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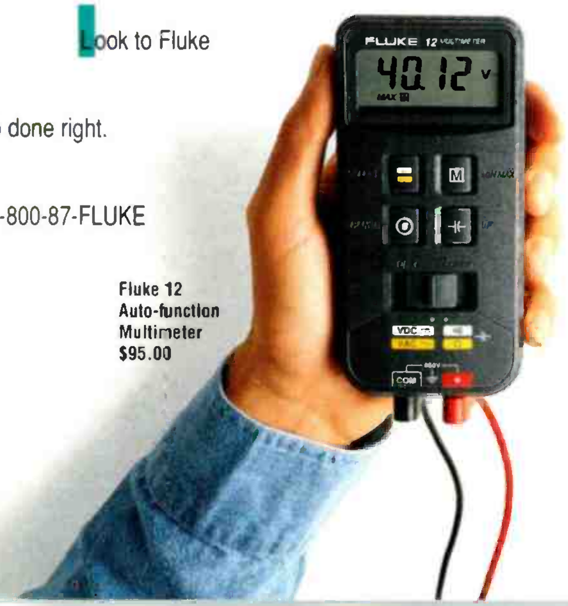

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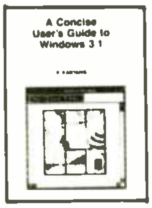

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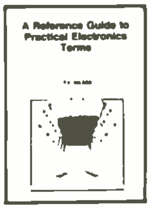

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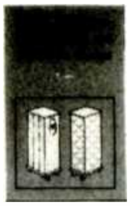

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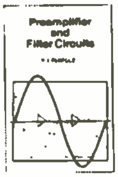

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January 1994

Electronics NOW®
Vol. 65 No. 1

BUILD THIS

TECHNOLOGY

FEATURES

PAGE 56

PAGE 77

DEPARTMENTS

AND MORE

ON THE COVER

Virtually any appliance you can buy today—from the refrigerator and microwave oven in your kitchen, to the VCR in your den, to the car in your garage—contains embedded microcontrollers. Even those engineers or technicians who do not encounter microcontrollers on a daily basis must understand the basics of microcontrollers to be successful. This month, we look at how to program two such devices. First, on page 35, we take an in-depth look at Microchip Technology's PIC 16C5X, a new breed of low-power 8-bit microcontrollers, and how to program it. Next, on page 35, we delve into Motorola's MC68705, one of the industry's most widely used microcontrollers, and show you how to build an inexpensive programmer for it.

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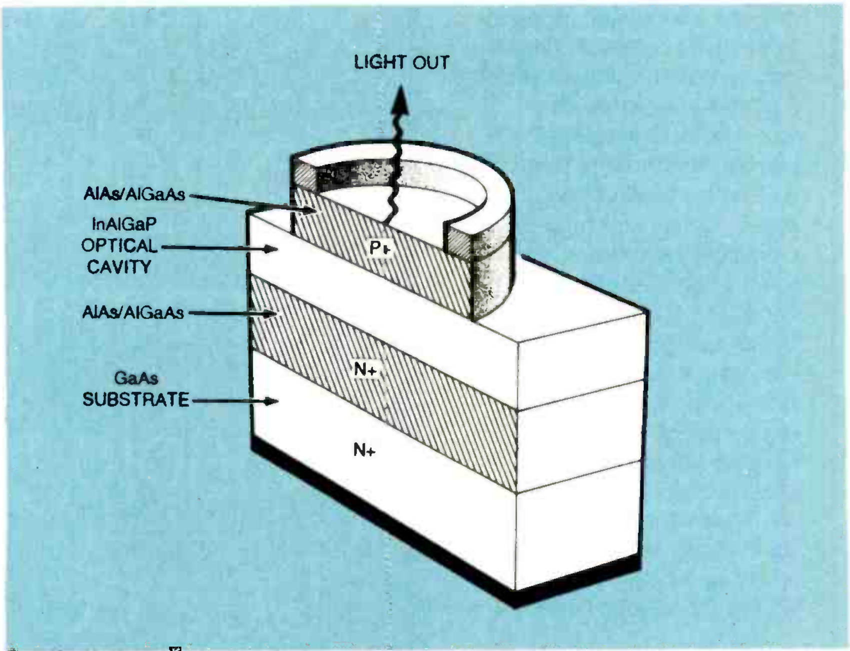
A review of the latest happenings in electronics.

Semiconductor laser advance

The first vertical-cavity, surface-emitting laser (VCSEL) to produce visible light was demonstrated by researchers at Sandia National Laboratories (Albuquerque, NM). According to the researchers, the VCSEL is an important leap forward in laser technology because this device promises many new commercial applications for semiconductor lasers. One example given was the possible use of the VCSEL in plastic fiber-optic communications and its use in printing with optical technology.

The VCSEL emits light perpencicular to the top surface of the semiconductor die. This contrasts with the more typical emission for semiconductor lasers: from the cleaved edge of the die parallel to its plane. A VCSEL output beam has a narrow angle and a circular beam cross section. Visible light emission from a point close to the surface of the die makes it easier to assemble closely packed arrays of VCSELs whose output will form multiple parallel beams.



Sandia National Laboratories' vertical-cavity, surface-emitting laser (VCSEL) emits visible light from an aperture 12 micrometers in diameter on the laser die's top surface. The semiconductor device includes a quantum well, active optical cavity, and phase-matching layers sandwiched between distributed Bragg reflectors. Its visible light is emitted in a well-defined circular beam.

The electrical injection process permits the laser to be operated directly from the AC line rather than requiring that it be pumped by another laser, making the power supply more complex. This line operation feature opens more potential commercial applications for injected lasers than their laser-pumped counterparts, which are generally confined to laboratory research.

Sandia reports that the new lasers emit light in the bright red 639- to 661-nanometer wavelength region of the visible light spectrum. (The shortest wavelength previously reported for a VCSEL diode was 699 nanometers, at the extreme limit of visibility.

Bright red light-emitting VCSELs could find a place in the improved laser "pointers" used for lectures and slide presentations. Models now available include conventional edge-emitting semiconductor lasers whose beam is more fan than round shaped. Other applications are seen in communications based on plastic fibers, arrays for displays, holographic memories, and telemetry systems.

It is pointed out that the 639-nanometer VCSEL wavelength closely matches 633-nanometer wavelength of helium-neon gas lasers now found in supermarket checkout bar-code scanners. This might make possible a lower cost substitute for those lasers.

The VCSEL is intended for pulsed operation at room temperature. Peak emitted power, which occurs at 650 nanometers, can exceed 3.3 milliwatts. At that wavelength, the threshold current is 2.7 volts and the output beam has a 20-micrometer diameter. The devices can be from 10 to 30 micrometers in diameter, less than half the thickness of a human hair.

Sandia National Laboratories has filed an invention disclosure, and it reports that optoelectronic device manufacturers have expressed interest in the device. Many are seeking to do cooperative research or sign development agreements with the laboratory.

Semiconductor slowdown

The slowdown in the semiconductor market will continue through mid-1994, according to the October 1993 report from Advanced Forecasting Inc. (Cupertino, CA).

Dr. Moshe Handelsman, a spokesman for Advanced Forecasting, reports that the semiconductor industry is now buying a lot of new manufacturing equipment to meet its present demand. However, he added that because orders are flat—and his company's forecasting

Continued on page 83

VIDEO NEWS

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

DAVID LACHENBRUCH

• **Cable compatibility.** When Congress passed the Cable TV Act of 1992 it required the FCC to issue rules to assure the compatibility of cable TV with such consumer-electronic products as TV sets and VCR's. Congress also required the FCC to report on its proposals in advance of putting them on the books. The FCC has now made its report, which was based largely on compromise recommendations by a committee composed of representatives of cable and electronics industries—but in some respects, its proposals went beyond that agreement.

The proposals are designed to let consumers enjoy the benefits of such TV and VCR features as picture-in-picture, on-screen menus, and the ability to tape one program while watching another. As an "intermediate" starter, the FCC served notice that it will prohibit scrambling of basic-tier channels, a practice adopted recently by some big-city cable systems.

The Commission said that its long-term goal was to eliminate set-top boxes and to end delivery of scrambled signals to consumers' tuners. It endorsed the development of a "decoder interface" system that would allow either current analog or future digital signals to enter the VCR or TV tuner for channel selection and then exit into a plug-in decoder.

Among other rules proposed by the Commission: For the short term, before the interface is developed, give consumers the option of having all unscrambled signals delivered directly to their TV sets or VCR's, bypassing set-top boxes. In addition, it would require cable systems to offer subscribers boxes with multiple descramblers, timers, and other features to let them use the special features of their equipment. Cable systems would be required to let consumers use commercially available remote controls with their set-top boxes.

And as new cable systems are built or older ones rebuilt, the rules would require cable companies to adhere to standard channel number and frequency designations (IS-16), originally developed in 1983, covering 153 channels, and now being expanded. That would eliminate the problem of non-standard channel designations.

The rules would set up standards that TV sets and VCR's must meet in order to be advertised as "cable ready" or "cable compatible." Those would include a built-in decoder interface connector, the ability to tune all channels specified in the IS-16 standard, and improved tuner performance and shielding.

• **Video CD progress.** The new "Video CD" standard for compressed full-motion video on a five-inch compact disc is beginning to bear fruit in terms of proposed products. Hungry for a new, appealing product in a severe recession, most major Japanese consumer-electronics manufacturers demonstrated prototypes or mockups of Video CD products at the Japan Electronics Show. JVC, co-developer of Video CD (with Philips), showed three prototypes—standard and mini component Video CD decks and a unit combined with a video-game console. Matsushita (Panasonic) demonstrated a three-disc changer that provides more than 3½ hours playing time. Sony showed a mini component version, while Hitachi displayed a Video CD player built into a TV set, and Sharp showed a mini deck.

Philips, which is pushing its CD-I interactive multimedia system, said that it will not offer a dedicated video CD player, but that its digital-video cartridge add-on would enable CD-I machines to play Video CD's as well as new interactive, full-motion discs. Matsushita said that its 3DO Multiplayer, now on the market, would be able to play Video CD's when a full-motion video adapter is available this spring.

• **Video-game alliance.** Video-game manufacturers are lining up with semiconductor makers to develop new and more sophisticated interactive systems. Nintendo and Silicon Graphics announced that they are developing a 64-bit system scheduled for launch at the end of 1995 at less than $300. That was followed by an announcement from Sega that it is working with Hitachi on a new-generation game system built around Hitachi's 32-bit RISC chip.

Pioneer has entered the increasingly crowded video-game field with LaserActive, combining the analog video of laserdisc with encoded digital operation. Pioneer says that the system combines laserdisc's full hour of high-resolution full-motion video and FM audio with the same 540-megabytes of storage used by existing CD-ROM game systems. LaserActive doesn't come cheap, however. It's expected to be priced at $800 for the basic player, with $500 extra for adaptor modules that will let it play Sega or TurboGrafX software, and $300 for a karaoke module.

• **Landmark.** Despite the recession, and amid all the talk of HDTV and the marvelous products of the future, the American public seems pretty satisfied with the "old-fashioned" TV set. Last September became the first month in which the industry sold more than three million color TV sets, according to EIA figures. Although EIA charts only sales to dealers, it's obvious that the public is buying by the way dealers are opening their checkbooks. In the final week of September, more than one million color sets were sold. That's the same number sold in the full year of 1964, the tenth year after the introduction of color TV. Ω

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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.

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DISK DILEMMA

Could you give me a clear explanation of what happens when a hard disk is formatted and how that differs from the formatting of a floppy disk?—B. Feoger, Sharon, IN

Disk drives, both floppy and hard, are very important parts of any computer system because that's where data eventually winds up. A failure in any other component could cost you money to repair, but perhaps some of the data you have on your disks can't be replaced at any price. So always remember that routine backups can turn a major disaster into a minor inconvenience.

The physical layout of a hard disk is similar to that of a floppy disk. Basically it is a spinning magnetic platter, or disk, with a record/playback head mounted on an arm so that it can move across the platter. While a floppy disk has a single magnetic surface, a hard disk can have several, and each platter has its own pair of heads mounted on a pair of arms—one for each side of the plate.

The platters of a hard disk spin at 3600 rpm and the heads "fly" some 10 microns above the platter's surface. This close tolerance is required so that the heads can read and write magnetic patterns on the disk without actually touching the surface. At 3600 rpm, physical contact between the head and the plate could destroy both. But, because the strength of the magnetic patterns decrease with the square of the distance, too great a distance would make read/write operations impossible.

The format of a hard disk is almost identical to that of a floppy disk. As you can see from Fig. 1, each platter is separated into a series of tracks and sectors by a series of magnetic patterns on each surface. The tracks are the concentric circles on the disk, and the sectors divide the tracks into pie-shaped pieces. Since hard disks usually have more than one platter, the term "cylinder" was coined to refer to all the related tracks on all the platters. Cylinder 3, for example, refers to track 3 on the platters.

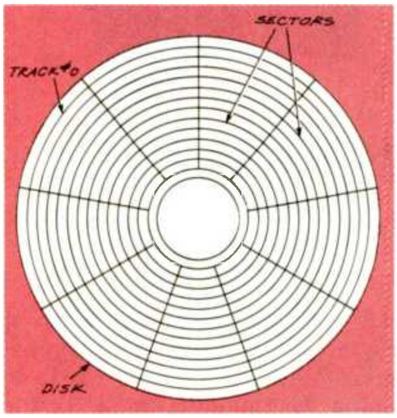

FIG. 1—THE LAYOUT OF A HARD DISK is almost identical to that of a floppy disk. The tracks are the concentric circles on the disk and the sectors divide the tracks into pie-shaped pieces.

Hard disks require two formatting operations: a low-level and a high-level format. A DOS format can perform both functions on a floppy disk but it can do only a high-level format on a hard disk. During a low-level format, the sector address (track and sector number) and a few other bytes are written at the start of each sector. That separates the track into sectors. Along with the sector addresses are sync bytes and gap bytes which let the computer know that a sector address is about to be read. This preliminary format, also referred to as a "physical format," can be performed only by the hardware on the controller card on older drives. Newer drives are low-level formatted at the factory.

Once the sector addresses are written on the disk, DOS is able to do a high-level format. This involves dividing the disk into five different sections: the boot record, the partition table, the file allocation table, the root directory, and the data area.

The boot record contains a small program that DOS must have to load the operating system from the disk. The partition table is created by the DOS FDISK program, and it stores the size of the disk. If you want to use the whole disk as a single drive, only one partition is created, but it's also possible to break the disk into multiple partitions. The size and location of each partition is stored in the partition table and that table is located in the boot record.

The file-allocation table, or FAT, is a list of all the sectors on the disk. DOS keeps the status of each sector here; whether it's in use or available. The FAT is such an important part of DOS that two identical copies of the FAT are maintained, and DOS is always comparing the two to verify the accuracy of the data.

The root directory contains a list of all the files on the hard disk. It also stores the date, time, size, and location of the file's first sector in the FAT. When DOS wants a file, it goes to the root directory for the name and then to the FAT for the location of the data. The data area occupies the majority of the disk, and this is where the file data is stored.

There's a lot more to the innards of a hard disk but these are the basics. If you're interested in learning more about how they work, I would suggest a trip to your local library or bookstore. That's the best way to unravel the mysteries of disk storage, find out exactly what a "cluster" is, and understand what a "CRC error" really means to you.

PULSE COUNTER

I'm building a circuit that must count the number of pulses produced by a sensor. I'm using half of a 4518 binary counter, but the pulses are negative-going

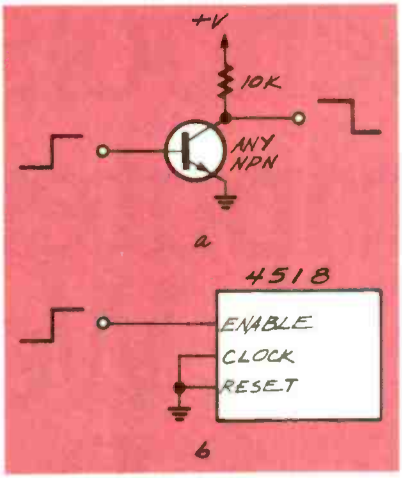

FIG. 2—PULSE INVERSION can be done with a single transistor (*a*). But the 4518 doesn't need that because its enable input can replace the clock input, and the device will trigger on a negative-going pulse (*b*).

and the clock input of the 4518 must see positive pulses. Other than inverting the pulses by adding even more hardware to the board, is there some simple change I can use to get around this problem?—R. Olive, New York, NY

I don't really understand why a hardware inversion of the pulses is such a big deal because, as shown in Fig. 2-*a*, all you need to do the job is a single transistor. If you're dead set on being a hardware minimalist, you're lucky that you're using a 4518 because that IC can easily be set to trigger on a negative-going pulse.

The 4518 has both a clock and an enable input. Normally the clock input is used to increment the count, but the enable input can be used for the same purpose. Since the clock input is active-high and the enable input is active-low, a slight rearrangement of signal lines will let the 4518 respond to negative-going pulses.

The circuit setup to do this is shown in Fig. 2-*b*. In normal operation, the enable input is made high and the chip will then respond to positive-going pulses at the clock input. But by keeping the clock input grounded, the chip's count will advance with each negative-going pulse at the enable input. No matter how you set up the chip, however, a high on the reset pin will always set the count back to zero.

SWIMMING LIGHTS

I have a swimming pool and I'm about to put some lights around it so the pool can be used at night. I'm a bit nervous about how to do this because the lights I'm planning to use run on 120-volt household current and the bulbs are rated 25 watts each. Are there any special precautions I should take?—C. Berger, Torrence, CA

The only precaution I can think of is that you should return all the stuff you bought to the store and get your money back. What you have in mind is known in the technical journals as a "bad idea."

Lighting up a swimming pool is a terrific idea both from the point of aesthetics and safety, but having 120 volts anywhere near the water even with a GFCI is asking for trouble—to say nothing of the fact that it might be a violation of local laws.

There are low-voltage (usually around 12 volts) quartz halogen lights available. They throw just as much light and won't turn your pool into a gigantic bug zapper. Ω

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Tinley Park, IL

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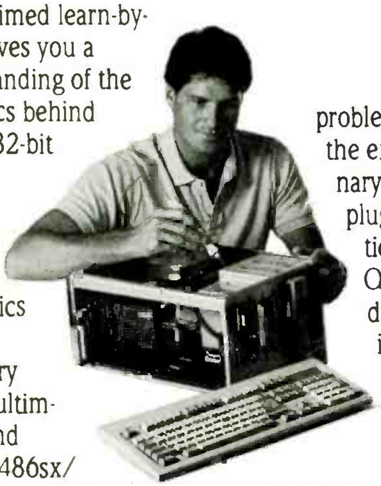

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Angston, SA Australia

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D. Gatlin
Carrollton, GA

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LETTERS

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

PARTS LIST CORRECTION

In my article, "Triple-Output DC Power Supply" (**Electronics Now**, October 1993), the part number for transformer T2 was inadvertently omitted. It defines T2's voltage and current rating. It is Jameco Electronics AC1210 (12 VAC Sec. at 1 Amp).

JOHN F. KEIDEL

KEEPING JOBS IN THE U.S.

I'm guessing that there are many (legions?) of us in the same boat as Michael Kiley, whose letter appeared in the October issue of **Electronics Now**. Mini-cellular and fiber-optic manufacturing will be going up and military electronics contracts are declining.

Isn't this coincidence a made-to-order call for military equipment manufacturers to enter commercial (non-defense) electronics? Of course, American workers *might* find work installing the cable and repeaters, but what country (or countries) will manufacture the cable and the electronics at the ends of the cable? How about the transceivers for the new mini-cellular systems or the mini-cellular repeaters?

Will the U.S. Congress act to protect U.S. workers? Or have so many members of Congress received enough contributions for their re-election campaigns that they are now indifferent to the transfer of work to off-shore corporations?

E. JONES JR, WB2DVL
Somerset, NJ

IN THE SAME BOAT

Thank you for publishing Mike Kiley's letter in the October issue of **Electronics Now**. It summed up very well my gut-wrenching fears about my future in electronics; I have been seeing the same things happening.

I am employed by a manufacturer of industrial electronic instruments. Our new products, all based on surface-mount assembly, are made by an outside board-stuffing job shop. I am almost 40 years old and don't have the resources (time and money) to drop everything and return to college for five years. But I see no alternative if I am to provide for my family's future.

Frankly, I'm scared to death and I am not sure what I can do. Moreover, I believe that the North American Free Trade Agreement (NAFTA) will only hasten the process Mike discussed.

I felt so strongly about that issue that I copied Kiley's letter and enclosed it with a letter from me to my congressman! I'm sure that there are others out there who have experienced similar frustrations and feelings. Perhaps some of them will write in to tell us about the actions they took.

Again, thanks for publishing the letter. It made me feel better to know that I am not alone.

M.A. GERMAINE
Mt. Gilead, OH

THE POSITIVE APPROACH

I have never before written to a magazine or newspaper in response to a letter from a reader. However, after reading the letter from Michael Kiley (**Electronics Now**, October 1993), I felt I had to express another viewpoint.

Jeff Holtzman was correct in his original assessment. Jobs will be eliminated as technology advances. The invention of the automobile eliminated the blacksmith's job. A secretary who knows shorthand but has no computer skills will certainly have a difficult time finding a job.

I have worked in the electronics field since I was in my teens back in the early 1960s. When I first went to work in the electronics field, transistors had not replaced electron tubes. Because some equipment included transistors, I had to learn about them. However, about the time I had mastered transistors, integrated circuits came along. I resisted the study of them for some time, but it soon became obvious that they were not going to go away. So, I gave in and studied ICs and digital electronics.

Then, computers began to appear everywhere. Although by that time I could design and build microcontroller-based equipment, I stayed away from computers with keyboards. I thought that I would always be able to hold a good job with good pay. After all, I had a strong hardware background.

In 1990, it finally sank in that I would need programming skills if I were to continue to earn the kind of money I had been earning. So I went to a local college and took two semesters of C programming. Because I did not take the courses for credit, no prerequisites were required; I simply audited the classes to gain the knowledge that I would need in the future. I now work in a job whose content is about 50% electronics hardware and 50% software. I would still prefer to concentrate on hardware, but that does not seem to be enough in today's job marketplace.

I think that Mr. Kiley's attitude is quite prevalent in our society today. In the first place, I think that a lot of our country's problems are due to a government that is too large and too inefficient. We cannot continue to depend on the government to provide lifetime jobs.

Most government employees are overpaid for the work they do, and their benefits seem to be out of proportion for those jobs. Their pay scales and workloads should be more in line with the private sector. Too many people think that this country owes them something simply because they were fortunate enough to have been born here.

They make no effort to advance their job skills to adapt to a changing global economy. It seems to me that most job-specific technical training that was taught in 1974 is of no real value today.

I also disagree with Mr. Kiley's statement that you need a college education to get a good job. Sure, it helps a lot, but there are other ways to prepare yourself for a good job. I do not have a college education, yet I have always been able to get and hold what is considered to be a good job. I have always pushed myself to keep my job skills current with job market demands.

Even in the relatively small Phoenix, Arizona, job market, there are some 20 to 30 jobs offered in each Sunday newspaper for people with current technical or computer skills.

But one has to start somewhere. Sometimes that somewhere means you have to start over and head in another direction. I suggest that Mr. Kiley try to shed his negative views, take some classes in computer programming, and plan for an entry-level position in that field. An investment of that kind in his future should pay off. Neither this country nor the rest of the world is going to slow down and wait on him.

R. C. BUCK, III
Fountain Hills, AZ

MONEY MATTERS

I would like to thank you for saving me a lot of money. I planned to spend $90 on an audio mixer until I saw the schematic in *Q&A* (**Electronics Now**, October 1993). I checked my parts bin and found that I only had to buy the IC and an enclosure. Those items cost me only $10—a far cry from the $90 I was going to spend!

Thank you again, and keep up the good work.

D. KISER
Elmira, NY

PARTS UPDATE

HESC has sold hundreds of the kits offered in the article "Build the Audio Expander" (**Electronics Now**, March 1993). However, HESC reports that sourcing and cost considerations no longer permit them to offer those kits.

However, we have recently discovered a source for the Philips TDA3810 IC specified for that project. It can be ordered from Consolidated Electronics, 705 Watervliet Avenue, Dayton, OH 45420-2599 (1-800-543-3568). This new source will now allow even more readers to build the Audio Expander.

We want to thank everyone who purchased the kit. We hope they are now enjoying the benefits of the Audio Expander and basking in the satisfaction of having built it all by themselves.

PHILL HAUSMAN
Fort Wayne, IN

NEW USE FOR PHONE-LINE SIMULATOR

While most issues of **Electronics Now** contain at least several articles that interest me, the August 1993 issue contained the "Phone-Line Simulator;" by itself, it was worth much more to me than the price of a year's subscription. It solved a problem that has been annoying me for two years.

I wanted to transfer several megabytes from the files of my 1983 model Timex/Sinclair TS2068 computer to an IBM-compatible 286 PC with modem. The TS2068 has 64 kilobytes of memory, a cassette tape drive, and a 2400-baud modem. The TS2068 uses a non-ASCII code and cannot be directly connected to a PC.

However, the hardware and software associated with the modem allow the transmission of ASCII files. Therefore, the two computers can be connected by phone line. However, that is not always a satisfactory arrangement because it ties up another person's line or machine, and it takes a lot of his time.

I had transferred some sensitive financial files by printing them out from the TS2068 computer and reading them with an optical character reader into the PC. While that process was time consuming compared to the speed that one can transfer data with modems, it certainly is faster than keying the data into the PC.

The Phone-Line Simulator allows me to connect the modems from the two incompatible computers and transfer the files without human assistance—quickly and privately.

K.G. Pratt
Newport News, VA

DIC SC-7000 Desoldering Tool

Desoldering components is a snap even for field technicians with this unique desoldering tool.

CIRCLE 10 ON FREE INFORMATION CARD

It would be surprising to find a reader of this magazine who was not well versed in the fine art of soldering. But *d*esoldering is another matter entirely. It seems as if every technician has his own favorite method. The DIC *SC-7000* desoldering tool seems to provide the right mix of features for everything from removing through-hole components from 12-layer boards to removing surface-mounted devices. It is available from, among other distributors, Howard Electronic Instruments (6222 North Oliver, Wichita, KS 67220; phone 316-744-1984).

Technicians who need to desolder components only occasionally often find that the fastest and easiest way to go is a simple hand-operated spring-loaded vacuum tool. Desoldering braid is another favorite for low-volume desoldering. Higher-volume applications—where many circuit boards need to be reworked in an efficient, cost-effective manner—often require a full service/rework center with multiple soldering irons and desoldering tools.

The *SC-7000* desoldering tool is unique in that it plugs directly into an AC outlet and is self-contained. No bench-top vacuum pump and connection hoses are required because the diaphragm pump is integrated into the handheld unit. The direct in-line connection between the pump and the tip provides such efficiency that 8-layer boards can be worked. That increases to 12 layers if the bottom side is pre-heated. The rated vacuum is 600 mm Hg, and the rated air flow rate is 15 liters per minute with an open tip. The maximum vacuum can be reached in 0.2 seconds.

The *SC-7000* is a gun-shaped device, measuring at its widest dimensions about 7 × 7½ × 1¾ inches. It weighs less than one pound. The black plastic housing contains carbon, which helps to prevent damage to sensitive components form electrostatic discharge or ESD.

A rotary temperature control is located on the rear end of the gun. It can be adjusted from 300°C to 400°C (525°F to 842°F) Above the temperature control is an indicator lamp that remains steady as the tool comes up to operating temperature, and that blinks when the desired operating temperature is reached. If the temperature setting is reduced, the indicator remains unlit until the tip reduces to the new, reduced temperature. The tool heats up quickly, reaching its mid-point temperature (375°C) in about 2 minutes, and it also has a quick recovery time.

A power switch for the unit is located at the butt end of the gun, and a trigger for the vacuum pump is at the customary trigger location for a gun.

There are two other sets of controls on the *SC-7000*. First is a mechanical toggle that switches the desoldering tool between its suction and its hot-air blow functions. Another set of mechanical controls are used to change the two-piece filter cartridge which mounts behind the tip, above the trigger.

The filter cartridge design is effective in maximizing the life of the filter. Most of the solder and flux removed accumulates on a hard plastic base that is in front of the fibrous filter. When the cartridge is full, it is simply thrown away. Replacement filter cartridges cost about $3 each.

To remove surface-mounted components, a hot-air tip and hot-air filter cartridge are required. Tips can be changed easily with the small open-ended wrench supplied with the desoldering tool. An SMD accessory kit is recommended. It includes not only the hot-air blower nozzle and filter, but also stainless-steel wire and blades, and holders for the wire and blades, all of which make SMD removal possible.

Surface-mounted devices can be removed in several ways with the hot-air blower. One method is to slip some stainless-steel wire under the legs of an IC, forming a loop. The wire is then used to lift the legs as the blower melts the solder that holds them to the circuit board.

Another method is to insert a short length of stainless steel wire into the wire holder. As each lead is heated, the wire can be slipped under the lead, lifting it from the board. With a little practice, it is possible to desolder individual leads of a flat pack or small-outline package.

Continued on page 85

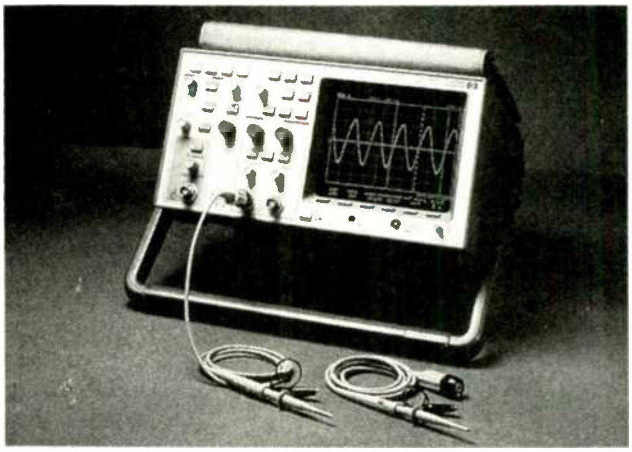
NEW PRODUCTS

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

500-MHZ BENCHTOP OSCILLOSCOPE. The new *Hewlett-Packard HP 54600A* delayed-sweep oscilloscope is intended for those who need digital oscilloscope performance but don't want to sacrifice the real-time display and user friendliness of analog scopes.

The two-channel *HP 54610A* oscilloscope has a vertical bandwidth of 500 MHz. It can make accurate measurements of high-speed, ECL-based digital circuits and analog circuits with operating frequencies greater than 150 MHz because of its 1 nanosecond per division sweep speed.

HP 54610A has a rated accuracy of 0.01 % of full scale. It includes such digital features as pretrigger viewing, waveform storage, and measurement automation. Nevertheless, it has the familiar controls and interactive display of an analog scope. The instrument has a viewable external trigger that allows users to make such common digital-circuit measurements as propagation delay and setup and hold times.


CIRCLE 16 ON FREE INFORMATION CARD

Hewlett-Packard reports that the oscilloscope can be upgraded with add-on modules and software links. Optional accessories include interface modules for remote control and output to RS-232C, HP-IB- and parallel-interface for printers and plotters. Test automation modules for mask template testing and automatic sequencing with pass/fail testing and conditional branching are also offered. Measurement and storage modules are also available.

HP ScopeLink and BenchLink software packages permit the transfer of screen images, waveforms, instrument setups, and test-automation sequences to MS-DOS-based or Windows operating system applications.

The *HP 54610A* oscilloscope, complete with power cord and two probes, is priced at $4995.

Hewlett-Packard Company
Direct Marketing Org.
P. O. Box 58059,
MS51L-SJ
Santa Clara, CA
95051-8059
Phone: 1-800-452-4844

LEATHER DISKETTE HOLDER. A pocket-sized, leather diskette case from *Browning & Drum's* adds class to your software presentations. It is also a distinctive sales tool when imprinted with your company's logo and given away to customers.

The case protects disks that you might carry between home and office or take along on business trips. Available in burgundy or black smooth-grained leather, the case holds two 3.5-inch diskettes and your business card.


CIRCLE 17 ON FREE INFORMATION CARD

The diskette holder is priced at $15.95 or six for $89.

Browning & Drum
P. O. Box 468
Brookline Village, MA
02147
Phone: 617-566-4300
Fax: 617-566-4208

HANDHELD TRANSMISSION-LINE TEST SET. The *186T* handheld analog and digital transmission-line test set from *American Reliance* performs four test functions. The test set is packaged in a case about the size of a handheld portable DMM. In addition to its role as a transmission line test set, it is a transmission line impairment measuring set (TIMS), and an autoranging DMM. It also has telephone handset functions.

The *186T* field tests voice and data (two- or four-wire) telecommunications circuits from 20 to 50 kHz. It includes a 20 to 50 Hz synthesized sinewave generator. It has a telephone handset with dial, talk, and listen capabilities. The instrument complies with IEEE 743-1984 (Bell Standard 41009).


CIRCLE 18 ON FREE INFORMATION CARD

An optional RS-232C interface permits communication between the 186T and a host computer. Built-in dialing permits a user to dial with dial pulse, tone

(DTMF), or MF signals. Handset functions combined with an internal DC hold circuit permit one tester to communicate with another over the line under test.

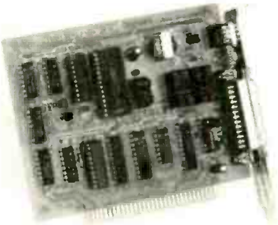
As a transmission line test set, it measures frequency, dBm level, signal-to-noise ratio, return loss, noise, noise-to-ground, noise-with-tone, and impulse noise. The DMM functions include the measurement of DC voltage and current, true-rms AC voltage, resistance, and capacitance.

The *186T* has a two line, 16-character LCD display. Its speaker volume is adjustable. It can be powered from eight AA cells or the AC line.

The *186T* handheld transmission-line test set has a list price of $1975.

American Reliance, Inc.
11801 Goldring Road
Arcadia, CA 91006
Phone: 800-654-9838
Fax: 818-358-3838

CONTEST CARD. A new PC plug-in interface board with a voice recorder/keyer and continuous-wave interface allows amateur radio operators to record useful information. The *Contest Card* from *Unified Microsystems* permits amateur operators to record their CQs, call signs, contest exchanges, or other voice messages for transmission under PC control. The *Contest Card* can also be used with PC-based repeater controllers for ID and special voice messages. It can also directly drive an external speaker for non-radio applications. Voice messages are stored on the card in non-volatile memory, saving computer memory or disk space. The built-in CW interface allows your computer to send CW on both negatively and



CIRCLE 19 ON FREE INFORMATION CARD

positively keyed amateur-radio transmitters.

The card is compatible with IBM XT, 286, 386, and 486-based PCs. The *Contest Card* is compatible with contest-logging software. The included disk contains a voice keyer-control program and programming information for writing your own software for controlling the *Contest Card*.

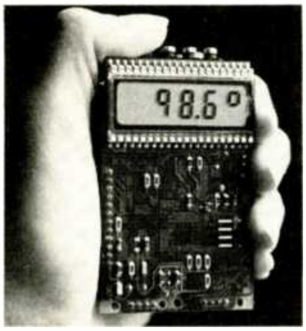
The *Contest Card* sells in kit form for $119.95; assembled and tested it is $179.95. Cables are not included. Add $5 for shipping to the U.S. and Canada.

Unified Microsystems
P. O. Box 133
Slinger, WI 53086
Phone: 414-644-9036

COMPACT DATA LOGGER. The *Tattletale 5F-LCD* data logger from *Onset* can gather data and provide control signals when left unattended. Packaged in a case that measures 2.2 × 3.1 inches, it has a 4-character, 2.1-inch LCD readout that displays all of its activities.

The data logger has eight channels for analog input, 12-bit resolution, and 480-kilobit data storage. Application programs developed with either IBM - PC-compatible or Macintosh computers can be stored in the data logger's ROM.

The 9-volt battery-powered instrument will permit users to develop data-acquisition and control applications with Onset's TTBASIC or tokenized TxBASIC—



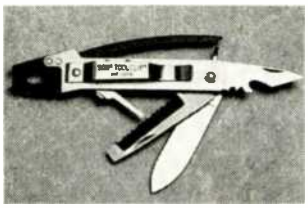
CIRCLE 20 ON FREE INFORMATION CARD

BASIC language dialects with added commands for data-acquisition.

The *Tattletale 5F-LCD* sells for $495. A starter kit of accessories for application development is priced at $95. The price of its case is $35, and a 3-button keypad is priced at $25.

Onset Computer Corporation
536 MacArthur Blvd.
P. O. Box 3450
Pocasset, MA 02559
Phone: 508-563-9000
Fax: 508-563-9477

TECHNICIAN'S POCKET TOOL. The *SOB ToolClip* from *Jensen Tools*, combines 13 functions in one pocket tool. It includes pliers, a gripper, a wire cutter, a spear-point blade, a serrated edge blade, a utility blade, two screwdrivers, two wire strippers, a file, a pry bar, and a bottle opener. The wire cutter can easily cut chain-link fencing.



CIRCLE 21 ON FREE INFORMATION CARD

The tool is equipped with a bail for attaching it to a chain or belt. The pliers, wire cutters, and grippers can all be worked with one hand, a useful feature when the other hand is occupied. It is made of stain-resistant steel and can be cleaned with water or non-corrosive solvents.

The *SOG ToolClip* is priced at $59.95.

Jensen Tools Inc.
7815 South 46th Street
Phoenix, AZ 85044
Phone: 602-968-6231

MOTOR-TABLE CALCULATOR. *MotorCalc* from *Extech* is said to be the first and only calculator with built-in 1993 National Electrical Code (NEC) tables. The calculator works directly in units of volts, amperes, volt-amperes, watts, power factor, kilowatts, and kilovolt amperes (kVA).

CIRCLE 22 ON FREE INFORMATION CARD

MotorCalc can calculate the performance of single- or three-phase induction or synchronous motors. It will also permit the user to calculate wire sizes in accordance with NEC tables 310 and 310-17. Problems related to parallel or derated wires sizes can quickly and easily be solved with a button push.

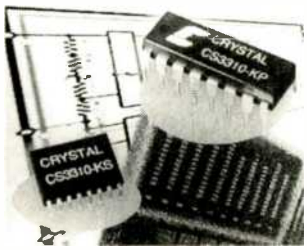
The calculator is organized so that it automatically finds mixed wire conduit sizes and determines loads for single- or three-phase motors in amperes per NEC Tables 430-148 and 430-150. It can determine overload protection per NEC 430-32, and compute fuse and breaker sizes per NEC Table 40-152. It can also find NEMA starter sizes.

The *MotorCalc* sells for $129.

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

STEREO DIGITAL VOLUME CONTROL. *Crystal Semiconductor's CS3310* is a single-chip integrated circuit for high-fidelity stereo volume control. It offers a wide dynamic range of 110 dB, and total harmonic distortion less than 0.001 %. The device's low-noise active output stage can drive a 600-ohm load. It is expected to find applications in digital-audio workstations, multi-track recorders, and home surround-sound processors.

The *CS3310* overcomes clicking, popping, and "zipper noise" during volume changes—audible artifacts that degrade system performance and sound quality. It performs volume changes at zero crossings to give noise-free level transitions.



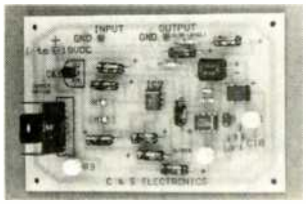
CIRCLE 23 ON FREE INFORMATION CARD

The manufacturer says it preserves dynamic range over the entire adjustable range because volume control is performed in the analog domain. The device's logarithmic control provides precise changes for low-level signals. It has a simple three-wire serial interface that controls two independent audio channels and allows daisy-chaining of multiple units for multi-channel audio systems.

The *CS3310* stereo digital volume control in 16-pin plastic DIP or SOIC packages is priced at $6.60 each in lots of 1000.

Crystal Semiconductor Corporation
P. O. Box 17847, 78760
4210 South Industrial Drive
Austin, TX 78744
Phone: 512-445-7222
Fax: 512-445-7581

AUDIO LEVEL CONTROLLER. The *Model ALC235P* automatic audio- level controller module from *C&S Electronics* provides user adjustable audio output. Small signals are amplified and large levels are attenuated without introducing noise or distortion. The module is intended for radio, television and recording studios. It can be used with scanners, transceivers, and PA amplifiers.



CIRCLE 24 ON FREE INFORMATION CARD

The controller's output level is held constant by a light-dependent resistor (LDR). As the input signal amplitude changes, the LDR changes its resistance. It varies circuit gain to produce a nearly constant output. Three controls permit the user to match specific audio units. The module includes a 2-watt onboard amplifier in addition to its 100-millivolt low-level output. It also has an onboard volume control.

The *ALC235P* automatic audio-level controller is priced at $49.95.

C&S Electronics
P. O. Box 2142
Norwalk, CT 06852-2142
Phone/Fax: 203-866-3208

TRUE-RMS DIGITAL MULTIMETER. All functions and ranges of *Protek's Model D-937* 3¾-digit, 4000-count, true-rms digital multimeter can be entered by switch. It has an LED port with optically-coupled serial output for data-logging or recording.

CIRCLE 25 ON FREE INFORMATION CARD

The unit's liquid-crystal display includes annunciators and a 42-segment bargraph. The *D-937* offers full autoranging for all functions except current. It provides logic and data hold, relative set, and min/max with 100-millisecond capture time. It also has data storage and recall.

An adaptor mode can expand the functions for custom applications such as sensor or current measurements. The DMM includes a holster, built-in tilt stand, safety probes, two "AA" alkaline cells, and an instruction manual.

The *D-937* DMM is priced at $139.

Protek
P. O. Box 59
Norwood, NJ 07648
Phone: 201-767-7242
Fax: 201-767-7343

ESD-SAFE SOLDER DISPENSER. The ESD-safe *FD-1001* solder dispenser from *OK Industries* has manual and automatic dispensing controls that regulate solder paste deposition. It has a timing range of

CIRCLE 26 ON FREE INFORMATION CARD

0.1 to 1.0 seconds for precise dispensing control.

The system includes a foot pedal for activating the dispensing process, a syringe stand, and a quick-connect hose assembly with a locking syringe adaptor. The dispenser also includes a 30-piece set of syringe needles and a static-dissipative plastic base.

The price for the *FD-1001* solder-dispensing system is $765.

OK Industries
4 Executive Plaza
Yonkers, NY 10701
Phone: 914-969-6800

DSP/DATA-ACQUISITION BOARD. The *Model 310A* PC add-in board from *Dalanco Spry* is built around a digital signal processor IC for digital signal processing and data acquisition. It offers floating-point math DSP, and its throughput capabilities are intended for data-logging and data-output.

Based upon Texas Instrument's TMS320C31 floating-point DSP IC, the IBM PC/AT-compatible board operates at 33 MHz for up to 33 MFLOP performance. Data acquisition for four differential channels at 14-bit resolution with programmable gain is offered. It has a maximum sampling rate of 150 kHz. One 12-bit, 300-kHz analog output is available. The board can accommodate 0 or 1 wait-state static RAMs with capacities of 32 K to 512K words.

The *Model 310A* is sold

Continued on page 30

NEW LITERATURE

Use The Free Information Card for fast response.

Excel for Science and Technology; by Peter Gaeng. Abacus, 5370 52nd Street SE, Grand Rapids, MI 49512; Phone: 1-800-451-4319; $34.95 including diskette.

This book explores the capabilities of Excel for the professional scientist and technologist. After a brief overview of Excel 4 worksheets, databases, and graphics, the book discusses Excel Solver and the Scenario Manager. The book also covers mathematics functions such as graphs, curves, numerical integration drawing, and tables.

In the physics section, Gaeng's book has a collection of formulas for such subjects as oscillation and waves, and animated diagrams. Of interest to those working in chemistry, is the section that discusses stoichiometry and the rule of alligation technology; it includes information on conversion, logical construction sets, and illumination.

Under the heading of statistics and social sciences, the book explains how to gather empirical data and perform deductive and database statistics, correlation, and linear regression. Ecologists, will be pleased to find how Excel can be applied to chart growth, decay and population dynamics. The chapter also explores the significance of different ecological models.

The companion diskette will help readers to apply the concepts presented in the book. The macros and worksheets included on the disk are based on the special Excel powers described in this book.

CIRCLE 40 ON FREE INFORMATION CARD

1993 Short Form Designers' Guide and New Product Update. Analog Devices, Inc., 181 Ballardvale Street, Wilmington, MA 01887; Phone: 617-937-1428; Fax: 617-821-4273; free.

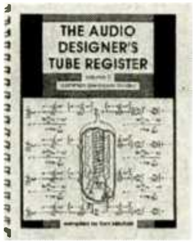
This is the latest in Analog Devices' series of combined designer's guides and product catalogs. It is intended to help designers find an Analog Devices product that will meet their application needs.

