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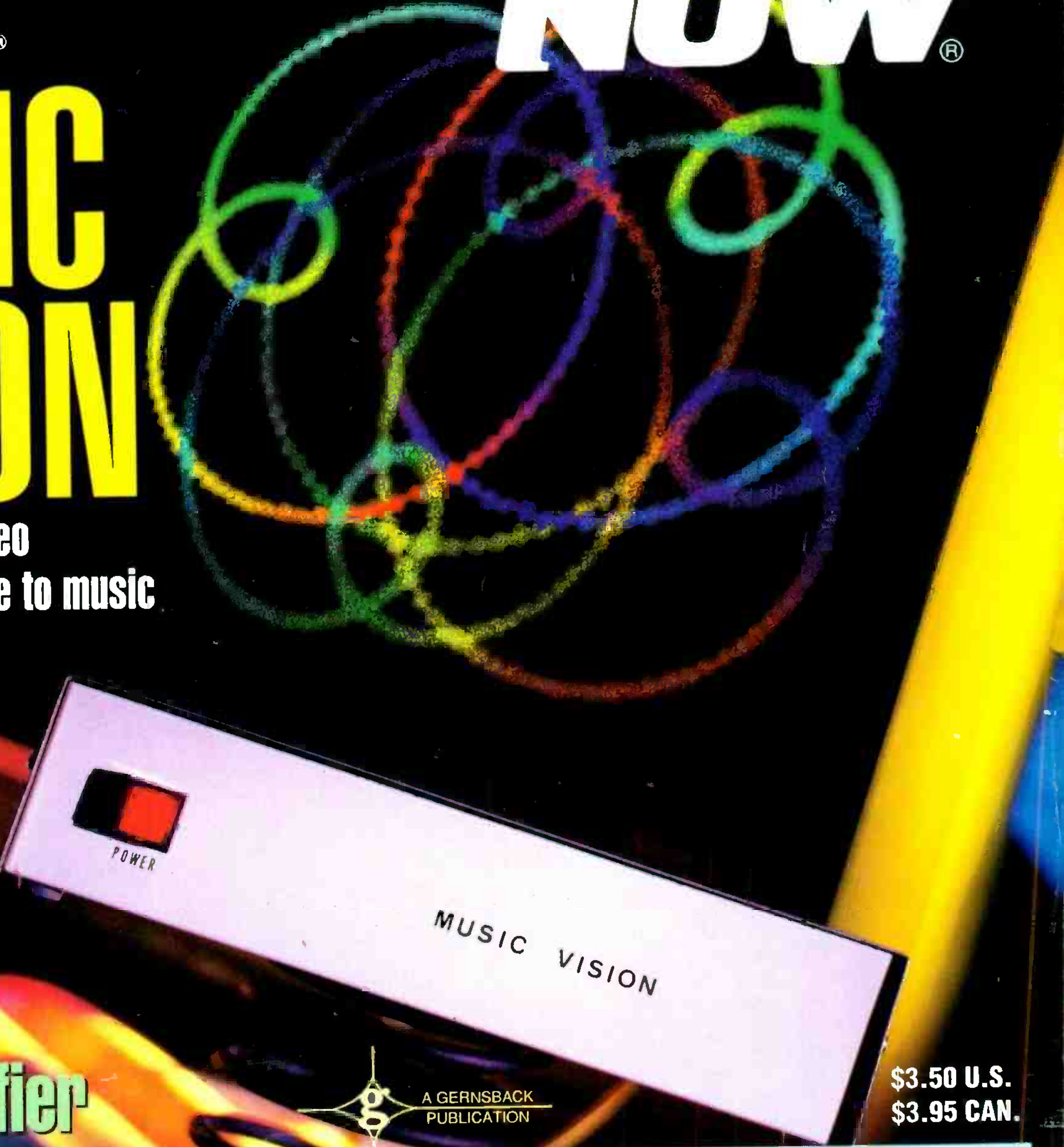

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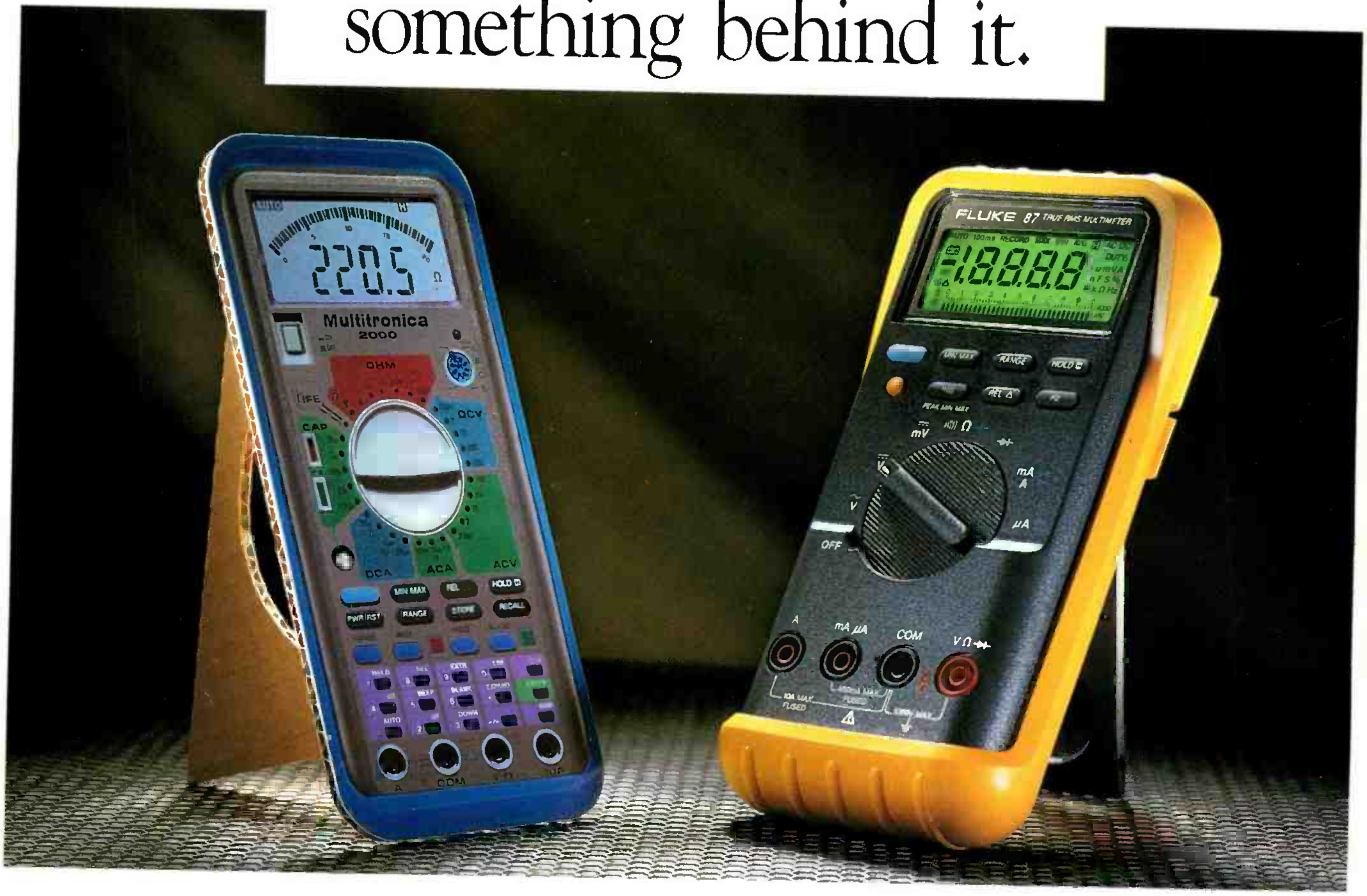

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WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

GPS system tracks Parisian buses.

One of the busiest bus routes in Paris is now being monitored by the Altair satellite communication system. The city's bus company has set up its pilot program based on the American Global Positioning System (GPS) to pinpoint bus locations to within 33 feet. The bus position information is sent to both a control office and passengers waiting at stops along a north-south route through Paris.

Commuters can watch the movement of the buses' on a liquid crystal display screen located at the stop. It informs them of the time of arrival of the next bus within an accuracy of about a minute. The system can also be used by the Paris police and fire departments as well as emergency medical vehicles and taxis.

The Altair system, developed by Cityloc, a consortium of the French manufacturers GTMH and SAGEM, is based on the 24 orbiting GPS satellites. Each bus is equipped with a GPS receiver and a transmitter for transmitting its location to a central station at regular intervals. The equipment for each bus costs about $2000.

When the buses travel in tunnels or narrow streets where buildings block GPS signal reception, a backup system is activated. Each bus has a computer that processes direction data from an on-board gyro and distance traveled from an on-board odometer.

Data from the GPS satellites and the bus backup system is gathered and sent through an internal computer network to several locations. The route's district control office compiles a precise overview of all bus locations on the route. A dashboard display on the bus keeps the driver informed about the location of buses both in front of and behind his vehicle along the route.

Passengers on the bus hear continuous announcements about the next stops and the estimated times of arrival there. Meanwhile, people waiting for buses are told when the next two buses are expected to arrive, and they are informed about disruptions that could cause delays.

The LCD screens at the bus stops receive their data by radio. Altair regulates traffic flow, permitting the buses to be positioned more uniformly. If an emergency condition is detected on any bus, security personnel can be dispatched immediately to the precise location.

The city of Paris is evaluating the program to determine if it should be extended to all 260 city bus routes.

Global Positioning System Upgrade

The Federal Aviation Administration (FAA) awarded a contract last August for an improvement in the Global Positioning System (GPS) called the Wide-Area Augmentation System. This system will make location fixes obtained from GPS satellites far more accurate by correcting them in real time with a supplementary signal.

The system will be mandatory for commercial aircraft flying over the United States, but private aircraft, ships, and vehicles of all kinds can take advantage of the improved accuracy, if the owners are willing

THE ALTAIR COMMUNICATION SYSTEM pinpoints bus locations in Paris with signals from GPS satellites. A liquid-crystal display at bus stops keep commuters informed of bus locations. Drivers and controllers can also keep tabs on bus locations and arrival times.

to install an additional receiver.

Non-military owners of GPS receiver will be able to pinpoint their locations to within about 7 meters, or 21 feet, anywhere in the United States. This compares with an accuracy of within about 100 meters or 300 feet now possible with existing, uncorrected GPS receivers. However, the FAA system will have no effect on the higher accuracy that can be obtained by U.S. military GPS receivers in aircraft, ships and ground vehicles. They receive different, more accurate signals from the GPS satellites.

A $475 million contract was awarded to a consortium led by Wilcox Electric, a subsidiary of Northrop, that includes Hughes Aircraft, a subsidiary of General Motors, and TRW. The consortium expects to complete system testing by late 1998 or early 1999.

The GPS system now consists of a constellation of 24 satellites orbiting 11,000 miles above the earth. Each transmits a unique signal that identifies itself. The receiver, some now smaller than a pocket book, picks up signals from the four or five satellites in radio range any time. The receiver then determines its own position on earth relative to the positions of each of the satellites in range by triangulation.

The Wide-Area Augumentation system will consist of 36 receiving stations in the United States located at selected, precisely surveyed sites. Each of the stations will receive the signals transmitted by the GPS satellites and calculate its own position based on that data. The position, determined by triangulation from the satellite signals, will then be compared with the station's true known location and an error is determined.

That error will then be transmitted to a central station which will collect error signals from all 36 stations and determine an overall correction factor. That factor will then be transmitted to an independent geosynchronous satellite in stationary orbit 22,000 miles above continental United States. (Geosyn-chronous communications and weather satellites are stationed over the equator.)

The FAA's geosynchronous satellite will then retransmit the correction factor to aircraft in flight, or any other GPS receiver. The GPS receivers will continue to determine their own positions directly from the GPS satellites, but those positions will then be fixed more precisely with the correction signal received from the geopsynchronous satellite.

An FAA spokesman said that the seven-meter accuracy is far more precise than any that can be obtained from radar or other existing navigation systems. This will permit FAA air-traffic controllers to direct aircraft closer to each other by without additional risk. Nevertheless, radar will be still kept on commercial aircraft, if only for backup.

FAA officials believe that as early as 1998 GPS could be the only electronics navigation system still functioning throughout the United States. The FAA would like to phase out the existing system of radio beacons that was installed in the 1940s. They see the possibility that commercial air lines can recover some of the costs associated with receiver installation for the Wide Area Augmentation system in fuel savings. Commercial aircraft would no longer be required to deviate from straight-line routes to fly over radio beacons as they do today.

Cyberglove offers a touching experience

Virtual reality has been advanced with the invention of a glove that adds the sense of touch to virtual reality. Developed by Ron Renzi of Sandia National laboratories, it is a byproduct of the Sandia's work on virtual environments as a training method for workers dismantling military weapons.

Renzi said that adding the sense of touch makes the virtual experience more lifelike, adding that "it allows you to feel more immersed in the environment." The tactile sensations help the users orient themselves spatially by permitting them to feel their way around the virtual space.

Renzi and his co-workers have simulated the sensation of touching struc-

Continued on page 125

VIDEO NEWS

WHAT'S NEW IN THE FAST-CHANGING VIDEO INDUSTRY

BY DAVID LACHENBRUCH

Digital camcorders arrive

As we go to press, the first consumer digital camcorders are scheduled to arrive in American stores. Both Sony and Panasonic are now selling the Digital Video Cassette (DVC) camcorders in Japan, and both have promised to have them in the U.S. in plenty of time for affluent videomaniac Christmas shoppers. Three models have been announced—two by Sony and one by Panasonic—with several more brands imminent. The camcorders are based on the industry-standard DVC format approved by some 55 hardware and tape manufacturers (*Electronics Now*, July 1995). The new format uses metal evaporated tape one-quarter-inch wide, with two standard-size cassettes—one presumably for camcorders, the other for VCR decks.

Nobody is offering a DVC deck yet—simply because that format is designed to function as a companion to digital broadcasting, including the U.S Grand Alliance format. However, camcorders aren't dependent on TV broadcast standards (except for playback), and the new models bring digital quality to high-end consumer and semi-professional videotaping. Both the new Sony and Panasonic models use the smaller cassette—about the size of a DAT cassette—to provide up to one hour's recording (with horizontal resolution of some 500 lines) in either standard or letterboxed aspect ratio. Sony's high-end and Panasonic's only announced version use three CCD pickups, while Sony's lower-priced model has a single pickup.

Neither company has announced prices yet, but in Japan their list prices range from the equivalent of about $2400 to $4000 (at recent dollar-to-yen exchange rates). To bring them to compatibility with today's analog TV sets, they include digital-to-analog converters that provide output in NTSC standard (PAL versions for Europe are expected shortly). The camcorders have neither digital inputs nor outputs; because they are capable of making near-perfect copies that is a very touchy subject, any action awaiting a formula for preserving copyrights.

Panasonic describes the 500-line output of its version as "nearly 20% more than laserdisc and 50% more than a live broadcast." Panasonic's signal-to-noise ratio is given as 54 dB, two to three times better than existing consumer video equipment. All versions contain a "snapshot" mode, permitting them to be used as high-resolution, full-frame still cameras while normal audio is continued. Sony's models have two 12-bit stereo audio pairs, while the Panasonic model offers two audio modes—12-bit for two soundtracks and 16-bit for a single stereo pair.

Obviously, at those very high initial prices, those close-to-perfection camcorders aren't for everyone. Their sales will be confined to high-end product dealers with knowledgeable salespeople who can properly describe and demonstrate the camcorders' advantages. Although they are billed as "consumer" models, their appeal is expected to be largely to pro and semi-pro videographers at first, until prices come down. Some cable systems and broadcast news departments might also be interested in the camcorders, the latter because they are still cheaper than digital broadcast camcorders (but also have fewer editing features). The new camcorders are not for everyone—*yet*—but they are a landmark in both technology and standardization (no Beta-VHS rivalry here).

Digital broadcast questions

With field-testing of the Grand Alliance HDTV system almost completed, the FCC has launched a major inquiry about the future of digital broadcasting. One of the top questions: How compulsory should HDTV be—for both broadcasters and TV set manufacturers? The current broadcasters are greedily eying the future digital broadcast spectrum as an opportunity to provide multiple broadcasts in compressed standard-definition, allowing them to offer several shows simultaneously and thus compete better with multi-programming cable systems. The Commission will ponder whether digital broadcasters must be required to program a certain amount of high definition and whether TV set manufacturers must adhere to mandatory rules specifying that sets must be capable of receiving both digital and analog broadcasts.

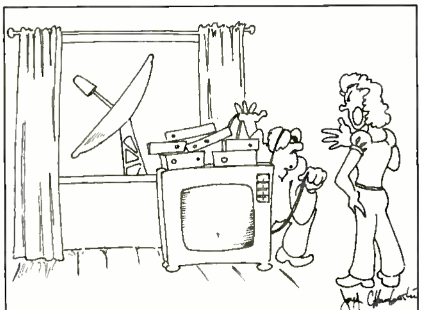
Among other questions: Because broadcasters will be required to adopt new frequencies for digital broadcasting, how long should they be permitted to broadcast on both digital and analog frequencies. And what is the best way to allocate the existing TV bands after analog telecasting ceases? The answers to those and other questions significant to the future of digital broadcasting should come next year, about the same time the FCC officially selects an HDTV system and allocates channels for it.

Mouse for TV

While computers are spouting wireless remote controls, TV sets are beginning to sport mouse-like devices. This strange cross-pollination is showing up, in its early stages, in new generations of Packard Bell computers and Zenith TV sets.

Packard Bell's current line of computers, like last year's, features some models with built-in TV and radio reception. This year, however, Packard Bell has added a familiar gimmick as an optional add-on for some of its models—a very conventional-appearing wireless remote control, designed to operate all TV, audio, and telecommunications functions of the computers.

Zenith has gone in exactly the opposite direction. All of its new TV sets with StarSight on-screen program guide come equipped with "Z-Trak," a convenient, small remote-control device whose principle feature is a trackball that controls an on-screen cursor. Maneuvering the cursor to different parts of the screencalls up various icons. When the trackball is pressed while the cursor is on an icon, a detailed menu appears—which is also controlled by the trackball. The trackball's cursor is also used to maneuver through the StarSight on-screen menu system. But, just in case the TV's owner isn't computer literate, Zenith also includes a conventional remote with those sets. EN



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Q & A

READERS QUESTIONS, EDITORS ANSWERS

60 LEDS, ONE AT A TIME

Could you please explain how I can hook up 60 LEDs to count from 1 to 60 sequentially? I am trying to make a clock and would appreciate any help you can give me.—W. Closs, Cambridge, Ont., Canada

We gather that the hour, minute, and second hands of your clock will be LEDs arranged in a circle, and the position of the hand will be indicated by lighting one LED at a time. Although we can't publish complete plans here, we can get you started. We'll have to assume that you already know how to set up binary counters and get them to count at the right speed.

What you need is a demultiplexer circuit that has 60 outputs and accepts a binary number telling it which output to activate. The binary numbers from the counter can select the individual LEDs.

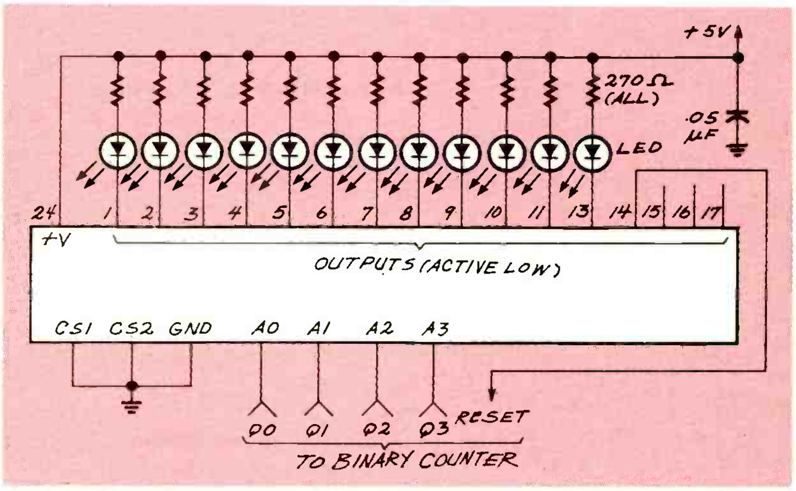


FIG. 1—A DEMULTIPLEXER selects a different LED for each binary number at its input. The counter resets after a count of 12.

The widely available 74154 (74LS154, 74HC154) IC is a demultiplexer with 16 outputs. Figure 1 shows how to use it for the hour hand of your clock. The first twelve outputs go to LEDs, and the thirteenth can be used to reset the binary counter. Note that all the outputs of the 74154 are active-low, which means that the selected output is in the "low" (0-volt) state and the others are in the "high" (+5-

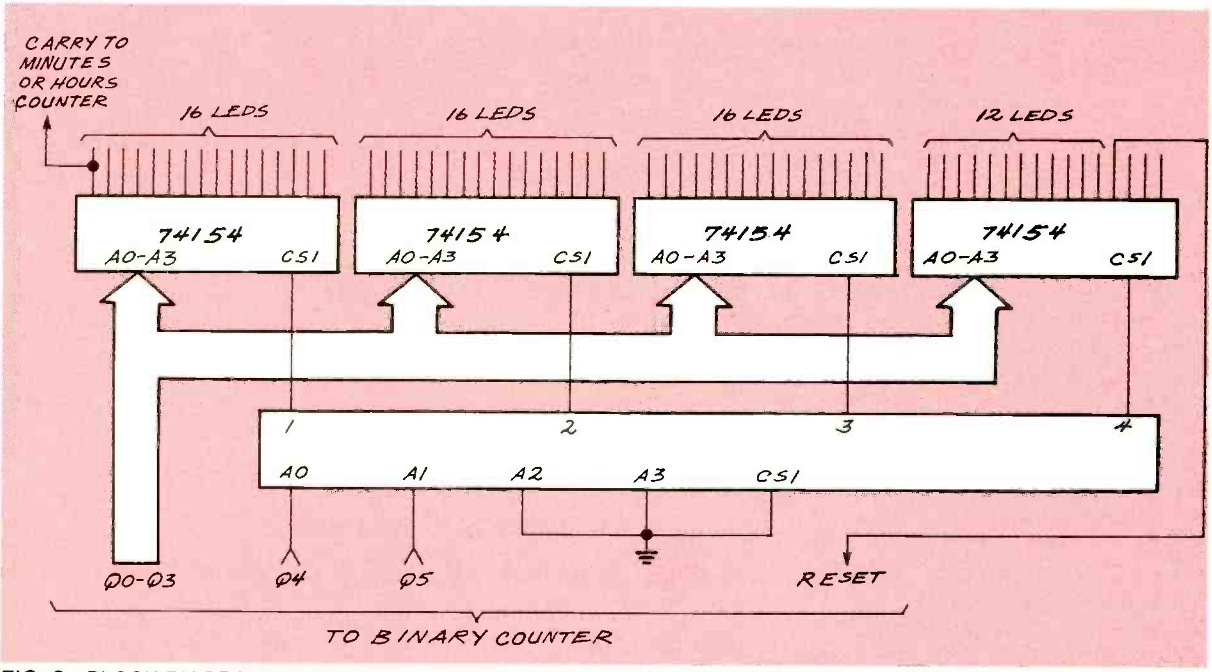


FIG. 2—BLOCK DIAGRAM shows how to cascade demultiplexers to get 60 outputs. Connections not shown are as in Fig. 1.

volt) state. The reset inputs of most binary counters are also active low (0V to reset, +5V to run).

For the minute and second hands, you'll need to cascade five demultiplexers to get 64 outputs (of which you will use 60, plus the 61st for reset). Figure 2 is a block diagram of how to do this. Notice that you can use one of the outputs as a "carry" to the next binary counter; for example, the second hand carries to the minute counter, and the minute hand carries to the hour counter.

AC WATTMETER

I want to build an AC wattmeter. It must operate on 120V AC and have a range from 0 to 1500 watts to cover most domestic equipment. I just want to plug in equipment and read out the wattage consumption without doing any calculations.—D. Cranston, Lakewood, CA

A true wattmeter is a complicated instrument. But if all the wattages that you want to measure are at the same voltage (120V AC) and the loads are resistive (such as lights, heaters, or motors under load), then you can fake it by using a set of resistors as shown in Fig. 3.

Just pass the current through an 0.12-ohm resistance (four 0.47-ohm, 5-watt resistors in parallel), connect an AC voltmeter across the resistance, and read volts as kilowatts. That is, every volt across the resistance corresponds to 1000 watts (equal to 8 amps) drawn by the load. Remember that the voltmeter terminals are "hot"; use insulated pin sockets so that you won't touch the contacts accidentally.

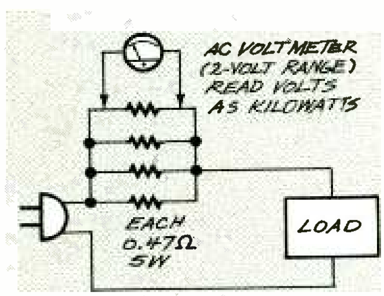


FIG. 3—POWER CONSUMED by an appliance can be estimated accurately from a voltage reading across a series resistance. The voltage drop across the resistor is negligible.

On inductive or capacitive loads, such as unloaded motors or transformers and computer power supplies, your wattmeter will read high because the current and voltage are not in phase.

BLOOD OXYGEN MEASUREMENT

My doctor puts a clamp on my finger to check the oxygen level in my blood. The machine looks simple enough, like a DMM with a sensor on a cord, but he won't let me take it apart to find out what's inside. Can you help me?—F. Moore, Riverton, WY.

An oximeter measures the amount of oxygen in your blood by shining light through some part of your body—traditionally the earlobe, nowadays often the finger—and comparing the transmission of two different wavelengths, 800 nm (in the near infrared) and 640 nm (bright red). If they're about the same, your oxygen is very low; if your blood is well oxygenated, the 640 nm transmission will be much higher. The light sources are LEDs, and the detector is a silicon photodiode or phototransistor (see Fig. 4).

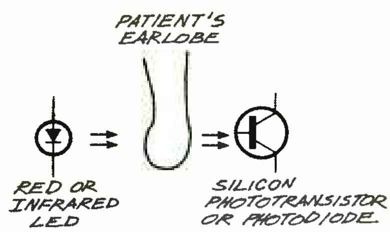
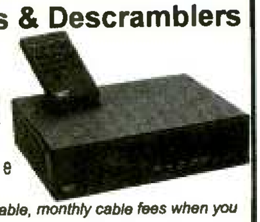


FIG. 4—OXYGEN in the bloodstream is measured by comparing light transmission through an earlobe at 640 and 800 nanometers.

The ear clips that come with exercise machines, for measuring your pulse, work much the same way, except that they operate deeper in the infrared region of the spectrum and detect changes in blood volume rather than oxygenation. We published plans for a pulse monitor of this type in our September and November 1982 issues. EN



LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

TELCO-IN-A-BOX ERROR

Several of our eagle-eyed readers picked up on an error that appeared in the "Telco in a Box" schematic on page 44 of the September issue of *Electronics Now*. As it was shown, there was a positive voltage connected to both sides of relay RY2's coil, which would make it impossible for it to work. As it is supposed work, the Darlington transistor pair draws current through the relay coil to ground through the SCR. For it to work that way, the +V connection at the collector of Q1 should be removed. The corrected schematic is reprinted here. Sorry for the confusion.—*Editor.*

ACOUSTIC CANCELLATION REBUTTAL

I am responding to an item about acoustic cancellation that appeared in the "Hardware Hacker" column in the June issue of *Electronics Now*. I disagree with Don Lancaster's assessment of the technology.

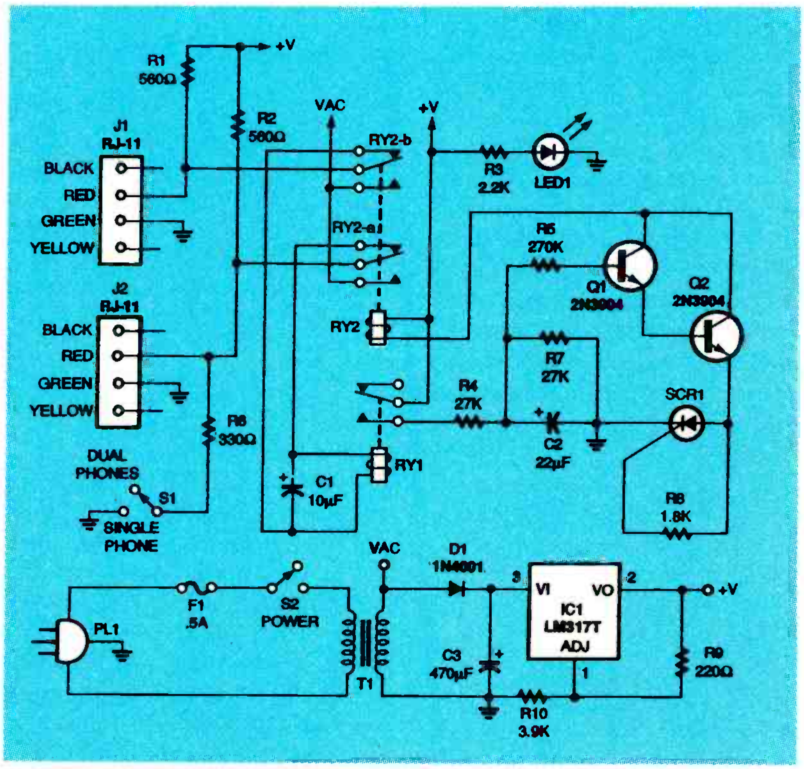
First, Mr. Lancaster expressed disdain at the limitation to the low frequencies. Active noise cancellation can work on higher frequencies, but so can less-expensive, passive methods. Low-frequency noise can be reduced effectively only through electronic cancellation, so it makes sense to concentrate there. Mr. Lancaster said that active headphones can achieve a modest reduction. However, we have sold our NoiseBuster headphone to thousands of consumers, many of whom find the noise reduction to be dramatic.

Second, Mr. Lancaster stated that the problem with an active noise-control application for reducing air-duct noise is that it fails to get rid of *all* noise. Isn't it better to reduce a significant amount of the irritating, fatiguing din emanating from a ventilation system than none? There is no other way to reduce that noise.

It is true that a confined area such as a headphone is the simplest application. However, there are many other viable applications. Perhaps Mr. Lancaster is not up to date on acoustical cancellation. Noise Cancellation Technologies is now in full production of a volumetric cabin-quieting system for turbo prop aircraft. That system cancels the primary frequency and its harmonics in the entire cabin.

It seems that Mr. Lancaster's overall problem with active noise cancellation is that it doesn't eliminate all noise. Obviously, the technology will not leave you in complete silence. But many people are not interested in complete silence. They just want some degree of relief from the daily drone of background noise. To say that active noise cancellation "doesn't work" simply is not true. I would be happy to invite Mr. Lancaster down to our Maryland lab facility to experience our dramatic demonstrations, if he is interested.

MICHAEL J. PARRELLA
President
Noise Cancellation Technologies, Inc.
Stamford, CT



REPRINTED TELCO IN A BOX SCHEMATIC. The +V connection at the collector of Q1 (see *Electronics Now*, September 1995) has been removed.

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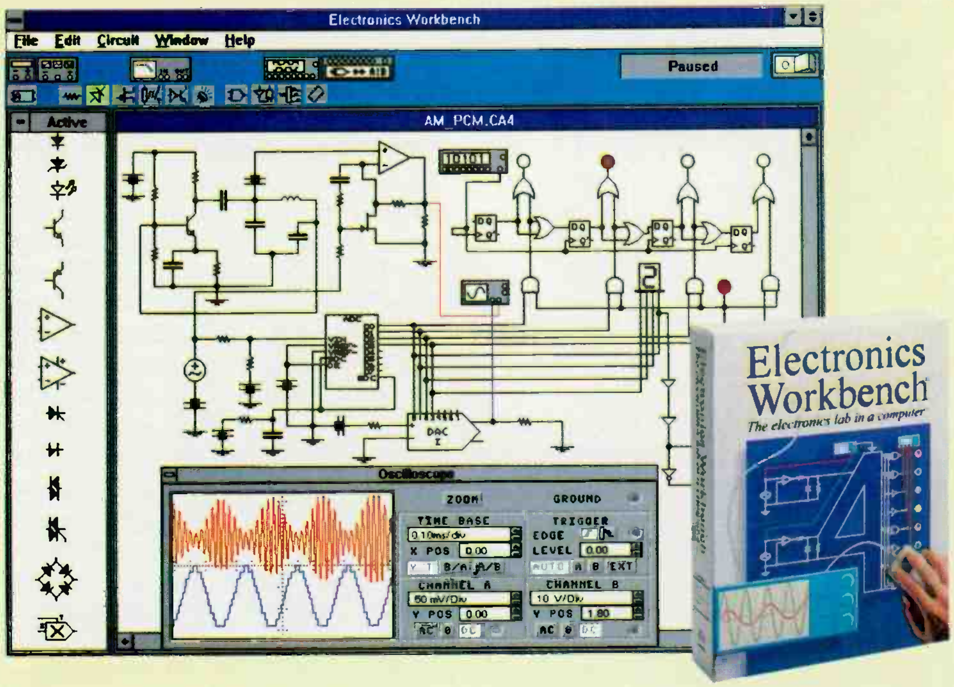

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INTERACTIVE

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THE VOICE OF EXPERIENCE

I have been reading *Electronics Now* and several other electronics-related magazines for more years than I would like to admit. My interest in electronics began when my father told me to find another hobby and stop smelling up the house with the basement lab.

For the next couple of years, I built crystal sets for my friends, so they could use them when they were supposed to be asleep. I learned a lot about the old, pre-1941 radios. I joined the navy five days after Pearl Harbor at the age of 17, and spent the next 30 years in some field of electronics or nuclear weapons or going to school.

Over the years, I have noticed in both the "Letters" and "Q&A" columns that basically the same types of questions are asked and the same general types of circuits are requested. I would like to suggest to electronics hobbyists and professionals that they start a filing system and place in it those articles from magazines and other sources that are of interest.

I have done that for many years. I collect both the comments and corrections for each article in the same place. As time passes, I cull through my files and discard those articles on projects that I will never try, or those for which I have lost interest. I always save articles on circuit fundamentals or history. When filing things, be sure they are marked to identify the source.

That type of filing system has two advantages: One, you can always find all the related articles that you have saved. And two, it greatly reduces the number of old magazines lying around.

ROY A. NORMAN,
LCDR USN, Ret.

Write To:
Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

KEEP YOUR DAY JOB

The letter from James M. Laughlin (*Electronics Now*, August 1995), bemoaning the lack of good electronics jobs, prompted me to write. I am a graduate electronics engineer with a BS and an MSEE and 30 years of experience. Some years ago, I taught a technician-level course in electronics at a local vocational school.

Most of the students in my classes had non-technical jobs paying between $15,000 and $25,000 a year (on average, about $10 an hour). Starting at the entry level in electronics, it would take years to earn that much. Those who now have jobs with 20 years "good" experience can make $30,000 to $50,000 a year, but they are at the very top of the field. One ad says: "Earn up to $60 per hour." That would be the case only for an owner/operator of a thriving, long-term business operation. Business today, however, is far from thriving.

I saw the handwriting on the wall for my students, and advised them to keep their present jobs and do electronics on the side at home. I also told them to look at two- and three-family homes to own and manage.

I have always felt that an engineering education is the best education you can get, but it is the poorest job you can have, for many reasons.

PAUL JAMES
Bayside, NY

I agree with James McLaughlin's assessment of the job market in the U.S. He is correct that most job opportunities are in the service industries and not in electronics.

I have a B.S. in electrical engineering, two years of electronics manufacturing experience with a well-known company, and have been freelancing for five years since I was laid off. You can add to my plight the 28,000 rocket scientists that NASA and its contractors recently laid off. Tell me, what are rocket scientists and electrical engineers going to do, and what work can they retrain for when they are already the most highly trained people in the country?

ROBERT BILAS
Pittsburgh, PA

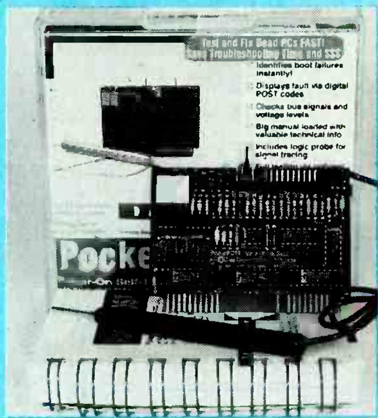
EN

EQUIPMENT REPORTS

PocketPOST Diagnostic Card

POST codes can provide the only clues when a PC won't boot.

CIRCLE 15 ON FREE INFORMATION CARD



Troubleshooting electronic circuits is a skill that's acquired over time. Basically you follow a series of clues to eventually reach the troubled part of a circuit. But usually there are enough clues to point one in the right direction. For example, if a TV set is completely dead, it makes sense to begin your troubleshooting in the power supply section.

Computer troubleshooting also requires skills that can be learned only with experience. Many problems have an obvious cause, which can be narrowed down to one of the computer's subsystems. Among the most difficult problems to solve, however, is when a computer just won't boot because of a problem with its motherboard.

Although it's easy enough to swap out a motherboard, it's often not economical to do so. Sometimes a replacement motherboard is simply not available for one reason or another. In these cases, the only alternative, however unpleasant, is to troubleshoot and repair the board yourself or pay someone else to do it.

Even an experienced technician needs something to help pinpoint the problem—almost any one of the many components on it can bring down, or "crash" the entire board.

Because motherboard problems can be so difficult to find, all motherboards generate POST (power-on self-test) codes during the boot process. The POST verifies that all of the major subsystems of your PC are functioning properly. If they are, the computer's BIOS (basic inut/output system) continues booting the PC. If any test fails, testing halts, and a value is latched in I/0 port 80 (hex).

To find out what is latched in port 80, you'll need a POST-code reader. *PocketPOST*, from Data Depot, Inc. (1710 Drew Street, Clearwater, FL 34615, 813-446-3402, 800-767-3424), is a small POST code diagnostic card that installs in an empty expansion slot on the motherboard. The card measures only 3-3/4 inches long by 2-3/4 inches high, yet it has many helpful functions built-in.

A 6-position jumper block configures the card for different motherboard types; EISA, clone, PS/2, Compaq, AT, or XT. The AT position is the factory default setting. Four tiny LEDs indicate whether motherboard voltages are present (+12, +5, −12, and −5). A fifth LED indicates when one of those voltages, selected from a 4-position jumper block, is less than 95% of the proper level. POST codes are displayed on two 7-segment hexadecimal LED displays.

PocketPOST also has a 3-LED logic probe built in. The LEDs indicate whether a signal applied to an included external logic probe is high, low, or active. In addition, a 10-position jumper block allows the logic-probe LEDs to display the status of one of the ten following motherboard signals: AEN, MWR, MRD, IOW, IOR, REF, CLK, ALE, or OSC. The tenth position on the block is jumpered if the external logic probe is used. Another jumper enables a test of all segments of both displays. Another LED on the board indicates the status of the motherboard's reset signal; a corresponding jumper sets the LED to either continuously display the reset status or to trap its activity if it's too quick to see otherwise

The primary function of PocketPOST is to help determine why a computer won't boot, but it can also be helpful if the computer boots, but does not run properly. PocketPOST is priced at $299.

Using PocketPOST

PocketPOST is very easy to use. A jumper block on the card configures it for different architectures. Most of the time the jumper is simply left in the AT factory default position. The card installs in any empty bus slot, but preferably one that allows the card's displays to be viewed easily. As with all expansion cards, the power to the computer should be off during installation.

A motherboard should have clean plus and minus 12 and plus and minus 5 volt supplies. If all power supply indicators are illuminated after turning power on, then most power-supply problems can pretty much be ruled out. If there's enough reason to suspect that one of the voltages is not high enough, a jumper can be installed to indicate whether the selected voltage is within 95% of its specified level. Test points on the card can be used in conjunction with a voltmeter to measure exact motherboard voltages.

Examining the status of the motherboard signals with PocketPOST's logic probe can be helpful if you know what the line should be doing at any given time. The external logic probe connects to the card, and a jumper enables the card's logic indicators to display the status of the signal applied to the probe.

After power is turned on, you must observe the hexadecimal display and jot down any codes that appear. The codes flash until the computer either fails or boots. If no codes appear, either the card is configured wrong, the system board or the PocketPOST card is defective, or the system does not issue codes.

On a non-booting computer, the last POST code that remains displayed on the card indicates the motherboard subsystem that is causing the problem. The POST codes that flashed by indicate properly performing circuitry.

With valid POST codes in hand, you must refer to a POST codes table in the user's manual to determine what the defective parts are. Each computer BIOS initializes its circuitry in a different order. The user's manual included with the PocketPOST card lists the POST codes of most BIOS manufacturers. It is important that you know the right POST codes for the particular motherboard BIOS you have. The manual also lists telephone numbers for different BIOS manufacturers so that you can contact them if you don't see the codes for your machine listed.

Tracking a problem using the wrong POST codes could cause more trouble than it fixes. With a list of the right codes, the information that appears on PocketPOST's hexadecimal display can help locate troublesome parts. POST codes can inform the user of specific problems such as ROM BIOS checksum failure, CMOS RAM shutdown register failure, cache errors, and so on. A good BIOS will thoroughly test a motherboard and generate very specific POST codes on power up.

