SPECIAL INSERT: UNDERSTANDING VIDEO SIGNALS!

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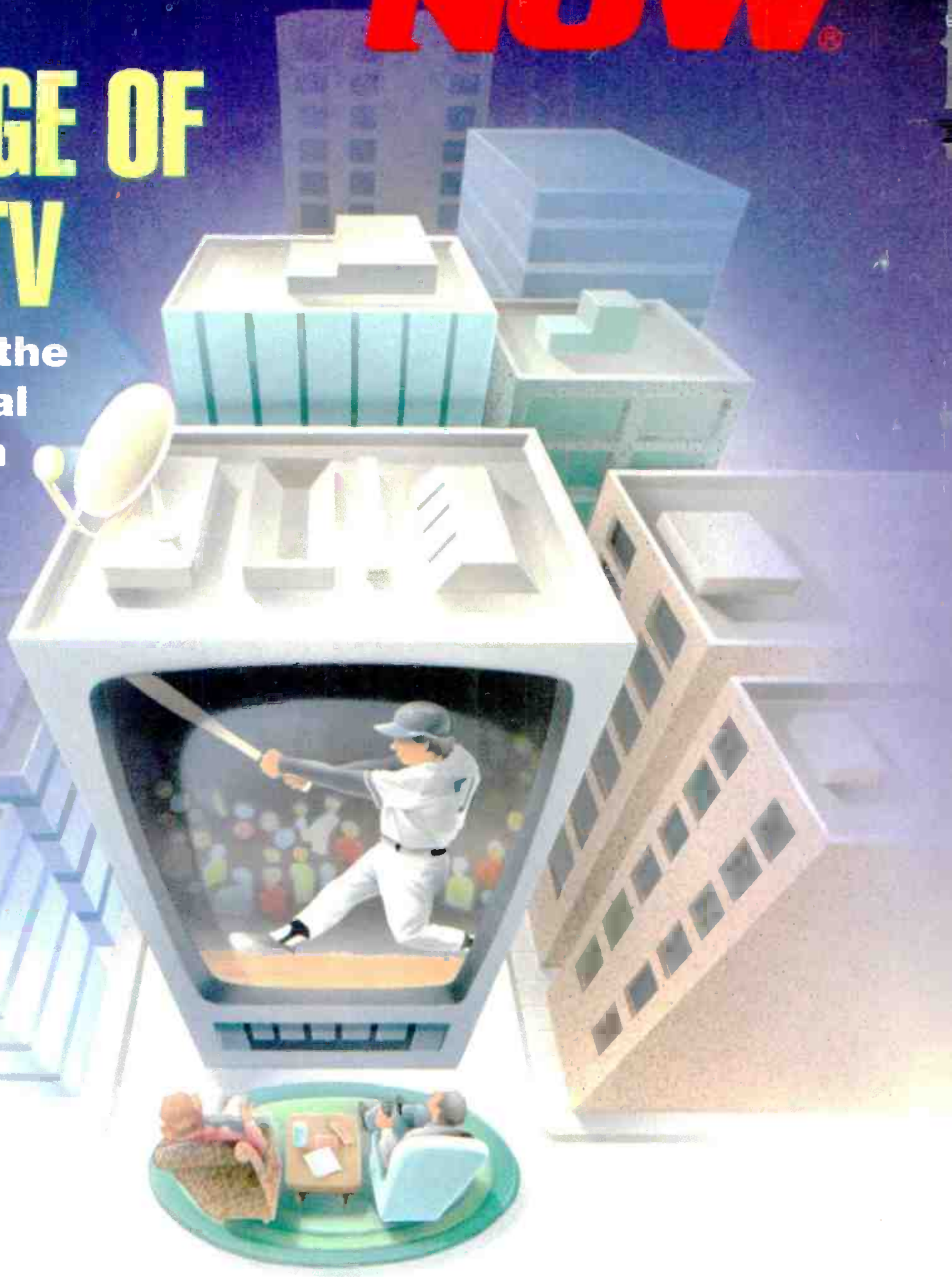

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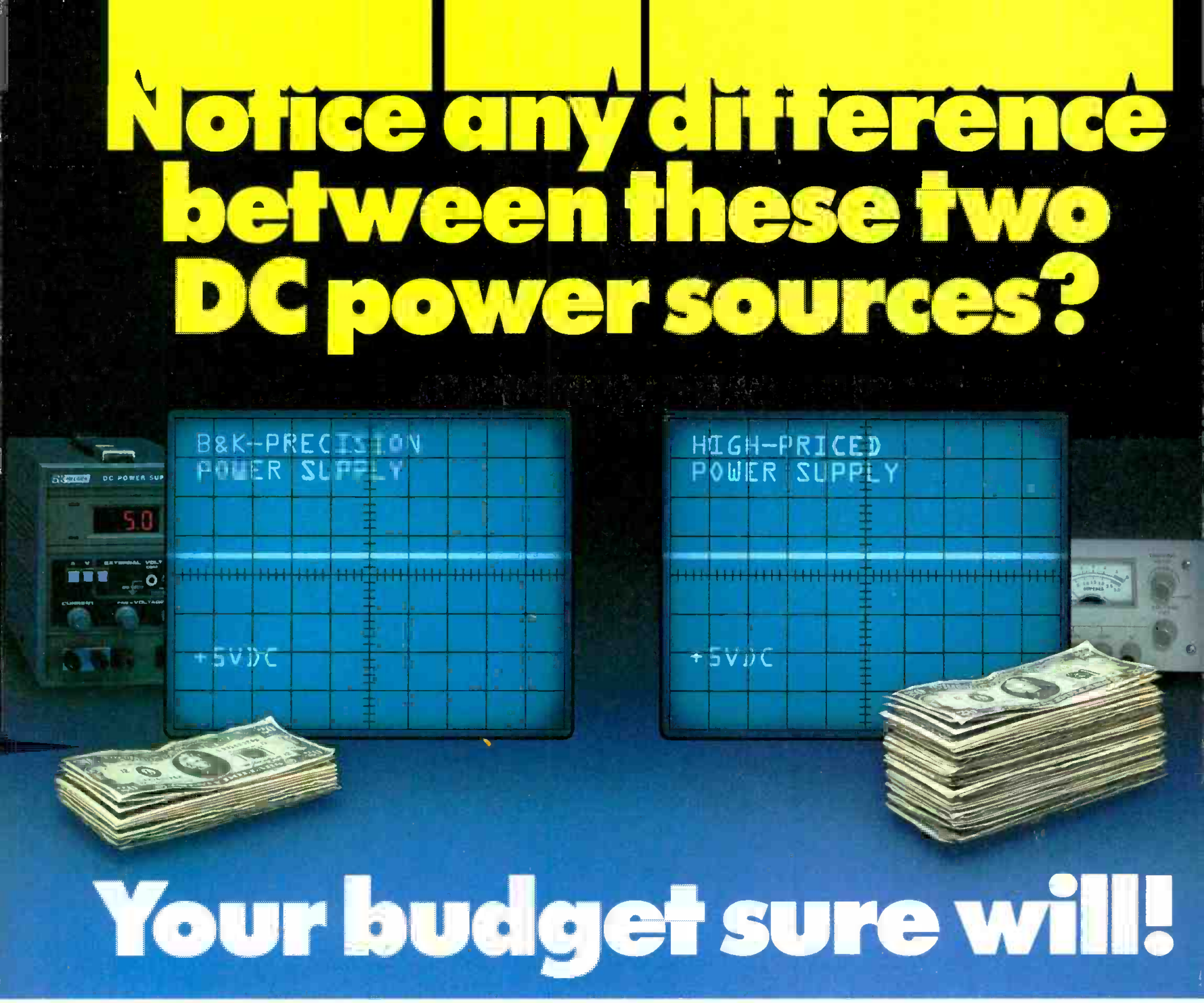

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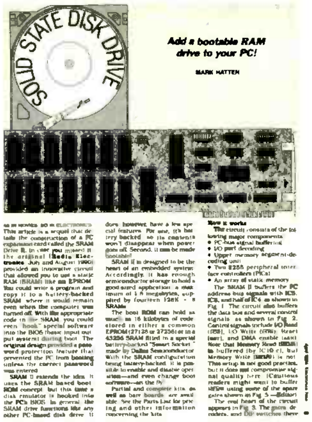

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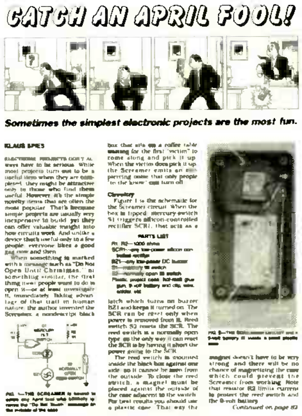

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DEPARTMENTS

AND MORE

ON THE COVER

Nothing on TV? Not for long! Thomson Consumer Electronics' Digital Satellite System could bring to the masses the picture and sound quality that previously could be achieved only by installing an 8- to 12-foot dish antenna. DSS requires only an 18-inch dish and a set-top integrated receiver/decoder. Two high-powered satellites will deliver up to 150 channels of programming, including such services as HBO, Cinemax, CNN, ESPN, and the Disney Channel, as well as pay-per-view movies and live sports and concert events. To find out how DSS could change the way you view TV, turn to page 33.

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WHAT'S NEWS

A review of the latest happenings in electronics.

Bipolar lithium battery doubles laptop computer operating time

The first practical bipolar lithium-ion battery suitable for powering laptop computers and other portable electronic products has been announced by Yardney Technical Products Inc., Pawcatuck, CT. Yardney says its electrochemical system offers better performance and longer life than conventional nickel-cadmium and monopolar lithium rechargeable batteries.

The company reports that its bipolar lithium-ion battery will power a typical laptop computer for six-to-eight hours per charge. This compares with the three-to-four hour limit expected of nickel-cadmium batteries.

The Yardney battery has a microporous separator between thin positive and negative electrodes in a multicell assembly that the company says provides short current paths through the stack rather than across the surface of each electrode. This, it claims, minimizes resistance losses along or across electrodes. Self-heating, a response that can limit useful life in monopolar lithium-ion cells is said to be reduced.

PERFORMANCE CHARACTERISTICS OF RECHARGEABLE BATTERIES

Characteristics	Lead-Acid	Nickel-Cadmium	Nickel-Metal Hydride	Yardney Lithium-Ion Monopolar	Yardney Lithium-Ion Bipolar
Cell Voltage	2.0	1.2	1.2	3.6	3.6
Energy Density (Wh/L)	85	90	120	200	250
Specific Energy (Wh/Kg)	30	40	60	100	120
Cycle Life	<500	>500	>500	>1200	>1200
Self Discharge (%/mo)	<5	<30	<45	<2	<2
Power Density (W/L)	G	E	A	A	E
Specific Power (W/Kg)	G	E	A	A	E
Key:	A=Average		G=Good		E=Excellent

NESDA Challenges U.S. Copyright Act

The National Electronics Service Dealers Association (NESDA) has come to the aid of Peak Computer Corporation in its legal battle with MAI Systems Inc.

NESDA and its associated organizations filed a friend-of-the-court brief in Washington DC last November on behalf of Peak which has been sued by MAI Systems for alleged violations of the U.S. Copyright Act.

MAI says the software which operates its computers is licensed only to the owners of those computers, and only licensed owners should be allowed to turn them on. Its suit charges that Peak and other service companies are breaking the law by turning on the computers for service.

Two lower courts agreed with MAI that by turning on a computer a "copy" of the operating program is made in the computer's RAM. This, MAI says, violates Sec. 117 of the U.S. Copyright Act.

NESDA believes that if the ruling is allowed to stand, manufacturers of such products as appliances, audio and video equipment, and heating and air-conditioning controls could claim a similar exclusive right to their "intellectual property." According to NESDA Executive Director Clyde Nabors, "NESDA has no choice but to oppose" the lower court's ruling, which he views as "another of a long string of thinly-veiled attempts by some manufacturers to eliminate competition from independent service [organizations]."

The NESDA brief challenges the ruling on several points of law. In its brief, NESDA referenced a previous Supreme Court ruling that concluded that a market for the service of a product exists after the sale of the product. In effect, the Court said that even if a manufacturer does not monopolize the sale of its product, it can still be charged with illegally trying to monopolize the service of those products.

The NESDA brief, entitled the "Service Industry Signal," is being filed by attorney Ron Katz of the San Francisco office of Coudert Brothers, a New York law firm. To recover the cost of the brief as well as the cost of future "signals" from the service industry, NESDA has requested contributions to the "S.I.S." legal defense fund from concerned service dealers and technicians. The contributions are to be sent to the SIS Fund, c/o NESDA, 2708 West Berry Street, Fort Worth, TX 76109.

Optical filter speeds natural-gas detection

The Gas Research Institute is supporting the development of a natural-gas pipeline monitoring system by Westinghouse Electric Corporation. The work being done at the Westinghouse Science & Technology Center in Pittsburgh. A survey vehicle was fitted with a gas detection system based on an electro-optic crystal filter. The system promises reliable leak detection at speeds five to ten times faster than are possible from existing leak-detection vehicles.

Existing systems are based on a flame-ionization detector that responds to combustible gas in air samples continuously drawn into the vehicle through ground-level in-

Continued on page 84

VIDEO NEWS

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

DAVID LACHENBRUCH

• **Satellite power.** While the cable and telephone companies talk about the digital superhighway, the first high-powered digital satellite system—projected eventually to offer 150 channels—is preparing for sale of receivers and programming to the general public this spring. (See separate article on page 33 of this issue.)

Receivers and 18-inch dishes—suitable for mounting on window ledges or rooftops—initially will be sold to the public through mass-market dealers including Sears and Circuit City. The Digital Satellite System (DSS) receivers will be offered at $700 ($900 for a multi-TV system) along with separately-priced subscription program packages. The Digital Satellite System, using a Hughes satellite, is scheduled to offer 55 channels at the start, increasing to about 150 channels when the second bird is launched by this summer.

Two companies will offer program packages, consisting for the most part of cable programming and video-on-demand movies. DirecTv and U.S. Satellite Broadcasting (USSB) both use the same standards and emanate from the same satellite. It will be the first digital-video program service available to the general public, and it will include what is claimed to be CD-quality audio. Programming will be digitally compressed for transmission and decompressed at the receiver. Initially, RCA will have the exclusive right to sell receivers, but Sony has received a license to become the second source for these receivers when RCA's exclusivity ends.

• **Commercial killer.** The idea of eliminating commercials when taping TV shows has been tried many times with little success. Some efforts have resulted in taping only the commercials and killing the rest of the program. A new system, due on the market shortly, seems to offer a foolproof way to watch programs and skip the blurbs. The invention by Jerry Iggulden, called "Commercial Free," will first be marketed by Arista Technology as an add-on recording accessory under the name "Commercial Brake" at about $200, and later the system is expected to be built into some VCRs.

Commercial Free uses sophisticated microprocessor technology. The entire program, commercials and all, is recorded on the tape. The electronic brain in Commercial Free keeps track of commercial "clues"—periods when sound and video are cut off momentarily. It puts invisible and inaudible signals on the tape to denote these clues. When the program has been recorded, the device inspects that program "map" and notes where clusters of regular short intervals are located. On playback, it instructs the recorder when to go into fast-forward, skipping through the commercials. The screen turns a blank blue during those intervals, which reduces the time watching commercials from minutes to mere seconds of fast-forwarding.

• **Index Plus.** Another VCR gadget—this one developed by Gemstar Development, which invented the VCR Plus video-programming system—promises to help you keep track of your tapes. Gemstar currently is showing VCR manufacturers its "Index Plus," which uses program identification material transmitted by TV stations and cable networks under the recently authorized extended data service (EDS) rules. The EDS rules set aside the second field of Line 21 of the vertical blanking interval for various services, including extended closed captions.

Index Plus captures the program identification signals transmitted by the stations during home taping and, upon demand, can display a list of programs stored on the cassette that is in the recorder. Using a remote control, the viewer can select the desired program and the VCR will fast forward or reverse to that program—no counter or time numbers are required. In addition, the system remembers all the programs recorded using the EDS signal and can display a list of them, identifying which cassette—by index number—contains each listed program.

• **Video-game war.** Almost every week seems to bring a new entry in the TV-based interactive market, still keyed mainly to games. Last year, Nintendo's supremacy was challenged by Sega, which made a significant dent in the cartridge-based game field. Both companies have CD-based games as well. Atari recently introduced the Jaguar cartridge game. More elaborate CD-based systems for games as well as educational and other entertainment uses include CD-I by Philips, which is expected to gain new adherence this year, and 3DO, currently being marketed by Panasonic but with AT&T and Sanyo expected to offer their own versions soon. JVC has introduced a player called "X'Eye," which is compatible with Sega's cartridge and CD-based systems. Other video-game systems are yet to be developed, along with interactive long-distance game systems, to be offered to customers by both cable-TV and telephone companies.

Videogame violence worries Congressmen, who have held hearings on the subject and have urged the industry to set up a voluntary ratings system. At least three groups are proposing different systems, and there was frantic activity at the recent Consumer Electronics Show in Las Vegas to develop a self-rating protocol before the government steps in and legislates a rating system. Ω

Q & A

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

MEMORY CONFUSION

I've been using an IBM-compatible computer for several years and I'm constantly confused about which memory is which. Some programs are designed to use extended memory, some use expanded memory, and recent versions of DOS use high memory. I'd like a clear explanation of exactly what these different memory types are and which is the best to use.—F. Rische, Affneg, NY

The answer to that question can cover a lot of pages, and the fact that you can even ask the question is a result of some very bad decisions on the part of the early DOS designers. It was decided by somebody that 640 kilobytes was the maximum amount of memory that would ever be needed by DOS applications. Whoever made that decision more than ten years ago is responsible for today's problem of fitting size-ten programs in a size-five operating system.

Take a look at the memory map of a typical DOS system in Fig. 1. The map differs for the different microprocessors (8088, 80286, 80386, etc.), but the essential parts are the same. The first 640 kilobytes (640K) of memory is called conventional memory. It has to hold, starting from address 0000, data necessary for both the hardware (the interrupt table) and DOS (device drivers, BIOS or data, and DOS itself). The remaining area up to 640K can be used for programs, TSR (terminate and stay resident) programs, and data.

The memory area from 640K to 1 megabyte is the high RAM area for the storage of such data as the video BIOS, I/O BIOS, and system BIOS data. The exact address ranges assigned in this area depend on the details of each computer.

Memory above 1 megabyte is referred to as extended memory. The first 64K of this area (1024K to

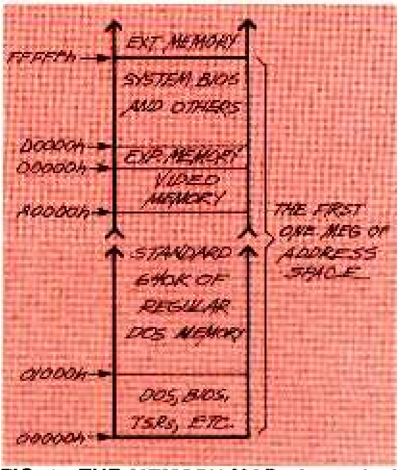


FIG. 1—THE MEMORY MAP of a typical DOS system shows that the first 640K of memory (the conventional memory) has to store the hardware interrupt table, device drivers, BIOS data, DOS itself, and programs.

1088K) is called the high memory. This is where recent versions of MS-DOS have allowed you to relocate most of the DOS code and TSRs such as mouse drivers. This software bandage has eased up the usual memory squeeze, but it's far from an ideal solution. Extended memory is just the linear address range from 1 megabyte to the end of the memory installed in your computer.

The last type of memory, expanded memory, really has nothing to do with DOS because it's not part of the microprocessor's memory map. If you have 1 megabyte of expanded memory, DOS has no direct access to it. To use expanded memory, your computer needs expanded-memory management software that reserves a range of memory in the microprocessor's address map and then swaps pages of expanded memory in and out of that area. Data in expanded memory is therefore available only a page at a time as it's copied to an area in the main memory map. The first heavy-duty user (and the originator) of expanded memory was Lotus. Even ten years ago, the typical business spreadsheet could easily outgrow the available 640K of memory.

By the way, there's nothing new about expanded memory. Apple was using the same technique for years in the Apple II series to swap two sets of 16K storage for the top of the 6502's memory map.

The answer to which type of memory is best depends on the software. Newer software such as Windows and OS/2 are operating systems that can use all memory in a linear fashion. In other words, you can keep loading data into memory until you run out of installed memory. This is also how the Macintosh operating system works. Programs that run under DOS, however, are always going to be at the mercy of DOS's limitations. Some software publishers produce DOS products that can use extended or expanded memory, but they will always be limited, one way or another, by the ten-year-old 640K barrier.

The real solution to this limit would be a total rewriting of DOS to eliminate the 640K barrier. You can wait for it if you want, but I don't think it will ever happen. One of the most unshakable tenets of Microsoft is the issue of backward compatibility, and producing a DOS that could treat memory as an unrestricted linear array and still handle earlier programs would be a mammoth undertaking.

ELUSIVE READINGS

I'm having a problem at my workbench that I hope you can help me with. The readings I get on my voltmeter and oscilloscope seem to vary from day to day. What makes this so unusual is that the varying readings are coming the same test points in the same circuits. Do you have any idea what could be causing this problem?—D. Hutch, Gale, CA

I'll begin this by giving you the benefit of the doubt regarding the

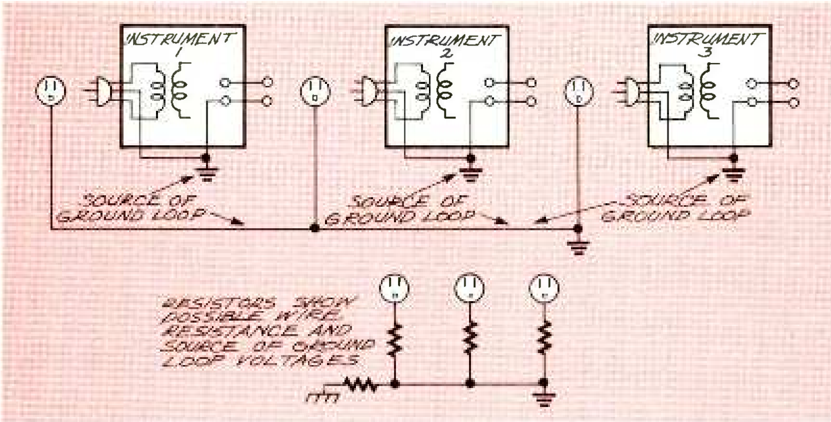


FIG. 2—GROUND LOOPS are caused by improper grounding. Ground-loop voltages can interfere with test measurements because the voltages in a ground loop can be larger than the signals you're trying to measure.

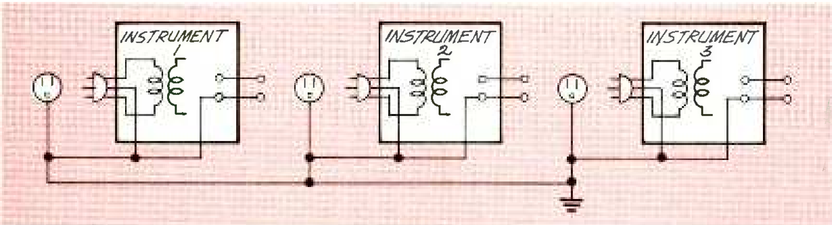


FIG. 3—TO PREVENT GROUND LOOPS, use two wire plugs to provide the line power to the test instruments and a separate wire to bring the input grounds of the instruments to a common ground.

quality of your test instruments and the extent of your expertise. Even though there are several possible reasons for your problem, my best guess is that you're falling victim to one of the oldest, and most overlooked sources of bench problems I can think of—bad grounding in the AC line that supplies power to the bench.

You went into great detail about your bench setup but didn't say a lot about the way you supply power to the test instruments. If you look at Fig. 2, you'll see the two main ways that ground loops get into an electrical system and, possibly, mess up measurements. Remember that while the voltages in a ground loop are small in comparison to the line voltage, the signals you're trying to measure are often smaller than the ground-loop voltages that interfere with them.

I can't tell you how many times I've seen test benches that were set up with meticulous care but with no thought whatsoever put into the distribution of line power. For best results, you should wind up with something that resembles Fig. 3. You'll notice that two-wire plugs are used to provide the line power to the instruments and that a separate wire is used to bring the input grounds of the instruments to a common ground point which is, in turn, connected to a solid earth ground.

IMPEDANCE MATCHING

I do a lot of home audio recording using microphones, and was recently given several old, but still useable low-impedance mikes. However, all my equipment has inputs designed for high-impedance mikes. As a result of this mismatch, I get extremely low recording levels and a lot of hum. Is there any simple circuit I could build to make these mikes work with my equipment?—M. Bith, Phoenix, AZ

The easiest way to do what you have in mind is to use a transformer to step up the voltage from the low-impedance mikes. However, there are certain disadvantages to using transformers. It's much easier for you to build an impedance-matching circuit for each of the mike inputs you'll be using.

The schematic in Fig. 4 is a small one-transistor amplifier that will provide more than enough gain to solve your problem. The component values aren't critical and as long as you stay within twenty percent or so of the values shown in the schematic, the circuit will operate properly. The layout of the circuit isn't critical either, and it draws so little power that a 9-volt battery will last as long as its rated shelf life. Ω

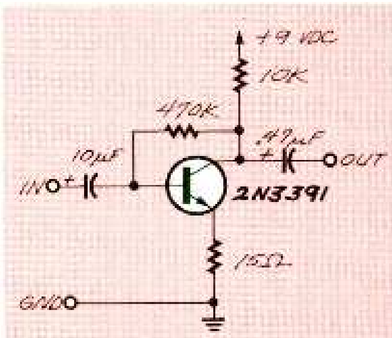


FIG. 4—THIS ONE-TRANSISTOR amplifier will provide more than enough gain to use low-impedance mikes with high-impedance equipment.

LETTERS

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

PC ANTENNA CONTROL

The article, "PC-Based Universal Remote Control," by Jon Beck (**Electronics Now**, June 1993), and the improvement suggested by R.S. Fleishmann II in the December 1993 *Letters* column, prompted me to build the circuit for my Houston Tracker V satellite system. I wanted to focus my satellite dish on a different satellite to record a program in the middle of the night. Although later model satellite receivers have that capability, mine does not; computer control appeared to be the answer.

Unfortunately, the circuit with the five 4051 digitally-controlled analog switches would not work. Apparently the impedance of the row/column contacts on the Tracker V remote is extremely high (although the slightest contamination of its contacts prevents it from operating). By connecting the 4051s (in an off state) in either Bek's or Fleishmann's circuit puts the remote in a transmit condition. Regardless of what I tried, neither circuit would work.

That annoyed me, so I became determined to solve the problem. I found that stock optoisolators worked well. That discovery inspired me to design the simple and totally reliable circuit shown in Fig. 1. It has the additional advantage of providing total electrical isolation between the computer and the remote control.

The circuit has one 74LS541 octal bus/line driver and two quad optoisolators with darlington output (NEC or equivalent). The circuit can control a 16-function (4×4 matrix) keypad. It is driven by the parallel port of an IBM PC or compatible with a short GWBASIC program. Figure 2 is a sample program that drives the antenna for two moves which can be expanded for more moves.

Although the circuit draws less than 10 milliamperes when in standby, I am developing another circuit with a CMOS driver to permit the control to be packaged as a battery-powered portable unit.

ROBERT M. HARKEY, W4CUG
Charlotte, NC

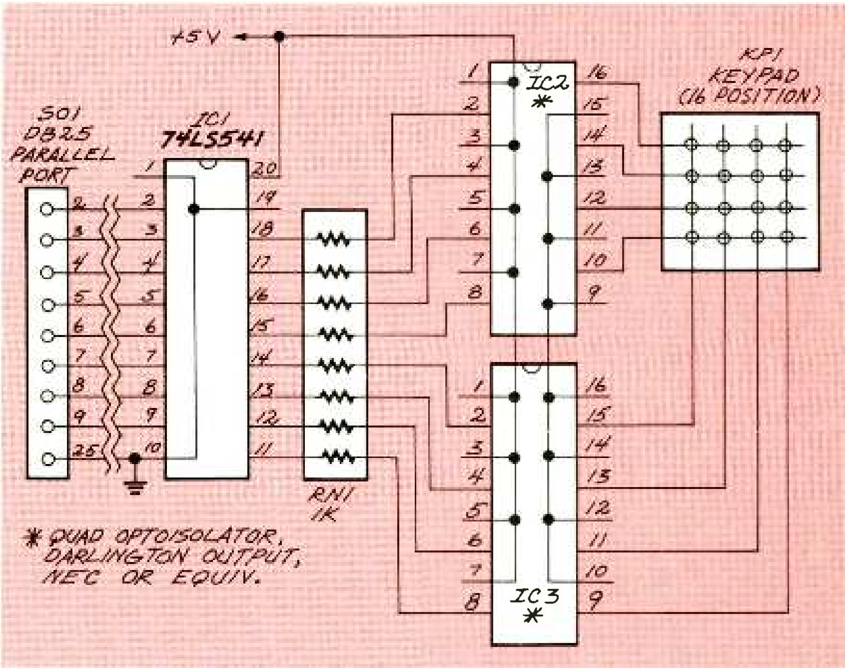


FIG. 1—REMOTE CONTROL FOR SATELLITE TRACKER includes a 74LS541 and two quad optoisolators with darlington output.

```
10 'FILENAME: REMOTE1.BAS.  USED W/TRACKER V REMOTE & COMPUTER.
20 'BY R. HARKEY, 12/93.
30 CLS: KEY OFF:
40 D=&H378: 'LPT1 PARALLEL PORT USED
50 OUT D,255:
60 PRINT"PROGRAM START TIME:  ";TIME$
70 PRINT"(PRESS Q TO QUIT PROGRAM)":
80 INPUT"WHAT IS THE FIRST FAVORITE CHANNEL";A$: GOSUB 340:
90 INPUT"WHAT TIME TO EXECUTE (6 DIGIT)";B$: GOSUB 340:
100 INPUT"WHAT IS THE SECOND FAVORITE CHANNEL";C$: GOSUB 340:
110 INPUT"WHAT TIME TO EXECUTE (6 DIGIT)";D$: GOSUB 340:
120 ROW=8: COL=1: X$=A$: Y$=B$: GOSUB 150:
130 ROW=12: COL=1: X$=C$: Y$=D$: GOSUB 150:
140 LOCATE 20,1: END:
150 LOCATE ROW,COL: PRINT"CURRENT TIME IS  ";TIME$:
160 IF INKEY$="Q" THEN 140 ELSE 170:
170 PRINT"EXECUTION TIME IS ";Y$: IF TIME$=Y$ THEN 180 ELSE 150:
180 OUT D,183: GOSUB 330: OUT D,255: GOSUB 330:
190 IF X$="0" THEN G=215:
200 IF X$="1" THEN G=238:
210 IF X$="2" THEN G=222:
220 IF X$="3" THEN G=190:
230 IF X$="4" THEN G=237:
240 IF X$="5" THEN G=218:
250 IF X$="6" THEN G=189:
260 IF X$="7" THEN G=235:
270 IF X$="8" THEN G=219:
280 IF X$="9" THEN G=187:
290 OUT D,G:
300 GOSUB 330:
310 OUT D,255:
320 RETURN:
330 FOR Y=1 TO 3000: NEXT Y: RETURN: 'DELAY TIME
340 IF (A$="Q") OR (B$="Q") OR (C$="Q") OR (D$="Q") THEN GOTO 140
ELSE RETURN:
```

FIG. 2—SAMPLE PROGRAM IN GWBASIC for driving satellite antenna under PC control.

PROTECTING VINTAGE TUBES

The article entitled "Vintage Radio" by Marty Knight (**Electronics Now**, January 1994) contains an incomplete instruction that, if followed, could cause the destruction of valuable tubes. I refer to the statement "Replace the line cord with a cloth-covered cord from your hardware or lighting store."

Before the development of high-voltage filament tubes such as the 35Z5 and the 50L6, most tubes had 6- or 12-volt filaments. In the typical AC/DC radio made in the late 1930's and early 1940's, the voltage drop across those series-connected filaments was only about only 60 volts. It was necessary to add extra resistance to the line cord to allow the set to be powered from the 120-volt AC line.

The earlier sets had a *ballast tube* that looked like a conventional metal tube; it was plugged into a tube socket. The ballast tube contained a wirewound resistor with a high-watt rating that became very hot (almost red hot!) during normal operation. To keep a heat source of that kind out of the cabinet—especially after plastic enclosures became popular—the *resistor line cord* was developed. It was commonly used in the late 1930's and early 1940's.

The resistor line cord was a three-wire cord with two stranded copper conductors and a third resistance wire which was connected in series with the filament string. It looked like a conventional cloth-covered line cord, although it was a little thicker because of an asbestos layer under the cloth cover. Heat was dissipated over the length of the cord.

You could identify a resistor cord because it had three wires coming out of one end and was terminated by a two-prong, AC-line plug on the other end. When it was powering a working radio, the cord became warm to the touch. The host radio had a printed notice stating that the cord should never be shortened either pasted on its back or on a tag fastened to the cord. Those cords are long gone; I doubt if any are available except on old radios.

During World War II when materials were scarce, some do-it-yourself articles advised substituting a 120-volt incandescent lamp bulb as a dropping resistor. The power dissipated depended on the tubes in the radio. I recall one construction article for a combined radio/night light with the lamp acting as the dropping resistor.

A discrete resistor with a high-watt rating in series with the line cord was another alternative—if it were mounted so that it would not be a fire threat or burn anyone by accident.

My point is that a conventional two-wire, cloth-covered lamp cord is not a satisfactory replacement for a resistor line cord. Its use could result in putting twice the rated voltage across your tube filaments—making your tubes very unhappy in their old age.

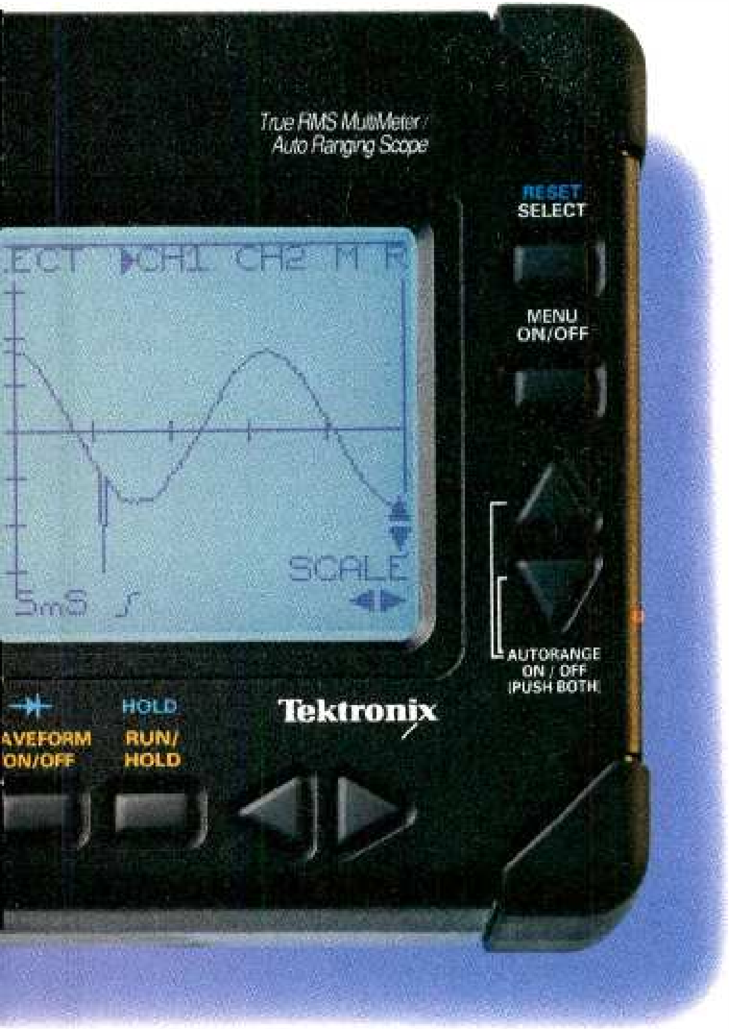
NORM HOSLER, W2SFV
Lake Ariel, FL

AUDIO SCRAMBLING SYSTEM

In reading "Audio Scrambling System" by William Sheets and Rudolf Graf (**Electronics Now**, December 1993), I was amused by

Continued on page 81

l of the trades.



push of a button, you'll see exactly what you're measuring.

Easy to afford, too.

At only 2.2 pounds, TekMeter won't weigh heavily on your belt, and it won't do much damage to your wallet, either. Starting at $859,* the TekMeter packages a remarkable set of capabilities that will enhance your productivity and will be easy to justify.

Put one in your hands today.

Of course, the best way to take full measure of TekMeter is to try it for yourself. For the name of your nearest authorized Tektronix distributor, call 1-800-426-2200, ext. 800 and put one to the test.

Once you've seen everything TekMeter can do—and how easily it does it—we think you'll agree it's the one tool you won't want to trade for anything else.

Come test drive the TekMeter at your local distributor and judge for yourself.

Tektronix

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EQUIPMENT REPORTS

Elenco Electronics SM-220K Decision Maker

The typical electronics hobbyist today builds circuits with leaded components—the kind with leads attached that pass through holes drilled in a PC board. Surface-mount components, by contrast, seem to be dreaded by hobbyists because their small size makes them difficult to work with, particularly for those with less-than-perfect vision. Surface-mount components are rarely specified in this magazine's construction projects because the authors who design the projects usually don't like to work with the tiny components either. They also want to keep the projects as easy to build as possible because cost-effective mass production is usually not a concern. Nevertheless, surface-mount technology (SMT) is here to stay, headed our way (toward hobbyists, that is), and will probably replace conventional through-hole, leaded-component technology altogether in the years to come.

Surface-mount components typically cost less than leaded components, and PC boards are usually cheaper when holes don't have to be drilled in them. Board space is saved when surface-mount components are used. That trims the cost of PC boards (smaller boards cost less to produce) as well as the cost of cases to package them in.

Surface-mount components have made miniature products producible as well as practical. Tiny gadgets such as cellular telephones and pocket pagers couldn't be made as small if it weren't for SMT.

While miniaturization is primarily a concern for the consumer and military electronics industry, the hobbyist is likely to see more and more surface-mount projects in the future. Although surface-mount components aren't often specified in these pages, they do show up. Take, for example, the TG2000 sweep generator in this issue. That project makes extensive use of SMT, but considering the kit's cost, it's a project that should be attempted only if the builder has prior SMT assembly experience.

