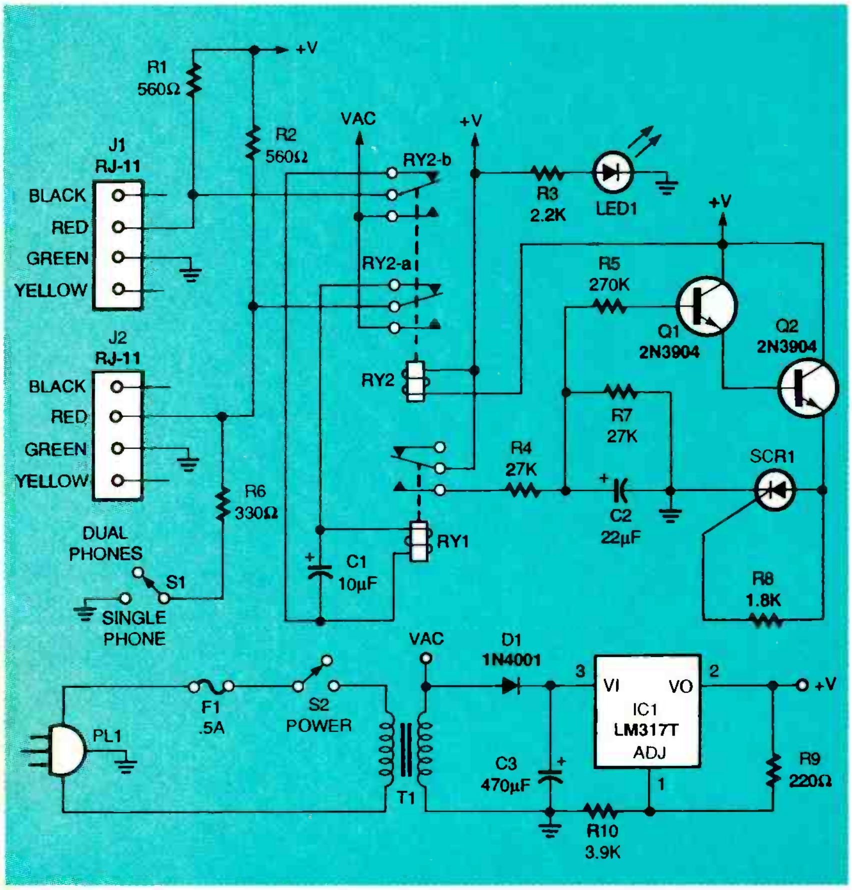


FIG. 1—TCB SCHEMATIC. When telephones plugged into J1 and J2 are both off-hook, they transmit and receive their own audio.

you pick up the handset, the telephone line voltage drops back down to about 7-volts DC. The central office equipment detects the drop in line voltage, stops ringing the telephone, and connects your telephone to the calling party.

How does TCB work?

Two telephones can be plugged into the TCB, which will then simulate all telephone-line functions. When both telephones are on-hook, the TCB supplies 24-volt DC line voltage to both telephones. Although the telephone company supplies 50 volts, the 24 volts will work well because the resistors in series with the telephones have lower values than those used by the telephone company. Moreover, 24 volts DC is both safer to work with and easier to generate.

When one telephone handset is taken off-hook, its line voltage drops to 7 volts DC. The TCB senses this and, if the other telephone handset is on-hook, it emits a ring signal. The ring signal is a 60-Hz sinewave at about 37-volts peak-to-peak. It is applied to the line for one second and halted for one second, repeatedly, until the other handset is picked up. Although the telephone company's ring signal is a 20-Hz squarewave at 50-volts peak-to-peak, the lower ringing voltage is used for two reasons. One is for safety, and the other is because it's easier to pick the ring voltage directly from the secondary of an AC transformer than to generate it with additional circuitry.

When both handsets are off-hook, both lines are loaded to 10-volts DC. The TCB senses the condition, halts the ring signal, and connects both telephones together. Note that when the TCB is ringing the on-hook telephone, it is also sending the ring signal to the off-hook telephone. Depending on the design of the off-hook telephone, it might or might not ring. You might also hear the ringing from the speaker of the handset as a loud buzzing. This is not a problem—just a distraction. Telephones are designed to accept a ring signal even when they are off-hook.

Circuit description

Figure 1 is the schematic for the TCB circuit. When both handsets are on-hook, resistors R1 and R2 supply power to them, and the rest of the circuit can be ignored. When both telephones are off-hook, they transmit and receive their own audio, so all that the TCB does is supply power to them through R1 and R2. If switch S1 is closed, resistor R6 simulates a telephone being plugged into J2, permitting the testing of only one telephone. The rest of the circuit can be ignored in this example.

Now consider the situation where one handset is on-hook and one is off-hook. That causes

PARTS LIST

All resistors are ½-watt, 5%.
R1, R2—560 ohms
R10—3900 ohms
R3—2200 ohms
R4, R7—27,000 ohms
R5—270,000 ohms
R6—330 ohms
R8—1800 ohms
R9—220 ohms
Capacitors
C1—10 µF, 35 volts, electrolytic
C2—22 µF, 35 volts, electrolytic
C3—470 µF, 35 volts, electrolytic
Semiconductors
D1—1N4001 diode
Q1, Q2—2N3904 NPN transistor
LED1—light-emitting diode, any color
IC1—LM317 3-terminal adjustable positive voltage regulator
SCR1—200-volt, 6-ampere silicon controlled rectifier (Radio Shack No. 276-1067)
Other components
F1—½-ampere fuse
J1, J2—RJ-11 telephone jack (see text)
PL1—AC plug and linecord
RY1—SPST reed relay (12 VDC, 11 mA coil; 1-ampere, 125 VAC contacts)
RY2—DPDT miniature relay (12 VDC, 43 mA coil; 1-ampere, 125 VAC contacts)
S1, S2—SPST switch
T1—120/25.2 VAC transformer, 450 mA
Miscellaneous: perforated construction board, fuse holder, project case, wire, solder

the on-hook line to go to 24 volts DC and the off-hook line to go to 7 volts DC. The coil of relay RY1 is connected across the two telephone lines, and the voltage difference between the two lines energizes it. When the contacts of RY1 are closed, C2 charges through R4; it takes about 1 second for C2 to charge to 12 volts DC. The 12-volts DC across C2 causes a voltage-controlled switch consisting of R5, Q1, Q2, SCR1, and R8 to close, thus energizing RY2.

When RY2 is energized, RY1 is removed from the circuit and a 60-Hz, 37-volt peak-to-peak sinewave is placed on the telephone lines causing the telephones to ring. Because RY1 is removed from the circuit, capacitor C2 starts discharging through R7. It takes about 1 second for the capacitor to discharge to about 2.4 volts DC. That lower voltage level causes the voltage-controlled switch to disable RY2, removing the ring voltage from the telephone lines and putting relay RY1 back in the circuit. If one telephone is still off-hook and one is on-hook, the cycle is repeated.

The voltage-controlled switch works as follows: Transistors Q1 and Q2 are connected as a Darlington pair, which couples the voltage across C2 to SCR1. Resistor R8 supplies gate current to the SCR, which is organized so that C2 must charge to 12 volts DC before the SCR will turn on. When SCR1 turns on, the switch is essentially closed, and relay RY2 is energized. When the voltage across C2 drops to about 2.4 volts, Q1 and Q2 force SCR1 to turn off, thus turning the electronic switch off. Resistor R3 and LED1 provide a power-on indication for the user.

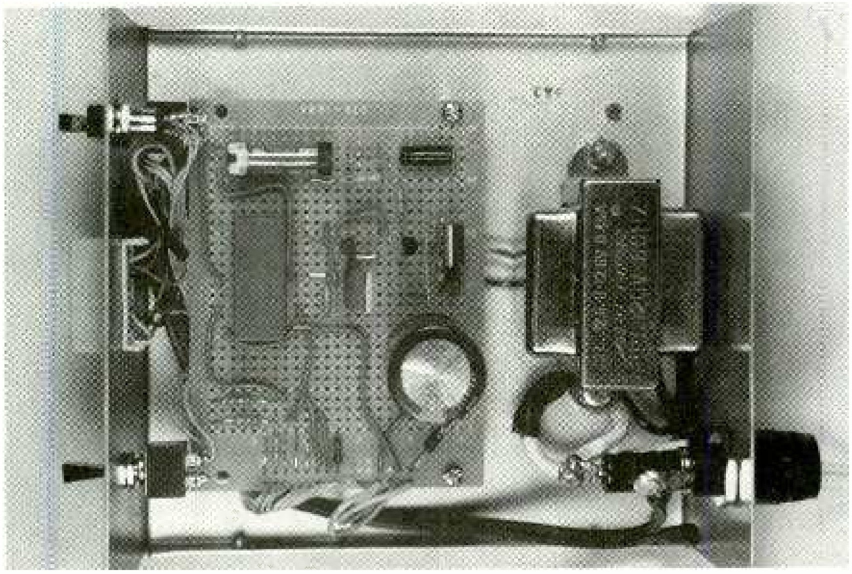


FIG. 2—THE FINISHED BOARD can be mounted in a metal case. Jacks J1 and J2, switches S1 and S2, and LED1 are mounted on the front panel.

Construction

The circuit is so simple that a PC board is not necessary. Use point-to-point wiring. The power cord and AC plug PL1 were obtained from a 6 foot extension cord that usually sells for less than $1. The female end was cut off, making it a line-cord. Jacks J1 and J2 were two parts of a duplex telephone jack adapter that was cut apart. Snap off the male end and solder the wires directly to the exposed leads. However, any RJ-11 jacks will work well. Mount the finished board in a metal case. Any standard project case will do. Mount jacks J1 and J2, switches S1 and S2, and power indicator LED1 on the front panel of the case. Figure 2 shows the inside of the author's prototype unit.

How to use TCB

The TCB is easy to use. Plug a telephone into each of the two telephone jacks and turn the unit on. If you pick up the handset of one of the telephones, the other telephone will ring. When the handset of the other telephone is picked up the ringing stops, and you can talk normally between the telephones, as if a connection had been made by your local telephone company.

If you are testing an answering machine, plug it into one jack, and plug a standard telephone into the other jack. Pick up the handset on the standard telephone, and the answering machine will start ringing and should pick up the line. You will then hear the answering machine's outgoing message in the handset you are holding. The same procedure applies to the testing of modems, fax machines, or virtually any other telephone device whose operation you want to verify. Ω

BY DON LANCASTER

An "all-channels" FM transmitter

Plus electronic-filter fundamentals, switched-capacitor IC resources, a narrow, tunable bandpass circuit, and active noise-cancellation.

I WANT TO START OFF WITH MY USUAL REMINDER THAT I TRY TO RUN A NO-CHARGE TECHNICAL HELPLINE AT (520) 428-4073. PLEASE NOTE MY RECENT AREA CODE CHANGE. THE BEST CALLING times are 8 AM to 5 PM on weekdays, Mountain Standard Time.

I am also the sysop for the *GEnie PSRT RoundTable* and have a similar helpline service there with reprints of most of my columns, and a library forum for Shawn Carlson's *Society for Amateur Scientists*, Steve Hansen's *Bell Jar* vacuum newsletter, Steve Robert's *Nomadness Notes*, Jim Fitzsimons' *Math Wonders*, and others.

We have more than 1300 files in our library, most of them not available elsewhere. You will also find information on wavelets, Basic Stamps, patents, book-on-demand publishing, GhostScript, and Acrobat. I am often asked to give out free Internet services, or free E-mail, or free books, or free coconut anchovy pizzas. But the askee never seems to get around to explaining exactly how this would be funded.

You can send messages to me at my SYNERGTICS@GENIE.-GEIS.COM Internet address to ask questions you want answered on PSRT or in future columns, or to ask for catalogs or place orders. Private email responses are billable at my personal consulting rates, making *GEnie* much cheaper. A typical PSRT reprint download costs you 21 cents. *GEnie* also newly provides full Internet access.

"All channels" FM transmitter

I've had several helpline requests for this one, as a paging override for a factory or plant cable system, or as a "please buy this house" realtor's message one that is received on an FM tuner set to *any* station. I can also see several emergency vehicle traffic-clearing applications for this as well.

I don't have a plug-and-go answer, but I do have a fairly simple paper design that *might* work, one that uses more of that *Fourier series* I have been looking at. Any decent FM receiver will exhibit the *capture* effect: When two competing signals are being received, and if one of them is even slightly larger, then *only* the stronger signal shows up as output audio, interference free. The capture effect happens because of the receiver's limiter circuitry. So, that's a good starting point. If your nearby signal is stronger than a distant one,

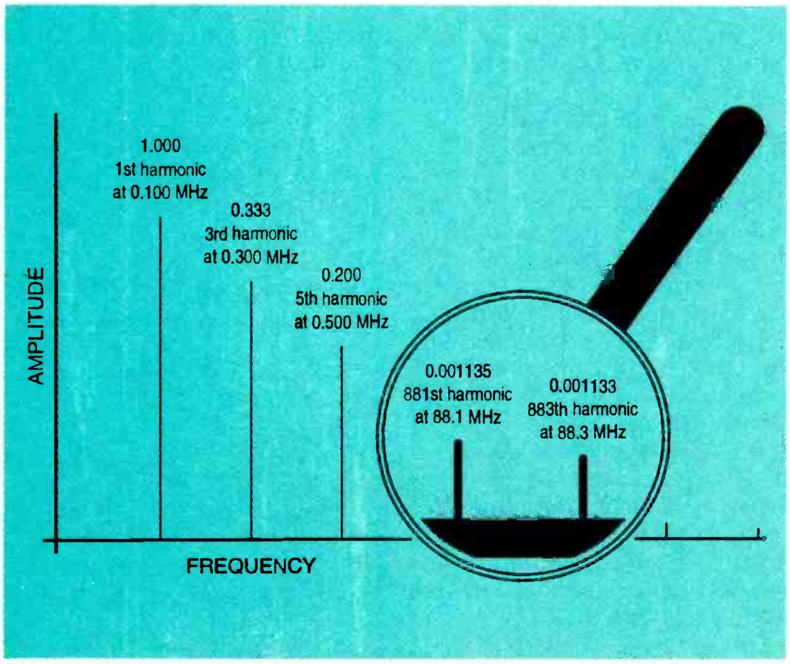


FIG. 1—A FAST RISE 100 KHZ SQUARE WAVE has harmonics well into the FM band. The harmonics match existing FM station channels.

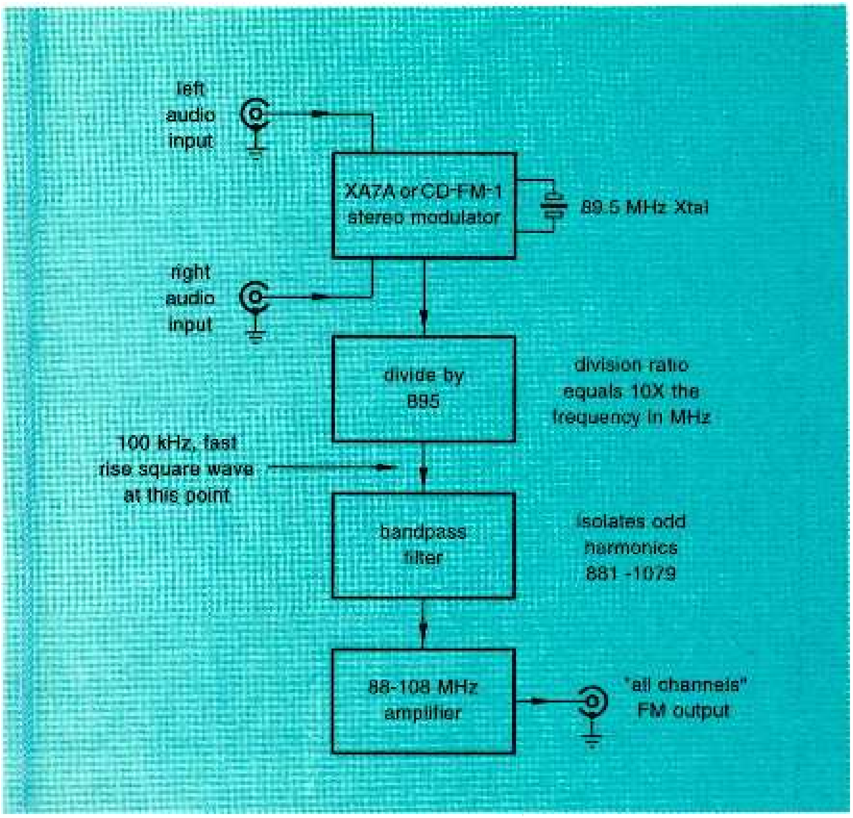


FIG. 2 – ONE POSSIBLE SCHEME for an "all channels" FM generator.

then only the stronger nearby signal will be received.

I've written about stereo broadcasters a few times in past columns. The best starting point is the *Rohm* BA1404 stereo chip. The BA1404 makes a dandy low-cost stereo multiplexer, but is a terrible transmitter. Frequency drift and tuning accuracy slashes range or outright stops reception on digitally synthesized receivers, especially with car radios.

The one- or two-channel solution is to use the BA1404 to drive a crystal-stabilized FM transmitter. But linear frequency modulation of a crystal oscillator is more than a little bit tricky. A lab full of obscure test equipment, a lot of math, and years of experience are needed before you can even think about doing it.

I've explained how the *Pioneer* CD-FM-1 or the *Sony* XA7A auto CD adapters give you an off-the-shelf design solution. But the real problem here is not to transmit on a single channel, but to create *identical* signals on *all* the FM channels at once. Those FM channels run from 88.1 through 107.9 MHz, with an 0.2-MHz channel spacing.

Figures 1 and 2 show how the Fourier Series "comb transmitter" approach might handle this for us. A square wave has a fundamental frequency plus 1/3 the third harmonic, 1/5 of the fifth harmonic, and so on. So, start with a single-channel transmitter using one of those CD car adapters. Divide that down to precisely 100 kHz, making sure the final stage is an ultra-high-speed divider with a rise time better than two nanoseconds.

At this point, you have an FM square wave with lots of harmonics. For instance, there will still be two millivolts or so of the 881st harmonic at, of all places, 88.1 MHz. And, surprise, surprise, there is also an 883rd harmonic at 88.3 MHz, an 885th harmonic at 88.5 MHz, all the way up to the 1079th harmonic at, wonder of wonders, 107.9 MHz. Sure, the high-end "stations" will be a tad weaker than the low-end ones, by about 20 percent or two decibels or, from the center of the band, plus or minus one percent, or one decibel either way. So, just add some gain and a bandpass filter to build up an all-channel FM broadcaster. Those one-dollar MAR chips from *Mini-Circuits Labs* should work just fine for predrivers in the circuit.

To be sure, you'd have problems getting this one to behave in the real world. A wide dynamic range would be needed, as well as thorough shielding. To prevent instabilities, you might want to mill each stage out of a block of solid aluminum. Or, at the very least, use stripline and double ground planes all the way around. There's also some very restrictive FCC regulations on this sort of thing. Transmitting unwanted messages to anyone, ever, is a definite no-no. But neither of these should be a problem on any private cable system. One solution to a "buy my house" application is to use several ultra-low-power curbside sites. Or perhaps go to some sort of a "lossy line" leaky cable that acts as a distributed antenna.

Filter fundamentals

An electronic filter can be defined as a frequency-selective network. A filter can emphasize wanted information while rejecting noise. *Low-pass*

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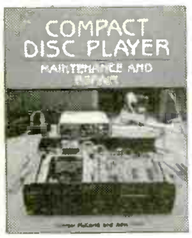
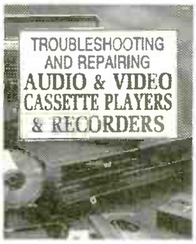
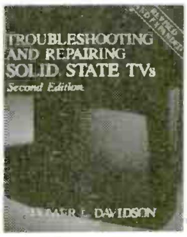


2790P $17.95



3795P $19.95



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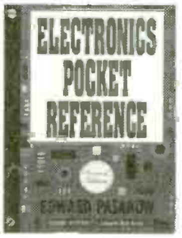
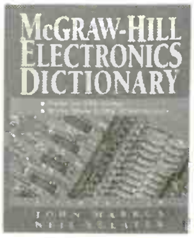


0487375 $24.95



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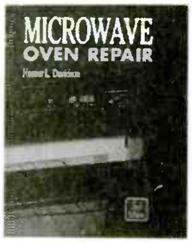

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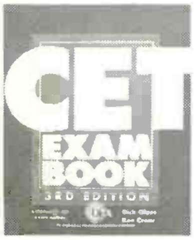
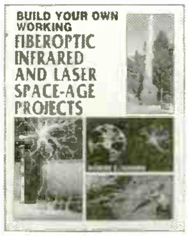
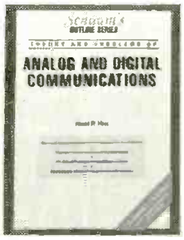


4199P $17.95



2724P $17.95



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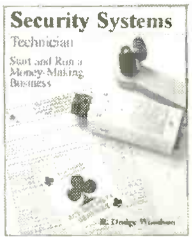
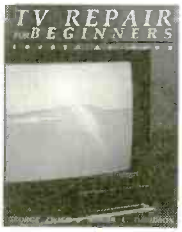
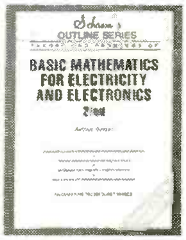


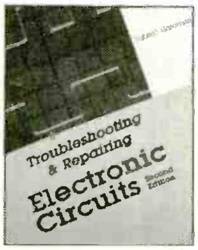
0717753 $19.95



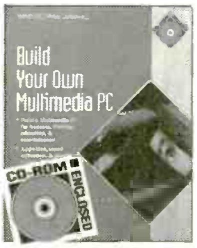
3627P $19.95



0044392 $12.95



3258P $19.95



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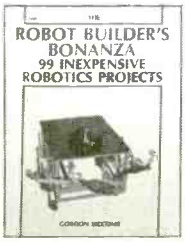
3475P $21.95



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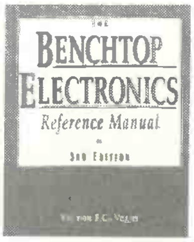

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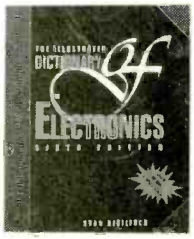

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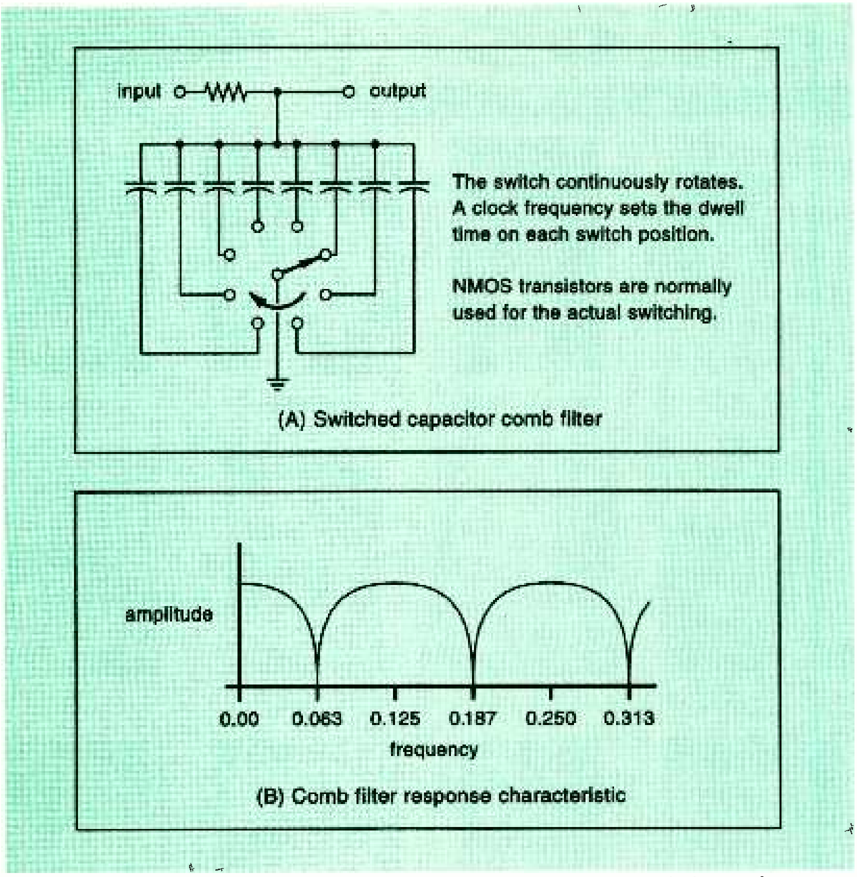

FIG. 3—COMB FILTER BUILT UP by using switched capacitor techniques. Lowpass, bandpass, and highpass versions are also possible.

filters sustain the lower frequencies but obstruct higher ones. One example of a low-pass filter is the treble control on any hi-fi. Noise-reducing capacitors connected to ground in a power supply line are also low-pass filters, often called *bypasses.*

Bandpass filters select midrange frequencies while rejecting the higher and lower ones–the tuning dial on a radio, for instance. Audio equalizers are made from overlapping bandpass filter circuits, each of which can be adjusted independently.

High-pass filters block lower frequencies but emphasize the higher ones. The bass control on a hi-fi is one example of a high-pass filter. By adjusting its cutoff frequency, you can selectively de-emphasize any of the lower musical notes.

Actually, there is no such thing as an electronic high-pass filter. One of these would also be able to transmit microwaves, heat, light, and cosmic rays as well. The frequency response of any electronic circuit usually sets an upper limit, making all high-pass filters into bandpass ones.

Similarly, a true low-pass filter must respond down to DC, including any circuit bias or offsets. Audio low-pass filters add a large decoupling capacitor to block DC, and thus become a bandpass filter in the process. Other more specialized filter types include *band-stop* filters that reject a range of frequencies, *notch* filters that are just very narrow band-stop filters, and *delay networks* that adjust phasing at chosen frequencies.

There are several ways to build a filter. *Classic* filters use fixed inductors and capacitors. *Transmission-line* filters are just the UHF or microwave equivalent of classic *L-C* filters. The big difference is that the inductance and capacitance is *distributed*, rather than *lumped. Active* filters use combinations of resistors, capacitors, and op-amps instead. Advantages include low cost, high gain, and easy tuning.

Mechanical filters make use of the physical resonance of a crystal, ceramic resonator, or magnetostrictive rods. *Surface-wave* filters use constructive and destructive interference of sonic waves on a piezoelectric surface. A *switched-capacitor* filter is a hybrid analog and digital scheme–more on this shortly. Finally, *digital* filters will treat the filter problem as a group of numbers with digital signal processing, FFT transforms, or even wavelets.

The *order* of any filter determines how strong or how powerful it is. For instance, a *first order* low-pass filter should, at best, fall off at six decibels per octave, cutting its response in half as the frequency doubles.

A *second-order* low-pass filter can have a response that drops 12 decibels per octave. An *eighth-order* filter drops down at a rate of 48 decibels per octave. This gets real tricky on bandpass designs. For instance, a second-order bandpass filter might drop off rather steeply just outside its passband, but its ultimate high- or low-frequency falloff will be six dB per octave. The initial falloff rate is set by the Q of the filter which, for a second-order section, ends up as the inverse of the bandwidth.

The *style* of a filter is set by the underlying math used to determine its response. Filters using *Bessel* math provide the flattest time delay but a poor amplitude response. *Butterworth* filters provide the flattest passband amplitude. *Chebycheff* filters provide faster amplitude drop-offs, but at the price of lumpy passband ripple. *Elliptic* filters will add one or more notches just into the stopband, and give the steepest possible falloff, but these suffer from far poorer ultimate signal rejection.

Actually, these strange names are part of a *continuum* of possible filter responses. In an active filter, all you have is a stack of cascaded first- and second-order sections. Each one has a *cutoff frequency* and a *damping* factor. By suitably changing these values, you can create any filter from Bessel on up through elliptic.

In general, you can't do nearly as much with a filter as you'd like to. Increasing the order adds cost, noise, linearity, dynamic range, shielding, losses, tuning, stability, and response problems, besides totally trashing the transients and time delays.

One nasty filter response is called *group* delay. For instance, if a modem tone frequency for a one has a different group delay than that for the zero, then at times you'll get a one, a zero, neither, or both.

In general, digital filters let you do much more, much better than analog filters. For instance, a filter with a "brick wall" or "reject everything" response is impossible with analog designs, but can be created easily with digital techniques. Group delay is also more easily dealt with, and so are the elegant new *constant phase* designs.

Sadly, digital filters are currently restricted to operating on big amplitudes and low frequencies, or to non real-time uses. And they have their own set of problems, not the least of which is *aliasing*, or generating nasty in-band artifacts from out-of-band signals.

By using wavelets or fast Fourier transforms, you can find the full spectrum of a waveform rapidly. Analog filters must instead be swept slowly. You can soon expect to see a revolution in radio receivers. Start at the front end, downconvert, and then digitize. From there, do *everything* digitally. Several technical notes on this are offered by *Harris Semiconductor* and *Analog Devices*. You'll find much more on filtering in my *Active Filter Cookbook*, now in its brand new second edition and *seventeenth* printing. See my nearby *Synergetics* ad for information on its availability.

Switched-capacitor filters

There's an interesting hybrid filter scheme based on both analog and digital technology. This is known as a switched-capacitor filter. The basic idea is shown in Figs. 3 and 4. The switch goes 'round and 'round at a clock rate that is a multiple of the desired center frequency. Now, for a given switch position, there's only one capacitor in the circuit. This capacitor should either increase or decrease its charge according to the *difference* between itself and the input signal. Each capacitor thus retains a *sample* of the recent previous input history.

Now for the neat part: At DC or very low frequencies, the capacitors will pretty much track the input. As the frequency increases, the capacitors may charge or discharge. At a frequency of exactly *one-half* the one-trip-around rate, any capacitor will charge on one pass and discharge on the next, giving a zero output. At a frequency of precisely the one-trip-around rate, any capacitor charges identically on each pass and gives you a *maximum* output.

This simple example forms a *comb* filter. The first null frequency will be determined by the switching rate and the number of capacitors. In this example, the first null frequency is at 1/16th the data rate. Comb filters can reject a fundamental and *all* of its harmonics. One major application for comb filters is separating NTSC color and brightness signals. Different combinations of resistors, switches, and capacitors could build high-quality low-pass, high-pass, band-pass, or band-stop responses. Switching is normally handled by CMOS analog switches.

Advantages of switched capacitor filters include precise tuning over a wide frequency range, plus lower cost and small size. And because everything is done on the silicon chip, there is no need for any external capacitors.

Dozens of switched capacitor filter chips are now available from several sources, some approaching a dollar each. Our resource sidebar for this month shows you several of the main suppliers involved. Of these, check into *Maxim* and *Linear Technology* first. Free samples of these filter chips are available from Maxim.

Sadly, there have been quite a few false starts involving these switched capacitor filters. Early versions had excessive noise floors, caused by the transient feedthrough of the clock. That happens because of the gate-to-source capacitance in any CMOS device. The dynamic range is set at the low end by the noise floor, and at the high end by clipping, distortion, or other nonlinearities. Today, these glitch and noise-floor problems have been minimized. Still, though, switched capacitor filters are strictly limited to larger signals. They are not at all suited for microvolt-size inputs. Typical devices are limited to ultrasonic or lower frequencies. But they sure are a useful tool.

A narrow bandpass filter

There is this interesting new LTC 1164-8 chip from *Linear Technology*. This device creates an easily tunable and ultra-narrow eighth-order elliptic bandpass filter. The bandwidth is one percent of the center frequency. Cost is around $24 in single quantities. Figure 4 shows the details. The chip goes ahead of an op-amp in such a way that the generated noise floor is independent of the gain. With a single 5-volt supply, the current draw is around two milliamperes and the maximum center frequency is 4 kHz. The input clocking frequency is 100 times the center frequency. Output noise is half a millivolt. The stopband attenuation is fifty decibels or so. Careful ground-plane shielding is required. Be certain to carefully read the LTC1164 data sheet.

Gain is adjusted by changing the input resistor. Note that the *smaller* the resistor, the *higher* the gain. A gain of 1000 is possible, but you will get the best dynamics at unity gain. To use the circuit, set the gain by picking the input resistor, apply an input signal you want filtered, and a 100× square-wave clock derived from any old TTL or CMOS source.

