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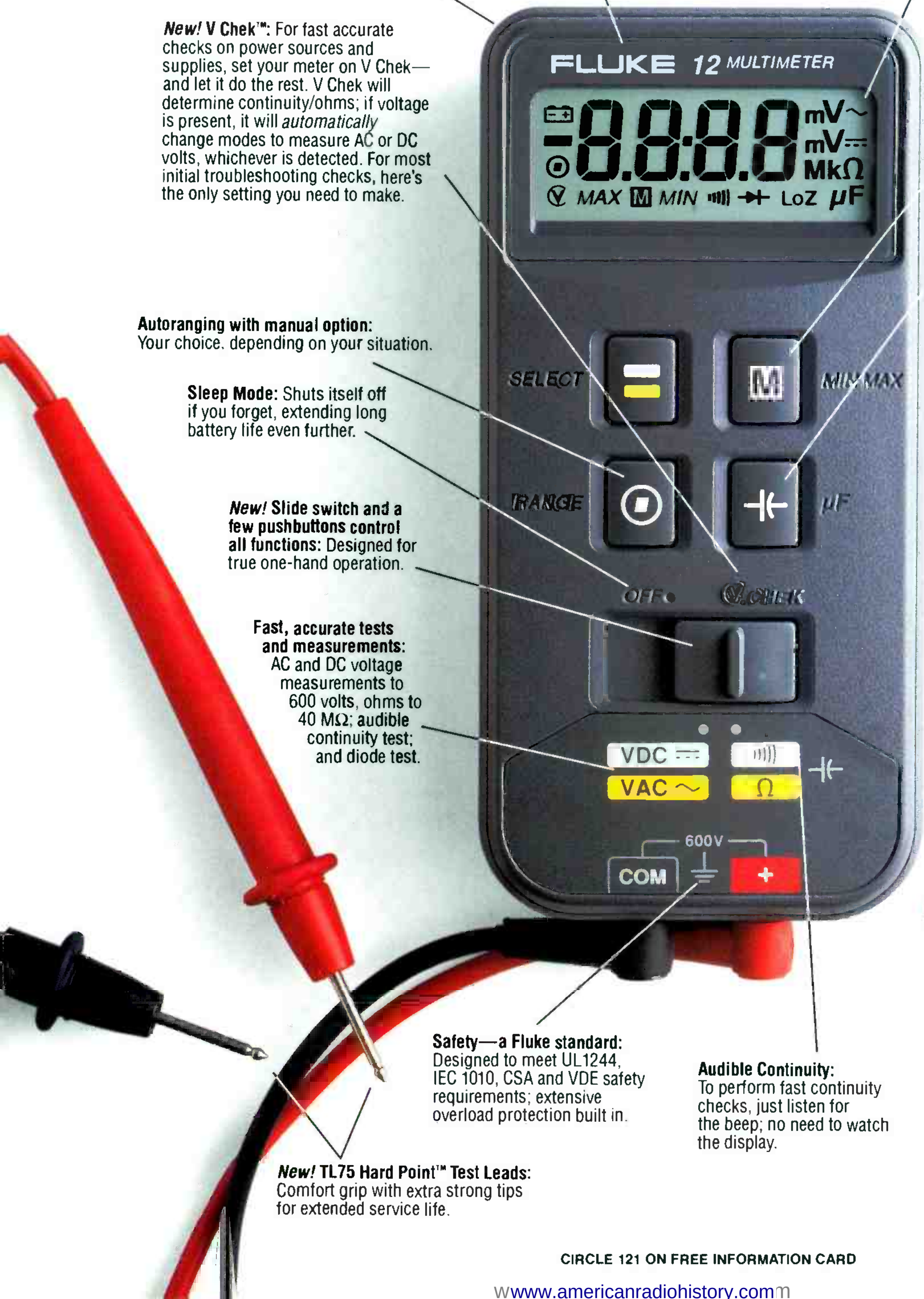

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CIRCLE 121 ON FREE INFORMATION CARD

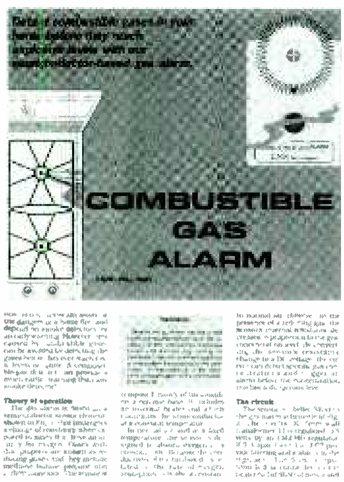
July 1993

Electronics NOW®

Vol. 64 No. 7

ON THE COVER

Today's personal computers are powerful data-processing machines, but they are limted in that they depend on *you* to input that data. They lack the ability to sense and act upon real-world events. But now it's possible to link your PC to the outside world. The Experimenter bridges the gap between your computer and its environment by allowing information to be input from various types of sensors. The computer peripheral provides eight inputs capable of voltage measurement, four timer/counter inputs, and 34 digital I/O terminals. With the Experimenter, you can build such projects as a computerized weather station,a PC-based home-security system, or a computer-controlled robot. It works with virtually all computers. Turn to page 31 for all the details.



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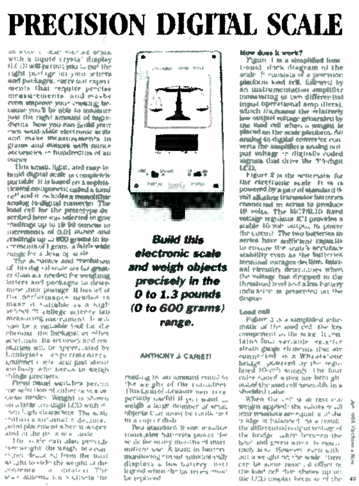

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CIRCLE 178 ON FREE INFORMATION CARD

A review of the latest happenings in electronics.

The First Amendment versus BBS

Does the right to free speech extend to statements posted on a computer bulletin board? That's the basic question being probed in a lawsuit brought against Peter DeNigris, a Suffolk County, NY government worker, by Medphone, a medical equipment company based in Paramus, NJ. The company, claims to have lost between $30 million and $40 million due to plummeting stock values as a direct result of a series of statements that DeNigris posted on the Prodigy online service. Prodigy was not named in the suit. Medphone claims that the statements were deliberate falsehoods intended to damage the company. DeNigris counters that his on-line statements were true and that they were protected by the First Amendment.

DeNigris, who lost $9000 on Medphone stock more than a year before he began using Prodigy, posted his first message about Medphone in July, 1992: "Medphone gets great publicity, but the stock will go nowhere. Having been a shareholder, I caution you against the hype the company manages to get out. That was followed by about 25 additional negative messages over the next 90 days. According to Medphone, some of the DeNigris' messages accurately predicted the stock's performance the following day, and the overall effect of the on-line statements caused the stock to drop from $1.75 to 37.5 cents a share.

Computer bulletin boards, which provide real-time, instant communications, fall somewhere between having a conversation between friends and reading a newspaper or magazine. This case will determine whether relatively uncensored BBS postings—which have potential audiences of more than two million people—have the same protection under the First Amendment as do spoken words and printed articles.

Winning inventors

There were 41 winning high-school students in the Eleventh Annual Duracell/NSTA Scholarship Competition. The winning battery-powered inventions were chosen in March at Duracell headquarters in Bethel, CT, from a field of 100 finalist projects.

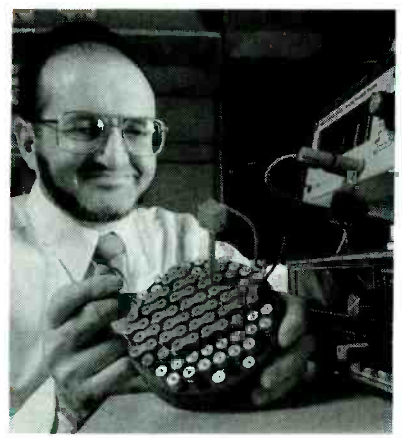
PRIZE-WINNING DEVICES in the eleventh annual Duracell/NSTC Scholarship competition include the first prize Accelerometer (front) and, clockwise, the Portable Launch Base, the Electronic Precision Vise, the Katakana Blackboard, the Stoveguard, and the Car Jack Jinx.

The $10,000 first-place scholarship went to Aaron James Passey, a senior from Bothell, WA, who designed and built an accelerometer, an electronic device that measures and visually displays acceleration and changes in acceleration in real time. Second place $3000 scholarships went to six students with interests in mechanics, electronics, engineering, and physics, whose inventions ranged from a portable launch base with the ability to individually or simultaneously launch multiple model rockets to the "Car-Jack Jinx," a remote-controlled device that lets a car owner turn off the engine to foil a thief. Ten more students received third place $500 scholarships, while 25 others received cash awards of $100 each.

The competition is open to U.S. high-school students, grades nine through twelve. They must build a battery-powered device that is educational, useful, or entertaining.

Thermoelectric generator

Scientists at the GE Research and Development Center (Schenectady, NY) earlier this year demonstrated to officials of Rochester Gas and Electric Corporation (RG&E) the technological viability of a "continuous" gas furnace, a residential heating unit that would continue to operate even during a lengthy power outage. The technology centers on a solid-state thermoelectric generator that can directly convert heat from the combustion of natural gas into 100 to 300 watts of electricity, which is more than enough to operate the blower and other electrical requirements of a standard home-heating system. The breadbox-sized device could be built into new gas furnaces. Unlike gasoline- and kerosene-powered generators used as emergency backups, the thermoelectric system can run unattended, is maintenance free, and does not require the homeowner to store potentially hazardous fuel.



GE PHYSICIST DR. LIONEL LEVINSON tests a thermoelectric generator used in prototype "continuous" gas furnaces.

The RG&E-funded project included the construction of a small, 70-pound heater-generator system with thermoelectric output. The test unit directly converted the heat from the combustion of diesel fuel into 160 watts of electric power. Approx-

continued on page 90

VIDEO NEWS

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

DAVID LACHENBRUCH

• **Cable vs. TV sets.** Cable TV and consumer electronics products such as TV sets and VCR's are becoming less compatible as time goes by, and there's fear that the situation will become far worse with the development of digital transmission. The Cable Act of 1992 orders the FCC to improve the interfaces between cable and the products used in the home to receive them. The first results in the Commission's inquiry are not encouraging.

The two sides could agree on nothing except that the situation needs improving. The consumer electronics industry, through the Electronic Industries Association (EIA), said cable was to blame for virtually all the problems, while the National Cable TV Association (NCTA) put the onus on the manufacturers. Particularly targeted for censure by the EIA was cable systems' increasing tendency to scramble all channels, thereby rendering useless such TV features as picture-in-picture and wireless remote control, as well as ability to record one channel while viewing another.

NCTA, in turn, blasted TV manufacturers for poor tuners which it said make cable boxes necessary, and for telling consumers their sets are "cable ready," thereby needlessly raising their expectations. NCTA urged a return to a standard back-of-set baseband interface such as Multi-Port, developed by the two industries years ago. EIA retorted that its members spent millions of dollars installing Multi-Port connectors on the rear of their sets but the cable TV industry refused to go along. The end of the discussion is not yet in sight.

• **Channel mapping.** Complicating the problem of TV-cable interface is a new practice by cable systems, becoming increasingly widespread, known as "channel mapping." This is a system whereby channel numbers assigned by cable systems to the various programs they carry bear no relationship to the frequency the channel is supposed to occupy. A 10-year-old preliminary standard developed by the cable and TV industries assigns a specific frequency to each cable channel, from 1 through 99 (currently this standard is in the process of being amended to include channels above 99).

In channel mapping, the cable systems apply to each channel number a frequency that only their own converter boxes understand. For example, CNN might be listed as Channel 10 (whose standard frequency is 192–198 MHz), but it actually would be sent out on 240–246 MHz, which is Channel 27 under the standard. However, the set-top boxes provided by the cable system are "mapped" to tune to 240–246 MHz when Channel 10 is dialed. This naturally creates havoc with those cable subscribers trying to tune these channels on a "cable ready" TV without a box. In Manhattan, for example, more that 10 channels have been mapped to come in on changed channel numbers. Since pay-per-view programming is very profitable for cable systems, and a cable box is required to receive pay-per-view programs, a subscriber might think that channel mapping is simply designed to harass him into using a cable box so that he can be sold pay-per-view programs.

Not so, say the cable operators. The re-mapping, they say is virtually required under the cable act, given the inadequate shielding in TV sets. The Act requires VHF broadcast stations to be carried on their broadcast channels, but that would result in direct off-air pickup interference in many sets if they were carried on their actual frequencies. Another advantage of channel mapping, the cable systems say, is that it permits uniform newspaper listing of programs by channel in any viewing area. The third advantage is that it makes pay programs easy to tune. For example, the viewer can select a variety of movies and starting times on a single channel, but in reality, that channel covers a number of frequencies, which are changed with each selection. So far as the viewer is concerned, 11 pay movies are on Channel 35, for example, when in reality they may be on 10 different frequencies.

• **Measuring picture tubes.** The introduction of widescreen TV sets with 16:9 aspect ratio CRT screens is complicating the issue of measuring screen sizes. The subject was already complicated enough before the arrival of the new sets.

For example, do you know that if you ship a 27-inch TV set to Canada, it gains two inches when it crosses the border, and when you unpack it, lo and behold, it's a 29-incher? Similarly, a set shipped from Japan will shrink when it reaches American waters! That's because the U.S. TV industry measures screen size in a way that differs from the methods of all other countries.

The U.S. TV measurement method dates back from before commercial TV. The first significant use of cathode-ray tubes was in oscilloscopes. The size of the screen, which was circular, was measured as a diameter. The first monochrome TV sets also had round faces, and they were measured in diameter. With the introduction of the rectangular tube, the same method of measuring the screen was kept, but now it was from corner to corner.

In the 1950's, the Federal Trade Commission (FTC) ruled that this "overall" diagonal measurement was deceptive, because it included the thickness of the glass walls of the tube. It mandated that measure-

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Q & A

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

SOFTWARE RESET

I am using an IBM XT as a process controller, and I find that I often need to reset the entire system—both manually and automatically—under the control of the software I'm using. The motherboard I'm using is from a real IBM XT and it has no provision for resetting it. Is there some circuit I could build that will let me do this?—B. Schif, Jaibee, FL

A lot of people think that there's nothing you can do with an outdated but still functional computer. This includes XT's, Apple II's, and even the prehistoric Timex Sinclair. I'm using one of those old timers as the "brains" of a home controller, so I'm glad to find that someone else out there has had more or less the same idea.

Any computer that gives you access to its bus through slots is a good candidate for long life—there's more to a computer than just word processing, running games, and using other software.

Adding a reset capability to an XT is pretty simple—as long as it uses an 8284 IC as its main clock generator. Although I don't have a schematic for the IBM XT, I know there's an 8284 on the motherboard, so you won't have any trouble adding a reset button to it. Once you know how to add manual reset, triggering it with software shouldn't be difficult either.

Although I can't be certain about the details, the clock circuit built around the 8284 is probably pretty close to the schematic shown in Fig. 1. I haven't put in component values because they're going to vary from motherboard to motherboard. What's important here, however, is that simply grounding pin 11 will cause the 8284 to generate a reset pulse for the 8088. All you need is a normally open, momentary, SPST switch connected between pin 11 and ground and you've finished the

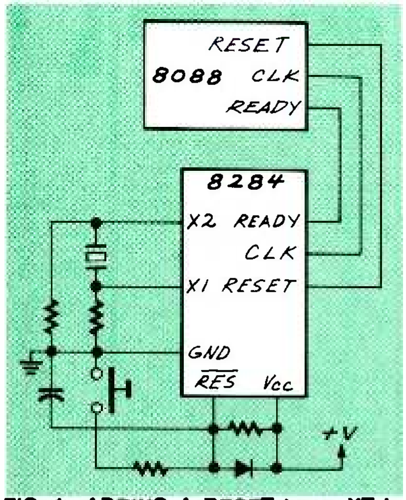

FIG. 1—ADDING A RESET to an XT is simple if it has an 8284 IC as its main clock generator. Grounding pin 11 of the 8284 will cause it to generate a reset pulse.

installation of a manual reset switch.

If the IC's aren't clearly numbered or, as is sometimes true, the IC's are house-numbered, you can find the 8284 by tracing back from pin 21 of the 8088, its reset input. The location of the 8284 should be close to that of the 8088 on the board. Another clue for locating it is that it should be next to the 14-MHz crystal that's used as the basis of the system clock.

You can't connect a manual switch to the reset pin of the 8088 because the power-up sequence of the 8088 is really picky about variables like pulse width and shape. The 8284 takes care of all that for you, and one of its main jobs is to reset the 8088.

Resetting under software control is a bit trickier than doing it manually. You didn't go into the specifics of your setup, so I don't know what kind of I/O you have available. But if you're using the XT as a controller, I imagine you have some hardware that decodes and responds to specific I/O commands. You must reserve one of them for reset.

The manual switch can be located in parallel with a small relay that is activated under the control of your software. Once you have the relay in place, resetting the XT is simply a matter of sending the appropriate word out the port, decoding it, and then using that to energize the relay. That's the easiest way to do it and, if I had your problem, that's the way I'd solve it.

Because the XT will be reset, you don't have to worry about resetting the relay. The system bootup process performed by the BIOS will take care of that function for you.

MIXED FAMILIES

I know this is an elementary question, but I've just started studying logic design and I want to be able to use IC's from different logic families in the same design. My problem is that the CMOS part of the design has to run on nine volts, but the TTL part has to run on five volts. Is there some conventional way to do this kind of thing?—T. Melvin, Darian, CT

From the moment that CMOS logic first appeared on the market, people have been mixing it with TTL logic. Some of the incentive for doing that disappeared when the 74CXXX CMOS equivalents of TTL chips were developed. However, if you have a reason for using the standard members of both logic families in the same design, you must take special measures to accommodate them.

The simplest way to handle your problem is shown in Fig. 2. The schematics there should tell you all you need to know about mixing the two families together—even if each side of the design is working off a different voltage. While there are no special requirements for the TTL IC's, you should use a 4049 hex inverter/buffer on the CMOS side when unequal power-supply voltages are used.

The 4049 has a lot more muscle than other standard CMOS gates,

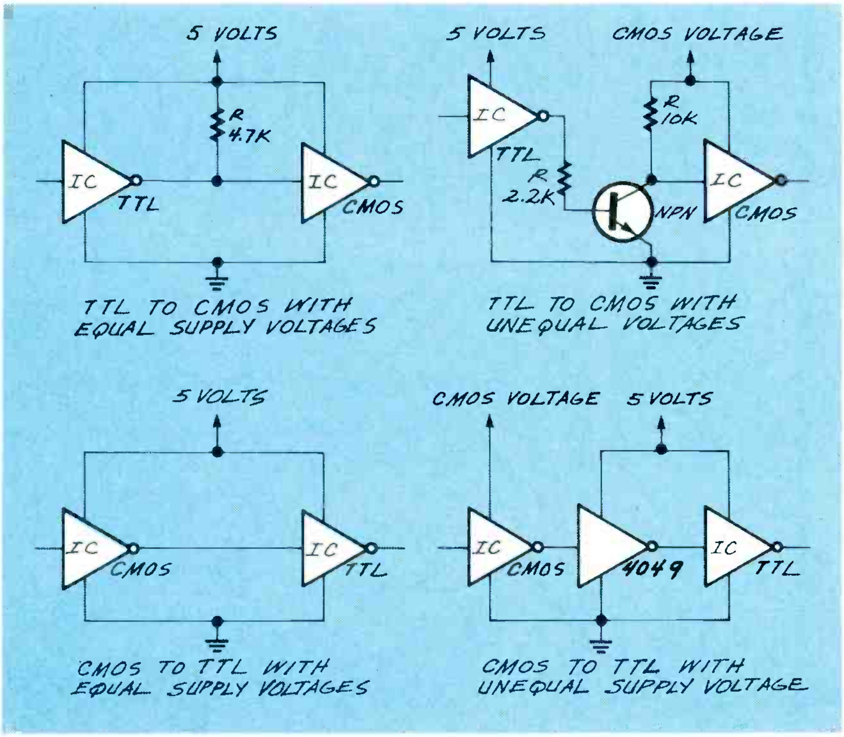

FIG. 2—TO USE CMOS AND TTL family parts in the same logic design, you must take special precautions.

and it works a lot better as a voltage translator or current driver in this kind of application. If the logic inversion done by the 4049 is a problem for you, you can put two of the inverters together or replace it with the 4050, a noninverting version of the 4049.

I'm using the 4049 in the schematic for two reasons. The first is that spare inverters are usually handy to have available on the board. The second reason is that, in these days of dwindling numbers of suppliers who service the hobbyist market, it's often easier to find a 4049 than a 4050.

There are other ways to mix logic families. Some are more elegant and some are simpler, but none of them are easier and, for sure, none is cheaper.

MEMORY BOOST

I want to add more memory to my IBM compatible but, after going through some mail-order catalogs, I'm confused about the type of chips to buy. My motherboard uses SIMM's, and it seems that there are two different types available on the market. For instance, one kind is described as 1K × 8, and the other is described as 1K × 9. I know the extra bit has something to do with checking data but I'm not sure. What's the difference?—H. Bansh, Denver, CO

For reasons known only to the original hardware designers of the IBM PC, an entirely separate market was created for the people who manufactured memory for IBM's family of personal computers. I don't know why they did that, but then again, I don't know why the dinosaurs disappeared from the earth either.

Although the PC uses the same definition for a byte as every other computer ever made (8 bits), it was decided that each byte would have nine bits associated with it. Eight of them would store the data and the ninth would be known as the "parity bit." That extra bit is used as a check on the validity of its associated byte. If you've been using an IBM clone (or, to be kind, a compatible), the chances are that you've had the computer come to a grinding halt with the somewhat mysterious message "Parity Error at XXXX:XXXX." That happens when the parity check fails, and the BIOS decides that everything you've been doing for the last couple of hours should be lost.

The parity check is one of the crudest forms of a validity check you can imagine. All it takes is one error to make the entire computer lock up.

A parity check is a form of addition that's done on the eight bits making up each byte, and the result of the operation—either a one or a zero—is stored in the ninth (parity) bit. If the data bits have an even number of 1's, the parity will be set to 1. If the number of 1's contained in the data bits is odd, parity will be set to zero.

To understand why I call this a really crude check, just consider the odds of having a parity error caused by a real error in the data it's supposedly checking. As a simple example, let's see what kind of insurance we can get from a parity check when we're dealing with a four-bit digit.

1. One possible value has none of the bits set high.
2. Four possible values have only one of the bits set high.
3. Six possible values have only two bits set high.
4. Four possible values have only three of the bits set high.
5. One possible value has all of the bits set high.

Because there are only sixteen possible values when dialing with a 4-bit digit, everything works well if we're transferring a "0" or an "F," but the odds of having a parity check catch an error with the other 14 digits are only 62.5% in the worst case and 75% in the best case!

Although anybody with earlobes can see that a parity check is really no check at all, you're still stuck with the fact that you need memory that has nine bits available for each byte—a ×9 part—in order for your machine to work properly.

The Macintosh doesn't bother with parity checking, and uses only eight bits for each part—a ×8 SIMM. Maybe the folks at Apple know something we don't. Ω

LETTERS

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MPC-2 CORRECTION

A mistake appeared in the schematic for my MPC-2 article (*Electronics Now*, May 1993)—probably as a result of a recent change in the schematic-capture software that I've been using. The schematic is missing a connecting line between the phone-line side of C1 and the relay wiper on one side of C3. The error appears only on the schematic itself; the foil pattern is correct. The corrected schematic appeared in the June issue, as part of the "Phone Line AutoCoupler" project. I apologize for any inconvenience that might have resulted.
MIKE HAGANS

HAMFEST HAPPENING

The Zero-Beaters Amateur Radio Club will hold its 31st annual hamfest on Sunday, July 18 at the Bernie H. Hilleman Park (Washington Fairgrounds) in Washington, MO, from 6 AM to 3 PM. There will be food and refreshments, flea-market bargains, seminars, dealer displays, and non-ham displays. Exams will be conducted by volunteer examiners on a walk-in basis starting at 10 AM; bring your original license and a photocopy. Admission and parking are free. Vendors can a rent space for $4.00. For more information, write to me at P.O. Box 24, Dutzow, MO 63342; call 314-459-6581 or 314-239-0060; or talk-in at 147.240 + repeater.
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GET OFF THE MICROSOFT BANDWAGON!

Jeff Holtzman's *Computer Connections* column has become little more than a Microsoft propaganda machine; it offers scant technical information and nothing else of any value. Even Don Lancaster occasionally interrupts his dogmatic tirades to offer some potentially useful information. Most of us understand that competition is good—not something to be discouraged as Mr. Holtzman does with his fatalistic disregard of anything that doesn't come from Mother Microsoft.

It seems that Mr. Holtzman's Microsoft bias is more than just pragmatic, though, when he bashes CD-I—the OS-9-based interactive multimedia standard from Sony and Philips—in favor of VIS. His reason seems to be that the Tandy system is based on a version of Microsoft Windows that has been retrofitted for embedded systems use.

But, as Mr. Holtzman himself said in his April 1993 column, "people buy cars, not engine, transmission, and chassis." Consumers won't buy a home-entertainment system just because it comes from Microsoft. OS-9 is much better suited to the task, being a time-proven preemptive multitasking embedded real-time operating system. I suspect that Mr. Holtzman really knows very little about CD-I and OS-9, and probably couldn't care less. In light of the one-sidedness in **Electronics Now's** computer section, I think it's fair to request a little space for an alternative viewpoint.

An operating system like Microware's OS-9 would provide a solid foundation for operating systems of the future. OS-9 is composed of any number of discrete modules that link the kernel to the hardware. The interface between these "black boxes" is simple and well-documented, so any programmer can write new device drivers.

OS-9 is easily reconfigured because the modules are not compiled together. It can be stripped down to bare essentials for embedded systems, run on a desktop PC or a laptop, or blown up into a large multi-user system. Ethernet and Internet support are available. OS-9 uses the UNIX programming and I/O model, which, despite the existence of incompatible versions, has been standardized by the IEEE. OS-9 offers the technical advantages of UNIX without the excess!

OS-9 runs on the Macintosh, Amiga, and Atari computers as well as others like the IMS MM/1, computers from Frank Hogg Labs, and the PT-68K4—an updated version of the computer featured in a series of articles in **Radio-Electronics** a few years back. And OS—9000, Microware's portable version of OS-9, runs on PC's with '386 or ,.486 processors (and comes with Virtual PC that runs MS-DOS and Windows), as well as the 68020–68040 and several RISC processors. And that doesn't even begin to exhaust the possibilities.

OS-9's modularity means that it could very easily be cloned. Many vendors could offer OS-9 work-alikes—each coming with its own suite of device drivers and retaining software compatibility with other versions. Computer companies could offer everything from hand-held personal assistants to graphics workstations using OS-9 or their own clones.

Mr. Holtzman's "might makes right" sentiment suggests that if it isn't totally dominant it's not worth talking about. That is, of course, a totally self-fulfilling prophesy. If we all ignore anything that isn't firmly entrenched, nothing new will ever arise, and we will deserve the resulting stagnation.

The makers of the PT/68K are now working on a 68020-based computer that could be a good topic for another series of articles. For hobbyists who like to learn and do it themselves, the OS-9 operating system offers tremendous potential and opportunities. Electronics hobbyists, if anyone, can appreciate the technical merits of an operating system and, being intelligent people, should be above the bandwagon approach. Let's cut the propaganda and get back to the nuts and bolts!
JOEL EWY
Derby, KS

ANOTHER LOOK AT THE LIGHT

I must disagree with the opinions expressed in the letter from Stephen Schleick (*Electronics Now*, June 1992) regarding the relationship between lamp life and switching frequency.

We have all seen that flash of lamp death at turn on, but that occurs *when* a lamp dies, not why. Yes, there is a large in-rush of current—about ten times the steady-state value—for a millisecond or two at turn-on, but the filament reaches normal operating temperature only after many milliseconds. Yes, the rapid temperature change temporarily stresses the lamp, encouraging burnout, but evidence suggests that "infant" lamps recover completely with no cold working or other harmful cumulative aftereffects.

It's been proven empirically by many lamp-flasher manufacturers that lamp flashing extends lamp life as much as ten times normal. I am conducting an experiment in which, at the moment, all but one of the constantly-on lamps have burned out, while none of the flashing lamps have burned out. Aircraft fleets are installing landing light flashers because it has been determined that life increases.

An exhaustive search at the University of Wisconsin engineering library for some simple statement on lamp aging turned up only an indication that lamp life varies inversely with duty cycle, independent of frequency (MHz to kHz) and, with the thirteenth power of applied voltage.

All of this is in accordance with the anecdote told by Mr. Schleick's "rocket scientist" friend, who had to replace his eight-year-old bulbs within days of normal operation. But to claim that, because the lamps burned out right away when switched, switching frequency ages lamps, is irrational.

DAVID PECK
Edgerton, WI

REEL-TO-REEL TAPE SOURCE

A question in the *Q&A* column (*Electronics Now*, January 1993) asked for a source for 10½-inch reels of recording tape. Sound Investment Corp. (3586 Pierce Drive, Chamblee, GA 30341) is a small mail-order company that I have patroniozed for years without trouble. I own a 10½-inch-capable Revox G77 MK II, a half-track model. It still delivers high-quality sound, especially if the tapes are recorded from CD's.

RANDY L. RHOTON
North Bend, WA

RATING OPERATING SYSTEMS

After reading Jeff Holtzman's *Computer Connections* in the April issue of *Electronics Now*, I couldn't repress a feeling of sadness and disgust. I have been using PC's running MS-DOS, VAX's (VMS), Unix boxes, Unix with X Windows, the Commodore Amiga, and MS-Windows daily for the past several years, in my professional career.

I can tell you that MS-Windows and MS-DOS would be in about third place if I were to rate the operating systems that I prefer to use.

It's easy to speculate, as Mr. Holtzman has done, about the future of the computer industry: Just pick as the winner the biggest guy with the most money and the best marketing. In my opinion, the reason that Microsoft now dominates in the computer industry is really simple. The company's first customers were inexperienced users of MS-DOS so they were able to get them to use an inferior graphics user interface (GUI).

In other words, the neophytes had very little choice. The bundling of MS-DOS and MS-Windows with nearly every IBM or compatible personal computer built around an Intel microprocessor certainly boosted Microsoft's position.

Moreover, it makes sense that third-party application software houses will write software for the biggest market first—and that's MS-DOS/MS-Windows.

Nevertheless, no one will argue the points made about the dominance of Microsoft and Intel in the computer industry. I am saddened and disgusted to see all that cash going to Microsoft to raise an inferior product to the same level of capability, performance, and functionality that was reached by alternative operating systems and GUI's some time ago.

FRED HEITKAMP
Dayton, OH Ω

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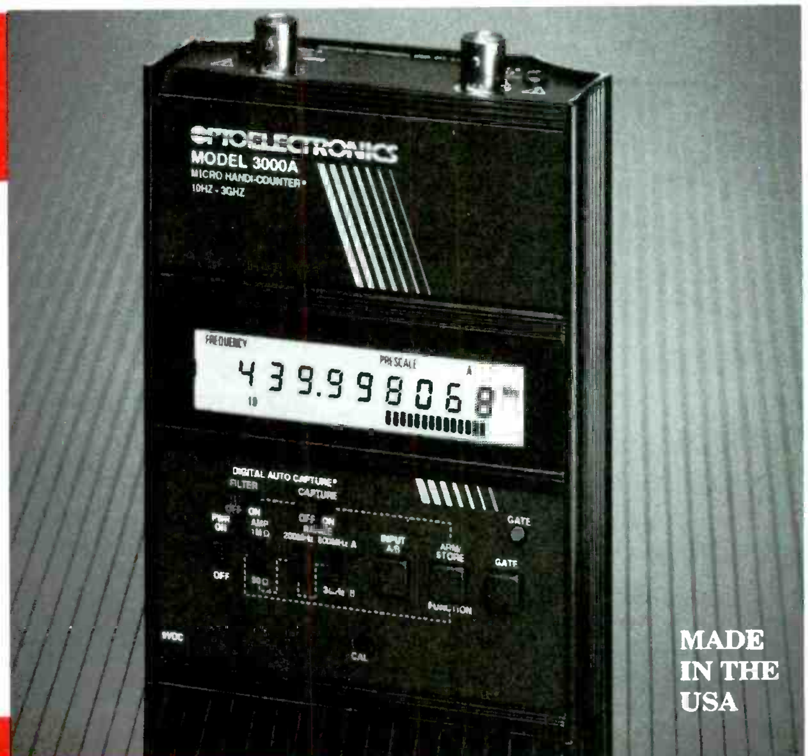

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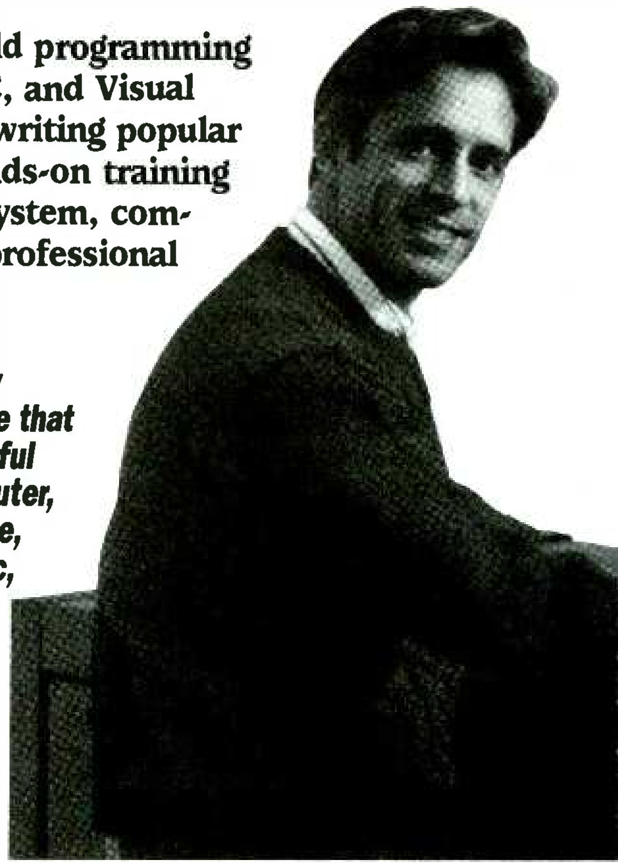

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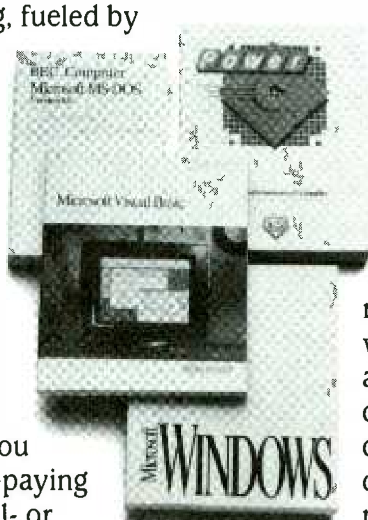

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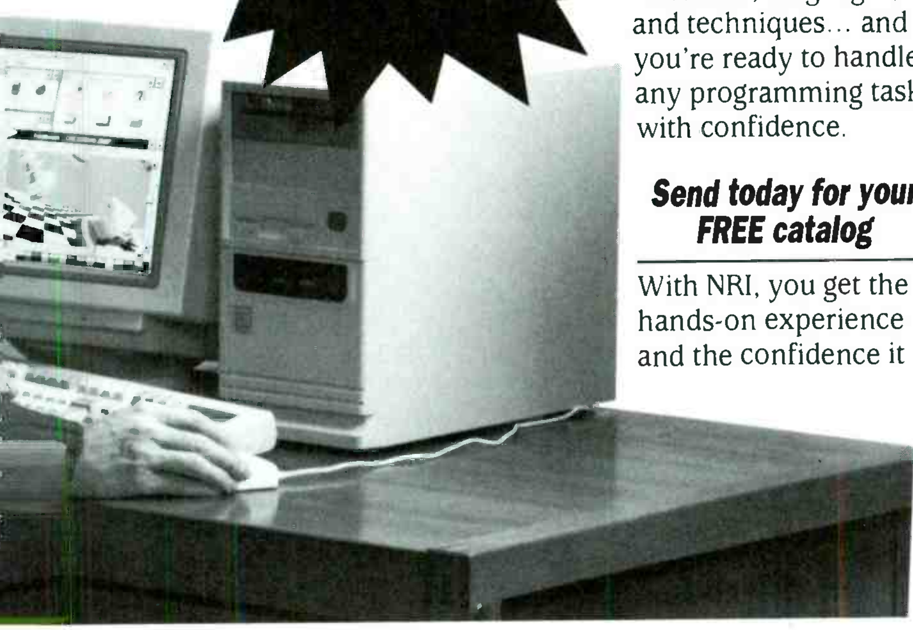

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EQUIPMENT REPORTS

AVCOM PSA-37D Spectrum Analzyer and PTR-25A Portable Test Receiver

It's possible to install a satellite-TV system without any test equipment—but it's not recommended for any professional installer who intends to stay in business very long! Test equipment can help an installer adjust a satellite system for maximum performace. On strong satellite transponders, the improvement from fine tuning might not be noticed. But for marginal signals, every bit of tweaking can make a dramatic difference.

We recently had the opportunity to install a satellite-TV system using two tools made just for the job: the PSA-37D Portable Spectrum Analyzer and the PTR-25A Portable Test Receiver. Both are from Avcom of Virginia, Inc. (500 Southlake Blvd., Richmond, VA 23236).

Aiming a satellite antenna can be tricky business, and we can only sketch the details here. But it's worth noting that if your antenna aim is off a quarter of an inch, you can miss the satellite by hundreds of miles! In satellite TV, Signals are received from geosynchronous (apparently fixed) satellites located in an arc some 22,300 miles over the equator; the satellites are spaced at 2-degree intervals.

The first step in aiming a dish is to fix it on the highest satellite in the arc. That particular satellite varies with location, but it is always the satellite located closest to due south. Armed with a compass, protractor, and aiming data for the installation site, the installer aims the dish by adjusting its azimuth and elevation. The next step is to move to other satellites, and to fine tune the position of the mount so that the dish can track the arc properly.

Experienced installers can get a dish to track the satellite arc reasonably well without any test equipment. But it's virtually impossible to get a system operating to its *maximum* potential without making some measurements. As first-time installers, we relied heavily on Avcom's spectrum analyzer and portable test receiver. And thanks to that equipment, our installation was problem-free.

Unlike most spectrum analyzers, the battery-powered PSA-37D is designed specifically for satellite TV installation and servicing. It provides five operating ranges in 500-MHz blocks. The highest range is the C-band downlink frequencies, 3.7–4.2 GHz. Second is the 950–1400 MHz band, the output of standard LNB's or low-noise block downconverters. (The LNB is an amplifier that boosts the extremely weak signals collected from the dish, and converts them to a lower frequency so that they can be transmitted over standard coaxial cable to a satellite receiver.) A third range is the European standard block downconverter frequencies from 1250–1750 MHz. Two lower RF ranges, 1–500 and 500–1000 MHz, makes the analyzer useful for a wide variety of service applications including cable TV and cellular telephone. The analyzer can provide power to the LNB (+18 volts DC) through its BNC connector.

The main advantage of using a spectrum analyzer instead of a receiver when peaking a dish is that it's far more sensitive. Small changes that might not be noticed in a video image can be seen on the analyzer's CRT.

Another use for the analyzer actually comes before the dish needs to be aimed. The first step of any satellite installation is the *site survey*. For a successful installation, you must be able to "see" the satellites without obstructions such as trees or buildings. The site must also be free of terrestrial interference or TI. The spectrum analyzer (used with a either a standard feedhorn and LNB or a special feedhorn sold by Avcom), can quickly pinpoint sources of TI.

As valuable as a spectrum analyzer is, there are some tasks that are easier with a satellite receiver. One example is targeting the first satellite. An error of a couple of degrees could cause the dish to receive signals from the wrong satellite, making all further attempts to align the dish onto the satellite arc frustrating. A spectrum analyzer can't identify the satellite the antenna is fixed on. But an installer armed with a receiver can quickly identify a "bird."

For example, on our initial aiming attempt, we were happy to find a signal with only minor adjustment. But when we looked at the picture on the PTR-25A portable test receiver, we knew something was

continued on page 93

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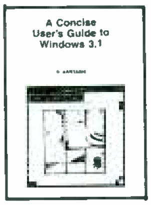

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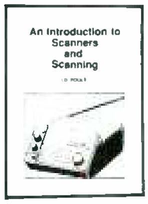

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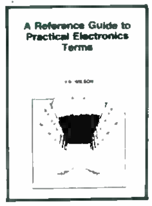

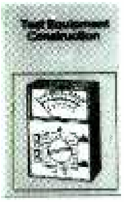

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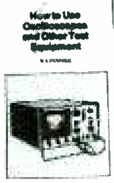

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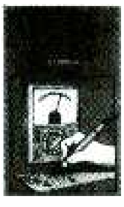

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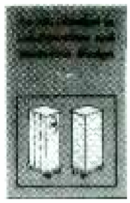

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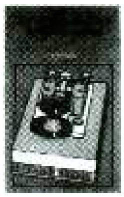

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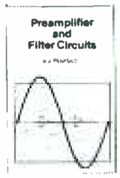

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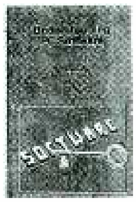

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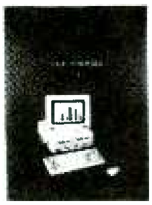

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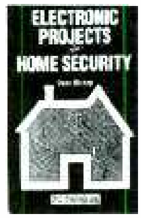

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LINEAR POWER SUPPLIES. *American Reliance's LPS Series* of linear programmable DC power supplies includes five models, each controlled by an internal microprocessor, with power output ranging from 30 watts to 165 watts. The power supplies are easy to use, with all data entry done on a front-panel keypad.

The output voltage and current can be monitored on the built-in LCD panel, and an optional RS-232 interface allows remote talk-and-listen control. Other features standard to the *LPS Series* include low line and load regulation, low output ripple and noise, a voltage/current step up/down function, power-off memory for voltage and current settings, and output enable/disable. All models except the *LPS-301* also feature an intelligent forced-fan cooling system that will prevent overheating.

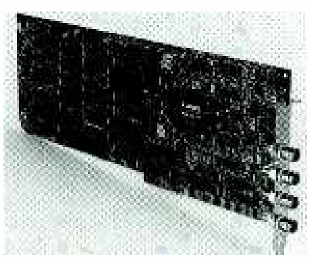
CIRCLE 16 ON FREE INFORMATION CARD

The series includes two dual-range, single-output models: The *LPS-301* is rated at 30V/1A or 15V/2A, and the *LPS-302* is rated at 30V/2A or 15V/4A. The *LPS-303* is a single-output unit rated at 90W with a voltage output of 30V and a current output of 3A. Two triple-output models offer two independently variable channels and a fixed-output channel. The model *LPS-304 offers two 30V/1A outputs along with a fixed 5V/2A output, while the LPS-305* offers two 30V/2.5A outputs as well as a 5V or 3.3V output at 3A.

The *LPS Series* of linear programmable DC power supplies range in price from $225 to $599.

American Reliance Inc.
9952 East Baldwin Place
El Monte, CA 91731
Phone: 818-575-5110
Fax: 818-575-0801

ARBITRARY WAVEFORM BOARD. For special analog test signals that cannot be obtained from ordinary function generators, arbitrary waveform generators, which combine a high-speed D/A converter, on-board dual-access waveform memory, and a digital timebase, fit the bill. *Datel's PC-420* offers two generator output channels (up to 10-MHz output frequency) on a plug-in board for IBM PC/AT and compatible computers. The



CIRCLE 17 ON FREE INFORMATION CARD

PC-420 is controlled by a "virtual instrument" simulated function generator that runs under Microsoft Windows. Data can be loaded from an external disk file, a front-panel function generator, or a powerful polynomial equation parser. Waveform data is stored in two 32,768-sample memories. It can be played back from a selectable memory offset index and then looped any number of times, which allows storage of multiple waveforms and non-stop generation. The board can be used for complex waveform testing in audio and acoustics, control loops, machine simulation, modem testing, receiver calibration, and biomedical research.

The *PC-420* arbitrary waveform board costs $1495 (quantity discounts are available).

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

LOW-FREQUENCY SMT CRYSTAL. To generate the standard 32.768 kHz frequency used in clock radios, wrist watches, timers, computers, telecommunications systems, and other applications in which real time is displayed in seconds, minutes, hours, and days, *Ralton Electronics* shaped its *Model RSM-200* crystal into a little tuning fork. Standard quartz crystals ordinarily generate much higher frequencies, which are not convenient for divide-by-60 countdowns. The tiny tuning fork is hermetically sealed in an SMT package. The tuning-fork crystal features high accuracy of ±30-ppm at 25°C. Surface-mount pinout is on 5.6-mm centers. For automatic insertion, units are tape-and-reel packaged in lots of 1000.

The *Model RSM-200* tuning fork crystal costs

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$0.55 each in OEM lots of 10,000.

Raltron Electronics Corporation
2315 NW 107th Avenue
Miami, FL 33172
Phone: 305-593-6033
Fax: 305-594-3793

TRAINER OSCILLOSCOPE. *MCM Electronics' Tenma Trainer Oscilloscope* is aimed at students and entry-level electronic hobbyists. The low-cost instrument features high (5mV/div.) sensitivity, a smooth

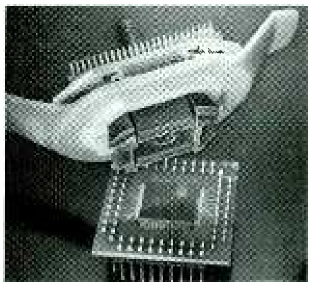
CIRCLE 19 ON FREE INFORMATION CARD

roll-off (exceeding 20 MHz), and a maximum triggering sweep speed of 0.2µsec/div. The *Tenma Trainer* comes with two probes, power cord, and owner's manual. It's covered by a two-year warranty.

The *Tenma Trainer* oscilloscope costs $320.

MCM Electronics
650 Congress Park Drive
Centerville, OH 45459-4072
Phone: 800-543-4330

SQFP TEST CLIPS. According to *ITT Pomona*, their models *5871* and *5872* are the world's first test clips that enable accurate, full-count test access to the newest 80- and 100-pin small quad flat package (SQFP) semiconductor devices produced at 0.5mm lead spacings and 1.4mm case heights. The 80-pin *5871* and 100-pin *5872* provide flexible contacts at 0.0197-inch (0.5mm) lead spacing ("pitch") to assure positive electrical contact



CIRCLE 20 ON FREE INFORMATION CARD

with each pin while under test.

A mechanical lock-on design assures continued accurate connection even when the board is tilted. The test clips' low-profile design provides a stable electrical path to a scope or other instrument. Both models can be used on surface-mounted devices while the host board is inserted into its standard-spaced computer/system slot. That type of configuration allows signals to be sampled during normal system operation.

SQFP test clips models *5871* and *5872* cost $540 and $608, respectively.

ITT Pomona
1500 East Ninth Street
P.O. Box 2767
Pomona, CA 91769
Phone: 909-469-2900
Fax: 909-629-3317

AC POWER-LINE TESTER. *Extech's 310115 AC Power-Line Analyzer* is able to diagnose power problems as a stand-alone unit, or it can be connected to a PC or laptop to view events in real time. The analyzer is easy to use. Once it is plugged into a grounded outlet, it

CIRCLE 21 ON FREE INFORMATION CARD

monitors the power for 24 to 74 hours, storing the data in internal RAM. The data can be transferred to a PC by connecting the analyzer to the computer's serial communications port. Power Audit Software provides complete analysis of spikes, sags, surges, dropouts, power failures, true-RMS AC line voltage and frequency, common-mode noise, high-frequency noise, phase shift, and neutral line voltage. Each power audit chart contains the actual disturbance event data, indicates symptoms related to that type of disturbance, and recommends a specific solution. Power disturbances are presented in four easy-to-understand formats—detailed or summary reports, bar or pie charts, power-quality audit, or sinewave graphics. The analyzer comes with software, RS-232 cable, and a six-foot power cord.

The *AC Power-Line Analyzer* costs $595.

Extech Instruments Corp.
335 Bear Hill Road
Waltham, MA 02154
Phone: 617-890-7440
Fax: 617-890-7864

WORK-STATION ESD MONITORS. Two work-station monitors from *3M* continuously test wrist straps, personnel, work surfaces, and ground connections for electrostatic discharge (ESD). Models *720* and *722* directly measure DC resistance of the grounding system, which means that changes in capacitance due to a person's size, dress, posture, location, and the way the wrist band is worn will not affect the true resistance reading, as is the case with impedance monitors.

Unlike periodic testing devices, the *720* and *722* work-station monitors notify the user of static-control equipment failures as they occur, eliminating time-consuming, costly audits and record keeping. Continuous monitoring also detects intermittent failures caused by such things as improperly worn wrist straps or dry skin.

CIRCLE 22 ON FREE INFORMATION CARD

The work-station monitors, which are automatically activated when plugged in, continuously pulse a signal that is returned to the monitoring device through a special wrist strap and cord that contain two separate sets of independent conductors. The monitors apply a low current of less than 5 mA at 0.2-second intervals. A resistor bypass warning notifies the operator when resistance drops below 1.5 megohms and current-limiting resistors are being bypassed. Both monitors provide audible and visible alarms. In addition, the *722* features adjustable volume on the audible alarm, an optional audible alarm for the mat, and a remote jack that monitors visitors to the work station.

The *720* and *722* work-station ESD monitors have suggested retail prices of $124 and $190, respectively.

3M Electronic Specialty Markets
6801 River Place Blvd
Austin, TX 78726-4599
Phone: 512-984-6674

FOUR-CHANNEL OSCILLOSCOPES. Two recent additions to *Tektronix' TAS 400* family of analog real-time oscilloscopes provide greater capabilities for tougher service applications where multiple channels must be displayed to troubleshoot circuit conditions, such as three-phase power or logic circuitry. The 100-MHz *TAS 475* and the 200-MHz *TAS 485* scopes both offer four channels with a full range of amplification and attenuation.

CIRCLE 23 ON FREE INFORMATION CARD

Though tailored to the analog scope user, the *TAS 400* scopes are based on the popular, streamlined TDS (Tektronix Digital Scopes) family's interface, which makes operation virtually intuitive. The analog oscilloscopes offer a balanced combination of buttons, knobs, simple menus, and such features as autoset, save/recall setups, cursors, and set-to-50% triggering. The hybrid design houses the entire acquisition system for each input channel, drastically reducing the parts count, the calibration time, and the need for manual adjustments. The integrated design also boosts the instruments' reliability—so much so that Tektronix will provide a free replacement if a *TAS 400* oscilloscope fails within a three-year period.

The *TAS 475* and *TAS 485* four-channel analog oscilloscopes cost $2395 and $3495, respectively.

Tektronix, Inc.
Test and Measurement Group
P.O. Box 1520
Pittsfield, MA 01202
Phone: 800-426-2200

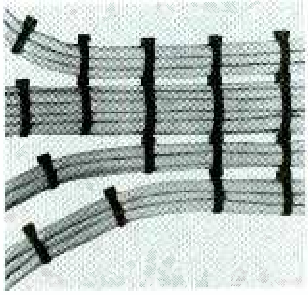
OHM EXTENDER. A portable, battery-operated unit called the *Ohm Extender*, when used with your digital multimeter, provides you with the equivalent of an expensive milli- and micro-ohmmeter. The battery-operated unit is based on the four-wire Kelvin configuration (two-sense/two-source), which measures the voltage drop directly at the resistance source. The *Ohm Extender* is easily adjusted to your own DMM, and allows you to read down through the milliohm range into the lower portion of the micro-ohm range.

CIRCLE 24 ON FREE INFORMATION CARD

That allows you to measure shunt resistors, precisely determine wire length, verify circuit-board trace resistance, read motor and transformer values, and check switch and relay contacts.

The *Ohm Extender* costs $161, postpaid.