Give SMT a try

If you've never worked with SMT components, then you ought to try it at least once. With patience, it's not that difficult, and a project such as the SM-200K Decision Maker kit from Elenco Electronics, Inc. (150 W. Carpenter Ave., Wheeling, IL 60090, 708-541-3800) actually makes it fun.

The Decision Maker is a neat little circuit that randomly lights one of six LEDs when a button is pushed. The LEDs are laid out in a hexagonal pattern that "spins" like a roulette wheel for a few seconds before settling on one LED. An accompanying pulsating beep is heard while the display spins. A red plastic lens labeled with six "answers" (Ask Again, Maybe, Always, No Way, Forget It, and Positively) fits over the finished board. The idea here is that you ask it a question, press the button, and it gives you an answer. It's similar to a *Magic 8-Ball*, only more fun to play. The kit includes a PC board, SMT components, the plastic lens, some solder, an instruction manual—and even a 9-volt battery.

Although the circuit is composed entirely of surface-mount components, it is a simple project to build; only two ICs and a handful (actually a pinch) of passive components are used. However, the kit includes a wide variety of different kinds of surface-mount components, making it a good first-time SMT project.

Soldering surface-mount components is actually very easy if the right techniques are used, although it is a bit tedious. The main problem is holding the components in place while soldering, because there are no leads to do it for you. One technique suggested in the manual worked quite well: Parts are first held down on the board with bits of masking tape with at least one terminal and solder pad exposed. After that pad is soldered, the tape can be removed and the part will stay put while you solder the rest of the pins or pads. We found it to be very important to use a clean, sharp-tipped soldering-iron at all times. The pencil tip we used worked well as long as we minimized the solder used. Even a small blob of solder on the iron's tip will easily "jump" to the adjacent pins on an SMT IC. We found holding the part with tweezers while soldering to be more difficult.

The main reason for building this kit is to gain experience with SMT components. The PC board has a small practice area and a few extra SMT components are included for those who want to practice the soldering technique before starting work on the actual circuit. We test-soldered one component in this area before starting on the working section. It's a good idea to use this section at least once, if only to make sure your soldering iron tem-

Continued on page 83

NEW PRODUCTS

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

TRIPLE-OUTPUT DC POWER SUPPLY. A new 35-watt triple DC power supply from *Hewlett-Packard* has three different outputs. The outputs of the *HP E3630A* are 0 to 6 volts with a 2.5-ampere maximum current, 0 to 25 volts, and 0 to −25 0.5-ampere maximum current.

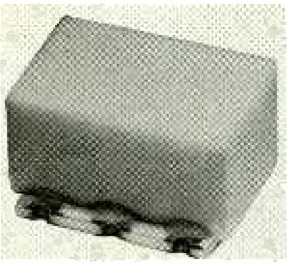
Separate digital meters on the *HP E3630A* permit simultaneous monitoring of voltage and current of any of its outputs. The 0.01 % load and line regulation assure steady outputs despite changes in power line voltage and load. It offers auto-tracking so that one voltage control adjusts the +20-volt and −20-volt outputs simultaneously. The outputs, which track each other to within 1%, are protected against overload and short-circuit damage.

The *HP E3630A* with an AC power cord, operating manual, and 3-year limited warranty is priced at $500.

CIRCLE 16 ON FREE INFORMATION CARD

Hewlett-Packard Company
Direct Marketing Org.
P. O. Box 58059
MS51 L-SJ
Santa Clara, CA
95051-8059
Phone: 1-800-452-4844
Ext. 7941

WIDEBAND MIXER. A new surface-mount, wideband 5 to 2500-MHz mixer is available from *Mini-Circuits*. The *RMS-25 MH* is packaged in an a ceramic case that measures 0.25×0.31×0.2 inch. The stated typical VSWR ratings are: LO: 1.60:1, RF 1.6:1, and IF1.10:1. The mixer has been built to pass MIL-M-28837 shock and vibration tests. All connection pads on the mixer have solder over a nickel-barrier.



CIRCLE 17 ON FREE INFORMATION CARD

The *RMS-25MH* is priced at $7.95 each in 10 to 49 quantities.

Mini-Circuits
P. O. Box 350166
Brooklyn, NY 11235-0003
Phone: 718-934-4500
Fax: 718-332-4661

CIRCLE 18 ON FREE INFORMATION CARD

SURROUND-SOUND MONITOR. A multi-channel audio monitor from *Leader Instruments* displays the surround-sound images in several formats. The *Model 5836A*, accepts up to five channels for left/center/right/surround and left/center/right/left-surround/right-surround systems.In addition, an X-Y (Lissajous) phase display can be selected between any pair of channels.

On-screen displays include level readouts in the X-Y mode and electronically-generated graticules for both X-Y and surround-sound imaging. Inputs accept both balanced and unbalanced feeds. They also accept a digital-serial feed that complies with the AES/EBU format. A "spot killer" reduces beam current in the absence of a CRT protection signal. The monitor, which fits in a standard half-rack adapter, can be remotely controlled.

The *Model 5836A* is priced at $6995.

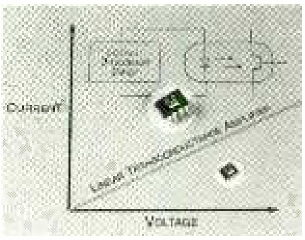
Leader Instruments
380 Oser Avenue
Hauppauge, NY 11788
Phone: 516-231-6900 (in NY) or 800-645-5104

LINEAR OPTOCOUPLER DRIVER. The *UC39431* and *UC39432* precision adjustable shunt regulators from *Unitrode* can function as optocoupler drivers in switching power supplies and as complete front ends for power supplies. Both of these ICs will replace common-emitter transistor amplifiers to provide linear control of an optocoupler's LED current. This results in greater accuracy than could be obtained from a nonlinear amplifier output.

The *UC39431* includes a linear transconductance amplifier, stable voltage reference, and three precise, low-temperature coefficient resistors that can be connected to provide one of six regulated output voltages. The *UC39432* is similar to the *UC39431*, but it does not have internal resistors. Its construction permits access to the error amplifier inputs and voltage reference. The gain of the linear transconductance amplifier is programmed by an external resistor to improve stability in closed-loop, optocoupler-feedback circuits.

The shunt requlators also have applications in voltage-to-current converters, flyback converters, magnetic-amplifier controllers, and analog voltage sensors.

The *UC39431BN* and



CIRCLE 19 ON FREE INFORMATION CARD

UC39432BN are priced at $1.25 each in 1000 quantities.

Unitrode Integrated Circuits Corporation
7 Continental Blvd.
Merrimack, NH
93054-0399
Phone:603-424-2410
Fax: 603-424-3460

VL-IDE-DISK CONTROLLER. A new 32-bit *CSA-6210* VESA VL-Bus IDE disk controller from *CMD Technology* supports up to four IDE disk drives. It is compatible with Novell NetWare disk mirroring, Windows NT RAID 0, 1, and 5, and Windows FastDisk and MS-DOS driver support.

The *CSA-6210* is compatible with an IBM PC or compatile computers with VESA VL-bus slots. It includes CMD's IDE Software Toolkit which permits custom tailoring. Its specifications include sustained transfer rates up to 8.2 megabytes per second, with peak transfer rates up to 8.33 megabytes per second.

CIRCLE 20 ON FREE INFORMATION CARD

The *CSA-6210* disk controller, owner's manual, and IDE Software Toolkit is priced at $69.

CMD Technology Inc.
1 Vanderbilt
Irvine, CA 92718
Phone: 714-454-0800
Toll Free: 800-426-3832

ELECTRICAL CONTACT CLEANER. Electical contact cleaner in an aerosol can from *Caig Laboratories* is free of carrier solvents that could contaminate the environment. *ProGold* G100 spray cleans and lubricates gold plated, base-metal plated, and other contact surfaces of edge connectors, battery terminals, plugs, relays, sockets, and switches. The manufacturer recommends it for abrasion reduction, and elimination of arcing, tarnishing, and contamination from airborne particles.

CIRCLE 21 ON FREE INFORMATION CARD

A 2-ounce aerosol can of *G100 ProGold* is priced at $24.95.

Caig Laboratories, Inc.
16744 West Bernadino Drive
San Diego, CA 92127
Phone: 629-451-1799
Fax: 619-451-2799

HIGH-VOLTAGE PROBES. Three high-voltage probes from *ITT Pomona* are in-

CIRCLE 22 ON FREE INFORMATION CARD

tended for use with handheld or bench digital multimeters and oscilloscopes. *Model HV-40B*, intended for low-frequency measurement with instruments with 10-megohm input resistance, is rated at 40 kilovolts DC plus peak AC to 300 Hz with a 1000:1 voltage division ratio. With a DMM, it provides stepdown voltage readings. It has retractable-sleeve digital multimeter plugs on a 2-meter cable.

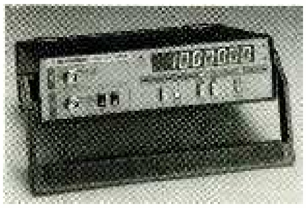
Model HV15HF is intended for measuring higher frequencies. It has a 5-MHz bandwidth, 15 kilovolt maximum input voltage rating (DC plus peak-to-peak AC), 3-picofarad input capacitance, 500-megohm input resistance, and a compensation range of 15 to 50 picofarads. The desired input is selected with a thumb-slide switch located on the handle of the test probe. A 1.5-meter cable is terminated with a BNC connector.

The *Model HV6* can make measurements at 6 kilovolts (DC or peak AC) and it has a 10-kHz bandwidth. It is intended as an accessory for 1-megohm and 10-megohm ranging multimeters. It has slide-switch selectable input and a 1.2-meter cable with retractable-sleeve DMM plugs.

The *Models HV40B* and *HV6* are priced at $90, and the *Model HV15HF* is priced at $195.

ITT Pomona Electronics
1500 East Ninth Street
Pomona, CA 91766-3835
Phone: 909-469-2900
Fax: 909-629-3317

MICROWAVE MULTIFUNCTION COUNTER. The *Model 1856A* microwave multifunction counter from *B + K Precision* has a bandwidth of 5 Hz to 2.4 GHz. It includes a crystal oscillator timebase with 0.5-parts per million stability from 18 to 28°C and 1 part per million from 0 to 50°C. Rated sensitivity is 50-millivolts at 2.4 GHz. An 8-digit LED display has kHz/microsecond, gate, and overflow indicators.



CIRCLE 23 ON FREE INFORMATION CARD

The *1856A* is suitable for making accurate and repeatable measurements of radio-transmitter output frequencies up to 2.4 GHz. *B + K Precision* says it provides measurement accuracy that exceeds FCC standards. Its upper range permits it to measure transmitter output for worldwide Personal Communications Services (PCS).

The *Model 1856A* microwave multifunction generator is priced at $499.

B + K Precision
6470 West Cortland Street
Chicago, IL 60635
Phone: 312-889-1448
Fax: 312-804-9425

HIGH-SPEED GANG PROGRAMMER. The *AR-9808* EPROM gang programmer from *American Reliance* can program up to eight EPROM memories simultaneously. It has nine 32-pin zero insertion force (ZIF) sockets. The master EPROM is located in the first socket.

Only one keystroke per-

CIRCLE 24 ON FREE INFORMATION CARD

mits the *AR-9808* to program up to eight slave 8-megabit EPROMs or 2-megabit flash EEPROMs from the master memory. The ZIF test sockets can be removed and replaced. The address, data, control, supply, and programming voltage lines to each socket are electrically isolated to prevent defective memories from affecting the programming of the other memories.

The programmer also includes detection circuitry that verifies correct memory insertion in the sockets. It can be controlled remotely from its parallel port with an IBM PC or compatible computer under an optional software package.

The *AR-9808* EPROM programmer is priced at $1495.

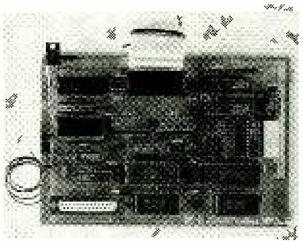
American Reliance Inc.
11801 Goldring Road
Arcadia, CA 91006
Phone: 800-654-9838 or 818-303-6688
Fax: 818-358-3838

EPROM EMULATOR. The new *ROMY-16* EPROM emulator from *J&M Microtek* emulates 2716 to 27010 EPROMs or 6116 to 628128 SRAMs for 8- and 16-bit microcontroller systems. This emulator permits a code program to be downloaded and tested with the results seen immediately. The memories need not be removed from the host system.

To emulate an EPROM, a PC can read and write data to it while the host CPU reads from the *ROMY-16*. To emulate an SRAM, both the PC and the host CPU can read and write data to the *ROMY-16*'s memory. The type and size of the memory device can be varied without circuit board changes.

For 16-bit microcontrollers, the emulator can emulate two EPROMs that share the same address line but have separate data lines. When emulating 8-bit microcontrollers, the memory with the lower byte value primarily emulates the target ROM or RAM.

To debug microcontrollers, the *ROMY-16* has a built-in, high-speed communication protocol port that can be turned on and off and located at any memory page. The user's program can send a message to the PC by down-



CIRCLE 25 ON FREE INFORMATION CARD

loading a simple communication routine into the emulator. An optional program (*UMPS V2.1*) allows on-board debugging.

ROMY-16 EPROM emulators range in price from $195 through $245, UMPS V2.1 is priced at $100 each CPU. Add $7 S&H.

J&M Microtek, Inc.
83 Seaman Road
West Orange, NJ 07052
Phone: 201-325-1892
Fax: 201-736-4567

BENCHTOP DIGITAL MULTIMETERS. *Goldstar Precision* is offering two new microprocessor-controlled

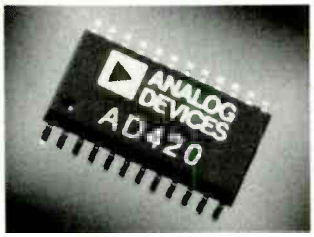
CIRCLE 26 ON FREE INFORMATION CARD

benchtop digital multimeters that have 4½-digit, 19999-count displays, 0.1% DC accuracy, and 20-megohm resistance ranges.

Both *Models DM-342B* and *DM-343B* can measure frequencies to 200 kHz and they can perform fast continuity tests with a beeper. Their functions include data hold and the abilitiy to check semiconductor diodes, batteries and transistor Hfe. In addition, the *Model DM-343B* can make true RMS measurements and measure decibels. It can also display minimum and maximum readings and has a compare mode; RS-232C or GP-IB interfaces are optional accessories.

The *Model DM-342B* is priced at $199.95, and the *DM-343B* is $279.95.

Goldstar Precision Co. Ltd.
13013 East 166th Street
Cerritos, CA 90701
Phone: 310-404-0101
Fax: 310-921-6227



CIRCLE 27 ON FREE INFORMATION CARD

DIGITAL-TO-ANALOG CONVERTER. This 16-bit DAC IC from *Analog Devices* can drive either 4 to 20 or 0 to 20 milliampere current loops. The *AD420* can be a single IC interface between a microprocessor and a standard current loop. Its output voltage is 0 to 5 volts, 0 to 10 volts, or ±10 volts.

The *AD420* requires a 12- to 36-volt supply; loop compliance is from zero to the supply voltage minus 2.5 volts.

The *AD420* is priced at $10 in quantities of 1000.

Analog Devices Inc
181 Ballardvale Street
Wilmington, MA 01887
Phone: 617/937-1428
Fax: 617/821-4273

CIRCLE 28 ON FREE INFORMATION CARD

EIGHT-PORT VIDEO SPLITTER. The *VOPEX-8M* video splitter from *Network Technologies Inc.* allows one MacIntosh to drive up to eight monitors displaying the same image.

The *VOPEX-8M* is in a 8 × 6.3 × 2.5-inch plastic case and it is powered by 120-or 230-volts AC.

The VOPEX-8M with a 3-foot interface cable is priced at $865.

Network Technologies Inc.
1275 Danner Drive
Aurora, OH 44202
Phone: 216-562-7070
Fax: 216-562-1999 Ω

DRAWING BOARD

Why build a tachometer?

ROBERT GROSSBLATT

Advances in technology can be good and bad. They're good because they can lead to the development of really neat gadgets that can make our lives easier, and the gadgets continue to get better and cheaper with each passing day. However, technological advances can be bad if, while making something easier, they also eliminate the need for us to think.

Once upon a time a four-function calculator cost over a hundred bucks. Today, just about the only place you can find such a simple calculator is as a giveaway item with a six pack of soda. It's good that they're so cheap, but it's bad also because basic arithmetic skills aren't emphasized in schools as much these days. It seems that not as many twelve-year olds today can do long division as well as they could 15 years ago, and I've yet to meet anyone under thirty years old who knows how to derive a square root on paper.

We are rapidly becoming a civilization that is incapable of functioning without a pair of AA batteries—and, as we all know, they're not included! But it's time to put away my soapbox and get back to the business at hand.

Designing a tachometer

You can probably go to any auto-parts store and buy a tachometer for under $50. It will come with a black box, three wires, and an incredibly spiffy looking display that's guaranteed to dress up the appearance of your dashboard. This basic no-brainer can be installed in the time it takes for a commercial break during your favorite TV show. Given all this, why would you even think about building your own? The parts and time required to build it are going to cost more than a store-bought unit, to say nothing of your aggravation in getting the thing to work.

Fortunately, there are still enough of us around who have enough curiosity to want to know how things work, and a sufficiently large enough ego to know for sure that we're capable of doing whatever we put our minds to.

Tachometers are usually included only on higher-end model cars or as part of an outrageously priced accessory package. Luckily for the more stubborn people, tachometers are not very difficult to build. There are lots of designs around (there are even several "tachs on a chip"), but the basic approach to building them is usually the same. In line with my well established procedure, I'll be using common ICs and standard value components.

The fundamental components of a tachometer are shown in Fig. 1. The critical elements of the design are the timebase and the counting circuitry. If the circuit can't keep accurate time, the values that it feeds to the display are not going to be very useful. Fortunately, achieving timebase accuracy is simple and achieving reliability in a pulse-counting circuit is simply a matter of careful design.

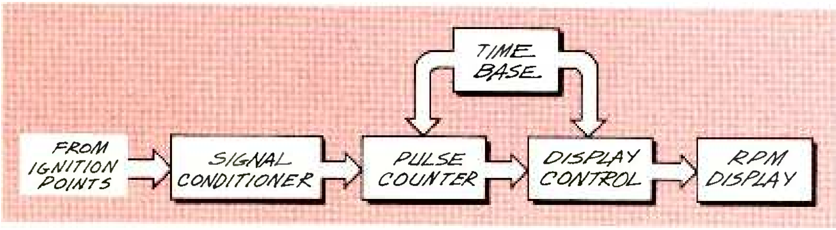


FIG. 1—FUNDAMENTAL TACHOMETER COMPONENTS. The critical elements are the time base and the counting circuitry.

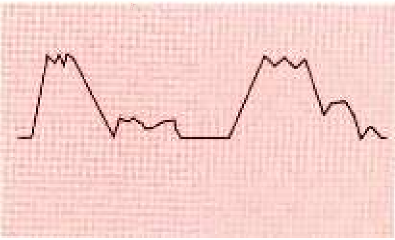


FIG. 2—A CAR'S IGNITION SYSTEM is exceptionally noisy. The pulses from the coil are in the kilovolt range, and are far from clean. They usually look something like this.

Notice that there's a separate section that conditions the signal which is fed to the tachometer circuit. Whenever you want to do something with a car's ignition system, you have to pay extra special attention to be sure that the signal you get is the signal you want. However noisy a car's electrical system might be, the ignition system is the noisiest of all. Remember that the pulses being fed from the coil are in the kilovolt range. Moreover, they're not clean square waves. If you put them on an oscilloscope you'll probably see a waveform like the illustration shown in Fig. 2.

The circuit shown in Fig. 3 is a good starting point for a signal-conditioning circuit. Notice that the signal is picked off the distributor points and not one of the spark-plug wires. The signal frequency at the distributor points is always greater than at any one of the plugs. (For example, it's four times greater for a four-cylinder engine.) And even though tachometers are really just counters that can measure very low frequencies, the higher the input frequency, the easier it is to get accurate readings.

The circuitry shown in Fig. 3 is nothing more than a series of re-

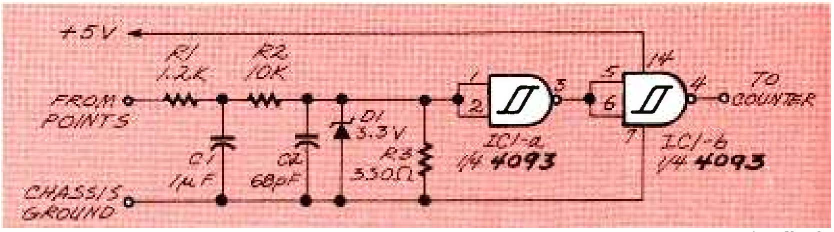


FIG. 3—SIGNAL-CONDITIONING CIRCUIT. The signal is picked off the distributor points where the frequency is greater than at any one of the plugs.

sistors and capacitors that are designed to "swallow up" any higher-order harmonics, cut the amount of power presented to the tachometer input, and isolate the tachometer from the ignition system. The values shown for the components are middle-of-the-road numbers that should work well for just about any car on the road—there isn't much difference between cars in this part of the ignition system. You might have to adjust the components slightly for your car, but you'll only have to make minor changes in the resistor values.

If you have any doubts, make the numbers higher rather than lower. The values of the capacitors can be changed slightly without their having much effect on the circuit. It's really just a question of parts you happen to have lying around.

By the time the raw pulse gets through the RC circuits, it's at a safe power level, and the majority of the signal's initial harmonics and rippling "aftershocks" have been removed. The Zener diode guarantees that the voltage level won't be high enough to fry IC1-a's inputs. The final clean up of the pulses is done by the two 4093 Schmitt triggers (IC1-a and -b) that are set up as simple inverters. By the time an input pulse gets through those, it's a TTL-compatible pulse with a frequency of one count per point pulse.

Put this part of the circuit together and hook it up to the coil wire on your car's distributor. The ideal way to see if everything is okay is to use an oscilloscope and look at the pulses produced by IC1-b. If you don't have a scope, you can probably work out some circuit with an LED and a timing light; have the LED light when there's no pulse, and shine the timing light on the LED. If everything is working, you should never see the LED light while the timing light is on. This method is not exact, and it depends on the timing light you use. If anyone out there can think of a neat way to verify this part of the circuit, I'm open to ideas. Let me know if you think of something and I'll spread it around to everyone.

Designing the counter circuit isn't as straightforward as you might imagine because the number of pulses per engine revolution depends on how many cylinders your car's engine has.

Let's assume that an engine has only one cylinder. If it's a four-stroke engine, the plug will fire only once for every two revolutions of the engine. A two-stroke engine fires once per revolution, but unless you have an old dirt bike or an ancient SAAB, you can forget about two-stroke engines altogether.

About the only place you'll see two-stroke engines these days is in chain saws and outboard engines, and there's a very good reason for it. There will be a special mention here for anyone who knows what that reason is.

The rules for multi-cylinder four-stroke engines is just a simple extension of the single-cylinder example. A single-cylinder engine fires each time the crankshaft rotates twice (every 720°). A two-cylinder engine fires once every 360° of rotation, a four-cylinder fires every 180 degrees, a six-cylinder every 120 degrees, and so on.

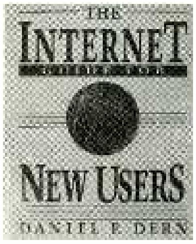
When you design the counting and timing circuitry for the tachometer, it must be configured to match the number of cylinders in a given engine because you will be relying on the number of pulses coming from the coil to reveal engine rpm. When we get together next time, we'll work out the details of these two circuits. Ω

NEW LITERATURE

Use The Free Information Card for more information on these books and literature.

The Internet Guide for New Users; by Daniel P. Dern. McGraw-Hill Inc., 1221 Avenue of the Americas, New York, NY 10020; Phone: 1-800-2-MCGRAW; $27.95.

This book provides a map and traveler's guide to the Internet. It explains procedures for entering the system to newcomers and it gives experienced users key information about the concept of the Internet and its facilities.



CIRCLE 40 ON FREE INFORMATION CARD

Dern explains the similarities and differences between the Internet, CompuServe and other on-line services. He describes the fundamentals of Internet naming and addressing, and he explains Unix in enough detail for most Internet users. The author goes on to explain how to use the Internet's basic online facilities: electronic mail, Usenet, remote-login, and file transfer.

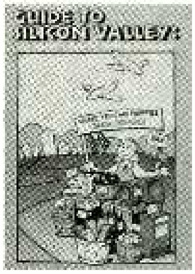
This guide will be of value to owners or users of IBM personal computers or compatibles, Apple Macs, Amigas, and Unix-based computers. It explains how to pick a suitable organization for an account based on the user's needs, interests, and budget. In addition, the book explains how to gain access to existing lists of Internet providers and services, and it cites examples of the growing list of commercial and business services. The author also explains why it is necessary to follow Internet protocol in all interactions.

Leigh Weimers' Guide to Silicon Valley: An Insider's Tips for Techies & Tourists; by Leigh Weimers. Western Tanager Press, 1111 Pacific Ave., Santa Cruz, CA 95060; Phone: 408-425-1111; $12.95.

This book views the region south of San Francisco, popularly known as "Silicon Valley" as if it were a place apart—a separate island or country where the denizens have their own language, rituals and style. It should prove to be useful whether you travel there on business or arrive there simply as a curious tourist in this fabled "cradle of high tech."

The book serves as a guide to the Valley's largest companies and venture capital firms. The author has first hand knowledge of the area; she was living there back when its principal products grew on trees in the 1950s. Ms. Weimers writes a feature column about Silicon Valley for the San Jose *Mercury News*, a nearby city not considered to be in the Silicon Valley.

She addresses both the "ancient" history and current events—personal and economic—and names names of local personalities. The book contains detailed information on lodging, dining, sightsee-



CIRCLE 39 ON FREE INFORMATION CARD

ing, shopping, the visual and performing arts, sports, nightlife, and places to take the kids. And you'll even get practical information on climate, available public transportation, and how to get around on your own. Add to that lists of wineries, annual events, parks, and a handy telephone number directory.

Ready-to-Build Telephone Enhancements; by Delton T. Horn. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; $16.95.

This book explains how to customize your telephone with enhancements that will do things like correcting an annoying ring or preventing your children from wasting your money on long-distance or 900 numbers. Intended for the

CIRCLE 38 ON FREE INFORMATION CARD

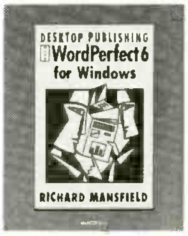
electronic hobbyist, it offers step-by-step instructions, schematic diagrams, parts lists, and layout diagrams for more than two dozen telephone-related projects.

Horn explains how to turn your standard telephone into a terminal in a multipurpose home communications system that will save you time, money, and grief. The projects described include, in addition to the musical ringer and the 900-number disconnect circuit, a Touch-Tone signaler and decoder, hold-button circuit that turns on music, and a computerized auto-dialer.

You'll be able to make a call timer with automatic hang-up as well as circuits for long-distance lockout, an auto-answering modem, and a tape-recorder interface. For the hearing impaired, there is an earpiece amplifier and a flashing-ringer.

Desktop Publishing with WordPerfect 6 for Windows; by Richard Mansfield. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $24.95.

This book concentrates on desktop publishing with WordPerfect 6 for Windows. It will be helpful in the design of logos and the layout of brochures, newsletters, and display advertising. The illustrated text gives beginners as well as intermediate users step-by-step instructions in applying the graphics tools and techniques with the



CIRCLE 37 ON FREE INFORMATION CARD

mouse. Mansfield explains WordPerfect 6's enhanced graphics features, including button bars and menus and support for Windows fonts and WordPerfect Draw. He also describes how to make graphics projects more exciting with multicolumn layouts, custom templates, and graphics macros.

All this should help readers to acquire an "artist's eye"—useful in setting up attractive, balanced layouts. The author also gives advice on the selection of type size and styles, and he comments on fads and fashion in desktop publishing. Hundreds of before-and-after examples are included.

Wiring Control Products Catalog. J&J Electronics, Inc., 6 Faraday, Irvine, CA 92718; Phone: 714-455-4460 or 800-735-4553; Fax: 714-455-4474.

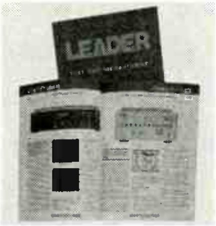
This 172-page catalog describes J&J Electronics' wiring control product line. It includes information on more than 2300 parts divided into nine separate product sections. These include solderless crimp terminals,

CIRCLE 36 ON FREE INFORMATION CARD

connectors and lugs, cable ties and accessories, wire and cable holding devices, heat-shrinkable tubing, and circuit board hardware.

Full-Line Catalog No. 24. Leader Instruments Corporation, 380 Oser Avenue, Hauppauge, NY 11788; Phone: 1-800-645-5104, in NY, 516-231-6900; free.

This 120-page, color catalog presents complete descriptions and technical specifications for 81 of Leader's electronic test instruments. Included are 10 new products. The instruments described include general-purpose analog and digital test instruments, digital storage oscilloscopes and many units of specialized test instruments and equipment.



CIRCLE 35 ON FREE INFORMATION CARD

These instruments include audio, function, and radio-frequency generators, audio analyzers, video generators and monitors, and programmable RGB generators. Leader also offers meters and bridges, frequency counters, and benchtop power supplies.

The Virtual Reality Primer; by L. Casey Larijani. McGraw-Hill Inc., 1221 Avenue of the Americas, New York, NY 10020; Phone: 1-800-2-MCGRAW; $24.95, paperback, $40 hardcover.

This book explains *virtual reality*, a complex computer-based technology. It is believed to have many commercial applications beyond entertainment. Ms. Larijani explains how virtual reality works and where it's going. She also speculates on its future impact.

CIRCLE 34 ON FREE INFORMATION CARD

Countersurveillance

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HAVE YOUR VISA or MC CARD AVAILABLE

Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

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Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

CLAGGK INC. EN
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling).

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Amount of payment $____________
Sales tax (N.Y.S. only) ____________
Total enclosed ____________
Bill my ☐ VISA ☐ MasterCard
Card No. ____________
Expire Date ______ / ______

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Name ____________
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All payments in U.S.A. funds. Canadians add $4.00 per VHS cassette. No foreign orders.

The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

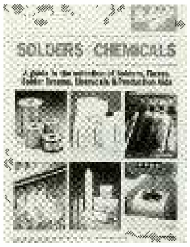
The Dollars You Save

To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

You'll find out what is needed to create a virtual world—hardware and software, networking capabilities, and audio/video equipment. The book contains objective reviews of representative VR products and it reports on the latest developments, participants in the field, and investors. As a bonus you'll receive a useful glossary of 200 virtual reality terms.

Solders & Chemicals Guide. Multicore Solders, Inc., 1751 Jay Ell Drive, Richardson, TX 75081; Phone: 214-238-1224; Fax: 214-437-0288; free.

This six-page brochure is a quick reference guide to Multicore Solders' complete product line. The company's products include cored wire solder,

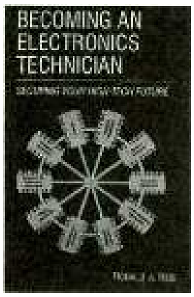


CIRCLE 33 ON FREE INFORMATION CARD

flux, wave and static bath solders, solder creams, surface-mount device adhesives, and cleaning liquids. Prototype-production equipment and process-control instruments are also included in this flier.

Becoming An Electronics Technician: Securing Your High-Tech Future; by Ronald A. Reis. Merrill, Macmillan Publishing Company, 866 Third Avenue, New York, NY 10022.

Have you ever considered becoming an electronics technician?. If you are thinking about a career in electronics, this book will answer a lot of questions you might have. The topics covered in this book include the author's views on where the electronics industry is headed, and a discussion of the differences in training and duties of degreed electronic engineers, electronics technicians, and technical support personnel.



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You'll get answers to questions on the formal training needed and its cost today. You'll also get some good advice on what is really important in electronics courses, and how to succeed as a student. The author comments on the range of duties available to technicians and ecpected earnings.

This lively book discussed the benefits as well as the drawbacks, and it quotes working electronics technicians about their work. You'll learn about the tradeoffs of becoming an independent technician and owning your own service company as opposed to climbing the corporate ladder. And you'll get the lowdown on factory vs. field work. Ω

Experience The New Technology Behind Today's Advanced Computer Systems With…

McGraw-Hill's Computer Electronics Series

NEW! Now you have a fast, easy, low-cost way to meet the challenges of today's computer electronics. McGraw-Hill's unique new learning series is as innovative as the technology it explains, as fascinating as the experiments you perform.

From circuit theory to the Pentium chip, you master one subject at a time with the McGraw-Hill Computer Electronics Series. Twelve unique modules, sent to you one every 4-6 weeks, give you a thorough understanding of such subjects as digital logic, microcomputer operation, data storage devices, data communications, PC servicing, local area networks, and more.

Each module goes right to the heart of the matter. You waste no time on extraneous material or dry history. Instead, you get a fast, efficient, and lively learning experience…a nontraditional approach to the most modern of subject matter.

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Your learning experience is reinforced through the integration of vividly illustrated text with actual electronic experiments. In fact, by the time you complete your sixth module, you will have assembled the McGraw-Hill Prototyping Design Lab, a breadboarding lab you'll use long after you complete the series for building up and testing prototype circuits. Your modules also feature indexed binders to preserve your text, backup materials, and notes for convenient referral.

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You'll be introduced to basic electronics principles and discover the role of key electronic components, including resistors, capacitors, and transistors.

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- Semiconductors and Linear Applications
- Digital Logic Fundamentals
- Flip-Flops, Counters, and Registers
- Microcomputer Fundamentals
- Mass Data Storage Systems
- Data Communications
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- Embedded Microprocessor Controllers
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City/State/Zip ______________________

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A new, high-power direct-broadcast satellite promises to change the way America looks at TV.

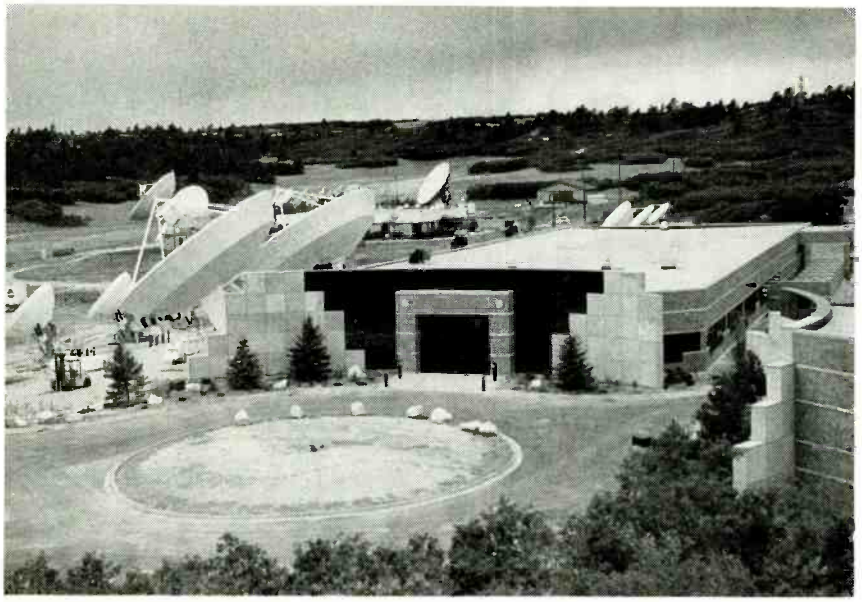
BRIAN C. FENTON

THE NEW AGE OF SATELLITE TV

BEGINNING THIS APRIL, CONSUMERS IN THE U.S. will have another option for receiving television programming. A new direct-broadcast satellite, now in geosynchronous orbit, will begin beaming programming to satellite dishes only 18 inches in diameter. The digital signals will be decoded by an integrated receiver/descrambler which will reproduce them with "near-laserdisc quality." The programming, which will be available from two suppliers, will consist of up to 150 channels of cable networks, movies, sports, and pay-per-view events. Audio programming with "compact-disc quality" will also be available.

Direct satellite broadcasting to small-dish antennas has been attempted several times since the FCC set aside a portion of the Ku band for high-power broadcasts in 1982. Although other proposed systems have never gotten off the ground, the Digital Satellite System or DSS already has. The first satellite of the two-satellite system was launched in December; the second is scheduled for launch in June.

A number of companies have joined forces—and invested over one billion dollars—to make the new satellite system a reality. Among the main players, Thomson Consumer Electronics is building the receivers and marketing them under its RCA brand name which it purchased from General Electric. Thomson is also developing the digital compression technology. Hughes Space and Communications Company built and launched the first satellite and is building a second one. Di-



DIRECTV'S PROGRAMMING WILL BE UPLINKED to the satellite from this facility, shown here under construction, in Castle Rock, Colorado.

recTv, Inc. a unit of GM Hughes Electronics, is one program distributor. United States Satellite Broadcasting or USSB, a subsidiary of Hubbard Broadcasting, Inc., is the second.

What can I watch?

DirecTv owns eleven of the sixteen transponders on the first DBS satellite and all sixteen transponders on the second satellite. USSB owns the other five transponders.

DirecTv will distribute many major cable services including CNN, the Discovery Channel, the Disney Channel, Encore, and six new Encore channels scheduled to begin operation this year. Other programming that can be purchased from DirecTv includes the Sci-Fi Channel, the Weather Channel, ESPN, and four channels from Turner Broadcasting.

Two pricing packages have been announced. All of DirecTv's basic services will be available as a package for $21.95 per month. A premium package, that would include the Encore channels and any other premium service that sign on with DirecTv, will cost $29.95 per month. (The company is actively trying to reach a distribution agreement with HBO and Viacom, which have signed an exclusive agreement with USSB.)

DirecTv also plans to offer pay-per-view movies and sporting events. It has reached agreements with several leading studios including Paramount Pictures, Columbia Pictures, Tri-Star Pictures, and Universal. Because of its channel capacity, DirecTv will be able to show popular movies on multiple channels, with starting times every half hour. Movies will be priced from $0.99 to $3.99.

Sporting events will also be offered, and they are expected to cost $4 to $6 on a per-game basis. Other pricing plans would allow subscribers to purchase season subscriptions for a team for about $10 or $12 per month. DirecTv also hopes to offer season subscriptions for an entire league. With as many as 30 channels set aside for sporting events, DirecTv is planning to offer "any game from any league on a pay-per-view basis," according to a company spokesman.