For quick and dirty experiments, simply use one sixth of a 74HC14, a variable resistor, and a capacitor to make a square-wave clock source. One obvious use for the chip is for checking real-world harmonic performance of the magic sinewaves I looked at a few columns ago. But one major warning over *any* narrow band filter: *If your signal is changing rapidly, most of it will be missed!* That happens because the high Q of the filter takes a long time to build up a useful result. It's sort of the same as whapping a large pendulum with a hammer. Nothing much happens with one ping. Its only when hundreds of well timed pings occur that oscillation starts. Thus, narrow-band filters must be very accurate and tuned very *slowly*. And they will work only with very

SWITCHED CAPACITOR FILTER RESOURCES

Analog Devices
PO Box 9106
Norwood MA 02062
(617) 329-4700

Burr-Brown
6730 S Tucson Blvd
Tucson AZ 85706
(602) 746-1111

Cermetek
1308 Borregas Ave
Sunnyvale CA 94088
(408) 752-5000

Crystal Semiconductor
PO Box 17847
Austin TX 78744
(800) 888-5016

Datel
11 Cabot Blvd
Mansfield MA 02048
(508) 339-3000

EGG/Reticon
345 Potero Ave
Sunnyvale CA 94086
(408) 738-4266

Exar Corp
PO Box 49007
San Jose CA 95161
(408) 732-7970

Linear Technology
1630 McCarthy Blvd
Milpitas CA 95035
(408) 432-1900

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800

National Semiconductor
2900 Semiconductor Rd
Santa Clara CA 95052
(800) 272-9959

SGS-Thomson
1000 E Bell Rd
Phoenix AZ 85022
(602) 867-6259

Texas Instruments
PO Box 809066
Dallas TX 75380
(800) 336-5236

slowly changing signals.

The data sheet doesn't mention it, but I suspect that the LTC1164 also responds to the second and higher harmonics of your center frequency as well. This is called *aliasing*. Therefore some external prefiltering appears to be a good idea. This device seems ideal for a lot of telecommunication and midrange audio applications, especially for vibration studies and harmonic analysis. But, for ultra-low frequencies (such as seismography or brainwave research), digital FFT or wavelet techniques are the only way to go these days.

Two contests

Let's have a pair of contests this month. Either (A) Add to our dialog

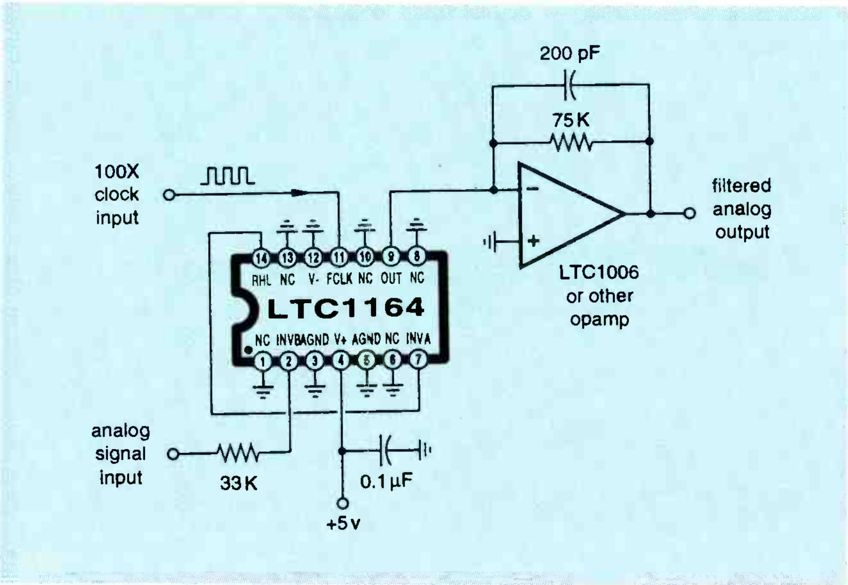

FIG. 4—AN ULTRA SELECTIVE switched capacitor bandpass filter. The center frequency can be tuned by adjusting the digital 100× clock.

NAMES AND NUMBERS

Active Sound & Vib Control
8858 Blue Sea Drive
Columbia MD 21046
(410) 381-9359

Bell Jar
35 Windsor Drive
Amherst NH 03031
(603) 429-0948

GEnie
401 N Washington St
Rockville MD 20850
(800) 638-9636

Harris Semiconductor
Box 883
Melbourne FL 32902
(407) 724-7000

IC Card Systems & Design
6151 Powers Ferry Road NW
Atlanta GA 30339
(404) 955-2500

Mini-Circuits
PO Box 350166
Brooklyn NY 11235
(718) 934-4500

Nomadness Report
PO Box 2185
El Segundo CA 90245
(310) 322-1655

Pioneer
Box 1720
Long Beach CA 90801
(213) 835-6177

Quatech
662 Wolf Ledges Parkway
Akron OH 44311
(800) 553-1170

Radio World
5827 Columbia Pky #310
Falls Church VA 22041
(703) 998-7600

Roberts Hydraulics
311 North Morgan Street
Chicago IL 60607
(312) 829-1365

Rohm Corporation
Box 19681-631
Irvine CA 92713
(615) 641-2020

Special Shapes
PO Box 7487
Romeoville IL 60446
(708) 759-1970

Society Amateur Scientists
1549 El Prado
San Diego, CA 92101
(800) 873-8767

Sony
9 West 57th St 43rd Fl
New York NY 10019
(212) 371-5800

Sycard Technology
1180-F Miraloma Way
Sunnyvale CA 94086
(408) 749-0130

on "all channels" FM schemes, or (B) Show me an unusual new use for an ultra narrow, switched capacitor bandpass filter.

There'll be a dozen or so of my *Incredible Secret Money Machine II* books going to the better entries. Plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all. Please send your *written* entries to me here at *Synergetics*, rather than to *Electronics Now* editorial.

New tech lit

An update on those active noise-cancellation topics we looked into several columns back: I've uploaded a tutorial and resource directory as NOISCNCL.TXT. There's also a new *Active Sound and Vibration Control News* with free sample copies available.

More on FM radio RBDS services: There is now an Internet forum up at http://pcbf1131e.util.ch/~uer/rdsh000.htm. As always, *Radio World* is the best place to get RBDS information. Hundreds of stations now provide RBDS services, ranging from song title and artist, traffic and weather, coupon promotions, on up to GPS navigation corrections.

Those new plug-in PCMCIA cards for laptop computers are also known as PC cards. One trade journal that zeros in on these is *IC Card Systems & Design*. A pricey source for books on the PCMCIA standard is *Sycard*. One source of cards is *Quatech*.

Bargain hydraulics are offered by *Roberts*. Unusual modelmaking parts are available at *Special Shapes*.

The magic sinewave stuff that I looked at a few columns or ago has now been improved and upgraded as MAGICSIN.PDF. I've got actual chips and working hardware. Co-developer packages are newly available for this emerging opportunity.

For most small-scale startups most of the time, patents are certain to end up as a net loss of time, energy, money, and sanity. Find out why this is true in my *Case Against Patents* resource package. An autographed copy of my *Incredible Secret Money Machine II* is included in the patents resource pack.

My usual reminder that most of the resources mentioned appear in the *Names & Numbers* or that *Switched Capacitor Filter Resources* sidebar. I've managed to wrangle a special ten free hour *GEnie* PSRT trial per the *Need Help?* box. EN

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Synergetics
Box 809-EN
Thatcher, AZ, 85552
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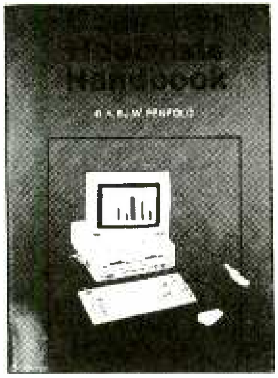

☐ INTERNATIONAL RADIO STATIONS GUIDE—BP255—$9.95

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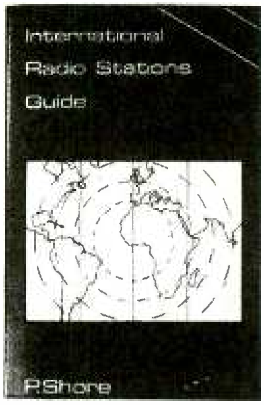
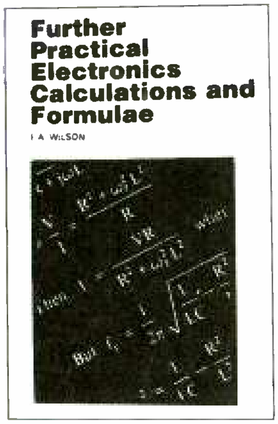
Includes coverage on Listening to Short Wave Radio, ITU Country Codes, Worldwide Radio Stations, European Long Wave and Medium Wave Stations, Broadcasts in English and more.





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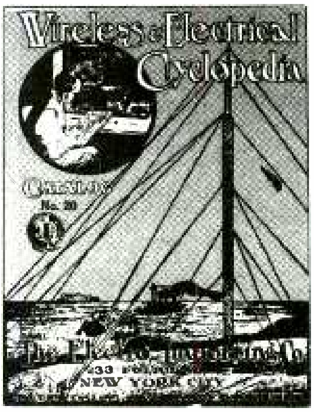

☐ WIRELESS & ELECTRICAL CYCLOPEDIA—ETT1—$5.75

A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period Take a look at history and see how far we have come. And by the way, don't try to order any of the merchandise shown, it's unlikely that it will be available. And if it is, the prices will be many times higher.

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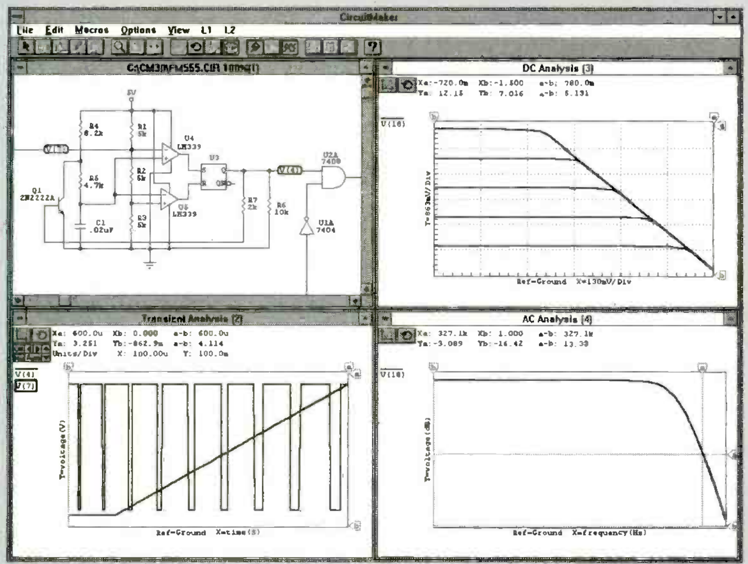

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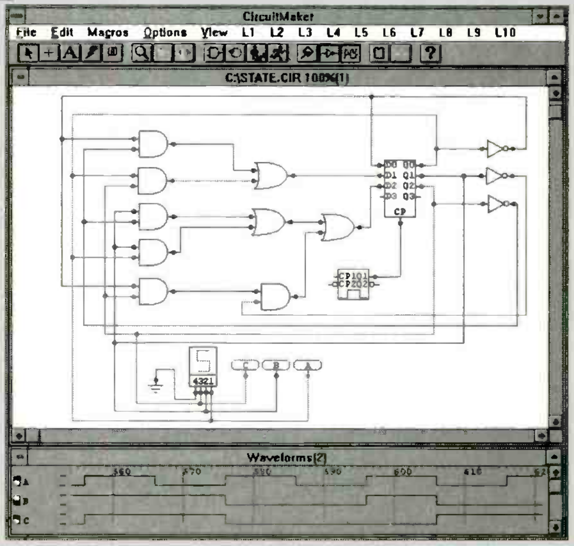

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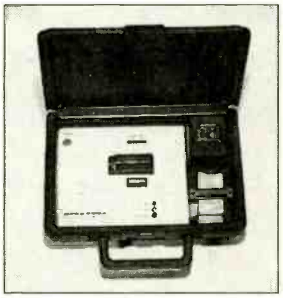

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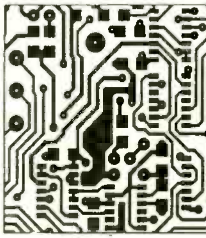

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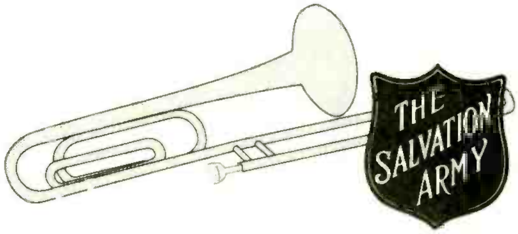
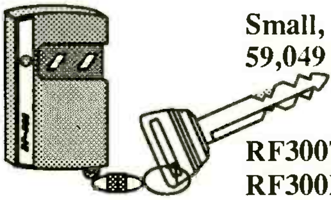


Miniature Transmitters and Receivers



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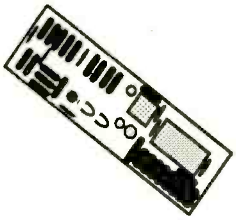

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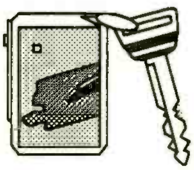

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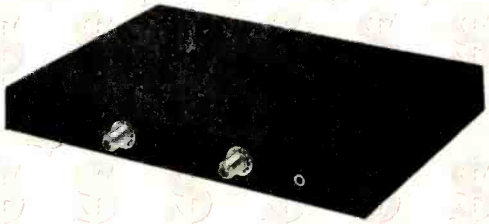

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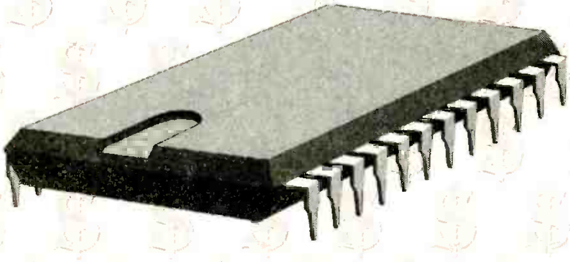

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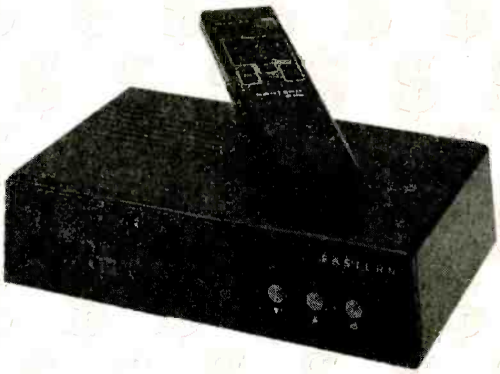

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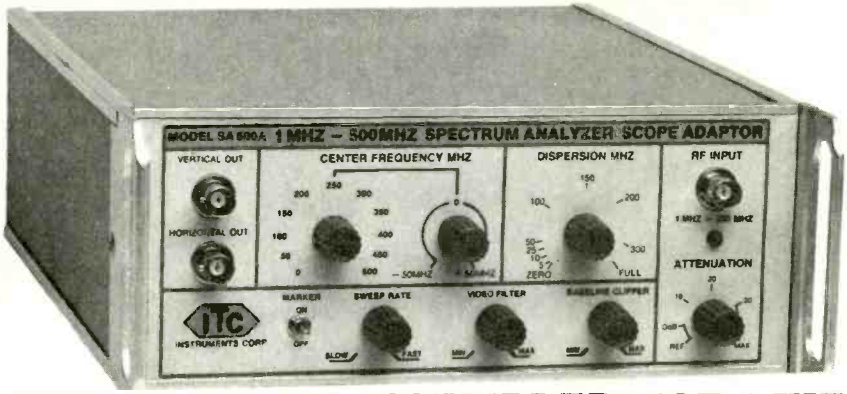

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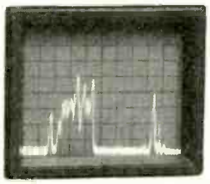

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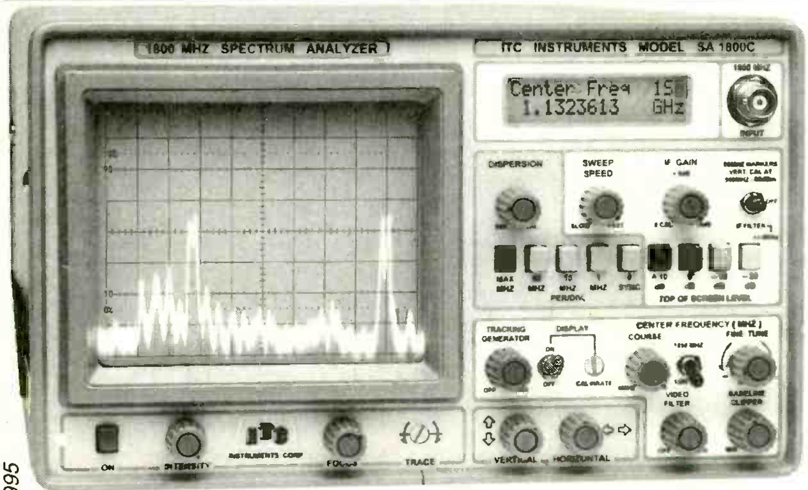

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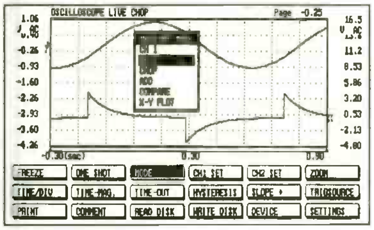
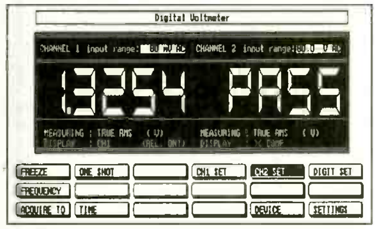
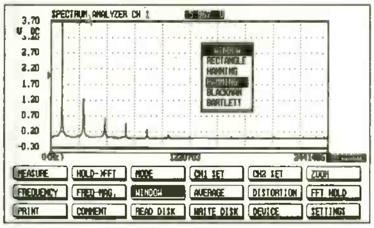


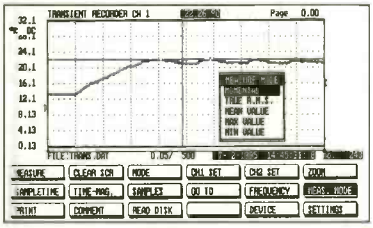
* voltmeter



* spectrum analyzer



* transient recorder



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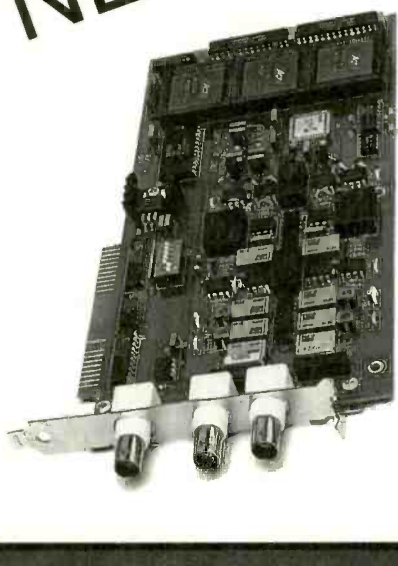

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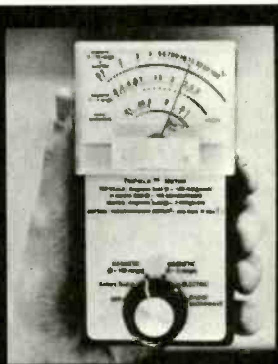

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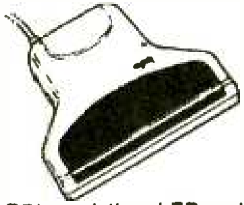

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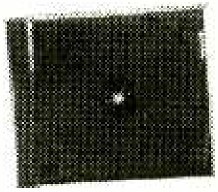

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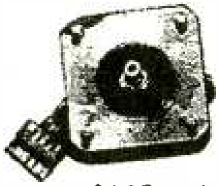

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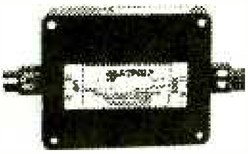

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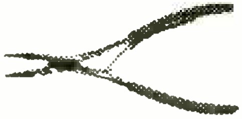

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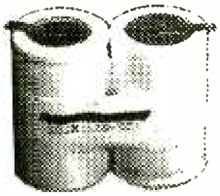

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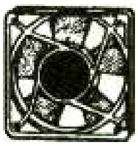

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40-CHANNEL CB TRANSCEIVER MODULE

These are new units with book and schematics. They have been tested to be fully functional. The microphones are missing. All the controls and channel readout were in the mike. Build a remote base or use for parts.

95A001 — **$10.00 each**

DIODE GRAB BAG

Thousands of diodes of all kinds, including Zeners, Power, Schottky, Signal, etc.

94Z007 — **Half Pound Mix - $14.95**

250 WATT TRANSISTOR PAIR

Complementary pair MJ15024 and MJ15025, 250 Volt, 16 Amp transistors used for high power audio and other linear applications. Application notes included.

92S012 — **One Pair for $9.95**

RESISTOR RIOT

⅛, ¼, ½ Watt, power, precision, fixed, adjustable, etc. Thousands of pieces.

92P023 — **5 Lbs. for $4.95**

TIP110 TRANSISTOR

2A, NPN Darlington.

94S003 — **49¢ each**

100 for $39.95 - 1000 for $250.00

3300µF 16V AXIAL CAPACITOR

1.625"L x 0.625"D. (95P013)

95P013 — **50 for $19.95**

USED TUBES - $1.00 EACH

Your choice. Pulls, tested good.

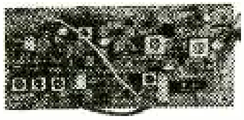
6AK5	6DE4	7Y4
6AX4	6SN7	12AU7
6CG8	6V6	12SJ7

Prices good until October 31, 1995

INFRARED KIT

Includes assembled transmitter unit with thirty buttons, detector unit, printed circuit board, detector amplifier IC, and all parts needed to detect the signal from the transmitter and convert it to a serial TTL signal. Schematics included.

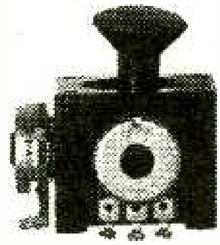
93V010 — **$19.95 each**



TV DEMODULATOR BOARD

Takes channel 3, 4 or 5 signal and demodulates the audio. Comes with info and schematics, and additional schematics to build add-on video demodulator board.

92A028 — **$14.95 each**

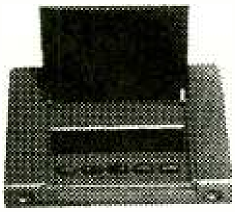


JOYSTICKS

Two 150K pots.

93P005

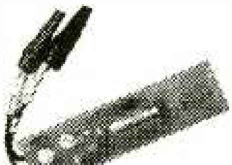
$3.95 each



14-DAY PROGRAMMABLE TIMER

Originally used to control a satellite receiver through its IR port at a distance of up to 23 ft. Time on/off for eight distinct events. Modify it for your needs or dismantle it for its parts. Programmable with a 2732 EPROM in a removable "personality" module, the unit may be modified to control any IR device through its IR port. Contains Z80 CPU, clock display and associated parts. Operates from 9VDC 500 mA wall transformer which is included. BRAND NEW!

92V014 — **$9.95 each**



TELEPHONE LINE TEST MODULE

When hooked up to your phone line, this unit will flash and answer the line after the first ring - then hang up! Originally used for testing. Can be used to thwart prank phone callers. Two alligator clips make hookup easy.

95Z002 — **$2.49 each**

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Minimum order $15.00.
California residents add sales tax.
Shipping additional on all orders.

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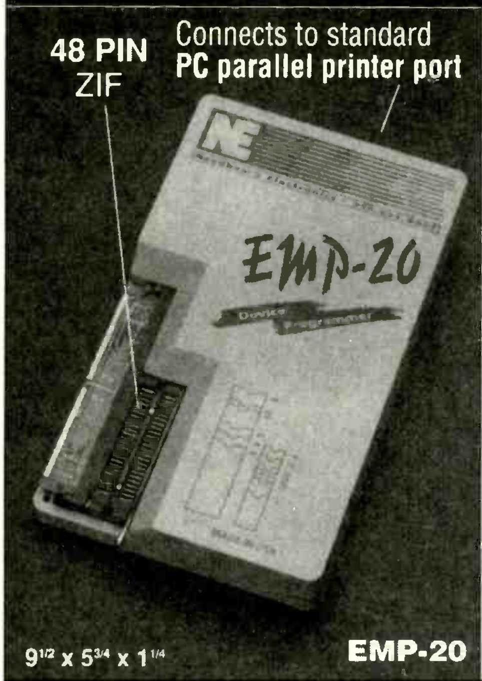
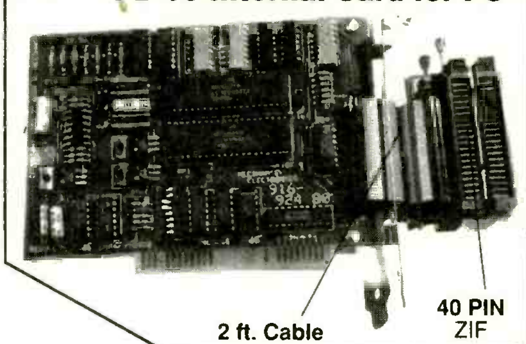
CIRCLE 215 ON FREE INFORMATION CARD

Device Programmers

$449.95 — **$139.95**





- Easy to use software, on-line help, full sceen editor
- **Fast Programming** (EMP-20) 27C010A, 23 seconds 28C020, 34 seconds 27C040, 95 seconds
- **Made in USA**
- 1 Year Warranty
- Technical Support by phone
- 30 day Money Back Guarantee
- FREE software upgrades available via BBS
- Demo SW via **BBS (EM20DEMO.EXE) (PB10DEMO.EXE)**
- **E(e)proms** 2716 - 8 megabit, 16 bit 27210-27240, 27C400 & 27C800,
- **Flash** 28F256–28F020, (29C256–29C010 (EMP-20 only))
- **Micros** 8741A, 42A, 42AH, 48, 49, 48H, 49H, 55, 87C51, 87C51FX, 87C751,752
- **GAL, PLD** from NS, Lattice, AMD-**16V8, 20V8, 22V10** (EMP-20 only)

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CIRCLE 257 ON FREE INFORMATION CARD

Tube & General Purpose Projects

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HIGH QUALITY CHASSIS FOR NEW TUBE PROJECTS!

LC SERIES
FIELD REMOVABLE TOP AND BOTTOM 0.080" ANODIZED ALUMINUM PANELS. FRONT & REAR PANELS 0.063" GOLD ANODIZED ALUMINUM; OTHER PARTS BLACK ANODIZED. VENTED CAGES & OAK ENDS AVAILABLE.

LC Series

MODEL	SIZE (mm) W x D x H	PRICE $ A	PRICE $ B
LC-1	100 x 100 x 50	45.00	47.50
LC-2	150 x 100 x 50	50.00	52.50
LC-3	200 x 100 x 50	55.00	57.50
LC-4	300 x 100 x 50	60.00	62.50
LC-5	150 x 150 x 75	50.00	54.00
LC-6	200 x 150 x 75	55.00	59.00
LC-7	300 x 150 x 75	60.00	64.00
LC-8	400 x 150 x 75	65.00	69.00
LC-9	200 x 200 x 75	60.00	64.00
LC-10	250 x 200 x 75	65.00	69.00
LC-11	300 x 200 x 75	70.00	74.00
LC-12	425 x 200 x 75	75.00	79.00
LC-13	250 x 250 x 100	70.00	76.00
LC-14	300 x 250 x 100	75.00	81.00
LC-15	350 x 200 x 100	80.00	86.00
LC-16	425 x 250 x 100	85.00	91.00

ALL HARDWARE SUPPLIED.

SESCOM BOXES ARE USED BY HUNDREDS OF CONTRUCTORS!

USE IS LIMITED ONLY BY YOUR IMAGINATION!

NEW LARGER SIZES

Metal Cabinets

MODEL	W x D x H (IN)	PRICE $ A	PRICE $ B
MC-1A	4 x 3 x 2	12.00	14.00
MC-2A	6 x 3 x 2	14.00	16.00
MC-3A	8 x 3 x 2	16.00	18.00
MC-4A	4 x 5 x 3	14.00	16.00
MC-5A	6 x 5 x 3	16.00	18.00
MC-6A	8 x 5 x 3	18.00	20.00
MC-7A	4 x 7 x 4	16.00	18.00
MC-8A	6 x 7 x 4	18.00	20.00
MC-9A	8 x 7 x 4	20.00	22.00
*MC-10A	8.5 x 7 x 1.75	32.00	34.50
*MC-11A	8.5 x 10 x 1.75	34.00	36.50
*MC-12A	8.5 x 14 x 1.75	36.00	38.50
*MC-13A	8.5 x 7 x 3.5	33.50	36.00
*MC-14A	8.5 x 10 x 3.5	35.50	38.00
*MC-15A	8.5 x 14 x 3.5	37.50	40.00
*MC-16A	17 x 7 x 1.75	34.50	38.00
*MC-17A	17 x 10 x 1.75	36.75	40.25
*MC-18A	17 x 14 x 1.75	42.75	46.25
*MC-19A	17 x 7 x 3.5	36.75	40.25
*MC-20A	17 x 10 x 3.5	39.25	42.75
*MC-21A	17 x 14 x 3.5	45.25	48.75
EXTRA PAIR FRONT/REAR PANELS		5.00	7.50

WOW, DO WE HAVE BOXES!

Rack Chassis

MODEL	W x D x H (IN)	PRICE $ A	PRICE $ B
1RU5	19 x 5 x 1.75	34.00	44.00
1RU7	19 x 7 x 1.75	36.50	48.50
1RU10	19 x 10 x 1.75	38.75	50.00
1RU12	19 x 12 x 1.75	42.75	56.00
1RU15	19 x 15 x 1.75	45.75	58.00
1RU17	19 x 17 x 1.75	48.75	60.00
2RU5	19 x 5 x 3.5	36.50	46.50
2RU7	19 x 7 x 3.5	38.75	50.75
2RU10	19 x 10 x 3.5	41.25	53.00
2RU12	19 x 12 x 3.5	45.25	58.25
2RU15	19 x 15 x 3.5	48.25	60.50
2RU17	19 x 17 x 3.5	51.25	62.50
3RU5	19 x 5 x 5.25	46.00	56.50
3RU7	19 x 7 x 5.25	48.50	60.75
3RU10	19 x 10 x 5.25	51.00	63.00
3RU12	19 x 12 x 5.25	54.00	68.25
3RU15	19 x 15 x 5.25	57.00	70.50
3RU17	19 x 17 x 5.25	60.00	72.50
EXTRA PAIR FRONT/REAR PANELS		7.50	9.00

SESCOM ALSO STOCKS ALL KINDS OF USEFUL PARTS FOR CONSTRUCTION INCLUDING CONNECTORS, SCREWS, METERS, TOOLS, ETC.

Audio Transformers for Tube Construction

Inputs – Line/Mic

MODEL	PRI Ω	SEC Ω	CASE STYLE	USE	PRICE $ A	PRICE $ B
AT-1	150	60k	A	MIC INPUT	40.50	42.50
AT-2	15k	15k	A	LINE INPUT	40.50	42.50
AT-3	15k	600	B	LINE OUTPUT	46.75	48.50

Tube Outputs

MODEL	PRI Ω	SEC Ω	CASE STYLE	USE	PRICE $ A	PRICE $ B
OT-1	5k	8	B	EL84 3 WATT	9.00	11.00
OT-2	6k	4,8,16	B	EL84 10 WATT	12.00	16.00
OT-3	7k	4,8,16	B	EL34 20 WATT	18.00	24.00

ULTRA LINEAR DESIGN

OUTPUT TRANSFORMERS DESIGNED FOR SIMPLE OUTPUT STAGES AND FEATURE FREQUENCY RESPONSE ±2 dB 40-15k Hz.

Power Supply

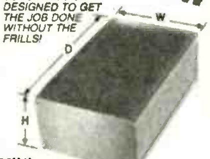
MODEL	SECONDARY #1	SECONDARY #2	SECONDARY #3	CASE STYLE	USE	PRICE $ A	PRICE $ B
PT-1	125V/ 25mA	6V3/ .3A		B	PRE AMP	9.00	11.00
PT-2	250-0-300 40mA	5/ 2A	6V3/ 2A	B	5W AMP	16.00	24.00
PT-3	300-0-300 70mA	5/ 2A	6V3/ 2A	B	10W AMP	20.00	26.00
PT-4	400-0-400 180mA	5/ 3A	6V3/ 4A	B	20W AMP	24.00	30.00

CASE STYLE A

CASE STYLE B

GREAT LITTLE BOXES FOR LOW COST CONSTRUCTION
DESIGNED TO GET THE JOB DONE WITHOUT THE FRILLS!