Micro-Ohm Measurements
P.O. Box 460
Brookshire, TX 77423
Phone: 713-934-4659



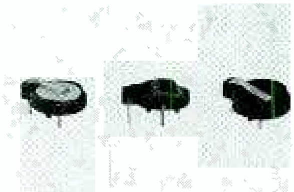
CIRCLE 25 ON FREE INFORMATION CARD

CABLE AND WIRE ORGANIZERS. Those who are confronted with confusing tangles of wires and cables could benefit from using *Strap-Loc* continuous-length cable ties from Advanced Cable Electronics. The product consists of a spool of cable tie and locking devices. Because it comes in continuous roll, it can be cut to fit any different size and number of cables, and can be used to fasten and bundle large cables, to separate and space wires and cables, to fasten though panels, and to create multiple wrappings for extra-high tensile strength applications. *Strap-Loc* allows wire bundles to lie flat and pass through narrow openings, to be separated for easy tracing and termination, and to be fastened to guide wires for aerial support. It eliminates the need for "daisy-chaining" and for stocking a large inventory of assorted cable-tie lengths. The low-insertion-force locking device assures strength and stability. A stainless-steel grip-lock is recessed into the lock body to protect wires, and rounded edges on the strapping prevent damage to wire insulation.

Strap-Loc comes in 250- and 500-foot spools.

Advanced Cable Electronics Corp.
Westborough, MA 01581
Phone: 508-366-0669

COIN CELL HOLDERS. A series of three PC-mount, low-profile, "button-type" lithium coin cell holders from Keystone Electronics is designed specifically for use with memory backup, computer memory, telecommunications, power transfer, emergency power backup systems, and pre-programmed video and electronic games. *Catalog No. 500* is a 12mm single-capacity, 3-volt holder. The 6-volt *Catalog No. 501* accepts two stacked, 3-volt, 12mm button-type batteries. *Catalog No. 502* accommodates a single, 16mm coin cell.



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All three holders feature unique "air-flow" support legs that permit safe flow soldering and enhanced air circulation around the battery, and notched slots that assure quick and easy battery insertion or replacement. The units are made of UL-rated glass-filled nylon, and are impervious to most industrial solvents. They are equipped with nickel-over-copper-plated spring-steel contacts with clearly marked polarities.

The coin cell holders' prices range from 48-cents each in bulk quantities.

Keystone Electronics Corporation
31-07 20th Road
Astoria, NY 11105-2017
Phone: 718-956-8900
Fax: 718-956-9040 Ω

NEW LIT

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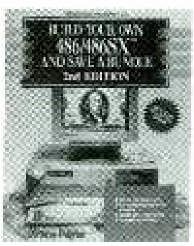
Build Your Own 486/486SX and Save a Bundle, 2nd Edition; by Aubrey Pilgrim. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; Fax: 717-794-2103; $19.95.

If you'd like to own a computer with the power and efficiency of top-of-the-line models, without shelling out the money required to purchase one, you don't have to resort to theft.

This book shows how to assemble a high-powered IBM-compatible computer—complete with any combination of peripherals, input devices, and graphics capabilities—for hundreds of dollars less than any commercially sold model.

Using little more than a screwdriver and a pair of pliers, even those with little or no technical experience should have no trouble following the book's step-by-step, heavily illustrated instructions.



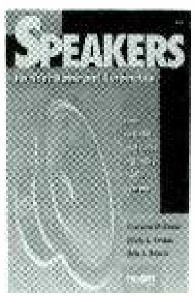
CIRCLE 40 ON FREE INFORMATION CARD

The book not only provides all the direction needed to build a computer, but also provides a short course in microcomputer operation. Tips are included on which software will best suit your needs, and what business and personal tasks you will be able to perform with your home-built 486 or 486SX computer.

Completely updated to cover new components, parts, and prices, the book explains how and where to find the best components and peripherals at the lowest prices available. The book also explains how to inexpensively upgrade older PC's by installing new memory boards, displays, and drives.

Speakers for Your Home and Automobile: How to Build and Enjoy a Quality Audio System; by Gordon McComb, Alvis J. Evans, and Eric J. Evans. Prompt Publications, Howard W. Sams & Company, 2647 Waterfront Parkway East Drive, Indianapolis, IN 46214-2012; Tel: 317-298-5710; Fax: 317-298-5604; $14.95.

It doesn't matter how good your stereo components are, if you don't have decent speakers. This book shows do-it-yourselfers and technicians how to build quality speaker systems for use in the home and the car. With clear instructions and illustrated examples, the book details the construction of four home speaker systems—a compact bookshelf speaker, a small 2-way speaker intended for unobtrusive use in a living room, a large 3-way speaker, and a ported-reflex 3-way speaker—and a variety of automotive speaker installations. The book explains how speaker systems work, including the science behind the system; the effect of enclosures on sound quality; and the design factors behind various speaker types.



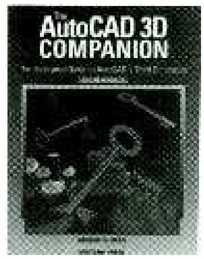
CIRCLE 39 ON FREE INFORMATION CARD

The book also covers the construction of speakers designed to fit specific areas and purposes and the addition of finishing touches for a professional look. Appendices are filled with design equation and conversion charts, and a glossary of audio and speaker terminology is included.

Even those who aren't interested in building their own speakers should glean enough information from reading this book to enable them to make more informed decisions when buying speakers.

The AutoCAD 3D Companion: The Illustrated Guide to AutoCAD's Third Dimension for Release 12; by George O. Head. Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $27.95; companion diskette: $49.95.

Mastering AutoCAD Release 12's powerful 3D capabilities doesn't have to be difficult. This book teaches everything needed to draw effectively in 3D. Special emphasis is given to the 3D Toolkit, with 52 ready-to-load AutoLISP programs designed for maximum 3D productivity. Those programs are also available on the companion diskette, which is available separately.



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The first 14 chapters each take the reader step-by-step through the use of a specific tool. Those include 3D Preview, an overview of essential features; the User Coordinate System (USC) that is used to set up drawings, create new origins, rotate drawings, work with text and dialogue boxes, save and restore the USC, and use 2D commands; DView, which is used to operate the Camera; View Ports, used to divide up views as Tiles; Surfaces, including such things as extrusions, faces, meshes, complex shapes, and holes; Paper Space; and Shading and Rendering.

Two subsequent tutorials provide real-life examples of AutoCAD 3D applications. Readers are shown what is involved in the development of complete mechanical and architectural models using AutoCAD 3D software. Ω

You're zooming up a single shot 10 ns spike, an event you simply cannot see on any $3,000 digital scope. Unless it's the new TDS 320 with its incredible over sampling. Truly the world's first affordable 100MHz digital real-time scope.

At 500 Megasamples/sec, our new TDS 320 combines the storage and data manipulation benefits of digital with the signal fidelity of analog real-time. So you can make precise, confident measurements quickly. What's more, its intuitive user interface means you'll actually spend more time working with this digital scope than learning how to use it. And finally, we consider its price tag (a mere $2,795) yet another spike the competition can't catch. So call your authorized Tektronix distributor today. Or call us at (800) 426-2200, ext. TDS3 to place your order.

Tektronix

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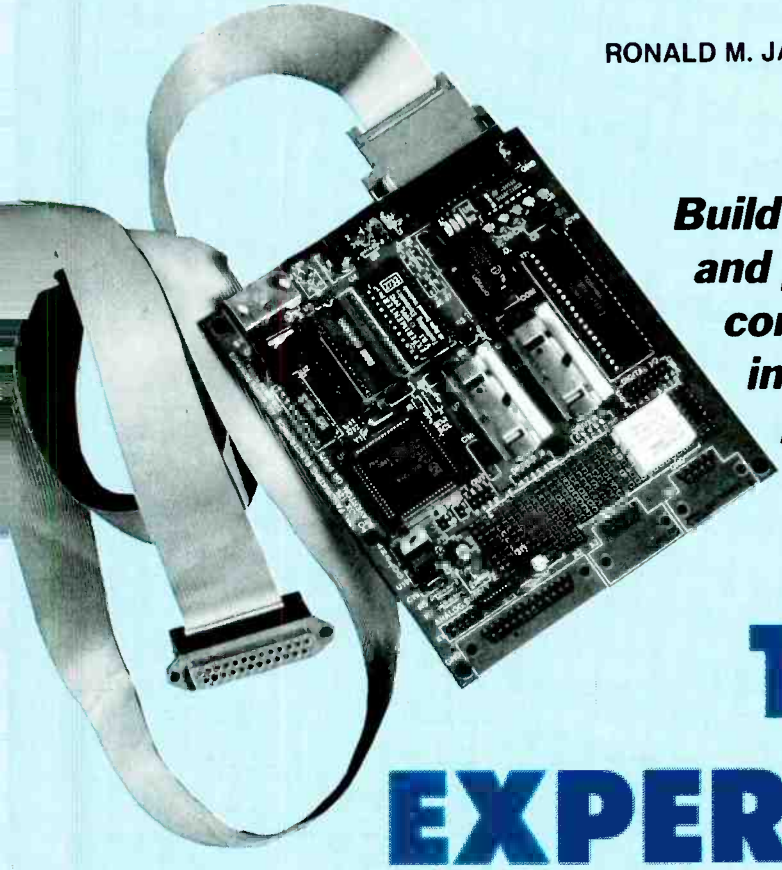
RONALD M. JACKSON



Build the Experimenter, and put your personal computer to work doing interesting and useful real-time tasks.

THE EXPERIMENTER

JUST IMAGINE WHAT WOULD HAPPEN if your personal computer had the ability to sense real-world events taking place around it and was able to respond by controlling those events in some useful way. You would then have unlimited possibilities for building fascinating computer-based projects. With a variety of sensors you could build such projects as a computerized weather monitoring station, a sophisticated home-security system, or perhaps add voice recognition to your computer.

If your home computer could control electric motors, you could build a robot that could be programmed and operated from your PC. You might even consider a computer-controlled telescope that would automatically track star movements.

The Experimenter, a computer peripheral circuit described in this article, actually offers those capabilities. Its circuitry is built on a double-sided PC board that will work with most of the popular brands of personal computers available today that meet certain minimum performance requirements.

The missing link

The Experimenter is the missing measurement and control link between your personal computer and the outside world. It provides eight inputs capable of voltage measurement, four timer/counter inputs, and 24 digital input/output (I/O) terminals. The Experimenter features eight high-voltage, high-current outputs, and a power relay. The variety in outputs provides a wide range of capabilities for driving and controlling motors, solenoids, and alarms, as well as generating useful control signals. The Experimenter has its own power supplies and its circuit board includes unused space for adding circuitry and connectors for projects of your own design.

The Experimenter's measurement and control features were designed to be user-friendly. An on-board microcontroller interprets measurement signals and control commands sent from your PC. The microcontroller has enough built-in computing power to relieve your PC of any additional housekeeping burden. This "intelligence" permits your own PC to operate on standard software, making it quicker and easier to get your real-time projects up and running and put to use.

The Experimenter is connected to your computer through a serial port, so you can connect it to almost any brand of personal computer including IBM-compatible PC's, Macintosh, Atari, and Commodore. In the coming months we will present many projects based on the Experimenter. They will include an ultrasonic "radar," that can measure distances to objects as its transducer rotates, and a desktop meteorological station.

The necessary software to run these projects will be included. It will be written in Microsoft's QuickBASIC for DOS-based IBM PC and AT compatibles that are equipped with CGA, EGA, or VGA display boards. Most of the programs can also be adapted to the Macintosh. Owners of other personal computers, however, might have to modify the programs for the BASIC dialect that is compatible with their particular computer.

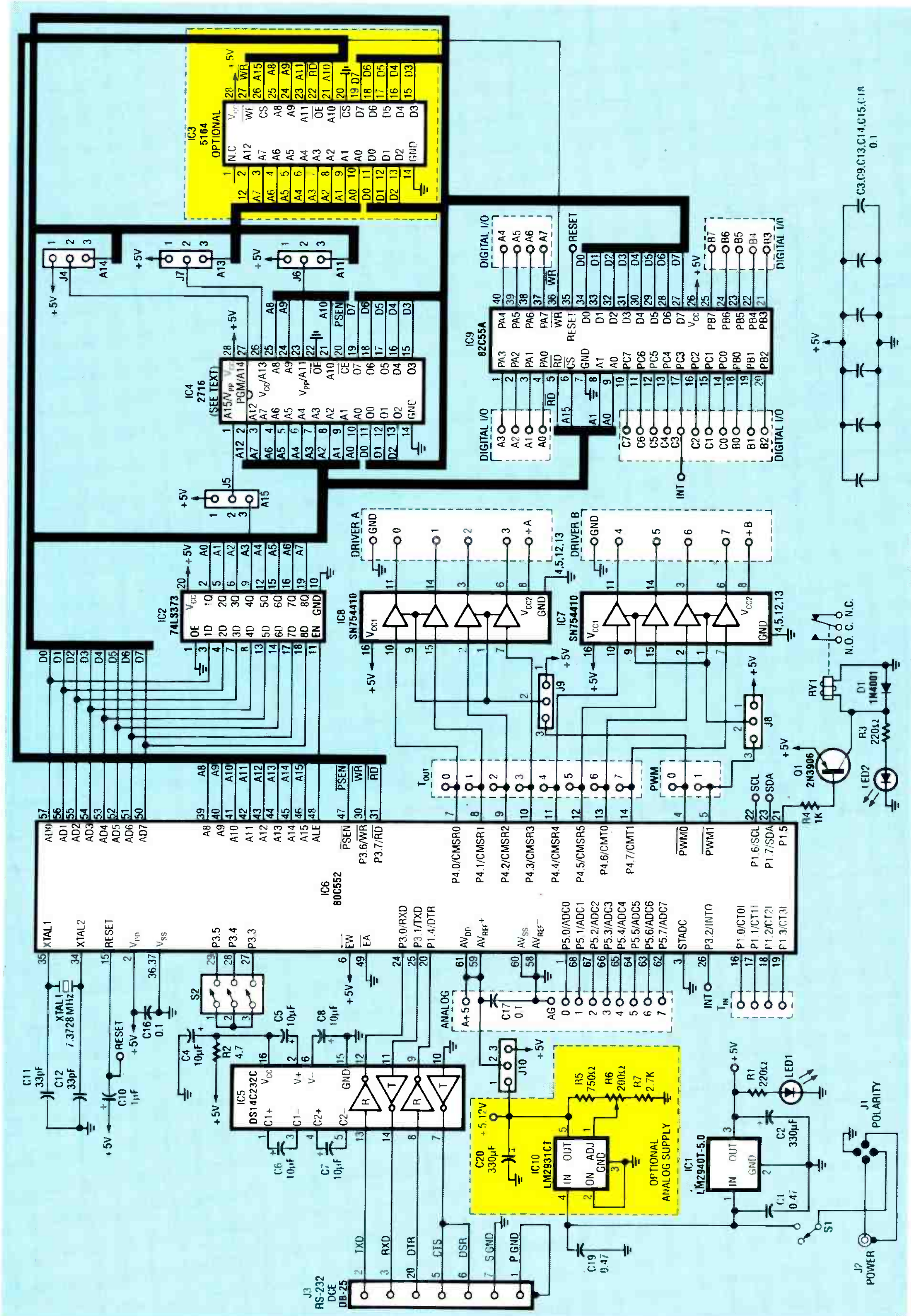


FIG. 1—EXPERIMENTER SCHEMATIC. Most of the measurement and control capability is embedded in the microcontroller, IC6.

The Experimenter schematic

Figure 1 is the schematic for the Experimenter. Its DC power requirement of 6 to 15 volts is introduced at coaxial jack J2. Because the center conductor of the power plug is positive on some power supplies and negative on others, jumper block J1 provides a convenient way to select between the two different configurations. Switch S1 is the main power switch for the Experimenter.

Voltage regulator IC1, an LM2940T-5.0, provides the regulated +5-volt logic supply which powers all of the logic circuitry as well as some other circuit functions. A special low-dropout voltage regulator, IC1 allows the Experimenter to run from a 6-volt battery.

Adjustable voltage regulator IC10 is an optional regulator that can be added to obtain a separate 5.12-volt supply to operate analog circuitry. This analog supply can provide an adjustable reference source, isolated from the relatively noisy logic supply. Its presence makes possible more accurate voltage measurements.

If you plan to build any analog circuitry that will be under the command of the Experimenter, this regulator will help you to avoid possible noise problems, and its presence will simplify circuit debugging. This option is recommended if you anticipate a need for the highest analog measurement accuracy that can be obtained from your Experimenter.

The "brain" of the Experimenter is IC6, an Intel 80C552 CMOS microcontroller with an 8-bit internal microprocessor, as well as many additional measurement and control functions. The microcontroller includes a serial port, baud-rate generator, clock oscillator, analog multiplexer, analog-to-digital converter, counters, timers, and pulse-width-modulators (PWM).

Your PC is connected to the Experimenter through J3, a standard 25-pin female "D-"style connector (DB-25). Because the EIA RS-232C accepts larger voltage swings than are obtained from standard logic devices, IC5 (a DS14C232CN RS-232 driver) is required to adapt the RS-232C interface to your processor. The device also contains a voltage doubler and inverter that, along with capacitors C5 to C8, provides the ±10 volts required by the RS-232C standard.

A 7.3728 MHz crystal is used in the microcontroller's clock. The frequency is evenly divided into standard baud rates for RS-232C by the baud-rate generator contained in IC6. Three-position DIP switch S2 allows rates to be selected from 300 baud to 38.4 kilobaud.

The analog multiplexer in the microcontroller provides eight analog voltage-measurement inputs. The analog-to-digital converter can measure these inputs with 5-millivolt resolution (10 bits) over the range from 0 to 5.115 volts. That is a useful voltage for powering many sensors such as thermistors for temperature measurement and photocells for light sensing.

Capacitor C10 provides a reset signal for both microcontroller IC6 and the 82C55A parallel interface IC, IC9. That reset signal causes the microcontroller and parallel interface chip to initialize their internal registers when the logic supply is switched on. The lower eight bits of the address bus multiplex on the same lines as the data bus. The 74LS373 octal latch, IC2, holds the address value while data is on the bus.

Software for the microcontroller is stored in EPROM IC4. The contents of the EPROM, in Intel hexadecimal format, are available as file ELNOW01.OBJ, which is part of a self-extracting ZIP file called EXPER.EXE on the *Electronics Now BBS* (516-293-2283, 1200/2400, 8N1).

The Experimenter can accommodate many different brands and bit densities of EPROM. Jumpers J4 to J7 organize the Experimenter for use with different EPROM's. Although it was not included in the prototype, the Experimenter has space on its PC board, labeled IC3, for adding more memory; the space can accommodate an 8K byte static RAM.

The microcontroller has four counter/timer inputs ($T_{IN}0$–$T_{IN}3$), at pins 16 to 19. The inputs can count pulses or measure time intervals for applications such as counting raindrops in a weather station, counting rotations of a motor shaft, or measuring distance with an ultrasonic rangefinder.

Timer outputs 0 to 7 appear at the microcontroller's pins 7 to 14; they are available directly on the PC board at the pads labeled T_{OUT}, 0–7. The timer outputs are also buffered for higher voltage and current applications by SN754410 driver chips IC7 and IC8. The driver outputs (labeled DRIVER A, 0–3 and DRIVER B, 4–7 on the PC board) provide eight high-powered channels for controlling DC and stepper motors, solenoids, and other powered devices.

Each driver has its own power input (DRIVER A+ and DRIVER B+) which must be connected to an external power source of 4.5 to 36 volts DC. Each of the eight outputs can source and sink up to 1 ampere. Separate high-current grounding points are also provided for the driver outputs.

A metal heatsink is mounted "piggyback" on top of each high-power driver IC to conduct heat from these devices. The heatsinks are soldered in place to pins 4, 5, 12, and 13 of each IC. If you elect to use sockets for positioning the driver IC's on the circuit board rather than soldering them directly to the board, cooling will be less effective. If you make that decision, limit the maximum current that will appear at each output to about 700 milliamperes.

The driver IC's are thermostatically protected, and they will shut down automatically if their internal temperature exceeds their threshold levels. However, they are not protected against current overloads or short circuits. Caution: if more than 1 ampere is drawn from any driver output, the driver could be destroyed.

Jumpers J8 and J9 permit

the drivers to remain continuously enabled, or permit them to be enabled under the control of the pulse-width-modulated outputs of the microcontroller ($\overline{PWM0}$ and $\overline{PWM1}$, pins 4 and 5). Those outputs provide a continuous stream of pulses of controllable frequency and duty cycle. Those outputs are also directly available on the PC board at the location marked PWM, 0 and 1. By varying the duty cycle, the driver outputs will provide varying amounts of power to a load such as a DC motor. By varying the power, the rotational speed of the motor can easily be controlled.

The Experimenter has one relay, RY1, that can switch high-current loads up to 8 amperes. That is a useful value for actuating large alarm horns, switching the power supplies to the driver IC's, and handling other heavy-current loads. The processor controls the relay through buffer transistor Q1. Indicator LED2 lights when the relay's coil is energized. Diode D1 prevents inductive voltage spikes from damaging the relay coil when the transistor turns off. Again, connections to the relay terminals are directly available on the PC board next to the relay.

Digital input/output device IC9 (an 82C55A) provides 24 bits of digital input or output. Digital outputs can be timed with 1-millisecond resolution. Digital inputs are useful for such tasks as binary sensing (determination of the positions of door or window switches) in alarm systems. Digital outputs are also useful as low-current signals and as strobes for controlling circuitry such as would be included in an ultrasonic rangefinder.

A large grid along the lower edge of the Experimenter's PC board is available for wiring your own projects. The 5-volt logic supply and ground are prewired to every fourth connection in the top and bottom rows of the grid. That corresponds to the standard power pin locations for most logic components—the upper right corner for V_{CC} and the lower left corner for V_{SS}. Any IC devices that do not conform to that power-distribution pinout should be installed to the right or left of the power connections.

Below the wiring area are pads for mounting extra connectors: one high density, one DB-25, and two DB-9. You can add any of those connectors to suit your particular application. The connector locations are marked X1 through X4 on the PC board.

PARTS LIST

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

R1, R3—220 ohms
R2—4.7 ohms
R4—1000 ohms
R5—750 ohms
R6—200 ohms, trimmer
R7—2700 ohms

Capacitors

C1, C19—0.47 µF, 50 volts, Mylar
C2—330 µF, 6 volts, electrolytic
C3, C9, C13–C15, C18—0.1 µF, ceramic
C4–C8—4.7 µF, 35 volts, electrolytic
C10—1 µF, 50 volts, electrolytic
C11, C12—33 pF, ceramic
C16, C17—0.1 µF, 50 volts, surface-mount chip capacitor
C20—330 µF, 6 volts, electrolytic

Semiconductors

IC1—LM2940CT-5.0 voltage regulator, National Semiconductor or equivalent
IC2—74LS373 octal latch, Texas Instruments or equivalent
IC3—5164 8K byte static RAM or equivalent (optional, see text)
IC4—27xxx family EPROM, or equivalent (see text and Fig. 4)
IC5—DS14C232CN RS-232 driver
IC6—S80C552-1A68 CMOS microcontroller, Intel or equivalent
IC7, IC8—SN754410NE high-current driver IC, Texas Instruments or equivalent
IC9—82C55A parallel interface, Toshiba or equivalent
IC10—LM2931CT voltage regulator, National Semiconductor or equivalent (optional, see text)
LED1, LED2—Red light-emitting diode, T1 package
D1—1N4001 silicon diode
Q1—2N3906 PNP transistor

Other components

RY1—SPDT relay, 5-volt coil (Omron G5LE-114P-PS)
S1—DPDT switch
S2—3-position DIP switch
XTAL1—7.3728 MHz crystal
J1, J4–J10—wire jumper
J2—5.5/2.0mm coaxial power jack
J3—PC-mount female DB-25 connector

Miscellaneous: PC board, six plug bumpers (rubber feet), 6–15 volt DC power supply with 5.5mm/2.1mm coaxial plug, TO-220 heatsink for IC1, two 16-pin DIP heatsinks for IC7 and IC8, 28-pin DIP socket for IC4, 16-pin DIP socket for IC5, 68-pin PLCC socket for IC6, 40-pin DIP socket for IC9, wire, solder.

Note: The following items are available from Fascinating Electronics, PO Box 126, Beaverton, OR 97075:

- **PC board silkscreened on both sides—$59.90**
- **Programmed EPROM (contains Experimenter operating software)—$49.90**
- **Kit including PC board, programmed EPROM, all components, assembly instructions, and a reference and applications manual (does not include user connectors X1–X4, analog supply, and wall-mount supply)—$149.90**
- **Assembled and tested Experimenter (includes reference and applications manual and analog supply)—$199.90**
- **9-volt, 500 mA wall-mount DC power supply—$11.90**
- **Analog power supply components—$4.90**

Please include $3.40 for shipping and packaging. Foreign orders must inquire for pricing and availability. You can order by telephone using VISA or Mastercard weekdays from 10:00 AM to 5:00 PM, Pacific time at (800) 683-KITS.

Commands

The Experimenter recognizes a variety of measurement and control commands. To familiarize you with the commands, the Experimenter has a built-in, user-assistance system. If you send the Experimenter a question mark (?) at the start of a line, it lists all of its commands and their parameters. To determine the status of an individual command, enter the command name (or abbreviation), followed by a question mark.

Experimenter commands and responses are standard ASCII letters and numbers. You don't have to deal with binary codes. So, for testing, you can "talk" to the Experimenter with a communications program, just as you do with an on-line computer bulletin board system. It is also easy to control the Experimenter with most programming languages.

ECHO-EXP.BAS, also contained within the self-extracting ZIP file (EXPER.EXE) on the *Electronics Now BBS*, is a simple communications program for the Experimenter, implemented in Microsoft's QuickBASIC. Using that program, anything you key in is sent to the Experimenter, and anything the Experimenter sends is shown on your PC's screen. The program can be modified to run on other personal computers, and a Macintosh version is also available.

Voltage measurement

The Experimenter has eight analog voltage measurement channels, again available directly from the PC board at the location marked "ANALOG, 0–7." (Separate analog power and ground connections are also provided.) Each channel measures from 0 to 5.115 volts with 5 millivolt (10-bit) resolution. If sent the command ANALOG 5, the Experimenter will quickly measure the voltage on channel 5, and return the result as a number expressed in millivolts. Commands can be abbreviated with the use of just the first letter, so the command "A 5" will produce the same result.

Suppose you were adjusting a potentiometer to monitor the angle between elements of a robot arm. The external connections of the potentiometer would be wired to the analog ground and power supply (AG and A+5), and the wiper would be wired to one of the eight analog inputs. By reading the voltage represented by the potentiometer's wiper position, you can calculate the angle within a fraction of a degree!

TABLE 1—COUNTER/TIMER COMMANDS

```
C channel function wait

    channel = counter/timer channel number
              none     channel 0 assumed
         0 to 3 available channel selections

    function        = counter/timer measurement function
                           Counter Measurements:
    none or 0       report the current count (counter unchanged)
                    1      report, restart counter, count on rising edge
                    2      report, restart counter, count on falling edge
                    3      report, restart counter, count on both edges
                    4      report, reset counter (counter is stopped)
                           One Channel Timer Measurements:
                    5      report positive going pulse duration
                    6      report negative going pulse duration
                    7      report rising-edge to rising-edge period
                    8      report falling-edge to falling-edge period
                           Two Channel Timer Measurements:
                    9      report rising-edge to falling-edge time
                    10     report falling-edge to rising-edge time
                    11     report rising-edge to rising-edge time
                    12     report falling-edge to falling-edge time

    wait     = timer measurement first-edge waiting period
                    none     use previous (or default) value
                    0        unlimited wait
    1 to 255        waiting period, in 0.1 S steps
```

TABLE 2—I/O COMMANDS

```
D 3 mode

    mode    = ports A, B, and C are set to inputs and outputs:
```

mode	A7-A0	C7-C4	B7-B0	C3-C0
128	out	out	out	out
129	out	out	out	in
130	out	out	in	cut
131	out	out	in	in
136	out	in	out	out
137	out	in	out	in
138	out	in	in	out
139	out	in	in	in
144	in	out	out	out
145	in	out	out	in
146	in	out	in	out
147	in	out	in	in
152	in	in	out	out
153	in	in	out	in
154	in	in	in	out
155	in	in	in	in

```
D port output.1 duration.1 output.2 duration.2 output.3

    port     = port selection
                 none or 0      port A is selected
                 1       port B is selected
                 2       port C is selected

    output.1        = initial output value
                 none    report port value and duration remaining
                 0 to 255       assign value to outputs

duration.1      = time duration output.1 is present on pins
                 none or 0      duration is unlimited
                 1 to 65535     duration in mS

    output.2        = next output value (after duration.1 is over)
                 none or 0      assign 0 to outputs
                 1 to 255       assign value to outputs

duration.2      = time duration output.2 is present on pins
                     as above for duration.1

    output.3        = final output value (after duration.2 is over)
                     as above for output.2
```

Measurements

The Experimenter provides four pulse-counting and time-measurement inputs (T_{IN}, 0–3). The counters have 16 stages and reach a maximum count of 65535. When a counter or timer reaches its maximum value, it stops. Table 1 lists the COUNTER/TIMER commands.

When used as counters, any of these inputs can make a count on rising edges of waveforms, falling edges, or either edge, for that matter, depending on the function selected for each counter. The maximum count rate exceeds a kilohertz. The counters are well suited for mechanical monitoring tasks

TABLE 3—H-BRIDGE COMMANDS

```
H group direction duration speed type

group     = select groups of buffered channels and PWMs
                        For DC Motors:
                0       DRIVER A channels 0, 1, PWM0
                1       DRIVER B channels 4, 5, PWM1
                2       DRIVER A channels 2, 3, PWM0
                3       DRIVER B channels 6, 7, PWM1
                        For Stepping Motors:
                0       DRIVER A channels 0, 1, 2, 3
                1       DRIVER B channels 4, 5, 6, 7

direction       = motor direction control
                none    report motor remaining duration
                0       stop
                1       forward
                2       reverse
                3       stop  (for stepper:  coils off)

duration        = how long to drive the motor, then return to stop (0)
                none or 0       drive duration unlimited
                1 to 65535      drive DC motors in mS, steppers in steps

speed     = PWM control for DC motor, step duration for steppers
                        For DC Motors:
                none or 0       PWM settings are not affected
                1 to 255        the PWM is set as in E command
                        For Stepping Motors:
                none or 0       rate is not changed
                        (default is 255 mS/step)
                1 to 255        step duration in mS

type      = type of motor and driver configuration
                none    type of motor is not changed
                        DC Motors:
                0       DC motor, positive polarity (default)
                1       DC motor, negative polarity
                        Stepping Motors:
                2       3 coil unipolar, 1 phase positive drive
                3       3 coil unipolar, 1 phase negative drive
                4       3 coil unipolar, half-step positive drive
                5       3 coil unipolar, half-step negative drive
                6       4 coil unipolar, 1 phase positive drive
                7       4 coil unipolar, 1 phase negative drive
                8       4 coil unipolar or 2 coil bipolar,
                        2 phase positive drive
                9       4 coil unipolar or 2 coil bipolar,
                        2 phase negative drive
                10      4 coil unipolar or 2 coil bipolar,
                        half-step positive drive
                11      4 coil unipolar or 2 coil bipolar,
                        half-step negative drive
```

TABLE 4—INDIVIDUAL OUTPUT COMMANDS

```
I channel state duration complement.duration cycles

channel = buffered channel number
                none    channel 0 assumed
                0 to 7  available channel selections

state   =       initial state of channel
                none    report state, duration, cycles remaining
                0       initial state to be 0 (logic low)
                1       initial state to be 1 (logic high)
                2       complement the current state

duration        =       duration for the initial state
                none or 0       duration of state is unlimited
                1 to 255        duration in 1 mS increments

comp.dur        = duration for the complement state
                none or 0       0 duration between cycles
                1 to 255        duration in 1 mS increments

cycles  = limit on the number of cycles
                none or 0       cycle without limit
                1 to 255        perform this number of cycles then stop
```

such as counting wheel rotations, motor-shaft rotation, or robot arm movements.

Experimenter's counters can run individually or simultaneously. The accumulated counts are reported on command, and can be set to do so either with or without stopping the counter. Take, for example, a raindrop detector that sends one pulse to the $T_{IN}0$ input for each drop of rain it counts.

The command "C 0 1" will start counting pulses on this input (and report an accumulated count of 0). By periodically issuing the command C 0 1, Experimenter will report the number of raindrops detected since its last command, reset the counter, and start counting anew.

Time measurements are taken and reported immediately. In an example taken from the upcoming ultrasonic "radar" project, the command C 0 11 initiates a measurement of the time interval from the transmission of an ultrasonic pulse output to the detection of its echo from a distant object.

The ultrasonic pulse transmission is indicated and marked by the rising edge of the pulse sent to $T_{IN}0$, and the returning echo is indicated by the rising edge of a pulse sent to $T_{IN}1$. The time measured between those two edges is reported and used by the computer to determine the distance to the distant objects with a resolution of about 0.010 inch.

The Experimenter measures pulse widths, pulse periods, or channel-to-channel times from 250 to 655,350 microseconds, with 10-microsecond resolution. If the Experimenter doesn't see a pulse within a reasonable (and selectable) length of time, it responds with a timer value of 0. This prevents the Experimenter from "hanging" if no pulses are detected.

Digital input/output

The Experimenter provides 24 bits of digital input or output. Digital input is useful for reading digitally encoded sensors. Digital output can be buffered to drive displays, or it can be interfaced directly to control a digital-to-analog converter. The DIGITAL-I/O command can also initiate outputs with controlled time durations. This function is especially useful for generating different timing-control signals.

Table 2 shows the details of the DIGITAL-I/O command. The digital I/O bits are configured as either input or output in two groups of 8 bits and two groups of 4 bits. To use the digital I/O, you must first write the desired mode to Port 3. The mode byte configures the ports as inputs and outputs. The sixteen different input/output configura-

TABLE 5—PWM COMMANDS

```
E channel width period

        channel = pulse-width-modulation output channel
                        none or 0       channel 0 is selected
                        1       channel 1 is selected

        width   = pulse-width setting
                        none    report current pulse width setting
                        0       always off (low)
                        1 to 254        variable pulse width
                        255     always on (high)

        period  = set the period of the PWM pulse
                        none    use previously assigned value, default 0
                        0 to 255        Frequency = 7372800/(510*(1+period)) Hz
```

TABLE 6—RELAY COMMANDS

```
F relay.number state

        relay.num       = since there is only one relay on this version of
                the Experimenter, the relay number is ignored.

        state   = reads or sets the relay's state
                        none    report the relay's current state
                        0       relay coil off
                        1       relay coil on
                        2       toggle the relay's state
```

TABLE 7—GENERAL COMMANDS

```
G select off/on

        select  = selects the information or control function:
                        none or 0       manual (default) / computer control mode
                        1       echo typing
                        2       append a <lf> after each <cr>
                        3       append a 0 to timer measurements

        off/on  = disable or enable the selection
                        none or 0       turn the selection off
                        1       turn the selection on
```

tions are listed in Table 2.

To read a digital input, use the DIGITAL-I/O command with only the port-number parameter. The Experimenter will read the specified port and return a number from 0 to 255. The mode byte can only be written, and cannot be read.

To write to a digital output, use the DIGITAL-I/O command with both port number and output value parameters. The output value, from 0 to 255, will appear on the selected port.

The Experimenter also has a built-in timer on its output ports. Up to three different output values can be specified, with time durations ranging from 1 to 65,535 milliseconds between them. The first output value will appear on the port for the duration specified, then the second output value will appear on that port, and the progression will be continued. The last output value will remain on the port until a new DIGITAL-I/O command is issued.

Driver commands

As shown in the schematic, the eight timer-driven outputs (T_{OUT} 0–7) are buffered for high-power applications (DRIVER A, 0–3 and DRIVER B, 4–7). The pulse-width modulators can control the duty cycle of the drivers. The drivers themselves can be controlled in a variety of ways with the H-BRIDGE and INDIVIDUAL-OUTPUT commands. Two commands are provided to make it easier for you to use these outputs for different applications.

Power-on default for all outputs is high (logic 1), with all outputs enabled by the pulse-width modulators. The ENABLE-PWM command controls the PWM's. When controlling a DC motor, the H-BRIDGE command can also adjust a pulse-width modulator.

The H-BRIDGE command combines the four channels on each driver to control either one stepper motor or two DC motors. Experimenter includes two driver IC's (IC7 and IC8), so two stepper motors or four DC motors can be driven. The H-BRIDGE command permits the driving of 12 different DC and stepper motors. This includes all of the readily available commercial stepper motors and permanent-magnet brush-type DC motors. Table 3 lists the parameters for this command.

Stepper motor operation can be educational and a lot of fun. These motors are easily adapted for building computer-controlled mechanical gadgets that require precise position and speed control. A stepper motor is included in the forthcoming ultrasonic "radar" project.

Consider the example of a two-coil bipolar stepper motor. It can be connected to DRIVER A 0 to 3. A suitable power supply must be provided for the A+ and GND inputs. The stepper motor can be run in full steps or in half steps. Half stepping permits the greatest precision in object movement. (It gives the greatest angular resolution.) Table 3 shows half-stepping as drive type 10.

The command "H 0 1 100 50 10" will cause the stepper motor on DRIVER A (0) to move in the forward direction (1), for 100 half-steps; each half-step takes 50 milliseconds with a type-10 drive pattern. The command H 0 2 100, commands the motor to rotate in the reverse direction (2) for 100 half steps. Experimenter's memory remembers the step duration and drive type data presented to it earlier.

The INDIVIDUAL-OUTPUT command creates a single pulse, specific number of pulses, or a continuous stream of pulses on any of the eight timed outputs. This is a useful output for many testing and control applications.

Table 4 shows the parameters for the INDIVIDUAL-OUTPUT command. For each channel, you can specify an initial state, the duration that the channel should remain in that state, the duration that the channel should remain in the complement state, and the number of cycles that should be repeated. For example, the command "I 6

1 10 50 200" will produce pulses on output 6, starting with a logic 1 for 10 milliseconds, then logic 0 for 50 milliseconds, repeating the cycle for 200 pulses.

To read the status of an INDIVIDUAL-OUTPUT command, issue the command with only the channel parameter. The Experimenter will respond with three numbers: the current state of the channel, the remaining duration of the current state, and the number of cycles remaining to be output.

The INDIVIDUAL-OUTPUT command is usually limited to creating pulses of 255 milliseconds. Here is a clever way of getting longer time durations: When the complement-duration is 0, the total duration of the output pulse will be the duration multiplied by the number of cycles. Thus a pulse of up to 65.025 seconds (255 ms × 255) can be made.

The H-BRIDGE and INDIVIDUAL-OUTPUT commands share the same output drivers. Any command that affects outputs in use by another command will cancel that other command. For example, if an H-BRIDGE command is given, any INDIVIDUAL-OUTPUT commands using that four-bit data group will be canceled.

The ENABLE-PWM command lets you set duty cycle and frequency for the pulse-width modulators. Table 5 lists the parameters for this command. The power-on default is always on (logic 1). When DC motors are driven, unwanted resonances can occur between the PWM drive frequency and the rotation frequency of the motor. That situation can cause rough motor rotation. With the ENABLE-PWM command, the PWM drive frequency can be changed to obtain smoother DC motor operation. The frequency is adjustable from about 56 Hz to about 14 kHz.

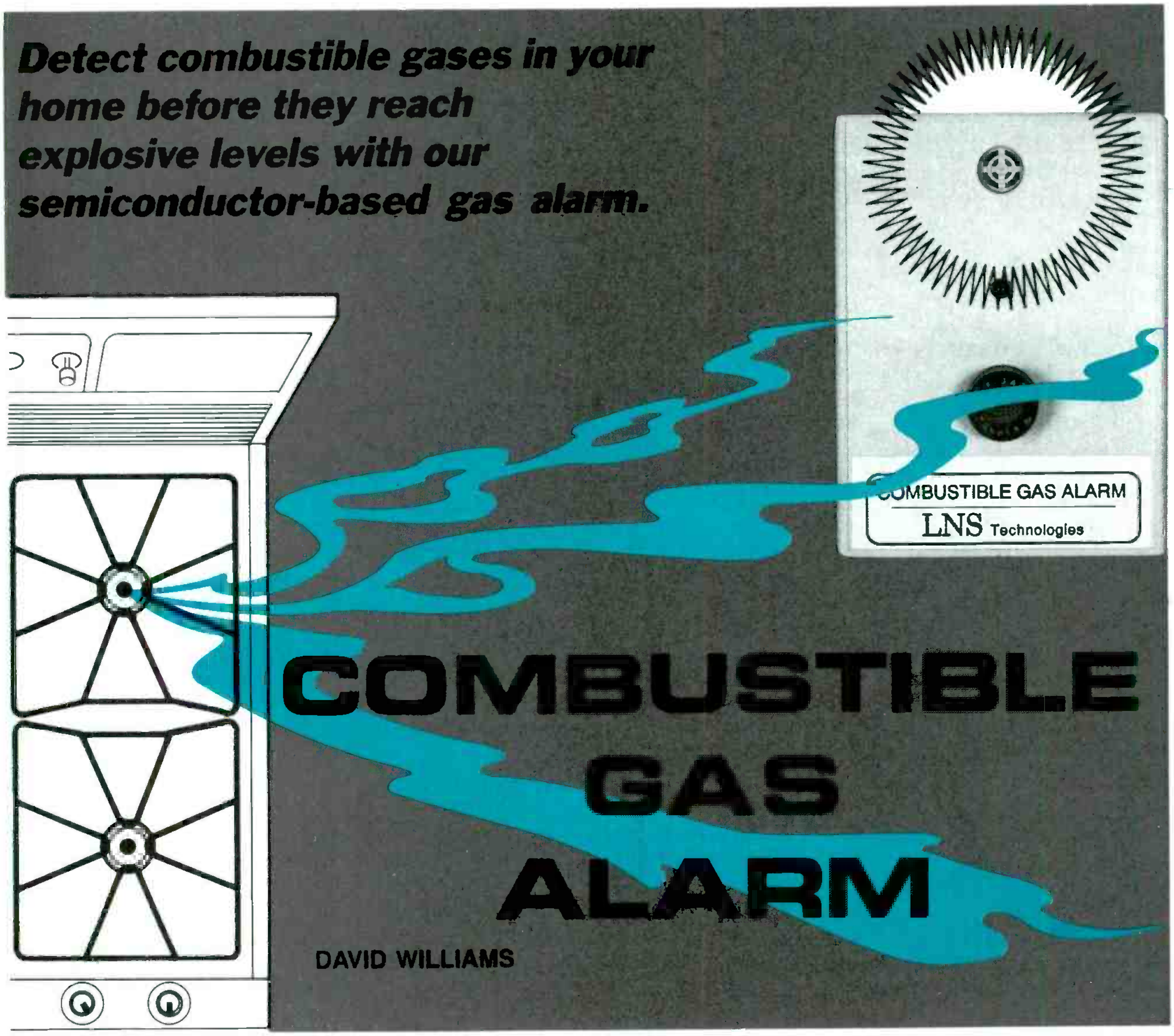
Other commands

The FLIP-RELAY command lets you to set, reset, or toggle the single-pole, double-throw relay, and to read and report the relay's state. The relay is useful for controlling large currents, such as those needed to drive large motors, actuate alarm horns, or provide system power. The format for the FLIP-RELAY command is shown in Table 6.

One final command, GENERAL-INFORMATION/CONTROL, is shown in Table 7. General information about the Experimenter is reported and special functions are controlled. The special functions control data formatting to make Experimenter's communications more readable. Manual-mode defaults enable those functions, while computer control-mode defaults disable them for more efficient communication.

Next Month

That's it as far as Experimenter operating theory and commands are concerned. Unfortunately you'll have to wait until next month to we build and test the board. We will also provide the foil patterns at that time. In the meantime you can begin to acquire parts for the project. Ω



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Theory of operation

The gas alarm is based on a semiconductor sensor element, shown in Fig. 1, that undergoes a change of resistance when exposed to gases that have an affinity for oxygen. Gases with that property are known as *reducing gases* and they include methane, butane, propane, and carbon monoxide. The sensor is composed mainly of tin dioxide on a ceramic base; it includes an internal heater coil which maintains the semiconductor at a constant temperature.

In normal air, and at a fixed temperature, the sensor is designed to absorb oxygen at a constant rate. Because the conductivity of the tin dioxide is related to the rate of oxygen absorption, it is also a constant in normal air. However, in the presence of a reducing gas, the sensor's internal resistance decreases in proportion to the gas-concentration level. By converting the sensor's resistance change to a DC voltage, the circuit can detect specific gas concentrations and trigger an alarm before the concentration reaches a dangerous level.

The circuit

The sensor is labelled SEN1 in the gas-alarm schematic of Fig. 2. The 9-volts DC from wall transformer T1 is regulated to 5 volts by an LM2940 regulator, IC3. Capacitors C1 and C2 provide filtering and stability to the regulator. The 5-volt output from IC3 is connected to the heater coil of SEN1 at pins 2 and

5. The sensor's internal resistance element is connected in series with resistor R1 to form a voltage-divider circuit. Note that R1 is a calibrated resistor that has been specifically matched to each gas sensor by the manufacturer and is included with the purchase of each sensor. Do not substitute any other resistor for R1 or the alarm trip point will be incorrect.

The SEN1/R1 combination results in 2.5 volts across R1 in the presence of approximately 5,000 parts per million (ppm) of methane gas at a temperature of 20 degrees Celsius. That concentration level represents 1/10 the level at which methane becomes explosive in air. The trigger point is low enough to provide advanced warning of a natural gas leak, yet is high enough to avoid false alarms from common home vapors such as hair sprays or cooking fumes.

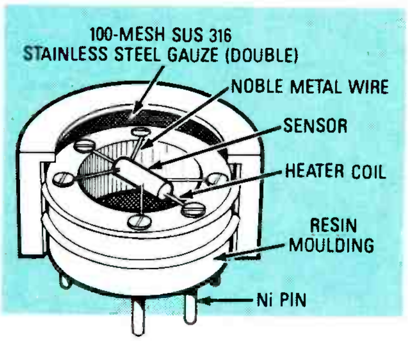


FIG. 1—THE GAS SENSOR is mainly composed of tin dioxide on a ceramic base; the resistance of the sensor varies depending on the concentration of reducing gases in the air.

The output voltage from the SEN1/R1 divider goes to the positive input (pin 2) of an LM311 comparator (IC1). The negative input (pin 3) is set to a reference voltage determined by R2, R3, R4, and thermistor R8. Those components provide a 2.5-volt reference voltage at room temperature. Because SEN1's gas detection is based on the principle of chemical adsorption, its output voltage is affected by humidity and temperature changes, and that can cause variations in the alarm trip point. Therefore, a negative temperature coefficient (NTC) thermistor (R8) is used to effectively adjust the threshold voltage to compensate for those variations.

In the presence of a reducing gas, the resistance of SEN1 will drop and the voltage at pin 2 of IC1 will rise. When it reaches 2.5 volts or greater, the output of IC1 will turn on transistor Q2 which will in turn activate the buzzer, BZ1. Resistor R5 provides some hysteresis to IC1 and capacitors C5 and C6 provide noise filtering on the comparator inputs.

A flashing light-emitting diode (LED1) indicates that the sensor is operating with the correct supply voltage. An LM3909 low-power LED flasher (IC2) uses C3 to set the flash rate at approximately 1 hertz. A DS1233 voltage detector (IC4) monitors the 5-volt output from IC3. If the output falls below 4.75 volts, the DS1233 will turn off transistor Q1, which in turn will turn off IC2 and the LED.

A 9-volt battery (B1) and blocking-diode (D2) provide battery-backup operation for short power outages. The LM2940 is a low-dropout regulator that will give a regulated output with input voltages as low as 5.8 volts. (A normal regulator works properly only when the input voltage is above 7.5 volts.) Therefore, the LM2940 regulator allows for longer backup times as the battery voltage drops. The gas alarm draws approximately 170 milliamps during operation; that relatively high current draw is due to the heater element in SEN1. A fresh 9-volt alkaline battery will provide slightly over an hour of backup operation. If you want longer backup operation, you must replace B1 with a higher-capacity external nickel-cadmium or lead-acid battery.

Construction

The easiest way to build the gas alarm is with a PC board. Artwork is provided here; etched and drilled boards can be purchased from the source

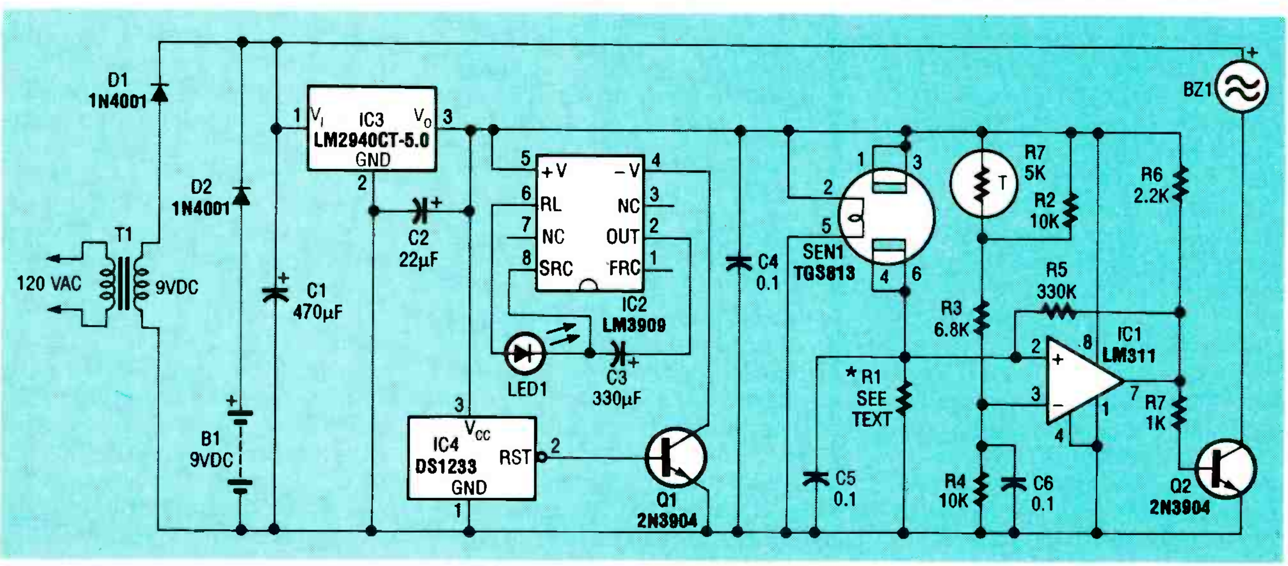


FIG. 2—THE SENSOR'S RESISTANCE ELEMENT is connected in series with resistor R1 to form a voltage-divider circuit; R1 is specifically matched to each gas sensor by the manufacturer.

PARTS LIST

All resistors are ¼-watt, 5%
R1—Calibration resistor, included with sensor (see text)
R2, R4—10,000 ohms
R3—6800 ohms
R5, R6—330,000 ohms
R7—1000 ohms
R8—5000-ohm thermistor
Capacitors
C1—470 µF, 16 volts, electrolytic
C2—22 µF, 10 volts, electrolytic
C3—330 µF, 6 volts, electrolytic
C4–C6—0.1 µF, ceramic
Semiconductors
IC1—LM311 voltage comparator
IC2—LM3909 LED flasher
IC3—LM2940CT-5.0 (or 7805T) voltage regulator
IC4—DS1233 power monitor
Q1—2N3904 NPN transistor
D1, D2—1N4001 diode
SEN1–TGS813C gas sensor (Figaro)
Other components
B1—9-volt battery
T1—9-volt DC, 300 mA wall transformer
BZ1—12-volt DC buzzer
Miscellaneous: PC board, 9-volt battery connector, enclosure (SERPAC #231-I, or similar), hardware, two 8-pin IC sockets, wire, solder
Note: The following items are available from LNS Technologies, 20993 Foothill Blvd, Suite 307R, Hayward, CA 94541-1511 (510) 886-9296:
- **SEN1 gas sensor, 6-pin socket, and calibration resistor (R1)—$24.00**
- **Complete kit of parts for the gas alarm, including PC board, all parts, and plastic enclosure—$49.00**

Please add $5.00 S&H to all orders. California residents must add local sales tax. MC/VISA orders accepted.