USSB will offer at least 22 channels of programming. Initially, its lineup will contain 14 premium channels (including multiplexed and time-shifted HBO, Cinemax, Showtime, and The Movie-Channel) and six basic-cable services. USSB will also provide two free, advertiser-supported services that will be available without restriction to everyone with a DSS home receiving system, whether or not they subscribe to any USSB service. According to USSB, the channels will include news, entertainment, public-service, and children's programming. They won't, however, be available when the service is initially launched.

DIRECTV PROGRAMMING

Monthly

CBC Newsworld
CNN
CNN Headline News
C-SPAN
C-SPAN2
The Cartoon Network
Country Music Television
Court TV
The Discovery Channel
Disney Channel
E! Entertainment Television
Encore
Encore 2: Love Stories
Encore 3: Western
Encore 4: Tweens
Encore 5: Mystery
Encore 6: Action
Encore 7: True Stories
Encore 8: Starz!
ESPN
Family Channel
The Golf Channel
The Learning Channel
The Nashville Network
Northstar
Sci-Fi Channel
Superstation TBS
TNT
The Travel Channel
Turner Classic Movies
USA Network
The Weather Channel

Pay-Per View

Paramount Pictures
Columbia Pictures
Sony Picture Classics
TriStar Pictures
Turner MGM Film Library
Universal Pictures

USSB PROGRAMMING

Premium Services

Cinemax East
Cinemax West
Cinemax 2
Flix
HBO East
HBO West
HBO2 East
HBO2 West
HBO3
The Movie Channel East
The Movie Channel West
Showtime East
Showtime West
Showtime 2

Basic Services

All News Channel
Comedy Central
Lifetime
MTV
Nickelodeon
VH-1

THE RCA DSS Digital Satellite System receiver is about the size of a VCR. It has a smart-card slot on its front panel.

The price for monthly programming from USSB begins at $7.95 for a package of six basic services: MTV, VH1, Nickelodeon, Comedy Central, Lifetime, and the All News Channel. For $23.95, a "Showtime Plus" package includes all basic services plus Showtime East and West, Showtime 2, The Movie Channel East and West, and Flix. An "HBO Plus" package, which includes the East and West feeds of HBO and HBO2, HBO3, Cinemax East and West, Cinemax 2, and the basic services will cost $24.95. All of the programming distributed by USSB is available for a monthly cost of $34.95 under the name "USSB Premium Plus."

The agreements between USSB and HBO, and USSB and Viacom (Showtime and The Movie Channel) grants USSB the exclusive right to distribute the premium channels from the new DBS satellite. As a result, any consumer who wants, for example, both HBO and ESPN will have to order the services through both DirecTv and USSB.

According to Stanley E. Hubbard, USSB President and COO, the exclusive deals are an important way to distinguish between the two program providers. "Every DSS home will be able to have simple, and seamless access to all the programming on the system, whether it's through DirecTv or USSB. So as far as we're concerned it's a non issue." Hubbard went on to say that if every cable system had two service providers, "I don't think that the Cable Act of 1992 ever would have been necessary."

If a consumer chooses to buy programming from both DirecTv and USSB, he will receive two bills. USSB doesn't see that as a drawback, because the bills will also distinguish between the two program providers. USSB also believes that it is important to send a bill that doesn't vary from month to month. According to Hubbard, USSB is "among the believers that DirecTv's pay-per-view offerings are going to be extremely successful and [therefore] there will be some wild swings from month to month. We're frankly afraid to share the bill with them because of that."

The DSS receiver

A DSS receiver is required for viewing any of the programming offered by DirecTv and USSB. Thomson Consumer Electronics developed the set-top integrated receiver/decoder (IRD) for its RCA DSS Digital Satellite System. Low-volume production of the receiver began last December in Thom-

FINDING THE SATELLITE

To receive programming from the new direct-broadcast satellite, the dish must be able to "see" it. In general, the installation site must have a clear view of the southern horizon. The exact aiming coordinates vary from location to location as shown below. Note that the azimuth angles listed are compass headings, but they do not take into account the variation between true south and magnetic south. Call a local airport to find the magnetic deviation in your area.

City	Azimuth	Elevation
Atlanta, GA	207°	46.6°
Chicago, IL	199°	39.7°
Dallas, TX	188°	51.8°
Denver, CO	173°	44.0°
Des Moines, IA	191°	41.4°
Las Vegas, NV	157°	45.6°
Los Angeles, CA	150°	46.2°
Miami, FL	221°	51.6°
Nashville, TN	202°	45.6°
New Orleans, LA	201°	52.9°
New York, NY	211°	37.5°
Pittsburgh, PA	210°	38.4°
Portland, ME	221°	30.9°
St. Louis, MO	196°	44.0°
Salt Lake City, UT	163°	41.2°
Santa Fe, NM	171°	47.8°
Seattle, WA	151°	31.5°
Washington, DC	215°	38.4°
Wichita, KS	185°	46.3°

son's facility in Juarez, Mexico. A second high-speed assembly line will be completed by the middle of the summer, and will give Thomson the capacity to build about one hundred thousand receivers and digital cable boxes per month.

RCA has the exclusive rights to build and market the DSS receivers for eighteen months, or until one million units have been sold. After that, other manufacturers will offer DSS receivers. Sony is the first licensee of the DSS technology.

The digital receiver contains four new custom ICs, including the world's first high-volume decoder for the MPEG-2 compression system developed by the Moving Picture Experts Group.

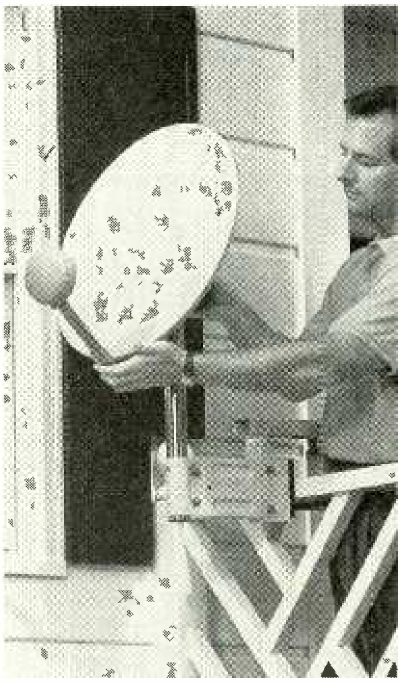
Initially, two DSS models will be available. The basic model is priced at $699, and includes the IRD, an 18 × 20-inch parabolic dish/antenna, and a universal infrared remote control. Mounted at the focal point of the dish is a low-noise block downconverter (LNB) that receives the signals broadcast from the satellite in the 12.2–12.7 GHZ band; it down converts them to a frequency of 950–1450 MHz. The output of the LNB is fed to the set-top IRD, which decodes the transmission and feeds it to a TV or monitor. Video, S-video, and RF (Channel 3 or 4) outputs are provided.

An upgraded system, priced at $899, will included an LNB with two outputs so that a second IRD can be connected to the system. (A second receiver is required for recording one channel while the viewer is watching a second.) The upgraded receiver will also have two sets of video and two sets of stereo audio outputs. A more capable universal remote control, which can operate a VCR, cable box, laserdisc player, and a TV, will also be included in the step-up system.

Both IRDs include a 15-pin D-style connector on their rear panels for a high-speed data port. A second, 9-pin, low-speed serial data port is offered on the upgrade receiver. At this time, no data services have been announced.

The DSS receiver contains built-in switching so that a TV antenna or cable can be connected up to the system. Current FCC regulations do not permit network signals to be sent via DSS to areas where they can be received easily over the air.

The rear panel of the receiver also contains a modular phone jack. The phone connection is required so that monthly usage—especially pay-per-view events—can be reported to programming providers. It can also ensure that the box hasn't been stolen or moved from its assigned address, which is important for regional program distribution.



THE SMALL DISH ANTENNA required to receive digital signals from an orbiting should be easy to install. Thomson estimates that more than 90% of the nation's homes will have a clear line of sight to the satellite.

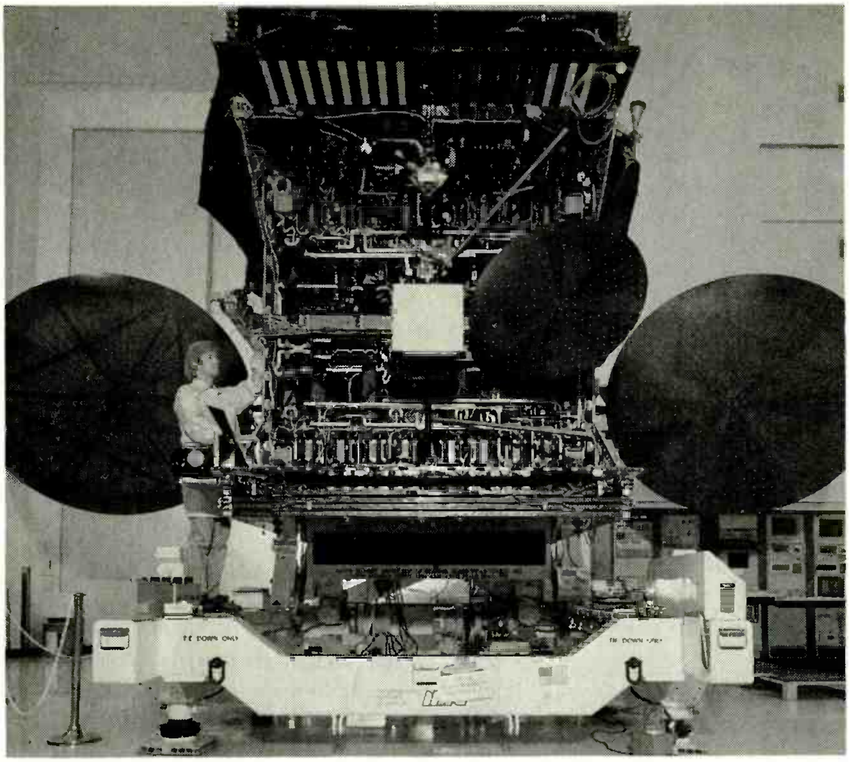
The DSS user interface is an on-screen point-and-shoot menu. Thomson officials demonstrated a menu system that could be configured to show programming by category (sports, movies, and comedies, for example) or by time and programming service. The system also allowed the review of current billing information.

The receiver also has other programmable features. Favorite-channel scan lists can be created for up to three users—mom, dad, and kids, perhaps. The receiver also allows "pay-per locks and limits" to be set. Parents could, for example, program per-event spending limits or rating ceilings to prevent their children from accessing undesirable programs. The entire system can also be locked unless the proper four-digit code is entered.

The front of the receiver has a slot for "smart card" insertion. The smart card contains subscription and decoding information and records program purchases. The conditional-access encryption method was developed by News Datacom.

Although the small dish helps make a DSS system far easier to install than a conventional satellite system, Thomson recommends that it be installed by

RCA TECHNICIANS TEST an early DSS receiver.



THE FIRST HIGH-POWER DIRECT-BROADCAST SATELLITE shown here in its final assembly stages. It weighs about 3800 pounds.

professionals. (This expense is not included in the purchase price.) Nevertheless, the company will provide a do-it-yourself kit containing all necessary cables and hardware for $69.95. A VHS video tape showing how to install the system is included.

Along with developing the receiver system, Thomson is also developing the digital compression hardware. Initially, programming from the satellite will be compressed in the MPEG-1 format. That format is the same one being used to put video on CD-ROM and CD-I discs. Thomson had hoped to have encoders for the improved MPEG-2 format ready for its product launch. Thomson executives say that assignment has proven to be more difficult than originally projected and—as of today—the company is behind schedule. When Thomson completes its developments of MPEG-2 encoders, broadcasts will shift to that compression scheme. All DSS receivers contain MPEG-2 decoders.

RCA executives like to point out their ability to shift from MPEG-1 to MPEG-2 as an example of the forward-compatibility of the DSS system. According to James E. Meyer, an RCA senior vice president, "It has the capability for receiving 16×9 wide-screen-format TV signals as well as HDTV broadcasts once that revolutionary technology is in place. . . . There will be no cries of 'interim technology' with the introduction of RCA DSS."

The Hughes satellite

The first DBS satellite, called DBS1, was launched in December 1993 from Kourou, French Guiana aboard an Arian rocket. A second satellite, also a Hughes model HS-601, is scheduled for launch in June. It will be co-located with the first satellite in geosynchronous orbit at 101° west longitude. That location is one of only eight orbital slots, spaced 5° apart, that are available for DBS in North America. The satellite's high power and wide spacing make small diameter antenna reception possible. The 101° west slot is the prime orbital position available because it is centered over the U.S.

Each satellite has sixteen high-power (120-watt) transponders. By comparison, C-band satellites that distribute conventional satellite TV to antenna dishes that are typically seven to ten feet in diameter have an average power of 16 watts per transponder.

Each transponder on analog satellites can distribute several audio signals and one, or sometimes two, video signals per transponder. The 32 transponders on the two DBS satellites can distribute about 150 channels of programming, thanks to digital "compression" or bit-rate reduction. An exact number of channels can't be given because not all programming will be compressed the same way. The compression ratio for, say, a live sporting event would be much lower than for an old black-and-white movie. The frame rate of the source material—and the desired quality of the output—also affect the compression ratio that can be achieved. Hughes estimates that each transponder can broadcast up to four live video signals or up to eight movies simultaneously.

The amplifiers, according to Hughes, will amplify either analog or digital signals, and will be capable of transmitting HDTV signals and compact disc-quality audio. The uplink signals will be sent from the DirecTv Castle Rock Broadcast Center in Colorado. The facility will be capable of transmitting up to 216 simultaneous broadcast channels to the two satellites.

The satellites have an expected operational lifetime of about twelve years. Although the electronics on board will probably still be operating after that time, the spacecraft will run out of fuel. Geostationary orbiting satellites require propellants to ensure their precise positioning because the gravitational effects of the sun and moon can move them.

Will the service sell?

All of the companies involved in the DSS project are optimistic about its chance for success. The first target will be the ten million rural homes that

Continued on page 82

Build a professional looking function generator for your electronics workbench.

BUILD THE AUDIO WIZARD TEST GENERATOR

JOHN WANNAMAKER

EVERY TEST BENCH NEEDS A FUNCtion generator—without one, the bench is incomplete. This article describes the construction of the Audio Wizard, an inexpensive function generator that's loaded with features. It's perfect for filling that vacancy on your test bench.

Audio Wizard has a front panel not much larger than a dollar bill, and a small size to match. It has features usually found on many expensive units, yet the parts to build it should cost no more than $175.00—and that's only if you have to purchase all the parts. A good spare parts collection might already contain most of the parts needed.

The Audio Wizard can produce sine, triangle, and square waves in two ranges at frequencies from 1 hertz to 20 kilohertz, as well as bursts of both sine and square waves. Ramp and pulse outputs are available in two ranges with widths adjustable from 1 millisecond to 4 seconds. The unit has an internal sweep generator of sine, triangle, or square waves from 1 hertz to 1 kilohertz and from 20 hertz to 20 kilohertz. The built-in frequency counter for monitoring output frequency can also monitor an external input and act as an events counter. X-Y outputs can be applied to your oscilloscope with a stop-sweep feature for a frequency readout at any point of interest during the sweep.

Circuitry

The frequency counter is a SUB CUB II unit manufactured by Red Lion Controls (20 Willow Springs Circle, York, PA 17402), and it's available from Digi-Key. The counter module, shown in Fig. 1 as MOD1, has a 0.35-inch high, six-digit liquid-crystal display. Pulses at 1-second intervals are derived from the AC power line which has a typical accuracy of 99.99 percent. Transistor Q5 and a 4518 dual synchronous counter, IC7, square and then count the 60-hertz line frequency to produce 1 pulse per second that triggers a 50-microsecond one-shot multivibrator, IC8-a, which produces negative-going pulses to update the counter unit. Those pulses also trigger a 5-microsecond one-shot multivibrator (IC8-b) which resets the synchronous counter.

Op-amp IC9 and associated components condition any signal present at the external input jack J5. The maximum frequency input at J5 is 500 kHz. A 50-millivolt peak-to-peak signal is sufficient up to 100 kHz.

In the events mode, when rotary switch S1-c is in mid position, the counter is held in a constant update condition and no reset pulse can be generated. Any input pulse of 0.5 volt or more with a width of 0.5 millisecond will advance the readout one count.

In Fig. 2, an XR 2206 function-generator chip made by EXAR (IC1) provides a triangular output at pin 2 when S1-a is open. With S1-a positioned so that potentiometer R1 is in the circuit, both R1 and R2 can be adjusted for a sinewave output with 0.5 % or less harmonic distortion.

While IC1 can also produce a square wave, that waveform can create glitches at the peaks of triangle and sine waves. To eliminate that possibility, op-amp IC3-a is configured as a comparator to square triangle and sine waves. Circuit values limit the rise and fall times to eliminate unwanted glitches.

Pin 7 of IC1, the frequency-control input, is at a DC reference level of about 3 volts. The voltage is buffered by IC2-a and applied across 10-turn frequency-adjust potentiometer R20. SWEEP switch S2 selects either the wiper of R20 or the internal ramp voltage to be isolated by IC2-b and applied back to pin 7 of IC1 through a network consisting of current-limiting resistor R23, diodes D3 through D7, and R16.

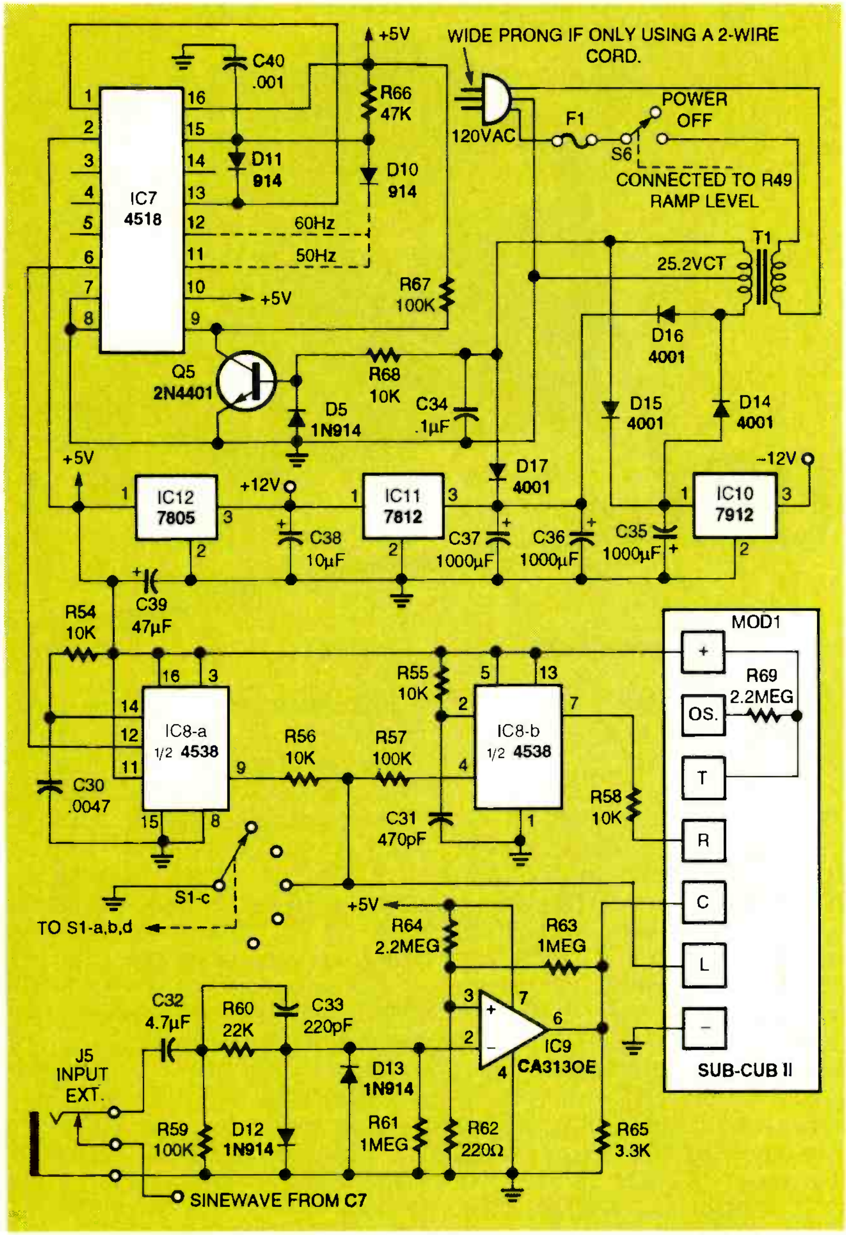


FIG. 1—THE COUNTER MODULE (MOD1) has a 0.35-inch high, six-digit liquid crystal display. Pulses at 1-second intervals are derived from the AC power line which has a typical accuracy of 99.99 %.

The adjustable gain of op-amp IC4-a is provided by DB switch S3 and resistors R31–R33. All output adjustment levels of R24 are considered to be 0 dB. The two spring-return positions of S3 give either a 2 dB gain or a 3 dB loss. When the 0 dB and −3 dB levels are set to appropriate oscilloscope graticule lines, many other points to −40 dB can be extrapolated as can be seen in Fig. 3. DC offset is applied to the non-inverting input of IC4-b to avoid affecting signal level and be totally independent of LEVEL control R24 and DB switch S3.

Capacitors C3 and C4 determine the frequency limits of the high range: about 20 Hz to 20 kHz. When S1-b connects C5 and C6 in parallel with C3 and C4, those components determine the low-frequency range limits of 1 Hz to 1 kHz.

Bursts of both sine and square waves are created when a positive pulse is applied to the anodes of D1 and D2. That prevents IC1 from oscillating without affecting the DC level at pin 2 about which the waveform varies.

Figure 4 contains a dual CMOS version of the familiar 555 timer (IC5). Each timer's output triggers the other's input. After transistor Q2 gives IC5-a a kick start on initial power-up, the circuit continues to oscillate (one timer is on while the other is off). Timing capacitors C20 and C21 charge through constant-current source Q1. The linear voltage rise across the capacitors is isolated by IC6-a, a very high input impedance op-amp.

The sweep voltage to IC1 is the linear charge across C20 and C21, so the sweep, or charging action, can be stopped when spring-loaded switch S5 is moved to the HOLD position. This also stops waveworm ramp formation. Ideally, the voltage on the capacitors would not change at that time. However, capacitor leakage will affect the charge.

Fortunately, the change is slow enough to be able to get a frequency readout accurate within 0.2 % if the second update after pressing HOLD is applied. The hold feature will be especially useful with a very slow sweep and with X-Y oscilloscope operation where the ramp output will be the sweep for the oscilloscope. Frequencies at or near the beginning and end of sweep can be determined. The HOLD switch can be jogged so that the sweep moves across the CRT in many small steps. Either the low- or high-frequency range can be swept, and the waveform can be sine, triangle, or square.

The pulse current is amplified as the outputs of IC5-a and IC5-b alternately turn on Q4 and Q3. If resistor R45 is replaced with a short circuit (a length of wire), the J3 output can drive 10 TTL loads. Rise and fall times are about 300 nanoseconds. The same WIDTH switch (S4) affects both ramp and pulse operation; ramp width controls the burst time and pulse width controls the dead time.

Construction

For those who wish to make their own PC board, foil patterns are included in this article. However, a ready-to-use PC board and silkscreened front panel are available from the source given in the Parts List. Following the parts-placement diagram in Fig. 5, solder all components and DIP sockets on the board. Double check your work before continuing.

If you plan to buy the silkscreened front panel, it must be used with the same enclosure as the prototype. Complete instructions for fitting the controls on the front panel and for fitting the board in the specified enclosure are included with the front panel order. If you intend to use a different enclosure and front panel, it's up to you to decide on an appropriate layout, although you might want to make it similar to the prototype.

Regardless of the enclosure and front panel you use, mount all controls on the front panel and wire them to the board as shown in Fig. 5. Clip off the orientation tab from each potentiometer so that it fits flat against the inside of the front panel. The shafts of most of the potentiometers specified have the correct length. However, you must cut the plastic shaft of R20 to the same length as the other shafts before mounting it.

Place the completed front panel face down and the completed PC board component-side up so that its front edge is at least ⅝ inch from the bottom of the front panel. Maintain that spacing as you wire from panel to board with different colored wire. The SUB CUB counter unit mounts on a small PC board. Solder connections to that board before snapping it on the counter module. You can make your own mounting board with the foil pattern provided here. Prepare the SUB CUB mounting board by soldering 2.2-megohm resistor R69 in place as shown. Solder one end of five 4-inch flexible wires to the counter mounting board and the other ends to the main board as shown in Fig. 5. Do not snap the module into its mounting board until all wiring is complete.

Mount transformer T1 on the inside of the rear panel. Drill ventilation holes and a hole for the power cord. Slide the rear panel into the slots on the enclosure's bottom shell. If you're using the recommended enclosure, mount it to the molded stubs with No. 4 × ⅝ sheet-metal screws in two places. When the transformer and PC

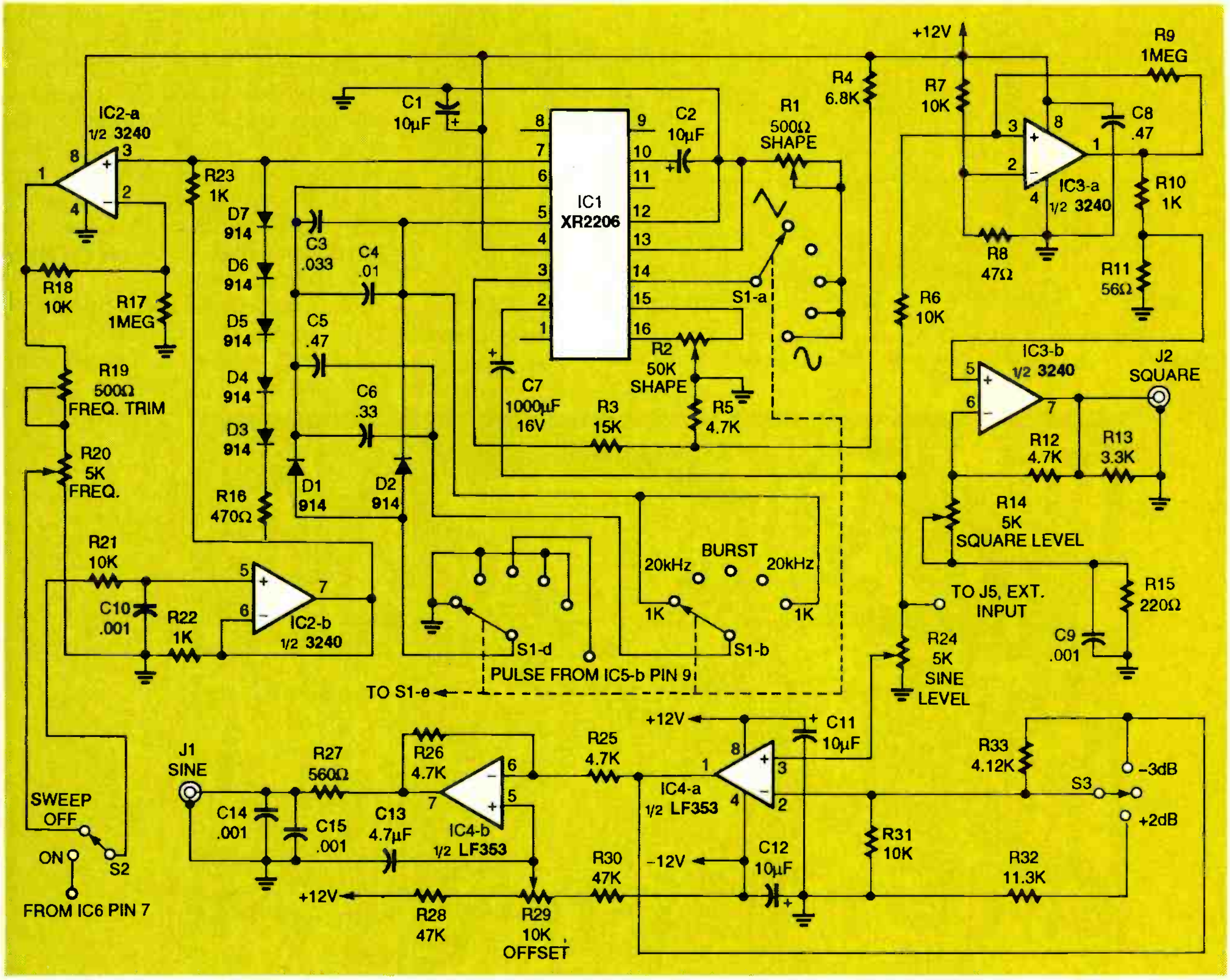


FIG. 2—AN XR 2206 FUNCTION-GENERATOR CHIP provides a triangle output at pin 2 when S1-a is open.

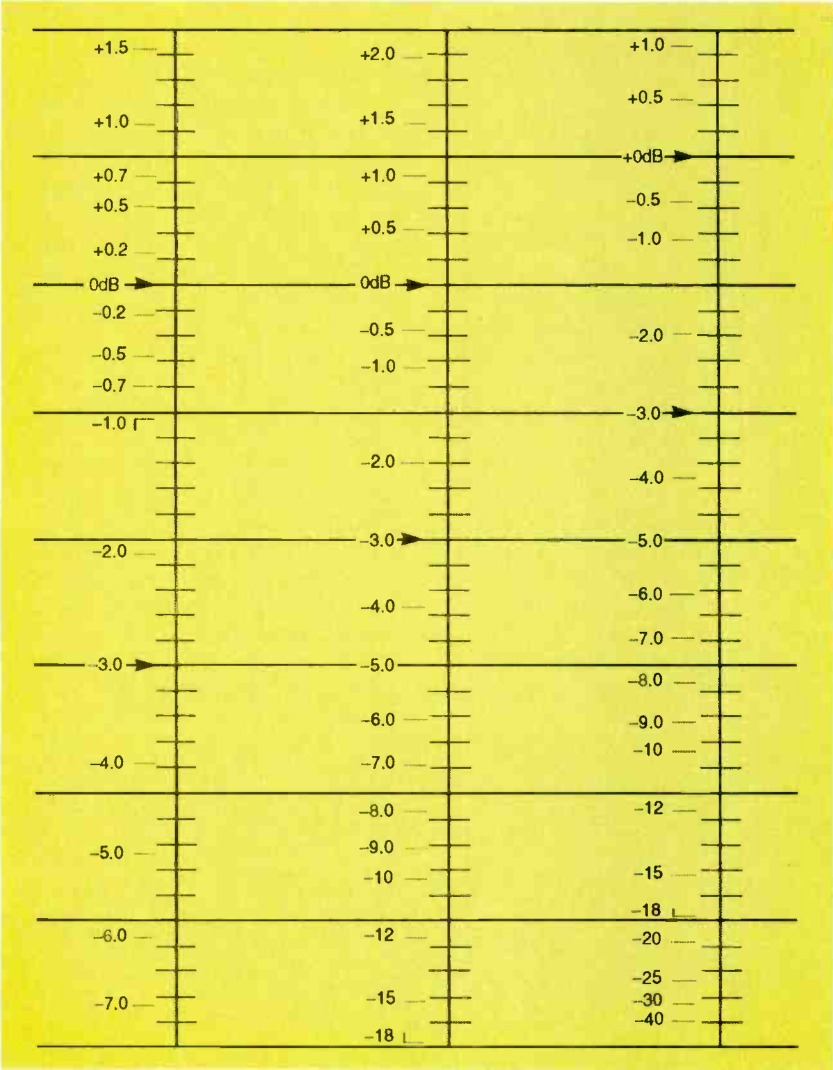


FIG. 3—WHEN THE 0 dB AND −3 dB LEVELS are set to appropriate oscilloscope graticule lines, many other points to −40 dB can be extrapolated.

board are in place, cut the transformer leads long enough to reach the board. Enlarge any PC-board holes as required to accept the transformer and power cord wires.

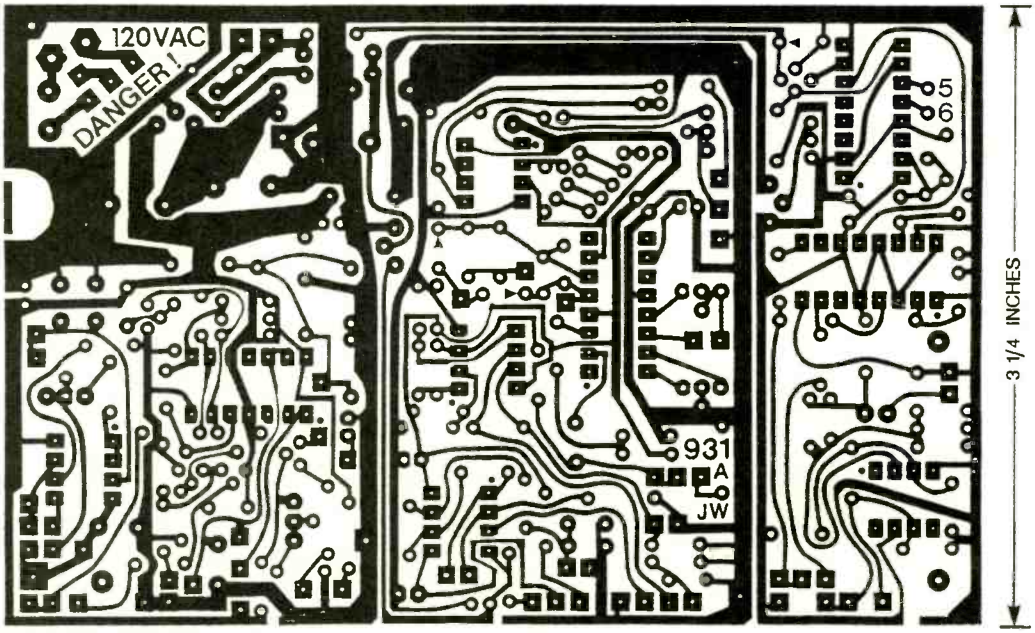
When all wiring is complete, snap the SUB CUB unit onto its mounting board. Insert two 2-56 × ¾ machine screws in the holes on each side of the display cutout. Hold them in place with nuts. Slide the SUB CUB mounting board over the screws so that the counter fits flat against the inside of the panel. If there is any mechanical interference from the nuts, cut away some plastic on each side of the SUB CUB unit. Add two more nuts to hold the counter in place. Notice that the tilt handle on the prototype is not made for the enclosure; it must be purchased separately and adapted to fit. Figure 6 shows the inside of the prototype unit.

Checkout

Do no insert any ICs into their sockets until instructed to do so.

Insert the 0.315-ampere fuse (F1). Preadjust on-board trimmers R1 and R2 to mid position and all other trimmers fully counterclockwise.

Adjust an oscilloscope for 2 milliseconds/division, 2 volts/division, and a DC input. Con-



AUDIO WIZARD FOIL PATTERN.

nect the test probe to pin 3 of 7812 regulator IC11; the metal tab of this regulator is a convenient ground point. (Note that the tab of IC10 is *not* at ground potential!)

Set automatic triggering for the oscilloscope and move the trace to the bottom graticule line. Turn RAMP LEVEL control clockwise; this also turns on the power. Plug the line cord into an AC outlet. The oscilloscope should indicate +12 volts from IC11 with no visible ripple.

Next check the voltage at pin 3 of IC12 (the 7805) and pin 3 of IC10 (7912); these should read +5 and −12 volts, respectively, with no visible ripple. If all voltages are correct, leave power on for 30 seconds and carefully check each regulator tab for overheating. A warm tab is acceptable, but none of them should be hot to the touch. If they are, it indicates a probable short that must be cleared.

Unplug the power cord and wait 20 seconds for all voltages to decay. Insert IC7, IC8, and IC9 in their sockets. Set S1 to the 1 kHz sinewave position. Reapply power and check each IC for heat emission over the next 10 seconds. No device should get hot, an indication that one might have been inserted backwards. The frequency display should show a single "0."

Unplug the power cord again. Connect one lead of a non-polarized capacitor (any value from 0.01 to 0.1 µF) to the anode of D15. Connect the other lead to the junction of diodes, D12 and D13, and restore power. Within 3 seconds, the display should show steady reading of 120 Hz (100 Hz for 50-Hz line).

If you have any problem with the readout, the suggestions will help. The collector of Q5 should show a 60-Hz square wave varying from 0 to near +5 volts. Pin 1 of IC7 should have a +5-volt pulse occurring once every 100 milliseconds. Pin 6 should have a pulse occurring once per second.

Put the FUNCTION/RANGE switch in the burst position. The display should show a continuous fast count upwards, and it should count to well above 10000 within 90 seconds. By selecting any other position than burst, the display should again be 120 Hz. Remove the temporary capacitor connecting D15 to D12 and D13.

Turn off power and, after the voltages decay, insert IC1–IC4 into their sockets. Set the SINE/TRIANGLE OFFSET to mid position, SINE/TRIANGLE/SQUARE FREQUENCY fully counterclockwise and then one turn clockwise, SQUARE LEVEL and SINE/TRIANGLE LEVEL to mid position, FUNCTION/RANGE to 20 kHz sinewave, and SWEEP to off.

Set the oscilloscope for an AC input, position the trace on the middle graticule line, and set 0.5 volt/division and 0.1 millisecond/division, and reapply power. The oscilloscope should display about 4 cycles of a sine-like waveform of more than 1-volt p-p. Trigger the oscilloscope as necessary. The frequency readout should indicate about 4000 Hz.