NEW



MINI PROJECT BOX
ALTHOUGH NOT DESIGNED FOR TUBE CONSTRUCTION, THERE ARE VERY USEFUL IN LABS. DESIGNED WITH SIX 0.040" FLAT RAW ALUMINUM PANELS AND MICRO EXTRUSION.

Mini Project Boxes

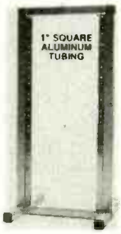
MODEL	SIZE (IN) W x D x H.	PRICE $ A	PRICE $ B
MPB-1	1 x 2 x 1	1.95	2.25
MPB-2	1 x 4 x 1	2.40	2.75
MPB-3	1 x 6 x 1	2.85	3.25
MPB-4	1.5 x 2 x 1.5	2.05	2.25
MPB-5	1.5 x 4 x 1.5	2.55	2.85
MPB-6	1.5 x 6 x 1.5	3.00	3.60
MPB-7	1.5 x 2 x 3	2.25	2.55
MPB-8	1.5 x 4 x 3	2.75	3.15
MPB-9	1.5 x 6 x 3	4.00	4.50
MPB-10	1.5 x 2 x 5	2.50	3.00
MPB-11	1.5 x 4 x 5	2.95	3.55
MPB-12	1.5 x 6 x 5	4.25	5.05
MPB-13	2 x 2 x 2	2.20	2.60
MPB-14	2 x 4 x 2	2.65	3.15
MPB-15	2 x 6 x 2	4.40	5.00
MPB-16	2 x 8 x 2	6.65	7.35
MPB-17	3 x 2 x 3	2.45	2.95
MPB-18	3 x 4 x 3	2.90	3.50
MPB-19	3 x 6 x 3	4.20	4.90
MPB-20	3 x 8 x 3	4.65	5.45
MPB-21	4 x 6 x 3	4.55	5.15
MPB-22	4 x 10 x 3	4.75	5.45
MPB-23	4 x 12 x 3	5.70	6.30
MPB-24	4 x 14 x 3	6.10	6.80

PERFORATED OR PLEXIGLASS PANELS ALSO AVAILABLE

RACKEM 'N' STACKEM Table Top Racks

MODEL	HEIGHT IN RACK UNITS	PRICE $ A	PRICE $ B
RSR-6-19	6	70.00	80.00
RSR-8-19	8	75.00	87.50
RSR-10-19	10	70.00	80.00
RSR-12-19	12	70.00	80.00

CLEAR FINISH STANDARD. ADD /B FOR BLACK OR /G FOR GOLD.



PICTURED WITH OPTIONAL RE-1 RACK EARS

RACKEM 'N' STACKEM BOXES

MODEL	W x D x H (IN)	PRICE $ A	PRICE $ B
RSB-3	7.5 x 3 x 1.65	25.00	30.00
RSB-5	7.5 x 3 x 1.65	31.25	36.25
RSB-7	7.5 x 3 x 1.65	38.00	43.00
RSB-9	7.5 x 3 x 1.65	45.00	50.00
RSB-11	7.5 x 3 x 1.65	51.50	56.50
RSB-13	7.5 x 3 x 1.65	58.25	63.25

ASSORTED MOUNTING ACCESSORIES ALSO AVAILABLE

ALL BOXES ARE SHIPPED FLAT FOR EASY FABRICATION
UNLESS OTHERWISE NOTED BOXES HAVE FLAT PANELS CONSTRUCTED OF 0.063" ANODIZED ALUMINUM (SIDES ARE 0.125"). FRONT AND REAR PANELS ARE CLEAR, BALANCE OF BOX IS BLACK. BLACK OR GOLD FRONT & REAR AVAILABLE FOR AN ADDITIONAL $5.00.

Pots

PART #	Ω	TYPE	PRICE $ A	PRICE $ B
APOT-1	100k	S LIN	2.75	3.00
APOT-2	100k	S LOG	2.75	3.00
APOT-3	100k	D LIN	5.50	6.00
APOT-4	100k	D LOG	5.50	6.00
APOT-5	470k	S LIN	2.75	3.00
APOT-6	470k	S LOG	2.75	3.00
APOT-7	1M	S LIN	2.75	3.00
APOT-8	1M	S LOG	2.75	3.00
APOT-9	1M	D LIN	5.50	6.00
APOT-10	1M	D LOG	5.50	6.00
APOT-11	100k (FOR BALANCING)	D LOG	6.50	7.00

MOUNTING HOLES 10mm (.393") DIA.; SHAFTS 6mm (.236") DIA., BLACK MATTE KNOBS 15mm (.590") DIA. X 14mm (.551") SUPPLIED.
S = SINGLE D = DUAL

Sockets

PART	TYPE	PRICE $ A	PRICE $ B
TS-1	7 PIN S	1.90	2.10
TS-2	7 PIN P	1.90	2.10
TS-3	9 PIN S	1.90	2.10
TS-4	9 PIN P	1.90	2.10
TS-5	8 PIN OCTAL S	2.50	2.70
TS-6	8 PIN OCTAL P	2.50	2.70

GENERAL PURPOSE SOCKET TYPES, FULL MOUNTING DETAILS INCLUDED IN CATALOG TB-1.
S = SOLDER P = PC MOUNT

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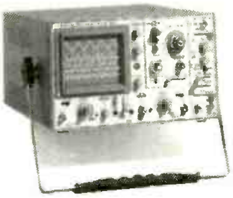
CIRCLE 269 ON FREE INFORMATION CARD

INSTEK® Test & Measuring Instruments ISO 9002 CERT. #934163

100 MHz Cursor Readout Scope 4 ch, 8 traces OS-6101 $1,499.95

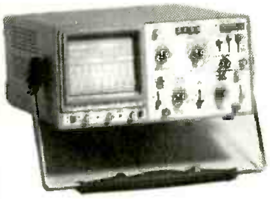
* 4 independent channels, 8 traces
* Time /Voltage cursor measurement
* ALT triggering function for 4 ch.
* Sweeps to 2ns/div, Delayed Sweep
* TV Sync., Ch. 1 output, Z-axis input
* 2 probes(x1, x10)

100 MHz Scope, 4ch. 8 traces
Best value all purpose scope
OS-6100B $1,329.95



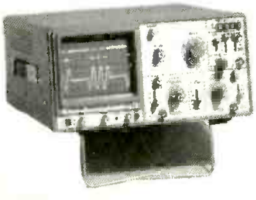
* 4 channels, 8 traces
* High sensitivity 500μV/div
* Sweeps to 2ns/div, Delayed sweep
* 20 kV accelerating voltage
* TV sync., Z-axis input
* A and B gate output
* Best price 100 MHz scope
* 2 probes(x1, x10)

50 MHz Triggering Oscilloscope OS-653 $699.95



* Dual Channel
* Hold Off Function
* Delayed Sweep
* Built-in Delay Line
* TV Sync
* ALT Triggering
* High sensitivity 1 mV/div
* Trigger level lock function
* Z-axis input, CH1 output
* 2 probes(x1, x10)

20 MHz Oscilloscope OS-622B $344.95



* Dual trace, X-Y operation
* TV Sync., Z-axis input,CH 1 output
* High sensitivity 1 mV/div
* Trigger level lock
* 2 probes (x1, x10)

OS-645B - 40 MHz Cursor readout........$ 734.95
OS-625B - 20 MHz Cursor readout........$ 549.95
OS-623B - 20 MHz w/Delayed Sweep........$ 449.95
OS-935 - 5 MHz One channel........$ 209.95

DC Linear Power Supplies Single Output

* Constant voltage and constant current mode
* Voltage regulation ≤0.01%
* Current regulation ≤0.2%
* Low ripple and noise
* Overload and reverse polarity protection
* Features 2 analog or 1 digital meter(PS series)
  2 analog or 2 digital meters(PR series)

PS-1830 : (0-18V, 0-3A)........$209.95
PS-1830D : Digital Display........$219.95
PS-1850 : (0-18V, 0-5A)........$219.95
PS-1850D : Digital Display........$244.95
PS-3030 : (0-30V, 0-3A)........$224.95
PS-3030D : Digital display........$254.95
PS-6010 : (0-60V, 0-1A)........$209.95

PR-1810H : (0-18V, 0-10A)........$349.95
PR-3060 : (0-30V, 0-6A)........$314.95
PR-6030 : (0-60V, 0-3A)........$299.95
PR-6030D : Digital Display........$399.95

Triple Output DC Power Supplies

* Two variable 0-30VDC, 0-3A outputs
* One fixed 5VDC, 3A output
* Auto tracking
* Auto serial and parallel operation
* Constant voltage and constant current mode
* Continuous/dynamic load can be selected
* Features 4 analog or 2 digital displays

PC-3030 : (0-30V, 0-3Ax2)........$499.95
PC-3030D : Digital display........$549.95

Programmable DC Power Supplies

* High stability , low drift, 4 digit display
* Front/rear output-sense switch selectable
* Auto step running w/timer settings
* 100 point programmability (PPS series)
* 50 point programmability (PPT series)
* Auto serial and parallel operation (PPT series)
* Auto tracking (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

PPS-1860G: (0-18V, 0-6A)........$1099.95
PPS-3635G: (0-36V, 0-3.5A)........$1099.95
PPS-6020G: (0-60V, 0-2A)........$1099.95
PPT-1830G: (0-18V, 0-3Ax2, 0-6V, 0-5A)........$1399.95
PPT-3615G: (0-36V, 0-1.5Ax2, 0-6V, 0-3A)........$1399.95

Digital Display Function Generator FG-8016G $239.95

* Frequency Range: 0.02Hz to 2MHz
* Three Instruments in one: Function generator, Pulse generator & Frequency counter.
* Sine, Triangle, Square, TTL Pulse and CMOS output
* Built-in 6 digit counter with INT/EXT function
* 1000:1 tuning range
* Variable DC offset control

FG-8015 Function Generator
* 0.02Hz-2MHz (No Counter)........$189.95

FC-8131 Intelligent Counter 1.3GHz........$469.95
FC-8270 Intelligent Counter 2.7GHz........$629.95
UC-2010G Universal Counter........$294.95

Digital Multimeter & C Meter DM-8034(3½ digits) $179.95

* 8 Function, AC/DC voltage, AC/DC current, resistance
* Built-in C meter, diode test and audible continuity check
* High voltage 1000V and 20A range
* 0.5% basic accuracy

DM-8040 (3¾ Digits, True RMS)
* Measures ACV to 50 kHz........$339.95

DM-8055 (5½ Digits)........$649.95
* 0.006% basic accuracy
* 1μV, 1mΩ, 1nA resolution
* dBm measurement
* Auto range, relative mode, Max/Min

DM-8055G(5½ Digits, GPIB)........$889.95

Model DM-392 (3¾ digits) $109.95

* Auto/Manual ranging(38 ranges)
* 42 Segment analog bar graph
* Data Hold/Min-Max memory /Relative mode
* Auto power off
* Overload protection
* Audible continuity check /diode test
* Capacitance: 1pF-40μF
* Frequency: 0.1Hz-1MHz
* 20 Amp range
* Double high energy fused (1A, 20A)
* 0.3% DCV accuracy
* **AC True RMS** (DM-394 only)

DM-351 : 3½ Digits w/Continuity, Auto Off........$54.95
DM-352 : 3½ Digits, Cap. Freq. hFE, 20 Amp........$79.95
DM-353 : 3½ Digits, Cap. Freq. Temp. hFE........$84.95
DM-391 : 3¾ Digits, Auto, Cap. Freq. Min/Max....$99.95
DM-392 : 3¾ Digits, Hold, Min/Max 20Amp........$109.95
DM-393 : 3¾ Digits, Peak, Logic, hFE, Freq........$119.95
DM-394 : 3¾ Digits, TRMS, Same as DM 392....$129.95

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Shipping and handling to Canada, $10 (U.S. currency); Overseas, $15 (foreign orders must be prepaid); CT residents add 6% sales tax. Supplements will be sent 4-5 times a year on a fully-guaranteed, 30-day trial basis. They may be cancelled at any time.

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PP-4763A/GRC power supply produces 28 VDC 50 amps from 115/230 VAC 22/11 amp 47-63 Hz input; +/-0.5% regulation. Has meters 0-50 VDC and 0-80 amps DC; 13.5x19.5x15, 145 lbs. (Shipped UPS) **USED...$195.00**

HANDS-FREE HEADSET

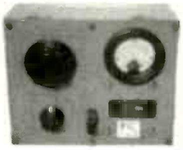
U'NICOM 49.86 MHz FM radio headset for use in high noise areas. Has throat mic and ear cushions with EPA noise-reduction rating of 23 DB. Also Volume and Squelch, Velcro adjustable head web and mic straps, 6" antenna, and fiberglass case. Requires two 9V batteries; 6 lbs. **MODEL 7800H, NEW** .... **$99.50 each**

50 UH ROLLER INDUCTOR

38-TURNS 3/8"W edgewound silvered ribbon forms 8"Lx4.3" dia coil; fiberglass end plates. P/o 1 KW antenna tuner; o/a 7.3x13x5.2, 8 lbs. sh. **#L1/CU938, USED** **$65.00**

10 UH ROLLER INDUCTOR, 18-turns #16 silver-tinned wire forms 2" dia coil. 3.5x4.5x2.6, 3 lbs. **#021-7029, NEW** **$28.00**

AUDIO OUTPUT METER



TS-585 output meter for audio amps, filters, oscillators. Ranges 0.1-5 mw, -10-+7 dbm; 1-50 mw, 0-+17 dbm; 10-500 mw, +10-+27 dbm; 100-5000 mw, +20-+37 dbm read on 3.5" dia meter. Multiplier circuit x0.1, x1, x10, x100 allows input impedances 2.5 to 20000 ohms in 40 steps; 30-10000 Hz response. 8.5x11x5.5, 17 lbs.
USED .... **$79.50; MANUAL-REPRO** **$8.50**

TEST EQUIPMENT

HP-400E AC VOLTMETER, 1 mv-300 V full scale & -72-+52 DBM in 12 steps. **Used-checked** **$155.00**

HP-410C MULTIMETER, +/-15 mv-1500 VDC in 11 steps, 0.5-300 VAC in 7 steps, DC current 1.5 ua-150 MA, & 10 ohms-10 Megohms. **Used-checked** ... **$195.00**

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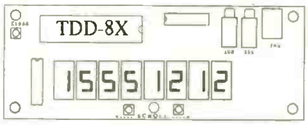
New Low Price! **$59.00**

The TDD-8X features a large 8-digit LED display and decodes all 16 DTMF digits. The 104 character memory is viewed, without loss of data, by scrolling either left or right.



Although a computer is not required, the serial ASCII output allows automatic logging of decoded number groups. ToneLog™, our IBM/Compatible logging software is included. Available accessories include a Plastic Mounting Kit ($15), Audio/Computer Cables ($20) and a 12VDC AC Power Adapter ($10).

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Info: (503) 687-2118 **Orders: (800) 338-9058** Fax: (503) 687-2492

Or contact motron.info@emerald.com for a catalog via the Internet

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CABLE TV DESCRAMBLER KITS

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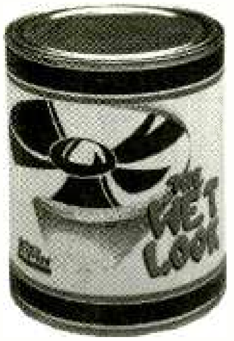
3-In-1 Universal Remote

This remote will operate any remote controlled cable box, TV or VCR at just a fraction of the cost of a factory replacement! This unit is already preprogrammed to include the most common codes. It is attractively styled, durable, and easy to set up and operate. The manufacturer even offers a toll free consumer help line to answer questions and provide customer assistance. Requires 2 AAA batteries (not included).

#EN-180-565 .... $11.95(1-9) **$9.95**(10-UP)

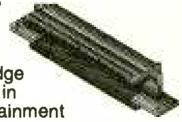
The Wet Look™



The Wet Look™ is a new generation of high gloss polymers formulated especially for the speaker industry. This superior coating provides a protective "coat of armor" for your paper cone speakers. A special U/V inhibitor has been added to reduce the decaying effects of the sun's ultraviolet rays. The Wet Look™ makes paper cones resistant to water, humidity, sun, and salt. Best of all, it's easy to apply and cleans up with soap and water. 1 pint can.

#EN-340-510 (Clear) **$8.95**EACH
#EN-340-512 (Black) **$8.95**EACH

72 Pin Game Cartridge Connector



Quality replacement for the game cartridge connector used in Nintendo Entertainment Systems (NES). Repeated loading and removal of game cartridges damages the connector contacts and produces symptoms such as a flashing blank screen or distorted picture. Revitalize your unit by replacing the game connector. It's simple; there is no soldering required and only a phillips head screwdriver is needed to complete installation in minutes! Our replacement connector has gold plated game contacts for long life, superior conductivity, and resistance to oxidation. One year warranty.

#EN-091-900 $8.95(1-9) **$7.95**(10-UP)

BigFoot™

"Copper tip" design standard 1/4" phone plug. Unsurpassed quality ensures low noise and high conductivity connection. All metal/nylon construction with external solder connections. Insulator sleeve included. 5/16" ID barrel. Made in the U.S.A.

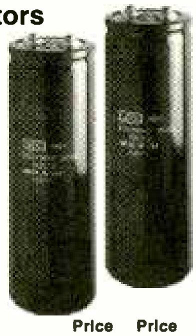
#EN-092-200 (Mono) .... **$2.25**(1-9) **$1.95**(10-49) **$1.75**(50-UP)
#EN-092-206 (Stereo) .... **$3.25**(1-6) **$2.90**(10-49) **$2.65**(50-UP)

RS-232 A-B Switch

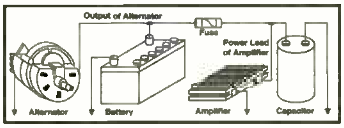
High reliability rotary type switch. Fully shielded, heavy gauge steel construction with gold plated connectors. All pins switched through (except ground). Used to switch multiple printers or computers. Full one year warranty. Net weight: 1-3/4 lbs.

#EN-130-010 .... **$9.95**(1-2) **$8.95**(3-9) **$7.95**(10-UP)

Car Stereo Power Supply Capacitors



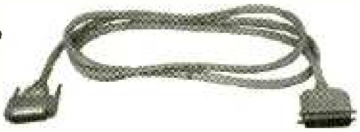
Most car amplifiers' power supplies simply lack the capability to produce large amounts of instantaneous power. These computer grade, car stereo capacitors work by storing energy and supplying, on demand, a quick burst of energy to the power amplifier. The result is tremendous bass punch and dramatically improved transient response. Feature gold plated terminals.



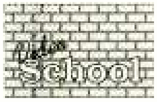
Part #	Value	Voltage	Dimensions	Weight	Price (1-15)	Price (16-UP)
EN-029-1000	1,000,000 uf	16 VDC	3"(dia.) x 8-1/2"	3 lbs.	$59.80	$52.80
EN-029-1005	1,000,000 uf	20 VDC	3"(dia.) x 8-1/2"	3 lbs.	79.80	73.50

Printer Cables

25 pin male RS-232 to 36 pin male Centronics connector. Fully shielded and molded cable with all 25 conductors connected. Convenient thumbscrew hardware on the RS-232 connector.



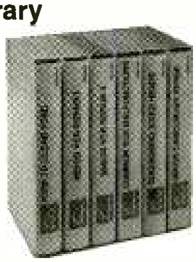
Part #	Length	Price (1-9)	Price (10-49)	Price (50-UP)
EN-130-220	6 ft.	$4.50	$3.90	$2.90
EN-130-225	10 ft.	5.50	4.95	3.75
EN-130-227	15 ft.	8.50	7.90	5.90
EN-130-228	25 ft.	10.90	9.50	7.90
EN-130-229	50 ft.	19.80	17.50	14.90



Video School videos make it easy for anyone to comprehend the complex operations of VCRs, camcorders, and more. From How to Clean VCRs for the video rental store, to Minor Camcorder Repair for the advanced service shop. There is something for everyone! These tapes also make great new employee orientation videos.

Electronic Video Library

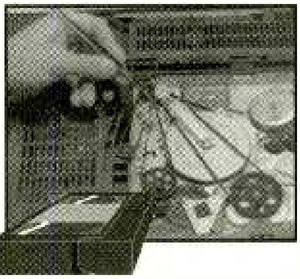
Save over $25.00 by purchasing this complete library of six Video School instructional videos. You'll receive VCR 1-How To Clean VCRs, VCR 2-Minor VCR Repair I, VCR 3-Minor VCR Repair II, VCR 4-Common VCR Malfunctions, VCR 5-Diagnosing Video Heads, and Cam 1-Minor Camcorder Repair. Net weight: 5 lbs.



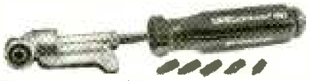
BUY THE SET AND SAVE!

#EN-505-550 .... **$195.00**EACH

Part #	Description	Price
EN-505-010	VCR 1, How To Clean VCRs	$28.95
EN-505-020	VCR 2, Minor VCR Repair I	38.95
EN-505-025	VCR 3, Minor VCR Repair II	38.95
EN-505-050	VCR 4, Common VCR Malfunctions	38.95
EN-505-035	VCR 5, Diagnosing Video Heads	38.95
EN-505-030	VCR Test Patterns Alignment Tape	23.95
EN-505-040	Cam 1, Minor Camcorder Repair	38.95
EN-505-085	Microwave Oven Repair	39.95
EN-505-080	Nintendo Repair and Maintenance	33.95
EN-505-090	IBM Compatible Computer Assembly	28.95
EN-505-095	Hi-Fi Alignment Test Tape	29.95



Skew Driver Pro



This unique tool features a gear driven offset bit driver to be used in tight spots or where conventional screwdrivers just won't fit. Includes 1/4" and 3/16" slotted bits, T15 Torx® bit, and 2 phillips bits that are contained in the handle compartment. Can also be used with a 1/4" electric drill. Made in the U.S.A. Net weight: 1/2 lb.

#EN-360-178 $39.90(1-5) **$34.50**(6-UP)

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Source Code: ENM

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Advanced project produces a burst of light energy capable of burning holes in most materials. Hand-held device uses rechargeable batteries. 500 joules of flash energy excite either a neodymium glass, yag or other suitable 3" laser rod. This is a dangerous CLASS IV project (individual parts/assemblies available). LAGUN1 Plans $20.00
LAGUN1K Kit / Plans .... Price on Request
Extended Play Telephone Recording System
READY TO USE! Automatically controls and records on our X-4 extended play recorder, taping both sides of a telephone conversation. Intended for order entry verification. Check your local laws as some states may require an alerting beeper.
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Neat little device allows you to make hand and shock balls, shock wands and electrify objects, charge capacitors. Great payback for those wise guys who have wronged you!
SHK1KM Easy to Assemble Electronic Kit $24.50
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All New Technology!
Stuns/immobilizes attackers up to 15 feet away!
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Beeper device, 3 mile range.
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Highly sensitive stethoscope mike.
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All New - The Ultimate in Home/Office Security & Safety!
Simple to use! Call your home or office, push a secret tone on your telephone keypad to access: • On premises sounds and voices • Ongoing phone conversation w/break-in capability • Up to 10 external electrical functions, lights, TV, alarms, coffee pots, heater, etc. CAUTION! Check legality with your state's attorney general's office before use for monitoring of voices.
TELECOM2 Kit, includes PC Board $149.50
TELECOM2 Ready to Use $199.50
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Easy to build, RED Beam, visible for miles. Use for light shows, window bounce holography, cloud illumination and much more! LAS1KM Kit w/1mw Laser Tube, Class II. $69.50
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STUN40 Ready to Use $69.50
STUN10 Smaller Unit $39.50
Ion Ray Gun
Projects charged ions that induce shocks in people and objects without any connection! Great science project as well as a high tech party prank. IOG3 Plans $8.00
IOG3K Kit/Plans $69.50
Invisible Pain Field Generator
Shirt pocket size electronic device produces time variant complex shock waves of intense directional acoustic energy, capable of warding off aggressive animals, etc.
IPG7 Plans ....$8.00 IPG7K Kit/Plans ...$49.50
IPG70 Assembled $74.50
1000 Ft++ Potato Cannon
NOT A TOY. Uses electronic or piezo ignition. CAUTION REQUIRED!
POT1 Plans.......
(Dangerous Product).............$10.00
FireBall Gun
Shoots flaming ball - two shot capacity
Great for special effects and remote fire starting. CAUTION REQUIRED!
FIREBALL Plans (Dangerous Product).....$10.00
TV & FM Joker / Jammer
Shirt pocket device allows you to totally control and remotely disrupt TV or radio reception. Great gag to play on family or friends. Discretion required.
EJK1KM Easy to Assemble Electronic Kit $24.50
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4,000 volts in the palm of your hand! Experiment with anit-gravity, hovercraft, ion guns, force fields, plasma guns, shock devices, wireless energy and electrical pyrotechnics. Input: 9-14VDC.
MINIMAX4 Ready to Use .... $ 19.50
"Laser Bounce" Listener System
NEW - Latest Technology! Allows you to hear sounds from a premises without gaining access. Aim at room window and listen to sounds from within via reflected laser light. Not for illegal use. Requires video tripods.
LWB3K 5mw Laser and Receiver Kit $149.50
LWB30 Ready to Use, includes Laser Gun Sight $199.50
5mw Visible Red Pocket Laser
Utilizes our touch power control!
VRL5KM Kit / Plans................................$ 74.50
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Puts subjects under control using highly effective electronic stimuli. Intended for parties and entertainment but must be used with caution. Includes valuable text book reference and plans.
EH2 Plans and Text Book $19.50
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Easy-to-Install 4-Tube Kit for Cars, Trucks, Vans!
Available in Pink, Purple, Blue or Green - please specify color when ordering.
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License Frame Kit (Specify Color)
LIC1K ....$ 24.50
Flash-To-Music Option for above kit FMU1.......................$ 29.50
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Subminiature! Crystal clear, ultra sensitive pickup transmits voices and sounds to FM radio. Excellent for security, monitoring of children or invalids. Become the neighborhood disk jockey!
FMV1 Plans.......$7.00 FMV1K Kit and Plans $39.50
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READ BY ELECTRONIC BUYERS AND SELLERS AND TRADERS

INSTRUCTIONS FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues.**Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface**, add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $4.00 per word.

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. ELECTRONICS NOW is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in ELECTRONICS NOW is limited to electronics items only. All ads are subject to the publishers' approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
ELECTRONICS NOW 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 -- Antique Electronics	270 -- Computer Equipment Wanted	450 -- Ham Gear Wanted	630 -- Repairs-Services
130 -- Audio-Video Lasers	300 -- Computer Hardware	480 -- Miscellaneous Electronics For Sale	660 -- Satellite Equipment
160 -- Business Opportunities	330 -- Computer Software	510 -- Miscellaneous Electronics Wanted	690 -- Security
190 -- Cable TV	360 -- Education	540 -- Music & Accessories	710 -- Telephone
210 -- CB-Scanners	390 -- FAX	570 -- Plans-Kits-Schematics	720 -- Test Equipment
240 -- Components	420 -- Ham Gear For Sale	600 -- Publications	730 -- Wanted

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category #________ **Special Category $30.00 Additional** ______________________

1 - $37.50	2 - $37.50	3 - $37.50	4 - $37.50	29 - $72.50	30 - $75.00	31 - $77.50	32 - $80.00
5 - $37.50	6 - $37.50	7 - $37.50	8 - $37.50	33 - $82.50	34 - $85.00	35 - $87.50	36 - $90.00
9 - $37.50	10 - $37.50	11 - $37.50	12 - $37.50	37 - $92.50	38 - $95.00	39 - $97.50	40- $100.00
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The Data Genie HT-28 is a portable, stand-alone IC tester and identifier. It can test and identify most TTL 74 and CMOS 40/45 series of IC's as well as being able to test 4164-411000 and 4416-44256 series of DRAM's. Powered from the included AC adapter or alkaline batteries (optional).

- Up to 600 hours of operation on four "AA" alkaline batteries.
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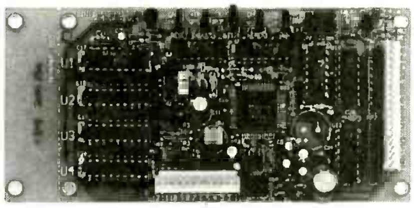
#MI-12-2800 $189.95

DIGITAL VOICE MODULE

The DVM-58D has variable length message capabilities and can store up to 16 individual messages for immediate playback. Use it to add real voice prompting or instruction to any project, via the mic. input. Standard 1Mb DRAM on-board (32 sec.@ 32K bps) with options to expand up to 16Mb (8 min.@ 32K bps). ADM recording with selectable 16/32/44K bps sampling rates and very low power consumption.



#MI-10-5858	$89.95
1Mb DRAM	$5.15
4Mb DRAM	$21.95

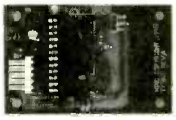
RF TRANSMITTER + ENCODER MODULES

The TX-99 interfaces with the TX-01 as the RF carrier module. 300 MHz AM with a typical range of 100' line-of-sight. (Key-chain transmitter is also available, model TX-99K $15.95)

#MI-10-9903 $5.95

The TX-01 Motherboard can encode a 12-bit address code with 4096 possible code combinations or can be used to encode an 8-bit address code with a 4-bit data code.

#MI-10-001E $9.95


+


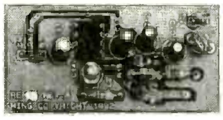
RF RECEIVER + DECODER MODULES

The RE-99 interfaces with the RE-01 as the RF carrier's receiver module and requires only a few solder connections to mate the two. 300 MHz AM.

#MI-10-9904 $6.95

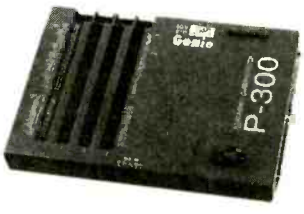
The RE-01 Motherboard will decode a 12-bit address or 8-bit address with 4-bits of data, depending on which of the two included IC's is installed into the board.

#MI-10-001D $14.95


+


PC INTERFACE CARD PROTECTOR

The Data Genie P-300 is a device that allows quick and easy installation of add-on cards or prototype circuits for testing externally on your PC without having to turn off the computer. Maintains complete protection for your motherboard via the built-in protection circuitry & current limit fuses. Adds 3 expansion slots.



#MI-12-P300 $349.95

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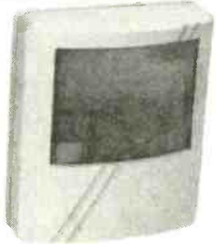
The Medusa Passive Infrared Detector has been tested at 20V/m over the frequency range 20 to 1000 MHz, proving that the unit has ultra-high RFI protection and reliability. With N.C contacts including tamper, plus selectable pulse counts of 1,3 or 5, Medusa makes for confident installations.

Detects ambient body heat and movement to trigger your connected security system, announcement buzzer, or warning device.



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Large quantity available
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100 for $150.00
INCREDIBLE SAVINGS!
30' CABLE
A GREAT DEAL!
Originally made to connect Digital Audio Tape machine to a remote controller, this "snake" cable consists of four separate 9 conductor plus drain wire, foil-shielded cables in one jacket. The conductors are stranded 24 AWG wire. Each end of each smaller cable is terminated with DB-9P connectors. The cable is well-made and quite flexible for its size. Snake cable nominal O.D. is 0.52". Interior cable O.D. is 0.15". The outer jacket can be slit and removed if only the 9 conductor cable is required. DB-9 connectors include thumbscrew hold-downs. If you are using multiconductor shielded cable this is a great deal.
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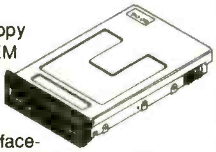


Sony # MP-F11W-2Z
Brand new 720 KB floppy drives. Built for an OEM product, these are, in every way, compatible with PC/XT/AT computers except that the faceplate is slightly larger than those on exact replacements. The faceplate size on these is 4.04" X 1.23". (Normal size is 4" X 1"). The faceplate is removable and can be trimmed if desired. In some cases it may work without trimming. Also, we have found that, when used in 5.25" bays with the adapter kit below, the adapter can easily be modified to accommodate the unit. Because of this slight inconvenience, we are selling these drives at an incredibly low price.