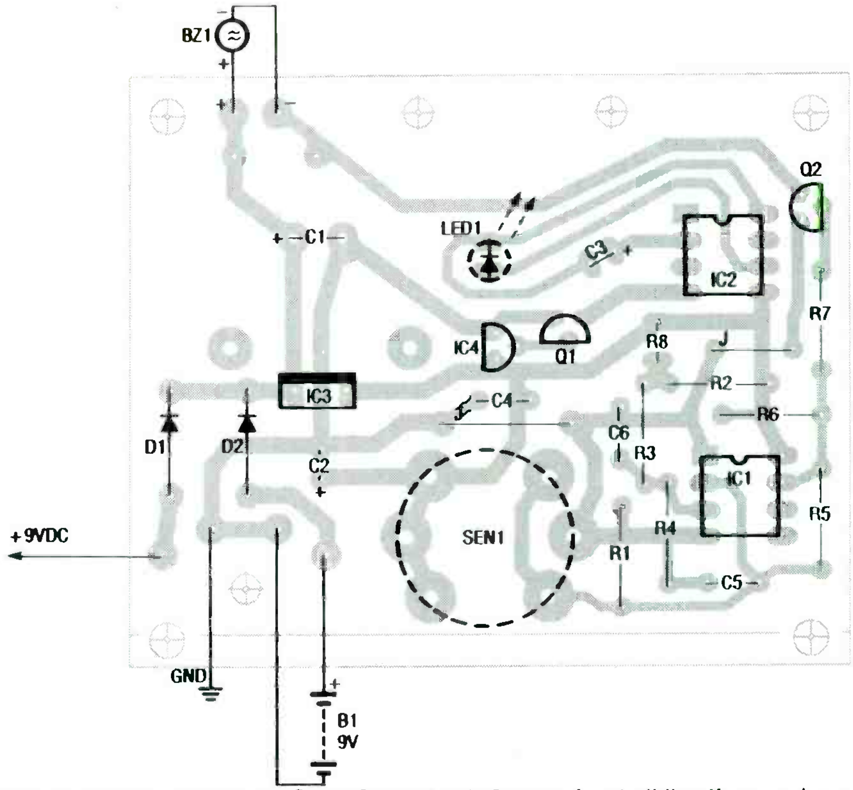
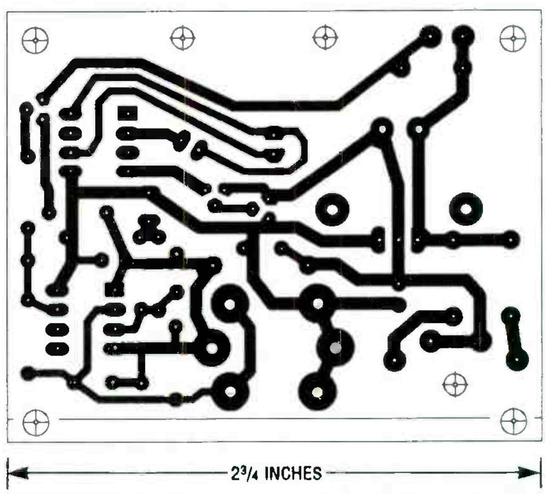


FIG. 3—FOLLOW THIS PARTS-PLACEMENT DIAGRAM when building the gas alarm. Install two wire jumpers at the locations marked "J."



FOIL PATTERN for the gas alarm.

mentioned in the Parts List. Figure 3 is the parts-placement diagram.

Two wire jumpers must be installed on the PC board at the locations marked "J." Next, install resistors R1 through R6. Note that the calibration resistor (R1) has a solid gray body with no color bands. Install diodes D1 and D2, paying close attention to their polarity.

Sockets are recommended for IC1 and IC2, and they can be installed now. (Don't insert the IC's yet.) Next install ceramic capacitors C4, C5, and C6, and thermistor R8. The voltage monitor (IC4) and the transistors (Q1 and Q2) look very similar, so pay careful attention to their identity, and to their orientation. Install electrolytic capacitors C1, C2, and C3, and the voltage-regulator IC3.

Note that LED1 and SEN1 (both shown with dashed outlines) are mounted on the foil side of the circuit board. That arrangement allows the parts to

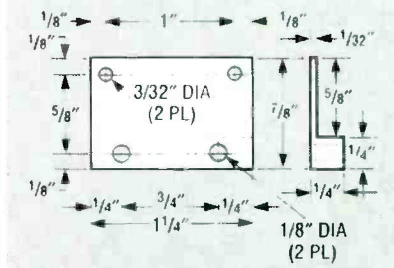


FIG. 4—IF YOU USE THE SAME CASE as the prototype, the buzzer must be mounted to the PC board with this metal bracket.

fit through openings in the top cover of the plastic enclosure.

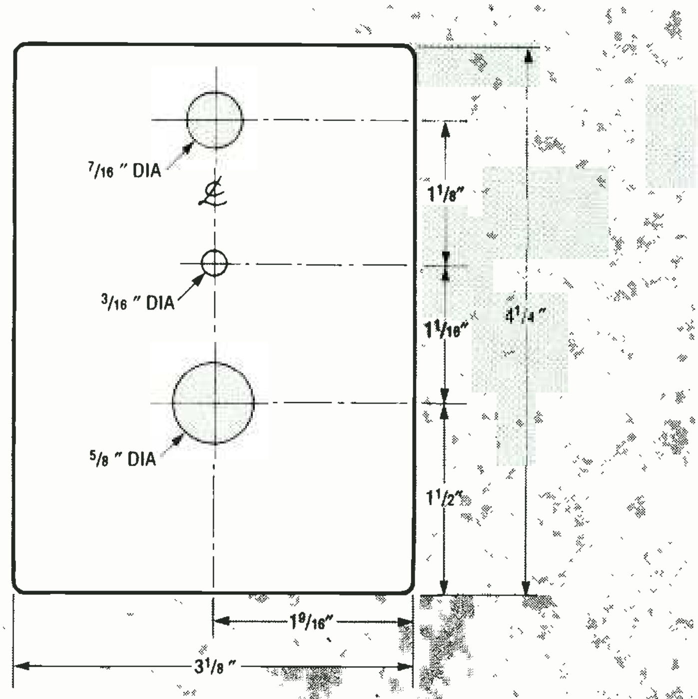


FIG. 5—THE TOP COVER of the case must be drilled as shown here to accommodate the LED, the gas-sensor socket, and the buzzer.

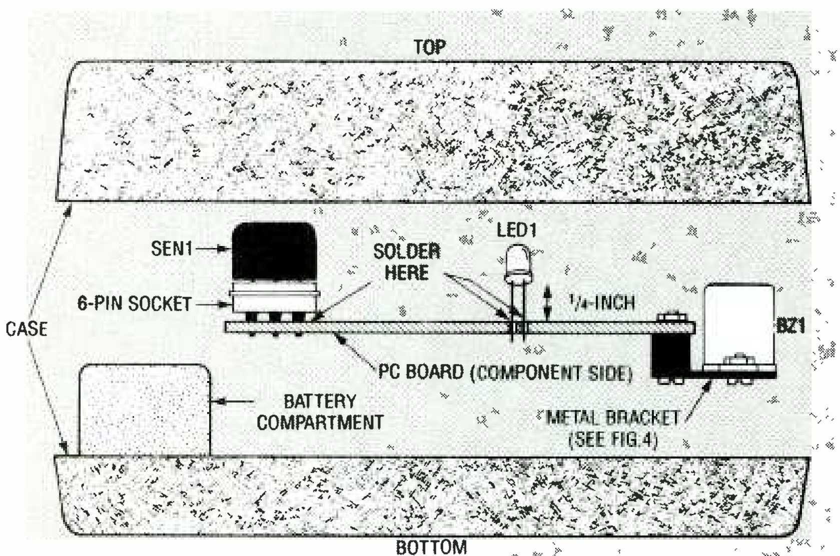


FIG. 6—THE FINAL ASSEMBLY fits into the plastic enclosure as shown here. The PC board should lie flat against the four plastic standoffs.

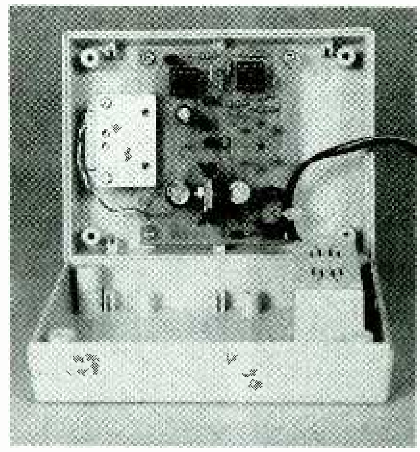


FIG. 7—A FINISHED UNIT looks like this inside. The board is held in place with four self-tapping screws.

When soldering the LED to the foil side of the PC board, make sure that its bottom edge is ¼-inch from the board. The sensor has a 6-pin socket that should be installed on the foil side of the board.

Next attach the wires for the battery connector, making sure that the red wire goes to the positive pad. It is also necessary to observe the correct polarity when attaching the wires from the 9-volt DC wall transformer T1. You can check the output of T1 with a DC voltmeter to determine which wire is positive if you're not sure. Then unplug the transformer and solder the wires in the proper locations.

The last step is to attach the buzzer to the PC board with a metal bracket and screws (included in the kit). The bracket is necessary only if you are using the same case that is supplied in the kit. Figure 4 shows the dimensions of the bracket in case you have to make one. Otherwise you can mount the buzzer anywhere off-board, or hot-melt glue the buzzer in place.

Final assembly

If you use the same enclosure as the prototype, drill the three holes in the top cover as shown in Figure 5. (Note that the case included with the kit comes pre-drilled.) Figure 6 shows how the buzzer mounts to the metal bracket and how the final assembly fits into the plastic enclosure. Be sure to solder the two wires from the buzzer to the locations shown in Fig. 3. Position the PC board so that the LED, the gas-sensor socket, and the buzzer can be seen through the holes in the top of enclosure. (The sensor should not be in its socket yet.) The PC board should lie flat against the four plastic standoffs in the case, and held in place with four #4 × ¼-inch self-tapping screws. Figure 7 shows the inside of the prototype.

Cut or file a slot in the bottom edge of the case for the transformer wires to fit through when the case is closed. Screw the two halves of the enclosure together with the four remaining screws.

Operation

Plug the gas sensor into its socket (polarity is unimportant), and plug the wall transformer into an AC outlet. The red LED should flash to show that the unit is powered up.

continued on page 93

PRECISION DIGITAL SCALE

AN EASY-TO-READ PRECISE SCALE with a liquid crystal display (LCD) will permit you to put the right postage on your letters and packages, carry out experiments that require precise measurements, and maybe even improve your cooking because you'll be able to measure just the right amount of ingredients. Now you can build your own solid-state electronic scale and make measurements in grams and ounces with ounce accuracies to hundredths of an ounce.

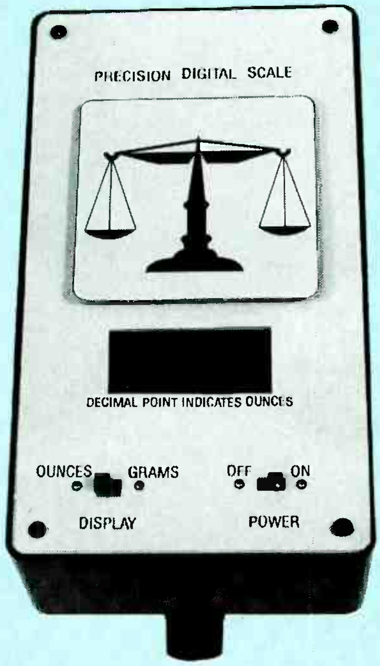
This small, light, and easy-to-build digital scale is completely portable. It is based on a sophisticated component called a *load cell* and it includes a monolithic analog-to-digital converter. The load cell for the prototype described here was selected to give readings up to 19.99 ounces in increments of 0.01 ounce and readings up to 600 grams in increments of 1 gram, a fairly wide range for a desktop scale.

The accuracy and resolution of this digital scale are far greater than are needed for weighing letters and packages to determine their postage. It has all of the performance needed to make it suitable as a high school or college science lab measuring instrument. It will also be a valuable tool for the chemist, the biologist or other scientists. Its accuracy and resolution will be appreciated by hobbyists, experimenters, gourmet chefs, and just about anybody who needs to weigh things precisely.

Front-panel switches permit the selection of either OUNCE or GRAM modes. Weight is shown on a large 3½-digit LCD with ½-inch high characters. The scale features automatic decimal-point placement when it is operated in the its OUNCE mode.

The scale can also provide *tare* weight, the weight of a container deducted from the total weight to yield the weight of the contents of a container. The scale automatically offsets the reading by an amount equal to the weight of the container. This form of measurement is especially useful if you want to weigh a large number of small objects that must be contained in a cup or dish.

Two standard 9-volt alkaline transistor batteries power the scale for many months of intermittent use. A built-in battery-monitoring circuit automatically displays a low-battery (BAT) legend when the batteries must be replaced.



Build this electronic scale and weigh objects precisely in the 0 to 1.3 pounds (0 to 600 grams) range.

ANTHONY J. CARISTI

How does it work?

Figure 1 is a simplified functional block diagram of the scale. It consists of a precision platform load cell, followed by an instrumentation amplifier (consisting of two differential input operational amplifiers), which increases the relatively low output voltage generated by the load cell when a weight is placed on the scale platform. An analog-to-digital converter converts the amplifier's analog output voltage to digitally coded signals that drive the 3½-digit LCD.

Figure 2 is the schematic for the electronic scale. It is is powered by a pair of standard 9-volt alkaline transistor batteries connected in series to produce 18 volts. The MC78L10 fixed voltage regulator IC1 provides a stable 10-volt output to power the circuit. The two batteries in series have sufficient capacity to ensure the scale's accuracy stability even as the batteries terminal voltages decline. Internal circuitry determines when the voltage has dropped to the threshold level and a low battery indication is presented on the display.

Load cell

Figure 3 is a simplified schematic of the load cell, the key component in the scale. It contains four variable resistive strain-gauge elements that are connected as a Wheatstone bridge, powered by the regulated 10-volt supply. The four color-coded wires are brought out of the load cell assembly in a shielded cable.

When the cell is at rest (no weight applied) the values of all four resistors are equal, and the bridge is balanced. As a result, the differential output voltage of the bridge, taken between the blue and green wires, is essentially zero. However, even without a weight on the scale, there can be some residual offset of the load cell that shows up on the LCD display because of the

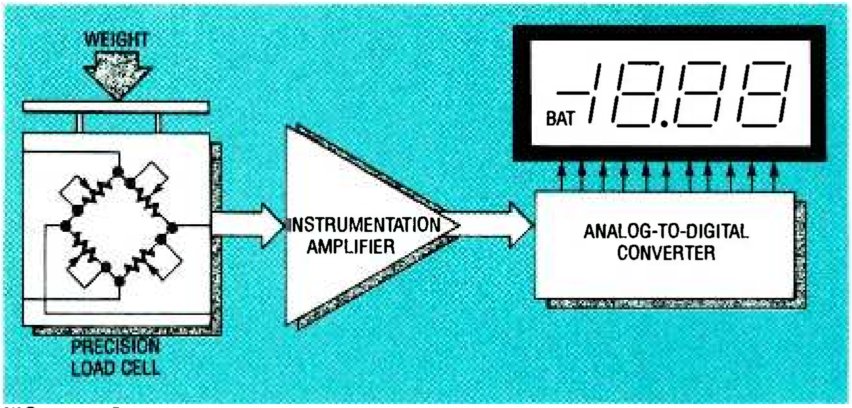


FIG. 1—BLOCK DIAGRAM OF ELECTRONIC SCALE WITH LOAD CELL: Controls permit measurements in ounces or grams.

weight of the scale's load platform. Moreover, the load cell itself might have some built-in zero offset due to minor manufacturing imperfections.

The total voltage offset of the bridge circuit, including the effect of the platform weight and a container, can be cancelled out by with zero-adjust potentiometer R11 in the LM324N instrumentation amplifier circuit. It can be adjusted with a control knob mounted on the front of the case. The same control can null out the effect of an empty container placed on the scale platform for tare measurements when needed.

When a true weight is placed on the scale, two of the resistors in the Wheatstone bridge circuit increase in value while the other two decrease in value. This unbalances the bridge, generating an output voltage. Full-scale (1.3 pounds/600 grams) output voltage of the load cell is 10 millivolts.

The prototype scale was designed to measure weights that are generally less than 1 pound (0.453 kg), but the upper limit of the load cell can be exceeded under certain conditions that will be discussed later.

Scale circuitry

Refer to the schematic in Fig. 2 and see that sections a and b of IC2, a quad differential-input operational amplifier, form a differential instrumentation amplifier. This circuit amplifies the output voltage of the load-cell bridge circuit and provides a differential output voltage that is sent to analog input pins 30 and 31 of IC4, an ICL7106 analog-to-digital converter.

The gain of the differential amplifier is determined by the values of resistors R4 through R9, and is about 48. A feedback network composed of potentiometer R4 and resistor R5 allow circuit gain to be adjusted to compensate for variations in load cells.

Operational amplifier IC2-c is essentially a voltage follower that is driven by the green output wire of the load cell. The output of this op-amp section feeds the negative differential input of IC4, the A/D converter. The 100-ohm feedback resistor R14 permits the voltage-follower circuit to add a zero offset to the output of op-amp IC2-c from the control potentiometer R11 so that the LCD will show zero when no weight is on the scale.

The 3½-digit A/D converter IC4 contains the necessary circuitry to drive the LCD. This IC includes seven-segment decoders, display drivers, a clock, and the backplane square-wave signal generator.

The differential analog input voltage required for a full- scale display of 1999, applied between pins 30 and 31 of IC4, is twice the reference voltage fed between pins 35 and 36. That voltage is provided by the 10-volt regulated supply discussed earlier and a voltage divider consisting of resistors R16, R17, R18, R19, and R20. When the scale is operated in its OUNCE mode, R18 and R19 are shorted out by front panel switch S2-b. The reference voltage fed to pins 35 and 36 of IC4 then has a fixed value of 0.232 volts.

When the scale is in the GRAMS mode, the reference voltage is increased to about 0.817 volts as S2-b is opened. This increase in reference voltage causes the display reading to decrease in magnitude by a factor of 3.52, which is the conversion of the full scale display of 1999 ounces (neglecting the decimal point) to 566.7 grams. When in the GRAMS mode, the display permits weight readings greater than 567 grams. Up to 1800 grams (1.8 kilograms can be handled by the load cell on that scale without damaging it.

Section d of EXCLUSIVE OR gate IC3 provides the decimal point in the OUNCES mode. An EXCLUSIVE OR gate produces a high logic output only when the logic levels fed to the input terminals oppose each other.

Section d of IC3 is connected as a conditional inverter. The backplane signal generated by IC4 is fed to input pin 12 of IC3-d, while the logic level fed to pin 13 is either 0 or 1 as determined by switch S2-a. When operating in the OUNCES mode, the positive voltage at pin 13 makes the output at pin 11 the inverse of the backplane signal. This is the requirement for actuation of any LCD segment.

The inverted backplane signal, fed to pin 12 of the LCD, causes the decimal point to be activated in the OUNCES mode. When S2-a is set to GRAMS, the backplane signal is not inverted; this removes the decimal point.

Section d of IC2 functions as a voltage comparator (it has no feedback resistor) to warn the user when the battery is near the end of its service life and must be replaced. The positive input of the comparator is connected to the 10- volt regulated bus. The negative input is connected to the output of a voltage divider made up of resistors R1 and R2.

When the battery terminal voltage is above 12 volts, the output of the comparator remains low. However, when the battery is almost depleted, its terminal voltage falls below 12

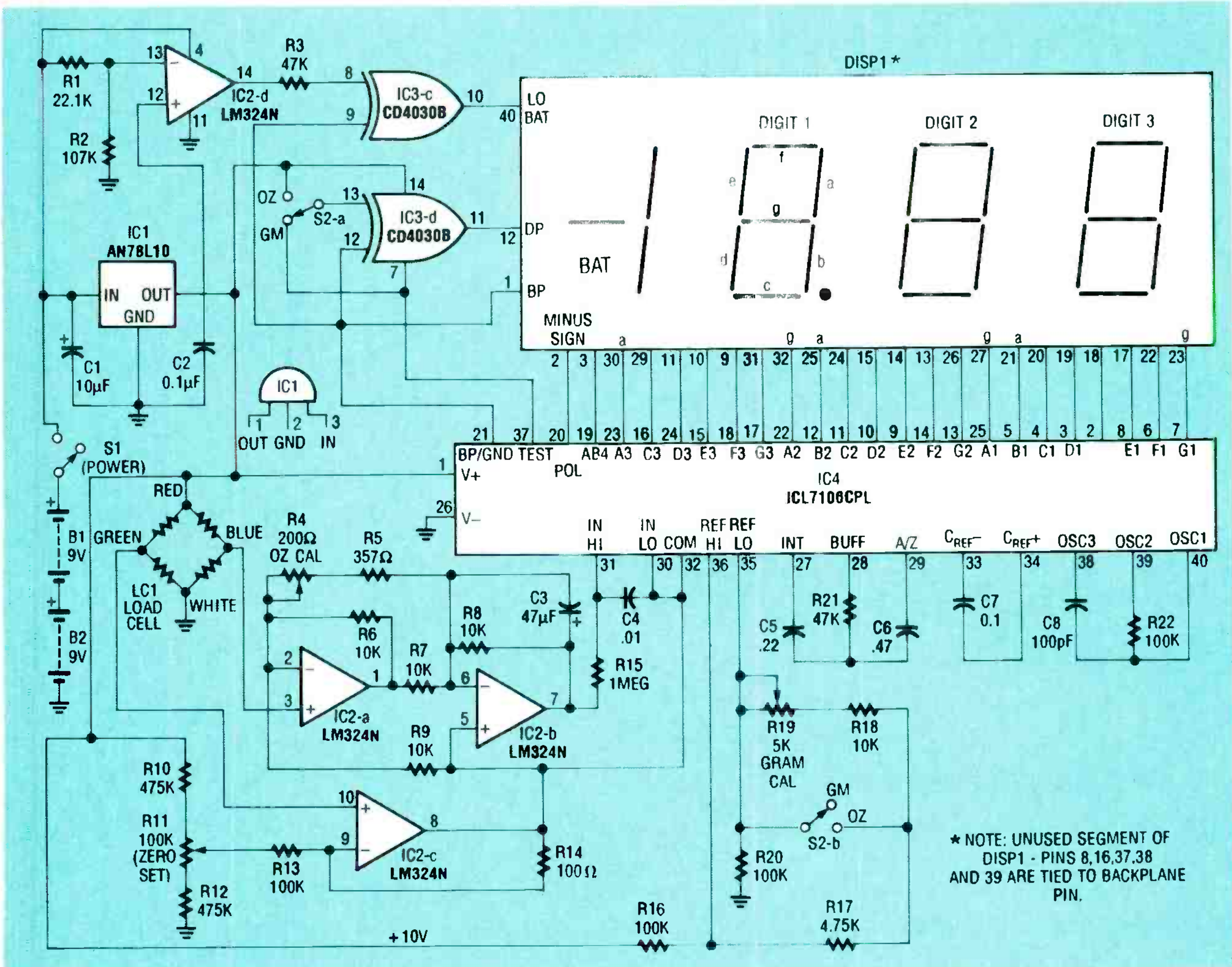


FIG. 2—SCHEMATIC DIAGRAM OF THE ELECTRONIC SCALE: Components are on main circuit and display boards. The off-board controls are on the front panel and case.

volts, and the output of the comparator goes high.

Section c of IC3 functions as a conditional inverter in a manner that is similar to IC3-d. When the output of comparator IC2-d goes high with falling battery voltage, IC3-c inverts the backplane signal fed to pin 9 of IC3-c. This in turn is fed to the "BAT" segment of the LCD, displaying it when the batteries need replacement.

Building the scale

Building this scale calls for both circuit board assembly and discrtete point-to-point wiring as well as mechanical fabrication. The electronic components are inserted and soldered to two circuit boards and later those boards are interconnected by wires and assembled in a stack to the front panel.

The project also calls for drilling and forming holes in the aluminum case cover and plastic project case. A rigid base is required for mounting the load cell inside the case to take full benefit of the load cell's performance. A suitable platform must also be provided for the scale. The wiring between circuit boards and from the circuit boards to the panel-mounted controls should be done only after the mechanical work is complete. The electronics assembly is discussed here first.

The electronic circuitry is on two printed-circuit boards: main and display. The full-scale foil patterns defining the copper laminated circuit conductors (solder side) for both boards are included here if you want to make your own boards. Alternatively you can purchase them

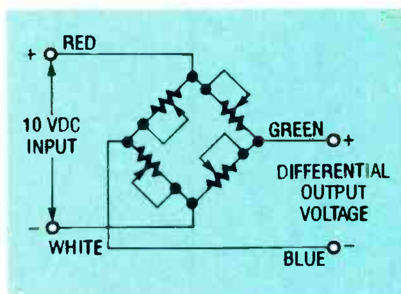


FIG. 3—SCHEMATIC FOR LOAD CELL. The cell in this scale is rated for 1.3 pounds or 600 grams.

from the source listed in the Parts List. There are no critical component arrangements in the circuitry, so it can also be made by point-to-point wiring on perforated phenolic board.

Figure 4 is the parts placement diagram for the main circuit board. Observe the correct polarity of all polarized components when inserting them in the board. Sockets are recommended for all DIP-packaged in-

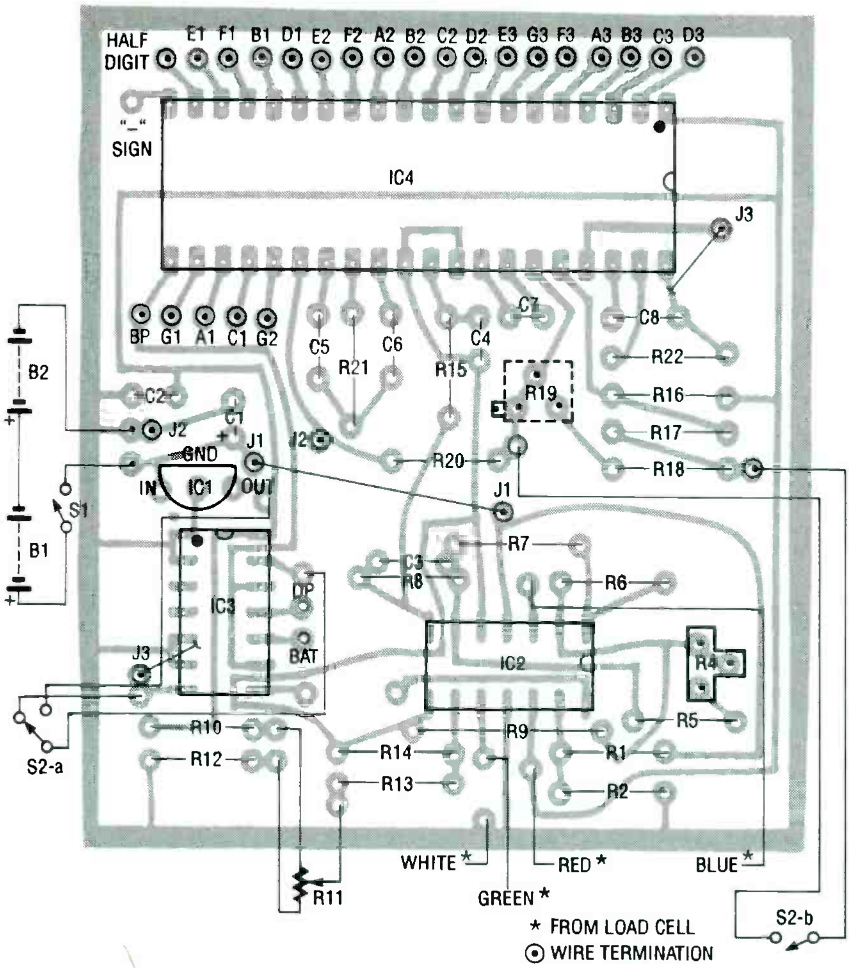
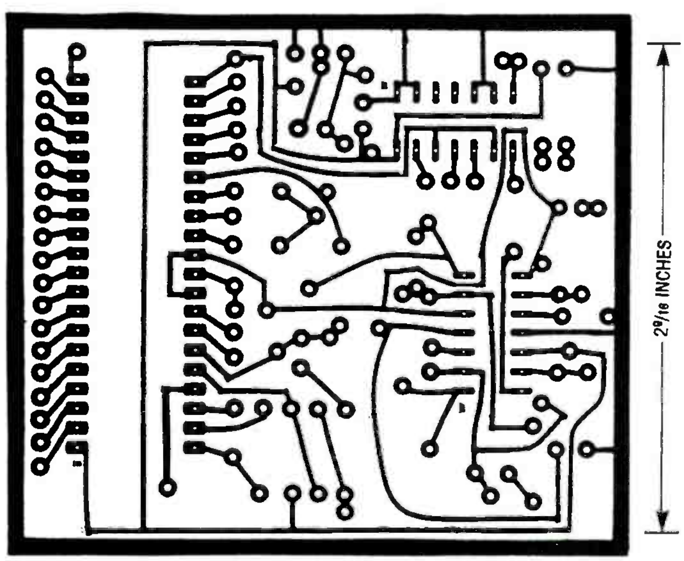


FIG. 4—PARTS ASSEMBLY DIAGRAM for the main circuit board of the electronic scale.



FOIL PATTERN FOR MAIN CIRCUIT BOARD.

tegrated circuits to permit them to be removed easily in the event of a malfunction, or to simplify troubleshooting and repair, should they ever be necessary.

The Parts List specifies most of the resistors as 1% metal-film units for the analog circuitry. The stability of the circuit will depend on those tight tolerance values. Do not substitute carbon-film resistors because they are unstable with respect to ambient temperature changes.

PARTS LIST

All resistors are ¼-watt, 1%, metal film, unless otherwise specified.

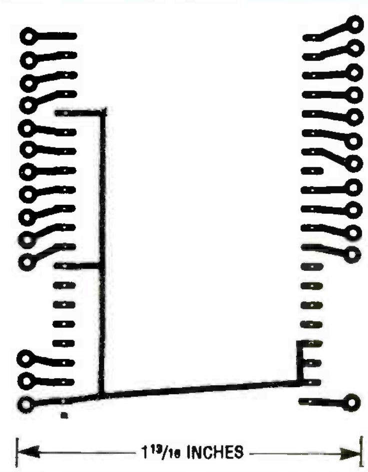
R1—22,100 ohms
R2—107,000 ohms
R3, R21—47,000 ohms, 1/4-watt carbon resistor
R4—200 ohms, cermet potentiometer, PC mount
R5—357 ohms
R6, R7, R8, R9, R18—10,000 ohms
R10, R12—475,000 ohms (See text)
R11—100,000 ohms potentiometer, panel-mount
R13, R16, R20—100,000 ohms
R14—100 ohms
R15—1 megohm, 1/4-watt, carbon composition
R17—4,750,000 ohms
R19—5 megohm cermet potentiometer, PC mount
R22—10,000 ohms, 1/4-watt, carbon

Capacitors

C1—10µF, 25-volt, radial-leaded electrolytic
C2, C7—0.1µF, 50-volt ceramic disc
C3—4.7µF, 25-volt radial-leaded electrolytic
C4—0.01µF, 50-volt ceramic disk
C5—0.22µF, 50-volt metal-film
C6—0.47µF, 50-volt metal-film
C8 100 pF. 50-volt ceramic disk

Semiconductors

LC1—Load Cell Model C2G1 (1.3-pound/600-gram) NMB Technologies, Inc., Chatsworth, CA 91311 (see text)
IC1—AN78L10, fixed 10-volt regulator, Motorola or equivalent
IC2—LM324N quad operational amplifier, Motorola or equivalent
IC3—CD4030B quad two-input exclusive OR, Harris or equivalent



FOIL PATTERN FOR LCD-DISPLAY BOARD.

IC4—ICL7106CPL, analog-to-digital converter, Harris or equivalent

Other components

B1, B2–9 volt alkaline transistor radio batteries

DISP1—3½-digit LCD display, Digikey LCD002 or equivalent

Miscellaneous: two circuit boards: main and display, project plastic case with aluminum cover (see text), IC sockets for all DIP ICs and display (see text), battery clips, project case with cover (see text), baseplate for mounting load cell LC1 (see text), three-inch square micarta or phenolic platform, four 3-mm screws, sets of standard screws, nuts and, spacers as required, flat washers with ½-inch I.D.(see text), stranded insulated hookup wire in a variety of colors, solder wire, and solder wicking.

Note: The following parts are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463:

- **Etched and drilled set of two PC boards—$19.95**
- **LC1—load cell, 1.3 lb/600 gm—$71.50**
- **IC1—AN78L10, 10-volt regulator—$2.00**
- **IC2—LM324N quad operational amplifier— $2.00**
- **IC3—CD4030B quad two-input exclusive OR— $2.00**
- **IC4—ICL7106CPL, analog-to-digital converter—$15.75**
- **DISP1—3½-digit LCD display —$11.75**
- **Set of 15 metal-film resistors—$8.00**

Please add $5.00 postage and handling. New Jersey residents please add 6% sales tax.

Figure 4 shows the three jumper wires needed to complete the circuit. These are: pin 4 of IC2 to the plus side of capacitor C1 (JU1); pin 26 of IC4 to the minus side of capacitor C1 (JU2); and pin 37 of IC4 to pin 7 of IC3 (JU3). The jumpers should be made from standard insulated hookup wire (24 to 28 AWG) inserted on the component side of the board with care taken in their placement so they do not interfere with the insertion of other components.

When all the components have been soldered to the boards, inspect all soldered joints for open circuits, short circuits or "bridging," and cold solder joints, which will appear as dull blobs of solder without smooth fillets.

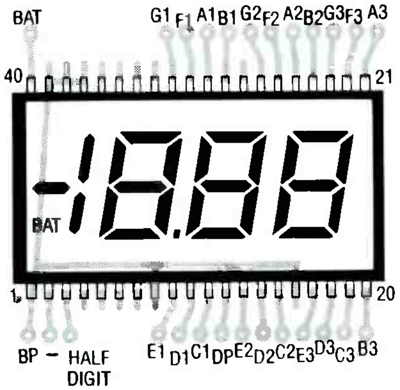


FIG. 5—LCD CIRCUIT-BOARD assembly. Wires connect the pins of the LCD module to the main circuit board.

If any of those faults are located, remove the solder by reheating the joints with a soldering pencil and applying a desoldering wick. Then resolder the joints and trim any excess lead lengths close to the board.

Carefully insert IC2, IC3, and IC4 in their sockets. Be sure they are properly oriented in accordance with the reference notches shown Figs. 4 and 5. Check to see that all pins fit securely in their sockets and that none has been accidentally bent under a DIP.

The glass-covered, 40-pin LCD DIP module is fragile and must be handled carefully. Figure 5 shows how the LCD DIP is located on the display circuit board. Be sure that the key pins (1, 20, 21 and 40) are located as shown. Figure 5 also gives the

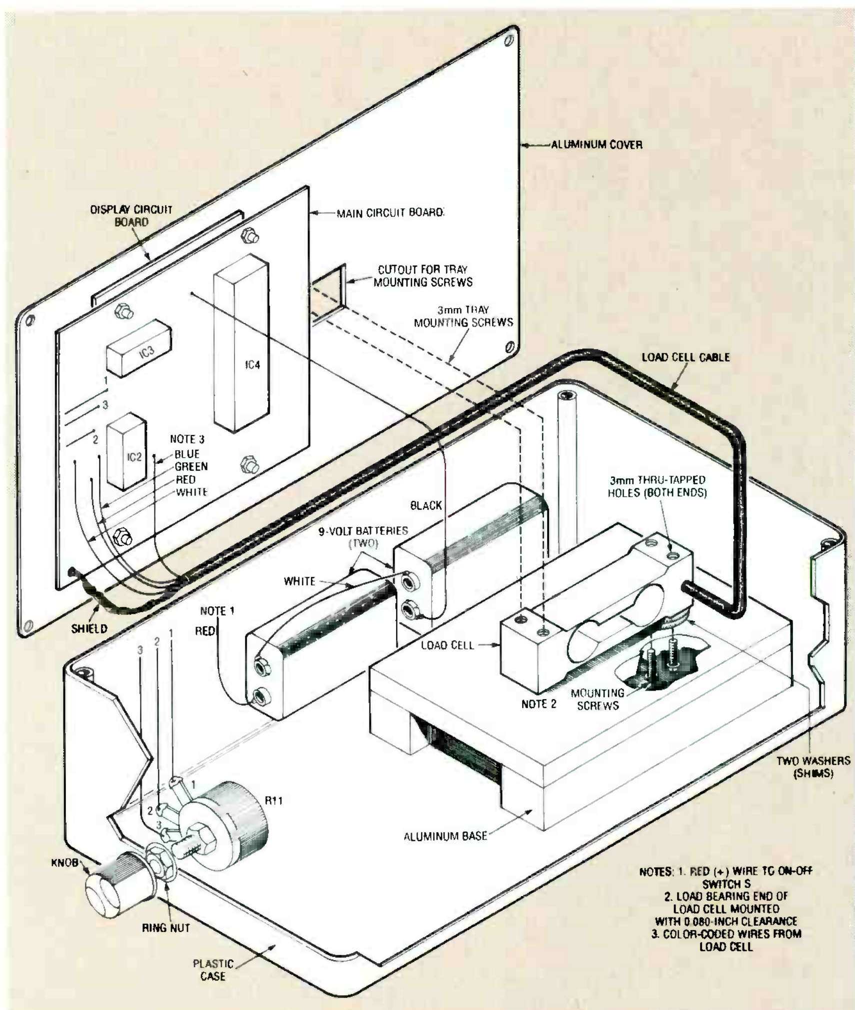


FIG. 6—CASE-COVER ASSEMBLY. Make the load-cell base, and drill holes in it for mounting it to the bottom of the case as well as the holes for mounting the load cell to the base. Then drill the holes in the case for mounting the load cell/ base assembly and the hole for the control potentiometer.

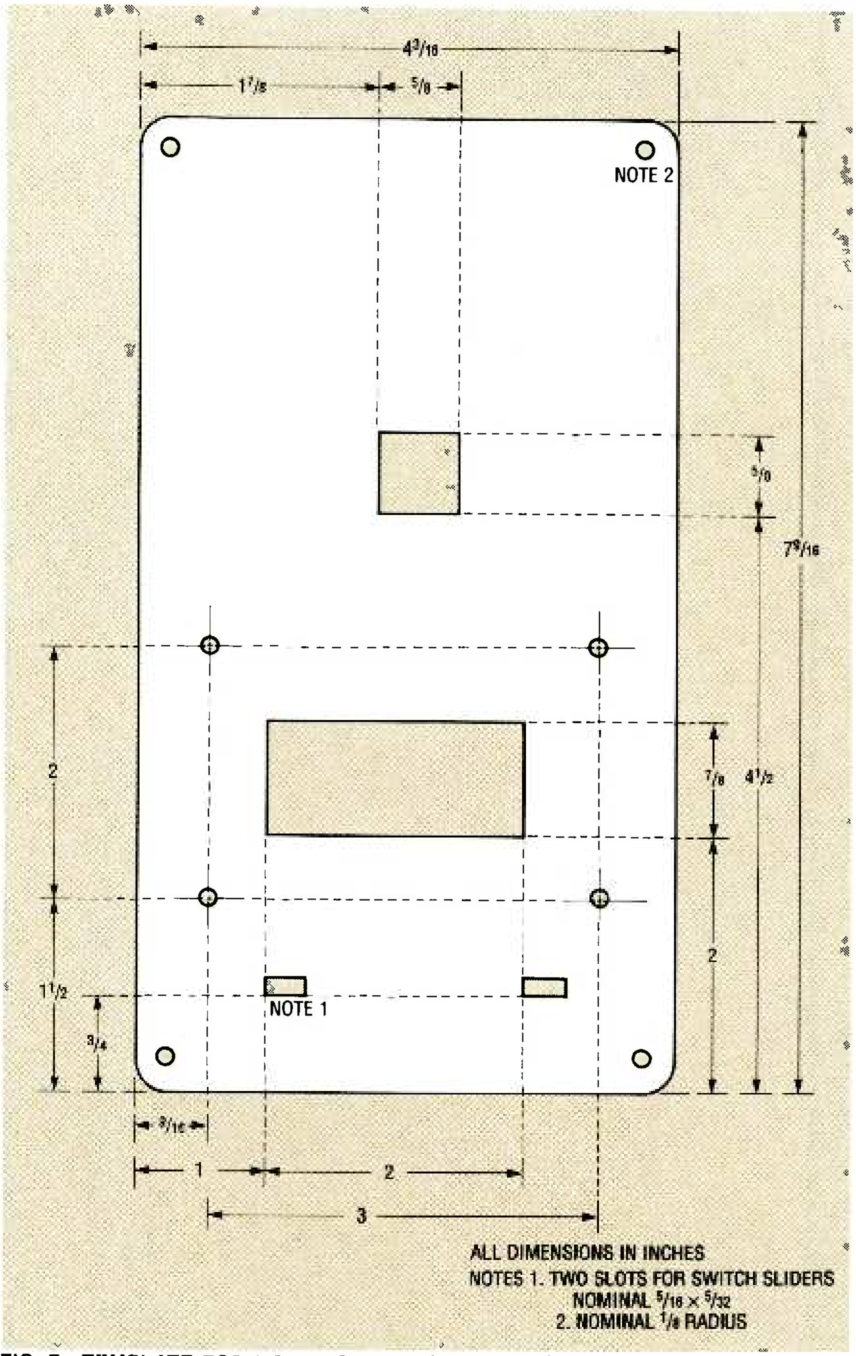


FIG. 7—TEMPLATE FOR HOLE FORMING in the aluminum cover panel. Locate the switch-mounting holes by using the switches as templates.

alphanumeric pin identifications for subsequent interboard point-to-point wiring.

The LCD DIP can be soldered directly into the display board as illustrated, but is is recommended that 20-pin headers be made to act as a socket.

Hole forming steps

The prototype scale is housed in a plastic project case with inside dimensions of 7¼ × 4 3/16 × 2¼-inches deep as shown in Fig. 6. It has an aluminum cover that measures 7 9/16 × 4 3/16 and serves as the scale's front panel. Figure 7 is a template for drilling and forming the holes in that cover. Drill or punch all holes and openings in the aluminum cover as shown. If you use a larger case, center the template in the larger panel area.

Drill a hole in the front center of the plastic case as shown in Fig. 6 to accommodate the threaded bushing of zero-effect potentiometer R11. Assemble R11 to the case, and fasten it in position with its locknut and lockwasher.

Figure 8 is an exploded view of the front panel/cover assembly showing how the circuit boards are fastened together with screws, spacers, and nuts to form two separate decks. Position the switches S1 and S2 in the slots cut for them in the cover, and mark the locations of their holes on the panel. (The switches selected for the prototype have tapped holes in their brackets so no nuts are needed.) Drill the holes and insert and fasten the switches to the aluminum panel.

Refer to Fig. 8 and cut a 3 by 3-inch square from 0.030 to 0.040-inch thick phenolic laminate or other suitable thin, rigid board. After deburring its edges and rounding its corners, drill two holes at its center for two flathead 3-millimeter screws as shown in Fig. 6. (The hole spacing must be the same as the spacing between the two tapped holes in the top surface of the load cell.) Countersink the holes slightly for the flathead screws.

The load cell, shown in Fig. 6, has two through-drilled and tapped holes at each end, spaced 5/16-inch apart. *Caution: the holes are tapped to accommodate 3 millimeter screws so that the substitution of non-metric screws will strip the threads in the load cell.* The end marked with an arrow identifies the load-bearing side.

Figure 6 shows the one-inch high extruded aluminum channel that was fastened to the bottom of the plastic case of the prototype to function as a rigid base for the load cell. Four holes were drilled in the bottom of the case and four matching holes were drilled and tapped in the bottom of the channel to fasten it to the case. Two holes were also drilled in the far end of the channel to accommodate two more 3-millimeter screws for mounting the load cell to the rigid base from the underside.

The composition and size of the rigid base are not critical, and alternatives can be used if a six-inch length of thick-wall aluminum channel is not avail-

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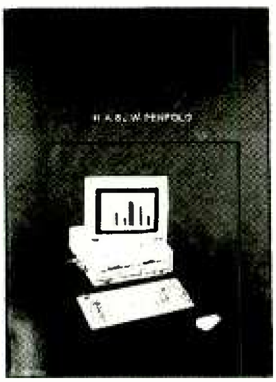

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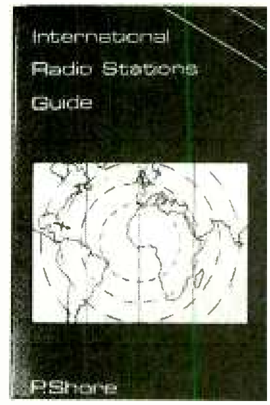

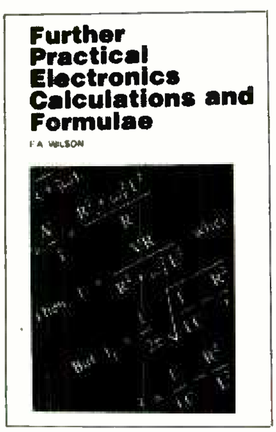

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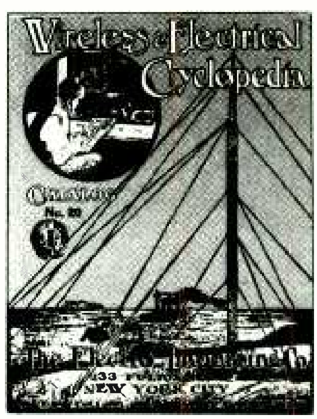

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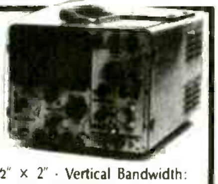

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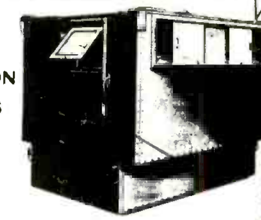

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Enclosed in shelter that is fully insulated with aluminum exterior and plywood interior. 74"L × 57"W × 60½"H, 620 lbs. Has two sliding windows and is louvered for ventilation, which is filtered. A 400 watt, radio frequency communications transmitter. It is used for voice or transmission of beacon signals to aircraft in the frequency range of 190 to 500 KC. Power requirements are 230 VAC. Units are unused and in excellent condition. Units are complete with all accessories including cables, antenna, controls and many other parts and accessories. Fits into 6' commercial truckbed. **Price: $1595.00**

ANRITSU ML422B

Anritsu ML422B Programmable Selective Level Meter. Has synthesized frequency tuning (rotary dial on keypad entry). Automatic tone search for unknown signals, swept frequency, keypad data entry for amplitude and frequency limits, IEEE488 computer control capability. **Frequency range:** 50HZ to 30MHZ (8 digit LED readout). **Stability:** ≤ ±5 × 10 – 7/0 to 45°C, ≤ ±1 × 10 – 6/year. **Bandwidths:** Wideband, 48khz, 3.1khz and 20hz (–3dB). **Amplitude Range:** –120dBM to +30dBM depending on bandwidth setting (5 digit readout and meter). **Amplitude Accuracy:** ±0.15dB to ±1.5dB depending on level range and frequency setting. **Input Impedence:** 75 ohms terminated unbalanced or 10Kohm unterminated balanced. 75, 124, 135, or 600 ohms terminated balanced. 1.5Kohm and 20Kohm unterminated balanced. **Distortion:** Input ≤ ±10dBM, single tone, 2nd and 3rd order ≤ –70dBc from 1Khz to 12mhz. **I.F. Rejection:** ≤ –70dBM @ 56.6mHz, ≤ –80dB elsewhere. **Image Rejection:** ≤ –80dB. **Phase Jitter:** ≤0.5° p-p, 0.1° resolution. **Power:** 115V, 3.15A, 60hz AC. **Size:** 16¹³⁄₁₆"W × 7⅜"H × 19¾"D. Wt: 45 lb. **Price: $$6,500.00**

AN/URM-120 50 OHM THRU-LINE RF WATTMETER

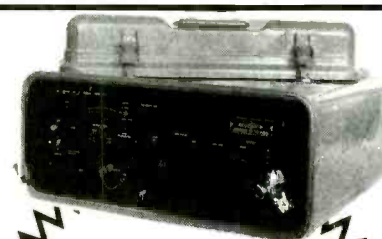
Frequency range: 2MHZ to 1000MHZ. **Power range:** 10 Watts to 1000 Watts. USWR≤ 1.0B to 1. Uses three plug-in coupler elements, (included). CU-753 2 to 30 MHZ 50 to 100 Watts
CU-754 25 to 250 MHZ 10 to 500 Watts
CU-755 200 to 1000 MHZ 10 to 500 Watts
Connector: Type N. Case included. **Size:** 7"W × 6⅝"H × 7⅓"D **Weight:** 6.5 lbs. New **Price: $285.00**

COLLINS 51S-1 GENERAL COVERAGE RECEIVER

Frequency: 2 to 20 MHZ, **Calibration:** 1KHZ/div., **Reception:** USB, LSB, AM, CW and RTTY; **Sensitivity:** SSB or CW or RTTY, 0.6 Micro Volts for 10dBs S/N ratio, AM, 3 Microvolts for 10dB S/N ratio. **Selectivity:** SSB, 2.75 KHZ mechanical filter; CW, RTTY, 800HZ XTAK Filter. AM 5KH2. **Dimensions:** (H × W × D): 7.75" × 14.75" × 14.0". **Weight:** 28 pounds. **Power:** 115/230V, 50 to 400 HZ, 125 Watts. **Price: $1095.00**

COLLINS KWM—2A TRANSCEIVER

Frequency Range: 3.4 to 30 MHZ except 5.0 to 6.5MHZ. **Unit Cover:** 80, 40, 20, 15 and 10 meter. Amature bands. **Modes:** SSB, CW or RRTY. **Sensitivity:** 0.5 uv for 10 db S + N/N. **Selectivity:** 2.1 KHZ, 6db down; 4.2 MHZ, 60 db. **Image Rejection:** ≤40db. **Power Output:** 3.4 to 15 MHZ 100 watts PEP, 50 ohms; 15 to 25 MHZ, 90 watts PEP, 50 ohms; 25 to 30 MHZ 80 watts PEP, 50 ohms. **Plate Input:** 175 watts PEP on SSB; 160 watts CW **Size:** 14.75" × 7.75"H × 14"D. **Weight:** 18 lbs., 3 oz. **Price: $795.00**



HEWLETT PACKARD 8640B-OPT 323 SOLID STATE SIGNAL GENERATOR

(w/o synchronizer) Frequency range: 450 KHz to 512 MHz, to 1100 Mhz with external frequency doubler option supplied. Ten Frequency bands in octave increments from 500 KHz; band 11 for doubler use. Accuracy: 6 digit LED read out. Stability: < 1000 ppm. Output power: –145 dBm to +10 dBm (0.013 V to 2 V) into 50 Ω. Impedance is 50 Ω, VSWR < 2.0 on 2 V and 1 V range < 1.3 on other ranges >. Modulation: Internal AM, FM and PM, external AM, FM and PM. Pulse frequency: 0.05 to 5 kHz. General: Power Requirements: 100, 120, 220, 240 V, 48 hz to 420 hz, 2 amps. Size: 6" (H) × 19" (W) × 13¼" (D). Wt. 60 lbs. Includes ruggedized case and manual.