PocketPOST can't actively test a computer, as it is a passive device. It also can't display POST results any better than a system BIOS can report them. Problems that can't be detected before boot up, such as bad hard disk sectors or hardware incompatibilities, also can't be detected through POST results. But like any other tool, PocketPOST is very useful when used for the right jobs.

It is inevitable that old computers—and maybe even new ones—will break down. Anyone who is responsible for maintaining a lot of computers will find PocketPOST to be a worthwhile investment, and one that will inevitably pay off in reduced repair time. EN

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NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

HANDHELD OSCILLOSCOPE/DMM

THE TEKSCOPE THS 700 combined handheld digital oscilloscope and multimeters from Tektronix have the high-speed and high-bandwidth response required for rapid and accurate electronic troubleshooting. The Models THS 710 and THS 720 include digital real-time (DRT) oversampling that reduces aliasing and allows single-shot capture at full bandwidth.

Both channels of the THS 720 TekScope digitize at a rate of 500 megasamples per second, 20 times the acquisition speed of handheld instruments previously available. Oversampling allows users to capture and compare two signals on two channels simultaneously at the instrument's full 100-MHz bandwidth. The THS-710 samples at 250 MS per second at a 60-MHz bandwidth.

Both TekScopes are packaged in book-size flat cases that measure 8.5×7×2 inches with simplified front panel controls, icon-based menu selection, and a backlit liquid-crystal display. The instruments weigh three pounds. They are built to withstand the rigors of field and factory use. Isolated Channel architecture makes simultaneous probing on two channels safe.

Each channel is isolated from the other and from the chassis, allowing the module to float safely above earth ground potential.

The user can select 21 automatic measurements, and the instruments can also store up to 10 waveforms and 10 test setups in memory. Built-in pulse-width and video triggering, permit triggering on and capture of a wide selection choice of events. True autoranging permits easy signal acquisition and hands-off operation.

CIRLE 20 ON FREE INFORMATION CARD

THE THS 710 OSCILLOscope/DMM has a price of \$1795.00 and the THS 720 is priced at \$2195.00. Each includes a built-in rechargeable nickel cadmium battery, tilt stand, carrying case, two 100-MHz oscilloscope probes, an AC adapter, DMM leads, an RS-232 port, and PC- or printer-connection cables.

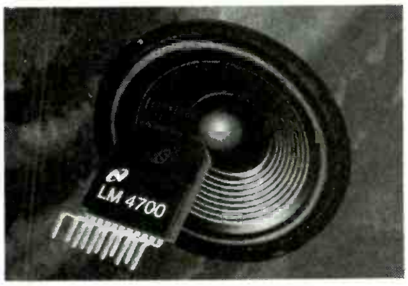
TEKTRONIX

Literature Distribution Center
P. O. Box 1520
Pittsfield, MA 01202
Phone: 1-800-426-2200
1-800-835-7732 or a faxed data sheet (No. 40169)

30-WATT MONOLITHIC POWER AMPLIFIER

THE LM4700TF MONOLITHIC single-channel audio power amplifier from National Semiconductor can deliver 30 watts of continuous average output power into an 8-ohm load; THD is less than 0.08% from 20 Hz to 20 kHz.

The device is intended for consumer combination stereo systems, powered speakers, multichannel audio visual receivers, and high-end TV sets. The single-channel amplifier delivers high-output power while maintaining a level of audio power to match that of discrete semiconductor amplifiers.



CIRLE 21 ON FREE INFORMATION CARD

Internal circuitry protects the monolithic IC from the damaging effects of instantaneous temperature peaks, overvoltage, under voltage, and overloads. The protective circuits monitors the output transistor's safe operating area (SOA) and dynamically protects the device from SOA violations and fault conditions.

The LM4700TF also has a fade-in, fade-out mute mode that eliminates output transients when it is enabled or disabled. By combining the mute function with under-voltage protection that minimizes output spikes and power transients during power up and power down, the LM4700TF is said to be virtually "popless" and "clickless." A standby function that can be controlled by external digital logic lowers current consumption to about 2.1 milliamperes. This makes the amplifier suitable for power-conserving electronic products.

The LM4700TF is packaged in an 11-lead, isolated TO-220 case that eliminates the need for an insulator . This minimizes the possibility of short-circuiting due to faulty assembly or related component failures.

The LM4700TF is priced at $2.50 each in quantities of 1000.

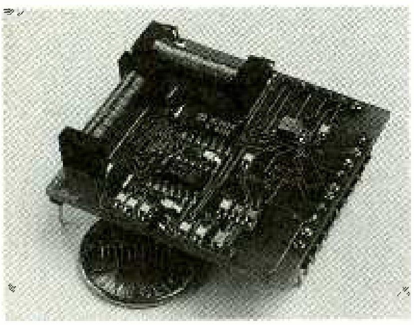
NATIONAL SEMICONDUCTOR CORPORATION
2900 Semiconductor Drive
Santa Clara, CA 95052-8090
Phone: 1-800-272-9959

ELECTRONIC COMPASS MODULE

THE VECTOR-2X MODULE from Precision Navigation is a two-axis "strapped-down" magnetometer with no moving parts that is a component for an electronic compass. It must be combined with a microcontroller, digital display, and controls, to becomes a functioning compass. It can be integrated into aircraft, ships, vehicles, Global Positioning Satellite (GPS) receivers., antenna direction indicators, and surveying instruments

It is said to be suitable for hobbyists, students, and experimenters, who want to build their own electronic compasses and learn about magnetic fields, and compass navigation. Smaller than a matchbox, the Vector-2X is based on proprietary technology first developed under contract with the U.S. Government.

Magneto-inductive compasses consumes less than one-third the power of fluxgate compasses. The Vector-2X has a rated accuracy within 2+deg root



CIRLE 22 ON FREE INFORMATION CARD

mean squared (RMS). When powered from a single 5-volts supply, it draws less than 10 milliamperes. It has a continuous sampling rate of 10 Hz.

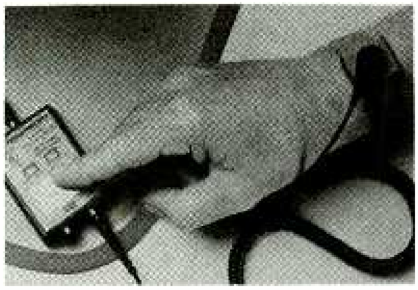
The *Vector-2X* electronic compass module is priced at less than $50.

PRECISION NAVIGATION, INC.

1235 Pear Avenue, Suite 111
Mountain View, CA 94043
Phone: 415-962-8777
Fax: 415-962-8776

WRIST-STRAP TESTER

THE MODEL 6086 ELECTROstatic discharge (ESD)-protective wrist-strap tester from ITT Pomona permits the wearer to verify wrist strap and ground cord integrity with a simple touch motion. This will assure proper grounding before any ESD-sensitive device or circuit is handled.



CIRLE 23 ON FREE INFORMATION CARD

The portability of the tester makes it practical for either a quick tests by many persons working in an ESD-protected area or as a continuous ground-point integrity tester at one station. With both the tester and a wrist strap connected to a common ground, touching the metal surface of the tester lights a green TEST GOOD LED (and will sound an optional audible signal) if the resistance of the wrist strap is between 500 kilohms and 10 megohms.

The tester can be mounted near a work area with the hook and loop adhesive strips provided. Alternatively it can be mounted with an integral button snap stud or attached directly to an ESD-protective work mat. It has two banana plug sockets for attaching the wrist-strap cord. The UL-listed tester is powered by the 120-volt AC wall-outlet adapter included. Both tester and wrist strap must be connected to a common ground.

The Model 6086 ESD-protective wrist strap tester is priced at $69.00.

ITT POMONA ELECTRONICS

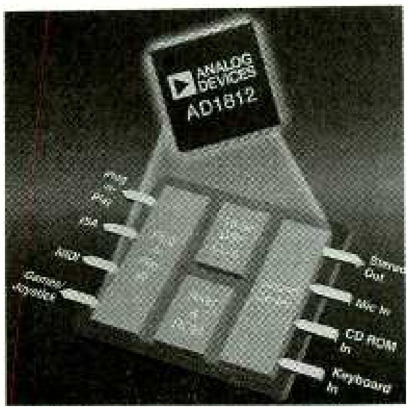
1500 East Ninth Street
Pomona, CA 91766-3835
Phone: 909-469-2900
Fax: 909-629-3317

SINGLE-CHIP PC SOUND SYSTEM

THE AD1812 SOUNDPORT Controller from Analog Devices synthesizes sound with a digital signal processing (DSP) core while a CODEC manages sample rate conversion and synchronization.. The single-chip monolithic IC provides the functions of five logical multimedia devices: 16-bit sound card, Windows sound system CODEC, joystick port, MIDI sound and music synthesis.

This device can reduce a circuit's component count, complexity, and cost. It allows computer and board-level computer manufacturers to configure 16-bit, CD-quality sound in their products while including compatibility with emerging audio standards.

To provide compatibility with SoundBlaster's software, a 16-bit, fixed-point DSP core is embedded in the AD1812. That core runs a game audio synthesis program which approximates the waveforms of FM synthesizer ICs. It uses the same audio parameters passed from Sound Blaster Pro games and applications to FM synthesizer ICs. However, t the sound output is created by a different technique.



CIRLE 24 ON FREE INFORMATION CARD

An integrated full-duplex stereo CODEC includes signal processing technology developed by AD called Continuous Time Oversampling-(CTO). This allows a range of multimedia signals to be converted from analog to digital format and back again to analog on a single device. CTO also permits the integration of new functions as they are introduced.

The AD1812 SoundPort Controller is priced at $25.00 each in 10,000 quantity. The price includes a complete set of multimedia drivers.

ANALOG DEVICES, INC.

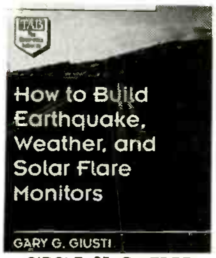
181 Ballardvale Street
Wilmington, MA 01887
Phone: 617-937-1428
Fax: 617-821-4273

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

How to Build Earthquake, Weather, and Solar Flare Monitors

by Gary G. Giusti,
Tab Books Inc., Blue Ridge Summit, PA 17294-0850
1-800-822-8158
$19.95



CIRCLE 25 ON FREE INFORMATION CARD

This book explains how to build a complete scientific monitoring station by constructing and combining the more than 40 projects presented. Parts for most of the projects cost less than $25. Of particular interest to electronics and science hobbyists and amateurs, Giusti's book includes instructions for making inexpensive yet highly sensitive and accurate instruments for monitoring seismic activity and meteorological phenomena such as lightning, and solar flares.

Each project discussed in the book includes easy-to-follow directions and a list of readily available parts. The projects include a basic seismometer, a seismic-solar flare monitor, a water-seepage detector, a Geiger counter, and an earthquake alarm. The projects have ascending levels of complexity.

Helpful appendixes cover such subjects as the basic electrical laws, electrical/electronic schematic symbols, the names and addresses of component suppliers, and a suggested supplementary reading list. Other data in the book includes information and statistics on solar phenomena, weather forecasting and seismic activities.

Building a 3D Game Engine in C++

by Brian Hook.
John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012
Phone:1-800-CALL-WILEY
$34.95

CIRCLE 26 ON FREE INFORMATION CARD

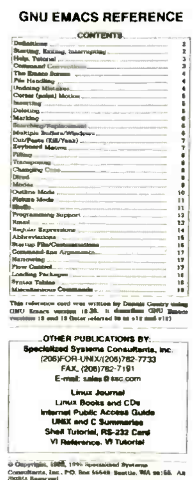
This book and diskette on 3D games is intended for the professional game programmer concerned with the programming of games. It explains how to build a "game engine" that can then be customized to produce a variety of 3D games. Unlike game programming kits that start with a finished game engine and an explanation of how to add on a few features, this book gives the reader/programmer the opportunity to start from scratch.

Mr. Hook provides experienced C++ users with all the technical information and programming code required to create 3D games. It reveals the technical details, short cuts, and tricks- of-the-trade needed to design and develop games. It explains how to create real-time 3D graphics, implement collision and boundary detection, and use artificial intelligence algorithms to create "intelligent" entities.

The included diskette contains AST3D, a C++ library designed for 3D game programming. It also contains source code for Borland and Watcom C++ compilers, and a 3D game engine that will permit programmers to create their own games.

GNU Emacs Pocket Reference

Specialized Systems Consultants, Inc.,
P. O. Box 55549
Seattle, WA 98155
Phone: 206-782-7733
Fax: 206-782-7191
e-mail: sales@ssc.com
$4.50



CIRCLE 27 ON FREE INFORMATION CARD

This is a revised, pocket-sized reference that summarizes GNU Emacs, a screen editor available for Unix systems and other platforms. Emacs is easily configurable through key-bindings and user-definable functions. The reference describes cutting and pasting, command conventions, programming functions, and multiple buffers.

Emacs has modes that make editing more convenient. The guide describes major and minor modes, with detailed sections on the outline and picture modes. A separate section is devoted to programming support. This revised guide includes Versions 18 and 19. EN

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Radio Distribuiting Supply
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Gadsden, AL 35903

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2829 E. McDowell Road
Phoenix, AZ 85008

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El Cajon, CA 90202

Signal Electronics
22307 Ocean Avenue
Torrance, CA 90505

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8431 Commonwealth Avenue
Buena Park, CA 90621

All Electronics
14928 Oxnard Street
Van Nuys, CA 91411

Gateway Electronics of CA
9222 Chesapeake Drive
San Diego, CA 92123

Mac's Electronics
191 South "E" Street
San Bernardino, CA 92401

Electronics Warehouse
2691 Main Street
Riverside, CA 92501

Orvac Electronics
1645 E Orangethorpe Ave.
Fullerton, CA 92631

Sav-On Electronics
13225 Harbor Blvd.
Garden Grove, CA 92643

Marvac Dow Electronics
980 S. A Street
Oxnard, CA 93030

Kandarian Electronics
1101 19th Street
Bakersfield, CA 93301

Whitcomm Electronics
105 W. Dakota #106
Clovia, CA 93612

Marvac Dow Electronics
265-B Reservation Road
Marina, CA 93933

Minuteman Electronics
37111 Post St., Suite 1
Fremont, CA 94536

HCS Electronics
6819 S. Redwood Drive
Cotati, CA 94931

Halted Specialties Co.
3500 Ryder Street
Santa Clara, CA 95051

JDR Micro Devices
2233 Branham Lane
San Jose, CA 95124

Metro Electronics
1831 J Street
Sacramento, CA 95814

The Radio Place, Inc.
5675-A Power Inn Road
Sacramento, CA 95824

HSC Electronics
4837 Amber Lane
Sacramento, CA 95841

Colorado
Gateway Electronics of CO
2525 Federal Blvd.
Denver, CO 80211

Centennial Electronics
2324 E. Bijou
Colorado Sps., CO 80909

Connecticut
Signal Electronics Supply
589 New Park Avenue
W. Hartford, CT 06110

Electronic Service Prod.
437 Washington Avenue
North Haven, CT 06473

Georgia
Norman's Electronics, Inc.
3653 Clairmont Road
Chamblee, GA 30341

Idaho
The Current Source
5159 Glenwood
Boise, ID 83714

Illinois
Tri State Elex
200 W. Northwest Hwy.
Mt. Prospect, IL 60056

Maryland
Mark Elec. Supply Inc.
5015 Herzel Place
Beltsville, MD 20705

Massachusetts
U-Do-It Electronics
40 Franklin Street
Needham, MA 02194

Michigan
Purchase Radio Supply
327 East Hoover Avenue
Ann Arbor, MI 48104

Norwest Electronics
43087 Plymouth Road
Livonia, MI 48150

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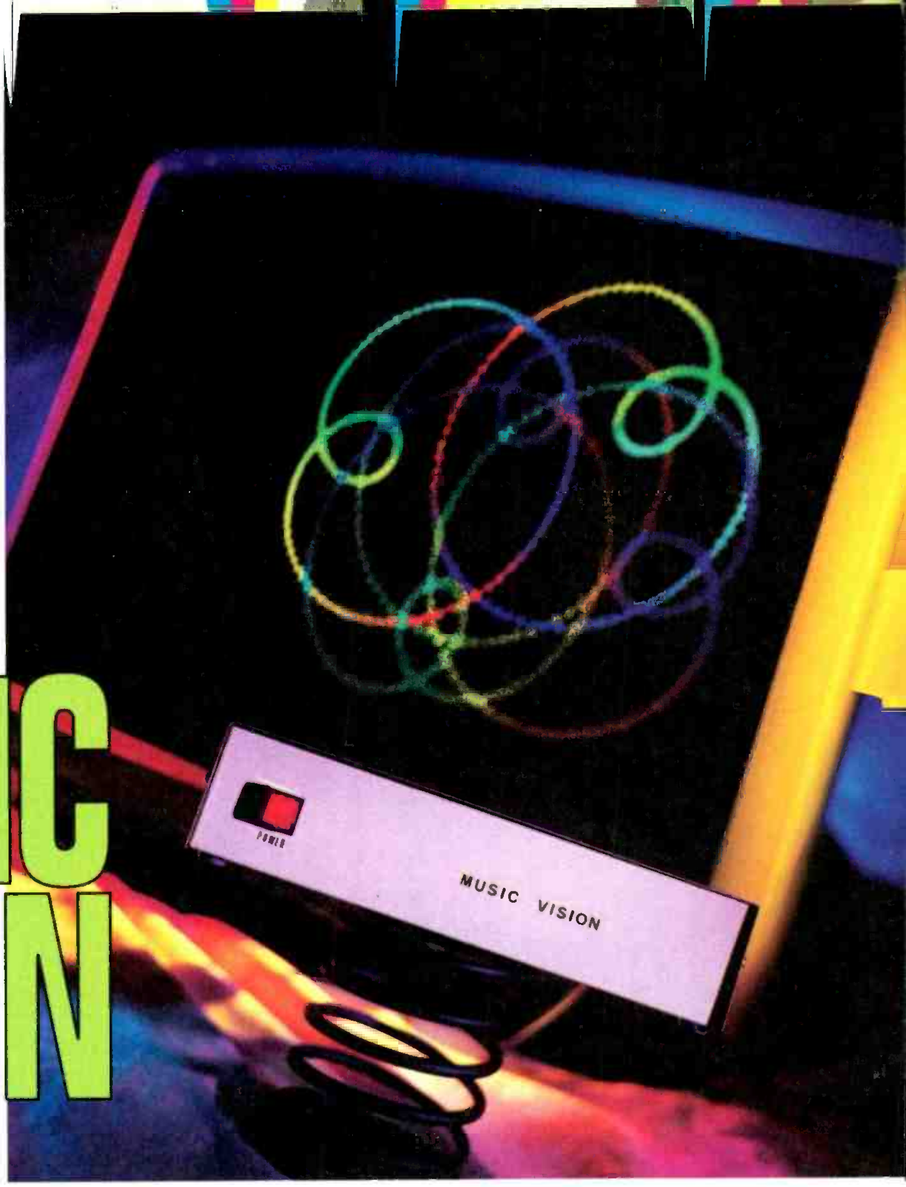
Music Vision adds a new dimension of entertainment to your existing home entertainment system.



MUSIC VISION

STEVEN DUANE KRAFT

REMEMBER THE COLOR ORGANS OF the 1960s and 1970s? How about other devices that respond to music with flashing lights, scanning laser beams, or spinning arrays of LEDs? All those approaches can add new excitement to music, but they are limited by the need for a darkened room, a blank wall or ceiling, small displays, and minimal color variety.

Music Vision lets you view kaleidoscopic patterns that dance in response to music right on your TV screen. You also benefit from the inherent advantages of superior color, contrast, and pattern persistence offered by modern color TV picture tubes. The display is bright enough to view under normal room lighting conditions. The Music Vision circuit is greatly simplified by the availability of programmable logic that allows the entire circuit (minus the power supply) to be built on a 5- × 6-inch PC board. Total parts cost is under $150.

Background

The concept of using audio waveforms to generate visual patterns on a TV picture tube dates back to the 1950's. Even prior to that, people experimented with the generation of unique shapes from quadrature phase shifted signals (see Hardware Hacker, May 1989).

Figure 1 shows a series of simple patterns produced by quadrature phase shifted sinewaves displayed on an x(t) verses y(t) plot. A combination of two fixed frequency sinewaves drives the y-axis of an oscilloscope-type display. The x-axis is driven by the same sinewave signals, except they are phase shifted 90 degrees through an ideal quadrature filter. Each pattern in Fig. 1 is produced by harmonically related sinewaves and only two frequencies. Typical audio signals containing many more frequencies will create more complex and highly dynamic displays if viewed in real time.

In the past, the only way to generate real-time patterns on a TV with an audio signal was to physically modify the TV for direct access to its horizontal and vertical deflection circuits—not a simple task for the novice electronic experimenter. This project will allow you to display audio signals in real time on any standard TV monitor, in the form of dynamic multicolor patterns—without having to make any modifications to the television set.

Block diagram

Figure 2 shows a block diagram of the Music Vision circuit. The basic concept involves processing an audio signal input into two components (x and y) that are phase shifted approximately 90 degrees relative to each other. The signals are then digitally sampled and stored in a video RAM buffer as an array of data bits. Bit locations in RAM correspond with the horizontal (x-value) and vertical (y-value) positions of points to be illuminated on the TV screen. The video RAM is periodically read and erased in synchronism with video frame scanning. The resulting serial video data is combined with colorburst and sync signals to generate an NTSC-compatible composite video output signal.

The Music Vision circuit essentially converts the standard raster-scanned TV screen into an oscilloscope-type display where horizontal and vertical positions are directly controlled by x and y signals. The 90 degree phase shift between the two signals generates complex and dynamic two-dimensional patterns on the TV screen when music, voice, or other audio signals are applied to the input. The audio frequency content of the input signal determines the color of the video pattern being displayed.

Circuit description

The Music Vision circuit is broken up into individual sections for the sake of discussion. The schematic in Fig. 3 shows the analog filter circuits that provide the audio frequency encoder and quadrature filter functions. Low-level audio from the automatic level control circuit is amplified and buffered by op-amp IC2-c. The filter made up of IC2-a, R15–R17, and C11–C13 boosts bass and attenuates treble. Prototype testing indicated that too many high frequency components tend to scramble the fundamental patterns. A 1.6 kHz low-pass filter was found to adequately limit this effect.

Quad op-amp IC1, along with associated resistors and capacitors, forms an audio frequency pseudo-quadrature filter. This circuit produces two output signals (x and y) which possess a relative phase difference of approximately 90 degrees over the desired audio frequency range. A simple op-amp integrator circuit could have been used as a true quadrature filter with exactly 90 degrees of phase shift, but further experimentation showed that more interesting patterns could be produced with a dual lead-lag filter network. The amplitude response of outputs x and y results in frequency-distinguishable elliptical patterns that are more balanced in geometric size through the audio mid-range.

Figure 4 shows typical patterns generated on a TV screen by a single sinewave at various audio frequencies. It also illus-

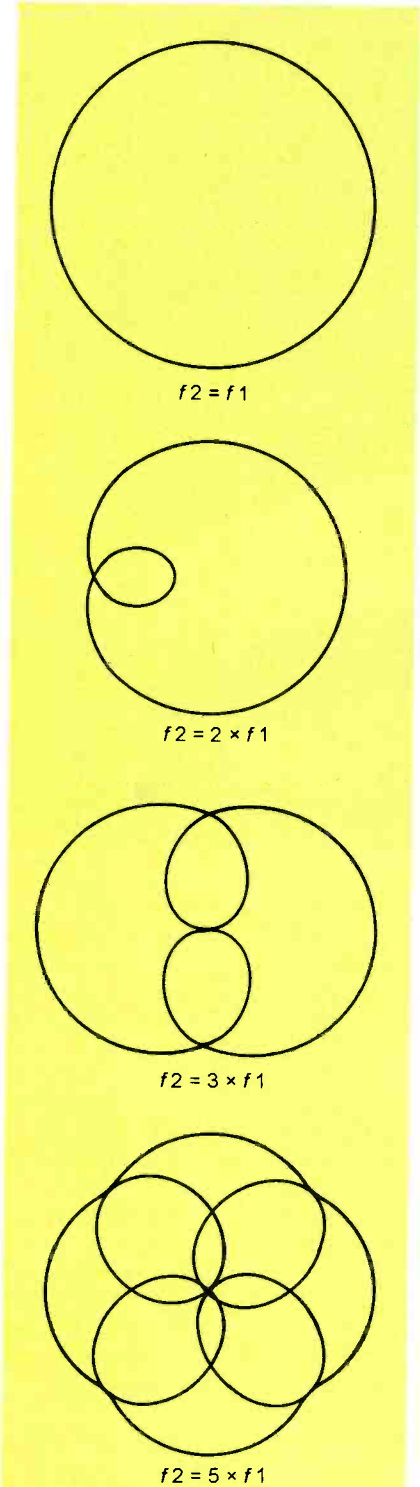


FIG. 1—THESE SIMPLE PATTERNS were produced by quadrature phase shifted sinewaves displayed on an x(t) verses y(t) plot.

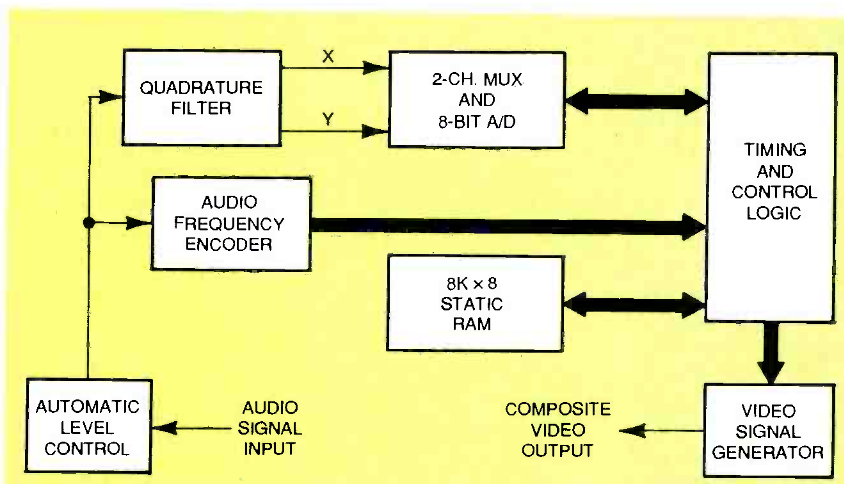


FIG. 2—BLOCK DIAGRAM of the Music Vision circuit. An audio signal is processed into two components that are then digitally sampled and stored in a video RAM. The video RAM is periodically read and erased in synchronism with video frame scanning. The resulting serial video data is combined with colorburst and sync signals to generate an NTSC composite output.

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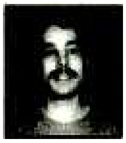

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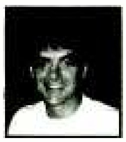

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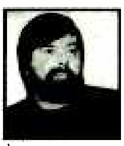

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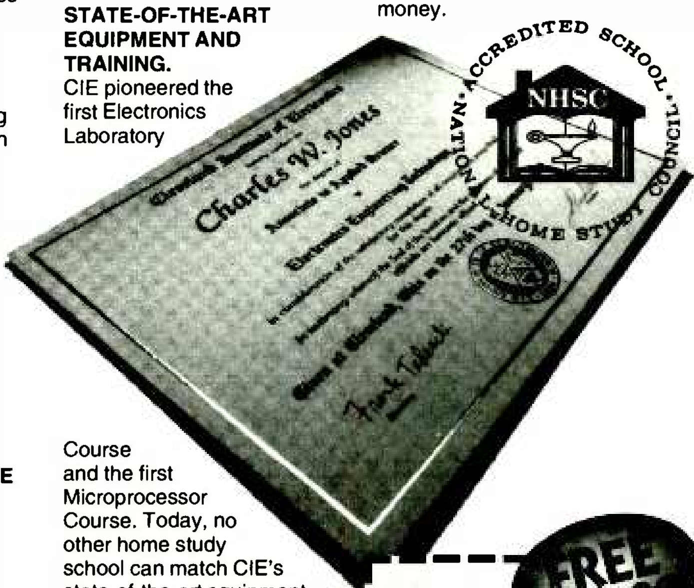

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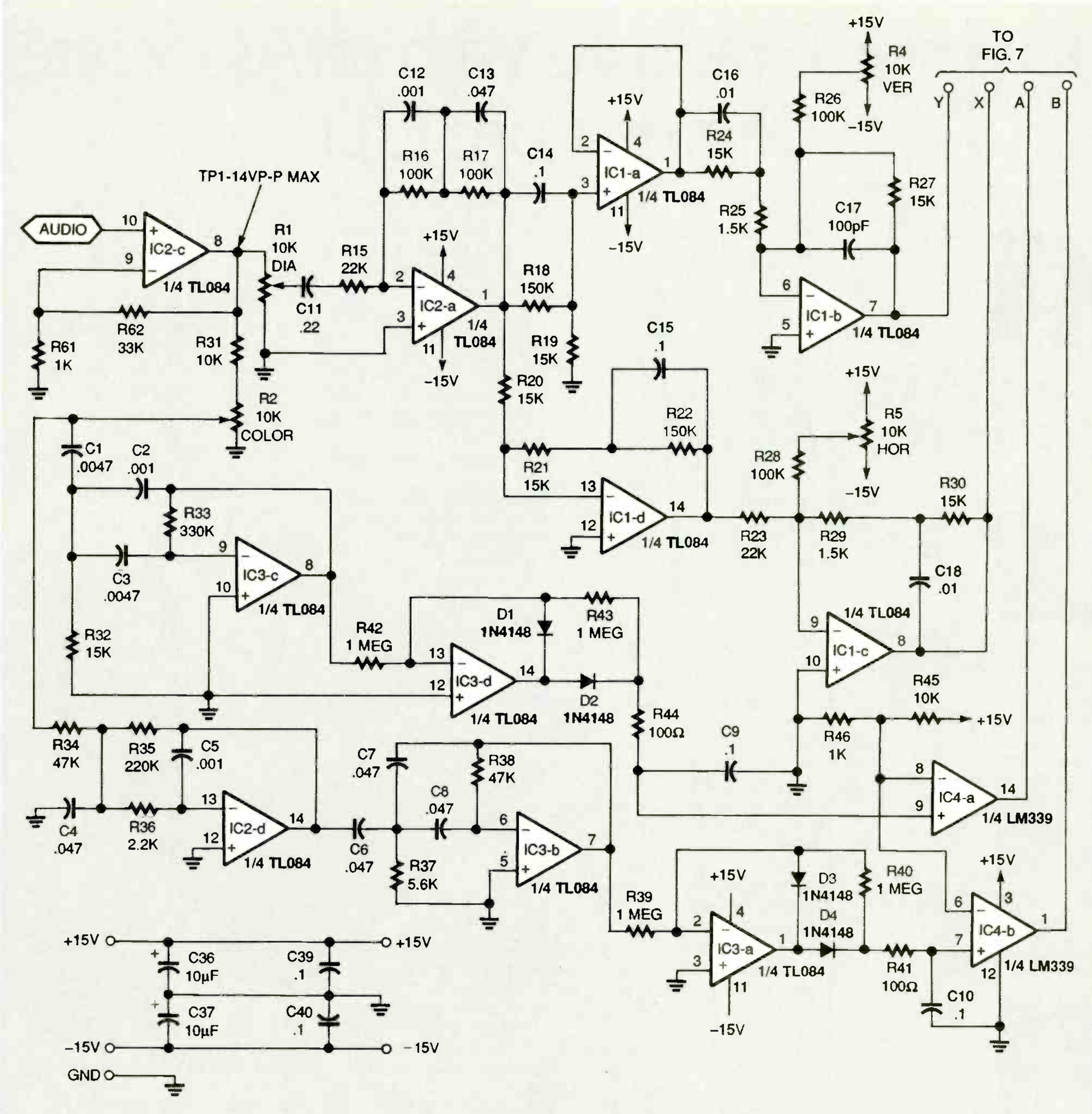


FIG. 3—MUSIC VISION SCHEMATIC. Analog filter circuits provide the audio frequency encoder and quadrature filter functions.

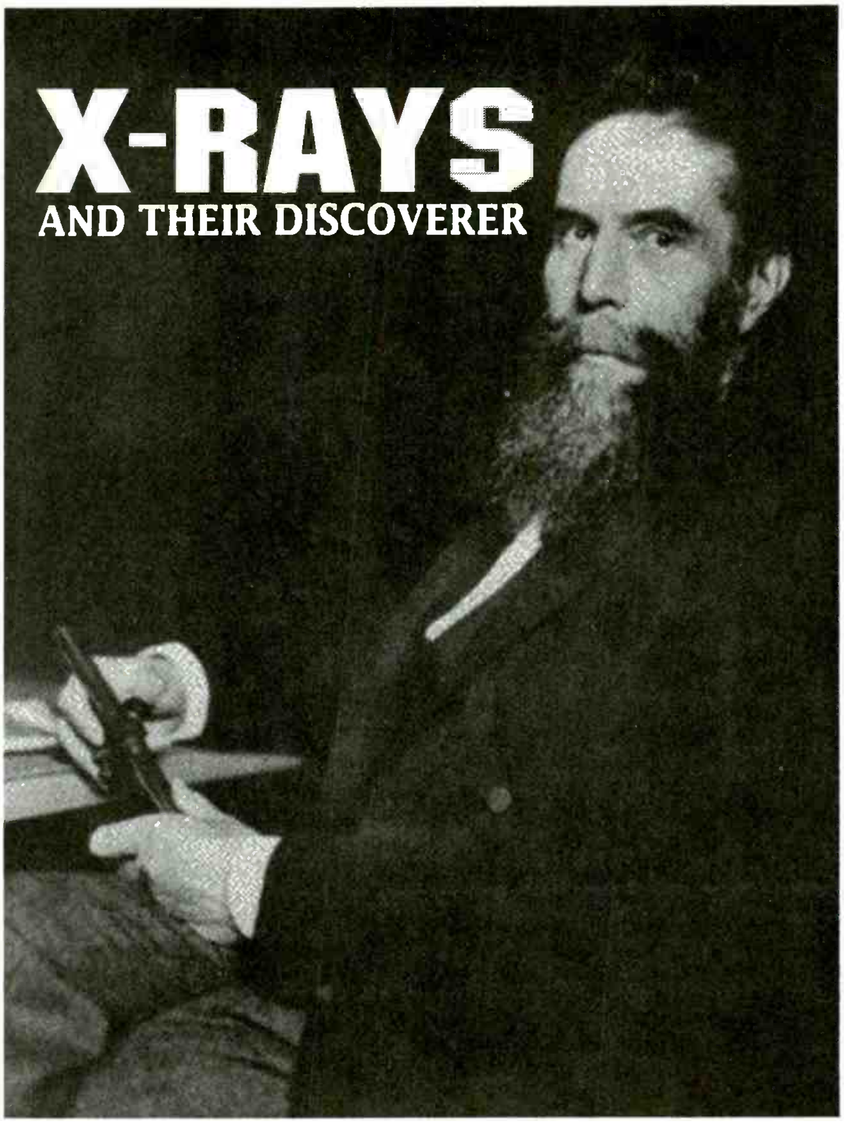
trates the correlation between displayed pattern color and signal frequency. The four colors are controlled by the 2-bit digital output from frequency encoder comparators IC4-a and -b. Each comparator monitors the output of a separate audio signal level detector circuit (IC3-a or IC3-d). The detector circuits are driven by two separate audio filters. Op-amp IC3-c is part of a 1-kHz high-pass filter, and op-amps IC2-d and IC3-b form a bandpass filter by cascading a 200-Hz high-pass filter with a 1-kHz low-pass filter.

Superimposed frequency responses of both filters are shown in Fig. 5. By properly adjusting the color threshold potentiometer R2, the corresponding progression of pattern colors encoded by logic signals A and B can be obtained. Only one color can be displayed at any given instant. This is based on the instantaneous combination of dominant frequencies present in the audio signal. However, due to TV image persistence and the rapid time-varying frequency content of most music, the illusion of multiple simultaneous colors is produced.

The schematic diagram in Fig. 6 shows the automatic level control circuit. Its sole function is to maintain a pattern-filled TV screen over a wide range of input signal levels. Line-level audio signals from a stereo system are isolated by the 1-megohm summing resistors R12 and R14. Left and right

Continued on page 133

X-RAYS AND THEIR DISCOVERER



A hundred years have passed since Wilhelm Konrad Röntgen discovered X-rays, but new applications in science, medicine, electronics and industry continually still keep popping up.

LUTHER STROUD AND NEIL SCLATER

"HUNCH YOUR SHOULDERS FORward, take a deep breath—and don't breathe or move! Ready?" This is what you hear from your physician or a technician before the buzz and click that tells you invisible rays have passed through your body and impinged on photographic film. Having X-ray pictures taken at a physician's or dentist's office is the way most people are deliberately exposed to this high-frequency radiation—and then for only a fraction of a second.

The large X-ray negative tells the physician a lot about your heart, lungs and other internal organs. No needles, tongue depressors, chest thumping, or other invasive procedures. And it tells a lot about the properties of X-rays—their ability to penetrate cloth, paper and flesh to reveal, in shadowy outline, the presence of disease, the location of bone fractures or the presence of foreign bodies.

But there is nothing new here, you say, you knew all this. Most of us take the X-ray exam for granted, and could not visualize modern medicine without it. So why raise the subject at this time? The answer is that X-rays were first discovered, quite by accident, one hundred years ago this month.

What is more, the role for X-rays is still expanding from its original—and perhaps still most important one— in medical diagnostics. However X-rays are also used to treat cancers, analyze materials, detect contraband, inspect the quality of welds, and even reveal more about the universe. Although still in the experimental stage, X-ray lithography holds promise for sub-micrometer, high-density integrated circuit fabrication. And, don't forget the X-ray television and X-ray lasers.

Serendipitous discovery

On November 8, 1895, physics professor, Wilhelm Konrad Röntgen (often Anglicized to Roentgen) (1845 - 1923), was working in his laboratory at the Physical Institute at the University of Wurzburg, Germany, trying to duplicate and understand the results of experiments done by others in the emerging field of electrical conduction through a vacuum or gas.

Professor Röntgen knew what the others had accomplished, and he had all of the apparatus needed to permit him to duplicate their findings. Fortunately for science, medicine, and mankind, he was a trained scientist who quickly recognized the value of his discovery and lost no time in trumpeting it to the world. But before saying more about how Dr. Röntgen discovered, X-rays, the work of the other scientists, principally English and German, should be put in perspective so you can appreciate the fortuitous circumstances surrounding his discovery.

Perhaps you recall reading about Heinrich Geissler (1814 - 1891), a German instrument maker, master glass blower, and physicist from the article "Seeing the Unseen" in the October 1995 *Electronics Now*. In the 1850s Geissler invented a gas-filled, light-emitting tube that produced a controlled, continuous source of bright light. He accomplished what he set out to do—develop a source of continuous light for spectroscopy, but later it was found that his tube could be pulsed. It became the ancestor of the modern flashlamp.

Geissler also contributed to the development of the modern vacuum pump, necessary equipment for evacuating closed tubes for all experiments in electron conduction through vacuum and gas tubes. About that same time, the English physicist Michael Faraday (1791-1867), best known for his pioneering work in electromagnetic induction and the discoverer of the basic principles of the electric motor, was also investigating electricity in gas-filled tubes.

Others active in the field at the time were the German physicists Johann Wilhelm Hittorf and Julius Plucker. Hittorf named the mysterious flow of electricity in tube "cathode rays," but we now know that they were really streams of electrons. During the next 20 years Plucker, Hittorf, and others in Germany revealed most of the important characteristics of ionized gas and cathode rays.

To carry out their experiments, those scientists needed power supplies. Most started off by wiring large batteries in series, and some even tried friction machines. Eventually they turned to the battery-powered induction coil. It was compact, portable, and easily controlled by a switch in the primary circuit. During the 1850s, another German instrument maker, Heinrich Ruhmkorff, improved the coil by separating the primary and secondary coils with a glass bobbin. Later interrupters, formed by moving wires in and out of a mercury pool, were installed for switching the primary windings.

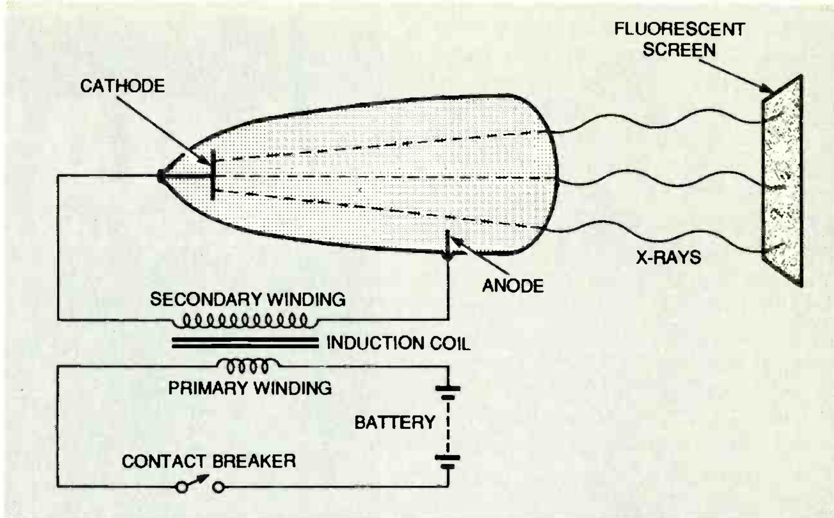


FIG. 1—A CROOKES tube with a power supply consisting of a battery and a coil. X rays emitting from the right end of the tube will cause a screen coated with barium salts to fluoresce.