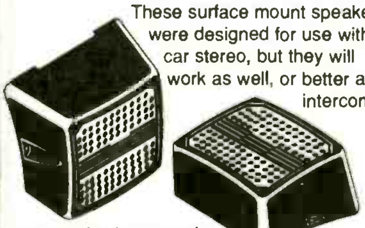
$14.00 each

CAT# MPF-11SF

10 for $120 .00

INSTALLATION KIT for MPF-11SF allows for installation into 5.25" drive bays. Simply cut and remove three plastic gussets to install. **CAT# FDD-3.5** $3.50 each

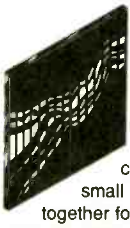
GREAT DEAL! *SURFACE MOUNT SPEAKERS*



These surface mount speakers were designed for use with car stereo, but they will work as well, or better as intercom or communications speakers in your home or workshop. 4", 4 ohm, speakers mounted in an unbreakable black plastic, slant-faced enclosure. They are rated 5 watts. Enclosure measures 4.82" X 4.5" X 2.45"h.

CAT# SK-411 **$3.75 per pair**

9 VOLT 60 MA SOLAR PANEL



These 6" X 6" glass enclosed photovoltaic panels produce 9 Vdc at 60 ma. Ideal for charging batteries and powering small devices. Put two or more together for more current and voltage. Includes hook-up instructions.

CAT # SPL-960 **$5.25 each**

Super NINTENDO POWER SUPPLY

Nintendo # SNS-002
New, original wall transformer with 9 foot cord and co-ax plug with center pin positive. Output 10 Vdc @ 850 ma. UL and CSA listed.

$6.00 each **CAT # DCTX-1085**

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3.56" X 2.12" X 0.75"

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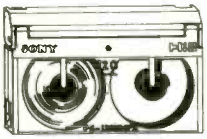
"HI-8" VIDEO CASSETTE (USED)



SONY Hi-8 T-120
Top quality, metal particle 120 minute video cassettes. Used for a short time, then bulk-erased, each cassette has its own plastic storage box. Satisfaction Guaranteed.

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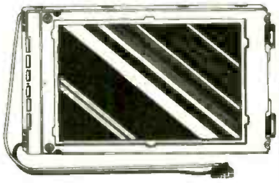
640 X 480 LCD PANELS WITH BUILT-IN DIGITIZER

Two sizes available, both originally designed for laptop computer/note pad. Built-in digitizer to be used with a stylus for hand written notations. Onboard drivers operate on 5 vdc (logic) and 18 vdc (LCD). Full documentation on both units.

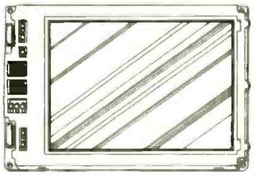
SHARP LM64P90



Built-in CCFT backlight. Overall dimensions: 10.19" x 7" x 0.35" Viewing area: 7.88" X 6" Dot size: 0.27mm X 0.27mm. White dots on black background. **CAT # LCD-31**

$40.00

SHARP LM64194F



Overall dimensions: 8" x 5.75" Viewing area: 6" X 4.5". Dot size: 0.21mm X 0.21mm Black dots on white background. **CAT # LCD-32**

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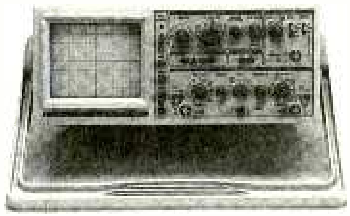

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Bandwidth	20 MHz	40 MHz	60 MHz
Model	OS-3020	OS-3040	OS-3060
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160 x 128 dot LCD with built-in controller (T6963C)
20 character x 16 line $79.00 or 2 for $149.00

Mfr.: Toshiba TLX-1013-EO. *Unit is EL back-lit. Dim: 5⅟₁₆" L x 4⅟₁₆" H. The built-in controller allows you to do text and graphics*

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5V power required • Built-in C-MOS LCD driver & controller • Easy "Microprocessor" interface • 98 ASCII character generator • *Certain modules are backlit, call for more info.*

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size	mfr.	price	size	mfr.	price
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640x400 (backlit)	Panasonic	$35.00	256x128	Epson	$20.00
640x200	Toshiba	$19.00	240x128 (backlit)	Optrex	$20.00
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Links 3270 mainframe systems to IBM PC

Proteon ProNet-4 Model p1347 Token Ring Board $79.00
16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

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Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

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Enclosed

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• Open Frame Construction • Standard Interface Connector
• Degaussing Coil Included • *Mfg.: Samtron*

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Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V)

Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um² • Ceramic 24 pin DIP package. • Mfr: Sony, Part# 016AL

LINEAR TYPE

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CELL SITE TRANSCEIVER $99.00

These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030–889.980 MHz with the receive channels 45 MHz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. Channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions are available.

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BY JEFF HOLTZMAN

How to solve all your PC problems

Go cold turkey: sell your PC.

CONUNDRUM: HOW CAN THE FOLLOWING BE TRUE: PC = PC? IN HONOR OF THE LAST MONTH OF SUMMER VACATION, I'D LIKE TO DEDICATE THIS MONTH'S COLUMN TO A VERY serious subject, albeit one with a lighthearted side. The subject concerns the very difficult problem of personal-computer ease of use. In spite of all our best efforts during the past few decades, things are not getting better, but worse. Following are several ideas for dealing with the problem in an efficient manner. These ideas are descriptions of several magazine articles I don't have time to write, but would love to read. (Note placement of tongue firmly in cheek.) The articles are:

- Why the computer will never get easier
- WYSIWYG is really WYGINWYS
- Real men prefer the command line interface
- Sell your copy of Windows, put your kids through college
- Networks are for nitwits
- Do what Nancy does
- Renounce graphics, sound, and video
- Forswear Microsoft products and survive
- Go cold turkey: sell your PC

Why the computer will never get easier

The computer industry has a vested interest in difficulty. If it was easy, anybody could do it, and if anybody could do it, lots of people would lose their jobs. The subterfuge then is to proclaim a goal that is the exact opposite of the real goal, and to keep shifting the focus to various pieces of the puzzle. Doing so will ensure that no one, neither customers nor competitors, will ever be able to figure out what the goal is, or even if there is one.

Approximately every five years or so, propose a new technology as

FIG. 1–RESOLVE ALL YOUR PC PROBLEMS in one fell swoop. Just say no.

the universal solution to the problems facing computers. Examples include Structured Programming, Networks, Artificial Intelligence, and Object-Oriented Programming. For the past few years, the GUI has been touted as the solution to difficulty. Yet has no one noticed that the complexity of system configuration has increased geometrically? Do you know what every line in your CONFIG.SYS does? How about your SYSTEM.INI? Do you think that is an accident?

WYSIWYG is really WYGINWYS

Pronounce that as "Whizzy Wig is really Wiggin Whiz." The theme of this article is: "What You See Is What You Get" is a lie; the truth is, "What You Get Is Never What You See."

This article will not bore us with technical descriptions of device-independent programming models, resolution differences between printers and monitors, page-description languages, markup languages, or anything of the sort. The real purpose is to expose the collusion among major manufacturers and the government. In the name of full employment, the government has worked behind the scenes with industry leaders to ensure that products from different manufacturers are fundamentally incompatible with one another.

One of the primary beneficiaries of this economic system is the government itself, which has to set up—secretly, of course—incompatibility certification labs (ICLs). The purpose of these labs is to certify products as incompatible at a fundamental level. Manufacturers are forbidden from releasing commercial products that show any significant level of compatibility with similar products from other manufacturers. Running these labs is actually the purpose of the super-secret National Security Agency (NSA), which contrary to popular opinion measures security in terms of economic stability, not military might, stealth, or sophistication.

The software industry is the major beneficiary of the activities of the ICLs. Devising, developing, and supporting complex models that abstract common features helps ensure employment for a wide range of professionals: modelers, programmers, testers, technicians, management, third-party support organizations, and more. The bugs and inconsistencies thereby created help feed a press hungry to print bad news. It also feeds consumers' increasingly cynical views of both government and business. It also contributes to an ever-expanding spiral of bug fixes and upgrades. Full employment for everyone! A chicken in every pot! A bug in every product!

Real men prefer the command line interface

(Women aren't really interested in technology, so don't worry about the implicit sexism in the title of this article.)

Whereas early articles showed that WYSIWYG is not all it's cracked up to be, this article begins laying the groundwork for an anti-WYSIWYG backlash. The upshot is this: Anything GU(I) can do, CLI can do better; CLI can do anything better than GU(I).

Using examples such as vi, TROFF and $\TeX$, this article will prove that CL-based edit/format duos can do anything that GUI-based word processors and desktop publishers can do, but at significantly less cost, with greater reliability, and with greater understanding on the part of the user.

A related topic is: "Who needs spreadsheets when you've got COBOL and FORTRAN?"

Sell your copy of Windows, put your kids through college

After proving the higher innate efficiency and accuracy of the CLI, the next step is to divest yourself of your GUI, most likely Windows. Right away you'll recover a good 40 MB of disk space. You'll also start sleeping better because you'll be able to start focusing on content once again, leaving appearance to someone else. You'll thrill to monospaced printouts in Courier. You'll revel in tools simple enough to operate without thought—like riding a bike. Productivity will zoom at least 400% within days!

Of course, without Windows, you'll have no need for Windows applications. Depending on the degree to which you had been led down the path, you should be able to recoup another 100 MB of disk space, or even more. In the return to CLI computing, this essentially means that you'll never have to buy a computer again. So instead of perpetually buying products with 4 to 5 year obsolescence cycles, you can buy a computer once and bank the rest. Potential lifetime savings could easily amount to $100,000 or more.

Networks are for nitwits

People who really want to share files trade floppies, temporarily connect using LapLink, or use an on-line service. Corporate networks are simply a way to usurp individual power. The primary beneficiaries are the network dweebs, not the users, and certainly not the corporation.

Even within the computer industry, network dweebs occupy an exalted position. They have their own jargon, incomprehensible even to dweebs in related specialties. They're responsible to no one, come and go as they please, and use any flimsy excuse to bring the network down at the most inopportune moment for users. Within a PC, nothing—not even multimedia—causes more trouble than networking hardware and software.

So to regain control over your life and simplify your existence, forego networking.

Do what Nancy does

Is it an accident that every 18 months or so a whole new generation of computer hardware is released that makes everyone want to dispose of their current inventory and upgrade? No, it is no accident. But that doesn't mean we have to respond like trained rats to some Skinnerian buzzer.

When it comes to hardware (and software) upgrades, take a tip from Nancy Reagan: Just say no.

Renounce graphics, sound, and video

Multimedia has already shown itself to be more concerned with surface presentation than deep content. So giving up the CD-ROM and sound card should not be difficult. Doing so will result in further gains in hard-disk space. A side effect will be a two-order-of-magnitude reduction in system complexity, and a corresponding increase in robustness and reliability. No more unexplained crashes! No more frozen mouse pointers just before your file is actually saved.

Forswear Microsoft products and survive

Yes, this is a capitalist society, but enough is enough. The next step on the way back to a simpler, more self-determined way of life is to forswear use of all products made by Microsoft. We started by giving up Windows; now let's throw in DOS, networking, applications, programming tools, games, utilities, and anything else that may be lurking around. (We're considering offering a one-time-per-user exception for one copy of a crucial Microsoft program, such as QBasic or Flight Simulator.) Conservative estimates are that system stability will increase at least as much as by giving up multimedia. We also expect significant disk and memory savings as well.

Go cold turkey: sell your PC

I think my high-school class was among the last to learn how to use a slide rule. You probably don't even know what one is. (If not: A slide rule is a self-powered low-maintenance analog device for multiplying and dividing by adding and subtracting logarithms.) It was easy to get three places of decimal accuracy from a slide rule; whereas today's CPUs (e.g., Pentium) and applications (e.g., Windows calculators) can't even guarantee that. So you don't need a PC to do accurate number crunching.

Nor do you need one to do word processing. Used equipment stores are filled with typewriters rendered obsolete by the computer revolution; they can be had for a song. However, a typewriter can be a high-maintenance item just like a PC; you may want to simplify even further to what *Byte* magazine long ago referred to as the "Generic Word Processor:"the standard wood-barreled #2 pencil. An electric pencil sharpener is a politically correct peripheral, although favor will shine on those who opt for manual devices.

Ask yourself: Did Newton need a PC to invent calculus? Did Einstein need one to invent the theory of relativity?

Conundrum resolved

Politically correct equals no personal computer.

E-mail

Someone sent me a huge uuencoded file via internet mail. The file contained a demo of something the sender thought I (and you) might be interested in. I'll never know because I aborted the download as soon as I realized what was going on. Sending large unsolicited files via email is very bad etiquette. Feel free to send a short, concise summary of your product—but not the product itself—via email. If I'm interested, I'll get back to you.

Someone else suggested doing a column on Linux, a UNIX clone for Intel-based CPUs. In essence, Linux is a shareware product developed and supported by programmers all over the world. I have heard and read good things about Linux, but to date have no hands-on experience with it. Frankly, the thought of installing it and learning enough about it to say something intelligent is not terribly appealing, based primarily on years of difficult experiences installing and testing commercial operating systems, such as DOS, Windows, OS/2, and other Intel UNIX clones. On the other hand, I'm not totally against it, either. If there's a lot of interest, I'll give it a second thought. Let me know.

Also, I enjoyed hearing from 14-year old Billy K., from Des Moines. Billy is interested in everything to do with computers and electronics, and I bet someday he'll turn out to be a crack engineer.

You can reach me on CompuServe as 72170,2226, or via the Internet at 72170.2226@CompuServe.Com. EN

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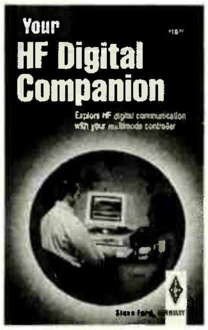

CIRCLE 337 ON FREE INFORMATION CARD

This book is an introduction to high-frequency (HF) communication that provides the practical information needed for the amateur radio operator interested in communicating in that region of the spectrum. It is written simple English without being filled with confusing jargon.

Steve Ford explains the differences between HF digital communication and other operating modes and its advantages. He explains how to set up a HF digital station that permits the use the digital modes to talk to radio amateurs anywhere in the world.

The book explains such subjects as hunting for digital DX, work mailbox and bulletin-board systems, and how to compete in contests that test operating skills. Other topics discussed are RTTY and the AMTOR, PacTOR, CLOVER, and G-TOR digital modes. The book contains lists of helpful books and newsletters as well as sources for equipment and software. An extensive glossary defines the terms unique to communication in the digital modes.

E-Mail Security:

How to Keep Your Electronic Messages Private
by Bruce Schneier.
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Phone: 1-800-CALL-WILEY
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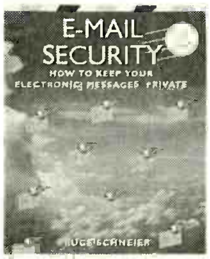


CIRCLE 338 ON FREE INFORMATION CARD

Today, messages can be sent by computer modem a lot faster than they can by sent by the traditional services from messenger and postal system to Federal Express or UPS. However, in transmitting over open telephone lines, your message is far more vulnerable to interception by unwanted persons than ever before. So you have a tradeoff between speed and security.

This book is all about how to regain some or all of the privacy lost to E-mail. The average electronic mail message passes through a half dozen intermediate stages between its source and its destination, and there are no laws to prevent prying eyes from reading that message.

You probably don't want coworkers, hackers, or even your supervisor to read you messages. Worse yet they might be intercepted by business competitors or others intent on prying into your personal affairs. In the absence of laws governing the interception of E-mail (which perhaps could not really be enforced anyway), you are responsible for protecting your own computer communications.

Bruce Schneier tells you how to do so. He has divided his book into two sections. The first section is devoted to the issues of privacy, electronic mail, encryption, authentication, and keeping your private "key" private. The roles of patents, government, and export laws are examined.

The second section focuses on achieving E- mail privacy. It warns users about how messages are intercepted, read, copied, and even (in some cases) altered for malicious purposes. The author explains how you can avoid those breaches of privacy.

Mobile Communication Satellites:

Theory and Applications
by Tom Logsdon.
McGraw-Hill Book Company
11 West 19th Street
New York, NY 10011
Phone: 1-800-2-MCGRAW
$55.00

CIRCLE 339 ON FREE INFORMATION CARD

This book is all about the latest advances in global wireless communication. Tom Logsdon explains the present status and the future prospects for the constellations of communication satellites that are now being deployed in geosynchronous, low-altitude, and medium-altitude orbits. He then describes how those satellites are revolutionizing communications and navigation for ships, aircraft, commercial and emergency vehicles, and even private cars.

The book includes explanations of such important communications concepts as constellation selection, spread-spectrum, digital implementation, and data-compression. You'll find out how analytical tools select the most efficient constellation configurations and how mobile communication satellites are designed. You'll also learn how and why signal formats and frequencies are selected.

Getting Started with Lotus 1-2-3 for Windows

by Barbara R. Farrell.
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Phone: 1-800-CALL-WILEY
$13.95

CIRCLE 340 ON FREE INFORMATION CARD

Barbara Farrell has written this primer on Lotus 1-2-3 for Windows for use in introductory personal computing courses. The book is intended for those persons with a working knowledge of personal computers and Windows but no previous experience with the Lotus 1-2-3 spreadsheet program.

Basic skills are taught in short segments of focused activities based on realistic applications. Each lesson has eight key elements to help the reader master important concepts and skills. The emphasis is placed on the reader's ability to apply those skills in daily work.

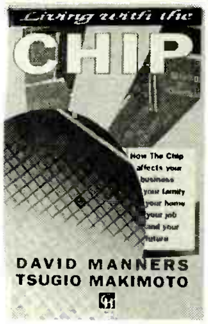
Learning objectives are given at the beginning of each lesson, and the book is organized so that the reader can meet those objectives while actually preparing spreadsheets. This approach encourages learning by instructing the student in how to accomplish a practical objective and reinforcing that learning.

Lists of procedures provide ready references to the steps required to complete each lesson, and step-by-step instructions teach the reader how to apply those lessons to solve specific spreadsheet objectives.

The reader is encouraged to practice newly acquired skills by doing independent projects with decreasing levels of text support. A reference section at the end of the book lists all of the commands needed to complete the projects presented in the text.

Living with the Chip:

How the Chip Affects Your Business, Your Family, Your Home, Your Job, and Your Future
by David Manners and Tsugio Makimoto
Chapman and Hall
One Penn Plaza
New York, NY 10119
Phone: 212-564-1060
$16.95



CIRCLE 341 ON FREE INFORMATION CARD

This book presents an essentially non-technical overview of the integrated circuit and the industry it spaw-ned. It describes how the devices work, reviews the history of their development, discusses their present status, and makes predictions about the future directions and trends for these semiconductor "chips."

The authors start off by discussing how microelectronic device advances have led to the development of ever more sophisticated, reliable and lower cost products such as radios, calculators, personal computers, fax machines, telephones, VCRs and camcorders.

The book than goes on to review the history of the IC, naming key contributors to its development and identifying and describing the roles of the many multinational manufacturers who have had or still hold key positions in the technology.

The concept of the "learning curve" is described, relating it to the normal decline in prices as production ramps up. You will also learn about the necessity for having second or alternative sources for popular devices.

The reader will find useful information here about the specialties of the various manufacturers that should be useful in tracking down sources for specific kinds of chips. The book even ventures into a discussion of corporate reputations, listing those manufacturers who have remained innovative and dynamic (making them attractive employers) and those which have fallen behind the flock.

"The Audio Source" Summer Sale Catalog

Sescom, Inc.
2100 Ward Drive,
Henderson, NV 89015-4249
Phone: 800-634-3457 (orders only)
or 702-565-3400
Fax: 800-551-2749 (orders only)
or 702-565-4828
Free

CIRCLE 342 ON FREE INFORMATION CARD

This Sescom catalog offers a range of audio products and accessories that are available at discount prices. The products include those designed to "plug-n-play" in existing systems. The recently designed, easy-to-connect, easy-to-use accessories can be installed in rack systems or placed in appropriate positions in the listening room.

The products include a four-channel audio distribution amplifier, a stereo-buffer amplifier, and a stereo combiner. The catalog describes a selection in-line devices that eliminate AC hum. These include XLR connector adapters, audio SIPs, portable microphone line drivers, a dual interface box, and a stereo line driver.

Digital Power Supplies Brochure

Kepco, Inc.
131-38 Sanford Avenue
Flushing, NY 11352
Phone: 718-461-7000
Fax: 718-767-1102
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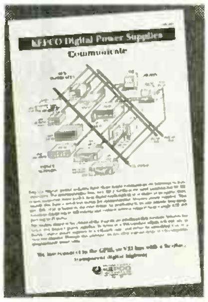
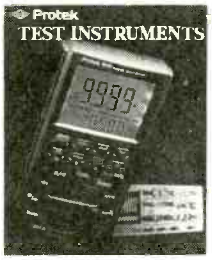

CIRCLE 343 ON FREE INFORMATION CARD

This Kepco brochure describes the company's line of digitally programmable power supplies for integration into host test systems. The supplies make use of either the SCPI or CIIL control languages and communicate with either the GPIB (IEEE 488.2) or a long-range serial bus (IEEE 1118); VXI is also supported.

Kepco has introduced its line of MST high-density, 200-watt programmable power supplies. The latest design concepts permit the package size to be reduced so that nine modular supplies will fit in a standard 19-inch rack. Text and illustrations describe how to installing multiple power supply modules, each rated for up to 1000 watts.

Test Instruments Catalog

Protek,
154 Veterans Drive
Northvale, NJ 07647
Phone: 201-767-7242
Fax: 201-767-7343
Free



CIRCLE 344 ON FREE INFORMATION CARD

This new catalog from Protek documents it product line of digital storage oscilloscopes, function generators, multifunction digital multimeters, and analog meters. More than 70 test instruments and accessories are described and pictured in this catalog.

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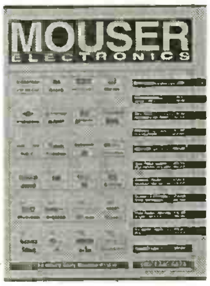

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NEW PRODUCTS

continued from page 30

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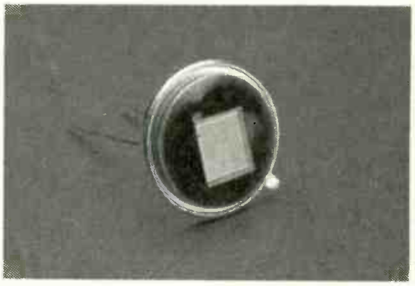

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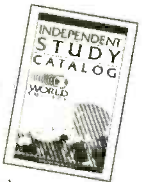

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AUDIO CONNECTOR OVERVIEW

XLR, Unbalanced, and DIN Connectors

THREE DIFFERENT CONNECTORS ARE IN WIDE USE TODAY IN CONSUMER AUDIO EQUIPMENT. THEY ARE THE SO-CALLED RCA PLUG AND JACK, THE 1/4-INCH MONO AND STEREO PLUG AND jack and the 3.5-millimeter mono and stereo plugs and jacks. DIN and XLR connectors are more likely to be found on top-of-the-line consumer audio products and professional audio equipment for recording studios and radio and TV stations.

The connector specified for audio equipment depends on the price and aqpplication of the audio equipment.

Regardless of where the equipment is made, the manufacturer must choose standard connectors that are compatible with and appropriate for the price and application of the equipment in the country where he intends to sell it.

The mini plug accepts wire with shield braid. The tip of the plug contacts the center conductor of the wire, while the cylindrical metal extension of barrel of the plug contacts the shield braid. The wire has some of the properties of unbalanced coaxial cable, but the shield braid is not coaxial with the central lead. If the barrel has internal threads, it is identified by its diameter and the number of threads per inch. A 5/8-inch diameter barrel with 27 threads to the inch would be specified as 5/8×27TPI.

The phone plug is a larger version of the mini plug and is used to terminate cables joining audio components. The phone plug looks like the mini plug but it is called a phone plug because it was originally used as a connector for manually operated telephone switchboards. Phone plugs can have two or three elements, and they have barrels that are 1 1/4-inch (31.8 mm) long.

Phone plugs are used primarily on headphones and microphone

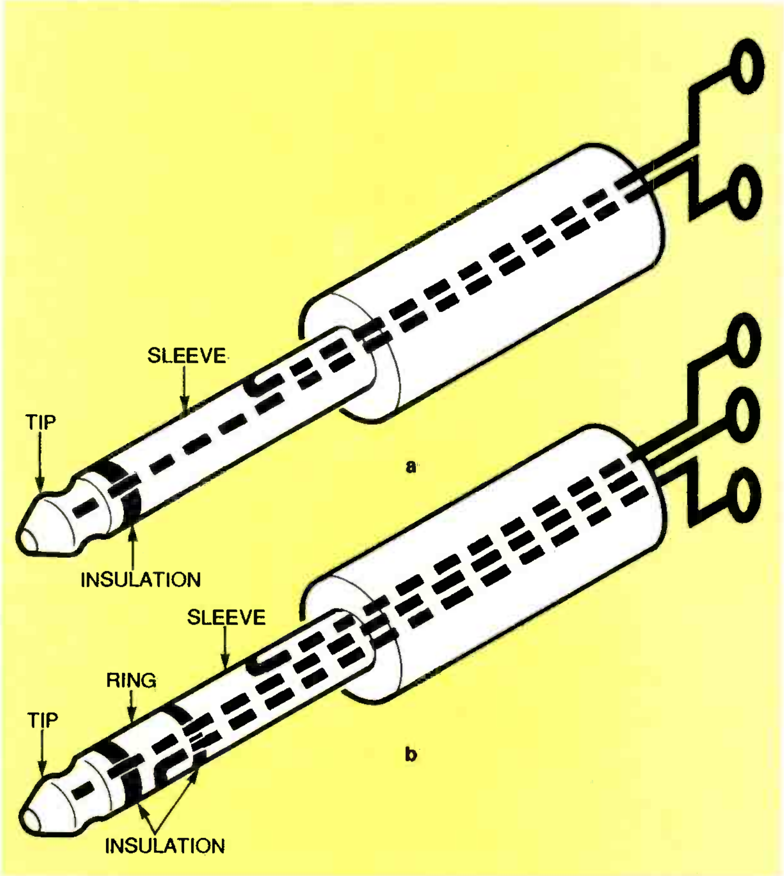


FIG. 1—PHONE PLUGS: The mono, two-conductor version (a) and the stereo, three-conductor version (b).

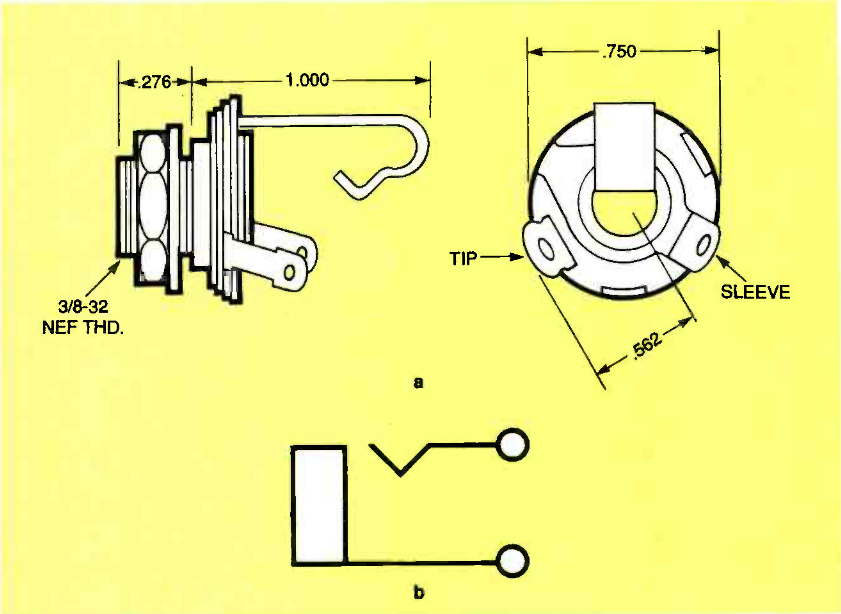


FIG. 2—PHONE JACK: 1/4-inch mono jack (a) and its schematic symbol (b).

cords. They are available in 1/4-inch (6.35 mm), 1/8-inch (3.5 mm) and 3/32-inch (2.5 mm) plug diameters. In those parts of the world where metric measurements are standard, the 1/8-inch (0.141-inch diameter) plug is called the 3.5 mm plug. Both two- and three-conductor styles with matching sockets called jacks are readily available.

Figure 1-a shows a monophonic phone plug. An insulated ring isolates the *tip* from the *sleeve* to provide two insulated contact surfaces. The dotted lines represent the internal wiring. Figure 1-b shows a stereophonic plug that also has an insulated tip and sleeve, but a third insulated element called the *ring* is inserted between the tip and sleeve to provide a third insulated contact surface. Both mini and phone plugs can be either monophonic or stereophonic.

In both the 1/4-inch and 3.5 mm mono and stereo plugs, the sleeve is the ground connection and the tip is the "hot" connection. In the 1/4-inch and 3.5-mm stereo plugs, the ring is the "cold" connection for left or out-of-phase signals and the tip is for right or in-phase signals. Phone plugs are available in right-angle form.

Figure 2-a is a drawing of 1/4-inch open-tip mono jack, and Fig. 2-b is its schematic symbol. Figure 3-a is a drawing of a 1/4-inch open-tip stereo phono jack, and Fig. 2-b is its schematic symbol. There are also other jack configurations for closed tips, closed tips and open rings, transfer, and "break" circuits.

Phono or phonograph plugs are primarily found in "line-level" audio or video systems. The names phono and phone are similar so they should not be confused. Today phono plugs are referred to as RCA plugs. Figure 4 shows one version of the RCA phono plug. It has a 0.125-inch diameter or 3.1 mm tip. RCA connectors typically connect a CD player to a stereo receiver with a shielded cable.

The XLR connector

The plugs previously described are single-cable connectors. Audio components can have a large number of jacks, so a large number of cables might be required. Consequently, the space behind a rack housing those components can look like a maze. In addition to being unsightly, this situation can make it difficult to locate and trace individual cables. Moreover, it can lead to the making of incorrect connections.

One solution is the use cables terminated with XLR connector plugs. Sometimes called Cannon plugs (a reference to the manufacturer, now ITT Cannon), they are standard input and output connectors for professional and some high-end (semi-professional) audio equipment.

Figure 5-a shows a three-contact keyed XLR in-line socket, and Fig. 5-b shows a three-contact keyed XLR in-line plug. It is possible to insert the plug in its jack in only one way. There are also five-contact keyed XLR connectors.

XLR connectors typically connect low-level signals from microphones to mixers or public address systems. They are also used to connect line-level signals such as the outputs and inputs from mixers and signal-processing circuits to power amplifiers.

XLR connectors are balanced connectors, which helps to reduce any

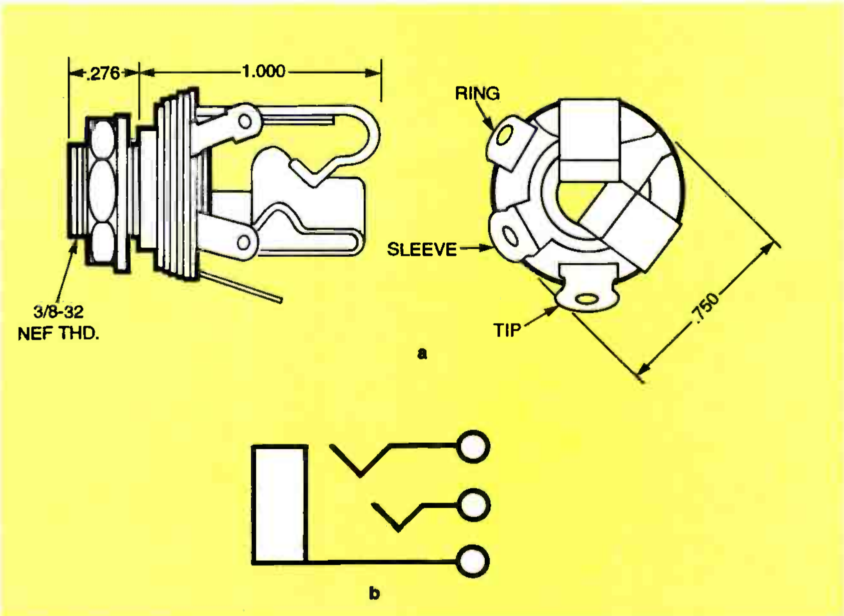


FIG. 3— PHONE JACK: 1/4-inch stereo jack (a) and its schematic symbol (b).

noise and hum pickup by the system in which they are installed. Figure 6-a shows an XLR panel socket, and Fig. 6-b shows an XLR panel plug.