CIRCLE 39 ON FREE INFORMATION CARD

The 160-page guide includes component selection "trees" and summary specifications. It also includes information on Analog Devices' packaging, and it identifies the company's latest products. Price and performance information is included.

Analog Devices claims that its catalog covers the industry's broadest line of analog-to-digital and digital-to-analog converters, operational amplifiers, instrumentation amplifiers, digital signal processors, voltage references, and analog multipliers. Coverage is also given to motion-control products and ICs for reading disk drives and servo control.

The Audio Designer's Tube Register: Volume 1, Common Low-Power Triodes; compiled by Tom Mitchell. Media Concepts, P. O. Box 1408, Norwalk, CA 90651-1408; Phone: 310-594-4717; Fax: 310-430-0020; $18.



CIRCLE 38 ON FREE INFORMATION CARD

Surprisingly, many audio purists and designers still prefer the performance of electron tubes over transistors. This book fills the information vacuum created by the decline of the electron tube market. Said to be a reliable reference source on tubes, it catalogs 14 of the most popular low-power triode tubes that have been in audio equipment for the past 30 years. They are still available from suppliers.

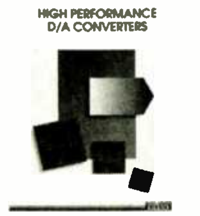
Rather than being a reprint of old data dredged up from dusty, yellowed catalogs, the data in this book has been recently researched, compiled, and verified in the author's own laboratory.

You will find 11 graphs and 7 data tables for each of the 14 tube types. Also included are specifications data including maximum ratings, physical dimensions, and brief comments that will be meaningful for designers who intend to include tubes in their circuits.

High-Performance D/A Converters. Burr-Brown Corporation, P. O. Box 11400; Tucson, AZ 85734, Attn: Mary Douglas, Inquiry Handling Manager; Phone: 1-800-548-6132 or 602-746-1111; Fax: 602-889-1510; free.

Burr-Brown is offering its latest eight-page, full color catalog that highlights more than 30 industry-standard and recently introduced digital-to-analog converter products. The booklet contains product descriptions and specifications, selection guides, and applications notes.

Two new sections feature digital audio and ultra-high-speed digital-to-analog converters. A selection guide is organized by ap-



CIRCLE 37 ON FREE INFORMATION CARD

plications and product features to guide designers to the DAC that will best meet their needs. An information request card is included with the catalog.

Practical Troubleshooting with the Advanced Video Analyzer; by Robert L. Goodman. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; $24.95.

This book tells you how to troubleshoot with a proprietary video analyzer. It explains in detail just about everything you would want to know about Sencore's VA62A Video Analyzer and its accessories. With this instrument you can troubleshoot various video equipment including TVs, VCRs, camcorders, laser-disc players, and computer monitors.

CIRCLE 36 ON FREE INFORMATION CARD

After describing each of the video analyzer's operating features and explaining how to hook them up for the tests, Goodman covers TV and VCR servicing. Among the topics he takes on are troubleshooting video amplifiers and the aligning of TV chroma, video IF, and video detector circuits. He also provides guidance on how to troubleshoot TV sync and AGC systems.

With this book you can learn to analyze vertical sweep and "sandcastle" circuits, and how to troubleshoot horizontal-sweep systems. Included is an explanation of Sencore's NT64 NTSC color pattern generator, VC63 VCR test accessory, VC93 all-format VCR analyzer, VG91 universal video generator, and TVA92 video analyzer.

The Designer's Guide to Incredibly Embeddable Single Board Computers and Flat Panel Systems. Computer Dynamics, 107 South Main Street, Greer, SC 29650; Phone: 803-877-8700; Fax: 803-879-2030; free.

This 32-page, catalog from Computer Dynamics includes complete descriptions, photographs, and specifications of the company's line of "Incredibly Embeddable" PC-compatible, single-board computers.

The power of these computer boards depends on the installed processor. There are boards based on the almost ancient Intel 8088 as well as those that include the speedy Intel 486DX2.

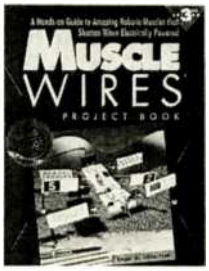
CIRCLE 35 ON FREE INFORMATION CARD

The catalog also includes descriptions of flat-panel display systems that feature "DisplayPacs," products. These combine a variety of flat-panel displays (liquid crystal and electroluminescent, for example), and touchscreens with single-board computers to form operator interface systems.

Other flat-panel products being promoted include the VAMP, a combination color LCD panel and touchscreen that can plug into any standard VGA analog output. A similar FP-Kit has a PC bus flat-panel driver card. The brochure also contains information on the company's software development tools. Some can program ROMs and touchscreens; others are for system development. Products include expansion boards, PCMCIA interface boards, and a line of accessories.

Muscle Wires Project Book, Third Edition; by Roger G. Gilbertson. Mondo-tronics, Inc., 524 San Anselmo Avenue #107-20, San Anselmo, CA 94960; Phone: 800-374-5764 or 415-455-9330; $17.95.

This book will tell you everything you want to know about designing, building and operating robotic devices that contain "shape memory wires," also known as "Muscle Wires." These nickel-titanium filaments contract when conducting electricity, and they are capable of lifting weights that are thousands of times their own weight.



CIRCLE 34 ON FREE INFORMATION CARD

Gilbertson's book examines the use of Muscle Wires in heat engines and other industrial, medical, and aerospace applications. They are said to have potential roles in such products as prosthetic limbs, robotics, and virtual reality systems.

Included are detailed instructions and sources for the wires, related materials, components, and software needed to complete 15 projects. The book offers enough practical advice and guidance so that you can put Muscle Wire to work in model railroads, science projects, radio-controlled vehicles and come computer-controlled systems.

Instrumentation Design Guide & Catalog. Calex Manufacturing Company, Inc., 2401 Stanwell Drive, Concord, CA 94520; Phone: 800-542-3355; Fax: 510-687-3333; free.

This 106-page brochure from Calex describes the company's many modular load-cell and strain-gage signal conditioners, DC isolated transmitters, constant-current sources, alarms, and operational amplifiers.

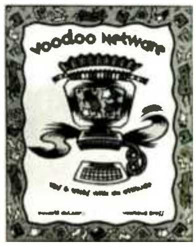
CIRCLE 33 ON FREE INFORMATION CARD

The catalog describes DC-to-DC converters and linear power supplies for powering instrumentation modules. It also contains detailed design specifications, circuit diagrams and descriptions, a selection guide, block diagrams, performance curves, and prices. Tutorial articles on operational amplifiers, constant-current theory, instrumentation amplifiers, and grounding and shielding should prove useful to readers.

Voodoo NetWare: Tips & Tricks with an Attitude for Version 4.0; by Emmett Dulaney. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $27.95.

This book presents the key points of the NetWare 4.0 operating system in a lively format packed with tips and traps. It explains how to put the network's power in the hands of the network administrator. It also offers guidance on how to choose the right server cards and cables to get a system up and running smoothly.

Dulaney tells you how to use NetWare 4.0's new utilities to add, delete, and monitor stations on the network. It explains how to get things done quickly and efficiently with command-line shortcuts, and how to streamline system management. This can be done with log-in scripts, improved backup and security, and sensible directory trees.



CIRCLE 32 ON FREE INFORMATION CARD

Information in this book will help you solve printer problems encountered in networks. Proven methods will ensure that printed documents appear on command. It also covers adding and working with MS-DOS, DR-DOS, Windows, and diskless workstations. Included are insider tips on how to set up trustees, control traffic with Audit, and clear. Other topics included are messaging, disabling, re-enabling, and troubleshooting the network. Ω

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DRAWING BOARD

Adding old-fashioned gauges to modern automobiles.

ROBERT GROSSBLATT

Nothing in life comes without a price of some kind. As we get closer to the twenty first century, there are fewer and fewer global truths around, but this is definitely one of them.

Once upon a time, given a certain amount of really basic automotive understanding and a screwdriver, you could fix your own car. If you were out driving and your car conked out in the middle of nowhere, you could pop the hood and get yourself going again. As cars became more and more dependent on electronics, your chances of making a successful quick fix, temporary or not, got worse and worse.

There's no arguing the fact that cars are technically better than they used to be. Not too many years ago, the only place you would go with a car that had more than fifty thousand miles on it was to the garage. Now, a car with more than one hundred thousand miles on the odometer is considered to be just about broken in. This is true because of advances in metallurgy, design, engineering, and electronics. But remember that there's no such thing as a free lunch. And that's just as true in 1993 as it was in 1893.

A significant part of the increased efficiency of modern cars is due to the increased amount of electronics in the car. Now many of the mechanical systems in your car are controlled by electronics of one kind or another. Little by little, PC boards are being put between the driver and the car.

For the most part, this is a good thing, but it's something you should be aware of when you're driving. Anti-lock braking is a terrific step forward, but it means that when you step on the brake pedal, braking control is shared with electronics rather than being exclusively a function of pressure of your foot. The ABS system checks each wheel sequentially and applies braking pressure only to the wheels that are turning. In essence, the brakes are pumped individually, which is a great help in avoiding skids and other braking nightmares.

An ABS system is only one example of how electronics has been used to increase automotive efficiency. Such things as fuel injection, all-wheel drive, and even engine performance have benefited from the introduction of electronics. This is a good thing, but it's moved the driver further from the control of the vehicle. Don't get me wrong, all of this stuff is great—*as long as it works.*

Electronics that are designed to assist in the control of what we can refer to as "life safety" systems (such as braking) are designed to be fail-safe. If anything goes wrong with them, they're supposed to drop out of the line. All other electronic controls in a car are made to handle automotive "operational" systems. These include such things as fuel injection and engine operation. Failure in any one of these systems is not life threatening and won't cause the car to go out of control—all that happens is that the car will stop running.

Anybody who has had an electronic problem with his car and has had to replace the "computer" knows that it's an expensive replacement. If you get the broken part and open it up, you'll be amazed at what you find because the component density there is minimal indeed—certainly nothing like that on a computer motherboard, power supply, or other component that you can buy for a tenth the price. But, because there aren't any automotive electronic standards for a car's computer, and there's no alternative to replacing it, there's not a lot you can do about it.

The engine- and fuel-control systems in your car, among others, are constantly being monitored by the car's computer and, if it detects a problem, either a warning light will come on ("Service Engine Soon" in a GM car), or some other indicator will be activated. The problem with all this stuff is that it has no meaning for the owner of the car. Sure, there are things you can do to make the light flash a code number that you can then look up in a book to determine the problem sensed by the computer. But chances are you won't have the book with you at three o'clock in the morning when you get stuck on a road exactly seventeen miles from nowhere.

If any reader has a code list and knows what to do to make the warning light flash the code numbers, drop me a line with the information and the year and make of the car referred to. I'll publish the code lists here because it's good stuff for everybody to have and, as we all know, we motorists have to stick together.

The only defense a driver has these days is to install his own electronics in the car. That will let him know, in unambiguous terms, exactly what's going on under the hood. That won't tell them what the warning lights mean, but hopefully it will point out potential problems before the computer sees them and causes the car to die. This is what gauges were for, but since most modern cars are really short on helpful dashboard instruments, we'll just have to build them ourselves.

As with any other design problem, the first consideration when you set out to add electronics to a car is to think about how you're go-

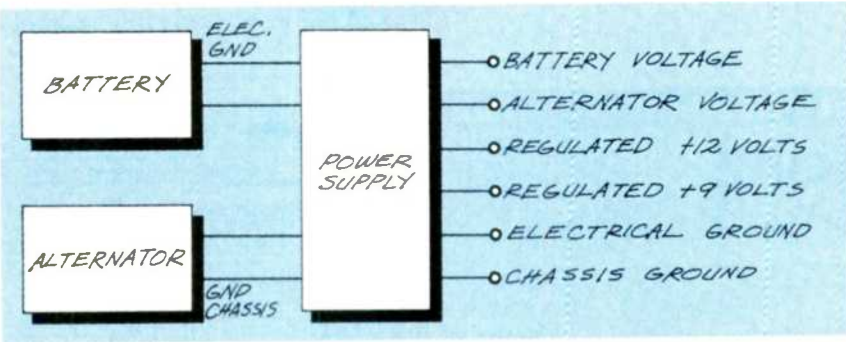


FIG. 1—POWER SUPPLY BLOCK DIAGRAM. This supply will allow us to add various accessories to a car, and reduce the effects of the car's electrically noisy environment.

ing to power them. You can count on a car to provide a solid source of 12 volts, but that's just the beginning. A car battery's voltage will drop below 12 volts when it's under load (even down to a low of 9 volts when the starter is cranking). So depending on a constant 12-volt supply isn't always a good idea.

Because, in the grand scheme of things, the frequencies that you'll find running around a car are fairly low, anything we design can be run from a 5-volt supply. Our first design job, then, is to come up with a reliable, regulated 5-volt supply that can provide a clean source of power in an automobile. This isn't as straightforward as you might think because a running engine creates just about the worst environment you can imagine for electronics. The ignition and spark system generate an unbelievable amount of noise and voltage spikes, the mechanical systems create vibration, and the engine produces heat, oil mist, and other things that can play havoc with the reliable operation of any sensitive electronics.

To ensure a clean 5-volt supply no matter what's happening with the car (short of a completely dead battery), we'll have to take an unusual approach to the design and layout of the supply. This will have the goal of reducing the effects of the car's electrically noisy environment. The overall approach is shown in Fig. 1 The main supply is going to generate the following voltages:

1—A pass-along voltage that's equal to the operating voltage of the automobile. This is just a buffered version of the voltage at the positive terminal of the battery, and it can be used for monitoring the state of the charging system, as a power source for recharging batteries, and other loads.

2—A regulated 12 volts that's available just in case we need it. A lot of sensors you might add to the car must operate from 12 volts and, since we're in the design stage of the supply, we have to include it in the circuit.

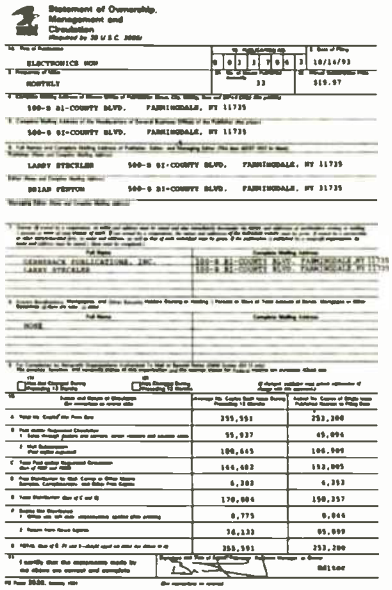
3—A regulated 9-volts. This is the preregulated supply for the most of the electronics. Even a seriously discharged battery can be counted upon to supply 9 volts, especially because the electronics load we're going to add to this regulator is really light.

4—The alternator voltage. Whether or not you have to add this one depends on your car's charging system. If you have a separate alternator (or generator) and regulator, the voltage at the positive terminal of the alternator is an important value to have when you're monitoring the health of the car's charging system. If the voltage regulator is built into the back of the alternator, this information will be slightly less useful but should still be made available.

5—Electrical ground. This is the voltage at the negative terminal of the battery.

6—Chassis ground. In the best of all possible worlds, this is supposed to be the same as the electrical ground, but the older your car, the less likely this is to be true.

When we get together next time, we'll go through the details of the power supply and the power considerations for each module we want to add. Then we'll begin designing the circuitry needed to add real monitoring to the car. Ω



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F 1	8,775	9,044
2	76,133	85,099
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Editor

NEW PRODUCTS

continued from page 23

CIRCLE 27 ON FREE INFORMATION CARD

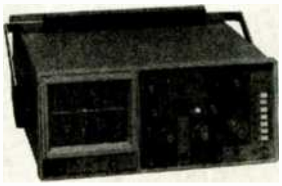
with a bundled software package that includes an assembler, debugger, signal and spectrum display, and record and playback to or from the disk. The MODA program is included. It manages multichannel data acquisition and simultaneous record and playback for stimulus and response applications. It also provides advanced pre-triggering options.

The *Model 310A* DSP/data-acquisition board with software is priced from $699.

Dalanco Spry
89 Westland Avenue
Rochester, NY 14616
Phone: 716-473-3610
Fax: 716-271-8380

DIGITAL-STORAGE/ANALOG OSCILLOSCOPE. The model *2522A* from *B+K Precision* combines the flexibility of a digital storage oscilloscope (DSO) with the versatility of an analog scope. Like other DSOs, it can freeze and greatly magnify waveforms for closer inspection. Digital display modes include roll, refresh, hold, save CH2, and pretrigger storage. The *2522A* offers 20 megasample/second real-time sampling on each channel, so that waveforms can be stored with resolution to 10µs/division. The instrument has an equivalent time-sampling bandwidth of 20 MHz for repetitive waveforms.

The *2522A* also provides full 20-MHz dual-trace analog scope operation at the touch of a button. Analog features include up to 1-mV per division vertical sensitivity and V-mode for viewing two signals unrelated in frequency. The user can choose from 19 calibrated sweep time ranges with full adjustment between ranges.



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Digital-mode operation includes ×100 time/division ranges to extend sampling time to as much as 50 seconds per division. That allows the viewing of slow events that wouldn't be possible on an analog scope. Stored waveforms may be further expanded ten times for closer examinations. A plotter output is also provided.

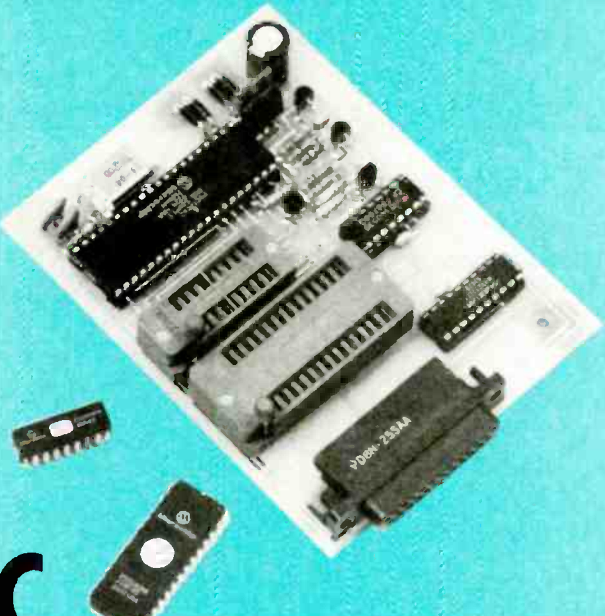
Additional features include front-panel x-y operation, channel 1 analog output, channel 1 and channel 2 digital outputs on the rear panel for driving an analog plotter, and an 8×10-cm CRT.

The *2522A* DSO/analog scope, complete with two 10:1 probes and instruction manual, has a suggested price of $1099.

B+K Precision
6470 West Cortland Street
Chicago, IL 60635
Phone: 312-889-1448
Fax: 312-794-9740

FRED EADY

Peter Piper picked a peck of PICs and programmed them himself!



PIC MICROCONTROLLER PROGRAMMER

THIS ARTICLE WILL INTRODUCE YOU to a new and very popular RISC (reduced instruction set computer) -like microcontroller called PIC from Microchip Technology.

It will also show how to build a full-function PIC16C5X microcontroller programmer. The PIC16C5X hardware and software examples—and a PIC16C5X cross assembler—will allow you to develop your own PIC applications. Everything you need to get started costs only about $70.

What's a PIC?

The PIC16C5X series of 8-bit microcontrollers are low-cost, low-power, high-speed, CMOS devices that contain EPROM, RAM, I/O, and a CPU in an 18- or 28-pin DIP package. The PIC16C5X microcontrollers clock from DC to 20 MHz, have 8 to 20 I/O lines, and incorporate sleep, timer, and watchdog functions.

PIC OTP (one-time programmable) devices are also available. They are not erasable either electrically or with ultraviolet light. PIC OTP parts are typically plastic-cased and less expensive parts than their corresponding devices that contain EPROM. They are usually used only in thoroughly tested and stable designs where no future code changes are likely to occur. This project is a perfect example of that. The programmer is based on an OTP device to make it affordable.

The PIC EPROM-based devices are normally cased in ceramic packages with a transparent window that allows the memory to be erased and reused just as in the popular 27XXX series of EPROMs. These devices are ideal for the testing and prototype phase of a design because they can be reused. However, they are much more expensive than OTP devices.

This programmer can program devices from the PIC16C5X family—both OTP and EPROM variants. A PIC17C42, in OTP form, acts as the PIC16C5X programmer controller. (In the next installment of this article, a PIC17C42 programmer will be described.)

The PIC16C5X family

The PIC16C5X microcontroller programmer is capable of reading, verifying, blank-checking, and programming the PIC16C54, PIC16C55, PIC16C56 and PIC16C57 in both the plastic OTP and ceramic EPROM packages. For security-sensitive applications, each PIC device includes a security EPROM fuse that can be programmed to prevent others from reading the EPROM code. The differences in the four PIC16C5X parts are the oscillator type, the number of available I/O (input/output) pins, and the size of the internal EPROM and RAM. Table 1 provides an overview of the erasable PIC16C5X devices.

Not only is the PIC physically compact, its built-in high-efficiency microcode allows compact programming. A 33-element, single-cycle, single-word instruction set permits the creation of programs that would normally require microcontrollers that use 100-element (or greater) multi-cycle, multi-byte instruction sets. In comparison, the 8749H has almost 50 MOV-oriented instructions which actually make up only a small part of the complete 8749H instruction set. Each PIC16C5X instruction word is 12 bits in length with the mnemonic (the opcode) and operand (the register, memory location or direct data to be manipulated) fully defined within the 12-bit word. All 33 PIC16C5X instructions are shown in Table 2, which is reprinted from a PIC data sheet.

PIC's high microcode execution speed is attained because a Harvard architecture, or the Harvard dual-bus concept, is

TABLE 1—OVERVIEW OF UV-ERASABLE DEVICES

Part #	EPROM	RAM	I/O	Supply Voltage	Osc. Freq. Range	Package Options
PIC16C54	512 × 12	32 × 8	13	4.0 - 5.5 V	DC - 20 MHz	18-pin Windowed CERDIP
PIC16C55	512 × 12	32 × 8	21	4.0 - 5.5 V	DC - 20 MHz	28-pin Windowed CERDIP
PIC16C56	1K × 12	32 × 8	13	4.0 - 5.5 V	DC - 20 MHz	18-pin Windowed CERDIP
PIC16C57	2K × 12	80 × 8	21	4.0 - 5.5 V	DC - 20 MHz	28-pin Windowed CERDIP

TABLE 2—INSTRUCTION SET SUMMARY

BYTE -ORIENTED FILE REGISTER OPERATIONS

(11-6)	(5)	(4 - 0)
OPCODE	d	f(FILE #)

d = 0 for destination W
d = 1 for destination f

Instruction-Binary	(Hex)	Name	Mnemonic	Operands	Operation	Status Affected	Notes
0001 11df ffff	1Cf	Add W and f	ADDWF	f, d	W + f → d	C,DC,Z	1,2,4
0001 01df ffff	14f	AND W and f	ANDWF	f, d	W & f → d	Z	2,4
0000 011f ffff	06f	Clear f	CLRF	f	0 → f	Z	4
0000 0100 0000	040	Clear W	CLRW	-	0 → W	Z	
0010 01df ffff	24f	Complement f	COMF	f, d	$\bar{f}$ → d	Z	2,4
0000 11df ffff	0Cf	Decrement f	DECF	f, d	f - 1 → d	Z	2,4
0010 11df ffff	2Cf	Decrement f,Skip if Zero	DECFSZ	f, d	f - 1 → d, skip if zero	None	2,4
0010 10df ffff	28f	Increment f	INCF	f, d	f + 1 → d	Z	2,4
0011 11df ffff	3Cf	Increment f,Skip if zero	INCFSZ	f, d	f + 1 → d, skip if zero	None	2,4
0001 00df ffff	10f	Inclusive OR W and f	IORWF	f, d	W v f → d	Z	2,4
0010 00df ffff	20f	Move f	MOVF	f, d	f → d	Z	2,4
0000 001f ffff	02f	Move W to f	MOVWF	f	W → f	None	1,4
0000 0000 0000	000	No Operation	NOP	-	-	None	
0011 01df ffff	34f	Rotate left f	RLF	f, d	f(n) → d(n+1), C → d(0), f(7) → C	C	2,4
0011 00df ffff	30f	Rotate right f	RRF	f, d	f(n) → d(n-1), C → d(7), f(0) → C	C	2,4
0000 10df ffff	08f	Subtract W from f	SUBWF	f, d	f - W → d [f + $\overline{W}$ + 1 → d]	C,DC,Z	1,2,4
0011 10df ffff	38f	Swap halves f	SWAPF	f, d	f(0-3) ↔ f(4-7) → d	None	2,4
0001 10df ffff	18f	Exclusive OR W and f	XORWF	f, d	W ⊕ f → d	Z	2,4

BIT- ORIENTED FILE REGISTER OPERATIONS

(11-8)	(7-5)	(4 - 0)
OPCODE	b(BIT #)	f(FILE #)

Instruction-Binary	(Hex)	Name	Mnemonic	Operands	Operation	Status Affected	Notes
0100 bbbf ffff	4bf	Bit Clear f	BCF	f, b	0 → f(b)	None	2,4
0101 bbbf ffff	5bf	Bit Set f	BSF	f, b	1 → f(b)	None	2,4
0110 bbbf ffff	6bf	Bit Test f,Skip if Clear	BTFSC	f, b	Test bit (b) in file (f): Skip if clear	None	
0111 bbbf ffff	7bf	Bit Test f, Skip if Set	BTFSS	f, b	Test bit (b) in file (f): Skip if set	None	

LITERAL AND CONTROL OPERATIONS

(11-8)	(7 - 0)
OPCODE	k (LITERAL)

Instruction-Binary	(Hex)	Name	Mnemonic	Operands	Operation	Status Affected	Notes
1110 kkkk kkkk	Ekk	AND Literal and W	ANDLW	k	k & W → W	Z	
1001 kkkk kkkk	9kk	Call subroutine	CALL	k	PC + 1 → Stack, k → PC	None	1
0000 0000 0100	004	Clear Watchdog timer	CLRWDT	-	0 → WDT (and prescaler, if assigned)	TO, PD	
101k kkkk kkkk	Akk	Go To address (k is 9 bit)	GOTO	k	k → PC (9 bits)	None	
1101 kkkk kkkk	Dkk	Incl. OR Literal and W	IORLW	k	k v W → W	Z	
1100 kkkk kkkk	Ckk	Move Literal to W	MOVLW	k	k → W	None	
0000 0000 0010	002	Load OPTION register	OPTION	-	W → OPTION register	None	
1000 kkkk kkkk	8kk	Return,place Literal in W	RETLW	k	k → W, Stack → PC	None	
0000 0000 0011	003	Go into standby mode	SLEEP	-	0 → WDT, stop oscillator	TO, PD	
0000 0000 0fff	00f	Tristate port f	TRIS	f	W→ I/O control register f	None	3
1111 kkkk kkkk	Fkk	Excl. OR Literal and W	XORLW	k	k ⊕ W → W	Z	

used instead of the classic Von Neumann, or single-bus, implementation. The devices have separate bus and memory space allocated for instructions and data. All program-controlled objects—such as I/O ports, memory locations and timers—are physically implemented as hardware registers. For instance, most microcontrollers require different instructions for writing to an I/O port directly and for writing to an internal register. (The 8749H, for example, uses OUTL to write to an I/O port while MOV is used to access internal registers.) With PIC devices, however, the instruction is the same: only the register destination is changed. The MOVWF instruction is used to write to either an I/O port or a general-purpose register. The reduced number of PIC mnemonics can reduce a novice PIC programmer's learning curve dramatically.

The shorter the instruction cycle time and the fewer instruction cycles per instruction, the faster your code will execute. To clear (set to hex 00) I/O port 1 on the 8749H requires the OUTL P1,A instruction which consumes a total of 2 instruction cycles. An additional cycle is required for the CLR A instruction that should be executed prior to the OUTL instruction unless the 8749H's accumulator contains hex 00. The PIC part performs the same function against register 6 (register 6 is the 8-bit B I/O port on the PIC) with a simple CLRF 6 which it executes in a single instruction cycle. Also consider that the 8749H's maximum clock rate is 11 MHz (for a 1.36-microsecond instruction cycle) versus 20 MHz for the PIC (for a 200-nanosecond instruction cycle). PIC devices with 25-MHz clock rates should be available in early 1994.

The PIC16C5X data memory (RAM) bus is 8 bits wide while the program memory (EPROM) bus is 12 bits wide. The Harvard dual-bus configuration allows the PIC to perform high-speed bit, byte, and register operations. Harvard architecture also inherently allows the overlapping of instruction execution cycles, or pipelining. Pipelining is the simultaneous execution of the current instruction as the next instruction is being read from program memory. Traditional Von Neumann architecture requires that information be fetched over a single shared, or multiplexed, bus.

Figure 1 is a block diagram of the dual-bus PIC16C5X. The internal logical and physical components that make up the PIC16C5X family are similar to those of any other microcontroller you might encounter. However, the way these common components are interconnected via the dual-bus Harvard architecture is the key to the reduced instruction set and the high execution speed of the PIC16C5X family.

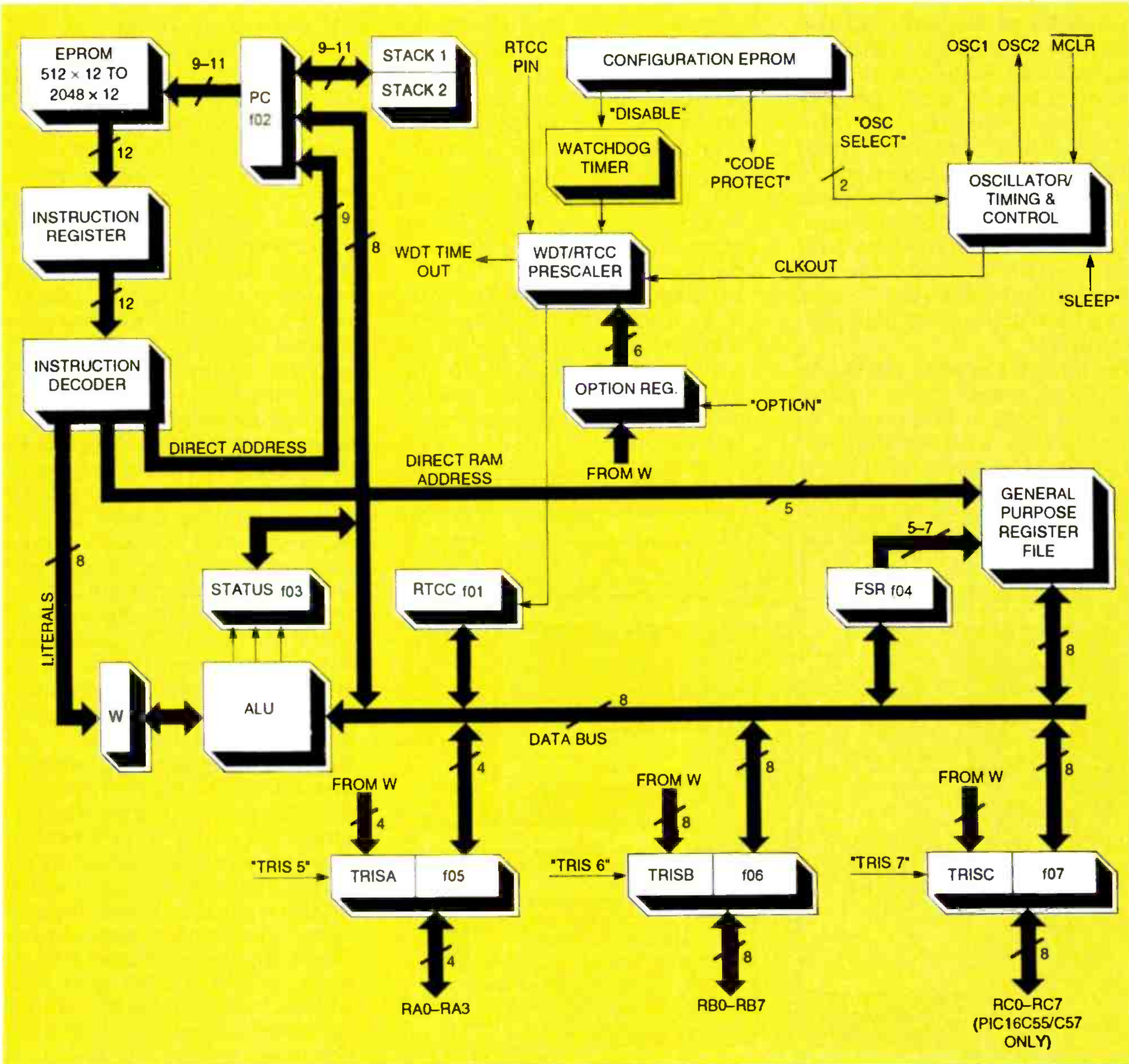


FIG. 1—DUAL-BUS PIC16C5X BLOCK DIAGRAM. The dual-bus Harvard architecture allows reduced compiled code count and high execution speed.

Register file concept

All PIC program objects are implemented as physical registers within the PIC IC. To understand how the PIC hardware works, you should understand the PIC register-file concept. Refer to Fig. 2 as the registers common to all PIC16C5X devices are described.

The Operational Register File provides a means for indirect data addressing, a real-time clock/counter, a program counter, a status word register, a file-select register, and also includes the I/O registers.

Indirect Data Addressing Register (f00)—This register is not physically implemented. It uses the contents of the File Select Register (FSR), or f04, to indirectly address any one of the 32 available file registers for use as a data register or pointer register depending upon the intent of the instruction that called f00.

Real Time Clock/Counter (f01)—The Real Time Clock/Counter, or RTCC, can be read and written to just like any other register. The RTCC can also be incremented by an external signal applied to the RTCC pin or by the internal instruction clock. Applications that would involve the RTCC are event counting and time measurement. The RTCC can also be prescaled using the PIC's internal programmable prescaler.

Program Counter (f02)—The Program Counter, or PC, generates addresses for EPROM cells containing the 12-bit user-written program instruction words. The PC is 9 to 11 bits wide depending upon the type of PIC. The 10th and 11th bits of the PC come into play when using the paging capabilities of the EPROM-rich PIC16C56 and PIC16C57 devices, thus allowing for PIC programs up to 2048 words long. A 2-word stack area is provided for call and return operations

Status Word Register (f03)—The Arithmetic Logic Unit (ALU) status, reset status, and page-preselect bits for the larger program memories of the PIC16C56/57 are contained within f03. It is comparable to the PSW (Program Status Word) found in most other microprocessors. Power-down and Time-out bits used by the Watchdog Timer (WDT) and sleep instructions are also held within f03.

File Select Register (f04)—As previously noted, the File Select Register (FSR or f04) is used in conjunction with f00 to indirectly select 1 of 32 available file registers. Because only bits 0–4 are needed to select the general-purpose register file (addressed 00 through 1F hexadecimal), bits 5–7 of the FSR are read-only and are always set to binary 111. If no indirect calls are used in the program, the FSR can serve as a 5-bit wide general-purpose register.

I/O Registers (f05–f07)—Ports A, B, and C (f05, f06, and f07 respectively) comprise the I/O registers for the PIC16C55 and PIC16C57 processors. Port C (f07) is a general-purpose register on the PIC16C54 and PIC16C56 as there are not enough pins on these devices to accommodate another physical I/O port. Port A is a 4-bit I/O register with bits 4–7 defined as binary 0000. Ports B and C are full 8-bit implementations. These I/O registers can be read and written to just like any other registers in the register file and are capable of having related I/O pins placed in high-impedance states for isolation or read operations. Any I/O pin can be independently programmed for input, output, or bi-directional operation.

General Purpose Registers (f08–f1F)—This second set of registers is addressed 08–1F hexadecimal for the PIC16C54, PIC16C55 and PIC16C56. Take another look at Fig. 2 and you will see that the PIC16C57 extends the General Purpose Register presence to f7F (addressed 7F hexadecimal) via bank switching. These registers are most commonly programmed to act as internal user RAM.

Special Purpose Registers—The PIC16C5X register file also includes Special Purpose Registers. One is the W, or Working Register, which is essentially an accumulator. W is used heavily for internal data-transfer operations. Three other write-only I/O-control Special Purpose Registers, TRISA, TRISB, and TRISC, determine if the bits in the corresponding Port registers (Ports A, B, and C), and thus their respective I/O pins, are input or output. A binary 1 corresponds to high-impedance or input mode, while a binary 0 allows output of that bit position to the related I/O pin. For example, if W is loaded with binary 00001111 and TRISB is executed, Port B, or f06, would hold bits 0–3 at a high-impedance, or input state, and it will output the contents of register f06 bits 4–7 to the I/O pins.

The last of the Special Purpose Registers is the Option Register. The Option Register defines prescaler assignment to the RTCC or Watch Dog Timer (WDT). The prescaler is shared by RTCC and WDT and this assignment is mutually exclusive; only one resource can be pre-

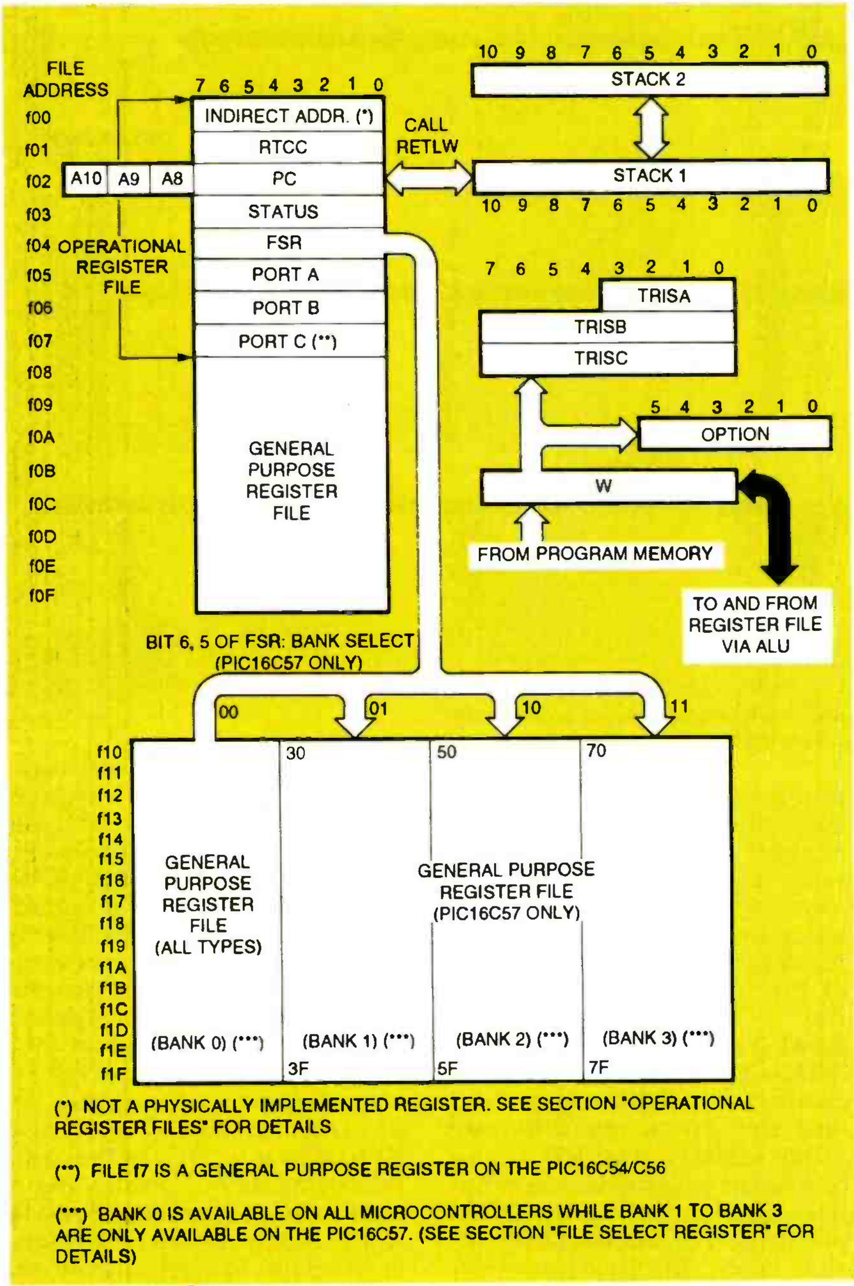


FIG. 2—**SHOWN HERE are the registers common to all PIC16C5X devices.**

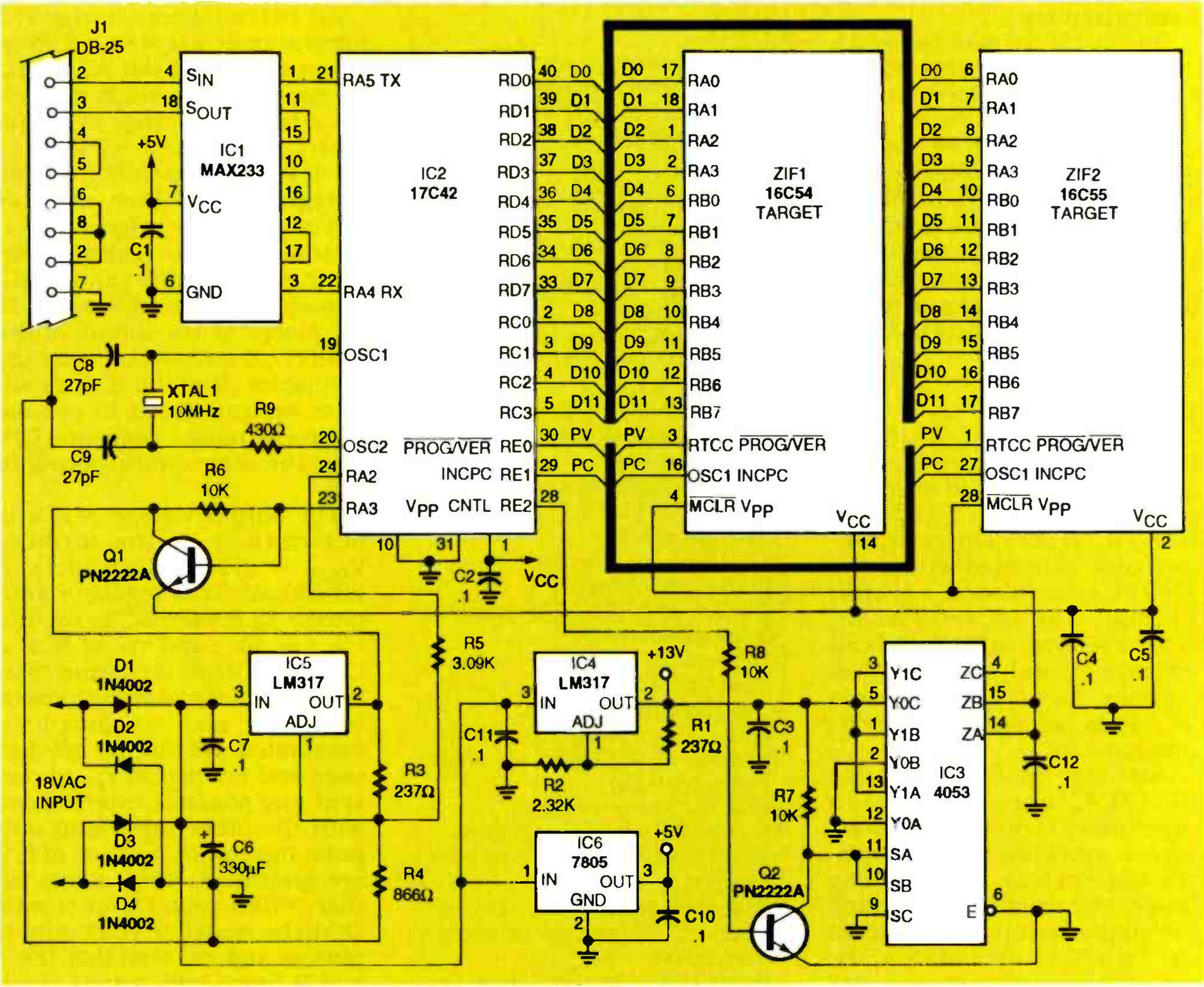


FIG. 3—THE PIC17C42'S UNIQUE I/O CAPABILITY allows the programmer to be implemented with relatively few components.

scaled at a time. Other bits within the register determine which signal edge RTCC will clock on, and if the RTCC input signal is internally or externally generated.