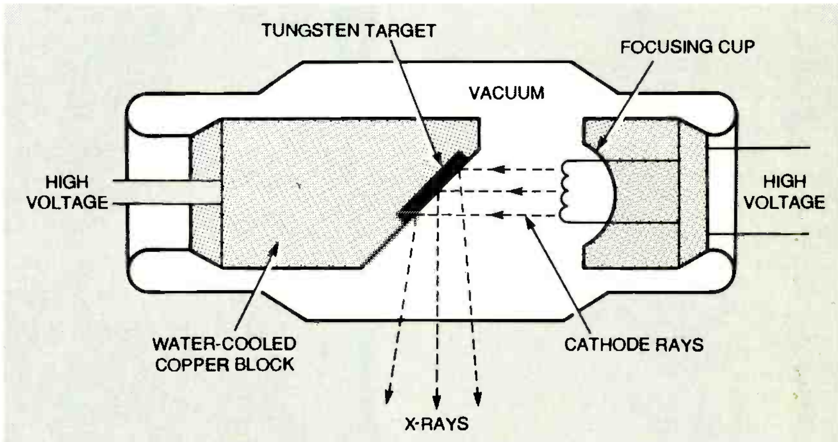


FIG. 2—A MODERN X-RAY TUBE contains a heated cathode that emits electrons and a tungsten anode. The X rays are focused by the bevel to the side of the tube. A heavy water-cooled radiator dissipates the heat generated by electron bombardment.

In 1875 the English physicist, Sir William Crookes (1832 - 1919) improved on the Geissler tube, and in 1879 he demonstrated peculiar glow phenomena by passing current through a cathode tube that contained traces of gas. Crookes found that if the air pressure in the tube is reduced by a vacuum pump to about 1 centimeter of mercury, a thin bright streamer can be seen between the anode and cathode of the tube. Its color depends on the gas in the tube.

As the pressure is lowered further, the streamer is replaced by a bright column of light filling the whole space between the electrodes. This was the stage reached in Geissler tube and in modern neon and argon lamps. If the pressure is reduced further to about 1 millimeter of mercury, the positive space shrinks and dark spaces appear.

Finally the column disappears entirely, and the pressure at about 0.001 millimeter of mercury the walls of the tube glow with a greenish light (*fluorescence*). Crookes did not know it then, but this stage must be reached to cause X-ray radiation. The phenomena pro-

Continued on page 140

HIGH-POWER HI-FI AUDIO AMPLIFIER

This powerful stereo amplifier offers outstanding performance.

REINHARD METZ AND MYZIL BOYCE

THIS IS THE SECOND PART OF THE article on the construction of a high-performance, lightweight, stereo amplifier for the demanding audiophile that can be built for less than $500 in parts. It outperforms factory-built units costing up to ten times that amount and is comparable to top-of-the-line commercial products. It can be packaged for home installation or as a more rugged portable version for sound reinforcement in halls and theaters.

The first part of this article published last month covered the building of two amplifier channel circuit boards and one switching power supply board that include most of the circuitry for this amplifier. It also explained the winding of two custom transformers.

This second and final part covers the construction or purchase of a suitable metal case as determined by the reader's packaging preference—home or portable stereo amplifier. It also covers the mounting and wiring of all off-board components, the matching of output MOSFETs, and the test procedures that apply to both versions.

Case options and packaging

There are two options for packaging this amplifier: The version for home use will be enclosed in a case that is cooled by convection, conduction and radiation. However, the portable version will be enclosed in a case cooled by two muffin-type DC fans. The dimensions of the two cases differ as does the placement of the three circuit boards within them.

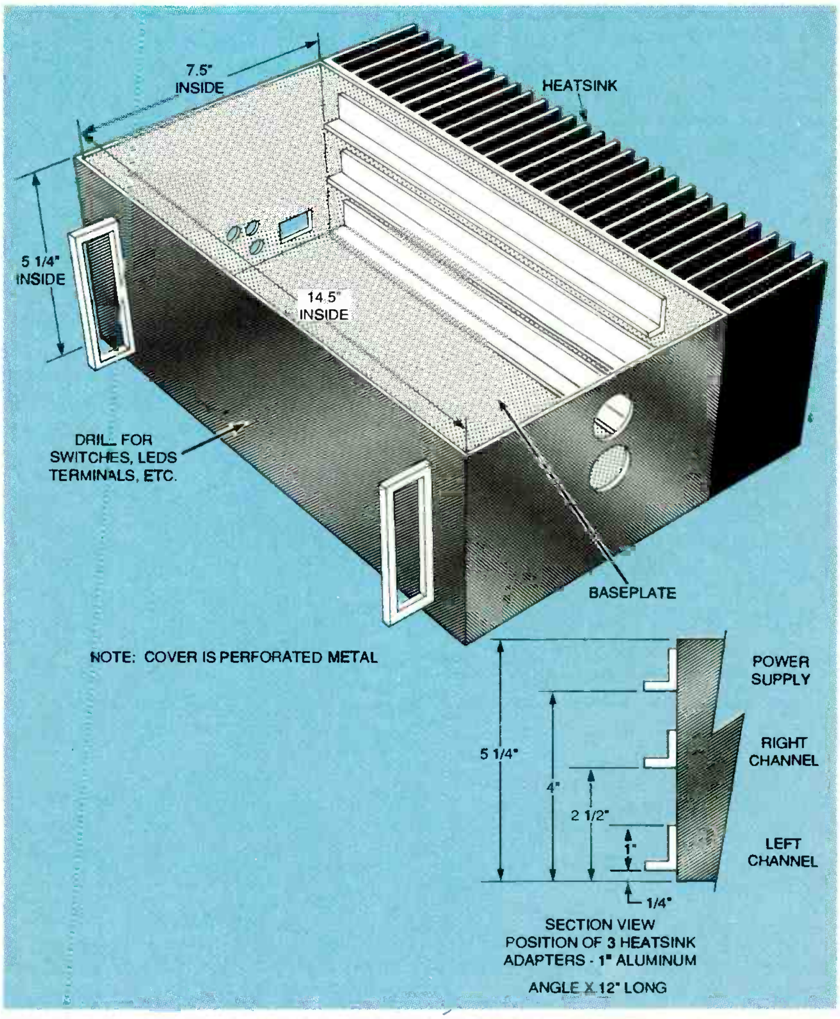


FIG. 7—INSIDE CASE DIMENSIONS FOR THE HOME AMPLIFIER. These minimum inside dimensions are given for a case to be made by you or purchased. The locations for mounting the three aluminum heatsink adapters are also given.

PARTS LIST—AMPLIFIER BOARD

All resistors are ¼-watt, 1%, unless otherwise specified.
R1, R73, R74, R75, R76, R77—46,400 ohms
R2, R3, R60—2050 ohms
R4, R5, R8, R9,R26, R28—100 ohms
R6, R7, R10, R11, R38, R55—10,000 ohms
R12, R13—33.2 ohms
R14—162 ohms
R15, R16, R20, R21, R23, R29, R30, R31, R32, R45, R47,R49, R50, R52, R56—1000 ohms
R17—402 ohms
R18, R43—10,000 ohms, trimmer potentiometer, PCB mount, top adjust Clarostat 408N103
R19, R22, R46, R48, R78—5110 ohms
R24—20,000 ohms
R25, R27—330 ohms, 3 watt, 10%
R33, R34—2000 ohms, 5 watts, 10%
R35—50 ohms
R36—1500 ohms, 2 watts, 10%
R37—5110 ohms, ½ watt, 10 %
R39, R40, R44, R51, R57—825,000 ohms
R41—46,400 ohms
R42—402 ohms
R53, R54—510 ohms, 1 watt, 10 %
R58, R59—15,000 ohms
R61, R62, R63, R64, R65, R66, R67, R68, R79, R80—200 ohms
R69, R71—1210 ohms
R70, R72—27,400 ohms
R79, R80—200 ohms (optional)

Capacitors
C1—10μF, polyester film
C2, C6—150 pF ceramic monolithic
C3, C4—100μF, 50 V, aluminum electrolytic
C5—0.1μF,50V, polyester film
C7,C20, C23, C24—82 pF ceramic monolithic
C8, C9—0.22μF, 50 volts polyester film
C10, C16, C17—10μF, 25 volts aluminum elecrtrolytic
C11—10μF, 35 volts aluminum electrolytic
C12, C14—0.1μF,100 volts polyester film
C13, C15—100μF 100 volts, aluminum electrolytic
C18—1500 pF ceramic monolithic
C19—1μF, 25 volts volts, aluminum electrolytic
C21, C22—0.01μF, 50 volts, polyester film

Semiconductors
D1, D2, D12, D13, D14—1N4002 silicon diode
D3, D4— 1N4728A silicon diode, 3.3V
D5, D6, D10, D11, D15—1N4742A silicon diode,12 V
D7, D8—1N4744A, silicon diode, 15V
D9—1N4740A silicon diode, 10V
LED 1, LED 2, LED 3—light-emitting diode T-1-3/4, red or green
Q1, Q2, Q6, Q8, Q9, Q10, Q11, Q14—NPN transistor, Motorola MPSA06, or equiv.
Q3, Q4, Q5, Q7, Q12, Q13, Q15—PNP transistor Motorola MPSA56, or equiv.
Q16, Q17, Q18, Q19—P-channel, depletion mode MOSFET, International Rectifier IRFP9240 or equiv. (Q26 optional—see text)
Q20, Q21, Q22, Q23—N-channel, depletion-mode MOSFET, International Rectifier IRFP240 or equiv. (Q27 optional—see text)
Q24—N-channel MOSFET, depletion mode, International Rectifier IRF510 equiv.
Q25—VN0610LL N-channel MOSFET switch (TO-92) Motorola or equiv.
IC1, IC2—LM334Z constant-current source, National or equiv.
IC3—LM339AN quad comparator, National or equiv.
IC4—LF411CN JFET input op-amp Texas Instruments or equiv.
IC5, IC6—LF357N JFET input op-amp, National or equiv.
IC7—LM358 dual low power op-amp National or equiv.
IC8—LM317T medium-current, three terminal adjustable positive voltage regulator, Motorola or equiv.
IC9— LM337M medium current,3-terminal adjustable negative voltage regulator, Motorola or equiv.

Other components
F1, F2—fuse, 10 A
J1—jack, RCA-style
J2—jack, ¼ inch Rean No. 550-20301 or equiv.
RY1—relay, PCB, Potter & Brumfield T90N5D12-12 or equiv.
S1—switch, DPDT, E-Switch TA2EECAU or equiv.
TC1—thermostat, 80°, Airpax 67F080 or equiv.

Miscellaneous (amplifier board): amplifier circuit board, two heatsinks for TO-220 devices, five dual screw terminal blocks, OST, Inc. No. 16 and No. 18 insulated hookup wire, solder

Miscellaneous (packaging) case with perforated metal cover (selection optional); heatsinks (for the convection-cooled version—one aluminum-finned 14×3×¼-inches, EG&G Wakefield No. 510 (for fan-cooled version, two finned aluminum finned 12×3×3¼-inches, EG&G Wakefield 510 (cut in half lengthwise); three 1×1×12-inch aluminum angle sections; power cable, two tubeaxial muffin-type DC fans, 3.5-inch diameter (60 to 80 CFM),(Optional); 120 VAC, 3-pin power jack; power switch, 20 ampere, panel mount, No.18 AWG insulated hookup wire, flat ribbon cable, No. 28 AWG; mica thermal-conducting washers; assorted nuts, bolts, lockwashers; silicon grease, mica thermal-conducting insulators for TO-220 cases, solder.

Note: The following options for parts are available from A and T Labs, Box 4884, Wheaton, IL 60189
- **Amplifier printed circuit board for one channel, double-sided, plated-through holes, silk screened, solder masked (two required) (K6PCB1)—$39.00**
- **Switching power supply board,double-sided, plated-through holes, silk screened, solder masked (one required) (K6PCB2)—$42.00**
- **Switching power supply power transformer(K6T4)—$52.00**
- **Switching power supply driver transformer (K6T2)—$15.00**
- **Power supply inductors L1, L2, and L3 (K6L)—$32.00**
- **Heatsink set for convection-cooled case (K6HS1)—$110.00**
- **Heatsink set for forced-air cooled case case (K6HS2)—$110.00**
- **Set of 8 matched MOSFETs for 1 amplifier channel (K6Q)—$90.00**

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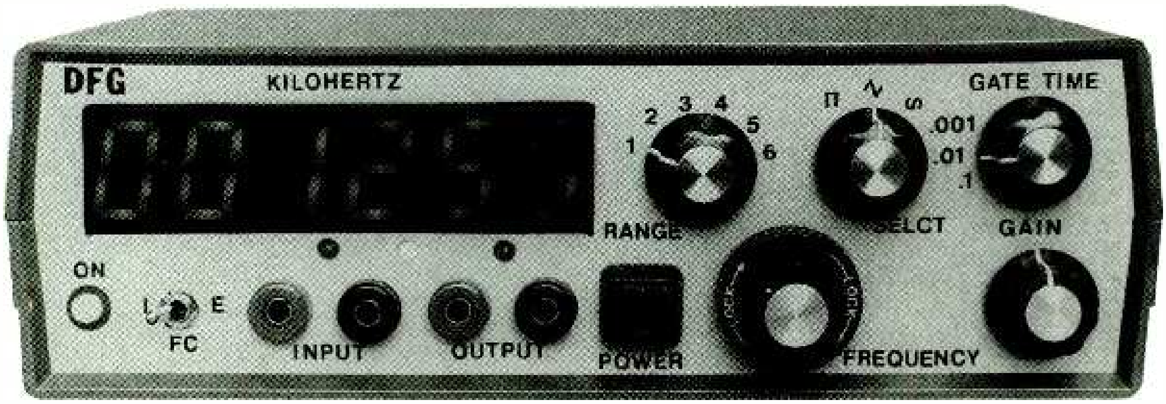
Figure 7 is the outline drawing of the home or convection-cooled case, giving its minimum inside dimensions, and Fig. 8 is the assembly drawing of this version showing the arrangement and orientation of the three circuit boards. It provides basic information on the mechanical work required to mount the circuit boards, panel-mounted power switch, socket, LEDs, jacks and other components.

Figure 9 is an outline drawing similar to Fig. 7 for the forced-air cooled, portable case giving

Continued on page 143

BENCHTOP FUNCTION GENERATOR



Build this digital function generator that produces square, sine, and triangular waves from 0.1 Hz to 1 MHz, for a fraction of the price of a commercial unit.

CARL J. BERGQUIST

AVOID THE HIGH PRICES OF MOST off-the-shelf commercial test equipment by building your own instruments whenever possible. Factory manufactured instruments certainly perform well—the equipment on the market today offers so many accessories and features that further improvement seems almost impossible. However, for most experimental and hobby test and measurement applications, many of those extras are just not necessary. So unless you're planning to start your own repair service, the cost of those commercial instruments is hard to justify.

Build this digital function generator that will produce square, sine, and triangular waves from about 0.1 Hz to over 1 MHz, and display the output frequency on a digital readout. The digital display eliminates the tedious task of calibrating a panel dial. And, with the flick of a switch, the display section can function as an independent frequency counter. This is a handy feature for quick measurements or in situations where more than one counter is required. Best of all, however, is that the function generator will do all this at a fraction of the cost of commercial units.

Circuit operation

Figure 1 is the schematic diagram of the function generator circuit. The heart of the circuit is IC1, an Intersil/Harris ICL8038 VCO/precision waveform generator. This chip, plus a handful of discrete components, produces square, sine, and triangle waveforms. The 8038 is configured as a voltage-controlled oscillator (VCO), with its frequency determined by resistor network R1 and R2 and one of the range capacitors (C2 to C7).The signal shape (sine/triangle/square) is selected by switch S2, the frequency range by S1, and the exact frequency is set by R1. Notice that R1 is a 10-turn, panel-mount potentiometer with a locking feature. This feature allows for a more precise frequency setting and lets you "lock in" the frequency.

The output of the generator is tied to both a signal terminal via gain-control R4 and to the clock input of IC3, the first of six CD4026B decade-counter ICs that make up the frequency counter section of the circuit. The 4026's can drive seven-segment LED displays directly, thus reducing parts count. Counter/divider IC3 divides the input signal by 10, passes the result on to IC4, and sends the remainder to the display. The six counters are cascaded, with the divide-by-10 output of one connected to the clock input of the next counter/divider, in turn.

While this circuit has six divider stages, as many digits as desired can be added. With a six-digit display, the maximum reading can be 99999.9, 9999.99, or 999.999 kHz, depending on the value of the time-sampling capacitor. The advantage of using the 4026's is that each digit is independent, and whether the display requires two digits or twenty, they are easily obtained by cascading

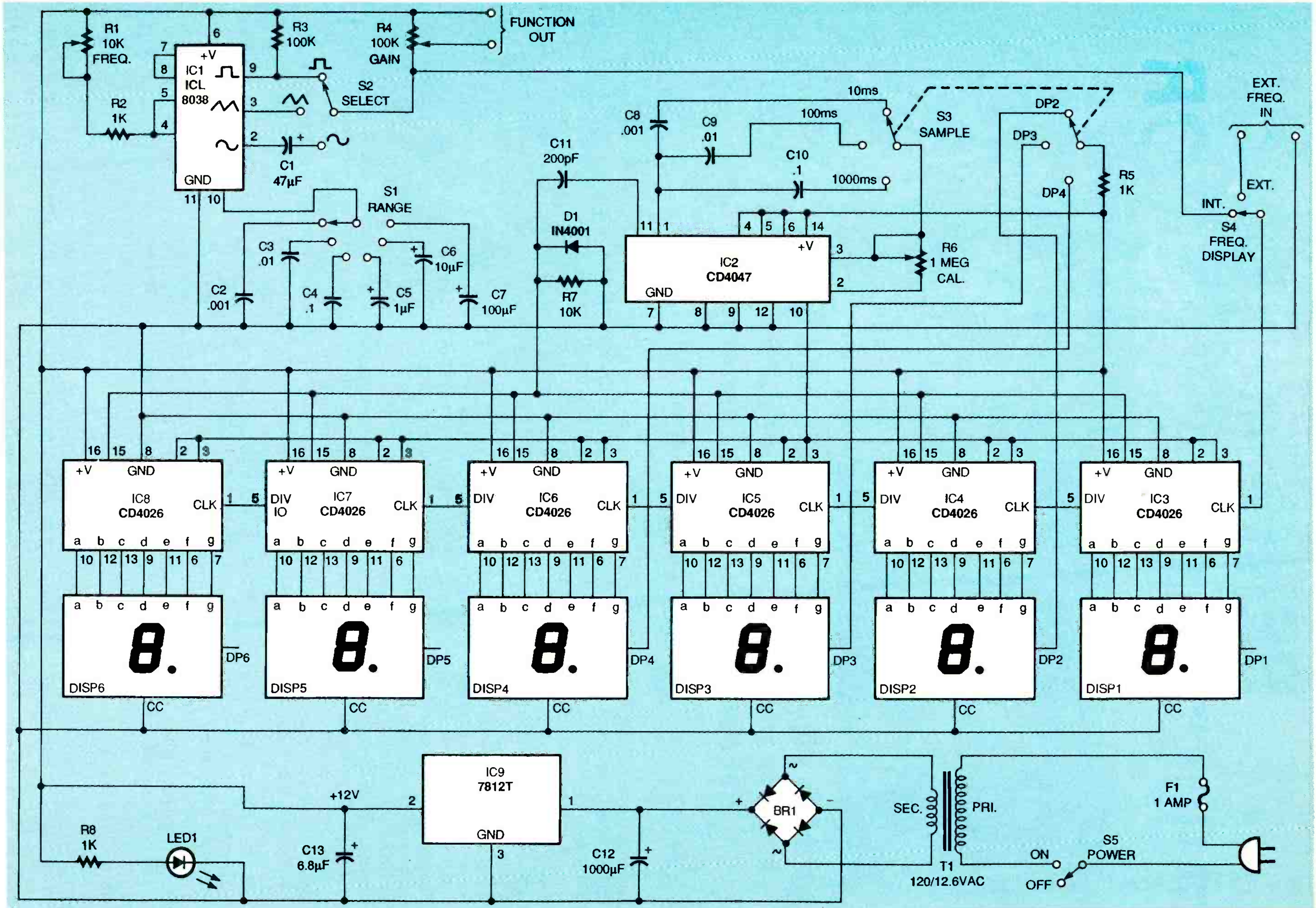


FIG. 1—FUNCTION GENERATOR SCHEMATIC DIAGRAM. The heart of the circuit is IC1, an Intersil/Harris ICL8038 VCO/precision waveform generator.

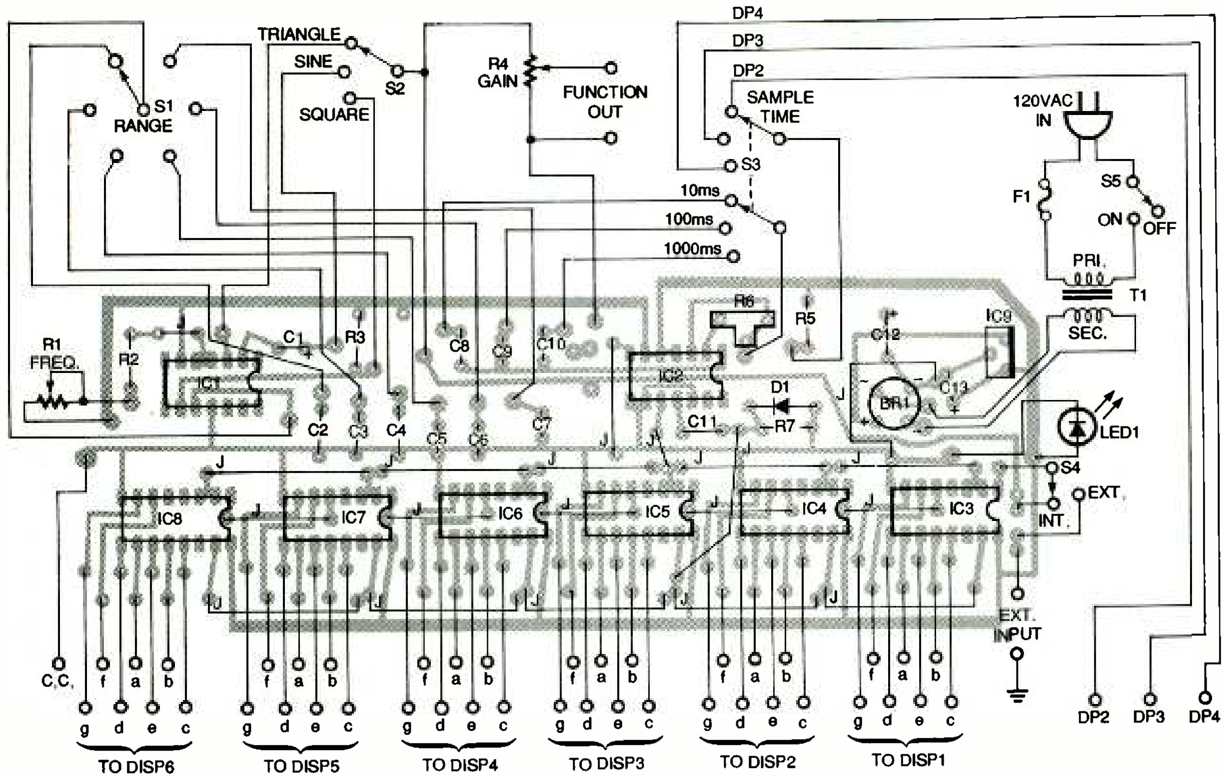


FIG. 2—MAIN BOARD PARTS-PLACEMENT DIAGRAM. Notice that the jumpers from pin 5 of one 4026 to pin 1 of the next run under the IC sockets.

the 4026s. A six-digit display allows readings up to one megahertz at the lowest gate time, with a resolution of thousandths of a kilohertz.

The CD4047B monostable/astable multivibrator (IC2) provides the sample or gate time for the frequency-counter circuit. One of the capacitors C8, C9, or C10, in conjunction with R6, forms the RC timing network. If C8 is selected, the resolution is in tenths of a kilohertz, and the sample time is set at 10 milliseconds. Capacitor C9 increases the sample time to 100 milliseconds and the resolution to hundredths of a kilohertz, while C10 provides thousandths of a kilohertz resolution with a one-second sample interval.

If resolution to ten thousandths of a kilohertz is needed, a one-microfarad capacitor can be switched in, but the sample time will increase to 10 seconds. An additional disadvantage to using the higher gate times is that the display will flash at a rate of about 3 Hz. The reading is valid and easily comprehended, but some people find the flashing display annoying. Notice that one pole of DP3T switch S3 selects the capacitor, and the second pole controls the position of the decimal point.

Except for the transformer, the power supply is built on the PC board. The power supply circuit is based on an LM7812 12-volt regulator IC that is well suited for this application.

Building the generator

Printed circuit boards were used in building the prototype, although other techniques such as point-to-point wiring will work just as well. One PC board contains the main circuitry, and the three 2-digit LED display modules are mounted on a second board. The two boards are interfaced with either 42-conductor ribbon cable or 42 individual leads; the display is not multiplexed, so each of the segments will require a separate wired connection.

Figure 2 is the parts-placement diagram of the main board. First install all jumper wires and then the IC sockets. (Notice that the jumpers from pin 5 of one 4026 to pin 1 of the next run under the IC sockets.) Next install the discrete components, observing the polarity of C1, C5 to C7, and D1. Last, solder hookup wire of appropriate lengths for the panel-mounted switches, audio output, signal input, and potentiometers.

Now apply +12 volts DC to the power connection points, and with a voltmeter check pin 6 of the 8038, pins 4, 5, 6, and 14 of the 4047, and pin 14 of the 4026s for +12 volts. If that voltage appears where it should, install the ICs in the sockets and set the board aside.

Figure 3 is the parts-placement diagram of the display board. If you plan to use sockets for the displays, insert and solder them first. Mounting the seven-segment displays in sockets allows for easy changes in the type or style of display, and easy replacement of faulty units. If sockets are not used.

PARTS LIST

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

R1—10,000 ohms, 10-turn locking potentiometer
R2, R5, R8—1000 ohms
R3—100,000 ohms
R4—100,000 ohms, panel-mount potentiometer
R6—1 megohm, PC-mount potentiometer
R7—10,000 ohms

Capacitors

C1—47 µF, aluminum electrolytic
C2, C8—0.001 µF, polyester
C3, C9—0.01 µF, polyester
C4, C10—0.1 µF, polyester
C5—1 µF, tantalum electrolytic
C6—10 µF, tantalum electrolytic
C7—100 µF, aluminum electrolytic
C11—200 pF, ceramic disc
C12—1000 µF, aluminum electrolytic
C13—6.8 µF, tantalum electrolytic

Semiconductors

IC1—ICL8038 VCO/precision waveform generator (Intersil/Haris)
IC2—CD4047B CMOS monostable/astable multivibrator
IC3–IC8—CD4026B CMOS decade counter/divider
IC9—LM7812T positive 12-volt regulator
D1—1N4001 diode
LED1—Light-emitting diode, any color
DISP1–DISP6—Three MAN6740 dual-digit, 7-segment, common-cathode display module (National Semiconductor)
BR1—2-ampere bridge rectifier

Other Components

S1—SP6T rotary switch
S2—SP3T rotary switch
S3—DP3T rotary switch
S4—SPDT toggle switch
S5—SPST toggle switch, 120-volts AC
T1—120-volts AC to 12.6-volts AC, 1-ampere power transformer
F1—1-ampere slow-blow fuse

Miscellaneous

PC boards, IC sockets, hookup wire, knobs, solder, instrument case, hardware, panel-mount fuse holder, linecord and plug, linecord grommet, LED holder, clear red display lens, input/output jacks

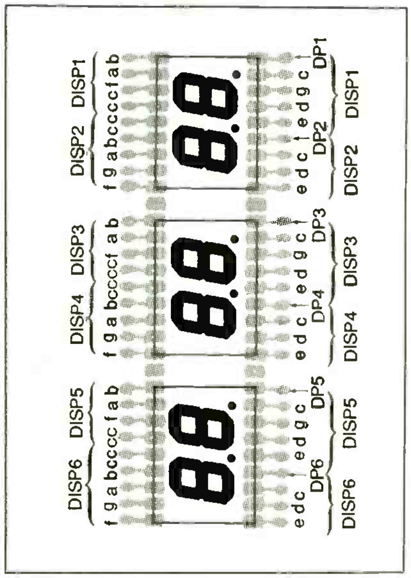


FIG. 3—DISPLAY BOARD parts-placement diagram. Solder lead wires to the appropriate pads for connecting the display board to the main board.

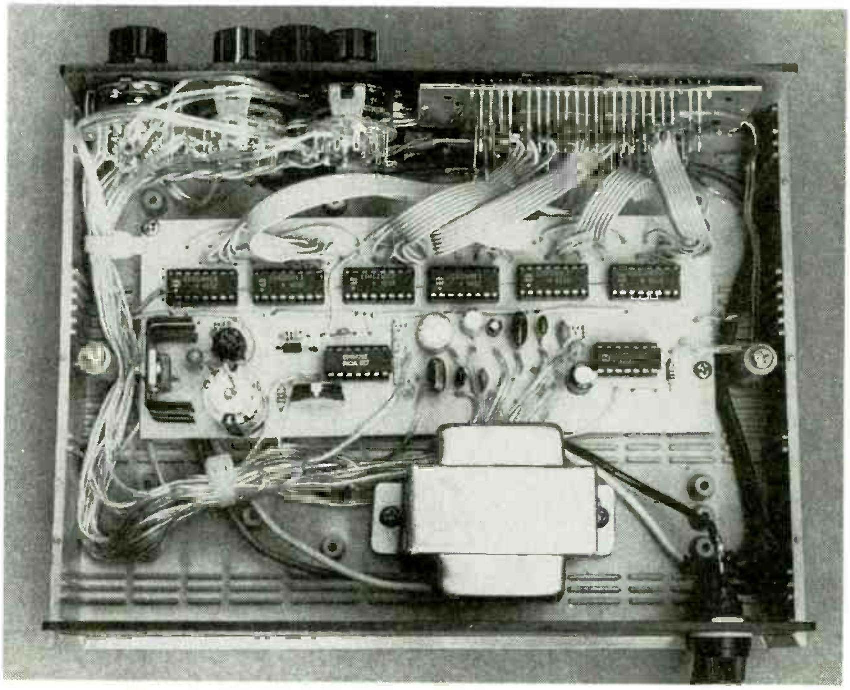


FIG. 4—THE INSIDE OF THE PROTOTYPE UNIT. The front panel was painted yellow so that black dry transfer lettering would be visible when applied.

then solder the display modules directly to the PC board. Also solder lead wires to the appropriate pads for connecting the display to the main board.

After both boards are completed, interface them with ribbon cable or hookup wire. Be sure to connect the display's common cathode bus to ground, and the second, third, and fourth decimal points to switch S3. The generator/counter can now be tested.

Apply power to the unit and a six-digit display should appear; if not, remove power and double check the wiring and component orientation. This procedure should locate the problem; if not, reconfirm the +12 volt DC connections. As a last resort, try replacing the ICs.

The prototype is housed in an 8- × 6½- × 2½-inch bench-style instrument case. If you use the same or a similar-size case as the prototype, lay out the holes for the controls and jacks in the same positions as on the prototype, or you can lay them out in any logical pattern. Drill the appropriately sized holes in the front panel to accommodate the switches, jacks, and potentiometers, and cut out a rectangular hole to accommodate the display. The prototype has banana jacks for its input and output connections, but you can use any style of jack that best suits your needs. Make sure the display cutout matches the chosen display modules. Drill holes in the rear panel for the fuse holder and linecord grommet.

The front and rear panels of the prototype case were molded in black plastic. Therefore, the front panel was painted yellow so that black dry transfer letter-

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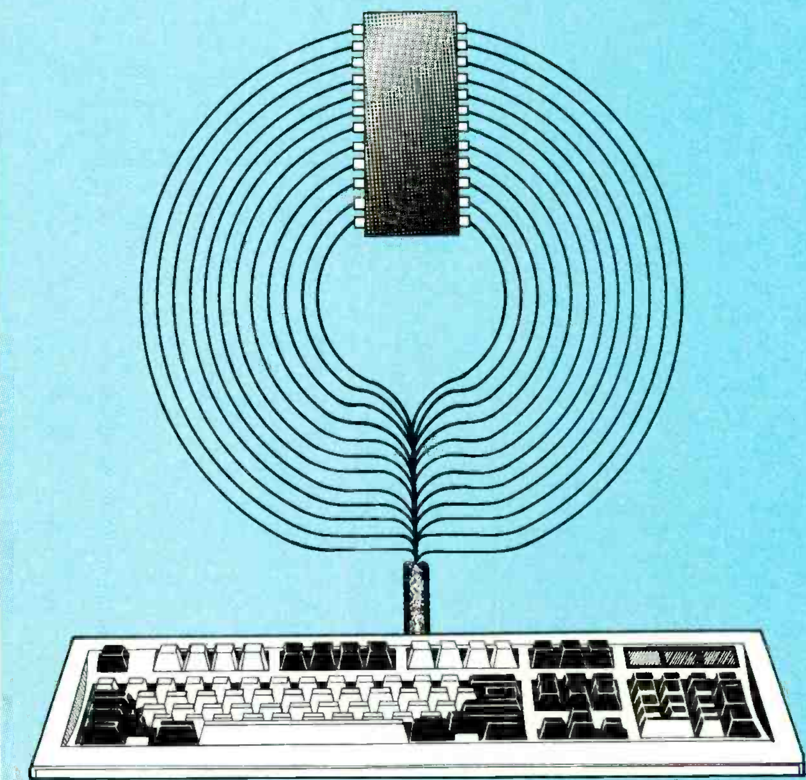
G. Y. XU

Low Cost EEPROM Programmer



Get a handle on your firmware with this low-cost EEPROM programmer.

FIRMWARE—HARDER THAN SOFTware, softer than hardware—is the lifeblood of both custom microcontrollers and embedded systems. Creating firmware—not writing the software, but programming in into the hardware—has traditionally been a headache. But no more. The EEP-1 programmer described in this article lets you program EEPROMs—electrically-erasable programmable read-only memories. The programmer is an easy-to-build, easy-to-use, yet powerful development tool for both professionals and hobbyists. It's built around an Intel 8031 microcontroller, requires just a few support ICs, and can be assembled for under $40.

The device can program both bipolar and CMOS versions of the most popular devices: 2K (2816 and 28C16), 8K (2864 and 28C64), and 32K (28256 and 28C256). In this article, both bipolar and CMOS memories will be referred to simply as EEPROMs, and the bipolar designations will refer to both types.

An interesting feature of the project is that it can be used to create its own control software. In other words, you can use EEP-1 to program an EEPROM, then let that EEPROM control the EEP-1! In addition, the EEP-1's PC-based control program can also create a disk file by reading the content of an EEPROM inserted in the EEP-1's programming socket.

This article presents complete plans for building the EEP-1, including schematic, parts list, and PC board patterns. In addition, the author is selling complete and partial kits of parts, PC boards, and software. To use the EEP-1, you'll need a PC with a free serial port and a standard 9-pin serial cable.

Circuitry and operation

The complete schematic appears in Fig. 1. In addition to the EEPROM being programmed, the circuit contains four ICs and a voltage regulator.

IC1 is a line-powered DS1275 RS-232 transceiver made by Dallas Semiconductor. The function of IC1 is to convert RS-232 signals to TTL levels, and TTL signals to RS-232 levels. The DS1275's transmitter operates by "stealing" power from the communication line, instead of relying on an internal DC source. Doing so eliminates the need for a ±12-volt supply, but there is a catch. When DC power is off and the communication link is still connected, the device could suffer internal latch-up, which could in turn lead to excessive current flow and device destruction. For that reason, Schottky diode D2 provides a conducting bypass. Since the forward conducting voltage of D2 is only 0.1 volt, it will be the first to conduct, thereby eliminating latch-up danger to the DS1275.

The heart of the programmer is IC2, an Intel 8031 microcontroller. It is an 8-bit device that can address 64K bytes of program memory and 64K bytes of data memory. The EEP-1 uses program memory to store its control program, and data-memory addresses for EEPROM programming. Capacitor C2 provides a power-up reset signal for the microcontroller, thereby initializing it into a known state. After reset, program execution begins at address 0000h.

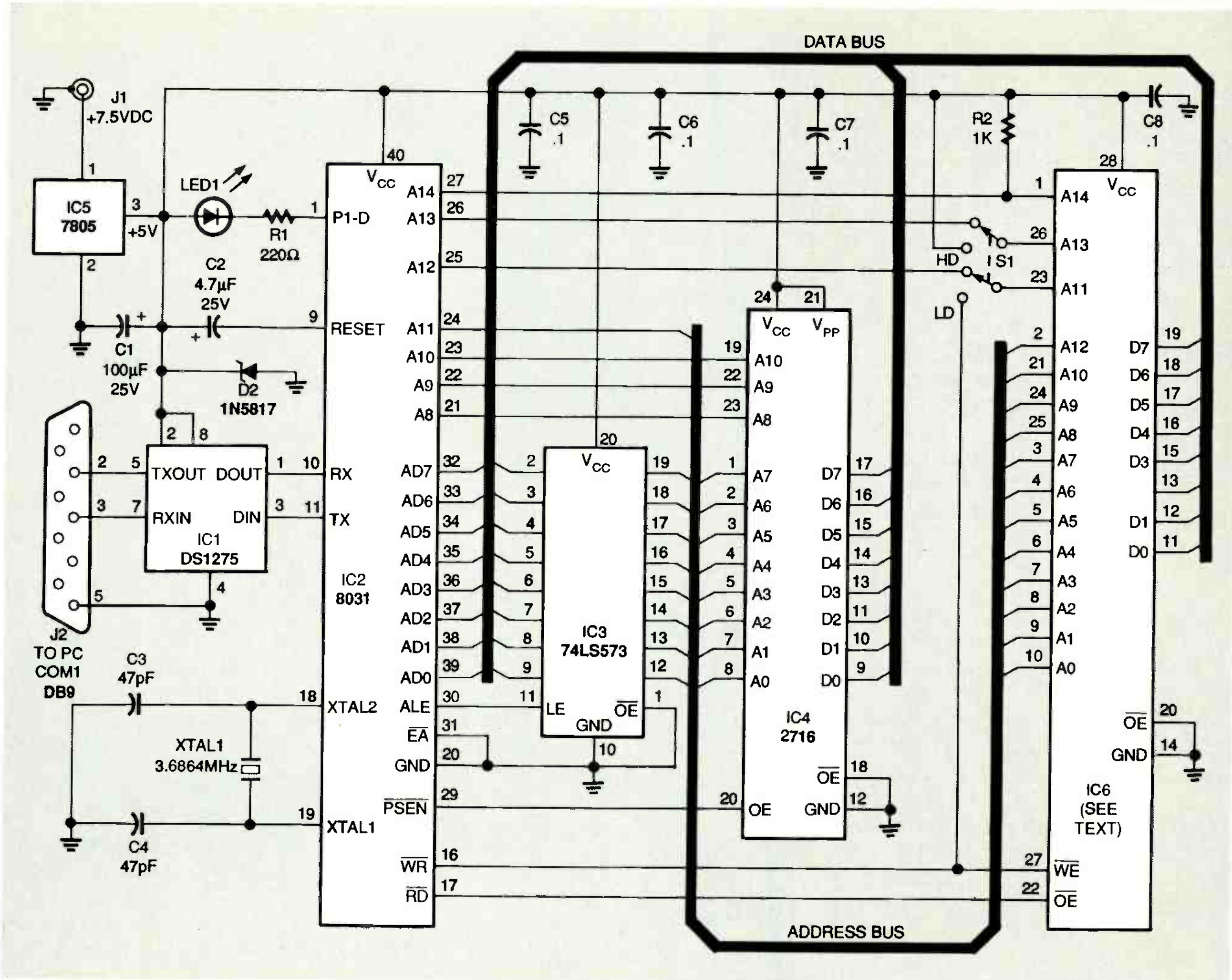


FIG. 1—COMPLETE SCHEMATIC of the EEP-1 EEPROM programmer, a low-cost way to create the firmware for your next microcontroller project.

The microcontroller's clock depends on crystal XTAL1 and capacitors C3 and C4. The clock frequency is 3.6864 MHz, which allows it to communicate with an IBM PC at 9600 bps. Communication occurs via the 8031's RX (receive) and TX (transmit) pins. In this configuration, only three lines are needed: receive, transmit, and ground. To simplify the connection, a straight-through 9-conductor cable with DB9 connectors on each end is used. With this cable, pin 2 at one end connects to pin 2 at the other end. The same is true of pins 3 and 5. The female end of the cable connects to the PC, and the male end to the EEP-1. An LED connected to the 8031's low-order output port provides a programmable system-status indicator.

The 8031 multiplexes its low-order address lines with the data bus. This means that pins 32 to 39 carry both addresses and data at different times. What IC3 does is latch the contents of those pins at the point during the CPU's machine cycle when they carry valid address information. Fortunately, the 8031's address latch enable (ALE) signal at pin 30 makes doing so easy, by using the signal to drive the latch-enable input of octal D latch IC3, a 74LS573. Later, when ALE goes low, pins 32 to 39 carry eight bits of data.