If a problem exists, check the following points: Pin 7 of IC1 and pin 1 of IC2 should be at approximately +3-volts DC. The counterclockwise terminal of the FREQUENCY control potentiometer (R20) should be approximately 2.85 volts DC. The wiper terminal of R20 and pin 5 of IC2 should be about 2.5 volts DC, and both should vary smoothly from near 0 volt with

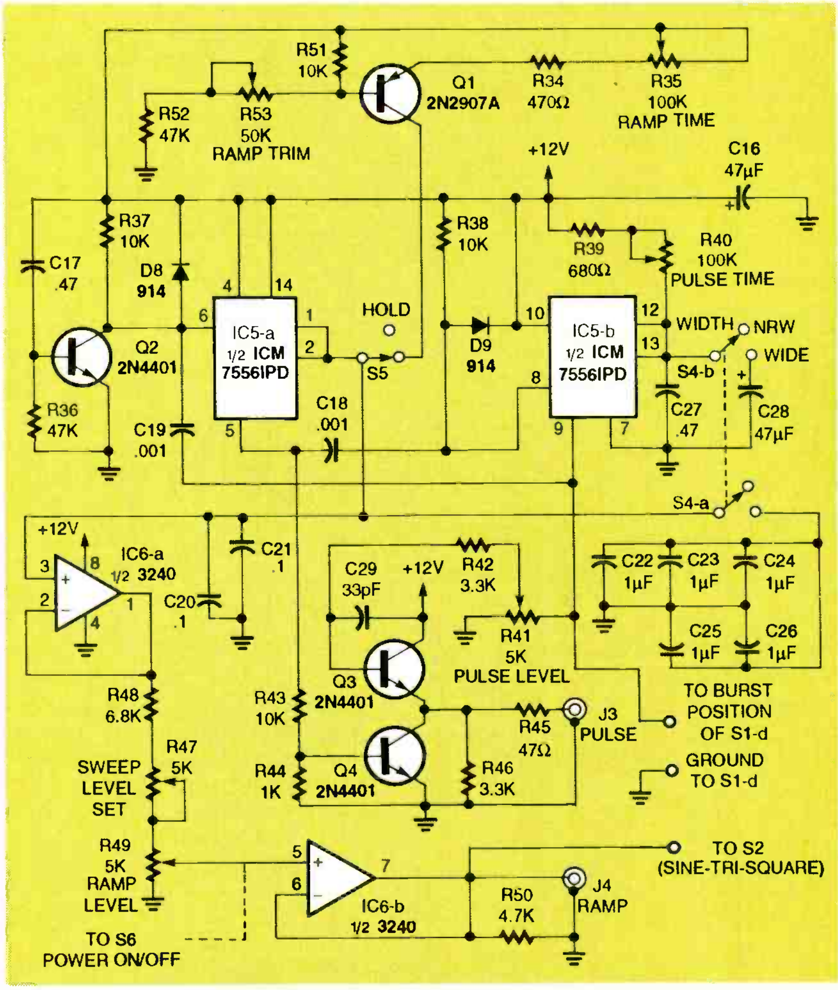
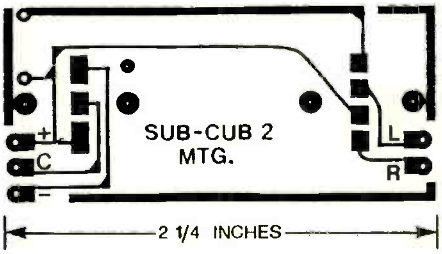


FIG. 4—A DUAL CMOS TIMER'S (IC5) output triggers another timer's input. Once Q2 starts IC5-a on initial power-up, the circuit continues to oscillate.



SUB CUB II MOUNTING BOARD.

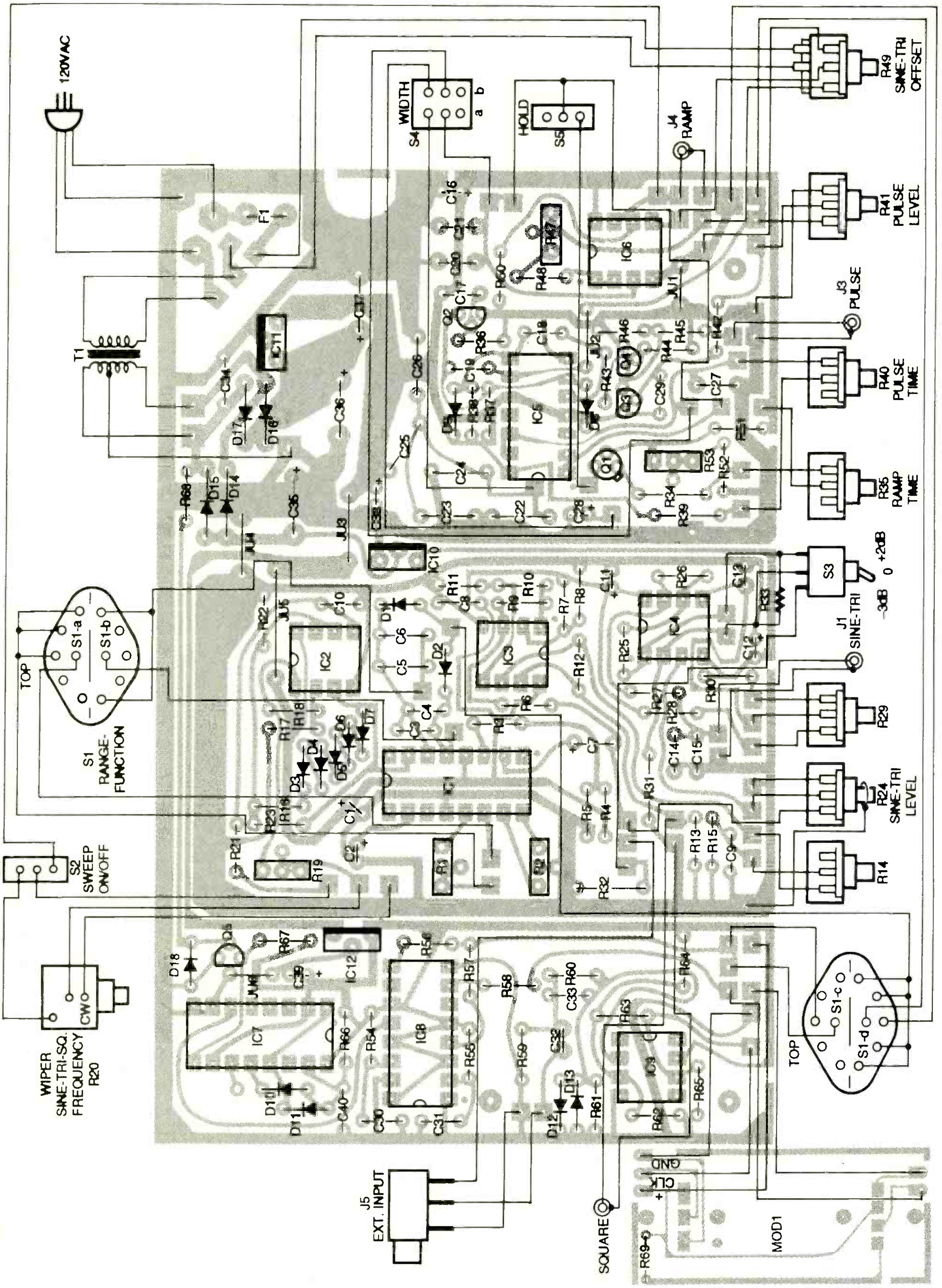


 FIG. 5—PARTS-PLACEMENT DIAGRAM. Install all ICs in DIP sockets.

PARTS LIST

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

R1—500 ohms, single-turn trimpot, ¼ or ⅜ inch square
R2—50,000 ohms, single turn trimpot, ¼ or ⅜ inch
R3—15,000 ohms
R4, R48—6800 ohms
R5, R12, R26, R26, R50—4700 ohms
R6, R7, R18, R21, R37, R38, R43, R51, R54–R56, R58, R68—10,000 ohms
R8, R45—47 ohms
R9, R17, R61, R63—1 megohm
R10, R22, R23, R44—1000 ohms
R11—56 ohms
R13, R42, R46, R65—3300 ohms
R14, R24, R41—5000 ohms, 16mm panel-mount potentiometer
R15, R62—220 ohms
R16—470 ohm
R19—500 ohms, ⅜-inch square upright multiturn trimmer
R20—5000 ohms, 10-turn precision potentiometer
R27—560 ohms
R28, R30, R36, R52, R66—47,000 ohms
R29—10,000 ohms, 16mm panel-mount potentiometer
R31—10,000 ohms, ¼ watt, 1%
R32—11,300 ohms, ¼ watt, 1%
R33—4120 ohms, ¼ watt, 1%
R34—470 ohms, ¼ watt
R35, R40—100,000 ohms, 16mm panel-mount potentiometer
R39—680 ohms, ¼ watt
R47—5000 ohms, ⅜-inch square upright multiturn trimmer
R49—5000 ohms, 16mm panel-mount potentiometer with switch (S6)
R53—50,000 ohms, ⅜-inch square upright multiturn trimmer
R57, R59, R67—100,000 ohms
R60—22,000 ohms
R64, R69—2.2M, ⅛ watt

Capacitors

C1, C2, C11, C12—10 µF, 25 volts, electrolytic
C3—0.033 µF, 50 volts, metal film
C4—0.01 µF, 50 volts, metal film
C5, C8, C17, C27—0.47 µF, 50 volts, metal film
C6—0.33 µF, 50 volts, metal film
C7—1000 µF, 16 volts, electrolytic
C9, C10, C14, C15, C18, C19, C40—0.011 µF, 50 volts, polyester
C13, C32—4.7 µF, 25 volts, non-polarized electrolytic
C16, C28, C39—47 µF, 16 volts, electrolytic
C20, C21, C34—0.1 µF, 50 volts, metal film
C22–C26—1 µF, 50 volts, metal film
C29—33 pF, 100 volts, ceramic disc
C30—0.0047 µF, 50 volts, polyester
C31—470 pF, 100 volts, ceramic disc
C33—220 pF, 100 volts, ceramic disc
C35–C37—1000 µF, 25 volts, electrolytic

Semiconductors

IC1—XR2206 function generator (Exar)
IC2, IC3, IC6—CA324OE dual op-amp (Harris)
IC4—LF353 dual op-amp (National)
IC5—ICM7556IPD dual CMOS timer (Harris)
IC7—4518 dual CMOS counter
IC8—4538 dual CMOS monostable
IC9—CA3130 CMOS op-amp (Harris)
IC10—7912 −12-volt regulator
IC11—7812 +12-volt regulator
IC12—7805 +5-volt regulator
D1–D13, D18—1N914 diode
D14–D17—1N4001 diode
Q1—2N2907A PNP transistor
Q2–Q5—2N4401 NPN transistor

Other components

J1–J4—BNC panel jack with ground tab
J5—3.5mm jack with N.C. switch
S1—4-pole, 5-position rotary switch (2 decks)
S2—SPDT miniature toggle switch
S3—SPDT miniature momentary toggle switch with center-off
S4—DPDT miniature toggle switch
S5—SPDT miniature toggle switch, one side momentary
S6—SPST switch (part of potentiometer R49)
T1—power transformer, 120-volt primary, 24-volt center-tapped secondary, 300 milliamps
F1—TR5 subminiature fuse, 0.315-amps
MOD1—SUB CUB II display counter (Red Lion Controls, 20 Willow Springs Circle, York, PA 17402)

Miscellaneous: TR5 fuse socket, polarized power cord, knobs for ¼-inch shaft (0.6-inch maximum diameter), enclosure (PAC TEC #CM6-300K, black), tilt handle (Hammond Mfg., for box # 546-1598C), multicolored ribbon cable, 5 8-pin IC sockets, 1 14-pin IC socket, 3 16-pin IC sockets, PC board, solder, etc.

Note: The following items are available from John Wanamaker, Rt. 4, Box 550, Orangeburg, SC 29115:

- **PC board, silkscreened front panel, and packet of construction drawings (panel may be available for only one year following publication)—$34.00 ppd. USA, money orders only (Canadian customers, $35.00 ppd., postal money orders only)**
- **Construction drawing packet—$4.00 ppd. USA, money orders only (Canadian customers, $4.50 ppd, postal money orders only)**

SC residents must add 5% tax. Allow 4 weeks for delivery.

R20 turned to its maximum clockwise position to 2.85 volts DC at the maximum counterclockwise position. Return R20 to a setting of 1 turn clockwise after performing this last check. Pin 2 of IC7 should now show a sinewave of more than 2-volt p-p that varies around a DC level of +6 volts.

With a sinewave output at jack J1, alternately adjust R1 and R2 for the best sinewave shape—equal areas and amplitudes above and below the zero line. The SINE/TRIANGLE LEVEL control should vary the output from 0 to 3-volts p-p.

Adjust SINE/TRIANGLE/SQUARE FREQUENCY control fully clockwise. The frequency should increase to at least 20,000 Hz. (The last 1 or 2 turns of the potentiometer might cause the frequency to drop by 200 Hz or so.) If 20,000 Hz cannot be reached, either the capacitiance value of C3 or C4 is too high.

Adjust SINE/TRIANGLE/SQUARE FREQUENCY control fully counterclockwise. The frequency should drop to about 2000 Hz. Adjust R19 clockwise until the frequency is 20 Hz. The frequency can drop to 0 if R19 adjusted too far.

Rotate the FUNCTION/RANGE switch to 20 kHz triangle. Maximum output at J1 should be about 6-volts p-p. The waveform will not have ideally sharp transitions at its peaks. Switch to the 1-kHz ranges for triangle and then sine waves. Both shapes should be clear except for a slight curvature of the triangle wave.

Adjust for a 5 kHz sinewave at J1. Switch the oscilloscope to DC input at 2 volts/division, and position the trace across the middle graticule line. Adjust SINE/TRIANGLE LEVEL fully clockwise and trigger the oscilloscope to verify that it moves the sinewave up and down 2 volts. With the SINE/TRIANGLE OFFSET, position the trace so that the sinewave varies equally above and below the middle graticule line. Position the knob on the offset control shaft so that it points to the mid-position marking when there is no offset.

Adjust the oscilloscope for 0.2 volts/division, 2 milliseconds/division, and AC input. With the generator at 5 kHz, adjust SINE/TRIANGLE LEVEL and the oscilloscope's vertical positioning control for a peak-to-peak sinewave that covers exactly 7.9 vertical graticule spaces. Flip S3 to −3 dB and hold it there; the sinewave should now cover 5.6 graticule spaces. Readjust the 0 dB level to cover 6.2 spaces. Flip S3 to the +2 dB position and hold it there. The peak-to-peak amplitude should increase to cover 7.8 spaces. The output of J2 should be a square wave, adjustable via the SQUARE LEVEL control from +1 to near +10 volts.

IC5 can stop oscillation due to an irregularity in the potentiometer when varying RAMP TIME or PULSE TIME, or when the burst mode is selected. You can restore oscillation by turning the power off for 10 seconds before turning it on again.

Unplug power and wait for the voltages to decay. Insert IC5 and IC6 in their sockets. Adjust RAMP TIME, PULSE TIME, RAMP LEVEL, and PULSE LEVEL to mid range. Set the WIDTH switch to "narrow" and SWEEP to "off." Set the oscilloscope for 2 volts/division, 20 milliseconds/division, and a DC input. Position the trace for 0 volts on the bottom line, and set triggering for negative edge.

Observe the pulse at J3; at least two pulses of about 5 volts should be seen. Trigger the oscilloscope as required. Vary the PULSE LEVEL control to see that amplitude varies from 0 to +10 volts. Vary the RAMP TIME control to see that it controls the time between pulses. The PULSE TIME should control pulse duration.

Adjust RAMP TIME and PULSE TIME to their maximum counterclockwise position. Change the oscilloscope to 0.5 milliseconds/division and adjust triggering for a steady display of 5 or more pulses. Adjust R47 so that the time between pulses is 1 millisecond.

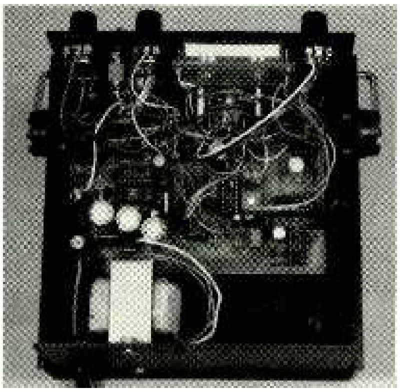


FIG. 6—HERE'S THE INSIDE of the prototype unit. It's a tight fit in the specified enclosure.

Adjust RAMP LEVEL to the maximum clockwise position. Change the oscilloscope input to 0.5 volts/division. Observe the ramp output at J4; several ramps should be seen, each lasting 1 millisecond. The PULSE TIME should control the time between ramps. While observing the ramp, adjust R47 so that the ramp's peak amplitude is 3 volts.

The proper ramp amplitude varies depends on the characteristics of the XR2206 chip selected, and R47 should be adjusted as follows: Set the SINE/TRIANGLE/SQUARE FREQUENCY control for 20 Hz on the 20-kHz range. Measure the DC voltage at pin 7 of IC2 and then readjust R47 for a ramp peak that equals the pin-7 voltage.

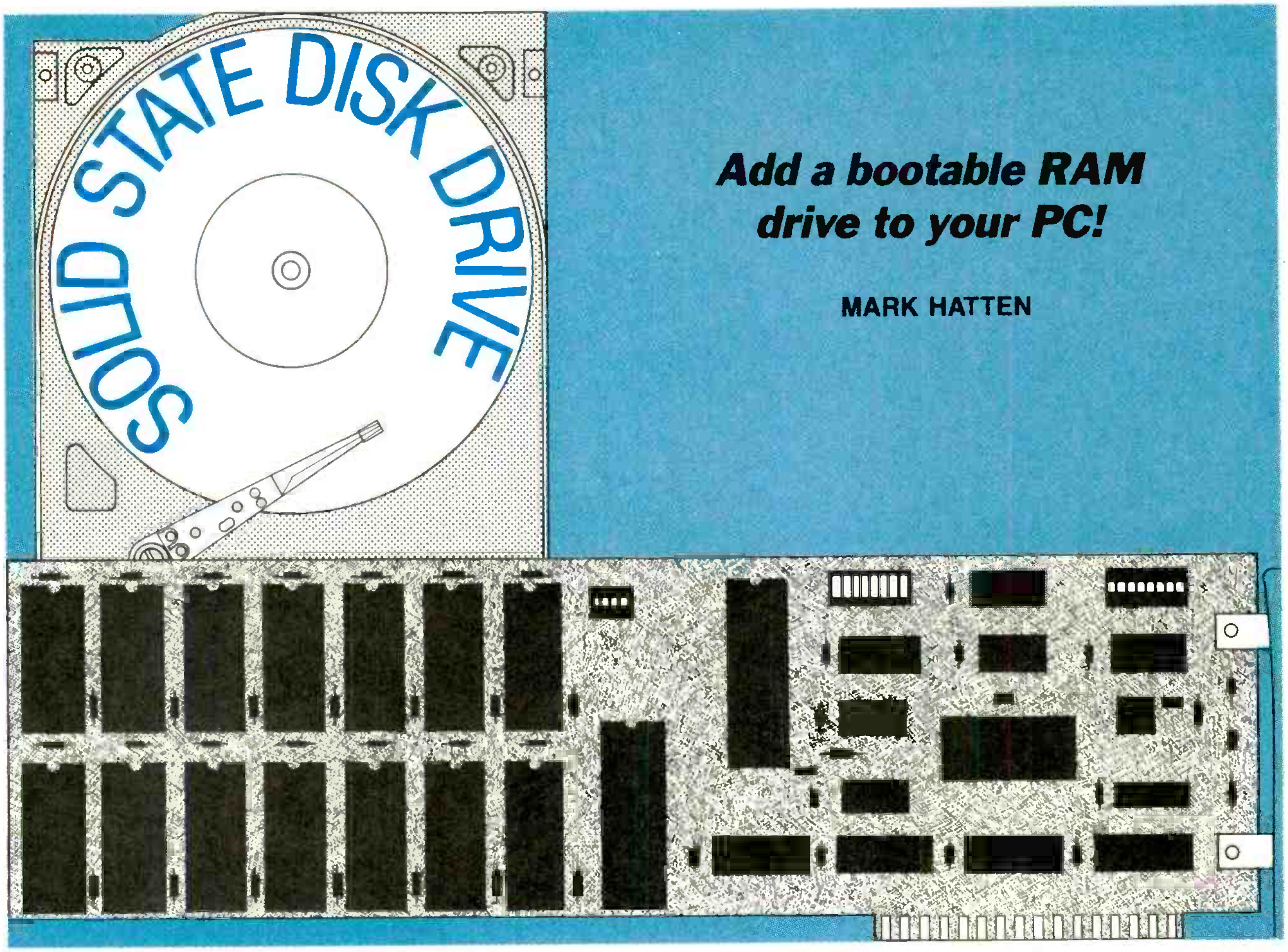
Adjust RAMP TIME and PULSE TIME for a ramp that lasts 10 milliseconds and for a time period between ramps of 10 milliseconds. Readjust the oscilloscope for 5 milliseconds/division. Adjust SINE/TRIANGLE/SQUARE FREQUENCY to 285 Hz. Select the burst position of the FUNCTION/RANGE switch. Observe the output at J1; the oscilloscope should display burst groups with three cycles in each group. If the oscilloscope does not trigger correctly on the bursts, trigger it externally with the pulse output.

Set the FUNCTION/RANGE switch to the 1-kHz sinewave position. Adjust the output to any convenient level. Set the SWEEP switch to "on." You should observe the sinewave sweeping from about 1 kHz at the far left to 10 Hz or less at the right. The RAMP TIME control affects the length of the sweep. It is best to trigger the oscilloscope with the pulse. A slight lowering of the RAMP LEVEL control will raise the lowest frequency at the right of the trace. If the burst mode is selected while the SWEEP switch is "on," the sweep will automatically be on the 20-kHz range, and the sweep will be from near 20 kHz at the left to 20 Hz at the right.

The best arrangement for using the HOLD switch is to set the oscilloscope in the X/Y mode with the generator's ramp providing sweep for the oscilloscope. Not all oscilloscopes achieve X/Y operation in the same way. Refer to your oscilloscope's manual to determine how your model does this.

Select "wide width" and adjust RAMP TIME fully clockwise; this should give a sweep of about 4 seconds. Once you have X/Y operation, press HOLD several times during the sweep. The trace should stop and you can get a frequency readout of that point. Try both the 20-kHz and 1-kHz ranges. Whenever you set sweep, the square wave is also being swept. A digital oscilloscope does not have X/Y capability in its memory mode. The best arrangement in using one is to adjust the oscilloscope's internal sweep to match that of the generator.

This completes the checkout procedure. Your function generator should now be ready to give you faithful service and it will be a valuable addition to your workbench. Ω



SOLID STATE DISK DRIVE

Add a bootable RAM drive to your PC!

MARK HATTEN

AS IN MOVIES, SO IN ELECTRONICS. This article is a sequel that details the construction of a PC expansion card called the SRAM Drive II. In case you missed it, the original (**Radio-Electronics**, July and August 1990) provided an innovative circuit that allowed you to use a static RAM (SRAM) like an EPROM. You could write a program and copy it to a battery-backed SRAM, where it would remain even when the computer was turned off. With the appropriate code in the SRAM, you could even "hook" special software into the BIOS (basic input output system) during boot. The original design provided a password-protection feature that prevented the PC from booting unless the correct password was entered.

SRAM II extends the idea. It uses the SRAM-based boot-ROM concept, but this time a disk emulator is hooked into the PC's BIOS. In general, the SRAM drive functions like any other PC-based disk drive. It does, however, have a few special features. For one, it's battery-backed, so its contents won't disappear when power goes off. Second, it can be made bootable!

SRAM II is designed to be the heart of an embedded system. Accordingly, it has enough semiconductor storage to hold a good-sized application: a maximum of 1.8 megabytes, supplied by fourteen 128K × 8 SRAMs.

The boot ROM can hold as much as 16 kilobytes of code, stored in either a common EPROM (27128 or 27256) or in a 43256 SRAM fitted in a special battery-backed "Smart Socket," made by Dallas Semiconductor. With the SRAM configuration being battery-backed, it is possible to enable and disable operation—and even change boot software—on the fly!

Partial and complete kits, as well as bare boards, are available. See the Parts List for pricing and other information concerning the kits.

How it works

The circuit consists of the following major components:

- PC-bus signal buffering
- I/O port decoding
- Upper memory segment-decoding unit
- Two 8255 peripheral interface controllers (PICs)
- An array of static memory.

The SRAM II buffers the PC address-bus signals with IC5, IC8, and half of IC4, as shown in Fig. 1. The circuit also buffers the data bus and several control signals, as shown in Fig. 2. Control signals include I/O Read ($\overline{\text{I/OR}}$), I/O Write ($\overline{\text{I/OW}}$), Reset (RST), and DMA enable (AEN). Note that Memory Read ($\overline{\text{MEMR}}$) is buffered (by IC10-c), but Memory Write ($\overline{\text{MEMW}}$) is not. This setup is not good practice, but it does not compromise signal quality here. (Cautious readers might want to buffer $\overline{\text{MEMW}}$ using some of the spare gates shown in Fig. 5.—*Editor*)

The real heart of the circuit appears in Fig. 3. The gates, decoders, and DIP switches there

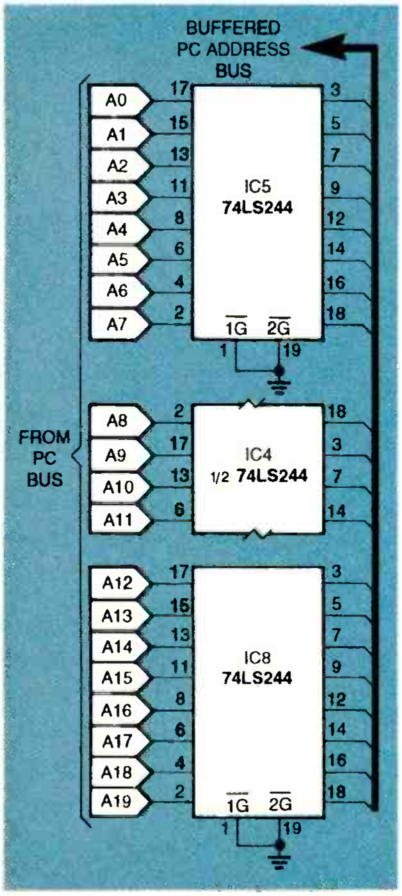


FIG. 1—ADDRESS BUS BUFFERING appears here. The other half of IC4 drives several control signals; that is shown in Fig. 2.

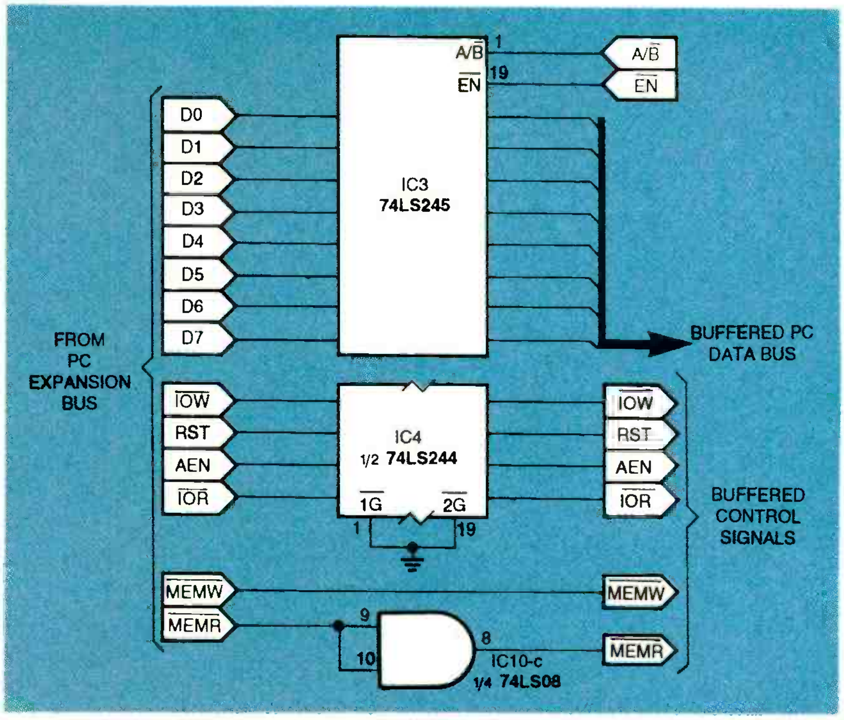


FIG. 2—DATA BUS AND CONTROL SIGNAL BUFFERING is shown here. Note that the memory-write line is unbuffered.

TABLE 1—S3 DETERMINES 32-BYTE BASE ADDRESS

Base Address	S3-a	S3-b	S3-c	S3-d
512	1	1	1	1
544	0	1	1	1
576	1	0	1	1
608	0	0	1	1
672	0	1	0	1
704	1	0	0	1
736	0	0	0	1
768	1	1	1	0
800	0	1	1	0
832	1	0	1	0
864	0	0	1	0
896	1	1	0	0
928	0	1	0	0
960	1	0	0	0
992	0	0	0	0

allow you to set board operation so it occurs at addresses that do not conflict with other equipment you might have installed in your PC.

I/O port decoding is accomplished by IC6, IC7, IC9, and IC10. Pin 3 of IC9-a is normally low, but whenever there is an I/O read or write, it goes high. If, in addition, AEN is low (there is no DMA activity), then IC9-b is high. In this case, both inputs to IC10-a are high, so its output also goes high.

Now look at IC7, a 4-bit comparator whose A=B output goes high when all four input bits, A0–A3, are equal to all four corresponding input bits, B0–B3. In practice, this means that the CPU address lines A5–A8 must be equal to the values set by the DIP switch S3. In addition, the PC bus address line A9 must be high.

The net effect of that circuitry is to define the base I/O port at which the SRAM circuitry will be decoded. The base address, as set by address line A9, is 512; depending on which switch positions of S3 are set, that values increase by 32 (512, 544, ... 992), as shown in Table 1. In conjunction with 1-of-8 decoder IC6, DIP switch S1 furthers narrows the decoded address to an eight-byte segment within the 32-byte block, as shown in detail in Table 2.

Now return to the decoding. When the address-bus value equals the value set by the DIP switches, and when either I/O Read or I/O Write goes active, and AEN is inactive, IC9-c goes low, IC10-b goes low, and that in turn enables data-bus transceiver IC3 (shown in Fig. 2). Transfer direction (into or out of the CPU) is determined by the state of IC3 pin 1, which is in turn driven by IC10-d (refer to Fig. 3 now), which is normally thought of as an AND gate. However, in this case, IC10-d functions as a 2-input negative OR gate—when either input goes low, the output goes low. In other words, when the CPU

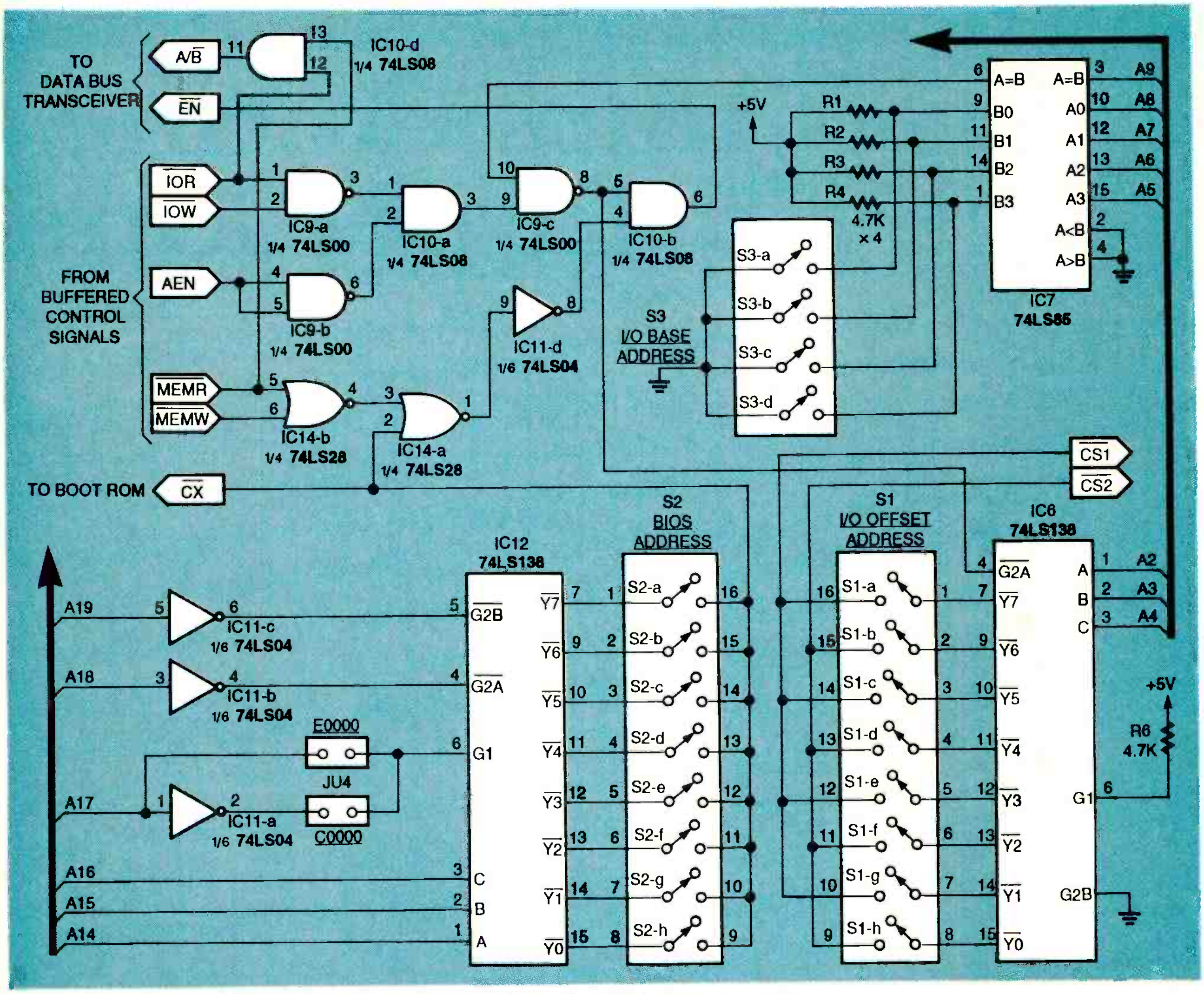


FIG. 3—ADDRESS AND I/O PORT DECODING occurs here. The DIP switches permit the selection of a base I/O address, an offset I/O address, and a memory-segment address to which the boot SRAM can be addressed. Logically, S1 is a 2P4T switch that provides the two chip selects that drive the 8255s shown in Fig. 4.

TABLE 2—S1 DETERMINES 8-BYTE OFFSET

On Positions				
1+2	**3+4**	**5+6**	**7+8**	**Standard Usage**
512	520	528	536	GAME PORT
544	552	560	568	
576	584	592	600	
608	616	624	632	
640	648	656	664	
672	680	688	696	
704	712	720	728	
736	744	752	760	COMM2
786*	776	784	792	
800	808	816	824	HDISK CNTRL
832	840	848	856	
864	872	880	888	LPT
896	904	912	920	
928	936	944	952	MONO ADAPT
960	968	976	984	CGA ADAPT
992	1000	1008	1016	FLOPPY/COMM1

reads either memory or an I/O port, and the proper decoding occurs as discussed earlier, the CPU can read whatever is on the SRAM II's data bus.

The other input to IC10-b comes from IC11-d, which is in turn driven by IC14-a. Its inputs come from two sources: high-order address decoder IC12 (by way of DIP switch S2), and the OR'ed output of IC14-b. That gate goes high whenever there is either a read from or a write to system memory. Therefore, by tracing from IC14-b to IC14-a to IC11-d to IC10-b, you can see that data-bus transceiver IC3 can be enabled in a second way—when there is a system memory access.

I/O port decoding is done in two steps. DIP switch S3 sets a base address, and DIP switch S1 sets an 8-byte offset. Although S1 consists of eight individual

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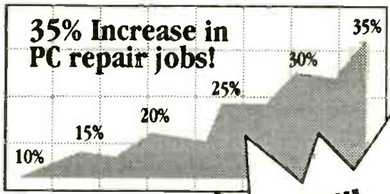

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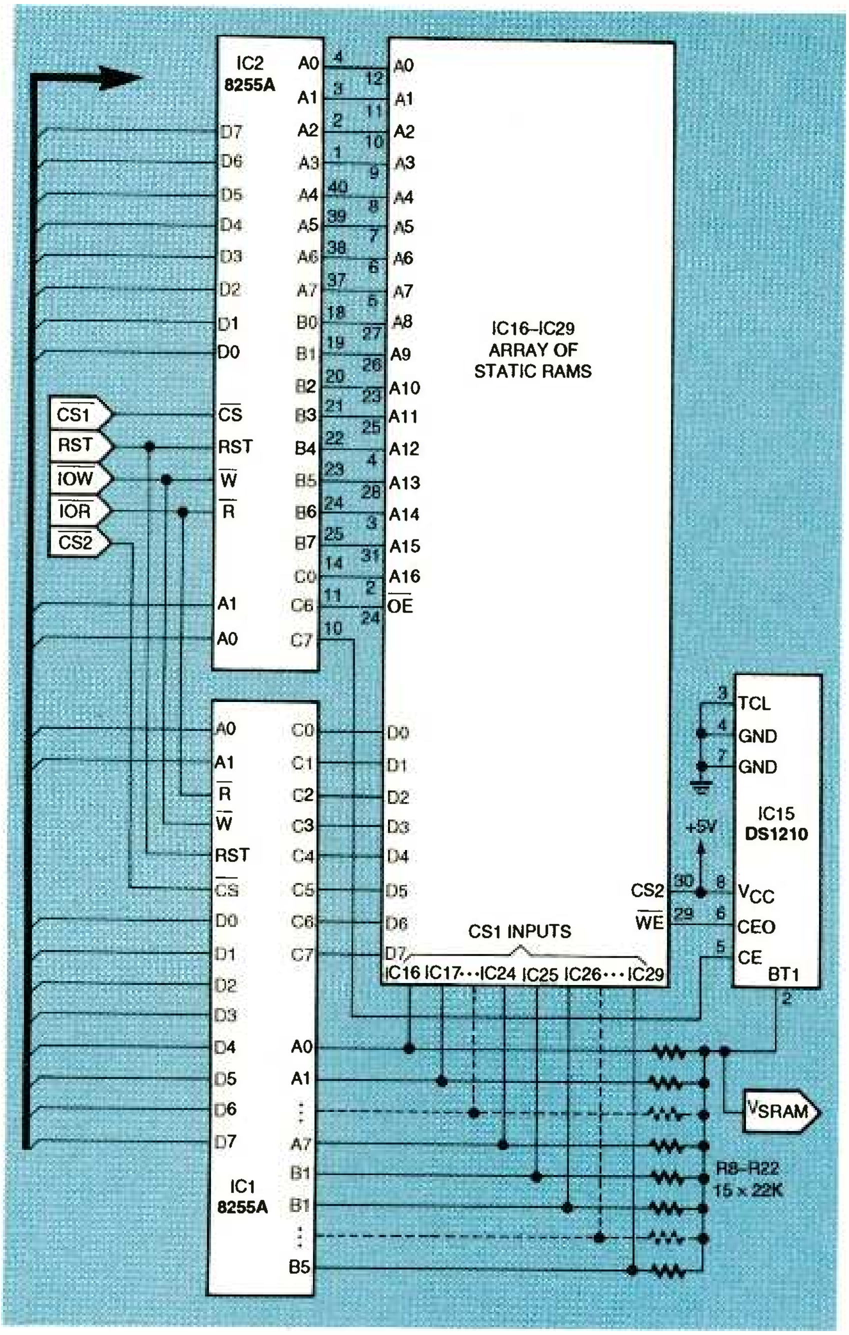


FIG. 4—TWO 8255s DRIVE ADDRESS AND DATA BUSES and control lines of an array of up to 14 static RAM's. IC15 is a data guard that disables the SRAM write line whenever power drops.