Price: $1,295.00

Current Hewlett Packard Prices: $12,050.00

GENERAL MICROWAVE 476 THERMALELECTRIC POWER METER

With type 4240A power head.
Power range: 30n watts to 10m W (–45 to +10 dBm).
Frequency Range: 0.01 to 18 GHz
VSWR: 1.5 from 0.01 to 0.015 GHZ
1.35 from 0.015 to 10 GHZ
1.6 from 10 GHZ to 18 GHZ
Connector: Type N
Meter Size: 4.5 inches
Accuracy: ±1% of full scale on all ranges
Built in 10 KHZ calibration signal. **Power Requirements:** 115V/230V, 50-1000HZ @ 5 watts.
Size: 6.1"H × 5.1"W × 11.3"D.
Weight: 7 lbs.
Includes 4 Attentuators: DC to 18EHz
Attenuation: 20dB, 10dB, 3dB, 6dB, Manual and Carrying Case. **Price: $275.00**

HEWLETT PACKARD HP1200A DUAL TRACE SOLID STATE OSCILLOSCOPE

Vertical Sensitivity: 0.1mV to 20v/div. Band Width: DC to 500KHz. Input: Differential or single ended, 1meg ohm, 45pf. Time Base: 1 microsec to 5 sec./division with a × 10 magnifier. Trigger: Internal/External. Horizontal Sensitivity: 0.1v to 1.0v/div. Bandwidth: DC to 300KHz. Input: Single ended, 1meg ohm, 20pf. CRT: 8 × 10 cm. Calibrator: 1V. Size: 8⁵⁄₁₆"W × 11¾"H × 18¹¹⁄₁₆"D. Wt: 34½ lbs. Power: 115/230, 47 to 440Hz, 50 watts. **Price: $150.00**

BIRD TERMALINE MODEL 82A RF LOAD

Frequency range: DC to 3500 MHZ. **Impedance:** 50 OHMS + 5%. **VSWR:** Less than or equal to 1.15 to 1 up to 1GHZ 1.3GHZ to 3.5GHZ. **Power:** 500 watts D.C. Conenctor: Type N. **Size:** 5¹⁵⁄₁₆"W × 8¹⁵⁄₃₂"H × 19⁹⁄₁₆"D. **Weight:** 21 Lbs.

NEW **Price: $175.00**

I.R. TANK PERISCOPE

Type M-24. Rugged military construction. Contains two independent infrared image converter tubes plus correction lenses, prisms, and eyepieces. The binocular viewing system is directly connected to a prism-type periscope. The image tubes have dynamic focus provided by a built-in adjustable voltage divider. This unit requires 10 to 15 KV at low current for operation. Unable to supply power supply. Dimensions: 18"H × 9"W × 4½" thick. Weight: 17 lbs. Stock #OP9001. **Price: $200.00**

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CIRCLE 236 ON FREE INFORMATION CARD

PC-BASED OSCILLOSCOPES OUTPERFORM
STAND-ALONES IN COST AND PERFORMANCE

CHASE SCIENTIFIC INTRODUCES 4 NEW PC-SCOPES

By Staff Writer -

Chase Scientific Company has currently introduced 4 new PC-based Digital Storage Oscilloscope boards with useful bandwidths of 20, 40, 60, and 100MHz. Each ChaseScope™ System is completely self-contained on a ***single mid-size (10") add-on board*** (for IBM PC-compatible only), at prices that will make the competition cry. Just plug the board in and load the ChaseScope™ System software (**free with board**) and you're on your way.

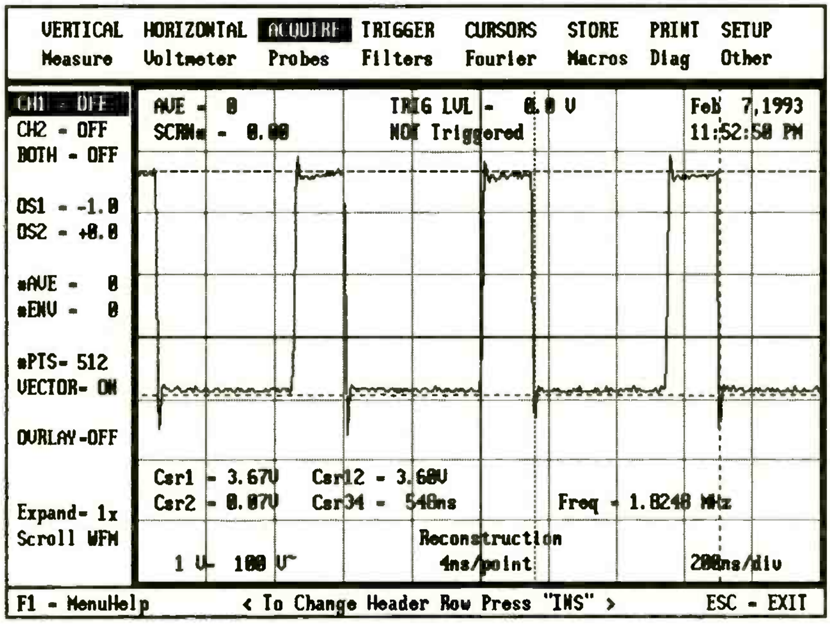
These boards have 2 completely independent vertical channels, each with their own 25 or 40 megasample /sec 8-Bit A/D converter, 8K/32K/128K static ram, and 10 vertical gain settings (in 1,2,5 steps) standard. This gives you the same high performance whether you are using one channel by itself or multiple channels simultaneously (not a common feature mong other add-ons). Also, there are 27 timebase settings in 1,2,5 steps.

Post and Pre-Triggering are available for time reconstructed waveforms as well as one-shot waveforms due to the board's ability to use ***random interleaved sampling.***

These PC based scopes are designed with the latest in **Surface Mount Technology**, providing better performance, reliability, and features than any other board its size on the market today.

SPECIAL FEATURES:

- Up to 40 Megasamples/sec one-shot digitizing rate.
- 8K Words/Channel standard (32K optional).
- Plot to any Epson or HP LaserJet compatible printer.
- Macro Language for Automated Testing.
- Store and Retrieve WaveForms from Disk.
- Built-in Functions include Ave,Freq,T_R,T_F,PW,Env,FFT
- Professional Scope Software works with virtually all CGA, EGA, VGA, or Hercules compatible monitors.



Actual Screen Output on HP LaserJet IIP at 150dpi

COMPARISON CHART OF CHASE SCIENTIFIC PC-OSCILLOSCOPES

MODEL #	CS100-40*	CS60-25	CS40-25	CS20-25
PRICE (probes not incl.)	$795	$695	$595	$495
BANDWIDTH				
Repetative (-3dB)	100 MHz	60 MHz	40MHz	20 MHz
Single-Shot (Sample Rate/4)	10 MHz	6.2 MHz	6.2 MHz	6.2 MHz
MAXIMUM DIGITIZING RATE (Two-Channel Simultaneous)	40 Ms/sec	25 Ms/sec	25Ms/sec	25 Ms/sec
NUMBER OF CHANNELS	2 (+ 1 external trigger/enable)			
TIME BASE RANGE **	20ns-2 sec/div	50ns-2 sec/div	50ns-2 sec/div	50ns-2 sec/div
MAXIMUM TIME RESOLUTION	250 ps	400 ps	400 ps	1 ns
VERTICAL RESOLUTION	+/- 0.4% (8-Bit A/D)			
MEMORY (Standard)***	32K words	8K words	8K words	8K words

* = Available 2nd Qtr 93
** = Screen display can zoom up to 10X
*** = 32K option available (128K for CS100)

All Scopes have 10mV/div - 10V/div input sensitivity in 1,2,5 steps (20pF, 1Mohm)

FOR INFORMATION PACKAGE CALL 1-800-866-7899, FAX (408) 479-8572

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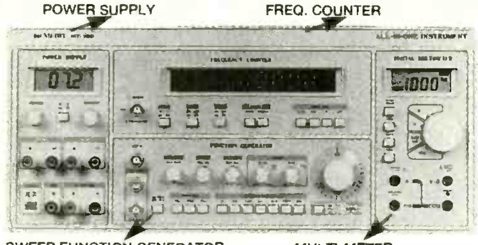


MT-100
Reg. $595.
$399.00

Four Instruments in One Instrument

1 Function Generator
- Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
- 0.02 Hz ~ 2MHz

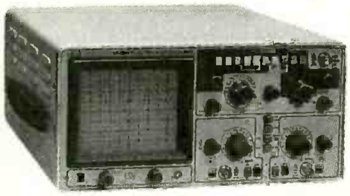
2 Frequency Counter
- 8 Digit LED
- 1 Hz ~ 100MHz
- ± (1 Hz + 1 dgt. + Time Base Error)

3 Power Supply
- 3-1/2 Digit LCD
- Triple output: #1. 0~50V, 0.5A MAX #2, 15V, 1A #3. 5V, 2A

4 Digital Multimeter
- 3-1/2 Digit LCD
- DCV, ACV, Ω, DCA, ACA
- ± (0.5% + 2 dgts)

BEST BUY! O'SCOPES

2 Yr. Parts/Labor Warranty



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40 MHz
Dual/Delay
Reg. $695.
$499.00

OS-3304/3324, 25 MHz
- DC to 25 MHz. Dual Channel
- 6" Rectangular CRT with Internal Graticule 10x8cm (Phillips P31)
- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
- Rise time 14n Sec. or less.
- Full TV Trigger for TV-V & TV-H
- Acceleration Potential 2kV

OS-3315, 40 MHz Sweep Delay
- DC to 40 MHz. Dual Channel
- Delayed Sweep 100nS to 1 Sec.
- 6" Rectangular CRT with Internal Graticule 10x8cm (Phillips P31)
- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
- Rise time 8.5nS or less.
- Full TV Trigger for TV-V & TV-H
- Acceleration Potential 12kV

GoldStar Oscilloscopes
OS-7020A. 20MHz Dual
Reg. $525. **$395.00**
OS-902RB. 20MHz Dual/Read Out
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Reg. $695. **$575.00**
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Reg. $895. **$695.00**
OS-8100. 100MHz 8 Trace
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Other Models *Call for Price*

FG-150

Reg. $395. **$229.00**

2MHz Sweep / Function Generator w/Built-in Frequency Counter

- 4 Digit LED Display
- 0.2 Hz ~ 2.0 MHz
- Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
- Linear or Logarithmic Sweep
- Variable DC Offset Control
- 10 MHz Frequency Counter

Best Buy!

1.0 GHz Counter FC-200
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High Resolution Frequency Counter

- 1.0 Hz ~ 1.0 GHz
- 8 Digit LED Display
- Auto & Manual Range
- Measured Value Hold
- 4 Selectable Gate Times
- Below 20mV Input Sensitivity
- 1mΩ & 50Ω Input Impedance
- 10:1 Input Switchable Attenuator

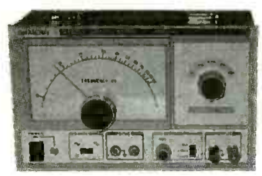
Reg. $199. **$119.00**

RF Signal Generator, SG-310 100KHz - 150MHz

- 100KHz ~ 150MHz, 6 Ranges.
- Accuracy : ± 5%
- RF Output: 100 m Vrms (Up to 35MHz Unloaded)
- Modulation
  Int. 1KHz (AM) 30%
  Ext. 50Hz ~ 20KHz
- Audio Output: 1KHz Min 2 Vrms

Reg. $199. **$119.00**

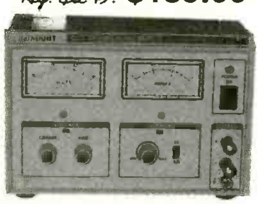
Audio Generator, AG-350 10Hz ~ 1MHz



- 10Hz ~ 1MHz, 5 Ranges.
- Accuracy : 5% ± 2
- Output Inpedance : 600Ω
- Sine Wave Output
  - Range : 10Hz ~ 1MHz
  - Output Voltage : 8 Vrms
- Square Wave Output
  - Range : 10HZ ~ 100KHz
  - Output Voltage : 15Vp-p

Reg. $249. **$159.00**

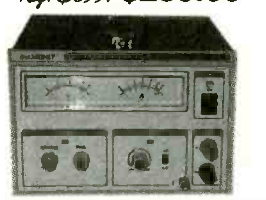
DC Power Supply, PS-500 0-30VDC, 0-3A



- 0 ~ 30VDC Continuously Variable
  - Regulation : ≦ 0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 3A Constant Current
  - Regulation : ≦ 0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

Reg. $399. **$289.00**

DC Power Supply, PS-540 0-16VDC, 0-10A



- 0 ~ 16VDC Continuously Variable
  - Regulation : ≦ 0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 10A Constant Current
  - Regulation : ≦ 0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

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*OAK N-12 (WITH VARI-SYNC)	$ 54.00	$ 49.00	$39.00	$35.00
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*JERROLD DRZ-450	$59.00	$49.00	$45.00	CALL
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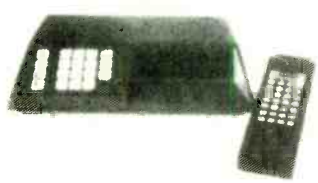

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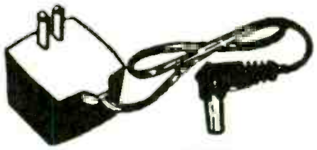

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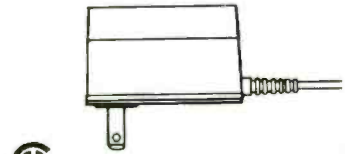
CR655

13,000 7.5VDC/50MA UL/CSA WALL ADAPTERS



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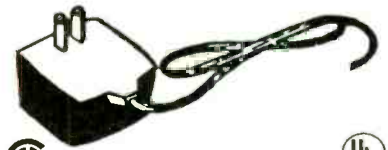

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CR881

3,000 24VDC/400MA WALL ADAPTERS

$2.38 ea/1000

CR915

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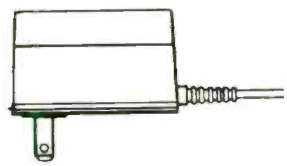
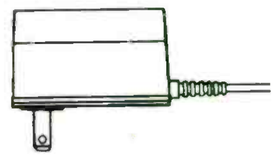


WHITE

$1.75 ea/1000

CR919

10,000 12VDC/300MA WALL TRANSFORMERS

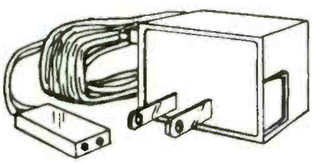


WHITE

$1.48 ea/1000

CR922

12,500 10½VAC/700MA WALL TRANSFORMERS



$1.95 ea/500
$2.80 ea/100

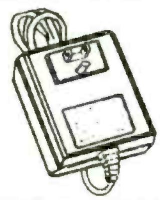
CR099

40,000 14VAC/500MA WALL TRANSFORMERS

$1.95 ea/500
$2.29 ea/100

CR961

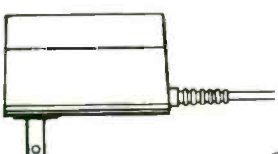
10,000 16VAC/1.25A UL/CSA WALL TRANSFORMERS



$2.95 ea/1000
$3.25 ea /500

CR924

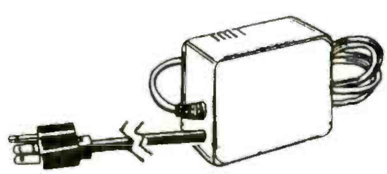
3.6VDC/900MA UL/CSA WALL TRANSFORMERS



$2.25 ea/1000
$2.45 ea/500

CR918

18.5VDC/1 AMP TABLE TOP POWER SUPPLY



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$3.95 ea/500

CR638

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New

300W MOSFET AUDIO MONO POWER AMPLIFIER
AF-3 ▲▲▲

Kit: $165.00
Assembled & Tested: $195.00

Power Output: 300W into 4 ohms RMS (0.1% THD). 200W into 8 ohms RMS (0.02% THD) • Frequency Response: 10 Hz - 20 KHz. • Total Harmonic Distortion: Less than 0.03% • Input Sensitivity and impedance at 1 KHz, IV 47K • Load Impedance: 4 - 16 ohms. • Power Requirements: ±55 to ±65V DC 8A May use Mark V Model 009 Transformer • Suggested Capacitor 10,000uf100V Model 019 • Suggested rack mount cabinet: Model LG-1925

120 W MOSFET POWER AMPLIFIER (MONO)
TA-477 ▲▲

Kit: $68.00
Assembled & Tested: $85.00

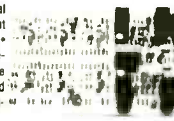
T.H.D.: Less than 0.007% • Power Output: 120 watts into 8 ohms RMS • Frequency Response: 8 Hz - 20 KHz. + 0-0.4 dB • Sensitivity IV • Power Requirements: ±55 VDC @ 3 amps. May use Mark V Model 003 Transformer • Suggested Capacitor 10,000uf80V-100V Model 019 • Suggested rack mount cabinet: Model LG-1925

120W + 120W LOW TIM PRE AND MAIN STEREO AMP.
TA-800MKII ▲▲

Kit: $63.92
Assembled & Tested: $73.95

Power Output: 120 watts RMS per channel into 4 ohms load. 72 watts RMS per channel into 8 ohms load • Frequency Response: 10 Hz - 20 KHz. • Total Harmonic Distortion: Less than 0.01% • Tone Control: Bass: ±12 dB, Mid: ±8 dB. Treble: ±8 dB • Sensitivity: Phono Input, 3 mv into 47K. Line, 0.3 v into 47K. Signal to noise ratio 86 dB • Power Requirements: 40V DC @ 6 amps. May use Mark V Model 001 or 008 Transformer • Suggested rack mount cabinet: Model LG-1924 or 1925

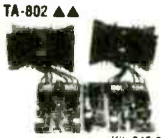
FULLY COMPLEMENTARY SYMMETRICAL FET STEREO PRE-AMP.
TA-377A ▲▲▲



Kit: $59.95
Assembled & Tested: $75.00

Frequency Response: 10 Hz - 100 KHz. • RIAA Curve Deviation: ±0.2 dB, 30 to 15,000 Hz • Total Harmonic Distortion: Less than 0.007% at rated output • Channel Separation at 1 KHz: Better than 70 dB • Hum and Noise: Phono: Better than 70 dB, Aux: Better than 90 dB, Phono Sensitivity: 2 mV @ 47K • Output: 1.5V (0.01% T.H.D.) • Record Output: 150 mV • Maximum Output at 0.1% Distortion: 15V • Power Requirements: 30 V x 2 @ 400 ma. May use Mark V Model 010 Transformer • Power Consumption: 12W • Suggested rack mount cabinet: Model LG-1684 or LG-1983 • Suggested Volume Control: ALPS 100K ohm dual V.R., Model 022

80W + 80W PURE OC STEREO MAIN POWER AMPLIFIER
TA-802 ▲▲



Kit: $45.94
Assembled & Tested: $59.72

Power Output: 80 watts per channel into 8 ohms • Total Harmonic Distortion: Less than 0.05% at rated power. • Intermodulation Distortion: Less than 0.05% at rated power • Frequency Response: DC to 200 KHz. -0 db.-3 db. @ 1 watt • Power Requirements: 30 VAC x 2 @ 6 amps. May use Mark V Model 001 or 008 Transformer • Suggested Capacitor 8,200uf50V Model 017 • Suggested rack mount cabinet: Model LG-1924

VIDEO / AUDIO SURROUND SOUND PROCESSOR
SM-333 ▲▲★

Kit: $73.00
Assembled & Tested: $85.00

Frequency Response: 20 Hz - 20 KHz. • Total Harmonic Distortion • Front Channel: 0.05% • Rear Channel: Less than 0.25% • Input Signal Voltage: 0.1 to 3.5V • Output: Front Channel: 0.1 to 3.5V • Rear Channel: 6.6V • Delay Time: 5 to 50 milliseconds • Input Impedance: 47K • Power Requirements: 100-120 VAC, 60 Hz (Case & Transformer are included)

60W + 60W STEREO POWER AMP. (WITH MIC. & GUITAR INPUT)
SM-302 ▲▲★

Kit: $73.00
Assembled & Tested: $85.00

Frequency response: 20Hz to 20 KHz • Total Harmonic Distortion: <0.1% • Power output 60W per channel into 4 ohm load RMS • 33W per channel into 8 ohm load RMS • Input Sensitivity: Mic/Guitar 10 mv • Hi 380 mv • Lo 640 mv • Signal to noise ratio: Better than 70 db • Power Consumption: 100W. (Case & Transformer are included)

(TOROIDAL) TRANSFORMERS**

MODEL	DESCRIPTION	
#001	28V x 2 6A, 30V x 2 6A	$28.00
#002	36V x 2 3A	$23.00
#003	40V x 2 6A	$30.00
#004	24V x 2 6A	$23.00
#005	26V x 2 3A	$17.00
#006	18V x 2 5A	$17.00
#007	53V x 2 8A	$45.00
#008**	28V x 2, 30V x 2 6A	$38.00
#009**	48V x 2, 53V x 2 8A	$66.00
#010	30V x 2, 36V x 2 400mA	$ 8.50
#011**	9V x 2, 22A	$60.00

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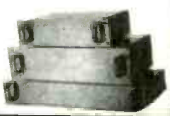
MODEL	H"	x W"	x D"	
LG-1273	3"	12"	7"	$23.85
LG-1684	4"	16"	8"	$28.50
LG-1924	4"	19"	11½"	$34.50
LG-1925	5"	19"	11½"	$38.00
LG-1983	2¾"	19"	8"	$32.50



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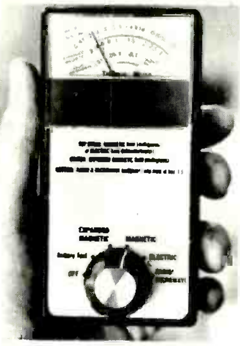

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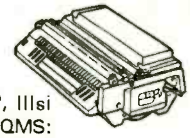

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TR-304	Recharge Kit for HP IIP (LPB-4) laser printer.	$21.95
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TR-370	Recharge Kit for Sharp Z-50/55/70 copier.	$34.95
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9710	200 grms of high quality black toner for CX.	$9.95ea/10
9730	250 grms of high quality black toner for SX.	$12.50ea/10
8011-Blue/Br	200 grms of Blue/Brown toner for CX & SX.	$22.95ea/10
8057	150 grms of high quality black toner for PC.	$10.95ea/10
Felt-CX,SX	replacement treated felt for all models.	$0.90ea/10
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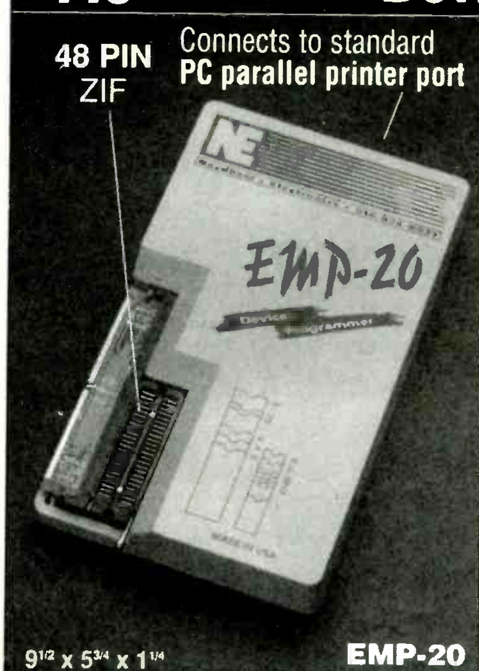

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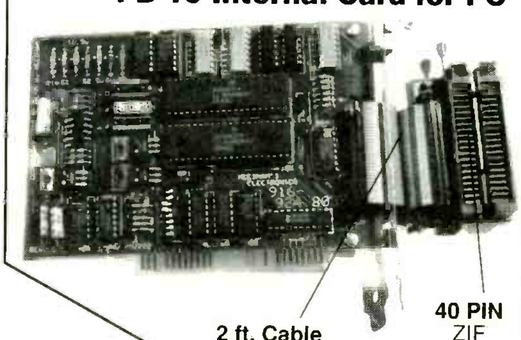

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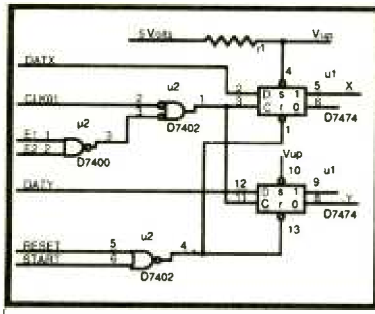

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DS-4	10 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	71.50
DS-5	12 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	76.00
DS-6	16 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	81.00
DS-7	4 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	69.00
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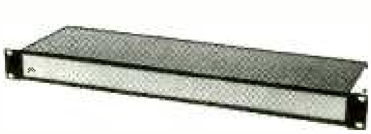

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RACK CHASSIS

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1RU10	19 x 10 x 1.75	35.25
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2RU7	19 x 7 x 3.5	35.25
2RU10	19 x 10 x 3.5	37.50
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MC-6A	8 x 4 x 3	23.15
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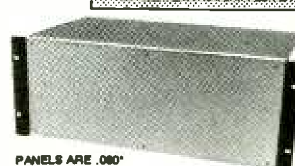

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RF tone transmitter board features compact size with two push button switches, variable trimmer resistors, IC circuitry, several transistors, a slug tuned coil and various resistors and capacitors. Designed to operate on 9VDC. Size 2-1/4"x 1-3/16". New but no specs. We do know it was used in remote control applications.

G3237 $1.25
10/10.00 - 100/80.00

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G3256 "Somewhere my love"
G3257 "What the world needs"
G3226 "Pomp & Circumstance"
$1.00 each

10 POSITION DIP SWITCHES

Incredible value on these brand new 10 position dip switches. Other dealers offer these at up to several dollars each. We made a special purchase of these factory prime switches and are offering them at a blowout price!

50¢ ea.
G3312
10/$4.50 100/$40.00 1000/$350.00

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Two seperate high power amps on one PC board. Each amp has its own level control and puts out an incredible 20 Watts RMS. Features red LED "on" indicator and low distortion circuitry. Great stereo booster amp for your car sound system. Use with any speakers capable of handling at least 20 Watts. Operates on 12VDC. Size of board: 6"x 2.25". Complete with all parts, PC board and instructions. Skill level 2.

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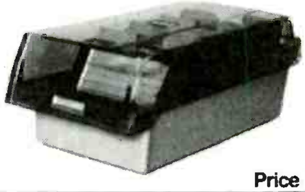

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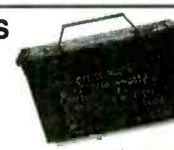

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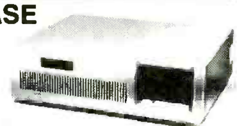
IBM PC/AT CASE



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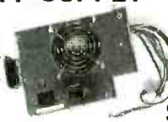

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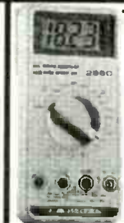

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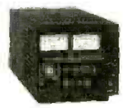

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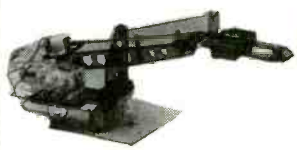

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- +5VDC @ 1 Amp
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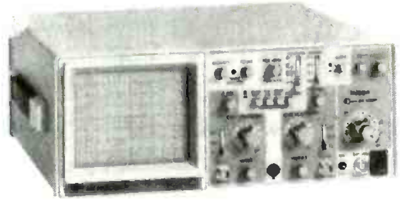

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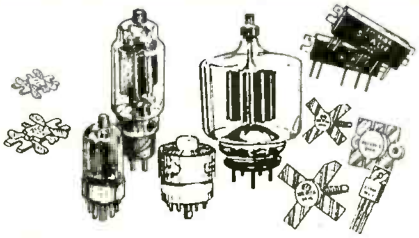

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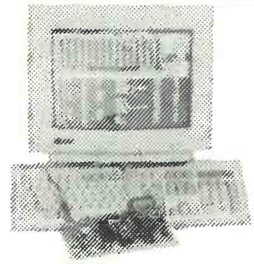
68705 DEVELOPMENT SYSTEM

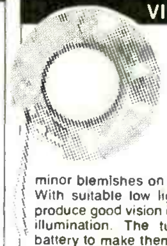


This kit allows an IBM compatible computer to be used as a complete development system for the Motorola 68705P/U/R series of microcontrollers. Included with the kit is a powerful software simulator package, programming and demonstration software, and a 68705 eprom programming board, that connects to the printer port. The total cost of the software and the PCB and all the on-board component kit for the programmer is only: **$170**
For a ready built and tested programmer add an extra $60
A trainer should also be available at the time of publication. This board measures 16" X 9" and accommodates the 68705P/U/R, and features A-D, D-A, LCD display, keypad, serial port and latched I/O lines. Pricing available upon request.
In the near future we also plan to cater for the HC705J2, 68HC705K1 and 68HC705C8 series, by way additional software and necessary adaptor boards. These will be made available to all registered users of the programmer.
Note that an evaluation disc for the programmer and simulator package, which also includes more information and pictures of the programmer, and some of the other items in this advertisement, is available for $9.

FM TRANSMITTER KIT — MKII

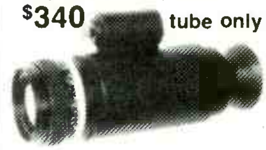
This low cost FM transmitter features pre-emphasis, high audio sensitivity as it can easily pick up normal conversation in a large room, a range of well over 100 meters, etc. It also has excellent frequency stability: The resultant frequency shift due to waving the antenna away and close to a human body and/or changing the supply voltage by +/- 1V at 9V will not produce more than 30KHz deviation at 100MHz! That represents a frequency deviation of less than 0.03%, which simply means that the frequency stays within the tuned position on the receiver.
Specifications: Tuning range: 88-108mHz, Supply voltage 6-12V, Current consumption @ 9V: 3.5mA, Pre-emphasis: 50uS or 75uS, Frequency response: 40 Hz to greater than 15KHz, S/N ratio: Greater than 60dB, Sensitivity for full deviation: 20mV, Frequency stability (See notes): 0.03%, P.C.B. dimensions: 1" X 1.7".
Construction is easy and no coil winding is necessary: The coil is preassembled in a shielded metal can. The double sided, solder masked and screened PCB also makes for easy construction. The kit includes a PCB and all the on-board components an electret microphone, and a 9V battery clip. **$8**

IMAGE INTENSIFIER TUBE AND NIGHT VIEWER KIT



These 18mm image intensifier tubes are similar to ones used in night vision equipment during the Gulf War. They are ex-military and may have some minor blemishes on the viewing screen. With suitable low light lenses they will produce good vision in as little as starlight illumination. The tubes require a 3V battery to make them operational.

$340 tube only



The viewer illustrated was made using some low cost plastic tubing and matching fittings, a low light camera lens, and an eyepiece. We can supply a custom machined kit of parts (Mostly aluminium) for our latest casing: This kit includes everything except the front lens and the battery. The eyepiece is included.

$70 for the case kit without the front lens

The lens we used is a 50mm "C" mount f1.4 video lens, for a 1" format (Cosmicar type: B5014A) and we will supply details of an American supplier of this lens: Approx. $100.

MINIATURE FM TRANSMITTER

Not a kit, but a very small ready made self contained FM transmitter enclosed in a small black metal case. It is powered by a single small 1.5V silver oxide battery, and has an inbuilt electret microphone.
Specifications: Tuning range: 88-108MHz, Antenna: Wire antenna-attached, Microphone: Electret condenser, Battery: One 1.5V silver oxide LR44/G13, Battery life: 60 hours, Weight: 15g, Dimensions: 1.3" X 0.9" X 0.4". Some would call this a miniature "BUG" and sell it for much more than our price of: **$25**

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*All you need to supply is ground pole to mount dish on. (23/8" O.D.)

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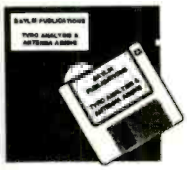

Satellite Analysis and Antenna Aiming Software

An extremely valuable tool for designing and installing TVRO's, tailored for ease of use by professionals and dealers as well as by technically orientated TVRO owners. Demonstrates how changing parameters such as dish size or LNB noise temperature affect picture quality. The program performs both TVRO system analysis and antenna aiming. The analysis subcomponent, is especially useful for predicting performance when viewing signals from a particularly weak satellite. The aiming subcomponent calculates azimuth and elevation angles and range to all satellites within "view" of a TVRO. The names and latitudes of all world-wide C and Ku-band broadcast satellites, presently in service or to be launched by 1995, are listed. The user simply enters TVRO site latitude and longitude.

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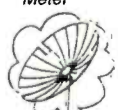

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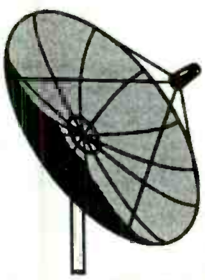

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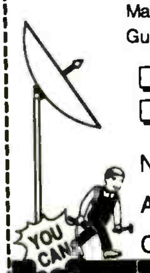

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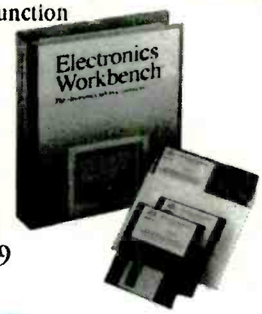

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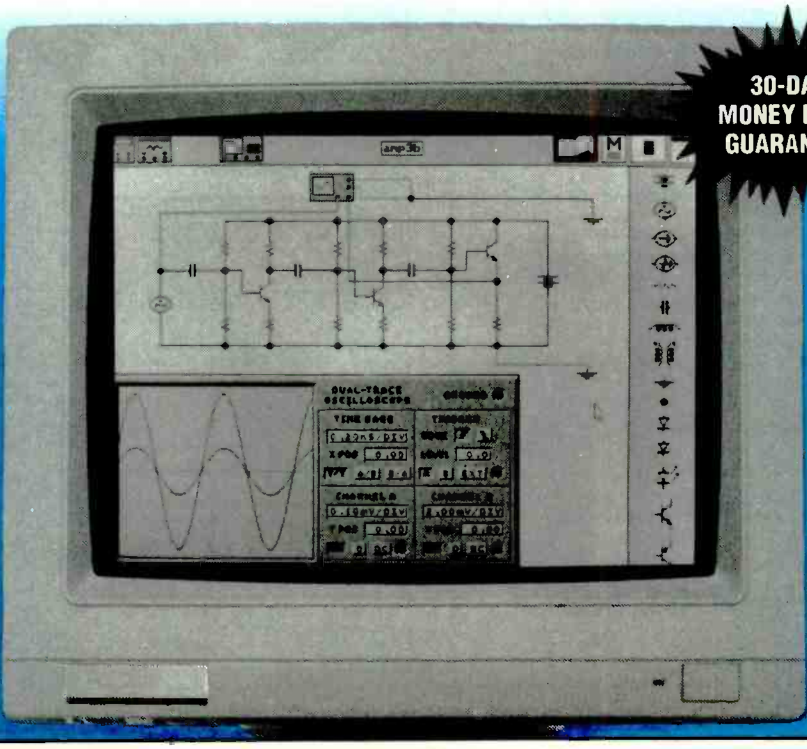

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8088-2	3.25	8284	1.49
8155	2.25	8286	3.50
8156	2.25	8287	2.49
8202A	8.00	8288	3.50
8212	1.25	8530	3.00
8214	2.00	8741	7.00
8216	1.25	8742	7.00
8224	1.25	8748	7.00
8228	1.75	8749	7.00
8237-5	2.80	8755	7.00
8243	1.75	80286-8 PLCC	8.50
8250	2.95	80287-8	125.00
(16450)	6.50	80287-10	135.00
(16550)	13.00	V-20-10MHZ	6.50

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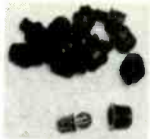
CIRCLE 219 ON FREE INFORMATION CARD

Parts Express International Inc.

Grill Guides



Ball and socket type grill guides for attaching speaker grill to cabinet. To use, simply drill the appropriate size holes in cabinet and grill frame. 12 pair per package.

#RJ-260-367 **$1.80** Per Pkg

Honeycomb Tweeter

Unique tweeter with a square diaphragm of honeycomb material. Diaphragm is 1" square. Excellent dispersion. 13/16" voice coil. Frequency response: 2,000-20,000 Hz. Impedance: 8 ohm. Power handling : 25 watts RMS, 40 watts maximum. 4" x 3-1/4". Limited availability. Net weight: 1 lb.

#RJ-279-110 **$2.90** Each

Fluorescent Work Light

Handy light operates on 120VAC or 12VDC. Puts light where you need it. Extra bright 15 watt tube. 15 foot oil resistant power cord with wall adaptor and cigarette lighter plug. Two hooks provided for hanging. Net weight: 2 lbs.

#RJ-360-490 **$18.95** Each

Triplett DMM

The Triplett model 2202 digital multimeter is a full function DMM with built-in transistor and battery testers. Large, easy to read LCD display. Rotary switch for easy one hand function selection. The test leads conveniently attach to meter so they are always in reach. Test leads, manual, and carrying case included.

#RJ-390-140 **$47.00** Each

High Voltage Cap Kit

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

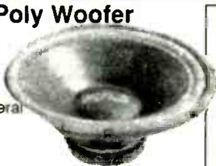
#RJ-020-950 **$49.95** Each

5-1/4", 2-Way Pioneer

5-1/4" paper cone woofer with a 1" post mounted polymer tweeter. 4 ohm impedance. Response: 100-20,000 Hz. Power handling : 35 watts RMS, 50 watts maximum. 2-3/4" mounting depth. Limited availability. Net weight: 2-1/2 lbs.

#RJ-269-065 **$12.80** Each

Pyle 15" Poly Woofer



15" poly woofer with a 60 oz. magnet and 2" voice coil. Mineral filled poly cone with poly foam surround. Poly cone provides proper internal damping to help control cone motion at high power excursion. Power handling: 100 watts RMS, 145 watts max. VAS= 10.9 cu ft., QTS=.53, fs= 30 Hz. Frequency response: 20-3,000 Hz. SPL= 98 dB1W/1M. Impedance: 4 ohm. Net weight: 9-1/2 lbs.

#RJ-292-070 **$64.80** Each

Pickering Headphones

We made a special buyout directly from the manufacturer on these super quality personal headphones. 1" dynamic high velocity element with strontium ferrite magnet. Adjustable headband with foam ear cushions. 5 ft. cord to 3.5 mm and 1/4" adaptor included.

#RJ-249-100 **$2.49** Each

Mini Super Tweeter

Super paper cone tweeter with silver mylar dust cap. Impedance: 8 ohm. Power handling capability: 2 watts RMS. 9-1/16" voice coil. 1-1/2" diameter cone with mounting tabs. Mounting holes: 1-7/8" on center. Limited availability.

#RJ-279-120 **50¢** Each

3" x 5" Speaker

Standard radio and TV speaker. 16 ohm impedance. 3 watts maximum power handling. Limited availability.

#RJ-299-115 **$1.95** Each

Duracell "J" Battery

Popular TV/stereo remote control battery. Size "J", 6 volt alkaline. Duracell #7K67.

#RJ-140-090 **$3.40** Each

10", Thruster Car Woofer

Heavy duty car woofer capable of handling 175 watts max (125 RMS). 4 ohm impedance. Polymerized paper cone with red poly foam surround. Resonant frequency: 26 Hz. VAS= 5.89, QMS= 4.6, QES= .27, QTS= .26. Frequency response: 30-2,000 Hz. Magnet weight: 38 oz, 2" voice coil. SPL= 92 dB 1W/1M. Net weight: 6 lbs.

#RJ-293-090 **$29.95** Each

Large Input Terminal

Large input cup with push spring terminals and 4 lug terminal strip on rear. Flush mounted housing measures: 4" x 5-1/2" outside diameter. 4-5/8" x 3-1/16" mounting hole required. Limited availability.

#RJ-269-220 **95¢** Each

15" Thruster

Super duty, 15" car audio bass driver. Low 25 Hz resonant frequency. Weather resistant polymerized paper cone with red poly foam surround and two color printed dust cap. Power handling capability is 250 watts (170 watts RMS). 2" high temp voice coil with rear vented pole piece. 4 ohm impedance, 50 oz. magnet. Frequency response: 23-2,000 Hz, VAS= 19.04, QMS= 3.96, QES= .21, QTS= .20, SPL= 97.85 dB 1W/1M. Net weight: 11 lbs.

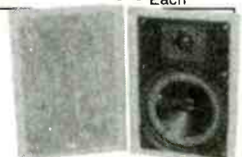
#RJ-293-150 **$59.95** Each

Pyle 10" Poly Woofer

Long throw poly woofer with poly foam surround for superb low bass. Mineral filled poly cone assures low frequency sound that is smooth, tight, and low in distortion. 2" voice coil, power handling: 85 watts RMS, 130 watts max. fs= 43 Hz. Frequency response: 25-3,000 Hz. SPL= 95 dB 1W/1M. Impedance: 4 ohm. 40 oz. magnet. VAS=1.8 cu ft., QTS= .34, QMS= 10.92, QES= .35. Net weight: 8 lbs.

#RJ-292-030 **$45.80** Each

Deluxe In-Wall Speakers



Perfect surround speakers. Customize your media room with these super quality, in-wall speaker pairs. Full size 6-1/2" woofer. Heavy duty 1" soft dome tweeter. Built-in crossover. Fits any standard 2 x 4 or larger wall. Retrofit design allows easy installation in new or existing walls. Response: 50-20,000 Hz. 8 ohm impedance. 40 watts RMS, 60 watts maximum. Includes provision for easy 70V/25V transformer mounting. Overall dimensions: 8-1/2" x 12". Net weight: 9 lbs.

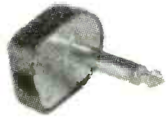
#RJ-300-036 List $299.95 **$109.50** Pair

The Loudspeaker Design Cookbook IV

This book describes the "science" of loudspeaker design, however applying it is an "art". Using the information in this book will yield hundreds of possible variations in speaker design, with some subtle and not-so-subtle differences. 1991 copyright, fourth edition. Author: Vance Dickason. 154 pages paperback.

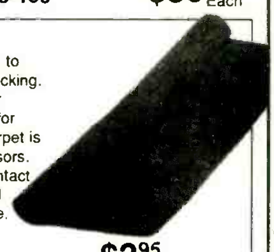
#RJ-500-035 **$29.95** Each

Right Angle 1/4" Phone Plug (Mono)



#RJ-099-020 **65¢** Each

Cabinet Carpet



This high quality carpet conforms easily to sharp corners because it has no stiff backing. You can also stretch it to cover irregular shapes. This is the covering of choice for car, stages, and amplifier cabinets. Carpet is strong yet easy to cut with knife or scissors. Adhere with spray adhesive or latex contact cements. Provides protection and good looks. Sold by the linear yard. 54" wide.

#RJ-260-765 (Dark Charcoal)
#RJ-260-767 (Medium Grey)
#RJ-260-768 (Jet Black)

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TTL LOGIC

PART#	PRICE	PART#	PRICE	PART#	PRICE
7400		74LS		74LS173	.39
7400	.29	74LS00	.25	74LS174	.39
7402	.29	74LS02	.25	74LS175	.39
7404	.35	74LS04	.25	74LS191	.49
7405	.29	74LS08	.25	74LS193	.59
7406	.35	74LS10	.25	74LS221	.59
7407	.35	74LS14	.39	74LS240	.49
7408	.29	74LS20	.25	74LS241	.55
7410	.29	74LS30	.25	74LS244	.69
7414	.35	74LS32	.25	74LS245	.69
7432	.35	74LS38	.29	74LS257	.39
7447	.85	74LS42	.39	74LS273	.69
7473	.49	74LS51	.25	74LS293	.59
7474	.39	74LS73	.39	74LS367	.39
7475	.39	74LS74	.29	74LS373	.65
7476	.59	74LS75	.29	74LS374	.65
7483	.59	74LS83	.49	74LS688	1.99
7486	.39	74LS85	.49		
7490	.59	74LS86	.29	74S	
7493	.45	74LS90	.39	74S00	.29
74116	1.49	74LS93	.39	74S02	.29
74121	.49	74LS107	.39	74S04	.29
74123	.49	74LS112	.39	74S08	.29
74150	1.29	74LS123	.39	74S32	.35
74151	.39	74LS125	.39	74S157	.49
74153	.39	74LS126	.39	74S163	.45
74154	1.25	74LS138	.39	74S188	1.89
74157	.45	74LS139	.39	74S287	1.69
74161	.49	74LS151	.39	74S288	1.69
74163	.69	74LS153	.39	74S373	.49
74174	.49	74LS154	1.15	74S374	.59
74175	.49	74LS155	.49	74S387	1.59
74191	.85	74LS157	.39	74S571	2.95
74221	.45	74LS163	.49	74S573	2.49

EPROMs

PART#	ORG	SPEED	Vpp	PINS	PRICE
2732A-200	4096 x 8	200ns	21V	24	4.25
2764A-250	8192 x 8	250ns	12.5V	28	3.95
27128A-200	16384 x 8	200ns	12.5V	28	4.75
27256-250	32768 x 8	250ns	12.5V	28	4.75
27C256-250	32768 x 8	250ns	12.5V	28	4.45
27C512-150	65536 x 8	150ns	12.5V	28	6.25
27C101-150	131072 x 8	150ns	12.5V	32	8.25
27C201-150	262144 x 8	150ns	12.5V	32	10.95
27C401-150	524288 x 8	150ns	12.5V	32	29.95
27C401-120	524288 x 8	120ns	12.5V	32	32.95

STATIC RAM

PART#	ORG	SPEED	PINS	CMOS	LP	PRICE
HM6116LP-2	2K x 8	120ns	24	Y	Y	2.95
HM6116LSP-15	2K x 8	150ns	24/.3"	Y	Y	3.59
HM6264LP-10	8K x 8	100ns	28	Y	Y	4.95
HM6264LSP-10	8K x 8	100ns	28/.3"	Y	Y	5.49
HM62256LP-10	32K x 8	100ns	28	Y	Y	6.19
HM62832-20	32K x 8	20ns	28/.3"	Y	Y	12.95
5525785PL-10	32K x 8	100ns	28/.3"	Y	Y	7.95
HM628128LP-10	128K x 8	100ns	32	Y	Y	19.95
HM628128LP-85	128K x 8	85ns	32	Y	Y	21.95

EEPROMs

PART#	ORG.	SPEED	# PINS	CMOS	PRICE
2816-450	2K x 8	450ns	24		3.55
2816-250	2K x 8	250ns	24		4.45
2816-150	2K x 8	150ns	24		5.45
28C16-250	2K x 8	250ns	24	Y	5.45
28C16-150	2K x 8	150ns	24	Y	5.95
2864-250	8K x 8	250ns	28		7.95
28C64-250	8K x 8	250ns	28	Y	8.25
28C64-150	8K x 8	150ns	28	Y	8.95
28C256-250	32K x 8	250ns	28	Y	29.95

SERIAL EEPROMs

PART#	ORG.	# PINS	CMOS	PRICE
93C06	256 bit, 5V	8	Y	1.49
9346	1024 bit, 5V	8		1.95
93C46	1024 bit, 5V	8	Y	2.25
93C56	2048 bit, 5V	8	Y	2.95
93C66	4096 bit, 5V	8	Y	4.95

DALLAS SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
DS1202	5.95	DS1230Y	29.95	DS1283	16.95
DS1210	7.95	DS1231-20	5.95	DS1286	19.95
DS1213B	15.95	DS1232	3.95	DS1287	16.95
DS1215	11.95	DS1233	2.69	DS1387	24.95
DS1216B	24.95	DS1237-1	13.95	DS1613C	23.95
DS1220Y	12.25	DS12434Y	29.95	DS1632	5.95
DS1225Y	19.95	DS1244Y	44.95	DS1667	11.95
DS1227	7.49	DS1259	8.95	DS2132	19.95
DS1228	6.49	DS1260	16.95	DS2400	2.39

6500 SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
65C02	5.95	6520A	3.49	6532	3.95
6502	3.95	6522	3.79	6545A	4.95
6502B	5.95	6522A	4.95	6551A	3.79
6520	2.95	6526	11.95	6581	12.95

6800 SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
6800	1.99	6810	1.29	6845	2.29
6802	3.49	6821	1.99	6847	10.95
6809	3.95	68B21	2.95	6850	1.89
6809E	2.95	6840	2.39	6852	4.95

INTERSIL SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
ICL7106CPL	4.95	ICL7665SCPA	3.95	ICM7216BIPI	29.95
ICL7107CPL	4.95	ICL8038CCPD	3.69	ICM7231BFIPL	9.95
ICL7109CPL	9.95	ICL8211CPA	2.29	ICM7555IPA	.79
ICL7660CPA	1.79	ICLM7207AIPD	7.95	ICM7556IPD	1.29
ICL7663SCPA	3.95	ICM7208IPI	19.95		

VOLTAGE REGULATORS

PART#	PRICE	PART#	PRICE	PART#	PRICE
UA78S40	1.35	7815K	1.39	7915T	.45
78L05	.39	7824T	.45	7915K	1.49
7805T	.45	7824K	1.39	7924T	.45
7805K	1.39	79L05	.39	7924K	1.49
78M05C	.39	7905T	.45	LM317T	.57
7806T	.45	7905K	1.49	LM323K	3.25
7808T	.45	7906T	.45	LM337K	2.95
78L12	.39	7908T	.45	LM337T	.87
7812T	.45	79L12	.39	LM338K	4.45
7812K	1.39	7912T	.45	LM350K	3.59
78L15	.39	7912K	1.49	LM350T	2.85
7815T	.45	79L15	.39	LM723	.49

8000 SERIES MICROPROCESSORS

PART#	PRICE	PART#	PRICE	PART#	PRICE
8031	3.65	82C55-5	4.95	80486-33	499.95
8032	6.95	8742	14.95	8087	89.95
80C32	8.95	8748H	8.95	8087-2	129.95
8085A	3.19	8749H	9.95	8087-1	169.95
8088-1	6.95	8751H	29.95	80287-XL	74.95
8155	3.69	87C51	39.95	80387-SXP	74.95
8251A	3.49	8755A	14.95	80387-DXP	79.95
8253-5	2.79	R80286-16	24.95	80487-SX	369.95
8255-5	2.95	80386-33	119.25	ODP486-SX20	329.95

DATA ACQUISITION

PART#	PRICE	PART#	PRICE	PART#	PRICE
ADC-0800	24.95	DAC-0800	1.89	MB40576	3.95
ADC-0804	2.95	DAC-0806	1.69	MB87020	26.95
ADC-0809	3.95	DAC-0808	1.49	MC1408-6	1.69
ADC-0816	19.95	DAC-0830	7.95	MC1408-8	1.49
ADC-0817	16.95	DAC-1020	9.95	ZN428E8	8.95
ADC-0820	10.95	DAC-1021	7.95	ZN429E8	3.95
ADC-0831	4.95	DAC-1022	7.95	ZN449E	6.95

4000 SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
4001	.25	4040	.59	4066	.29
4011	.25	4046	.69	4069	.25
4013	.29	4049	.25	4070	.29
4016	.39	4050	.29	4071	.25
4017	.49	4051	.59	4093	.39
4023	.25	4052	.59	4538	.89

Z80 SERIES

PART#	SPEED	# PINS	DESCRIPTION	PRICE
Z80A-CPU	4.0MHz	40	8-bit MPU	1.49
Z80B-CPU	6.0MHz	40	8-bit MPU	2.59
Z80A-CTC	4.0MHz	28	Counter Timer circuit	1.49
Z80B-CTC	6.0MHz	28	Counter Timer circuit	2.95
Z80A-DART	4.0MHz	40	Dual Asynch. Receiver/Trans.	3.59
Z80B-DART	6.0MHz	40	Dual Asynch. Receiver/Trans.	3.95
Z80A-DMA	4.0MHz	40	Direct Memory Access circuit	3.95
Z80A-PIO	4.0MHz	40	Parallel IO controller (MK3881-4)	1.79
Z80B-PIO	6.0MHz	40	Parallel IO controller (MK3881-6)	2.95
Z80-SIO/0	2.5MHz	40	Serial IO controller (MK3884)	3.59
Z80A-SIO/0	4.0MHz	40	Serial IO controller (MK3884-4)	3.59
Z80B-SIO/0	6.0MHz	40	Serial IO controller (MK3884-6)	4.95
Z80A-SIO/1	4.0MHz	40	Serial IO controller	3.59
Z80A-SIO/2	4.0MHz	40	Serial IO controller (MK3887-4)	3.59
Z80B-SIO/2	6.0MHz	40	Serial IO controller (MK3887-6)	3.95
Z80-SIO/9	2.5MHz	40	Serial IO controller	4.95
Z8671	8.0MHz	40	8-bit MPU with Basic	18.95
Z84C0008	8.0MHz	40	8-bit MPU CMOS	5.95
Z84C1008	8.0MHz	40	Direct Mem. Access (DMA) CMOS	9.95
Z84C2008	8.0MHz	40	Parallel IO controller (PIO) CMOS	5.95
Z84C3008	8.0MHz	28	Counter Timer Circuit (CTC) CMOS	5.95
Z84C4008	8.0MHz	40	Serial IO controller (SIO/0) CMOS	6.95
Z84C4108	8.0MHz	40	Serial IO controller (SIO/1) CMOS	6.95
Z84C4208	8.0MHz	40	Serial IO controller (SIO/2) CMOS	6.95
Z84C5010	10.0MHz	40	Z80 RAM80, CMOS (CPU, 2K bytes SRAM, OSC)	10.95
Z0765A08	8.0MHz	40	SS/DD flopply disk controller	5.95
Z0853006	6.0MHz	40	Serial Comm. Controller (SCC)	5.95
Z0853606	6.0MHz	40	Counter/Timer IO	7.95

LINEAR

PART#	PRICE	PART#	PRICE	PART#	PRICE
MAX232	3.95	LM358	.49	NE602AN	1.95
LM301	.39	LM380	.99	LM741	.29
LM307	.39	LM380N-8	1.29	LM747	.59
LM308	.65	LM393	.35	LM1458	.39
LM309K	1.49	LM555	.29	LM1488	.39
LM311	.39	LM556	.49	LM1489	.39
LM317K	1.99	NE558	.69	LM1881	4.95
LM318	.99	LM565	1.49	LM3900	.49
LM324	.35	LM566	1.19	LM3909	1.39
LM339	.39	LM567	.55	LM3914	2.19

GALS

PART#	SPEED	# PINS	REPLACES	IN	OUT	PRICE
16V8	35ns	20	10L8 TO 16RP8	8	8	1.95
16V8-15	15ns	20	10L8 TO 16RP8	8	8	2.25
20V8	35ns	24/.3"	14L8 TO 20RP8	20	8	2.95
20V8-15	15ns	24/.3"	14L8 TO 20RP8	20	8	3.45
22V10	35ns	24/.3"	PGM OUTPUTS	22	10	6.95
22V10-15	15ns	24/.3"	PGM OUTPUTS	22	10	13.95

LIGHT EMITTING DIODES

PART#	DESCRIPTION	PRICE
MAN72	7-SEGMENT .3" COMMON ANODE LED	.99
MAN74	7-SEGMENT .3" COMMON CATHODE LED	.99
LED-JR	JUMBO T1-3/4 RED LED	.10
LED-JG	JUMBO T1-3/4 GREEN LED	.14
LED-JY	JUMBO T1-3/4 YELLOW LED	.14
LED-JB	JUMBO T1-3/4 BLUE LED	2.25

MOTOROLA SERIES

PART#	PRICE	PART#	PRICE	PART#	PRICE
MC1330	1.49	MC145406	2.49	68488	24.95
MC1408-8	1.49	MC146818A	4.29	68681	8.95
MC3470	1.19	MC146818P	4.95	68701	22.95
MC3479	3.95	14433	5.95	68HC000-10	15.95
MC3486	.95	14490	4.49	68HC000-12	18.95
MC3487	.95	14495	3.29	68HC000-16	21.95
MC145026	1.89	14497	6.49	68HC11A1P	16.95
MC145027	2.69	14499	3.95	68HC705C8P	18.95
MC145028	2.69	68000-12	12.95	68HC705C8S	34.95
MC145151	7.95	68230-10	9.95	68HC705K1P	5.95

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UNITED STATES PATENT NO. 5,055,960

A USEFUL AND WORTHWHILE TOOL for the
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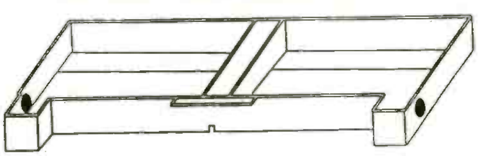
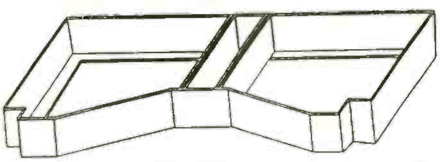
A PRECISION MOLDED, HIGH IMPACT, CLEAR PLASTIC TOOL THAT REPLACES THE VIDEO CASSETTE WHILE DIAGNOSING THE PROBLEM. THE VCR OR CAMCORDER WILL FUNCTION IN ALL MODES AND THE MECHANISM WILL BE OPEN FOR INSPECTION, MEASUREMENT & ADJUSTMENT

VHS - SVHS - VCR's & CAMCORDERS



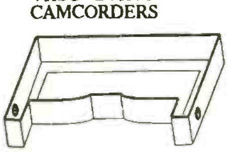
VT-103 $9.95

BETA I II III & CAMCORDER



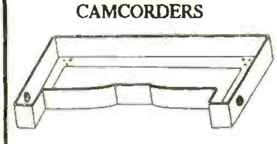
BVT-100 $9.95

VHSC - SVHSC CAMCORDERS



CVT 100 $9.95

8MM - VCR's CAMCORDERS



EVT 100 $9.95

NOTICE !!
THE ORIGINAL VHS VU-THRU TOOL WILL WORK IN ALL VCR'S, NEW UNITS OR OLDER UNITS-FRONT LOAD,--TOP LOAD,--SIDE LOAD, AND CAMCORDERS. INCLUDING THE DISCONTINUED "G" CHASSIS VCR'S.
(see page 9 of our up-dated ILLUSTRATED & COPYRIGHTED instruction manual)

INSTRUCTION MANUAL
HOW TO:

* Clean Video Heads	pg 3
* Check tape end sensors	pg 5
* Renew drive wheels	pg 4
* Adjust loading posts	pg 7
* Renew pinch roller	pg 6
* Clean erase & audio heads	pg 7
* Check Spindle sensors	pg 8
* Adjust tape guides	pg 9
* AdjustTracking head	pg 7
* USE IN "G" CHASSIS	pg 9
* PLUS MANY TIME SAVING TIPS	

FREE
WITH ANY ORDER
5 HEAD CLEANING SWABS
1 OZ. HEAD CLEANING FLUID
1 RUBBER RENEWING TOOL
1 INSTRUCTION MANUAL

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$ 13.45 total

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HEWLETT-PACKARD 3314A

Function Generator provides sine, square, and triangle waveforms from .001 Hz to 19.99 MHz with an amplitude range of 0.01 mV to 10 V p-p into 50 ohms.