Watchdog Timer (WDT)—The watchdog timer must be reset under software control or it will time out and generate a processor reset. If a program is operating normally, the built-in commands to reset the watchdog timer are executed within specified time limits eliminating a processor reset. On the other hand, if the microprocessor leaps beyond the existing program or begins to loop within the program, the watchdog timer reset commands will likely not be executed in a timely manner, and a watchdog timeout will occur. A full-blown processor reset would be issued to clear the error condition.

The PIC16C5X watchdog timer does not require any external components; it operates on its own internal RC oscillator. The PIC16C5X WDT operates even if the main processor clock is not operational. The typical WDT time-out period is 18 milliseconds. The prescaler can be assigned to the WDT and extend the time-out period to over 2 seconds.

Another function of the WDT is to aid wakeup operations during the PIC16C5X sleep mode. The sleep mode can also be exited at a WDT timeout or on the occurrence of an external input.

PIC16C5X oscillator options

Four oscillator options can be used with the PIC16C5X series of microcontrollers: a crystal oscillator (XT), a high-speed crystal oscillator (HS), a low-power crystal oscillator (LP), and an RC-network oscillator (RC). One-time programmable (OTP) devices can be purchased with any one of those oscillator configurations pre-programmed. EPROM devices can be programmed to use any of the four oscillator configurations. The XT, HS, and LP devices need a ceramic resonator, crystal, or buffered external clock source to establish oscillation, while the RC configuration requires only a resistor and capacitor. Naturally, the ceramic-resonator and crystal-oscillator configurations are more accurate time-keeping devices, but if high timing accuracy is not required, the RC oscillator approach can be used to cut costs and complexity.

Reset circuitry

The PIC16C5X devices use an internal Power-On Reset (POR) circuit in conjunction with the Oscillator Start-Up Timer, OST, to alleviate the need for the traditional reset capacitor and resistor in most situations. To use the POR circuitry you need only tie the MEMORY-CLEAR pin ($\overline{\text{MCLR}}$) to +5 volts. If the power ramps up slowly or you have a very slow clock speed, the typical RC reset circuit can be used.

The PIC17C42

The intelligence for the PIC16C5X microcontroller programmer is provided by a 40-pin, 16-bit, Harvard-Architecture PIC17C42. The programmer code is housed within the PIC17C42's 2K × 16 on-chip EPROM. The PIC17C42 contains 256 bytes of RAM and can address a total of 64K × 16 of program memory. The on-chip 2K × 16 is sufficient for the PIC programmer.

Just like the PIC16C5X, the PIC17C42 uses instruction pipelining, dual-bus architecture, a watchdog timer, a register file system, and a sleep mode, the functions of which are similar but more robust on the PIC17C42. In addition, the PIC17C42 contains an on-board USART (universal synchronous/asynchronous receiver/transmitter), five multipurpose I/O ports, and two 8-bit timer/counters.

PIC16C5X programmer

The PIC17C42 is very versatile in that the I/O pins can, under program control, assume many identities. It is the PIC17C42's unique I/O capability that allows the PIC16C5X microcontroller programmer to be implemented with only 3 ICs (in addition to the regulators) and a handful of common components (see Fig. 3). Rather than attempt to cover all of the PIC17C42 I/O configurations, we will describe in detail the I/O functions that pertain to the operation of the PIC16C5X microcontroller programmer. Reference the schematic diagram as we "PIC" apart the programmer's inner workings.

PARTS LIST

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

R1, R3—237 ohms, 1%
R2—2320 ohms, 1%
R4—866 ohms, 1%
R5—3090 ohms, 1%
R6–R8—10,000 ohms
R9—430 ohms

Capacitors

C1–C5, C7, C10–C12—0.1 µF, 25 volts, monolithic
C6—330 µF, 35 volts, electrolytic
C8, C9—27 pF, 5 volts, NPO

Semiconductors

IC1—MAX233 RS-232 transceiver
IC2—Pre-programmed PIC17C42 microcontroller
IC3—CD4053B CMOS multiplexer
IC4, IC5—LM317LZ adjustable voltage regulator
IC6—7805 5-volt regulator
D1–D4—1N4002 diode
Q1, Q2—PN2222A NPN transistor

Other components

ZIF1—18-pin zero-insertion-force socket for PIC16C54/56 target microcontroller
ZIF2—28-pin zero-insertion-force socket for PIC16C55/57 target microcontroller
XTAL1—10 MHz crystal
T1—18 VAC transformer, 500 mA
J1—PC-mount female DB-25 connector

Miscellaneous: PC board, IC sockets, 25-conductor ribbon cable, solder.

Note: The following items are available from E D Technical Publications, P.O. Box 541222, Merritt Island, FL 32954, Phone/Fax 24 hours 407-454-9905:

- **Complete PIC16C5X kit including PC board, transformer, female DB-25 connector, and all electronic parts (no ZIF sockets or cables)—$69.95**
- **PC board only—$30**
- **Programmed PIC17C42—$30**
- **Software on diskette—$10**

Please add $7.50 shipping for the full kit and $3.00 shipping for parts and software. Check, money order, or COD only.

The PIC16C5X microcontrollers require a regulated programming supply voltage (V_{PP}) of +13 volts DC and a variable power source (V_{CC}) that can be switched between +4.5 and +5.5 volts DC under program control. V_{CC} is varied during the verification process.

All DC voltages for the PIC programmer are derived from the output of 18-volt AC transformer T1, which feeds the full-wave bridge rectifier arrangement comprised of diodes D1–D4 and capacitor C6. The unregulated DC from the output of the bridge is fed simultaneously to three voltage regulators (IC4, IC5, and IC6). Bypass capacitors C7 and C11 are placed at the inputs of the LM317LZ adjustable voltage regulators (IC4 and IC5) to ensure stability and to reduce transient noise. Capacitor C10 does the same on the output of IC6.

The output voltage of IC4 is determined by the formula $V_{OUT} = 1.25V\ (1 + R2/R1) + R2(150\mu A)$. This regulator supplies +13.5 volts DC to inputs YIA, YIB, YOC, and YIC of IC3, a CD4053B triple 2-channel analog multiplexer/demultiplexer. Inputs YOC and YIC along with associated output ZC are not used and are tied to V_{PP} to prevent any possible interference with the other input and outputs. Inputs YOA and YOB of IC3 are grounded. That allows either +13.5 volts DC or 0 volts DC to be routed to IC3's output pins ZA and ZB. Note that the A and B input and output channels of IC3 are wired in parallel. That is done to provide a 50- to 100-ohm source impedance for the target PIC's $\overline{\text{MCLR}}$ inputs. Any impedance outside those limits may allow the target PIC to latchup during programming. Capacitor C12 acts as a filter to suppress any V_{PP} transient voltages.

The voltage V_{PP} (+13.50 volts DC) is also directed to the IC3's select inputs, SA and SB, through resistor R7, with input SC tied to ground. Transistor Q2, with resistors R7 and R8, comprise a means of selecting either of IC3's V_{PP} voltage input pairs, YOA/YOB or YIA/YIB, to be routed to the paralleled output pair, ZA/ZB. V_{PP} selection is performed under program control. The logic state of pin 28 of IC2 (RE2) determines if Q2 is on or off. Transistor Q2 provides a path to ground for inputs SA and SB when it is turned on, and blocks the path to ground, letting V_{PP} be applied to those inputs through R7 when it is turned off. With Q2 turned off, inputs SA and SB of IC3 are logic 1s and SC is a logic 0 (pin 9 of IC3 is permanently grounded), so the ZA/ZB outputs are at +13.5 volts DC. With Q2 turned on, all three inputs (SA, SB, and SC) are logic 0, and the ZA/ZB outputs are at 0 volts DC. The selected V_{PP} voltage at the output pair of IC3 is then applied directly to the $\overline{MCLR}$ pins of the target PICs, zero-insertion-force sockets ZIF1 and ZIF2.

The PIC16C5X programmer must include circuitry to provide +4.5- to +5.5-volts DC to the target PIC sockets to verify PIC programming margins. In other words, the PIC programmer must be able to correctly read a freshly programmed PIC at minimum and maximum rated V_{CC} voltages to ensure that the PIC will perform its duty over its entire specified voltage range. An LM317 (IC5) generates these voltages. However, the circuit must not only be able to switch the target PIC socket's V_{CC} between +4.5- and +5.5-volts DC, it must also provide a means to supply and remove the switched V_{CC} power to the target PIC socket. To do this, the versatility of the PIC17C42's I/O subsystem is put to work. A controlled V_{CC} network for the target PICs is implemented using only three components and minimal program overhead.

Pins 23 and 24 of IC2 (RA3 and RA2, respectively), are I/O pins with Schmitt trigger inputs and open-drain outputs. The associated source for these pins is internally grounded within the PIC17C42. By simply adding a pullup resistor, RA3 and RA2 can be used to switch between ground and voltages up to +12 volts DC.

With IC5 in a standard configuration, the value of R4 is normally used to determine the output voltage. By changing R4's value, IC5's output voltage changes proportionately. That is accomplished by switching R5 in parallel with R4 using the open-drain capability of RA2. The combined resistance of R4 and R5 in parallel is less than the lower value of the two resistors (676 ohms in this case). The closer pin 1 of IC5 (the adjust pin) is taken to ground, the less its output voltage will be. So, by simply writing a 1 or 0 to I/O pin 24, we can switch between +4.5- and +5.5-volts DC.

Grounding the adjust pin of IC5 would result in an output voltage of +1.25 volts, which would not completely turn off V_{CC} to the target PIC sockets. A negative voltage must be applied to the LM317's adjust pin to bring the output voltage to 0 volts DC. To avoid adding a negative supply voltage, the PIC programmer uses a simple transistor switch controlled by open-drain I/O pin 23 (RA3). To compensate for the voltage drop across the transistor, the output voltages of IC5 are set for +4.9- and +5.9-volts DC. When RA3 is at logic 0, the base of Q1 is grounded and V_{CC} does not flow across Q1's junctions. When RA3 is a logic 1, resistor R6 pulls the base of Q1 up to V_{CC}, turning Q1 on, allowing V_{CC} (+4.5 or +5.5 volts) to reach target sockets ZIF1 and ZIF2.

Naturally, IC1 and IC2 need +5 volts DC to operate. That voltage is supplied by IC6, a 7805 +5-volt regulator.

The PIC16C5X programmer hardware communicates at 9600 bits per second (BPS) with the PICPROG terminal program. The 9600 BPS connection is provided by the PIC17C42 internal USART with the aid of the MAX233 RS-232 transmitter/receiver, IC1. The PICPROG program is interactive and provides a pathway for data and commands to be passed to and from the PIC programmer hardware. Once valid commands are recognized by the PIC17C42 controller, firmware residing within the PIC17C42 takes over and performs the requested operation. The user is informed throughout the operation as to the amount of success or failure that has occurred during the requested operation.

Blank checks are performed with target PIC's V_{CC} at +4.5-volts DC. All program and verify operations take place with V_{CC} at +5.5-volts DC. This guarantees that the target PIC will operate reliably over its entire voltage and temperature range.

The PIC16C5X uses an internal Program Counter (PC), eliminating the need to supply address information to the target. The programming/verify mode is entered by raising the $\overline{MCLR}$ pin from ground to V_{PP} while holding the RTCC pin at TTL high and the OSC1 pin at TTL low.

After program/verify mode is invoked, the PIC16C5X internal PC is set at FFF hexadecimal. The configuration EPROM is located at this address and is the first word to be programmed. All data transfers occur on Ports A and B of the target PIC and Ports C and D of the PIC17C42. The configuration fuses, actually bit positions, consist of two fuses, or bits, that determine the PIC oscillator type, a watchdog enable fuse to enable or disable the watchdog timer, and the code protection fuse. The PICPROG program lets you enter your desired configuration fuse setup, or if you have copied a previously programmed PIC, the PICPROG program provides a means to pass those fuse settings to the new PIC automatically. PICPROG also lets you save the copied configuration fuse map to a file for future use. (Remember, you cannot read a code-protected PIC.) The configuration fuse is programmed by pulsing the RTCC pin TTL low for 10 milliseconds using a 100-microsecond pulse train. All other locations are programmed by pulsing the RTCC pin low for 100 microseconds.

Program verification is achieved by again pulsing RTCC low for 100 microseconds while holding OSC1 low. The falling edge of OSC1 is used to increment the PC. By not raising OSC1 to a TTL-high level, the PC is not incremented. This operation places the freshly programmed data out on the PIC port pins to be read and verified by the PIC17C42 firmware. The

Continued on page 55

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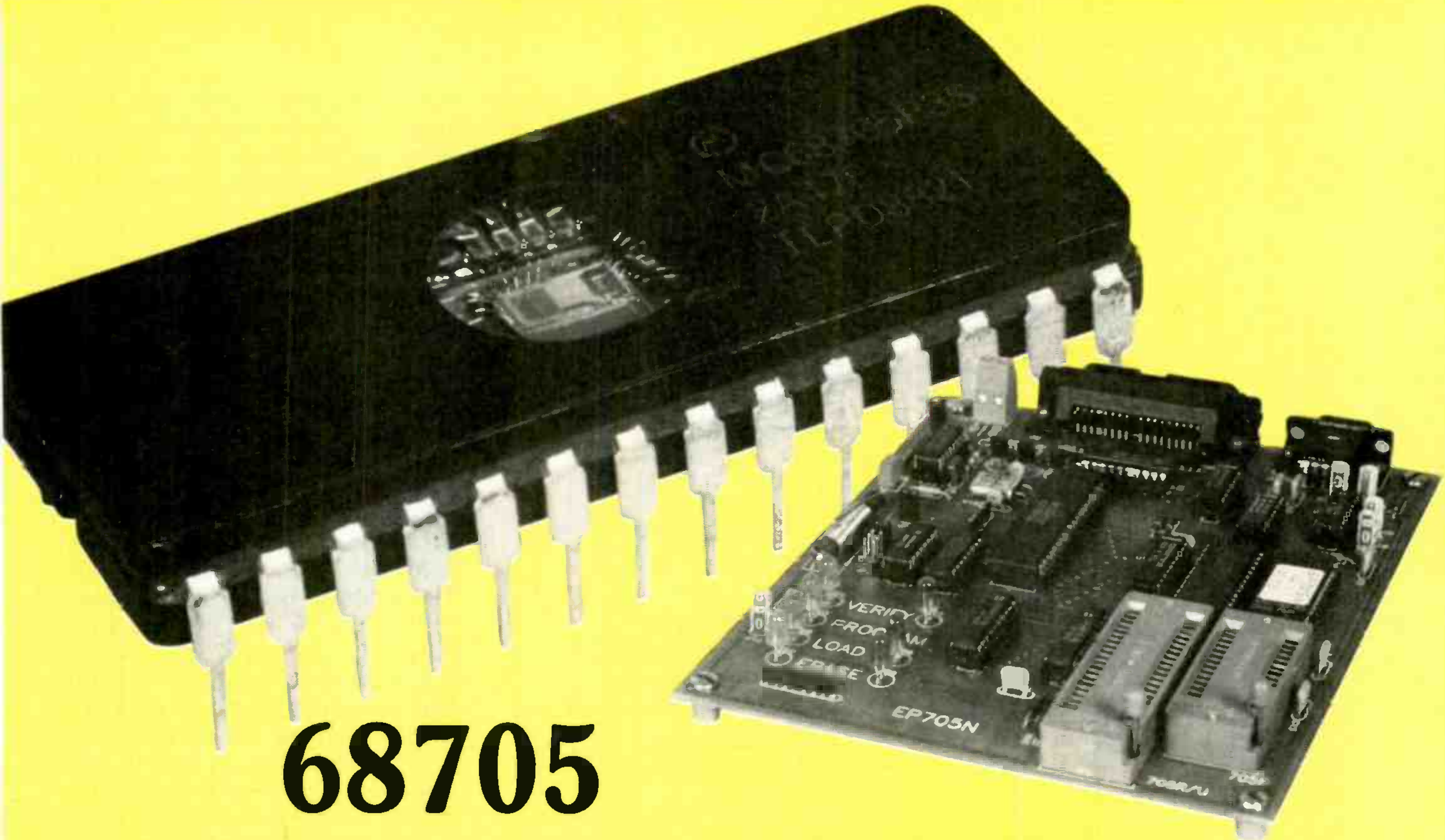

68705 MICROCONTROLLER PROGRAMMER

Now you can program your own 6805 microcontrollers with this inexpensive programmer.

BRIAN BEARD

THIS ARTICLE WILL DESCRIBE THE design of a programmer for the 68705 called the EP705N. The 68705 microcontroller differs from the 6805 in that it has EPROM in place of masked ROM, so that it can be erased and reprogrammed again and again.

The microcontrollers in Motorola's 6805 family are some of the most widely used microcontrollers on the market today. They are optimized for control applications, rather than general-purpose data processing and, are imbedded inside such products as VCRs, printers, modems, toys, and appliances. Today there are over 30 devices in the 6805 family with new ones being added every year. Every member of the family has the same 8-bit CPU core, so if you can program one device you can program any member of the family.

The 68705 is ideal for small control projects because it is easy to program and because it is available to hobbyists for less than $17. The EP705N can program the P3, P5, R3, R5, U3, and U5 versions of the 68705. The "5" parts are identical to the "3" parts except for the addition of an EPROM security feature that prevents the viewing of code in a programmed device. Table 1 compares the features of the various versions.

The EP705N is flexible, quick, and easy to use. It operates from a single 5-volt supply thanks to its own DC-to-DC converter which provides the 21 volts required for programming. LED indicators show the status of the programming process. A parallel printer port and a serial port allow it to be connected to most personal computers. Figure 1 shows the functional blocks that make up the EP705N and how they are interconnected.

Theory of operation

Because the HMOS (high-density NMOS) 68705 processors have no external address or data bus, they cannot access external programs. They can be programmed, however, because of a bootstrap program in a small section of ROM in each 68705. Normally, when the

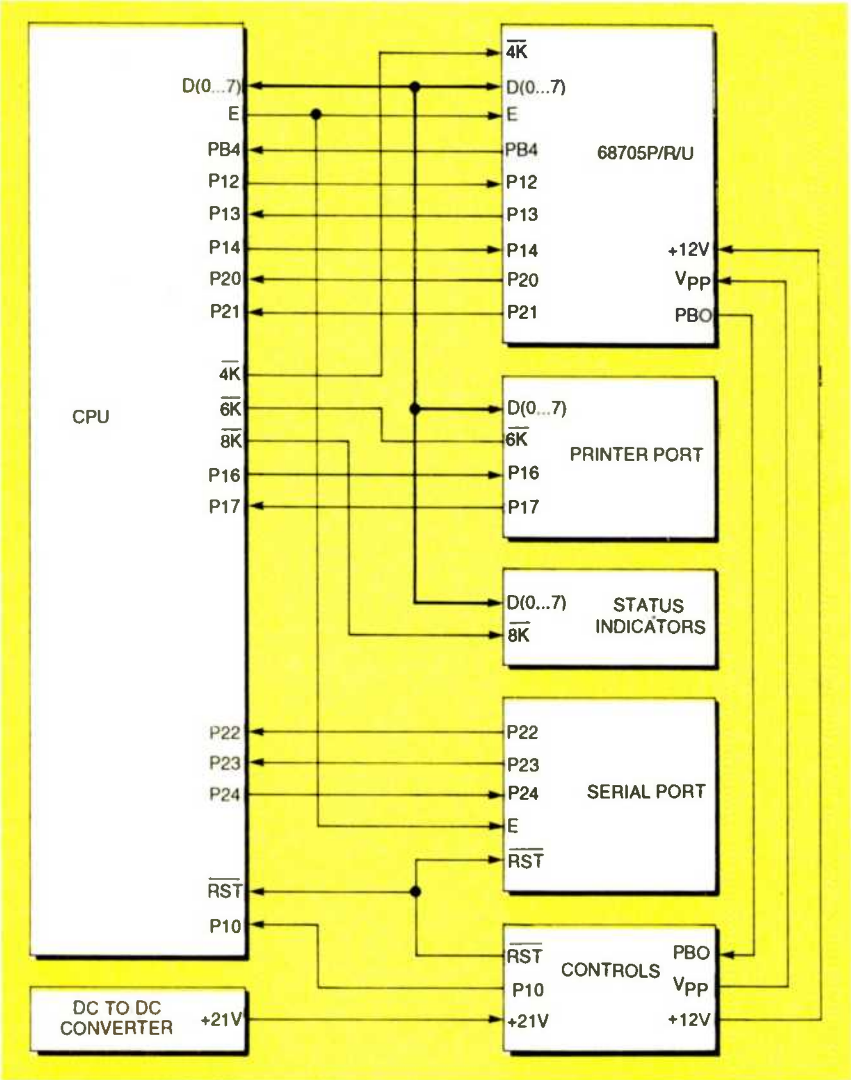

FIG. 1—THE FUNCTIONAL BLOCKS that make up the EP705N and how they are interconnected.

TABLE 1—CHIP FEATURES

	68705P	68705R	68705U
Number of pins	28	40	40
On-chip RAM (bytes)	112	112	112
On-chip ROM (bytes)	115	120	120
On-chip EPROM (bytes)	1804	3776	3776
Bidirectional I/O lines	20	24	24
Input only I/O lines	0	8	8
A/D	No	Yes	No
Timer	Yes	Yes	Yes
External Interrupts	1	2	2

TABLE 2—MEMORY MAP FOR THE EP705N

\$0000–\$001F	MPU REGISTERS, 6803, IC9
\$0020–\$3FFF	UNUSED
\$4000–\$5FFF	DATA OUTPUT TO 68705
\$6000–\$7FFF	PRINTER PORT INPUT
\$8000–\$9FFF	LED OUTPUT PORT
\$A000–\$BFFF	ADDRESS 000 LATCH SET
\$C000–\$DFFF	RAM, 6264, IC11
\$EC00–\$FFFF	EPROM, 2764, IC12

RESET pin goes high, the program counter is loaded with the reset vector from the on-chip EPROM. However, if the TIMER pin is at +12 volts when RESET goes high, the program counter is loaded with the starting address of the bootstrap program instead.

The bootstrap program is designed to work with the hardware shown in Motorola Application Note 857 (AN857) consisting primarily of a 2764 EPROM and a 4040, 12-bit ripple counter. The 2764 is preprogrammed with the object code destined for the 68705. The 4040 supplies the address to the 2764 which in turn supplies the data to port A of the 68705. The 4040 is cleared and incremented by control lines from port B of the 68705. The bootstrap program starts the 4040 at address \$000 and increments up to the 68705's maximum address: \$7FF for the P3/P5, and \$FFF for the R3/R5/U3/U5. At each address corresponding to EPROM in the 68705, the bootstrap program takes the data from port A and programs it into the EPROM.

After reaching the maximum address, the bootstrap program clears the 4040 and makes one more pass through the address space to compare the data at port A with the contents of its on-chip EPROM. The +21 volts required to program the 68705's EPROM (V_{PP}) is switched by PB0. Additional lines from port B are used to signal that the EPROM is programmed and the program is verified.

The 68705 being programmed expects to interact with the hardware specified in AN857. The circuitry of the EP705N emulates the functions of that hardware. The programming data comes from the RAM buffer via a latched port (IC14 in Fig. 2) instead of from a 2764 EPROM. A 6803 monitors the count (PB3) and clear (PB4) lines from the 68705 and modifies its pointer into the RAM buffer, which replaces of the 4040 counter. The control line from the 68705 that switches V_{PP} to the chip is still controlled directly by the 68705.

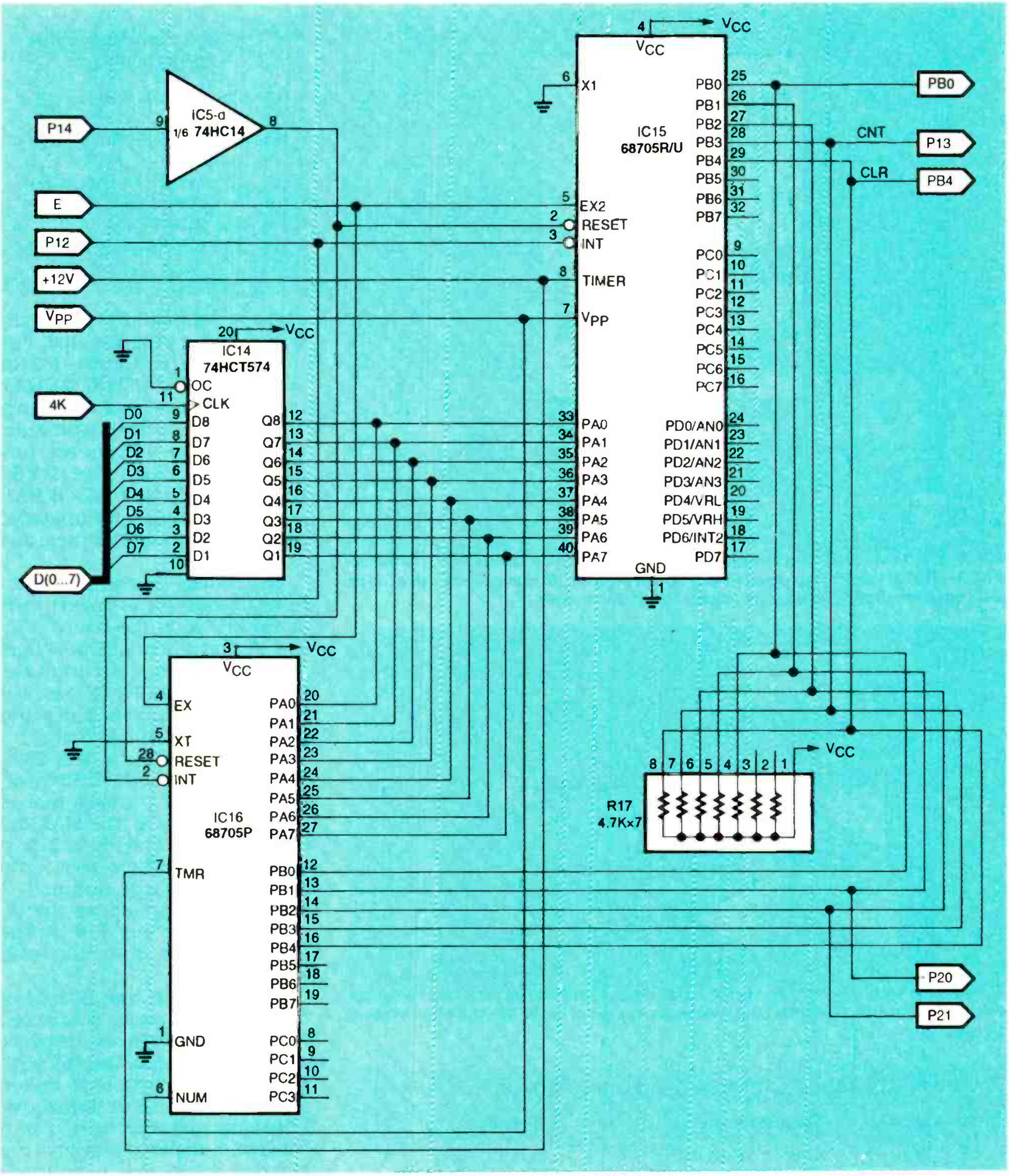

FIG. 2—28-PIN 68705's are programmed in the IC16 socket and the 40-pin chips in IC15. Only one 68705 can be programmed at a time.

Figure 2 shows the sockets for the 68705 chips. There are two 68705 sockets because of the different pinouts on the chips. The 28-pin 68705s are programmed in the IC16 socket and the 40-pin chips in IC15. Only one 68705 can be programmed at a time even though there are two sockets. Note that the RESET and INT lines to the 68705 are controlled by the 6803 processor. The 6803 uses the RESET line to keep the 68705 inactive until programming begins. The INT line serves as a "data ready" handshake line to the 68705.

The EP705N requires a supply of 5-volts DC at 500 milliamperes. The 21 volts (V_{pp}) needed to program the microcontroller is supplied by the DC-to-DC converter circuit shown in Fig. 3. Trimmer R4 adjusts the 21-volt supply, which is applied to the V_{pp} pin of the 68705 by the

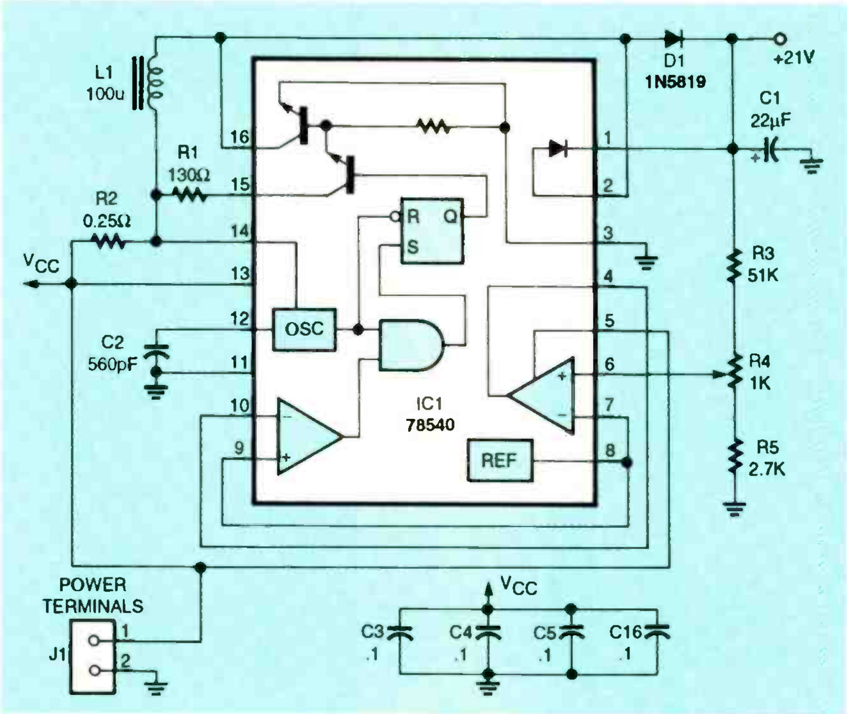

FIG. 3—THE 21 VOLTS (V_{PP}) needed to program the EPROM is supplied by this DC-to-DC converter circuit. Trimmer R4 adjusts the 21-volt supply.

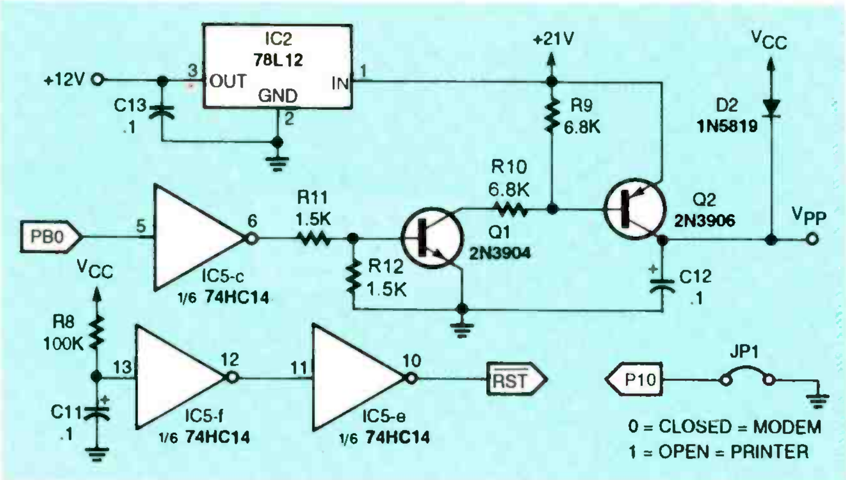

FIG. 4—THE 21-VOLT SUPPLY is applied to the V_{PP} pin of the 68705 with this switching circuit.

TABLE 3—EP705N SERIAL CONNECTOR

Pin	Circuit	Description	Direction
1	CF	Carrier detect, DCD	from EP705N
2	BB	Receive data, RD	from EP705N
3	BA	Transmit data, TD	to EP705N
4	CD	Data Terminal ready, DTR	to EP705N, n/c
5	AB	Signal ground, SG	—
6	CC	Data set ready, DSR	to EP705N
7	CA	Request to send, RTS	to EP705N
8	CB	Clear to send, CTS	from EP705N
9	CE	Ring indicator, RI	from EP705N, n/c

switching circuit shown in Fig. 4. The 21-volt supply also serves as the source for the 12-volt regulator, IC2.

Table 2 shows the memory map of the EP705N. Note that this is the memory map for the 6803 processor in the EP705N.

TABLE 4—MODEM MODE MENU SCREEN

[U] Upload ASCII S19 file to buffer
[P] Program 705 from buffer and verify
[C] Generate buffer checksum
[H] Buffer display, HEX × ASCII
[M] Modify buffer
[D] Download buffer to S19 file
?

and not the memory map of the 68705 being programmed. Figure 5 shows the circuitry for the 6803 (IC9), EPROM (IC12), RAM (IC11), and address decoding. The EP705N operating program and interrupt vectors are programmed into the 2764 EPROM. The 6264 8K × 8 RAM is used as a buffer for uploaded programs, variable storage, and a stack.

The status of the programming process is indicated by the seven LEDs on the board. Figure 6 shows how LEDs 1–7 are wired and what they indicate. Green LEDs indicate the successful completion of a step and red ones indicate a failure.

The serial port on the 6805 programmer is RS-232 compatible. Figure 7 shows the serial-port circuitry. The MAX232 (IC6) contains two RS-232 drivers, two RS-232 receivers, and an on-chip charge-pump. The charge-pump generates the bipolar voltages needed by the RS-232 drivers from the 5-volt supply.

Table 3 shows the pinout of the EP705N's serial connector. None of the handshake lines are actively controlled by the EP705N. The DTR (DATA TERMINAL READY) line is not connected. Lines DSR (DATA SET READY) and DCD (DATA CARRIER DETECT) are wired to a logic-high condition at all times. The RTS line is received, buffered, and looped back to the host as CTS, so that CTS (CLEAR TO SEND) tracks RTS (REQUEST TO SEND). The baud rate is selected with jumper block JP2 (Fig. 7). All of the standard baud rates from 600 to 9600 baud are available.

The parallel printer port circuitry is shown in Fig. 8. Each byte sent to the port from a per-

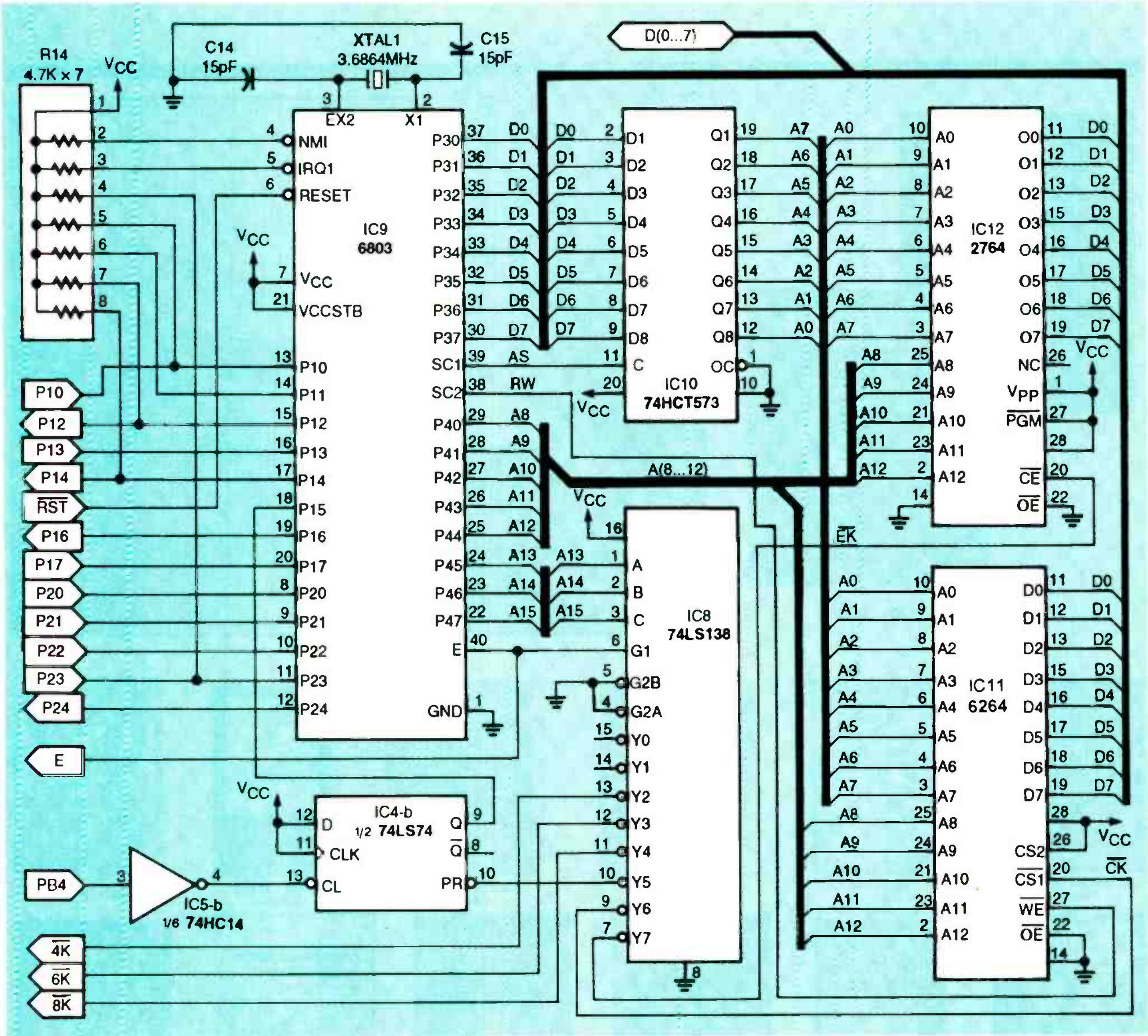

FIG. 5—THE EP705N OPERATING PROGRAM and interrupt vectors are programmed into the 2764 EPROM. The 6264 8K × 8 RAM is used as a buffer.

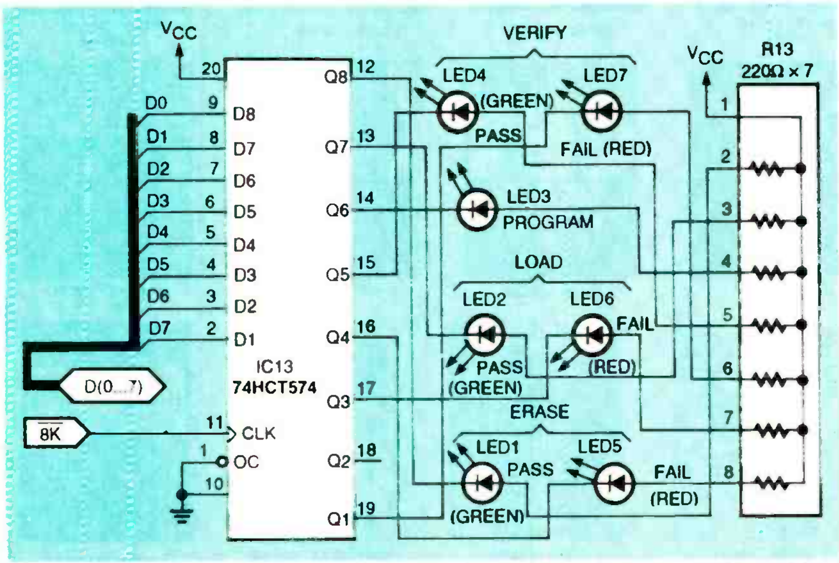

FIG. 6—THE STATUS OF THE PROGRAMMING PROCESS is indicated by seven LEDs. Green LEDs indicate success, and red ones indicate failure.

sonal computer is signaled by DST (DATA STROBE) strobing low. DST sets flip-flop IC4-a, which sets the BUSY line and latches the new byte into IC3. The 6803 monitors the BUSY line (P17), and when it detects activity it reads the new byte from IC3. After processing the new byte, the 6803 strobes ACK (ACKNOWLEDGE) (P16) low. The rising edge of ACK clears the flip-flop which clears the BUSY line allowing the host computer to send the next byte.

The EP705N can operate in two different modes. If jumper block JP1 in Fig. 4 is open, the EP705N acts like a printer. It monitors the parallel and serial ports and accepts data from whichever one is active. The S19 output of an assembler can

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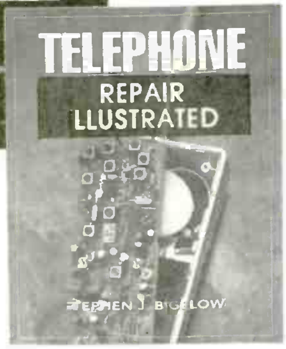

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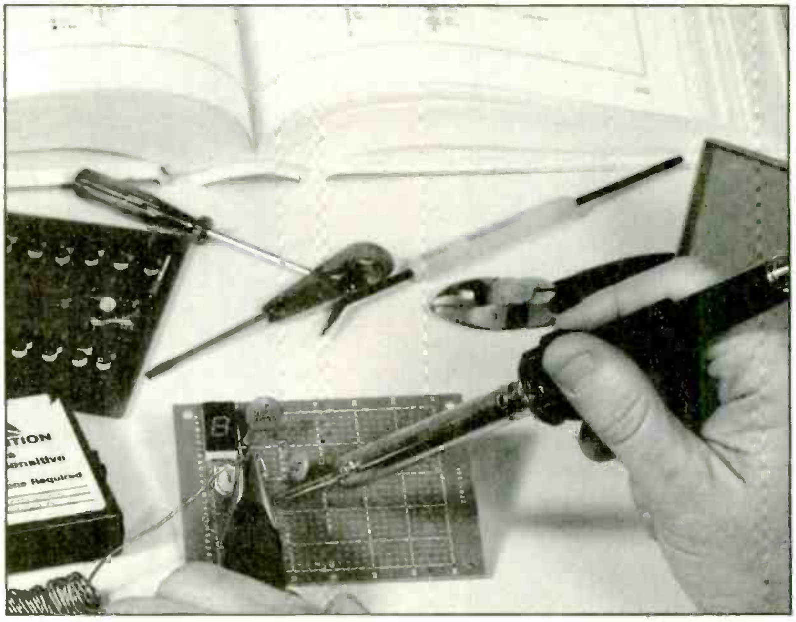

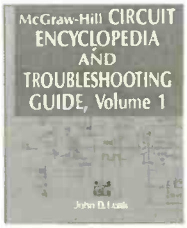

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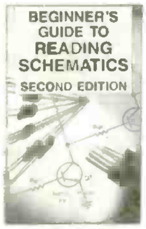

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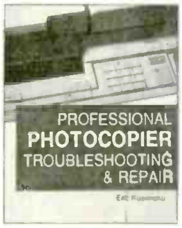

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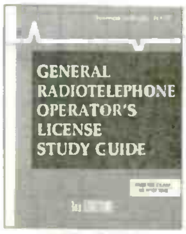

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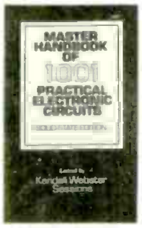

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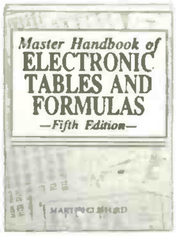

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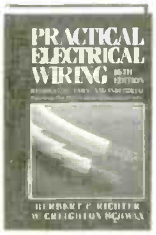

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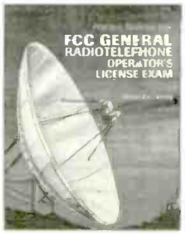

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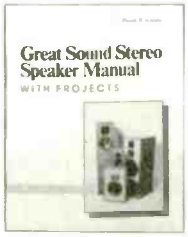

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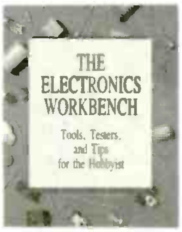

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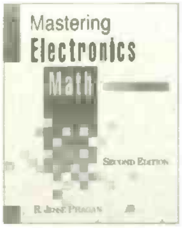

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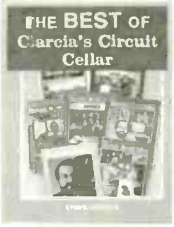

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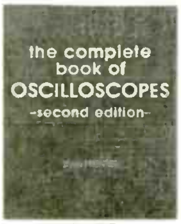

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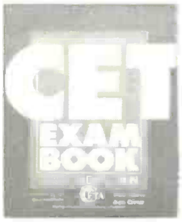

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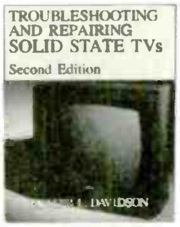

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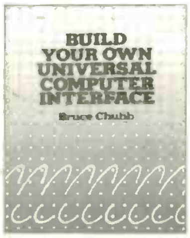

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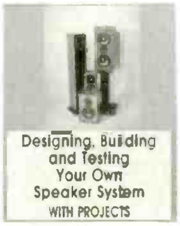

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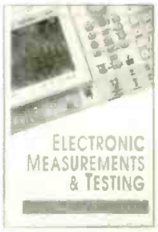

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be sent from a computer to the EP705N just as if it were a printer. For example, on an MS-DOS system, you would simply connect the EP705N in place of your printer and type in the normal print command "PRINT (FILENAME).S19."