XLR adapter/transformers can adapt a microphone with a ¼-inch plug to a public address amplifier or mixer that has an XLR input jack. There are also adapter/transformers that will adapt a professional microphone with an XLR plug to an amplifier or mixer with a ¼-inch input jack.

Internationally accepted standards as well as the American EIA standards

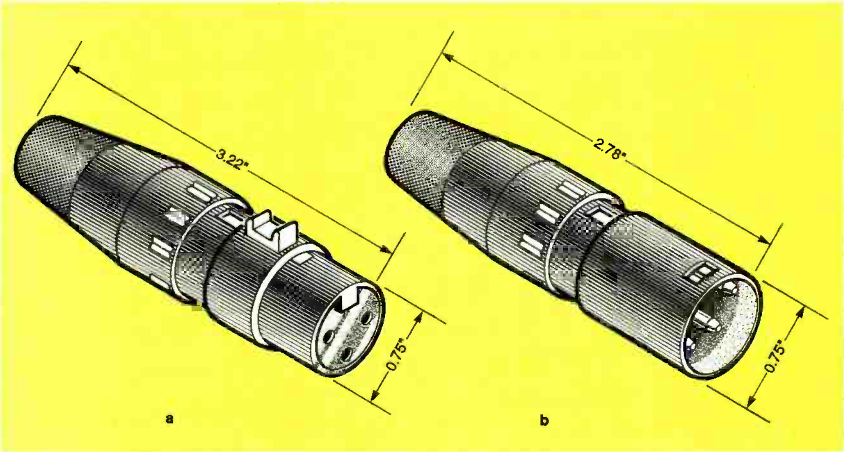


FIG. 5—IN-LINE XLR CONNECTORS: jack (a) and plug (b).

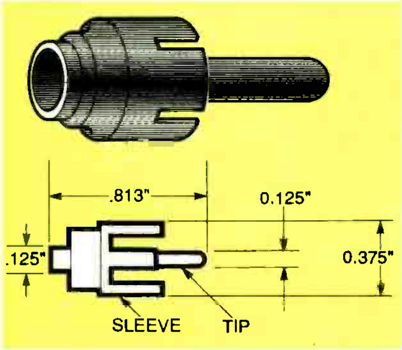


FIG. 4—RCA PLUG is formed from sheet brass, and the tip and sleeve are insulated by phenolic.

RS-221 (10-79) and RS-297A (6-70) specify the pin numbers on XLR contacts. On a three-contact XLR, pin 1 is the ground connection, pin 2 is the audio (in-phase) connection, and pin 3 is the audio (return or out-of phase) connection. In Fig. 5-a, contact 1 is at the left, contact 2 is at the right and contact 3 is at the bottom.

On five-contact XLRs, the first three pins have the same functions as those on the three contact version with pins 2 and 3 assigned to channel 1. Pins 4 and 5 for channel 2 have the same functions as pins 2 and 3, respectively.

When the male and female connectors are joined together, pin 1 of the male makes contact with pin 1 of the female, establishing the ground connection before pins 2 and 3 are connected simultaneously. XLR connectors are usually used in balanced circuits with a ground connection, but they can function in unbalanced circuits.

There is no standardization as to the way the wires of the cable are connected to the terminal points of the plug or jack (also called a socket).

Unbalanced connectors

Unbalanced connectors for audio equipment were first introduced in the 1930's, but were modified for military equipment during World War II. One example is the PJ-042 military-style connector. After the war, a ¼-inch phone jack, based on the PJ-042, became popular for consumer audio applications. The original military design was simplified to make it easier to manufacture.

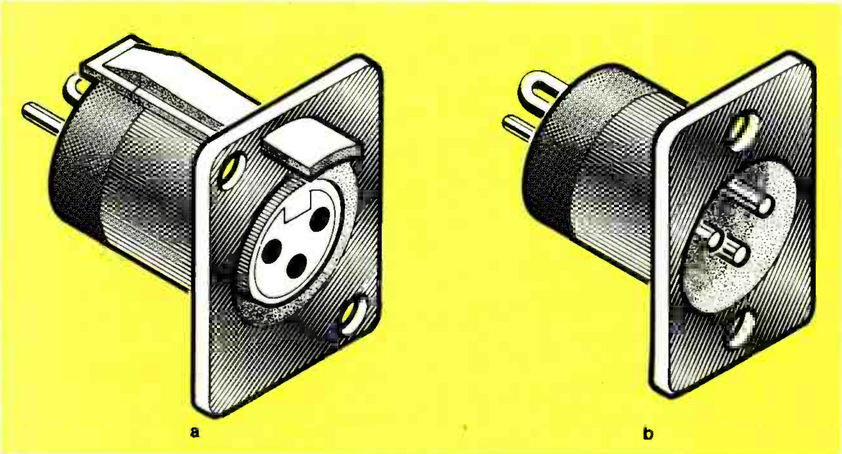


FIG. 6—XLR PANEL CONNECTORS:jack (a) and plug (b).

One of the early manufacturers of the ¼-inch phone jack was Switchcraft, Chicago, Illinois. Although the Switchcraft products were successful, a lower cost audio connector developed by Cinch Connectors of Elk Grove Village, Illinois, became even more popular because of its lower cost. It has since become known as the RCA connector.

The RCA connector was and is made by forming flat brass stock into a tulip shaped sleeve and a cylindrical tip insulated by phenolic insulation. This connector could be made in high volume and was later adopted as the connector of choice for the Hi-Fi industry that was forming in the 1950's. However, the ¼-inch phone jack still offers lower contact resistance, which means less noise introduced into the system. It also offers better strain relief for portable cords.

In the mid 1950's, while stereo was still in its infancy, a need developed for two conductors with a shield to carry the left and right signals and their common ground. The PJ-068 military standard connector, similar to the ¼-inch jack but with three contacts, had been developed by then.

With the PJ-068 as its model, a

Continued on page 159

SCHEMATIC SOFTWARE

continued from page 34

in that they can draw schematics, but they don't create netlists, generate a bill of materials (BOM), or lay out PC boards. Their sole purpose is to put your circuit designs on paper using schematic symbols. Most drawing programs can create schematic diagrams, even Windows' Paintbrush—but it takes a lot of time to draw them. Schematic draw programs simplify the process by "canning" common symbols, such as resistors and transistors, in a library file, where they can be called on screen, placed quickly, and wired together. In this section we look at three schematic draw programs ranging in price from $20 to $99.

Product:	Schematic Plus
Version:	0.4
Price	$20
Platform:	Windows
Publisher:	Steven Poulsen

For rock-bottom price you can't beat Schematic Plus, a Windows-based shareware program written by Steven Poulsen. Despite its low $20 asking price, Schematic Plus has some advanced editing features such as automatic annotation. It doesn't generate netlists or have circuit-simulation capability, but the program is easy to use and certainly powerful enough to draw schematics if you can live without zoom and block functions. Interestingly, the program saves the drawings to files in the Windows' MetaFile format (WMF), which means you can import your schematics directly into text and graphics applications, such as Word for Windows. That's the only way you can print the schematic to hard copy; the program itself doesn't have any kind of printer support.

All wiring is orthogonal (drawn only horizontal or vertical). Devices are placed on the drawing one at a time by highlighting its name from a component library. Unfortunately, repetitive part placement isn't supported. The component library contains about a dozen or so devices, some of which you'd seldom use, like the node summer (see Fig. 2). So be prepared to spend a fair amount of time creating device symbols with the library editor. However, you don't have complete freedom when designing new devices because library symbols are built on a 68-by-68 grid, and a dot takes up nine grid squares. That limits you to about 15 pins per device. So if you need to create a 68-pin IC, forget it. According to the author, the library editor will improve considerably as the software advances from version 0.4 to 0.6 over the next few months. Library devices are saved as individual files in a directory, and you can sort parts by storing them in different subdirectories.

Overall, Schematic Plus is an

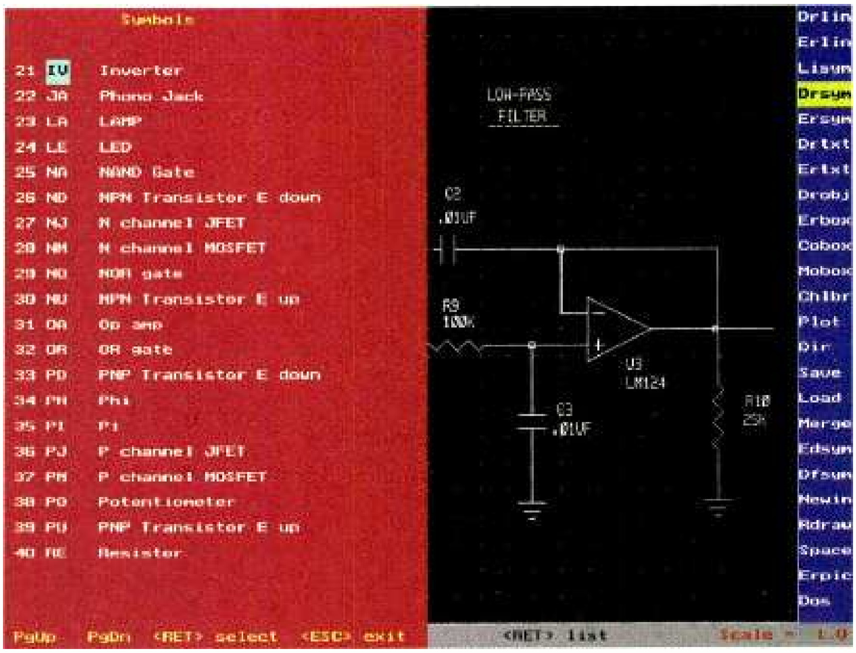


FIG. 3—WHILE AUTOSKEM IS DIFFICULT TO USE, it will run on any PC which has just 384K of RAM and a single floppy drive. Which is perfect for owners of an 8088 or 286 system.

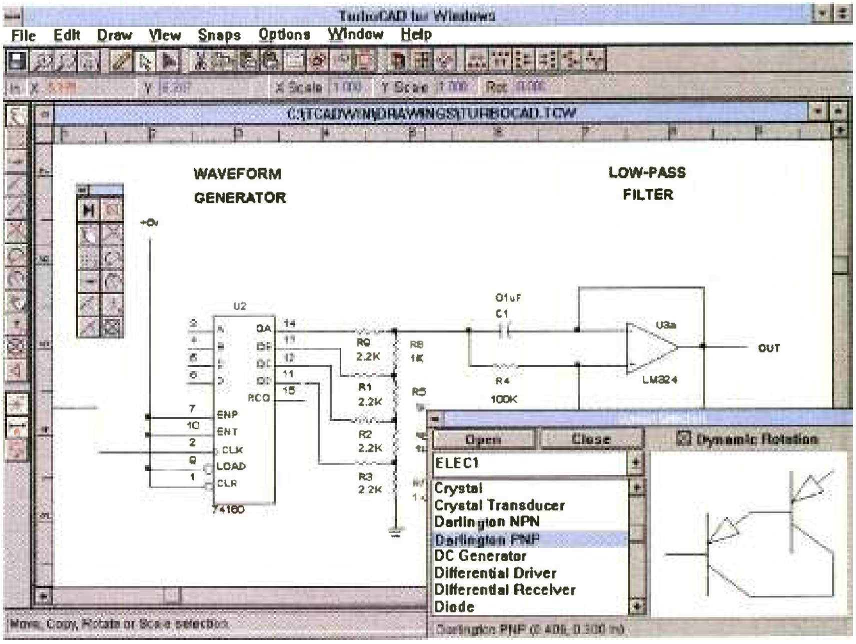


FIG. 4—TURBOCAD SCREEN. The nice thing about using a CAD program to draw schematics is that the software is a lot more versatile.

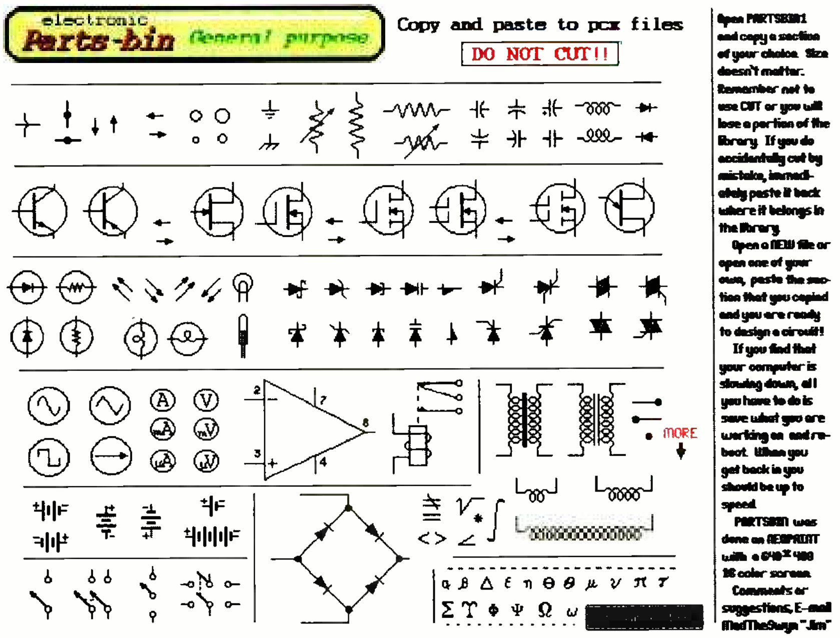


FIG. 5—ELECTRONICS PARTS-BIN is freeware created by Jim Marinelli that lets you build schematics from clip art.

excellent program for drawing and importing schematics into documents. And it's a dynamite buy for the money. The program was originally available to American Online subscribers only, where you can find Steven Poulsen should you need technical support, but it's now available on the *Gernsback BBS* (516-293-2283, v.32, v.42bis), CompuServe, and Internet under the filename SCH06.ZIP. Download time is about eight minutes.

Product:	AutoSkem
Version:	1.41
Price	$29
Platform:	DOS
Distributor:	BSOFT Software

If you're a starving student saddled with an old circa-1986 PC, you might want to consider AutoSkem—a very inexpensive ($29) DOS-based schematic drawing program that lets you create simple schematics on vintage computers that don't have the resources to run Windows. All it takes is any IBM-PC or PC clone, including a lowly 8088-based machines with 384 kilobytes of RAM and a floppy drive. Be warned, though, AutoSkem isn't an easy program to use, and it lacks some basic editing features.

While not nearly as sophisticated or powerful, AutoSkem has the look and feel of Schema, a very-successful, high-end schematic-capture program from the 80's that was just recently put out to pasture. Drawing and editing commands are located in a menu column displayed along the right side of the screen (see Fig. 3), and are selected by the cursor keys or mouse. A handful of the more basic commands, like grid on/off and cross-hair sizing, are controlled by the keyboard's function keys, and are not listed in the menu.

Schematics are constructed from three basic objects: lines, symbols, and text. Lines aren't orthogonally locked, making it easy to draw diagonals but harder to square corners. Symbols representing electronic devices are stored in symbol libraries, each of which can hold up to 100 symbols. While there's no limit to the number of libraries you can have, a schematic can be drawn using components from only a single library. If the component doesn't exist in the selected library, it's simply not shown in the drawing.

Part designations and values are placed on the drawing with a text editor, and are not a part of the device itself. Both symbols and text can be rotated and sized before placement—but not after. For devices that need more than 30 lines to construct (the maximum you can use for a symbol), AutoSkem offers an object editor, which is basically a block capture feature that saves the drawing to an object file.

Like symbols, objects can be called from a menu and placed anywhere in a drawing. Their advantage is that they can contain text and symbols, as well as lines. Their disadvantage is that they can't be scaled or rotated.

The drawing area is 1000 by 1000 units square, but only one-ninth of it is visible on the screen at any time, making it difficult to draw large schematics. Yes, you can zoom out to see the overall picture, locate the area of interest, and zoom back in. But you can't run commands from the zoom-out mode.

So a lot of initial part placement must be done by guess and by golly. Compounding the problem is that devices can't be edited after placement; they can only be moved. And if the object to be moved is bigger than the viewing window, it has to be erased and placed again—a tedious job, indeed.

AutoSkem's greatest attribute is undoubtedly its print features, which, for a DOS drawing program, are quite remarkable. Drawings can be output to a dot-matrix printer, LaserJet printer, or HPGL plotter. All or any part of the drawing can be selected for printing, and the selected area of the drawing can be rotated and sized to fit the paper.

Six years ago AutoSkem would have been a big hit at any price. But today it's as dated as the dinosaurs it's designed to run on. However, $29 is a tempting carrot. So if you'd like to try this program, you can find an abridged, but fully functional version of AutoSkem on the Gernsback BBS or America Online under the name AUTOSK14.ZIP. Download time for this program is about four minutes.

Product:	TurboCAD
Version:	2.0
Price	$99
Platform:	Windows
Publisher:	IMSI

Any drawing program can draw schematics. The drawback here is that creating the symbols (transistors, inductors, ICs, and so on) takes a lot of patience and time. However, there are some CAD drawing programs that have electronic symbol libraries—like TurboCAD for Windows. Unlike some drawing programs with similar libraries, such as AutoCAD, TurboCAD's $99 price won't break the piggy bank. There's even a library module with PC board layout symbols (see Fig. 4).

The nice thing about using a CAD program to draw schematics is that it has a lot more to offer, like unlimited zoom, multiple drawing layers, and extremely large drawing sheets. Although you can find schematic capture programs with the same features, they are generally very expensive.

The basic TurboCAD package comes with a limited number of schematic symbols that include a capacitor, resistor, and a handful of TTL ICs. For real work, though, you'll want to buy one or more of the 20 extra-cost libraries IMSI sells for use with TurboCAD. But as you add libraries to the setup, cost goes up. Fortunately, the libraries aren't that expensive. For example, the TTL, ECL, and CMOS libraries sell for $29.95 each. Or you can get all three, along with several other electronic modules, for just $79.95 when you purchase the Electronic Design library.

A shortcoming in using a CAD program to draw schematics is that it can be overkill some of the time. You have a lot more power than you need, so some things are a little more complicated than they should be. And the learning curve is steeper. That's why TurboCAD is not recommended for hobbyists who only need to draw simple schematics. But if you need a drawing program to create complex schematics frequently, then TurboCAD could be just the ticket you're looking for.

Product:	Electronics Parts-bin
Price	Free
Platform:	Windows
Publisher:	Jim Marinelli

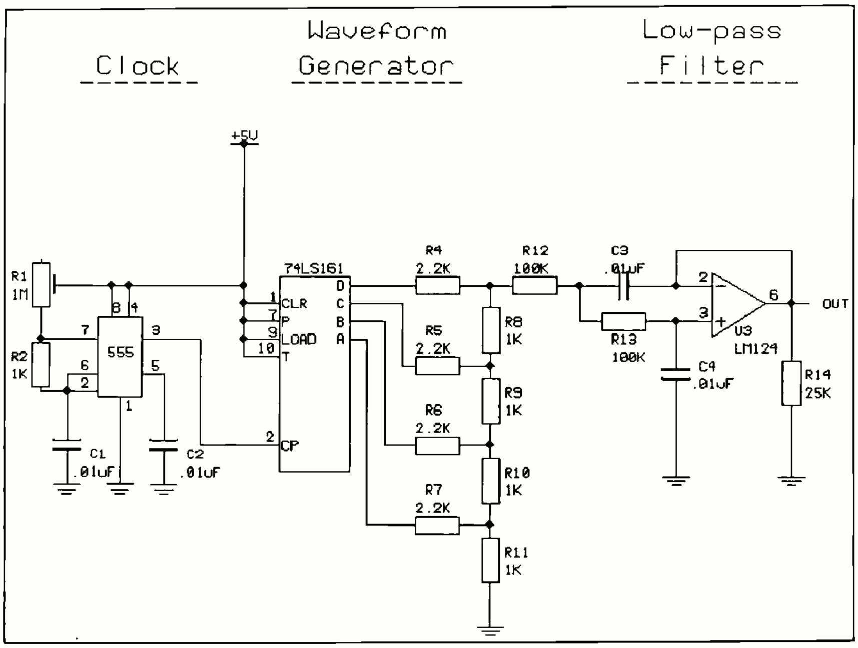


FIG. 6—BOARDMAKER's screen could not be captured, which is why you see a printout instead.

Electronics Parts-bin lets you build schematics from clip art (see Fig. 5). The clip art library of general purpose electronics components is contained in a file called PARTBIN1.PCX that's available on the *Gernsback BBS*, and can also be found in the software forum of America Online. Download time is about 11 minutes. To use the library, open up PARTBIN1.PCX in a drawing program like Windows' Paintbrush and copy the component you wish to the clipboard. Open a new or existing file and paste the component in place. Lines and text are provided by the drawing program.

Schematics with PCB layout

One of the joys in life is taking an idea from concept to a working device. The project doesn't have to be complicated or earth shaking—but it surely has to end in an etched printed-circuit board. If the design is simple—consisting of a couple of ICs and a fistful of passive parts—it's easier to do the PC board layout manually rather than run the design through a bunch of netlists. For such manual design, the software should be simple and to the point. The following three programs—all DOS-based British imports—fill the bill. They let you draw schematics plus manually layout a PC board using screens and commands that are common to both.

Product:	BoardMaker I
Version:	1.5
Price	$95
Platform:	DOS
Publisher:	Ohio Automation

If you're in the market for an economical schematic drawing program with PC board layout that's easy to use, yet powerful enough to handle large designs, you'll fall in love with BoardMaker I. This program can lay out circuit boards up to 17 inches square. It has advanced drawing and editing features normally found in programs costing several hundred dollars, and it supports a wide range of printers, pen plotters, and photoplotters. You can buy BoardMaker I for just $95.

Basically, BoardMaker I is a DOS-based PC board layout pro-

TABLE 1

	AutoSkem	BoardMaker I	CADPAK II ISIS Supersketch	CircuitMaker	Easy-PC	Easy-PC Pro	Electronics Workbench	EZ-Route Std EZ-Logic	Schematic Plus	SuperCAD	SuperCAD for Windows	TurboCAD for Windows	WinScheme
Price	$29	$95	$159	$299	$195	$349	$299	$249	$20	$99	$149	$99	$179
Format	DOS	DOS	DOS	Windows	DOS	DOS	Win/DOS	Windows	Windows	DOS	Windows	Windows	Windows
RAM required	384K	512K	640K	2MB	512K	640K	4MB	512K	2MB	640K	1MB	2MB	2MB
Hard disk required	N	N	2MB	7MB	N	5MB	4MB	3MB	N	N	2MB		10MB
Schematic	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Capture	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	Y
PCB netlist	N	N	N	N	N	Y	Y(1)	Y	N	Y	Y	N	N
Simulation netlist	N	N	N	Y	N	Y	Y(1)	Y	N	Y	Y	N	Y
Design rule check	N	N	N	N	N	Y	Y	Y	N	Y	Y	N	Y
PCB Layout	N	Y	Y	N	Y	Y	N	Y	N	N	N	N	N
Circuit Simulation	N	N	N	Y	N	Y	Y	N	N	Y	Y	N	N
Analog	N	N	N	Y	N	Y(1)	Y	N	N	Y(1)	Y(1)	N	N
Digital	N	N	N	Y	N	Y(1)	Y	N	N	Y(1)	Y(1)	N	N
Drawing Features													
Ortho disable	n/a	Y	Y	N	Y	Y	N	Y	N	Y	Y	Y	N
Diagonal wires	Y	Y	Y	N	Y	Y	N	Y	N	Y	Y	Y	N
Auto annotate	N	N	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y
Supports buses	N	N	Y	Y	N	N	N	Y	N	Y	Y	N	Y
Repeat object placement	N	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N
Rotate part prior to place	Y	Y	Y	Y	Y	Y	N	N	Y	M	M	Y	Y
Zoom range/on-the-fly	n/a	Y	Y	20:01	Y	Y	N	Y	n/a	draw to fit	24:1	n/a	10,000:1
Auto pan	N	Y	Y	N	Y	Y	Y	Y	N	N	N	Y	N
Find/search	N	N	Y	N	N	N	N	N	N	Y	Y	N	N
Editing Features—Placement													
Rotate	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mirror	N	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y
Find	N	N	Y	N	N	N	N	N	N	Y	Y	N	N
Undo	N	N	Y	Y(2)	N	N	N	Y	N	Y	Y	Y	Y
Rubberband	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Block													
Move	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Hide	N	N	N	N	N	N	N	N	N	N	N	Y	N
Delete	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Save	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y
Part reference													
Move	Y	n/a	Y	Y	N	Y	N	N	N	N	N	n/a	Y
Hide	N	n/a	Y	N	N	N	N	N	N	Y	Y	n/a	Y
Delete	Y	n/a	Y	Y	N	N	N	N	N	N	N	n/a	Y
Adjustable font size	Y	n/a	N	N	N	N	N	N	N	N	N	n/a	N
Global reannotate	N	n/a	Y	Y	N	N	N	N	N	Y	Y	n /a	N
Library													
Screen directory	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
DeMorgan	N	N	Y	N	N	N	N	N	N	Y	Y	N	Y
Printer Output													
Fit to page	Y	Y(3)	N	N	N	N	Y	n/a	n/a	N	n/a	n/a	n/a
Border off	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Y	n/a	Y	Y	n/a	n/a
Title box off	n/a	n/a	n/a	Y	n/a	n/a	n/a	Y	n/a	Y	Y	n/a	n/a
Software control	Y	Y	Y	Y	Y	Y	Y	Y	n/a	Y	Y	n/a	n/a
Plotter Output													
Fit to page	Y	Y	Y	N	N	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Maximum page size (inches)	8×20	17×17	34×34	34×34	17×17	17×17	n/a	34×34	n/a	n/a	34×34	n/a	n/a
Software control	Y	Y	Y	N	Y	Y	n/a	Y	n/a	n/a	Y	n/a	n/a

1) Extra cost **2) Limited to move and change only** **3) Except dot-matrix printers**

gram with access to a library of schematic symbols. Although the two programs share the same drawing editor, they don't share libraries or communicate between each other. In other words, you don't have access to the schematic library when it is in the PC board layout mode, and you can't import schematics into the PC board program for layout. Each program is independent of the other, and you can run only one at a time. An opening menu gives you the choice between schematic draw and PC board layout. An advantage of sharing the same drawing editor is that the commands are identical, which means you don't have to adjust to a new set of commands as you switch from one program to the other. The commands are easily accessed from seven pull-down menus, plus there's a keyboard shortcut for every command or command string.

BoardMaker I's schematic library comes with a total of 75 parts that include a good spattering of analog, logic, and discrete components, as well as a handful of lesser used devices like a microphone and Schottky diode. But as you've probably guessed, a library this small and diverse doesn't contain all the devices needed for the example schematic. That's why two ICs had to be created from the library editor. Like the schematic and PC-board layout editors, the library editor is a stand-alone program that's listed as one of the opening menu choices. And like all BoardMaker I programs, the library editor has the same screen setup and command menus, which makes the BoardMaker I package really easy to learn and use. New devices can be made from scratch or by modifying an existing component; there is little difference between the two. Each library can hold up to 250 symbols, depending on the symbol's complexity, and there's no limit to the number of libraries you can create.

The components are easily accessed from a pull-down menu. Parts can be rotated and mirrored before and after placement. The ability to zoom in and out and pan during placement and editing are two very powerful features that make working with this program a real pleasure. Repeat placement is provided, and there's automatic backup that saves your drawing to file at scheduled intervals without you having to think about it. Output can be sent to dot-matrix, LaserJet, and PostScript printers, plus HPGL and DMPL penplotters. If you don't mind fiddling with sizing parameters, the drawing can be made to fit the page for everything but a dot-matrix printer. Gerber and NC-Drill files—used by professional circuit-board manufacturers—are also supported.

Unfortunately, BoardMaker I wouldn't allow a screen shot to be made of its screen, which is why you see a printout in Fig. 6 instead. So you don't get to see the pull-down menus that include the component library. For that drawing, two ICs had to be created. The boxy European resistor symbols could easily be redrawn to U.S. standards.

BoardMaker I is extremely easy to use, and it is full of features you wouldn't expect in a program costing so little. And, unlike many schematic draw/PC board layout packages, BoardMaker I schematics are so good looking that you won't be embarrassed to publish them. Good looking schematics, the ability to lay out large circuit boards, and low cost just might make this the buy of the century.

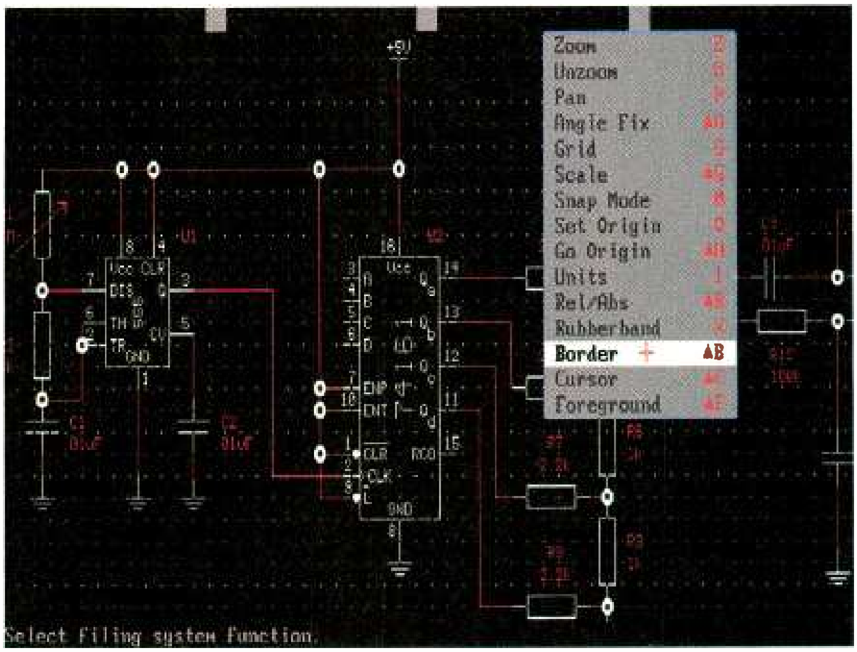


FIG. 7—EASY-PC IS BASICALLY A PC board layout program with a schematic component library, and it is the precursor of BoardMaker I.

Product:	Easy-PC
Version:	10142
Price	$195
Platform:	DOS
Distributor:	BSOFT Software

When the author first started testing Easy-PC, he thought he had picked up an old copy of BoardMaker I and loaded it by mistake. Everything that Easy-PC does—from the opening menu, to the drawing/editing tools, to output support—smacks of an early version of BoardMaker I. And for good reason: both are written by the same person. Essentially, Easy-PC is the forerunner to BoardMaker I, and while the two are very much alike, there are some significant differences. For openers, Easy-PC lists for $195, which is $50 more than BoardMaker I.

Like BoardMaker I, Easy-PC is a DOS-based PC board layout program with a library of schematic symbols in addition to

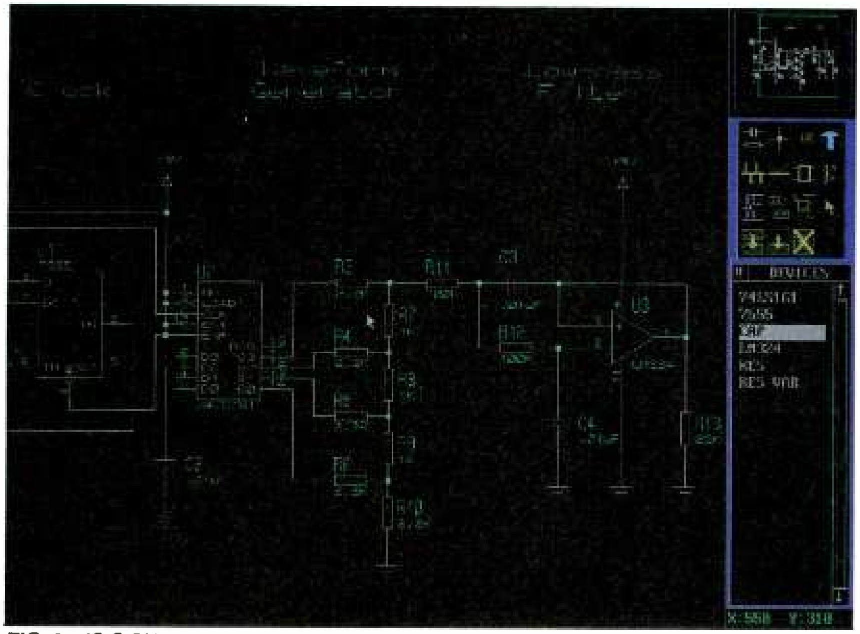


FIG. 8—ISIS SUPERSKETCH'S EXTENSIVE LIBRARY contains all the symbols needed to create the *Electronics Now* benchmark schematic.

cheaper and easier to use. On the other hand, Easy-PC has a larger component library, and its files are upgradable to Easy-PC Pro, a fully-featured schematic capture and PC board layout program. The one you choose should depend on your present and future needs. For quickie projects, BoardMaker I is the best choice. For more ambitious designs go with Easy-PC because it has Gerber file and NC Drill support. But read on before deciding on either.

component footprints and pads. The schematic draw and PC board layout programs are separate, and access to the programs is through a main menu. The Easy-PC programs share a common editor, and the commands are the same for all programs. Up to this point BoardMaker I and Easy-PC are virtually identical. The only difference is the look of the menus and the way they're organized. But here's where the two packages part ways.