$3000.00

TEKTRONIX 465B

Portable Oscilloscope, 100 MHz dual trace, 5 mV/div sensitivity, 2 nS/div sweep rate with 10 mag, trigger view, versatile trigger selection, alternate sweep.

$825.00

HEWLETT-PACKARD 141T W/ 8555A AND 8552B

Spectrum Analyzer mainframe with broadband RF Section, .01 to 18 GHz and high resolution IF section.

$3200.00

WAVETEK 178

Programmable Waveform Synthesizer, 1uHz to 50 MHz frequency range, synthesized 8 digit accuracy trigger, gate, burst, lin/log sweep, 20 volts peak-to-peak output into 50 ohm. Sine, triangle, square, ramps, and DC.

$2100.00

HEWLETT-PACKARD 182T/ 8558B SPECTRUM ANALYZER

Spectrum Analyzer, 100 kHz to 1500 MHz plug-in with the 182T cabinet style mainframe, resolution bw from 1 kHz to 3 MHz, simple knob operation.

SPECIAL $2450.00

HEWLETT-PACKARD 3336B

Synthesizer Level Generator is an excellent precision source from 10 Hz to 20.9 MHz, frequency resolution of .001 Hz, level accuracy within .15 dB over full range, AM and phase modulation. Programmable over HPIB, harmonics down more than 5 dB. Options available.

SPECIAL $650.00

FLUKE 8050A

Digital Multimeter, 4.5 digit LED, relative reference, dB, dBm, dBV, dBW, conductance, diode test, .03% basic dc accuracy, true RMS from 20 Hz to 50 kHz.

$200.00

HEWLETT-PACKARD 8568B

100 Hz to 1.5 GHz frequency range, amplitude range -135 to +30 dBm, direct plot, HP-IB.

$19750.00

HEWLETT-PACKARD 8568A

100 Hz to 1.5 GHz frequency range, 10 Hz resolution BW, trace markers with amplitude and frequency readout.

$11750.00

HEWLETT-PACKARD 1740A

Portable Oscilloscope, 100 MHz BW, 5 mV/div, dual-channel oscilloscope selectable input impedance, 8 x 10 cm CRT.

SPECIAL $500.00

HEWLETT-PACKARD 3586B

Selective Level Meter, makes carrier measurements to 32.5 MHz. Voice channel measurements from 50 Hz to 100 kHz, works with the HP 3336 Level Generator. Options available.

SPECIAL $850.00

TEKTRONIX 7L5/L3

Spectrum Analyzer plug-in, 20 Hz to 5 MHz, digital storage and averaging, reference level selection in 1 dB steps. Option 25 provides tracking generator. Comes with L3 plug-in module.

$3950.00

TEKTRONIX 475

Portable Oscilloscope, 200 MHz bw, dual trace, 2 mV/ div sensitivity, 1 nS/ div sweep rate, delaying timebase, trigger view, and beam finder.

$925.00

TEKTRONIX 2445

150 MHz Portable Oscilloscope, four channel, 1 nS/div sweep rate, 2 mV/div sensitivity, sweep rate, cursors, waveform cursors.

$1850.00

WANTED: ELECTRONIC TEST EQUIPMENT! CALL OR FAX US YOUR LIST.

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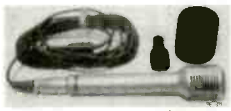
PORTABLE STROBELIGHT

Strobe uses exciter which operates from 3 to 28 VDC 500 MA and has mount base that will fit on broomstick. Change plug to a car lighter plug and strobe makes great emergency light for car or boat! Bulb size: 1.5"H x 1.3" dia; cord 60". 3 lbs. **#SDU-30/E,** unused ... **$24.95 LIGHTER DC CORD & PLUG,** 15 ft. ...**$4.00**

SONY ECM-260F CONDENSOR MIC

SONY ECM-260F CONDENSOR MIC, 200 ohm FET mic has 50-14000 Hz response and >98 db dynamic range. 7"L x 1.5" dia metal body has Cannon XLR-3-12 connection. Includes 20 ft cable with mating connector and phone plug, wind screen, stand adapter and case. Requires one AA battery. 3 lbs sh. **NEW** **$37.50**

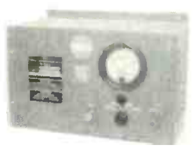


TEKTRONIX 1106 BATTERY PACK

TEKTRONIX 1106 BATTERY PACK for 455, 465, and 475 scopes with option 017. Nickel-cadmium batteries provide 22-24 VDC 7 amp-hr 5 amps max output. Charges from 90-120/200-240 VAC input. 2.6x11.5x17, 20 lbs.
GOV'T-RECONDITIONED w/book **$125**

ME-165 SWR POWER METER

ME-165 SWR POWER METER for HF transmitter tests. Provides 52 ohm 600 watt load with SWR of 1.1:1 or less up to 30 MHz using 12/ 600 ohm non-inductive 50 W resistors. Has 0-600 W meter, function switch, and N connections. 13.5x9.8x9.8, 20 lbs sh. **USED** ... **$45 GOV'T-RECONDITIONED** ... **$125**
Manual **$8.50**



H-P 500 MHZ COUNTER

HEWLETT-PACKARD 5328AF/096 FREQUENCY COUNTER with opt 030 for 5-512 MHz freq-range 15 MV sensitivity and opt 011 for HP-1B computer interface. Has 9-digit LED display and resolution 0.1 Hz-1 MHz in 8 decade steps. Channels A & B 100 MHz module have 1-10-100 ATTEN and Marker output. Requires 120/240 V 48-66 Hz. 3.5x18.5x19, 28 lbs sh. **Used-Reparable** **$350**
Checked, except for HP-1 Computer Interface **$495**

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HEATH TEST EQUIPMENT

SM2420	Digital Frequency Counter	165.00
4226(or equal)	Dual Trace 25 MHz Scope	295.00
	Non-Operative Condition (CRTOK)	189.00

HEATH EDUCATIONAL SYSTEMS

Z-DOS	Software Documentation, Vol. I & II	39.50
Z-DOS	Microsoft Documentation, Vol I	19.75
ET750	750 Hole Breadboard Block	6.95
ET340	340 Hole Breadboard Block	2.95
ET170	170 Hole Breadboard Block	1.95
ETB3300	2250 Hole Experiment Breadboard	19.95
ETB6201	Dig. Experiment Circuit Brd Module	34.50
EEA3104A	Electronic Ckts Guide & 2 Audio Tapes	14.50
HCA3000	Univ. RF Connector Adaptor Kit	49.00

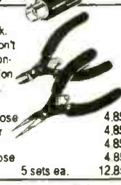
MISCELLANEOUS

B1060	*500 Insul. Lug Asst, AWG12-22 w/case	12.50
HT301	*Deluxe Ratchet Close Lug Crimp Tool	11.50
	*Combination Both Items	19.95

BNC Receptacle Assemblies

BC60	BNC / Banana Plugs	
BC70	BNC / Test Clips	
BC80	BNC / Alligator Clips	
	4.45 10 Mixed @ 3.95	BC70

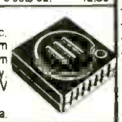
Stainless Pliers Set



Designed for precision electronic work. Stainless, rustproof, washable and won't contaminate. Furthermore, they're non-magnetic. Features: box joint, precision ground cutting edge and plastic grips. Fits palm. Limited quantity available.

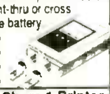
H104A	5-1/4" Offset Needlenose	4.85
H104B	4-1/4" Diagonal Cutter	4.85
H104D	5" Long Needlenose	4.85
H104E	4-3/4" Short Needlenose	4.85
H104AE	One Set of 4 14.85, 5 sets ea.	12.85

Quick Guard Motion Alarm



Instant attachment to car computer etc. by magnets. Emits 80db pulsed alarm signal if disturbed. Simple arm & disarm w/spiral key. 20 sec. entry & exit delay. Auto reset after 30 sec. of alarm. 9V battery operation.
ST23 ***SPECIAL*** 12.85 ea. 10 @ 10.50 ea.

MODULAR-TELCO RJ11 & RJ45 CABLE TESTERS



These economical hand-held units test their respective cables for opens & miswiring. Identifies straight-thru or cross wired cables. Equipped with 9V alkaline battery

DX50	RJ11-12 Tester	29.95
DX50-DEC	MMJ-DEC Tester	32.95
DX45	RJ45 Tester	36.95
DX40A	10BaseT Tester	39.95

GT100 / Up to 40 Computers Share 1 Printer

This PrintShare Starter Kit has everything you need to share your printer with two computers: (1) printer transmitter, (2) computer receivers, (2) 25ft. inter-connect cables & manual. Allows expansion up to 40 computers. Collision avoidance technology, intelligence detection and auto switching. No software required.

Any topology using 4 wire modular cable.

GT100 Starter Kit	178.50
Extra Rcvr. - (PC)	59.50
Extra Xmtr. - Printer	59.50

HEATH LEARNING COURSES

Note: The small kits of component parts usually supplied with manuals are not available and prices reflect this omission. All courses are new, and with exam

EE110	Laser Technology	24.50
EE3140A	Concepts of Electronics, 2 Vol.	36.50
EE4201	Fiber Optics Learning Course, SPECIAL	18.50
EE6201	Lab Experiments Digital Tech w/Guide	18.50
	Easy Programming Course for H-P11C & 15C 250 pg.	8.95

EDUCATIONAL BOOKS

These books are brand new & represent a saving over publishers list prices. All hard bound except (soft) as noted.

Concise Intro to Engineering Economics, Hard	12.50
TTL Cook Book, Lancaster (soft), Sams	4.95
Assembly Language Program (soft), Intel	4.95
Decision Making Under Uncertainty, Hull, P-Hall	8.95
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Fans & Systems, Applications Manual AMCA	2.95

BOOKS BY MC GRAW HILL

Software Reliability, Musa Iamino, Hard	8.95
Introducing The Unix System, McGilton & Morgan	8.95
Digital Electronics, Tokheim & Activities Man., 2 Vol.	5.95
A Reference Guide to Practical Electronics (soft)	3.95

BOOKS BY MERRILL

Experiments in Electronic Dev.	5.50
Digital Experiments-Trouble Shooting, Cox (soft)	6.95
Experiments in Electric Circuits, Stanley, 2nd	6.95
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Principles of Electric Circuits, Floyd, 3rd Ed.	12.95

CLOSEOUT - 65%-75% OFF!

Round Telephone Cable, Solid AWG-26

Stk #	# Wires	Lgt. Ft.	Price	Special
TDC4-25	4	25	~~1.95~~	.55
TDC6-25	6	25	~~2.95~~	.95
TDC6-50	6	50	~~5.90~~	1.75
TDC6-100	6	100	~~11.95~~	3.25
TDC8-50	8	50	~~8.95~~	2.95
TDC8-100	8	100	~~17.85~~	4.85

CLOSEOUT - 55%-60% OFF!

Round Telephone Cable, Solid AWG-24

TDD4-250	4	250	~~21.45~~	9.25
TDD6-100	6	100	~~13.95~~	5.95
TDD6-250	6	250	~~33.45~~	14.95
TDD6-500	6	100	~~61.95~~	27.95
TDD8-100	8	100	~~19.95~~	7.95
TDD8-250	8	250	~~46.95~~	19.50
TDD8-500	8	500	~~87.95~~	38.75

9V Battery Snap Clip
100 for 7.95 500 for 29.95
MOLDED

GT400 / Up to 40 Computers Share 4 Printers

World's first PrintShare system that supports up to four working printers simultaneously. Easy printer selection with software provided. Order a GT400 Transmitter ($89.50) for each computer and Receiver ($89.50) for each printer. Free 25ft. modular cable with each. No auxiliary power required. Run up to 1200ft. Flexible topology, first come, first served, collision avoidance. Additional Bonus: 10% DISCOUNT, over 10 units.

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with Built-In Microphone **$209**
with Mic & additional 1000 digit memory **$229**
with Mic, 2000 digits, Serial Port, Software, *and* Caller ID **$289**

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See who is calling before answering phone !
Prevent unauthorized access to modem/BBS.

TSR "Pop-Up Window" software saves to disk. Unit uses computer screen to display call
DATE, TIME, AREA CODE,
PHONE NUMBER
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CID Converter	$59
CID Converter Kit	$42
TSR Software	$7.50
60-pg CID book	$14.50 (w/purchase)

Attention: Caller ID Programmers/Developers
DOS Caller ID development "Toolbox"
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CID Generator Box (rings 2 phones, outputs Caller ID msgs - $165

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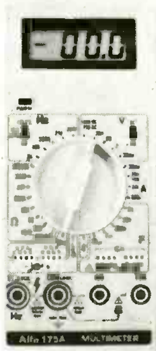
DMM + LCR Meter
Most Versatile DMM

Inductance: 1µH-40H
Capacitance: 1pF-40µF
Frequency: 1Hz - 4MHz
Temperature: -40 - 302 °F
TTL Logic Test 20MHz
Diode, Continuity
Volt, Amp, Ohm
3999 count display
Peak Hold
Auto power off
Ruggerdized case.
Rubber Holster $8.00



DMM 175A $67.95

DMM with 20 MHz
Frequency Counter
Most Popular DMM

Freq. Counter 1Hz-20MHz
DCV 0.1mV-1000V
ACV 0.1 mV-750V
ACA/DCA 0.1µA-10A
Resistance 0.1Ω-2000MΩ
Capacitance 1pF-20µF
TTL Logic test 20 MHz
Transistor HFE test
Diode test
LED test
3 1/2 digit display
10 MΩ impedance

Fluke Multimeter

Fluke 12		$79.95
Holster C-10		$10
Fluke 70 II		$65
Fluke 73 II		$90
Fluke 75 II		$127
Holster C-70		$15
Fluke 77 II		$147
Fluke 79 II		$167
Fluke 29 II		$167
Fluke 83		$225
Fluke 85		$259
Fluke 87	True RMS	$285
Fluke 86	Automotive	$359

LCR Meter 814 $199.95

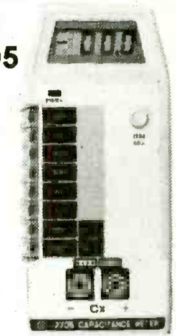
The Best Handheld LCR

Inductance: 0.1µH-200H
Capacitance: 0.1pF-20,000µF
Resistance: 1mΩ-20MΩ
1% basic accuracy
Dissipation factor indicates leakage in capacitor and Q factor in inductor
Zero adjustment to reduce parasitics from test fixture
Best for high frequency RF and surface mount components.
SMD and chip component test probe $25.00

LCR Meter 195 $119.95

Very Popular LCR

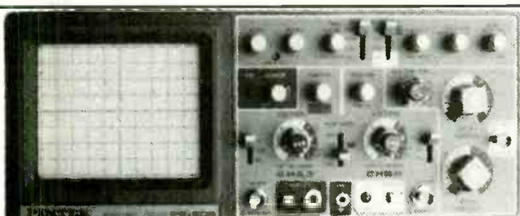
Inductance: 1µH-200H
Capacitance:0.1pF-200 µF
Resistance:0.01Ω-20MΩ
Basic accuracy:R:1%, C:2%, L:3%
Test frequency 1 kHz



Capacitance Meter 7705 $57.95

0.1 pF-20,000µF in 9 ranges
0.5% basic accuracy
Zero adjustment ± 20pF to compensate parasitics from test fixture

Also Available:
Heavy duty DMM, AC/DC clamp meter, Thermometer, Light meter pH meter, High voltage probe Digital caliper, Anemometer Elctronic scale, Force guage Tachometer, Humidity & EMF adapter, Sound level meter Frequency counter, SWR/field strength/power meter, Dip meter



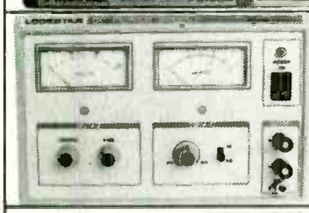
20 MHz Oscilloscope with Delay Sweep PS-205 $429.95

Dual Trace, Component test, 6" CRT, X-Y Operation, TV Sync, Z Modulation, CH2 Output, Graticule Illum, 2 probes each has x1,x10 switch. Best price with delay sweep.

PS-200 20 MHz DUAL TRACE	$339.95
PS-400 40 MHz DUAL TRACE	$494.95
PS-405 40 MHz DELAY	$569.95
PS-605 60 MHz DELAY	$769.95

20 MHz Digital Storage Oscilloscope DS-203 $729.95

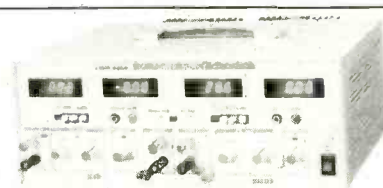
Switchable between digital and analog modes
2 K word per channel storage
Sampling rate: 10 M sample /sec
8 bit vertical resolution (25 Lerel/div)
Expanded Timebase 10ms/div - 0.5 s/div
Refresh, Roll, Save all, Save CH2, Pre-Trig
Plotter Control



DC Power Supply PS-303 $159.00

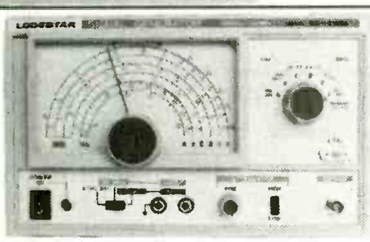
0-30 VDC, 0-3A output

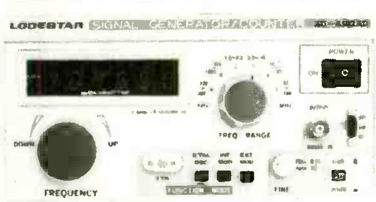
0.02% + 2mV line regulation
0.02% + 3mV load regulation
1 mVrms noise and ripple
Short circuit and overload protected
PS-8200 with digital voltmeter $179.00
Also available: 30V/5A, 60V/3A, 60V/5A 16V/10A, 30V/10A



DC Power Supply Triple Output PS-8202 $499.95

Two 0-30 VDC, 0-3A outputs
One fixed 5VDC, 3A ouptput
Capable of independent or tracking operation
Constant voltage and constant current mode
Four digital meters for volt and current display
Excellent regulation and low ripple
Short circuit and overload protected
Also available: 30V/5A triple output
60V/5A dual tracking





RF SIGNAL GENERATOR SG-4160B $119.00

100 kHz-150MHz sinewave in 6 ranges
RF Output 100mVrms to 35 MHz
Internal 1kHz, External 50Hz-20kHz AM modulation
Audio output 1 kHz, 1 Vrms

RF SIGNAL GEN./COUNTER SG-4162 AD $229.95

Generates RF signal same as SG-4160B
Frequency counter 1Hz - 150 MHz for internal and external source
Sensitivity <50mV

AUDIO GENERATOR AG-2601A $119.00

10Hz - 1MHz in 5 ranges
Output 0-8Vrms sinewave
0-10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
0.05% 500Hz - 50kHz
0.5% 50Hz - 500kHz
Output impedance: 600 ohm

AUDIO GEN./COUNTER AG-2603AD $229.95

Generates audio signal same as AG-2601A
Frequency counter 1Hz-150MHz for internal and external sources
Sensitivity <50mV

FUNCTION GENERATOR FG-2100A $169.95

0.2 Hz -2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1

FUNCTION GEN/ COUNTER FG-2102AD $229.95

Generates signal same as FG-2100A
Frequency counter 4 digits
Feature TTL and CMOS output

SWEEP FUNCTION GEN./COUNTER $329.95

0.5Hz to 5 MHz in 7 ranges
Sweep: Linear 10:1/Log 10:1 20ms to 2s
AM Modulation
Gated Burst, Voltage Control Generator
Generator Control Voltage & 6 digit counter
1Hz-10MHz for internal & external sources

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9 - $18.75	10 - $18.75	11 - $18.75	12 - $18.75	37 - $46.25	38 - $47.50	39 - $48.75	40 - $50.00
13 - $18.75	14 - $18.75	15 - $18.75	16 - $20.00				
17 - $21.25	18 - $22.50	19 - $23.75	20 - $25.00				
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able. A base can be formed from steel channel if it is thick enough to be rigid, or it can be constructed as a channel from ¼-inch or thicker glass fiber or other suitable rigid plastic laminate. Wood is not recommended as a base construction material. All bases must be one inch high if a case with the same height dimensions as the prototype is used.

Carefully drill two holes in the base with the proper spacing to accommodate the two 3-millimeter screws for cantilever mounting the load cell. Use the template, Fig. 7, for reference. The front set of drilled holes in the load cell will be directly under the center line of the ⅝ × ⅝-inch cutout in the aluminum cover plate.

Position the load cell as shown in Fig. 6 above the holes previously drilled in the base. Find two flat washers with inside diameters of at least ½-inch that are approximately 0.040-inch thick, and locate them over the holes in the base to act as shims. Fasten the load cell to the base with two 3-millimeter screws from the underside of the base. The flat washers permit a clearance space of about 0.080-inch under the cantilevered load end of the load cell.

The base plate with load cell can then be fastened to the bottom of the case. It can be seen that any weight impressed upon the load end of the cell will cause it to deflect. This action generates the electrical output signal that is amplified and converted to provide the digital readout.

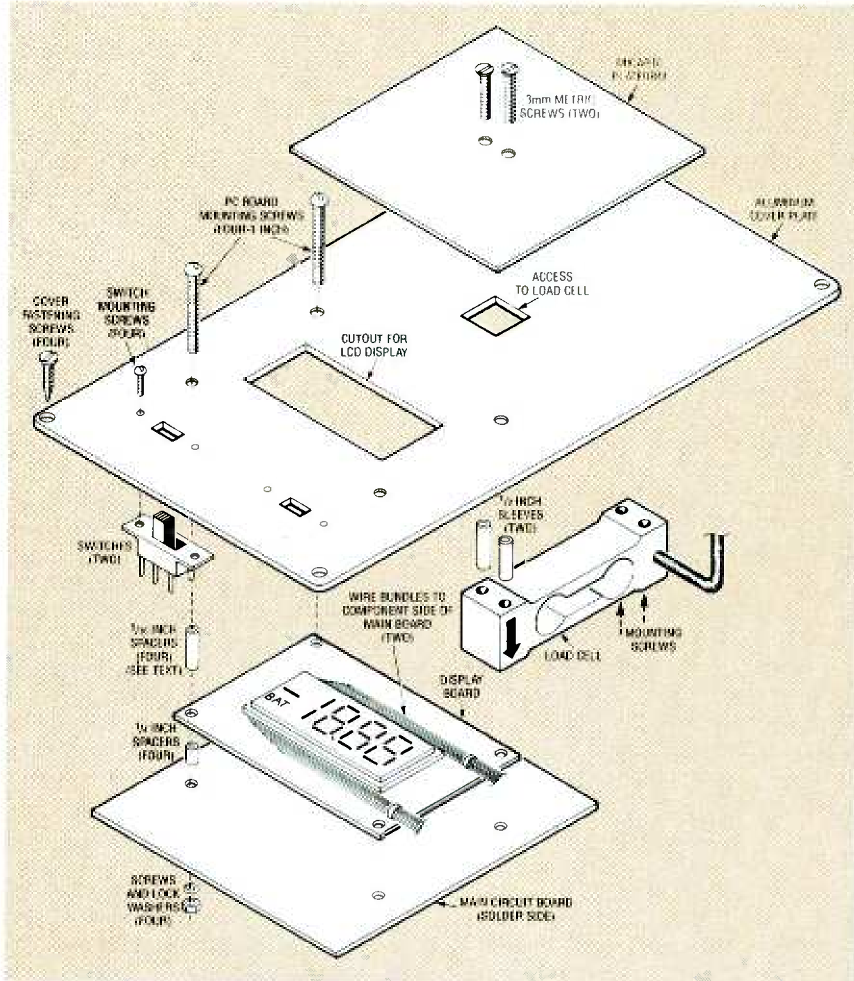


FIG. 8—PANEL/CIRCUIT BOARD ASSEMBLY: The completed boards are mounted as shown with appropriate screws, spacers and nuts.

Electrical interconnection

With the cutting and drilling complete and the load cell mounted on its base, which is secured to the bottom of the case, the off-board interconnection wiring should be completed next. Use standard stranded 24 to 28 AWG insulated hookup wire to make all connections. Different colored insulation will simplify the wiring task and make any troubleshooting and signal tracing easier.

Cut all wires to lengths that will leave enough slack to permit the circuit boards to be stacked as shown in Fig. 8, but not long enough to interfere with cover closure. Strip the insulation back about ⅛ inch from both ends of each insulated hookup wire.

Refer back to Figs. 2, 4, 5, and 8 and complete all of the wiring between the main circuit board and the display board. Then complete all off-board wiring as shown in Figs. 4 and 6, again making sure that the wire lengths are long enough to permit opening the cover, yet not long enough to interfere with cover closure. When the wiring is complete, bundle related groups of wires with thin cable ties or bind them with cord to relieve stress on individual wires and improve the appearance of the wiring.

Sufficient space was allowed in the prototype between the side of the load cell base and the wall of the case to permit the two 9-volt batteries to fit snugly in position without clips or clamps. Terminate the red and black wires by soldering snap-on caps for the appropriate battery terminals. Also make up a jumper from insulated hookup wire with caps soldered on each end for the series connection as shown in Figs. 2 and 6.

As the last step, connect the four color-coded leads from the load cell's shielded cable as shown in Figs. 2, 4, and 6, observing the color coding shown. Twist a short length of the braided shielding at the end of the load-cell cable to form a solid wire, and tin it with solder. With a hand drill, form a hole about 0.060-inch in diameter in the copper foil border of the main circuit board, which acts as a ground bus. Push the twisted and tinned braid end through that hole and solder it to the copper ground bus.

Final assembly

Position the circuit boards as shown in Fig. 8, and with the appropriate spacers and screws, fasten them to the cover plate. The spacers between the panel and display board must be cut precisely so that the LCD module is flush with the underside of the cover but not under stress. The spacers between the display and main boards should be approximately ¼-inch long.

The ⅝ × ⅝-inch cutout cut into the cover allows the scale platform to be mounted to the load cell with screws and a pair of spacers when the scale is completely assembled. The length of the spacers will depend on the desired distance between the top of the mounted load cell and the underside of the scale platform, but they should be kept less than ¾-inch long. (The spacers in the prototype are ½-inch long.)

Assemble the cover panel with attached circuit boards to the case, and fasten it with screws at four corners. Then assemble the platform with the two 3-millimeter screws and spacers. After satisfying yourself that the mechanical phase is complete, remove the platform and cover, and proceed with the electrical tests.

Electrical tests

A digital or analog voltmeter with an input resistance of at least 1 megohm will be needed for the electrical test of the digital scale. A filtered, regulated DC power supply able to provide +15 volts DC to power the circuit under test will also be needed. An oscilloscope will be useful if the circuit does not function correctly when the power is switched on.

Limit the current from the external power supply to about 40 milliamperes after connecting the supply with the proper polarity. (The scale will normally draw about 30 milliamperes.)

Set potentiometers R4, R11, and R19 to their midpositions. Switch S2 to OUNCES. Apply power to the circuit and measure the output of voltage regulator IC1 between the 10-volt bus and circuit ground. The voltmeter reading should be between +9.5 and +10.5 volts.

If you do not obtain voltage in that range, do not proceed until the circuit fault is found and corrected. The most likely causes of improper voltage are: 1. incorrect input voltage polarity, 2. a short circuit in the wiring, or 3. a polarized component incorrectly located on the circuit board.

Recheck to be sure the DIP-packaged IC's: IC1, IC2, IC3, and IC4 are properly oriented as is the polarity mark on electrolytic capacitor C1. Measure the voltage and its polarity at the input of IC1 to be sure that it is at least +12 volts DC. Recheck the wiring of the main circuit board for any possible shorts or cold solder joints. Check the wiring to switches S1 and S2-a.

After you have verified that voltage regulator IC1 is delivering the proper voltage, proceed with the test. Display DISP1 should show a number, positive or negative. If it is blank, there will probably be a fault with IC4 or DISP1.

Check the orientation of DISP1, IC4 and all of its associated components. Check pin 21 of IC4 with an oscilloscope for the presence of the 100-Hertz backplane squarewave signal. If no waveform is present and no fault can be found in the wiring, replace IC4.

Rotate the knob of the zero-adjust panel-control potentiometer R11 over its range while observing the display. If the circuit is wired correctly, negative numbers should appear on the display when the control knob is set at its maximum counterclockwise position, and the negative sign should drop out as the knob is turned clockwise to its maximum position.

If the potentiometer is wired incorrectly and the knob does not cause the changes previously described, correct this fault by interchanging the two outer wires from the lugs of control potentiometer R11. If the display reading cannot be adjusted through zero because of the effect of the weight of the platform, reduce the value of either resistor R10 or R12 by at least 10 % in increments until the operating range of the control is centered.

If the segments or complete digits of the display are not correctly formed, there is either a wiring error between IC4 and DISP1, or there is a short or open circuit in one of the conductors on either of the circuit boards. Identify the incorrectly formed digits and, by referring to Fig. 2, find the faulty connections.

When you are satisifed that the display readings are correct as the knob of zero-adjust potentiometer R11 is rotated over its range, the scale can be calibrated. Reassemble the cover and platform, and make these adjustments with the platform attached to the load cell because its weight must be nulled out by zero-adjust potentiometer R11.

Calibrate the circuit first in the OUNCES mode because the GRAMS calibration depends on the final setting of potentiome-

continued on page 87

TABLE 1
WEIGHT EQUIVALENT TABLE

1 ounce (avoir.)	= 28.35 grains
1 ounce (troy)	= 31.10 grains
1 pound (avoir.)	= 0.453 kilogram
1 pound (troy)	= 0.373 kilogram
1 gram	= 15.43 grains (troy)
1 gram	= 0.032 ounce (troy)
1 gram	= 0.035 ounce (avoir.)

TABLE 2
WEIGHT CONVERSION TABLE

To Convert	Into	Multiply by	Conversely, Multiply by
grams	grains	15.43	6.481×10^{-2}
grams	ounces (avoir.)	3.527×10^{-2}	28.35
kilograms	pounds (avoir.)	2.205	0.4536
ounces (avoir.)	pounds	6.25×10^{-2}	16.0

ThumbDrum

Let your fingers do the tapping with the ThumbDrum.

JOHN SIMONTON and KENT CLARK

LAST MONTH WE WENT OVER THE theory on how the ThumbDrum operates. Now let's build it and get it working.

Getting it together

Step 1 is to decide what you're going to build. You must build the sensor board and either the MIDI computer or the analog tone board. Remember that MIDI does not produce sound, so if you build that version you will need a MIDI keyboard, sound module, or MPC (Multimedia PC) to produce the actual sounds. If you're after a system that generates those funky drum sounds, you'll need the sensor board and the tone board.

When assembling any circuit board, remember that polarized components such as electrolytic capacitors, diodes, and IC's must be installed with the proper polarity. Do not use a solder gun; when you release the trigger, the powerful magnetic fields it generates can damage some IC's.

Although the circuits can be assembled with wire-wrap or other common prototyping techniques, printed circuit boards provide the best results. Foil patterns were provided last month, and ready-to-use boards are available from the source mentioned in the Parts List. If you don't use PC boards, make wire runs as short as possible on perforated board.

Since the sensor board is common to all configurations, it makes a good starting point for assembly. The sensor-board circuitry is built on a single-sided circuit board, and its parts-placement diagram is shown in Fig. 4. Even though it is a single-sided board, the piezoelectric discs (PZ1–PZ8), their associated trimmer resistors (R1, R2, R5 R8, R11, R17, R20, and R23), and the power/overload indicator LED1 mount on the solder side of the board—which ends up facing the top side of the ThumbDrum so that these parts will be able to peek out through holes in the top of the case. (Note that all of the parts that mount on the solder side of the board are shown with dashed outlines.)

It's best to start the sensor board assembly by installing the parts on the component side of the board. When inserting voltage-regulator IC1, press it down against the board because there won't be room for it to stand up when the computer or tone board is in place.

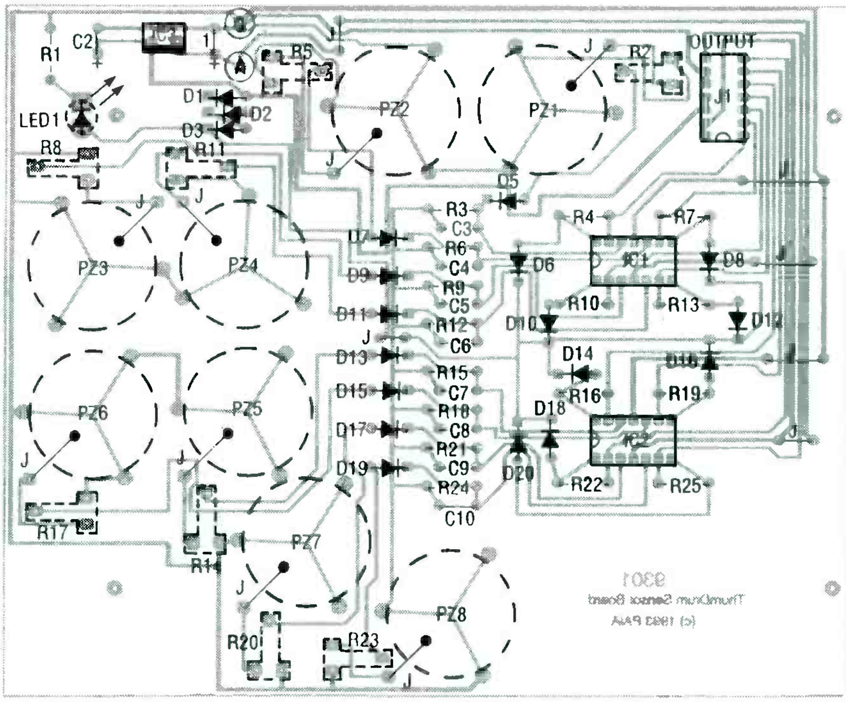


FIG. 4—SENSOR-BOARD PARTS-PLACEMENT DIAGRAM. The piezoelectric discs, their associated trimmer resistors, and LED1 mount on the solder side of the board.

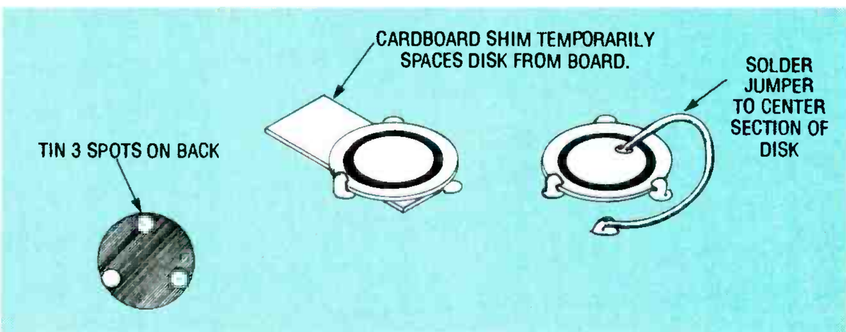


FIG. 5—PREPARE EACH PIEZOELECTRIC DISC as shown here. Make sure that the silver face of the sensor is pointing away from the board.

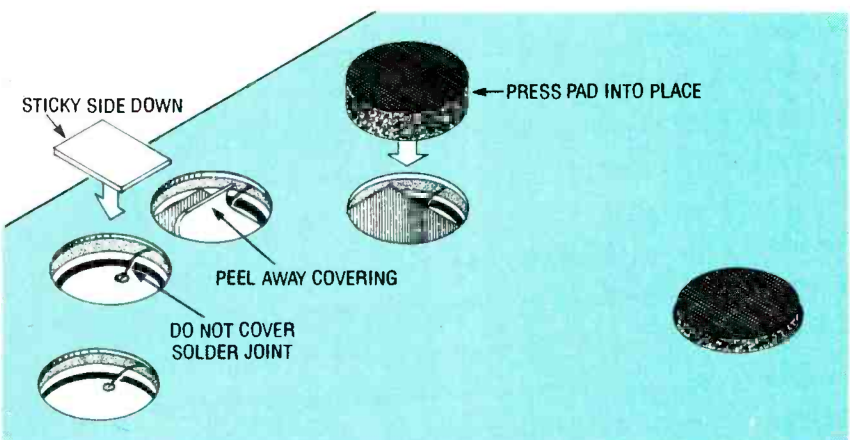


FIG. 6—MOUNT A FOAM-RUBBER CUSHION on each piezoelectric disc as shown here.

The piezoelectric discs that mount on the solder side of the board must be raised off the board slightly. That not only prevents the brass disc from shorting out traces underneath, it also provides a suspension mount for the disc that mechanically isolates it from the circuit board. Without that mechanical isolation, the striking force on the sensor can be transmitted through the board to other sensors, resulting in a mechanical "cross-talk" that might cause unintended drums to sound. Keeping cross-talk to a minimum effectively increases dynamic range.

Tin the three mounting pads for each piezo disc and the corresponding points on the circumference of each disc with small solder bumps. (The silver face of each sensor points away from the PC board.) Mount the discs by remelting the solder (see Fig. 5). Be aware that the brass disc of the sensor will quickly soak up heat. A typical 25-watt soldering iron must be held in place for some time before the disc accepts solder. That's permitted, because the discs are not temperature sensitive—but your fingers are, so let them cool a little bit before touching them. Temporarily space the disc off the board with shims made of narrow strips of thin cardboard (about 5 business cards worth) while re-melting the solder connections. Pull the shims out when the solder has cooled.

Make the connection between the active face of the sensor and the circuit board with the smallest diameter wire you can find: 30-gauge wire-wrap wire is ideal. Solder one end of the wire to the indicated pad on the board and the other end directly to the silver face of the sensor. Pre-tin the wire before soldering, and do it quickly. Soldering to the brass disc takes lots of heat, but the thinly deposited tin-lead coating in the center of the disc doesn't require much heat at all. If you blow it the first time and wind up with a small hole in the silver and the wire not attached, just solder to another place. A small hole won't effect the operation of the sensor much. After the jumper wire is in place, a round foam-rubber cushion should be mounted on each piezo disc as shown in Fig. 6. The cushions are included in the ThumbDrum kit, but you can make them by cutting out circles from an old computer peripheral mouse pad.

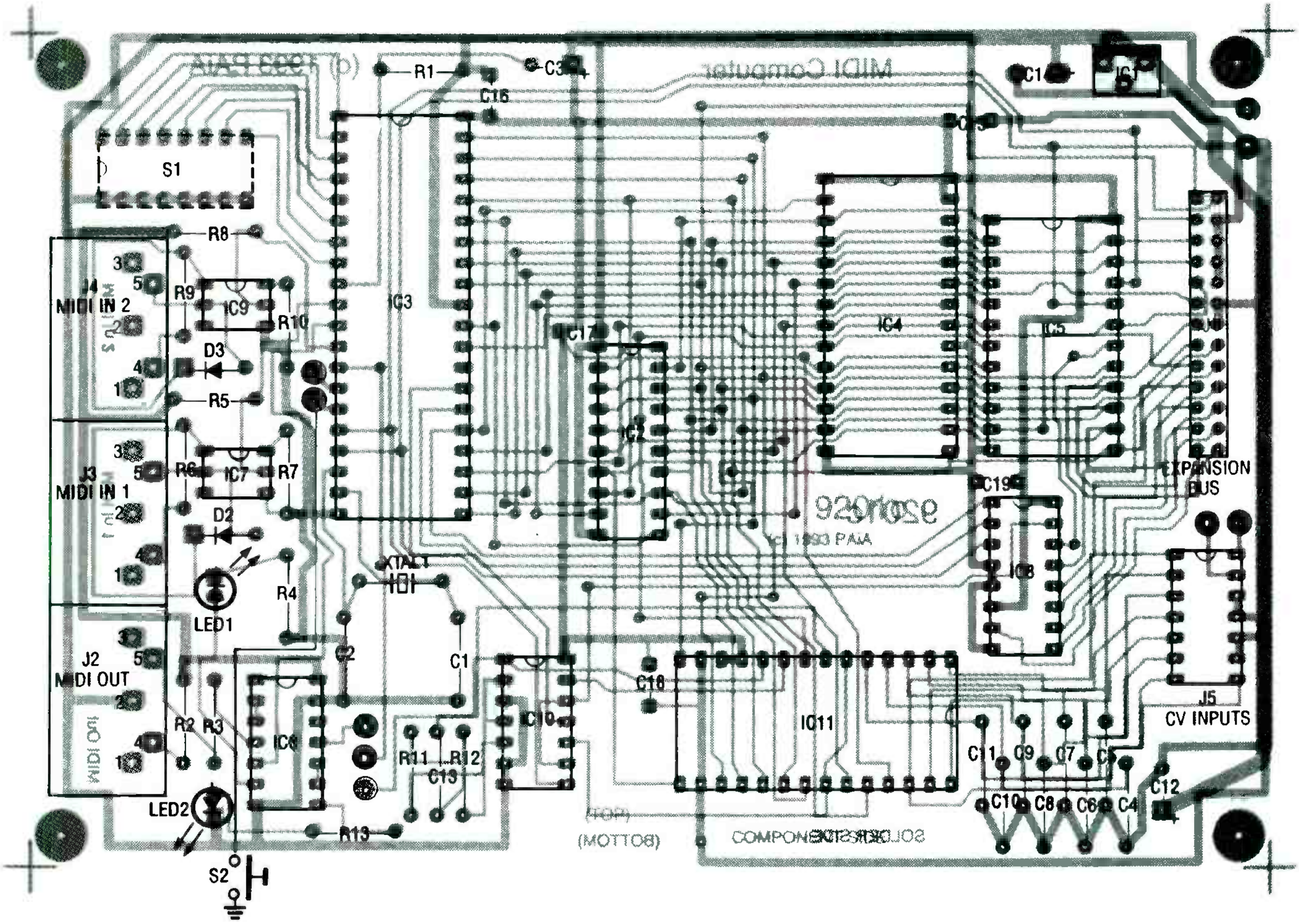


FIG. 7—MIDI COMPUTER PARTS-PLACEMENT DIAGRAM. DIP switch S1 mounts on the solder side of the board.

Solder the trimmer resistors and LED1 to the solder side of the board. The pads for those components are made larger than normal to make soldering easier, and to give more mechanical strength where the pads adhere to the board. Allow about ¼-inch of space between the bottom of the LED's base and the circuit board.

In the prototype, a four-inch long, 14-conductor ribbon cable terminated in DIP headers makes the connections between the sensor board and computer or tone boards. The sensor end of the cable can be soldered directly into the DIP pattern at J1. Make sure that the pin-1 conductor of the ribbon cable (usually marked with a color stripe) corresponds to pin 1 of J1.

When you've finished assembling the sensor board, do the following tests: Temporarily apply +12-volts to the circuit board pads "A" (+) and "G" (−), and make sure that LED1 lights. Turn all of the sensitivity trimmers fully clockwise and tap each pad—you should see the LED brighten very briefly with each tap. If you use a voltmeter, set it to its 10-volt DC scale across the outputs of the individual sensors (pins 1–8 of J1). You should see no voltage until you hit the pad, and then you'll see an upscale swing. If the sensor assembly doesn't perform that way, stop and find out why.

Turn off the power to the sensor board, and put the assembly aside while you build either the MIDI computer or the tone board.

MIDI computer

The MIDI computer is built on a double-sided board as shown in Fig. 7. One component, DIP switch S1, mounts on the solder side of the board, so that it will be accessible through an opening in the bottom of the case.

The author is not a big fan of IC sockets, because the only re-

SENSOR BOARD PARTS LIST

All resistors are ¼-watt, 10%.
R1—1500 ohms
R2, R5, R8, R11, R14, R17, R20, R23—100,000 ohms, trimmer potentiometer
R3, R6, R9, R12, R15, R18, R21, R24—1 megohm
R4, R7, R10, R13, R16, R19, R22, R25—1000 ohms

Capacitors
C1, C2—100 µF, 15 volts, Electrolytic
C3–C10—0.01 µF, ceramic disc

Semiconductors
IC1, IC2—LM324 quad op-amp
IC3—7805 5-volt regulator
D1–D3, D5–D20—1N914 diode
D4—not used
LED1—red light-emitting diode

Other components
S1—SPST slide switch
T1—12-volt DC wall transformer
PZ1–PZ8—piezoelectric disc transducer
J1—14-pin DIP socket

Miscellaneous: PC board, foam-rubber pads, double-sided tape, wire-wrap wire, ribbon cable, project case, hardware, solder

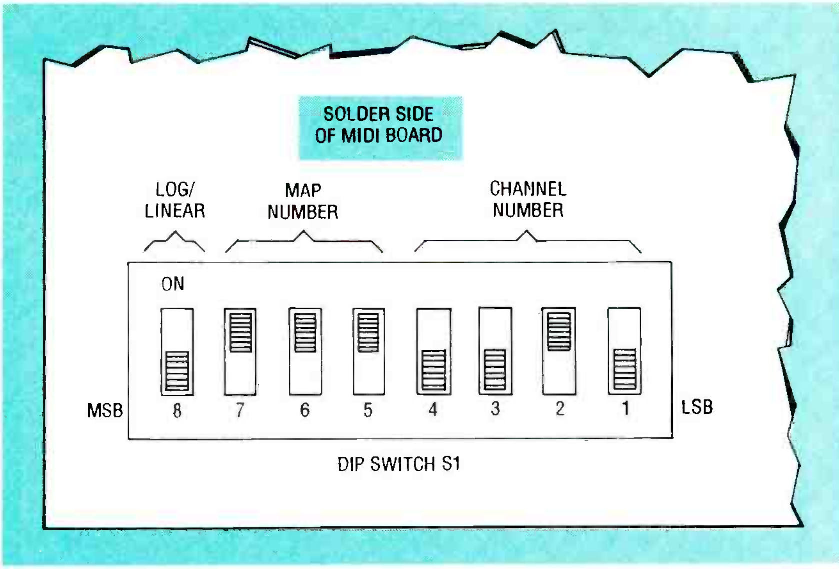


FIG. 8—FOR TESTING, set DIP-switch S1 as shown here. The four least significant switches (1–4) set the MIDI channel, switches 5–7 select one of eight "maps" assigning different drum sounds to different pads, and the Log/Linear switch (8) selects a logarithmic or linear response.