In the printer mode the EP705N performs all operations automatically. The result of each step in the programming process is marked by the appropriate LED. If any step fails, a red LED will light up and the process will cease. When programming is complete and successful, there will be four green LEDs glowing.

When power is first applied to the EP705N, all LEDs come on for one second to verify that they are operational. The EP705N then checks the 68705's internal EPROM to determine if it is completely erased. If it is erased, the chip is ready to be programmed and the green ERASE LED comes on. The EP705N will now wait for you to send it an object file via either the parallel or serial port.

The object file must be in the Motorola standard S19 format. Any 6805 assembler will generate this type of output. As the object file is sent to the EP705N, it is converted to binary code and stored in the RAM buffer. If there is an error in the conversion, such as a non-hex character or a bad checksum, the red LOAD LED lights.

If the entire S19 file is received successfully, the green LOAD LED comes on. After an object file is loaded, programming of the 68705 begins. Completion of the programming step is marked by the program LED. The last step is to verify the pro-

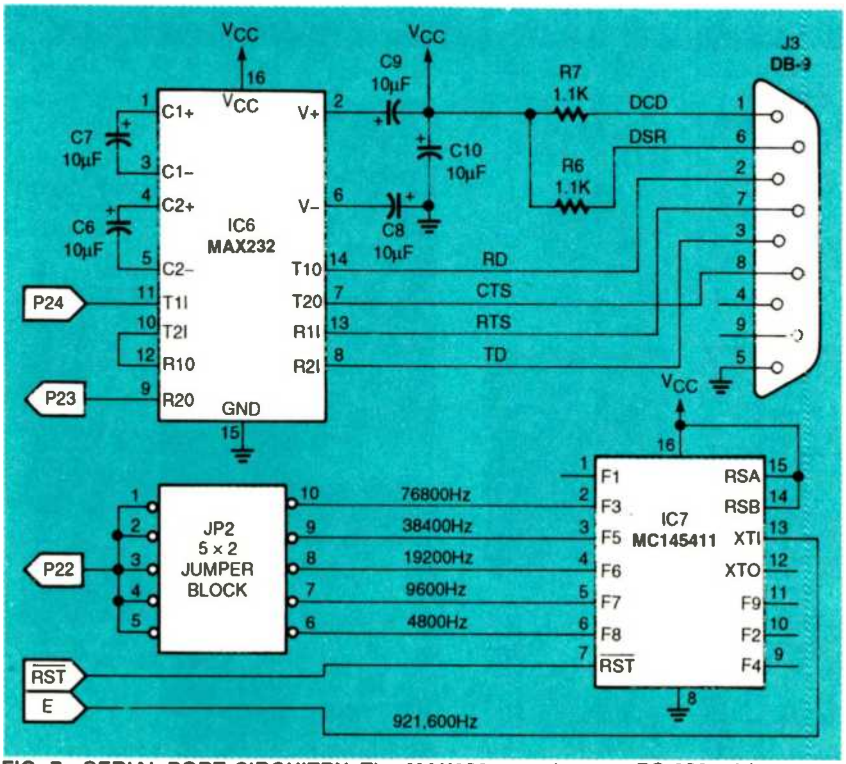
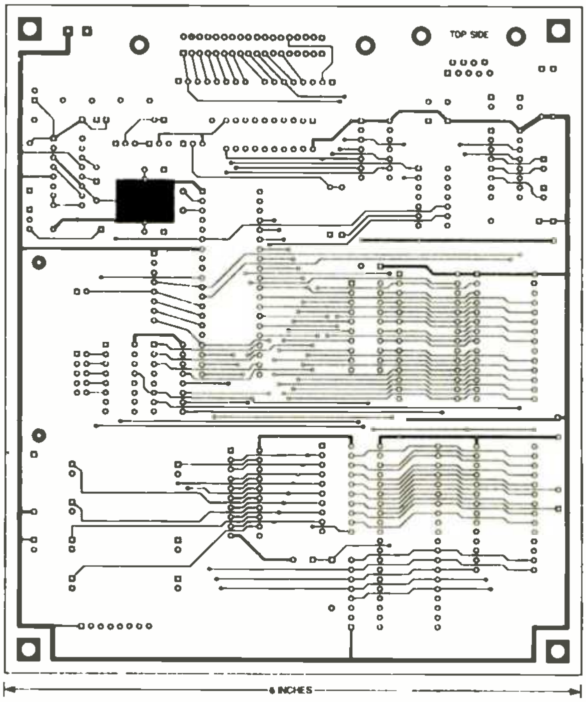
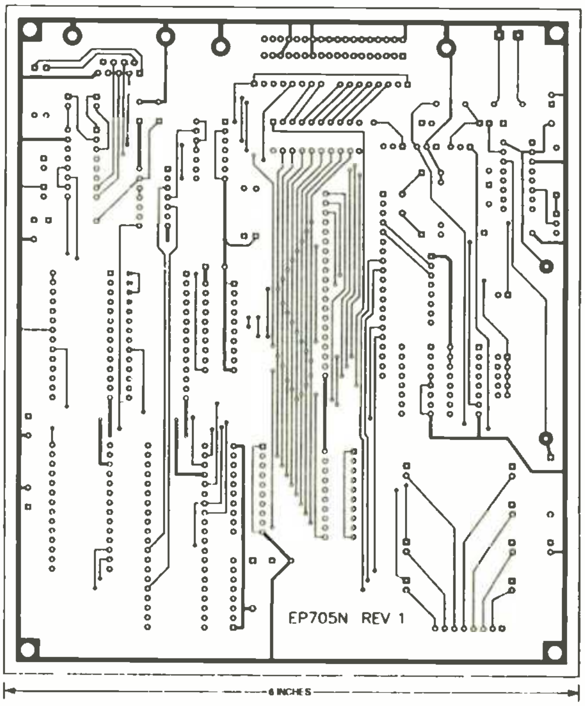


FIG. 7—SERIAL-PORT CIRCUITRY. The MAX232 contains two RS-232c drivers, two RS-232c receivers, and an on-chip charge-pump that uses the 5-volt supply to generate the bipolar voltages needed by the RS-232c drivers.



COMPONENT SIDE of the 6805 programmer board.



SOLDER SIDE of the 6805 programmer board.

PARTS LIST

All resistors are¼-watt, 5%, unless otherwise noted.
R1—130 ohms
R2—0.25 ohm or less
R3—51,000 ohms
R4—1000 ohms, ⅜-inch upright trimmer
R5—2700 ohms
R6, R7—1100 ohms
R8—100,000 ohms
R9, R10—6800 ohms
R11, R12—1500 ohms
R13—220 ohms × 7, 8-pin SIP (pin 1 common)
R14–R17—4700 ohms × 7, 8-pin SIP (pin 1 common)

Capacitors
C1—22 µF, 50 volts, electrolytic
C2—560 pF, Mylar
C3–C5, C11, C13, C16—0.1 µF, ceramic disc
C6–C10—10 µF, 16 volts, radial electrolytic
C12—0.1 µF, 50 volts, ceramic disc
C14, C15—15 pF, ceramic disc

Semiconductors
IC1—78S40 switching regulator
IC2—78L12 12-volt regulator (TO-92 case)
IC3, IC13, IC14—74HCT574 octal D-type flip-flop
IC4—74LS74 dual D-type flip-flop
IC5—74HC14 hex inverter
IC6—MAX232 RS-232 interface
IC7—MC145411 bit rate generator
IC8—74LS138 3-to-8 decoder
IC9—MC6803 microcomputer
IC10—74HCT573 octal latch
IC11—6264 8K × 8 CMOS RAM
IC12—2764 8K × 8 EPROM (preprogrammed)
D1, D2—1N5819 Schottky diode
Q1—2N3904 NPN transistor
Q2—2N3906 PNP transistor
LED1–LED4—Green light-emitting diode
LED5–LED7—Red light-emitting diode

Other components
J1—2-contact terminal block
J2—25-pin female right-angle Centronics connector
J3—9-pin female DB-9 connector
JP1—1 × 2 jumper header and one shorting jumper, 0.1-inch spacing
JP2—5 × 2 jumper header and one shorting jumper, 0.1-inch spacing
L1—100 µH coil
XTAL1—3.6864 MHz crystal

Miscellaneous: PC board, two 14-pin IC sockets, four 16-pin IC sockets, four 20-pin IC sockets, two 28-pin IC sockets, one 40-pin IC socket, one 40-pin ZIF socket, and one 28-pin ZIF socket.

Note: The following items are is available from Lucid Technologies, 7439 Highway 70 South, Unit 297, Nashville, TN 37221:

- **Partial EP705N kit (includes PC board, programmed 2764 EPROM (IC12), MC145411 bit-rate generator (IC7), documentation disk (5.25", 360K IBM format), and schematics)—$45**
- **Same kit as above but without PC board—$25**

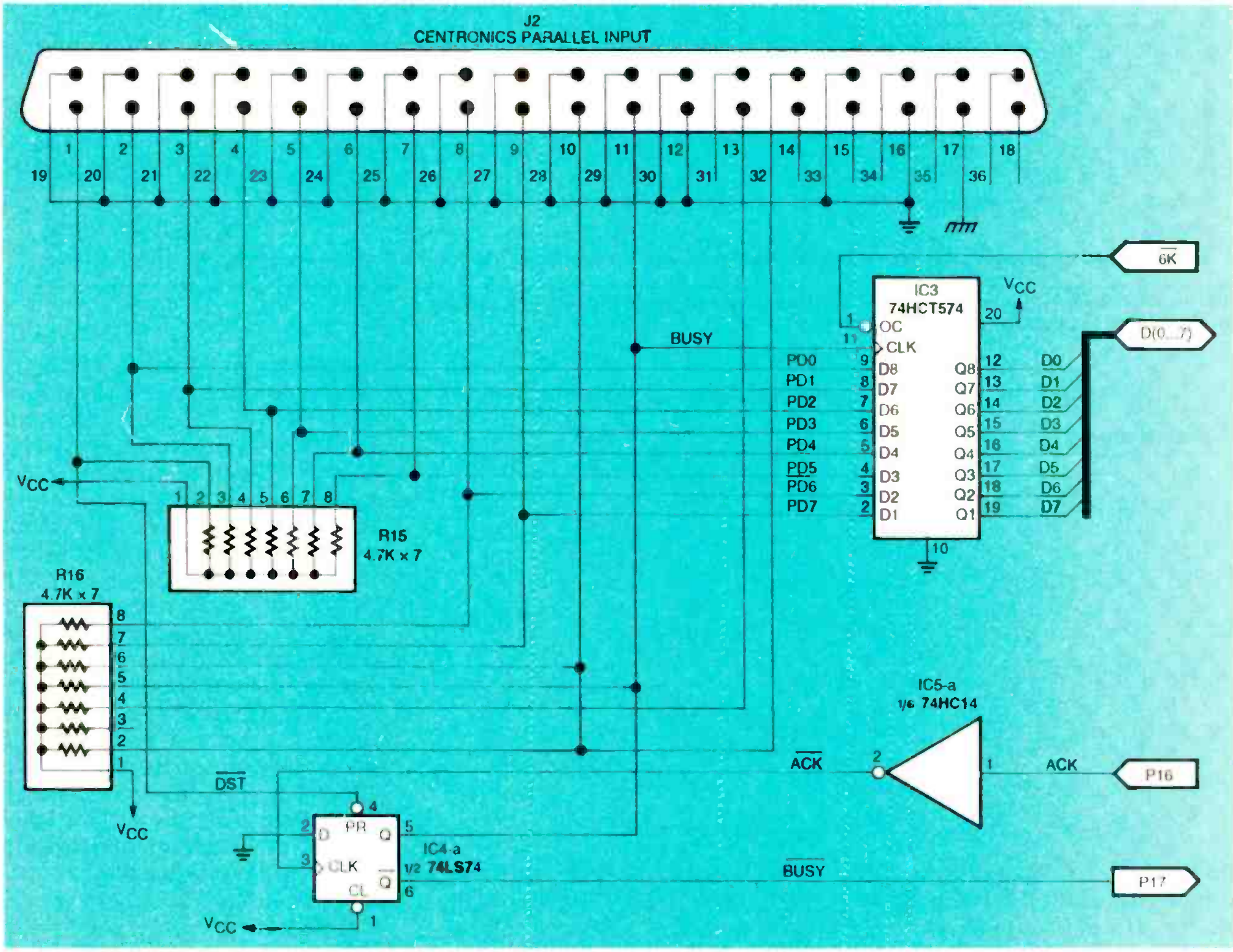


FIG. 8—PARALLEL PRINTER PORT CIRCUITRY. Each byte sent to the EP705N is signaled by scdst strobing low.

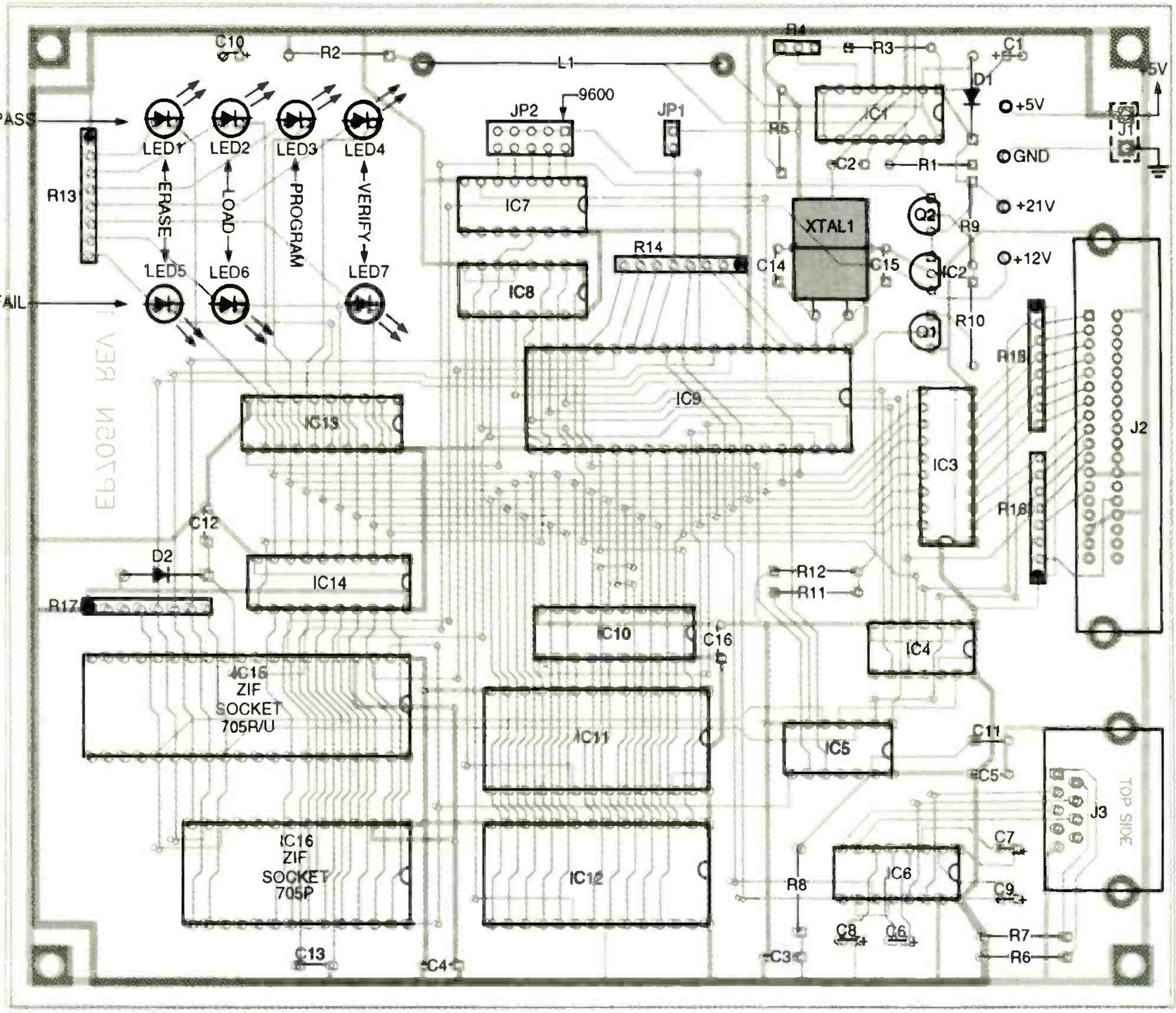


FIG. 9—PARTS-PLACEMENT DIAGRAM. Install sockets for all of the ICs, and put ZIF sockets in the locations for IC15 and IC16.

TABLE 5—IC POWER PINS

Reference	Type	Gnd	V_{CC}
IC1	78S40	3	13
IC3, IC13, IC14	74HCT574	10	20
IC4	74LS74	7	14
IC5	75HC14	7	14
IC6	MAX232	15	16
IC7	MC145411	8	16
IC8	74LS138	8	16
IC9	6803	1	7,21
IC10	74HCT573	10	20
IC11	6264	14	28
IC12	2764	14	28
IC15	68705R/U	1	4
IC16	68705P	1	3

grammed EPROM against the object file loaded in the RAM buffer. If verification is successful, the green LED comes on; if not, the red one does.

If jumper block JP1 is short-circuited, the EP705N acts like a modem and uses only the serial port. To use this option your computer must have a communications program capable of ASCII file transfer. This mode allows you to interact with the EP705N via the menu shown in Table 4. The modem mode is not a completely automatic mode: the erase check is still done when power is applied, but after that you must tell the EP705N to perform each step of the programming process. In the printer mode, if something goes wrong, the only indication is a red LED. However, in the modem mode, a problem will generate a specific error message. The modem mode also allows the contents of the RAM buffer to be examined, modified, and downloaded.

Construction

The design of the EP705N is complex enough to make point-to-point wiring difficult. An etched and drilled PC board is available from the source mentioned in the parts list. Foil patterns are provided here for readers who wish to make their own boards. The rest of the parts are readily available. A parts-placement diagram is shown in Fig. 9. Begin by installing all parts on the board, but do not insert the ICs in their sockets at this time.

With no ICs installed in the sockets, attach a 5-volt DC supply to J1 and check the V_{CC} pins for all the IC sockets. Table 5 shows the power and ground pins for all the ICs making it easy to check.

Install the DC-to-DC converter chip, IC1, in its socket. Turn on the power and measure the voltage at pin 1 of IC1. Adjust trimmer R4 to get a reading of 21 volts. Now measure the voltage on pin 7 of the IC15 target socket; it should be about 4.9 volts. If it is close to 21 volts there is a problem in the circuitry around Q1 and Q2. Measure the voltage on pin 8 of the IC15 target socket; it should be 12 volts.

Turn off the power supply and allow the charges to bleed from the electrolytic capacitors. Plug the ICs in their respective sockets, taking care to orient them properly. Figure 10 shows the completed prototype.

A parallel connection to the EP705N can be made with any standard parallel printer cable. If you are using a parallel printer now, disconnect the cable at the printer end and connect it to the EP705N. Serial connection to the EP705N might be more difficult. The EP705N is designed as a DCE (data communications equipment) device. It uses a 9-pin female D connector that is directly compatible with the 9-pin serial ports found on most IBM-standard computers. The pin assignments and signal directions for the EP705N are shown in Table 3.

With the power off, install an erased 68705 in its appropriate ZIF socket. Note that the power to the EP705N should always be turned off whenever a 68705 is installed or removed. You are now ready to work with your EP705N and begin programming your own 68705s and putting them to work. Ω

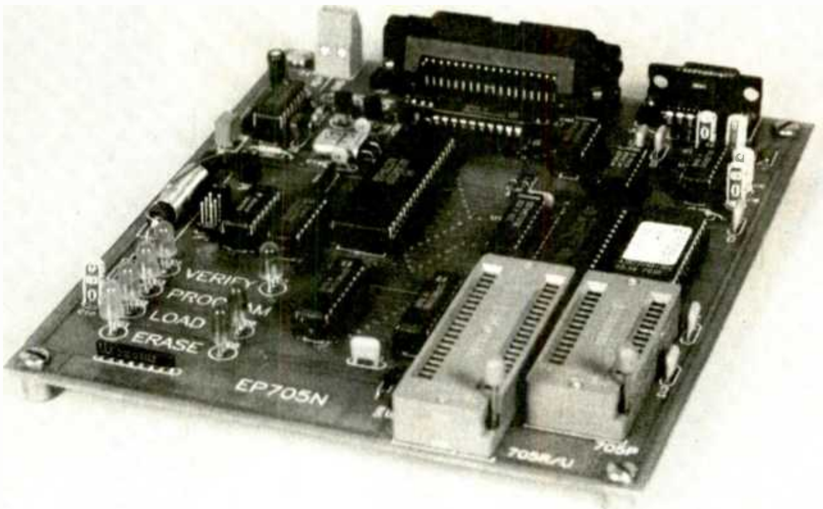


FIG. —THE COMPLETED PROTOTYPE. Any 5-volt power supply can be connected to power-input terminal block J1.

PIC PROGRAMMER

continued from page 41

program/verify operation involving pulsing the RTCC pin is performed up to 25 times per location. When verification is successful, a 3× overprogramming pulse train is applied to assure the location is programmed solidly. A final verify is performed by keeping the RTCC pin at TTL high and raising the OSC1 pin to TTL high. Again, the newly programmed contents at this memory location are presented to the port pins to be verified by the PIC17C42. If the memory location fails to verify properly, the PICPROG program is notified and the program operation is halted. Otherwise, the falling edge of OSC1 increments the target PIC's internal PC.

Once the configuration bits have been programmed and verified, the target PIC PC now contains 000 hexadecimal, which is the beginning of PIC program memory. The program/verify operation is performed for the rest of the memory locations and a final read/verify is performed to assure everything went OK.

In summary, there are 3 basic steps to programming a PIC:

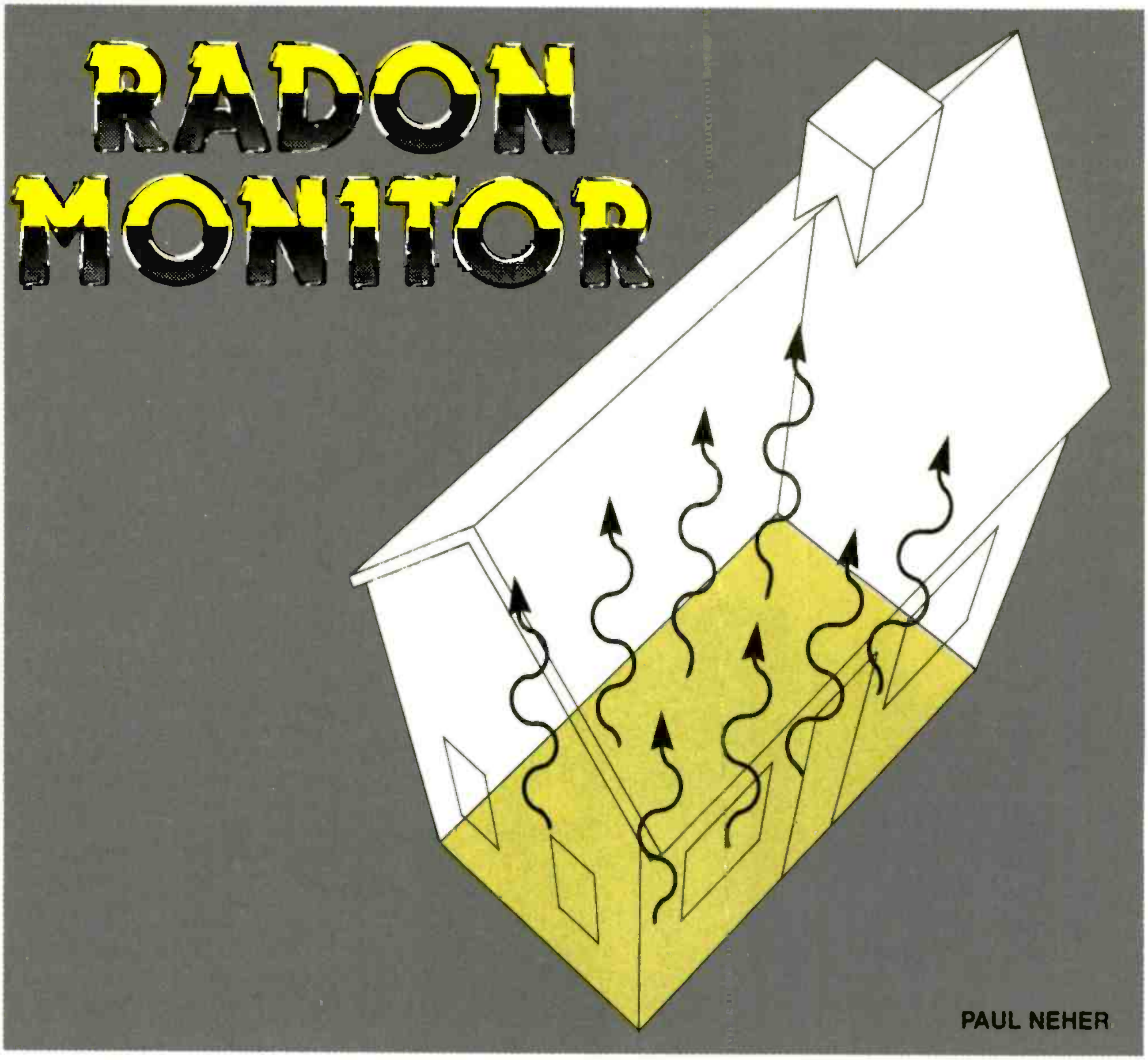
1. Write and assemble your source code.
2. Blank-check the device you wish to program.
3. Program and verify your device.

Rather than to explore the in-depth details of the firmware here, use the programming method flow chart to follow along in the supplied PIC17C42 source code for a detailed explanation of just how the bits and bytes get transferred and programmed.

Next month

Next month we'll finish up this project. We'll start by building the programmer, and because the programmer itself requires a pre-programmed PIC17C42 microcontroller, we'll show you how to build a programmer for that as well. In the meantime, gather together all of the parts you'll need. Ω

RADON MONITOR



PAUL NEHER

Build this radon monitor to detect a possible health threat in your home and, while doing it, learn more about radioactivity.

THIS TWO-PART ARTICLE DISCUSSES the design, construction, and use of a simple, inexpensive environmental radon gas detector that you can build. It is called the beverage can environmental radon monitor or BERM because its ionization chamber sensor is made from a readily available aluminum beverage can. You will be given a choice of methods for measuring and recording events or rates that can be translated into units of radon density.

Most people are exposed to environmental radon in excess of the natural rate because of the time they spend indoors. This first article explains what radon is, why it is a health hazard, and the importance of knowing the level of radon in the rooms of your house where you spend most of your time while indoors. It also includes the information needed to build the ionization chamber, its amplifier circuitry, and alternative circuits for charging the chamber's internal high-voltage capacitor to 500 volts.

The second part of this article covers pulse-rate measurement, instrument calibration, and the conversion of pulse rates to radon density units. The article also offers alternative methods and circuits for performing these functions.

Even if the BERM is only crudely calibrated, it can warn you of unsafe radon levels in your home. However, when properly calibrated, it can give readings that compare favorably with those obtained from professional radon monitoring instruments costing thousands of dollars. Constructing the BERM will give you "hands on" experience in measuring a common form of radioactivity, and give you a better understanding of how it produces isotopes, subjects not easily grasped in lectures or from reading.

The cost of parts to build the BERM, exclusive of a power supply, is typically less than $20. Because most of the components are readily available, you might be able to reduce even that modest cost by making use of parts you already have on hand. You will need the standard electronic technician's set of hand tools as well as such basic electronic test equipment as a two-channel oscilloscope and either an analog or digital multimeter.

What is radon?

Radon is a natural, inert, radioactive gas emitted from the earth. Odorless, colorless, and invisible, it is a byproduct of the radioactive decay of uranium. Because it is inert and does not chemically bond to elements, it is released from the soil into the atmosphere. Radon is emitted almost everywhere on earth, but some geographical regions have higher concentrations than others, depending on the local geology and soil porosity.

Radon becomes a health problem when it decays and produces other short-lived isotopes called *daughter products* or *progeny*. These chemically active isotopes are usually formed as charged particles (ions). They bond readily to other substances such as dust and smoke particulates. Table 1 lists a portion of the decay chain of radon 222 and its short-lived progeny.

When radon decays, it releases alpha particles with an energy of 5.5 million electron volts (5.5 MeV). That would seem to be a large amount, but alpha particles travel only 4 to 7 centimeters (1.5 to 2.5 inches) in air before dissipating their energy in the ionization of air molecules. A piece of paper or even human skin is thick enough to stop alpha particles. Direct exposure to radon, unlike direct exposure to beta particles, gamma rays, X-rays, or even ultraviolet light, poses little risk for humans.

The health threat from radon is indirect. Energetic alpha particles can cause chromosomal damage to the thin layers of lung tissue when humans breath air contaminated by radon and its progeny. That damage is a potential cause of lung cancer, especially when coupled with the effects of cigarette smoke in the lungs.

There are several different forms of radon, but radon 222 is the most prevalent form, and is of the most concern to health researcher. The number 222 refers to its isotope number. The alpha particles emitted by radon and its progeny are helium nuclei.

Most of the radon 222 that is inhaled is either exhaled directly or it diffuses into the bloodstream where its alpha emission does little detectable damage. However, radon's short-lived progeny such as polonium 214 and polonium 218 are more likely to emit alpha particles that are capable of damaging sensitive human tissue.

The alpha particles from the decay process of polonium 218 have 6.0 MeV of energy while those from poloniun have 7.7 MeV, both higher than the 5.5 MeV of radon 222. For this reason, researchers believe that they are the agents primarily responible for inducing lung cancer in situations where radon 222 is present in amounts considered to be above the safe level.

Radon has been a constituent of the air for millions of years. We became aware of its existence only when instruments were developed that could detect and measure it. Its presence is of concern because of the alarming statistics on death due to lung cancer. Its presence has long been considered a contributing factor to those deaths. However, it is difficult to separate cancer attributable to radon alone from that attributable only to smoking or to smoking in the presence of radon.

The harmless concentration of radon in the outdoor air is about one-thousandth of its concentration in the ground. This can be demonstrated by placing an inverted bucket on bare ground over a suitable radon monitor. The radon emanating from the soil collects inside the bucket until an equilibrium condition is reached. The monitor will probably indicate a radon concentration that is several orders of magnitude higher than that in the surrounding air, but less than the soil concentration in the soil.

A house with a foundation, walls, floors, and a roof can be

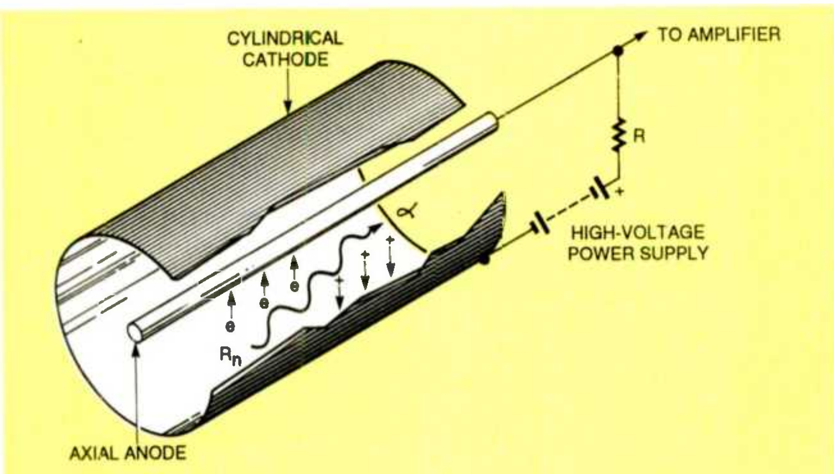


FIG. 1—THEORY OF RADON MONITOR IONIZATION CHAMBER. Positively charged anode wire attracts electrons and negatively charged cathode attracts positively charged ions. The recombination of electrons and ions causes a current that produces a voltage pulse.

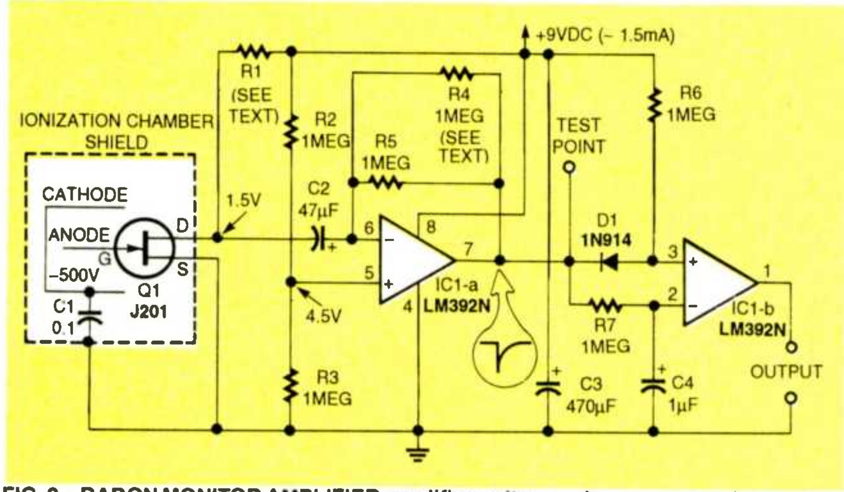


FIG. 2—RADON MONITOR AMPLIFIER amplifies voltage pulses across resistor R1 and then detects them for counting by separate pulse-rate counting circuitry.

TABLE 1
THE DECAY CHAIN OF RADON 222

Isotope	Name	Half life	Decay process	Energy
Rn 222	Radon	3.82 day	alpha	5.49 MeV
Po 218	Polonium	3.05 min	alpha	6.0 MeV
Pb 214	Lead	26.8 min	beta	1.0 MeV
Bi 214	Bismuth	19.7 min	beta	3.3 MeV
Po 214	Polonium	164 µs	alpha	7.7 MeV

considered analogous to a bucket. It will also trap radon that leaks into the indoor airspace, especially if all the doors and windows of the house are closed. Under these conditions, the indoor radon might be 10 to 100 times more concentrated than outdoor radon. People in developed countries typically spend most of their time indoors at work, at school, or at home, so they could be exposed to radon concentrations that are considered to be high enough to endanger health.

Units

The amount of radon in the air, termed specific activity, is measured in units of picoCuries per liter (pCi/l). This can be interpreted as 2.22 disintegrations per minute per liter of air. Typical radon concentration in the outside air is about 0.1 to 0.2 pCi/l. Radon gas in the soil, at a depth of about 15 inches, is typically 100 pCi/l.

The Environmental Protection Agency (EPA) has stated that a radon level within a home of 4 pCi/l or less will present little or no health threat. It has published recommendations for specific actions to be taken where higher concentration levels are found. These include follow-up testing in other rooms in the home. Nevertheless, it is ultimately up to the homeowner to decide what radon level is acceptable for his home in the absence of a scientifically established absolute safe threshold level for radon exposure.

Published risk comparisons indicate that a radon concentration of 30 pCi/l carries about the same cumulative risk as smoking two packs of cigarettes per day.

Detectors

There are many commercial instruments and techniques available for measuring radon indoors. Most detectors for evaluating indoor radon levels are passive in that they do not require external power. Examples include activated charcoal cannisters or nuclear-track etch detectors. These detectors are exposed to indoor air under specified test conditions. After exposure, they are sent off to a laboratory for analysis, the same approach used in detecting X-ray exposure with passive detection badges.

The principal drawback to passive detectors is that they measure radon concentration at only one specific location for a specified period of time. Many variables influence radon concentration levels; therefore, a single estimate of radon concentration is likely to have a significant error.

Obviously, radon concentration surveys based on two or more passive measurements will provide a more accurate assessment than a single measurement, but they are expensive because the price of a "one-time-only" passive detector can range from $25 to $100. If you conduct only one test, the EPA recommends that it be run under *worst-case conditions*.

By worst case conditions, the EPA means that the test should be made in any living space in the home or building that is closest to the ground (just above the floor slab, crawl space or basement) at a time of the year when ventilation is at a minimum—typically during the winter.

The air exchange rate and type of heating and cooling system in a house or building can cause wide variations in the amount of radon present due to differences in the way air is introduced, circulated and exhausted. There can also be daily variations in radon concentration. Because randon readings might exceed limits considered to be safe, it is recommended that radon concentration levels be measured over a one-year period in different locations in the home to obtain the best estimate of long-term risk.

Only an active radon monitor such as the BERM is capable of monitoring radon continuously. Commercial instruments capable of doing that typically cost several thousand dollars. The BERM radon monitor has many of the features of the expensive instruments at a far lower price.

BERM readings will be not be very accurate unless they are compared against those of a properly calibrated test instrument. Nevertheless, even if it is not calibrated, the BERM will yield relative data that is accurate enough to indicate if a radon hazard exists in your home. You can use a BERM to locate the "worst case" room in your house where a follow-up test with a precisely calibrated monitor should be performed if you suspect excessive levels.

Ionization chamber theory

The easiest way to measure the presence of radon is to detect the high-energy alpha particles that it emits as a result of radioactive decay. As can be seen in Table 1, the alpha particle has a kinetic energy of about 5.49 MeV which ionizes the air passing through it. On average, about 34 eV is required to ionize air.

Therefore, assuming that an alpha particle dissipates all of its energy ionizing air, about 100,000 (10^5) electron-ion pairs are generated over a path length of about 4 centimeters (1.5 inches). As a result, a charge of 10^{-14} coulombs can be collected by the electric field inside the ionization chamber.

The BERM ionization chamber, shown schematically in Fig. 1, has a cylindrical form factor because it is constructed from an aluminum beverage can. It has an axial, positively charged wire anode that extends the length of the can.

Negatively charged electrons (e) are attracted to the positively charged anode and arrive a few microseconds after an ionizing event while positively charged ions (+) are attracted to the negative cathode cylinder liner. A few milliseconds later the ions recombine with electrons from the high-voltage, DC-power supply.

The resulting current flow produces a small voltage pulse across the resistor in series with the power supply. That pulse is then amplified, detected, and counted. The number of counts per minute can then be multiplied by a constant that includes the effective volume of the chamber to determine specific radon activity in units of pCi/l. The presence of radon "daughters" produced in the chamber increases the count rate.

The BERM ionization chamber design is based on the assumption that the air inside the chamber is a representative sample of the air in the room that is being monitored. The air in the BERM is slowly exchanged by diffusion through openings in the chamber.

Chamber size

A 12-ounce aluminum beverage can was selected for making the ionization chamber

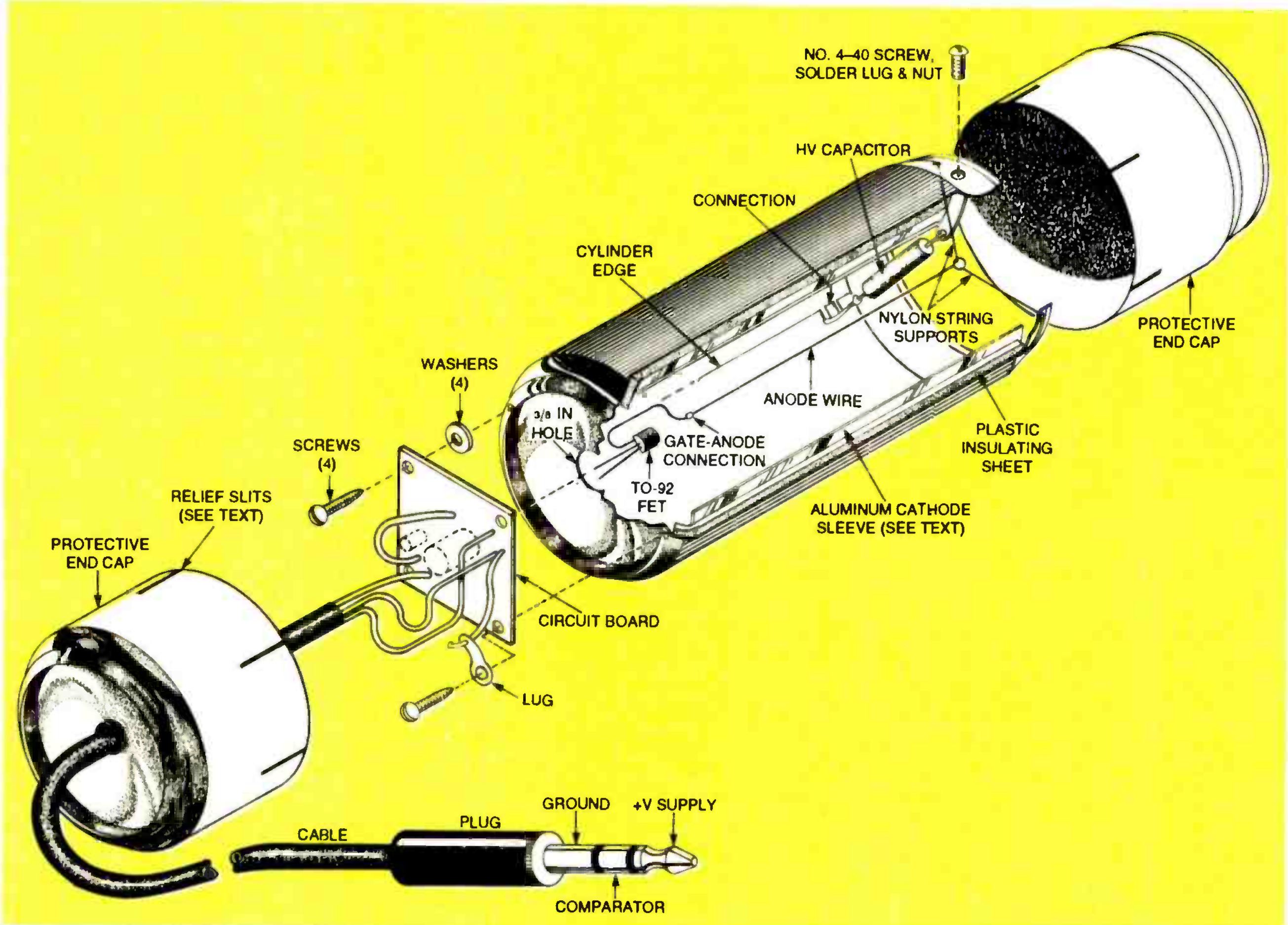


FIG. 3—CUTAWAY OF RADON MONITOR IONIZATION CHAMBER. A beverage can forms the chamber, an aluminum can forms the cathode, and half cans form protective end covers. Amplifier circuit board is shown left of center.

because, in addition to its ready availability, its size is standardized. This size uniformity permits BERM calibration based on chamber size. The can's dimensions are large enough for alpha particles to dissipate most of their energy ionizing air. As stated earlier, the amount of charge generated determines the amplitude of the current pulse collected on the anode.

Ionization caused by beta particles and other naturally occurring radiation, primarily gamma rays, causes lower amplitude pulses in a chamber of this size. This means that it is easier to discriminate the larger alpha ionization pulses from those caused by beta particles and gamma rays as well as by amplifier noise.

High-voltage supply

A nominal but stable 500-volt differential is required to set up an electric field between the anode and cathode. The ion collection efficiency of this chamber remains fairly constant over a voltage range of 200 to more than 1000 volts.

Unfortunately, any noise generated by the 500-volt supply would be coupled directly into the amplifier input. This establishes the additional requirement that the combined noise, ripple, and short-term drift be less than 100 microvolts.

The high voltage is obtained from a charged, 0.1-microfarad metallized-polypropylene-film capacitor. A suitable capacitor will hold its charge long enough to power the ionization chamber for several weeks. It must be recharged whenever the 9-volt battery is replaced.

Before using the BERM, its high-voltage capacitor must be charged from a suitable source. (Alternative methods for obtaining the required voltage will be explained later.) The high-voltage supply was designed to be stable and not be an electrical noise source.

Circuit description

Figure 2 is the schematic for the amplifier. To maximize the amplifier input signal, its capacitance must be minimized. This is done by connecting the chamber's anode wire directly to the gate of JFET Q1. The effects of excess capacitance and leakage current that would be present if a printed circuit had been used for the connection are eliminated. This approach holds total input capacitance to around 7 picofarads. An input pulse charges the gate of Q1 about 1 millivolt.

The charge must be kept on the gate long enough for the amplifier to respond. An input resistance large enough to maintain a long pulse width would introduce too much thermal noise for a good signal-to-noise ratio.