While Easy PC's menus are easy enough to use, it takes time to navigate them because the commands are nested and one menu often spawns another. Fortunately, each menu has a keyboard equivalent that frequently reduces a lot of mousing around to a single keystroke (see Fig. 7). However, the keyboard commands aren't intuitive or easily remembered, which is why the keyboard reference chart was posted in a conspicuous spot.

You'll want to keep a list of the symbol libraries close at hand, too, because (unlike BoardMaker I) Easy-PC's screen lacks a library list. Parts are selected by typing their names from a command line—which forces you to memorize them or refer to the symbol charts found in the loose-leaf user's guide. But after thumbing through these lists to the point where the pages looked like a well-read paperback novel, the author gave up and tacked the pages to the wall above the keyboard reference chart. Despite a high parts count, the schematic library lacks some very basic components, including a variable capacitor and an op-amp. That's because over 80% of the nearly 500 devices are dedicated to TTL logic. For the example drawing, symbols had to be created for two analog ICs plus a variable resistor. Thankfully that's easy enough with the library editor also found as an option in the opening menu. But again, you have to quit what you're doing to access it, because only one Easy-PC program can run at a time.

Printer and file output is good to excellent, depending on your application, with support for dot-matrix, LaserJet, and HPGL printers and plotters. While the drawing can't be sized to fit the page, it can be scaled in increments of ¼, ½, 1, 2, and 4 times. Also included are utilities that generate Gerber files and standard NC Drill files, both of which are used by service bureaus to etch and drill finished printed-circuit boards.

Easy-PC is not BoardMaker I, and visa versa. BoardMaker I is cheaper and easier to use.

Product:	CADPAC II
Version:	2.28
Price	$159
Platform:	DOS
Publisher:	R4 Systems Inc.

CADPAC II is a combination of two DOS-based circuit design applications: ISIS Supersketch schematic draw and PC board II printed circuit board layout, both from Labcenter Electronics. Supersketch represents the entry-level program in the ISIS (Intelligent Schematic Input System) family of design software which includes ISIS Designer and Ares. While you'll find Supersketch's learning curve steeper than most schematic draw programs, you'll discover the advanced features, like auto wire routing and global device replacement, well worth the effort. And although the learning curve is steep, the price certainly isn't. At $159, CADPAC II is just $10 more than Easy-PC, which doesn't hold a candle to it.

Supersketch comes with several thousand drawing symbols stored in seven library modules, which are divided into such groups as CMOS, TTL, and memory devices. In addition there's an empty user module that can be used as a staging area to assemble new libraries from parts moved or copied from other libraries. New devices are created from the main drawing and can be saved to any library. Often it's possible to reduce the library part count by splitting the device into prefixes

Continued on page 159

OVER/UNDER VOLTAGE

continued from page 40

Therefore, monostable multivibrator IC2 provides a ½-second delay to keep RY1 turned off long enough for the voltage across C5 to return to normal. When pin 7 of IC1 goes high it triggers IC2, and the high output at pin 6 of IC2 causes the output of NOR gate IC3 go low which turns Q1 off and de-energizes RY1.

Switch S2 lets you quickly check the circuit's operation at any time. Pushing S2 raises the voltage at the junction of R2 and R5 and turns RY1 off. Reset switch S1 restores normal operation. Switch S1 turns the circuit on initially. An LM7805 voltage regulator (IC4) provides a constant 5 volt supply for the integrated circuits and the relay control current. No power switch was added to the circuit, as the device is intended to be on all the time. Note that the neon indicator lamps contain internal current-limiting resistors that aren't shown in the schematic.

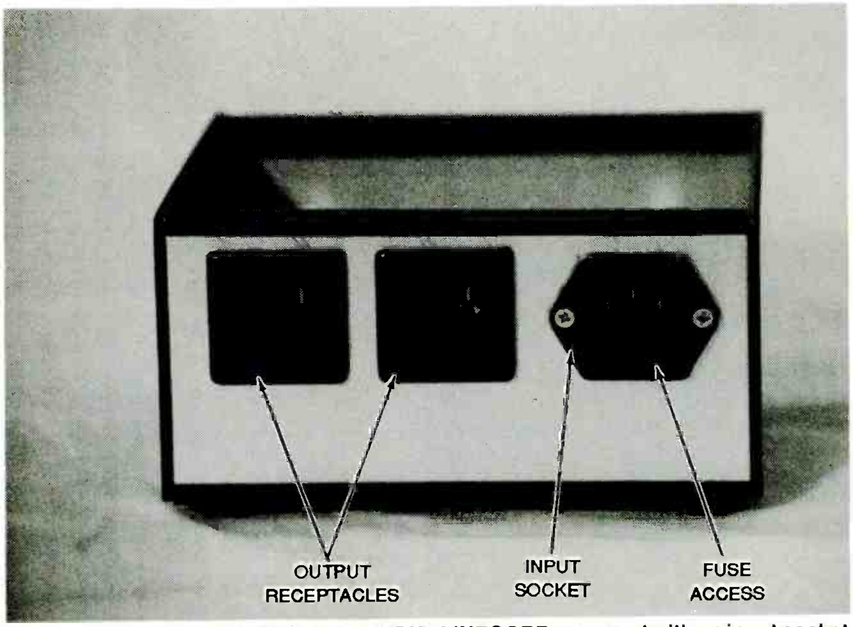


FIG. 3—A COMPUTER-TYPE POWER INPUT LINECORD was used with an input socket mounted on the back of the case.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—7500 ohms
R2—3800 ohms, 1% metal film (see text)
R3—412 ohms, 1% metal film (see text)
R4—100 ohms, trimmer potentiometer
R5—7385 ohms, 1% metal film (see text)
R6, R8—10,000 ohms, 1% metal film
R7—2692 ohms, 1% metal film (see text)
R9, R10—4700 ohms
R11—39,000 ohms
R12—10,000 ohms
Capacitors
C1, C4—0.1 µF, ceramic disk
C2—22 µF, 10 volts, tantalum electrolytic
C3—1 µF, 25 volts, tantalum electrolytic
C5—1000 µF, 35 volts, electrolytic
Semiconductors
IC1—ICL7665 over/under voltage detector (Maxim or equivalent)
IC2—74121 monostable multivibrator
IC3—74LS02 quad 2-input NOR gate
IC4—LM7805 +5 volt regulator
BR1—DIP bridge rectifier, 1 ampere, 50 volts (Marlin Jones #5225-BR or equivalent)
Q1—2N3904 NPN transistor
Other components F1—3-ampere fuse, 115 VAC
S1, S2—pushbutton switch, normally open
RY1—Solid state, normally open AC relay (240 volts, 10 amperes, see text)
T1—Power transformer, 120 VAC primary, 12 VAC secondary (Marlin Jones # 6485-TR or equivalent)
MOV1–MOV3—Metal oxide varistor, 130 VAC, 10 amperes
NE1, NE2—neon indicator lamps with built-in current limiting resistors
PL1—grounded IEC-type line cord with IEC-type input socket and built-in fuse-holder (optional, see text)
SO1, SO2—grounded AC receptacle (only one is necessary, others are optional)
Miscellaneous: Project case, circuit board, hardware, 20-gauge stranded hookup wire, solder.

Note: The following items are available from TDL Electronics, 5260 Cochise Trail, Las Cruces, NM 88012-9736, 505-382-8175, Fax 505-382-8810:
- **Etched and drilled PC board—$8.50 postpaid**
- **Kit of PC board and all board-mounted parts (including power transformer)—$39.95 postpaid**
- **PC mount power transformers, solid-state relays, and input and output connectors are available from:**

**Marlin P. Jones and Assoc., Inc.
PO Box 12685
Lake Park, FL 33403-0685
407-848-8236**

**All Electronics Corp.
PO Box 567
Van Nuys, CA 91408-0567
800-826-5432**

**Herbach and Rademan Co.
PO Box 122
Bristol, PA 19007-0122
800-848-8001**

- **The aluminum case (model MC-5A) is available from:**

**Sescom, Inc.
2100 Ward Drive
Henderson, NV 89015-4249
800-634-3457**

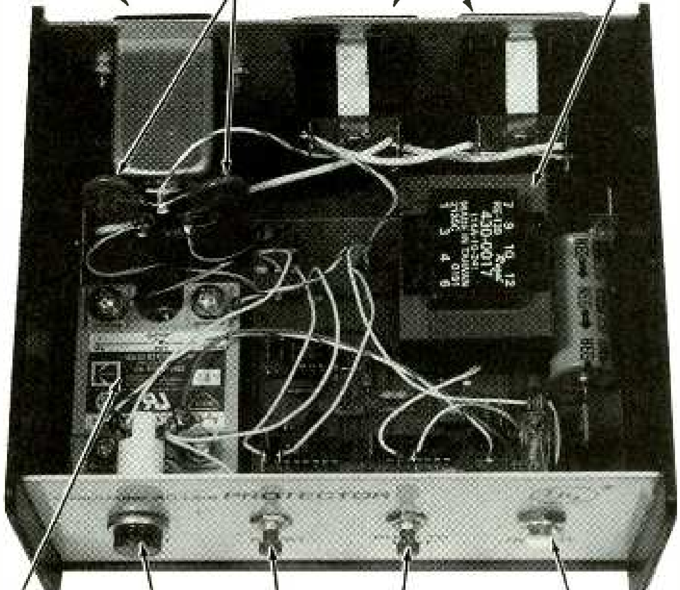


FIG. 4—THE INSIDE OF THE COMPLETED PROTOTYPE. The MOVs are soldered to the input power connector; the fuse is built into this connector and is not visible in the photo.

Construction

The circuit layout is not critical. You can build the circuit on a PC board or it can be wired point-to-point. A foil pattern is provided so that you can make your own board or one can be purchased alone or as part of a kit from the source given in the Parts List. All the logic including the power transformer mounts on the small, single-sided PC board.

A parts-placement diagram is shown in Fig. 2. Install the parts as indicated. Only one jumper wire is required in the position marked "J." Sockets for the ICs are optional. Remember to observe polarity on electrolytic capacitors C2, C3, and C5. Use No. 20 AWG stranded wire for all connections to and from the PC board and between the input and output receptacles. (All parts within the dashed outline in Fig. 1 are board-mounted, and connections outside the dashed lines are hard wired.)

Because the author did not keep a complete stock of 1% metal-film resistors (and you probably don't either), he designed the PC board to accept a series pair of resistors for R2, R5, and R7. That should make it easier to find a pair of 1% resistors that will combine for the correct value. If you have 1% resistors of the exact values for R2, R5, or R7, install a jumper in one of the locations and the resistor in the other.

Install the socket for an IEC-type detachable power input linecord on the back of the case (see Fig. 3). Fuse F1 is built into this socket, and the three MOV surge protectors are soldered directly to its lugs. You can use a regular linecord if you like, and eliminate SO1. Just remember to install the fuse separately if you eliminate the socket. Also be sure to use a polarized three-conductor line cord and remember to connect the green ground wire to the case—if a metal case is used—and to the ground terminals of the output receptacles. Mount the neon panel lamps that indicate input and output power on the front panel along with the test and reset buttons.

Figure 4 shows the inside of the completed prototype. The PC board is mounted to the bottom of an aluminum enclosure with four ⅜-inch long threaded metal standoffs.

CALCULATING RESISTOR VALUES

The Protector circuit is designed so that the voltage at the junction of resistors R2 and R5 is set to be 2 volts when the AC line voltage is 115 volts (see Fig. 1). That voltage is somewhat arbitrary, but it does need to be above the 1.3-volt switch point of the comparators and well below the unregulated DC voltage from the power supply. Proportionally, the voltage at that point will decrease to 1.65 volts when the line voltage drops to 95 volts, and it will increase to 2.26 volts when the line reaches 130 volts. These values (1.65 and 2.26) correspond to the switch points that set the width of the window.

A value of 10K for R6 and R8 sets the current through R5-R6 and R7-R8 (the current into the comparator is negligible). At the 1.3-volt switch point, a current of 130 microamperes will flow (1.3V/10K). Pin 6 is the high-side comparator so the voltage drop across R5 will be 2.26 − 1.3 = 0.96 volt. At 130 microamperes, a resistance of 7385 ohms is needed. For the low-side comparator at pin 3, the corresponding voltage drop is 1.65 − 1.3 = 0.35 volt. So R7 must be 2692 ohms.

Values for R2, R3, and R4 were calculated by recognizing that the current flow in this branch should be large compared to the flow in R5-R6 and R7-R8. We'll let this current be 5 milliamperes, and knowing that the voltage at the junction of R2 and R5 is 2 volts, the R3-R4 series combination should be 400 ohms. Because the flow in the parallel combination of R5-R6 and R7-R8 must be considered, the 400 becomes 460 ohms. A 100-ohm trimmer in series with 412 ohms will work. With the power transformer used in the prototype there is a 19-volt drop across R2. With a 5-milliampere current flow, R2 must be 3800 ohms. Ω

Calibration

Set the trimmer potentiometer R4 to mid-range. If you have a variable transformer (Variac) and an AC voltmeter, you can check the low voltage turn-off point. Adjust the variable transformer to 110 to 115 volts as indicated on the voltmeter. Push the reset button and slowly decrease the input voltage until the relay opens. (A lamp plugged into the Protector's output makes this easy to observe.) Adjust R4 so that the relay turns off (opens) with an input of about 95 volts. Ω

BRIDGE CIRCUITS

continued from page 42

0.3% on the 100-ohm and 1-megohm ranges where the R1/R2 ratios are 1/100 and 100/0, respectively. To be a practical instrument, the Fig. 3 circuit must include a sensitive null-balance detector.

Figure 4 is a schematic for a ×10 DC differential amplifier for use with an external analog volt-ohmmeter to form such a detector. This circuit must have its own own independent 9-volt power supply. The LF351 is a low-cost BIFET operational amplifier available from Motorola, Texas Instruments, National Semiconductor, and others.

ampere or 100-microampere range for high-sensitivity. In the 100-microampere range, the circuit must first be balanced by short-circuiting its input terminals together and trimming the multiturn 10-kilohm SET-BALANCE control for a zero reading on the meter.

Wheatstone variations

The Wheatstone bridge circuit of Fig. 2 can be configured in three other ways without invalidating the basic balance equations, as shown in Figure 5. In each form R1/R2 are known as the bridge's ratio arms. Notice that the bridge's signal-source and detector terminals can be transposed without upsetting the ciruit's balance equations. This also holds true for the various versions of capacitance and inductance bridges. The most useful Wheatstone bridge variation is that shown in Fig. 5-a.

Figure 6 shows a modern six-range version of this circuit, and Table 2 lists its benefits over the circuit in Fig. 3. Its null sensitivity (which is proportional to the R3/R2 ratio at balance) is very high on all ranges, and varies from 0.003% at R3's full scale balance value, to 0.03% at one-tenth of full scale.

By confining all measurements to the top nine-tenths of the R3 range, one can measure all resistance values in the 1-

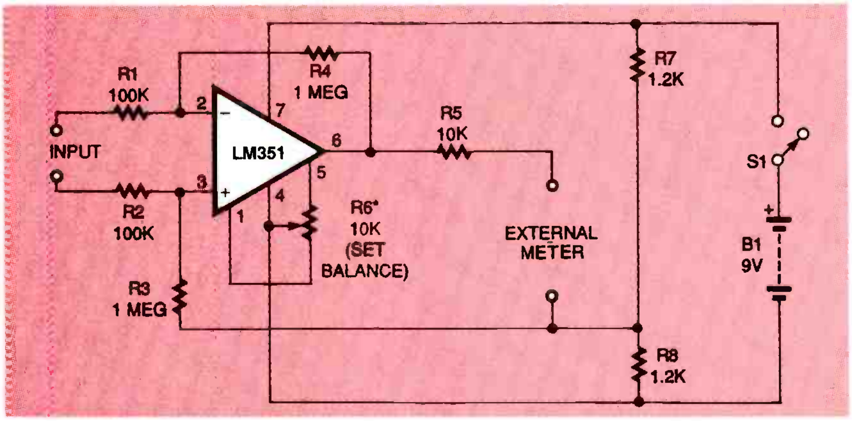


FIG. 4—A DC NULL POINT AMPLIFIER for use with an external digital multimeter or analog volt-ohmmeter

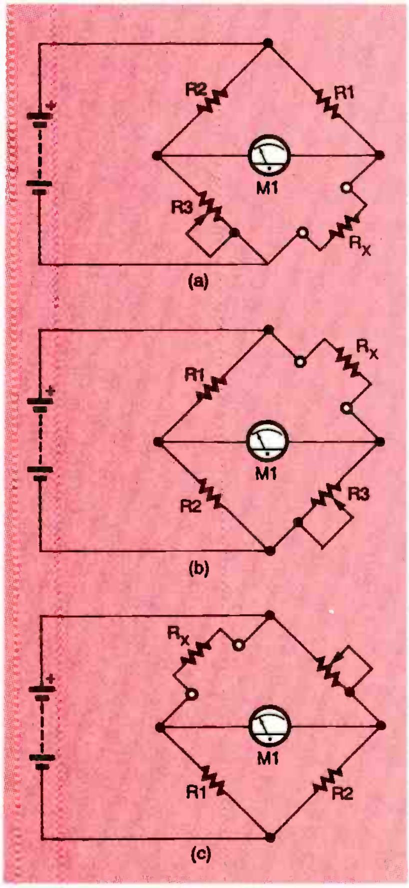


FIG. 5—THREE ALTERNATIVE VERSIONS of Wheatstone bridges follow the same rules as the circuit in Fig 2.

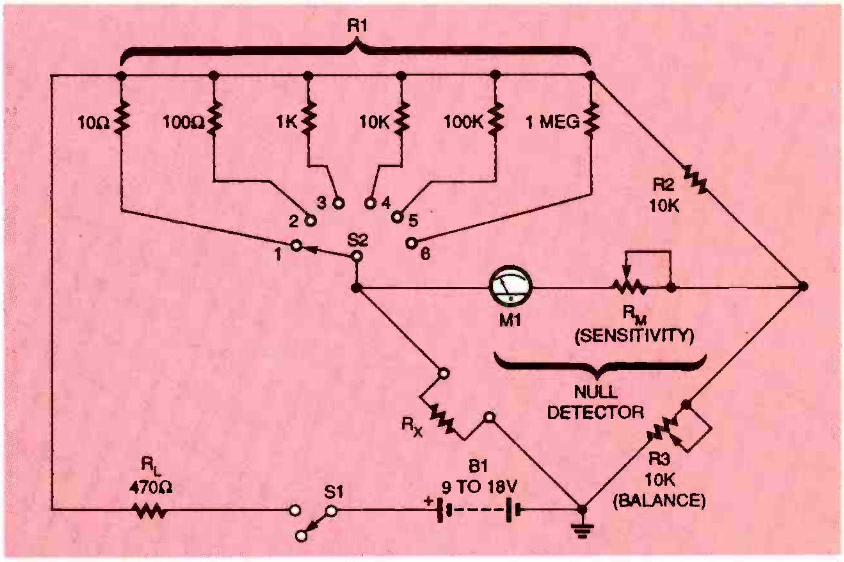


FIG. 6—HIGH-SENSITIVITY, SIX RANGE Wheatstone DC resistance-measuring bridge.

The LF351 has a JFET input for low input offset voltage and BIFET technology provides wide bandwidth and fast slew rates with low bias currents as well as low input offset currents and supply currents. It is the functional equivalent of the LF353, and the LF347 is a dual version.

An external volt-ohmmeter can be set to its 2.5-volt DC range for low-sensitivity measurements, or to its 50-micro-

TABLE 2
RESPONSE OF 6-RANGE HIGH-SENSITIVITY BRIDGE

Switch S1 Range	Bridge Range	Resistor R1 Value (Ohms)	R1/R2 Ratio (Ohms)	Bridge Null Sensitivity (Nominal)
1	0-10	10	1/1000	Proportional
2	0-100	100	1/100	to value of R3
3	0-1k	1k	1/10	to 0.003% at
4	0-10k	10k	1/1	full scale on
5	0-100k	100k	10/1	all ranges
6	0-1MEG	1MEG	100/1	

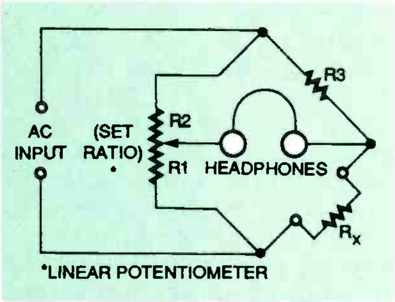


FIG. 7—AC POWERED Wheatstone bridge with variable ratio-arm balancing and headphone-detection.

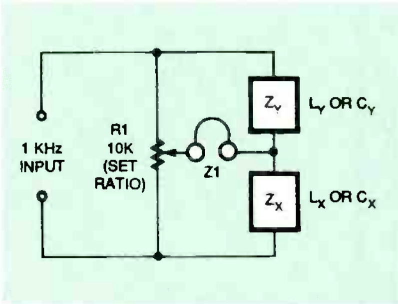


FIG. 9—WHEATSTONE BRIDGE for determining both capacitive and inductive reactances.

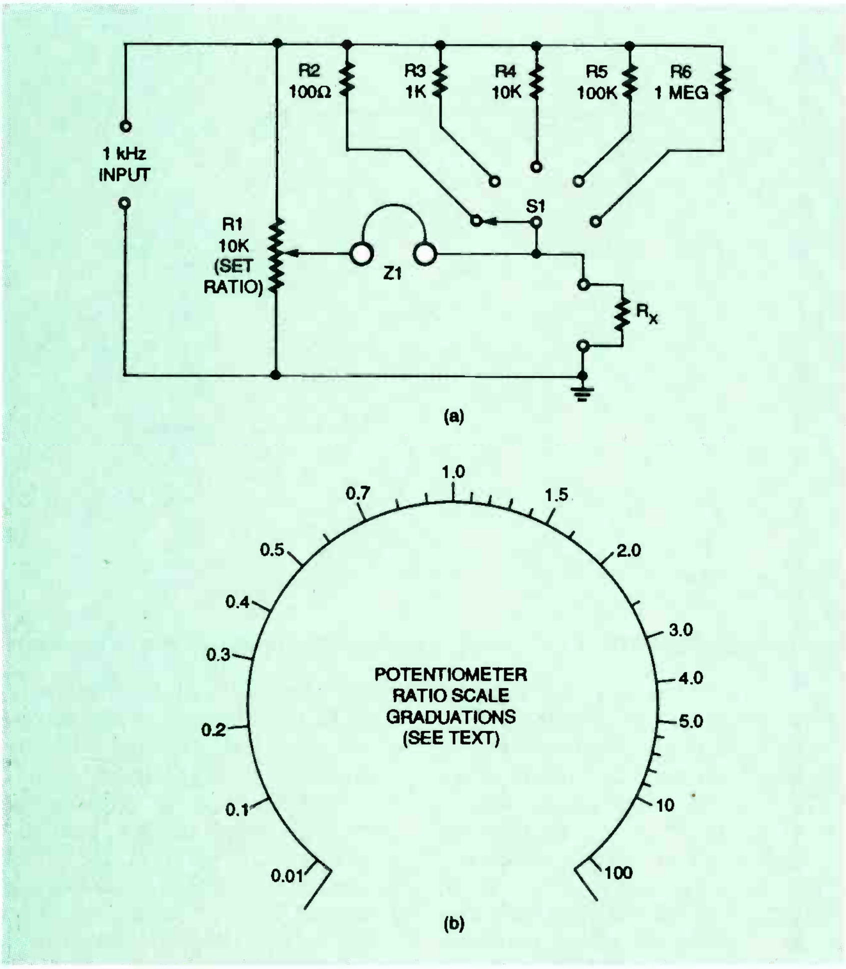


FIG. 8—FIVE-RANGE resistance bridge, with rotary panel potentiometer scale markings (*a*) and typical ratio scale markings (*b*).

ohm to 1-megohm range with excellent null sensitivity.

A Wheatstone bridge can be energized from either an AC or DC source without altering the fundamentals of its operation. Figure 7 is the circuit for an AC-energized Wheatstone bridge whose balance condition is maintained with an infinitely-variable pair of "ratio" arms consisting of potentiometer R1 which provides the resistive values of R1 and R2.

The sum of the resistive values of R1 and R2 equals the resistive value of potentiometer. The balance sensitivity of this circuit is high enough to permit detection with headphones.

Figure 8 shows a five-range version of the Wheatstone bridge circuit of Fig. 7. It covers a resistive range of near-zero to near-infinite ohms with its highest precision between 10 ohms and 10 megohms. Rotary panel potentiometer R1's ratio equals one when its wiper is at midrange. The diagram shows expected typical scale graduations for a calibrating this control potentiometer. These must be manually marked as described later in this article.

To measure with the Fig. 8 circuit, connect the bridge to a 1-kHz sinewave generator, insert the unknown resistor R_X, and adjust rotary switch S1 and rotary panel potentiometer R1 until a null can be detected by listening with the headphones. When that occurs, the value of resistor R_X equals the value of the resistor connected to S1 multiplied by the scale value on potentiometer R1. A balance can be obtained on any range, but for the highest precision, the balance should occur with an R1 scale reading between about 0.27 and 3.0.

To calibrate the scale of panel potentiometer R1, insert a 10-kilohm, 1% resistor in the R_X position. Then index rotary switch S1 progressively through its 100-ohm, 1-kilohm, 10-kilohm, 100-kilohm, and 1-megohm positions. Mark the scale at each sequential balance point as 0.01, 0.1, 1.0 (mid-scale), 10, and 100.

Repeat this procedure with

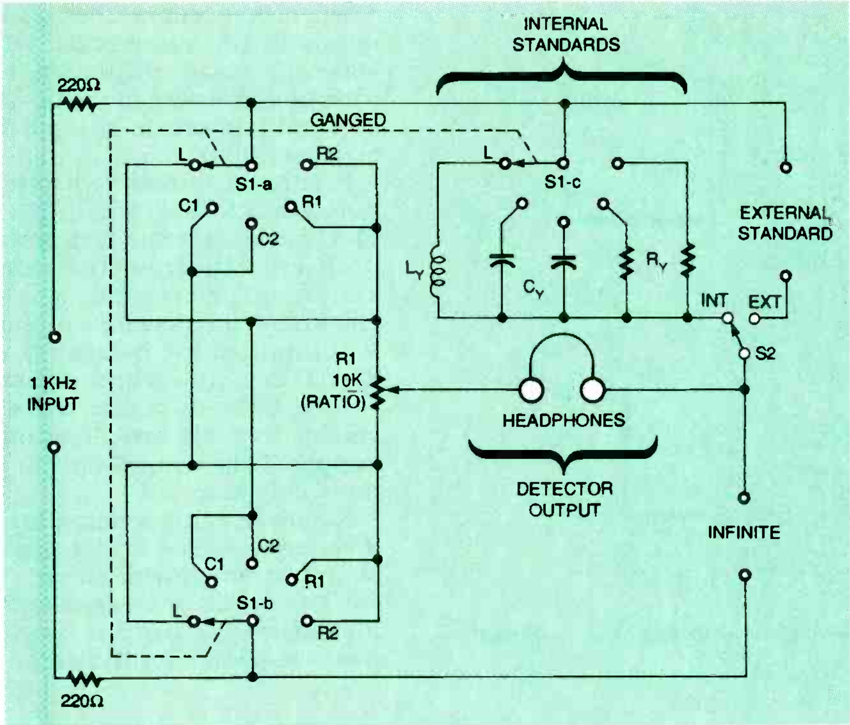


FIG. 10—LCR BRIDGE with headphone null detector.

R_X values that are multiples or submultiples of 1.5, 2, 3, 4, 5, etc., until the scale is completely calibrated, as shown in Fig. 8-b.

Resolution and precision

There are four important quality characteristics of a measurement bridge: (1). measurement range, (2) balance-sensitivity, (3) resolution, and (4) precision. The term resolution refers to the accuracy with which the R_X value can be read from the bridge's controls. For example, in Figs. 3 and 6, R3 gives a resolution of about 1% of full-scale if it is a manually-calibrated, linear, potentiometer, or about 0.005% of full-scale if it includes a four-decade resistor box.

The resolution of the bridge in Fig. 8 varies from ±1% at a "1" ratio to ±2% at a 0.3 or 3.0 ratio, to ±5% at a 0.1 or 1.0 ratio.

The term precision refers to the basic accuracy of the bridge, assuming that it has perfect balance-sensitivity and resolution, and equals the sum of the R1/R2 ratio tolerance and the tolerance of the resistance standard R3. If the R1/R2 ratio is set strictly by precision resistors, the ratio's precision equals the sum of the R1 and R2 tolerances. However, there are other techniques that permit resistors to be matched so that ratio errors are reduced to only about ±0.005%.

**TABLE 3
STANDARDS VS. BRIDGE VALUE**

	Standards Value	Bridge Range
R3	100 Ω	10 Ω -1 k
	100 k	1 k-100 k
	1 MEG	100 k-10 MEG
C3	100 pF	10 pF-0.001 μF
	0.01 μF	0.001 μF-0.1μF
	1 μF	0.1 μF-10 μF
L3	1 mH	100 uH-10 mH
	100 mH	10 mH-1 H
	10 H	1 H-100 H

For example, if the high-resolution Wheatstone bridge in Fig. 6 is made with R1 and R2 as 1% resistors and R3 is a manually-calibrated control potentiometer, the circuit will have a basic precision of only 3%. However, if the values of R1 and R2 are correctly matched, the precision of the bridge increases to ±1.005%.

The circuit's precision can be increased to ±0.105% with a ±0.1% multidecade resistor box in the R3 position. Bear in mind that additional errors can creep in when you are measuring very low or very high resistance values. The most likely cause will be the resistance values of switch contacts and leads when measuring low resistive values, and leakages when measuring high values.

The overall quality of a bridge depends on its balance-sensitivity, resolution, and precision. Thus, the circuit in Fig. 6 offers excellent sensitivity and very good resolution and precision. Consequently, it can function as the basic circuit of either an inexpensive, simple bench test instrument or as a component in a precision laboratory instrument, depending on how it is built.

By contrast, the bridge in Fig. 8 has intrinsically poor resolution and precision. This means that it is suitable only for fast, imprecise measuments such as might be satisfactory for servicing equipment.

Capacitance and inductance

An AC-energized Wheatstone bridge can measure reactance, resistance, capacitance (C) and inductance (L). The circuit in Fig. 9 is a modification of the circuit in Fig.7 to measure C or L values by replacing R4 and R_X with comparable reactances. This will work if C_X or L_X are reasonably pure and have 1-kHz impedances greater than about 1 ohm and less than 10 megohms.

The difficulty in trying to measure inductance with this circuit is that accurate inductors (for use in the Z4 position) are hard to find, and inductive impedances are only 6.28 ohms per millihenry at 1 kHz.