The system's control program is stored in IC4, a 2716 EPROM or 2816 EEPROM. The author used an EEPROM while developing the project, but switched to lower-cost EPROM for the finished product. Doing that is possible because the 2716 and 2816 are pin-compatible, except that pin 27 is the programming voltage input (V_{PP}) for the 2716, and the write-enable input ($\overline{WE}$) for the 2816. The good news is that for normal read operations, pin 27 can simply be tied high.

The EEPROM to be programmed must be inserted into the empty socket denoted by IC6. Switch S1 and resistor R2 adapt the circuit for different EEPROM types, as discussed next.

EEPROM type and selection

You might think that all EEPROMs are the same, but it's not quite that simple. For example, although all 2864's are 28-pin devices, the function of pin 1 varies by manufacturer. For example, on Xicor's X2864A,

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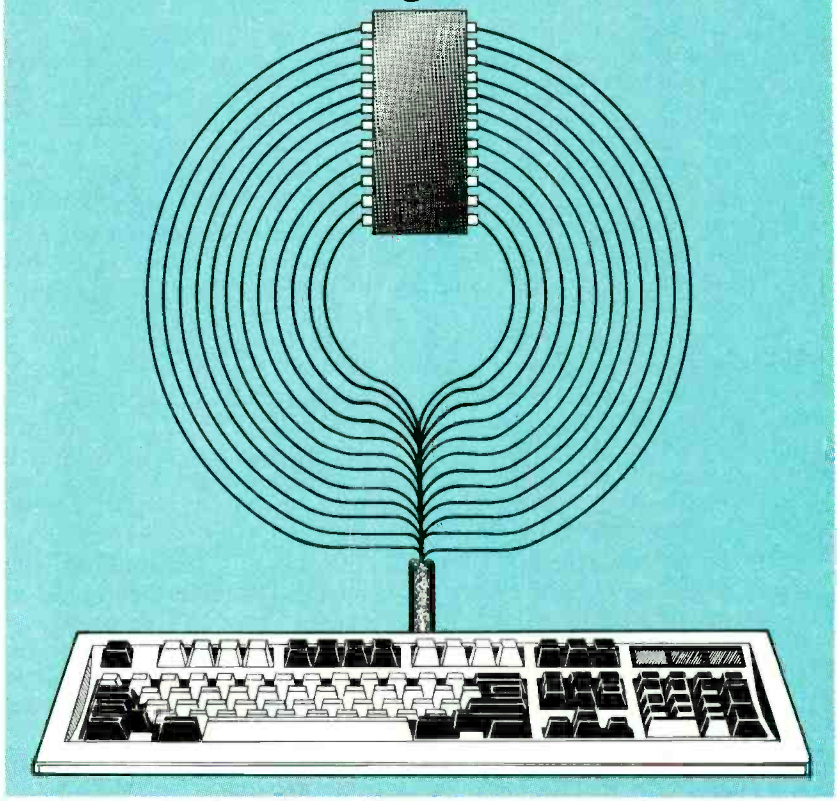
G. Y. XU

Five Easy EEPROM Projects



Put your EEPROM programmer to work.

LAST TIME PLANS WERE PRESENTED on how to build a $40 EEPROM programmer that, in conjunction with any standard PC, allows you to read and write popular 2K, 8K, and 32K EEPROMs. Now you'll see the value of having an EEPROM programmer by building five easy EEPROM-based projects.

To illustrate the variety of uses to which EEPROMs may be applied, the projects will function in a variety of environments: With an 8031 microcontroller, an 8085 microprocessor, a Z80 microprocessor, and in a "dumb" (no microcontroller or microprocessor) LED controller.

Projects I–IV are really variations on the same theme: Use one bit of a microcontroller or microprocessor to blink a discrete LED in one of several patterns. Project V shows how an EEPROM can be used as a data-storage device, thereby providing different display patterns on a seven-segment LED.

In addition to having some fun, you'll learn several things by performing these experiments. Probably the most important thing you'll learn are some of the tradeoffs among microcontrollers on one hand, and microprocessors on the other. You'll also learn about support circuitry required by various families, and about assembly-language programming. You will find the process of "learning by doing" to be highly effective in learning about both hardware and software aspects of the control world.

To perform the experiments, you'll need a modest investment in equipment: an EEPROM programmer (such as the EEP-1 presented last time), a 2816 EEPROM, a solderless breadboard, several assorted CPUs, and a few odds and ends (resistors, capacitor, crystals, etc.). You'll also have to create some software, but with the step-by-step directions given here, you should have no trouble.

Because each of the five projects is simple and self-contained, they are presented in a consistent format. Each project description contains an overview of the project, technical notes, a schematic, a parts list, and a program listing.

Software notes

Discussion in this section applies to all five projects. The executable programs and listings were created by several useful shareware products. Both are cross assemblers, which means that they run on one platform (PC compatible), but generate code for another (8031 etc.). One advantage of this type of cross assembler is that you can use one language to write programs for multiple CPUs. The disadvantage is that the code produced is typically less efficient than hand-tuned code written directly in a CPU's native language.

In some cases, highly efficient code is unnecessary; its only effect may be to increase development cost of a project. In other cases, such as communication drivers, highly efficient code is a must. One sign of the mature engineer is knowing when to apply various tradeoffs. But enough philosophy.

Specifically, A51.EXE is a code generator for the 8031/8051 line of microcontrollers, and TASM.EXE is a code generator for the 8085 and Z80 lines, as well as for numerous other microprocessors. Copies of both programs will be posted, along with the corresponding documentation files, on the Gernsback BBS (516-293-2283, v.32, v.42bis). Look for file ASMB.ZIP. In addition, EEPROJ5.ZIP on the BBS contains the source and binary files for the five projects. For more detailed and up-to-date information on the shareware assemblers, you may want to try the Signetics BBS (800-451-6644). If you end using any shareware program, be sure to pay the registration fee.

The general procedure for creating (or modifying) a program consists of three steps:

1. Type the source code into a plain ASCII file, using "ASM" as the file extension (e.g., TEST1.ASM). The documentation for the cross assemblers provides detail on available programming commands and the proper syntax for using them. By starting with the example programs, you should be able to pick up the language quickly.

2. Run A51 or TASM on the file. For example, executing "A51 LED1.ASM" will generate LED1.OBJ and LED1.LST. Executing "TASM -85 LED8085A.ASM" will generate LED8085A.OBJ and 8085A.LST. The "-85" tells TASM that the 8085 is the target microprocessor.

A word about file formats: An "OBJ" file is an Intel format hex file that contains an ASCII representation of the machine language generated by the cross assembler. The Intel hex format also includes error detecting information to help ensure file integrity. Most EEPROM and EPROM and plain old PROM burners accept data in the Intel hex format.

By way of contrast, an "LST" file is basically a reformatted version of the source code (the "ASM" file), along with the hex machine codes and hex addresses where they reside. In fact, the actual LST files from the example programs are printed along with this article.

3. Following the instructions supplied with your EEPROM programmer, burn the EEPROM with the OBJ file. Last, hook up the hardware and test it.

Creating a binary object file

Many EEPROM programmers accept the Intel Hex format files. But some do not; they instead expect raw binary files in which each byte of data is not an ASCII character, but rather an actual machine-language instruction (or data). The EEPROM programmer can handle both formats, but in case yours does not, here's how to create a binary image file from the LST file created by the assembler.

The procedure involves use of the DOS program DEBUG.EXE. Using Debug, you can create an arbitrary file of hex data up to 64K in length, or even more. The basic procedure is to invoke DEBUG, enter the desired hexadecimal data, specify in hex how many bytes to write, specify a file name, and then write the file to disk.

For example, to create an eight-byte file containing the values 00, 01, 02, ... 08 you would perform the steps shown in Listing 1. After starting the program, DEBUG's prompt is a hyphen. Press "?" followed by Return to see a list of Debug's single-letter commands. Unfortunately, for more information, you'll have to consult a third-party book or a DOS Technical Reference, available separately from Microsoft.

LISTING 1—CREATING A BINARY FILE

```
C:>debug (CR)+EP
-e 100 (CR)+EP
xxxx:0100 02.00 26.01 FF.02 77.03 02.04 8D.05 46.06 E0.07 (CR)
-n test.bin (CR)
-r cx (CR)
CX 0000
:8 (CR)
-w 0100 (CR)
Writing 00008 bytes
-q (CR)
```

To enter raw hex data, type "e" and an address, then press Return, shown here as (CR). Now you can enter hex data as pairs of ASCII characters. Press the space bar after each pair to move on to the next, or press Return to terminate data entry mode.

The four "x" characters preceding the address in Listing are arbitrary values, and will vary from machine to machine, even session to session. Those values represent the Intel memory segment, but for programs and data smaller than 64K, the segment address is irrelevant.

Next name the file using Debug's "N" command. Then specify the file length by inserting the proper value into the CPU's CX register. Next write the file to disk using Debug's "W" command, and exit using "Q." Verify that the file exists using DOS's DIR command; then reload the file into DEBUG by using the file name you specified as a parameter when you start DEBUG:

C:>DEBUG TEST.BIN

Then display the contents of the file using the "D" command. If all has gone well, the first eight bytes of the listing should contain the values you typed in.

Now let's look at the projects themselves.

Project I

In this project, the least significant bit (LSB) of an 8031/8051 microcontroller controls a single discrete LED. When the LSB goes low, the LED turns on; when the LSB goes high, the LED turns off. To make things a little more interesting, the software performs a two-second delay after each transition of the LSB.

Figure 1 shows the complete schematic; it doesn't get much simpler than that! The three major components are the microcontroller (IC1), low-order address latch (IC2), and external program memory (IC3). Note that for the 8031 to use external program memory, its $\overline{EA}$ pin must be tied to ground. In addition, to read data stored in the EEPROM, the microcontroller's $\overline{PSEN}$ (program storage enable)

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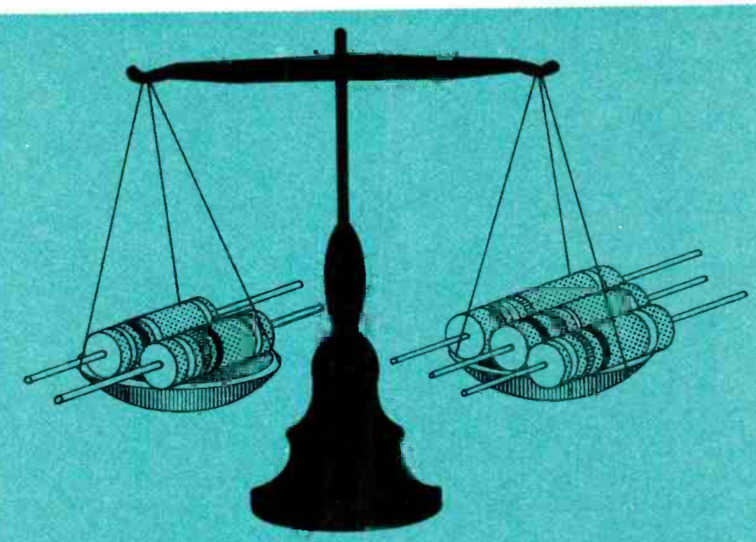
RAY MARSTON



BRIDGES: Matching Resistors and Capacitors

Learn about special resistance and capacitance bridges and substitution boxes.

THIS THIRD ARTICLE IN A SERIES ON measurement bridges is about special bridges that might not be known to all readers. However, the article includes schematics building some of these resistance-matching and ratio-matching bridges. They will give you an opportunity to learn about those bridges and then, after you build the circuits, you can match or duplicate resistors within a tolerance of ±0.003%.

The first part of this series discussed the Wheatstone resistance-measuring bridge and its derivatives, and the second part explained precision inductance, capacitance and resistance (LCR) bridges including the Maxwell and Hay AC bridges.

In addition to the DC and low-frequency AC bridges described in the two previous articles, there are three others that should be of value to experimenters and hobbyists. The first of these is the *transformer ratio-arm bridge*. Fig. 1 is the basic schematic for this bridge. The value of the ratio arms of this bridge (shown as switch-selectable at 0.1/1, 1.0/1, or 10.0/1 in Fig. 1) depends entirely on transformer T1's turns-ratios. Suitable transformers can be wound with a precision better than 0.01%.

The value of an unknown impedance Z_X can be balanced against that of a standard impedance Z_S either by varying the value of the standard or the value of the ratio arms. Resistors or capacitors can be balanced against each other by placing them on opposite sides of the bridge, as shown. In addition, a capacitor can be balanced against an inductance by placing both components on the same arm of the bridge.

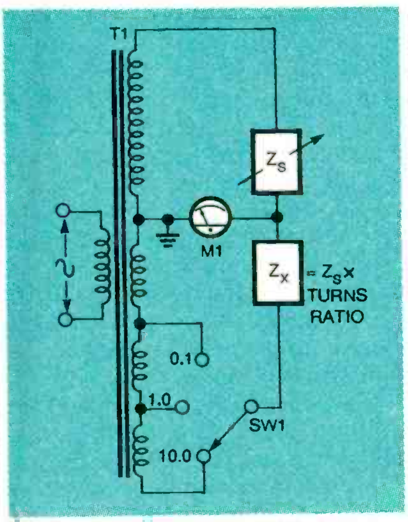


FIG. 1—A SCHEMATIC FOR a transformer ratio-arm bridge.

The *DC resistance-matching bridge*, shown in Fig. 2 is another important bridge. This simple circuit permits resistors to be matched to within ±0.1% or better. This bridge is based on two basic principles: (1) If R_A and R_B are equal, the value of R_{MATCH} will equal that of R_S at balance; (2) If R_A and R_B are equal, they will generate the same output voltage, regardless of the way they are connected across the power supply.

With the second principle in mind, R_A and R_B are joined by a 500-ohm potentiometer and they are connected to the DC supply through the biased polarity-reversal switch S1.

To measure with this resistance-matching bridge, connect R_S and R_{MATCH} in the locations shown. Notice that R_{MATCH} is shown simply as a fixed resistor (R_{M1}) in series with a variable resistor (R_{M2}). With the DC supply connected, a meter reading can now be taken. If necessary, trim R_{M2} and R3 to make this reading a reasonable value. Repeatedly toggle switch S1 and trim R3 until identical meter readings appear in both toggle positions. That completes the adjustment.

Trim the value of R_{MATCH} with R_{M2} to zero the meter reading. When it is zeroed, R_S and R_{MATCH} are matched. After R3 has been initially set, it should rarely require adjustment. The circuit's matching fidelity is limited to ±0.1% by the balance-detection meter's sensitivity.

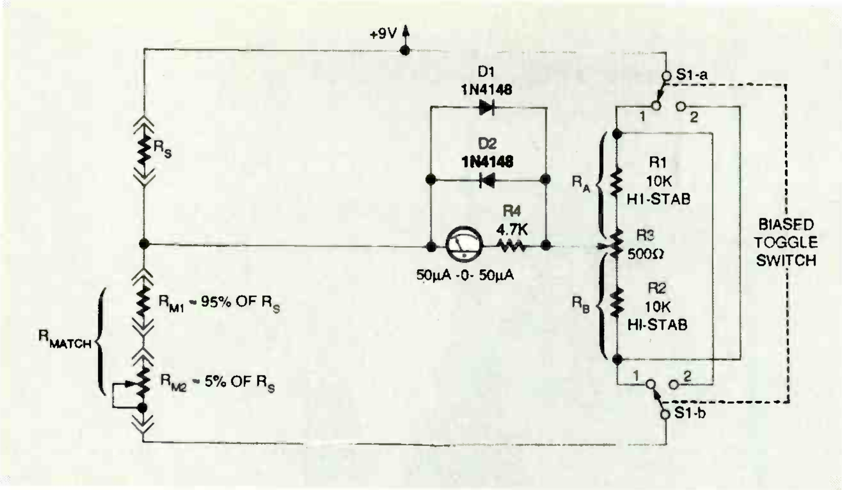


FIG. 2—THIS RESISTANCE-MATCHING bridge will match resistors within ±0.1%.

TABLE 1—CHARACTERISTICS OF RESISTORS

Resistor Type	Resistance Range (Ohms)	Tolerance Range (Percent)	Temperature Coefficient ppm/°C
Carbon comp.	1 - 100 M	± 5 - ± 20	±100 - ±1000
Carbon film	1 - 200 M	±0.5 - ±10	–800 - +200
Metal film	0.27 - 100 M	±0.01 - ±2	±3 - ±200
Cermet film	10 - 500 M	±0.05 - ±5	±50 - ±200
Wirewound			
Precision	0.001 - 60 M	±0.001 - ±1	±0.5 - ±50
Power	0.1 - 1 M	±1 - ±10	±20 - ±450

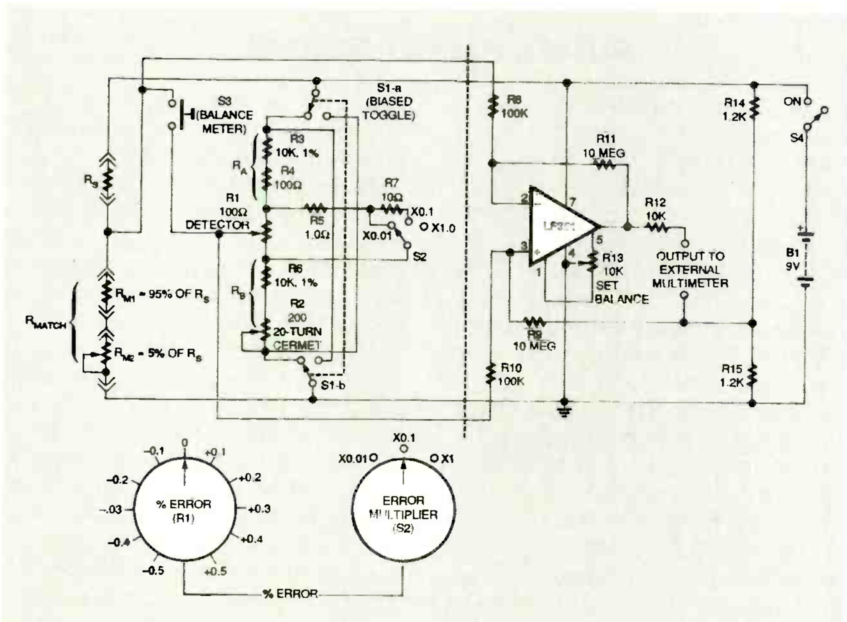


FIG. 3—THIS HIGH-PRECISION RESISTANCE-matching bridge will match resistors to within ±0.003%.

When building a resistance-matching bridge or when matching resistors, install only resistors whose resistive elements have low-temperature-coefficients measured in parts per million per degree Celsius (ppm/°C). Do not touch or handle those resistors while balancing or matching values. Table 1 give values of coefficients of resistance for the common commercial resistive elements. These include carbon film, carbon composition, metal film, thick film, and wirewound.

When making measurements with the bridge, be aware that the R_{MATCH} value can be trimmed (to make it equal R_S) with a series resistor to increase its value or a shunt resistor to reduce it.

Resistance-matching bridge. Figure 3 is the schematic for a precision resistance-matching bridge that includes a DC differential amplifier for driving the meter. It offers such high balance-detection sensitivity that resistors can be matched to within ±0.003%. This bridge also has the ability to indicate on potentiometer R1's calibrated scale, the percentage of the out-of-match error of R_{MATCH}. This scale spans ±0.5%, 0.05%, and 0.005% in three switch-selected ranges.

To set up the bridge initially, insert R_S and R_{MATCH} in their positions, connect operational amplifier IC1's output to an external multimeter, and connect the power supply through switch S4. Then close momentary pushbutton switch S3 and trim IC1's SET BALANCE control R13 to obtain a zero reading on the meter's most sensitive DC current range. Then release switch S3.

Now set potentiometer R1 at midscale and, with S2 initially set to its ×1.0 scale, toggle S1. Trim potentiometer R2 (and if necessary, trimmer R_{M2}) to find a setting where the meter reading are identical in both toggle positions. As potentiometer R2 nears the balance point, increase the balance sensitivity with S2, until a perfect balance is obtained on the ×0.01 range. That completes the initial setup procedure.

Resistor R_{MATCH} can then be matched to R_S by trimming R_{M2} for a zero reading on the meter. After the circuit has been set as described, R2 and operational

Continued on page 155

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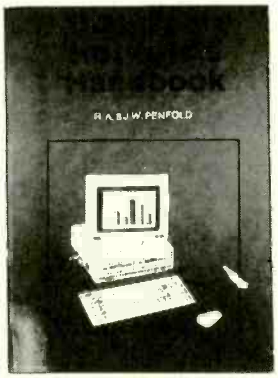

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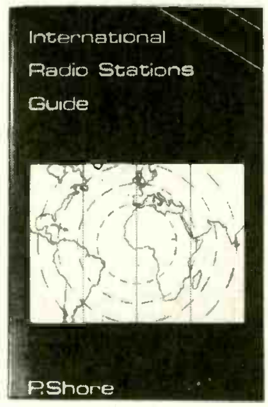

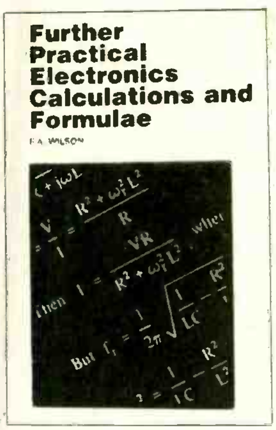

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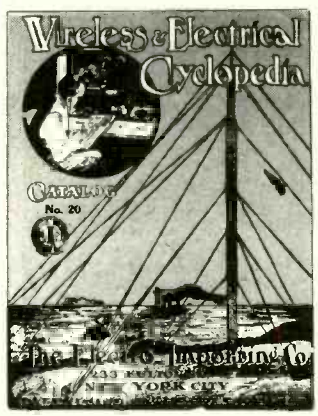

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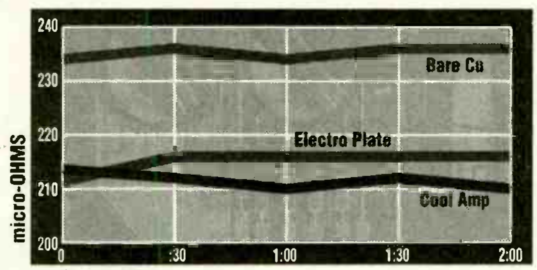
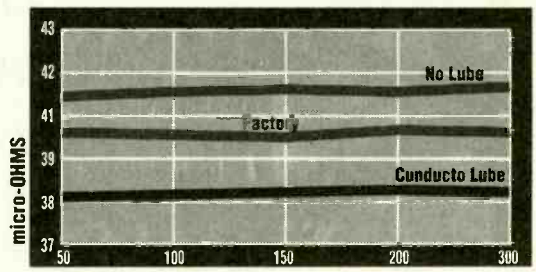


Conducto-Lube



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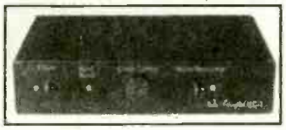

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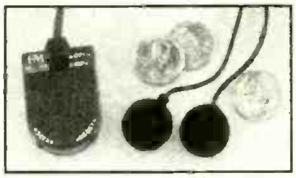

Fit an entire orchestra in the palm of your hand and still have room for the concert tickets with this Mini FM Radio that has an incredible sound. Features on/off button, seek button and reset button. Includes battery. If this isn't the world's smallest, it's close to it. But the sharp, clear sound that comes out will make you think you have a jam box. Black.

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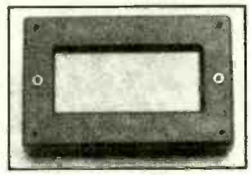

This meter has many useful applications such as Voltmeter, Thermometer, Db Meter, Watt Meter, Current Meter, Capacitance Meter, Lux Meter and LCR Meter. Features include: 200mV full scale input sensitivity, single 9VDC operation and decimal point selectable. In addition, it has 13mm figure height, automatic polarity indication, guaranteed zero reading for 0 volt input and high input impedance (>100M ohms). Specifications: Max input 199.9mV DC-Max. Display: 1999 counts (3-1/2 digits). Measuring method: Dual slope integration A-D converter system, plus many other features.

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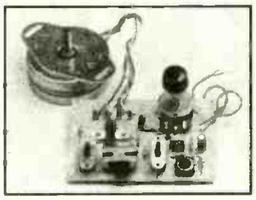

This kit allows you to adjust the speed and direction of a stepper motor. You can move the motor in one step increments or rotate it at a constant speed. There are a set of visual indicators that show the sequence of motor. Includes stepper motor, pc board, parts and instructions.

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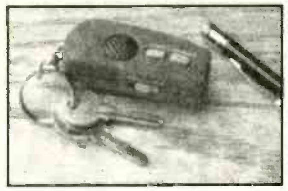
TALKING MEMO RECORDER / KEY CHAIN

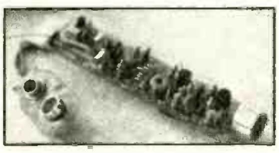


Records and plays messages up to 16 seconds (i.e. parking spaces, things to do, etc.) 16 seconds is a long time to dictate! Measures 3" x 1.25". Battery operated (included).

CAT #TM-1 **$19.95 each**

FM WIRELESS MIKE KIT

POWERFUL

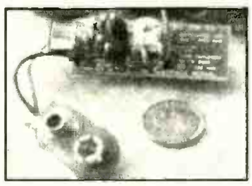


2 stage, wireless mike kit transmits over .5 mile (up to 1 Km in the open) Tunable to the upper part of FM broadcast band. Circuit does require the ability to "Tweak" RF circuits by stretching or compressing coils. With mike and 9V battery clip. Operates from 6-12V DC. 2.75" x .625" x .5" WT .06

CAT #FM-32 **$10.95 each**

9V DC FM TRANSMITTER KIT

POWERFUL



FM transmitter. Transmits over 100 meters in building and over 500 meters outside using .25 or .5 wavelength of wire. Transmits to the upper part of FM broadcast band (100-108MHz). Circuit requires the ability to "Tweak" RF circuits. Operates on 9V DC. 1.75" x .75" x .375" WT .05

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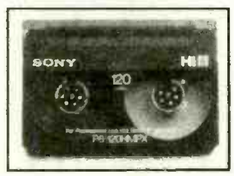

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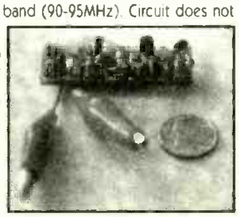

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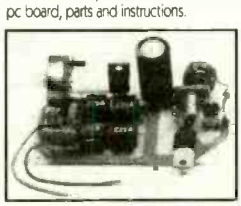

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160 x 128 dot LCD with built-in controller (T6963C)
20 character x 16 line $79.00 or 2 for $149.00
Mfr.: Toshiba TLX-1013-EO. *Unit is EL back-lit. Dim: 5¹⁄₁₆" L x 4⁷⁄₁₆" H. The built-in controller allows you to do text and graphics*

Alphanumeric—parallel interface

16x1..... 3 for $25.00	32x4..........$15.00	16x4..........$15.00
20x2..........$12.00	40x4..........$25.00	24x2..........$12.00
20x4..........$25.00	16x2..........$8.00	40x2..... 2 for $25.00
		4x2..........$5.00

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

Graphics and alphanumeric—serial interface

size	mfr.	price	size	mfr.	price
640x480	Epson	$50.00	480x128	Hitachi	$15.00
640x400 (backlit)	Panasonic	$35.00	256x128	Epson	$20.00
640x200	Toshiba	$19.00	240x128 (backlit)	Optrex	$20.00
			160x128	Optrex	$15.00

LASER PRODUCTS

HeNe Laser Head (10Mw max. output) TEM00. 15.5" long MFG:NEC **$99.⁰⁰**
Laser Power Supply (for HeNe tube) **$100.⁰⁰**

LASER SCANNER ASSEMBLY $29.⁰⁰
Assembly intended for a laser printer. Includes laser diode, polygon motor (6 sided) and misc. optics and lenses.

LASER DIODE (5mW) with collimator $20.⁰⁰

***LASER DIODE:* Sharp part#: LT022MC**
5mW at 780 nm, single transverse mode $10.⁰⁰

NETWORK

IRMA BOARD 8 bit $99.⁰⁰
Links 3270 mainframe systems to IBM PC

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

POS & BAR CODE

MAGNETIC CARD READER $25.⁰⁰
Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

HP bar code wand (HBCS 2300)................$35.00

POWER SUPPLYS

73 WATT SWITCHING $15.00 or 2 @ $25.00, (2) 4 pin power connectors attached • 115/230 Volt, Dim: 8.5" L x 4.5" W x 2" H • Output: +5V @ 2-9.75 A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A

68 WATT SWITCHING $12.00 or 2 for $20.00, 115/230 Volt, Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A

MISCELLANEOUS

ADAPTEC 4070A (RLL) OR 4000A (MFM) SCSI Controller, your choice $40.⁰⁰

IBM 370 option XT and AT emulation boards $50.00

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Comes with pinout. 12V at 1.4 Amp input • Horizontal frequency 15Khz. • Ability to do 40 and 80 column.

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• 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
• Open Frame Construction • Standard Interface Connector
• Degaussing Coil Included • *Mfg.: Samtron*

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MATRIX TYPE

"The Spy In The Sky" $29.⁰⁰

Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V)
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um² • Ceramic 24 pin DIP package. • Mfr: Sony, Part# 016AL

LINEAR TYPE

4096 element CCD $29.00
2048 element CCD $15.00 • 1728 element CCD $15.00

HACKER CORNER

CELL SITE TRANSCEIVER $99.00

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

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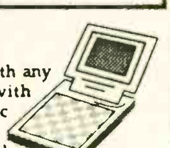
Portable Micro Terminal



Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal • Use by itself as electronic notebook • Onboard microprocessor, data RAM (32K) and Video RAM (64K) • Complex built in diagnostics and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dimensions: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1") **$99.⁰⁰ or 2 for $149.⁰⁰**

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(Motherboard can be purchased separately: $29.00 or 2 for $49.00)

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HP 6181C DC Current Source, 100 V, 250 mA $675.00
HP 6186C DC Current Source, to 300V,100mA $750.00
KEITHLEY 225 Current Source, 1 nA-99.9 mA $450.00

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MEGURO MQ-171 VHF Q Meter, 20-230 MHz $1,100.00
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GR 1433-X 6-Decade Resistor, 0.1 OHM-111K $550.00
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TEK 577D1/177 Storage Curve Tracer $2,250.00
TEK 7CT1N Curve Tracer, to 0.5W $500.00

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HP 6264B 20V at 20A CV/CC Power Supply $500.00
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HP E1420A-10,30 VXI Counter, 200 MHz & 2.5 GHz $1,500.00
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TEK DC5009 Programmable 135 MHz Count/Timer $750.00
TEK DC503A 125 MHz Universal Counter/Timer $500.00
TEK DC509 135 MHz High Resolution Counter $700.00
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HP 3586C Selective Level Meter $1,750.00
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ROCKLAND 752A-opt.02 Dual Low Pass Filter, 115 dB/oct $1,100.00
TEK AM502 Differential Amplifier $575.00

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HP 5371A Modulation Domain Analyzer $5,900.00
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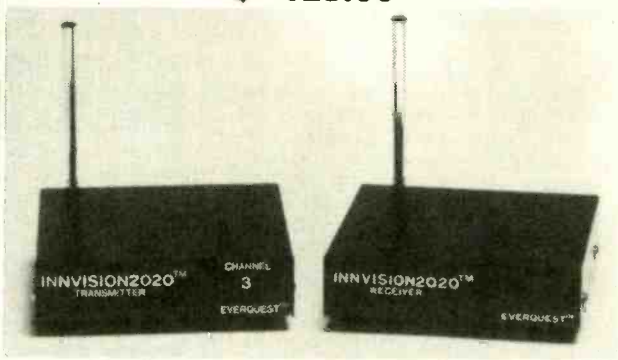

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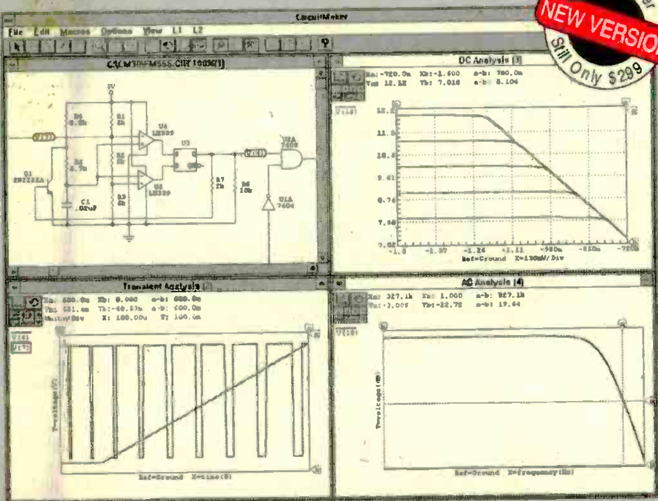

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CircuitMaker	YES	YES	YES	YES	YES	YES	$299
Electronics Workbench version 4	YES	NO	YES	NO	NO	NO	$299
Electronics Workbench Engineer's Pack	YES	NO	YES	YES	YES	YES	$599

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A free functional demo is available on the Internet (http://www.microcode.com), on CompuServe (GO MICROCODE) and on America Online (keyword search: CircuitMaker). A demo can be purchased directly from MicroCode Eng. for $10.

Printed Circuit Board Netlist Output

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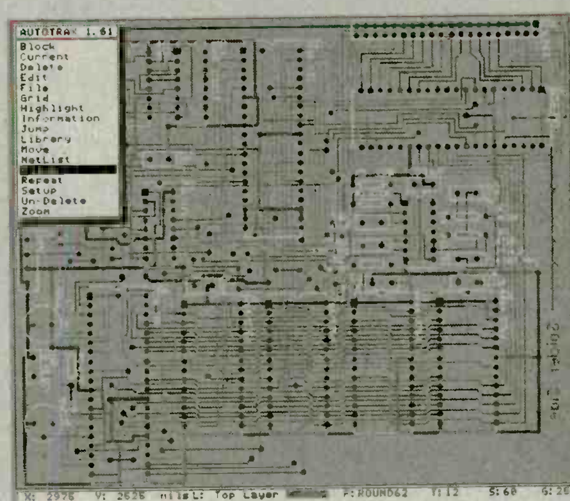

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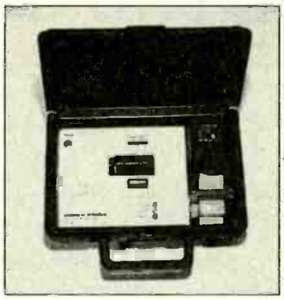

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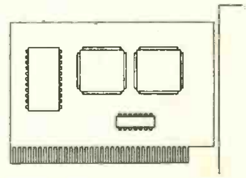

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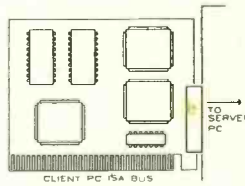

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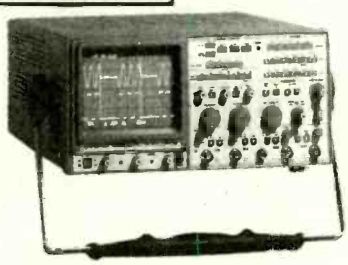

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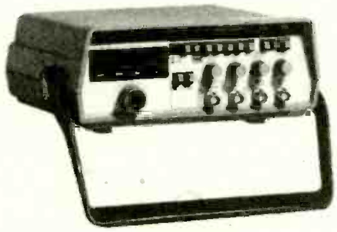

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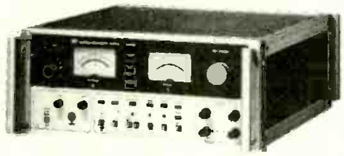

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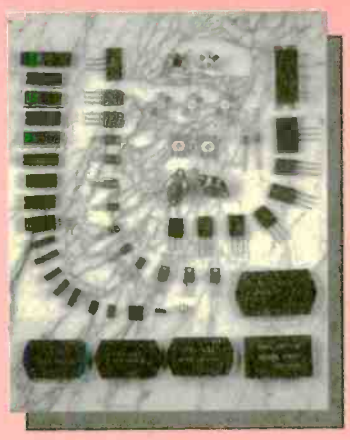

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Just one listen to this 12" dual voice coil subwoofer from Ultimate will leave no doubt that this sub can shake, rattle, and roll! Works extremely well in car audio, home theatre, or satellite/subwoofer systems. Handcrafted in the U.S.A.
◆Power handling: 350 watts RMS/500 watts max ◆Voice coil diameter: 2 inch ASV voice coil ◆Impedance: 6 ohms per coil ◆Frequency response: 18-1,000 Hz ◆Magnet weight: 90 oz. ◆Fs: 21 Hz ◆SPL: 88 dB 1W/1m ◆Vas: 5.9 cu. ft. ◆Qts: .421 ◆Xmax: .41" ◆Net weight: 11 lbs.

Ultimate

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Fluke Model 12 Multimeter

The Model 12 compact digital multimeter combines basic features, high performance, low cost and Fluke reliability. It was designed for first level electrical and electronic troubleshooting. Includes 9V battery, operating manual, and test leads. Two year manufacturer warranty.

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Features: ◆Measures AC/DC volts, ◆4000 count digital display, ◆Autoranging, ◆Automatic shut off, ◆Diode and continuity test, ◆1.5% accuracy, ◆V Chek™ overload protection mode, ◆Capacitance check to 999 uF, ◆0.9% accuracy, ◆Min/Max Record with time stamp, ◆Input change alert, ◆Continuity Capture™ (captures and records intermittent opens and shorts), ◆Net weight: 1 lb.

#EN-392-020 .... **$92.50**

Technicians' Turntable

Turntable to speed repair of VCRs, TVs and more. Easily turn unit for convenient repair. Holds up to 200 lbs. Dimensions: 20" W x 15" D x 1-1/8" H. Black pebbled surface. Includes 4 anti-skid adhesive feet. Net weight: 9 lbs.

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Idler Tire Kit

Have the tire you need in stock when you need it. This comprehensive kit contains 180 of the most commonly used tires in an easy-to-use case and a cross reference for 32 manufacturers crossing to over 600 VCR model numbers. A $400.00 retail value. Net weight: 1-1/2 lbs.

#EN-400-900 .... **$39.95**KIT

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Vifa D25TG-05 1" Poly Dome Tweeter

Excellent performance at a moderate price. This ferro fluid cooled 1" poly dome tweeter features a high loss diaphragm, user replaceable voice coil assembly, and high power handling.
◆Power handling: 100 watts RMS/140 watt max ◆Nominal impedance: 6 ohms ◆DC resistance: 4.6 ohms ◆Frequency range: 3,000-24,000 Hz ◆Magnet weight: 8.5 ozs. ◆Fs: 1500 Hz ◆SPL: 90 dB 1W/1m ◆Net weight: 1-1/4 lbs.

vifa

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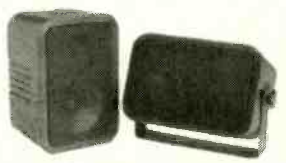
Audio Generator

Square wave and sine wave generator useful for a variety of audio applications. Generates 10 Hz to 1 MHz in 5 ranges. Output voltage: 8V RMS sinewave, 10V p-p squarewave. +/-3% dial accuracy. Output impedance: 600 ohms. Synchronization: +/-3% of oscillation frequency per VRMS. Dimensions: 6"H x 10"W x 5"D. Includes test lead, AC power cord, and manual. One year manufacturer warranty. Net weight: 6 lbs.

#EN-390-620 .... **$119.00**

Mini Weatherproof Speaker System



These mini weatherproof speaker cabinets are made from high impact polypropylene which is completely weather sealed making these perfect for indoor or outdoor use. These great sounding mini speakers feature a 5" polypropylene cone woofer and a mylar dome tweeter. Ideal for use as extension speakers or for surround sound. Small size blends easily into any decor. Frequency response: 130-20,000 Hz. 8 ohm impedance: 30 watts RMS, 60 watts maximum power handling capability. Mounting brackets included. Dimensions: 8" (H) x 5-1/2" (W) x 4-1/2" (D). Net weight: 10 lbs.

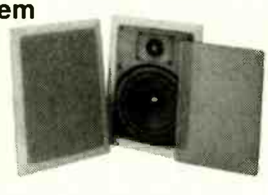
#EN-310-020 (Black)
#EN-310-025 (White) .... **$79.95**(1-3 PRS) ... **$74.80**(4 PRS-UP)

Professional Strobe Light

No top notch lighting display is complete without a powerful, high speed strobe light. This professional unit features an ultra bright xenon flash tube, reflective bowl, variable speed control, and on/off toggle switch. A 1/16" clear plexiglass cover is mounted on brass stand-offs to protect the flash tube assembly. Includes adjustable mounting bracket. Dimensions: 9-1/2" (W) x 8-5/8" (H) x 6-7/8" (D). Net weight: 7 lbs.