This problem was avoided by letting the gate float or self-bias. The result is that input impedance is maximized and noise is minimized.

A JFET can be self-biased because its gate leakage pulls the gate towards the drain-to-source voltage. By operating the JFET with only 1 to 2 volts from drain-to-source, the gate operating voltage is restored by a current of about 1 picoampere. Both of these techniques rule out the possible use of a circuit board as the gate-to-anode connection. With this design, an alpha ionization produces a large 100-millisecond pulse that is 20 to 40 dB greater than the amplifier's noise.

The principal drawback of this arrangement is that the drain resistor and the feedback resistor must be selected to match the specific JFET used. Moreover, it can take several minutes for the amplifier to stabilize after power is applied. The specified values of some components can be changed to improve BERM's performance after you perform the initial calibration steps.

Thermal stability is not a primary concern for this amplifier because it will normally be operating at room temperature. However, even with relatively wide ambient temperature swings, the BERM's overall calibration is very stable and remains unaffected by amplifier gain changes.

Operational amplifier

The LM392N is a low-power operational amplifier/voltage comparator performs as both an amplifier and comparator. The high-gain, internally frequency compensated op-amp is IC1-*a*, and the comparator is IC1-*b*. Both can operate from a single power supply over a wide range of voltages (3 to 32 volts). Current drain is 600 microamperes—essentially independent of supply voltage. The LM392N shown on Fig. 2 is in an 8-pin DIP package, but the LM392H in a metal can package can be substituted.

The op-amp functions as a current-to-voltage converter following the JFET's transconductance stage. Overall voltage gain is about 60 dB. However, amplifier power gain, due to the impedance transformation, is about 160 dB! To prevent regenerative feedback, the JFET's input must be electrically shielded from the op-amp's output, as will be discussed later.

Threshold detector

The comparator section (IC1-*b*) operates as a pulse-amplitude discriminator and detector. Under quiescent conditions, the positive input pin 3 is about 0.5 volt more positive than the negative pin 2, and the open collector output is high (high impedance).

When an ionization pulse occurs, the op-amp output swings sharply negative from its normal (half) supply voltage. Then it rises slowly with a 0.1 second time constant. If the negative-going peak has more than a 0.5 volt amplitude, the comparator switches state for a period determined by the pulse decay.

The combination of circuit time constants allows the comparator to track the low-frequency amplifier drift yet respond to alpha ionization pulses which are about five times greater than threshold. By adjusting amplifier gain to match the ionization chamber's signals, large alpha ionizations can be detected easily, while much smaller beta particle, gamma ray, and noise ionizations are rejected.

The comparator's output is an open collector which goes low (low impedance) whenever an alpha particle is detected. This output can be interfaced to any logic device, digital counter, or count-rate meter. This will be discussed in detail in Part 2 of this article.

Low-voltage power supply

The optimum low-voltage power supply for the amplifier is a 9-volt, battery. The BERM draws only a few milliamperes, so a 9-volt alkaline transistor battery is should provide an effective life in excess of 50 hours—in addition to permitting it to be a portable instrument. However, if you would prefer to power your BERM from the AC line, a schematic for a suitably filtered 120-volt AC to 9-volt DC converter will be in Part 2 of this article.

Chamber arrangement

Refer to Fig. 3, a cutaway drawing of the ionization chamber. The amplifier is built by point-to-point wiring methods on a prepunched 1¾-inch square circuit board with solder pads on one side. It can be seen, however, that all amplifier components except JFET Q1 are mounted and soldered on the component side of the board.

The drain and source leads of JFET Q1 are to be soldered onto the solder-pad side of the circuit board so that its plastic TO-92 package can extend into the can that forms the chamber through a hole formed in the bottom of the can. This arrangement effectively shields Q1's sensitive input from the rest of the amplifier circuit. As mentioned earlier, the anode wire is a direct an extension of Q1's gate lead, bent 180° away from the other two leads.

Cathode sleeve

Refer to Fig. 3. The approximate 500 volts from charged capacitor C1 are applied between the aluminum can chamber, which is grounded, and a cathode made as an aluminum inner sleeve or lining separated from the can's inner wall by sheet plastic insulation. This

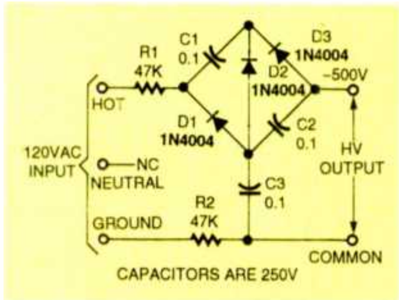


FIG. 4—VOLTAGE TRIPLER CHARGES ionization chamber capacitor. It is powered from the 120-volt AC line.

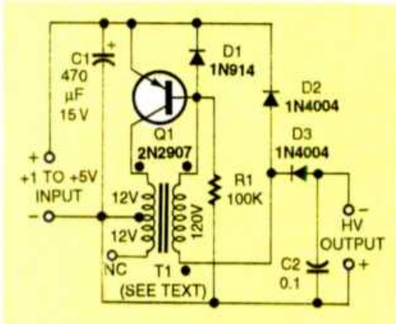


FIG. 5—BLOCKING-OSCILLATOR flyback circuit powered from DC is an alternative for charging the ionization chamber capacitor.

PARTS LIST

Figure 2 amplifier All resistors are ¼-watt, 5%.
R1—selected value (see text)
R2–R7—1,000,000 ohms, carbon composition
All capacitors are aluminum electrolytic, 15-volts, unless otherwise specified
C1—0.1 µF, 630 volts, metallized-polypropylene film, Sprague 730P104X9630 or equivalent
C2—47 µF
C3—470 µF
C4—1 µF
Semiconductors
IC1—LM392N operational amplifier/voltage comparator, National Semiconductor or equivalent
Q1—J201 JFET, National Semiconductor or equivalent
Miscellaneous 3 aluminum 12-ounce beverage cans, 1¾-inch square, punched circuit board with solder pads (Radio Shack No. 276-159 or equivalent), 4 No. 4 self-tapping sheet metal screws and matching washers, 1 4-40 screw and nut, polyethylene sheet (see text), 30-inch length of 3 conductor cable, ¼-inch diameter phone plug, 9-volt alkaline transistor battery, solder lugs, electrical tape, solder.

sleeve-within-a can construction provides the unit with excellent shielding from electrical noise.

With this design, the effective volume of the ionization chamber is considerably reduced, compared to its physical volume, because the electric field includes the end surfaces of the can. These end-surface fields must be accounted for during instrument calibration.

Chamber assembly

Obtain three identical clean, undented, 12-ounce aluminum beverage cans. (They are 4.8 inches high.) Cut the top from the tab end of one can to form the ionization chamber with a can opener so that a crimped-on ring remains. Form a ⅜-inch hole in the center concave bottom of the can.

Then, using the blank 1¾-inch square circuit board specified as a template, drill four small pilot holes on the rim at bottom of the closed end of the can, on top of its circular ridge. Later in the assembly procedure, self-tapping machine screws will be used to mount the circuit board on the end of the can as shown in Fig. 3.

Hold the circuit board in position on the end of the can with the solder tabs directed toward the can. Look in the open end of the can through the ⅜-inch hole and mark the locations of the solder pads that are suitable for Q1's drain and source pins. Plan your parts layout carefully so that one of those pads can be common to the ground or negative power supply pin on op-amp IC1-*a*.

Circuit assembly

Refer to Fig. 2. The selection of the value for drain resistor R1 will depend on the characteristics of the specific J201 JET (Q1) to be used in the circuit. Short the JFET's gate to its source and measure the drain-to- source current (I_{DS}) with a drain-to-source voltage of about 1.5 volts. Then calculate the drain resistor value based on this current and the voltage of the power source you intend to use:

Drain resistor R1 = $(V_S - 1.5)/I_{DS}$
For a J201 FET and a 9-volt battery, R1 should have a value between 10 and 33 kilohms.

When constructing the amplifier, use 1-megohm resistors for both parallel resistors R4 and R5. Form the axial leads of both resistors and solder them so that R5 will remain permanently in position while provision is made for the easy removal of R4 during the calibration process. By doing this, gain can be adjusted later by shunting 1-megohm resistor R5 with another value for resistor R4 until an optimum value is found.

Solder a short tinned wire to the output pin 7 of op-amp IC1-*a* to act as a test point to permit attaching an alligator clip lead or oscilloscope probe. Place a solder lug under one of the sheet metal screws holding the circuit board in position on the end of the can to act as a convenient circuit common or ground lug.

Other than this restriction on the placement of Q1 on the circuit board, the layout of the other components is not critical. Use the convenient pad locations bridged by the components you've selected and any necessary jumper wires to complete the wiring of the circuit. Complete the insertion and soldering of all components on the circuit board except for JFET Q1.

Insert and solder the source and drain leads of JFET Q1 on the solder-pad side of the board. Then carefully bend the gate lead directly away from the other two leads so that it is perpendicular to the solder-pad side of the circuit board.

Solder a length of bare copper wire (28 to 32 AWG) about 4 inches long to the gate lead of Q1, and straighten it so that it is perpendicular to the circuit board. Cut the free end of the anode wire to a length that is about 4½inches long. Twist a small loop (about ¹⁄₁₆-inch in diameter) on the end of the anode wire and solder the joint.

Carefully examine the circuit assembly to be sure that it was made according to the schematic, Fig. 2. Next, connect the chamber can solder lug to the circuit-board ground, connect the output of the comparator, positive supply, and ground connection to a three-conductor cable with plug attached.

Fasten the circuit board to the end of the chamber can with four No. 4 self-tapping sheet metal screws. Use small matching washers between the can rim and circuit board to act as standoffs to prevent the can rim from contacting any of the solder pads that exist on the circuit board.

Cathode assembly

Form the cathode for the ionization chamber by cutting both ends from another of the three cans, and slit the aluminum cylinder longitudinally, being careful not to deform or flatten it. Trim, square the ends of this aluminum sleeve to a length of about 3.7 inches. File off any sharp edges or burrs that could cut through the thin plastic insulation layer to be applied later.

The aluminum in the can has intrinsic spring qualities, so that if its slit edges are overlapped about ¼-inch they will retain their tendency to spring open. Cut two slots about ¼-inch deep and about ⅛-inch apart at right angles to the slit edge of the aluminum cylinder. Those slots form a "digit" for later termination of one end of capacitor C1.

Wrap and crimp a short length of tinned lead wire around this digit as shown in Fig. 3 so that when the cathode sleeve is installed in the can, the lead can be soldered to one end of C1.

The inner wall and ends of these cans have a plastic coating, but it is not dependable as an insulator between the cathode sleeve and the chamber can. Cut a sheet of polyethylene plastic approximately 2 mils thick sheet so that it will extend about ¼-inch beyond each end of the cathode sleeve and overlap its circumference. This material can be taken from sandwich bags, cleaner's garment bags, or other sources.

Drill a small hole in the rim of the can and fasten a small solder lug inside with a No. 4-40 machine screw and a nut as shown in Fig. 3. After being sure that all the metal chips and filings have been cleaned from the chamber can, insert the insulating film and press it against the inner wall of the can and then insert the cathode sleeve. After the insulated cathode has been inserted, check to be sure that there is no metal-to-metal contact between the can and sleeve.

Capacitor installation

Carefully select high-voltage capacitor C1 to make sure that it is a high-quality, low leakage component. If left fully charged, it should retain at least 37% of its charge for at least a month at room temperature.

Solder capacitor C1 to the internal lug with as short a length of lead as possible, as shown in Fig. 3. Position the capacitor in the mouth of the can against the side wall as shown in Fig. 3. Then solder the short wire stub on the cathode to the free end of capacitor C1. Clip its lead short and bend it toward the center of the can so that an alligator clip can be attached to it. Finally, check the resistance between the cathode sleeve and chamber can to be sure that it is effectively infinite.

Protective covers

Cut a third can in half and bend the tab of the top end back to its original unopened position. Carefully slip this top can half over the open end of the chamber can. Expect that it will form a tight "press fit." If the fit is too tight for easy removal, cut several longitudinal slits in the can half to permit slight expansion (see Fig. 3).

Drill a hole in the bottom of the other half can large enough to be able to insert a small rubber grommet which will pass the three-conductor cable. This can end will cover the circuit board and shield it from 60-Hz noise.

Continued on page 91

The vacuum-tube radio, once an important source of news and entertainment, has become a museum piece. But it's fun to revisit those old days of radio by restoring an abandoned set.

VINTAGE RADIO

MARTY KNIGHT

IT IS SATURDAY MORNING SO YOU DECIDE to go to the local flea market to search for an antique radio that you can revive. You never know what you'll find at those outdoor markets. Even if you don't find anything worth saving, at least you'll be walking around in the sunshine and mingling with the crowd.

After trudging up and down the seemingly endless rows of tables you suddenly get lucky and chance upon a real gem. Its obsolete wooden cabinet only hints at its age, so you pull back the heavy cardboard cover at the back and peek in to see the shape of its vacuum tubes—the best clue as to its age. Aha, you're satisfied that you have latched onto a real "oldie but goodie."

Sure, the cloth on the line cord is torn and scruffy and the rubber insulation has turned to brittle clay. Maybe a knob is missing, and there are water stains and mold on the cabinet, but otherwise the set looks complete. After some hard bargaining you get the price down to $25—not bad for a piece of electronic history.

Once you get this "jewel in the rough" home, you begin your exploration by removing the heavy cover, knobs, and screws that hold the dusty metal chassis to the cabinet. After sliding out the chassis you say to yourself, "I'm a member of an elite group that gets a kick out of dabbling in electronic archaeology and restoring old radios to life."

Even before you remove the accumulated layers of dust and grime from the chassis, bespeaking years of neglect in an attic or basement, you examine the tubes. Their shape will give you the most reliable clues about the age of the set. Then as you happily strip away the grime, you carefully note any damaged components that should be replaced along with other components whose replacement is dictated by their age.

If you are lucky, your cleaning efforts might reveal an old paper schematic pasted to the back cover giving the names of the manufacturers of the set and the tubes. An old schematic will simplify your search for replacement parts and permit you to consult one of the many books and catalogs now available that document the history of antique radios.

However, even without a schematic, the shapes of the tubes, the parts layout on the chassis, and even the appearance of the old resistors and fixed and variable capacitors (condensers) should offer abundant clues and hint at manufacturer, circuit design, and the set's place in history—always exciting.

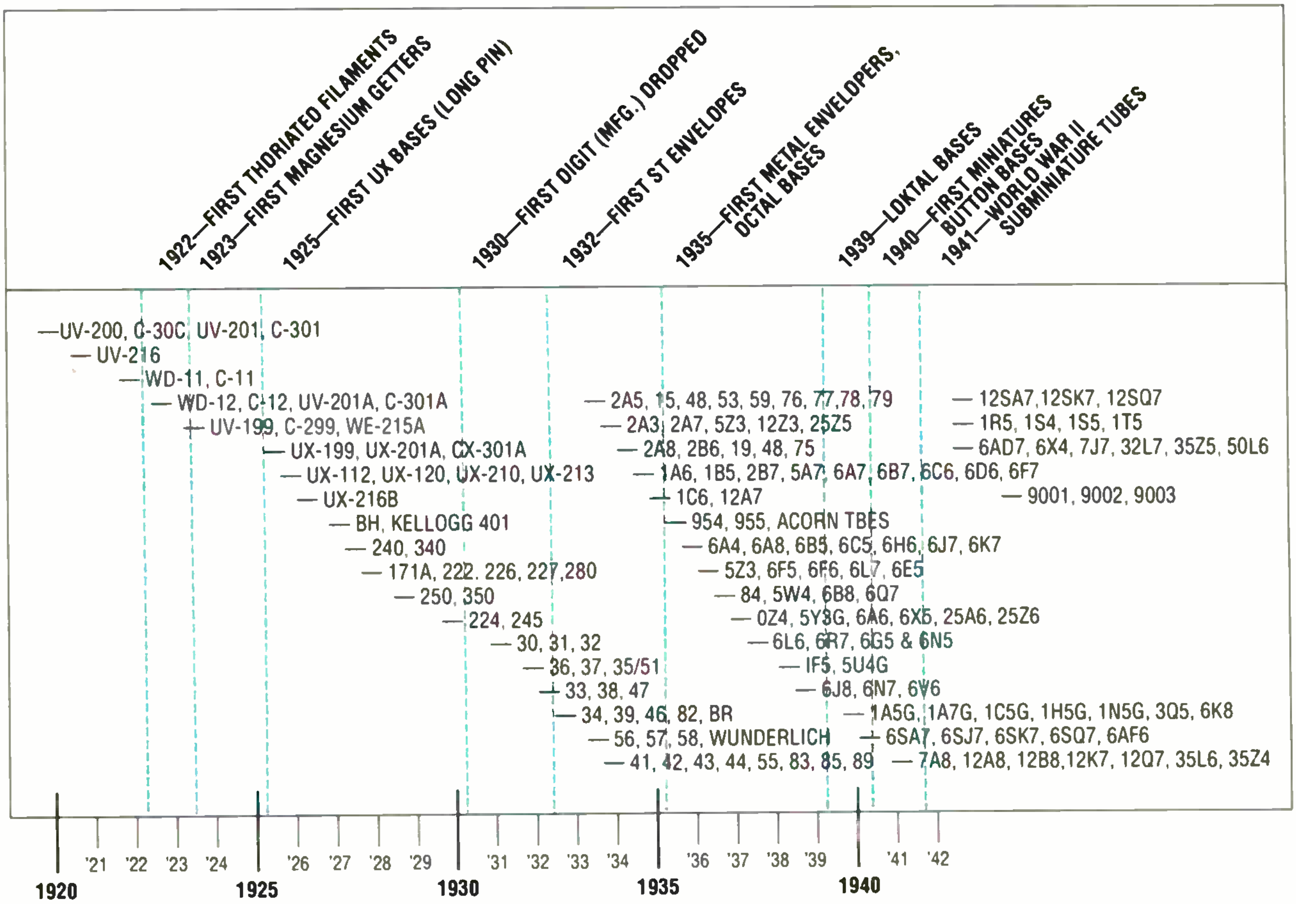
Regulation and set design

Perhaps it's not widely known, but there has long been a close correlation between the design of radio receivers and government broadcasting regulations. This was particularly true of those built during the 1920s. Radio communication was regulated in the United States from 1912 to 1927 by the Radio Act of 1912, administered by the Department of Commerce. This knowledge should come in handy if you chance upon a real "oldie."

The government didn't seem to give much thought to the future growth of radio broadcasting in the 1920s. For example, the Commerce Department licensed Westinghouse's radio station KDKA in Pittsburgh to operate at 500 kHz (in those days called kilocycles or kc). That also happened to be the maritime emergency radio band. Its hard to believe today, but this licensing policy meant that KDKA station engineers had to shut down their transmitter periodically to listen for distress calls from ships at sea!

Before 1922, radio licenses were haphazardly assigned to stations at frequencies between 500 and 1000 kHz without regard to their location or transmitting power. In fact, amateur radio operators had free access to the same frequencies. The cacophony of sound from competing radio stations reduced broadcast reception to audio babble.

TABLE 1



Vacuum Tube Development, 1921 – 1941

Early in 1922 a policy was introduced that licensed all broadcast radio stations to operate on 833 kHz. Even with reduced transmitting power, interference made listening impossible. Meanwhile, radio set ownership had increased from about 50,000 in 1921 to about 100,000 in 1922. Imagine the complaints government officials received about poor radio reception!

The first National Radio Conference sponsored by the Secretary of Commerce in the winter of 1922 resulted in the assignment of specific frequencies for both high- and low-power stations. At that time, high-power stations (from 500 to 1000 watts) were assigned to 750 kHz, and low-power stations (below 500 watts) remained on 833 kHz.

It didn't take long before that solution also proved to be inadequate. Because of their broadband reception characteristics, radios made at that time couldn't discriminate between the two frequencies. In effect, the selectivity of early radios was zero. About 1.5 million radios were made in 1924, and the market grew to 4.4 million radios per year five years later.

Although it was still difficult to tune to a program without interference, radio ownership grew to 5 million receivers by 1926. This was eight years before the Federal Communications Commission (FCC) was formed; some call this act the true birth of modern radio broadcasting.

March of technology

The first radio broadcasts could be heard with simple crystal diode detector receivers—if you were close enough to the transmitter. They could either be purchased or built by listeners as they are today. Crystal radio receivers were unstable and finicky, and they lacked a way to amplify the audio. These drawbacks essentially restricted their use to a single listener wearing headphones.

The invention of the vacuum-tube diode detector as a replacement for the crystal detector did little to improve radio reception. Developed by British scientist J.A. Fleming, it had a filament and plate but, like the crystal diode, it was unable to amplify. However, when American inventor Lee DeForest developed a tube with a third electrode called the *control grid*, the modern receiving tube arrived. Other innovations developed during that period included the tuned circuit and the grid-leak detector.

However, radio reception took another giant leap forward with the invention of the regenerative receiver by Edwin Armstrong in 1915. It included the triode, a tuned circuit, and grid bias. Positive feedback offered improved sensitivity, selectivity, and audio output power. However, its drawback was its dual-battery requirement—one to heat the filament and another for grid bias and plate voltages.

If you bought a radio in the early 1920s, you also had to buy several batteries, typically a dry Le Clanche lantern battery and a lead-acid automotive battery. Needless to say, they called for a strong shelf under the radio table and posed the ever present threat of spilled acid.

In the regenerative receiver, a small amount of amplified RF signal was fed back to the grid circuit of the triode, putting it on the verge of oscillation. This circuit design maximized signal gain and improved sensitivity, but the degree of feedback was difficult to control.

Slight changes in the ambient temperature, signal strength, battery voltage, or mechanical vibrations, for example, could cause the receiver to break into oscillation. (This was not surprising in view of the fact that an Armstrong regenerative receiver is essentially the same as an Armstrong oscillator.) If this occurred, the receiver was immediately transformed into a transmitter on the same frequency as the tuned signal. Imagine the howls that emitted from all the receivers in the neighborhood when one of them broke into oscillation!

Another frequently overlooked fact is that the regenerative receivers of the 1920s could continuously tune the maritime, limited broadcast and amateur bands that were located between 500 and 1500 kHz, all within the limits of today's 540 to 1600 kHz AM broadcast band.

Regenerative receiver popularity declined in 1923 with the introduction of the tuned-radio-frequency (TRF) radio. Better vacuum tubes, improved manufacturing techniques, and experience gained from solving earlier reception problems led to the TRF receiver.

Little more than a tuned RF amplification stage and a non-regenerative detector, these receivers eventually evolved into standard five-tube receivers that included two tuned RF stages, one detector, and two audio amplification stages. By 1926 the TRF receiver dominated the market and broadcast

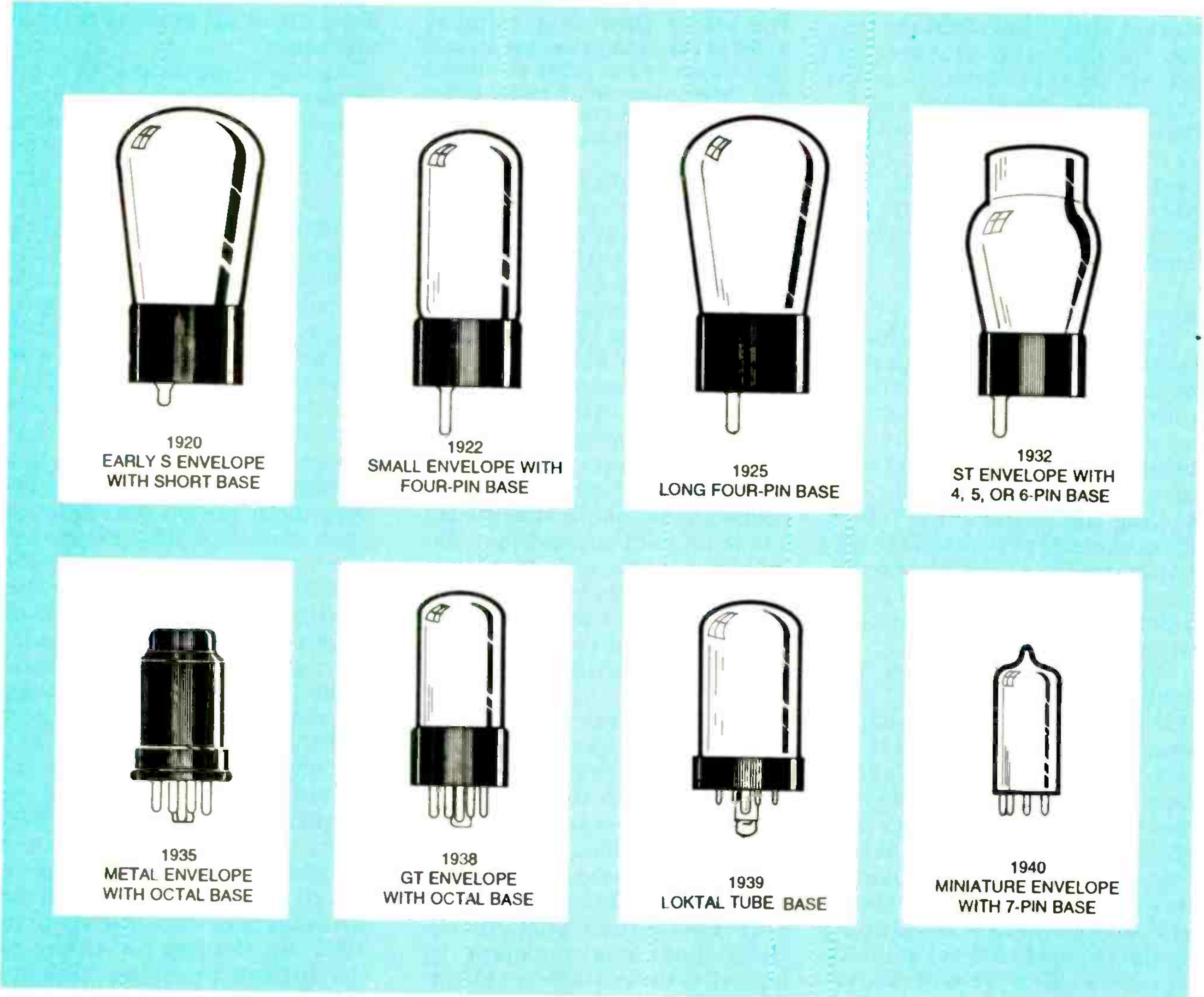


FIG. 1—THE CHANGES IN TUBE PROFILES WILL PROVIDE IMPORTANT CLUES about the age of the vintage radio you intend to restore.

stations were being licensed to operate over increments of 10 kHz. Radio was at last out of the dark ages!

But even the TRF receiver was not without its problems: strong signals were likely to cause the tuned triode RF stages to break into oscillation. The Neutrodyne receiver attempted to solve those TRF problems. It relied on a small amount of negative feedback to stabilize the tuned RF circuitry so the triodes did not oscillate.

After that development, second-generation TRF receivers took advantage of the screen-grid vacuum tube introduced in 1927. As a result, self-oscillation was eliminated and the door was opened for the first true "one-knob dialing" radios.

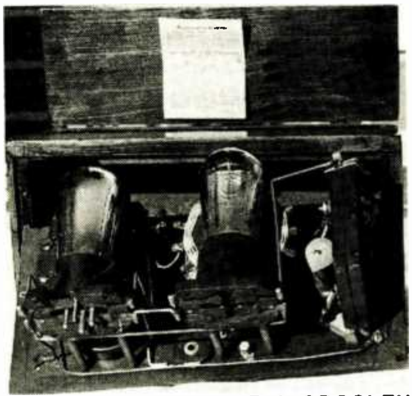
The TRF radio held the dominant share of the radio receiver market until 1932 when the Radio Corporation of America (RCA), under threat of anti-trust suits, released its superhetrodyne circuit for licensing by other manufacturers. After that landmark decision, the five-tube superhetrodyne receiver became the most popular consumer radio.

Receiving tubes

Each major advance in home radio receivers was supported by improvements in vacuum tube design and reliability. The age of any radio you might find in an attic or flea market can usually be determined by observing the shape of the tube's glass or metal envelope. Figure 1 illustrates the evolution of radio receiving tubes by date of manufacture based on the changes in their outlines.

The first vacuum tubes had bulbous glass envelopes and tubes with bulb or bottle shapes were being made for many years after that, particularly rectifier tubes. However, early in the 1920s some receiving tubes had glass envelopes whose diameters barely exceeded the diameters of their bases. Tube bases and sockets were standardized by the 1920s, but developments in base style were still taking place as late as 1939.

The first receiving tubes with metal envelopes were introduced in 1935. However, miniature glass "peanut tubes" with glass button bases (stems) and wire pins were introduced in the 1940s. Most postwar receivers had complements of these miniature tubes, but the larger tubes were in hi-fi equipment well into the 1950s, particularly for output stages.



THE INSIDE VIEW OF A CROSLEY model 51 regenerative receiver made in 1924 shows its two tubes and tuning dial. Battery-operated, it had a tuning capacitor whose plates opened like book covers as capacitance was varied.

Three distinct periods of vacuum-tube evolution are recognized. The first included tubes developed and manufactured during the period extending from World War I to 1922. Crudely made and not particularly reliable, there were likely to be performance differences between individual tubes because of slight differences in construction. The early tubes had tungsten filaments that lit up like weak pilot lamps when filament voltage was applied. Those early filaments served both as heaters and cathodes. These filament/cathode tubes are lumped into the first of three groups.

Because so few radios were made during this early period, vintage radio buffs consider them to be the true antiques worthy of preservation. If you locate one of them, you have a true find. However, because their components are fragile and replacement parts (other than those custom made by skilled artisans) are no longer available, those antiques are essentially unrepairable.

The introduction of the thoriated filament marks the start of the second period. The filaments of these tubes were coated with thorium-based chemicals capable of emitting clouds of electrons when the filament was heated to a dull, cherry-red color. However, this electron cloud was reasonably uniform within a wide range of applied filament voltage that assured generally stable circuit operation.

The third and final stage in the development of vacuum tubes began in 1927 when RCA introduced its new generation of tubes designed for AC-line operation. These tubes had separate cathodes that were heated by a separate filament. The cathode was a more efficient electron source than the coated filament. This design concept lives on in all modern cathode ray tubes.

Another interesting development was the loctal-base tube, a spinoff from the standard octal base design. It was intended for use in automotive radios and the bulky portable receivers available in the pre-World War II years. The center stem of the base locked into a mating socket hole with a spring that prevented the tube from being shaken loose by shock and vibration. This innovation quickly spread to the newer tube designs.

Nevertheless, some radio historians recognize a fourth development period that extends from World War II to the start of the transistor era in the 1960s and includes a wide range of inovations such as tube miniaturization and the introduction of improved materials. Table 1 identifies the tube types developed between 1920 and 1942.

Commercial television inspired many new tubes. For example, the Compactron—effectively several discrete tubes in a single envelope—was introduced for TV sets. However the introduction of the transistor in 1947 cut the legs out from under further receiving tube development.

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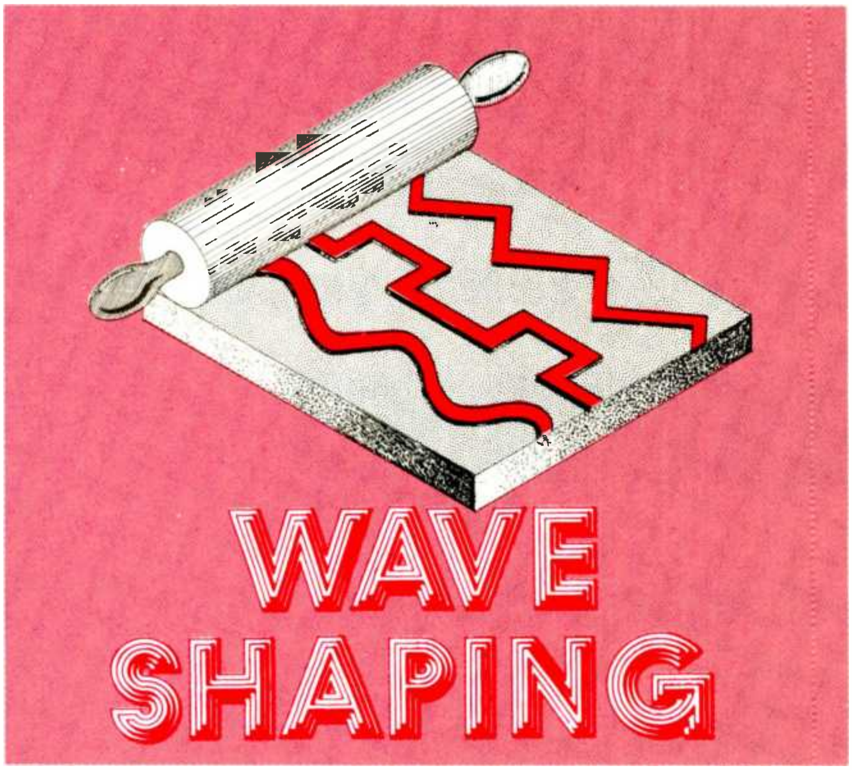


S1: the circuit locks into this state until Q2 is turned off by S2. At that time the output locks into the high state, and this action can be repeated as long as the circuit is powered.

Figure 2 shows a monostable (one stable state) multivibrator or *one-shot* pulse generator circuit. Its output is normally low, but switches high for a preset period (determined by the vales of C1 and R2) if Q2 is briefly turned off with S1.

Figure 3 shows an astable (no stable states) multivibrator or free-running square-wave generator. The on and off periods of the square wave are determined by the values of R3 and C1 and R2 and C2.

Figure 4 shows a *Schmitt trigger* or sine-to-square waveform converter. Transistor Q2 switches abruptly from the ON state to the OFF state, or conversely, as the base of transistor Q1 base rises above or falls below the predetermined trigger-voltage levels.

Several different practical astable multivibrator circuits were discussed in last month's article. This article will examine practical versions of three other multivibrators.

WAVE SHAPING

Learn the basics of waveform generation and shaping with bipolar transistor circuits that you can build and put to work.

RAY MARSTON

THE SUBJECT OF THIS ARTICLE IS waveform generation and shaping as performed by various kinds of multivibrator circuits and special-purpose oscillators. It is a continuation of last month's article on transistorized RC and LC oscillator circuits, and the astable multivibrator. Previous articles in this series have covered the basics of the bipolar junction transistor (BJT) and have presented a general roundup of popular BJT circuits starting with those basic transistor amplifiers: common-collector, common-emitter and common-base.

Multivibrator basics

A transistor multivibrator is a cross-coupled, two-stage switching circuit. Each active transistor stage is regeneratively cross-coupled to its companion; thus, one stage automatically turns on as the other turns off, and conversely. This cross-coupling can be arranged to give either stable or semistable switching. When stable cross-coupling is desired, the transistor switch locks permanently into the ON or OFF state until it is forced to change state by an external signal.

When the circuit is cross-coupled in a semistable manner, the transistor initially locks into the ON or OFF state, but then automatically becomes "unlocked" again after a delay period determined by the time constant of the cross-coupling components.

Schematics of the four basic transistor multivibrator circuits most commonly used are shown in Figs. 1 to 4. The Fig. 1 circuit is a manually triggered bistable (two stable state) multivibrator. The base-bias of each transistor is obtained from the collector of the other transistor, so that one transistor automatically turns off when the other turns on, and conversely.

The output can be driven low by briefly turning Q1 off with

Monostable circuits

The monostable multivibrator circuit in Fig. 2 acts as a triggered pulse generator. Normally transistor Q2 is driven into saturation through R2, so the output (taken from transistor Q2's collector) is low. Transistor Q1, which derives its base-bias from transistor Q2's collector through resistor R4, is cut off under this condition, and its collector is at the full supply voltage.

When a START signal is applied to Q2 by momentarily closing switch S1, Q2 switches off, driving the output high and driving Q1 on through R4. Regenerative switching action is caused by the reopening of S1.

Transistor Q2's base is driven negative by the charge on C1, and as soon as the regenerative response is complete, C1 starts to discharge through R2. Eventually its charge falls so low that Q2 turns on again, thus initiating another regenerative response. Now both transistors revert to their original states, and the output pulse terminates, completing the action of the circuit.

Thus, a positive-going pulse is developed at the output of this circuit each time an input trigger signal is applied by momentarily closing switch S1. The pulse period is determined by the values of R2 and C1. The relationship is:

Pulse period = $\approx 0.7 \times R2 \times C1$

Where the pulse period is in microseconds, C is in microfarads, and R is in kilohms.

The circuit in Fig. 2 can be triggered either manually by closing a momentary switch or by introducing an input trigger signal. That trigger signal can be either a negative pulse applied to the base of Q2, or a positive pulse applied to the base of Q1.

Figure 5-*a* is a practical schematic for a manually triggered monostable multivibrator. It can be triggered with momentary switch S1 by feeding a positive pulse to Q1's base through R2. Figure 5-*b* shows the circuit's waveforms.

In Fig. 5, the base-to-emitter junction of Q2 is reverse-biased during the operating cycle by a peak voltage equal to the supply voltage. This means that the maximum supply voltage should be limited to about 9 volts to prevent damage to the transistor. However, a supply voltage greater than the reverse base-emitter breakdown value of Q2 can be applied safely if silicon diode D1 is placed in series with Q2's base, as shown in Fig. 5.

This higher supply voltage provides the same kind of *frequency correction* that was described for the astable multivibrator in last month's article.

The value of timing resistor R3 in the Fig. 5 circuit must be large with respect to R1, but

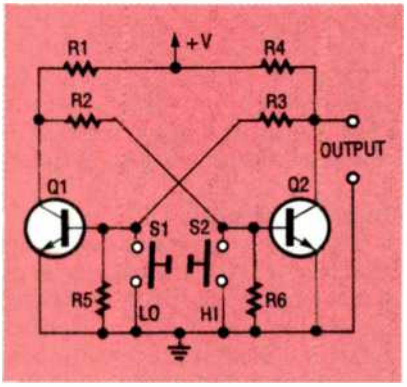


FIG. 1—A BISTABLE MULTIVIBRATOR intended for manual-triggering.

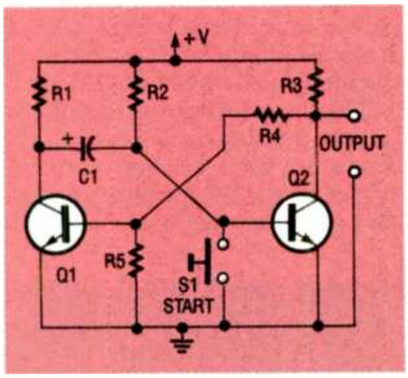


FIG. 2—A MONOSTABLE multivibrator designed for manual triggering.

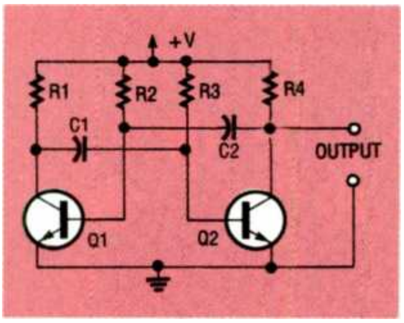


FIG. 3—AN ASTABLE MULTIVIBRATOR or free-running squarewave generator.

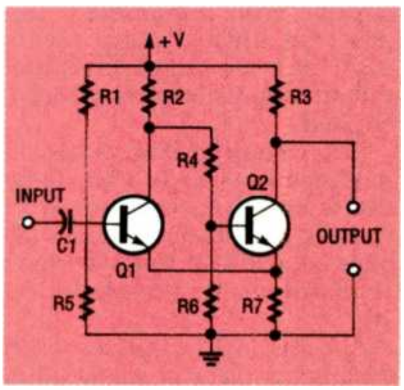


FIG. 4—A SCHMITT TRIGGER circuit is a sinewave-to-square wave converter.

must be less than the product of R5 and the h_{FE} of Q1. The pulse period for Fig. 5 equals 50 milliseconds divided by the value of capacitor C1 in microfarads; it will be 5 seconds with the value of C1 shown.

Long delays

If a Darlington transistor pair is substituted in place of Q2 in Fig. 5, the circuit will be able to provide very long timing periods. That substitution results in a very high effective h_{FE}, and permits the use of large values of R3, as shown in Fig. 6.

The Fig. 6 circuit can be powered from any DC source with an output between +6 and +15 volts to give a pulse output period of about 100 seconds with the values of the resistors and capacitors shown.

Keep in mind that a manually triggered monostable circuit such as those of Figs. 5 and 6 is dependent on the duration of the input trigger signal. The circuits trigger at the moment that a positive-going pulse is applied to the base of Q1 in Fig. 5 or Q3 in Fig. 6. If this pulse is removed before the monostable multivibrator completes its normal timing period, the period will end regeneratively, as previously described.

However, if the trigger signal has not been removed by the time the monostable completes its natural timing period, the timing cycle will end non-regeneratively. This means that the output pulse will have a longer period and falltime than if the trigger signal were removed earlier.

Waveform triggering

Figures 7 and 8 show alternative ways of applying input signal triggering to the monostable pulse generator. In each case, the circuit is triggered by a square-wave input signal with a short rise time. This waveform is differentiated by the differentiation circuit consisting of C1 and R1 to produce a brief trigger pulse.

In the Fig. 7 circuit, the differentiated input signal is rectified by diode D1 to provide a positive trigger pulse on the

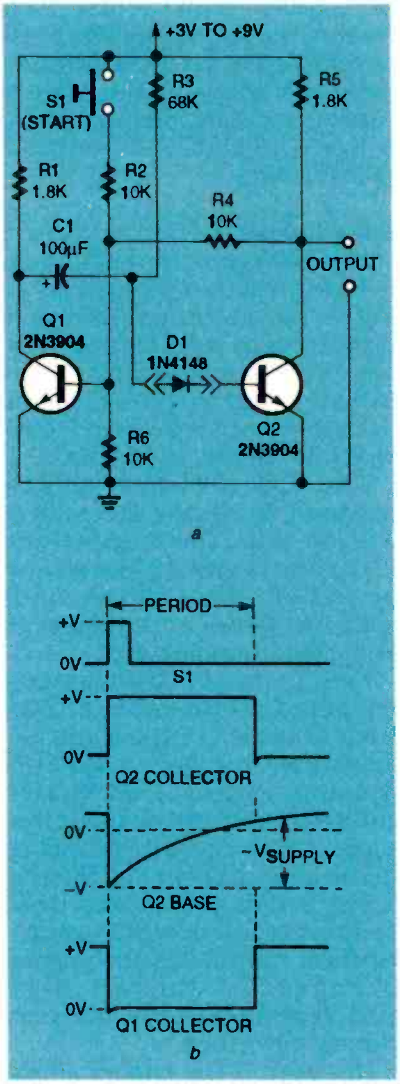


FIG. 5—A MANUALLY-TRIGGERED monostable pulse generator.

base of Q1 each time an external trigger signal is applied. In the Fig. 8 circuit, however, the differentiated signal is fed to the gate of transistor Q1. That change in the circuit makes the trigger signal independent of Q2. Notice that "speed-up" capacitor C3 in Fig. 8 is connected in parallel with feedback resistor R5 to improve the shape of the output pulse.

Both the circuits in Figs. 7 and 8 provide an output pulse period of about 110 microseconds with the values of resistors and capacitors shown. This period can be varied from a fraction of a microsecond to several seconds with a suitable choice of values for capacitor C2 and resistor R4.

The circuits in Figs. 7 and 8 can be triggered by sine or other non-rectangular waves if they are conditioned by a Schmitt trigger or similar sinewave-to-squarewave converter circuit. (The Schmitt trigger circuit is discussed later in this article.)

Bistable circuits

Figure 9 is practical schematic for the manually-triggered bistable multivibrator shown in Fig. 1 and described earlier. This circuit is also known as a R-S (reset-set) flip-flop and, like a toggle switch, it is also an elementary digital memory. Its output can be SET to the high state by momentarily closing switch S2. (Alternatively a negative pulse can be applied to the base of Q2.)

The circuit then "remembers" this state until it is RESET to the low state by a momentary closing of S1 (or by applying a negative pulse to the base of Q1). The circuit then "remembers" this new state until it is again set by S2. This cycle can be continued indefinitely as long as power is applied.

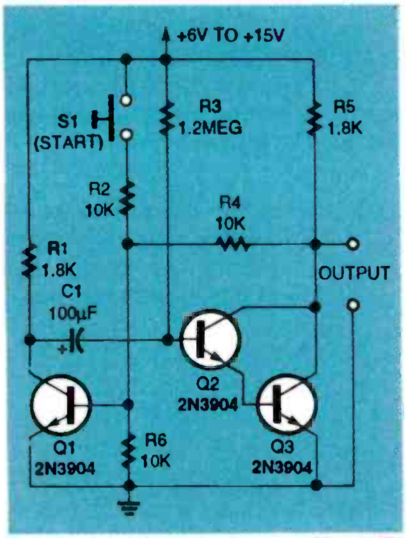


FIG. 6—A LONG-PERIOD (100-SECOND) monostable circuit.