The only difficulty in measuring capacitance is that the C_X value is proportional to the reciprocal of potentiometer R1 resistance scale markings. If the basic bridge is to measure both R and C, two calibrated sets of potentiometer R1 scales are needed. This drawback can be overcome by fitting R1 with a reversing switch. An example of this is shown as the multi-range LCR bridge of Fig.10. Thus, only a single scale as

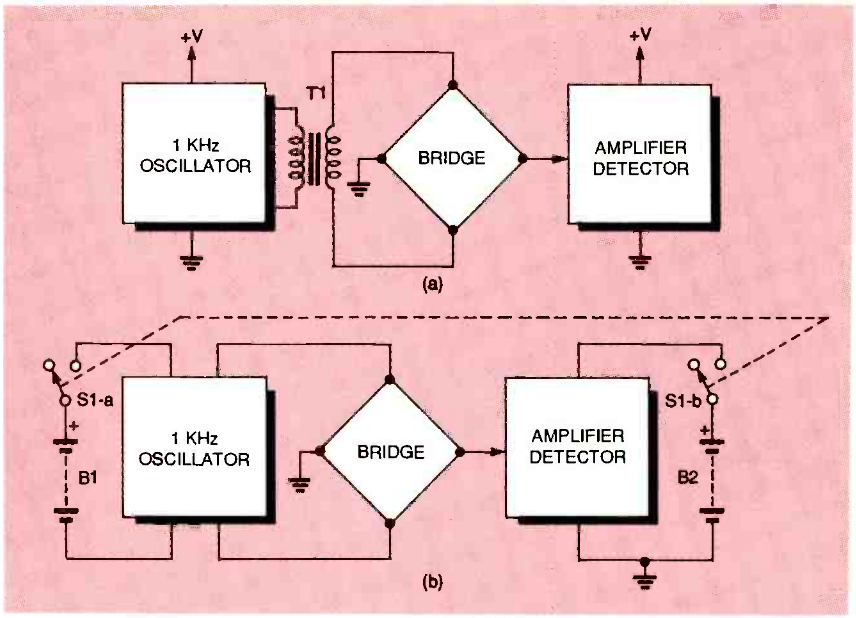


FIG. 11—ALTERNATIVES CIRCUITS for powering and detecting nulls in Wheatstone bridge circuits.

When that occurs, the C_X value equals 100 nanofarads. This 100-nanofarad standard can then be connected to the bridge and used to create a 1 microfarad standard.

Figure 11 shows two alternative block diagrams. Figure 11-a, the first option, is to power both circuits from the same supply but to isolate the oscillator by transformer-coupling its output to the bridge, as in Fig. 11-a. The second option, Fig. 11-b, is to power the oscillator from its own "floating" supply. This second option is more efficient.

Figure 12 is the schematic for a battery-powered bridge power source. It can provide either a 9-volt DC output or an excellent 1-kHz sinewave output with a peak-to-peak amplitude of 5

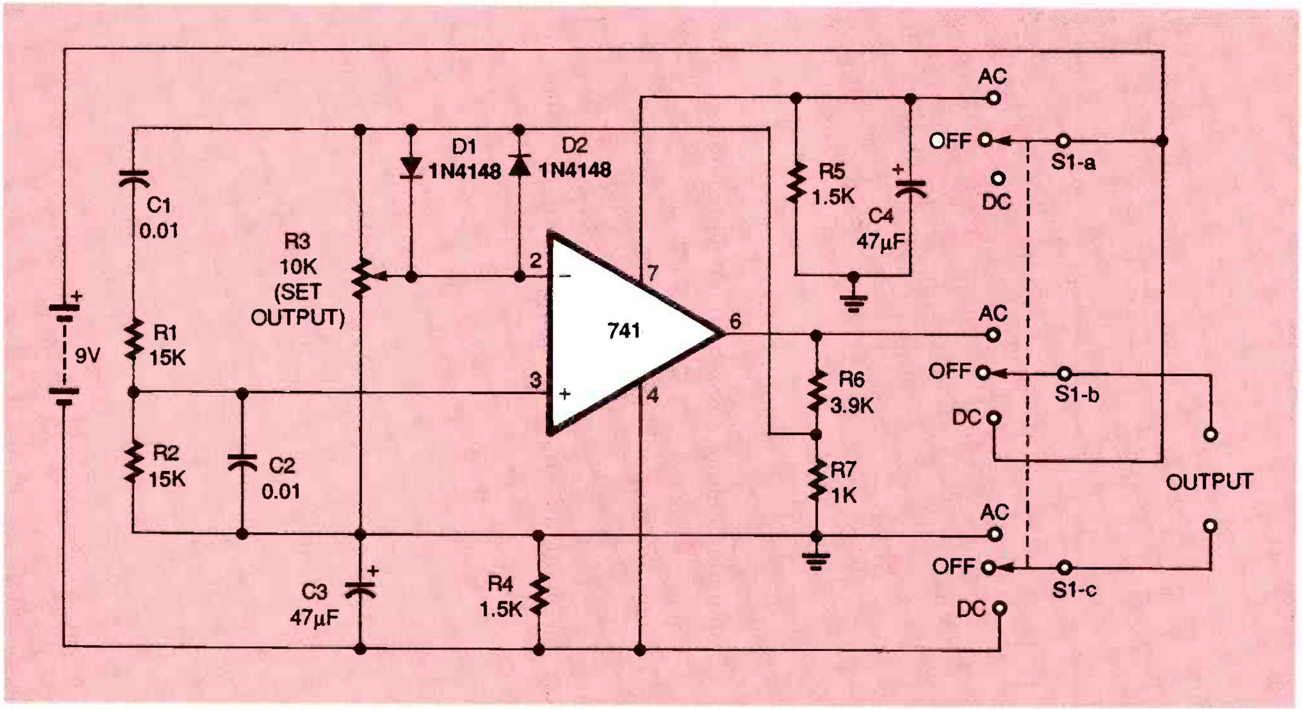


FIG. 12—POWER SOURCE for bridge circuits capable of 9-volt DC and 5-volt, 1-kHz outputs.

volts. The oscillator is a diode-stabilized Wien bridge oscillator that works from a split power supply derived from the battery through resistors R1 and R2.

The circuit has a low-impedance output, and consumes a less than 4 milliamperes of quiescent current. To set up the oscillator, connect its output to a suitable oscilloscope and trim potentiometer R1 to give a reasonably pure sinewave output of about 5 volts, peak-to-peak. Ω

shown in Fig. 8 is required.

The general purpose LCR bridge with headphone detector shown in Fig. 10 is a versatile instrument. Switch S2 permits it to be used with either internal or external L, C, or R standards. The midscale value of each range is equal to the value of the standard assigned for that range, as listed in Table 3.

When this instrument is calibrated, it can be help to create its own alternative measurement standards. For example, if an accurate 10-nanofarad capacitance standard is inserted across the EXTERNMAL STANDARD terminals, a 100-nanofarad standard can be created by moving potentiometer R1 to the "10" position and then connecting capacitors in parallel across the "X" terminal for a null balance.

MEMORY MODULES

continued from page 36

on a DRAM's capacitors will leak off, so it must be *refreshed* regularly. Refreshing data in a DRAM can be accomplished in several ways: each method calls for different combinations of RAS, CAS, and the address lines. Most modern computers have a special DRAM controller, in the form of an application specific IC (ASIC), that must manage both the memroy refresh function and data storage and retrieval chores.

DIP memory sources

Memory can be salvaged from many sources, such as obsolete or inoperative computers, old memory boards, and EGA and VGA video adapters. If you try to salvage memory from an inoperative computer, exercise caution. It helps to know the history of the system that you are planning to cannibalize so that you do not inadvertently transport problems from one system to another. Memory is just as likely as any other component to have failed.

TABLE 1—DRAM PART NUMBERS AND CONFIGURATIONS

256K x 1 (16-pin DIP)	256K x 4 (20-pin DIP)	1Meg x 1 (18-pin DIP)	1Meg x 4 (20-pin DIP)
1256	GM4C256	GM71C1000	GM71C4400
41256	HM44256	HM511000	HM514400
1C256	M5M44256	M5M41000	M5M44400
2801	MCM514256	MCM511000	MCM514400
3C256	TC514256	TC511000	TC514400
6207	MT4C4256	MT4C1024	MT4C4001
62L07	KM44C256	KM41C1000	KM44C1000
MT1259	P21014	P21010	uPD424400
M5M4256	HM4514258	TM54C1024	MSM514400
TMS4256	uPD424256	AAA1M300	HYB514400

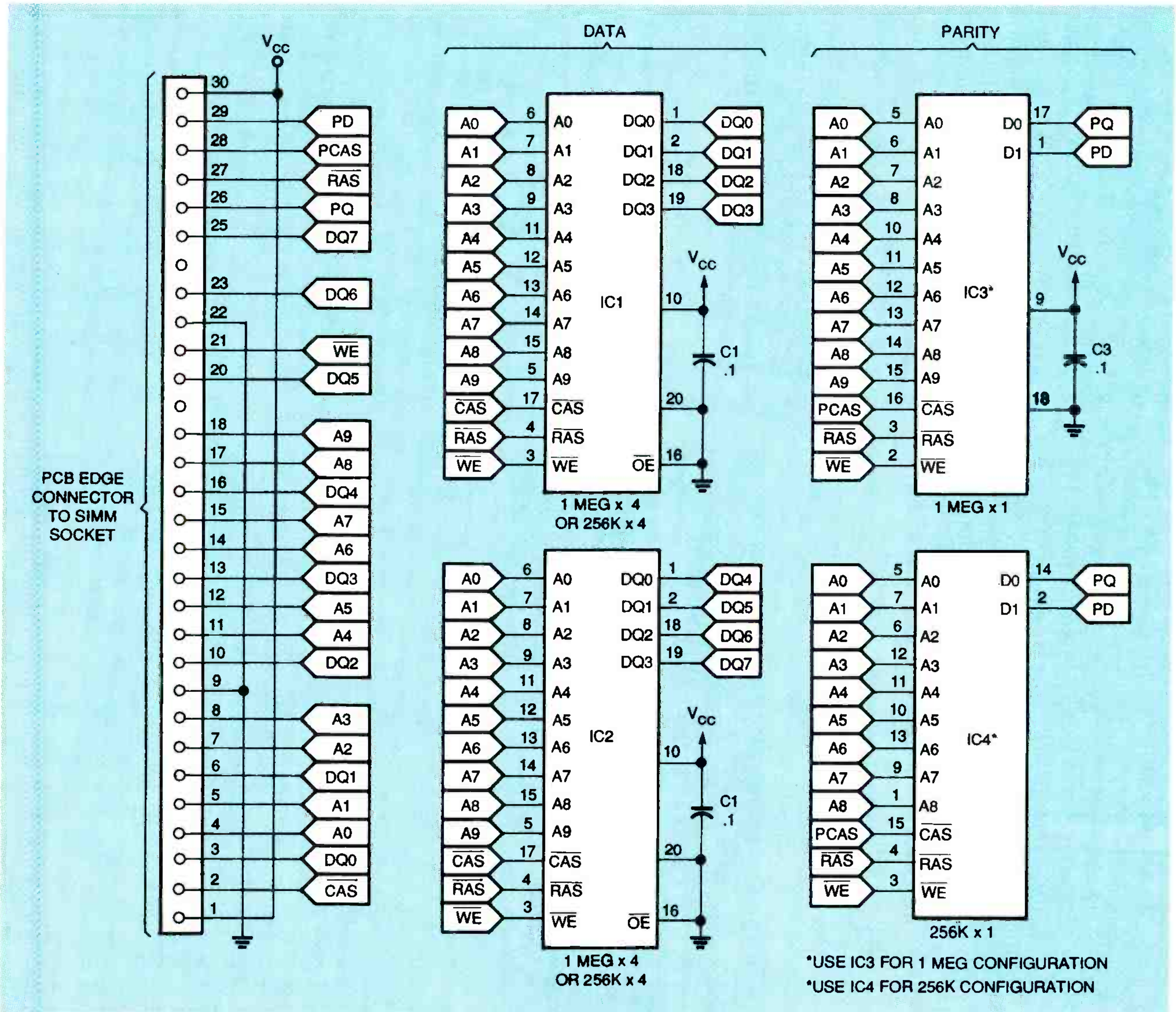


FIG. 2—THIS CONFIGURATION provides either 256 kilobytes or 1 megabyte of memory, populated in both cases with three DRAMs.

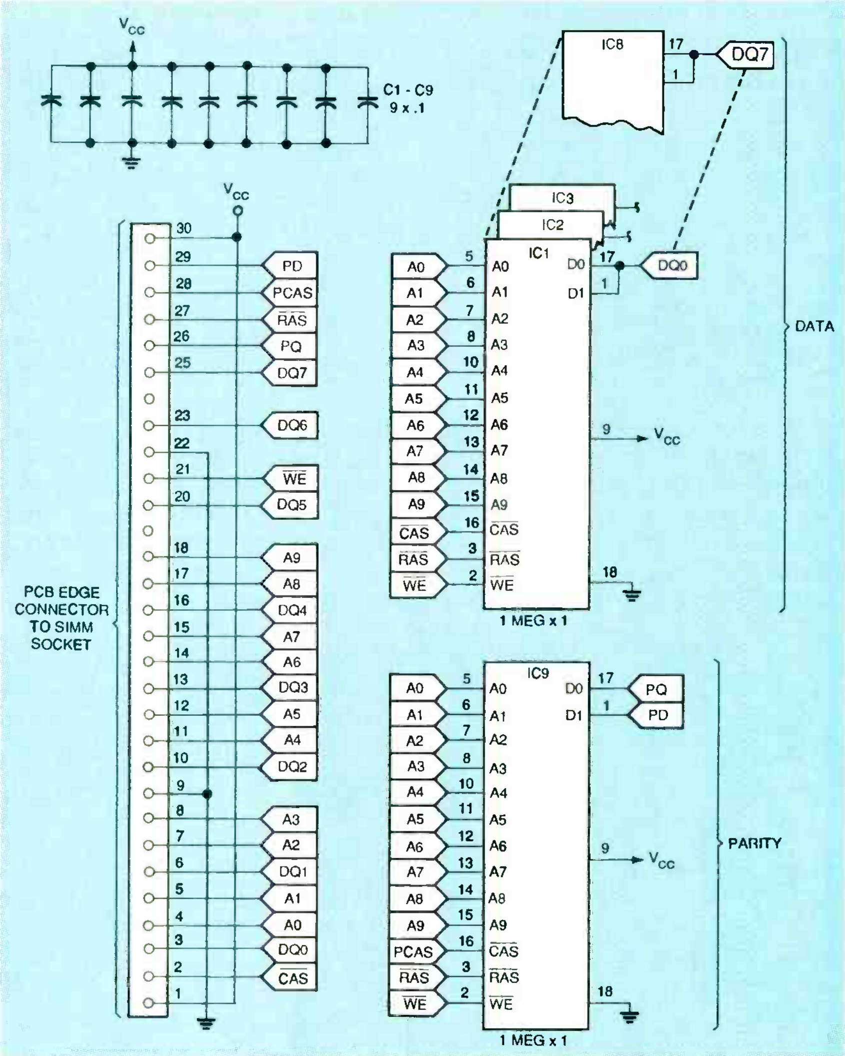


FIG. 3—SCHEMATIC of the 1-megabyte, nine-IC configuration.

256KB, 3-IC PARTS LIST

IC1, IC2—256KB × 4 DRAM
IC3—256KB × 1 DRAM
IC4—not used
C1–C3—0.1 µF, 50-volt, 0.3-inch center

1MB, 3-IC PARTS LIST

IC1, IC2—1MB × 4 DRAM
IC3—not used
IC4—1MB × 1 DRAM
C1–C3—0.1 µF, 50-volt, 0.3-inch center

256KB, 9-IC PARTS LIST

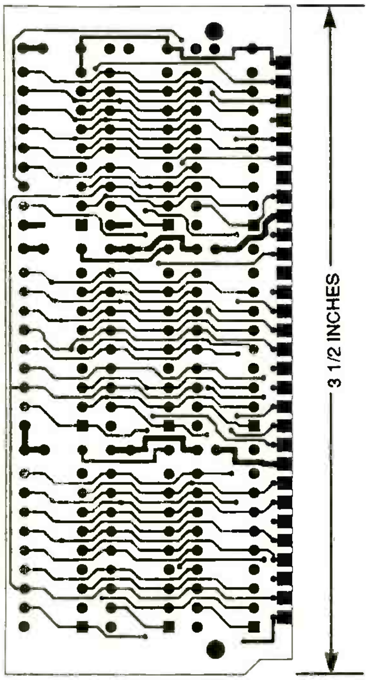
IC1–IC9—256KB × 1 DRAM
C1–C9—0.1 µF, 50-volt, 0.3-inch center

1MB, 9-IC PARTS LIST

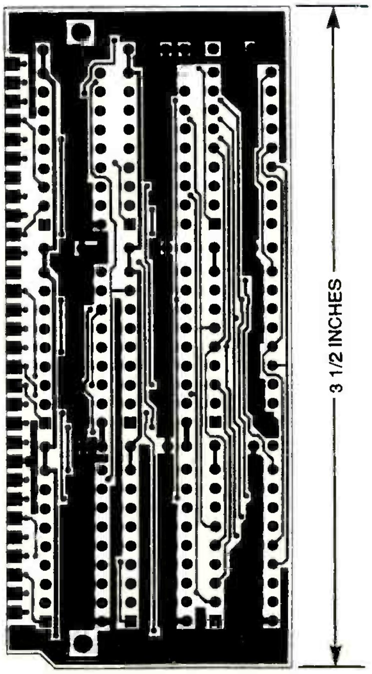
IC1–IC9—1MB × 1 DRAM
C1–C9—0.1 µF, 50-volt, 0.3-inch center

ORDERING INFORMATION

The following items are available from AutoTime Corporation, 6605 SW MacAdam Avenue, Portland OR 97201. Voice: (503) 452-8577, Fax: (503) 452-8495, Faxback: (503) 452-0208, Internet: info@autotime.com. 256K/1M dual-purpose 3-IC DIP-to-SIMM conversion kit (DUAL3CDIP-EN, $6.00), 256K 9-IC DIP-to-SIMM conversion kit (256K9CDIP-EN, $6.00), 1MEG 9-IC DIP-to-SIMM conversion kit (1MEG9CDIP-EN, $8.50). All kits include a PC board with through-hole plating, solder mask, silk screen, and decoupling capacitors. Memory not included. Add $3.95 shipping and handling on all orders. AutoTime's trained memory technicians will help with memory identification, assembly problems, and explain other memory conversion products.



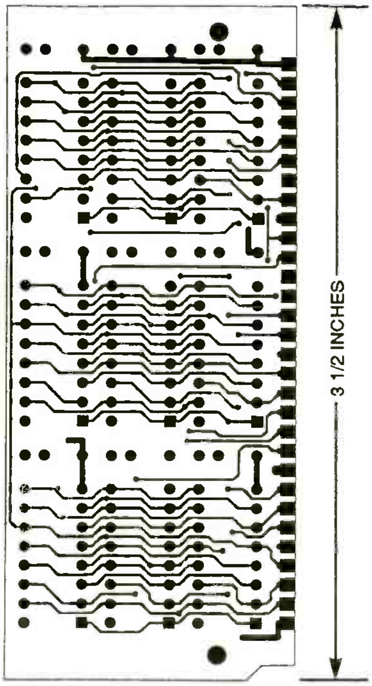
COMPONENT SIDE of the 1-meg board.



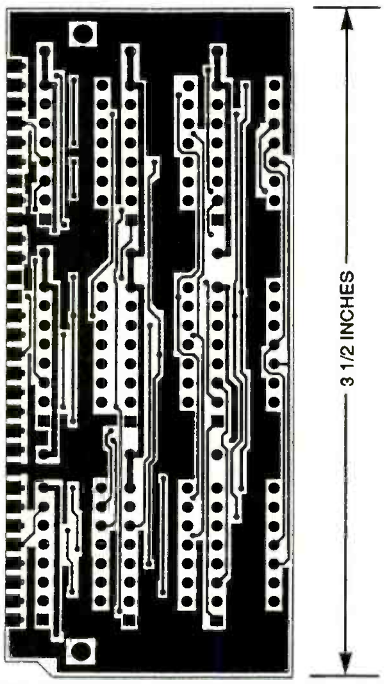
SOLDER SIDE of the 1-meg board.

Fortunately, the memory is socketed in many older computer systems. If it is not, you must unsolder it. With a good desoldering system and some diligence, DIP memory can be extracted without damaging it. When desoldering, apply the least amount of heat for the shortest amount of time. Excessive heat will damage or destroy the semiconductor device.

If you must desolder, exercise caution. Safety is paramount. Wear safety glasses and a shirt with long-sleeves to protect against molten solder that can splash during device removal. After removing the ICs, clean all excess solder from the pins of the DIP with a soldering iron. Then straighten the pins with needle-nose pliers. Store the removed ICs in anti-ESD foam, and handle the devices follow-



COMPONENT SIDE of the 256-kilobyte board.



SOLDER SIDE of the 256-kilobyte board.

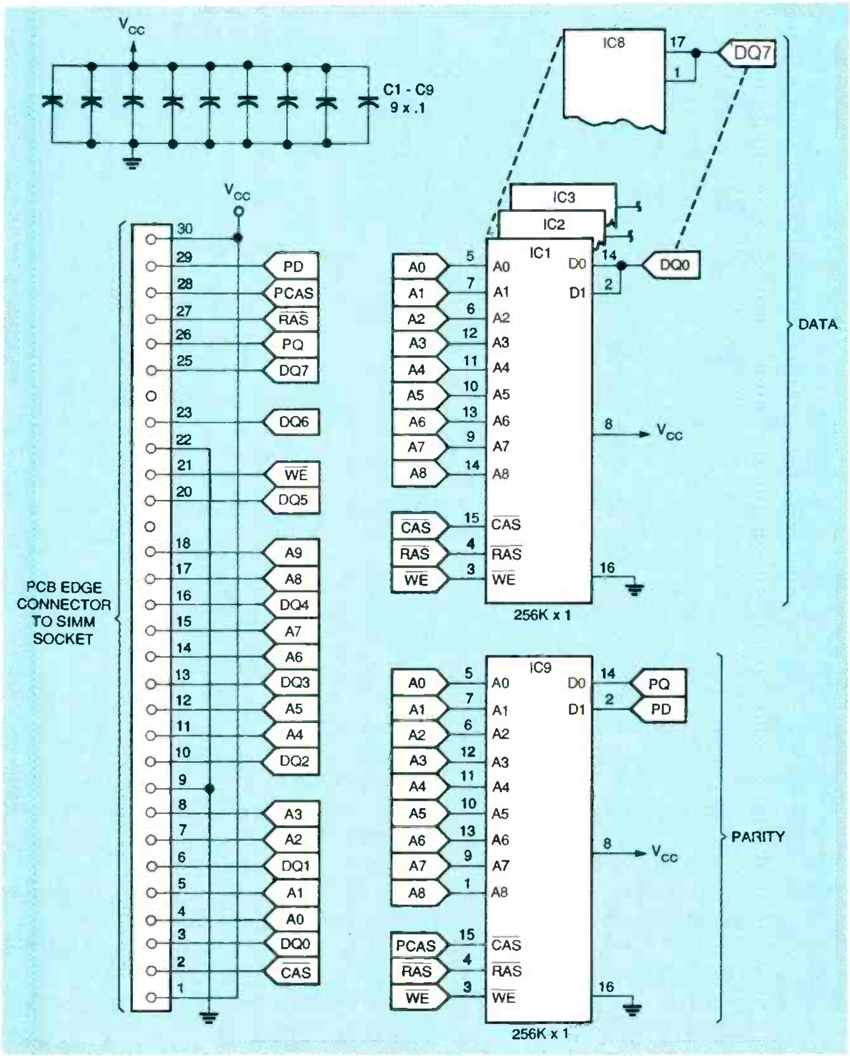


FIG. 4—SCHEMATIC of the 256-kilobyte, nine-IC configuration.

ing proper ESD protection techniques.

Many memory components can be used with this project. Table 1 identifies many of the most common devices. If you're unsure about the identification or classification of a device, refer to a data book or contact the kit vendor listed in the Parts List.

Memory access time is an important consideration. As computer system clock speeds increase, DRAM access times must follow. Most of the newer systems require memory with access times of 70 to 80 nanoseconds; some even require 60-nanosecond devices. If your computer's manual specifies the speed of the memory, you can safely use faster memory. But be wary of mixing different DRAMs with different speed ratings. The system might also have configuration jumpers that indicate memory access speed. Again, check your owner's manual.

Building the SIMM

The use of a PC board is mandatory for this project. Foil patterns are given here, but you can also purchase finished boards. To minimize potential clearance problems, remember that the layout of the components on each of the three boards is close. Use extra care during assembly, particularly if you make your own PC boards that do not have the solder mask that is applied to the commercial boards. Figure 5 includes three parts-placement diagrams, one for each of the three different board layouts.

Begin by tack-soldering the pins at the opposite corners of each IC. Before you complete the soldering, be sure that the component is seated flush against the board. Otherwise, adjacent boards might interfere. With tightly spaced motherboards, it might be necessary to trim the pins of the memory ICs after soldering them. If lead trimming is necessary, avoid cutting into the solder connections. That could fracture the solder and make the joint unreliable. After the board is fully as-

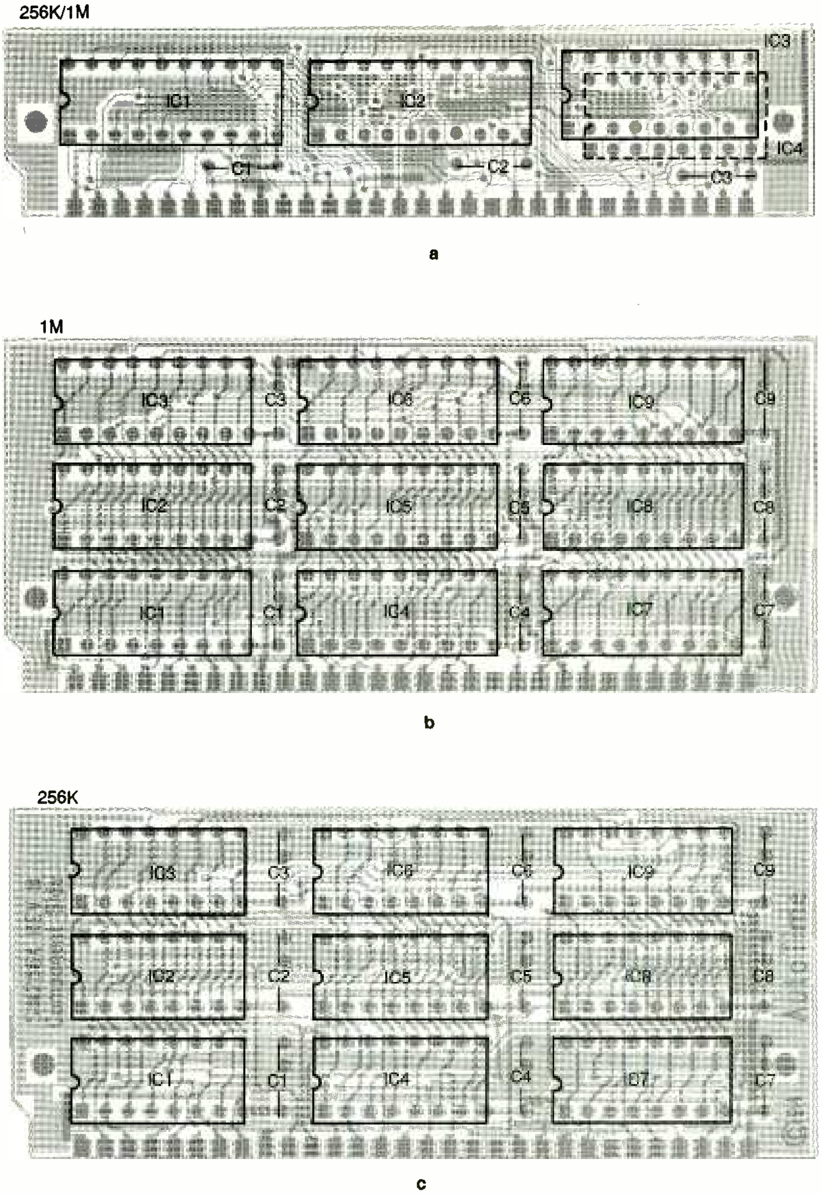


FIG. 5—PARTS LAYOUTS for the three-IC 256-kilobyte/1-megabyte board (*a*), the 1-megabyte board (*b*), and the 256K board (*c*).

sembled, inspect your work carefully for solder bridges and cold solder joints. Also, check with an ohmmeter to be sure

Installation and test

If you plan to install your SIMMs in an IBM or compatible PC, install the 30-pin SIMMs in multiples of two or four. Both 386SX and 486SX computers require pairs of boards for memory expansion because their system data buses are 16 bits wide. All 386DX and 486DX systems require four boards for their 32-bit data paths. Some motherboards might require CMOS configuration changes so that the hardware is aware of the new memory. Most newer PCs automatically detect new memory on power-up and then instruct you to run the setup program to "officially" configure the CMOS memory setup.

Some computers offer the option of complete or partial memory checks. After adding any new memory board, follow the complete checking scheme for several weeks.

Once your system is up and running, bring up your spreadsheet program and calculate your savings. Then, you can pat yourself on the back for recycling old memory. Ω

CO DETECTOR

continued from page 38

changes into account. The microcontroller also runs a low-battery routine that will indicate when the battery must be replaced.

Another reason for the microcontroller in this CO detector is that the optical reflector needs approximately 20 milliamperes of current to operate, which would preclude battery power. To solve this problem, the circuit includes an LT1121CZ-5 five-volt regulator (IC3) that features a shutdown pin. The microcontroller turns the voltage regulator on only long enough for the reflectivity of the CO reagent to be measured. That greatly extends the battery life allowing it to last approximately four months.

Another voltage regulator (IC4) supplies a constant 5 volts (V_{DD}) to the microcontroller. An LM258 op-amp connected as a voltage follower buffers the microcontroller's A/D channels. An MPSA14 Darlington transistor (Q1) turns buzzer BZ1 on and off. Resistor R5, diode D1, and capacitor C1 form a power-up reset circuit for the microcontroller.

PARTS LIST

All resistors are ¼-watt, 5%.
R1, R10, R11—510,000 ohms
R2—150 ohms
R3—680 ohms R4—2200 ohms
R5, R12—20,000 ohms
R6—1000 ohms
R7–R9—10,000 ohms
Capacitors
C1—0.1µF, polyester film
C2—100 pF, polyester film
C3—0.33µF, polyester film
C4—0.33µF, polyester film
Semiconductors
IC1—LM358 op-amp
IC3—LT1121CN8-5 5-volt regulator with shutdown feature
IC2—PIC16C71 microcontroller
IC4—LT1121CZ-5 5-volt regulator
MOD1—Omron EE-SY148 optical sensor
Q1—2N3906 PNP transistor
Q2—MPSA14 NPN transistor
D1—1N914 diode
BZ1—6- to 12-volt piezoelectric buzzer
Miscellaneous: 2½- × 1- × 1½-inch enclosure (Serpac No. 211), four ¾-inch long No. 4-40 aluminum standoffs, 5-inch long ⅛-inch brass channel, 3-inch long ¼-inch square aluminum, four rubber feet, PC board, solder.
Note: The following items are available from Cintron, Inc., P.O. Box 15, Roseville, MI 48066-0015:
- **Preprogrammed PIC 16C71 microcontroller—$24.95**
- **Software on 5.25 or 3.5 inch disk—$12.95**
- **PC board—$12.95**
- **A kit consisting of preprogrammed PIC 16C71, software, PC board, optical reflector, and enclosure—$49.95**

Check or money order accepted. Please add $3.00 to each order for shipping and handling. (Software and programmed microcontroller provides for single use license.)

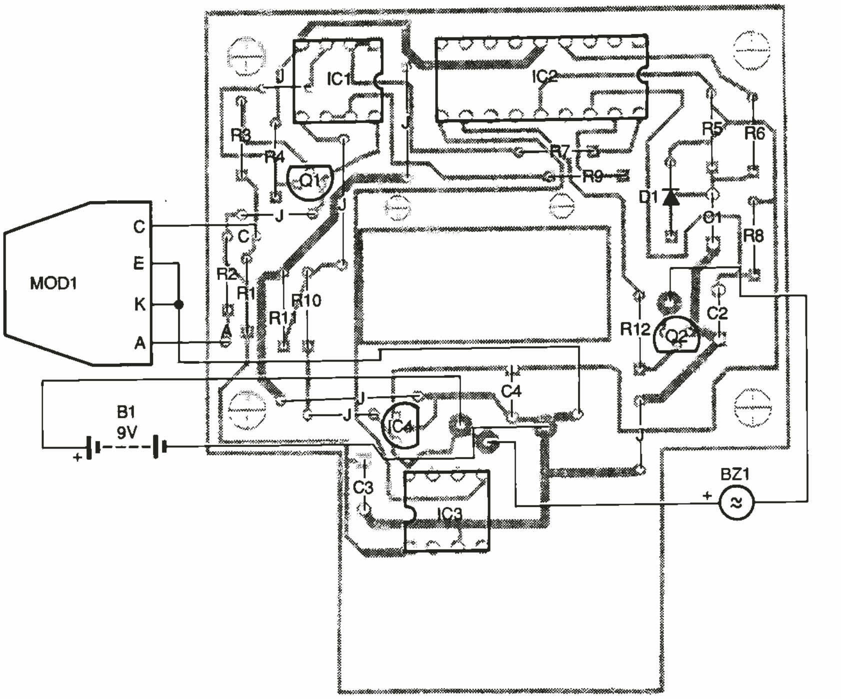
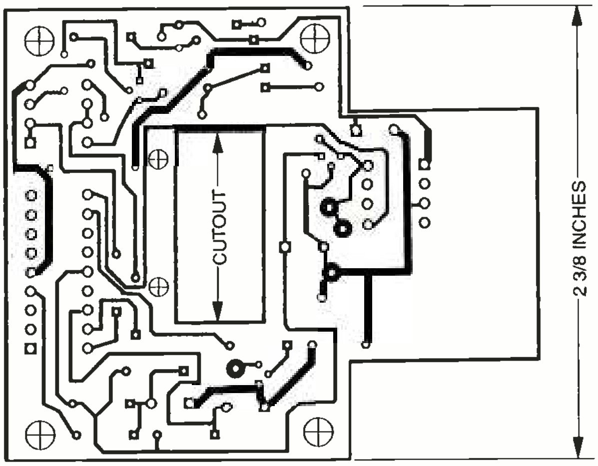


FIG. 4—PARTS-PLACEMENT DIAGRAM. The optical sensor (MOD1) and the 9-volt battery are mounted off-board.