#EN-243-072 .... **$92.80**

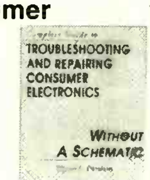
6-1/2" Two Way In-Wall System



This is our most popular in-wall. You won't believe how good these really sound. Big enough to produce great home theater sound and still fit everyone's budget. Put a pair in every room of your house. Great for front or rear speakers in your surround system. The 6-1/2" polypropylene woofer and 1" textile dome tweeter were specially designed with home theater in mind. The crossover network utilizes a mylar capacitor for crisp clean highs. 3 piece design make installation in new or existing walls a snap. Textured ABS frame and steel mesh grill are spray paintable to match (or blend into) any decor. Speaker front plate is "blacked out" for cleaner "through grill" appearance. System comes with speaker assembly, removable metal grill, heavy steel backer plates, screws and hardware, hole cut-out template, paint mask, and detailed installation instructions.
Specifications: ◆6-1/2" polypropylene cone woofer with poly foam surround. ◆1" textile dome tweeter/midrange. ◆8 ohm impedance. ◆3 component L/C crossover network. ◆Frequency response: 50-20,000 Hz. ◆Power handling capability: 60 watts RMS/100 watts max. ◆Sensitivity: 89 dB 1W/1M. ◆Overall dimensions: 8-1/2" W x 12" L x 3-1/2" D. ◆Hole size: 7-1/4" x 10-3/4". ◆Fits into standard 2" x 4" wall. ◆Net weight: 12 lbs. per pair.

#EN-300-036 .... **$104.95**(1-3 PRS) **$96.50**(4-11 PRS) **$85.50**(12 PRS-UP)

Troubleshooting And Repairing Consumer Electronics Without A Schematic



A common problem faced by repair technicians is having to troubleshoot electronic equipment without a schematic. With hundreds of illustrations, this indispensible guide demonstrates how to locate, test, and repair amplifiers, TVs, CD players, radios, power supplies, and more. Written by Homer L. Davidson. 320 pages. Copyright: 1994. Net weight: 1-1/4 lbs.

#EN-500-305 .... **$22.95**EACH

Isotip Butane Soldering Iron

The ideal soldering iron for field repairs where no AC power is present. Operates for up to 100 minutes of continuous soldering per refill. Uses standard butane (not included) available at most stores. Tip temperature is adjustable up to 1067° F. Iron also comes with a torch attachment which easily screws on in place of the soldering tip. As a torch, one refill will provide up to 1 hour of continuous flame. Temperature is adjustable up to 2372° F. A protective cap with a built-in striker and 2.4mm tip are included. Limited one year warranty.

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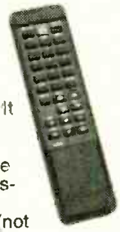
3-In-1 Universal Remote



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

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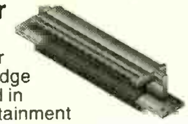
72 Pin Game Cartridge Connector



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

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

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

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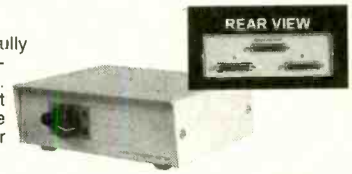
#EN-092-206 (Stereo) .... **$3.25**(1-9) **$2.90**(10-49) **$2.65**(50-UP)

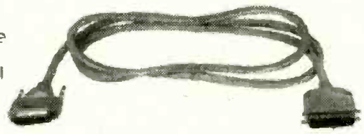
RS-232 A-B Switch



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

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

Printer Cables

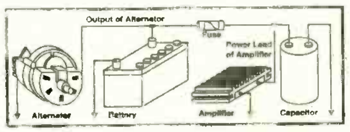


25 pin male RS-232 to 36 pin male Centronics connector. Fully shielded and molded cable with all 25 conductors connected. Convenient thumbscrew hardware on the RS-232 connector.

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

Car Stereo Power Supply Capacitors

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



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

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

Electronic Video Library

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

BUY THE SET AND SAVE!

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

Part #	Description	Price
EN-505-010	VCR 1, How To Clean VCRs	$28.95
EN-505-020	VCR 2, Minor VCR Repair I	38.95
EN-505-025	VCR 3, Minor VCR Repair II	38.95
EN-505-050	VCR 4, Common VCR Malfunctions	38.95
EN-505-035	VCR 5, Diagnosing Video Heads	38.95
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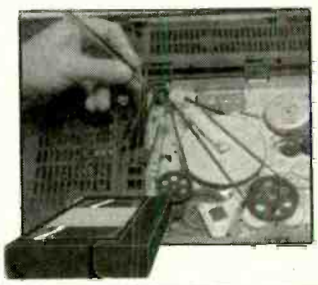

Skew Driver Pro

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

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

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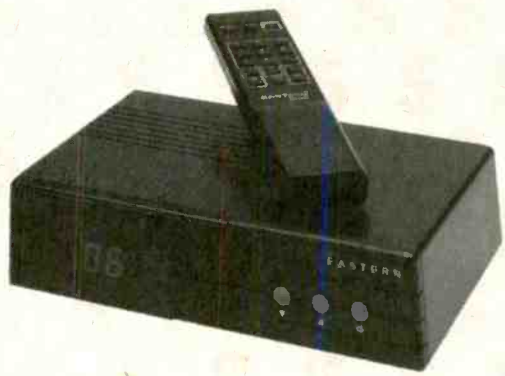

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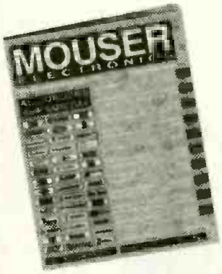

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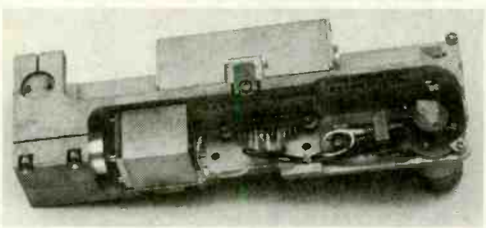

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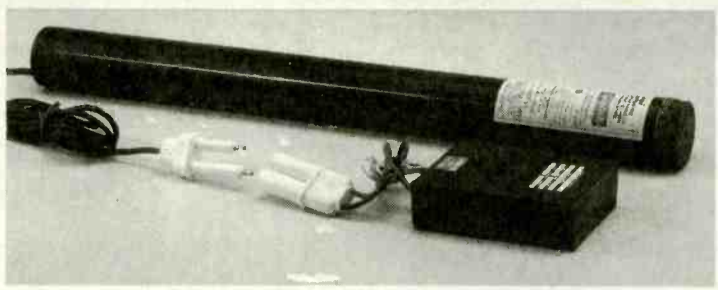

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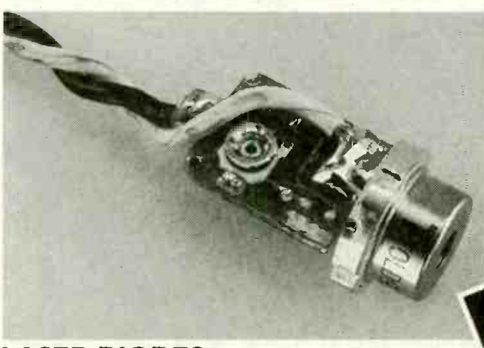

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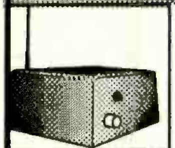


FM STEREO TRANSMITTER

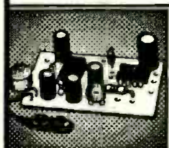
Own your own FM radio station. Any stereo signal you plug into the FMST-100 will be transmitted to any FM radio tuneable from 76 to 108MHz FM. Transmit a wireless link through an auditorium, from your car to your camper, listen to your CD's while mowing the lawn, Play music on one channel sing on the other. Clarity is excellent, aprox. 40dB stereo separation. Length of antenna determines the distance of transmission. Complete with stereo input level controls & crystal for stereo separation. 9v battery operation. SIZE: 1.5" x 2.5" x 3"

FMST-100 KIT $29.95 / Cabinet $8.95

PHONE TRANSMITTER

Small but mighty, it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz to 130MHz FM. You can also use it as a speaker phone. SIZE: 1.25" x .6".

TEL-B1 KIT $12.95 BUILT $29.95



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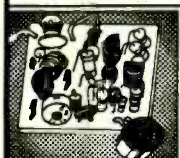
Listen through walls, hear conversations across the room. Add a parabolic reflector and hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra sensitive intercom. Can be used as a 1.5W AMP. We supply a mini-electret mike in the kit. Power requirement 6 to12v DC SIZE:1.75" x 1"

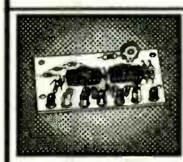
AA-1 KIT $10.95 BUILT $29.95



WIRELESS FM MICROPHONE

Small but mighty this little jewel will out perform most units many times it's price. It really stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. 6 to 12v DC. SIZE: 1.25" x 1"

WM-1 KIT $14.95

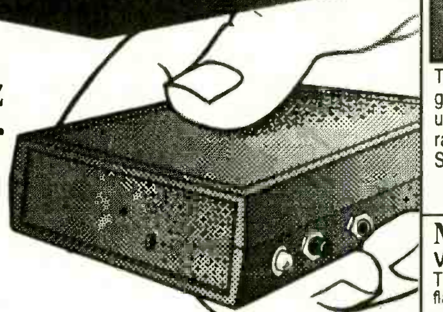


DC VOLTAGE MONITOR

If battery status is important, you need this kit. This kit uses 7 LEDs to monitor 12v DC in 1v, 1/2v, or 1/4v steps. Monitor 8v or 5v in 1/4v steps. Great for boats, motor homes, model planes or race car ni-cads. All parts and instructions are included. SIZE: 1.3" x 2.7".

VM-1 KIT $7.95

The 10GHz Transmitter is back...



The "ZAPPER II"

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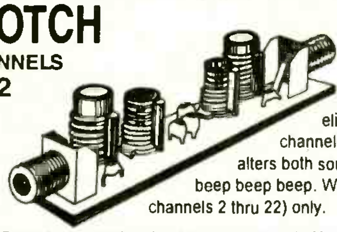
The "ZAPPER II" is a 10.450 GHz to 10.550 CW oscillator. It has a code key jack installed for those who want to send Morse code.

BUILT $49.95 KIT $39.95

TV NOTCH FILTERS

FOR CHANNELS 2 thru 22 ONLY



Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep beep beep. Works on cable channels 2 thru 22) only.

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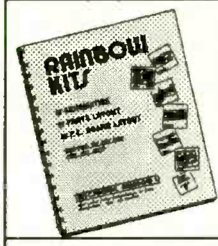
DF-222 KIT $14.95



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

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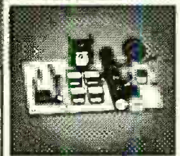

STROBE LIGHT

Do you need an attention getter, warning light, or flashing light for model airplanes? Then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate. Power requirement 6 or 12v DC. Size 3.5"x1.9"

ST-1 KIT $9.95

MICRO-LIGHT

Visible Over 1 Mile.

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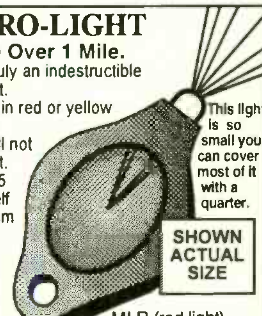

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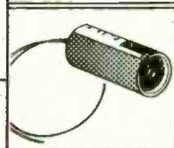

4.0 mW Laser Diode

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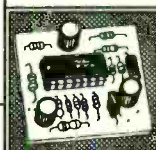
LDM-5 New Low Price $59.95



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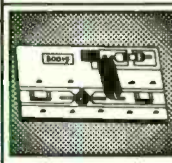
This VOX circuit can be used to operate a tape recorder, ham radio, CB radio, or turn on an alarm. The VOX-1 kit has 100MA of output that operates a relay, light, motor, ? What could you do with a sound activated switch? Power requirement 7.5 TO 18vDC. SIZE: .1.5" x 1.3"

VOX-1 KIT $6.95



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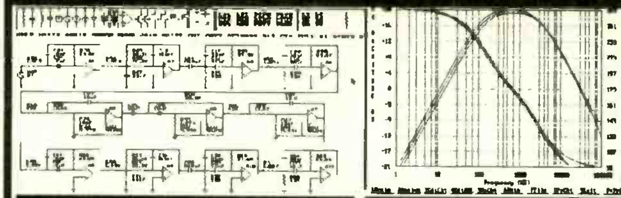

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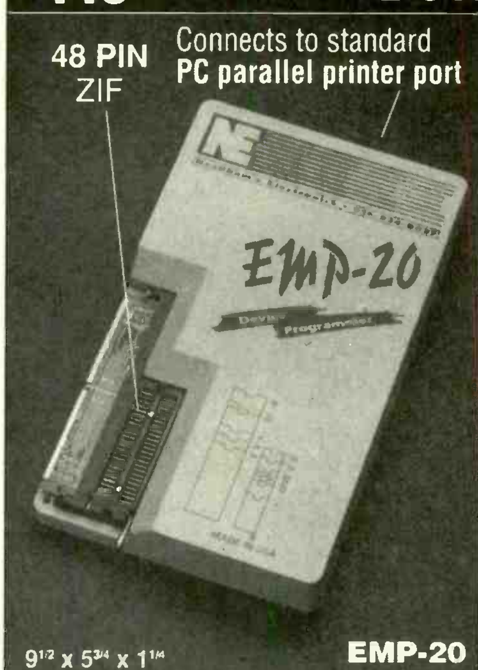

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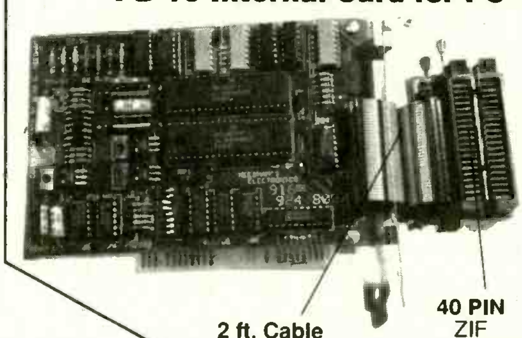

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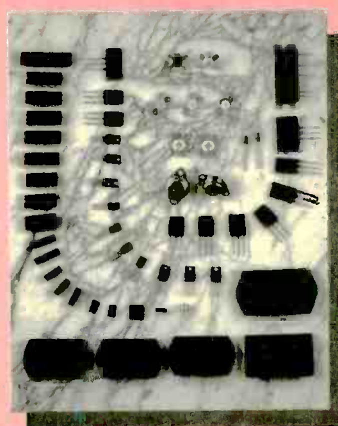

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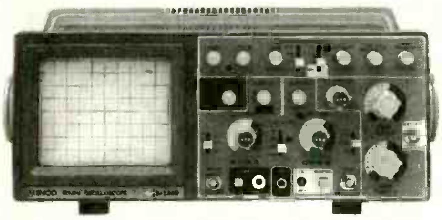


60MHz

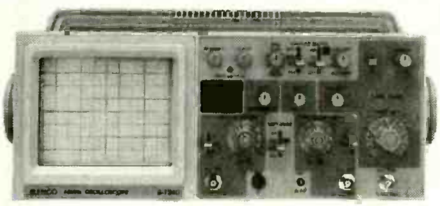
S-1360 $775

Delayed Sweep

S-1365 $849

Cursor Readout

- Voltage, Time
- Frequency differences displayed on CRT



40MHz

S-1340 $495

2- Channel

S-1345 $575

Delayed Sweep

- Beam Find
- Component Tester

25MHz

S-1325 $325

2- Channel

S-1330 $449

Delayed Sweep

- Beam Find
- Component Tester

Dependable Equipment at Affordable Prices

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2 Channel

Model 2120 $389.00

Delayed Sweep

Model 2125 $539.95

40MHz DUAL -TRACE

Model 1541B

$749.95

- 1mV/div sensitivity
- Video sync separators
- Z axis input
- Single sweep
- V mode-displays 2 signals unrelated in frequency

60MHz DUAL-TRACE

Model 2160

$949.95

- 1mV/div sensitivity
- Sweep to 5ns/div
- Dual time base
- Signal delay line
- Component tester
- V mode-displays 2 signals unrelated in frequency

100MHz THREE-TRACE

Model 2190

$1,379.95

- 1mV/div sensitivity
- Sweeps to 2ns/div
- Dual time base
- Signal delay line
- 19kV accelaerating voltage
- Calibrated delay time multiplier

20MHz ANALOG with DIGITAL STORAGE

Model 2522A

$869.95

- 20MHz analog bandwidth
- 20MS/s sampling rate
- 2k memory per channel
- 20MHz equivalent time sampling

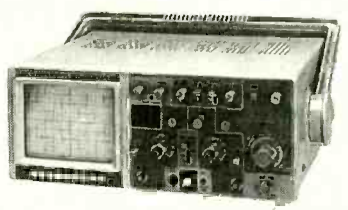
HITACHI POPULAR SERIES

V-212 - 20MHz, 2 Channel	$449.00
V-222 - 20MHz, DC Offset	$695.00
V-422 - 40MHz, Dual Trace	$849.00
V-522 - 50MHz, Dual Trace	$975.00
V-523 - 50MHz, Delayed Sweep	$995.00
V-525 - 50MHz, w/ Cursor	$1,069.00

HITACHI COMPACT SERIES SCOPES

V-660 - 60MHz, Dual Trace	$1,375.00
V-665A - 60MHz, DT, w/cursor	$1,449.00
V-1060 - 100MHz, Dual Trace	$1,549.00
V-1065A - 100MHz, DT, w/cursor	$1,695.00
V-1085 - 100MHz, QT, w/cursor	$2,125.00
VC-6045A - 100MHz, Digital Stor	CALL
VC-6025A - 50MHz, Digital Stor	CALL

Elenco DS-203 20MHz, 10MS/s Digital Storage Oscilloscope



$749 2K Word Per Channel • Plotter Output 8 Bit Vert. Resolution • 2048 Pts Hor. Resolution • Much More.....

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A handheld instrument that combines a 50MHz, 25MS/s dual channel digital storage oscilloscope with feature-packed 3000 count digital multimeter.

Model 93 - $1,225
Model 95 - $1,549
Model 97 - $1,795

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- True RMS volts; AC or AC+DC up to 600V

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Parts Express is proud to announce that we now stock the high quality NTE line of semiconductors. NTE has been supplying the electronics industry with top notch replacement parts for over 15 years. All NTE products meet or exceed industry specifications and offer an exclusive 2 year manufacturer warranty.

Ultimate 12" AU1290 Dual VC Subwoofer

Just one listen to this 12" dual voice coil subwoofer from Ultimate will leave no doubt that this sub can shake, rattle, and roll! Works extremely well in car audio, home theatre, or satellite/subwoofer systems. Handcrafted in the U.S.A. ◆Power handling: 350 watts RMS/500 watts max ◆Voice coil diameter: 2 inch ASV voice coil ◆Impedance: 6 ohms per coil ◆Frequency response: 18-1,000 Hz ◆Magnet weight: 90 oz. ◆Fs: 21 Hz ◆SPL: 88 dB 1W/1m ◆VAS: 5.9 cu. ft. ◆QTS: .421 ◆XMAX: .41" ◆Net weight: 11 lbs.

#EN-292-710 .... **$115.50**(1-3) **$107.80**(4-11) **$99.90**(12-UP)

Fluke Model 12 Multimeter

The Model 12 compact digital multimeter combines basic features, high performance, low cost and Fluke reliability. It was designed for first level electrical and electronic troubleshooting. Includes 9V battery, operating manual, and test leads. Two year manufacturer warranty.

FLUKE

Features: ◆Measures AC/DC volts, ◆4000 count digital display, ◆Autoranging, ◆Automatic shut off, ◆Diode and continuity test, ◆1.5% accuracy, ◆V Chek™ overload protection mode, ◆Capacitance check to 999 uF, ◆0.9% accuracy, ◆Min/Max Record with time stamp, ◆Input change alert, ◆Continuity Capture™ (captures and records intermittent opens and shorts), ◆Net weight: 1 lb.

#EN-392-020 .... **$92.50**

Technicians' Turntable

Turntable to speed repair of VCRs, TVs and more. Easily turn unit for convenient repair. Holds up to 200 lbs. Dimensions: 20" W x 15" D x 1-1/8" H. Black pebbled surface. Includes 4 anti-skid adhesive feet. Net weight: 9 lbs.

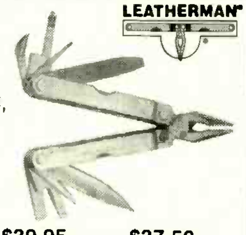
#EN-360-427 $28.50(1-3) **$23.80**(4-UP)

Idler Tire Kit

Have the tire you need in stock when you need it. This comprehensive kit contains 180 of the most commonly used tires in an easy-to-use case and a cross reference for 32 manufacturers crossing to over 600 VCR model numbers. A $400.00 retail value. Net weight: 1-1/2 lbs.

#EN-400-900 .... **$39.95**KIT

Leatherman Tool



LEATHERMAN®

The Leatherman tool is an extremely versatile and durable compact toolchest you can hold in your hand ... contains 12 useful tools in one! Needlenose pliers, regular pliers, awl, Phillips screwdriver, three slotted screwdrivers, can and bottle opener, wire cutters, file, knife, and 8 inch ruler. Made of only the highest quality 100% stainless steel. Includes sturdy leather sheath. 25 year manufacturer warranty. Net weight: 5 oz.

#EN-360-990 .... **$39.95**(1-3) ..... **$37.50**(4-UP)

Vifa D25TG-05 1" Poly Dome Tweeter

Excellent performance at a moderate price. This ferro fluid cooled 1" poly dome tweeter features a high loss diaphragm, user replaceable voice coil assembly, and high power handling. ◆Power handling: 100 watts RMS/140 watt max ◆Nominal impedance: 6 ohms ◆DC resistance: 4.6 ohms ◆Frequency range: 3,000-24,000 Hz ◆Magnet weight: 8.5 ozs. ◆Fs: 1500 Hz ◆SPL: 90 dB 1W/1m ◆Net weight: 1-1/4 lbs.

vifa

#EN-264-502 .... **$18.50**(1-3) **$16.80**(4-11) **$15.45**(12-UP)

Audio Generator

Square wave and sine wave generator useful for a variety of audio applications. Generates 10 Hz to 1 MHz in 5 ranges. Output voltage: 8V RMS sinewave, 10V p-p squarewave. +/-3% dial accuracy. Output impedance: 600 ohms. Synchronization: +/-3% of oscillation frequency per VRMS. Dimensions: 6"H x 10"W x 5"D. Includes test lead, AC power cord, and manual. One year manufacturer warranty. Net weight: 6 lbs.

#EN-390-620 .... **$119.00**

Mini Weatherproof Speaker System

These mini weatherproof speaker cabinets are made from high impact polypropylene which is completely weather sealed making these perfect for indoor or outdoor use. These great sounding mini speakers feature a 5" polypropylene cone woofer and a mylar dome tweeter. Ideal for use as extension speakers or for surround sound. Small size blends easily into any decor. Frequency response: 130-20,000 Hz. 8 ohm impedance: 30 watts RMS, 60 watts maximum power handling capability. Mounting brackets included. Dimensions: 8" (H) x 5-1/2" (W) x 4-1/2" (D). Net weight: 10 lbs.

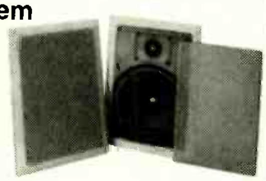
#EN-310-020 (Black)
#EN-310-025 (White) .... **$79.95**(1-3 PRS) ... **$74.80**(4 PRS-UP)

Professional Strobe Light

No top notch lighting display is complete without a powerful, high speed strobe light. This professional unit features an ultra bright xenon flash tube, reflective bowl, variable speed control, and on/off toggle switch. A 1/16" clear plexiglass cover is mounted on brass stand-offs to protect the flash tube assembly. Includes adjustable mounting bracket. Dimensions: 9-1/2" (W) x 8-5/8" (H) x 6-7/8" (D). Net weight: 7 lbs.

#EN-243-072 .... **$92.80**

6-1/2" Two Way In-Wall System

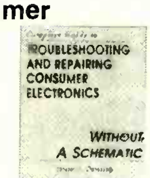


This is our most popular in-wall. You won't believe how good these really sound. Big enough to produce great home theater sound and still fit everyone's budget. Put a pair in every room of your house. Great for front or rear speakers in your surround system. The 6-1/2" polypropylene woofer and 1" textile dome tweeter were specially designed with home theater in mind. The crossover network utilizes a mylar capacitor for crisp clean highs. 3 piece design make installation in new or existing walls a snap. Textured ABS frame and steel mesh grill are spray paintable to match (or blend into) any decor. Speaker front plate is "blacked out" for cleaner "through grill" appearance. System comes with speaker assembly, removable metal grill, heavy steel backer plates, screws and hardware, hole cut-out template, paint mask, and detailed installation instructions.

Specifications: ◆6-1/2" polypropylene cone woofer with poly foam surround. ◆1" textile dome tweeter/midrange. ◆8 ohm impedance. ◆3 component L/C crossover network. ◆Frequency response: 50-20,000 Hz. ◆Power handling capability: 60 watts RMS/100 watts max. ◆Sensitivity: 89 dB 1W/1M. ◆Overall dimensions: 8-1/2" W x 12" L x 3-1/2" D. ◆Hole size: 7-1/4" x 10-3/4". ◆Fits into standard 2" x 4" wall. ◆Net weight: 12 lbs. per pair.

#EN-300-036 .... **$104.95**(1-3 PRS) **$96.50**(4-11 PRS) **$85.50**(12 PRS-UP)

Troubleshooting And Repairing Consumer Electronics Without A Schematic



A common problem faced by repair technicians is having to troubleshoot electronic equipment without a schematic. With hundreds of illustrations, this indispensible guide demonstrates how to locate, test, and repair amplifiers, TVs, CD players, radios, power supplies, and more. Written by Homer L. Davidson. 320 pages. Copyright: 1994. Net weight: 1-1/4 lbs.

#EN-500-305 .... **$22.95**EACH

Isotip Butane Soldering Iron

The ideal soldering iron for field repairs where no AC power is present. Operates for up to 100 minutes of continuous soldering per refill. Uses standard butane (not included) available at most stores. Tip temperature is adjustable up to 1067° F. Iron also comes with a torch attachment which easily screws on in place of the soldering tip. As a torch, one refill will provide up to 1 hour of continuous flame. Temperature is adjustable up to 2372° F. A protective cap with a built-in striker and 2.4mm tip are included. Limited one year warranty.

ISOTIP cordless soldering iron

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3-In-1 Universal Remote

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

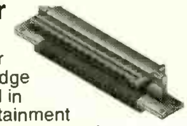
#EN-180-565 .... **$11.95**(1-9) **$9.95**(10-UP)

The Wet Look™

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

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

72 Pin Game Cartridge Connector



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

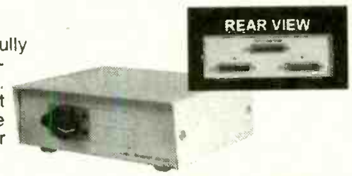
#EN-091-900 **$8.95**(1-9) **$7.95**(10-UP)

BigFoot™

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

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

RS-232 A-B Switch



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

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

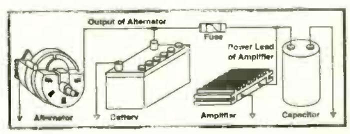
Printer Cables

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

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

Car Stereo Power Supply Capacitors

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



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

Electronic Video Library

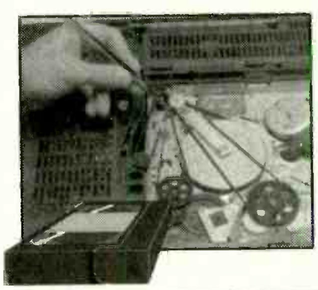
Video School videos make it easy for anyone to comprehend the complex operations of VCRs, camcorders, and more. From How to Clean VCRs for the video rental store, to Minor Camcorder Repair for the advanced service shop. There is something for everyone! These tapes also make great new employee orientation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

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

BUY THE SET AND SAVE!

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

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



Skew Driver Pro

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

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

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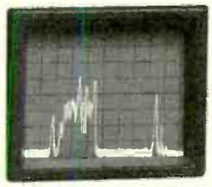
1 MHz TO 500MHz SPECTRUM ANALYZER



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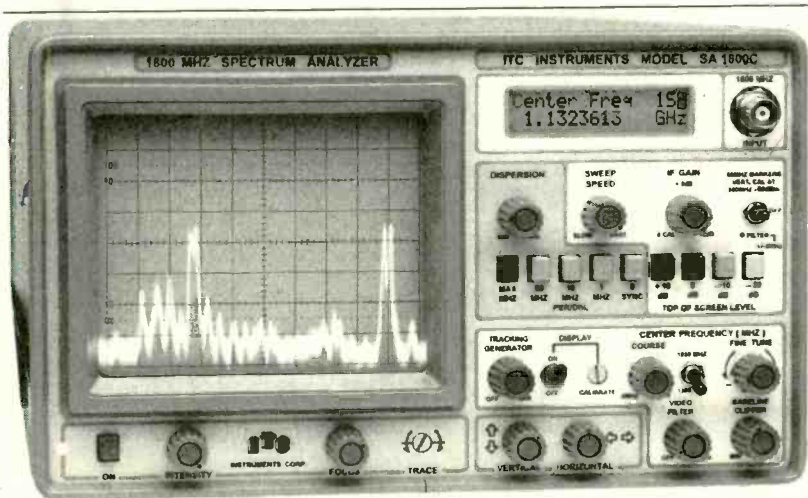

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SA500A, SA1300B, SA1800C

SPECTRUM ANALYZERS

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SA1800C Shown $2395.00

Model SA1300B **1-1300 MHz** ***In One Sweep*** **$1995.00** Options 1.3.5.6

SPECTRUM DISPLAY MONITOR $995.00

The **SA500A** easily attaches to any receiver IF output jack. Providing a panoramic signal display of your scanner or communication receiver. The **SA500A** is a Full Function Spectrum Analyzer with +/- 5KHz Narrow Band Filter, Center Freq. Display, 50 MHz Marker. **SA500A** The first affordable **Professional Spectrum Monitor/Analyzer** for all serious Ham Radio and Radio Monitoring Operators. With Opt. 1,3,5,6

TWO FULL FUNCTION ANALYZERS

Quality & Performance with 80dB on Screen, -100 dBm Sensitivity, Center Freq. Display, +/- 5KHz Narrow Band Filter 50 MHz Marker. **DISPERSION ZOOM**, Baseline Clipper, Adjustable Sweep Speed, Video Filter, and 40dB Input Attenuation. SA1300B 1-1300MHz

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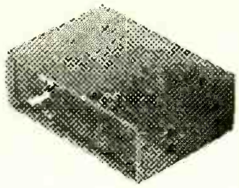
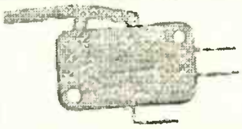
PROJECT BOX



Used to be the power control box for an MDS receiver. It has an on/off switch on front, three "F" connectors and coaxial power jack on rear. Attractive "clamshell" box measures approx. 4½" x 3½" x 1½".

95U009 **Three for $4.95**



MICRO SWITCH

With 1" plastic lever, N.O. and N.C. closed contacts.

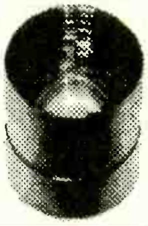
95B010 **$1.25 each**

SEALED LEAD-ACID BATTERIES

New, in crates, with 1994 date codes.
• 12 Volt, 12 Amp/Hour. 5.875"L x 3.75"W x 3.625"H. **Crate of 18 - $325.00**

95E024 **$19.95 each**

BRAND "X" LENS



Eyepiece-type magnifier. Focal length = 50mm, f3:2. Approx. dimensions: D=38mm, L=43mm. Excellent hand magnifier at approx. two power.

93L009 **$9.95 each**

USED TUBES **$1.00 each**

Your choice. Pulls, test OK.

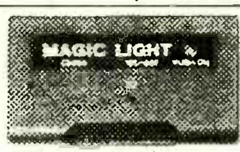
3CU3	6C5	6J5	12AU7
6AG5	6GF7	6SN7	12AV5
6AL5	6GH8	7B5	12DQ6

Price good through 12/31/95.

100' LONGWIRE ANTENNA KIT

For shortwave reception and transmission. End insulators included.

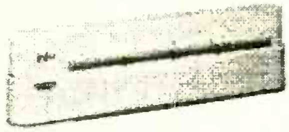
95A002 **$4.95 each**



MAGIC LIGHT

This pocket-sized ultraviolet light may be used for detecting invisible inks, minerals in rocks, etc. It's the same approximate size as a pocket pager and even has a belt clip to keep it handy. Runs on two "AA" batteries (not included). 3¼"W x 1¾"H x 1"D.

95L007 **$7.95 each**



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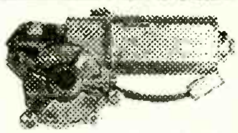
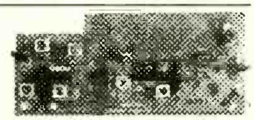


12VDC. Originally for automotive electric windows.

95M002 **$14.95**

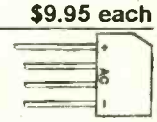


6 METER FSK BOARD

Crystal controlled on 50.675 receive frequency. Super het with 10.7MHz IF. Three ICs and one transistor. Not a kit! New, with schematics and spec sheet for major components.

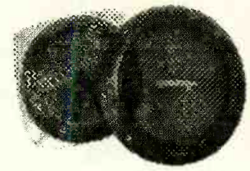
92A067 **$9.95 each**

BRIDGE RECTIFIER



KBL02. 200 Volt @ 4 Amps.

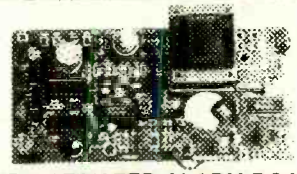
95S002 **$1.49 each**



SPEAKER & GRILL COMBO

Speakers are 4 Ohm, 5 Watt units measuring 4" square at the mounting flanges. The speaker grills are an attractive flat black color and measure 5" in diameter.

95Z014 **$4.95 per Set**

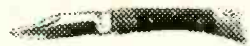


SOUND-ACTIVATED ALARM BOARD

Removed from unused alarm system. When activated, this board listens for sounds of forced entry and responds with a loud siren when tripped. Runs on 9V DC. Microphone is included. Speaker (95Z014) and battery holders are sold separately. Includes pinout diagram.

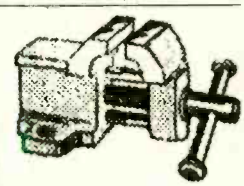
95Z015 **$4.95 each**

FOLDING LOCK KNIFE



Stainless steel blade, 5" open, 3" closed. Wood and brass handle.

94Z032 **$1.49 each**



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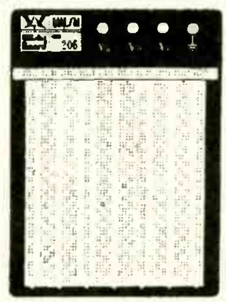

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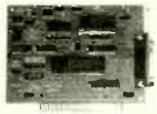

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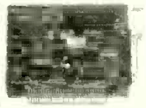

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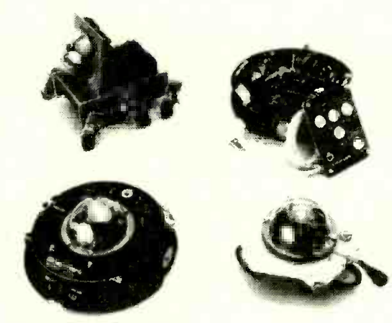

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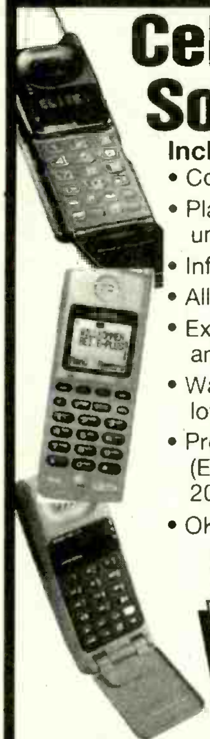

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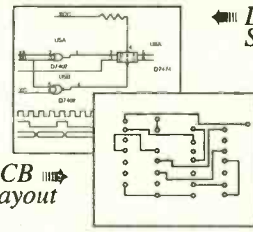

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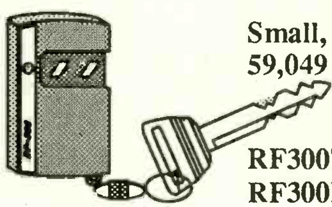

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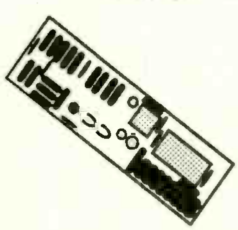

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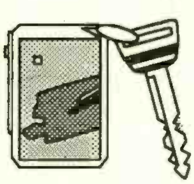

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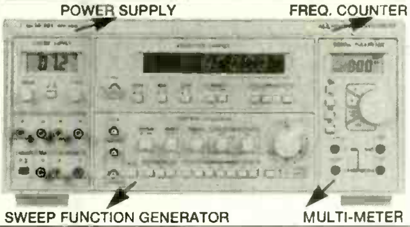

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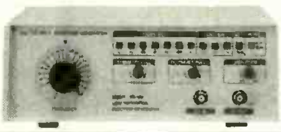

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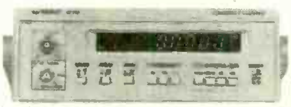

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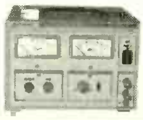

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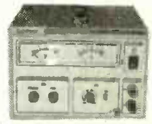

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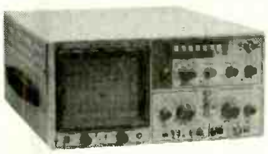

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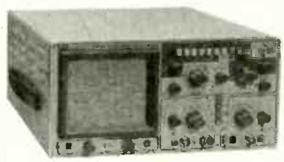

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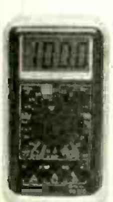

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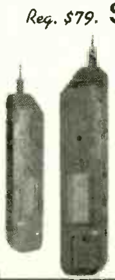

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Fluke Multimeter

Fluke 12	$84.95
Holster C-10	$10
Fluke 70 II	$67.5
Fluke 73 II	$94
Fluke 75 II	$129
Holster C-70	$16
Fluke 77 II	$149
Fluke 79 II	$169
Fluke 29 II	$169
Fluke 83	$225
Fluke 85	$259
Fluke 87	$287
Fluke 97 Scope Meter	$1785

LCR Meter 131D $229.95

Most Advanced LCR

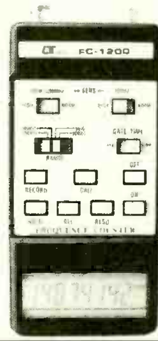
Dual display:L/Q or C/D
Inductance: 0.1µH-1000H
Capacitance:0.1pF-10,000µF
Impedance:1mΩ-10MΩ
0.7% basic accuracy
Auto/manual range
Dissipation factor & Q factor
Serial & parallel mode
Relative mode for comparison and to remove parasitics
Statistics, tolerance,
Best for design, incoming testing & production
SMD and chip component test probe $25.00

LCR Meter 814 $189.95

Best Resolution LCR

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

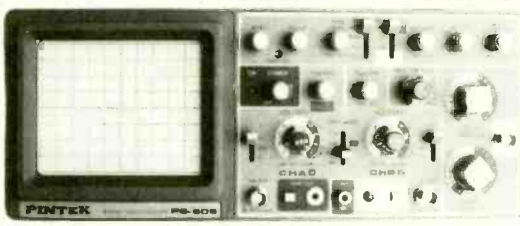
LIMITED QUANTITY SPECIAL
DIGITAL LCR METER $74.95
0.1pF, 1µH, 10mΩ resolution



Frequency Counter FC-1200 $129.95

Frequency:0.1Hz-1.25GHz
Display: 8 digit LCD
Period: 0.1µs-0.1s
Records Max/Min/Average
Data hold, relative mode
Telescoping antenna $8.00
Deluxe case $5.00

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



20 MHz Oscilloscope with Delay Sweep PS-205 $429.95

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

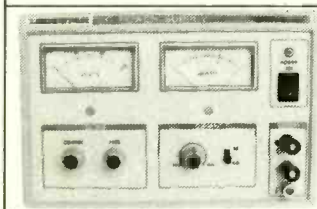
PS-200	20 MHz DUAL TRACE	$339.95
PS-400	40 MHz DUAL TRACE	$494.95
PS-405	40 MHz DELAY SWEEP	$569.95
PS-605	60 MHz DELAY SWEEP	$769.95

Scope Probe: 60MHz x1, x10 $15, 100MHz x1, x10 $22
250MHz x1, x10 $29, 250MHz x100 $39

Digital Storage Scope

DS-203 20MHz, 10M Sample/sec $729.95
DS-303 30MHz, 20M Sample/sec $849.95
DS-303P with RS-232 interface $1,049.95

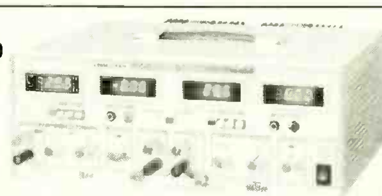
Switchable between digital and analog modes
2 K word per channel storage
8 bit vertical resolution (25 Lerel/div)
Expanded Timebase 10ms/div - 0.5 s/div
Refresh, Roll, Save all , Save CH2, Pre-Trig
Plotter control



DC Power Supply PS-303 $159.00

0-30 VDC , 0-3A output

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



DC Power Supply Triple Output PS-8202 $499.95

Two 0-30 VDC , 0-3A outputs
One fixed 5VDC, 3A output
Capable of independent or tracking operation
Constant voltage and constant current mode
Four digital meters for volt and current display
Excellent regulation and low ripple
Short circuit and overload protected
Also available: 30V/5A triple output $549.95
Dual tracking 30V/3A, 30V/5A, 60V/3A, 60V/5A

RF SIGNAL GENERATOR SG-4160B $119.00

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

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

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

AUDIO GENERATOR AG-2601A $119.00

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

AUDIO GEN./COUNTER AG-2603AD $229.95

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

FUNCTION GENERATOR FG-2100A $169.95

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

FUNCTION GEN/ COUNTER FG-2102AD $229.95

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

SWEEP FUNCTION GEN./COUNTER $329.95

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

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

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

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

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

50 MHz Triggering Oscilloscope OS-653 $699.95

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

20 MHz Oscilloscope OS-622B $344.95

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

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

DC Linear Power Supplies Single Output

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

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

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

Triple Output DC Power Supplies

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

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

Programmable DC Power Supplies

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

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

Digital Display Function Generator FG-8016G $239.95

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

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

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

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

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

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

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

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

Model DM-392 (3¾ digits) $109.95

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

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

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- Tunes 88-108 MHz.
- Powerful 2 stage audio amplifier.
- Sensitive, picks up sounds at the level of a whisper.
- Up to 1 mile range.
- Requires 9V battery. (Not incl.)