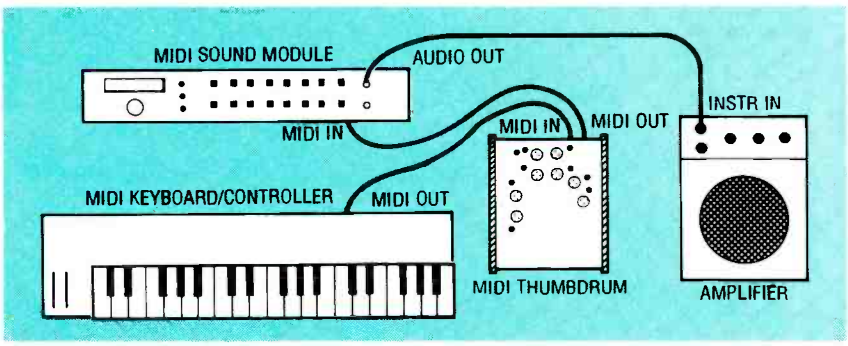


FIG. 9—THE MIDI JACKS allow keyboard/controllers to be daisy-chained into sound modules as shown here.

liable ones seem to be more expensive than the components that go in them. But microprocessor ROM chips are an exception and using sockets for IC3 and IC4 is recommended.

There are locations for some components on the circuit board that are not used in this application. Those components were marked with an asterisk (*) in Fig. 2 last month. The board is designed so that PC-mount DIN jacks can be used for the MIDI jacks, but in the ThumbDrum panel-mount jacks with leads going back to the circuit board are used. The REMAP button, S2, is also mounted off-the-board. One side connects to the circuit-board pad "B" and the other side connects to any convenient ground trace.

A 14-pin DIP socket is used for J5, which is the connector for the sensor board. When you install crystal XTAL1, position it on its side. Once all the parts are mounted and you've inspected your work carefully for solder bridges and bad joints, it's time to test the system.

Set DIP switch S1 as shown in Fig. 8. Plug the ribbon cable from the sensor board into J5 on the MIDI board, and make sure that the pin 1 positions on each side correspond. Turn on power to the sensor board and make sure the power LED lights. Tapping the percussion pads should cause the Send/Active LED to blink.

If the LED doesn't blink, check for solder bridges and misplaced parts. Check the voltage at the supply pins of the IC's (not at the socket).

For the final test, connect a MIDI cable from the Computer Board's J2 (MIDI OUT) to the MIDI input of your favorite keyboard, sound module, or MPC, and set this receiving device for MIDI Channel 1. As you strike percussion pads, you should hear sounds from the audio output of the receiving device. The specific sounds are largely immaterial at this point; you'll learn to select them as you use the ThumbDrum. Now install the electronics in the case, close the cover, and celebrate. The two boards are joined together and secured to the bottom of the case with standoffs and hardware (see photos).

TONE BOARD PARTS LIST

All resistors are ¼-watt, 10%.
R1—1000 ohms
R2, R5, R9, R16, R23, R31—10,000 ohms
R3, R4, R10, R11, R13, R17, R18, R24, R25, R32, R33, R39, R47, R6, R20, R27, R35—3.9 megohms
R7, R14, R21, R28, R36, R51—100,000 ohms, trimmer potentiometers
R8, R15, R45, R60—330 ohms
R12—15,000 ohms
R19—68,000 ohms
R22, R30—33,000 ohms
R26, R29, R44—1 megohm
R34—39,000 ohms
R37, R43—680,000 ohms
R38—2200 ohms
R40–R42, R46, R48, R50—2.2 megohms
R49, R52–R57—47,000 ohms
R58, R59—22,000 ohms
R61—10,000 ohms, potentiometer
Capacitors
C1, C13, C18, C26, C9—0.01 µF, ceramic disc
C2, C6, C10, C14, C19, C22—0.01 µF, Mylar
C5—0.05 µF, Ceramic
C7, C8—4700 pF, Mylar
C3, C4, C11, C12, C15, C16, C20, C21—0.001 µF, Mylar
C17—0.22 µF, Mylar
C23, C24, C27–C29—560 pF, Mylar
C25—0.1 µF, Mylar
C30—0.005 µF, Ceramic
C31—10 µF, 15 volts, electrolytic
Semiconductors
IC1, IC2—LM324 quad op-amp
IC3—5532 dual low-noise op-amp
D1–D5—1N914 diode
Q1—NPN silicon transistor (selected for noise, see text)
Other components
J1—14-pin input connector
J2—16-pin DIP socket
J3—¼-inch phone jack
Miscellaneous: PC board, ribbon cable, solder

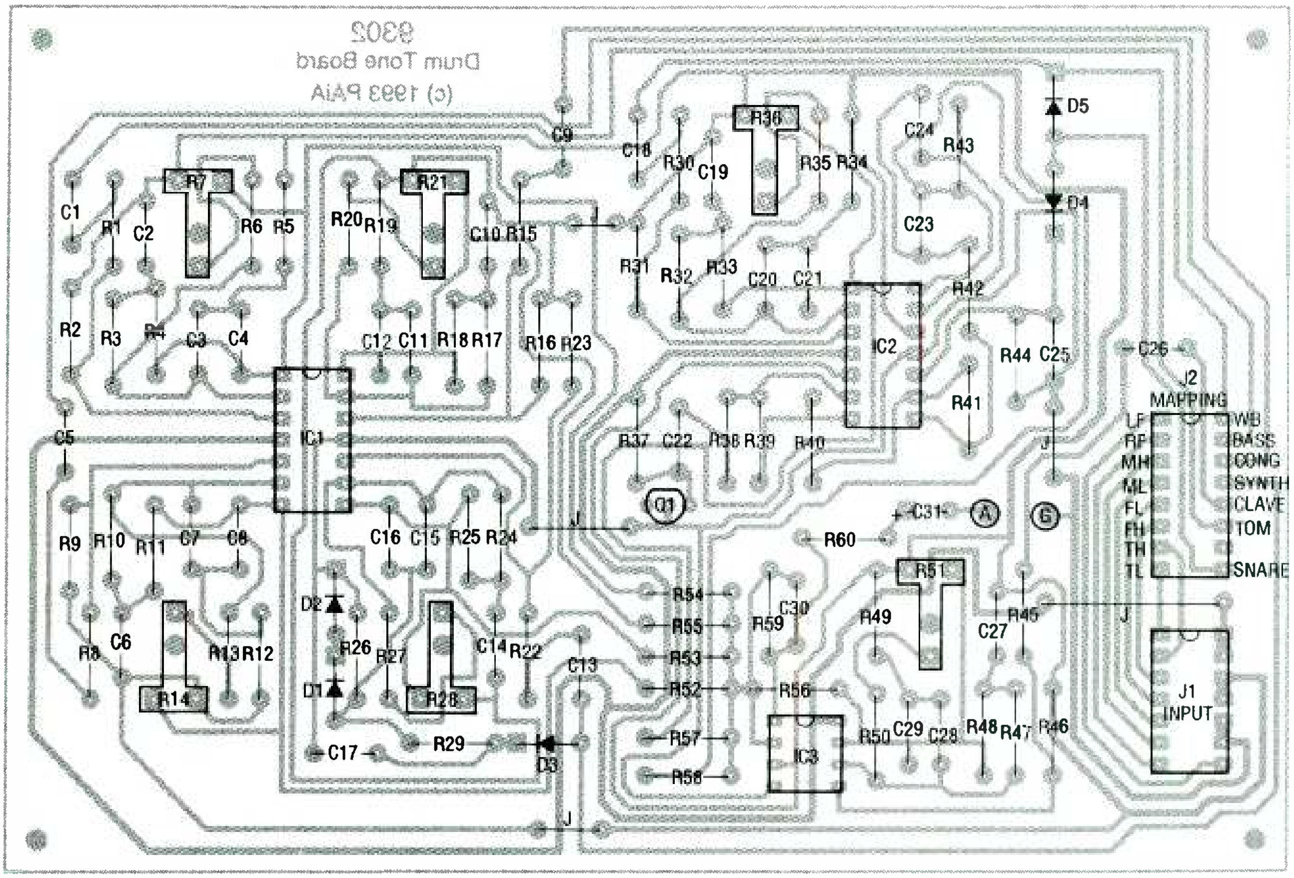


FIG. 10—TONE BOARD PARTS-PLACEMENT DIAGRAM. A hole under each trimmer allows adjustment from the bottom of the board.

Using the MIDI ThumbDrum

Setting the sensitivity trimmers is very important. Trigger pulses greater than 5 volts produce unpredictable results that will probably sound like all the drums going at once. Remember, the power LED on the sensor board provides an indication of an overload condition. If the power LED glows brighter, briefly, when a sensor is struck, it's an indication that the sensitivity is set too high.

A common way to use the ThumbDrum is in the configuration that we used to test it; simply plug it's MIDI Out into the MIDI In of a keyboard or sound module. The receiving device must be set to receive MIDI on the channel that the ThumbDrum is using for sending (from 1 to 16) as set by the four least significant switches of S1. (The DIP switches should be set to the MIDI channel number minus 1, in binary—channel 1 is 0000, channel 2 is 0001, channel 3 is 0010, and so on.)

The Log/Linear DIP switch number 8 (see Fig. 8) selects a logarithmic or linear response. If there seems to be a lack of dynamic range (the sounds are not soft enough) try turning that switch off to select a logarithmic response.

DIP Switches 5–7 select one of eight "maps" assigning different drum sounds (actually MIDI notes) to different pads. There are a few instrument-specific maps and general MIDI maps of different drum kits. There's a "Latin Kit" with claves and maracas and a "Rock Kit" with symbals and snares. They're too lengthy to include here, but they're part of the self-extracting ZIP file called EN-DRUM.EXE on the *Electronics Now BBS* (516-293-2283, 1200/2400, 8N1). The maps are provided with special thanks to Charles Fischer who configured them.

You're not stuck with just those eight drum maps; the ThumbDrum allows for remapping. Remapping requires that a keyboard—or some other source of MIDI note data—be plugged into the MIDI In jack. To change the MIDI note assigned to a pad, push the remap button and play a note on the keyboard. Release the remap button, and within five seconds hit the pad to which you want to assign the note. If you decide you don't want to make a change after hitting the remap button, just release it and wait five seconds.

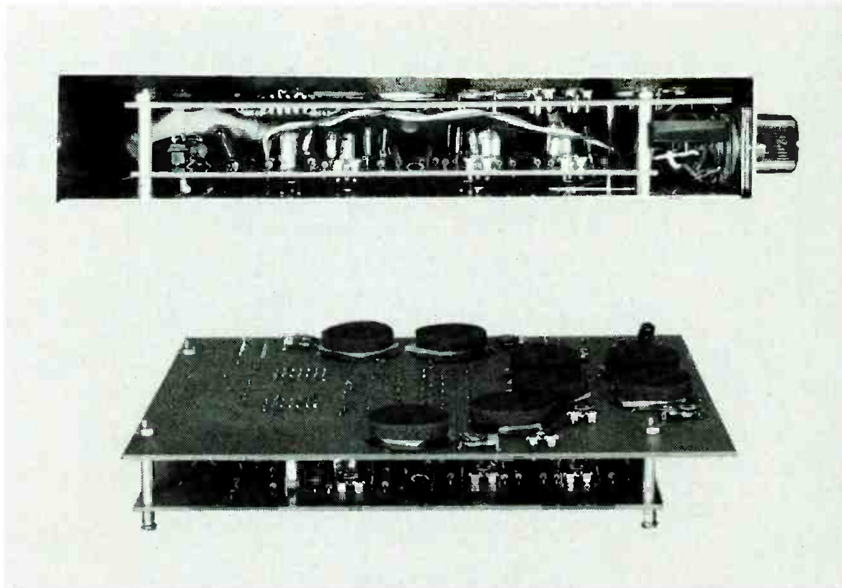
If you haven't installed any RAM on the MIDI computer board you will be able to change only map number 8, and the change will be lost when power is turned off. If you installed a 6116 RAM chip as IC11, you can change all maps but the data is volatile. If you've installed an MK48Z02 (a battery backed-up RAM), all maps can be altered and changes will not be lost when power is turned off.

The ThumbDrum's MIDI IN jack provides a "merging" function that allows data appearing there to be combined with information from the sensors to form the final MIDI output. That allows keyboard/controllers

MIDI COMPUTER PARTS LIST

All resistors are ¼-watt, 10%.
R1—4700 ohms R2, R3, R6, R9—220 ohms
R4, R13—680 ohms
R5, R8—3300 ohms
R7, R10, R11—100,000 ohms
R12—3900 ohms
Capacitors
C1, C2—33 pF, ceramic disc
C3—10 µF, electrolytic
C4–C11—0.1 µF, Mylar
C12—1 µF, electrolytic
C13—100 pF, ceramic disc
C14—100 µF, electrolytic
C15–C19—0.01 µF, ceramic disc
Semiconductors
IC1—7805 5-volt regulator
IC2—74HC373 octal latch
IC3—8031 8-bit microcontroller
IC4—2764 EPROM
IC5—6116 static RAM
IC6—74HC04 hex inverter
IC7, IC9—TIL111 optoisolator
IC8—74HC138 1-of-8 decoder
IC10—74HC02 quad NAND gate
IC11—ADC0809 8-input ADC
D1—not used
D2,D3—1N914 diode
LED1, LED2—red light-emitting diode
Other components
J1—optional expansion header
J2–J4—5-pin DIN (MIDI) socket
S1—8-position DIP switch
S2—normally open pushbutton switch
XTAL1—12 MHz crystal
Miscellaneous: PC board, ribbon cable, solder

Note: The following items are available from PAiA Electronics, Inc., 3200 Teakwood Lane, Edmond, OK 73013, Phone (405) 340-6300, Fax (405) 430-6378:
- **Sensor PC board only (item # 9301pc)—$16.50**
- **MIDI PC board only (item # 9201pc)—$27.25**
- **Tone PC board only (item # 9302pc)—$19.25**
- **Sensor board kit (item # 9301k, includes PC board and parts)—$54.25**
- **MIDI computer kit (item # 9201k, includes PC board, DIN jacks, and PROM with firmware)—$89.50**
- **Tone board kit (item # 9302k, includes PC board and parts)—$34.75**
- **Complete MIDI ThumbDrum kit (item # 9300m, includes case, PC board, all parts, and firmware in PROM)—$165.00**
- **Complete audio ThumbDrum kit (item # 9300a, includes case, PC board, and all parts)—$99.00**
- **Case only (item # 9300c, includes wood side panels)—$28.50**



THE SENSOR BOARD AND EITHER THE MIDI OR TONE BOARD are held together and mounted to the case with screws and spacers.

(which, like the ThumbDrum, has no sound-producing capabilities) to be daisy chained into sound modules as shown in Fig. 9.

Tone Board

The tone PC board, shown in Fig. 10 has, in addition to the normal component-mounting holes, a ⅛-inch hole drilled under each trimmer so the trimmer can be adjusted from the bottom of the board (and from the bottom of the case when the unit is finished).

All of the components for the Tone Board mount on the component side of the board. Sockets can be used for the IC's if you wish, as there is sufficient room for them. Use a 14-pin DIP socket for J1.

The DIP pattern marked J2 on the tone board is a jumper area where pads from the sensor board are connected to drum sounds. A DIP header can semi-permanently provide this mapping. A 16-pin socket is recommended here.

After you have assembled the board and have checked your work, plug the sensor board's ribbon cable into the socket at J1 on the tone board. Make sure pin 1 of the cable corresponds to pin 1 of the socket. Turn on the power and make sure the power LED lights.

The first test of the tone board is simply listening to it, so either connect the audio output to an amplifier or plug in a pair of headphones. Begin by setting all trimmers on the tone board fully counterclockwise. You should not hear any output from the tone board. As you slowly adjust the trimmers, you should hear a tone that begins to swell and then stay constant. When you hear the tone, back off on the trimmer and go on to the next one.

When you have confirmed that all the oscillator circuits work, jumper drum-sound circuits to finger pads one at a time at J2. (An eight-position DIP switch temporarily inserted in socket J2 makes it easy to test pads and oscillators one at a time.) Hit a pad and adjust the trimmer of the drum circuit connected to that pad. As you strike the pad while adjusting the trimmer, you'll first hear a dull pop, then a more of a drum-like tone, and finally sustained oscillation. Back the trimmer off from the sustained oscillation until you have a sound that most closely resembles a specific drum.

Setting the sensitivity trimmers on the sensor board is not as critical with the tone board as it is with the MIDI Board. Trimmers for pads driving the snare drum should always be fully clockwise. Ω

Build this versatile printer power controller.

PRINTER-MINDER

JIM COOKE

DO YOU DEBATE WHETHER TO TURN your printer on and off—or do you simply leave it on all the time? Perhaps you've got a remote data-logging or control application in which the printer need be on only occasionally.

Either way, Printer Minder can help. Printer Minder is an inexpensive printer controller that applies power to a printer whenever it receives a print request, and subsequently removes power following a one-hour delay after the printer has accepted the last character.

You can build Printer Minder from a kit for about $150. In case you wish to roll your own, we publish complete PC board patterns; in addition, bare boards are available separately.

Overview

You install Printer Minder between your computer and your printer, as shown in Fig. 1. When you first apply power to Printer Minder, it will prevent power from being applied to the printer. The reason is to protect the printer in the case of brownouts or power failures. Printer power remains off until the host CPU actually starts sending data. While in the power-off state, Printer Minder fakes the signals the computer needs to make it think that the printer is on and ready. That allows the computer to begin sending data without thinking there is a printer error. As soon as Printer Minder receives a character, it asserts a control signal to make the computer wait until Printer Minder gets through its power-up sequence.

When the printer does become ready, Printer Minder presents data to it, along with the necessary control signals. After the printer acknowledges the first character, Printer Minder drops out of the loop, and data simply flows through directly to the printer.

A retriggerable one-shot keeps power on to the printer for about one hour after the last character has been received. After the time limit expires, power turns off automatically. To help protect the printer from power-line transients, Printer Minder also includes several metal-oxide varistors (MOV's).

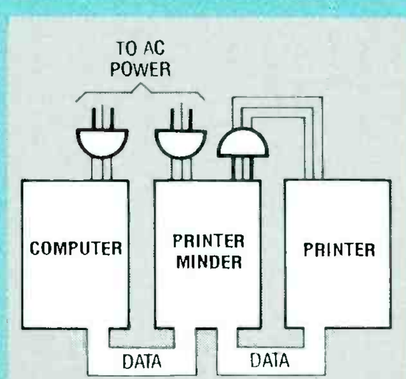


FIG. 1—PRINTER MINDER controls the flow of data and AC power to your printer. After a one-hour time-out, Printer Minder turns the printer off; as soon as data starts flowing again, it turns the printer back on.

How it works

Printer Minder consists of two main sections: AC Power Control and Logic Circuit. We describe each in turn.

Referring to Fig. 2, Printer Minder uses a relay (RY1) to control the power to the printer. Transistor Q1 drives the relay to handle the necessary current. The relay is a normally-open type; it is on only when IC8-a (the retriggerable one-shot) is active. The time constant of the one-shot is approximately one hour. What triggers the one-shot is a STROBE signal from the computer, labelled "BUF STB" in Fig. 2. After an hour passes, IC8-a times out, which de-energizes the relay, which in turn disconnects power to the printer. To indicate power status, LED1 lights up.

The one-shot also has a CLEAR input that is driven by a power-up signal (PUP), which is generated by C3, R13, and IC10-b; its purpose is to ensure that IC8-a remains clear (hence the printer remains off) when power is first applied to Printer Minder.

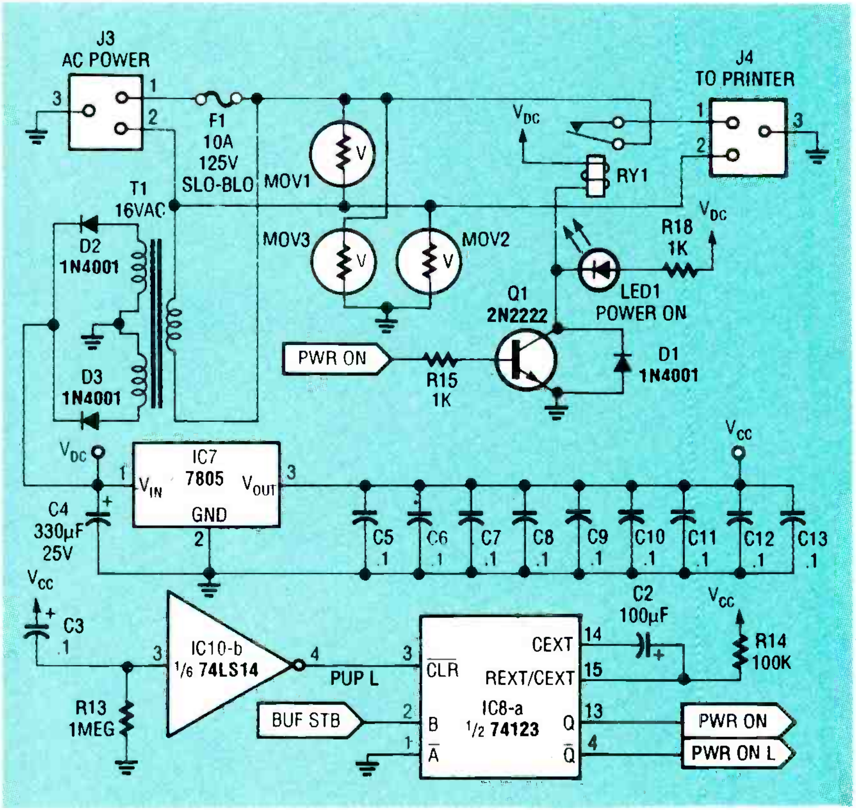


FIG. 2—RELAY RY1 controls AC power to the printer; it in turn is driven by Q1, which is driven by one-shot IC8-a.

Other components include three MOV's (MOV1–MOV3) that protect Printer Minder—and, more important, the printer—from voltage transients.

The power supply provides a regulated +5-volts DC (V_{CC}) for the logic circuit, and unregulated +12-volts DC (V_{DC}) to drive the relay and LED1.

Logic circuit

Let's discuss the simple case first; refer to Fig. 3. When printer power is on, Printer Minder simply routes the various control signals straight from the computer to the printer (for the STROBE signal), and from the printer to the computer (for the ACK, BUSY, PAPER OUT, and SELECT signals). Octal latch IC1 buffers the data lines, and should be sufficient in most cases. Buffer IC9 is optional; its purpose is to provide extra "oomph" when driving long or noisy transmission lines. The data inputs and outputs are shorted together on the PC

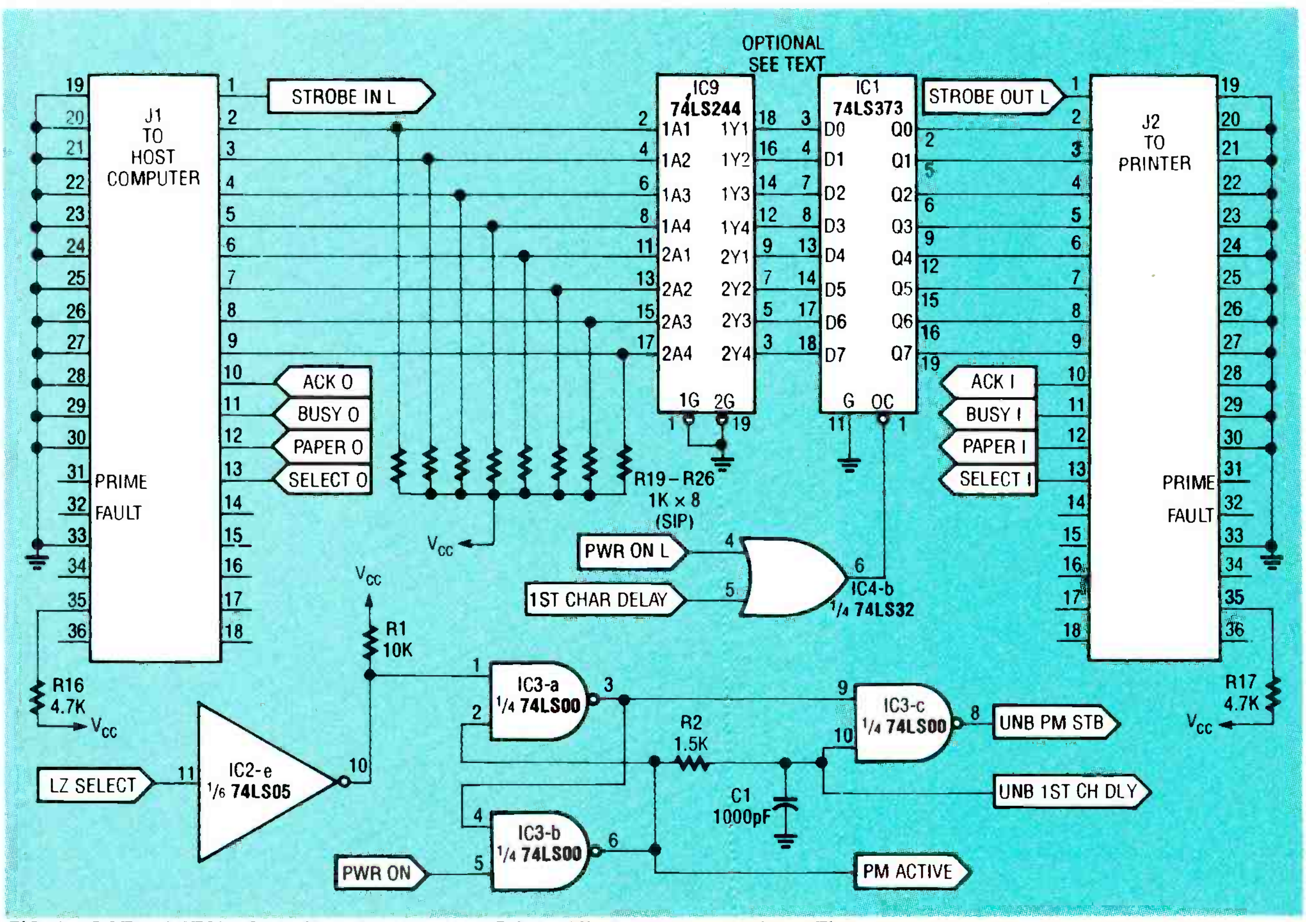


FIG. 3—OCTAL LATCH IC1 buffers data between Printer Minder and your printer. The latch is enabled by IC4-b.

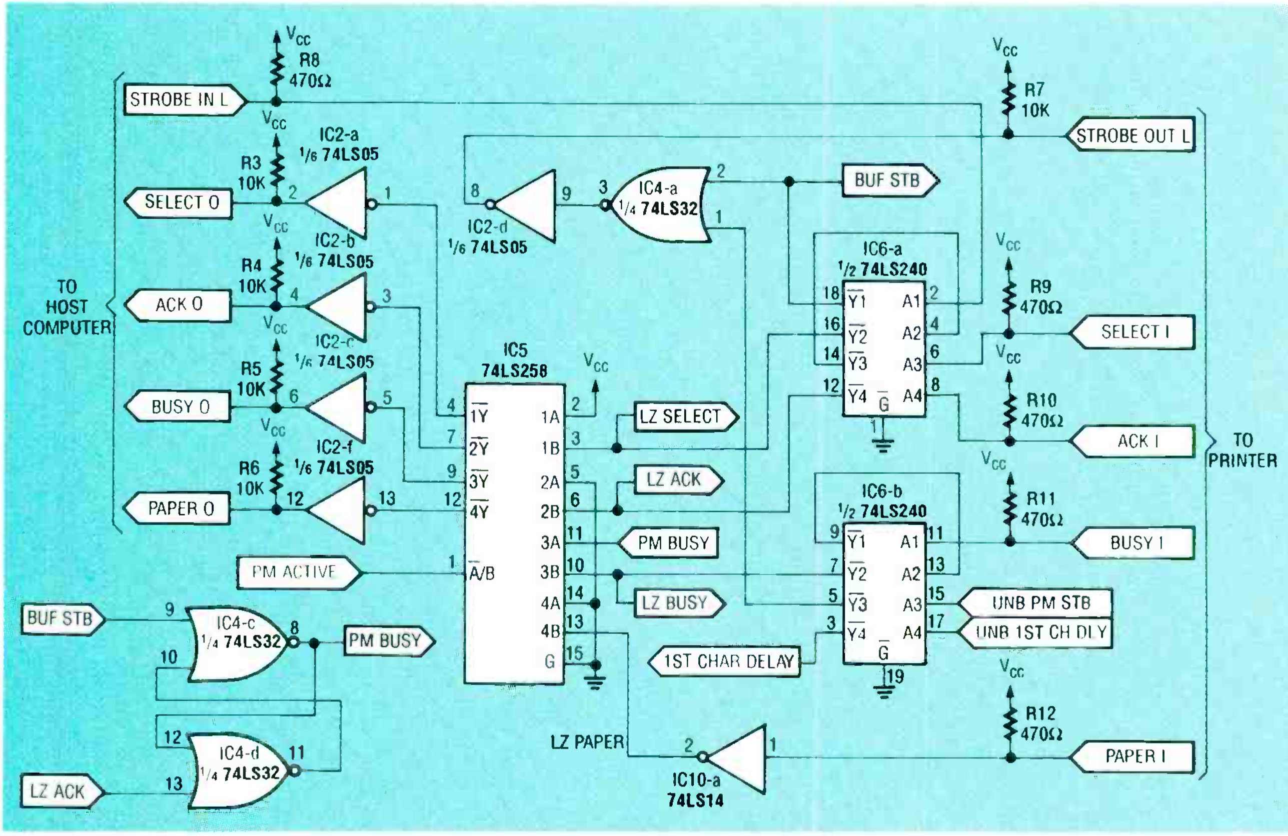
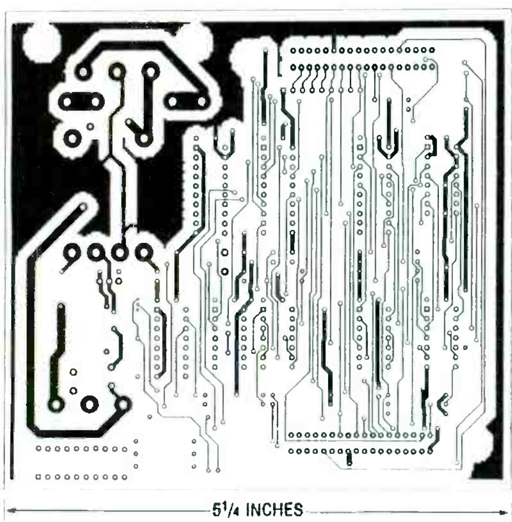
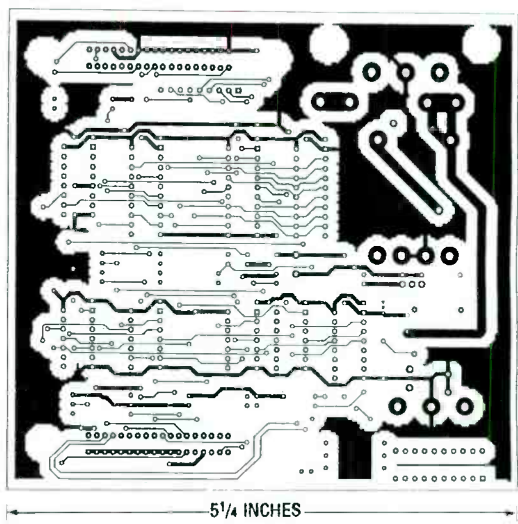


FIG. 4—MULTIPLEXER IC5 drives the printer's control lines with either actual signals (B inputs) or Printer Minder's simulated signals (A inputs) during power up.



COMPONENT SIDE for the Printer Minder.



SOLDER SIDE for the Printer Minder.

board; if you want to use IC9, you must cut those traces. Printer Minder does not process the FAULT and PRIME signals at all.

When the printer is powered down, the control logic has to "fake" the appropriate control signals, making it appear to the computer that the printer is on-line and ready, even though it's not.

Normally, when the printer is powered up and on-line, latch IC1 is "open," thereby allowing data to flow through. However, its function is different when the printer is powered off. OR gate IC4-b allows two signals, POWER ON LOW and FIRST CHARACTER DELAY, to enable IC1. POWER ON LOW comes from the one-shot (Fig. 2); it remains on continuously after the initial character has been received. FIRST CHARACTER DELAY is asserted only after the printer has come on-line and released its BUSY line.

Figure 4 shows how Printer Minder buffers and processes the four printer-status signals (ACKNOWLEDGE, SELECT, BUSY, and PAPER OUT). All four are routed through multiplexer IC5, which selects between the "live" signals (B inputs) coming from the printer and the "fake" signals (A inputs) generated by

PARTS LIST

All resistors are ¼-watt, 5%, except as noted.
R1, R3–R7—10,000 ohms
R2—1500 ohms
R8–R12—470 ohms
R13—1 megohm
R14—100,000 ohms
R15, R18—1000 ohms
R16, R17—4700 ohms
R19–R26—1000 ohms, 10-pin SIP

Capacitors
C1—1000 pF
C2—100 µF, 16 volts, Mylar
C3, C5–C13—0.1 µF
C4—330 µF, 25 volts, electrolytic

Semiconductors
IC1—74LS373, octal three-state latch
IC2—74LS05, open-collector hex inverter
IC3—74LS00, quad two-input NAND gate
IC4—74LS32, quad two-input OR gate
IC5—74LS258, quad three-state 2-to-1 data selector
IC6—74LS240, three-state octal buffer
IC7—LM7805, 5-volt regulator
IC8—74HC123, dual retriggerable monostable multivibrator
IC9—74LS244, three-state octal buffer (optional, see text)
IC10—74LS14, hex Schmitt trigger
Q1–2N2222 NPN or equiv.
D1–D3—1N4001 diode
LED1—standard red light-emitting diode
MOV1–MOV3—120-volt metal-oxide varistors

Other components
F1—10A, 125V, slow-blow fuse
RY1—SPST relay, 12 volts, 10 amp contacts
T1—Dual 8-volt winding power transformer (PSS2-16 or equiv.)
J1, J2—36-pin Centronics connector
J3—AC power input connector (IEC female)
J4—Switched AC power connector (IEC male)
Miscellaneous: PC board, enclosure, wire, sockets, etc.

Note: The following items are available from Jim Cooke, P.O. Box 834, Pelham, NH 03076, (603) 882-4460:
- **PC board only—$29**
- **PC board with all components—$99**
- **Silk-screened enclosure—$39**
- **Data and power cables—$19**
- **Complete kit with all parts, case, and cables—$149**

Add 5% for shipping. MC and Visa accepted. New Hampshire does not require sales tax.

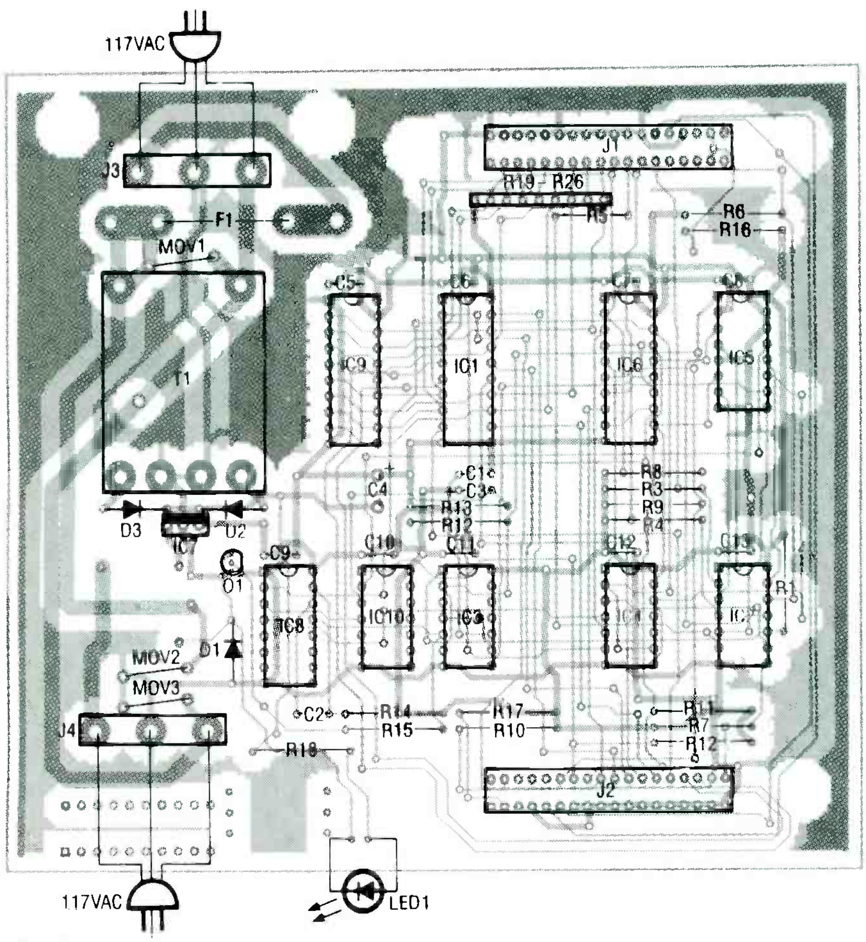


FIG. 5—Mount all components as shown here.

Printer Minder. The PM ACTIVE signal selects the A or B input; that signal is essentially a latched version of the printer's SELECT output. The latch consists of two cross-coupled NAND gates, IC3-a and IC3-b, as shown back in Fig. 3.

Returning to Fig. 4, that portion of the circuit also handles the STROBE signal that latches each byte of data into the printer. After buffering by IC6-a, STROBE drives the one-shot (IC8-a, Fig. 2) that keeps Printer Minder awake for one hour following the last character received.

Assembly and testing

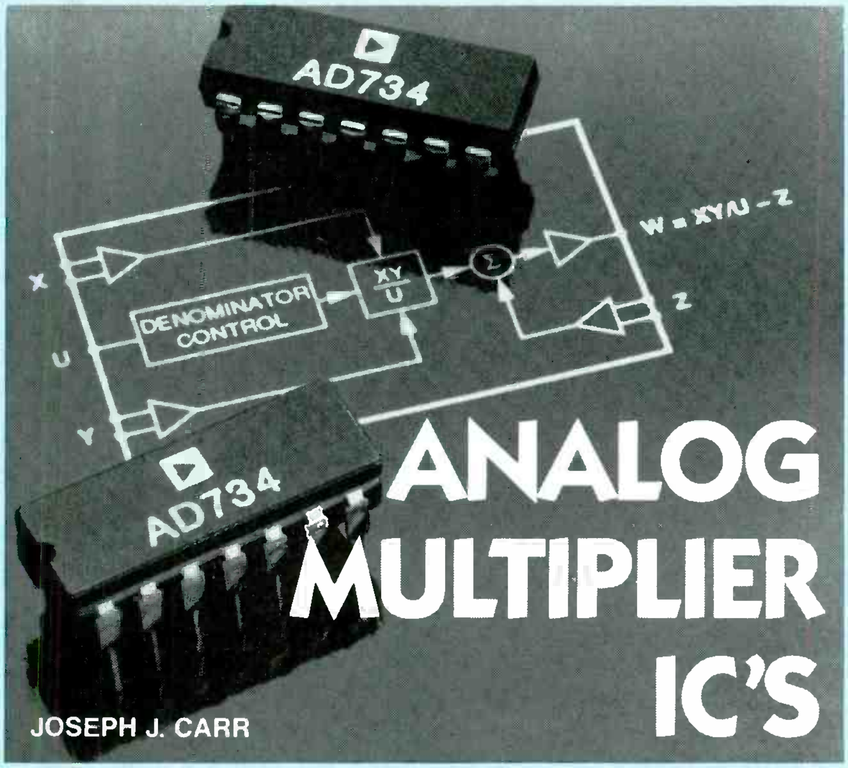
This circuit is moderately complex, so we recommend the use of a PC board. Suitable patterns appear here; you can also purchase a commercially prepared board from the source listed in the Parts List.

Figure 5 shows how to stuff the board. Except for off-board AC power connector J4, all components mount on the component side of the board. Use sockets for the IC's and check all connections carefully, especially those around the AC power section. *Use care when working on this project, as it contains an exposed source of 120 VAC!*

Because of the height restrictions of the enclosure, AC output connector J4 could not be PC-mounted, so we used a snap-in, panel-mount device with push-on connectors. Take care to properly connect the AC neutral line and safety ground to

continued on page 93

Learn how to multiply, divide, square, and get square roots of analog variables with an analog multiplier, and put that skill to work in your experiments and projects.



ANALOG MULTIPLIER IC'S

JOSEPH J. CARR

MONOLITHIC ANALOG MULTIPLIERS can multiply, divide, square, and extract the square root of analog inputs that represent various arithmetical values. Multiplier IC's can accept one or two inputs, and calculate analog outputs with few external components. These analog "math blocks" play important roles in data acquisition, automatic control, and instrumentation circuits. It's all a matter of how the input signals are connected to the multiplier.

Most popular IC multipliers perform what is called *variable-transconductance* multiplication in which the emitter currents of matched pairs of bipolar transistors are controlled. The calculations are represented by variations in gain. The results are then linearized and converted from differential to single-ended values.

Along about now you are probably saying to yourself: Who needs analog multipliers when there are so many low-cost digital computation techniques? The answer is that analog multipliers are appropriate where the factors needed for arithmetical calculations are analog signals representing "real-world" variables such as voltage, frequency, temperature, pressure, or flow rate.

The analog multiplier can perform the arithmetical calculations at or near the sensors or transducers that produced the variables. Moreover, the result will reflect instantaneous changes in the variables. If it is necessary to transmit the arithmetic solution to a remote computer, data logger, or display, only one channel will be needed, not the two or three that would be required if all variables were transmitted separately. Today that single analog result can easily and economically be converted to a binary code for more reliable transmission over long distances.

Analog multipliers are components in voltage-controlled amplifiers and video mixers. They are also found in radar receivers where they process radar returns, and they are in sonar receivers where they are located in automatic gain control circuits.

Specific applications for "math blocks" are:

- An *analog multiplier* can modulate or demodulate signals, make remote gain adjustments, measure power, or assist in curve fitting and linearizing.
- An *analog divider* can compute ratios of efficiency, attenuation, or gain, and then measure those ratios. It can also make remote gain adjustments.
- An *analog squarer* can double frequencies or measure the power of constant loads.
- An *analog square rooter* can compute vectors, root-mean squares (RMS), or linearize a flowmeter.

Don't be surprised if these "math blocks" are unfamiliar to you. Most readers of this magazine have studied such basic analog circuits as the operational amplifier and the linear circuits like active filters that include op-amps. But it's safe to assume that most have not studied analog "math blocks" unless they work in the analog instrumentation field.

Introductory electronics texts usually don't mention analog multipliers although they do describe the voltage multiplier, a different kind of circuit entirely. Moreover, most electronic engineering handbooks limit their coverage of analog multipliers to a paragraph or so. It turns out that IC manufacturers' data books and applications sheets and analog circuit design textbooks remain the best sources of information on those analog products.

Analog multipliers, like op-amps, had their origins back in the days when analog computation was the only game in town. Multipliers have evolved from discrete-component modules to hybrids since the 1960's—and they are now available as monolithic IC's with differing levels of complexity and on-chip support circuitry.

Figure 1 is a simplified block diagram of a single-ended multiplier that includes a gain-conditioning op-amp. The block, labeled "M," represents the multiplier "core," and the triangle represents the op-amp. The input signals are labeled X and Y. The circuit represented by this diagram can multiply, divide, square, or extract square roots if the proper external connections are made.

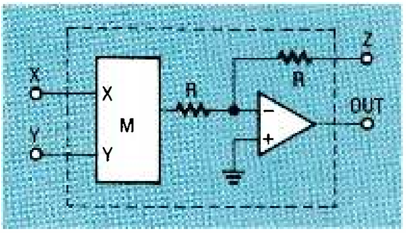


FIG. 1—FUNCTIONAL BLOCK DIAGRAM of a typical multiplier/divider.

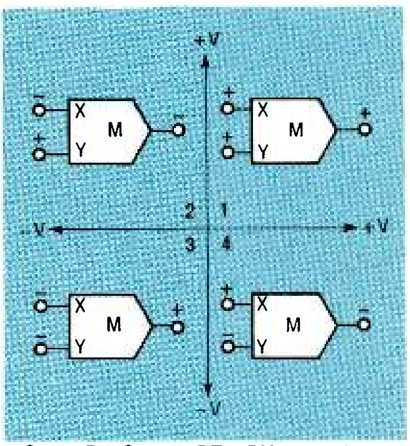


FIG. 2—DIAGRAM OF FOUR quadrants for multiplier shows how output polarity relates to input polarities.

Quadrants of operation

It will be useful to review the concept of quadrants before discussing multiplier circuitry: *single quadrant-*, *two-quadrant-* and *four-quadrant- operation*. Refer to Fig. 2 and notice the differences in the polarity symbols at the dual inputs and single output of each of the four five-sided symbols that represent a multiplier. The four quadrants are defined by Cartesian coodinates—right out of your old trigonometry book.

It can be seen that:

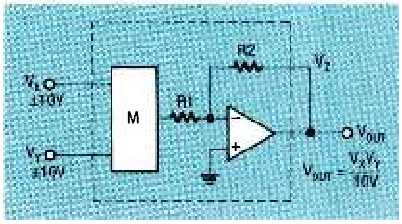


FIG. 3—MULTIPLIER IC CONNECTED as a multiplier.

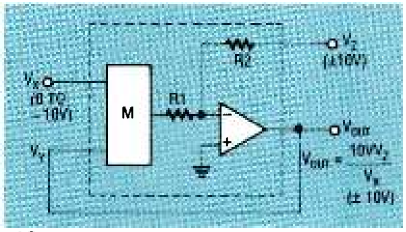


FIG. 4—MULTIPLIER IC CONNECTED as a divider.

- In Quadrant 1 both horizontal and vertical axes are positive, and that X and Y inputs to the multiplier are both positive, so its output is positive.
- In Quadrant 2 the horizontal axis is negative but the vertical axis is positive. The X input to the multiplier is negative and the Y input is positive, so its output is negative.
- In Quadrant 3, both the horizontal and vertical axes are negative. Because both X and Y multiplier inputs are negative, its output is positive.
- In Quadrant 4, the horizontal axis is positive but the vertical axis is negative. The X input to the multiplier is positive and the Y input is negative, so its output is going to be negative.

A one quadrant multiplier can handle either positive or negative inputs but not inputs that are either positive or negative. As a result, the output of a one-quadrant multiplier will always be positive.

Figure 3 is a functional block diagram of a four-quadrant multiplier connected for multiplication. The V_Z terminal is connected to the V_{OUT} terminal. The values of V_X and V_Y can be either positive or negative. The transfer function for the multiplier is:

$V_{OUT} = (V_X V_Y)/V_{ref}$

Where V_{ref} is a dimensional constant, usually 10 volts

Replacing V_{ref} with 10V:

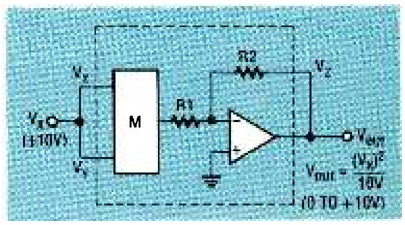


FIG. 5—MULTIPLIER IC CONNECTED as a squarer.

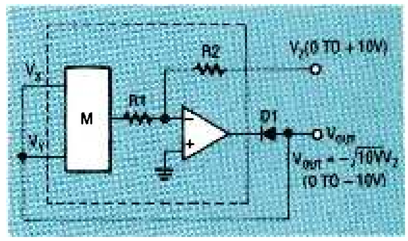


FIG. 6—MULTIPLIER IC CONNECTED as a square rooter.

$V_{OUT} = (V_X V_Y)/10V$

Where V_X and V_Y are limited to ± 10 volts.

If V_X and V_Y = 10 volts, V_{OUT} = 10 volts

Figure 4 shows the same four-quadrant multiplier connected as a *divider*. The V_Y input is connected to the V_{OUT} terminal, V_X is limited to 0 to −10 volts, and V_Z can be ±10 volts. For a numerator input V_Z, a denominator input V_X, and a constant of 10V, the equation for division with a multiplier is:

$V_{OUT} = 10V V_Z/V_X$

V_{OUT} will be 10 volts or less for V_Z equal to or less than V_X.

V_X has a single polarity and will not provide a meaningful result if it is close to zero. If V_X can be either positive or negative, the device is a *two-quadrant divider*, and the output will reflect the polarity of V_X.

Figure 5 shows the four-quadrant multiplier connected as a *squarer*. V_X and V_Y are tied together to form a new V_X, which is limited to ±10 volts. The V_Z terminal is again tied to V_{OUT}. The equation for a squarer is:

$V_{OUT} = (V_X)^2/10V$

A four-quadrant multiplier, used as a squarer, will have an output that is positive whether V_X is positive or negative.

Figure 6 shows the four-quadrant multiplier organized as a *square rooter*. Terminals V_X and V_Y are tied together and connected to the anode of diode D1 at the V_{OUT} terminal. The value

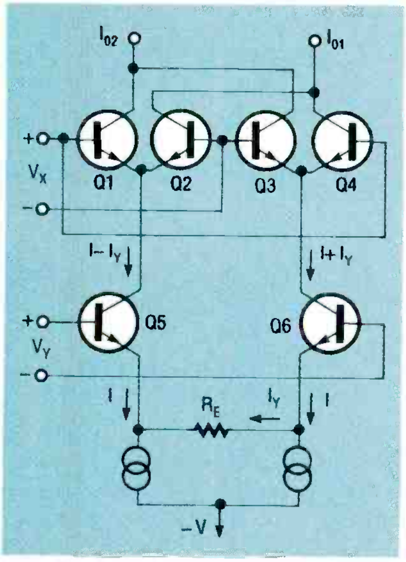


FIG. 7—FOUR-QUADRANT MONOLITHIC modulator is basically two two-quadrant transconductance multipliers.

to be squared (within a range of 0 to +10 volts) is connected to terminal V_Z. If the constant is 10V, the equation for determining the square root is:

$V_{OUT} = -\sqrt{10VV_Z}$

V_{OUT} will be in the range of 0 to 10 volts.

A square rooter works in one quadrant: Figure 6 shows an external diode that prevents latchup if the input polarity changes, even momentarily.

Commercial multiplier IC's

Commercial IC multipliers are typically four-quadrant extensions of the basic two-quadrant concept. A simplified four-quadrant monolithic multiplier circuit is shown in Fig. 7. The circuit can be viewed as a pair of cross-connected differential

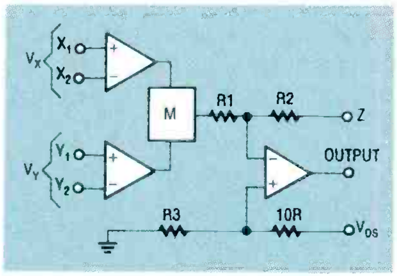


FIG. 8—FUNCTIONAL BLOCK DIAGRAM of an Analog Devices AD532 showing its differential inputs. Note the single Z input and the V_{OS} input.

pairs (Q1 and Q2 with Q3 and Q4) fed by controlled emitter current (from Q5 and Q6). Each half is single differential pair, the basis for the two-quadrant multiplier.

The operation of this transconductance analog multiplier IC will not be explained in detail here because of space limitations. You don't need to know exactly how the circuitry works if you just want to make practical use multipliers. However, there are many excellent references available on the core circuitry of this multiplier, known as the Gilbert "gain cell." (as shown in Fig. 7) in manufacturers' applications notes and analog circuit design texts.

However, notice that the output signals at I_{O2} and I_{O1} are differentially multiplied *currents*. A differential current-to-voltage converter is required to convert the current back to a voltage.

Now, to move this discussion from theory to practice, consider the Analog Devices' AD532, a ready-to-use complete multiplier IC. It multiplies in four quadrants, divides in two quadrants, and square roots in one quadrant. In addition to these basic functions, its differential X and Y inputs provide a lot of operating flexibility for both algebraic computation and transducer output conditioning.