CO DETECTOR FOIL PATTERN.

Construction

A Dremel power tool will be handy for drilling and grinding when building the CO detector. The instructions provided here assume that you will use the enclosure specified in the Parts List. If you use a different enclosure, the construction details will vary. Just follow the same critical specifications for the mounting height and position of the optical detector and the dimensions of the card guide.

The first step is to assemble the printed circuit board and solder the components as

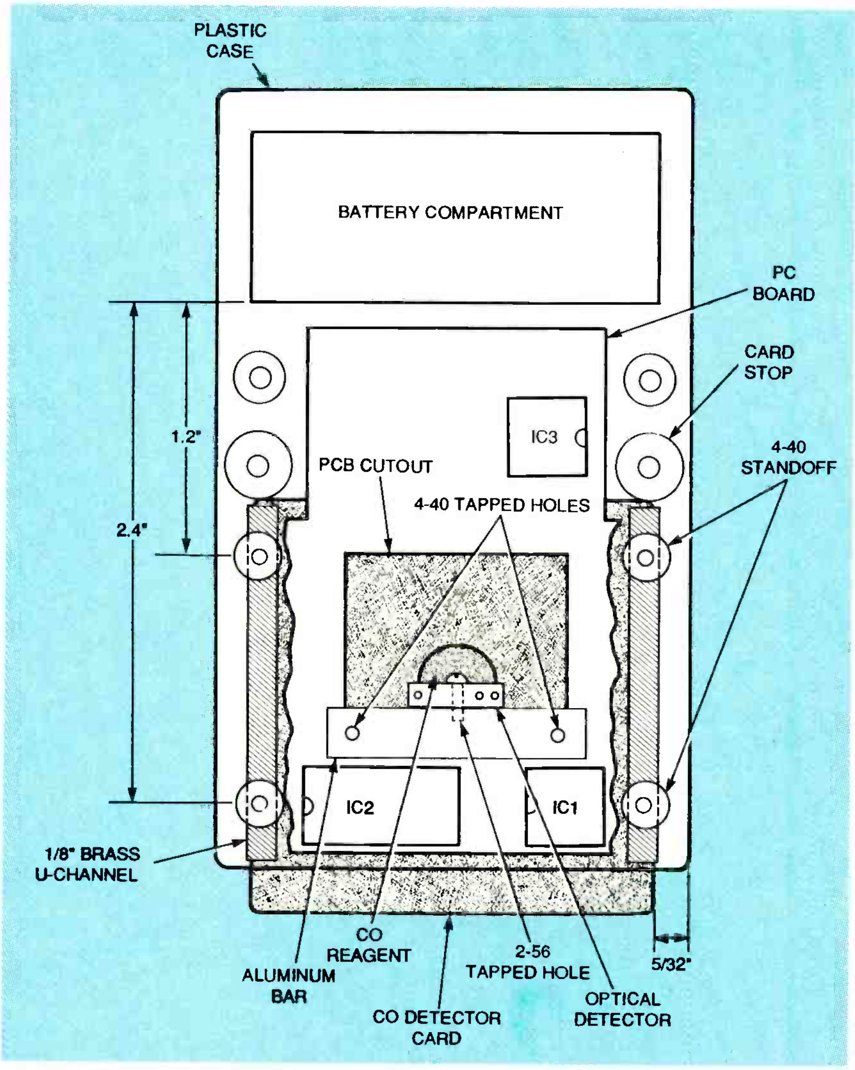


FIG. 5—AN ALUMINUM BAR holds the optical sensor in place. Brass U-channels are glued into slots cut in four metal standoff. The U-channels form a card guide.

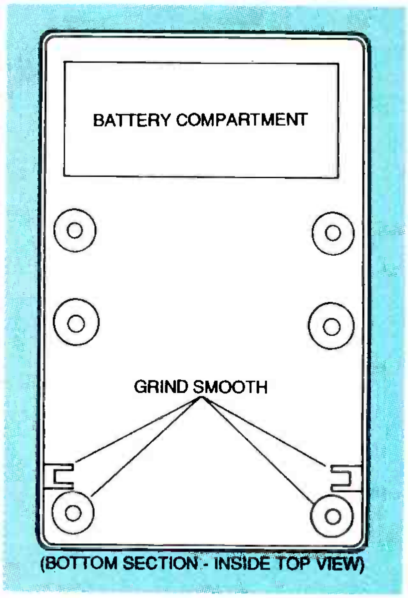


FIG. 7—PLASTIC STANDOFFS molded to the bottom half of the case must be removed.

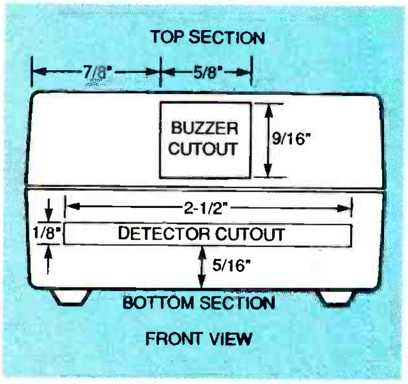


FIG. 8—CUT OR FILE a ⅛-inch wide inch slot, 2½ inches long, 5/16 of an inch from the bottom of the case.

shown in Fig. 4. Next place the ¼-inch square by 1.1-inch long aluminum bar over the locator holes on the PC board, as shown in Fig. 5. Mark the locations for the two holes on the aluminum bar and drill and tap them for No. 4-40 screws; screws will pass through these holes to hold the aluminum bar on the PC board. Next, rotate the aluminum bar 90° and measure and mark a point that is centered about the length and width of the bar. Drill and tap the marked point for a No. 2-56 screw that will hold the optical sensor in place and allow for height adjustment above the reagent surface.

Mount the optical sensor on the aluminum bar so that the sensor end is facing down through cutout in the PC board

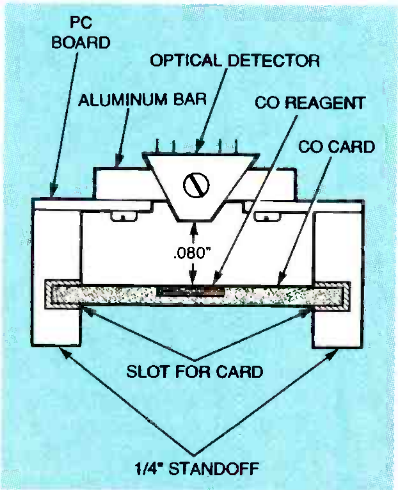


FIG. 6—THE END OF THE OPTICAL SENSOR should be facing down through cutout in the PC board. Remove the aluminum bar and optical sensor from the board and put it aside. The sensor must be 0.08 inch above the reagent surface.

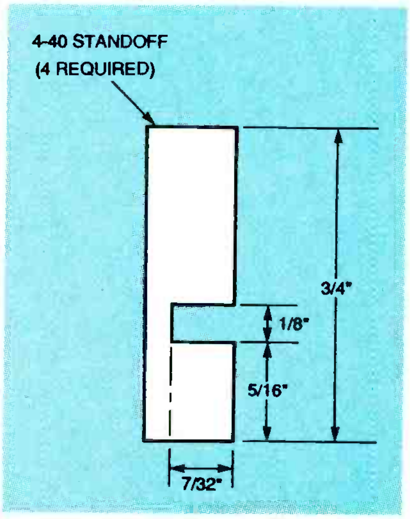


FIG. 9—A ⅛-INCH WIDE SLOT, 7/32-inch deep, must be cut into each of the four ¾-inch long aluminum standoffs, 5/16 of an inch from the bottom end.

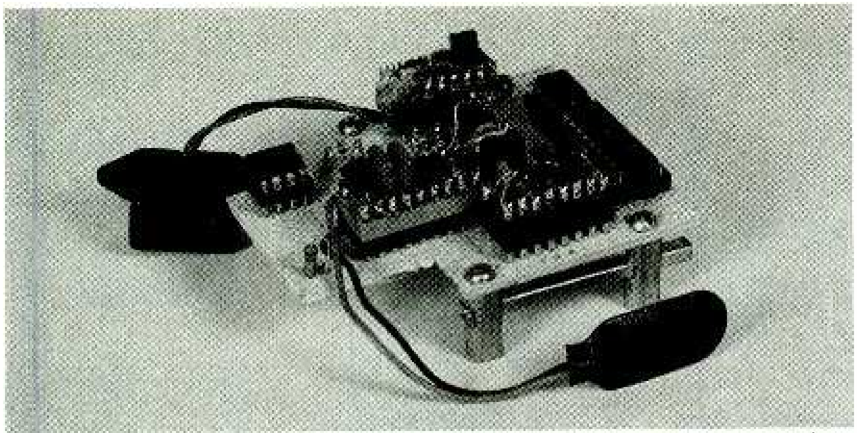


FIG. 10—PROTOTYPE CARD GUIDE/PC BOARD ASSEMBLY. This was assembled on perforated construction board so the component layout does not match the PC-board. The card guide would be the same design for either construction method.

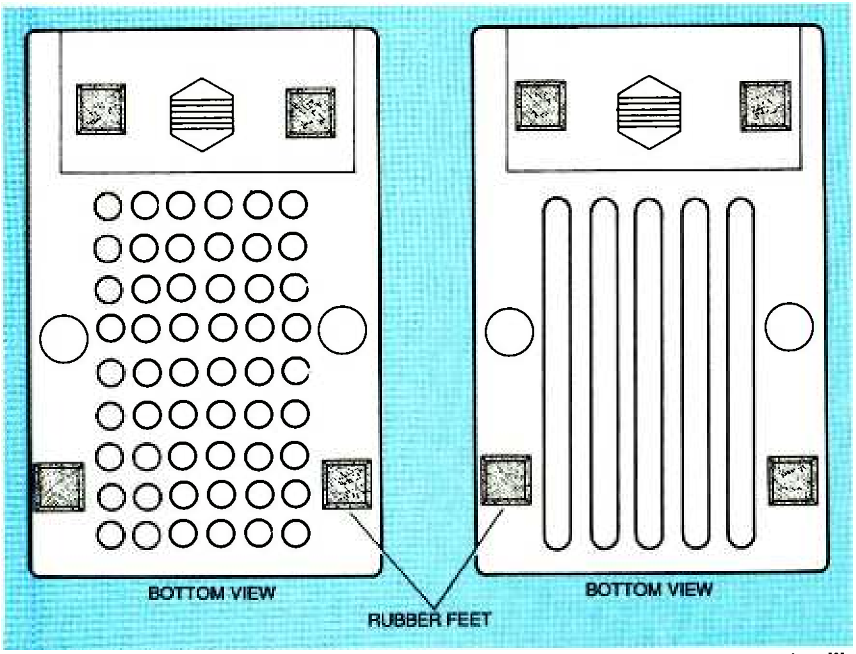


FIG. 11—CUT OR DRILL SLOTS OR HOLES in the bottom half of the case so air will reach the sensor. Also place four ¼-inch high rubber feet in the locations shown.

(see Fig. 6). Remove the aluminum bar and optical sensor from the board and put it aside. Grind down the plastic standoffs inside the bottom half of the case as shown in Fig. 7. Place the PC board inside the box, mark the four mounting locations on the bottom of the box, and drill a No. 4-40 hole at each location. Measure 5⁄16 of an inch from the bottom of box and cut or file a ⅛-inch-wide inch slot 2½ inches long (see Fig. 8). The slot is where the CO detector card will be inserted.

Make the card guide by cutting a ⅛-inch-wide slot 7⁄32-inch deep into each of the four ¾-inch-long aluminum standoffs, 5⁄16 of an inch from the bottom end (see Fig. 9). Mount the four standoffs with the slots facing toward the center of the case with four 4-40 screws through the bottom of the case. Cut the ⅛-inch brass U-channel into two pieces, each 1.7 inches long. Epoxy one of U-channels into the standoff slots on one side (Fig. 5), and do the same for the other U-channel on the other side (the grooves in the channels should face each other). After the card guide is finished, mount the PC board to top of the standoffs with four 4⁄40 screws. Make sure the CO detector card can be inserted in and removed from the card guide; squeeze the middle of the brass channels slightly with pliers to make a snug fit.

Now remove the four screws from the bottom of the case and lift out the PC board with the card guide attached. Mount the aluminum bar and optical sensor assembly. Insert the CO card so that a feeler gauge can be inserted between the card and the optical detector. Set the gap between the sensor and the card to 0.080 inch, as shown in Fig. 6. The detector will not operate properly if the gap is incorrect.

After the gap is set, remove the sensor card. Figure 10 shows the completed prototype card guide/PC board assembly. The prototype was assembled on perforated construction board, so the component layout does not match the PC-board version, but the card guide would be the same for either. Solder wires from the optical sensor to the PC board, as shown in Fig. 4. (The sensor pins are labeled C, E, K, and A—be sure to connect the sensor pins to the board correctly.) Cut or drill slots or holes in the bottom half of the case to permit air to reach the sensor, as shown in Fig. 11, and place four ¼-inch high rubber feet in the locations shown. Now put the PC board/card guide assembly back into the case.

Software

You need a programmed PIC microcontroller to run the CO detector. The object code and executable file is posted on the Gernsback BBS (516-293-2283, v.32, v.42bis) as a file called CO-DECT.ZIP for those who have the necessary equipment to program their own PIC. However, preprogrammed PICs are available from the source given in the Parts List. A simplified flow chart is shown in Fig. 12.

Calibration and use

Before using the CO detector, it is important to keep in mind that it will only indicate the presence of carbon monoxide gas at the detector. The detector should always be located where CO will most likely show up first.

Additionally, the detector operates by "waking up" every two minutes and then checking the CO card for any change in reflectivity. So, any change in CO concentration will have a two-minute lag.

The CO detector must be fitted with a new CO detector card. The cards are sold at most hardware stores. Write the date on the card when it is installed because the card must be replaced every three months. After dating the detector card, insert it into the slot with the yellow reagent side facing up until it hits the card stop.

Connect a fresh nine-volt battery to the detector. The beeper will sound twice when the battery is connected to indicate that the detector is working properly. If you remove the CO card, the buzzer will sound after a maximum two-minute lag. The sound will continue for 30 seconds and then repeat every two minutes or until a CO card is reinserted.

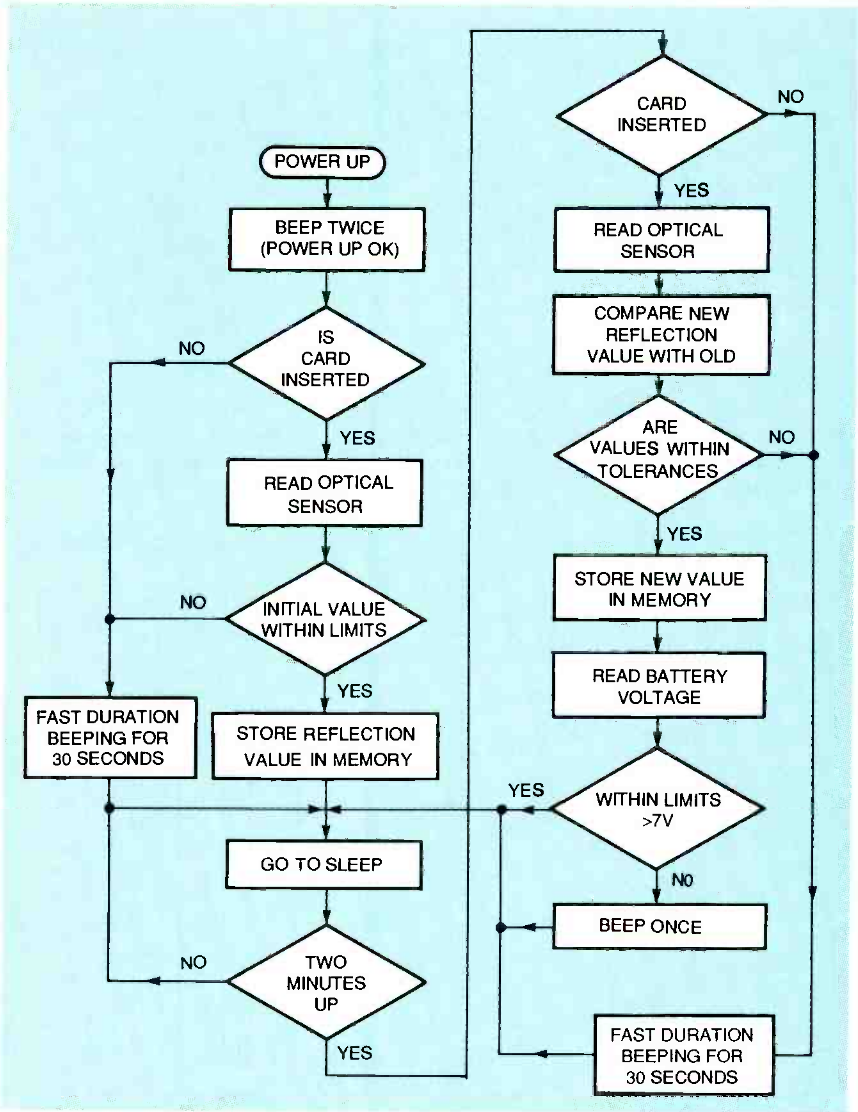


FIG. 12—SIMPLIFIED FLOW CHART for the PIC microcontroller software.

Slide the CO detector card back into the slot; the buzzer should stop sounding after a maximum of two cycles (each cycle is two minutes). The CO detector is now calibrated and ready to detect CO.

If, after initial power up, the buzzer should sound a short-duration beeping, there are four possible reasons for the alarm: One is that the carbon monoxide concentration is too high. This is a critical situation, and you should immediately look for the CO source. Two, the detector card is not inserted in the card slot properly. Three, the card has discolored. Discoloration can be caused by exposure to ammonia from cat litter boxes, ammonia, bleach, or sewer gas. If the detector card is exposed to any of those gases, replace it. Four, the detector is in a high ambient light condition and the calibration routine has caused an error. If this occurs, repeat the power up routine.

If the detector's buzzer sounds once every two minutes, it is an indication of a low battery (less than seven volts). To test the carbon monoxide detector, just remove the CO card and the buzzer should sound within two minutes.

Warning: This detector has been used by the author for about a year and has worked well. It is important to note however, that the circuit has not been tested by any scientific laboratory for operation under all possible conditions. Ω

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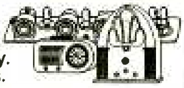

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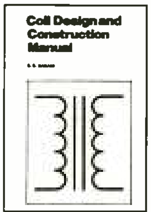

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SCHEMATIC SOFTWARE

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and suffixes, as is the case with many TTL ICs. For example, 74LS161 and 74ALS161 are graphically the same. So rather than listing every permutation of the device, it saves time and space to create a list of prefixes which can be attached to any devices in a particular library.

Devices are placed on the drawing from an on-screen window that serves as both a bill of materials list and library menu for parts used in the current drawing. Device names are copied to this window from the various libraries, and then highlighted for placement on the schematic. The optional auto annotation feature can assign reference values to the devices as they are placed. Commonly used symbols, such as input/output terminals and ground, are not a part of the bill of materials, but are instead represented as icons along with the editing commands in the tool kit window (see Fig. 8). Symbols can be rotated in 90° increments and/or mirrored before and after placement. Repeated symbol replacement is supported, as is global find and replace—you can replace all 4001 gates with 4011 gates, for example. Moving device nomenclature is a simple drag and drop procedure.

To draw a wire, all you do is click once on its origin and once on its destination. Supersketch has an auto wire router that draws the line for you, automatically selecting the best route and whatever corners are needed to make it orthogonal. When moving devices, the autorouter automatically cleans up the rubberband lines into short, orthogonal lines.

Supersketch's output features are super slick, and include support for all the popular printers and plotters. Sizing isn't as flexible as in some programs, but the 4-to-1 scaling factor lets you print a 32-inch drawing on an 8-1/2 × 11-inch page. A unique feature of Supersketch is its ability to produce output files suitable for graphics import into many popular word processor and desktop publishing programs.

When it comes to drawing schematics, Supersketch is unquestionably one of the best. The program is easy to use—once you've scaled the learning mountain—and it abounds with advanced drawing and editing features that really help speed up your work. The best thing about the CADPAC II package, though, is its superb PC board layout program.

Next month, we'll continue with a look at schematic-capture packages including SuperCAD, WinScheme, CircuitMaker, Electronics Workbench, EZ-Route, and Easy-PC Pro. Ω

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AUDIO UPDATE

continued from page 136

new three-conductor commercial connector was developed to be compatible with the commercial/consumer 1/4 phone jack so that both the mono and stereo versions were compatible. Over the years, audio equipment has became smaller and more portable, as a result of transistorized circuitry, so the 1/8-inch or 3.5 mm connector was developed. Attempts to make the even smaller 2.5-mm version a global standard have not, so far, been successful.

DIN connectors

In your audio work you might encounter a DIN audio connector. The term DIN is the abbreviation for *Deutsch Industrie Normenausschuss*, originally a German standard, but now widely accepted throughout Europe. DIN cables usually have three or five wires.

The DIN connector has a keyway making correct connection certain while eliminating wiring errors. The DIN arrangement makes it impossible to transpose input and output connections, so polarity follows automatically. Nevertheless, with separate cables, be sure to distinguish between the left and right channels when signal polarity is important.

One drawback to the DIN cable is that manufacturers assign different functions to the cable wires. This means that just because a DIN plug will fit a DIN jack, you can't be sure of the correct connection. Some components such as tape decks are supplied with one port for a DIN connector and other ports for RCA plugs.

Three- and five-pin DIN connectors are most common, but some have as many as eight pins. Because they all look alike, a three-pin DIN connector looks like an eight-pin DIN connector, so be sure to count the pins. EN

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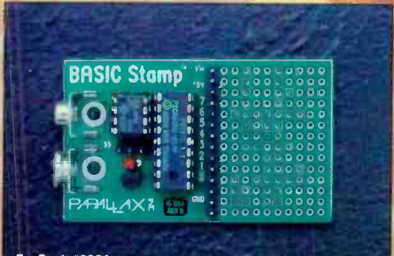

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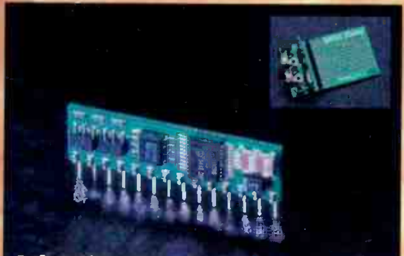

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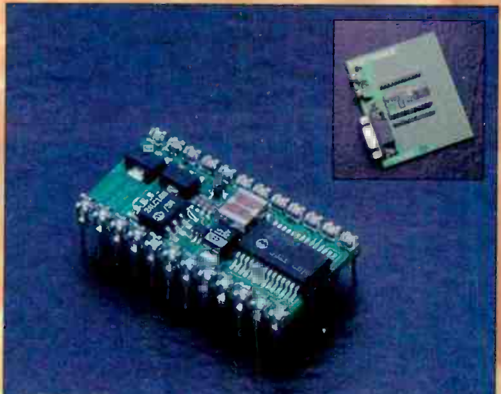

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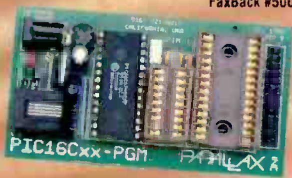

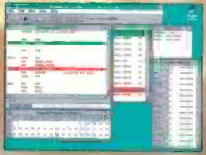

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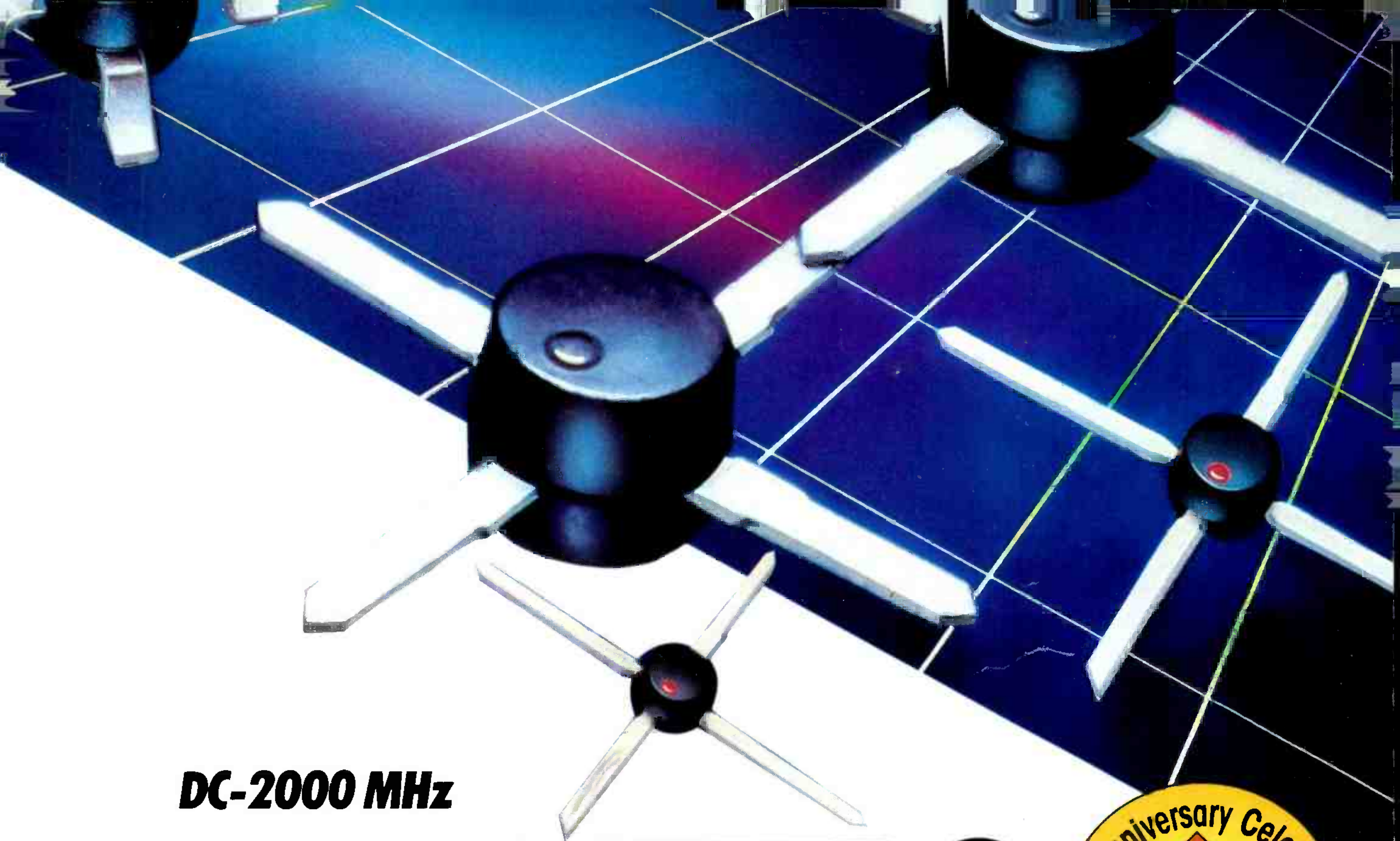

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AMPLIFIERS

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In plastic and ceramic packages, for low-cost solutions to dozens of application requirements, select Mini-Circuits surface mount or flatpack wide-band monolithic amplifiers. For example, cascade three MAR-2 monolithic amplifiers and end up with a 25dB gain, 0.3 to 2000MHz amplifier for less than $4.50. Design values and circuit board layout available on request.

It's just as easy to create an amplifier that meets other specific needs, whether it be low noise, high gain, or medium power. Select from our wide assortment of models (see chart), sketch a simple interconnect layout, and the design is done. Each model is characterized with S parameter data included in our 740 page RF/IF Designer's Handbook or available from our applications department.

All Mini-Circuits amplifiers feature tight unit-to-unit repeatability, high reliability, a one year guarantee, tape and reel packaging for SMD, off-the-shelf availability, with prices starting at only 99¢.

Mini-Circuits monolithic amplifiers...for innovative do-it-yourself problem solvers.

Mini-Circuits...we're redefining what VALUE is all about!

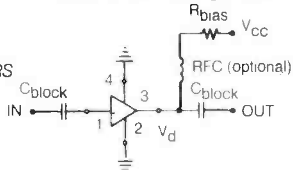
	MODEL	Freq. (MHz) DC TO	GAIN (Typ. dB) At 100MHz	MAX. Power (@ 1dB Compr.) dBm	NF dB (Typ.)	Price $ea. (Qty. 50)
MAR	MAR-1	1000	18.5	1.5	5.5	.99
	MAR-2	2000	12.5	4.5	6.5	1.35
	MAR-3	2000	12.5	10.0	6.0	1.45
	MAR-4	1000	8.3	12.5	6.5	1.55
MAR SM	MAR-6	2000	20.0	2.0	3.0	1.29
	MAR-7	2000	13.5	5.5	5.0	1.75
	MAR-8	1000	32.5	12.5	3.3	1.70
RAM	RAM-1	1000	19.0	1.5	5.5	*6.40
	RAM-2	2000	12.5	4.5	6.5	*6.40
	RAM-3	2000	12.5	10.0	6.0	*6.40
	RAM-4	1000	8.5	12.5	6.5	*6.40
	RAM-6	2000	20.0	2.0	2.8	*6.40
	RAM-7	2000	13.5	5.5	4.5	*6.40
	RAM-8	1000	32.5	12.5	3.0	*6.40
MAV	MAV-1	1000	18.5	1.5	5.5	1.10
	MAV-2	1500	12.5	4.5	6.5	1.40
	MAV-3	1500	12.5	10.0	6.0	1.50
	MAV-4	1000	8.3	11.5	7.0	1.60
MAV SM	MAV-5SM	50-1500	8.0	18.0	6.5	2.07
	MAV-11	10-1000	12.7	17.5	3.6	2.10
VAM	VAM-3	2000	11.5	9.0	6.0	1.45
	VAM-6	2000	19.5	2.0	3.0	1.29
	VAM-7	2000	13.0	5.5	5.0	1.75

*Qty. 10

MAR & MAV MODELS: Plastic flat pack...for surface mount, add SM suffix to model number and 5¢ to price. Example: MAR-2SM...$1.40.
MAV-5SM available plastic surface mount only.
RAM MODELS: Ceramic surface mount.
VAM MODELS: Plastic surface mount.

DESIGNER'S KIT, KH-1 available only $59.95 includes:
40 AMPLIFIERS* 10 MAR-1, 10 MAR-3, 10 MAR-4, 10 MAR-8
150 CAPACITORS* 50 100pf, 50 1,000pf, 50 10,000pf
740 page RF/IF DESIGNER'S HANDBOOK
MIXERS • POWER SPLITTER/COMBINERS • AMPLIFIERS
ELECTRONIC ATTENUATORS • I&Q/QPSK MODULATORS
ATTENUATORS/TERMINATIONS • DIRECTIONAL COUPLERS
RF TRANSFORMERS • DIGITAL ATTENUATORS
LIMITERS • PHASE DETECTORS • FILTERS
SWITCHES/DRIVERS • FREQUENCY DOUBLERS
** Values or models may be substituted without notice, depending on supplies.*

Typical Circuit Arrangement



finding new ways...
setting higher standards

Mini-Circuits™

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