SUPER-MINIATURE FM TRANSMITTER
Super small FM transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip (SMT) parts are pre-assembled to the circuit board.

XST500 (E-Z) Kit $44.95

- Miniature photo battery mounts right on circuit board. (Included)
- Tunes 88-108 MHz.
- Up to 1/2 mile range.
- Sensitive 2 stage audio amplifier, picks up sounds at the level of a whisper.

MICRO-MINIATURE FM TRANSMITTER
Including the battery, this is the Worlds smallest FM transmitter. Use with any FM broadcast receiver. Easy to assemble, uses pre-assembled circuit board.

XWB1000 E-Z KIT $49.95

- Up to 1/2 mile range.
- Miniature photo battery mounts right on circuit board.
- Transmits at 143 MHz.
- Amazing audio sensitivity, picks up sounds at the level of a whisper.

CRYSTAL CONTROLLED FM TRANSMITTER
Including the battery, this is the Worlds smallest crystal controlled FM transmitter. Transmits to any scanner type receiver. Easy to assemble, uses pre-assembled circuit board.

XTL1000 E-Z KIT $69.95

- Smallest Phone transmitter anywhere!
- Tunes 88-108 MHz.
- No batteries required, powered by phone line.
- Up to 1/4 mile range.
- Attach to phone line anywhere in house.

SUPER-MINIATURE PHONE TRANSMITTER
Worlds smallest FM phone transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip components are pre-assembled to the circuit board.

XSP250 (E-Z) Kit $34.95

- Dial your phone from anywhere and listen to the sounds inside your home.
- Two digit Touch Tone code for secure operation.

TELEPHONE SNOOP
Call home from anywhere, enter a two digit security code, and hear the sounds in your home. Automatically turns on without ringing the phone, verifies code, then activates for one and a half minutes.

XPS-CASE KIT $13.95
XPS1000 (C) KIT $49.95

- Transmits a continuous beeping tone.
- Adjustable from 88 to 108 MHz.
- Up to 1 mile range.
- Works with any FM broadcast receiver.

TRACKING TRANSMITTER
Only 0.7 by 2.4 inches, the XTR100 operates at voltages of 3 to 18 Volts and is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide and seek, and contests.

XTR100 (C) Kit $33.95

- Uses sensitive microwave transistor amplifier.
- Covers 1 to 2,000 MHz.
- Compact hand held unit.
- Includes miniature loud speaker for audio indication of detected signals.

SUPER SENSITIVE BUG DETECTOR
When the XBD200 intercepts a signal in the 1 to 2,000 MHz range, it emits a growl that increases to a high pitched squeal as the signal strength increases.

XBD200 (C) Kit $49.95

- Use with any FM broadcast receiver.
- Hear every sound in an entire house!
- Up to 1 mile range
- Powerful 2 stage audio amplifier.

MINIATURE FM TRANSMITTER
The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.

XFM100 (C) Kit $32.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Maintain anonymity on any call.
- Button for normal operation.
- 16 levels of voice masking.

VOICE CHANGING TELEPHONE
STOP THOSE ANNOYING TELEPHONE CALLS! Sound older and tougher when you want to. Not a kit. Fully assembled. Single phone operation only.

TRANSITION 2000 .... $89.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Use with any modular phone.
- 16 levels of voice masking.
- Connects between handset and phone.

VOICE CHANGING ACCESSORY
STOP THOSE ANNOYING TELEPHONE CALLS! Sound older and tougher when you want to. Not a kit. Fully assembled. Use with single or multi-line phones.

TRANSITION 2001 .... $59.95

- Uninterrupted 800 to 950 MHz coverage.
- Works with any scanner that can receive 400 to 550 MHz.

800-950 MHz SCANNER CONVERTER KIT
If your scanner can receive 400-550 MHz, just add the XLC900 for uninterrupted 800-950 MHz coverage. It converts all 800-950 MHz signals to 400-550 MHz so your scanner can receive them! Add our custom case kit for that "Professional" look.

XLC-CASE KIT $13.95
XLC900 (C) KIT $49.95

- Transmit high quality stereo to any FM stereo receiver.
- Built-in output level monitor for quick and easy tuning.
- Ideal for use with personal CD player.

FM STEREO TRANSMITTER
Transmit full-bodied Hi Fi stereo to any FM stereo receiver. Separate left and right inputs and gain controls. Includes an output booster stage for greater range.

XFS-CASE KIT $13.95
XFS108 (C) KIT $41.95

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- 3 TIMER COUNTERS
- 24 DIGITAL I/O

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- TRMS, 20 AMPS
- 12 BIT A/D
- OPTO-ISOLATED
- COMPLETE DMM

MODEL 40 .... $99
- RS-232 INTERFACE
- 28 LINES DIGITAL I/O
- 8 ANALOG INPUTS
- PWM OUTPUT

MODEL 70 .... $239
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- 16 BIT A/D
- 5.5 DIGIT
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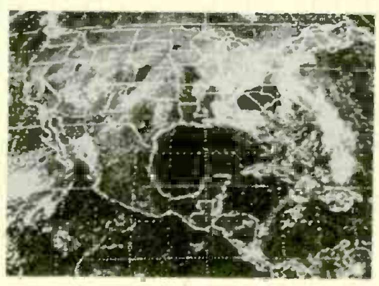
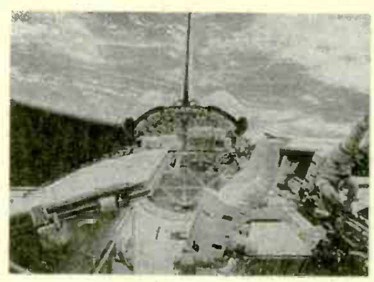


PC HF Fax Plus $129
PC HF Fax Plus is a simple, yet comprehensive HF system that receives Fax, RTTY, CW, and AMTOR on an IBM PC or compatible. It includes an FSK demodulator, advanced signal processing software, tutorial audio cassette, and complete reference manual. Just plug the demodulator into a serial port, install the software and get text and vivid images on your PC.

PC SSTV $149.95
PC Slow Scan Television is a complete system for sending and receiving full color amateur SSTV. The package includes an SSTV FSK modem, SSTV software, image capture utilities and reference manual. All popular formats are supported including Robot, Scottie, Martin and AVT. The system requires a 286, 386 or faster PC with VGA or super VGA display.



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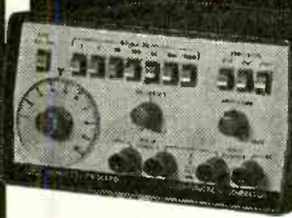


Hewlett-Packard 3311A
Function Generator, 0.1 Hz to 1 MHz, sine, square, triangle and + pulse waveforms.

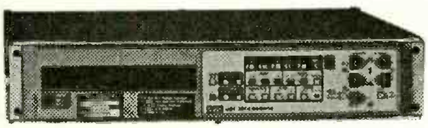
$300.00

Hewlett-Packard 1715A
Oscilloscope, 200 MHz bw, dual trace, deflection factor of 10 mV/div to 5 V/div over the full bw (5 mV/div to 150 MHz). delayed sweep and delta time mode.

$500.00 Special

Fluke 8520A
Digital Multimeter, 5.5 digit, ac/dc volts, 2 and 4 wire ohms, conductance, 20 ppm basic dc accuracy, burst memory and math capabilities.

$369.00 Special



Hewlett-Packard 435A
Power Meter compatible with entire series of HP 8480 power sensors. Can measure from -65 dBm to +44 dBm, full scale, at frequencies from 100 kHz to 50 GHz depending on which sensor is used.

$249.00

with cable $349.00

Hewlett-Packard 8558B
Spectrum Analyzer Plug-In, 0.1 to 1500 MHz, resolution bw from 1 kHz to 3 MHz, amplitude range is -117 to +30 dBm. Automatic and manual sweep.

$2150.00

Hewlett-Packard 3586B Selective Level Meter
Makes carrier measurements to 32.5 MHz, voice channel measurements from 50 Hz to 100 kHz, can use the 3336B Level Generator as an automatic tracking generator. Includes options 001, 003, & 004.

$850.00

Tektronix 475A DM44 Oscilloscope
250 MHz bw, dual channel, 5 mV/ div sensitivity, 1nS/ div sweep rate. With differential-time/DMM option. Includes 2 probes.

$975.00

Hewlett-Packard 8620C/ 86290C Sweep Oscillator System
86290C RF Plug-in, 2 to 18.6 GHz, +13 dBm maximum leveled output. The 8620C has full sweep and cw functions. Both are like new condition.

$2900.00 Special

Tektronix 7L12
Spectrum Analyzer Plug-In, 100 kHz to 1.8 GHz, 300 Hz to 3 MHz resolution, automatic phase lock, -115 dBm sensitivity.

$2500.00

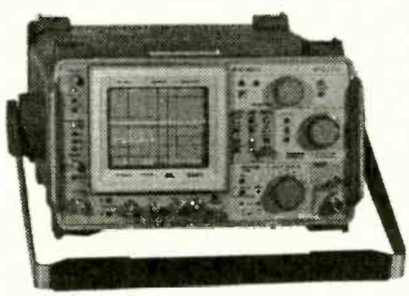
Tektronix 7L13
Spectrum Analyzer Plug-In, 1 kHz to 1.8 GHz, 30 Hz to 3 MHz resolution, -128 dBm sensitivity, 70 dB dynamic range, automatic phase lock.

$2750.00

Hewlett-Packard 239A
Oscillator provides a low distortion sine-wave output with >3 Vrms amplitude from 10 Hz to 110 kHz and less than -95 dB THD to 20 kHz.

$399.99

Tektronix 492 Spectrum Analyzer
50 kHz to 21 GHz, 80 dB dynamic range, amplitude comparison in 0.25 dB steps. Options 01, 02..



$7500.00

Wanted Test Equipment call or fax us your list!

Phillips PM5712
Pulse Generator, 1 Hz to 50 MHz, amplitude range 0.2V to 10V, DC offset:+2.5V, offers a fixed rise and fall time of 4 ns.

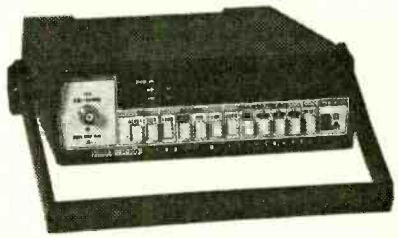
$550.00

Wavetek 3520 Signal Generator
1 MHz to 2080 MHz frequency range, GPIB, 32 complete front panel stored settings, non-volatile memory, power range is +10 to -137 dBm.

$3250.00

Wavetek 8502A/16934
Microwave Power Peak Meter, 30 MHz to 40 GHz frequency range,-20 to +20 dBm peak power range, full GPIB control. Includes 16934 Power Sensor.

$2950.00



Fluke 1900A
Multifunction Counter, 5 Hz to 80 MHz, provides frequency, period, period averaging and totalize measurements, 6 digit display, 1 MHz low-pass filter.

$189.00 Special

Hewlett-Packard 59501B
Isolated DAC/ Power Supply Programmer, HP-IB power supply control, HP-IB to power supply isolation, programmable range, programmable 10 Vdc output.

$189.00

Hewlett-Packard 331A
Distortion Analyzer, 5 Hz to 600 kHz, measures total harmonic distortion down to 0.1% full scale.

$199.99 Special

Hewlett-Packard 5335A
Universal Counter, 200 MHz counter, built in automatic rise time, duty cycle, pulse width, slew rate and phase measurements, auto triggering..

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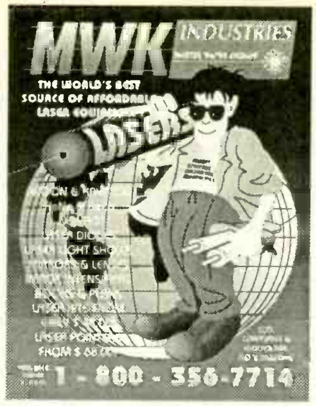

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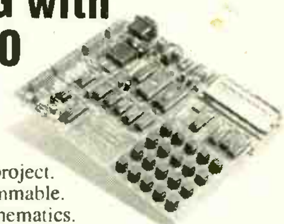

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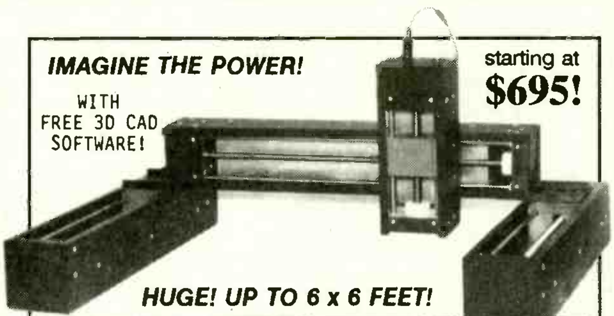

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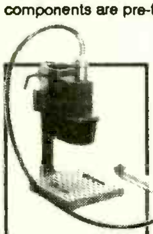

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78L12	.45
78L15	.45
7805T	.59
7806T	.59
7808T	.59
7810T	.59
7812T	.59
7815T	.59
7824T	.59
7805K	1.79
7812K	1.79
7815K	1.79
7824K	1.79
78M05	.59
78M08	.59
78M12	.59
78M15	.59
78M24	.59
UA78S40	2.39

Negative Output

79L05	.45
79L12	.50
79L15	.55
7905T	.59
7906T	.59
7908T	.59
7910T	.59
7912T	.59
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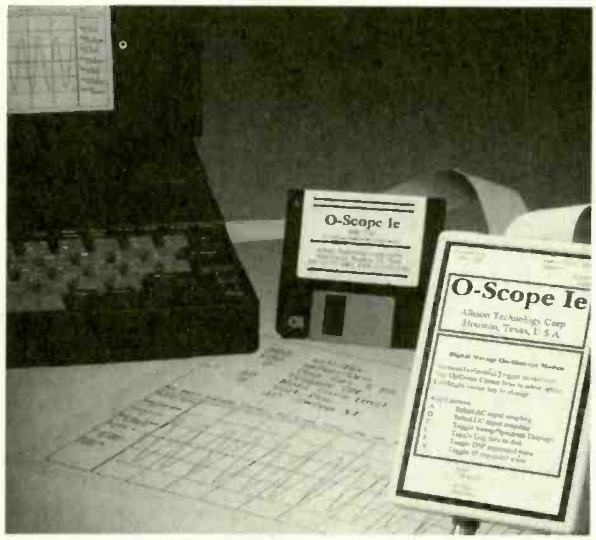

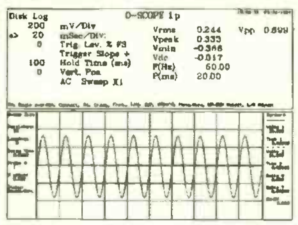

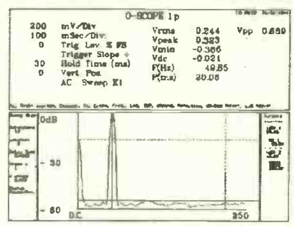

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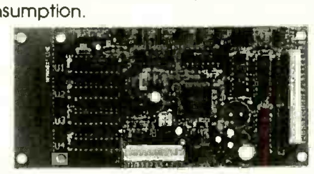
DIGITAL VOICE MODULE

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



#M105858	$89.95
1Mb DRAM	$5.15
4Mb DRAM	$21.95

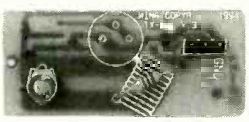
RF TRANSMITTER + ENCODER MODULES

The TX-99 interfaces with the TX-01 as the RF carrier module. 300 MHz AM with a typical range of 50' -100' line-of-sight. (Key-chain transmitter is also available, model TX-99K $15.95)

#M109903 $5.95

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

#M10001E $9.95



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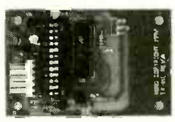


RF RECEIVER + DECODER MODULES

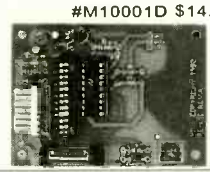
The RE-99 interfaces with the RE-01 as the RF carrier's receiver module and requires only a few solder connections to mate the two. 300 MHz AM.

#M109904 $6.95

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

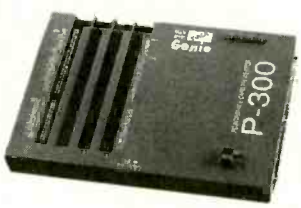
#M10001D $14.95

+



PC INTERFACE CARD PROTECTOR

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

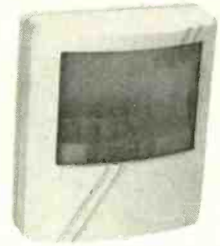


#M12P300 $349.95

PIR DETECTOR

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

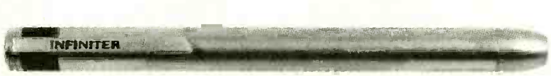
Detects ambient body heat and movement to trigger your connected security system, announcement buzzer, or warning device.



#M113300 $24.95
3+ at $19.95 each.

LASER POINTER

The Infiniter "NBK-2" Laser Pointer's high polished, chrome-like finish is lightweight and can project a beam over 150' to enhance any demonstration or presentation. It even works well on overhead projection screens and can be used in conference rooms, exhibition hall, construction sites, museums, etc.



(2-"AAA" Batteries not included) #M160012 $49.95

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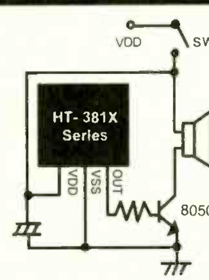
The HT-381XDPB Demo Sampler Kit comes complete with a preassembled playback board, battery holder and ten Holtek melody IC's. Great for experimenting or adding a musical melody to a project.

Included melodies:

Karinka•Happy Birthday•It's A Small World•Home Sweet Home•Yankee Doodle•Rock-A-Bye Baby•Are You Sleeping?•Song Of Joy•My Little Tricycle•When The Saints Go Marching In



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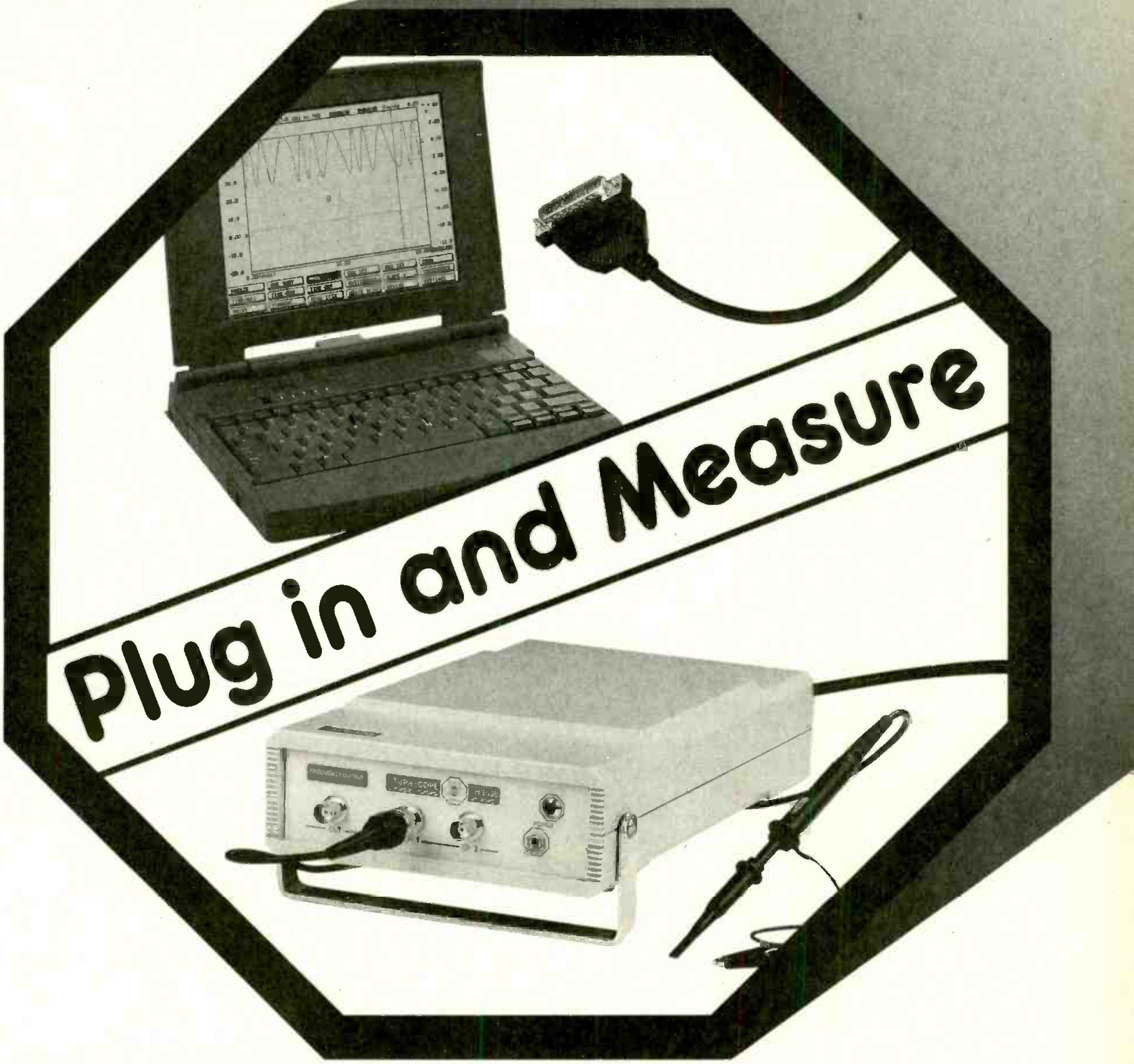
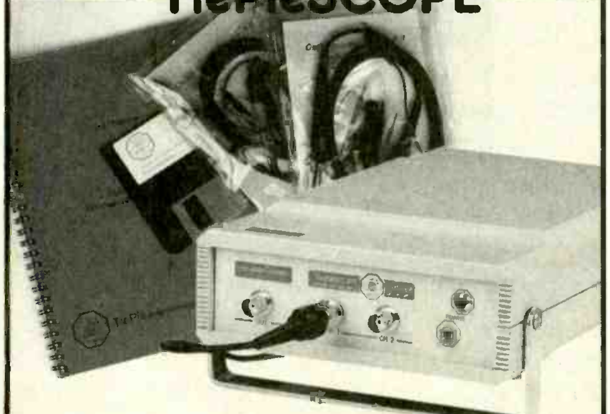


TiePieSCOPE



HS508 Complete set for US $1054

You can simply plug the new TiePieSCOPE - HS508 into the parallel port of your portable or desktop PC. With the advanced software, you can use this two channel, 8 bits, 50 MHz measuring instrument as a fast digital storage oscilloscope, including a lot more features than a single oscilloscope! Moreover, the TiePieSCOPE - HS508 contains a multiple display voltmeter (up to 5 MHz true RMS), a spectrum analyzer with an harmonic distortion meter and a transient recorder for recording a variety of signals.
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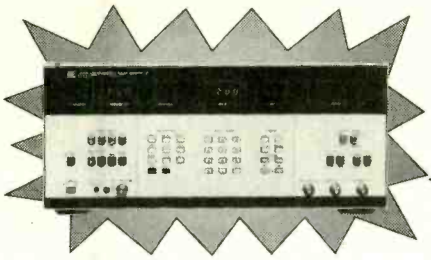

HP 8160A 50MHz PROGRAMMABLE PULSE GENERATOR

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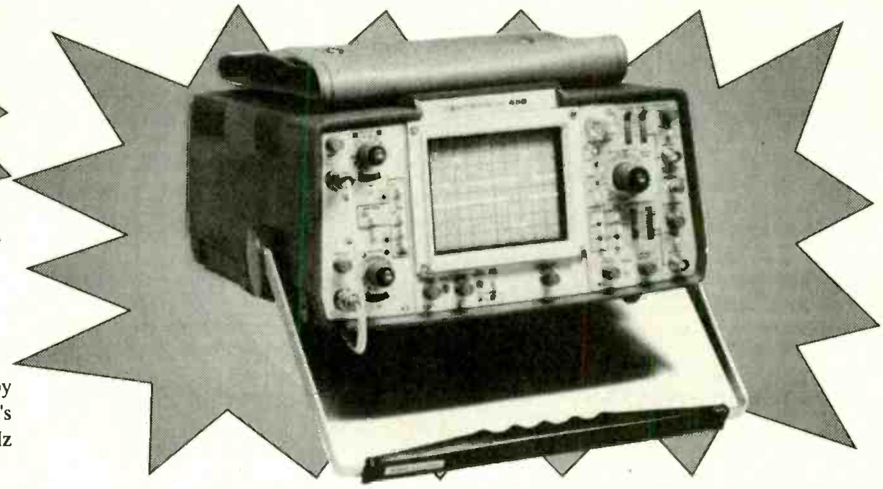
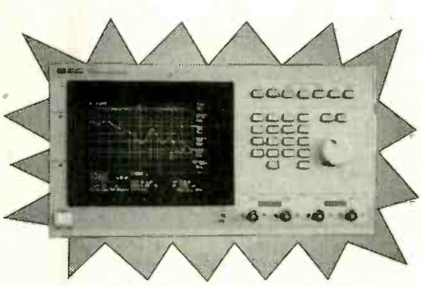


TEKTRONIX 465M

Proof is in the pudding when it comes to this instrument's track record. There's no doubt, that popularity speaks many languages when speaking of the "465M". This excellent instrument continues the tradition of the standard 465 oscilloscope by adding useful features such as CH-1, CH-2 sum or difference, trigger view in any combination, alternate sweep and trace selection versatility. Many technicians dream of owning a quality 100-MHz oscilloscope, but funding rairly permits. Fortunately, we were recently able to aquire a limited supply of 465M-s in very good condition. Our LOW PRICES will likely permit "you" to own one of the best scopes anywhere in the country. If your needs are current and action *swift* you too will be a member of a growing club!!!

VERY GOOD CONDITION................$695.00

These instruments are fully checked out and calibrated. They are supplied with an original front panel cover and complete service manual. Original TEK Probes are $75.00 each with each purchase.



HP54111D 500-MHz, 1 GSa/s DIGITAL COLOR SCOPE

This user friendly oscilloscope features, up to 8 bits of vertical resolution, pretrigger, automatic measurements, HP-IB, up to 2 gigasample capture when used with 54114A, excellent single shot transient signal capture, full trinitron color display programmable any way you like it, Instant print. Uses include:

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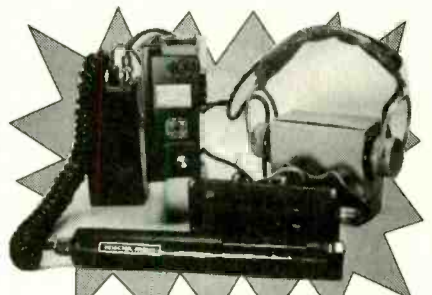

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This portable radiac set is loaded with all kinds of extras featuring six ranges of sensitivity for both Gamma or Beta radiation measurements. The 1st scale 0-1 rad/hr up to 0-5000 rad/hr. The unit comes supplied with headset & bat/charger. Req's only 4 AA Batteries. **Price: $149.95**

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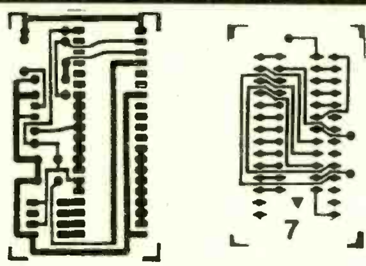

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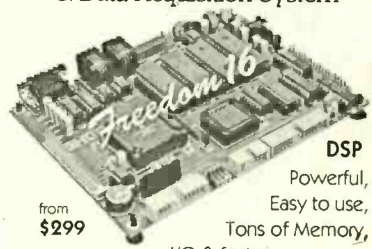

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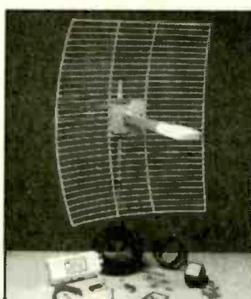

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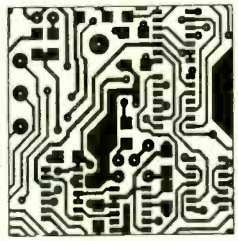

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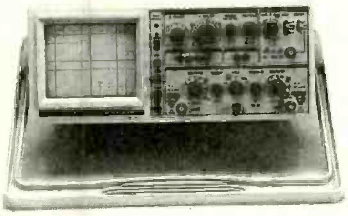

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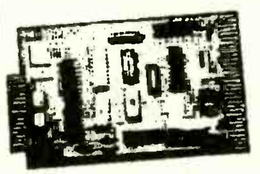

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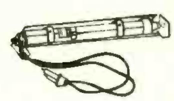

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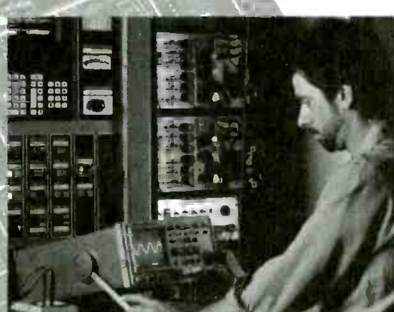

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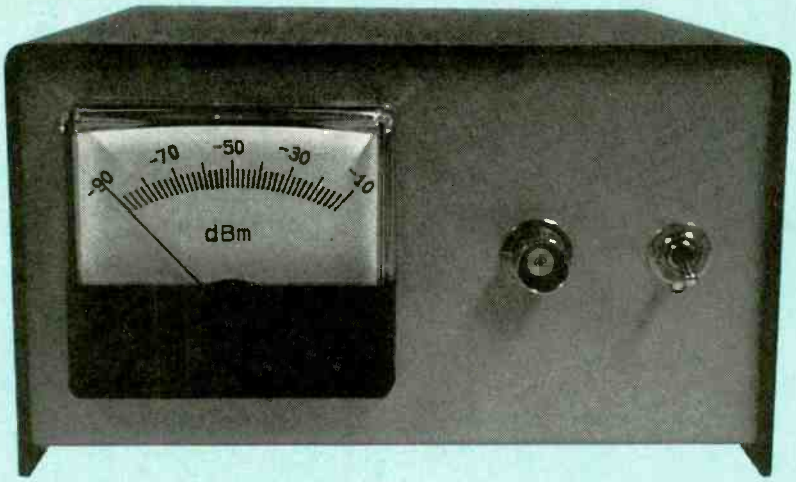

dB METER

Build this decibel meter and measure field strength, read filter outputs, and check oscillator injection values.

JOHN PIVNICHNY

A SIGNAL-LEVEL METER WITH A LOGarithmic or decibel scale can be a very useful test instrument for the electronics experimenter or radio amateur. The decibel (dB) can express many different electrical quantities in convenient form. Decibels compress widely varying electrical values onto a more manageable logarithmic scale. For example, the range of powers extending from 100 watts down to 1 microwatt is a ratio of 100,000,000 to 1 but it is expressed as only 80 dB.

This article explains how to build and use a decibel meter that covers an 80-dB range. Gains and losses through circuits such as attenuators, amplifiers, and filters, when expressed in dB, can be added together to produce the total gain or loss. (See the box for more information on decibels.)

Conventional linear reading, radio-frequency voltmeters typically cover only 20 to 30 dB before it is necessary to change ranges. This means that you must constantly switch the meter range as you tune across a filter's response curve. The procedure for checking several filters with different center frequencies becomes tedious. With this meter, you just record the decibels and you're done!

If you want to adjust the injection level for a mixer circuit to −30 dBm with conventional test equipment, you must make some calculations to convert a voltage reading to power. However, if you build this meter you won't have to make any calculations because the meter is calibrated directly in dBm, a unit of power referenced to a milliwatt (1 mW or 0.001 watt).

Power can be measured in dBm regardless of the circuit's input or output impedance, but this meter is designed so that if a circuit's impedance is known and specified, dBm measurements can be based on voltage. For the 50-ohm input of this decibel meter, 1 milliwatt of power corresponds with a voltage of 0.224 volts RMS. You just feed in the signal and read the dBm level on the meter scale.

WHAT IS A DECIBEL?

A decibel (dB) is a power or voltage measurement unit referred to another power or voltage. Log means common logarithm, power (P) is in watts, voltage (V) is in RMS volts.

dB = 10 log (P2/ P1)

dB = 20 log (V2/ V1)

A decibel meter is an instrument that directly measures the power level of a signal in decibels above or below an arbitrary reference level. It is also called a dB meter.

The dBm unit or *decibels above 1 milliwatt* is defined as 10 times the common logarithm of the ratio of a given power in watts to 0.001 watt.

dBm = 10 log (P/0.001)

A negative value such as −17 dBm means decibels below 1 milliwatt. As long as the impedance is known and specified, dBm can be computed with voltage. For a 50-ohm resistance, 1 milliwatt of power corresponds to a voltage of 0.224 volts RMS. Using this value in the decibel equation yields:

dBm (50 ohms) = 20 log (V/ 0.224)

The dBV unit or *decibels above 1 volt* is a voltage level equal to 20 times the common logarithm of the ratio of a given voltage in volts to 1 volt.

dBV = 20 log (V)

How does the meter work?

The decibel meter converter is based on circuitry within the CA3089E, a monolithic IC FM system from Harris Semiconductor. The device provides all the functions of a comprehensive frequency-modulation, intermediate-frequency system, but only part of this capability is needed for this decibel meter.

Figure 1 is the schematic for the decibel meter. The circuit consists essentially of IC1, the CA3089E, a 0 to 100-microampere meter M1, on-off switch S1, a few resistors and capacitors, and a diode. Most of the electronic components are inserted and soldered on a small circuit board that is mounted on standoffs above the bottom of the lower half of a metal project case. However some components are mounted on the back of the meter.

Figure 2 is the plot of DC volts out of METER OUT pin 13 of IC1 (33 kilohms to ground) vs. the input signal in microvolts on IF IN pin 1 converted to decibels

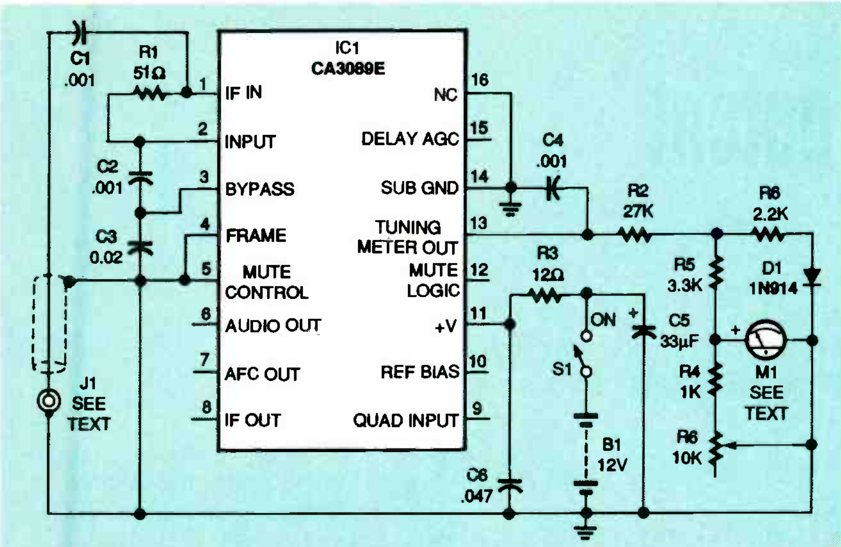

FIG. 1—SCHEMATIC FOR THE DECIBEL METER. The principal component is the CA 3089E FM IF IC because it contains the decibel conversion circuitry

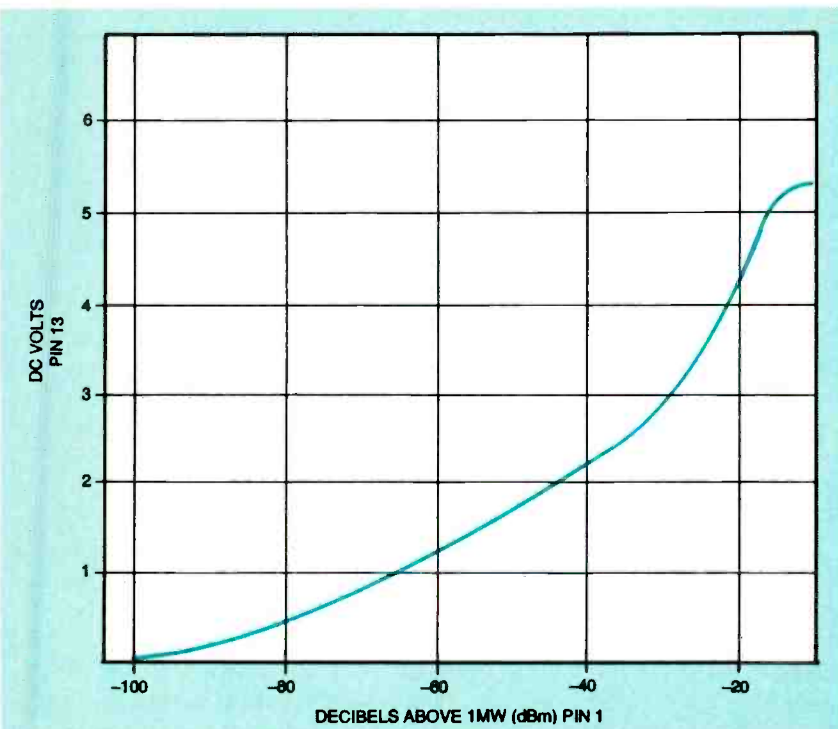

FIG. 2.—PLOT OF VOLTAGE AT IC1, pin 13 vs. the input signal in microvolts on IC1, pin 1 converted to decibels above 1 milliwatt.

above 1 milliwatt. IC1 detects the signal level and generates a nearly logarithmic DC output. To linearize the high end of this curve, diode D1 and resistor R6 shunt some of the DC current as the voltage on pin 13 rises above 3 volts.

The battery pack consisting of eight AA alkaline cells makes the instrument portable and eliminates the possibility of 50/60 Hz hum interfering with the readings. The meter draws only about 16 milliamperes, so battery life will be long. The meter will provide accurate readings as long as the output of the battery pack remains above 8 volts. No regulation of this DC is required.

Building the dBM meter

The electronic circuitry is mounted on a small 1½ ×2-inch circuit board. The components can be wired by point-to-point methods or they can be mounted on a PC board. A foil pattern for the circuit board is included in this article for those who wish to make their own. However, a finished circuit board can be purchased from the source given in the Parts List.

All of the electronic components are readily available from mail-order electronic distributors and electronics retail stores. Meter M1 has a custom-drawn scale graduated in 2 dBm units from −10 dBm to −90

Continued on page 158

PARTS LIST

Resistors are ¼-watt , 10%, unless otherwise specified.
R1—51 ohms
R2—27,000 ohms
R3—12 ohms
R4—1000 ohms
R5—3,300 ohms
R6—2,200 ohms
R7—10,000-ohms, trimmer potentiometer
Capacitors
C1, C2, C4—0.001µF ceramic disc
C3—0.02µF ceramic disc
C5 —33µF aluminum electrolytic, radial-leaded
C6—0.047µF ceramic disc
Semiconductors
IC1—CA3089 CMOS FM IF, Harris Semiconductor or equiv.
D1—1N914 silicon diode, glass axial-lead package
Other components
S1—toggle switch, SPST, panel-mount
J1—BNC receptacle connector, panel-mount
M1—meter, 0 to 100 µA (scale modified to dBm units, see text)
B1—eight alkaline AA cells in holder
Miscellaneous: circuit board (see text); project case, metal, 3 × 5¼ × 5⅞-inches; RG-174/U cable, 6 inches; battery holder for eight AA cells; three 4-40 × ¾ screws; nine 4-40 hex nuts; four 6-32 screws; two ¾-inch 6-32 threaded standoffs; aluminum channel; 3 inch length (see text), 12-volt battery clip, insulated hookup wire, solder.