SPST switches, in logical terms it functions as a 2P4T switch; every other output is wired in parallel, so you can enable only two positions of S1 at once (1+2, 3+4, 5+6, or 7+8). The selected output pair provides two chip-select signals that enable the 8255 PICs, as shown in Fig. 4.

But first finish the address decoding in Fig. 3. Another 1-of-8 decoder, IC12, works with S2 to decode a 16K block of high-address space, ranging from C8000 to EC000. Jumper JU4 selects either a low or a high start address (C000:0000 or E000:0000, respectively), and DIP switch S2 selects the desired 16K segment. Thus, when the system accesses the decoded address, IC13—the boot ROM/SRAM—is enabled by the signal that is labeled $\overline{CX}$.

On board memory addressing

You might have wondered how 1.8 megabytes of memory was squeezed into a DOS PC. EMS. No. XMS? Try again. Custom bank-switched memory? That's it!

Now look at Fig. 4. The two 8255s provide the complete interface to the memory array, including data bus, address bus, and control signals. Thus, accessing a given memory location amounts to writing the correct bits to the correct registers in the PICs.

The PICs are standard devices, installed in IBM's original PC and many PCs since then. Each PIC has four addresses: one for a control register and three for three 8-bit I/O ports (A, B, and C). The I/O port identification is simple, as shown in Table 3.

While still looking at Fig. 4, note that IC15 serves as an intelligent power controller. It controls the WRITE ENABLE line (as delivered by IC2) into the memory array. Whenever IC15 senses that power is dropping, it ensures that $\overline{WE}$ remains high until power switches over. That way, SRAM data cannot be inadvertently corrupted. Pull-up resistors (R8–R22) at each $\overline{CS}$ input provide just enough current to keep RAM data intact. Battery voltage should be 2.0–4.0 volts. Use a 3.6-volt lithium battery or a pair of AA alkaline cells.

Figure 5 shows the remaining components of the circuit. Boot

TABLE 3—PIC PORT USAGE

PIC	Port	Usage
1	A	Memory bank chip selects 1–8
	B	Memory bank chip selects 9–14, 1 unused bit, and the memory bank read/write line.
	C	Memory bank data bus 0–7
2	A	Memory bank address bus 0–7
	B	Memory bank address bus 8–15
	C	Memory bank address bus 8–15, and memory bank output enable and write enable lines.

PARTS LIST

Resistors
R1–R7—4700 ohms, ¼ watt, 5%
R8–R22—22,000 ohms, ¼ watt, 5%
Capacitors
C1–C27—0.01 µF, mini DIP
Semiconductors
IC1, IC2—8255-A peripheral interface controller (Intel)
IC3—74LS245 octal bus transceiver
IC4, IC5, IC8—74LS244 octal bus buffer
IC6, IC12—74LS138 1-of-8 decoder
IC7—74LS85 4-bit comparator
IC9—74LS00 quad NAND gate
IC10—74LS08 quad AND gate
IC11—74LS04 hex inverter
IC13—43256 static RAM, 100 ns
IC14—74LS28 quad NOR gate
IC15—DS1210 intelligent power controller (Dallas Semiconductor)
IC16–29—static RAM, 128K × 8 (Sony 581000P-10L or equiv.)
D1, D2—1N4148
Other components
S1, S2—8 position SPST DIP switch
S3—4 position SPST DIP switch
JU1, JU4, JU5, JU6—2-pin, 0.1-inch header (with jumpers)
JU2, JU3—not used
B1—3.6-volt lithium battery (>0.5 mAH)
IC13 socket—DS1213C Smart Socket (Dallas Semiconductor)
Miscellaneous: PC board, mounting bracket, IC sockets, solder, wire, etc.
Note: The following items are available from Hatronics, 145 Lincoln Street, Montclair, NJ 07042. (201) 783-7264:
- **Bare PC board—$62**
- **Kit of parts with 0K—$120**
- **Kit with IC13 EPROM—$135**
- **Kit with IC13 SRAM—$140**
- **Kit with IC13 EPROM and 1.8 MB SRAM—$410**
- **Kit with IC13 SRAM and 1.8 MB SRAM—$425**
- **Additional programmed EPROMs—$5**

Specify port address of boot module. All orders add $6 S/H. NJ residents add sales tax. Check, money order, COD, AMEX accepted.

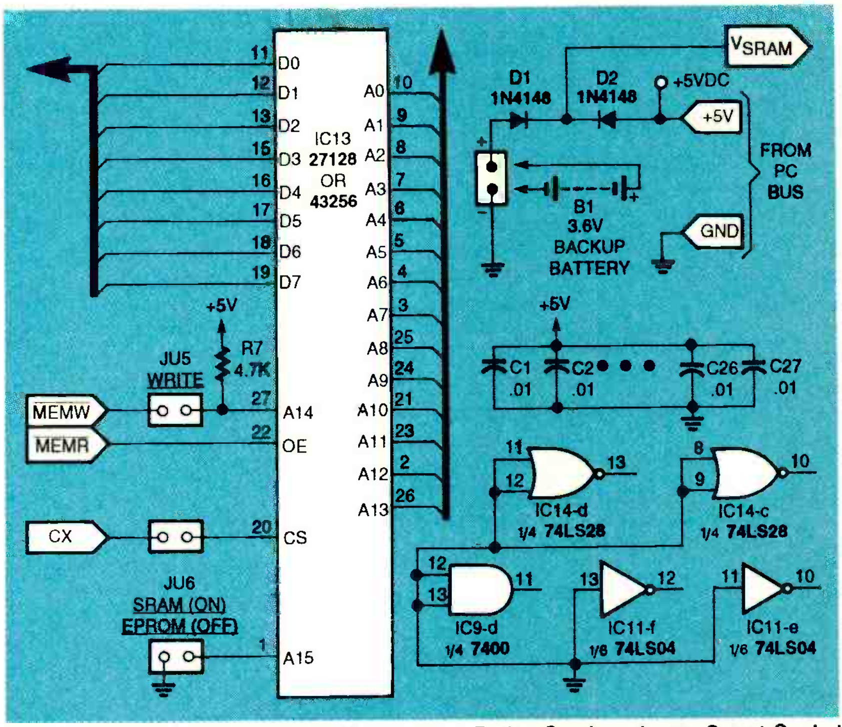


FIG. 5—MOUNT THE BOOT SRAM (IC13) in a Dallas Semiconductor Smart Socket, which has a built-in backup battery. The power supply has several 1N4148s that isolate the SRAM array back-up battery.

software is stored in IC13. Three jumpers control its operation: JU1 provides an overall enable/disable function for IC13; JU5 enables and disables writing to

TABLE 4—JUMPER SETTINGS

Jumper	State	Description
JU1	On Off	Enable SMRAM II Disable SRAM II
JU2	On Off	Not used
JU3	On Off	Not used
JU4	Upper Lower	C8000–DC000 E0000–EC000
JU5	On Off	Enable write to IC13 Disable write to IC13
JU6	On Off	IC13 = SRAM IC13 = EPROM

an SRAM in the IC13 Smart Socket; and JU6 allows you to select between SRAM and EPROM operation. Table 4 summarizes the functions of all jumpers.

Part of SRAM II's appeal is its battery back-up capability. The circuit is wired so that PC-bus power (+5 volts) and the battery pack both feed the separate power line used by the memory bank. The power line is labeled V_{SRAM}. The two power sources are isolated from each other by diodes D1 and D2. Bypass capacitors C1–C27 also appear in Fig. 5, as do several unused gates, whose inputs are grounded to avoid excess current drain.

Assembly and setup

Enough theory. Let's build something! First gather up all the tools you'll need, including a medium-power (35-watt) soldering pencil and some small-gauge solder. A Princess iron works well because of its small tip. Use thin diameter solder because thick solder can cause unwanted bridges.

The circuit is moderately complex, so a PC board is recommended for this proejct. Foil patterns are too large to print here, but they can be obtained by sending a self-addressed, stamped, business-size (No. 10) envelope to **Electronics Now**, SRAM PC Board, 500-B Bi-County Blvd., Farmingdale, NY 11735; you can also purchase an etched and drilled board from the author, as noted in the Parts List. The board components are not hard to assemble; the work can be completed in a few hours, depending on your experience. But haste makes waste, so don't rush!

Sockets are not mandatory, but they are recommended, par-

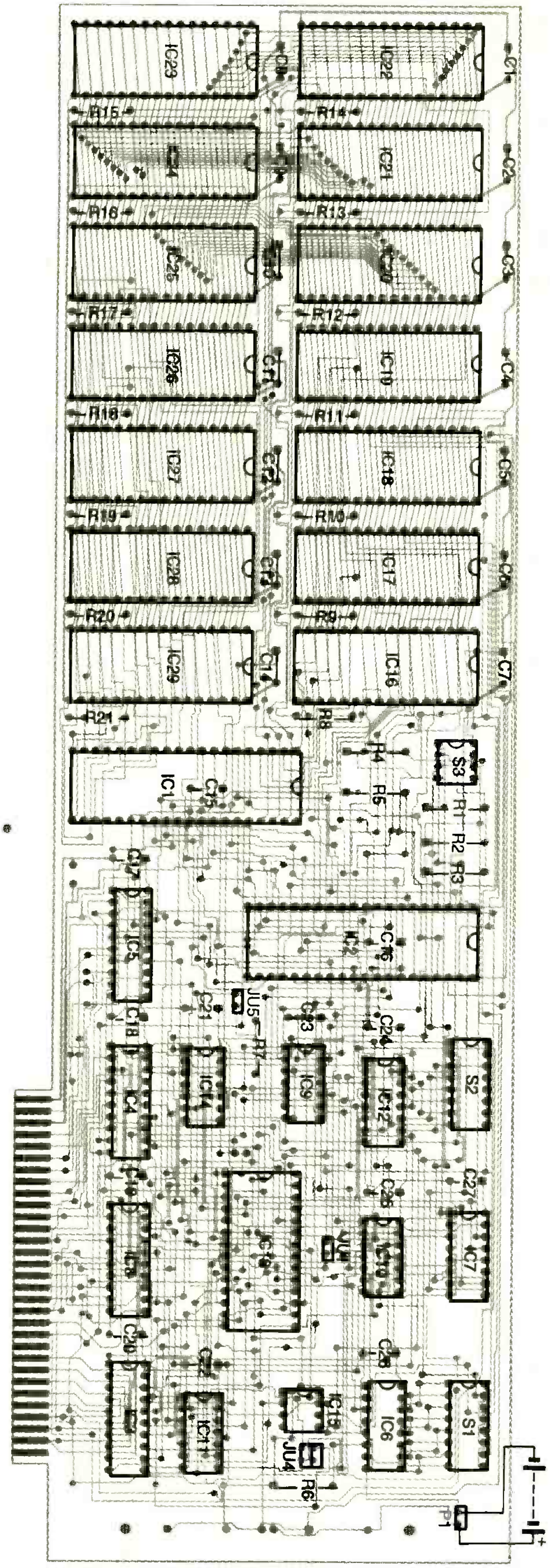


FIG. 6—MOUNT ALL COMPONENTS as shown here.

ticularly for the memory and LSI devices (IC1, IC2, IC13, IC15, and IC16–IC29). Refer to Fig. 6 as a guide for installing all components. Note: Before installing sockets for IC1 and IC2, mount and solder decoupling capacitors C15 and C16. If the sockets don't provide adequate clearance, mount the capacitors on the solder side of the board. After mounting all parts, check your work carefully. Some traces are *very* close together. Figure 7 shows the completed prototype.

To configure the board, you must define two things: the upper address segment where the boot ROM/SRAM will reside, and the base address of the eight I/O ports that control the board. Be sure the segment address does not conflict with any video card, network adapter, disk controller, or other device. Also, be sure that the I/O ports don't conflict either. Then refer to Tables 1, 2, and 4 to set the desired addresses. Last, install the board in your system.

Initializing the board

Create a directory on your hard disk and copy all the software from the distribution diskette to it. Software is also available from the *Electronics Now* BBS (516-293-2283, 9600, V32, V42bis) as a file called SRAM.ZIP. At a minimum, the following programs should be present: 128KZERO.EXE, ENABLE.COM, DISABLE.COM, 128SRAM1.SYS, and FLOPYIMG.EXE.

First initialize the board. Do this with the 128KZERO utility. To run this program type:

```
128KZERO xxx yy zz ["y"]
```

where xxx is the base port address, yy is the SRAM to start with, and zz is the number of SRAMs to initialize. The final parameter is optional. Normally the program asks for confirmation before clearing memory. But if you include a "y" at the end of the command line, the program will not request confirmation. The offset and number parameters allow you to specify individual SRAMs to erase; for now, erase everything. Following are several examples and explanations:

```
128KZERO 776 1 14
```

Initialize the board at I/O port 776. Require confirmation before proceeding.

```
128KZERO 512 5 1
```

Initialize a board at I/O port 512, starting and ending at SRAM 5. Require confirmation.

```
128KZERO 768 7 2 y
```

Initialize a board at port 768, starting with SRAM 7, and advancing to SRAM 8. Do not require confirmation.

Incidentally, for purposes of the software drivers, whenever you must specify an offset or SRAM number, IC16 corresponds to SRAM 1, IC17 to SRAM 2, and so on, until IC29, which corresponds to SRAM 14.

Creating a RAM drive

To address the SRAM ICs on the board as a disk drive, add a device driver to your CON%FGSYS file. The driver requires five parameters, each

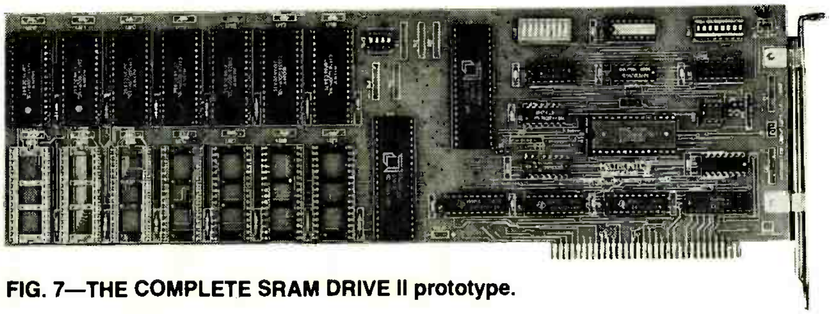


FIG. 7—THE COMPLETE SRAM DRIVE II prototype.

TABLE 5—S3 DEVICE DRIVER PARAMETERS

Prefix	Description	Note	Example
/	Base I/O port	Three-digit decimal value	/768
#	Number of SRAMs installed	Two-digit decimal value	#05
$	Number of directory entries	Three-digit decimal value, must be power of 2.	$016
%	Sectors per cluster	One-digit decimal value, must be power of 2. Default = 2.	%2
@	Number of sectors for FAT	One-digit decimal value, must be power of 2. Default = 6.	@6
&	SRAM offset	Two-digit decimal value. Number of SRAMs to skip before starting a drive.	&04

prefixed by a special character. Table 5 describes the parameters; Listing 1 shows a sample CONFGSYS. Note that the sample defines two drives, each 256K in size. The first drive skips the first three SRAMs, which account for 384K bytes of memory. That area might, for example, be used to emulate a 360K boot diskette.

Creating a boot drive

To create a boot "drive" on the SRAM II, you must do three things: 1) Create a boot floppy disk that contains the precise configuration you want. 2) Create an image of that floppy disk in the first three SRAM ICs (1C16–IC18). 3) Install a driver in the BIOS. The driver reads the SRAM II emulated disk rather than the A drive when booting (and subsequently). The software installation diskette includes several different BIOS drivers. The drivers are named xxxBOOT.DRV, where xxx corresponds to the three-digit decimal address where the board is installed.

To create a bootable SRAM drive, first create (and debug, if necessary) a bootable floppy disk that works exactly the way you want. Be sure to include the five SRAM II utility programs listed earlier. Then create the boot image on SRAM II with the utility FLOPYIMG, as follows:

FLOPYIMG xxx y

where xxx is the port address of the card, and y is a single digit corresponding to the floppy to use (0=A, 1=B). The program will then transfer, sector by sector, the contents of the specified floppy disk to the board.

Now load a driver into the boot ROM, with the utility INSTROM.

INSTROM xxxBOOT.DRV yyyy

where xxx is the port address and yyyy is the memory address when IC13 is decoded by S2 and jumper JU4.

Now you should be able to boot from SRAM II. Reset or power-cycle your computer and allow it to boot normally. You should see a brief sign-on message; then the system should boot from the SRAM drive. When boot is complete, you should have a 360K A drive If you loaded 128SRAM1.SYS to define any SRAM drives, it should appear when starting at drive C.

ENABLE.COM and DISABLE.COM are included in the floppy boot image so that SRAM II can be disabled. By typing the desired command with IC13's segment address, you can enable or disable the board. For example, if your board was installed at D0000, you could disable it by typing:

DISABLE D000

You could subsequently re-enable the board by typing:

ENABLE D000

Troubleshooting

If you can't get your computer to boot or to recognize SRAM II, first check the board construction.

If it passes inspection, check all jumper and switch settings. If these check out as well, the problem might be in the SRAM's or the boot SRAM. If there is a fault in the SRAM's, the clear utility (128KZERO) might tell you because it verifies all writes to memory.

To verify that the boot SRAM contains what it should where it should, use DOS's DEBUG program to dump the first few bytes. For example, if your board is located at C8000, start DEBUG. When the prompt appears, enter the following:

D C800:0

You should see a display like that shown in Listing 2. If not, your segment-decoding circuitry might not be working.

If all the hardware checks out, you could have a software problem. Create a boot floppy with no CONFIG.SYS or AUTOEXEC.BAT and install it in the SRAM. If this configuration will boot, you might have a path or command-line error. Ω

LISTING 1—SAMPLE CONFIG.SYS

```
device = ansi.sys
stacks = 64,256
device = 128sram1.sys /768 #16 $016 %2 &03
device = 128sram1.sys /512 #03 $016 %2 @2
buffers = 20
files = 30
break on
```

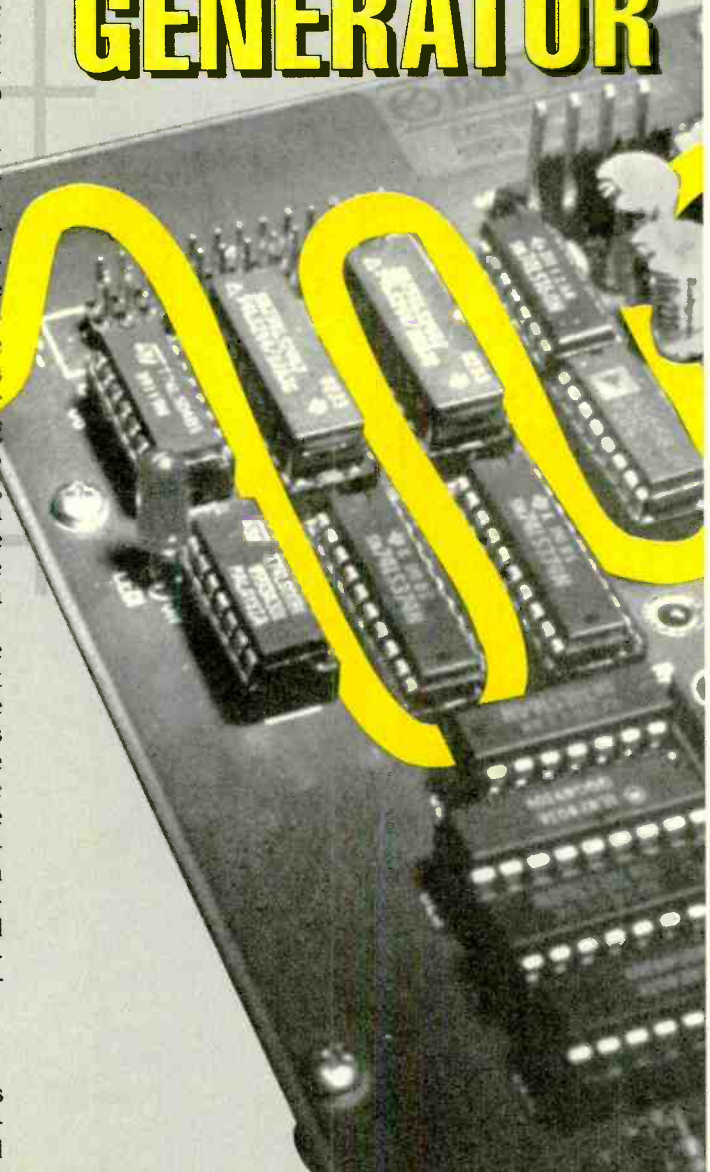
LISTING 2—DEBUG DUMP OF BOOT SRAM

```
C800:0000 55 AA 0C E8 72 00 CB 00-00 00 0E 00 40 08 00 00
C800:0010 50 72 6F 6D 4B 69 74 00-00 00 00 00 00 00 00 00
```

LAST MONTH, THE DESIGN OF A 2-GHZ SIGNAL GENERATOR was described. The article concludes here with construction tips and a Parts List. Because of the complexity and expense of the TG2000, construction should be attempted only by those with experience in building and troubleshooting high-frequency RF devices. Experience in mounting and soldering surface-mounted components is also required.

Let's build a 2-GHz RF signal generator.

PC-BASED RF SIGNAL GENERATOR



DAN DOBERSTEIN

Construction

You must use a PC board to build the TG2000. The foil patterns for making your own board are too big to print here, but you can obtain them by sending a self-addressed, stamped, No. 10, business-sized envelope to TG2000 Foil Patterns, Electronics Now Editorial Dept., 500-B Bi-County Blvd., Farmingdale, NY 11735. You can also purchase a completed board from the source mentioned in the Parts List.

Before mounting any components on the board, inspect it for shorts to ground on the power buses, and look for any possible defects in the board such as solder bridges. It is easier to find these problems before populating the board.

The TG2000 is made of about 75% surface-mount components and 25% through-hole components. The entire RF section is built from surface-mount components, and the computer digital interface is made with leaded components through-hole technology. Figure 1 is the parts-placement diagram. The mounting of surface-mount components present a considerable challenge for the kit builder. These components are very small and difficult to solder. Proper equipment is essential. A good quality soldering iron with a small needle tip and a medium tip is needed. The small tip will be useful for soldering the surface-mount components, but when a component is connected to the ground plane, the medium tip should be used because the needle tip will not be able to transfer enough heat for a good solder connection.

All the through-hole integrated circuits can be mounted in sockets, although sockets are not provided in the kit. A number of components are not used and they are indicated in the Parts List—do not install these components. One MMIC and a few discrete components are mounted on the bottom side of the board (see Fig. 2 for mounting details on these components). Pay attention to all polarity markings on both through-hole and surface-mount components. The input pins of the MMICs are marked with small arrows above their identification letters. Refer to the parts-placement diagram for their installation.

Spacer and shield mounting

The entire board area for surface-mount parts is shielded with a piece of double-sided PC-board. The shield is bolted to an edge-plated spacer made from 3/32-inch PC-board with ten 4-40 nuts and bolts. Figure 3 shows the cover/spacer assembly detail. Do not bolt the cover until final check out is done.

A double-sided bottom shield is mounted to the TG2000 board with seven 4-40 bolts and a nut and a washer as a standoff (see Fig. 3). Do not install this shield until the complete instrument operation has been verified.

If you are using the Anadigics VCO, you must hand wind and mount micro-coil L2 (it consists of 3 turns of No. 28 wire wound on a No. 60 drill bit). Tin the coil leads with solder. The enamel on the wire must be scraped away to tin the leads. After mounting L2, adjust the spacing of the coil to a width of about one wire diameter.

Two power options are available for the TG2000. Installing MMIC amplifier Q24 will boost maximum power output to above +7dBm. Normally this amplifier is omitted and a chip capacitor is jumpered across the location where it would go. The other option is a reduced power pick off at J3. By user selection of chip resistors that are mounted on the bottom side of the board, an attenuated signal is available at J3. For tracking-generator purposes, the attenuated signal is handy when a −50 to −20 dBm signal is needed. The higher output power produced by installing Q24 allows direct driving of diode mixers.

First power up

After all the components are mounted and the power buses are rechecked for shorts. The TG2000 is ready to be powered up. First check the voltage levels of all the supplies, including the −1- and 28-volt supplies. Then check the PLL operation. Execute the TG2000.EXE program and set the generator to produce a single frequency of 1200 MHz. The voltage on pin 1 of IC1-a should be about 2 volts. If the voltage is "railed" at either −1 or +28 volts, there is a problem in the PLL/VCO/prescaler system. If it is around 2 volts, try a frequency of 1900 MHz. It should be 18 to 20 volts. If these two frequencies work, chances are good that your PLL is operational and L2 can be tuned.

Command the TG2000 to a frequency of 1024 MHz. With the surface-mount shield in place and pressed lightly down, measure the VCO control voltage at pin 1 of IC1-a; it should be between 0.25 and 0.5 volts. If not, compress or expand L2 until the control voltage falls in that range. Now set the frequency to 2048 MHz. The control voltage should be between 21.5 and 25 volts; if not, adjust L2 again. The latter adjustment is much more sensitive because tuning diode characteristics flatten out at the high end of their range. Always make measurements with the shield in place. After you are satisfied, bolt down the surface-mount cover.

Troubleshooting

Many errors can cause the PLL loop to "open."

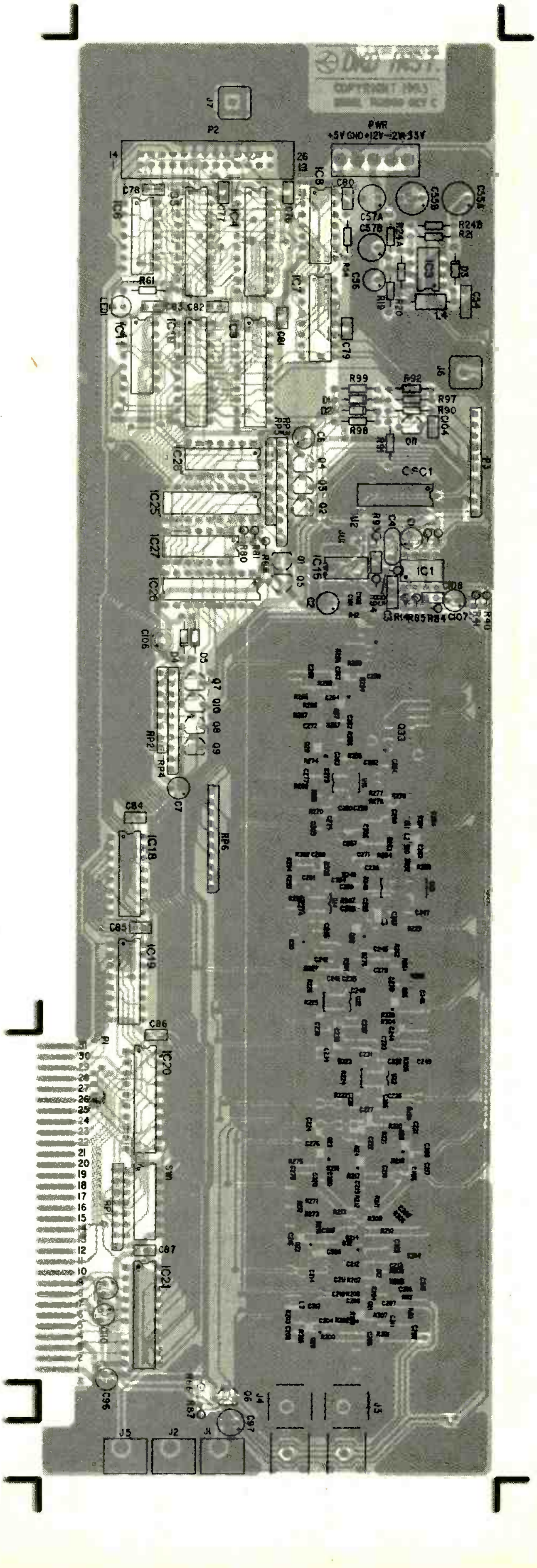


FIG. 1—THROUGH-HOLE PARTS-PLACEMENT. NOTE THAT ONE MMIC and a few discrete components mount on the bottom side of the board. The MMIC's input pin is marked with a small arrow above identification letters.

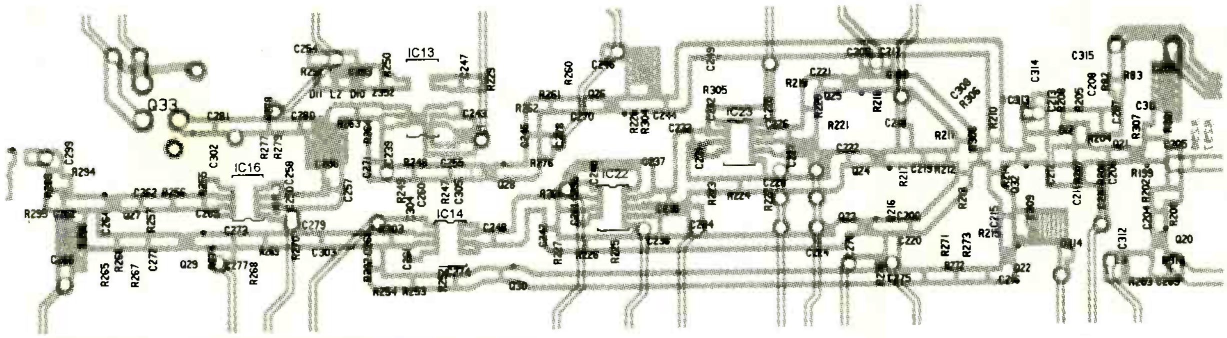


FIG. 2—SURFACE-MOUNT PARTS-PLACEMENT DIAGRAM. The surface-mount components present a considerable challenge for the kit builder.

TG2000 SURFACE-MOUNT PARTS

All resistors are in an 0805 package.
R42, R199, R221–R223, R225, R227, R230–R246, R254, R257, R259, R263, R268, R82—3300 ohms
R83, R215–R218, R228, R258, R274, R276—430 ohms
R270, R271, R273, R275, R277–R293, R296–298, R304–R306, R309—Not used
R201–R203, R209, R299, R300, R307, R310—510 ohms
R204, R205, R208—1000 ohms
R206—5600 ohms
R207—4700 ohms
R210–R214, R248, R264, R308—36 ohms
R220—18 ohms
R229, R247, R249, R252, R262, R267, R301, R303—68 ohms
R250, R251—22,000 ohms or 27,000 ohms
R255, R260, R265, R293, R294, R295, R302—110 ohms
R266—150 ohms
The following resistors are replaced by 0805-package capacitors:
R200, R209, R224, R226, R253, R256, R263, R269, R272—Any value between 2000 pF and 0.01 μF
R219—68 pF
R261—2.2 pF
For optional hybrid VCO
R263—not used R277, R279—68 ohms
R278—150 ohms
All capacitors are 0805 package
C101, C109, C199, C203–C214, C216–C222, C224–C234, C236–C241, C243–C248, C250–C255, C257–C264, C266–C280, C288, C299, C303, C306, C309, C311–C315—Any value between 2000 pF and 0.01 μF
C200, C235—6.8 pF
C201, C202, C223, C256, C257, C265, C281–C287, C289–C298, C300–C302, C307, C308, C310—not used
C215—4.7 pF
C249—1 pF
C257—Replace with micro coil identical to L2
C304, C305—3 pF
The following capacitors are mounted on top of resistors:
CP1—4.7 pF, mounted on top of R303
CP2—6.8 pF, mounted on top of R301
CP3—3 pF, mounted on top of R210
The following capacitors are replaced by resistors:
C242—18 ohms
For optional hybrid VCO:
C281, C282—2000 pF to 0.01μF
Diodes
D10, D11—Toshiba 1SV186
D12—Siemens BAR60 pin diode array
Inductors
L1—6 turns of No. 28 wire wound on a No. 50 drill bit, close wound
L2—3 turns of No. 28 wire wound on a No. 60 drill bit, deform to tune specs
L3—8 to 10 turns of No. 28 wire wound on a No. 40 drill bit, close wound
Integrated circuits
IC13—ADC20010 GaAs Mixer/VCO MMIC
IC14, IC16—NEC 584G divide-by-two prescaler
IC15—Fujitsu MB1501 1.1 GHz PLL
IC22, IC23—NEC 587G divide by 2/4/8 prescaler
MMIC amplifiers
Q20, Q21, Q24 (optional), Q31—MAR2 or MSA-0286 MMIC amplifier
Q22–Q27, Q29—MAR1 or MSA-0186 MMIC amplifier
Q28—INA-03184 MMIC amplifier
Q24, Q30—not used (jumper with 2000 pF to 0.01 μF)

This will show up as a VCO control voltage (pin 1 of IC1-a) railed at −1 or +28 volts. Use the BLINK diagnostic to verify that the data lines are under computer control. Use an oscilloscope to verify that the 4-MHz oscillator is operating and that its output is present at the MB1501. Verify that the MB1501 is receiving the reference oscillator and the VCO prescaled frequency by monitoring pins 13 and 14, which have the divided reference and VCO sample frequency on them respectively. The divided reference should be at 125 kHz and the divided VCO sample should be at 125 kHz if the PLL is locked. Assuming the PLL isn't locked, the pin-14 frequency can vary widely. Assuming that the MB1501 received the correct values of N and A, the VCO output pin will be close (within a factor of two) to 125 kHz.

If the frequency at pin 13 is not 125 kHz and the 4-MHz oscillator is present at pin 1, this indicates that the MB1501 reference divider is either not working or was not loaded properly. Component failure is very rare—check data lines using BLINK.EXE.

To verify the proper operation of the VCO and the divide-by-two prescaler, set the frequency to 1200 MHz, and open the loop up at R14. With a DC power supply, drive R14 to control the VCO frequency while watching the pulses at pin 14; the pulses should track changes in the control voltage.

This technique allows you to verify correct operation of the VCO, prescaler IC16, and the MB1501 N and A dividers using a low-frequency oscilloscope. In addition, the control voltage at pin 1 of IC1-a will toggle between −1 and +28 volts as the VCO frequency passes through the actual frequency commanded via the N- and A-register values.

Interface and DAC problems

The best way to test for interface problems is to use the BLINK diagnostic. This routine toggles all data lines at a 1-Hz rate, allowing signal tracing with a voltmeter. Verify the toggling at the pin of each chip serviced by the interface. If there's

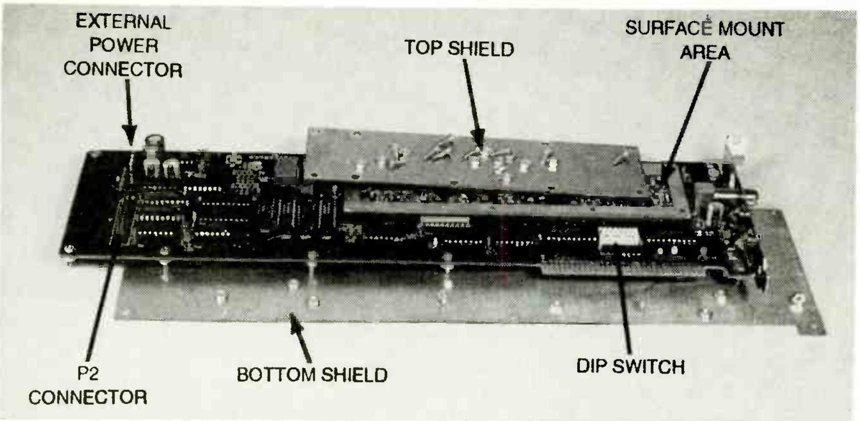


FIG. 3—THE TOP SHIELD IS BOLTED to an edge-plated spacer made from 3/32-inch PC-board material with ten 4-40 nuts and bolts. The double-sided bottom shield is mounted to the TG2000 board using seven 4-40 bolts with a nut and a washer as a standoff.

no toggling on any lines, check your software setup.

The DAC RAMP test must be done with an oscilloscope, because the ramp rate is too fast to be tracked with a voltmeter. With a scope and DAC RAMP running, you should see a ramp starting at 0 volts and ending at 10 volts. If you don't see a clean ramp waveform, check all the data lines and voltages.

Individual band problems

The bands past 30 MHz are impossible to check with a low-performance oscilloscope. However, because the band from 4 to 8 MHz needs every divider preceding it to work, the divider-chain operation can be verified with a low-bandwidth oscilloscope. Set the generator to sweep from 4 to 8 MHz (either linear or log) and observe the output with a suitable oscilloscope. The waveform envelope should be smooth with no sudden jumps in the output except at the sweep restart. Sudden amplitude changes could indicate a divider error in the chain.

Check the voltage at each MMIC amplifier. For any given band, only one RF path should be energized and the other MMICs should be turned off. If you suspect that a MMIC is faulty, check the installation polarity first. All the MMICs have a bias resistor connected in series to +12 volts. When they are "on" you should see about a 7- to 8-volt drop across this resistor, which results in about a 4.5-volt DC bias on the output pin of the MMIC. The input pin should have a DC level of about 1.5 volts. If any of these voltages differ significantly way off, look for short or open circuits, or a faulty MMIC.