The functional block diagram of the AD532 is shown in Fig. 8, and the complete schematic diagram is shown in Fig. 9. The AD532 IC has 28 transistors, a big increase from the six transistors in the basic Gilbert "gain cell" shown in Fig. 7. The

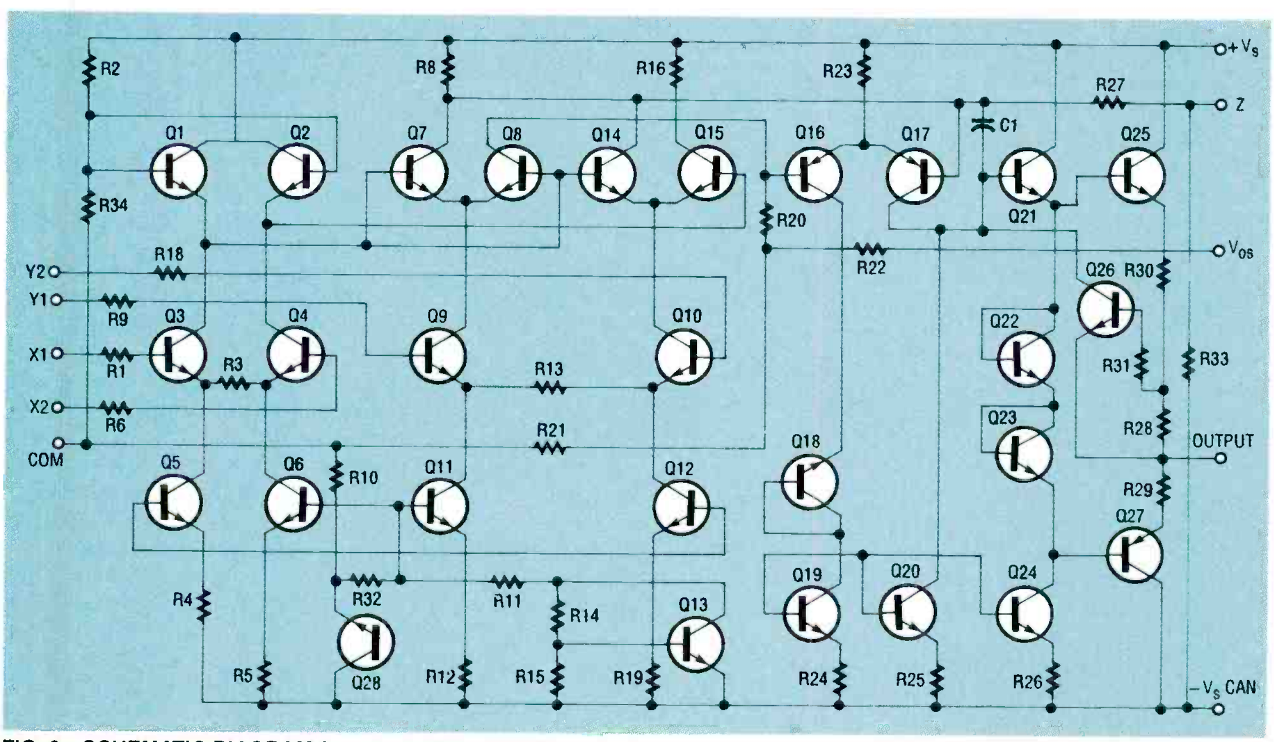


FIG. 9—SCHEMATIC DIAGRAM for a monolithic AD 532 multiplier.

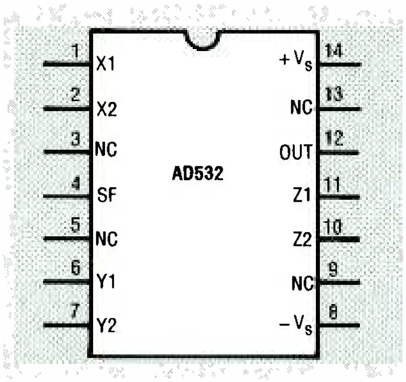


FIG. 10—PINOUT DIAGRAM for an AD532 in a 14-pin DIP.

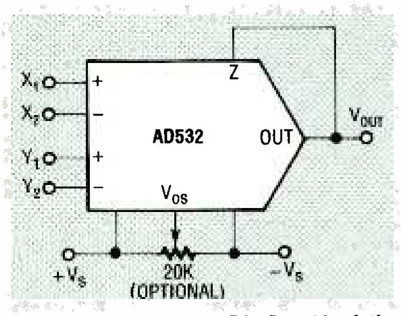


FIG. 11—SCHEMATIC DIAGRAM of the AD532 organized as a multiplier.

AD532 has pretrimmed adjustments for scale factor and offset. The product of the two inputs is resolved in a "gain cell." In the multiplying and squaring modes, the Z terminal is connected to the output to close the feedback around the output op-amp. (In the divide mode, the terminal is used as an input terminal.)

The X and Y inputs are fed to high-impedance differential amplifiers with low distortion and good common-mode rejection. The input voltages are converted to current, and the currents are multiplied together and then divided by a reference. The output current, $I_X \times I_Y/I_{ref}$ is converted to voltage by feedback around the output multiplier. The AD532 has a stated maximum multiplying error of ±1.0%, and offers a 10-volt output. It is powered by a ±15-volt power supply.

The built-in op-amp provides low output impedance and makes self-contained operation possible. The residual output voltage offset can be zeroed as V_{OS} in critical applications. (The V_{OS} terminal should be grounded when not used.)

Figure 10 is the pinout diagram for an AD532 packaged in a TO-116 14-pin DIP. However, it is also available in a hermetically-sealed TO-100 metal can and in a leadless chip-carrier package.

Multiplier

Figure 11 shows the AD532 multiplier organized as a multiplier. Its differential inputs change its transfer function from that given in Fig. 3 to:

$V_{OUT} = (V_{X1} - V_{X2})(V_{Y1} - V_{Y2})/10V$

The inputs can be fed differentially to the X and Y inputs, or single-ended by grounding the unused input. Connect the inputs according to the desired polarity in the output. The Z terminal is tied to the output to close the feedback loop. The offset adjust V_{OS} is optional, and it

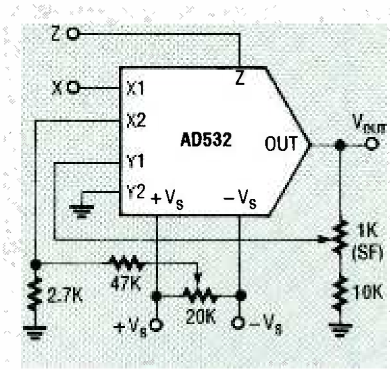


FIG. 12—SCHEMATIC DIAGRAM of the AD532 organized as a divider.

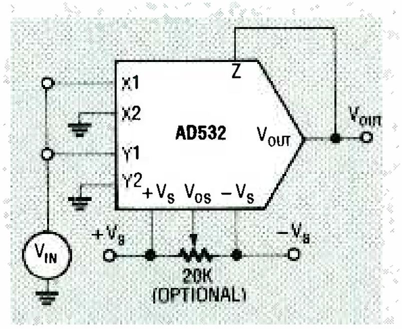


FIG. 13—SCHEMATIC DIAGRAM of the AD532 organized as a squarer.

is adjusted when both inputs are zero volts to obtain zero out, or to cancel the other system offsets.

Divider

The AD532 can be configured as a two-quadrant divider by

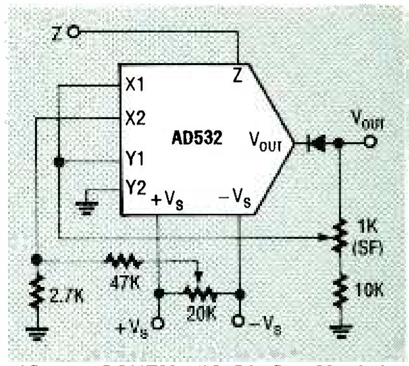


FIG. 14—SCHEMATIC DIAGRAM of the AD532 organized as a square rooter.

connecting the multiplier cell in the feedback loop of the op-amp and using the Z terminal as a signal input, as shown in Fig. 12. The transfer function when X1 is greater than X2 is:

$V_{OUT} = 10V V_Z/(V_{X1} - V_{X2})$

To avoid positive feedback, Analog Devices recommends that the X input be restricted to negative values. Thus for single-ended negative inputs (0 volts to −10 volts), connect the input to X1 and the offset null to X2; for single-ended positive inputs (0 volts to +10 volts), connect the input to X2 and the offset null to X1.

Squaring

The squaring circuit of Fig. 13 is a variation of the multiplier circuit.The transfer function for squaring is:

$V_{OUT} = (V_{X1} - V_{X2})^2/10V$

The differential input capability of the AD532 can be used, however, to obtain positive or negative output response to the input.

Square rooting

The connections for square rooting are shown in Fig. 14. Similar to the divide mode, the multiplier cell is connected in the feedback of the op-amp by connecting the output back to both the X and Y inputs. The diode D1 is connected as shown to prevent latchup as Z_{in} approaches 0 volts. The square rooting transfer function is:

$V_{OUT} = -\sqrt{10V V_Z}$

Here the V_{OS} adjustment is made with Z= 0.1 volts DC, adjusting V_{OS} to obtain −1.0 volts DC in the output, $V_{OUT} = -\sqrt{10V_Z}$.

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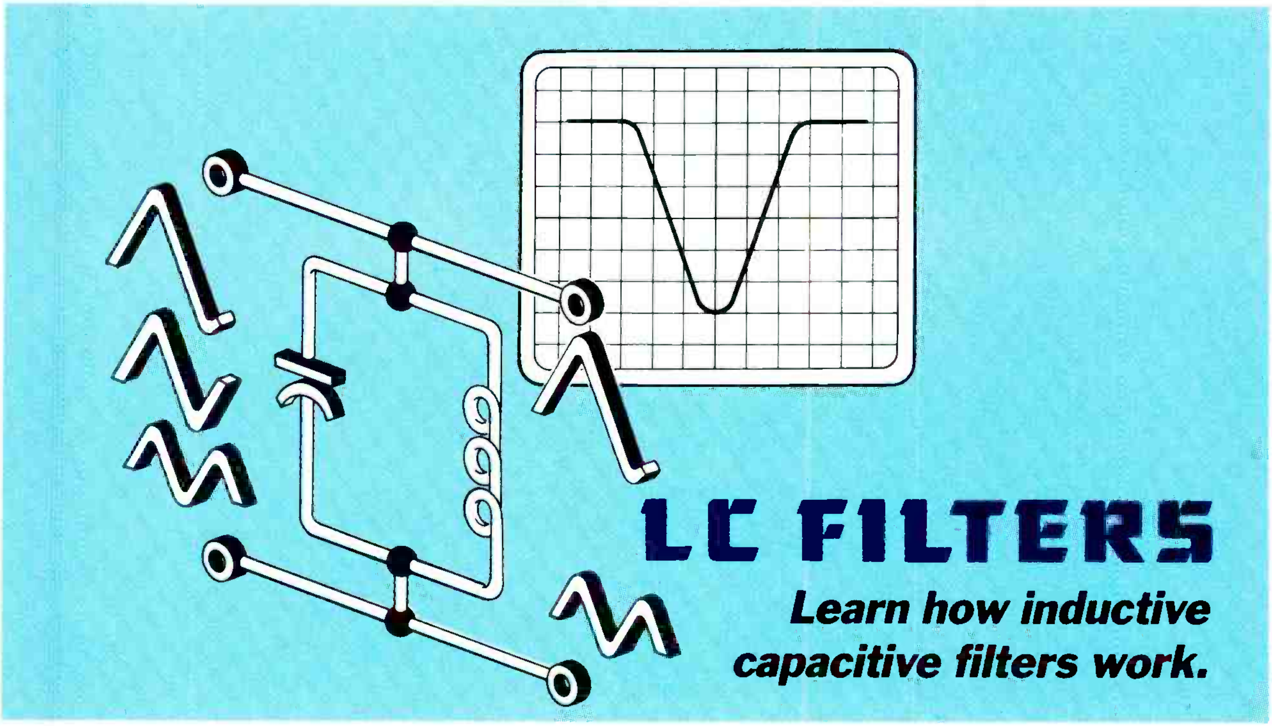

LC FILTERS

Learn how inductive capacitive filters work.

RAY MARSTON

THE PRIMARY APPLICATION FOR RESonant inductive capacitive (LC) filters these days are in high-frequency circuits. These filters, like resistive capacitive (RC) filters can easily be designed to perform low-pass, high-pass, bandpass, or notch filtering, but they have the additional benefit of offering at least 12 dB per octave of rolloff, compared to the 6 dB per octave of RC filters, which means sharper cutoff characteristics at all operating frequencies.

The series- and the parallel-resonant LC filters are the two "watershed" LC designs from which all others are derived. Figure 1-*a* shows a circuit for a series-resonant filter, and Fig. 1-*b* shows its simplified equivalent circuit. The R represents the resistance of the coil.

Series-resonant filter

The fundamental response of the series filter is that capacitive reactance C decreases with increased frequency, while inductive reactance decreases. The inverse relationship also holds. The filter's input impedance is equal to the difference between these two reactances, plus the value of resistor R.

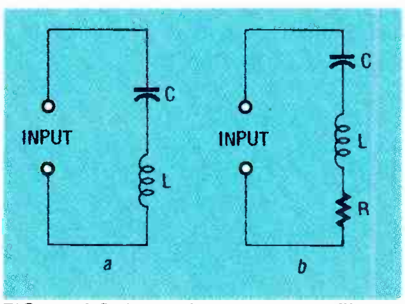

FIG. 1—LC SERIES-RESONANT filters: simplified schematic, *a*, and equivalent circuit, *b*.

At some specific frequency, the reactances of C and L could be 10 kilohms and 1 kilohm, respectively. Therefore the filter's input impedance (ignoring the value of R) will be 9 kilohms at that frequency. Many other similar examples can be given.

The key point to be made here is that at resonant frequency, f_c, the reactances of C and L will be equal (but 90° out of phase), and the filter input impedance will equal the value of R, as indicated by the dotted line at the bottom of the impedance vs. frequency characteristic curve Fig. 2-*a*. For example, if this occurs when the reactances of C and L are both 1000 ohms, and R equals 10 ohms, the input impedance would be 10 ohms, and the entire signal voltage would be generated across R.

The signal currents through effective resistance R flow through C and L, which both have reactances 100 times greater than the value of R in ohms. Consequently, the signal

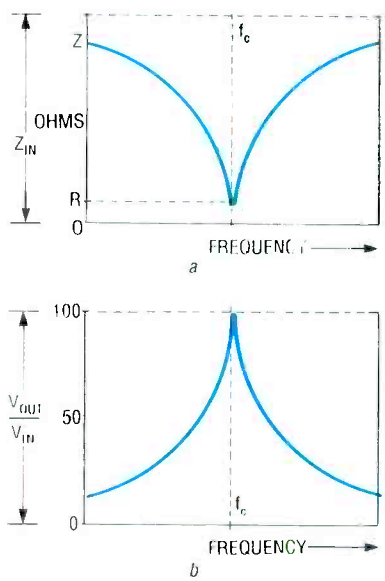

FIG. 2—LC SERIES-RESONANT FILTER: Plot of input impedance vs. frequency at resonance, *a*, plot of voltage output vs. frequency at resonance taken across L or C, *b*.

voltage generated across C and L is 100 times greater than the actual input signal voltage, as shown in Fig. 2-*b*, the curve of voltage vs. frequency. This voltage magnification, indicated by the sharp peak, is known as the circuit's Q.

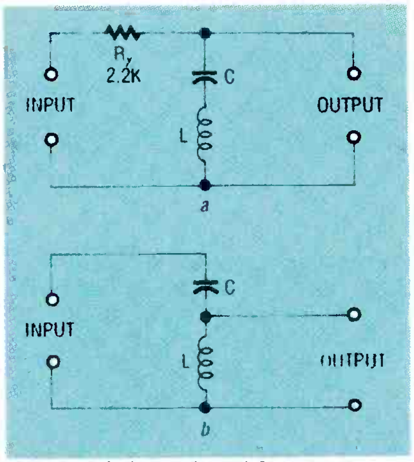

FIG. 3—LC SERIES-RESONANT filters: notch rejector, *a*, and notch acceptor, *b*.

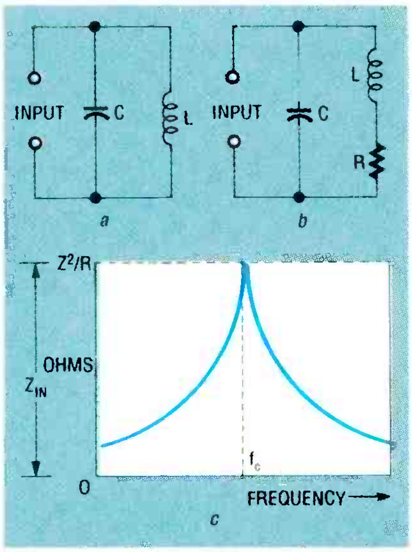

FIG. 4—LC PARALLEL-RESONANT filters: simple schematic, *a*, equivalent circuit, *b*, and plot of input impedance vs. frequency, *c*.

Notice in Fig. 2-*b* that the inductive and capacitive voltages are 90° out of phase, and the voltage generated across the series LC combination is effectively zero. The impedence of the filter at f_c is known as the filter's *characteristic impedance*, Z_O, and it equals $\sqrt{L/C}$.

Figure 3 shows two ways to make practical use of a series-resonant LC filter: In Fig. 3-*a*, 2.2 kilohm resistor R_x and the filter act together as a frequency-selective attenuator that gives high attenuation at the resonant frequency f_c, and lower attenuation above or below that resonant frequency. (The filter is a *notch rejector*.)

In Fig. 3-*b*, the input signal is applied directly to the filter, and the output is taken across the inductor L. This filter circuit acts as a *notch acceptor* that provides high gain at resonant frequency f_c and low gain above or below that frequency.

Table 1 lists the principal formulas that can be applied to both series- and parallel-resonant LC circuits.

Parallel-resonant filters

Figure 4-*a* shows the schematic for a parallel-resonant filter, and Fig. 4-*b* shows its equivalent circuit. The inductor's resistance is represented by R. In this filter, capacitive reactance decreases with increasing frequency, and inductive reactance increases with increasing frequency. The reciprocal relationship also holds.

Each component draws a signal current that is proportional to its reactance, but the two currents are 90° out-of-phase, so the total signal current is equal to the difference between the L and C currents. At resonance, L and C are equal so the total current falls nearly to zero.

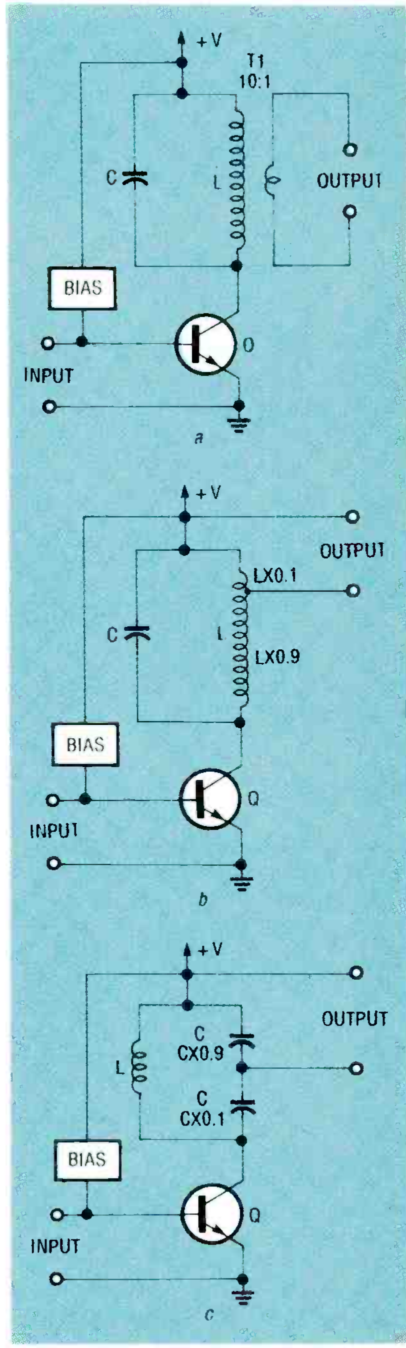

FIG. 5—LC TUNED AMPLIFIERS with low-impedance outputs: transformer coupling, *a*, auto-transformer coupling, *b*, and capacitive-divider coupling, *c*.

As a result, the filter acts as a near-infinite impedance. In practical filters, the presence of equivalent resistance R modifies the response by reducing the impedance at the resonant frequency f_c, Z_c, to $Z_O{}^2/R$. For example, if Z_O equals 1 kilohm and R equals 10 ohms, the value of Z_c will be 100 kilohms.

TABLE 1
DESIGN FORMULAS FOR INDUCTIVE-CAPACITIVE FILTERS
Formulas apply to series and parallel LC filters

$$f_c = \frac{1}{2\pi\sqrt{LC}} \text{ hertz} \qquad Z_o = \sqrt{\frac{L}{C}} \text{ ohms}$$

$$L = \frac{Z_o}{2\pi f_c} \text{ henries} \qquad C = \frac{1}{2\pi f_c Z_o} \text{ farads}$$

$$Q = \frac{X_L}{R} = \frac{Z_o}{R}$$

Note : f_c, Z_o, X_L

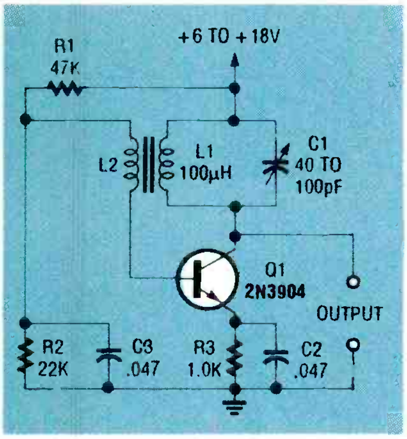

FIG. 6—TUNED-COLLECTOR feedback LC oscillator.

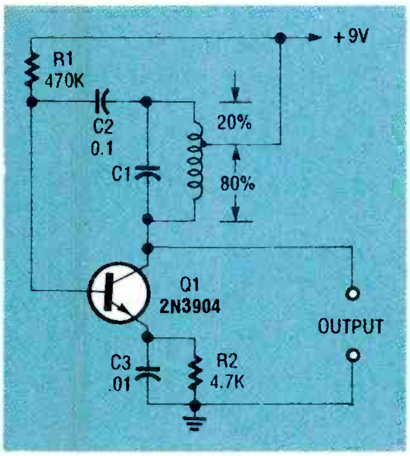

FIG. 7—SIMPLE HARTLEY LC oscillator.

Figure 4-*c* is the filter's frequency response: a plot of input impedance vs. frequency showing how the input impedance peaks at the resonant frequency f_c. All of the formulas in Table 1 apply to the parallel-resonant filter as well.

Output coupling

The two most popular applications for parallel-resonant tuned filters are in narrow frequency band amplifiers and in LC oscillators. In narrow-band amplifiers the filter usually functions as the collector load for common-emitter amplifiers as shown by three simplified schematics in Fig. 5. The filter provides high gain at its resonant frequency and lower gain above and below that frequency.

The drawback to these circuits is the problem of gaining access to the circuit's output signals without loading the tuned circuit and lowering its effective Q. Three ways to overcome this drawback are illustrated in Fig. 5.

One way to obtain output coupling is to consider the primary winding of an RF transformer as the filter's inductive component, and to take the output from the transformer's secondary, as shown in Fig. 5-*a*. This approach provides a fully floating output. If the transformer has a 10:1 turns ratio, the output signal will have an attenuation factor *a* of 10.

In a second method, the coil can be tapped as shown in Fig. 5-*b*, to obtain an output by autotransformer action. In the third method, as shown in Fig. 5-*c*, the required tuning capacitance is obtained from two series-connected capacitors. An output can be obtained across the larger capacitor by capacitive divider action.

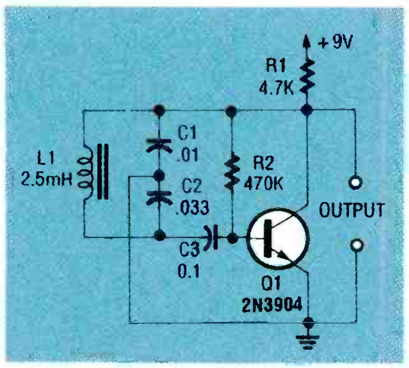

FIG. 8—COLPITTS LC OSCILLATOR produces a 37-kHz output.

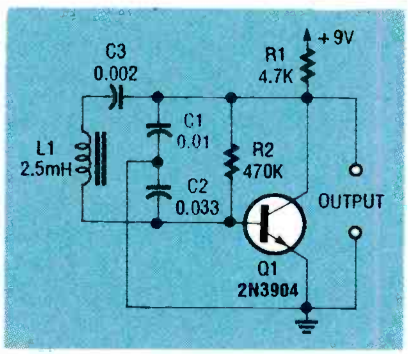

FIG. 9—CLAPP OR GOURIET LC oscillator producese an 80-kHz output.

In these schematics each circuit has arbitrarily been given an attenuation factor *a* of 10. Each has an output impedance of Z_c/a^2. Thus, if Z_c equals 100 kilohms and *a* equals 10, the Z output equals 1 kilohm.

LC oscillators

Figures 6 through 10 illustrate the different schemes for using a parallel-resonant filter as the tuning element in transistorized LC oscillators. The simplest of the LC oscillators is the *tuned-collector feedback* form shown in Fig. 6.

Transistor Q1 is connected as a common-emitter amplifier, L1 and C1 form the tuned collector filter, and L2 provides the collector-to-base feedback. Inductor L2 is inductively coupled to L1, providing transformer action. By adjusting the phase of this feedback signal, the circuit will give zero phase shift at the tuned frequency so that, if the loop gain (determined by T1's turns ratio) is greater than unity, the circuit oscillates. With the component values shown, oscillation frequency can be varied from 1 MHz to 2 MHz by trimmer capacitor C1.

Figure 7 is the schematic for a simple Hartley oscillator. The turns of collector load inductor L1 are tapped at a point 20% down from the top of the coil, and the circuit's positive power supply is connected to this tap point. As a result, L1 acts as an autotransformer so that the signal voltage appearing at the top of L1 is 180° out of phase with the voltage at its low end (nearest Q1's collector.)

The signal voltage at the top of the coil, (which is 180° out of phase with the signal at Q1's collector) is coupled the base of Q1 base by isolating capacitor C2. In this arrangement the circuit oscillates at a center frequency

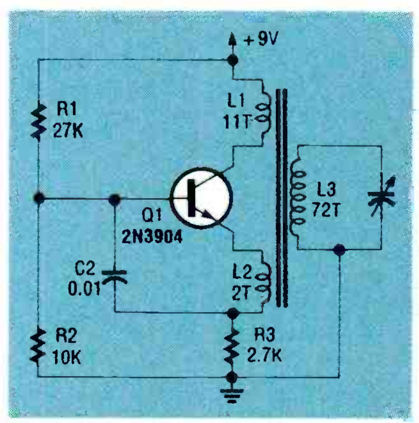

FIG. 10—SIMPLE REINARTZ LC oscillator.

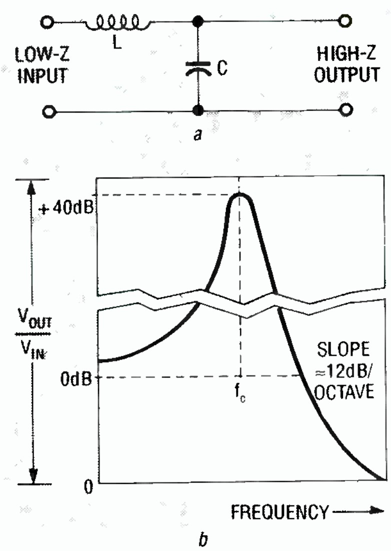

FIG. 11—FALSE L-TYPE LOW-PASS filter: schematic *a*, and frequency response curve.

determined by the values of L and C.

In general, circuit oscillation depends on tapping a common signal at a point in the tuned circuit so that phase-splitting autotransformer response is obtained. This tap point need not be made in the tuning coil; it can be made in the tuning capacitor, as in the Colpitts oscillator shown in schematic Fig. 9. With the component values in that figure, the oscillator will oscillate at about 37 kHz.

In Fig. 8, C1 is in parallel with transistor Q1's output capacitance, and C2 is in parallel with Q1's input capacitance. Consequently, capacitance changes caused by ambient and component temperature changes can shift the oscillation frequency.

This shift can be minimized and good frequency stability can be obtained by selecting values for C1 and C2 that are large with respect to Q1's internal capacitance.

Figure 9 shows a modified version of the Colpitts oscillator, known as the Clapp or Gouriet oscillator. Another capacitor, C3, with a value that is small relative to C1 and C2, is put in series with L1. This circuit's resonant frequency is determined principally by the values of L1 and C3 and it is almost independent of variations in transistor capacitance. The Clapp/Gouriet oscillator offers excellent frequency stability. With the component values shown in the schematic, it will oscillate at about 80 kHz.

Figure 10 is a schematic for a Reinartz oscillator. Its tuning coil has three inductively coupled windings. Positive feedback is obtained by coupling the collector and emitter signals of the transistor through coils L1 and L2. Both windings are inductively coupled to L3. The Reinartz oscillator oscillates at a frequency determined by the values of L3 and C1. The coil-turns ratios are typical for a circuit designed to oscillate at a few thousand kHz.

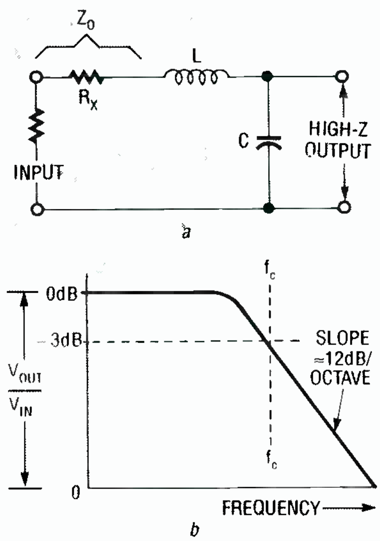

FIG. 12—TRUE L-TYPE LOW-PASS filter: schematic, *a*, and frequency response curve, *b*.

Low-pass and high-pass

Figure 11-*a* is a schematic for a "false" L-type low-pass filter. Inductor L and capacitor C act together as a frequency-dependent attenuator. At low frequencies the reactance of L is low and the reactance of C is high, so the circuit offers negligible attenuation. At high frequencies the reactance of L is high and that of C is low, so the circuit offers high attenuation.

Consequently, the circuit acts like a low-pass filter. It is called it a "false" filter because the circuit will only function correctly if it is driven from a source impedance equal to Z_O. (This is not shown in the diagram.) The circuit is actually a series-resonant filter (like Fig. 1) with its output taken from across capacitor C.

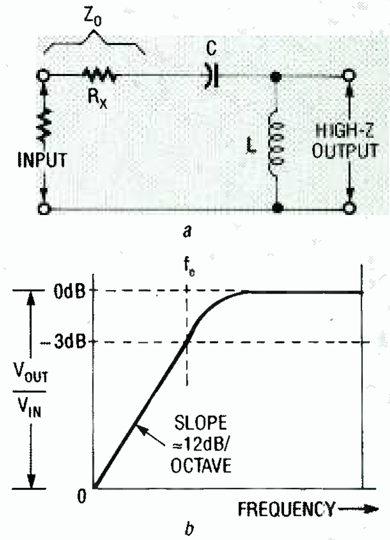

FIG. 13—L-TYPE HIGH-PASS FILTER: schematic, *a*, and frequency response curve, *b*.

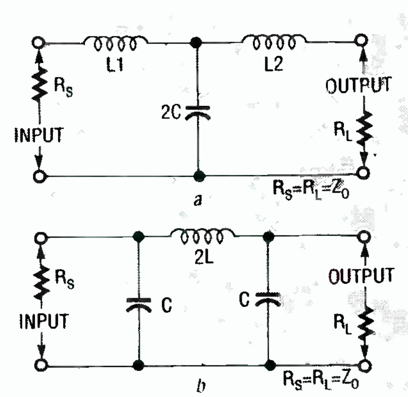

FIG. 14—LOW-PASS LC FILTERS: T-section schematic, *a*, and π-section, *b*.

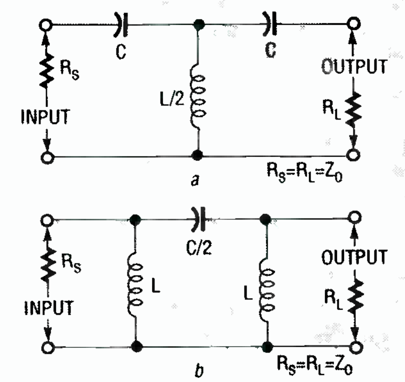

FIG. 15—HIGH-PASS LC FILTERS: T-section schematic, *a*, and π-section, *b*.

If the circuit is driven from a

continued on page 89

HARDWARE HACKER

Short-haul telemetry, max-min slope theory, SETI books and resources, a unique new optical link, and maximum power transfers.

DON LANCASTER

As I might have mentioned a time or two before, I am the sysop of *GEnie* PSRT, and I have bunches of reprints of my *Hardware Hacker*, *Ask the Guru*, *Blatant Opportunist*, *Resource Bin*, and *LaserWriter Corner* columns.

I also have hundreds of files on hacking, PostScript, and my book-on-demand publishing. Typical file downloading costs are around twenty one cents.

I've just made an arrangement with *GEnie* to provide you with a new, fast modem-access startup. Just autodial (800) 638-8369 and then type HHH. When prompted, enter your top-secret access code of XTX99005,SCRIPT.

Whatever you do, keep this secret password carefully hidden and do not reveal it to anyone else.

GEnie has many thousands of local access lines across the country. But if you live in a really remote area, it now offers a brand new (800) number service. It has also improved its Mac graphic interface.

We might start off with a pair of back-to-the-basic fundamentals...

Maximum power transfer

Suppose you're using an electrical or electronic generator and that it happens to provide a one-ohm source impedance and is outputting a one-volt signal. What is your "best" load resistance?

As Fig. 1 shows you, there is no "best" choice. Only compromises that depend entirely on exactly what you are trying to do.

If you make your load resistance fairly high, you'll get high efficiency and good regulation. *But you will be unable to get the maximum possible power from your generator*. Your AC power utility is an example of where generator impedance is made as low as possible to minimize all possible losses.

If you make your load resistance *equal* to your source resistance, you should extract the maximum possible power from your generator. But the efficiency will be a mere *fifty* percent and your regulation will be poor.

Video and RF transmission lines are important circuits in which you want to precisely match the load to the source. Besides delivering maximum power, you'll also minimize reflections and standing waves. Other areas where "make load equal source" is important are older power audio amplifiers driving speakers, car batteries when cold cranking, and solar cells trying to deliver as much power to the load as possible.

You also have the choice of using a very low load resistance. That will give you horrible efficiency and terrible regulation. It also will deliver only a tiny fraction of the possible generator power. But there are few lower-level uses where you want your generator to look and act like a *current source*.

For instance, a current-source load for a transistor amplifier can offer an enormously high voltage gain. Those unusual applications sometimes justify the low power and bad efficiency.

Note what this maximum power transfer curve is telling us: *You can deliver the most power to a load by throwing half of the generated power away in your source!*

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(602) 428-4073

The maximum power transfer curve is surprisingly broad. Double or halve your load and the power that gets delivered drops by only about twelve percent or so. Thus, an exact match might not be that important for maximum power transfer. A precise match just might be needed for other reasons: for example to eliminate standing waves and reflections.

If you are going to cause a mismatch, it usually pays to do so on the high side. That way overall efficiency will be better, even if delivered power drops a tad.

Let's look at several examples of how a bad source-to-load mismatch can severely impair efficiency. In Fig. 2, let's take a piezo striker and see what we can get out of it. Let's assume the striker has a source impedance of 10 megohms and outputs a peak of 1600 volts. We will also disable the spark gap to prevent their breakdown.

Into an open circuit, we get *zero* power. For maximum possible power, use a 10-megohm load, matching source to load. Half the voltage will appear across the load, and power will end up as 640 milliwatts. This is in accordance with the $P = E^2/R$ formula.

That's over half a watt, so we should be able to light a lamp with it, right? Wrong. As Fig. 2-*b* shows us, a flashlight bulb offers a resistance of about 10 ohms. With a 10-ohm load and a 10-megohm source, you can deliver only 256 *nano* watts!

Efficiency is essentially *zero*. Ergo, no light.

Can you do better? Substituting a neon lamp for a flashlight bulb would help bunches. Instead, you can place a transformer with a 1000:1 turns ratio between the striker and the bulb, as shown in Fig. 2-*c*. A 1000:1 turns ratio gives you a 1,000,000:1 impedance ratio. Your bulb now "looks" like a 10-megohm load to the source. And you should get nearly the full maximum power when flashing the lamp.

Remember, of course, that all piezoelectric devices are AC-only generators.

Most small impedance mismatches between source and load are not that big a deal. But bad ones (especially with high-value sources driving low-value loads) will severely degrade circuit efficiency.

Several columns back, we found several good reasons why any piezoelectric power production hacks were likely to end up a bad scene. Some of you helpline callers pointed out that there is an even more fundamental gotcha.

Most power generators are either *E-field machines* or *H-field machines*. An H-field machine uses a changing *magnetic field* to induce *current* into a *conductor*. An E-field machine will use a changing *electric field* to induce a *voltage* across an *insulator*.

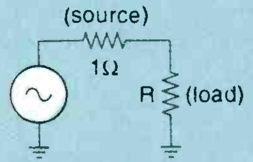
All E-field machines are inherently high-impedance devices. *The power density of all known E-field machines is extremely low.* E-field machines tend to operate at the inefficient extreme left of the maximum power transfer curve of Fig. 1. That is precisely where you don't want to be.

The current state of the art in both materials science and high-vacuum techniques simply will not allow the construction of any economical, high-power E-field machine.

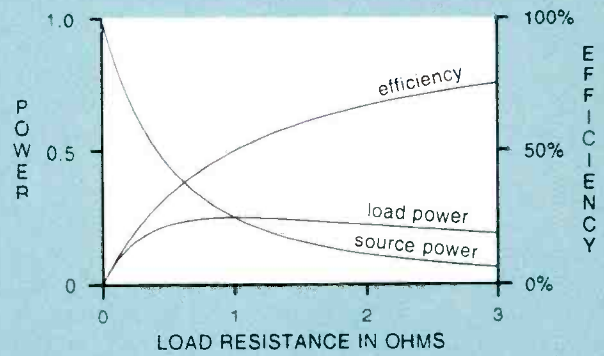
There *never* has been *any* E-field machine *ever* produced commercial "nickel-per-kilowatt-hour" AC power. I'll give you my book an *Incredible Secret Money Machine* if you can prove me wrong on this.

And while any piezoelectric generator is obviously an E-field machine, it is only a "fair to middlin" one at its very best. Sigh...

(A) Typical generator and normalized load. Varying load resistor R changes the total delivered power...



(B) Maximum power transfer takes place whenever the source resistance matches the load resistance...



(C) How to prove the maximum power transfer theorem...

Borrow these two rules from differential calculus...

$$d(uv) = vdu + udv$$

$$d(u^n du) = nu^{n-1}du$$

The voltage across the load will be...

$$V_L = R/(1 + R)$$

The load power E^2/R will simplify to...

$$P_L = R/(1 + R)^2$$

Take the derivative and set it equal to zero...

$$(1 + R)^{-2} - 2(1 + R)^{-3} = 0$$

And simplify to...

$$(1 + R) - 2 = 0$$

Which solves as R = 1.

FIG. 1—THE MAXIMUM POWER TRANSFORM THEOREM tells us that you deliver the most possible power to a load only when you purposely burn up half of the generated power in your source. Here are some key details.

Maximums and minimums

There are a number of fairly obious ways you could verify the naximum power transfer curve of ig. 1. Being lazy, I just told the in- redibly superb general-purpose ostScript computer language to lot it for me. The short and simple ig. 1 code appears in HACK65.PS n my *GEnie* PSRT RoundTable. As ve have seen before, PostScript is ow the ultimate hacker's language.

Or, you could go into the lab and ise a wattmeter and a variable load esistor. That should give you the same curve, again with its maximum value matching your source.

Let's try using some math instead. There's this ugly rumor going around that electrical circuits obey math rules and that you can predict what they will do simply by doing the underlying math.

In Fig. 1, there is a voltage divider that attenuates a 1-volt input by...

$e_{OUT} = R/(1+R)$

The output power should be this voltage squared, divided by the load resistance. That simplifies to...

$P_{OUT} = R/(1+R)^2$

You or a computer can then plot the curve for different values of R to generate the maximum power curve.

By the way, this stunt of using 1-volt generators with 1-ohm source impedances is called *normalization*. If you can ever analyze something using easy numbers instead of hard ones, it will usually pay to do so. Anything that can be scaled can also be normalized. Much more on this in my *Active Filter Cookbook*.

But there is a much better way to find the maximum power transfer point. There is a math process called *max-min theory* that easily lets you find maximum or minimum points for any reasonable curve. Figure 3 shows the key secret.

Any reasonable curve will also have a *slope*. A slope is simply the "steepness" or the "rise over run" of any tiny portion of the curve. One crude way to find the slope of any section on a curve is to pick a point just before and one just beyond the section and create a tiny triangle out of it. The rise/run (or *tangent*) of the triangle will equal the slope of the curve.

As Fig. 3 shows, there are only

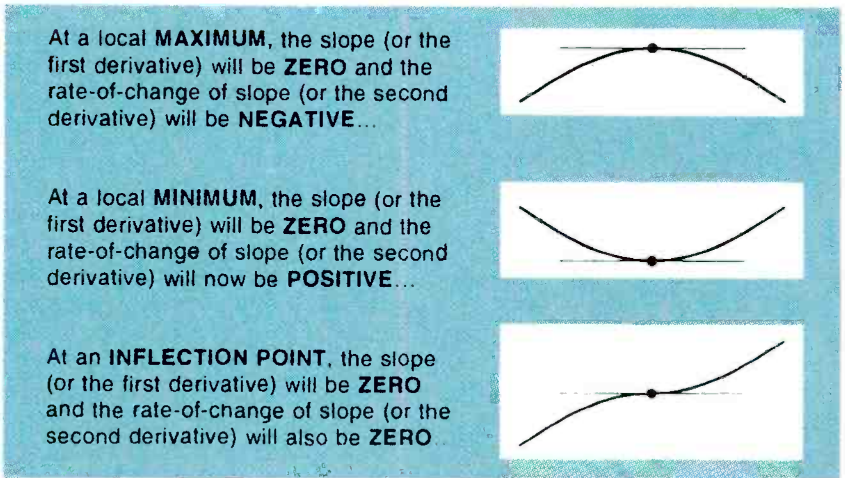


FIG. 2—MAX-MIN THEORY is a branch of differential calculus that lets you quickly and easily find a maximum or a minimum of any reasonable curve.

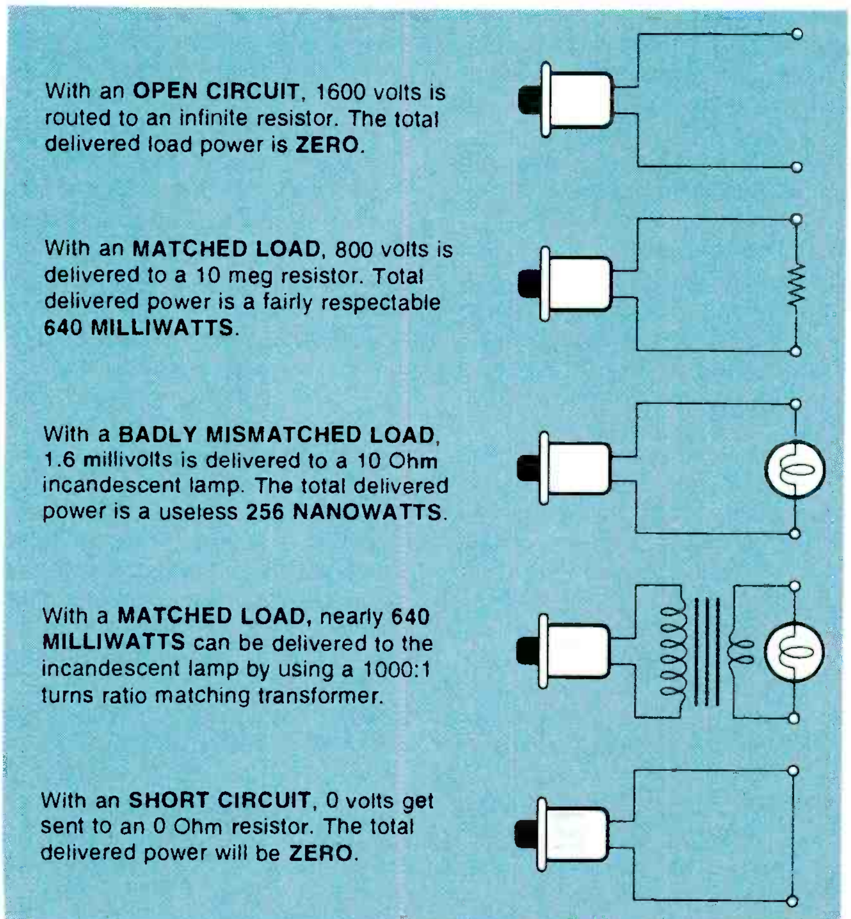


FIG. 3—GROSSLY MISMATCHING your source and load impedances can severely reduce your total available delivered power. Here are several examples that try to use a piezo striker as a power generator.

three possible conditions where you can get a zero slope on a curve. These happen only at a *local maximum*, at a *local minimum*, or, more rarely, at an *inflection point*.

Just find the math expression for the slope of your curve. Set it to zero and solve it. All solutions will be a maximum, a minimum, or an inflection point.

How can you tell which is which? Often, it will be completely obvious. If not, go one step further and find the *slope of the slope*. If you are at a local maximum (3-*a*), the rate of change of slope will be *negative*. At a minimum (3-*b*), the rate of change of slope will be *positive*. And if you are now at an inflection point, the rate of change of slope will be *zero*.

The "correct" and "exact" way to determine the slope for any curve is known as *finding the derivative*, and this whole field is called *differential calculus*. You could find a full set of rules in any college-level calculus 101 text. A good listing of calculus rules also appears in the *Mathematical Tables* that can be found in the *Handbook of Chemistry and Physics*.

I've shown how you use max-min theory to prove the maximum power transfer theorem in Fig. 1. Sure enough, the maximum is *exactly* at a load impedance that matches the source. Taking most derivatives is quite simple. For instance, a parabola, $y = x^2$ has a slope everywhere of 2x. Good old u^n and friends.

Advanced math can be neat stuff. And very valuable, too.

SETI resources

NASA has recently started a new and very aggressive SETI (search for extraterrestrial intelligence) program. In the first few hours of its operation, more frequencies have been observed in more ways than they have in the *entire* history of *all* previous ET watching.

One prominent researcher in SETI is Frank Drake. He is famous for the "Drake Equation" which accurately predicts the number of intelligent civilizations that are likely to be lurking in the universe at any given time. Frank has recently authored a new and highly readable book titled *Is Anybody Out There?* published by *Delacorte*.

So, I thought it might be a good time to do a resource sidebar on SETI. I've included the names of several associations and a listing of the better books.

Besides the three groups Frank mentioned in his book, I've added the *Amateur Radio Astronomers* who also publish a *Radio Observer* newsletter. But note that their main focus is on radio astronomy fundamentals, and they distance themselves from both ET watching and the UFO crowd.

For several reasons, I strongly feel that the odds for an imminent SETI contact are quite high. One reason is that our signal detection, processing, and computing abilities have skyrocketed in the last several years. And they should continue to do so.

Shortly after World War II, our sun suddenly turned into a radio star.

Captain Video, *Roller Derby*, and *Kukla, Fran, & Ollie* became our first goodwill ambassadors to outer space. Those signals are now 45 light years away from us, and have now swept through nearly a third of a million *cubic light years* of space.

Within that humongous volume are several hundred probable candidate star systems. Our own signals are easily detectable at this range with our present state of the electronic art. In another 45 years, *eight times* more volume will be swept out with eight times more star systems watching *Your Hit Parade*. *At a further signal strength drop of less than six decibels!*

We are now in transition between irritating hundreds of candidate star systems to annoying thousands more.

On the other hand, I do not believe that looking for obviously modulated narrow SETI signals in the expected "water hole" frequency band will not be the swiftest way to go. If Earth is an even remotely typical example, all the *unintentional* radiated signals swamp those *intentional* ones by at least a zillion to one.

And we have recently discovered spread-spectrum communications. If you really want to punch any signal through very high noise over great distances, spread spectrum is a very good way to go. The chances are that you could step up to multiple dimensions of spectrum spreading using, say, frequency, time, and some sort of a trellis modulation type of overlay.

Perhaps a "multi-level marketing scheme" in which the unswift could figure out that something unusual was happening, the fairly bright could receive useful information, and the superintelligent could grab the full set of plans. That surely would beat sending out prime numbers forever.

The signals might be there, but we just might not be smart enough to recognize them just yet. Perhaps the fundamental question to ask is: "What spreading and modulation scheme would give us the most bang for the buck?" And then start looking for something similar heading our way.

Let's have your thoughts on this.

New opto chips

Infrared data communications has recently become much simpler, thanks to a pair of *Sharp* circuits. Figure 4 shows details.

Those devices look like a transistor with a built-in lens. Their RY5AT01 transmitter outputs a burst of 500-kHz modulated infrared square waves if fed a logic one, and outputs nothing with a logic zero. This is a form of modulation that's called *Amplitude Shift Keying*.

The RY5AR01 receiver accepts an infrared signal and converts it back into digital logic levels. An internal digital filter rejects most interfering signals or noise.

The modulation scheme largely

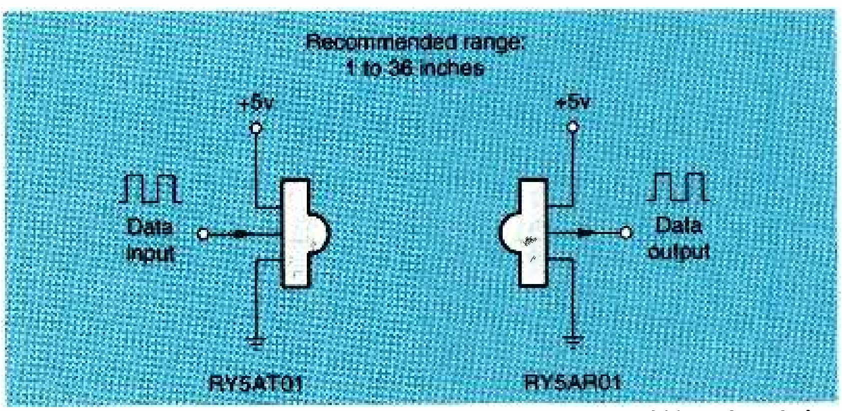


FIG. 4—NEW SHARP OPTO CHIPS offer all sorts of new possibilities for wireless communication, safety isolation, and short-haul telemetry. The 500-kHz pulse modulation largely ignores ambient light and most TV/VCR remotes.

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ignores ambient light. Signals from most interfering TV or VCR remotes are also strongly rejected. Data rates up to 19,200 baud are supported. The beamwidth is a somewhat narrow ten degrees, and the recommended range is from 1 to 36 inches.

Obvious hacker uses include safety isolation, data communication, aides for the handicapped, virtual reality, robotics, and for wireless mice.

Because of their narrow beamwidth, the two devices must point *directly* at each other at all times. While there is good rejection of ambient light and many random IR signals, the circuits offer no selective coding. This means that you will have to strictly isolate each optical linkup from any potentially interfering neighbors. This turns into an especially sticky problem in full duplex (two-way) data communication.

Sadly, Sharp's $10 intro price for these is in the "What are they on, and where can we get some of it?" range. These will be superb products when their prices fall to 60 cents each.

Short-haul telemetry

There are all kinds of emerging new uses for shorter-range wireless data communication. I'd like to apply the generic term *short-haul telemetry* to any of the newer methods that tries to send information a few inches or a few feet without any wires.

We've discussed one possible need in a previous column and in my ongoing *Hardware Hacker* book-on-demand reprints.

An *isopod* is a tennis-ball shaped beastie that you glomp onto an AC power wire. The isopod automatically measures and transmits the current to a nearby receiver. This can greatly simplify home energy management. No rewiring, no electricians, and no code hassles need be involved.

Another new demand is for a wireless pulse-rate sensor for use on an exercise bicycle computer. And there are thousands more. How about an "optical mouse" that senses where you are *looking*? Or new ways to get data onto or off of a rotating shaft or moving vehicle. Or how about ground-loop-free alternatives to data communications?

But why don't you tell me instead? For this month's contest, either (a) show me a use for the RY5AT01 and the RY5AR01, or else (b) dream up a brand new application for short-haul telemetry.