The following options are offered by Unicorn Electronics, Inc., Valley Plaza Drive, Johnson City, NY 13790 (607) 798-0260:

- Kit of parts including all electronic components, an etched and drilled circuit board, drilled case, and meter with dBm scale—$49.95
- Meter with dBm scale—$18.75
- Circuit board, etched and drilled—$3.00

Add $3.50 shipping and handling. Send check or money order. New York State residents add local sales tax.

BY DON LANCASTER

Another patent horror story

Plus more magic sinewaves, stepper motor driver chips, a mid-range Mensch computer, and PCMCIA plug-in card resources.

I JUST GOT YET ANOTHER LETTER FROM SOMEBODY TRYING TO PROTECT THE IDEA HE "INVENTED" BY GETTING A PATENT . AS IS TRUE NEARLY ALL OF THE TIME, HIS PRODUCT IDEA SIMPLY was not worth protecting. A similar product has been available off the shelf from a high-profile major supplier for several decades.

Yet this person never heard of the leading company in the field! He wasn't familiar with the trade journals involved, nor did he do an economic analysis of who would buy the product, or check into the excessive regulations in the target market. He also did not pick up on the fact that lots of potential buyers would prefer a zero-cost all-software solution instead.

The patent, if issued, could end up being totally worthless. First, the concept involves a completely obvious safety lockout device. Forgetting that you could buy one off the shelf, there are centuries of prior art involved. More important, the idea is completely obvious to any practitioner in the field. Almost certainly, hundreds of other patents would encroach on the claims.

It's not the least bit clear what purpose the patent would serve once he actually got one. It would not offer any "protection." Urban lore appears to confuse the words "patent" and "product." These two are totally unrelated.

A patent is a sheet of paper which gives you the right to sue someone. Like a stock option, it is worthless unless exercised. A product is the useful item that goes out the door and makes a profit for you.

Patents have nothing whatsoever to do with today's successful

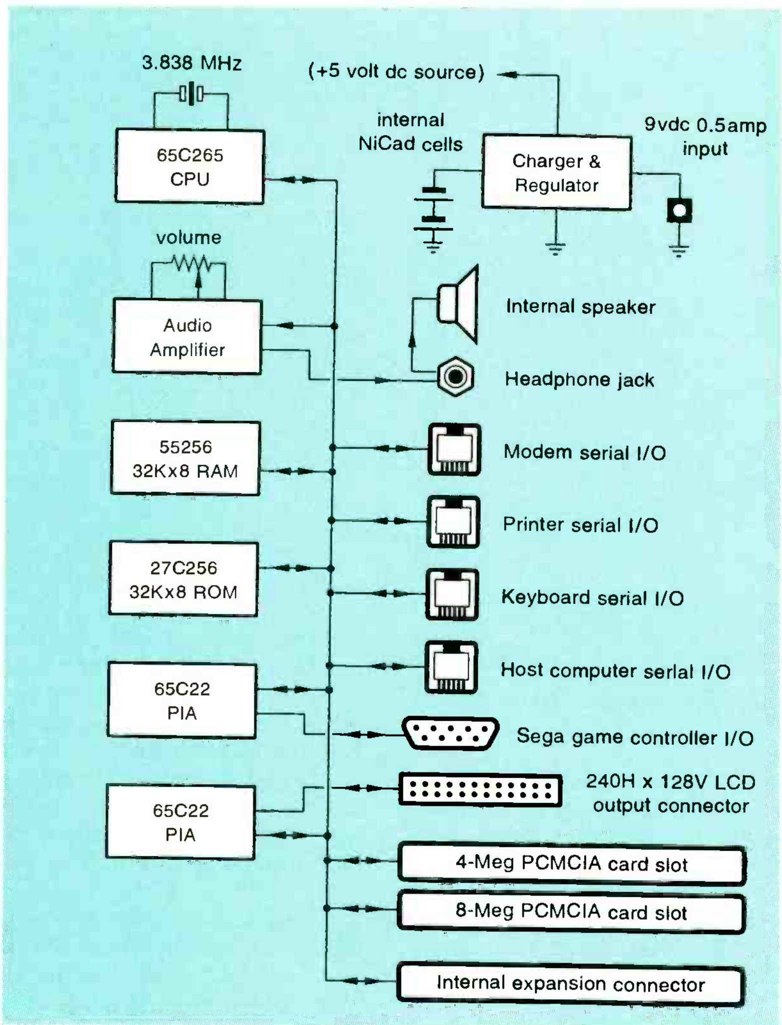

FIG 1—INTERNAL ARRANGEMENT of the Mensch Computer. This one is easily customized for a wide variety of mid-range needs.

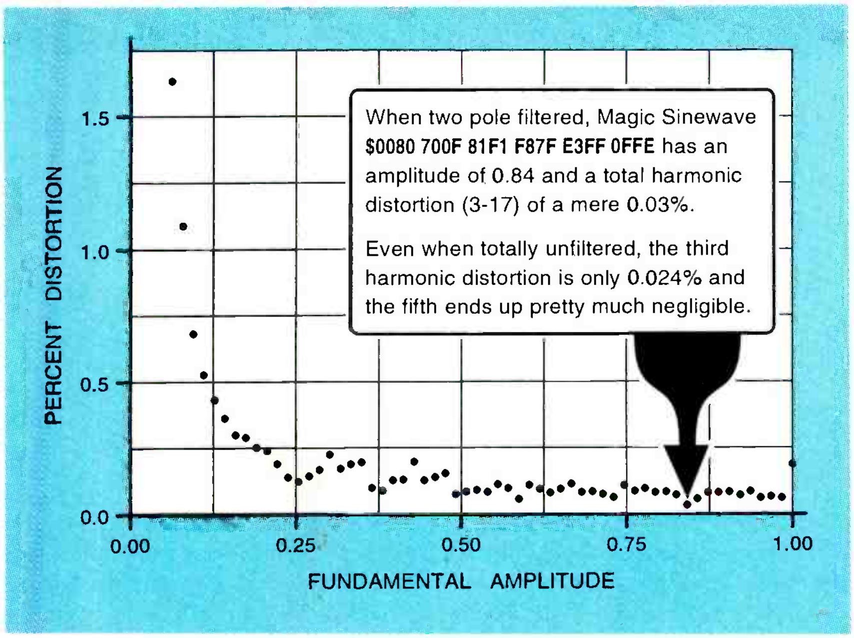

FIG 2—SOME PRELIMINARY 384-BIT MAGIC SINEWAVES which combine high efficiency and really low harmonic distortion.

product development! Most often, they are a totally unneeded sideshow, guaranteed to cost you time, money, and sanity—at least for most individuals and smaller startups the overwhelming majority of the time.

Do not even *think* about a patent unless you're (a) a long-term industry insider person who is (b) aggressively subscribing to all the relevant trade journals, shows, and technical publications, and who (c) has thoroughly done all his homework, generating (d) full production artwork and real working models currently in an advanced beta stage of (e) a genuinely and stunningly new product that has a (f) gross sales potential of at least $12,000,000.00.

Actually that 12-million dollar figure is sort of low. That's only the theoretical breakeven point. It is based solely on what percentage of final profits you are going to spend subsidizing attorneys and the patent system. The level at which a patent might start to overcome all of the hassles involved is more like a gross of forty million. Trying to patent any million-dollar idea is, of course, ludicrously insane.

In all my many years of running a helpline and developing hundreds of real-world products, not once have I ever found any small startup that has genuinely profited from the patent system. Yet I have thousands of examples of individuals very badly done in by patents—even murdered by them in heart-attack-during-litigation cases. Putting my money where my mouth is, there's a free Incredible Secret Money Machine II book for you if you can find any exception.

For a check list of when patents and patenting might make sense, look into WHEN2PAT.PDF on my *GEnie* PSRT. For working and proven real-world alternatives, pick up my *Case Against Patents* package.

The Mensch computer

What do you use when the BASIC Stamp is too wimpy and a laptop PC is clearly gross overkill? There's lots of emerging uses for a no-nonsense and easily customized experimenter's mid-range computer, especially one that can be battery powered. Enter the new *Mensch Computer* from *Western Design Center*. It is sort of a reincarnated *AIM-65* with touches of the *KIM-1* and *Apple IIGS* thrown in. Figure 1 shows details.

The computer itself is a sturdy 1-fi- by 7-fi- by 10-inch block—three pounds worth. Most of the weight is from the rechargeable battery. It has four modular-jack serial ports for keyboard, printer, modem, and a host PC programming link.

Two PCMCIA card slots might be

used for additional memory, as data recorders, for floppy disk substitutes, modems, or even a GPS receiver. A game-paddle port is provided for the *Sega* compatible six-button arcade pad. The computer also contains an internal speaker, volume control, headphone jack, and a 20-pin connector for the removable stand-alone LCD text and graphics display.

There are no parallel ports as such, but you could easily use the PCMCIA slots for data acquisition, industrial control, or CAD/CAM. An expansion connector is also provided. The Sega I/O is reprogrammable so there are a lot of ways to pick up a few extra data lines.

The black-and-white LCD display provides a 240 by 128 resolution, which is enough for fairly interesting graphics or 16 lines of 40 characters each. With some sneakiness, you can extend this to 21 lines of 60 smaller characters, or mix the two.

One recommended keyboard is the *Spacemate* by *Key Tronic*. It's full size with 85 keys, but no numeric keypad. Any serial communication keyboard or keypad could be used instead. Any old stock 12-volt, 1/2-amp AC adapter provides power. An "adding machine" thermal printer is an extra-cost option. The computer purposely has no video, color, floppy-disk, or hard-disk drives.

The Mensch computer is based on a 65C265 CPU. That microprocessor is a descendant of the 6502. It has a 16-megabyte address space and exceptionally powerful addressing modes. Also internal to the computer is 32K of EPROM and 32K of system RAM. Up to 12 megabytes of additional memory can be added in the PCMCIA slots.

The rest of the internal circuit is mostly two parallel interface chips, plus the usual "glue" items such as a speaker amplifier, charger, regulator, and a low-battery detector. Battery use is optional. The micropower CPU firmware has several battery-saving modes. Battery life depends mostly on the display activity and the peripherals.

Development work is easiest done using assembly tools already in place for the *Apple IIGS*. Development by cross-porting from a PC is possible. Fairly extensive subroutine libraries are built into the firmware.

1. Pick the number of bits per word. 384 is often a good choice.
2. Pick an amplitude *n* based on the number of ones per word.
3. Pick a desired number of efficiency-setting transitions.
4. Calculate the number of clumps *k*. This is *one-half* the number of transitions for even solutions.
5. Generate a list of all possible sums of *k* integers that total *n*.
6. For each entry on the list, fit it to a *n(1-sine)* function. Then select the one with the lowest classic Fourier series distortion.
7. Optionally "anneal" the final clumps by jittering their positions.
8. Compile and plot the results.

FIG 3—THE ALGORITHM that I'm now using to find magic sinewaves.

The list price of the Mench computer by itself is $365; quantity pricing is well under $200. With a display and keyboard, the price is $895.

Western Design Center has a very aggressive developer program and definitely welcomes your designs and suggestions. Free literature packages are available. Be sure to give a call.

This month's contest

I am not sure exactly what I'll be doing with my Mench computer just yet. Improving my helpline data base (now mostly a humongous notebook), serving my *Synergetics Consultant's Network* service, finding new magic sinewaves, and designing CAD/CAM flutterwumpers come to mind.

The beauty of this system is the ease with which it can become almost anything from a game to an e-mail terminal to a data acquisition system to a survey instrument to a personal organizer to a special calculator. Key *Western Design* watchwords are *user empowerment.*

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But why don't you tell me instead? For this month's contest, just tell me what you would use a Mench for. As usual, there will be a dozen or more *Incredible Secret Money Machine II* book prizes going out to the better entries. Plus the all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the best of all.

In addition, I will pass along the more interesting entries to the design engineering team at *Western Design Center*. At their discretion, they may or may not award Mench computers and development systems to several of the more promising entrants. Send your written entries directly to me here at *Synergetics*, and not to *Western Design Center* or *Electronics Now* editorial. Let's hear from you.

More magic sinewaves

I've been doing a lot more with the magic sinewaves I looked at a few columns back. There are several very exciting new opportunities here—megabuck ones even.

Your key secret to induction-motor speed controls, auto electronics, solar energy interface, power conservation, uninterruptible line conditioning, and related power electronics is just this: Come up with a cheap and efficient source for variable-voltage, variable-frequency power sinewaves. All this should be done by suitably flipping some ordinary "H-bridge" switches from a fixed direct current supply, preferably flipping only *one-half* of the bridge at any time.

A *magic sinewave* is a repeating long serial string of ones and zeros

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picked to give a variable fundamental frequency and amplitude, along with harmonics that are either zero or of tightly controlled low values. Compared to traditional *pulse-width modulation* (PWM), these magic sinewaves can be far more efficient, can allow much less heatsinking, use cheaper parts, produce far less high-frequency energy, can provide much cleaner waveforms, and are vastly more "microcontroller friendly."

To use a magic sinewave, you look up its sequence up in a table and shove it out a port. The frequency can be set separately by picking a suitable dwell time between output bits. Most of the job is easily done by a one-dollar PIC or other low-end microcontroller.

The magic sinewaves are brand new because the good ones have been so excruciatingly hard to find. Things do not begin to get interesting until you get up into the 200-plus bit range. And there's a lot of possible 200-bit numbers to thoroughly explore.

I started off here a few columns ago with a listing of 210-bit magic sinewaves that had zero harmonics 2 through 10. I expanded on this with several 420-bit solutions which I published in the June 1995 *Circuit Cellar* and in MAGICSIN.PDF on my *GEnie* PSRT.

Meanwhile, a math genius by the name of Jim Fitzsimons suggested a "minimum harmonic energy" scheme where you make each bit contribute as much of its energy as possible to the fundamental. This leaves all bits with neither the energy nor much inclination to generate lots of strong harmonics. While all odd harmonics are present, these are usually very weak.

Any magic sinewave trades off its length against the available amplitudes, the jitter, the harmonic distortion (with and without filtering), and how many efficiency-robbing transitions are needed. Optimizing everything at once gets real tricky in a hurry.

I'm now working with minimum harmonic energy synthesis on 384-bit words. There are compelling reasons to use a bit length that is a multiple of 96. First, you'd like each of your four sine quadrants to end up identical, especially if you are going to fit lots of amplitudes into a tiny address space. Second, you'd like a multiple of three for any three phase power applications. Third, you'd like all three of those phases to be working on the same *bit position* in an 8-bit word at any given time. Otherwise your code will get too hairy, of course, $3 \times 4 \times 8 = 96$. This also easily handles single-phase systems.

The solutions for 96 and 192 don't give enough amplitudes and require high distortions. 288 is marginal for low end applications. And values above 384 might raise the system clock rates or limit frequency choices.

Through a disgustingly sneaky *half bit offset* trick, you could make each one in your 384-bit word count *twice*. That would give you a seven-bit or 128-level low-jitter amplitude resolution from 0 to 100 percent of supply power in more or less uniform steps.

Figure 2 shows the distortion levels for one collection of 384-bit by 16-transition magic sinewaves. It's optimized both for low distortion and for best efficiency. Note that filtered total harmonic distortions average 0.1 percent or less!

One really useful 384-bit word has a quadrant of hex 0080 700F 81F1 F87F E3FF 0FFE. Using a two pole filter, the total distortion for harmonics 3 through 17 is a mere 0.034%. Even with no filtering, the third harmonic is way on down at 0.025% and the fifth is negligible.

Only 15 or 16 single-switch events are needed per quarter cycle. A PWM circuit might need up to 192 *double* switching events for *twenty five* times the switching losses.

Once you start synthesizing long magic sinewaves, there are all sorts of helpful games you can play. By *predistorting* you can force certain problem harmonics to zero. You can shift energy higher in frequency where it is more easily filtered. You can also *anneal* in which you jitter the bits around a little and see if any of the results get better. Annealing can significantly assist most of the low amplitude magic sinewaves.

By *clumping*, you can reduce all the

transitions without hurting the distortion all that much. A clumping can be based on an intelligent *prebias* that encourages a one if you have a previous one, and vice versa.

A newer and better approach to clumping is to simply list all possible integer clump combinations that sum to the desired amplitude. Then pick the best one. See SUMINTS.PS for some working code.

Figure 3 shows the algorithm I'm currently using to discover good magic sinewaves. So far it has given me good results, but not yet the best.

Some filtering is often needed with any magic sinewave. Typically, your motor inductance can give you the first pole for your filter. Results are dramatically improved if you can use a two-pole low-pass filter that drops off at -12 decibels per octave, and cutting off at the second harmonic.

Even *unfiltered* harmonic energy could get reduced with longer magic sinewaves or by permitting extra transitions per cycle. What does all this mean for you? There is now a brand new "magic" way to produce power sinewaves that looks like a very promising route to solve some rather sticky problems.

PostScript handles 384-bit words with aplomb. You simply put them into strings and then manipulate the strings. It takes around a thirtieth of a second to find all the harmonics of any magic sinewave. In fact, we're sort of having a race. Jim is using absolute mathematical rigor on a gonzo supercomputer. And I'm intuitively "shaking the box" to see what falls out of an Apple IIe. As of last night, the Apple was at least temporarily in the lead.

Much more on all this in my *GEnie* PSRT. Just search under *Fourier* or *sin* for FOURIER.PS, FASTFOUR.PS, MAGSINE.PS, and dozens more. The actual magic sinewaves using the algorithm from Fig. 3 are in MS384X16.TXT and SINTOOLS.PS.

I have some brand-new, ready-to-run hardware, including a three-phase system in less than 200 machine language instruction bytes! I also have lots of source code that can be made available on a consulting or a codeveloper basis. Give me a call if you want to tap this big bucks opportunity.

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A new stepper driver

National Semiconductor has been generous with free samples lately. Especially the LM45 temperature sensor, the ADC16071 Sigma-Delta converter, or the LMC6001 and LMC6462 op-amps.

The usual way you pick these freebies up is with the postcards in *E.E. Times, EDN, Electronic Design*, and other similar trade journals. Much more on this appears in my *Resource Bin* and *Blatant Opportunist* reprints.

National's LMD18245 stepper motor drive chip is interesting. Figure 4 shows additional details on this 3-ampere, 55-volt device.

There are several problems when driving a stepper motor. The first is efficiently sensing the motor winding current. National uses the "lossless" scheme in which 4000 or so identical output transistors are wired in parallel and then the current is sensed through only *one* of them. That gives a scale factor of a quarter mil per amp.

The second is to use *current* drive. When you attempt voltage-driving a stepper motor, you'll get into time constant problems that very much limit speed and power. Using current drive, you apply the full supply voltage to the stepper winding with *zero* current limiting resistance.

The inductance of the stepper winding should cause the current to ramp up at the usual Di/Dt $\surd$ e/L rate. When you reach the desired current level, you'll quickly turn your drive power off. You repeat this

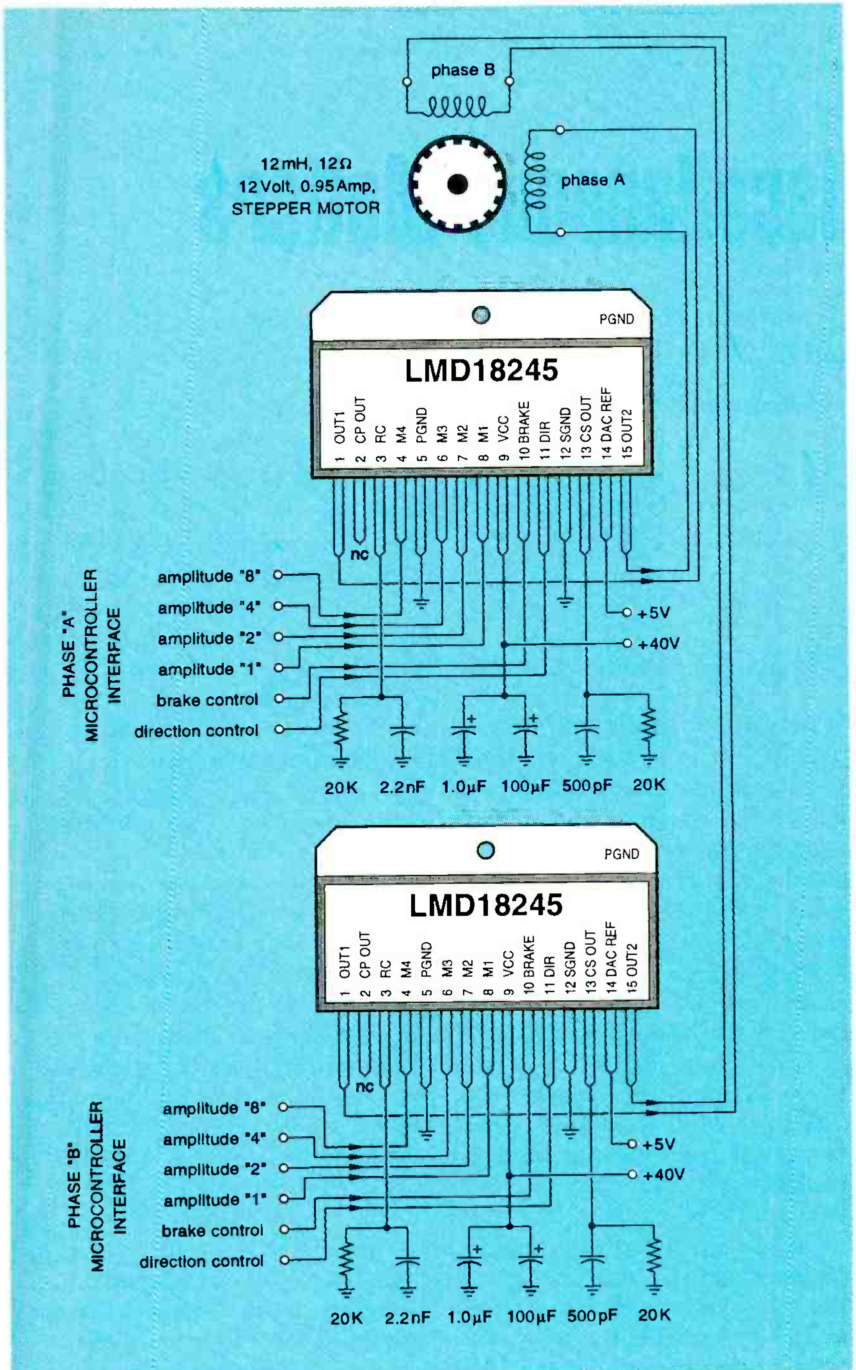

FIG 4—A HIGH PERFORMANCE stepper motor driver. Component values must be closely matched to the stepper.

process many times per stepper phase.

A third problem is that stepper motors usually require higher currents when they are stepping than when they are holding. National handles this with an on-board four-bit D/A converter. This lets you set your stepper drive current to sixteen possible levels. Including zero.

As with any coil, you'll *never* want to suddenly stop the current. Doing so will generate destructive voltage spikes. Problem four involves safely shutting down the drive. To do that there is a *brake* input that effectively shorts the stepper winding, letting the current safely decay to zero. A separate *direction* input lets you decide which end of the H bridge gets positive supply current.

The wide TO-220 package includes power drivers. Some heat sinking is required. A pair of chips are needed for two-phase stepper motor use as shown. This chip and others in the family may also be used in DC motor drives. External MOS transistors can be added for higher voltages. A PIC chip is ideal to control the LMD18245. Suitable interfaces are offered by *Scott Edwards Electronics* with his *Pseudo Stamp*.

PCMCIA card resources

Until recently, these plug in cards were called PCMCIA cards, short for *Personal Computer Memory Card Interface Association*. They are now referred to as *PC Cards*. The best starting point is the *PCMCIA Developer's Guide*. This book/disk combination is available from *Sycard Technology* for $90. One source for texts on cards and flash memory is *Anabooks*.

The leading industry trade journal is *IC Card Systems & Design*.

New tech lit

Hitachi is offering a pair of new data books on *Wireless Communications and Optoelectronics*. *Micrel Semiconductor* has a new data book on *Analog Power Integrated Circuits*. From *Temic* (formerly *Telefunken*), there's a catalog on *RF ICs for Wireless Applications*. A data book on surface-mounted transistors and such is offered by *Central*.

A *Power Factor Correction* guide is offered by *SGS-Thomson*. Speech modules suitable for toys and other low-end applications are offered both from *Ozen Sound Devices* and *Ming Engineering*. Ming also has a new *Electronic Products Catalog* with some great breadboarding stuff in it. Wall adaptors at ultra low costs in infinite variety are available by the zillions at *Surplus Traders*.

Motorola has a free sample pack including dozens of their new BRT *Bias Resistor Transistors*. You have a choice of an NPN or a PNP transistor along with a pair of integrated resistors. These are mostly for "RTL" glue logic, LED drivers, and such.

For the fundamentals of digital integrated circuits, check into my *TTL Cookbook* or *CMOS Cookbook*, either by themselves or as part of my *Lancaster Classics Library*. See my nearby *Synergetics* ad for details.

BY LARRY KLEIN

More Miscellaneous Matters

Live music, equipment "testers," and brain waves

LAST SPRING I TOOK MY SON TO A PETER SCHICKELE CHILDREN'S CONCERT THAT FEATURED THE AMERICAN SYMPHONY ORCHESTRA'S RED, WHITE, AND BLUEJEANS MUSIC Machine. The Lincoln Center program was witty, educational, and musically enjoyable, including as it did fugues from Bach, Hindemith, and Weinberger. Each time I get to hear a full orchestra at play, I compulsively devote a few moments to analyzing the differences I hear between live sound and that reproduced on a good audio system.

For me, most recordings sound psychoacoustically at odds with the playback environment. Instead of hearing an integrated, averaged, or merged acoustic, I'm aware of both the playback and the recording environments as separate and conflicting entities. In contrast, live music almost always sounds wonderfully real, aside from the specific acoustical balances at my seat in a particular concert hall.

Is this my own particular sensitivity or aberration—or is it a universal, but unacknowledged, phenomenon? I find that four or more channels of binaural reproduction are necessary to eliminate the subjective "venue conflict" between the recording studio or hall and home playback. Anyone have any additional thoughts on the matter? I'd like to know if readers feel the same way.

A new Times audio reviewer

Last year I had some words to say about the various newspaper columnists whose views on audio equipment are syndicated throughout the country. My complaint (of course, you know I had one) had to do with the nature of their evaluations, rather than the specifics of their choices. The problem, as I see it, is the essential unreliability of the newspaper critic as an arbiter of equipment quality.

Objective double-blind comparative listening tests are as rare in their writings as technical measurements. In essence, what we have is a group of equipment "tasters" telling you what they think they hear as influenced more or less by audiophile scuttlebutt, manufacturer brainwashing, price, their own expectations, and the phases of the moon. Their opinions are validated only by their alleged ability to detect and then describe in awesome detail sonic nuances unheard by those lacking the required sensibilities.

Hans Fantel, long-time equipment reviewer for *The New York Times*, has recently been replaced by a Mr. Lawrence B. Johnson. Hans and I have been friends since the late 1950s when, during my hi-fi servicing days, I repaired his power amplifier. I've had my disagreements with Hans over the years, but from all indications, his replacement is far more prone to audiophile blather than Hans ever was.

I've never met Mr. Johnson, and for all I know he's a fine fellow: He certainly has the credentials for his new position. We are told that he's been a journalist for three decades, has earned all sorts of academic awards, did postgraduate work in music history and theory, and has written for a variety of consumer and high-end publications dealing with audio, video, and musical matters.

His writing style is sprightly, but shows an unfortunate affection for the kind of florid phrasing beloved by high-end audio critics. In a recent column on small speakers, the sounds from the various models "evoked a notable aura of depth;" were heard as "vibrant," "possessing pop," "elegant," or "stodgy;" kept the listener "at an emotional distance," or conversely, made for "seductive listening" and "embrace"(?). Obvious interpretation problems arise when a wine taster's vocabulary is used to describe subjective reactions to a loudspeaker's performance. But more important, would the reviewer have the same nuanced subjective reactions to the same components a second time around if the listening were done blindfolded?

In any case, dozens of research papers have been written discussing the procedures necessary to ensure valid repeatable results in listening tests for loudspeakers and other components. Columnists, however sincere and otherwise learned they may be, who ignore such techniques in favor of reporting on what they think they hear under essentially uncontrolled test conditions are at best misleading their readers.

Brain waves

Since early in this century we've had a pretty good idea of the physical/electrical inner-ear mechanisms that forward sound to the brain. But what happens once the data reaches the gray matter has been difficult to determine. Sickness and physical injury to the brain have provided some clues as to the processes going on within our skulls. Tumors or lesions in given areas of the brain correlate with loss of function in sometimes mysterious ways. For example, a stroke or a head injury may cause the loss of a foreign language or the inability to attach names to common objects, or may selectively wipe out musical ability, specific memories, and so forth.

In any case, the days of attempting to track mental processes solely by delving into butchered brains is coming to a close, thanks to computerized brain-scanning techniques. Positron Emission Tomography (PET) not only generates three-dimensional pictures of the brain but can actually indicate the areas of the brain that are activated by thoughts or perceptions! The technique as I understand it involves injecting radioactively-tagged glucose, which is taken up preferentially by the areas of the brain activated by, say, a mathematical problem or music. On the computer screen the activated area literally lights up when turned on.

One of the basic findings of the new technology is rather startling: Although a stimulus such as a musical passage seems to be a discrete entity, different areas of the brain's auditory cortex handle different aspects of the incoming electrical nerve "signal." For example, the temporal lobes are thought to analyze pitch and timbre. And connections to and from the frontal lobes are essential to the interactive brain network that provides the perception and remembering of music. Other specialized feature detectors are used to decode the complexities of speech and music. Injuries in these specific areas can leave a person unable to process aspects of speech. Cellular circuits that process language and music are found on both sides of the brain, but the left hemisphere appears to contain language-specific regions, and the right has dedicated areas for music perception.

This has led some neurobiologists to suggest that musical involvement is a basic part of human heredity. It's not clear what evolutionary role music might play, but perhaps it's important to human social cohesion. Anthropologists tell us that even the most primitive peoples have music and dance rituals celebrating important events in their lives. From time to time I've reported on research that seemed to indicate that music, aside from its other pleasures, enhances thinking ability. Listening to Mozart, for example, is said to temporarily enhances mathematical ability. But in retrospect I wonder about the validity of the experimental design and the subsequent blue-sky speculation that attempted to explain the alleged findings. It seems simpler to suggest that people test better mathematically after listening to relaxing music, rather than to theorize that Mozart quintets temporarily set up specialized neural pathways in the brain that facilitate mental math.

Now a new study has been done with preschoolers in Los Angeles. One group of three year olds participated in daily group singing and received weekly piano lessons. A control group did not get the extra attention. After a year, the musically trained children were said to have scored 80 percent (!) higher on tests of spatial and temporal reasoning. There seems to be no question that early encouragement does tend to nurture musical talent. But does early exposure to music, if not specifically Mozart, provide brain training for budding physicists and mathematicians? Maybe, maybe not—but like chicken soup, it certainly can't hurt! EN

BY ALVIE RODGERS*C.E.T.

Shutdown Circuits

Troubleshooting shutdown circuits in television receivers

SHUTDOWN CIRCUITS CUT OFF POWER TO ELECTRONIC CIRCUITS WHEN A FAULT THAT COULD DAMAGE OR DESTROY THE CIRCUIT IS DETECTED. THE SIMPLEST AND BEST KNOWN shutdown devices are fuses and circuit breakers. They interrupt the power line when current exceeds their specified ratings. However, both fuses and circuit breakers are slow to respond to overcurrent (milliseconds to seconds) so they fail to provide adequate protection for sensitive electronic circuits. They can be destroyed by overvoltage in microseconds.

The automatic shutdown circuit was developed to disable the high-voltage circuits in color television receivers if a sudden voltage surge raises the input voltage beyond safe limits. The concept was widely accepted and now some form of shutdown circuit is included in most consumer electronic products such as color and projection TVs, VCRs and camcorders.

Shutdown circuits monitor circuits in which a defect can: cause the high voltage to exceed a specified safe level; damage power supplies; or destroy semiconductor devices, cathode ray tubes or other critical active and passive components.

In most consumer electronics products high-voltage regulation is a function of the main power supply regulation. It controls the operating variables of the deflection circuitry. Secondary scan and pulse-derived power supplies are, in turn, derived from the deflection circuits.

Because of this interrelationship between circuits, a closed-loop configuration has been established

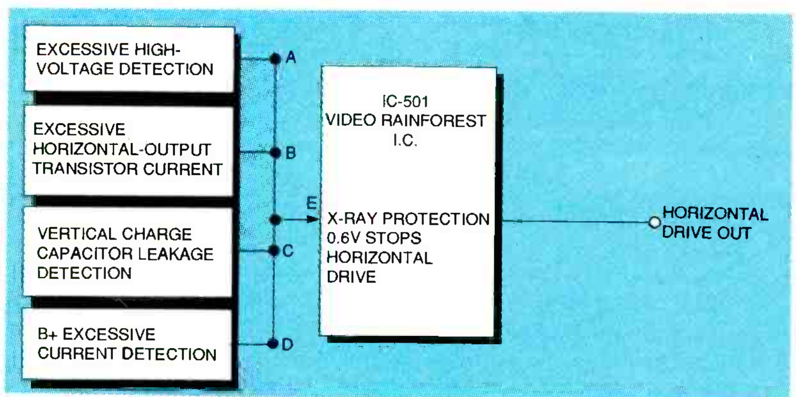

FIG. 1—THE CLOSED LOOP OF A SHUTDOWN CIRCUIT is shown in this diagram. Breaking that loop is the first step in effective troubleshooting.

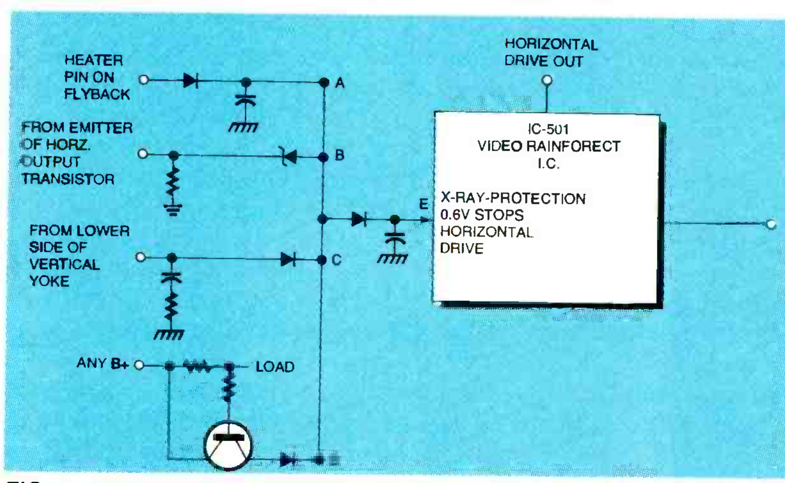

FIG. 2—THE ORIGINS OF MOST FAULTS are identified in this simplified diagram. The voltages on points A, B, C, and D are monitored.

* Reprinted from *Hitachi Hi-Lite*, a monthly technical publication from the Technical Services Department, National Service Division, Hitachi Electronics, Inc.

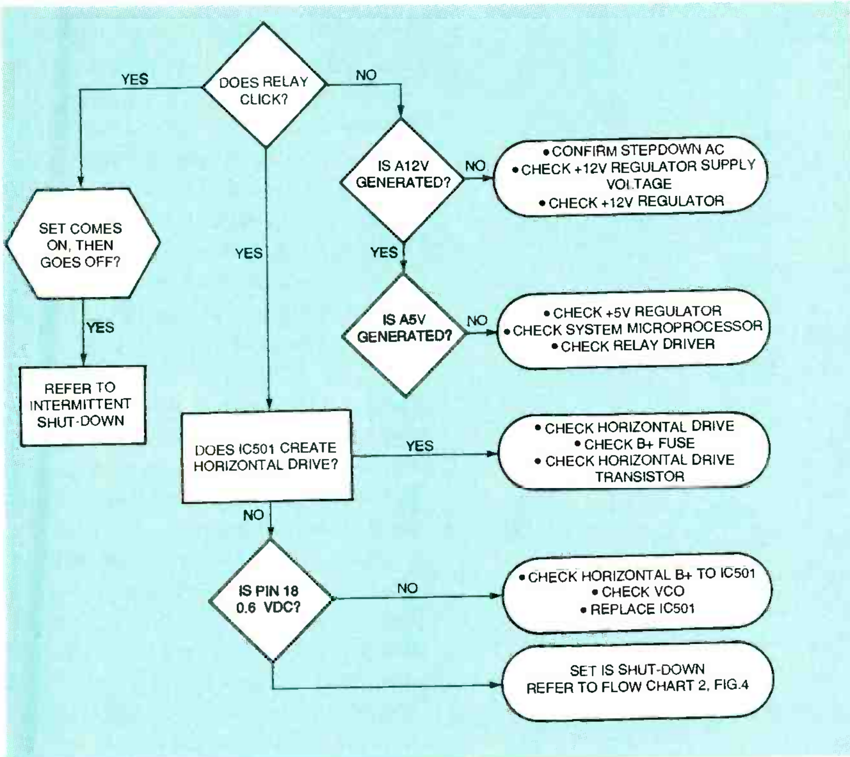

FIG. 3—FLOW CHART FOR SERVICING A DEAD SET.

in automatic shutdown circuits. In these circuits "cause and effect" can become indistinguishable. For example, a "no raster, no sound" fault can be traced to the main power supply, the horizontal and high-voltage circuitry, or even the shutdown circuit itself.

How shutdown circuits work

Defects in the horizontal sweep and shut-down circuits of TV sets exhibit the same symptoms—no raster, no sound. The deflection circuit is the primary load on the main power supply, and it is the source for most secondary power supplies. Consequently, the deflection circuit is often the first place to look in shutdown situations. When shutdown occurs, the removal of the primary load allows the output of the regulated B+ supply to rise to its maximum no-load level.

When troubleshooting a TV set, seek answers to the following questions:

1. If the circuit is in the shut down condition, is the cause loss of B+ regulation, a defect in the power supply, or is it a fault in the horizontal-deflection circuitry?

2. If the regulated B+ is at its maximum value, is the fault caused by a failure in horizontal sweep or a fault in the shutdown circuitry?

3. Is the shutdown circuitry activated because of a loss of regulation?

Shutdown circuits monitor many parts of the circuit and shutdown is a symptom of a fault in one of the circuits being monitored. Although shutdown can be triggered both by power supply and deflection circuits, consider first how shutdown is initiated by disabling horizontal deflection.

Figure 1 illustrates a typical circuit block diagram in which all shutdown inputs terminate at the X-ray protection input of IC-501, the video rain forest IC. This IC develops horizontal drive for the sweep section of the receiver. When the shutdown input reaches 0.6 volt DC (point E in Fig. 1), horizontal drive output is cut off, and the sweep section is disabled. Notice that the shutdown inputs can be divided into two categories: excessive voltage detection (points A and C), and excessive current detection (points B and D).

Figure 2 is a simplified circuit version of Fig. 1 showing the same shutdown inputs to IC501 and their origins. Notice the capacitor between point E and ground. It must charge to 0.6 volt DC for IC501 to initiate a

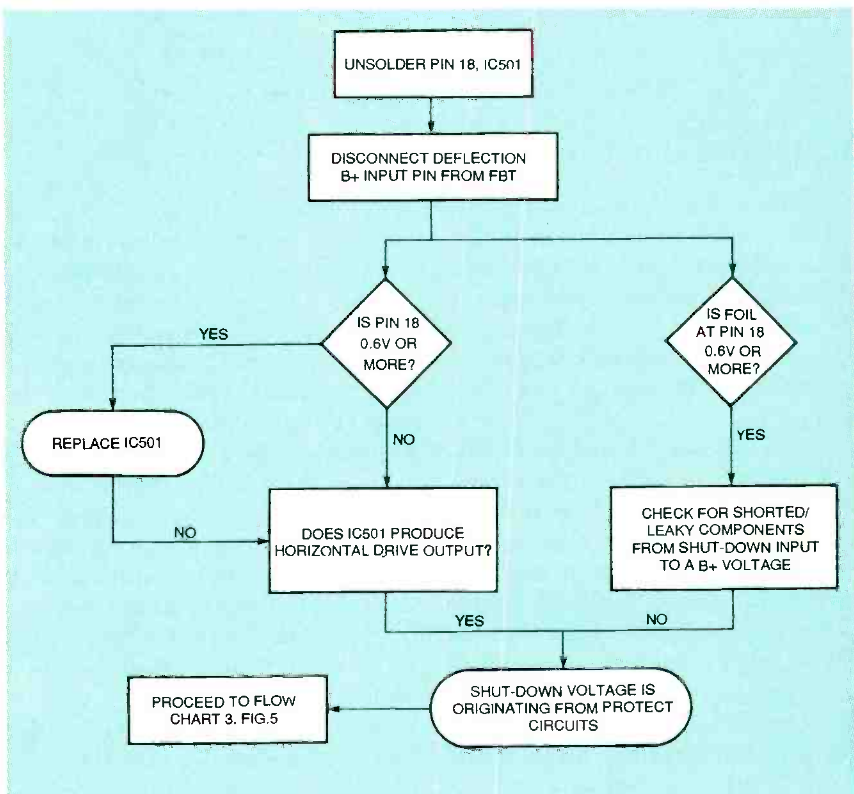

FIG 4—FLOW CHART FOR PRELIMINARY SHUTDOWN.