Another way to check out all the bands is with a frequency counter. By sweeping the entire bandwidth of the instrument at a slow rate, the counter will provide an indication of a problem. Many low-performance counters can cover the entire band of the signal generator. Unfortunately, because of the high harmonic content of the divider chain, the counter can lock onto a harmonic of the output frequency. With the right amount of attenuation, however, this problem can usually be circumvented. Ω

ORDERING INFORMATION

Note: The following items are available from DKD Instruments, 1406 Parkhurst St., Simi Valley, CA 93065. (805) 581-5771:

- **TG2000 kit—$790.00**
- **TG2000 assembled and tested—$1475.00**
- **Bare PC board—$135.00**
- **810B Spectrum Analyzer—$2275**
- **1800H Spectrum Analyzer—$3775**

Please add $15 for shipping and handling inside California; $17, Continental U.S.; $35, Alaska and Hawaii; $40, Canada. Contact factory for available options

Note: This price list supersedes the incorrect list presented in the March 1993 issue.

TG2000 THROUGH-HOLE PARTS

Resistors
R5, R14—3300 ohms
R19—180 ohms
R20, R54, R93–R96—2200 ohms
R21—47,000 ohms
R24A—18 ohms
R24B, R41—68 ohms
R40—750 ohms
R61—470 ohms
R80, R81, R84, R85, R88—22,000 ohms
R86, R87, R90, R91, R92, R97–R99—not used or optional
RP1, PR2, RP5—22,000 ohms, comm bus network
RP3—22,000 ohms, isolated network
RP4—2200 ohms, isolated network
RP6—330,000 ohms, isolated network

Capacitors
C1, C2, C6, C7, C56, C106, C107—1 μF, 35 volts, tantalum electrolytic
C3—0.1 μF, polyester (104K)
C4, C54—1000 pF, polyester
C55A, C55B—220 μF, 35 volts, electrolytic
C57A, C57B, C97—220 μF, 16 volts, electrolytic
C76–C87, C104, C108—0.01 μF, ceramic
C96, C105, C110—10 μF, 16 volts, tantalum electrolytic
C97, C104—not used
C103—1000 pF, ceramic disc

Semiconductors
IC1—LM358 dual op-amp (SGS Thomson)
IC3—MC34063A switching regulator (Motorola)
IC4, IC5—74LS244 octal buffer
IC6—74LS04 hex inverter
IC7—AD558 8-bit DAC (Analog Devices)
IC8, IC27, IC28—74LS164 8-bit shift register
IC9, IC10—74LS374 octal latch
IC11—74LS00 quad NAND
IC18, IC19—74LS138 one-of-8 decoder
IC20—74HCT688 address decoder
IC21—74LS245 bidirectional buffer
IC25, IC26—ULN2803A octal driver (Motorola)
D1, D2—not used
D3—1N4003 diode
D4—1N3600 diode
D5—Replace with 43-ohm resistor
LED1—red light-emitting diode
Q1–Q5, Q7, Q9, Q10—2N3906 PNP transistor
Q6, Q8, Q11—not used

Other components
OSC1—4-MHz crystal oscillator
L4—220 μH molded coil
J1, J2, J5—right-angle PC-mount RCA jack (J2 is optional)
J3, J6, J7, P3—not used (optional)
J4—right-angle or SMA PC-mount F connector
P2—2 × 13 header
S1—7-position DIP switch
PWR—4-pin 0.156-inch molex header

RAY MARSTON

POWER AMPLIFIERS

Learn about audio power amplifers and apply this knowledge to your circuit designs and experiments.

AN AUDIO POWER AMPLIFIER CAN boost weak signals from a tuner, CD player, or tape deck to fill a room with sound. This article focuses on the operating principles and circuitry of low-frequency power amplifiers based on the bipolar junction transistor (BJT). Recent articles in this series have discussed multivibrators, oscillators, audio preamplifiers, and tone-control circuits, all based on the BJT.

Power amplifier basics

A transistorized audio power amplifier converts the medium-level, medium-impedance AC output voltage of a preamplifier into a high-level, amplified signal that can drive a low-impedance audio transducer such as a speaker. A properly designed power amplifier will do this with minimal signal distortion.

Audio can be amplified with one or more power transistors in either of three configurations: Class A, Class B, and Class AB. Figure 1-*a* shows a single BJT Class A amplifier in a common-emitter configuration with a speaker as its collector load. A Class A amplifier can be identified by the way its input base is biased.

Fig. 1-*a* shows that BJT Q1's collector current has a *quiescent* value that is about halfway between the zero bias and cutoff positions. (The quiescent value is that value of transistor bias at which the negative- and positive-going AC input signals are zero.) This bias permits the positive and negative swings of the output collector AC current to reach their highest values without distortion. If the AC and DC impedances of the speaker load are equal, the collector voltage will assume a quiescent value that is about half the supply voltage.

The Class A circuit amplifies audio output with minimum distortion, but transistor Q1 consumes current continuously—even in the quiescent state—giving it low efficiency. Amplifier *efficiency* is defined as the ratio of AC power input to the load divided by the DC power consumed by the circuit.

At maximum output power, the efficiency of a typical Class A amplifier is only 40%, about 10% less than its theoretical 50% maximum. However, its efficiency falls to about 4% at one-tenth of its maximum output power level.

A typical Class B amplifier is shown in Fig. 2-*a*. It has a pair of BJTs, Q1 and Q2, operating 180° out-of-phase driving a common output load, in this example another speaker. In this topology, the BJTs operated as common-emitter amplifiers drive the speaker through push-pull transformer T2. A phase-splitting transformer, T1, provides the input drives for Q1 and Q2 180° out-of-phase.

The outstanding characteristic of any Class B amplifier is that both transistors are biased off under quiescent conditions because they are operated without base bias. As a result, the amplifier draws almost no quiescent current. This gives it an efficiency that approaches 79% under all operating conditions. In Fig. 2-*b*, neither Q1 nor Q2 conducts until the input drive signal exceeds the base-emitter zero-crossing voltage of the transistor. This occurs at about 600 millivolts for typical

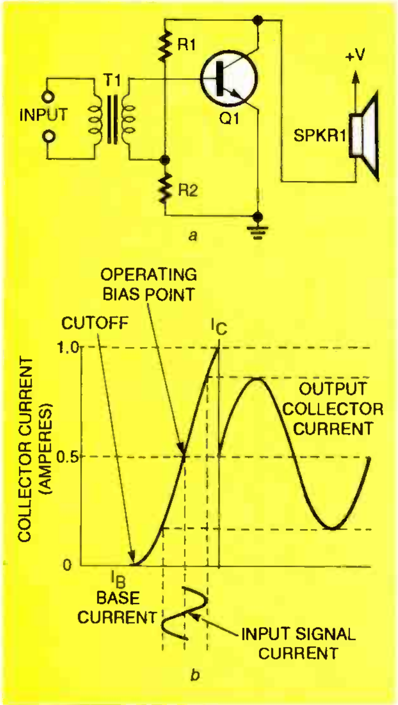


FIG. 1—CLASS A POWER AMPLIFIER circuit (*a*), and its dynamic transfer curve (*b*).

power transistor.

The major disadvantage of the Class B amplifier is that its output signal is seriously distorted. This can be seen from its dynamic transfer curve, also shown in Fig. 2-*b*.

Class AB fundamentals

Audio distortion caused by the crossover between two out-of-phase transistors is annoying. To overcome this defect, the classic Class B amplifier is modified into the third category called Class AB for most high-fidelity audio equipment. Fortunately, Class B distortion can usually be eliminated by applying slight forward bias to the base of each transistor, as shown in Fig 3-*a*. This modification sharply reduces the quiescent current of a Class B amplifier and converts it into a Class AB amplifier.

Many early transistorized power amplifiers were Class AB, as shown in Fig. 3-*a*, but that circuit is rarely seen today. That circuit requires one transformer for input phase-splitting and another for driving the speaker, both costly electronic componments.

In addition, the electrical characteristics of both Q1 and Q2 must be closely matched. The amplification of each transistor will be unequal if they are not, and it will be impossible to minimize output distortion. Figure 3*a* shows a dynamic transfer characteristic for a Class AB power amplifier.

The Class AB amplifier shown in Fig. 4 avoids both transformers and the need to match transistors. A complementary pair of transistors (Q1 an NPN and Q2 a PNP) is connected as an emitter follower. Powered by a split (dual) supply, the circuit's two emitter followers are biased

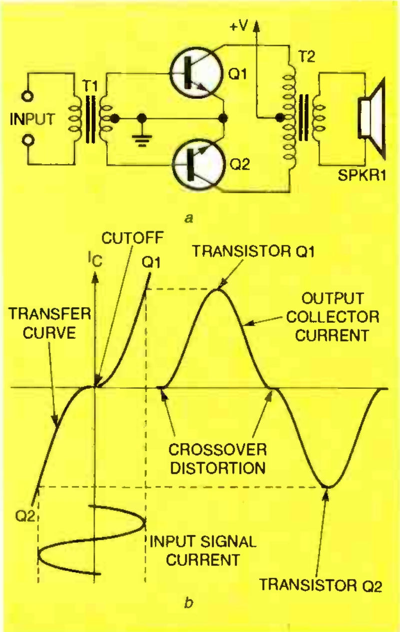


FIG. 2—CLASS B POWER AMPLIFIER circuit (*a*), and its dynamic transfer curve (*b*).

through R1 and R2 so that their outputs are at zero volts; no current flows in the speaker under quiescent conditions.

Nevertheless, a slight forward bias can be applied with trimmer potentiometer R3 so that Q1 and Q2 pass modest quiescent currents to prevent crossover distortion. Identical input signals are applied through C1 and C2 to the bases of the emitter followers, which avoid a split-phase drive.

When an input signal is applied to the Fig. 4 circuit, the positive swing drives PNP Q2 off while driving NPN Q1 on. Transistor Q1 acts as a current source with a very low output (emitter) impedance; it feeds a faithful unity-gain copy of the input voltage signal to the speaker. The transistor characteristics have little or no effect on this response.

Similarly, negative swings of the input signal drive Q1 off and Q2 on. Because Q2 is a PNP BJT, it becomes a current sink with minimal input (emitter) impedance. It also produces a faithful unity-gain copy of the voltage signal to the speaker, again with Q2's characteristics having little or no effect on the circuit's response.

As a result, the Fig. 4 circuit does not require that Q1 be matched to Q2, and neither input nor output transformers are required. Modification of this circuit, as shown in Figs. 5-*a* and *b*, work from single-ended power supplies. In Fig. 5-*a*, one side of the speaker is connected to the amplifier through high-value blocking capacitor C3, and the other end is connected to ground; in Fig.5-*b*, one side is connected to C3 and the other side is connected to the positive supply. All three circuits are popular in modern high-fidelity audio

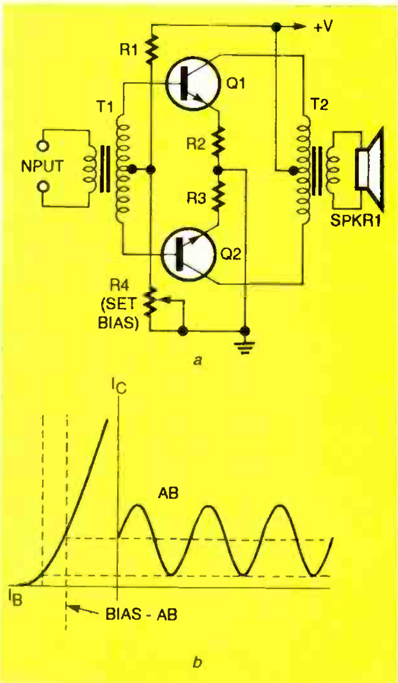


FIG. 3—CLASS AB POWER AMPLIFIER circuit (*a*), and its dynamic transfer curve (*b*).

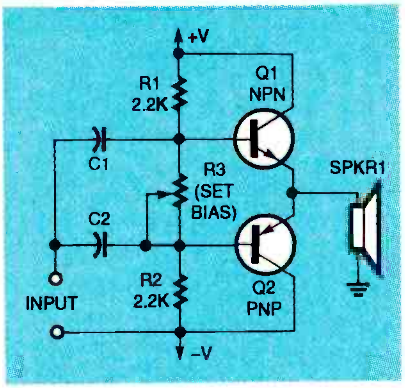


FIG. 4—CLASS AB POWER AMPLIFIER with a complementary emitter- follower output that must be powered by a dual supply.

power amplifiers based on integrated circuitry.

Class AB variations

The circuit in Fig. 4-*a* is a unity-voltage gain amplifier so one obvious improvement is to add a voltage-amplifying driver stage, as shown in Fig. 6. Transistor Q1, configured as a common-emitter amplifier, drives two emitter followers, Q2 and Q3, through its collector load resistor R1.

Note that Q1's base bias is derived from the circuit's output through resistors R2 and R3. This configuration provides DC feedback to stabilize the circuit's operating points and AC feedback to minimize signal distortion.

The Fig. 6 circuit illustrates how a form of auto-bias can be applied to Q2 and Q3 through the silicon diodes D1 and D2. If the simple voltage-divider biasing method in Fig. 4 is used in the Fig. 6 circuit, its quiescent current will increase as ambient temperature rises and decrease as it falls. (This is caused by the thermal characteristics of a transistor's base-emitter junctions.)

The biasing in Fig.6 is derived from the forward voltage drop of series diodes D1 and D2 whose thermal characteristics are closely matched to those of the base-emitter junctions of Q2 and Q3. Consequently, this circuit offers excellent thermal compensation.

Practical amplifiers include a pre-set trimmer potentiometer in series with D1 and D2. This component makes it possible to adjust bias voltage over a limited range. Low-value resistors R4 and R5 in series with the emitters of Q2 and Q3 provide some negative DC feedback.

The impedance of the Fig. 4 circuit equals the product of the speaker load impedance and the current gain of either Q1 or Q2. The circuit can be improved by replacing transistors Q1 and

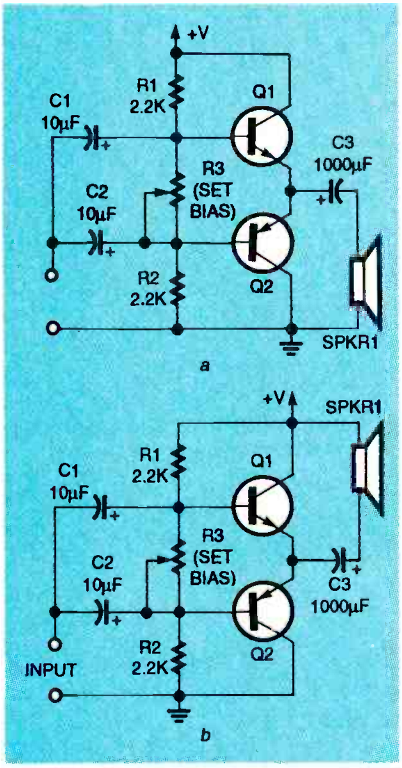


FIG. 5—ALTERNATIVE CLASS AB power amplifier that can be powered with a single-ended supply.

Q2 with Darlington pairs which will significantly increase the circuit's input impedance and increase the amplifier's collector load capacity.

Figures 7 to 9 show three different ways of modifying the Fig. 6 circuit by replacing individual transistors with Darlington pairs. For example, in Fig. 7, transistors Q2 and Q3 form a Darlington NPN pair, and Q4 and Q5 form a Darlington PNP pair. There are four base-emitter junctions between the bases of Q2 and Q4, and the output circuit is biased with a string of four silicon diodes, D1 to D4, in series to compensate for the Darlington pairs.

In Fig. 8, Q2 and Q3 are a Darlington NPN pair, but Q4 and Q5 are a complementary pair of common-emitter amplifiers. They operate with 100% negative feedback, and provide unity-voltage gain and very high input impedance. This *quasi-complementary* output stage is probably the most popular Class AB power amplifier topology today. Notice the three silicon biasing diodes, D1, D2, and D3.

Finally, in Fig. 9, both pairs Q2 and Q3 and Q4 and Q5 are complementary pairs of unity-gain, common-emitter amplifiers with 100% negative feedback. Because the pairs produce outputs that are mirror images of each other, the circuit has a complementary output stage. Notice that this circuit

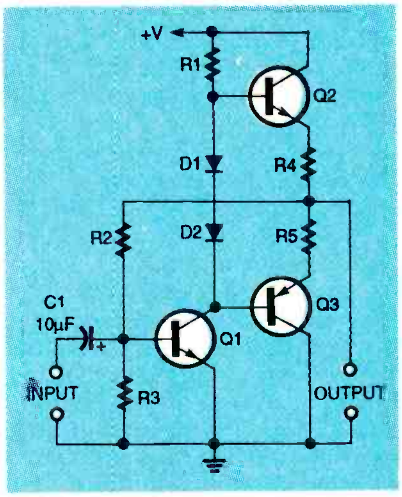


FIG. 6—COMPLEMENTARY POWER amplifier with a driver and auto-bias.

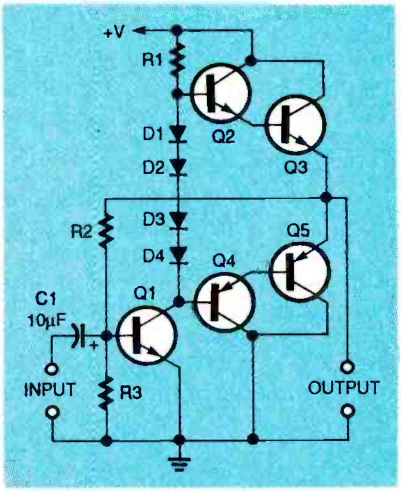


FIG. 7—POWER AMPLIFIER with Darlington output stages.

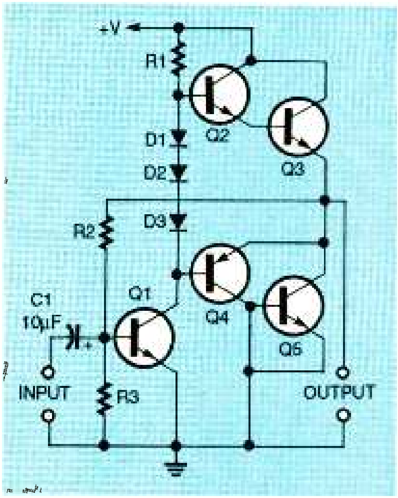


FIG. 8—POWER AMPLIFIER with partial complementary output stages.

has only two silicon biasing diodes, D1 and D2.

Amplified diodes

The circuits in Figs. 6 to 9 include strings of two to four silicon biasing diodes. Each of those strings can be replaced by a single transistor and two resistors configured as an *amplified diode*, as shown in Fig. 10.

The output voltage of the circuit, V_{OUT}, can be calculated from the formula:

$V_{OUT} = V_{BE} \times R1+R2/R2$

If resistor R1 is replaced by a short circuit, the circuit's output will be equal to the base-emitter junction "diode" voltage of Q1 (V_{BE}). The circuit will then have the thermal characteristics of a discrete diode.

If resistor R1 equals R2, the circuit will act like two series-connected diodes, and if R1 equals three times R2, the circuit will act like four series-connected diodes, and so on. Therefore, the circuit in Fig. 10 can be made to simulate any desired whole or fractional number of series-connected diodes, depending on how the R1/R2 ratios are adjusted.

Figure 11 shows how the circuit in Fig. 10 can be modified to act as a fully adjustable "amplified diode," with an output variable from 1 to 5.7 times the base-emitter junction voltage (V_{BE}).

Bootstrapping

The main purpose of the Q1 driver stage in Fig. 6, the basic complementary amplifier, is to give the amplifier significant voltage gain. At any given value of Q1 collector current, this voltage gain is directly proportional to the effective Q1 collector load value. It follows that the value of resistor R1 should be as large as

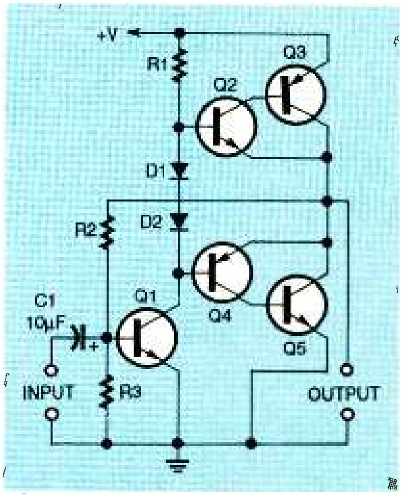


FIG. 9—POWER AMPLIFIER with complementaty output stages.

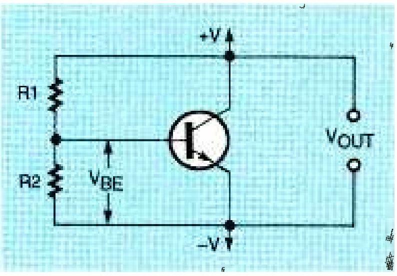


FIG. 10—FIXED-GAIN AMPLIFIED diode circuit.

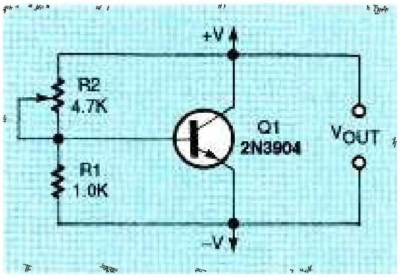


FIG. 11—ADJUSTABLE AMPLIFIED diode circuit.

possible to maximize voltage gain. However, there are several reasons why this does not work.

First, the *effective* or AC value of R1 equals the actual R1 value shunted by the input impedance of the Q2-Q3 power amplifier stage. Therefore, if R1 has a high value, the power amplifier input impedance must be even greater. That can usually be done by replacing Q2 and Q3 with high-gain transistor pairs, as was done in Figs. 7 to 9.

The second reason is that Q1 in Fig. 6 must be biased so that its collector assumes a quiescent half-supply voltage value to provide maximum output signal swings; this condition is set by the Q1's collector current and resistor R1's value.

The true value of R1 is predetermined by biasing requirements. To achieve high voltage gain, a way must be found to make the AC impedance of R1 much greater than its DC value. This is accomplished with the *bootstrapping* technique shown in Figs. 12 and 13.

In Fig. 12, Q1's collector load consists of R1 and R2 in series. The circuit's output signal, which also appears across SPKR1, is fed back to the R1-R2 junction through C2. This output signal is a near unity-voltage-gain copy of the signal appearing on Q1's collector.

If resistor R1 has a value of 1 kilohm, the Q2-Q3 stage provides a voltage gain of 0.9. As a result, an undefined signal voltage appears at the low end of resistor R2, and 0.9 times that undefined voltage appears at the top of R2. In other words, only one tenth of the unknown signal voltage is developed across R2. Therefore, it passes

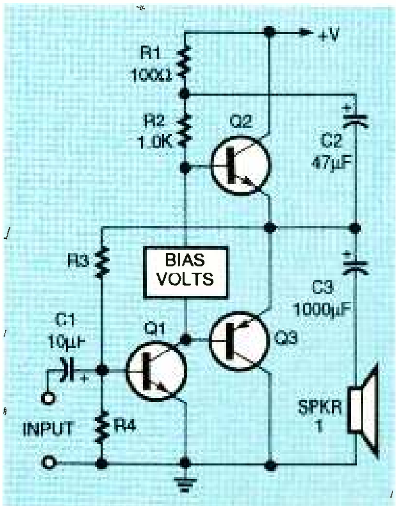


FIG. 12—POWER AMPLIFIER with a bootstrapped driver stage.

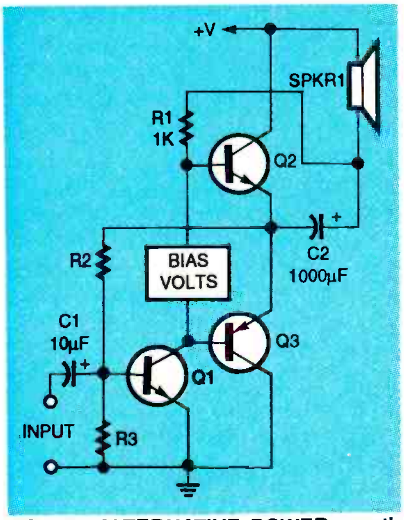


FIG. 13—ALTERNATIVE POWER amplifier with a bootstrapped driver stage.

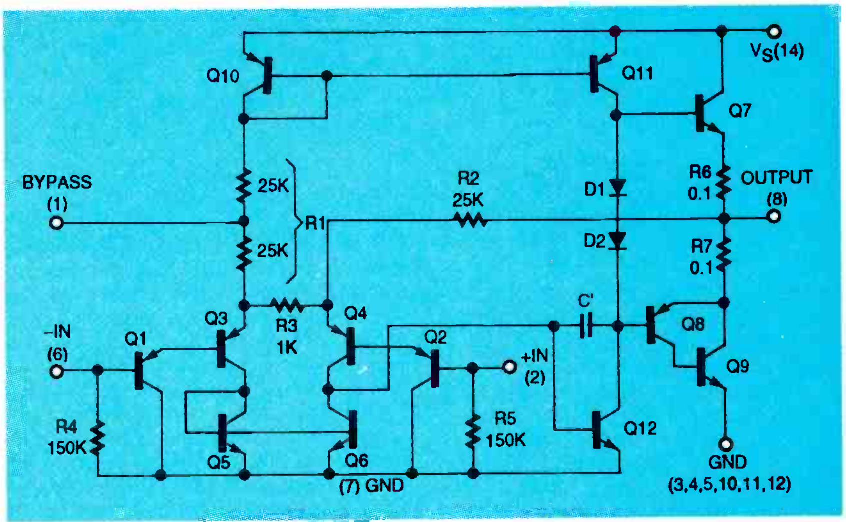


FIG. 17—SCHEMATIC FOR THE LM38 POWER AMPLIFIER IC from National Semiconductor. It has a 2-watt output rating.

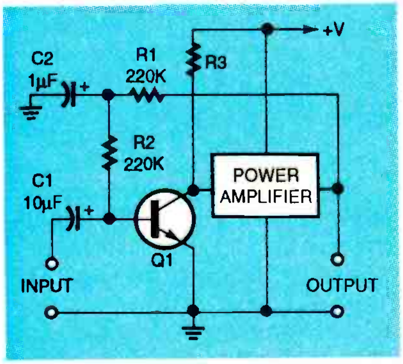


FIG. 14—DRIVER STAGE with decoupled parallel DC feedback.

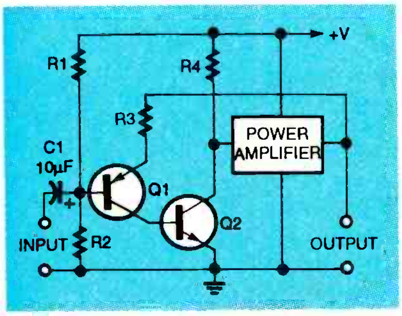


FIG. 15—DRIVER STAGE with series DC feedback.

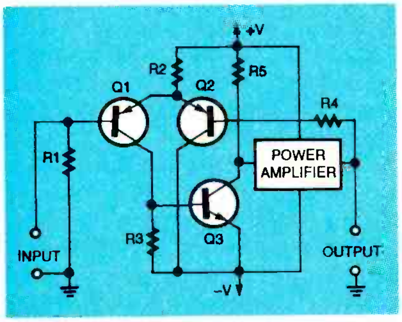


FIG. 16—DRIVER STAGE with a long-tailed pair input.

only one-tenth of the signal current that would be expected from a 1-kilohm resistor.

This means that the AC signal impedance value of R2 is ten times greater (10 kilohms) than its DC value, and the signal voltage gain is increased correspondingly. In practical circuits, "bootstrapping" permits the effective voltage gain and collector load impedance of Q1 to be increased by a factor of about twenty.

Fig. 13 is the schematic for an alternative version of Fig. 12 without one resistor and one capacitor. In this circuit, SPKR1 is part of Q1's collector load, and it is bootstrapped through capacitor C2.

As an alternative to bootstrapping, the load resistor can be replaced with a simple transistor constant-current generator. This design is found in many integrated circuit audio power amplifiers.

Alternative drivers

Returning once again to Fig. 6, notice that parallel DC and AC voltage from the R1-R2 divider network is fed back to the Q1 driver stage. This is a simple and stable circuit, but its gain and input impedance are low. Morover, it will work only over a limited power supply voltage range.

Figure 14 is a variation of the Fig. 6 circuit intended to function as a driver stage. Current feedback through resistors R1 and R2 allows the circuit to work over a wide supply voltage range. The feedback resistors can be AC decoupled (as shown) through C2 to increase the gain and input impedance, but at the expense of increased signal distortion. Transistor Q1 can be replaced with a Darlington pair if very high input impedance is desired.

Another alternative driver stage, Fig. 15, depends on series DC and AC feedback to give it more gain and higher input impedance than can be obtained from the Fig. 6 circuit. In this circuit, PNP transistor Q1 is directly coupled to NPN transistor Q2.

Finally, Fig. 16 is the schematic for a driver circuit specifically intended for use in amplifiers with dual or split power supplies that have direct-coupled input and output stages referenced to ground. The input stage of this driver stage is a long-tailed pair. Both the input and output will be centered on DC ground if the values of resistors R1 and R4 are equal. This circuit is found in many integrated circuit power amplifiers.

An IC power amplifier

Improvements in the power-handling capabilities of monolithic integrated circuits have permitted power amplifiers to be integrated on a single silicon substrate or chip. The techniques for designing integrated circuit power amplifiers are similar to those for discrete device circuits. It turns out that the similarities between discrete and IC power amplifier design are closer than for most other linear circuits.

Figure 17 is a simplified circuit diagram for the LM380, an IC power amplifier, drawn in the manufacturer's data book style. The LM380 was developed by National Semiconductor Corporation for consumer applications. It features an internally fixed gain of 50 (34 dB) and an output that automatically centers itself at one-half of the supply voltage.

An unusual input stage permits inputs to be referenced to the ground or AC coupled, as required. The output stage of the LM380 is protected with both short-circuit current limiting and thermal-shutdown circuitry.

The LM380 has two input therminals. Both Q1 and Q2 are connected as PNP emitter followers that drive the Q3 and Q4 differential amplifier transistor pairs. The PNP inputs reference the input to ground, thus permitting direct coupling of the input transducer.

The output is biased to half the supply voltage by resistor ratio R1/R2 (resistor R1 is formed by two 25-kilohm resistors and R2 has a value of 25 kilohms). Negative DC feedback, through resistor R2, balances the differential stage with the output at half supply, because R1 = 2R2.

The output of the differential amplifier stage is direct coupled into the base of Q12, which is a common-emitter, voltage-gain amplifier with a constant current-source load provided by Q11. Internal compensation is provided by the pole-splitting capacitor C'. Pole-splitting compensation permits wide power bandwidth (100 kHz at 2 watts, 8 ohms).

The collector signal of Q12 is fed to output pin 8 of the IC through the combination of emitter-coupled Q7 and the quasi-complementary pair of emitter followers Q8 and Q9. The short-circuit current is typically 1.3 amperes. Ω

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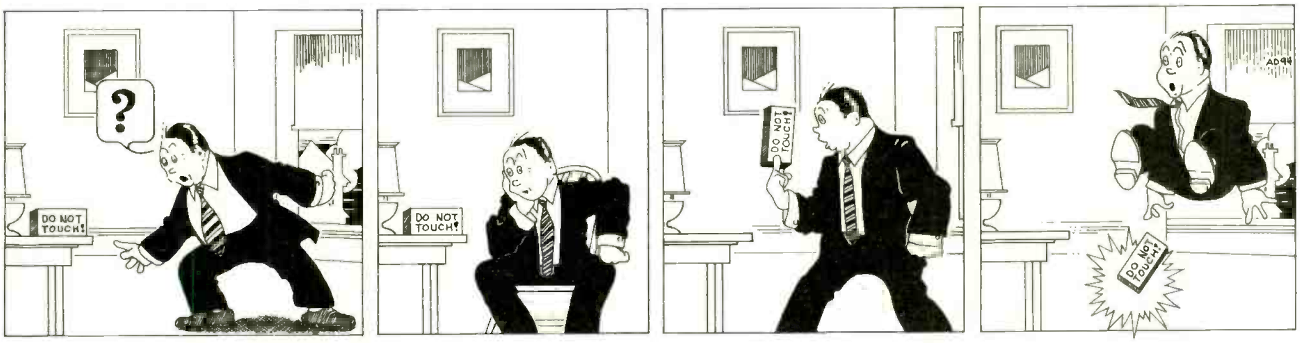


Sometimes the simplest electronic projects are the most fun.

KLAUS SPIES

ELECTRONIC PROJECTS DON'T ALways have to be serious. While most projects turn out to be a useful item when they are completed, they might be attractive only to those who find them useful. However, it's the simple novelty items that are often the most popular. That's because simple projects are usually very inexpensive to build, yet they can offer valuable insight into how circuits work. And unlike a device that's useful only to a few people, everyone likes a good gag now and then.

When something is marked with a message such as "Do Not Open Until Christmas," or something similar, the first thing most people want to do is open it—or at least investigate it, immediately. Taking advantage of that trait in human nature, the author invented the Screamer, a nondescript black box that sits on a coffee table waiting for the first "victim" to come along and pick it up. When the victim does pick it up, the Screamer emits an ear-piercing noise that only people "in the know" can turn off.

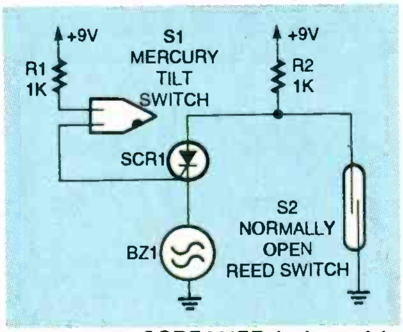


FIG. 1—THE SCREAMER is bound to catch any April fool who bllithely ignores the "Do Not Touch" message on the outside of the case.

Circuitry

Figure 1 is the schematic for the Screamer circuit. When the box is tipped, mercury-switch S1 triggers silicon-controlled rectifier SCR1, that acts as a latch which turns on buzzer BZ1 and keeps it turned on. The SCR can be reset only when power is removed from it. Reed switch S2 resets the SCR. The reed switch is a normally open type, so the only way it can reset the SCR is by having it short the power going to the SCR.

PARTS LIST

- R1, R2—1000 ohms
- SCR1—any low-power silicon controlled rectifier
- BZ1—any low-power DC buzzer
- S1—mercury tilt switch
- S2—normally open tilt switch
- Plastic project case, hot-melt glue gun, 9-volt battery and clip, wire, solder, etc.

The reed switch is mounted inside the black box against one side, so it cannot be seen from the outside. To close the reed switch, a magnet must be placed against the outside of the case adjacent to the switch. For best results you should use a plastic case. That way the magnet doesn't have to be very strong, and there will be no chance of magnetizing the case which could prevent the Screamer from working. Note that resistor R2 limits current to protect the reed switch and the 9-volt battery.

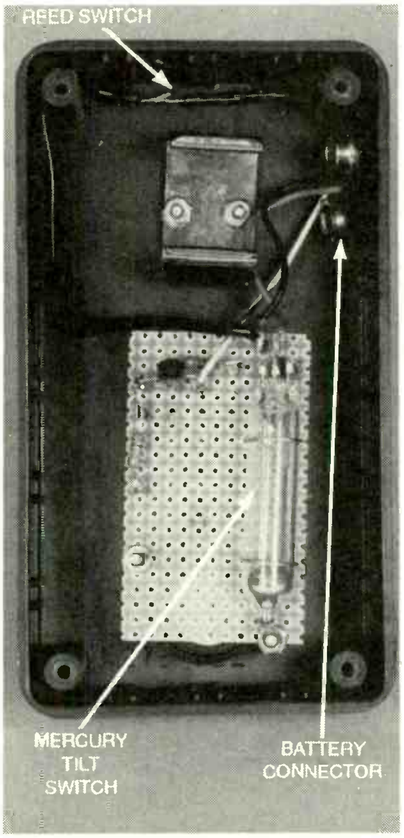
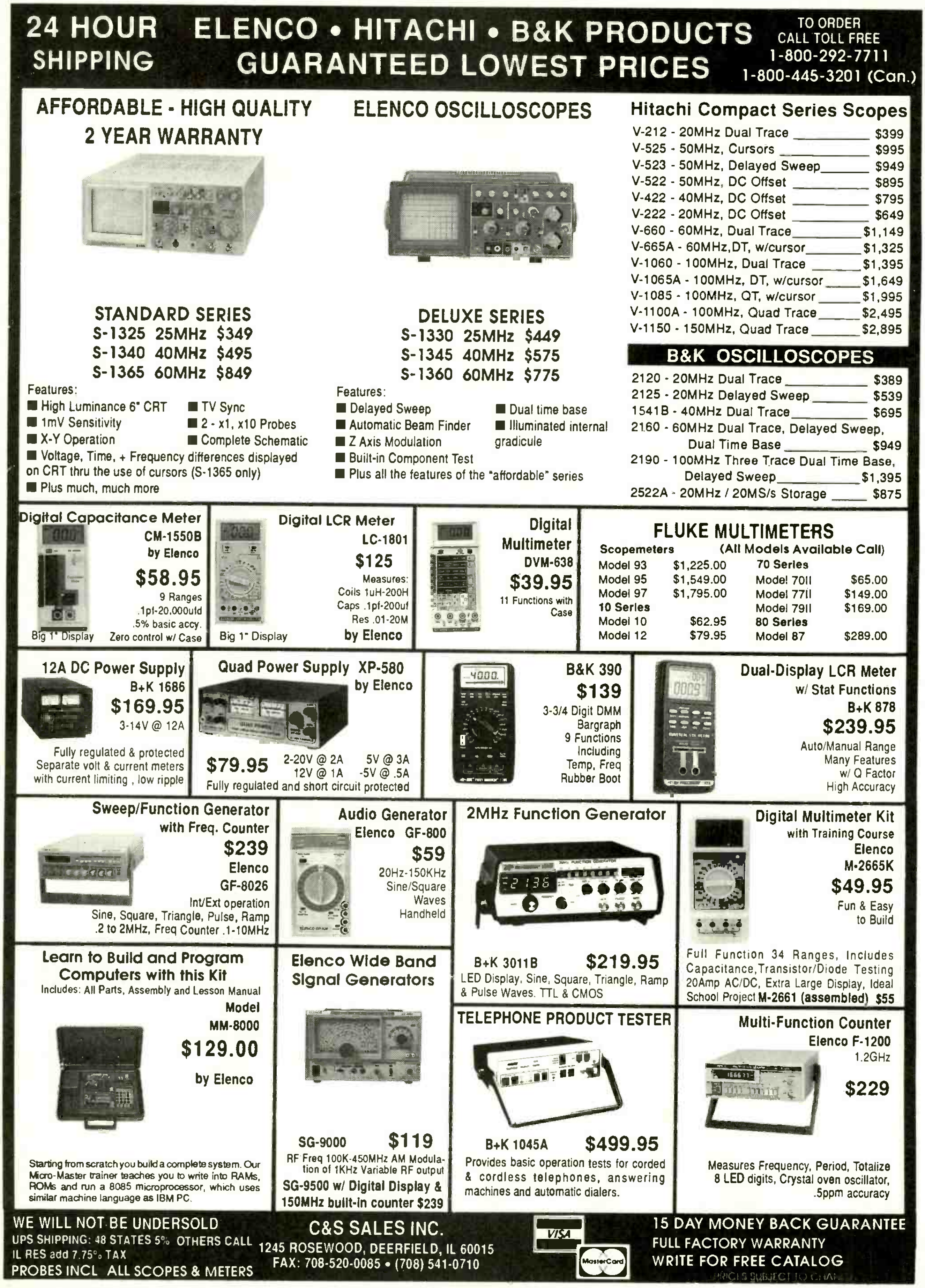
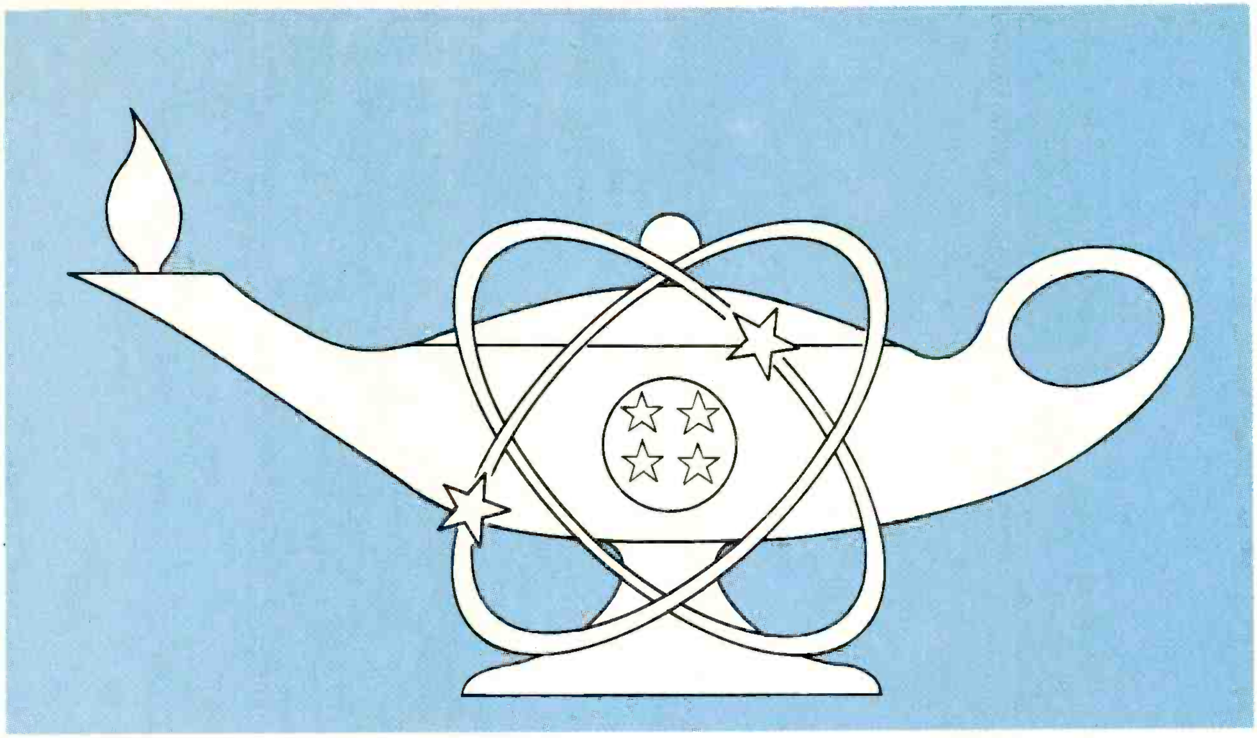


FIG. 2—THE SCREAMER CIRCUIT and a 9-volt battery fit inside a small plastic case.