The circuit in Fig. 9 can be modified to provide a divide-by-two or counting function by including two *steering* diodes (diodes D1 and D2) and associated components, as shown in Fig. 10.

The Fig. 10 circuit changes state each time a negative-going trigger pulse is applied. If, for example, the input pulses are derived from a squarewave input signal, the circuit will generate a squarewave output signal at half the input frequency.

The circuit generates a pair of output signals that are 180° out of phase, shown here as Q1 and Q2. The introduction of CMOS IC versions of the bistable counter circuit have largely eliminated any need for the construction of these circuits from discrete components.

Schmitt trigger

The last member of the multivibrator family to be discussed here is the Schmitt trigger circuit. It is a voltage-sensitive switching circuit that changes its output state when the input signal exceeds or falls below preset upper and lower threshold levels. Figure 11 shows how the Schmitt trigger converts sinewaves to square waves.

The Schmitt trigger circuit is emitter-coupled and has cross-coupling between the base and collector of transistor Q1, which provides the required regenerative switching. Capacitor C2 speeds up the switching action by shunting R4. The sinewave input signal is superimposed on a DC voltage. (The voltage is determined by trimmer potentiometer R8 and resistors R1 and R2) that is applied to the base of Q1.

A practical Schmitt trigger needs a sinewave input signal with an amplitude of at least 0.5

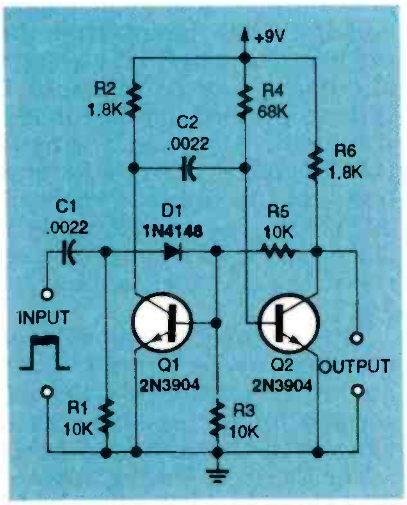


FIG. 7—A WAVEFORM-TRIGGERED monostable circuit.

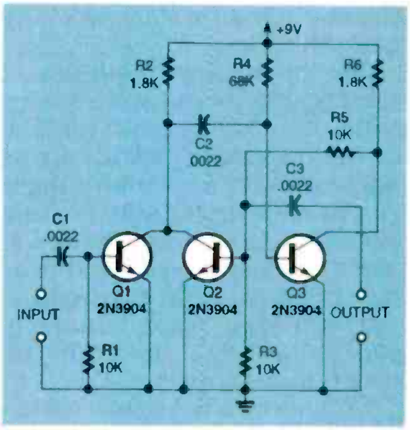


FIG. 8—A MONOSTABLE CIRCUIT with gate-input triggering.

volts, rms. The squarewave output signal symmetry varies with the input signal amplitude, so R8 must be adjusted to optimize that symmetry. The Schmitt trigger performs satisfactorily as a sinewave-to-squarewave converter at frequencies up to a few hundred kilohertz. The device produces squarewave output signals whose rise times are only a fraction of a microsecond.

Sawtooth generators

The astable multivibrator shown in Fig. 3 is one of a variety of circuits that can generate sawtooth waveforms. For example, it can generate negative-going sawtooth waves at the bases of both transistors Q1 and Q2. As a result, the astable multivibrator can be considered as another *free-running sawtooth generator*.

Similarly, the monostable multivibrators shown in Figs. 5 to 8 each generate a negative-going sawtooth on the base of Q2 during their active phases. They can be considered as *triggered sawtooth generators*.

Practical versions of Figs. 5 to 8 generate slightly nonlinear sawtooth waveforms because each of their timing capacitors charge exponentially (rather than linearly) through their timing resistors. This abberation can be easily overcome by replacing each timing resistor with a constant-current generator capable of generating linear waveforms.

A timing circuit based on the 555-type integrated circuit timer offers the best way to generate positive-going triggered sawtooth waveforms. However, if you want to generate free-running, positive-going sawtooth waveforms, this can be done with a unijunction transistor or UJT, connected in the circuit shown in Fig. 12.

The UJT is a three-terminal

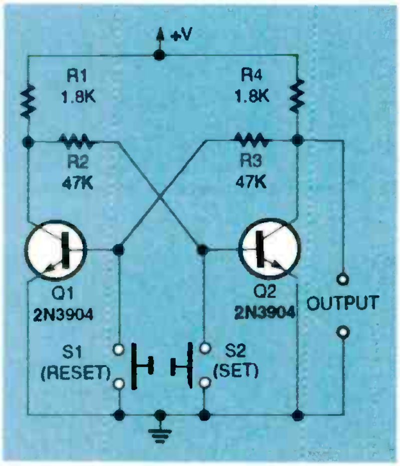


FIG. 9—A SWITCH-TRIGGERED FLIP-flop (R-S) bistable multivibrator.

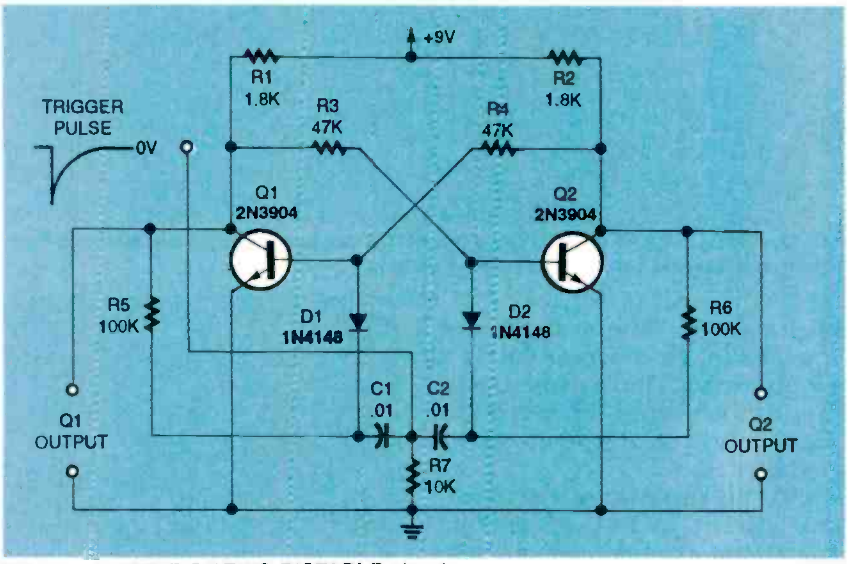


FIG. 10—A DIVIDE-BY-TWO BISTABLE circuit.

transistor whose terminals are identified as *emitter* (E), *base 1* (B1), and *base 2* (B2). A UJT is connected as shown in Fig. 12 as Q1 with its B2 positive with respect to B1, and with the input applied to its emitter terminal.

The emitter of the UJT Q1 presents a very high impedance until the input (emitter) voltage reaches a specific *firing* voltage. At that time, UJT Q1 switches abruptly to the ON state. When it is on, the emitter presents a low input impedance, and it draws a significant amount of current from the input circuitry. However, if this input current falls below a certain threshold value, UJT Q1 automatically switches back to its high input impedance state.

In Fig. 12, capacitor C1 charges exponentially towards the positive supply voltage through trimmer potentiometer R4 and R1 until the voltage on C1 reaches the firing value of the UJT Q1. At that time, the Q1 switches on and rapidly discharges C1. As soon as C1 is discharged, Q1 turns off again, so C1 starts to recharge again through R4 and R1.

This circuit generates a stable but nonlinear sawtooth waveform that van be varied from 25 Hz to 3 kHz by R4, with the value of capacitor C1 shown. Transistor Q2 and Q3 are connected as a Darlington emitter-follower

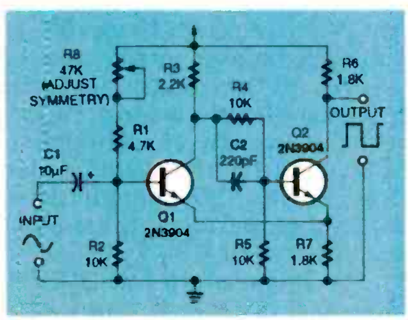


FIG. 11—SCHMITT TRIGGER sinewave-to-squarewave converter.

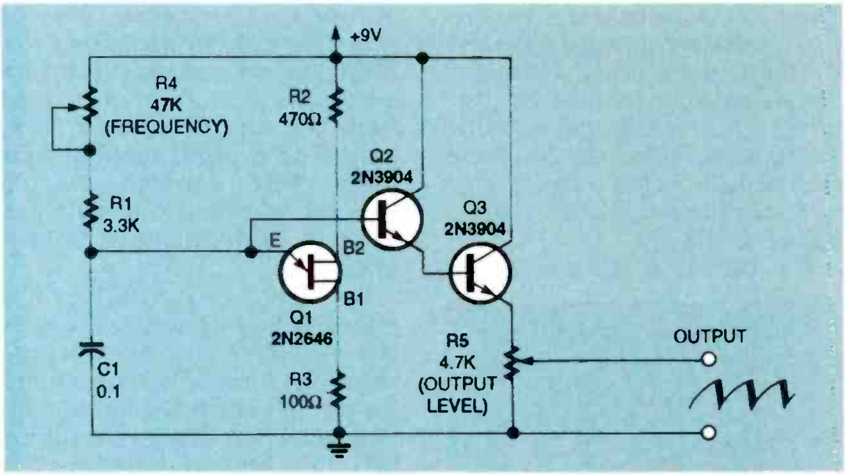


FIG. 12—**A NONLINEAR SAWTOOTH GENERATOR** that works over a range of 25 Hz to 3 kHz.

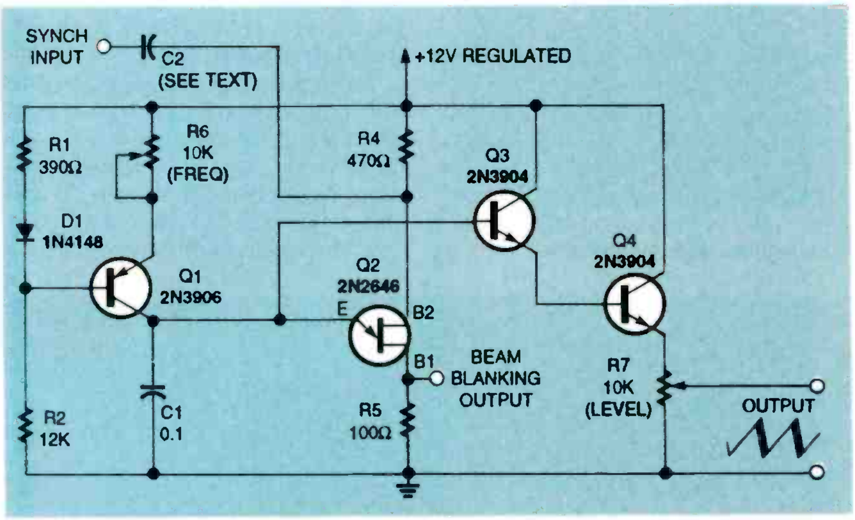


FIG. 13—**THIS LINEAR SAWTOOTH GENERATOR** can function as a oscilloscope timebase generator and can blank the CRT beam.

buffer stage. This arangement makes a low-impedance sawtooth waveform available at an output terminal taken from the wiper of output level potentiometer R5.

The linear sawtooth generating circuit in Fig. 12 can be modified to become an oscilloscope timebase generator. The modified circuit is shown in Fig. 13. Capacitor C1 is charged by a constant-current source. In this circuit, Q1 functions as a temperature-compensated, constant-current generator. It current can be varied from 35 to 390 microamperes by adjusting frequency trimmer potentiometer R6.

The linear sawtooth is available as a variable output whose amplitude can be varied by setting level potentiometer R7. The output between R7 and ground can be fed via a coaxial cable to the external timebase jack of an oscilloscope.

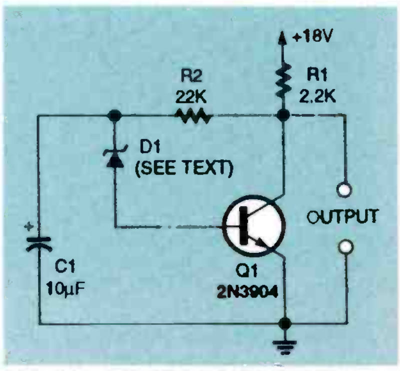


FIG. 14—**A WHITE-NOISE GENERATOR** has many applications.

Positive "flyback" pulses taken between resistor R5 and B1 of UJT Q2 at the beam-blanking output can be used to blank the oscilloscope beam if taken through a high-voltage blocking capacitor.

The operating frequency of the Fig. 13 circuit can be varied from 60 to 700 Hz with R6 if all of the component values are as shown. Other frequency ranges can be obtained by substituting other values for capacitor C1. The timebase generator can be synchronised to an external signal by feeding the external signal to UJT Q2 through the synch input capacitor C2.

This external signal, which must have a peak amplitude between 200 millivolts and 1.0 volt, effectively modulates the supply voltage (and thus the trigger point) of UJT Q2. It causes UJT Q2 to fire in synchronism with the external trigger signal.

Capacitor C2 must have a lower impedance than resistor R4 at the sync signal frequency. Also, capacitor C2 must have a working voltage that is greater than the external voltage from which the external signal is applied. If the sync signal has a rectangular form with short rise and fall times, the value of C2 need only be a few hundred picofarads.

White-noise generator

"White noise" is another useful waveform. It is a signal that contains a full spectrum of randomly generated frequencies, each having equal mean power when averaged over a unit of time. White noise is useful for testing audio and radio frequency amplifiers, and it is widely used to mask background noise to serve as a sleeping aid.

Fig. 14 is the schematic for a simple, practical white-noise generator. In operates on the principle that all reverse-biased Zener diodes inherently generate white noise. In Fig. 14, R2 and D1 are connected in a negative-feedback loop between the collector and base of common-emitter amplifier Q1. Negative feedback stabilizes the DC working levels of the generator. Capacitor C1 serves to decouple alternating current from the circuit.

The Zener diode acts as a

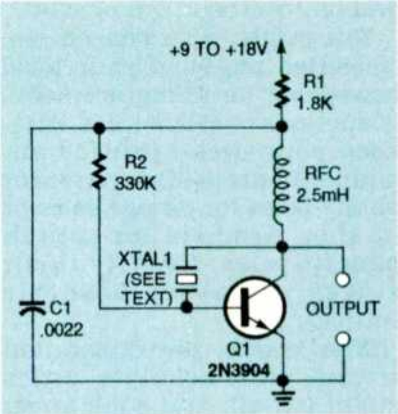


FIG. 15—A PIERCE OSCILLATOR with a parallel-mode crystal.

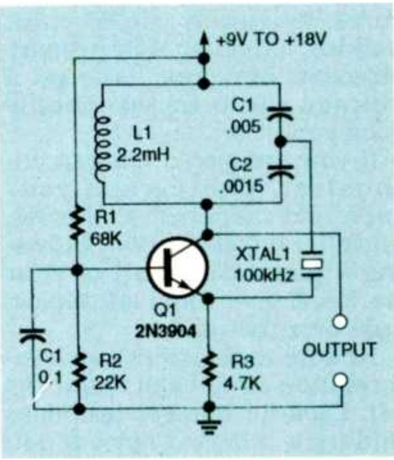


FIG. 16—A 100-kHz COLPITTS oscillator with a series-mode crystal.

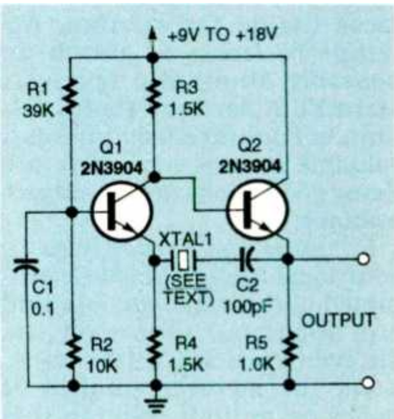


FIG. 17—THIS 50-kHz to 10-MHz oscillator will work with most series-mode crystals.

white-noise source that is in series with the base of transistor Q1. The Zener noise is amplified by the transistor to a useful level of about 1 volt peak-to-peak. Any Zener diode rated for 5.6 to 12 volts should work well in this circuit. Try different Zener diodes and compare the white-noise output.

Crystal oscillators

Crystal oscillator circuits generate accurate, stable frequencies because they include precisely cut piezoelectric quartz crystals which function as high precision electromechanical resonators or tuned circuits. The crystals in these circuits typically have Qs of about 100,000, and they can provide as much as 1000 times greater frequency stability than can conventional inductive-capacitive (LC) tank-circuit oscillators.

A piezoelectric crystal's operating frequency of a few kHz to 100 MHz is determined by its mechanical dimensions. The crystal, can be cut to provide either series or parallel resonant operation. Series-mode crystals present a low impedance at resonance, while parallel-mode crystals present a high impedance at resonance.

Figure. 15 is a practical schematic for a crystal oscillator that is designed for a parallel-mode crystal. The circuit is actually a Pierce oscillator, and it will oscillate with most 100-kHz to 5-MHz parallel-mode crystals without any circuit modification.

Figure 16 shows an alternative 100-kHz oscillator that was designed for a series-mode crystal. It is known as a Colpitts oscillator.

Its tank circuit, consisting of L1, C1, and C2, is designed to resonate at the same frequency as the crystal. However, the tank circuit component values must be changed if any other crystal frequencies are desired.

Figure 17 is the schematic for a useful two-transistor oscillator that will work with most 50 kHz to 10 MHz series-resonant crystals. In this circuit, Q1 is connected as a common base amplifier, and Q2 is an emitter follower. The output signal (from Q2's emitter) is fed back to the input (Q1's emitter) through C2 and the series-resonant crystal. This is a versatile oscillator circuit that will work even with a low-cost, marginal crystal. Because of that, the circuit can form the heart of a simple crystal tester. Ω

VINTAGE RADIO

continued from page 66

Panel controls

As the concept of the radio receiver changed from that of a laboratory curiosity to household furnishing, the packaging of radios underwent dramatic changes. For example, tuning dials in the mid-1920s were round, fluted knobs two to four inches in diameter. Typically, they were molded from black bakelite with contrasting recessed white scale markings from 0 to 100.

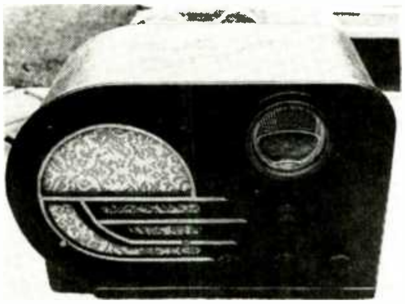
Dial calibration in units of 10 to 100 remained common as late as 1928. Toward the end of that decade, tuning dials that indicated tuning frequency were placed inside the cabinet and appeared in a small semicircular window. Numbers printed on a translucent drum were backlit by a small incandescent lamp, and an embossed escutchen plate formed the pointer. Later innovations, such as full-vision dials and the rotating pointer with fixed half-circle etched faceplate, were introduced between 1930 and 1932.

The excitement and glamor of airplanes had a major impact on the design of radio controls, particularly after Lindberg's successful solo flight to Paris in 1927. The aircraft-style round dial, mimicking an altimeter or tachometer, became quite popular. Those dials had a pointer that moved over nearly 360.° Demand for larger diameter dials grew from 1933 to 1941. The popular slide-rule dial first appeared in 1938; it has retained its popularity in transistorized radios because its pointer tracks across a long, easy-to-read faceplate.

Cabinet styles

Cabinet form is probably the most distinctive characteristic for determining the age of a radio. Unfortunately it's not practical to provide a simple identification diagram because of the many variations in style. The earliest radios were either an assembly of parts on a board or they were enclosed in boxes like laboratory instruments. Any exposed circuit became an excellent dust collector, making it almost impossible to clean without displacing or damaging some coil or capacitor.

In the early 1920s a radio receiver sold for about $40. Add to that the price of the horn-type loudspeaker, a table, batteries, and an antenna system, and the final price of the radio "system" could exceed $100.



PHILCO'S 38-10T SUPERHETERODYNE table radio could receive both broadcast and shortwave bands.

Consumer product designers soon recognized that style would sell radios. Many cabinets were oversized furniture and could easily have held as many as four radio chassis. That brings up an important point—when you get interested in vintage radios, consider where you will keep your collection before you add to it.

Most radios made in the 1940s had socketed tubes in metal chassis and were powered by the AC line. By that time effective and reliable rectifier tubes had been developed. The postwar years saw the growing popularity of radios with molded plastic cabinets in a variety of colors as well as simulated wood. Many of these radios incorporated the rounded streamlined shapes that characterized the ongoing "art-deco" style.

Getting started

The flea market is where you will probably get the best bargain—but don't forget the "buyer beware" warning. You might also try antique shops, but expect to pay more for an old radio in any established store that must pay its clerks a salary and pay overhead out of sales.

You might also search the classified pages of your local newspaper for announcements of auctions or estate sales. Also, keep your eyes open for announcements posted on trees or phone poles for garage sales or in shop windows for church benefit sales. Charity thrift stores are other possible sources.

Who knows, the exploration of your older relatives' attics might pay off. And don't forget neighborhood trash barrels on collection days. They might contain some forgotten treasures. (Naturally you'll be out walking your dog.) Your primary objective, of course, is to get a vintage radio in reasonably good condition.

If you are also a camera enthusiast, photograph your "new" old radio before, during, and after its restoration. Browsing a pictorial record of your work will give you a lot of pleasure over the years.

Be sure to record as much information as you can about the set. Look for nameplates, logos and trade names. Copy out patent numbers and their dates if you can find any. Tube location charts were often pasted on surfaces inside the cabinet. Attempt to learn as much as possible about the receiver. Marc Ellis' Antique Radio column in *Popular Electronics* is a valuable source, and there are many good books on the subject available.

Examine the catalog files in your local library. You'll be surprised about what you can find out about old radios on the shelves your local libraries. Look for advertisements of books on antique radio in this and other publications, and take advantage of fax and 800 phone numbers to obtain catalogs. You can also obtain a free copy of *Antique Radio Classified* by requesting one from A.R.C., P.O. Box 802-L11, Carlisle, MA 01741. It is a valuable resource in this field.

Restoring your set

It's important that you re-

Continued on page 86

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Electronics NOW® Volume 64

1993 Annual Index Electronics Now, Volume 64

Abbreviations: (ARE)Ask R-E; (AUD)Audio Update, (C)Construction; (CC)Computer Connections; (D)Department; (DB)Drawing Board; (ED)Editorial; (ER)Equipment Reports; (HH)Hardware Hacker; (LET)Letters (QA)Q&A; (VN)Video News; (WN)What's News

A Mini computer? Do they make Mickey, Donald, and Goofy computers too?

This one must be really difficult. You've been working on it for five years!

Shouldn't we plug these holes up so all the electricity doesn't leak out?

HARDWARE HACKER

Multimedia resources, digital bogey contest, CTCSS tone squelching, coin-mechanism sources, and low-distortion sinewaves.

DON LANCASTER

New hacking opportunities seem to be emerging daily. Word has it that there are bunches of new applications for those video camera CRT viewers and their support chips. Such applications include tiny oscilloscopes, VGA interfaces, virtual-reality lashups, 3D stereo, and even precision graticules.

Another exciting new area is called *binary optics*, in which zillions of plain old opaque dots can replace exotic combinations of costly lenses. This one is a sure-fire college thesis winner. At least one researcher is using nothing but PostScript and a grunt phototypesetter for his optical designs. Cheaper CD-ROM optics will be an important early use.

More on these two topics as they unfold. Meanwhile, let us look at an obscure standard that has lots of nonobvious new hacker uses.

Tone signaling

I get lots of helpline requests for schemes that permit voice and data to be routed over the same audio channel at the same time—interference-free, of course. You might want to do this to control a multimedia slide show, for selective calling on a multi-party intercom, or for remote robotics.

Other applications include an aide for the handicapped, home automation, a monitor for an alarm system, as an animation script to be saved to a cassette tape, as an "I've got the answer!" game or quiz response, to synchronize effects on a carnival ride, or for use as a radio private-calling feature.

Since any particular communication channel has a well-defined bandwidth, there are definite limits to what you can and cannot do here. So, we'll assume that low data rates are okay.

Touch Tones could be used, but all of those beeps might be annoying. The Touch Tone chips are offered by *Teltone*, *Silicon Systems*, and *Radio Shack*.

But *MX-Com* appears to have found a much better way. There is an obscure mobile communication scheme called CTCSS, which is short for *Continuous Tone Controlled Sub-audible Squelch*. The related standard is EIA-220-B.

As Fig. 1 shows, there are 39 standard or nearly standard tones in the specification, ranging from 67 hertz up to 250.3 hertz. In their intended use, these tones may be combined with voice messages on any radio channel. Only those channels set up to decode their selected tone can hear their message. The tone frequencies are *subaural* in that most phone or mobile communication gear sharply attenuates audio below about 300 hertz.

The MX365A is a typical chip that can be used either as the encoder of tones in Fig. 2 or the decoder of tones in Fig. 3. This device offers you a choice of hardwire programmable tones or a serial computer control. I've shown the hardwire mode, using the coding of Fig. 1. The MX365A costs $8 in single quantities.

If you apply low-frequency signaling tones directly, any lower speech or music frequencies could interfere with transmission. This is known as *talk-off*. And you will hear the actual tones on receive.

To beat those problems, a special on-chip digital high-pass filter is included. In the transmit mode, the filter gets rid of any low-frequency audio that could interfere with the tones. You run your input audio through the filter and then combine the tones with the filtered output.

The presence of tones causes the DECODE output at pin 13 to go low. For normal use, a low on pin 13 also turns *on* the output audio. Pin 18 is a *push to listen* feature. You can hold that pin at the positive supply level to provide continuous tone-independent audio.

There is also one really cute hack included in the encoder that can get rid of any *squelch tails* during normal communication. See the data sheet for details. Also, you'll need several receiver chips if you want to use several different tones at once.

The tone frequencies are set by the 1-MHz crystal. Presumably, you could lower the input clock frequency to lower all the available tones or to hit some "magic" frequency. This would end up as nonstandard, of course, but it would let you improve your audio quality as a result of an improved low-frequency response. And it might make your tones even more invisible.

The maximum data rates would also have to be sharply reduced for lower tone frequencies. Consider around 30 tone cycles as a minimum signaling interval. At 30 Hertz, this would mean about one-command-per-second maximum. If you want baud rate, you've got it; one baud! Use the lower tone frequencies for minimum audio interference and the higher ones for faster signaling.

MX-Com offers several variations

NEED HELP?

Phone or write your **Hardware Hacker** questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ 85552
(602) 428-4073

For fast **PSRT** access, modem (800) 638-8369, then an HHH. Then XTX99005,SCRIPT.

Tone Frequency	D5 (pin 5)	D4 (pin 6)	D3 (pin 7)	D2 (pin 8)	D1 (pin 9)	D0 (pin 10)
67.0	1	1	1	1	1	1
69.3	1	1	1	0	0	1
71.9	0	1	1	1	1	1
74.4	1	1	1	1	1	0
77.0	0	0	1	1	1	1
79.7	1	1	1	1	0	1
82.5	0	1	1	1	1	0
85.4	1	1	1	1	0	0
88.5	0	0	1	1	1	0
91.5	1	1	1	0	1	1
94.8	0	1	1	1	0	1
97.4	1	1	1	0	1	0
100.0	0	0	1	1	0	1
103.5	0	1	1	1	0	0
107.2	0	0	1	1	0	0
110.9	0	1	1	0	1	1
114.8	0	0	1	0	1	1
118.8	0	1	1	0	1	0
123.0	0	0	1	0	1	0
127.3	0	1	1	0	0	1
131.8	0	0	1	0	0	1
136.5	0	1	1	0	0	0
141.3	0	0	1	0	0	0
146.2	0	1	0	1	1	1
151.4	0	0	0	1	1	1
156.7	0	1	0	1	1	0
162.2	0	0	0	1	1	0
167.9	0	1	0	1	0	1
173.8	0	0	0	1	0	1
179.9	0	1	0	1	0	0
186.2	0	0	0	1	0	0
192.8	0	1	0	0	1	1
203.5	0	0	0	0	1	1
210.7	0	1	0	0	1	0
218.1	0	0	0	0	1	0
225.7	0	1	0	0	0	1
233.6	0	0	0	0	0	1
241.8	0	1	0	0	0	0
250.3	0	0	0	0	0	0
no tone	1	1	0	0	0	0
serial input	1	0	data	clock	x	x
test mode	1	1	0	0	1	1

FIG. 1—THE EIA-200-B CTCSS (Continuous-Tone, Controlled-Subaudible Squelch) tones can solve many hacker problems that require simultaneous voice and data signaling over the same channel. These can be hardwire or serial programmed with the MX365A codes shown.

on its basic chips. The MX315A is a transmit-only device. Its MX265A has a better microprocessor serial interface. The MX165B runs on a lower supply of 3.6 volts. Tone squelching and speech scrambling are combined in the MX375 and the MX275.

Multimedia resources

What is multimedia? I'll call this one *the use of computers for controlling high-quality video and audio*, and preferably at low cost and on your own desktop.

Two hot multimedia buzzwords are *convergence*, which tells you that TV sets, cable services, and telephones are getting more like personal computers and vice versa. And *nonlinear editing*, which means that you'll no longer have to edit materials in their traditional "A-B roll" order.

Newer Macs or the Amiga-based *NewTek Video Toaster* seem to be running away with all the multimedia marbles these days. NewTek recently introduced the *Screamer*, a small and cheap box that does the work of *forty* networked Video Toasters. Besides completely blowing away supercomputers and workstations at their end game, this one greatly shortens the time needed for rendering full animation sequences.

As a resource sidebar for this month I have gathered together a few magazine references and other resources that I have found useful to keep up with multimedia happenings. The list is not complete, so please let me know more about your favorite multimedia resources.

One thing that multimedia should eventually lead us to is...

The digital Bogey

Some people think that computers *will* be smarter than people. The time that this will happen is arguable, but it definitely will occur somewhere between 2:24 and 2:26 AM PST on April 17, 1998.

Note that the one-gigabyte RAM is rapidly approaching production, as is 1000:1 fractal and wavelet compression. At that point, we will routinely be handling both gigabytes of RAM and terabytes of efficiently compressed and realtime HDTV material, all at low cost.

Sometime after that, all parts of a

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multimedia experience could be handled fully digitally. *Everything* in a movie will consist of easily manipulated data. *There will be no difference between actors and props!*

Everything will be a special effect. Live actors will, of course, be totally unnecessary. As will the gaffers and grips and Foleys.

Given these stunning increases in desktop computing power, within two or three decades at most, it should be possible for an individual at home to produce something comparable to a first-run movie, at a total cost of, say, $75. Compare that to the $75,000,000 or so for today's old-line flicks. *This should give us a one million to one reduction in the costs for producing movie-like experiences.*

The primary video distribution, of course, would be by way of *Internet IV*, with later releases through library Teracubes, each of which can hold a decade or so of movies.

Naturally, the original script writer receives the lion's share of all income generated. And the final product will be *exactly* what the script writer had in mind.

I'll call this inevitable happening the *Digital Bogey*. As in Humphrey. A digital database should be able to totally define an actor's persona on a pixel-by-pixel basis. Both at macro and micro levels. It's the same way we process words and desktop publish today.

After teaching the data base all of the existing Bogey flicks, we could simply switch to auto and let 'er rip. Presto. Zillions of brand new Bogey movies.

For our contest this month, tell me more about the new upcoming Digital Bogey. Show me in 175,000 words or less what the consequences will be for a 1,000,000:1 reduction in all the costs of producing and distributing an entertainment experience comparable to a first-run movie.

Among other things, we can expect a shift in smog levels in the LA basin. *All* types of LA smog.

As usual, there'll be a dozen or so of my new *Incredible Secret Money Machine II* books going to the better entries, with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the best of all.

Elegant simplicity again

Elegant simplicity is a theme that we return to over and over again here. It should be one of your foremost hardware hacking goals. Just

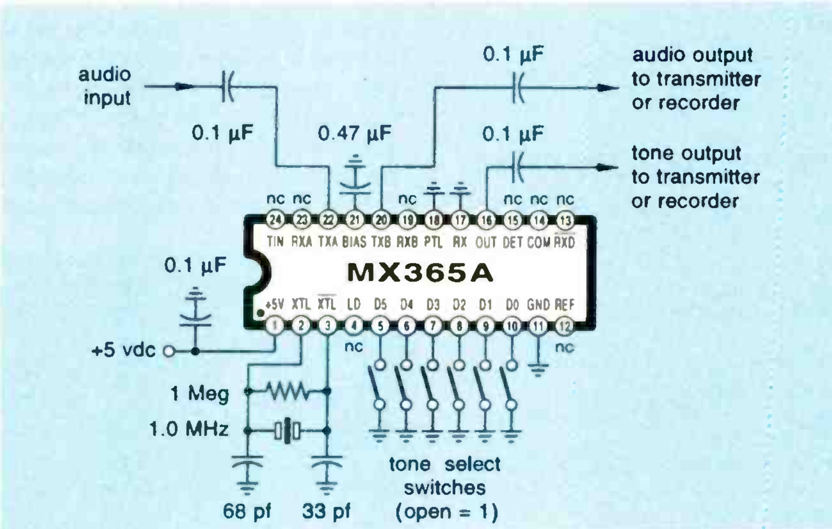

FIG. 2—TONE ENCODER with the MX365A.

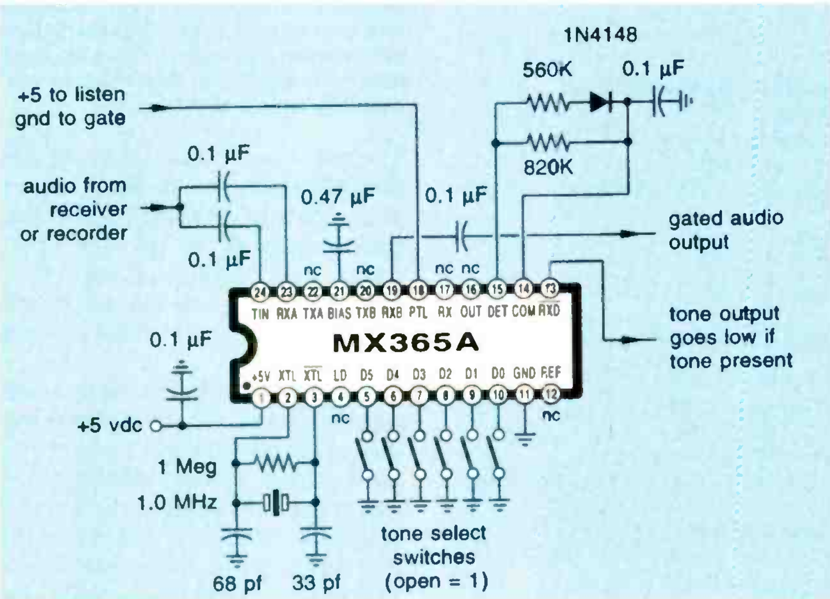

FIG. 3—TONE DECODER with the MX365A.

as the P-38 can opener is by far the finest invention of the twentieth century bar none, there are electronic circuits that clearly do more with less. They use the bare minimum of parts to provide unexpectedly sophisticated final results.

We've run many elegantly simple circuits on these pages, but there is one clear-cut winner which remains head and shoulders above all of the others put together. This, of course, is the original *Hewlett Packard* audio sinewave generator.

Linear Technology has long had a LT1037 ultra-low-noise op-amp that it is still real proud of. The gain of 20 million, offset of 25 microvolts, and common-mode rejection of 117 decibels are all right up there in the "adequate" range, beyond "fair to middlin."

The circuit is shown in Fig. 4. It is an ultra-pure 1 kHz sinewave generator. How pure? Less than 0.0025% distortion and 0.001% percent noise for a 6-volt rms output. The circuit is called a *Wein Bridge* oscillator. Temporarily assume that the light bulb acts like an ordinary resistor, providing a fixed gain of +3 for the op-amp. Now, at precisely 1 kHz, the series RC network will have *twice* the impedance of the shunt RC network, and both will offer the exact same phase shift. So, you'll have a sinewave running around an op-amp having a gain of 3 and a network that has a loss of ⅓.

The feedback network can act as

WHAT'S NEWS

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model shows that the industry will not recover in the next six months—this added manufacturing capacity will dictate cuts in IC prices. These, he said will "make the downward slope steeper."

Dr. Handelman said that a decline in consumption of ICs by the Computer Industry is the primary reason for the decline in the semiconductor industry. Moreover, he said that Advanced Forecasting sees a high rate of IC overbooking as a contributing factor. IC overbookings have surpassed their previous high peak, reached during the 1984 recession.

Advanced Forecasting depends on a quantitative, macroeconomic forecasting model that requires no retroactive modifications. "The model has been accurately applied to specific semiconductor products such as analog ICs, memories, microprocessors, and discrete devices," Dr. Handelman added. Ω

MULTIMEDIA RESOURCES

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a single-pole, high-pass filter while the shunt network acts as a single-pole, low-pass filter. Should the frequency change, the shifting impedance levels will automatically return the frequency to where it belongs.

Now for the most elegant part.

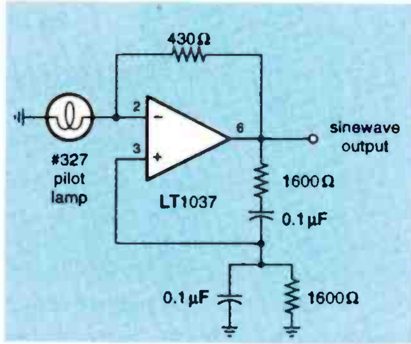

FIG. 4—AN ULTRA-LOW-DISTORTION 1-kHz sinewave generator. The pilot light acts as a stabilizing AGC loop in this elegantly simple circuit.

The circuit works only when the op-amp *already* has a sinewave present and a gain of precisely 3.0. If the gain is even a tad less than that value, the amplitude dies out. Slightly more, and the amplitude keeps getting bigger until it distorts badly.

Obviously, for this circuit to work, we need some way to regulate the gain of the op-amp. Set it above 3 to get it started, and then continuously adjust things to stabilize the desired amplitude. Naturally, you could do this with an AGC or *automatic gain control* loop. Maybe you could use an amplifier, a detector, and some sort of fancy multiplier stage. Any aerospace engineer could come up with a 10-chip, $500 solution, if he is given a few technicians and enough simulation time on a mainframe.

Would you believe you can use a plain old light bulb instead?

An incandescent light bulb is an example of a *nonlinear* resistance. If there is very little voltage across it, the resistance of the cold filament stays fairly low. When the voltage across the filament (and the current through it) increases, the filament warms up and its resistance increases.

The light bulb is a fully automatic, one-piece AGC circuit! On power up, it has a low resistance, and gives enough gain to start oscillating. At run time, its resistance continuously adjusts itself to give a constant and low-distortion output.

The thermal inertia of the lamp guarantees that all the AGC variations stay long-term only, instead of distorting the output waveform. This gives you elegant simplicity at its very finest.

Both RC networks must be matched very carefully, preferably better than one percent. That No. 327 bulb is a stock pilot light rated at 28 volts and 40 milliamperes.

As a second contest this month, tell me about your favorite example of elegant simplicity. Concepts similar to this superb sinewave oscillator, a P38 can opener, or a vortex cooler are what I'm after.

Coin changers

I have recently received lots of requests for low-cost sources of video-game coin mechanisms. As surplus, these are largely catch-as-catch can. But *Marlin Jones*, *American Science & Surplus*, and *Herbach & Rademan* sometimes stock them.

For larger quantities, try the ads in *RePlay*, *Playmeter*, or the *Automatic Merchandiser*. For antique versions, try the *Player Piano Company* or the ads in *Always Jukin'* magazine.

Lutech and *American Changer* are two sources for the dollar-bill changer mechanisms.

If you learn about other sources here, please let me know.

New tech lit

The Electrochemical Society is a good source for information on new battery technology, fuel cells, electroplating, corrosion, conductive polymers, and even Buckeyballs. It publishes *Interface* magazine and holds lots of trade conferences.

The third edition of the *Almanac of UFO Organizations and Publications* is offered by *Phaedra*. It's authored by David Blevins and costs $19.50. This is a combined Thomas Registry and Michelin Guide to the field. Of the 400+ resources listed, at least one of them (AI-TRAD) puts its money where its mouth is: one million dollars cash to anyone who is able to provide some *solid* evidence of either UFOs or aliens.

A fine selection of books and other resources for the handicapped is found at the *Disability Bookshop*.

Free samples of socket head caps are available from *Shear-Loc*. These caps instantly convert plain old cap screws into knurled knobs or thumbscrews, rosette grips, or tee-handles. Only a bench vise is needed to assemble the caps.

You can quickly and conveniently get copies of just about any technical standard from *Global Engineering Documents*. But note that it is often much cheaper to go directly to the standards associations themselves. We saw a full listing of these back in *Hardware Hacker, December 1991, and in my on-line and hard-copy reprints*.

Two rather strange and wondrous publications for this month are the Iron-Man Album and *Gas Engine*. They're for restorers of antique steam- and gas-powered tractors, respectively.

If you want to start up your own tech venture, be sure to get a copy of my newly revised *Incredible Secret Money Machine II*. Ω

EQUIPMENT REPORT

continued from page 18

The stainless steel blade can be used in a similar manner to remove PLCCs (plastic leaded chip carriers) and chip resistors and capacitors from circuit boards.

The *SC-7000* is available from Howard Electronic Instruments, Inc. for $395, which includes a convenient stand for benchtop use, and a cleaning pin set. An SMD removal kit, which includes a hot-air blower tip and other required materials is available for $47. Members for national, state, or local electronic association (including NESDA, ISCET, NARDA, and NESA) are eligible for a 10% discount.

Any technician who needs quality desoldering capability but who can't justify the purchase of a benchtop desoldering service center, will be well served by the DIC *SC-7000* desoldering tool. Ω

VINTAGE RADIO

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move the years of dust and grime from your new find with great care. First remove the chassis from the cabinet. Some models will have the loudspeaker mounted on the cabinet rather than the chassis: it too must be removed.

Also, many old radios have loop antennas attached to their back covers. Disconnect the leads to the antenna and set it aside. Whenever you disconnect or cut leads, note what you did and where in a notebook with comments on wire size and insulation color.

It is also a good idea to attach masking tape "flags" to the ends of any wires you cut or disconnect as well as to their termination points. Write codes or other useful data on the flags so that you can easily reconnect the wiring correctly at a later date—and avoid costly time-consuming mistakes.

Draw a parts layout diagram of the chassis showing the relative locations of the principal components, especially the tubes by type number. Remove the tubes and clean them with a damp cloth. Visit a TV/radio repair shop and ask the proprietor if you can use his vacuum tube tester. Tell him what you are doing, and you'll probably find that he will be glad to help you. Many independently run service shops stock replacement tubes.

However, if you are unable to find a local shop that handles tubes, check the classified pages of this magazine for mail-order companies that sell vacuum tubes. Some might be new unused products and others might be tubes that have been salvaged and rebuilt. Expect to find that pricing has increased markedly over their original prices, but if you only need a few, you'll find the prices to be reasonable.

Work on the chassis next. With a stiff one-inch paintbrush, remove most of the dust from the exposed surfaces. *Caution*: Do not use a vacuum cleaner—it might pull off an important part that you'll lose. Clean the surface of the chassis with a cloth dampened in water only—do not use soap or detergent! Cotton swabs such as Q-Tips are handy for cleaning in tight corners. Look under the chassis for obvious damage such as broken wires, split capacitors or broken resistors.

Replace the line cord even it appears to be in good condition. An AC cord with a hidden break in the insulation could prove to be lethal. If you are restoring a radio that was manufactured before World War II, look for a replacement cloth-covered cord. Try your local home lighting store or an electrical hardware supplier. It is important that the restored radio look authentic down to the line cord.

If practical, check the internal resistance of all paper (wax-covered) capacitors. Some vintage radio restorers replace all of those capacitors with modern film-type units with the same ratings that are approximately the same size.

Inspect all electrolytic capacitors for leakage: evidence of past leakage will show up as chalky dust or resinous seepage. Replace all electrolytic capacitors with their modern equivalents. Match the capacitance ratings as closely as you can, even if it means wiring several capacitors in parallel to obtain the right value. Also try to match the voltage ratings of the original equipment capacitors.