There will be dozens of the usual *Incredible Secret Money Machine II* book prizes awarded, along with an all-expense paid (FOB Thatcher, AZ) *tinaja quest* going to the best of all.

Be sure to send your written entries to me here at *Synergetics*, not to **Electronics Now** editorial.

New tech lit

From *Signetics*, there's a new and thick *Desktop Video Data Handbook* chock full of A/D, D/A and DSP chips. Also included are its genlocking video encoders.

From *NEC* there's a large packet of data sheets on *Infrared Control IC's*. Yes, these definitely include the fancy new teachable versions.

RF Design is a magazine that covers radio communications in the VHF and UHF range. Lots of ads for specialized IC's and components here. And *Wired* is a brand new magazine out of Multimedia Gulch that is quite interesting but hard to describe. The stories so far have included ones on cellular hacking and virtual reality.

Plotter codes appear in the *Plot Data Format Reference Book* from *Gerber*.

From *Cerac*, there's a freebie pocket-size periodical chart of the elements.

For the fundamentals of most digital integrated circuits, be sure to check into copies of my *TTL Cookbook* and *CMOS Cookbook*. Both are available per my nearby *Synergetics* ad.

Most of the items that I've mentioned appear in our *Names & Numbers* or *SETI Resources* sidebars. Be sure to check here first before calling our helpline. Let's hear from you. Ω

SETI RESOURCES

Associations:

Amateur Radio Astronomers
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Massapequa, NY 11758
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CIRCLE 328 ON FREE INFORMATION CARD

Planetary Society
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Pacific Astronomical Society
390 Ashton Avenue
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SETI Institute
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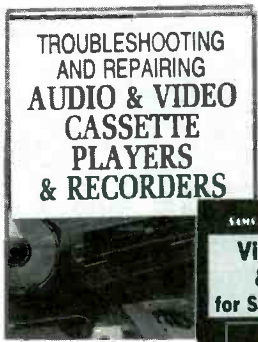

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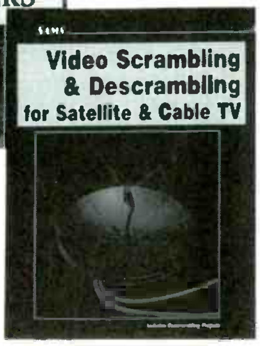

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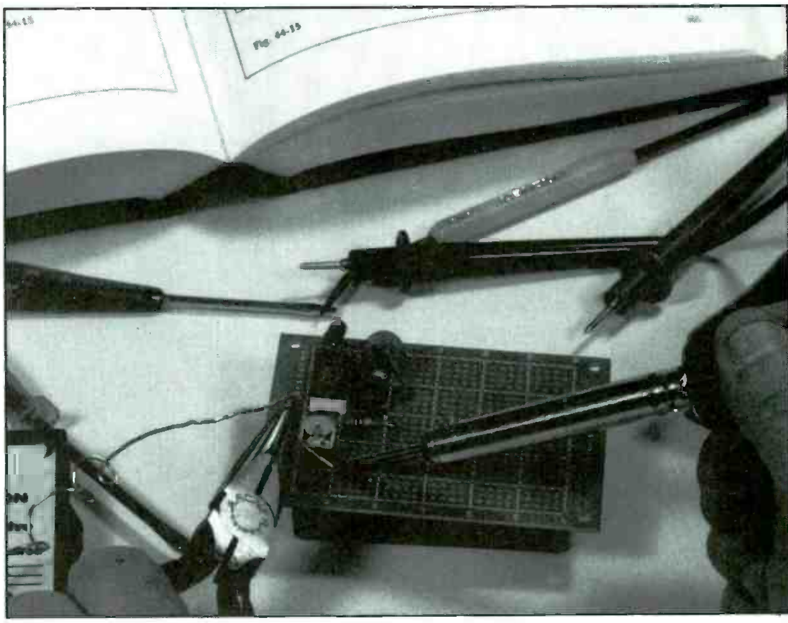

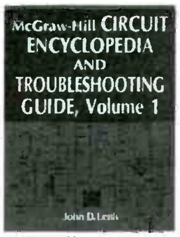

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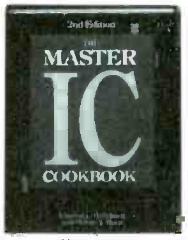

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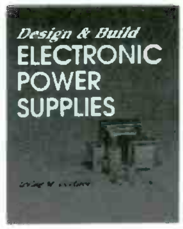

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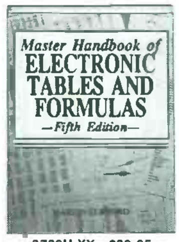

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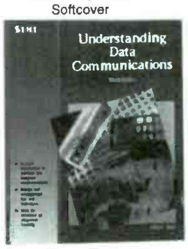

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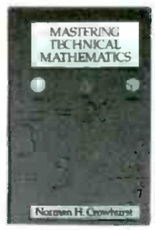

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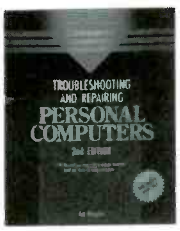

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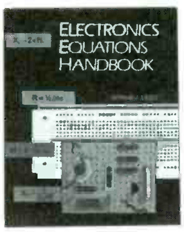

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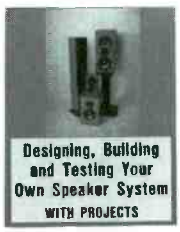

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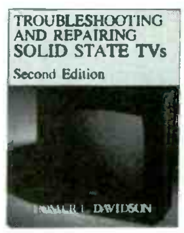

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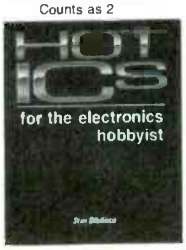

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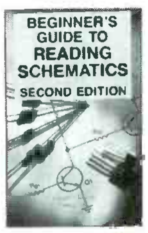

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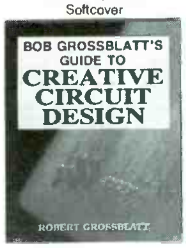

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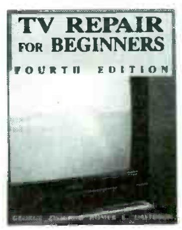

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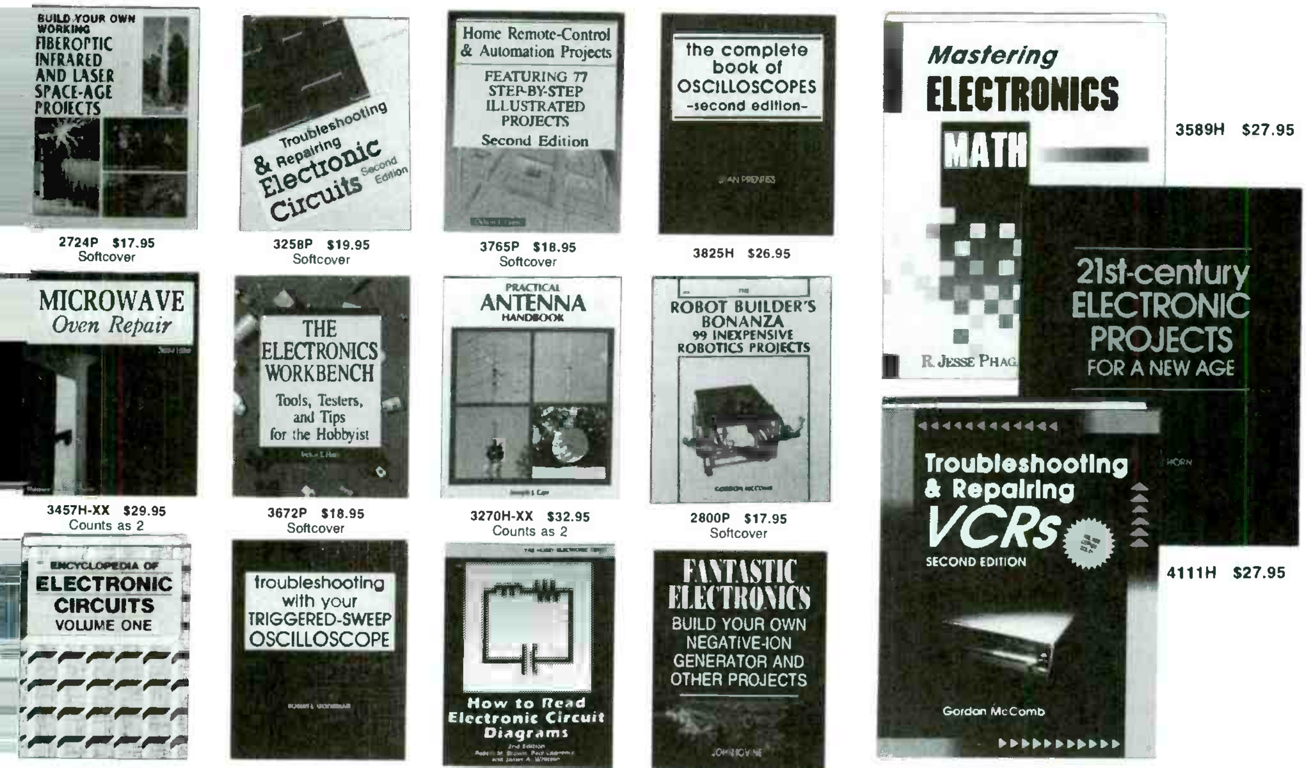

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Some reader suggestions concerning our SSAVI descrambler and something completely different.

ROBERT GROSSBLATT

Over the years, a lot of the projects we've worked on together have needed odd-ball decoders. I've said over and over again that my preferred solution is an EPROM. I've used EPROM's for everything from custom character generators to state detectors for weird numbers. If you've got the time and patience to work out a gates-only solution, you might improve your logical thinking skills, but it will take you a lot longer to get something working, it will make PC board layout a lot more complicated, and it will lock you into a particular design. EPROM's are more versatile because any modifications to the hardware in the design can be accommodated simply by programming some new code in the EPROM.

When you're in the middle of designing some hardware, a gates-only decoder might seem more attractive if you can't program an EPROM right then and there. But if you do a lot of hardware design, an EPROM programmer is just as essential as an oscilloscope.

I'm mentioning this because since we went through the basics of a SSAVI descrambler, I've received a lot of mail with alternatives to the EPROM decoding scheme I used to detect lines 24 and 257. Since it seems that a lot of you out there either prefer to do stuff with gates or don't have access to EPROM programmers, I'm going to pass along some of the decoders I've received.

All the decoders that were sent in are built with standard gates, so you should have no trouble getting the parts. Even though I have the greatest faith in my readers, I'd be a bit remiss if I didn't tell you that I haven't tried these circuits myself. You should experiment with them before you lock them into your decoder design.

The first one is from David Siegel of Livonia, Michigan and the schematic is shown in Fig. 1. It's a pretty slick design in that it's built with only three chips: two dual 4-input NOR gates and one dual 4-input AND gate.

The second decoder is from Chris Carson of Ottowa, Ontario. His design is a bit more complicated, but that's ok. Remember that more complexity makes a design more interesting. As you can see in Fig. 2, one nice feature is that only one pin is used for the line indicator. That can be handy if the rest of your descrambler wants the start and end of the vertical interval to be indicated on a single line.

Most of the circuits I received came from people in the northern part of the U.S. and Canada, so I can only guess that having to spend more time indoors during cold weather must have advantages. My apologies to the rest of you who sent me solutions—there are limits to the room I have here. My special thanks to both Chris and Dave for their designs—I know from my own experience that they took a lot of time to produce them.

If you come up with something interesting for video descrambling, drop me a note and I'll pass it along. Remember that there's strength in numbers. And now...

Something completely different

One of the considerations I use to choose the topics for this column is the amount of good material available on the subject. After a bit of

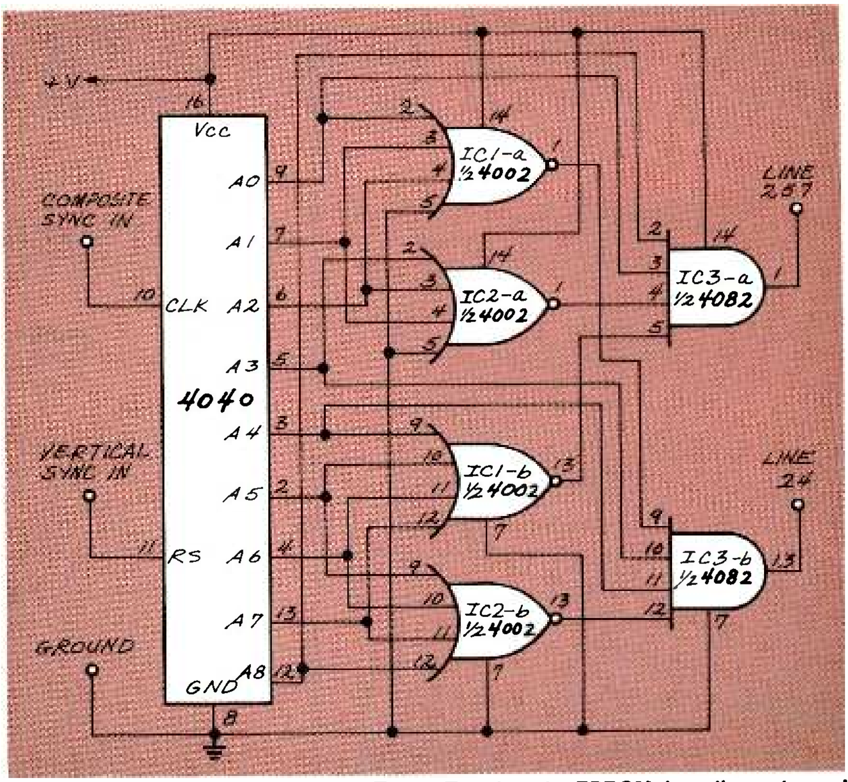

FIG. 1—MANY READERS SENT IN ALTERNATIVES to the EPROM decoding scheme I used to detect lines 24 and 257. This one uses only three chips.

earching, it occured to me that ıere has been virtually nothing pub- ɜhed on the "underground" sub- —ɜct of "unprotecting" software. ›ome years ago I did a basic tutorial n the subject for the Apple but, las, that computer has all but van- —ɜhed from the face of the earth. The ɩpple IIgs had a lot of promise but, ›ven though I think Apple is still naking the computer, it's been all ›ut abandoned by the software de- ›elopment community. And, unfor- unately, I know a lot of people who ɜhelled out an extraordinary amount ɔf money to buy them. Oh well.

My primary interest is in the PC amily and I suspect that the same is rue for the majority of you people. ⅂lthough software protection has ɔretty much disappeared in busi- ıess software, it's still used exten- —sively to protect computer games. The advent of inexpensive hard disks as well as the growth of game —sizes has changed the nature of copy protection in the last several years. Original disks are always readable and the files are easy to copy.

The trend in protection these days is the infamous document, or "doc" check. You know what I mean—the manual has some pages that are columns of numbers from which you have to get the right one to proceed with the game. Those pages, by the way, are often printed in some color combination that makes it virtually impossible to du- plicate them on a copying machine.

Getting rid of that kind of copy protection differs from the old meth- ods in that you have to find the place in the code that's calling the docu- ment check and eliminate it. Since manufacturers don't provide the source code for the software, you have to work your way through pages and pages of uncommented source code and raw hex.

Before we start on this, let me warn you that our discussion you have a working knowledge of DOS and some familiarity with computer programming in general. Although there are some good debuggers around that make the job easier, don't forget that "easier" is a rela- tive term. If you can't understand the information that's being dis- played, it doesn't matter how infor- mative it is (or isn't).

The basics of doc-check removal are simple. The program is looking for one piece of information from the manual that you have to enter at the keyboard. It then checks that against data either read in from disk or already in memory. If the check is successful, you go on to save the earth—or whatever. If not, instead of blasting into space you get blasted back to DOS.

If you're lucky, the comparison is made with the actual string you type in. All you have to do is find the table in the program with the stored strings and you're almost home free. That technique, however, isn't too common now because it's too easy to get around, and large tables can waste a lot of space. It's more common to have a table of check- sums for the numbers in the manual and do the verification with them.

If you don't know what check- sums are, you have a lot of home- work to do if you want to make sense of the discussions we're go- ing to have in the future.

No matter how familiar you are with programming or how much time you've spent hunting for bugs in a jungle of code, you'll find that making sense out of uncommented source code is, to put it mildly, a difficult task. When you're going through your own code, you know why each line is there. You also know the order in which things are supposed to happen, and when each routine is supposed to be called. That makes it relatively easy to trace the flow of a program and hunt for glitches.

When you're looking through someone else's source code, no matter how well commented, re- gardless of the language, or how logical the structure, it's always diffi- cult to get to the point where you really understand how the whole thing works. When you're working your way through pages of un- labelled op codes, it takes longer to figure out what's going on, and it's virtually impossible to get a com- plete handle on every aspect of the program.

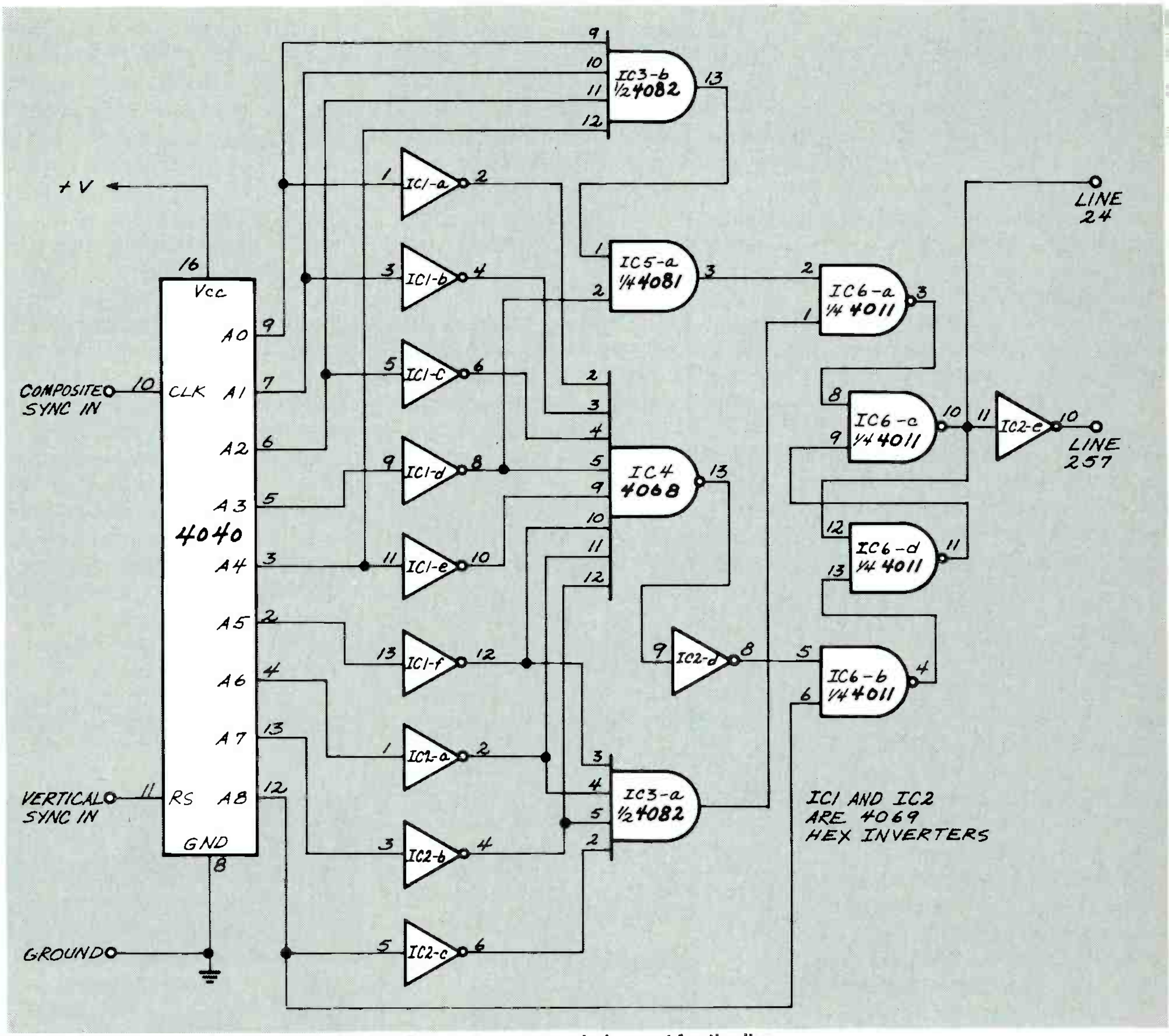

FIG. 2—THIS DESIGN IS MORE COMPLICATED, but only one pin is used for the line indicator, which is handy if the rest of your descrambler wants the start and end of the vertical interval to be indicated on a single line.

Breaking into someone else's code, especially when they've taken measures to make it as difficult as possible for you to do, means you have to have a systematic approach to the job and know exactly what you're looking for. If a program is looking for something from the disk or the keyboard, there are a limited number of instructions that can be used. The op codes are the sign posts that will help you figure out where the copy protection comes into play and how to get around it.

If you're going to be successful in removing the copy protection from a piece of software, you have to deal with the problem in a logical manner. The steps to follow are:

1. Be familiar with the software. The instructions that make up a piece of software are there to make things happen on the screen, make sounds come from the speaker, and get things from the keyboard. Even before you look at the code, you can get a good idea of how the code is structured by carefully noting the order in which things are happening.

2. Be familiar with your tools. No one, not even the person who wrote the code, can read the kind of uncommented source code produced by a debugger and follow it like the plot of a cheap novel. Comments and labels must be added to explain things normally understood only by computers. Each debugger has its own unique way of interpreting hex and deciding how it should be translated into source code. An ASCII string can be decompiled into some of the strangest source code imaginable, but if you know the behavioral quirks of your debugger, it's easier to understand.

3. Be familiar with the operating system. Programmers are free to do whatever they want as long as they limit their activity to data that's already in memory. When they want to get something from the keyboard or disk, however, there are only a few commands they can use. The 80XXX series of microprocessors are interrupt-driven. That means any

DIGITAL SCALE

continued from page 54

:r R4. If you have a set of standard apothecaries' weights, iey will save you time in the alibration process. An alter-iative is to obtain a set of new or at least unworn) quarters U.S. currency). One quarter veighs about 0.2 ounces.

There are 40 quarters to a roll. Remove the wrappers from two olls and stack the 80 coins on he platform. They weigh 15.82 unces or 448.5 grams. This nethod of calibration is sur-risingly precise.

With nothing on the scale latform and the unit set to unces mode, set the zero-ad-ust potentiometer R11 for a dis-lay of 0.00, with the minus sign deleted. Place the calibrat-ng weight on the scale and ad-ust R4 for the correct reading. Remove the weight, recheck zero, and repeat the calibration adjustment of R4. This com-pletes OUNCE calibration.

The ounces calibrating weight can be used for calibrating grams. Refer to Table 1, a handy English and metric weight equivalent reference and Table 2, a list of English to metric conversion factors. Convert the weight in ounces (avoirdupois) to grams. For example, if the set of 80 quarters was used for calibration, its weight of 15.82 ounces converts to 448.5 grams.

Trimmer potentiometer R19 calibrates the scale in GRAMS mode. Set S2 to the GRAMS position and, if necessary, set the display to read 000 with the minus sign extinguished and no weight on the platform. Place the calibrating weight on the scale and adjust R19 for the correct reading in grams. Remove the weight and recheck zero. Place the weight back on the scale and reset R19 if necessary. This completes the calibration of the digital scale.

The low-battery function of the display can be checked by substituting the filtered adjustable DC power supply for the battery. *Caution: Observe the proper polarity when making this connection.* Start with the power supply set at +15 volts DC as measured by a DC voltmeter, and slowly reduce the voltage until the "BAT" indicator on the display appears. This should occur when the supply output voltage approaches +12 volts DC. If the low-battery indicator does not perform as described, check IC2-d, IC3-c and all related components.

Scale operation

To operate the scale, first select weight mode—OUNCES or GRAMS, and then turn the power ON. Zero the display by adjusting the knob of the control potentiometer R11 on the front of the case. Be sure the minus sign is not displayed. The scale now is at your service.

For maximum sensistivity, select the OUNCES mode because with that setting, the display can resolve 0.01 ounce (0.283 grams), as compared with 1 gram in the GRAMS mode. If a display of weight in grams is desired, and a resolution of 1 gram is satisfactory, set the OUNCES/GRAMS switch to GRAMS. To convert grams to ounces refer to conversion Table 2.

Loads greater than 19.99 ounces will drive the OUNCES display off-scale. Weights as great as 3¾ pounds (1.8 kilograms) can safely be measured by taking advantage of the safe overload capability of the load cell. To obtain a weight measurement greater than 19.99 ounces, switch to the GRAMS mode which can handle up to 1800 grams without damaging the load cell.

Caution: do not place any object with a weight greater than 3¾ pounds or 1.8 kilograms on the scale or the load cell will be damaged.

To obtain net weight readings (tare), place an empty container on the scale before zeroing the display adjust control.

Turn the power ON only when actually making a measurement of weight, and don't forget to turn it off after you have finished. This will ensure long battery life. When the BAT indication is visible, replace the batteries. Ω

I/O operation (such as keyboard and disk access) has to include a particular set of op codes. Those are the Achilles heel of any copy-protection scheme because their presence indicates the possible location of code that's part of a protection scheme.

These days, most software is written in a high-level language such as a variety of C or Pascal. The days of assembly language seem to be coming to a close. There are lots of reasons for that, and the main one seems to be economic. It's much easier to move software from one type of computer to another (IBM to Mac, for example), if the code is written in a high-level language. And being able to make the software available for a wide range of computers means that the market grows that much larger.

For someone involved in the fine and gentle art of code cracking, the presence of a high-level language has certain consequences. While the programmer might be writing

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AUDIO UPDATE

Loudspeaker power ratings: midrange and woofer problems

LARRY KLEIN

Everything that I said last month about tweeter power ratings also applies, to some degree, to midranges and woofers. Except, unlike the situation with tweeters, the heat dissipation problem of the larger drivers is eased by heavier voice coils and the forced-air cooling provided by the greater diaphragm movement. This advantage is negated somewhat by the fact that most musical energy occurs in the midrange. An octave-band real-time analyzer clearly shows an energy hump centered around 500 Hz for classical music, and perhaps an octave or so higher for pop and rock.

In general, the lower the frequencies a midrange driver must deal with, the greater the applied mechanical and thermal stress. A midrange unit intended to perform at low frequencies down to 500 Hz or so must be ruggedly constructed because it is trespassing in typical woofer territory.

To minimize mechanical stress, the crossover frequency and its slope are carefully adjusted in low-crossover three-way systems to safely limit the amount of low-frequency energy reaching the midrange driver. An over-stressed midrange sounds raspy or otherwise distorted. If it continues to sound that way when the program volume is reduced, it has been pushed beyond recovery, and replacement is in order.

Woofers usually give you plenty of early warning when they are running into trouble, which is usually more mechanical than thermal. That wasn't always so, but improved cone and voice-coil materials and better cements have led to greater resistance to thermal meltdown. But at the mechanical end, the laws of acoustic physics still hold: For every additional lower bass octave that you want to reproduce, four times the speaker-cone excursion is required. For that reason, there are very few speakers that can reach loudly down to 20—or even 30—Hz, despite what the ads would have you believe.

The outer cone suspension (the surround), the inner cone suspension (the spider), the cone itself, and the voice coil are all mechanically at risk when a speaker is overdriven at low frequencies. A really whopping overdrive situation (such as would occur if a speaker were plugged into an AC outlet—something that should never be done) can tear the cone out of a speaker.

Speaker distortion

As a prelude to destruction comes distortion, which serves as an early warning to back off the volume. In general, the harder any component, electronic or mechanical, is driven, the higher its distortion. But distortion usually does not become obvious until the component approaches its mechanical or electrical limits. And operating at these limits is risky.

There is a kind of little-recognized distortion that occurs when a speaker is consistently run close to overload. It happens because copper wire increases its resistance as it heats up. The effect is so consistent that engineers can directly calculate the operating temperature of a voice coil by its rise in resistance above its room-temperature reference.

The voice-coil resistance shift is far from innocuous for several reasons. It not only can cause the crossover frequencies to shift, but, when reflected back to the amplifier, it also results in signal compression. An amplifier putting out, say, 12.5 watts into a speaker system with a measured 8-ohm impedance will deliver 10 watts into 10 ohms, and less than 7 watts into 15 ohms. Note that this is a dynamic effect in that the degree of compression varies with the varying temperature of the voice coil.

As is evident, the drivers in speaker system react differently t being pushed too hard. An ove driven woofer will "double" or "tr ple" at low frequencies, meanin that as the cone and voice coil ap proach their mechanical and mag netic limits, the cone motio becomes nonlinear, no longer track ing the electrical audio waveforn fed it. The result is second- an third-harmonic distortion. If pushe too hard at 50 Hz, for example, woofer will produce large amount of spurious 100- and 150-Hz energy in addition to the original 50-H tone.

Other sonic artifacts also resul from cone flexing (breakup), and rat tling or snapping noises may be heard as the rear of the woofe voice coil strikes the back of the speaker's magnetic structure. A long-term overload (such as migh cause the compression mentionec above) that is not quite large enough to cause mechanical problems car overheat a voice coil sufficiently fo it to warp, throw off its windings, o char.

In the past dozen years, advances in the cements and voice-coil materials have eliminated many of the thermal problems. That's why mechanical stress remains the primary woofer killer.

Minimum power

We can assume that the "minimum power" rating that appears on spec sheets is derived by determining how much amplifier power is required to achieve a reference sound pressure level of "x" dB. As mentioned earlier, most speakers have a minimum power rating that is easily met by virtually any available receiver or amplifier. But what happens when an amplifier runs out of voltage and/or current before it can drive the speakers to a desired volume level?

When an amplifier is pushed beyond its limits in an effort to proɹce a required sound-pressure vel from a given loudspeaker, it ips the positive and/or negative ɜaks of the musical waveforms. hort-duration overloads may not ɜ audible; longer overloads are freuently perceived as level compresion, rather than distortion. However, badly overdriven amplifiers roduce a raspy distortion, not unke that of a mistracking phono caridge. Low bass passages are likely ɔ take on a "mushy" quality beause of the spurious harmonics enerated by the overload. And as iscussed earlier, prolonged operaon with hard clipping is a frequent ause of driver damage, so clipping hould be avoided.

ʾroper power ratings

Arriving at a speaker system's ɪower rating is no easy task, even ɔr its designer. Ideally, a manufacurer designs for the highest power ;apability that can be achieved with- ı his cost and size constraints for a ɡiven model. Special high-temperaure materials such as voice-coil vire, voice-coil forms, and cements all play a part in squeezing the maximum power rating from any given speaker.

The test signal used to derive a system's power rating must be chosen carefully. The ubiquitous pink-noise signal used in so many other audio tests is totally inappropriate for power testing because, unlike music, it has equal energy per octave. In contrast with the midrange energy hump displayed by most music, pink noise shows up on a real-time analyzer as a virtually straight line, which is a poor representation of music.

The single rms ratings used by some manufacturers imply the use of a sinewave test signal, which, again, is totally unlike a musical waveform in shape or energy content. The most valid and informative way for a manufacturer to specify a speaker's power-handling capability is to state, however loosely, the power it can handle in a specific frequency range for a specific amount of time.

Listing specifications that way gives rise to a somewhat complex, but informative, power-handling capability specification, such as that used by Allison Acoustics: "At least 15 watts continuous at any frequency. Over most of the frequency range, at least 350 watts for 0.1 second, 125 watts for 1 second, 60 watts for 10 seconds."

Note the distinctions Allison makes between continuous and transient wattage levels. The difference between them is what allows you to play very loud music without problems, even though a continuous sinewave at the same peak level would certainly damage your audio equipment. In other words, your 100-watt (or even 200-watt) amplifier is certainly safe to use with typical speakers rated at 50 watts maximum so long as you don't feed continuous tones or pink noise to them, drive the amplifier into hard clipping, drop a tone arm, or lose a cable ground at high volume. In short, you have to abuse your speakers (and your ears) before disaster is likely to strike. If you don't ask for trouble, it probably won't happen. Ω

L-C FILTERS

continued from page 72

low-impedance source, the output will produce a steep signal peak at f_c, as shown in the frequency-response curve of Fig. 11-*b*. The magnitude of this peak is proportional to the circuit's Q.

Figure 12-*a* shows how Fig. 11-*a* can be modified so that it behaves like a true L-type low-pass filter. Resistor R_X is placed in series with the circuit's input so that the sum of R_X and R_S (the input signal's source impedance) and R (the equivalent resistance of L) equals the circuits characteristic impedance Z_O. The addition of this resistance reduces the circuit's Q to unity, but it results in a clean low-pass filter output shape as shown in Fig. 12-*b*.

Figure 13 illustrates how the principle just discussed can be applied to make an efficient L-type high-pass filter. The output is taken across inductor L

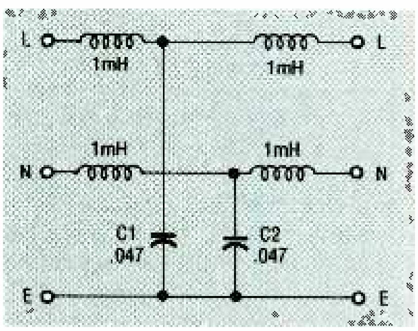

FIG. 16—T-SECTION POWER LINE input filter rejects interference on the power line to about 25 MHz.

rather than across capacitor C. The value of equivalent resistor E_X in both of these circuits can be reduced to zero if the filter's Z_O value is selected to match R_S, as given in formula 2 of Table 1. The outputs of these filters, like those of the series and parallel-resonant filters, must "see" only high-impedance loads to operate properly.

The most popular low-pass and high-pass filters are balanced, with matched impedances that are designed to be driven from, and have their outputs loaded by, a specific impedance value. Such filters can readily be cascaded to yield very high levels of signal rejection. Among those filters are the T-section and pi-section low-pass filters that are shown in Fig. 14, and the T-section and pi-section high-pass filters that are shown in Fig. 15.

All of these filters exhibit an output rolloff of about 12 dB per octave (40 dB per decade). Their outputs must be correctly loaded by a matching filter section or terminating load. The design formulas for them are given in Table 1.

Figure 16 shows an application for a T-section low-pass filter—an AC power-line filter that will block interference that is on the line from reaching a sensitive unit of equipment while also blocking any interference from that might be generated internally by that unit from reaching the power lines. This circuit can be made to operate at frequencies up to about 25 MHz. Ω

VIDEO NEWS

continued from page 6

ment be of the "viewable" diagonal, or the diagonal of the picture itself, rather than the tube. No other country followed our lead. Thus, in the U.S., smaller tubes lost an inch in diagonal measurement, while larger ones lost two inches (representing the thickness of the tube walls).

The new 16:9 TV's are measured the same way—diagonally, the viewable portion in U.S. and overall elsewhere. But because of the different dimensions, they're not directly comparable with standard 4:3 tubes. For example, the biggest widescreen CRT tube size is 34 inches in the U.S. and 36 inches elsewhere. In height, however, it would be the equivalent of a 28-inch standard 4:3 tube (U.S. measurement). A 30-incher is similar to a 25-inch standard tube stretched horizontally, and a 26-inch widescreen is a 21-inch tube with "ears." Ω

WHAT'S NEWS

continued from page 4

imately 60 watts were used to meet the electrical requirements of the heating system, which produced 7.2 kW or 25,000 BTU/hour of heat (about one-quarter the output of a typical home heating system). The "leftover" 100 watts of auxiliary power could have been used to run a sump pump, or even a TV set.

GE's generator is based on the effects of thermoelectricity explored more than 150 years ago by Thomas Seebeck. The Seebeck Effect refers to the electromotive force produced in a circuit formed by two wires of different metals, one of whose junctions is kept at a higher temperature than the other. The GE design includes several thermocouples, each of which has circuitry of dissimilar semiconducting alloys. Electricity is generated by the unequal heating of the two different alloys at their junctions. Ω

ANALOG MULTIPLIER IC'S

continued from page 68

This article is intended as an introduction to the multiplier IC. Any readers interested in performing experiments with the AD532 (or any other Analog Devices analog multipliers/dividers) are advised to request copies of the device's data sheets from:
Analog Devices, Literature Center, 70 Shawmut Road, Canton MA 02021, fax 617-821-4273

Analog Devices multipliers are available in single quantities from Allied Electronics (800-433-5700) or Newark Electronics (312-784 5100) for about $35 each.

Other sources

A comparison of analog multipliers will reveal variations in speed, linearity, signal bandwidth, operating quadrants, and internal circuitry.

Motorola offers two monolithic four-quadrant multipliers that also operate on the variable transconductance principle, the MC1494L/1595L and the MC1495L/1595L.

With associated peripheral circuitry, the MC1494/1594 can multiply, divide, square root, and determine mean squares. It can also function as a phase detector, frequency doubler, balanced modulator/demodulator, and an electronic gain control. It is powered from a ±15-volt supply.

Harris Semiconductor offers two wideband, two-quadrant analog multipliers, the HA-2546 and the HA-2547. The HA-2546, for example, is a two-quadrant device that has a voltage output with a 30-MHz signal bandwidth, 300 volt-per-microsecond slew rate, and a 17-MHz control input bandwidth.

Harris says that the HA-2546 is well suited for AGC circuits as well as mixer applications for sonar, radar and medical imaging equipment. The voltage output of the HA-2546 eliminates the current-to-voltage conversion stage required for current-output multipliers. Ω

COMPUTER CONNECTIONS

A bit meter in every basement.

JEFF HOLTZMAN

Last month we discussed how the computer, telecommunications, entertainment, publishing, and consumer electronics industries are converging. One way to view this convergence is to think of society as a big information-crunching machine (ICM). The purpose of this machine is to process information. Information in, information out. Figure 1, a variation on a theme initiated last month, indicates the idea.

"So what," you might say; "What's the big deal?"

The big deal is that the ICM is going—indeed, already has begun—to radically alter all aspects of life, such as how we work, how we play, and how we interact with other people. The ICM view of society says that both unsophisticated goods and labor-intensive services will soon become extinct, to be replaced by information-intensive goods and services produced by a computer-based infrastructure and operated by information workers. Maybe they won't become extinct—but they'll certainly be on the endangered species list.

Look at how we work now, and how we will work in the future. Right now many of us spend much of our time in front of computer screens. But there is still a significant number of people that perform manual labor in manufacturing and service industries (e.g., restaurants). However, these jobs are evaporating. No, they're not going south of the border, or to Korea or Japan. Because of a steady and increasing trend toward complete and total automation of most processes, these jobs are simply becoming unnecessary.

So be leery of government-sponsored jobs programs. No company in its right mind wants to increase the number of jobs involving manual labor. That type of job consistently provides the most expensive, least reliable link in the production chain. And any company that can't decrease cost, increase quality, and increase its ability to respond to a chaotic, rapidly evolving global economy... well, I sure wouldn't want to own stock in such a company—nor work for one.

Back to the ICM.

Anything, anywhere, anytime

A widely shared goal among computer visionaries is being able to access any kind of information, anywhere, anytime. Until recently, this type of vision reigned more in the realm of science fiction than fact. However, trends in the semiconductor and computer industries have in amazingly short order made available a set of building blocks powerful enough to start implementing the first tentative structures of this global network. A future in which your house has a bit meter next to the gas and electric meters is not far off.

For example, it is now *possible*—not necessarily easy or effective or efficient—to exchange email messages among all important services (AT&T Mail, BIX, CompuServe, Internet, MCI Mail, and more). However, these messages seldom carry more than ASCII text; binary file transfer is available only sporadically; and full multimedia data transfer (i.e., real-time audio and video) is still a long way off. What services there are still force people to spend a major fraction of their on-line time learning to use and tweaking the computer tools, rather than just seeking and capturing the information they want.

Information and hype

The computer industry has been slow to recognize and respond to growing demands for universal connectivity and data access. Attention has instead been shunted from meeting user needs to increasingly great hype and marketing warfare concerning operating systems, CPU's, graphical user environments, and the like. The technology-driven computer market continues to supply what it *can* (and what it finds interesting to build), rather than carefully ferreting out and responding to exactly what users need.

The fad-driven and haphazard way in which vendors rushed to add icon bars to Microsoft Windows applications is only one recent example of how much remains to be learned. Building solutions that correspond to no real-world problems has been a way of life at many technology concerns, large and small, for years. However, those days are over. Careful needs analysis and usability testing, rather than simply heaping feature upon feature upon feature, will certainly define the successful computer company of the 90's.

That statement applies to both hardware and software. For example, computers today are sold as daredevil items. No one buys a car expecting to pay extra for brakes; people consider them a built-in part of the system. But what sort of data-safety features does the average PC (or Mac or workstation) come with? To protect our data we must spend extra on peripherals (e.g., tape backups, redundant disk controllers, and uninterruptible power supplies) and utilities (virus scanners, disk repair software). Of course, if those problems ever are fixed, those of us in the consulting business may have to look for other lines of work.

Content, creativity, and capital

Now let's look at the entertainment industry (i.e., movie studios, record companies, and megacorporations like Time-Warner). That industry is in an extremely strong position in the emerging world of universal digital access to multimedia data. Even Bill Gates talks to Hollywood.

The entertainment companies have content (records and films), creativity, and capital. In some cases, these companies have major interests in all stages of the process. Time-Warner, for example, owns significant content, both print and film; the company is also the second largest cable-TV distributor. With control over all stages of the information creation and distribution process, TW's ability to monopolize, control, and censor the flow of information is frightening; it makes old fears about AT&T's domination pale by comparison. One currently circulating rumor concerns a possible TW/AT&T merger.

The entertainment industry is using new multimedia technologies in irresistible ways. Witness recent films like Terminator 2 and The Lawnmower Man, the virtual-reality chambers built by Disney, 3D video parlors, and the special-effects companies set up by the film studios. The entertainment industry understands user interfaces, how to make the technology transparent, and how to draw people into compelling alternate worlds. To the extent that it is going to survive as a separate entity, the computer industry had better pay attention to what's going on.

The computer industry is in imminent danger of being subsumed by Hollywood and the other points in the information-distribution chain. In this scenario, computer technology will drop to the level of plumbing—the shading in Fig. 1. Indistinguishable varieties of hardware will be mass-produced by robots for next to nothing. A friend talks about the time, probably within the next decade, when an entire computer, with a gigabyte of RAM and a megapixel full-color display will fit on a single chip that costs less than $3. Where will Intel, Motorola, and even IBM be then?

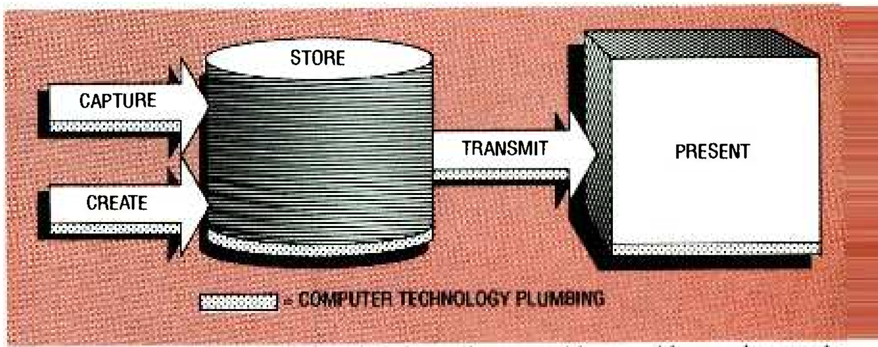

FIG. 1—SOCIETY IS BECOMING a big information-crunching machine, and computer technology will eventually drop to the level of plumbing.

Conclusions

Since the dawn of the industrial age, western society has defined itself by producing material goods; this type of production defined the overall economy, as well as how people worked, learned, and lived. Nowadays, there is less and less emphasis on physical production, and more and more emphasis on the "soft" side, on style, on intangibles, and on form rather than just on function.

So how does today's computer technology fit in a view of society as information grinder? It's clear that the hardware side of the industry is headed for pure commodity status, which spells bad news for U.S. manufacturers—and workers.

On the other hand, the software side has much to learn, but through partnerships with Hollywood and the like, has much opportunity to learn it. If it blows these opportunities, the computer industry per se will disappear, to be replaced by a hybrid consisting of companies that understand the ICM model.

Either way, opportunities will make the explosive growth of computers in the 80's seem minuscule by comparison. However, it will also mean excruciating pain for the manufacturers of "hard" goods. Over the long term, I wouldn't buy stock in any company that makes things you can put your hands on—unless it's the packaging for multimedia software.

News bits

Intel finally released two versions (60- and 66-MHz) of the Pentium, the successor to the 80486. Systems that use the Pentium should be released in early summer, and they'll be expensive, but early betas indicate less of a performance jump than with the corresponding switch from the 386 to the 486. Could this be the beginning of the end of Intel's hegemony in microprocessors?

Microsoft officially released MS-DOS 6.0; the product might perhaps be more accurately known as a better suite of utility programs for DOS 5; DOS itself has changed very little. DOS 6 is mostly a power-user's update that improves the bundled utilities (e.g., the 386 memory manager and backup programs), but hardly pushes the envelope. One nice feature is the configuration manager, which allows you to keep several boot configurations in one CONFIG.SYS, and select among them at boot time. You can also press hotkeys to bypass boot files altogether, or selectively execute lines in CONFIG.SYS. Overall, DOS 6 is more interesting for what it doesn't include than what it does. There is still no multitasking; no networking; no email; and only a mediocre graphical shell. Rumor has it that DOS 7 will really push the memory and file-system limitations we've lived with now for more than a decade.

I've been playing with several beta releases of OS/2 2.1. Although there are still bugs, this time IBM really seems to have done its homework. Speed of Windows applications running under OS/2 is now acceptable, i.e., comparable to simply running them in Windows. And the OS/2 WorkPlace Shell does have a habit of growing on you after you've used it for a while. One of my favorite features is still the Boot Manager, which allows you to boot to any one several previously defined partitions or extended disk drives, each of which may contain a totally different operating system.

Unix operating-system vendors have fought continually during the past decade over relatively insubstantial issues. In recent years, vendors coalesced around two groups of standards, those promulgated by the Open Software Foundation (which includes IBM, DEC, HP, and others), and those by a combination of AT&T and Sun. At long last, the walls have come tumbling down. HP, IBM, SCO, Sun, Univel, and Unix Systems Laboratories (formerly of AT&T, but recently purchased by Novell) announced the Common Open Software Environment (COSE, pronounced *cozy*), a global application programming interface that hopes to eliminate inter-platform portability problems. With Microsoft's Windows NT due to be released this spring, this is clearly an act of desperation.

Think HDTV is something? Then check out Ultra Definition TV (UDTV), a new project sponsored by the Japanese Government and 100 of Japan's largest electronics firms. This may be a tacit admission of defeat in the HDTV wars, so the Japanese are leapfrogging to the next generation.

Remember the switch from 256K to 1Mb DRAM's? Maybe you noticed increasing usage of 4-Mb devices? The industry is about to make the next jump: 16-megabit DRAM's. Toshiba, Fujitsu, and NEC are already producing on the order of 500,000 units per month, and promise to double or triple that quantity over the next year. Not to be outdone, NEC has introduced 16-megabit synchronous DRAM's, which provide 10-ns access times; initial production rates will be 30,000 units per month. The ultimate is Hitachi's recent breakthrough announcement: the so-called single-electron memory, which would allow construction of power-effective gigabyte semiconductor memories. But give it about ten years to reach commercial status.

Bell Atlantic has built a demo Intelligent Home, which is prewired with fiber optic cables and features extensive multimedia communications. Using a TV, users can access telephone, cable TV, shopping, and other information services. This is the kind of forward-thinking use of technology that we should see more of. Ω

EQUIPMENT REPORT

continued from page 22

wrong because the picture we were viewing, SportsChannel, was not on Galaxy 2 (our highest satellite), but on one satellite to the east!

The receiver also offers an handy audio "Squawk" that provides an audio indication of signal strength. It's a easy way to peak the dish position because it allows an installer to keep his eyes on his work instead of on a signal meter or spectrum analyzer.

The PTR-25A portable test receiver has a list price of $1395. The PSA-37D portable spectrum analyzer has a list price of $2475. Thanks to the time they can save an installer, they should pay for themselves in short order. And the improved performance they can potentially bring to a dealer's installed systems should keep his customers happy—and coming back for more! Ω

COMB. GAS ALARM

continued from page 42

When power is first applied, the alarm will sound for several seconds as the heater element brings the sensor to the correct operating temperature. After the alarm stops, it takes approximately 2 minutes for the sensor to stabilize before accurate gas concentrations can be measured. After the warm-up period, you can test the alarm by using alcohol instead of methane. Dip your fingers into some rubbing alcohol and rub them together directly in front of the sensor element. The alcohol vapors should trip the alarm and the buzzing should stop once the alcohol has dissipated.

To use the backup feature, install a fresh 9-volt alkaline battery and repeat the alcohol test with the wall transformer unplugged. Remember to remove the battery whenever the unit is not in use to prevent discharge. Your gas sensor alarm is now ready to use. Remember that methane gas rises in normal air, so the alarm should be mounted near the ceiling. Ω

PRINTER MINDER

continued from page 64

this connector. Perform the following tests before installing the board in a case:

1. With no power applied, use an ohmmeter to verify that there is more than 20 ohms resistance between +5 volts and ground.

2. Apply AC power and ensure that the +5-volt source is accurate. It's convenient to measure across pins 20 and 10 of IC1.

3. Without connecting the printer, verify that LED1 (Printer On) is off. Attach one end of a test lead to pin 1 of J1 (STROBE IN). Momentarily ground the other end of the lead (e.g., to pin 19 of J1). The LED should illuminate, and should remain on for about one hour. While it's on, there should be 120 VAC across power connector J4.

4. With the LED still on, verify the power-fail feature by momentarily removing input power. The LED should go out, and J4 should lose power.

If any of those tests fail, correct the source of the trouble before proceeding.

The last step is to mount the board. If you use a case like our prototype, slide it in the tracks extruded into the wall of the case, and then seal the case with two end caps.

Hooking up

Now you're ready to connect Printer Minder between your computer and your printer. To understand the wiring scheme, refer back to Fig. 1, and perform the following steps:

1. Unplug the AC cable from your printer; it will be used later.

2. Unplug the data cable from your printer and connect it to J1 of Printer Minder.

3. Now connect another data cable from J2 of Printer Minder to the input port of your printer.

4. Connect an AC extension cable from J4 of Printer Minder to the printer's AC input.

5. Now apply power to Printer Minder by connecting the AC cable removed from the printer in Step 1 to J3.

6. Verify proper operation by printing a file. Ω

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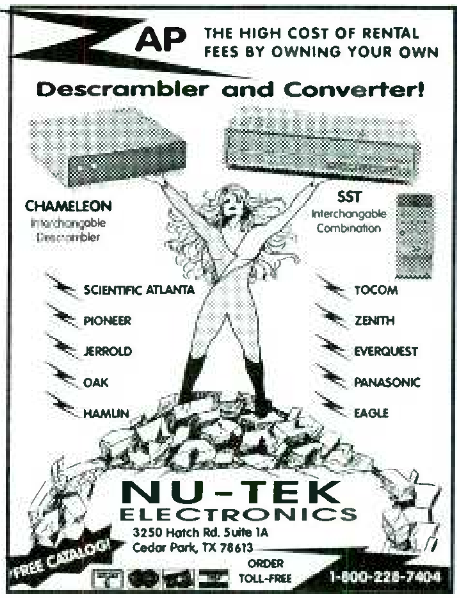

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DRAWING BOARD

continued from page 87

lines of code in quasi English-like statements, the cracker is poring through lines of hex produced by the high-level language's runtime library and compiler. The result is that the program flow presented by the uncommented source code produced by the debugger will often seem to be peculiar. That's because it was written by the compiler and not by the programmer.

All these things combine to make cracking software on the PC quite different from cracking stuff on older computers such as the late, lamented Apple II. But fear not, the basic techniques for cracking software are the same, and even a novice cracker is faced with the same basic detective work.

Next month we'll assemble our tools and step our way through some real-world examples. Ω

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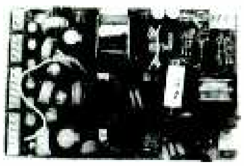

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—Input: 115VAC @ 60Hz

2-pin Molex input connector and 4 output connectors

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Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

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