Continued on page 82



CIRCLE 109 ON FREE INFORMATION CARD



NATIONAL ELECTRONICS TECHNICIANS DAY

International Electronics Technician's Day is the right time to join the ranks of the Certified Service Professionals

ELECTRONICS IS EXPANDING INTO all walks of human activity at a near explosive rate—nobody is immune to its influence. You need only look at the latest innovations in banking, business, communications, entertainment, finance, industry, medicine, military systems, and transportation. Leading the way are products and systems that include microprocessors or microcontrollers.

The personal computer has recently become a consumer "appliance," and increasingly powerful versions of the PC have been shrunk to notebook size. Planning is underway for the so-called electronic highway that will connect you to a vast national network and give you the benefits of interactive communications: You'll be entertained, or be able to make calls, go shopping, do your banking, and even attend classes without leaving the comfort of home.

"Intelligent"processors are now embedded in many of the products your encounter and use in everyday life—autos, cameras, diswashers, refrigerators, telephones, and TVs—to mention but a few.

The worldwide demand for electronics products and the rising complexity of products and systems has increased the demand for professionals trained in developing, integrating, maintaining and repairing this vast plethora of high-tech hardware.

Expert electronics technicians participate in the development, prototyping, and testing of new products. They also integrate and maintain all kinds of electronics systems and networks. And they are the people you call when today's generally reliable electronics products malfunction or fail. Their years of professional training and experience permit them to make needed repairs in a timely and economical manner.

In recognition of the skilled electronics technicians of the world, the International Society of Certified Electronics Technicians (ISCET) has proclaimed April 5, 1994 as International Electronics Technicians Day. That date assumes special

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meaning this year because, for the first time, ISCET examiners have been granted the privilege of administering commercial license examinations for the Federal Communications Commission (FCC). This will make it more convenient for candidates to take those exams because many more test locations will be available.

The administration of FCC examinations supplements ISCET's long-held role as examiners for its Certified Electronics Technician (CET) and Certified Appliance Technician (CAT) programs.

"ISCET's ability to certify commercial radio operators for the FCC is an important step forward for ISCET," declared ISCET Chairman Larry Steckler CET/EHF. "ISCET's professional certification of electronics technicians has been recognized internationally for more than 28 years; possession of ISCET certification indicates that the holder has met the highest professional performance standards," he added.

"By actively participating in FCC testing and including it in its activities, ISCET has once again demonstrated its leadership role and responsibility in the electronics industry," Mr. Steckler asserted.

National Testing Day

In addition to its designation as International Electronics Technicians Day, April 5, 1994, has also been designated as International Testing Day for the certification of electronics and appliance technicians. A large number of volunteer ISCET test administrators will encourage non-certified technicians to demonstrate their technical expertise on "T-Day." They are urged to take one or more of the many different professional exams being offered by ISCET.

So far, more than 150 ISCET Certification Test Administrators have volunteered to serve on Electronics Technicians Day. They will offer CET, CAT, and FCC testing from April 2 through April 9. A complete list of test sites (including **Electronics Now's** editorial offices in Farmingdale, NY) are presented above.

FCC exams

The two FCC examinations now available through ISCET are Element 1, *Basic Radio Law and Operating practice* and Element 3, *Electronic Fundamentals and Techniques Re-*

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quired to Adjust, Repair, and Maintain Radio Transmitters and Receivers. By passing both of those tests, the candidate will qualify for an FCC General Radiotelephone License.

Other FCC license exams will be made available from ISCET this year. As question "pools" for other elements are released to the Commercial Operator License Managers, ISCET test administrators will also be able to offer them. Included on the list of exams that ISCET is expected to be able to administer to applicants are:

- Elements 1 and 2 or 3 and 4, Telegraphy exam for receiving Morse code
- Element 5, Radiotelegraph-operating practices
- Element 6, Advanced radiotelegraph, technical, and legal
- Elements 7 and 9, Global Maritime Distress and Safety Systems (GMDSS) operating practices and radio maintenance
- Element 8, Ship-radar endorsement.

Those examinations are being developed in collaboration with FCC's Private Radio Bureau, Aviation and Marine Branch. George Dillon, Chief of the Branch, reports that the question pools for all of the exams should be available to the general public before the end of May, 1994.

The FCC released its first question pool to examiners on September 6, 1993. The first technician to be FCC certified by ISCET on September 16, 1993 was Antonio C. Gomez of Santa Isabel, Puerto Rico. Mr. Gomez received the first certificate serial number of I-93-000001.

In the beginning

ISCET was founded in 1970 by a committee of Certified Electronics Technicians. Their main purpose was to foster respect and recognition for their profession. By maintaining the rigorous standards of its certification program, ISCET can identify and recognize highly skilled and knowledgeable technicians. Membership is open only to those technicians who have passed the Journeyman CET exam, the CAT exam, or the Associate CET exam.

In addition to receiving regular newsletters and magazines, members are informed about ISCET-sponsored conventions and technical-training seminars. Members also receive frequent updates on new technology, an annual directory of industry information, and many other technical benefits available only members. At the annual National Professional Electronics Convention (NPEC), technicians receive the latest in advanced-technology training from knowledgeable, expert instructors.

The members are also invited to attend the annual ISCET convention and membership meetings. During NPEC, some members are selected to participate in ISCET's Product Serviceability Program.

ISCET's main function is the direction and administration of the CET program, developed to measure the theoretical knowledge and technical proficiency of practicing technicians. Responsible industry executives recognize a technician with CET certification as one who possesses professional training, experience, and competence in his specialty area.

Since its creation in 1965 by the National Electronic Association, the CET program has been widely recognized by technicians, Government agencies, manufacturers, and consumers. Many electronics companies encourage their technicians to qualify for ISCET certification—and some even require it! More than 35,000 technicians have proven their ability by earning the coveted ISCET certification.

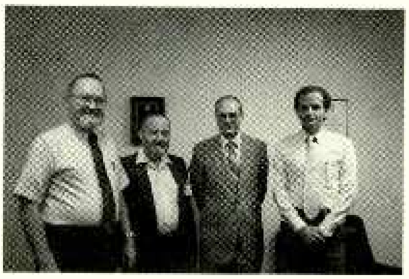
The CET exam

To become fully certified by ISCET, a technician must have at least four years of formal electronics training and experience, In addition, he or she must pass both a 75-question Associate and a 75-question Journeyman test. The passing grade for each of the multiple-choice exams is 75%.

The Associate examination covers basic electronics fundamentals, and each Journeyman option covers a specialized field of electronics technology.

An electronics technician or student with less than four years of experience may apply for Associate-level certification. The basic subjects on which the candidate will be examined include: Electronics Math, DC and AC Circuits, Transistors and Semiconductors, Electronic Components, Instruments, Tests and Measurements, and Troubleshooting.

The Associate exam is usually more challenging for the technician candidate than the specialty exam because it requires a broad knowledge of electronics plus the ability to analyze and troubleshoot circuit problems. Of the technicians who take this exam, about one-third pass on their first try.



LARRY STECKLER CET/EHF, ISCET Chairman and the Publisher and Editor-in-Chief of *Electronics Now* (second from left) with FCC officials at FCC's Licensing Bureau in Gettysburg, PA. From left, Gary Stanford, Steckler, Larry Weikert, and W. Reilly Hollingsworth.

CERTIFIED ELECTRONICS technicians William Warren, Donald Cressin, and Freeman Douglas, diligently take notes during a serviceability inspection at an ISCET conference.

Individual Journeyman exams focus on many different electronic specialties. The present set includes:

- Audio—The questions cover amplifiers and sound quality, system integration, speaker installation, servicing audio products, and troubleshooting audio systems. The exam includes questions on both digital and analog audio.
- Communications—The questions address communications circuits and transmission systems, AM and FM transmitters and their adjustment, receiver adjustment, and the servicing and troubleshooting of systems.
- Computers—The questions cover binary mathematics, logic gates, the basics of digital electronics and computers, local, area network organization, input and output peripherals, memory, elementary programming, and the troubleshooting of computer systems.
- Consumer—The questions cover both digital and analog circuits in consumer electronics products. There are, for example, specific questions on the troubleshooting and servicing of televisions and VCRs, and the operation of applicable service test instruments.
- Industrial—The questions cover DC and AC power supplies, transducers, sensors, switches, differential amplifiers, logic circuits, analog and digital circuitry, microprocessors and computer systems, and circuit analysis and troubleshooting of industrial electronic systems.
- Medical—The questions cover the principles of electrical safety, basic circuitry, the operation of electronic test instruments, telemetry, and the calibration of typical biomedical instrumentation.
- Radar—The questions cover both pulse and continuous-wave radar operation, radar transmitters and receivers, CRT display systems, radar power supplies, antennas, and the principles of transmission lines.
- Video—The questions cover the basics of video, knowledge of NTSC standards, test signal generation, the principals of video tape recording, VCR tape-drive mechanisms, camcorders, TV cameras and monitors, and the microprocessor as it applies to video.

The CAT exam

CAT testing is only one year old. "It opens a whole new field for the trained and certified technicians," says Mr. Steckler. "Have you closely examined modern appliances lately?" he asks. "Whether it's a microwave oven, washing machine, dishwasher, or air conditioner, it's likely to include electronic circuits—perhaps even a microcontroller," he commented.

"The appliance service technicians who service this equipment must learn about electronics as well as learning how to make the electrical and mechanical repairs they have traditionally made," Mr. Steckler said.

The new Certified Appliance Technician examination is independent of the CET Associate or Journeyman certifications. However, four years of practical, hands-on experience are also required, just as they are for the Journeyman CET option. The successful CAT receives a certificate that can be proudly displayed on the wall of his or her service center.

The CET examination consists of 100 multiple-choice questions on such subjects as electrical circuits and components, basic electronics, and the operating principles and repair practices for appliances such as refrigerators, ranges, ovens, diswashers, and trash compactors. Appliance technicians who pass the CAT are eligible to join ISCET.

Exam fees

The fee for the CET exam is $25. This includes both the Associate exam and one Journeyman option. However, if the Journeyman option is taken separately from the Associate exam, the fee for each exam is $25. Also, the fee for each additional Journeyman option is $25. The fee for the 100-question CAT exam is also $25. If a candidate fails any of these exams, the first retake is free, following a 60-day waiting period.

There are different examination fees for the FCC exams, but the minimum fee is $25 for one session. The fee for Element 1 is $25, and the fee for Element 3 is $30. However, if the two examinations for the General Radiotelephone Operator's License are taken in a single session, the fee is only $35.

There will be other combinations of elements and fees for the examinations that are not yet available. A complete list of those fees is available from the ISCET office, at the address given at the end of this column. Unfortunately, there is no provision for free retakes of the FCC exams.

Preparing for an exam

The best way to prepare for any of these exams is to study the available background subject material. ISCET offers excellent, inexpensive study materials that will help all candidates prepare for each of its exams. If you are at the entry level, the Study Guide for the Associate CET Test will give you an excellent review for this first test. The 96-page booklet is priced at $10. In addition, ISCET offers practice tests for most of the Journeyman options as well as excellent review texts on each of those options.

The FCC examinations are assembled from questions in the published question pool. By making the complete question pool available, the FCC has defined the limits of the basic knowledge that it expects each successful candidate to have. The availability of the pool also assures all persons taking the test that there will be no nasty surprises. ISCET is offering copies of the question pools for Element 1 and Element 3 for $10 plus $2 for shipping and handling costs. In addition, self-test computer software packages are available. Not surprisingly, being well prepared for all examinations will make the difference between passing and failing!

If, after reading this, you decide that you would like to take the CET, CAT, or any of the FCC exams, contact one of ISCET's volunteer test administrators listed in this article for details. As stated earlier, the exams are scheduled for the week of April 2 through April 9, 1994. For additional information, or to obtain an order form listing all of the available guidance and help materials, contact ISCET directly at 2708 West Berry St., Fort Worth, TX 76109; Tel. 817-921-9101, FAX 817-921-3741. Ω

LETTERS

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the R4-C12 network at pin 15 of IC4, a 74HC161 (sync 4-bit binary counter, async reset). Other readers might be less amused, however, because that network represents an attempt to patch a fundamental shortcoming. I should know—I learned about it the hard way!

Pin 15 on the 74HC161 is an *asynchronous* output, which means that it takes more time than the other (synchronous) outputs to reach the specified logic state after clocking. It's not possible to cascade 74CH161s as shown without getting nasty glitches in the output.

The size of the glitches will depend on the manufacturer of the IC in each socket, and it's unlikely that the R4-C12 network could effectively suppress the glitches in every circuit.

Because this circuit will fail to work correctly if a glitch sneaks through, your readers should know that IC selection might be required. I controlled the problem in my company's Voice Scrambler kits with clock delay and careful IC selection.

Eventually we developed a fully synchronous, digital subsystem for full-duplex scramblers as a single device. It has the added benefit of scramble/clear mode switching on a single pin. We at Decade Engineering will provide further details on this device (SCRAM3), if requested. We will also sell and ship small quantities of the device to individual purchasers.

MICHAEL A. HARDWICK
DECADE ENGINEERING
2305 5th St. NE
Salem, OR 97303-6832 Ω

We wear these, and I figure we can run the house on static electricity.

SATELLITE TV

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have no access to cable TV. Although the service doesn't offer any truly new programming to consumers, Thomson is confident that it can also attract some of the 20 to 30 million homes that have access to cable but don't subscribe. Of course, there is also a potentially huge market of subscribers who, for one reason or another, are simply dissatisfied with their cable companies.

The expected break-even point for both Hughes and USSB, the two companies that invested in the satellite, is only about 3% of all households or 3 million subscribers. A DirecTv spokesman, stressing the system's value, flexibility, and performance, said, "We'd be very happy with 10% penetration over the next half dozen years. We think we're going to get that if our market research is anywhere near correct."

Thomson stresses that even those homeowners who don't subscribe to cable—although they have access to it—do rent video tapes, often on a daily basis. Pay-per-view programming, of course, eliminates the need to travel to a video rental store.

The DSS system claims quality advantages over conventional TV program distribution. At a demonstration attended by **Electronics Now**, the picture—sent digitally via a traditional satellite and decoded by a DSS receiver—approached laserdisc quality. Only large-dish satellite systems and videodiscs can offer similar quality. DSS also has a larger channel capacity than any existing cable system, and the pricing packages announced so far are less expensive than similar cable packages.

Some analysts point out that DSS could be superseded by the so-called information superhighway and its interactive systems. DSS is, however, here now. The consumers' appetite for programming has been proven by cable (66% penetration) and by video rentals (about $3.8 billion industry in 1992). Whether consumers want to interact with their TVs is still open to debate.

Another possible shortcoming for the system is that a consumer who wants to receive digital satellite programming must invest at least $700. However, project spokespersons point out that $700 is a small fraction of the cost of a new, large-screen TV—which requires the highest quality signals.

At this time, only one thing is certain. Consumers now have an additional source for video entertainment. Ω

APRIL FOOL

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Construction

First select the components you will use. Any buzzer that can be driven from a 9-volt battery will work. Be sure the buzzer is capable of making a sound loud enough to be startling. The buzzer must be small enough to fit inside the case you selected along with the 9-volt battery.

IT'S A SIMPLE ENOUGH WARNING. But many an April Fool can't resist.

Mount the mercury switch in a slightly tilted position so that when the box is lying flat on a table (waiting for a hapless victim), it is not enabled. The mercury switch can be fastened in place with a hot-melt glue gun. Glue the reed switch to an inside surface of the case so that the field of a magnet placed on the outside of the case will close it. The reset magnet, if small enough, can be fastened to the palm side of a low-priced ring to make it as inconspicuous as possible. Figure 2 shows the inside of the author's prototype. Ω

EQUIPMENT REPORTS

continued from page 16

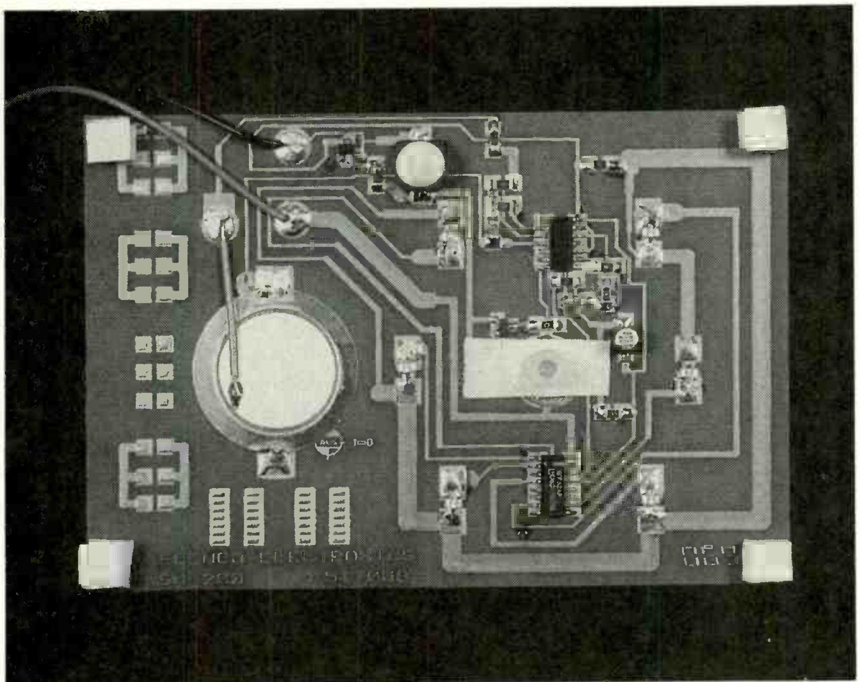
perature is satisfactory.

Chip capacitors and resistors are tiny rectangular components about 2 millimeters long with a tinned metal surface on each end. The chip rests on the board and the metallized ends are soldered to matching foil pads below them. The chip capacitors (two in all) are too small to have value labels. They are individually packaged and labeled and must be identified from the package. However, the chip-resistor values are actually easier to read than on their color-coded cousins, at least for people who can read the small numbers written on them. Interpreting color-coding takes more time than reading numbers. The first two numbers on a chip resistor indicate the first and second digits in its value, and the third number indicates the number of zeros that follow. So to find all the 470-ohm resistors, all you have to do is pick out all the chips labeled "471." Handling chip components is another story, however—tweezers are required, and if you sneeze, you could easily loose them to the carpet.

SMT transistors, diodes, and LEDs all have three pins, whether they're needed or not. They're about the same size as chip resistors with two leads on one long side and one on the other. They're also no more difficult to handle than the resistors and capacitors. Chip ICs, on the other hand, are very difficult to solder. The leads are spaced less than a millimeter apart, and it's very easy to create solder bridges between them.

The finished board must be tested before attaching the red plastic lens. All this involves is shorting two PC pads with the switch contact. The switch is just a curved piece of metal that rests on an outer trace while it spans an inner trace. Finger pressure snaps the center of the metal span down onto the center trace, completing the circuit. If the soldering work was done correctly and a battery is snapped into the connector, the Decision Maker should come to life. The lens is mounted over the board with thick double-sided foam tape; a plastic spacer is positioned between it and the switch. Squeezing the unit turns it on.

The SM-200K Decision Maker kit will give you valuable SMT experience and it is a great toy either for the builder or some kid he knows. The experience gained from the kit is worth more than its $21.50 price Ω



WITH CAREFUL HANDS and the right tools, soldering SMT components is easy.

continued from page 6

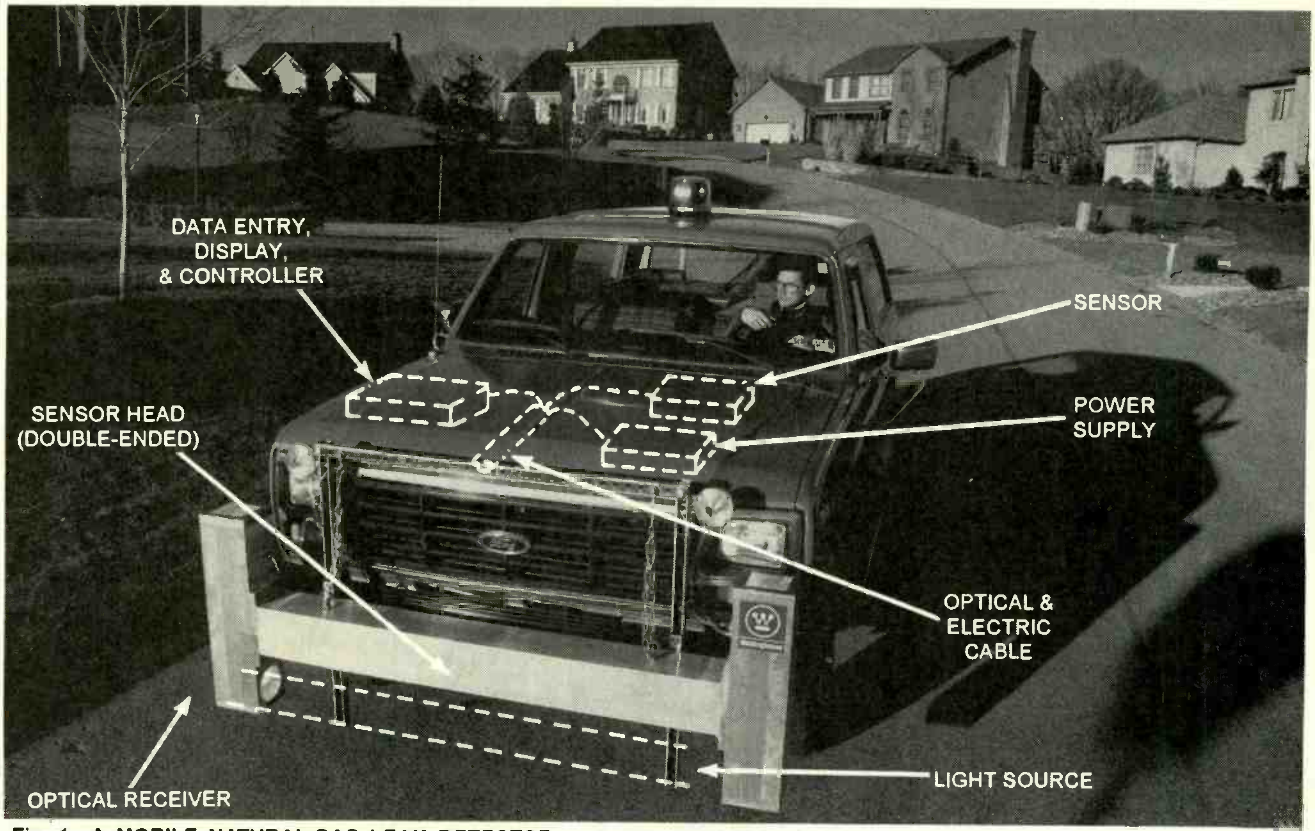


Fig. 1—A MOBILE NATURAL-GAS LEAK DETECTOR system developed by Westinghouse detects leaks up to ten times faster than existing systems. Its detector is an electro-optic crystal filter.

lets. In effect, the detector "sniffs" the air samples for escaping natural gas.

Leaks show up as an gauge indications accompanied by an audible alarm. However, the relatively slow response of this older detector limits the miles of pipeline that can be reliably inspected daily.

Westinghouse has replaced the sniffer with an optical-beam absorption sensor. It detects methane, the primary component of natural gas, in concentrations as small as one part per million. It can make 1000 measurements per second, permitting the survey vehicle to move faster along the pipeline. An on-board computer records and stores a continuous profile of gas concentrations as the vehicle moves along a gas pipeline. The record permits pinpointing the exact locations of gas concentrations that might exceed the specified safety level along the route.

Radio Shack opens in Moscow

Russians can now buy consumer electronics products and components in a Radio Shack store recently opened in Moscow. Shopping there will be a new experience for most Russian electronics hobbyists because the new store is set up the same way as American stores.

The new Radio Shack has fully stocked racks of merchandise in the middle of the store that permit customers to pick up and examine the goods before they buy them—a simple enough concept, at least in the United States.

This setup contrasts sharply with that of most Russian retail stores: usually only a limited supply of goods is displayed on shelves or in glass cases. Customers must first wait in line to select what they want—often without being able to touch or examine the goods; then they must wait in another line to pay for the goods and get a receipt that permits them to claim their purchases from another area.

The Radio Shack store in Moscow, which opened last December, is the result of a franchise agreement between Tandy Corporation (Fort Worth, TX) and the Florida-based Trident Group, which supplies such things as computers and accessories in 30 cities of the former Soviet Union.

Radio Shack's store, located on Moscow's Lensinsky Prospect, carries a full line of consumer-electronic products, most of which are also shipped from Ft. Worth. The store, is staffed by Russians and managed by Trident A/O, the Russian branch of The Trident Group. Ashley Worth, Trident Group vice president, said the Moscow store is the first of several Radio Shack stores to be opened in Russia in the future. Ω

HARDWARE HACKER

Useful auction magazines, a classic oscilloscope book, new cogeneration resources, and the fundamentals of SCSI communication.

DON LANCASTER

I finally got a closer look at a new book by Stan Griffiths entitled *Oscilloscopes: Selecting and Restoring a Classic*. It is a well written guidebook that lists all the older tube-type *Tektronix* scopes, their current prices, hidden gotchas, and overall desirability. It's a "must have" at $19.95.

Because used *Tektronix* scopes can be purchased for as little as $50, there is no reason why *every* hardware hacker shouldn't own at least two. Safest bets of the golden oldies: a plain 515A or a fancy 545B with a CA plug-in.

Fundamentals of SCSI

There is a lot of hacker interest in SCSI devices these days, so I guess it's time for a review. SCSI stands for a *Small Computer System Interface*, and it's detailed in document ANSI X3.131-1986, available from the *American National Standards Institute*. I'll concentrate on the specification for single-ended devices here.

SCSI allows up to eight devices to send 8-bit parallel data to each other on an asynchronous information swap. Although any number of the devices could be hosts, the usual setup is to have only one host that is served by up to seven peripheral devices. For example, the host computer might use an internal hard disk, an external hard disk, a CD ROM drive, and a laser printer.

Figure 1 shows how a SCSI bus is usually arranged: up to eight devices are connected together with 50-wire cables. All of the devices are daisy chained together. Note that only the "open" daisy chain arrangement is permitted.

Cable length can be up to a maximum of 20 feet, but *all devices must* be plugged into the same grounded AC outlet. Data rates to 4 megabytes per second are permitted. Because the data is in parallel, that rate is equal to a serial data rate of about 40 megabaud. Thus SCSI is potentially *much* faster than most of the popular computer networking schemes.

It's very difficult to move high-speed data around. Therefore, to prevent any noise or line reflections, all SCSI cables *must* be shielded and properly terminated. For short internal runs, conventional ribbon cable, with every second wire grounded, is acceptable. For longer external runs, special shielded SCSI cables are required. One good source for these is *Redmond Cable*.

Each end of the SCSI cable must be properly terminated to minimize standing waves and reflections. The rules are: *Always terminate both ends of a SCSI cable string. Never leave any extra terminators in the middle of any SCSI string.*

Figure 2 shows two methods for terminating a SCSI line. The intended cable impedance is 132 ohms, but 100-ohm cables will usually work satisfactorily. For a *passive* termination, insert a 220-ohm resistor to +5 volts DC, and a 330-ohm resistor to ground. Do that for each data and control line.

But note that one side effect is that each of the 18 lines has the equivalent of *two* 550-ohm resistors going from +5 volts to ground. Each continuously draws about 45 milliwatts for a total of nearly 2 watts, making it unsuitable for low-power applications.

Active termination is more common these days. In active termination, each line is terminated with a single 132-ohm resistor that is returned to a regulated 3-volt source. Because all SCSI lines are either three-state or open-collector, and because most of them do nothing most of the time, an active termination uses less power.

Several clever new dynamic switching schemes play intentional tricks with terminations to reduce further the power and improve data integrity.

Pin connections for a SCSI connector are shown in Fig. 3. Originally these were obtained with an unshielded dual-row header for internal use, or a special shielded and locking external connector. The internal connector is a plain 2 × 25-pin arrangement with the pins on the usual 100-mil centers.

Because the external connectors are so bulky, there are some latter-day variations. One is based on the plain DB-25 connector. I believe this alternative is incredibly dumb because of the possibilities for causing damage by confusing them with serial communication ports. *Apple* has switched to a small 30-pin rectangular connector, which is used on its *LaserWriter* Pro 630 and newer MacIntosh computers.

You'll find four kinds of connector lines. First, there are a lot of ground connections. These greatly simplify the shielding, especially on ribbon cables. Second, there is a TERMPWR lead that sends a protected +5 volts for termination power. Diodes normally prevent several devices from fighting each other on TERMPWR. Third, there are eight data lines

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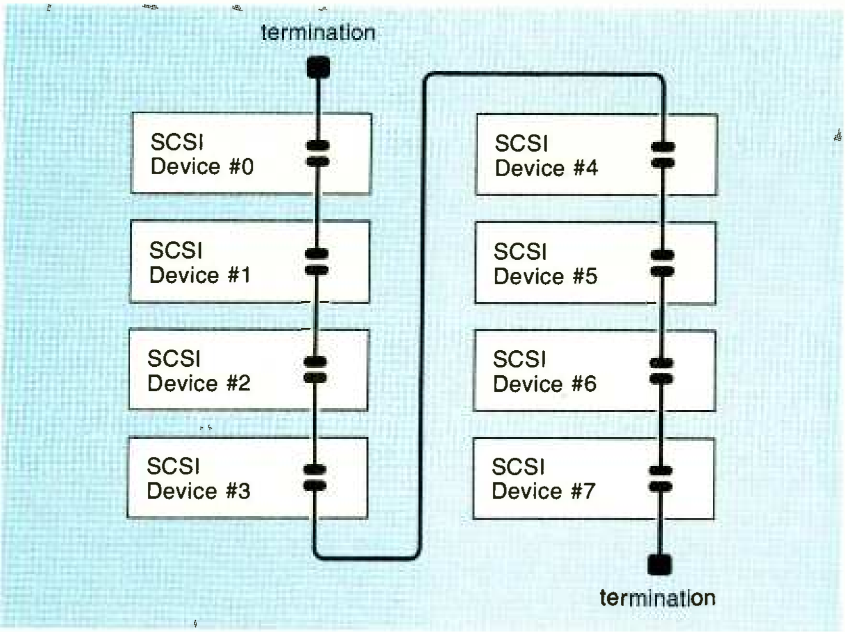

FIG. 1—SCSI COMMUNICATION allows up to eight devices to talk to each other at high speeds over short distances. The only connection scheme allowed is this open-ended daisy chain. Both ends of the chain must be terminated.

DB0 through DB7. Data is exchanged as parallel bytes over these three-state lines. There is also a ninth parity line, but it's rarely used.

Finally, there are nine control lines that are either three-state or have open-collector drivers. These include BSY for any bus access, SEL to select the device, C/D that determines whether the information being sent is control or data, or MSG when a message is being delivered.

The REQ line requests access, and ACK grants it. ATN is a start up call, and RST clears previous actions.

These lines are all detailed in the SCSI specification. They interact with each other to request, verify, and then send data between devices. The devices all take turns, with only one allowed bus access at any given time.

There is a carefully defined command order. Most of the time, the SCSI bus should just sit there and do nothing. The action always starts with *arbitration* and *selection* cycles. Then a string of *command* bytes is sent that sets up the size and action of a read or a write. Next are the data bytes, which are usually transferred in blocks, often of 1024 bytes. The access ends with the *status* and *completion* bus phases.

Each SCSI device has a unique ID number 0–7 associated to it. These match a high state on the equivalent data line. The ID numbers appear on the bus during *arbitration* or *selection*.

A very important rule: *Each SCSI device must* have a unique ID. Device no. 0 has highest priority. The convention is to give the main host an ID of 0 and the internal hard drive an ID of 7. Printers, CD readers, or other peripheral devices might be given mid-range values. Most of the SCSI peripherals have switches or jumpers that let you pick any ID you want. On the other hand, it can be extremely difficult to set a non-zero host ID.

Once again, no duplicate IDs are allowed, and the *lowest* ID always gets first recognition.

The SCSI specification describes in detail the actions that must take place during each data transfer stage.

Multiple-host SCSI?

There are many unexplored new SCSI hacking possibilities. One is to devise a simple and cheap manual A-B switch for SCSI. Believe it or not, commercial units sell for as much as $2200.

Hint: The key chips you'll need are available from *Pioneer*, especially the PIC3383. I will have more on this in a future column.

There is another opportunity in building an even simpler SCSI ID *changer*. It should permit any SCSI device to look like number 6 from one end and number 7 from the other. Or number 0 versus number 1. This could be a key component

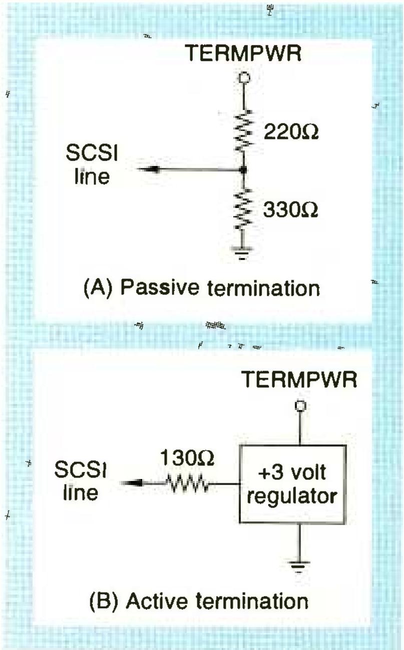

FIG. 2—BOTH ENDS of each SCSI line must be properly terminated.

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Amlan Inc
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Westport, CT 06881
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Redmond, WA 98052
(206) 882-2009

Virtual Reality World
11 Ferry Lane West
Westport, CT 06880
(203) 226-6967

US Government Information
(800) 359-3997

workaround if two systems insist on keeping their hosts as number 0.

Yet another project is to build a plain SCSI data input that looks like a computer's parallel data port. This lets you send low-level commands to outside devices from inside the SCSI environment. The real value here, of course, is that this lets you use PostScript on any homebrew CAD/CAM, PC drill, Santa Claus machine, or whatever.

Figure 4 shows how *shared SCSI communication* works. Here, a host and a PostScript printer can share one drive. Such tasks as Book-on-demand publishing run much faster, as most communication times are eliminated. And the little remaining communication that's still needed occurs at serial-equivalent speeds as high as 40 megabaud. But you do have to get clever.

The SCSI specification permits multiple hosts so that more than one computer can share a hard drive or other peripheral. You could even have *eight* hosts with exciting possibilities. But there are also some nasty catches.