Now, reconnect the loudspeaker and loop antenna, and apply power to the radio with an auto transformer (commonly called a Variac). Bring the voltage up slowly while observing the filaments and plates of the rectifier tube (examples include the type 80, the 5U4, or the 35Z5).

Raise the output of the autotransformer slowly until the tube filaments glow with a dull cherry-red color. A DC voltmeter between cathode and chassis ground might indicate the presence of a DC voltage before you see the rectifier filament glow. The slow increase of voltage will reform the oxide dielectric layers in the electrolytic capacitors without damaging them. Take at least a half hour to raise the autotransformer voltage to AC line voltage.

Keep an eye on the rectifier plates that surround the tube's filaments. If they should begin to glow, turn the radio off immediately! This condition indicates a short-circuit. It will then be necessary for you to troubleshoot the radio and make all necessary repairs.

Clean the cabinet with a damp cloth that can contain mild soap, but be sure you remove all traces of soap when you have finished the cleaning. Knobs and removable plastic parts can be scrubbed with a wet toothbrush rubbed in mild soap. Rinse these parts well in warm water and let them air dry.

The cleaning of the dials and related faceplates, pointers and cords will require special care. Because of the many different forms taken by these assemblies, only general cleaning instructions can be given. Proceed cautiously with water-dampened cotton swabs or suitable soft artists' brushes.

You might want to replace the loudspeaker grille cloth of your restored radio if it is embedded with dust and grime. You might be able to obtain grill cloth with a suitable matching color and weave from your local electronics store; if not try one or more of the many mail-order electronics distributors.

The woodwork or finish on the cabinet might need repairs. Broken parts of the cabinet or seams might need to be reglued. Don't attempt this work yourself unless you have had experience in fine furniture repair. An amateurish job will detract from the restored radio's appearance and value. Unless the finish is badly scarred, confine your finishing work to a light coat of furniture wax.

If you must refinish the cabinet yourself, seek the advice of an expert in a paint or hardware store before you purchase any stains, varnishes, or lacquers. It's important to keep the cabinet's original color and tone because that's part of its history. ■

AUDIO UPDATE

A Question of Power: What is the sound of one amp clipping?

LARRY KLEIN

For many serious music listeners, the advent of digital reproduction raised a troubling question: Can their present low- or medium-powered amplifiers cope with the 90-dB dynamic range inherent in CD technology?

Although my real-time analyzer confirms that well-recorded CDs register peaks 10 dB or so higher than the same music on an analog tape or disc, the average sound level in the listening room—which is determined by the volume control setting—is essentially unchanged. Furthermore, the dynamic range potential of a CD is not likely to be realized on most discs and, in any case, is usually manifested as a reduction in noise at low levels rather than as an increase in sound at high levels. And so, for the vast majority of listening, their CD players will not push amplifiers above and beyond the call of conventional duty.

Power adequacy

Whether your system has adequate amplifier power depends on: (1) speaker efficiency, (2) the acoustics and size of the listening room, (3) the kinds of music you listen to, and (4) how loudly you play it. Let's discuss the four factors in order.

(1) Speaker efficiency is usually given as a sensitivity rating written as 86 dB/W/m. This translates into the speaker producing a sound pressure level of 86 decibels when fed 1 watt of test signal and measured at an on-axis distance of 1 meter. A high-sensitivity (very efficient) speaker might have a rating around 94 dB, medium sensitivity is about 87 dB, and low sensitivity is about 81 dB.

For a practical perspective on these figures, it should be appreciated that a 3-dB increase in speaker sensitivity means that for a given volume level, 50 percent (!) less amplifier power will be required. In other words, a 30-watt amplifier feeding a speaker with an 84-dB sensitivity will sound as loud as a 60-watt amplifier feeding an 81-dB speaker. However, a 3-dB increase in output level is barely discernible; It takes a 5- or 6-dB increase (a tripling or quadrupling) of applied power to be audibly significant. (See Fig. 1.)

(2) The size and acoustic properties of a listening room can significantly influence power requirements. Reducing room size by half will cut the amplifier power requirement by about one third. Room furnishings can have an even greater effect, changing the power requirements over a range of about three to one.

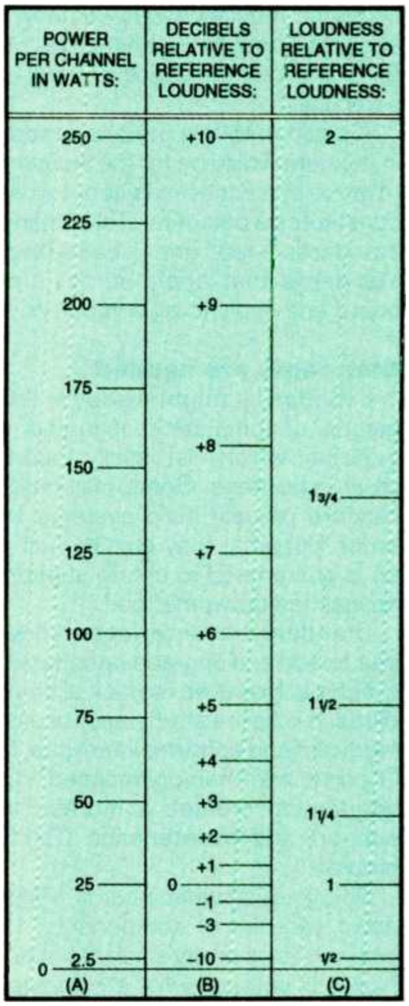

Fig. 1.—The three columns show (a) power output versus (b) decibel increases versus (c) subjective loudness over a 20-dB range of 2.5 to 250 watts. The arbitrary 0-dB reference level is 25 watts. Note the enormously increased power demands for relatively small changes of subjective loudness at high power levels.

A highly reflective ("live") room with metal and glass furniture and exposed hardwood or tile floors will need far less power than a "soft" room with absorbent carpeting, heavy drapes and heavily cushioned furniture. The soft room soaks up sound reflections before they have a chance to contribute to the overall acoustic energy level. Of course, the excessive reflectivity of a very live room will cause the sound to be overly "bright" and will confuse the stereo image, so a balance must be struck between a listening room's absorptive and reflective properties. Fortunately, the decor of most living rooms brings them fairly close to a happy medium.

(3) A listener whose taste runs exclusively to flute solos will need a lot less audio power than an audiophile whose compact-disc library consists of organ works, drum solos, and four different versions of the "1812 Overture."

(4) It has been estimated that listening-level preferences among individuals vary over a 30-dB range, with women usually preferring to listen at lower levels. (Whether the female preference derives from a greater sonic acuity or sensitivity or simply reflects an absence of "the louder, the better" audio machismo certainly won't be resolved without further research.) In any case, a 30-dB difference in preferred listening level translates into a 1000-to-1 difference in amplifier power requirements!

I've not given specific wattage figures for any of the circumstances discussed above, simply because of the difficulty in precisely specifying

Continued on page 90

COMPUTER CONNECTIONS

Falling prices are not necessarily a good thing.

JEFF HOLTZMAN

Prices of both hardware and software continue to drop, but this may be a mixed blessing. This month we'll examine trends in the hardware arena.

Intense price competition (as well as natural technological evolution) has roughly halved the cost of high-end PCs during the past two years. The effect has been to force many smaller PC clone vendors out of business, and consolidation among those that remain. For example, several years ago Tandy (Radio Shack) bought Grid systems, a maker of high-end portables. More recently, AST Research bought Tandy's computer line, lock, stock and barrel, thereby hurtling AST into a position as one of the three largest PC vendors. These trends are likely to continue. Industry analysts foresee the day, not far off, when most of the market will be dominated by just a few vendors.

These mega vendors will compete primarily on the basis of manufacturing efficiency. This will be a mixed blessing. On one hand, it will help keep prices low, and it should help keep quality high. On the other hand, it might well stifle innovation. And it will almost certainly reduce service and support because competitive pressures are off.

Think of how refrigerators are sold. Just a few characteristics—cubic feet, color, horizontal or vertical style—distinguish most models. Optional add-ons such as ice makers tend to be very expensive relative to the overall cost of the unit.

This is not a bad situation for refrigerators because they, compared to computers, are vastly simpler to use, operate, and maintain. Vendors do not require support centers staffed by hundreds of highly trained support technicians and engineers. Most people are capable of filling their own ice trays without having to be stepped through the procedure.

The situation with computers is obviously different. Every computer is different. Unlike adding water to an ice tray, adding peripherals to a computer requires extensive knowledge of computer architecture, in general and of the specific model in particular.

A solution to this peripheral add-in problem would be for the industry to arrive at a consensus about what constitutes a computer. This means standards—real ones, base-level standards that apply across the board and apply to all computers.

Standards are needed

Standards might reduce the number of computer configurations available, which—is usually touted as an advantage. Some mail-order vendors proudly build systems to order. But what they gain by doing so is guaranteed to create support headaches down the road.

Standard bus interfaces allow one to add and upgrade peripherals over time. However, the lack of standards in other related areas (use of hardware and software interrupts, I/O ports, and memory-mapped I/O addresses) creates a morass of support and maintenance (S/M) problems.

Ask yourself what a car is. Write down your list of components. I'll bet your list is pretty similar to mine. Now ask yourself what a computer is. What would you like to bet that our lists differ significantly? Did you include a mouse? A CD-ROM drive? A sound board? A fax? A modem? What kind of video system? How much RAM? What kind and how large a hard disk? What type of bus? What CPU speed? What type of floppy? Did you include a backup system? How about an uninterruptible power supply?

What's needed is a general definition of what constitutes a personal computer, a definition meaty enough to account for the broad range of possibilities. The definition should include standard hardware and software interfaces for all common devices, thereby reducing the potential for conflict and the effort and expertise required to overcome that conflict.

For example, a mouse should have a standard and unique connector so that it could never be mistakenly plugged into the wrong port. In a similar way, there should be a unique software interface based on a predefined software interrupt. When that mouse is plugged in, it should work correctly. When it is not plugged in, the computer should still work correctly. The same principles should apply to all other system components.

When I was a kid, the only way to buy a quality stereo system was to mix and match components from various vendors. Today, this is no longer the case. Quality systems that far exceed the needs finesse of the vast majority of listeners can be obtained for very reasonable prices.

The PC industry is still in the mix-and-match stage. In fact, this industry has grown up with an attachment to—a love affair with—the mix-and-match philosophy. However, most people have gripes about it. Users complain about the problems it creates, and manufacturers complain about its S/M cost.

Looking at the way cars are sold, rather than refrigerators, might provide a more relevant model. The automobile is a mechanism whose complexity is comparable in scope to that of the computer. There is wide diversity in kinds of automobiles, but this diversity is not, for the most part, based on fundamental technical differences among models. Further, the peripheral or "add-on" market is well standardized. Adding a trailer hitch, a luggage rack, or a better stereo seldom requires reconfiguring other system components.

It may be awhile

The fact is that cars and refrigerators evolved over fairly long periods of time before settling down to stable, consistent configurations. By contrast, computer technology is still in the rapid growth part of the curve. By way of illustration, in the late 1970s an editorial in one computer publication boldly proclaimed that 16-bit microprocessors would never catch on because most people used personal computers for word processing, and eight bits were enough to do everything that needed to be done. Today people wonder whether 32-bit devices will be able to satisfy our needs.

Some "standards" were created to compensate for a lack of prior direction. Take the EMS memory standard, for example. Until 386 and 486-based machines came to dominate the market, EMS was the most popular (and on 8088-based machines, the only) way to increase memory beyond 640K. In other words, EMS was needed only to satisfy shortsightedness in the original PC design. This response is much more common than most people realize. In fact, the very concept of a "PC Compatible" is really just a kind of patchwork quilt of pseudo-standards that have evolved to meet various needs. These standards are loose, ill-defined, and unenforced. To list just a few examples: AT bus timing, interrupts associated with serial ports above COM2, and EMS page frame mapping.

At bottom, what the PC industry did was agree to disagree. Rather than adopt standards for all these things, the industry instead opted to build the maximum possible versatility into each component. This versatility is great—except that it's so flexible. Versatility is precisely what leads to the system-compatibility headaches we've been discussing.

Large corporations might not like system-compatibility problems, but they typically have resources to deal with them. This is not the case with the so-called SOHO (small office and home office) market, which can seldom afford the technical expertise required to support complex system configurations, networks, and system upgrades.

Solution: PnP

How can these problems be solved? Can they be solved at all? They could be solved if computer hardware were made completely plug and play. Indeed, this is the focus of a new initiative spearheaded by Microsoft, Intel, and several key PC manufacturers. The Plug and Play (PnP) specification defines a way to avoid hardware conflicts. All peripherals connected to a PC would automatically be reconfigured every time the machine was powered up, without requiring any user intervention.

PnP has an ambitious goal, one that cannot be accomplished solely on the current generation of ISA bus computers. Hence PnP provides a migratory path that allows three levels of compatibility.

1. PnP cards will interoperate electrically and functionally with standard ISA cards in any existing ISA PC; however, that PC might not be fully auto-configurable.

2. By adding PnP software (utilities, BIOS enhancements, operating-system enhancements, and user interrogation), a mixed system can be made increasingly auto-configurable.

3. A system with only PnP cards and appropriate software will be fully auto-configurable.

In some ways PnP is like the microchannel architecture (MCA) and extended industry standard architecture (EISA) buses introduced in the late 1980s. Both EISA and MCA provide intelligent system-configuration tools and standards. However, PnP provides a smoother transition than did either EISA or MCA, which introduced buses that were physically incompatible with the AT bus, now known as the industry standard architecture (ISA) bus.

PnP works as shown in the flowchart in Fig. 1. After power up or a hard reset, devices required to

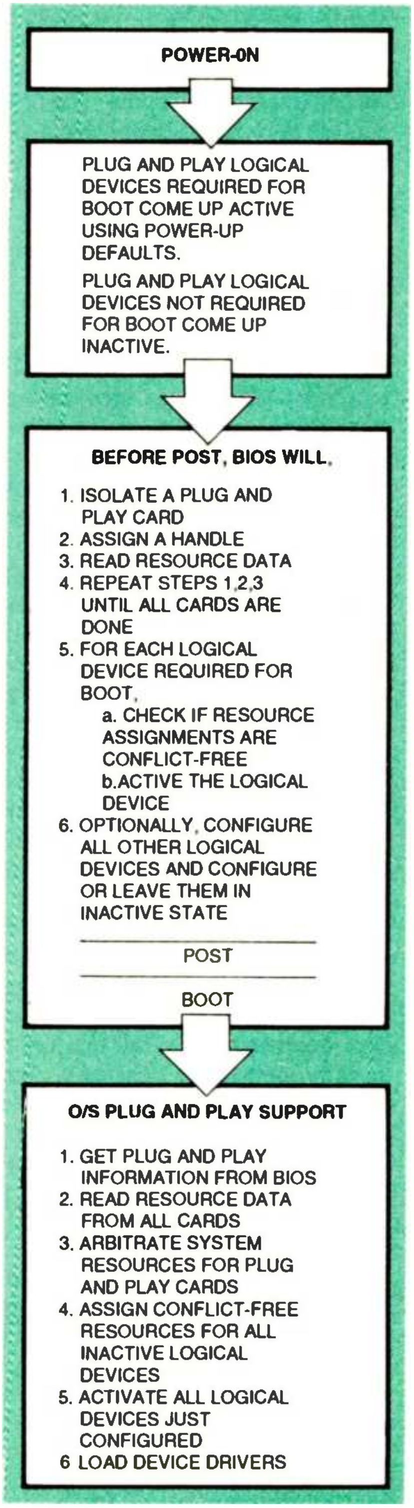

FIG. 1—THE PLUG AND PLAY ISA specification provides an automated way for a PC to reconfigure itself each time it is reset or powered up. Intelligence built into adapter cards, the system BIOS, and the operating system are intended to function together to ease user configuration headaches.

boot the system come up in an active state, and other devices come up in an inactive state. The system then performs an analysis of those devices present. Next the system assigns each resource in a way to prevent contention by two or more devices over that resource. The protocol for performing the analysis, an outline of the hardware requirements, and provisions are all defined in the PnP spec. You can get a copy of the spec on CompuServe; go PLUGPLAY.

PnP concerns

Two big concerns surround PnP. First is whether it can provide any value to the millions of PCs that already exist. Second is whether new expansion cards with PnP support will be more expensive than existing cards.

The point of the first concern is that if users need to upgrade their BIOSs, their operating systems, and the firmware (if any) on their peripheral cards to gain any advantage from PnP, they probably won't perform those upgrades. So even if every PC and every expansion card from now on came with built-in PnP support, it would still take 5–10 years before the standard could become universally accepted.

Cost is the second concern. If vendors chose to use PnP as a differentiating factor, i.e., to charge more for products that are otherwise identical to non-PnP products, users probably won't go for it. And why should they? It is questionable whether a mixed system can provide any benefit over a pure non-PnP system.

Conclusions

PnP might be too little too late. We need something like it, but by itself it might be insufficient. PnP does not cover SCSI device configuration. In addition, it is unclear how devices on standard 32-bit buses, such as those from the Video Electronics Standards Association (VESA) and Intel (PCI) can be managed. In addition, there is currently no support for other buses (e.g., those from Apple, Sun, and the other workstation vendors), nor operating systems (e.g., OS/2, Macintosh, and the UNIX dialects). Ω

AUDIO UPDATE

continued from page 87

all the variables involved. If you never intend to listen to music above a moderate level, 20 watts per channel should be adequate, whatever the sensitivity of your speakers. But if you want to listen to music at near-live levels, you'll need a great deal more power, particularly if your goal is to reproduce accurately the up-to-12-dB momentary music peaks found in most classical music—and certainly on CDs. To reproduce such peaks without clipping, an amplifier must be able to deliver, without faltering, almost 16 (!) times its average power. If its average power is 2 or 3 watts, then 16 times that figure is likely to be no problem. However, if you are running inefficient speakers in a large, well-damped room, the 12-dB peaks might exceed your amplifier's power output rating. Some of today's better medium-power amplifiers have up to 6 dB dynamic "headroom." This helps ease the stress of handling large momentary peak powers—and perhaps avoids the expense of a super-power amplifier.

Clipped sound

Theory aside, what do amplifiers sound like when they run out of power? That depends on several factors, such as the specifics of the amplifier circuitry, the program material, and the severity of the clipping. At one time there were amplifiers on the market that really went strange when driven into clipping. According to one well-known designer, the pulses and noise bursts produced by amplifier misbehavior on clipped signals were responsible for far more tweeter damage than the generally acknowledged culprit: the excessive high-frequency energy in the clipped waveforms.

But, assuming that the clipping is responsible for damage only to your audio sensibilities rather than your speakers, what does it do to the sound? A research project on the audibility of clipping done by Roy Allison in 1973 revealed some interesting facts. For example, waveform clipping that's barely visible on an oscilloscope is seldom audible. Overloads greater than 3 to 6 dB (depending on program material) were necessary before a critical listening panel clearly heard the ill effects. That means that a moderate-power, 25-watt amplifier could sound as if it had 25 to 75 more watts available than it really did under normal circumstances.

Another interesting effect: As the amplifier's input level control was turned up past the clipping point, the sound nevertheless continued to get louder, despite the fact that its peaks are clipped. This same psychoacoustic "trick" is used in radio and TV broadcasts to make commercials relatively louder than the average program level. By simultaneously limiting signal peaks and raising the average signal level, loud, attention-getting commercials are obtained without risking transmitter overload.

When amplifier clipping does reach the audible level, there is no mistaking its effects. Some program material is more revealing than others. For example, clipped piano music produces a rattling distortion with each note. For other instruments there is a loss of transient clarity, a "mushiness" in the musical attacks, or a harsh rasp at the moments of overload.

The bottom line

Theory aside, there is an easy way to resolve the question of whether your sound system would benefit from more power. Beg or borrow from a friend or friendly dealer an amplifier with at least three times the power of your present unit.

While playing your most demanding discs, listen carefully for a new openness, clarity, tighter bass, and lack of strain. To make sure you don't fool yourself, make notes listing whatever positive (or negative) changes you hear. Reconnect your original amplifier for another listening session with the same program material before you make your final decision.

If your listening tests reveal your old amplifier to be underpowered, you'll probably wonder how you nevertheless managed to live with it all those years. Ω

RADON MONITOR

continued from page 62

Initial checkout

Apply power to the ionization chamber with the cable and connect an oscilloscope to the op-amp test point shown in Fig. 2. After several minutes, JFET Q1 should have stabilized at its normal operating point with the drain at about 1.5 volts. The output of op-amp IC1-*a* should be half the 9-volt supply voltage with about 50 to 200 millivolts of low frequency noise riding on top of it.

When the amplifier is working properly, try to avoid bumping or vibrating the chamber because it is a sensitive vibration sensor, made even more sensitive as long as the anode wire remains unsupported. Shocks or vibrations will show up as large-amplitude, slow decaying sinewaves.

If the amplifier oscillates, produces square waves, or will not settle down after several minutes, check the drain voltage of JFET Q1 and the quality of the coupling capacitor C2. The amplifier circuit might have too much gain which can be reduced by substituting smaller values for resistor R4. Start with a 333 kilohm resistor which will reduce gain about 50%.

Anode support

Punch two small holes on the opposite sides of the can's rim as shown in Fig. 3. Insert a length of nylon monofilament fishing line through one hole, pass the free end through the loop at the end of the anode before passing it through the second hole. Pull both free ends of the line together around the outside rim of the can and, keeping tension in the line, tie them together with a knot. If the tension on the line is sufficient, the end of the anode will remain centered in the mouth of the can.

If a persistent 60-Hz waveform appears at the test point, pass a length of insulated hookup wire through the cable grommet in the bottom of the end cap and hook it up to repeat the test. Press on the end cap and examine the waveform again. If this shielding doesn't cure the problem, check carefully for other construction errors such as a missing ground connection or a noisy power supply.

Gain adjustment

Assuming that the ionization chamber and amplifier comply with the initial checkout requirements, it should be ready to detect alpha particles. However, additional amplifier gain adjustments might be necessary. Charge the capacitor C1 to −500 volts, and put the end cap back on. If you have no means for charging the capacitor, this can be done with either the voltage-tripler circuit shown in Fig. 4 or the DC converter shown in Fig. 5.

The voltage tripler shown in schematic Fig. 4 operates directly from the 120-volt AC line. It will produce a voltage close enough to 500 volts for satisfactory operation of the BERM. Because of the shock hazard associated with line-powered circuits, the use of a grounded, three-wire plug and line core is strongly recommended. This circuit should be enclosed in a suitable protective case to prevent accidental contact with the power line and any of the three large electrolytic capacitors C1, C2, and C3.

The DC converter schematic shown in Fig. 5 is a blocking-oscillator flyback circuit which can be powered from an adjustable, low-voltage DC supply. It will produce an output of several hundred volts with an input as small as 1 volt. Measure the converter's output with any voltmeter capable of measuring 100 volts before connecting the output to capacitor C1. Transformer T1, used as a step-up transformer in Fig. 5, can be any stock 20 VA transformer with a 120-volt primary and a 12-volt secondary.

Apply power to the amplifier and wait for its activity to settle. Typically, it will take several minutes for JFET Q1's gate to charge up and probably will take another minute for the coupling capacitor to charge before amplifier output reaches half supply voltage.

With the oscilloscope set for 1 volt per division and very slow sweep (0.2 second per division), the test point voltage should vary slightly as you wait to see an event. Expect the appearance of a large negative pulse (see the waveform in Fig. 2) on the oscilloscope screen indicating that you have just been lucky enough to capture your first alpha particle.

In a typical home you will see a few of these pulses each minute. However, because you are observing a random radioactive process, you might see several pulses or none in any given minute. Watch the oscilloscope screen for a few minutes and estimate the pulse amplitudes.

If the BERM amplifier has too much gain, the amplifier's output will saturate. However, if most of the pulses have an amplitude less than ½-volt, gain must be increased. The optimum gain setting occurs when pulses with peak amplitudes of about 2- to 3-volts appear without saturating the amplifier. Adjust the values of feedback resistors R4 and R5 to accomplish this.

Comparator

The last step in the check-out procedure, after gain adjustment has been completed, is to verify comparator operation. With an external pull-up resistor (100 kilohm to 1 megohm) connected to the positive supply, check its output with the second channel of your oscilloscope.

You should be able to verify that pulses with amplitudes over ½ volt drive the output low. Then complete the assembly of the BERM by putting the circuit board end cap back on.

Pulse counting and calibration

The second part of this article covers alternative pulse-rate counting techniques, calibration, sources of error and the conversion of pulse counts to specific activity to determine estimated amounts of radon present in the air. Ω

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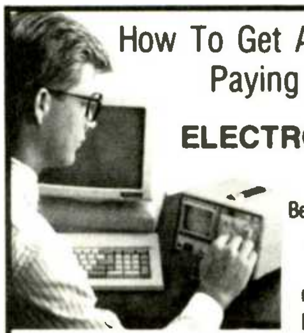

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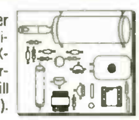

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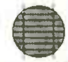

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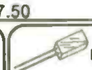

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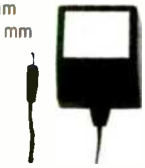

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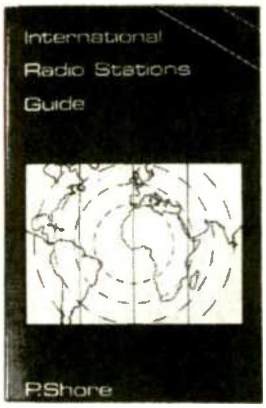

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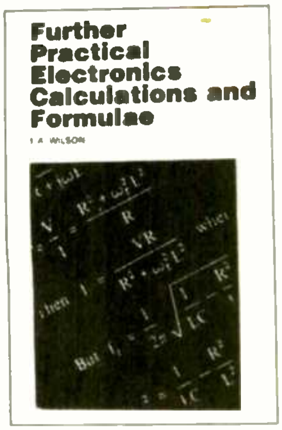

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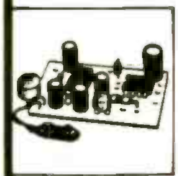

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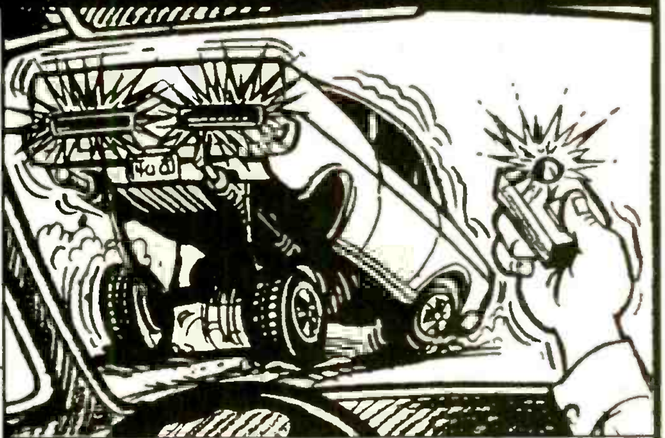

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Do you need an attention getter, warning light, or flashing light for model airplanes, then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate. Size 3.5"x1.8" operates on 6 or 12v DC only.

ST-1 **$9.95**

DIGITAL THERMOMETER

The DT-3 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. Measures temperature from -40F to 250F degrees. It has a remote sensor .25" SQ. and can be mounted many feet away from the meter. Size 1.5x1.2" 9vDC

DT-3 **$8.95**

CAPACITANCE METER

This kit will turn your digital volt meter into a capacitance meter. Turn that junk box of unmarked capacitors into a fortune of usable parts. Measures capacitors from <2.2pF to 2.2uF. 1.75"x2" 9vDC

CA-1 **$12.95**

VOLTAGE MONITOR

This kit has 7 multi-colored leds to monitor your 12, 8, or 5v DC systems. Build it to work in 1v, 1/2v, or 1/4v steps. Great for nicad packs, autos, boats, mobile homes, or battery chargers. P.C.B. 1.3"X2.7"

VM-1 **$7.95**

BLINKEY LIGHT

This kit is perfect for decorating hats, name badges, & model trains. Add a box, set it on the dash of your car, use it as an auto burglar alarm. Comes with 2 alternate flashing leds. Size .5"x.5" 9 to 12vDC

RB-2 **$3.95**

TV NOTCH FILTERS

Our TV filters eliminate unwanted TV channels or interference that alters both sound & video with a beep-beep-beep. Works on cable channels 2 thru 22. and the 'SNOOPER & BULLET.

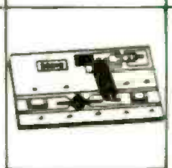
Note: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

DF-222 Kit **$14.95**

WIRELESS FM MICROPHONE

Small but mighty, this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80-MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. .8"x1" 6 to 12vDC

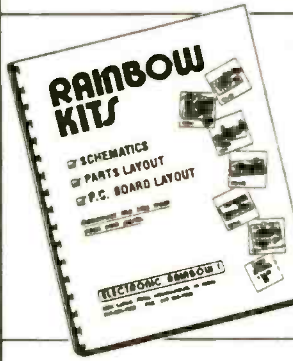
WM-1 **$14.95**



WIDE BAND PREAMP

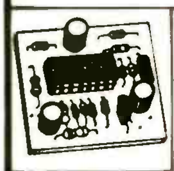
Ideal for preamp for scanners, hand held radios, frequency counters. Amplifies low level (weak) signals. If the signal is extremely low 2 amps can be used in series. 1MHz TO 2.5MHz @ 2.8dB nf 1dB compression = +0 dBm gain: 1MGHz-20dB to 2.5GHz-6dB Requires 12vDC @ 16Ma

WBA-6 **$19.95**



This Manual contains all schematics, parts & P.C. board layouts for all of the Rainbow Kits. Use your own parts to construct any of our kits.

KIT BOOK **$14.95**
$5.00 off if you buy any kit



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This VOX circuit can be used to operate a tape recorder, ham radio, CB radio, or turn on an alarm. The VOX-1 kit has 100MA of output. That operates a relay, light, motor, or ? What could you do with a sound activated switch? Size 1.5"x1.3" 7.5 TO 18vDC

VOX-1 **$6.95**

INDUCTANCE METER

This is the kit every one has been asking for. Turn your digital volt ohm meter into an inductance meter. It will read inductors 3uH to 7MH. Size 1.5"x1.6" 9vDC

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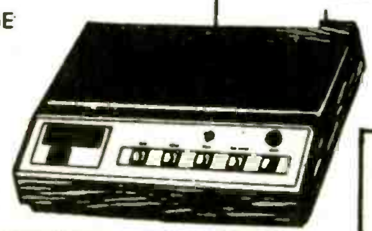

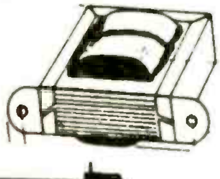

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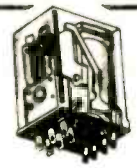

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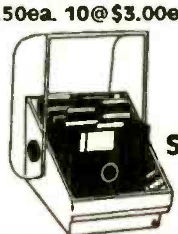

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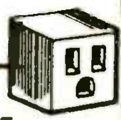

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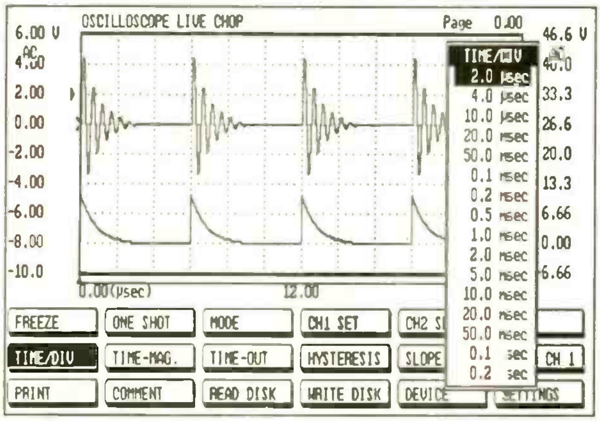

CONWAY Engineering, Inc. distributes the complete range of computer controlled measuring instruments of TiePie engineering. Connecting these instruments to a PC (MS-DOS 3.0 or higher) results in a number of comprehensive test instruments:

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Connect the HANDYPROBE to the parallel printer port of the PC and start the software. Measuring can be carried out at once. The HANDYPROBE does not need external power supply. Some technical specifications: 0.5 ... 400 volt software select input range; 100,000 samples/sec.; one input channel; 8 bits resolution (overall accuracy 2%). A complete software program consisting of a digital storage oscilloscope, spectrum analyzer, voltmeter and a transient recorder is provided. HANDYPROBE is very suitable for servicing and educational purposes.

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BEST PERFORMANCE: HANDYSCOPE

The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Due to its high resolution (12 bits), the HANDYSCOPE is a very accurate unit. The measuring time is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5 ... 20 volt (with a 1:10 probe up to 200 volt). The advanced software enables many measurements to be carried out. Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors. The length of the cable linking the PC and the HANDYSCOPE is 1.8 m, which can be extended to 3.8 m.

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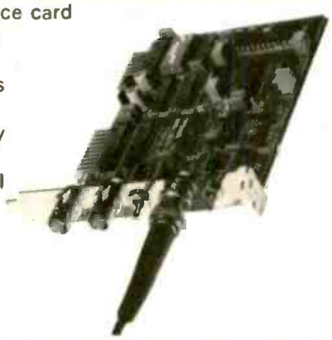
MULTIFUNCTIONAL: TP5008

The TP5008 is an interface card that provides an analog output in addition to two input channels. This output in combination with the two inputs may be used for the setting up of a complete control loop. The output may also be used as a function generator. The TP5008 has a resolution of 8 bits and a sampling rate of 200,000 samples/sec (200 KHz). The input range may be set to 0.5 ... 20 volt full scale deflection. The output range covers 1.25 or 2.5 volt. The TP5008 is fitted with BNC connectors and is delivered complete with a user manual and software. Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



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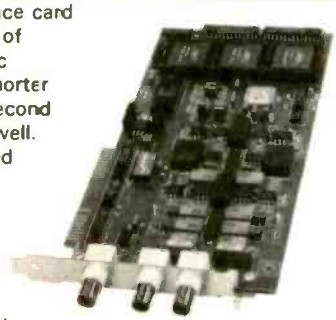
VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring time of 2x20 Megasamples/sec (8 bits). Phenomena shorter than 1 millionth of a second can still be measured well. The completely digitized triggering ensures very stable triggering with many trigger possibilities. The TP208 has an input range of 5 mvolt/div .... 20 volt/div (12 steps) and an auto calibration function. Since both channels may be sampled simultaneously, phase differences can be measured very accurately. Even single phenomena can be measured since each channel has a 32 KByte memory. Comprehensive software is provided.



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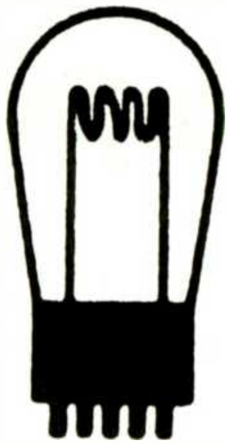

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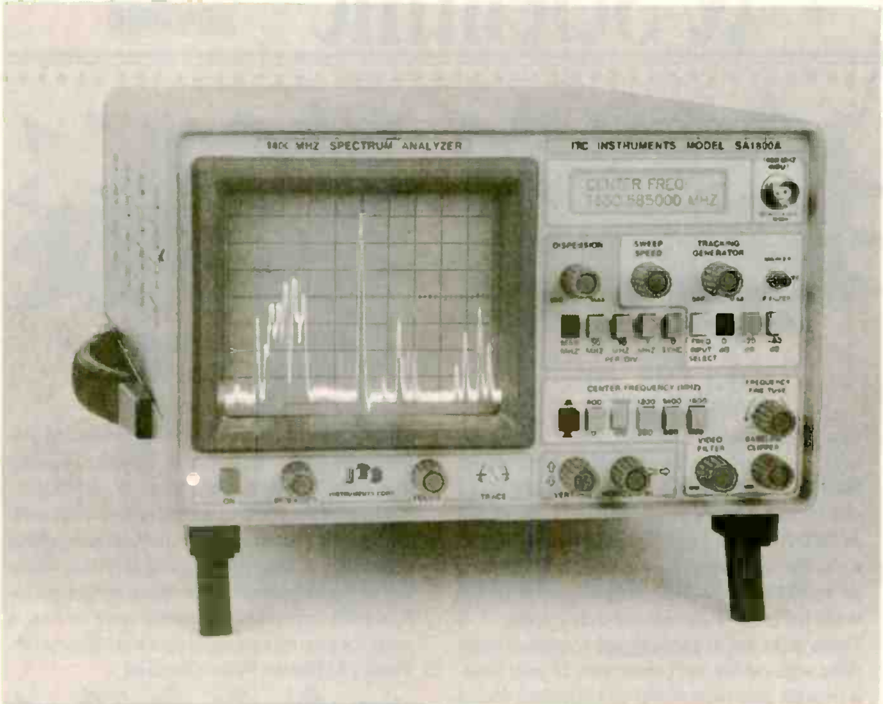

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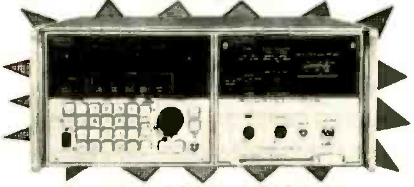

EATON 380K11/PM3602 SYNTHESIZED SIGNAL GENERATOR

This high speed RF Sweep Generator operates from 1Mhz-2000Mhz. Modulation is AM, FM, or Phase. This unit contains a high performance ovenized oscillator and HPIB interface. High-speed frequency switching time of 20 microseconds is unique to this unit, manuals available.
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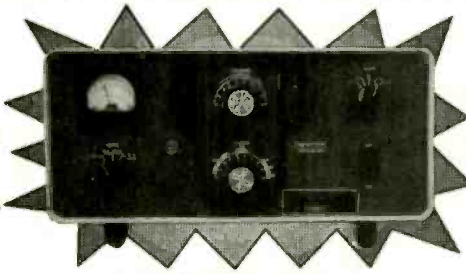

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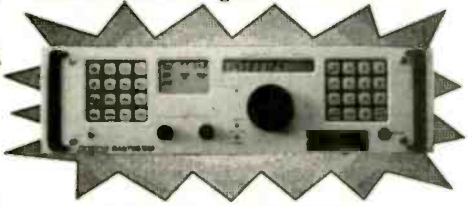

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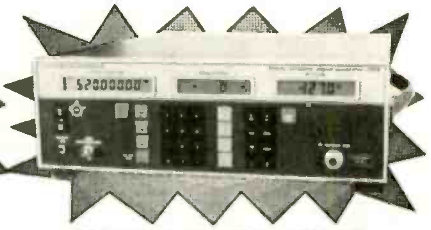
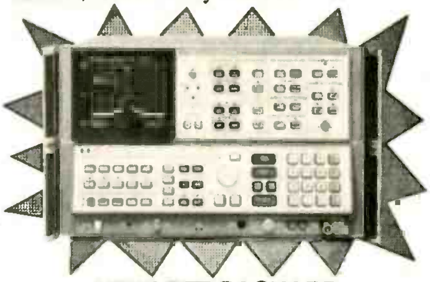
Orders must be prepaid by guaranteed instrument.**

Manuals available at extra cost



MARCONI SYNTHESIZED SIGNAL GENERATOR Model 2018

Freq range 80Khz-520Mhz with calibrated output levels from -127 dBm to +13dBm. Resolution 10Hz. It can be freq, phase or amplitude modulated from ext or int modulation sources. RF output resolution is 0.1dB, reversepower protection of up to 50W is possible without damage to the instrument. This instrument is microprocessor controlled and very easy to use, a must for any serious repair or development lab.
Price : $1500.00 Fully Checked



HEWLETT PACKARD 8568A SPECTRUM ANALYZER

This High Performance instrument features 10 Hz resolution over the 100Hz - 1.5Ghz freq range. Automatic zoom, signal track, multiple store/recall are only a few of the very useful functions you will find coupled with high accuracy time base and built in frequency counter.
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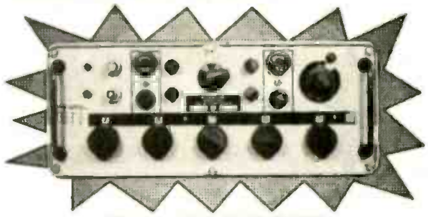

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Package INCLUDES all of this:

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*All you need to supply is ground pole to mount dish on. (3.5" O.D.)

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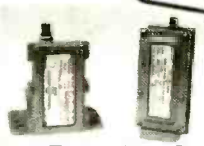

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0.6dbLNB	" "	179

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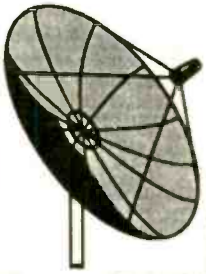

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10ft	" "	369
10ft H D.	" "	449
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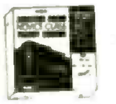

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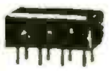

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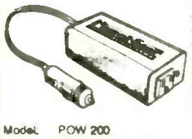

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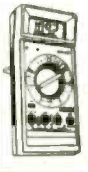

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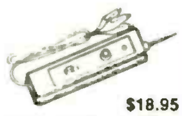

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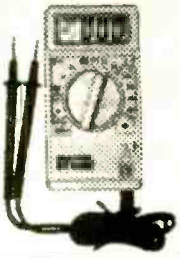

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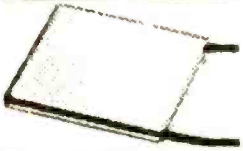

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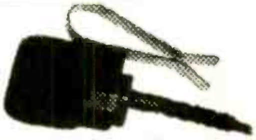

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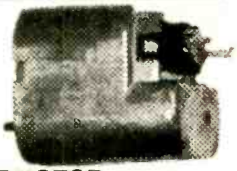

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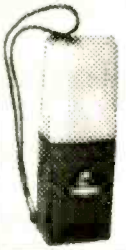

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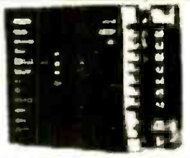

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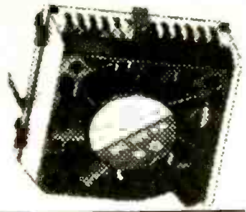

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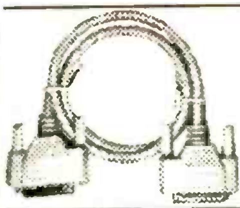

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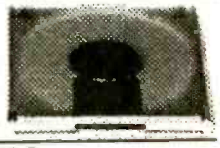

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200 assorted diodes - signal, power, Schottky, Zener, etc. (92S049) **$3.95**

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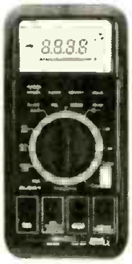

- Extra Large LCD, 4000 count with Bar Graph.
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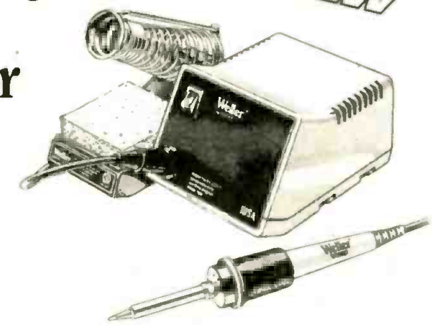

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12VDC @ 200mA ball bearing fan. 38 CFM with 12" wire leads. Size: 3-5/8" sq. x 1".

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12VDC 1 Amp Adaptor

Heavy duty Dc adaptor. 120VAC. 60 Hz input. 12VDC, 1 amp output. 6 ft. cord with 2.1mm DC coaxial plug (tip negative) UL listed.

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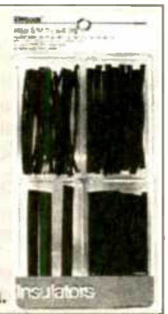
No. 220-0200F $24.95 ea.

Heat Shrink Tubing Kit



Contains 45 pcs.: (20) 3/32", (19) 3/16", (4) 3/8", (2) 3/4". Shrinks approximately one half original size. Each piece approximately 3-1/2" long.

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Window suction mount for easy installation. Complete with Velcro pads for quick removal.