Very bad things will happen if someone loads a file, somebody else changes it, and the first person then resaves the old file. These problems generally call for *adjudication*.

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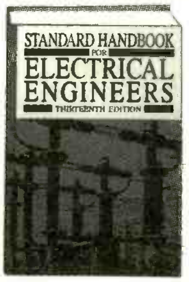

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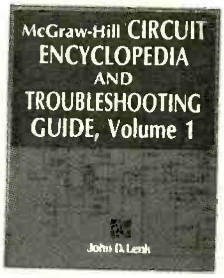

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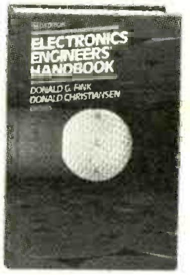

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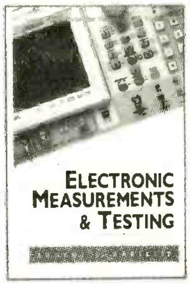

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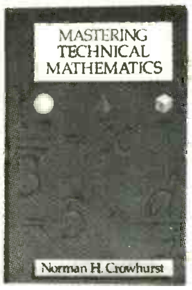

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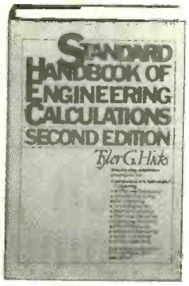

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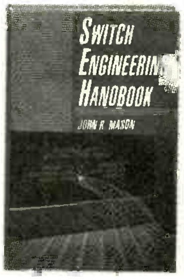

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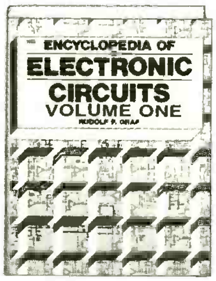

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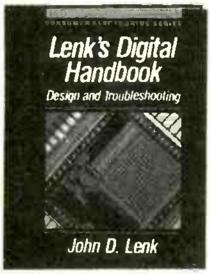

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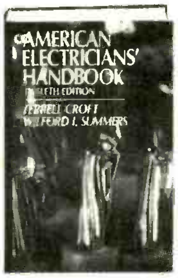

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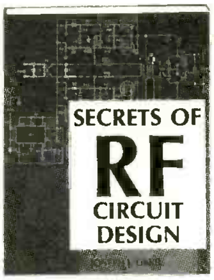

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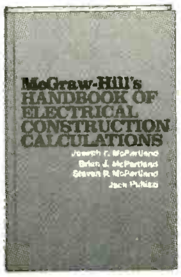

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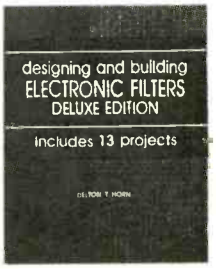

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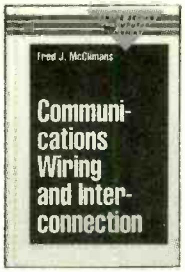

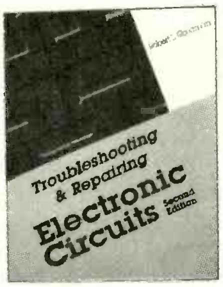

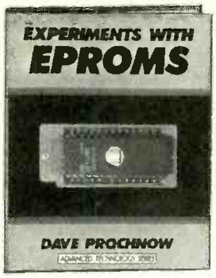

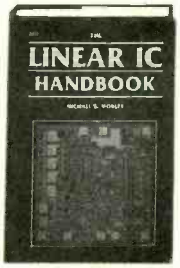

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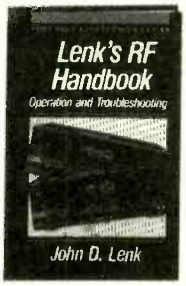

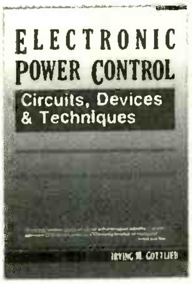

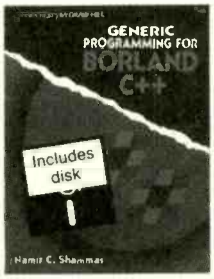

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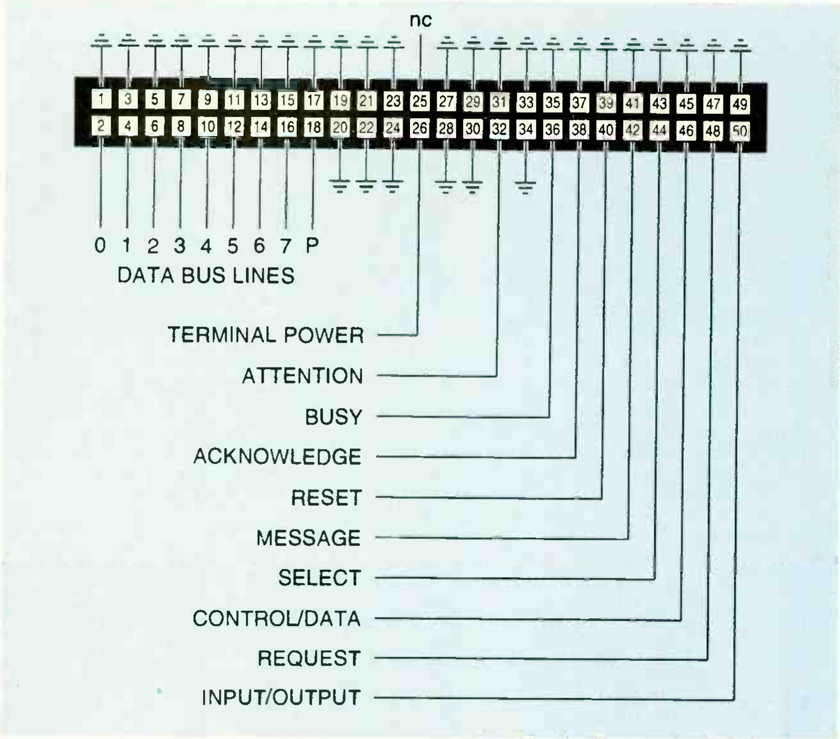

FIG. 3—PINOUTS FOR A SCSI CONNECTOR. The unshielded internal connector is shown here. External 50-pin connector numbering is the same.

Most SCSI systems start out with a *bus arbitration* phase that prevents outright conflicts between two hosts which try to grab market share at the same time. From the start *be sure that both of the hosts include the SCSI bus arbitration timing cycle*.

It does not specify the *arrangement* or the *partitioning* of the data tracks. This means that *all the host SCSI devices normally must* share the same operating system.

A third problem is that most SCSI hosts assume that they are the only hosts. Instead of checking the catalog and directory tracks of the drive for each access, they simply keep a copy of these tracks in their *host* memories. Now, if another host rewrites the files, the first host will certainly become confused because its internal disk directory copy will now be totally wrong.

One way to get around this is to make sure that you always *mount* and *unmount* drives so that any one of the drives is "known" by only one host at any time. As an example, PostScript has its *devmount* and *devdismount* procedures.

There is another route that I've been using to let both an Apple IIe and a MacIntosh write to the *internal* hard disk on my LaserWriter. You could even use this technique to let an IBM and MacIntosh share a common hard disk.

Pick your "main" operating system. In the case of any PostScript printer, this would be the internal PostScript firmware. So, immediately after you initialize your disk, you should very carefully define several *dummy files* of *fixed size and position*. You can then let your "alien" host use *only* its low-level SCSI *read and write to track and sector* commands to "force feed" data into the file.

This gets complicated very fast, but it definitely works. Let me know your thoughts on new hacker SCSI applications.

Cogeneration resources

Cogeneration is the production of electricity as a by-product of another activity. If the other activity accepts most of the cost, the cost

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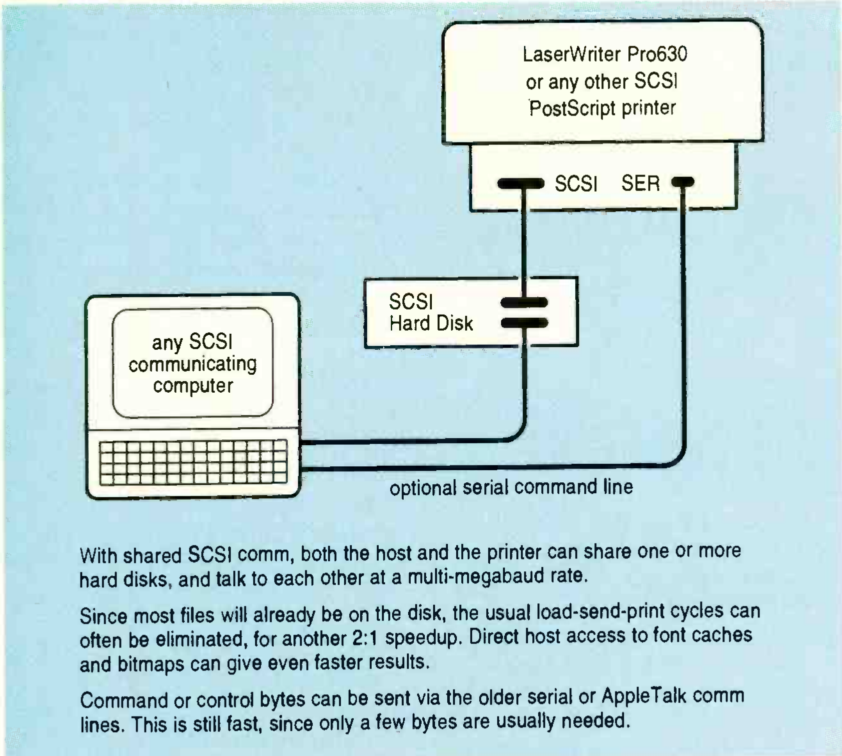

FIG. 4—SHARED SCSI COMMUNICATION can dramatically speed up most PostScript laser printing times. But adjudication details must be carefully worked out.

of electricity can end up surprisingly low.

For example, if chemical plants or hospitals need a lot of steam they might as well generate most or all of their own electricity while they are at it. Or, if you have a solar water-heater panel, it makes economic sense to use the waste energy for space heating.

A new *Micro-Cogeneration* book from Kirk McLoren of *Independent Power* includes some economic analysis to arrive at an astounding conclusion: With cogeneration, it can be far *cheaper* to generate electricity than to buy it from the power company—especially, if you are half a mile from any power line, have a reasonable home and lifestyle, use a diesel generator, and don't pay road tax on the diesel fuel. It's even better if you can obtain the free (but slightly contaminated) diesel fuel that is sometimes available at local airports.

The analysis inludes the utility's line-extension costs and the required minimum-purchase guarantees. It also includes making your generator more efficient by using the waste energy for heating.

For this month's resource sidebar, I thought I'd gather together important places you can go for more information on cogeneration, both for homebrew and industrial-strength needs.

In addition to Kirk's book, be sure to check out *Home Power* magazine. Lots of technical papers and videos are available through EPRI. And, of course, for the latest in any technical field, you can use the *Dialog Information Service*, available either by way of *GEnie* or your local library.

World Cogeneration is a free trade journal for commercial and industrial applications of cogeneration. Most of the other resources listed are trade journals or scholarly publications.

"Sumpthun' Else" contest

One thing I like to do is take some product and see just how it can be misapplied for wildly different purposes. An outfit called *Amlan* offers a mini-wire channel product by the roll. It costs about a dollar a foot and is intended to protect communication, alarm, and low-voltage wiring.

The channel is made from an attractive white vinyl and consists of a bottom half that folds up into a "U" shape, and a snap-on cap. The size is either a ⅝-inch square or a ⅝- ×

1-inch rectangle. It's even predrilled.

Now for the neat part: If you cut this material up into smaller pieces, you end up with very nice 30-cent cases for handheld projects. Perhaps a laser pointer, remote control, logic probe, bug detector, dog trainer, or signal injector. Free samples are offered by the manufacturer.

Have you taken a close look at toilet-refilling technology lately? A new version uses a snap-action differential water-pressure sensor. It cheaply and reliably replaces older float-type switches.

Well, what we really have here is a differential pressure sensor that can respond to a pressure difference of *a fraction of an inch of water*. Last time I checked, that's a sensitivity around 0.01 pounds per square inch.

There simply *has* to be unthought-of hacker and robotics uses for these sensors, especially for liquids other than water—possibly even for air or other gases. Your first hack here might be to couple it to an electrical switch or sensor.

So, for our contest this month, just tell me about any product that can be applied to make something totally different than its intended use. We'll call this a *sumpthun' else* contest.

There will be a bunch of the usual *Incredible Secret Money Machine II* books going to the dozen best entries. An all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two will go to the very best of all.

As always, send all your *written* entries to me here at *Synergetics* and not to **Electronics Now** editorial.

Federal auctions

Ever since the days of the mythical $25 Jeep, there's been lots of hacker enthusiasm over buying government surplus—particularly older military or defense electronics.

To get on military surplus bidding lists, contact the *Defense Logistics Supply Agency*. You then pick your areas of interest and they will mail you auction notices. If you do not actually bid, you will have to renew every few months.

General government auctions are handled separately. Many are held through the regional *General Ser-*

vices Agency offices. For more details, you contact the GSA office in your nearest large city. I've listed the Denver office in this month's *Names & Numbers* sidebar. But the process is the same anywhere: You contact them, tell them your interests, and get on selected bidder's lists.

There are also auctions from other US government agencies, such as the DEA or the Post Office. You contact them directly for more information. As a reminder, there is a main US government information number up at (800) 359-3997.

There are now two magazines that list upcoming auctions. These can simplify your search for what is being auctioned. One of these is the *Federal Auction Locator*, while a second is *Auction Magazine*.

If you are just interested in plain old commercial surplus grunge, refer to the insider secret news magazine that the retail surplus dealers and the distress merchandisers all subscribe to. It is the *ASD/AMD Trade News*. These folks also put on mammoth and incredibly bizarre trade shows.

By the way, those WW II military surplus Jeeps were always cut in half before delivery. Except for being a tad oversize, they can make dandy bookends. But be sure to check your local zoning regulations first.

New tech lit

A possible major advance towards room-temperature superconductivity appeared in the December 17, 1993 issue of *Science*, pages 1850–1852. It appears a lot more credible than the previous false starts. Temperatures of 250 Kelvins are being bandied about—a balmy Minnesota winter day.

Softwars is a new book by Anthony Clapes that's published by *Quorum Books*. It is a fairly thorough rundown on the ongoing legal battles over software protection and intellectual property rights. While the author does hide his IBM lawyer bias fairly well, his blatant misuse of the term "hacker" is unconscionable. Still a good read, though.

Virtual Reality World is a brand new *Meckler Publishing* newsletter.

For something totally different, the *Nomadness Report* is published by Steve Roberts who is really big on his bicycle telecomputing, high-tech ocean kayaks, and *Internet* surfing. I've posted on-line sample copies of his reports to *GEnie* PSRT.

Etchtalk is a useful free company newsletter about glass etching from *Armour Products*. Interesting casting materials and technical information are available from *Castcraft*. *Comus* appears to be a good source for tilt switches and motion detectors. Information on mechanical cables for robotics and related products is offered by *CMA*.

Maxim has announced its new MAX038 function-generator chip that generates high-frequency triangular, sine, and square waveforms. This one looks like it is going to turn into one rather hot hacker chip. Response is beyond 20 MHz. I expect kits will be offered shortly.

If you are interested in any self-publishing, be sure to check out my *Book-on-demand Resource Kit*, per my nearby *Synergetics* ad.

I've also got a brand new catalog with a much larger insider secrets section. You can write, call, or E-mail me at [SYNERGETICS] on *GEnie* or SYNERGETICS at GENIE.GEIS.COM on the Internet for your free copy. Or download it directly as SYNCAT1.PS from *GEnie* PSRT.

As usual, most of the stuff mentioned appears in either our *Names & Numbers* or *Cogeneration* sidebars. Be sure to check those lists before calling our no-charge voice helpline. Ω

No! No! You're supposed to use the electronic gun!!!

AUDIO UPDATE

Collecting old audio

LARRY KLEIN

I've been wondering about my preoccupation with old equipment. I have a small accumulation of "antique" test instruments and technical books, and only self-restraint (and my wife) keeps me from adding tons of old audio components to my collection of obsolete electronics. I have no illusions about the measurement qualities of the test equipment, although the readings from my model 433 Weston AC voltmeter (circa the late 1930s) that I bought in a thrift shop for $5 are a close match to what I get from a Fluke 8050A. Yard sales and thrift shops are the main sources of the material that feeds my habit; I'm actually afraid to attend ham swap meets for fear I'll run amuck and end up pleading with strangers to "Please stop me before I buy any more."

I remember an Altec Lansing speaker system (circa 1955) that I picked up at auction for $25 in the early 60's. It had a 604C coaxial driver installed, and the speaker and cabinet combination originally sold for more than $300—a lot of bucks in 1955! The speaker worked but sounded terrible. Retuning, bracing, and damping the 10-cubic foot cabinet helped some, but aside from efficiency, it was no match in sound quality for my far smaller AR-3 system. As a result, my garage-sale speaker purchases have been limited to smallish, high-quality units that usually end up in the systems of friends and relatives.

A year ago, when browsing through a thrift shop, I came across a sample of the very first cassette recorder ever made—the Norelco Model 150. Of course, I had to buy it. Ditto for a Pilotuner dating back to the early 50's, a copy of my very first FM tuner. Then there's the Brook all-triode preamp, the Browning FM tuner, the Rek-O-Kut turntable with Audax tone arm and turnover cartridge, and more. Given all that as a background, I was very pleased to get a review copy of the Audio Engineering Society's videotape entitled "An Afternoon with Jack Mullin."

The Mullin Collection

Jack Mullin could accurately be called one of the pioneers in audio/video recording history. Not only that, but he also established a museum whose displays significantly predate his own audio involvement. For example, his museum houses a working replica of Edison's 1877 prototype cylinder phonograph. We are able to hear it, as well as many of the other machines in Mullin's collection, on the VHS tape.

Edison's commercial cylinder machines and Berliner's 1895 flat disc players—and subsequent models—all sounded quite tinny despite numerous advertisements to the contrary. Things didn't change significantly until about 1925, when Bell Telephone Laboratories and Western Electric got into the act.

Although the playback machines continued to be all acoustic for several years, the recording process became all-electric, or in modern parlance, electronic. Mullin shows the condenser microphone, amplifier, and electrical cutter developed by Bell Labs and photographs of the "before" and "after" differences in a recording session. During the days of acoustic recording, the musicians were forced to crowd around the mouth of a large horn that terminated in a diaphragm driving a cutting stylus. In addition, some of the instruments played by the musicians had to be modified for greater acoustic output. Violins, for example, had a horn attached to beef up their output—which wreaked havoc on their tonal quality.

The new companion playback machines designed by Bell Labs and manufactured by RCA bore the Orthophonic label, as did the electrical recording process. The playback machines were still acoustic, but had a redesigned playback head with a specially designed aluminum diaphragm instead of a conventional mica diaphragm. The output of the tone arm was coupled to an exponential horn. The net result was a frequency range and a fidelity previously undreamed of. Mullin demonstrates a recording made by the acoustic process segued into the same piece recorded electrically. The improvement was astonishing!

Mullin is of the opinion that Bell's phonographic developments were deliberate steps in the direction of their real goal: talking pictures. We are shown a beautifully preserved (or restored) Vitaphone recording lathe made by Western Electric (Bell Labs' manufacturing facility) about 1926. Since the existing 12-inch, 78-rpm discs could provide no more than 4½ minutes per side, a 16-inch 33⅓-rpm with inside-out recording was developed for "talkie" use.

Radio killed the record

By the late 1920's, phonograph sales had gone into a steep decline because of radio, which basically played the discs for you for free. Of course, there were live broadcasts aplenty, but the phonograph remained a fine backup source for the stations. The Vitaphone system designed for talking pictures was enlisted to provide transcription recordings for broadcast use. By slightly crowding the grooves, fifteen minutes of recording time became available. Right through World War II, the electrical transcription disc was the main means for preparing programs in advance of broadcast and for supplying Armed Forces Radio with a variety of entertainment material.

During World War II, one of Jack Mullin's Signal Corps assignments was to analyze German electronics as he encountered it in the newly occupied territories. Through a series of adventures that he recounts on the videotape, he found several samples of the Magnetophon tape recorder in a Frankfurt, Germany, broadcast station along with about 50 reels of tape. It far surpassed any acoustic storage medium that Mullin had heard up to that time. Mullin subsequently dismantled a pair of Magnetophons and mailed them home as "spoils of war." Ultimately, Mullin rebuilt the machine with U.S. electronics, added high-frequency preemphasis to extend the response out to 15 kHz, and demonstrated it at various technical and engineering meetings.

One day a visitor mentioned that Bing Crosby might be interested in Mullin's machine because Crosby was prerecording his radio programs and the quality was not very good. It seems that in 1946 Bing Crosby was under contract to Philco to produce a weekly radio show. Crosby did not want to do the show live so he tried to maintain spontaneity by the use of edited transcription discs, a difficult, noisy, and low-fidelity process. The Crosby group tried sound recording on film, but the process was too clumsy to be useful. Wire recording was available—it had been developed by Armour Research during the war—but the fidelity was not adequate even for the AM broadcasts of the day. Jack Mullin to the rescue.

Mullin demonstrated his machine to Crosby and was subsequently hired to record and edit the Crosby show; he used the same tapes he had brought from Germany because there were no others.

During the same period, Mullin demonstrated the machine to a gentleman by the name of Alex Poniatoff, who owned a small manufacturing company called Ampex. In April 1948 Ampex introduced its classic Model 200 machine that became the standard broadcast and studio tape recorder of the time.

Meanwhile, Crosby Enterprises was paying Mullin and his group to develop a videotape machine. Mullin recounts how his group finally achieved some limited success and called a press conference to announce and demonstrate their new technology. As Mullin describes the demonstration, the viewers saw a gray blob moving diagonally upward across the video screen, which they were told was a plane taking off. The audience was mildly impressed, but in 1955 when Ampex demonstrated a video recorder with a high quality picture, Mullin decided it was time to get out of the video business.

I've given you only some of the highlights of Jack Mullin's presentation. If you would like a copy of the VHS videotape, it is available for $29.95 postpaid from the Audio Engineering Society, 60 East 42nd Street, Room 2520EN, New York, NY 10165-2520. Ω

I thought you fixed it. . .I can hardly hear it!

COMPUTER CONNECTIONS

1993 in review.

JEFF HOLTZMAN

'Twas a very good year, 1993, for the computer industry. Although it lacked epoch-making events, the year nonetheless saw numerous incremental improvements in operating systems, networking, CPUs, software, portable computers, and strategic business alliances.

With the perspective gained by the passage of a few months, I am better able to present an objective view of the events of 1993 in the computer industry.

Information infrastructure

In terms of long-term impact, the single most important computer-related event might not have been technical but political. As discussed in the February issue of this column, the Clinton administration has made a commitment to upgrade the nation's national information infrastructure (NII). It has the goal of redefining the concept that defined the growth of the telephone industry: universal service. It will take years, perhaps even a decade, before we see the results of this commitment, but at least we will have started.

Portable computing

After two years of industry speculation and rumor mongering, Apple released the Newton Messagepad, a stylus-based computer about the size of a small paperback book. As a product, Newton has turned out to be disappointing to many industry observers who had expected more—based on the product promotion. One of its most touted features, handwriting recognition, is poor.

Newton is apparently deficient in other ways as well, particularly in connectivity and data integratability. It took Apple several months to get a Macintosh connectivity kit out the door, and several more months to deliver a Windows version.

Newton nonetheless represents the most innovative product of 1993, so Apple is to be congratulated. I hope that the company's new less-visionary and more bottom-line oriented CEO, Michael Spindler, continues to push the stylus-technology envelope. It might take two or three generations to get it right, but that's almost always true in the computer industry. Apple has guaranteed itself a place in history by introducing the graphical user interface (GUI) to the general public a decade ago, in 1984, with a computer it called the Macintosh. Newton guarantees the company another spot in the history books.

Tandy also introduced a stylus computer called Zoomer. Less innovative but perhaps more practical than Newton, Zoomer is basically an MS-DOS based machine that has been adapted for pen-based input.

There were many incremental improvements in larger, keyboard-based computers in 1993. It is now possible to purchase battery-powered portable PCs at reasonable prices with bright color screens and as much CPU power, RAM, and hard-disk storage as the average or even above-average desktop PC. IBM's ThinkPad 750 is the king of the hill in this category. The only "gotcha" is that you must be willing to settle for VGA resolution—640 dots × 480 lines—which can be difficult to read if you're used to anything higher.

Other portable computer-related trends include docking stations and increased connectivity options. A docking station provides a simple means of attaching and detaching a computer from a variety of peripherals without having to plug-in individual cables. Docking stations have been around since the mid 1980s, but only in the past year have they become truly useful and reasonably priced. If you want one computer to serve both at home and on the go, a docking station can give you a larger keyboard and monitor, as well as preattached network, printer, and modem connections. Connectivity options include built-in Ethernet modules, better PCMCIA-card compatibility (watch for PCMCIA slots in desktop machines in '94), a low-priced RF-based hardware/software scheme from Traveling Software, and similar technologies based on the infrared communications system used for years by Hewlett-Packard calculators and peripherals.

Operating systems

The big news in operating systems wasn't very big. MS-DOS 6.0 was released amidst controversy, Windows NT amidst yawns, and OS/2 2.1 amidst accolades.

DOS 6 differs from its predecessor in two major respects: it comes with a disk-compression package called DoubleSpace, and it includes a memory-optimization utility called MemMaker. DoubleSpace caused the controversy. One major trade publication published reports of numerous instances of disk corruption that it claimed could be traced to DoubleSpace. Later that publication recanted, admitting "pilot error" in its testing methodology. It turned out that the test engineers had rebooted machines immediately after making changes to system files, and DOS 6's disk-caching program allowed the reboot to occur before writing all changes to disk.

Microsoft subsequently introduced DOS 6.2 which adopts a more conservative caching scheme as the default. In addition it ensures that the cache is flushed before the prompt is displayed. In between, IBM introduced its own version, DOS 6.1. The software package included a coupon for a third-party disk-compression program. All in all, there was no compelling reason to upgrade from DOS 5. Rumor has it that MS-DOS 7 will at long last shed the FAT file structure and allow multitasking. Look for it sometime this year or early next year.

Disk compression also found its way into the courts, primarily as a result of a suit brought by Stac Electronics against Microsoft, which, of course, promptly countersued. Neither case has come anywhere near litigation, but Stac has already suffered heavily.

Six months after its introduction, Windows NT proved to be something of a yawner. It gets good reports as a network server, but not as a network client or a stand-alone machine. Most applications developers seem focused on supporting and improving existing Windows 3.1 applications. They want to upgrade them to support version 2.0 of the object linking and embedding (OLE) specification. Some are also bypassing NT altogether and waiting for Windows 4, aka "Chicago," due out in mid to late '94.

OLE 2 is something worth watching very closely. A few applications now support it, including Microsoft's Word for Windows version 6.0, and ShapeWare's Visio 2.0. Conceptually, OLE 2 is fantastic; in practice, however, it requires *a lot* of RAM to work. Even on an 8-megabyte machine, there is still a lot of disk swapping, and that means S...L...O...W operation. OLE was in danger of failing to achieve the broadest possible industry support, but Microsoft recently joined the leading industry consortium, the Object Management Group (OMG). It is concerned with inter-application and cross-platform object sharing.

1993 also saw the release of several competing Windows-on-Unix technologies. None is likely to achieve technical success, not to mention business success. The technology that probably has the most chance of even moderate success is Wabi, which was developed by SunSelect, a software subsidiary of Sun Microsystems, and Unix Systems Laboratories, the former AT&T entity now owned by Novell. Wabi is a "super" emulation technology that allows Windows programs to run on RISC/Unix workstations. The "super" part comes in because Wabi does not emulate Windows, DOS, and ultimately an 80x86 CPU, as do most emulators. Rather, it translates MS-Windows calls into equivalent X-Windows calls (or sequences thereof, as necessary). This gives Wabi tremendous potential speed compared with traditional emulation technologies. The bad news is that numerous so-called "certified" applications—including Word for Windows, Excel, and other Microsoft applications—have uncovered bugs in Wabi. No doubt those bugs can be fixed, but by then it's likely that technology will have marched on, and a new level of emulation will be required. This is the same problem perennially faced by IBM with OS/2.

THIS YEAR

1993 witnessed many relatively small, evolutionary steps in the computer industry. In 1994 we will see more-radical steps, such as shedding real-mode 640K DOS and the FAT file system, and bundling basic networking software and utilities (E-mail) with the operating system. Pentium-based systems will quickly penetrate the market because of the growing number of vendors building 486 clones. Sixteen megabytes of RAM will become the de facto desktop standard, as will 350–500 megabyte hard disks. Battery life and screen resolution will continue to be the bugaboo of laptop users. A continued low ratio of CPU power to energy consumed will prevent widespread adoption of pen systems, which will nonetheless improve immensely. RF and IR will emerge as viable temporary/short-term solutions for connecting portables to main machines and networks. Look for increasingly sophisticated software that will help synchronize files across multiple machines.

Amidst all this Windows-related activity, it's easy to lose sight of OS/2 2.1. In short, IBM got it right this time. OS/2 provides the promised better DOS than DOS, and until Chicago becomes real, a Windows that is good enough. I am concerned about IBM's ability to track Windows upgrades, especially now that the company no longer has rights to Microsoft code. Regardless, with OS/2 2.1 IBM has a window of business opportunity, and users have an opportunity to experiment with a 32-bit operating system and an advanced user-interface paradigm, yet retain the ability to run existing applications.

CPUs and RAM

In 1993 Intel released the evolutionary successor to the 486, the Pentium. There's good news and bad news. The good news is that Pentium is fast. The bad news is that systems based on it are (still) not generally available, especially the 66-MHz speed champs (60-MHz units are easier to find). This has been good for buyers content with 486 machines; their prices continue to drop steadily. Intel has announced an OverDrive processor that will allow selected 486 motherboards to run crippled Pentiums; they should be available by mid 1994.

American Micro Devices (AMD), Cyrix, and Texas Instruments are selling 486 clones. As a result Intel is losing market share because it can't move customers up to Pentium systems fast enough. And all four companies have ensured steady work for their lawyers, for years to come. Intel and AMD are suing each other. TI and Cyrix are suing each other. And there are lots of other suits draining the semiconductor industry of valuable resources.

If Windows NT is the software industry's attempt to bring Unix to the desktop, the PowerPC is the hardware equivalent. POWER is IBM's acronym for Performance Optimization With Enhanced RISC; POWER refers to the RISC processors that form the heart of the company's RS/6000 workstation line. Part of IBM's historic 1991 accords with Apple and Motorola called for joint development of a more integrated POWER chip set—one that could form the basis of a mass-produceable, inexpensive computer. This effort came to fruition in fall of 1993 with IBM's release of several RS/6000 workstations. Apple appears committed to phasing 680x0 microprocessors out of its Macintosh line in favor of PowerPC microprocessors. Moreover, IBM will also introduce a line of "PCs" based on the PowerPC. An organization, called PowerOpen, has formed to help promulgate hardware and software standards to ensure compatibility.

The good thing about the PowerPC architecture is its performance/price ratio, which is much higher than that of the Intel line. PowerPC is likely to make a smooth transition in the Macintosh market, because it can run existing Macintosh applications as-is. This is not true for DOS/Windows applications which will require sophisticated emulation. Again, the problem with emulators is that they can be bug-filled and they lack performance, and they typically lag major operating system releases.

However, PowerPC might not have to suffer the indignities over compatibilty that OS/2 has been fighting all these years. Microsoft appears to be evolving all its major application programming interfaces (APIs) to the cross-platform model first exhibited by NT, which can already run on Intel, DEC, and MIPS platforms. I believe that Cairo, which is currently being billed as the successor to NT, will also be the successor to Windows 4. If my theory is correct, Cairo will run on multiple platforms, including Intel, PowerPC, DEC Alpha, MIPS R4400, Sun SPARC, HP PA, and perhaps others. Equally important, it will support the entire DOS/Windows API, along with the Unix-based NT API. It will, in short, run anything on anything. Maybe. We'll see. But that's the only realistic hope that PowerPC has to achieve anything other than a small fraction of the market.

An explosion in early July at the Sumitomo Chemical plant in Japan halted production of epoxy cresol resin, the key ingredient used to manufacture plastic IC packages. That plant met more than 50% of the worldwide demand for that resin. Consequently, IC prices, particularly DRAMs, increased, sometimes by a factor of three. Well before the end of the year, however, the situation was back under control, and prices returned to preexplosion levels. At this point, it is possible, at the retail level, to buy 16 megabytes of DRAM in 4-megabyte modules for less than $600, which is an incredible price for anyone who has followed the computer industry for more than a few years.

Other '93 highlights

Networking costs dropped radically, and performance prepared to surge ahead. IEEE 802.3 (Ethernet) network interface card (NIC) prices dropped to the $100 level, and several competing standards were proposed to increase Ethernet's basic 10 megabit per second (Mbps) data rate to 100 Mbps.

Borland is in deep trouble. The company has been pilloried for failing to deliver a Windows version of dBASE. Compared with multi-product rivals Microsoft and Lotus, Borland looks increasingly thin. Throughout the eighties, the company invented and reinvented itself every few years, first around Turbo Pascal, then around SideKick, later around Paradox and the C compilers. It's time that it does it again.

Retail software prices caved in during 1993, with the result that buyers now have to pay extra for support. On the other hand, look for much better built-in support, now that CD-ROM drives and sound cards are becoming so widespread.

Multimedia has been a pet topic of mine for years. 1993 saw a dramatic rise of general interest in the topic. More and more games, application programs, and even operating systems are now available on CD. Those versions typically carry extras ranging from clip art and fonts and on-line help to demo versions of other applications. The trend will continue in 1994. Ω

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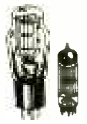

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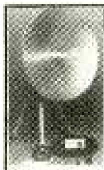

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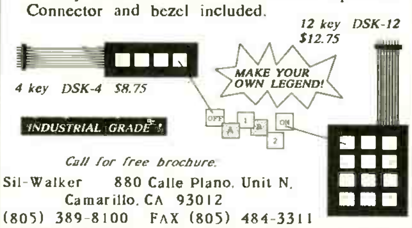

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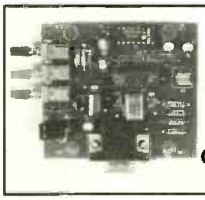

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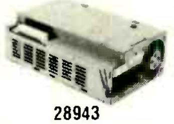

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Part No.	Watts	+5VDC (Amp)	+12 VDC (Amp)	-5 VDC (Amp)	-12 VDC (Amp)	1-9	10-24
101362	17.2	2	0.3	-----	0.3	$39.95	35.95
77981	28	2	1.5	-----	-----	12.95	11.49
98685	28	4.3	0.5	0.1	-----	19.95	17.95
28935	30	6	-----	-----	-----	12.95	11.49
103510	31	3	1	-----	0.33	19.95	17.95
28927	41.6	3.75	1.5	-----	0.4	19.95	17.95
28898	41.9	4.8	1.1	0.1	0.34	19.95	17.95
66131	42.5	2.5	2	-----	0.5	24.95	22.49
103958	42.5	2.5	2	-----	0.5	24.95	22.49
103544	42.6	3	2	-----	0.3	19.95	17.95
103173	42.6	3	2	-----	0.3	19.95	17.95
101354	44.1	3	2	0.3	0.3	49.95	44.95
88401	45	3	2	-----	0.5	39.95	35.95
28871	50.5	6	0.5	0.5	1	19.95	17.95
65912	53	7	1	-----	0.5	12.95	11.49
17056	54	5	1	1	1	49.95	44.95
101397	57.7	4	3	0.1	0.1	54.95	49.49
28943	59.1	6	2	0.3	0.3	24.95	22.49
101371	66	5.5	2.5	0.5	0.5	59.95	53.95
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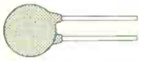
Capacitors



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Ceramic Disc (± 20%)

Part No.	Capacitance	Voltage	1-9
15405	22pf	50v	$.10
15341	100pf	50v	.10
15190	.001µf	50v	.10
15229	.01µf	50v	.10
15253	.047µf	50v	.12
15270	.1µ	50v	.15

Mylar (± 10%)

Part No.	Capacitance	Voltage	1-9
26884	.01µf	100v	$.11
26921	.033µf	100v	.15
26956	.1µf	100v	.19
26972	.22µf	100v	.27
26999	.47µf	100v	.35
27001	1µf	100v	.59

Dipped Tantalum (± 10%)

Part No.	Capacitance	Voltage	1-9
33486	.1µf	35v	$.19
33662	1µf	35v	.23
33734	2.2µf	35v	.27
33806	4.7µf	35v	.39
33689	10µf	35v	.65
33822	47µf	25v	2.49

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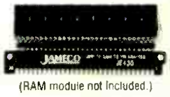

(RAM module not included.)

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Part No.	Product No.	1-9	10-99
93382	JE430	$9.95	9.49

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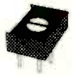

Part No.	Product No.	Ohms	1-9
42964	63P1K	1K	$.85
43078	63P5K	5K	.85
43001	63P10K	10K	.85
43051	63P20K	20K	.85
43027	63P100K	100K	.85

3/4" Rectangular 15-Turn Cermet

Part No.	Product No.	Ohms	1-9
41785	43P1K	1K	$.99
41890	43P5K	5K	.99
41822	43P10K	10K	.99
41873	43P20K	20K	.99
41911	43P50K	50K	.99

Microprocessor Crystals

Part No.	Product No.	Freq. (MHz)	1-9
14357	CY1.84	1.8432	$2.19
14533	CY3.57	3.579545	1.09
14592	CY4	4.0	1.09
14681	CY6	6.0	1.09
14699	CY6.14	6.144	1.09
14710	CY7.37	7.3728	1.09
14728	CY8	8.0	1.09
14402	CY12	12.0	1.09
14584	CY32.76	32.768KH	.89

TTL Crystal Clock Oscillators

Part No.	Product No.	Freq. (MHz)	1-9
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27924	OSC2	2.0	3.29
27967	OSC4	4.0	3.29
27991	OSC8	8.0	3.29
27887	OSC10	10.0	3.29

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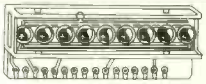

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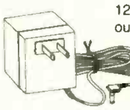

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