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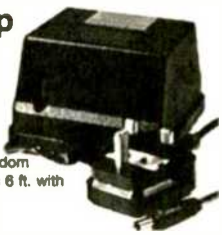

Output 15.5 VDC @ 23.25 Watts (1.5 amps) Input: 240 VAC, 50 Hz. 6 ft. input cord to transformer with 3 conductor fused United Kingdom type plug. Output line cord is 6 ft. with 2.5 mm coaxial plug. Motorola #SPN4067A

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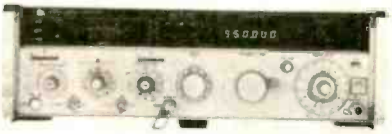

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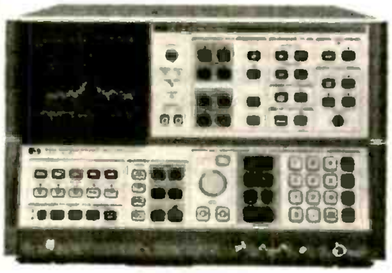

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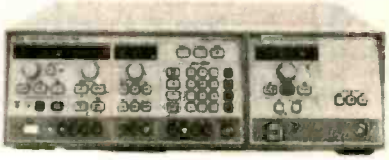

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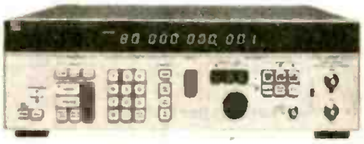

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***ProGold** and **DeoxIT** increase the performance and reliability of electrical components and equipment. They provide long-lasting protection, reducing the expense of repeated cleaning with expensive ozone-depleting solvents.*

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ProGold is specifically formulated to improve conductivity and protect gold, base metals and other precious metal surfaces. Use on gold connectors and contacts for maximum performance and protection. A common problem with gold plated surfaces is that the base metals migrate to the surface due to gold's soft and porous nature (dendrite corrosion). Once exposed, base metals oxidize, adding unwanted resistance that impedes electrical performance. Since gold plated surfaces are thinly coated, they are susceptible to scratching & abrasion, further exposing the base metals.

ProGold is a one-step treatment that conditions gold connectors, contacts and other metal surfaces, enhancing the conductivity characteristics to efficiently transmit electrical signals. ProGold coats the entire contact surface and connection, providing superior protection from abrasion (insertion resistance), arcing, RFI, wear and atmospheric contamination.

NEW! No Ozone-Depleting CFCs

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Environmentally-Safe!

DeoxIT™ & PreservIT™
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Both have excellent migration properties that coat the surfaces and protect them from future oxidation & contamination. These new advanced formulas contain improved deoxidizers, preservatives, conductivity enhancers, anti-tarnishing compounds, arcing & RFI inhibitors and provide extended temperature range.

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Neutralizes static build-up caused by friction & low humidity conditions.

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ElectricALL™
Rejuvenating Solution For All Electrical Applications. Cleans, Preserves, Improves & Protects Connections, Removes Corrosion & Oxidation, Reduces Wear, Abrasion, Arcing & RFI.

DegreasALL™
For degreasing, cleaning & defluxing equipment and parts. Removes oil, grease, dirt and contaminants including rosin flux from PCBs, components and metal parts. Biodegradable.

CAEON™ 27
For sensitive equipment applications. For removal of oil, grease & dirt from surfaces. (Freon® TF).

CAEON™ 28
Degreaser and cleaning liquid removes organic contaminants including rosin flux from PCBs, components and metal parts. (Freon® TMC).

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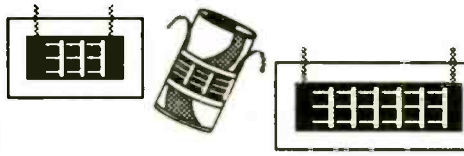
10" THRUSTER WOOFER

You will be amazed at the great sound of this very high quality 10" woofer that is perfect for upgrading your old system or new construction. These were made for a custom manufacturer by JBL and feature 8Ω impedance, poly foam surround, frequency response from 25HZ to 2KHZ and can handle up to 60 watts. Weight 2-1/2 lbs. Brand new and at an incredible blowout price!!!

G3311 $15.95

Pair for 30.00 (Include $5.00 S&H)

THIN FILM ULTRA-FLEXIBLE SOLAR MODULES



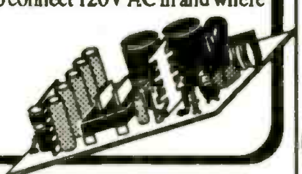
These are very unique ultra flexible thin film Amorphous Silicon solar cells. They are encapsulated in a clear flexible plastic film that allows them to be wrapped even around a pop can without damage. Great for charging NI-CADS, operating portable radios, electronic kits, model planes, camping equipment, etc. NOTE: The voltage output is actually higher than shown (which allows you to place a diode in series with one of the power leads when used in charging applications).

Stock #	Voltage	Current	Size	Price
G3974	1.5V	45ma	2" x 3.5"	$5.95
G3975	3V	90ma	3.25" x 6.0"	$11.95
G3976	6V	45ma	2.0" x 10.5"	$12.95
G3977	9V	45ma	1.85" x 12.5"	$13.95
G3978	12V	45ma	3.25" x 10.5"	$21.95

COMPUTER DRIVE SWITCHING POWER SUPPLIES

We have 3 types of these high quality switching power supplies made for computers. Each supply features output as shown and can operate from 120V AC. We don't have any schematics or other info on these but we do give you a simple hookup diagram showing where to connect 120V AC in and where the output is. Blowout Price on these high quality DC supplies!

Stock #	Size	Outputs	Price
G3687	7 1/2"x 2 1/8"	5VDC 2 amp, 12V 1 amp	$4.95
G3690	6 1/4"x 2"	5VDC 1 amp, 12V 2 amp	$5.95
G3688	5 1/2"x 3 1/4"	5VDC .5 amp, 12V 2 amp	$5.50



µLYNX TRACKBALL

MicroLynx trackball made by Honeywell for XT IBM compatible computers with MS-DOS up to version 3.0. Easy installation, connect between keyboard and computer -no serial I/O card needed. Features graphics driver, self contained menu for user programming of ball and button definitions, text and graphics modes, fast direct cursor motion, etc. Complete with cable, instruction manual, software on 5 1/4" floppy. Brand new in boxes. NOTE: For XT computers only!

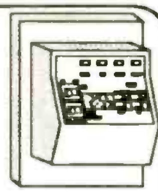
G3649 $4.50

MINI INFRARED MODULE

Type GP1U01 is sensitive to almost all infrared remote controllers and features high gain. Has only 3 hookup pins and operates from 5 to 9V DC (it will light a LED or close a low voltage relay from up to 50 ft. away). Size .9"x .3"x .4".

G3652 $1.29

NU-TONE ELECTRONIC PROGRAMMABLE TIMER



Model HST - 24 can be used for controlling all types of 120VAC loads up to 15 amps resistive (1800 watts). Features up to (4) on and (4) off settings per day (repeated daily). Wire directly into a 2 gang junction box and has 2 separate switches for Vent Lite and Nite Lite. Very easy to program and has LCD digital clock with readout. Has built in AA replaceable battery to maintain program even during a power failure. Helps protect your home against burglaries. Super Value! Overall size: 4 1/2 " square (including mounting plate). Brand New!

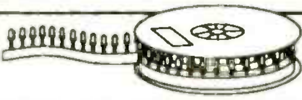
G3641 $10.95

DUAL HALL EFFECT SENSOR

These unique sensors turn on when a magnet is brought near. Supply voltage range 4.5VDC to 12VDC. There is actually two sensors on one ceramic substrate. Size only 5/8" x 5/16". With hookup diagram for lighting a LED when magnet is brought near.

G3646 $1.50
10/$12.00
100/$100.00

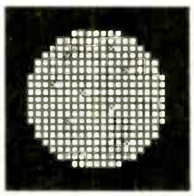
ULTRA-BRIGHT RED LEDS BY THE FOOT!



Super bright Jumbo (5MM) diffused lens Red LEDS by Toshiba. The reels are marked with MT4148-HRSB (the SB at the end means Super Bright!). You won't believe the quality and the matched brightness of these beauties until you see them! Operates at about 30 ma-60ma for maximum brightness and has a good viewing angle. They are on tape and reel put up by America West taping of Riverside Calif. We noticed a little tarnish on the leads on the LEDS on the first couple of wraps on the reels but all the inside LEDS look fine (and we had no problems soldering the tarnished ones in a test we did). Brand new, Blowout Price! Hurry, these will sell fast and we only have 50,000.

G3941 1 Foot $2.50 (About 24 LEDs)
1 Reel $120.00 (1500 LEDs)

IC MASK



These are the actual glass IC Masks used in transforming silicon wafers into ICs. They are fascinating to look at with a microscope. Great for educational use or just for a conversation piece. Each varies from above illustration. Comes in a plastic holder. Size is about 5" square.

G3698 $4.00

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LCD DISPLAYS

OPTREX 2x16-DMC 16207H-8 Bit ASCII Input Dim. 3 1/8x1 3/4x3/8 Char. Height .19" $5.99

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OPTREX 2x40-DMC 40218-8 Bit ASCII Input Dim. 7 3/16x1 5/16x13/32 Char. Height .19" $9.95

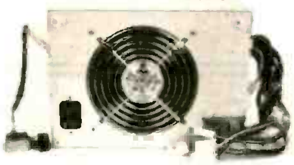
VERY EASY TO INTERFACE TO ALMOST ANY MICROPROCESSOR!!!!!!

SWITCHING POWER SUPPLIES

DELTA Switching Power Supply

Heavy duty switcher—A full 280 watts completly enclosed w/fan—UL and CSA approved— + 12V @ 7 amps— + 5V @ 37 amps -5V @ .75 amps— -12V @ .75 amps.

Measures 8 1/2"x 5 15/16"x7 3/8"



$17.95

SIRENS

Simply apply 12 volts to this little baby, then you had better hold your ears. Very loud!

$5.95

Great for car and intrusion alarms

STEREO AUDIO AMP

This 20 watt per channel, open frame, stereo audio amp comes completely assembled and tested. It also includes a self contained plug-in power supply. Less than .1 % distortion for you real "audio buffs". You supply the speakers and we will supply some of the cleanest audio you have heard. Unit includes volume, tone, and balance controls. Front panel measures 9"x3".

A steal at $12.95

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SSI-202 Decoder	2.25
8870 Decoder	.2.25
5087 Generator	.2.00
5089 Generator	.1.25

UART

NS16450	6.50
16550	10.95
TR1602B (COM 2017)	1.75
IM6402 +5v High speed AY5-1013 pin out	2.45
INS 8250	2.95

FANS

SANYO—BRUSHLESS
12 Volt DC at .07 Amps—
7 Blades
60 MM—2 3/8"x2 3/8"x1"
$5.95

TECHIDYNE—Brushless
12 Volt DC at .12 Amps—
7 Blades
80MM—3 1/8"x3 1/8"x1"
This size commonly used in Computer Power Supplies **$5.90**

PANAFLO—Brushless—12 Volt DC at .2 Amps 5 Blades—
119MM—4 11/16"x4 11/16"x1 1/2" **$5.99**

STATIC RAM

2016-2KK8 200 n.s.	1.00
2101-1 256X4 500 n.s.	.75
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2112A-2	2.50
2114L-3 1KK4 300 n.s.	.45
2125A-2 1KK1 70 n.s.	1.00
2147 4KX1	1.00
2148	1.00
6116P-4	1.00
6117	1.20
6264	1.40
62256 32KX8	5.00
128KX8	15.00

EPROM SPECIAL

We bought a large quantity of 2708s, 2716s, 2532s, 2732s, 2764s, 27128s, 27256s and 27512s from a computer manufacturer who re-designed their boards. We removed them from sockets, erased and verified them, and now we offer the savings to you. Complete satisfaction guaranteed.

Your Choice

2708	1/20	10/8.00
2716	1.75	10/15.00
2532	2.00	10/17.50
2732	2.00	10/17.50
2764	2.00	10/17.50
27128	2.50	10/20.00
27256	3.00	10/25.00
27152	4.75	10/40.00
1 Meg	8.50	10/77.50

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2108-4 8KX1	1.50
2118-4 16KX1-5Volt	.70
4027-4KX1-260 n.s.	.80
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4128 Piggyback	2.00
4164-150 n.s.	.49 or 9/3.50
4164-120 n.s.	1.10
4164-100 n.s.	1.40
TMS4416-16KX4-15-n.s.	2.75
4464-150 n.s.	1.40
4464-120 n.s.	1.45
4464-100 n.s.	1.45
4464-80 n.s.	1.45
41256-150 n.s.	1.25 or 9/9.95
41256-120 n.s.	1.30 or 9/10.99
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41256-60 n.s.	1.85
1 Meg - 100 n.s.	4.40
1 Meg - 80 n.s.	4.40
414256-80 n.s. 256 x 4	4.60

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8748	7.00
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8751H	12.95
8755	7.00

PROMS

82S123	1.49
82S126	1.49
82S153	1.75

8000/80000

8001	5.20	8237	1.90	8088-2	3.25	8257	1.50
8002	$2.50	8237-5	2.80	8155	2.25	8259A	1.85
8010	4.95	8243	1.75	8156	2.25	8259C-5	2.10
8031	2.95	8250	2.95	8202A	8.00	8275	10.95
8032	3.95	(16450)	6.50	8212	1.25	8279	2.25
8035	1.00	(16550)	10.95	8214	2.00	8284	1.49
8036	4.95	8251	1.10	8216	1.25	8286	3.50
8039	1.00	8253-5	1.75	8224	1.25	8287	2.49
8085	1.55	8254	1.80	8228	1.75	8288	3.50
8086	1.55	8255	1.50			8530	3.00
8088	2.20	8255-5	1.75				

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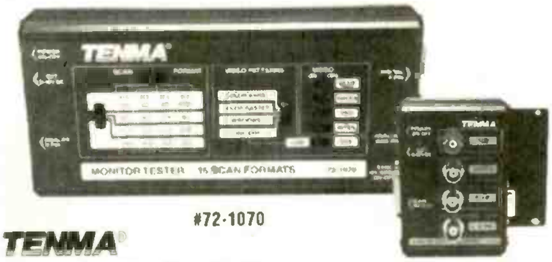

#72-1070 #72-1080

TENMA®
Computer Monitor Tester

Move into the highly profitable computer monitor repair market with this new Computer Monitor Tester by TENMA. Costs hundreds of dollars less than comparable units, and portability allows you to easily test a wide range of monitors on the bench or in the field.

•16 scanning frequencies from 15.7-70.8KHz •Five video patterns• Tests CGA, VGA, Super VGA, extended VGA, MDA PGA/K and high resolution monochrome monitors •Switchable sync on green

#72-1070 .... $359.99 (ea.)

TENMA® Monitor Adaptor

Made exclusively for the TENMA Monitor Tester. Inexpensive option attaches directly to tester. Greatly increases number of compatible monitor types.

•Unique "sidecar" design •Adaptor enables MAC II and BNC type interfaces •Includes mounting hardware •For use with #72-1070

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TENMA®
Deluxe DMM

Dual display multimeter is loaded with high tech features found only in meters costing hundreds of dollars more.

•Measures AC/DC to 750V
•AC/DC Current to 20A
•Resistance to 40Mohm
•Frequency to 2MHz
•Capacitance to 100MFD
•Transistor, diode and audible continuity test

#72-950 .... $83.99 (1-3) $73.99 (4-up)

Protective carry case
#72-089 .... $10.49 (ea.)

TENMA®
1GHz Spectrum Analyzer

Frequency range of 1MHz-1GHz makes this unit ideal for a wide range of RF applications. Applications include MATV, CATV, radio and cellular. On screen display allows at-a-glance readings.

•CRT readout with cursors •High sensitivity •Internal scale •5" high brightness CRT •Internal calibration •Displays waveforms without delay

#72-1085 .... $3295.95 (ea.)

TENMA®
20MHz Oscilloscope

The TENMA Trainer #72-905 is a basic dual trace 20MHz oscilloscope ideally suited for the student or entry level electronic applications.

•11" high brightness CRT with internal graticule •2KV accelerating potential •TV video sync filter •Front panel electronic trace rotation •Much more!

#72-905 .... $335.99 (ea.) $315.99 (2-up)

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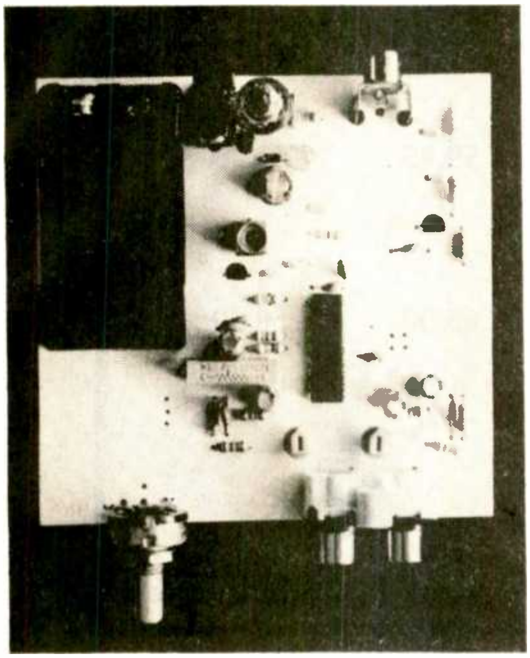


ALL NEW -- IMPROVED STEREO FM TRANSMITTER

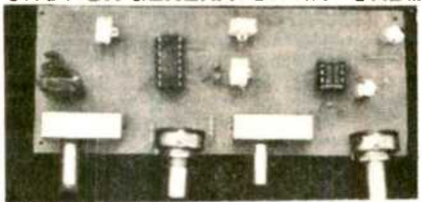
LOADED WITH FEATURES

* RF AMPLIFIER
* FRONT PANEL FINE TUNING
* STABLE OPERATION
* INPUT LEVEL ADJUSTMENTS
* WORKS WITH DIGITAL TUNED RADIOS
* 38KHz CRYSTAL MULTIPLEX CIRCUIT

DC'S all new FM Stereo Transmitter Kit based on the unique BA1404 Stereo Broadcaster Integrated Circuit that includes all the complex circuitry to generate the stereo signal. We've added an RF amplifier circuit to provided excellent transmit range. Additional features like electronic fine tuning, voltage regulation, 38KHz multiplex crystal, input level adjustment makes the Stereocaster the top of the line Stereo FM Transmitter.

ORDER STEREOCASTER $29.95

FUNCTION GENERATOR KIT ORDER FG2 KIT
$19.95



A great project to enhance your bench. This handy little function generator has a built-in buffer amplifier, a 3-decade range selector switch that covers 15 hZ to 25 khZ, output level control and function switch to select sine, square, or triangle.

MAKE CIRCUIT BOARDS THE NEW, EASY WAY

WITH TEC-200 FILM

JUST 3 EASY STEPS:

- Copy circuit pattern on TEC-200 film using any plain paper copier
- Iron film on to copper clad board
- Peel off film and etch

convenient 8½ × 11 size
With Complete Instructions

ORDER TEC200-10 (10-SHEETS) $5.95

POWER SUPPLY KIT
PS-1 $16.99

Output of this power supply is continiously adjustable from 1.2 to 25V DC. The LM317T voltage regulator provides excellent regulation and ripple rejection. Includes a 1 A transformer, PC board, LM317T, 2 binding posts, and all small parts.

MORE KITS

3 DIGIT LED DVM ONLY 3" X 3" READS 0 TO 100 V DC ORDER DVM3 $19.95
FM WIRELESS BROADCASTER FMI $ 9.95
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SEQUENCER PROJECT SEQKIT $ 9.50

CHRISTMAS TREE PROJECT

Build this unique seasonal project and have an unusual conversation piece. Powered by two D cells, 17 LEDs flash in a seemingly random fashon. Kit includes everything except batteries. ORDER XMASKIT $16.95

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REFER TO RADIO ELECTRONICS MAY 1990

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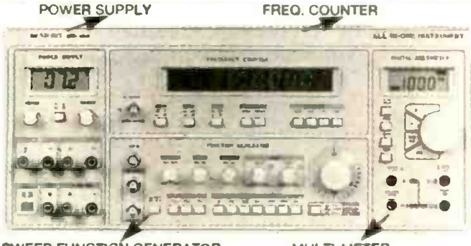
POWER SUPPLY — FREQ. COUNTER



SWEEP FUNCTION GENERATOR — MULTI-METER

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

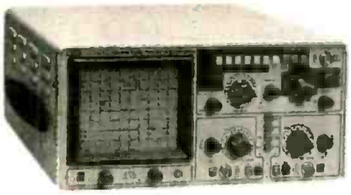
2 Frequency Counter
- 8 Digit LED
- 1 Hz ~ 100MHz
- ± (1 Hz + 1 dgt. + Time Base Error)

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



25 MHz Dual
Reg. $525.
$299.00

25 MHz Dual
w/Component Test
Reg. $595.
$379.00

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**
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Reg. $795. **$595.00**
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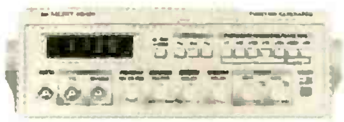
Reg. $695. **$575.00**
OS-904RD. 40MHz Dual/Read Out
Reg. $895. **$695.00**
OS-8100. 100MHz 8 Trace
Reg. $1395. **$1,145.00**
Other Models *Call for Price*

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

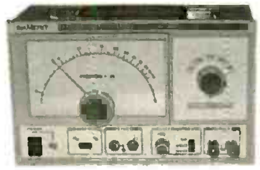
Best Buy!
1.0 GHz Counter FC-200
Reg. $395. **$199.00**

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**

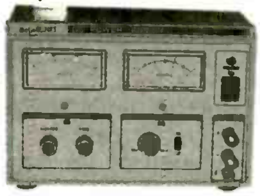
RF Signal Generator, SG-310 100KHz - 150MHz
- 100KHz ~ 150MHz, 6 Ranges.
- Accuracy : ± 5%
- RF Output: 100 m Vrms (Up to 35MHz Unloaded)
- Modulation
  - Int. 1KHz (AM) 30%
  - Ext. 50Hz ~ 20KHz
- Audio Output: 1KHz Min 2 Vrms

Reg. $199. **$119.00**



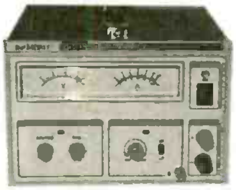
Audio Generator, AG-350 10Hz ~ 1MHz
- 10Hz ~ 1MHz, 5 Ranges.
- Accuracy : 5% ± 2
- Output Inpedance : 600Ω
- Sine Wave Output
  - Range : 10Hz ~ 1MHz
  - Output Voltage : 8 Vrms
- Square Wave Output
  - Range : 10HZ ~ 100KHz
  - Output Voltage : 15Vp-p

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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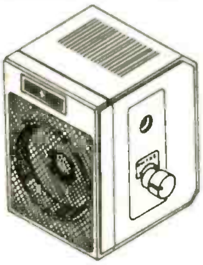

2 watt amplified monitor speaker with volume control. Ideal for CB, ham or other communication applications. 4 Inch 4 ohm speaker in black enclosure. 5.1" X 4.9" X 6.5" high. RCA jack input. Powered by 9 Vdc 500 ma. wall transformer (included).

CAT# SK-200

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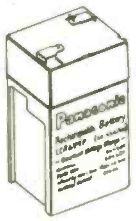
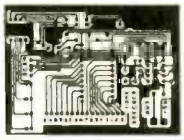


Panasonic# LCR6V4P Rechargeable Gell Cell battery. Measures:2.75" X 1.87" X 4" high.

CAT# GC-64

$12.00 each

Make PC Boards in Minutes...



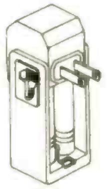
Five 8 1/2" X 11" sheets and instructions.

$ 9.95 per pack

Prototypers, developers and hobbyists can now make PC boards direct from CAD, PCB layout systems or magazines using a photocopier, or laser printer. Techniks Inc's new "Press-n-Peel" copy paper allows you to photocopy PC artwork and iron it on to copper-clad board. It can then be chemically etched in the usual fashion. The process is so easy and fast you won't believe it.

CAT# TEK-5

AA NICKEL CADMIUM BATTERY CHARGER



SANYO# NC-452

Battery charger for 2 or 4 AA nickel cadmium rechargeable batteries. Plugs into wall outlet and charges batteries in 8 to 10 hours. Can be folded for easy carrying and storage. 3.25" X 1.6" X 1.81" when folded. UL listed.

CAT# AAC-1

$ 2.50 each

SURFACE MOUNT LED

10 for $2.00

100 for $18.00

Surface mount LED chip. Green when lit, clear when off. Very tiny - whole unit is 0.115" X0.055" X 0.05" thick. 1mm (0.04") lens dia.

CAT# SMLED-2

CARBIDE DRILL BITS (USED)

High quality, solid carbide drill bits with 1/8" shanks. Ideal for precision drilling.

These bits were used in PC board manufacturing and were routinely removed from service while they still had lots of life in them. Available in the following sizes:

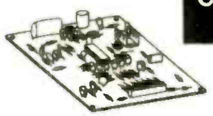
#	SIZE (")	CAT#
81	0.013	DRB-81
78	0.016	DRB-78
73	0.024	DRB-73
71	0.026	DRB-71
68	0.031	DRB-68
67	0.032	DRB-67
66	0.033	DRB-66
65	0.035	DRB-65
63	0.037	DRB-63
61	0.039	DRB-61
59	0.041	DRB-59
58	0.043	DRB-58
57	0.045	DRB-57
56	0.046	DRB-56
55	0.052	DRB-55
54	0.055	DRB-54
49	0.073	DRB-49

Minimum Purchase 10 Pieces Of One Size

10 of one size $ 5.00

50 of one size $ 20.00

MOTOR SPEED CONTROLLER AND TIMER



With a minimum of external wiring, this PC board will control the speed and duration of a 120 Vac motor or other load up to 300 watts. When activated, motor will operate for 10, 20 or 40 minutes or continuously at high, medium or low speed. To simplify hook-up we recommend using our membrane keypad, CAT# KPM-12 ($1.25 each) which, with slight modification works with this device. Instructions included.

$ 3.00 each

CAT # MSC-5

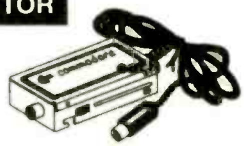
4 (USED) AA RECHARGEABLE BATTERIES

Battery pack with 4 AA nickel-cad batteries in series to make a 4.8 volt pack. Batteries have solder tabs and can be separated and reconfigured.

$ 2.00 per pack

CAT# NCB-41AAU

VIDEO/RF MODULATOR



Originally made for use with the Commodore computer, these good quality video modulators were probably originally designed for 9 Vdc use, but they operate well on 6-12 Vdc. They accept color video and audio, and a selector switch is provided for output to channel 3 or 4. Easy to hook-up. Requires a 6-12 Vdc power supply or wall transformer and a connector to interface with your audio/video source. Output is an RCA jack. Hook-up instructions included. 3" X 1.47" X 0.75".

CAT# AVMOD-3

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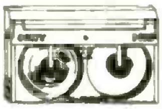
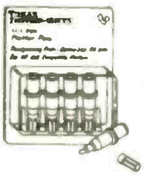
(USED) "HI-8" VIDEO CASSETTE



We have a new supply of these popular T-120 (120 minute) HI-8 video cassettes. These are top quality, metal oxide cassettes that were used for a short time, then bulk-erased. Each cassette has its own plastic storage box. New, they would sell for considerably more than we're asking. We've sold thousands, and our customers love them.

10 for $28.00 — **$3.00 each**
CAT# VCU-8

PLOTTER PENS



TI-1 style plotter pens. Assorted colors. 5 pens per pack.

For use on the following plotters:
Hewlett-Packard (all), Houston Instruments (695A & Image Maker), Roland DG(DXY-101, DXY-800), Enter (Sweet P600), IBM (all), and many other compatible plotters.

Two styles, paper and transparency, are interchangeable. Paper inks are lighter than transparency inks.

BLACK,	transparency, 0.3 mm tip	CAT# TR-3BK
BLACK,	transparency, 0.7 mm tip	CAT# TR-7BK
GREEN,	paper, 0.7 mm tip	CAT# PA-7G
GREEN,	transparency, 0.3 mm tip	CAT# TR-3G
GREEN,	transparency, 0.7 mm tip	CAT# TR-7G
BLUE,	paper, 0.3 mm tip	CAT# PA-3B
BLUE,	paper, 0.7 mm tip	CAT# PA-7B
BLUE,	transparency, 0.3 mm tip	CAT# TR-3B
BLUE,	transparency, 0.7 mm tip	CAT# TR-7B
RED,	paper, 0.3 mm tip	CAT# PA-3R
RED,	paper, 0.7 mm tip	CAT# PA-7R
RED,	transparency, 0.3 mm tip	CAT# TR-3R
RED,	transparency, 0.7 mm tip	CAT# TR-7R

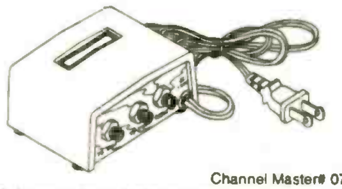
ASSORTED 5 DIFFERENT COLORS

ASSORTED,	paper, 0.3 mm tip	CAT# PA-3A
ASSORTED,	paper, 0.7 mm tip	CAT# PA-7A
ASSORTED,	transparency, 0.3 mm tip	CAT# TR-3A
ASSORTED,	transparency, 0.7 mm tip	CAT# TR-7A

All Plotter Pens Are In Packs Of Five

$ 2.00 per pack

EXPERIMENTER'S DELIGHT VHF TO UHF BLOCK CONVERTER

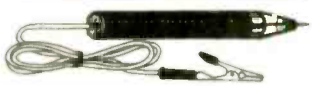


Channel Master# 0746.

This is one of those deals that's too good to be true. Brand new, in the box, Channel Master block converters. They used to be popular a few years ago before there were a lot of cable-ready TVs. Somewhere in the world we know there is still a demand for them- especially at this price. Designed to convert television VHF channels 2 through 13 and A through W to UHF channels 36 through 76. The box alone, is a great project box. The 10 ft. AC power cord, the interior components, F connectors and AC receptacles are well worth the price.

CAT# CM-0746
$2.00 each — 10 for $18.50

CONTINUITY TESTER



Snapit # 49661
Check fuses, light bulbs and electrical circuits for continuity. Bright incandescent lamp lights when circuit is complete. 3 foot lead with alligator clip. Probe tip can be used to puncture insulation when necessary. Nose cone slides up and covers probe when not in use. Requires two AA batteries (not included).

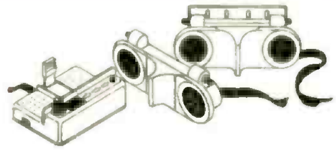
CAT # ED-100
$ 2.50 each

CIRCUIT TESTER

GB Electrical Inc. # GET-203
Handy pocket size tester checks for presence of AC or DC current from 110 Volts to 460 Volts. Bright neon indicators light when current is present. Also checks for "live" or hot wire and indicates AC or DC current.

CAT # CT-2
$ 2.50 each

ULTRASONIC PROXIMITY DETECTOR



The ED-100 was designed for use as an auto/RV/ truck back-up alarm. Two 40 khz ultrasonic emitter/ detector modules attach to the back of the vehicle and warn the driver when the rear of the vehicle is within 24 feet of another object. A digital display and audible beeper inside the car continually monitor the distance to impact. The ultrasonic modules measure 5.81" long X 1.9" wide X 2.05". Operates on 12 or 24 Vdc. Includes instructions for installation. The units are new, in original cartons and, as far as we know, in working condition. The company that marketed this device is no longer in business, and no manufacturer's guarantee is in effect. **We offer these ultrasonic detectors for experimentation only, and in no way wish to promote their usefulness as a driving aid.**

Original Sold For OVER $100.00.

$ 24.95 each
CAT # ED-100

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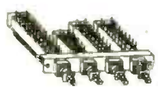
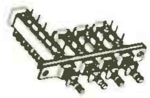


1 - 4PDT, 2 - 6PDT, 1 - 8PDT switches.
CAT# NISW-7
50 ¢ each

2 - 2PDT, 2 - 6PDT switches.
CAT# NISW-8
50 ¢ each



3 - 2PDT, 1 - 4PDT switches.
CAT# NISW-10
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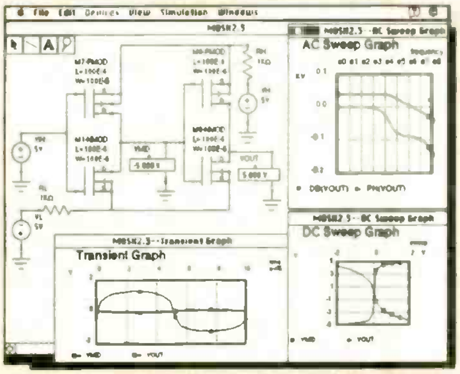

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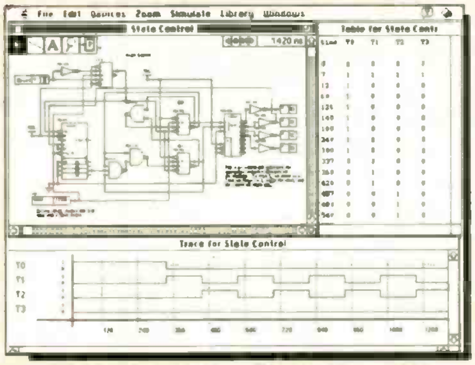

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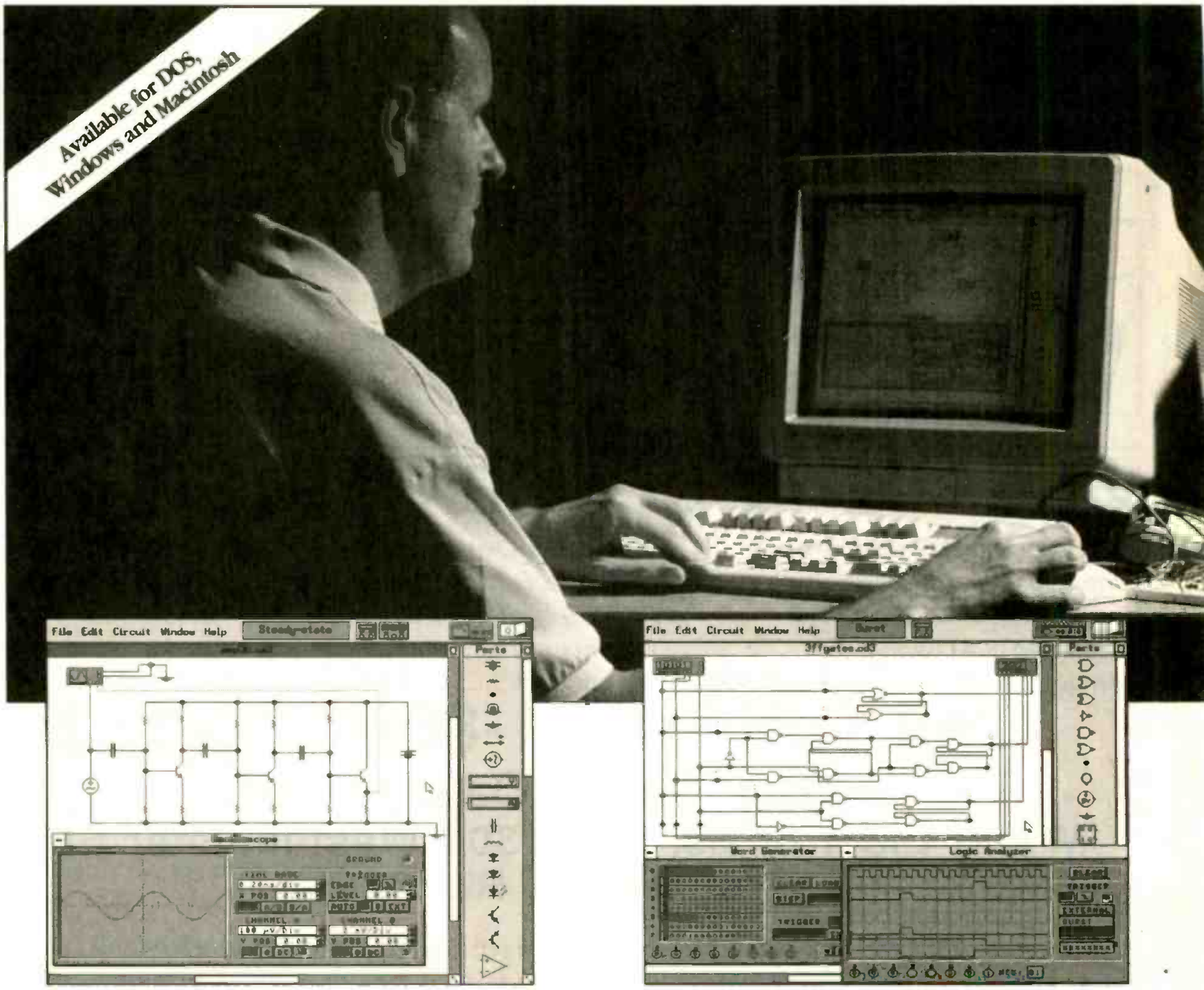

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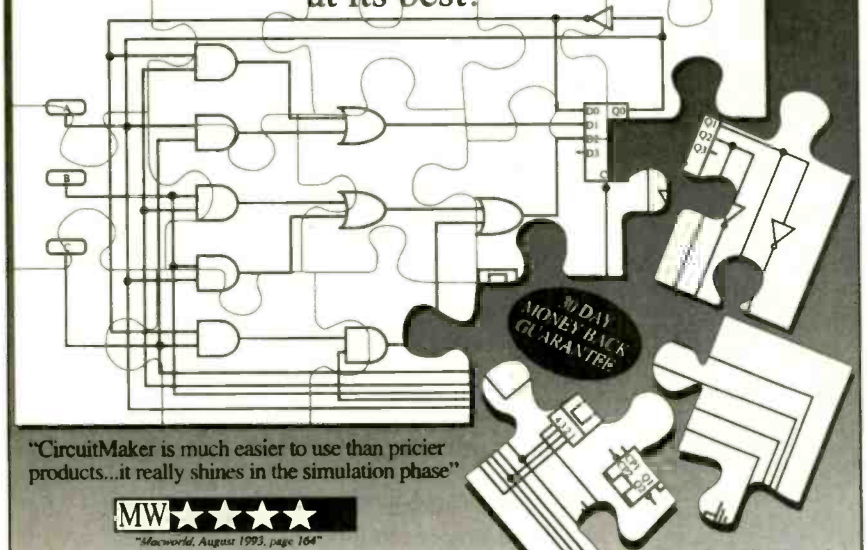

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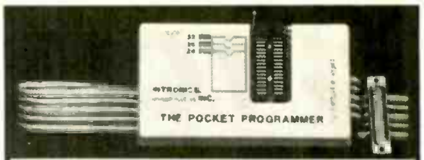

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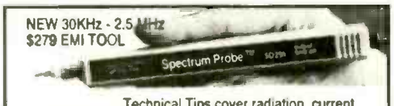

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USE ELECTRONIC SHOPPER CLASSIFIEDS

READ BY MORE THAN 100,000 ELECTRONICS BUYERS AND SELLERS AND TRADERS

INSTRUCTION FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for the additional ads (a photocopy of this form works well). Choose a category from the list below and write that category number into the space at the top of the order form. If you do not specify a category, we will place your ad under Miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

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

RATES

Our classified ad rate is $1.25 per word. Minimum charge is $18.75 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **Electronic Shopper** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 1 will appear in the July, 1993 issue that is on sale in June 3. Shopper ads will appear Jan., Mar., May etc. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

AD RATES: $1.25 per word. Minimum $18.75.

Send your ads with payment to:
Electronic SHOPPER, 500-B Bi-County Blvd. Farmingdale, NY 11735

CATEGORIES

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

CLASSIFIED AD COPY ORDER FORM

Ad No. 1—Place this ad in Category # ______

1 - $18.75	2 - $18.75	3 - $18.75	4 - $18.75
5 - $18.75	6 - $18.75	7 - $18.75	8 - $18.75
9 - $18.75	10 - $18.75	11 - $18.75	12 - $18.75
13 - $18.75	14 - $18.75	15 - $18.75	16 - $20.00
17 - $21.25	18 - $22.50	19 - $23.75	20 - $25.00
21 - $26.25	22 - $27.50	23 - $28.75	24 - $30.00
25 - $31.25	26 - $32.50	27 - $33.75	28 - $35.00
29 - $36.25	30 - $37.50	31 - $38.75	32 - $40.00
33 - $41.25	34 - $42.50	35 - $43.75	36 - $45.00
37 - $46.25	38 - $47.50	39 - $48.75	40 - $50.00

Ad No 1—Total words ______ x $1.25 per word = $ ______

All Caps words ______ x .20 per word = $ ______

Bold words ______ x .20 per word = $ ______

Bold Cap words ______ x .40 per word = $ ______

TOTAL COST OF AD No. 1 $ ______

Total classified ad Payment $ ______ enclosed.

[ ] Check [ ] MasterCharge [ ] Visa ($18.75 minimum credit card order)

Card # __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

Expiration Date __ __ / __ __
Signature ______

Name ______ Phone ______

Address ______ City State Zip ______

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DESCRAMBLERS FOR cable and satellite. Kits and assembled units. All types. Guaranteed. From $19.95. Free catalog. (212) 330-8035.

HAM GEAR FOR SALE

STATE OF THE ART hard to find radio communications related integrated circuits. Automatic audio volume controllers. See Feb. 1993 issue of "Electronics Now." **FREE** catalog. C & S Electronics, PO Box 2142, Norwalk, CT 06852-2142. Phone/Fax (203) 866-3208.

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PLANS-KITS-SCHEMATICS

ALL-IN-ONE CATALOG. AM/FM/HAM/SPY, transmitters/amplifiers, voice disguisers, descramblers, audio/TV/science projects. Start your own licensed/unlicensed radio station, books/plans/kits for import and export. 60 mouth-watering pages for $1.00. **PAN-COM INTERNATIONAL,** PO Box 130-F1, Paradise, CA 95967.

BUILD YOUR own neighborhood FM stereo or television station. Send SASE for complete catalog. **Sunset Electronics,** 16776 Bernardo Center Drive, Suite 110B, San Diego, CA 92128.

FM STEREO TRANSMITTER kit broadcasts any audio signal to FM stereo radios throughout your home. Uses unique BA1404 IC. Complete kit: PC board/components — $24.00. Visa/MC. **TENTRONIX,** 3605 Broken Arrow, Coeur d'Alene, ID 83814. (208) 664-2312.

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SINGLE BOARD COMPUTERS: 8051, up to 64K **EPROM, 256K NVRAM, RS232, 8255, 36I/O lines** 8 channel **A/D free BASIC** compiler, assembler. $16.25 (bare board), $29.75 (kit). ProBoard Circuits (409) 762-3414, 302 Holiday Drive, Unit 12, Galveston, TX 77550.

CAR-STARTER by RF-remote control. Full schematics, pcb-phototools, component-layout and instructions. Manufacturing is very cheap, start your own business. Compatible with keychain alarm transmitters, specifically designed for all model vehicles. Send $27.95 to IEE Engineering, 11765 19th Avenue, Montreal Canada, H1E-3R4.

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MAGAZINE SUPPORTING Z80, CP/M, S100, Kaypro, 8031, 6809 and more. **The Computer Journal.** 10th year of classic computer projects. Hardware, software, forth, assembler. Micro-C Kaypro disks and schematics. 6 issues, $24.00, free sample. 1 (800) 424-8825. TCJ, PO Box 535, Lincoln, CA 95648.

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COMPUTER SOFTWARE

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ELECTRONICS SOFTWARE. IBM. Large selection. Free catalog. Generic Software, PO Box 502, Dayton, OH 45401-0502.

COMPONENTS

ELECTRONIC FASTENERS. Stainless steel. Kits available. Free catalog. "RUSTY BOLT," Box 708S, North Attleboro, MA 02761.

FREE HOBBY catalog. Lowest prices, components, parts, tools, more! Gallimore Electronics, Box 70150-B, San Diego, CA 92167.

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CBTV DOCTOR Stop the Bullet and ID signal in cable lines. Send $17.50 and $2.50 S&H to R.R. Enterprise, PO Box 3532, Easton, PA 18043.

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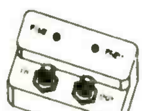

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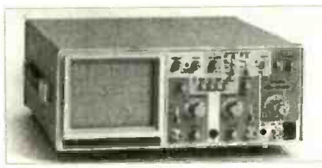

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2522A	20 MHz Storage	1099	850
3011B	2 MHz Function Generator	269	210
2005A	RF Generator	275	215
820	.1PF to 1F Cap Meter	269	210
510	Transistor Tester	230	180
1651	Tri-Output Power Supply	429	330
1630	30V 3A Power Supply	315	245
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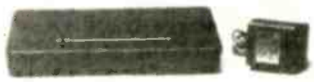

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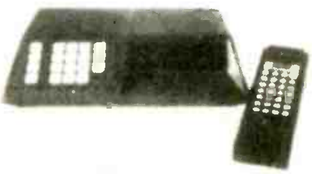

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