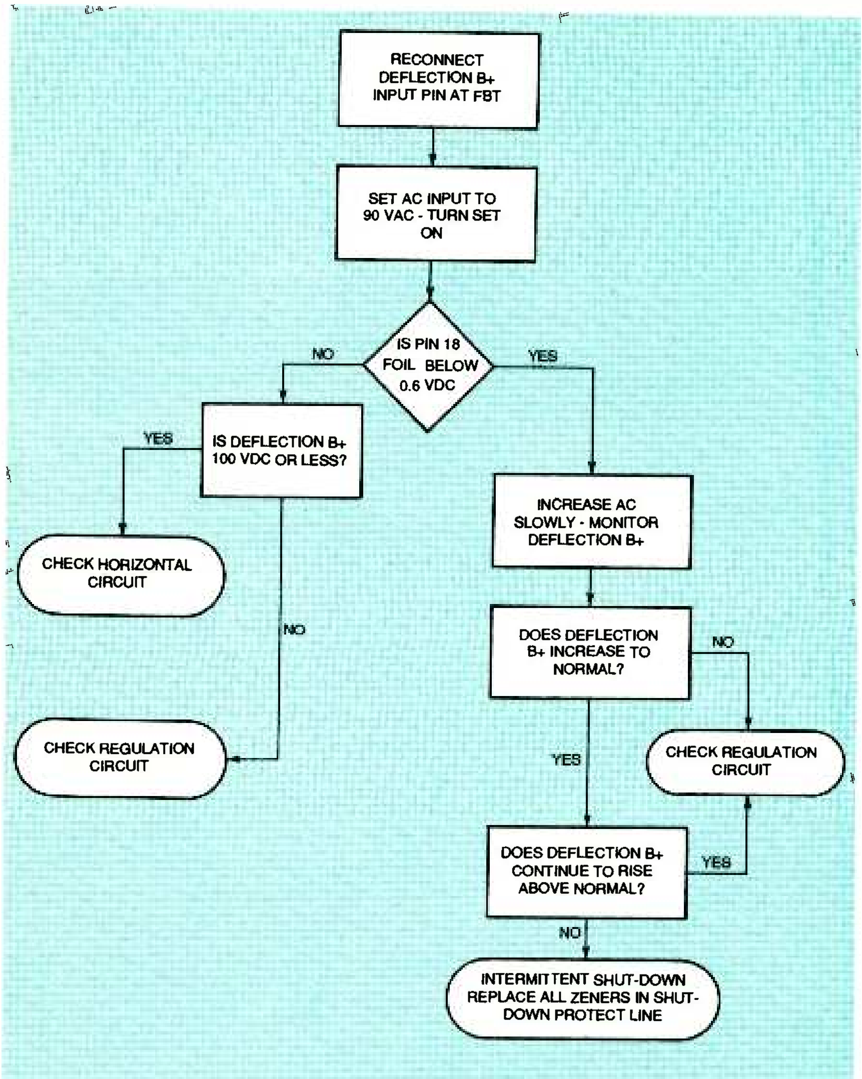

FIG 5—FLOW CHART FOR SERVICING A SHUTDOWN.

shutdown. This capacitor absorbs minor voltage variations on the X-Protect line to prevent nuisance shutdown. Those voltage variations can be caused by the varying demands on the fly-back transformer or high-voltage caused by the content of the TV picture.

Refer to point A in Fig. 2. The CRT heater pulses from the flyback are rectified to a DC voltage that corresponds to the relative value of high voltage. As the high voltage increases, the amplitudes of the CRT heater pulses increase, as does the value of DC voltage at point A. If the high voltage continues to increase, a potential of 0.6 volt DC is applied to the shut-down input of IC501 (point E), disabling horizontal drive.

Excessive current through the horizontal output transistor can be measured at point B of Fig. 2. The resistor shown in that branch is connected between the emitter of the horizontal-output transistor and ground, and current through this resistor reflects the current drawn by that transistor.

If transistor current increases, the current through the resistor increases. Consequently, the corresponding voltage drop across the resistor is applied to a Zener diode. If the transistor current continues to rise, it will eventually produce a voltage high enough to cause the Zener diode to conduct. That, in turn, will apply the DC voltage to point E and cause a shutdown.

Leakage in the relatively large value vertical charge capacitor connected to the lower side of the vertical yoke windings can be measured at point C of Fig. 2. The capacitor is grounded through a low-value resistor. The voltage drop across this resistor is normally zero volts DC. However, if the capacitor leaks, a DC component is developed across the resistor. That DC forward-biases the diode, and generates enough voltage at point C to cause shutdown.

Excessive current in any B+ line can be monitored at point D. There is a resistor between the B+ source and the load. Abnormal current demand from a power supply will increase the voltage drop across this resistor. This variation in voltage drop can usually be measured with a voltmeter and seen on an oscilloscope.

However, if current drain continues to increase, the voltage across the resistor will reach the threshold of the transistor (the base is 0.6 volts below the emitter), and the transistor will conduct. The voltage appearing at point D will then cause shutdown.

Simplified troubleshooting

Figures 3, 4, and 5 are flow charts to help in the diagnosis of a typical shutdown by following a step-by-step procedure to isolate the fault. The shutdown circuits form a closed loop that must be broken before you can start troubleshooting.

Figure 3 (Flow Chart For Servicing a Dead Set) diagrams a simple procedure for determining quickly if the TV set has a horizontal-drive defect; a standby power supply on-off defect; or an actual shutdown situation

When following this flow chart:

- Make sure that the TV set is connected to an isolation transformer.
- Confirm the on-off operation of the system's microprocessor by checking for a low/high or high/low transistion at the power ON-OFF pin. Disconnect the pin from the circuit board to eliminate possible circuit loading.
- Standby 5-volt B+ must be present whenever the set is connected to an AC source for microprocessor operation
- Check for open fuses.

Figure 4 (Flow Chart For Preliminary Shutdown) is intended for checking the condition of the horizontal output circuit and the ability of IC501 to produce an output unaffected by shutdown.

When following this flow chart, keep in mind that:

- The shutdown input pin designations for the video rain forest IC501 might vary by brand or model. Refer to the service manual to verify the correct input pin.
- All shutdown feedback voltages are developed when the horizontal circuit is running. With deflection B+ disconnected , there should be no developed voltage at the shutdown input to IC501.

Figure 5 (Flow Chart For Servicing a Shutdown) show the direct relationship between B+ regulation and shut down activity. Any defect that allows regulated B+ to increase will probably cause a shutdown.

When following this flow chart, remember that:

- Shutdown voltages can be momentary. Turn the set off and allow the circuits to reset after each test.
- Be sure to monitor deflection B+and shutdown inputs simultaneously.
- If at any time during these tests the shutdown line exceeds 0.6 volt DC or higher, disconnect the shutdown inputs one at a time to isolate the source.
- Zener diode leakage is a common cause of intermittent shutdown
- B+ regulator malfunctions will cause shutdown through the excessive high-voltage detect circuit.

The following practices should be observed when making use of any or all of the flow charts that are shown in Figs. 3, 4, and 5:

- Apply power to all products or circuits being serviced ONLY through an isolation transformer.
- Figures 3, 4, and 5 designate pin 18 of IC501 as the shutdown input, but this is not universally observed by all manufacturers. Be sure to verify the correct pin designation by referring to your TV set's service manual.
- Expect generated shutdown voltages to disappear after a shutdown. *Monitor the shutdown input continuously during servicing procedure, and be sure to turn off the power between steps to allow the circuit to reset.*

General comments

"Divide and conquer" techniques are basic to troubleshooting shutdown circuits. Be sure that you understand why each test is made. The correct interpretation of the results is the key to making successful repairs. Frequently it will be found that the cause of a shut-down is the replacement of a faulty component with one that is of inferior quality or has a rating that differs from the original equipment part.

Be sure to replace all faulty components with the *exact* OEM replacement part. This is particularly important for horizontal drive/output transistors, horizontal output transformers, Zener diodes, and integrated circuits.

The horizontal circuit current drain in most modern TV sets is between 450 and 650 milliamperes. Current exceeding 650 milliamperes will cause shutdown through the horizontal output transistor current detection circuit. The most common causes of this are a faulty flyback transformer, a faulty horizontal output transistor, or a shorted load on a scan-derived power supply.

A shutdown initiated by the high voltage detection circuit is generally caused by the flyback transformer, a shorted deflection yoke (uncommon), or a B+regulation circuit. EN

WHAT'S NEWS

Continued from page 5

co, stone, and wood by combining tactile sensations with computer images of three blocks. They devised an array of actuators or transducers that creates the sense of touching different textures, edges, or a rolling motion by vibrating against the fingertips. The actuators are thin rod-shaped plungers that tap the fingertip lightly when current is applied.

Each plunger is an small electromagnet enclosed in a steel sleeve that rests on a rare-earth permanent magnet inside a glove. Opposing forces between the magnets push the plunger up when the electromagnet is turned on. When the electromagnet is off, the attraction between the steel sleeve and the permanent magnet returns the plunger. (The prototype has two rows of three plungers per fingertip.)

The "cyberglove" contains a magnetic tracker that send signals to the computer which displays real-time computer-generated images of a user's hand moving in virtual reality. Strain gauges send signals that indicate the position of each of the user's fingers.

In addition to the tactile glove's possible use in training, Renzi envisions its use as a translator of Braille text on CD-ROMs for the visually impaired.

NEC develops 0.07-micron CMOS technology

The NEC Corporation has announced the development of CMOS devices with 0.07-micron features. This technology is said to make possible the fabrication of dynamic random-access memories (DRAMs) with capacities a thousand times greater than those of existing memory devices, while permitting significant increases in speed.

CMOS technology is widely used in the production of 16-megabit DRAMs with 0.5-micron features. According to NEC, 0.07-micron CMOS technology paves the way for 16-gigabit DRAMs. To achieve the breakthrough, NEC scientists overcame such challenging technical obstacles as the precise control of impurity distribution in the semiconductor substrate, short-channel effect, and the loss of punch-through immunity.

NEC reports that the 0.07-micron CMOS technology has proven to be highly reliable in laboratory tests. Ultra-high speeds of 19.7-picoseconds have been confirmed. The company sees the technology as applicable to the fabrication of microprocessors operating at speeds in excess of 1 GHz. The low 1.5-volt requirements are said to assure long-term reliability and low standby current drain. EN www.americanradiohistory.com

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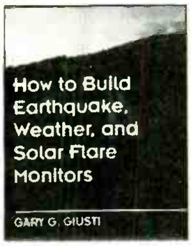

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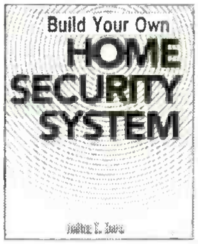

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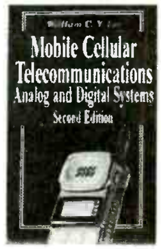

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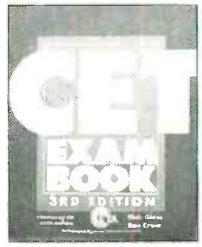

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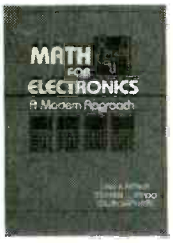

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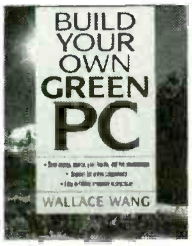

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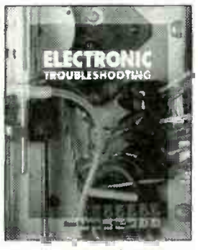

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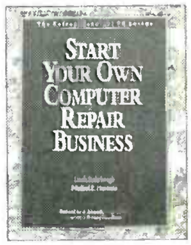

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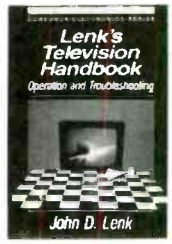

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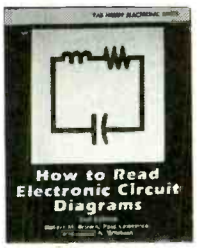

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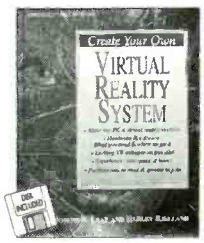

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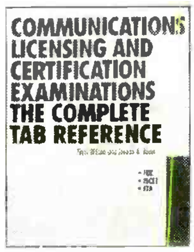

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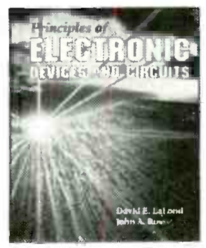

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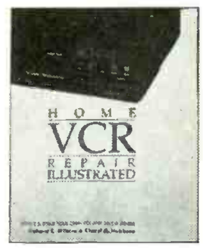

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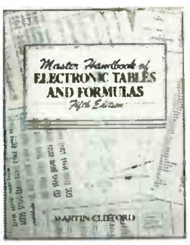

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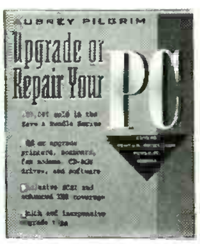

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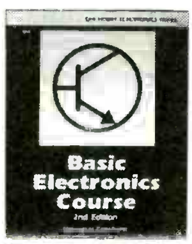

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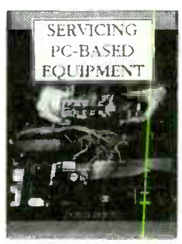

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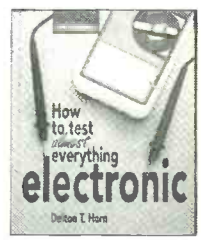

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BY JEFF HOLTZMANN

Abandon all hope

Entrepreneurial success is impossible in the computer industry.

WHAT ARE THE ODDS OF WINNING A STATE LOTTERY—SEVERAL MILLION TO ONE? AS BAD AS THAT SOUNDS, THE ODDS OF ATTAINING A SMASHING BUSINESS SUCCESS IN THE COMputer industry are much worse—and the risks are much greater. Do you dream of writing the next Doom? Or of designing and marketing some hardware widget that millions of computer users worldwide simply won't be able to live without?

If you're like most technical people, you probably think that all you have to do is build a better mousetrap, and people will come knocking. 'Taint so. In reality, building the product is the least of your worries. The real issues you'll have to deal with are: finance, manufacturing, sales and marketing, distribution, business management, and product support.

This discussion assumes that you are a lone inventor or entrepreneur, or possibly a member of a very small, very tightly knit group. The rules change considerably for those in corporate R&D (research and development) departments.

Technical (1)

What sort of product should you develop? Most techies answer the question in terms of their existing technical expertise. (There's an old saying that everything starts looking like nails to the guy with a new hammer.) That's precisely the wrong approach. Forget what you know. Find out what people want. Search for some overlap between what you know and what people want. If there is none, then learn something new.

When learning what people want, ask who the people are who want it, and whether they're really the people you want to sell to. Would you rather build something:

A. For which an established, mature market already exists (e.g., office-productivity software such as word processors and spreadsheets; PC expansion cards)?

B. For an established but dying market (e.g., software to help mainframe programs deal with turn-of-century conditions; memory-configuration conversion modules)?

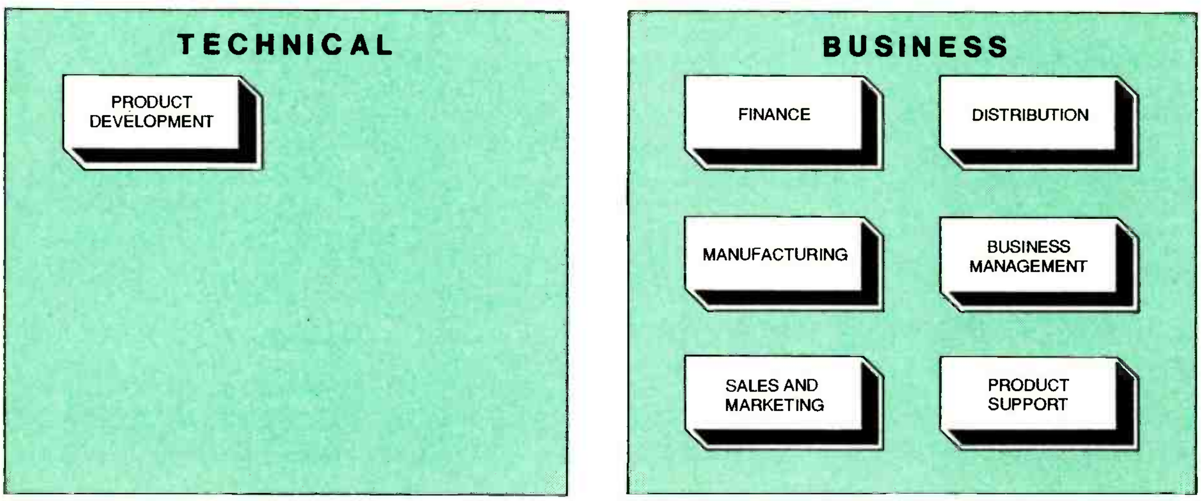


FIG. 1—BUSINESS SUCCESS requires that you do much more than just creating a fantastic new product.

C. For an emerging but unproved market (e.g., Internet Publishing; PC-telephone-fax-modem interface hardware)?

All three are viable options, but some have distinct advantages. Category A is least likely to succeed. Microsoft has sown up the office applications market; not even companies the size of Lotus and Novell/WordPerfect have been able to compete. The real market shaping up in this area is Microsoft Office Suite add-ons.

These add-ons are mini programs that perform a special function very well, or that integrate two or more applications. I expect a growing market for products in this category. Component-based object-oriented software makes it technically feasible; broad, shotgun approaches to software feature architecture makes it necessary. (Microsoft has won the office applications war by trying to be all things to everyone. Normally, that's not a viable strategy, but Microsoft has found a way to make it work.)

Category B might appear unexciting, but it does provide some very specific business opportunities. If you have the expertise and understand the market segment, get in there and strike as fast as you can before someone else does.

Category C is the most exciting, and in some ways the riskiest. On one hand, you won't have a Microsoft to compete against. On the other, if you don't pick your targets carefully, you could build a product for an emerging market that never emerges. Then you'll be back at square one, minus your time and money.

When you get all that figured out, you can build a prototype. Then the (techie) fun ends, and the real work begins. Everything from here on out is business, business, business.

On a related note, assume that you do build a hit product. It will be copied. If you think copyrights and patents can help, guess again. Patents are expensive to get, and even more expensive to defend. Suppose Microsoft copies your product. Do you really think you can beat them in court? It can be done—Stac Electronics, for example, beat Microsoft—but Stac had serious money in the bank.

In this area, I agree with Don Lancaster: Get in, make a quick killing, and move on to something else when the big birds start circling. (Stac is getting into Internet browsing and publishing tools, a slightly different product category from disk compression.)

Technical (2)

After targeting a market and a product, research the market to find out whether similar products already exist, and if so, their features and failings. Talk to users; find out what they like and dislike about current products, and about what they want, if they can articulate it. They probably can't, so learn interviewing techniques to get them to open up. Return to square one if a large, aggressive company has a product in that market (or is about to introduce one).

Research technologies for implementing your product. Don't assume your initial idea is best; it probably isn't. Don't be prejudiced by what you know.

Figure out what the best solution is, and if you're not an expert at it, become one, or outsource the expertise. Alternatively, hire an expert for some consulting to train you—but don't tell him why.

Technical (3)

After defining a market, a product, and an implementation technology, build a prototype. The prototype needn't be complete, but it should be bug-free. It should indicate the presence of all planned features, even though not all are implemented in the prototype. Test market it against real users. Modify the prototype. Do more test marketing. Home in on a final design, one that can be manufactured cost effectively. Design for low manufacturing and maintenance costs, and design for ease of use and ease of learning.

By the way, in case you didn't notice, even though the preceding three sections are titled "Technical," what they really concern is marketing. In other words, do the marketing before the technical stuff, or be honest and call what you're doing a hobby, not a business, and also be sure to change your expectations accordingly.

Business

If you've gotten this far, you can put away your soldering iron and C compiler. The fun is definitely over—or the definition has changed. If you can't accept that change, you can't be an entrepreneur. Here are some of the business activities you'll have to perform.

Financing: How will you pay for the initial marketing and manufacturing costs? Can you finance it yourself? How about partners (don't give up too much control)? Take a bank loan? But what will you use for collateral? How much do you need in operating expenses every month? How much do you need to accomplish the initial startup?

Manufacturing: Who will build your product? Can you do it on a kitchen table? Can you subcontract it? How much will it cost? What is the manufacturing plan? How will you finance component and in-progress inventory? What about product packaging and documentation?

Marketing and sales: How will you let your market know about your wonderful new product? Direct marketing ("junk mail")? Advertising (expensive)? Do you need a commissioned salesperson? If so, what's a reasonable cut for him or her?

Distribution: Can you handle distribution yourself with an 800 number and a card table in your basement? Can you get a national distributor to carry your product? How? With fierce competition for so-called shelf space, why should anyone pay attention to your unheard of new idea?

Business Management: Should you incorporate? Do you need a lawyer? An accountant? Will you hire people? After training them, how will you keep them? What about health insurance? What about bookkeeping? How will you pay your bills and collect your invoices?

Product Support: Is your product's setup, configuration, and ongoing operation self-evident? If not, how will you handle technical support? What about returns and repairs? What about bug fixes and new releases?

Abandon all hope

Given all of the above, there is little or no chance that a small entrepreneur can ever hope to build a new business in the computer industry, unless you've got not only technical savvy, but also twenty or so years of business experience. If you don't meet those qualifications, plan on getting a job in a large corporation. There you'll sign an agreement stating that the corporation owns everything you think of on or off the job, related or not to your job description, for the entire period of your employment, and likely afterward as well. In that situation, you'll have little or no contact with the marketing and business facets of the company, and will be encouraged to develop either your technical skills or your ability to manage technical employees. In other words, you'll learn nothing about how to run a business.

An alternative would be to work for a string of start-up companies, watching them fail one after another, and learning from their mistakes. Then with enough accumulated experience (at others' expense), you'll be qualified to go off and try it on your own.

Good luck. You'll need it.

E-mail

I received several interesting comments on the August 1995 column, "Engineering and Compromise." Rick Chinn, whose company builds audio equipment, writes that ". . . it is our founder's mandate that we build 80% products; that is, products that satisfy 80% of the marketplace. . . . this is where the sales peak occurs." Good advice.

On the other hand, John Huseby accused me both of trying to get adopted by Bill Gates, and of being a used-car salesman. Here's an edited version of his accusations: "As I was perusing my August *Electronics Now*, I came by your Computer Connections column . . . I can only hope that in next month's edition you will write, 'Last month I was only kidding. I confess, I was trying to get adopted by Bill Gates.' . . . The thing that scares me is that a lot of people think like your column reads, and that some of them may be software designers. . . . I'm one of those helpless infidels, commonly called a user, who has the profoundly stupid idea that operating systems should be designed for users, as opposed to being some kind of giant game for systems people to play. . . . I have lived under several . . . systems designed by people who felt their greatest achievement was that they never studied other operating systems before designing one. . . . Should we mere users, the amoebas of the computer chain, have any reason to expect that system developers should learn from their initial development efforts, and be able to more economically design and develop a new operating system on the same hardware architecture? . . . I just wonder what thoughts you would have if a car salesman noted that if you weren't willing to dole up the money for a Ferrari, you just shouldn't expect much in the way of reliability . . . You don't sell cars, too, do you?"

No, I don't sell cars. I stick strictly to snake oil. And although I have been in the same room with Bill, I have thus far been unable to attract his attention away from the other poor, abandoned waifs.

Several people took me to task for not discussing other operating systems in depth, particularly OS/2 Warp and Linux. I *always* make it a point when discussing Windows to compare specific features with OS/2. I agree with everyone who mentioned the idea that both OS/2 and Linux are architecturally superior to Windows 95. However, technical superiority does not make for market superiority. The Windows operating system is winning. OS/2 is losing. Linux is a blip on the screen, an interesting one to be sure, but I wouldn't run *my* entrepreneurial business on it.

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

MUSIC VISION

continued from page 28

channels are combined through summing amplifier IC2-b. Quad op-amp IC5 creates an AGC function with fast half-cycle response to signal peak levels, and slow recovery time constant. This lets you observe the short duration amplitude dynamics of displayed patterns, while avoiding clipped patterns when high amplitude peaks occur.

Op-amps IC5-c and IC5-d form part of a precision full-wave rectifier circuit used for signal level detection. Current booster Q1 allows rapid charging of capacitor C22, while AGC recovery time is determined by the C22-R56 time constant. Transistor Q2 and op-amp IC5-a comprise a voltage controlled amplifier. AGC trimmer potentiometer R3 sets the low-level audio signal at R52 to approximately 0.4 volts p-p.

The video control circuit is shown in Fig. 7. It consists of the high-speed, two-channel analog switch IC6, 8-bit analog-to-digital converter IC7, crystal controlled TTL oscillator IC10, 8K × 8-bit static RAM IC9, and timing control logic implemented via IC8 and IC11. Analog signals x and y are alternately sampled by IC6 at 447 kHz, which is also the conversion rate of the ADC0820 A/D converter IC7. Diodes D9–D12 provide input overdrive protection for IC7. After being processed by IC8, the resulting video data along with colorburst and sync outputs are combined and buffered by Q3. The resulting composite video signal is NTSC-compatible.

All timing control logic is implemented in a field programmable gate array (FPGA) device in order to greatly simplify the construction of this project and reduce its cost. The XC3030 FPGA manufactured by Xilinx replaces about 40 standard TTL parts in this design. The FPGA is configured upon power-up via configuration data pre-programmed into serial EPROM IC11. Hex code for the serial

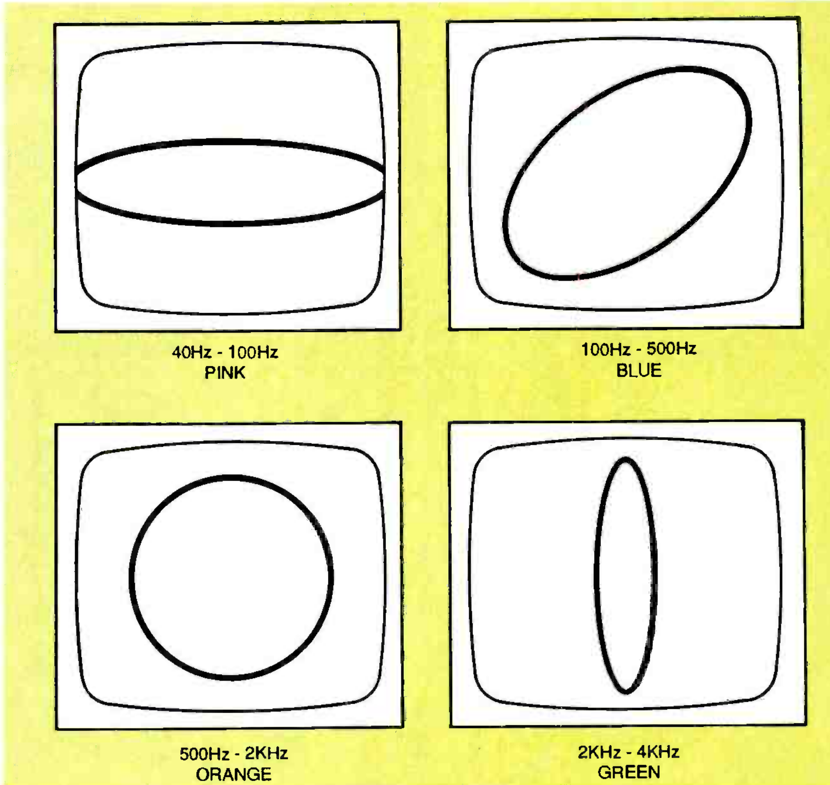


FIG. 4—TYPICAL PATTERNS GENERATED on a TV screen by a single sinewave at various audio frequencies. The four colors are controlled by the 2-bit digital output from frequency encoder comparators IC4-a and -b.

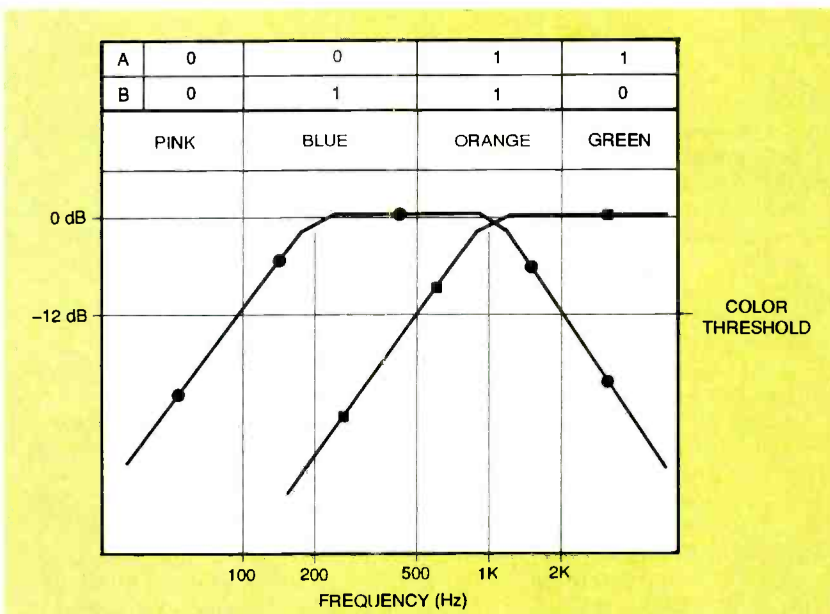


FIG. 5—SUPERIMPOSED FREQUENCY RESPONSES of both filters. By properly adjusting the color threshold, the corresponding progression of pattern colors can be obtained.

EPROM is available on the Gernsback BBS (516-293-2283. v.32, v.42bis) as file MUSICVIS.HEX.

A block diagram of the internal logic functions performed by the FPGA is shown in Fig. 8. The 14.31818 MHz clock signal is divided down to the standard 3.579 MHz colorburst frequency. Four clock phases permits four distinct colors to be gener-

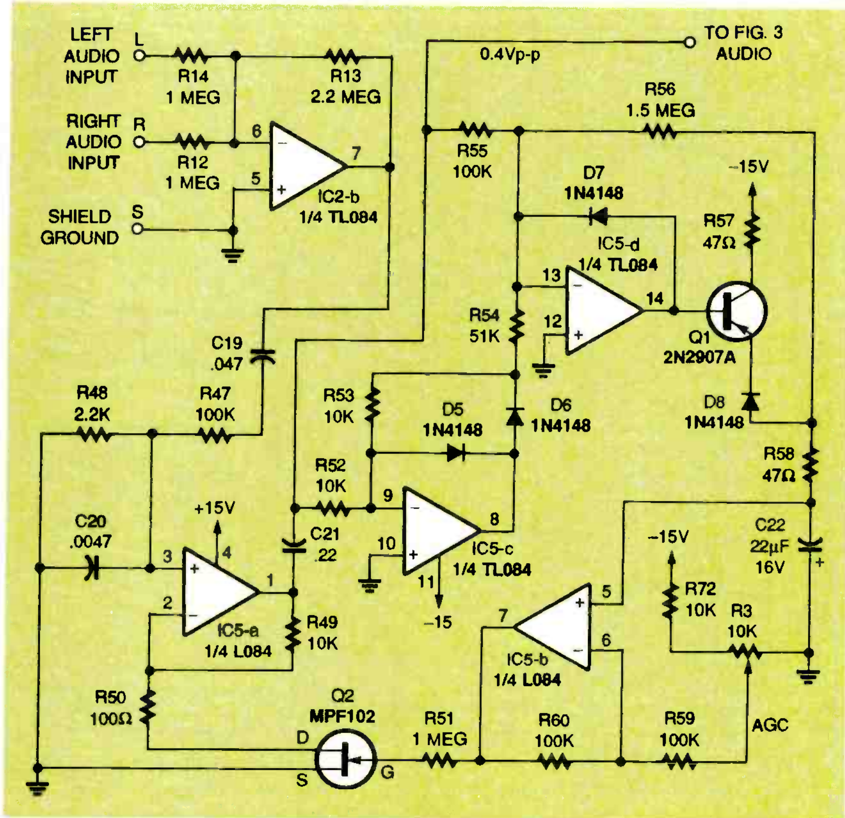


FIG. 6—AUTOMATIC LEVEL CONTROL CIRCUIT maintains a pattern-filled TV screen over a wide range of input signal levels.

ated on the TV screen, controlled by two external logic signals. Horizontal and vertical timing is generated by separate counter chains which produce the required video blanking and sync signals.

Data from A/D converter IC7 is routed to the 64K video RAM IC9 and stored in the form of bit-mapped patterns. Although this results in a relatively low resolution graphics display (190 × 246), the highly dynamic nature of the patterns makes it more than adequate in this application. A separate address counter continuously reads back the stored patterns in a raster scan fashion, while erasing the data as it is read. The read function is synchronized with the horizontal timing and interleaved with write operations occurring at the 447-kHz sample rate. The 8-bit data read back from RAM is converted to a serial video data signal and combined with color and blanking signals to produce the final video data output.

PARTS LIST

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

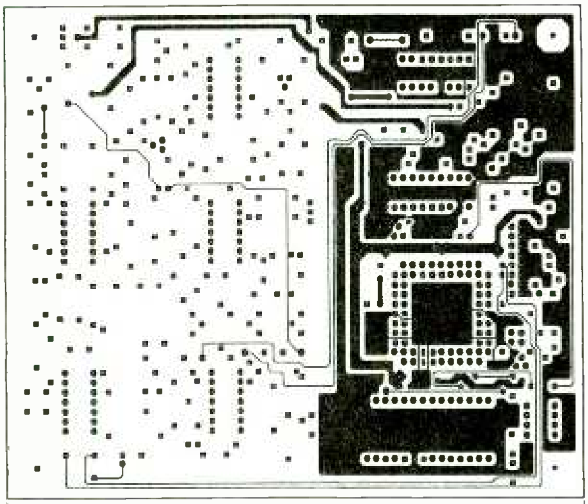
R1–R5—10,000 ohms, trimmer potentiometer
R6—200 ohms, trimmer potentiometer
R7—27 ohms
R8—2000 ohms
R9, R25, R29—1500 ohms
R10, R67—2700 ohms
R11, R46, R61, R65, R66—1000 ohms
R12, R14, R39, R40, R42, R43, R51—1 megohm
R13—2.2 megohms
R15, R23—22,000 ohms
R16, R17, R26, R28, R47, R55, R59, R60—100,000 ohms
R18, R22—150,000 ohms
R19–R21, R24, R27, R30, R32—15,000 ohms
R31, R45, R49, R52, R53, R72—10,000 ohms
R33—330,000 ohms
R34, R38—47,000 ohms
R35—220,000 ohms
R36, R48—2200 ohms
R37, R70, R71—5600 ohms
R41, R44, R50, R63, R64—100 ohms
R54—51,000 ohms
R56—1.5 megohms
R57, R58—47 ohms
R62—33,000 ohms
R68—180 ohms
R69—470 ohms

Capacitors

C1, C3, C20—0.0047 µF, 10%, Mylar
C2, C5, C12—0.001 µF, 10%, Mylar
C4, C6–C8, C13, C19—0.047 µF, 10%, Mylar
C9, C10, C28, C30–C35, C39, C40—0.1 µF, 10%, ceramic
C11, C21—0.22 µF, 10%, Mylar
C14, C15—0.1 µF, 10%, Mylar
C16, C18—0.01 µF, 10%, Mylar
C17—100 pF, 10%, NPO ceramic
C22—22 µF, 16 volts, tantalum electrolytic
C23, C24—0.0022 µF, 10%, Mylar
C25—47 pF 5%, NPO ceramic
C26—8–50 pF trimmer capacitor
C27, C38—1 µF, 16 volts, tantalum electrolytic
C29, C36, C37—10 µF, 16 volts, tantalum electrolytic

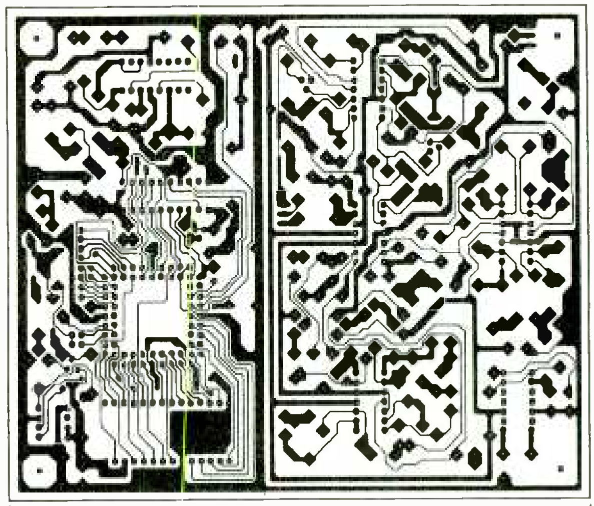
Semiconductors

D1–D12—1N4148 diode
Q1—2N2907A PNP transistor
Q2—MPF102 N-channel JFET (National Semiconductor)
Q3—2N3904 NPN transistor
IC1–IC3, IC5—TL084 quad op-amp (JDR Microdevices)
IC4—LM339 quad comparator (JDR Microdevices)
IC6—IH5142CPE SPDT analog switch (Harris/Hamilton Hallmark)
IC7—ADC0820CCN A/D converter (National Semiconductor/Digi-Key)
IC8—XC3030A-7PC68C FPGA (Xilinx/Hamilton Hallmark)
IC9—HM6264LP-12, 8K × 8, 120 ns RAM (JDR Microdevices TC5565APL-12 or equivalent)
IC10—14.31818 MHz TTL crystal oscillator module (Digi-Key)
IC11—XC1765DPD8C serial PROM programmed with Music Vision code (Xilinx/Digi-Key—blank devices only)



6-1/8 INCHES

COMPONENT SIDE of the Music Vision PC board.



6-1/8 INCHES

SOLDER SIDE of the Music Vision PC board.

Regulated DC power must be supplied to the Music Vision circuit board. The circuit requires the following voltages:

- +5V ± 0.25V (200 mA max.)
- +15V ± 0.75V (100 mA max.)
- −15V ±0.75V (100 mA max.)

Power supply noise and ripple should be less than 100 mV p-p for proper circuit operation. Many different power supplies will work with this project. One suitable design is shown in Fig. 9.

Construction

For best results, this project should be built on a PC board. If you prefer to make your own boards you can use the foil patterns provided here. Alternatively, a silk-screened and solder masked PC board is available from the source given in the Parts List. Pre-programmed XC1765 serial EPROMs (IC11) are also available from the same source.

Begin assembly of the circuit board by installing all IC sockets as shown in the parts-placement diagram of Fig. 10. Do not use a socket for TTL oscillator IC10. It should be soldered directly to the circuit board. Also, do not substitute a different part for the 68-pin PLCC socket specified in the Parts List since other sockets may be larger, causing physical interference with other parts on the circuit board. Next install the six trimmer potentiometers R1 through R6. Solder in the 16-pin and 4-pin male headers located next to R11 and R8 (be sure to install the shorting jumpers on each header as indicated). Install resistors R7 through R72, diodes D1 through D12, transistors Q1 through Q3, and capacitors C1 through C40.

If you are using a switching power supply for the 5-volt supply and it generates more than 100 millivolts of high-frequency noise, you should install a 27- to 100-µH inductor having less than 3 ohms DC resistance in the L1 position. If you're not using a switching 5-volt supply, simply install a jumper wire in the L1 location. Install a 27-µH, 5% inductor at location L2.

Inductors

L1—see text

L2—27 µH, 5% inductor (3 ohms max.)

Miscellaneous: one 68-pin PLCC socket (Digi-Key/AMP #821574-1—do not makes substitutes), one 8-pin DIP socket, five 14-pin DIP sockets, one 16-pin DIP socket, one 20-pin DIP socket, one 28-pin DIP socket, 2×2 male header, 2×8 male header, five shorting blocks, three RCA jacks, regulated DC power supply (+5V @ 200 mA, and plus and minus 15V @ 100 mA—Jameco), metal enclosure, and mounting hardware.

Note: The following items are available from Electrokraft, PO Box 598, Louisville, CO 80027:

• Solder masked and silk-screened PC Board with assembly instructions—$39.00

• Programmed XC1765DPD8C serial PROM—$13.00

• Partial Kit consisting of PC board, programmed XC1765 PROM, all electronic parts that mount on the PC board, and assembly instructions (does not include power supply or enclosure)—$140

• VHS video tape with 15 minutes of sample patterns produced by Music Vision from various recorded audio waveform combinations and music signals (amateur quality)—$9.00

Check or money orders only. Colorado residents please add appropriate sales tax. All prices postage paid.

POWER SUPPLY PARTS

(1) 120- to 12-VAC transformer
(1) 120- to 36-VAC transformer
(4) 1N4001 diode
(4) 1N4002 diode
(1) 1000 µF, 25-volt electrolytic
(2) 470 µF, 50-volt electrolytic
(3) 1 µF, 16-volt electrolytic
(1) LM7805 +5-volt regulator
(1) LM7815 +15-volt regulator
(1) LM7915 −15-volt regulator

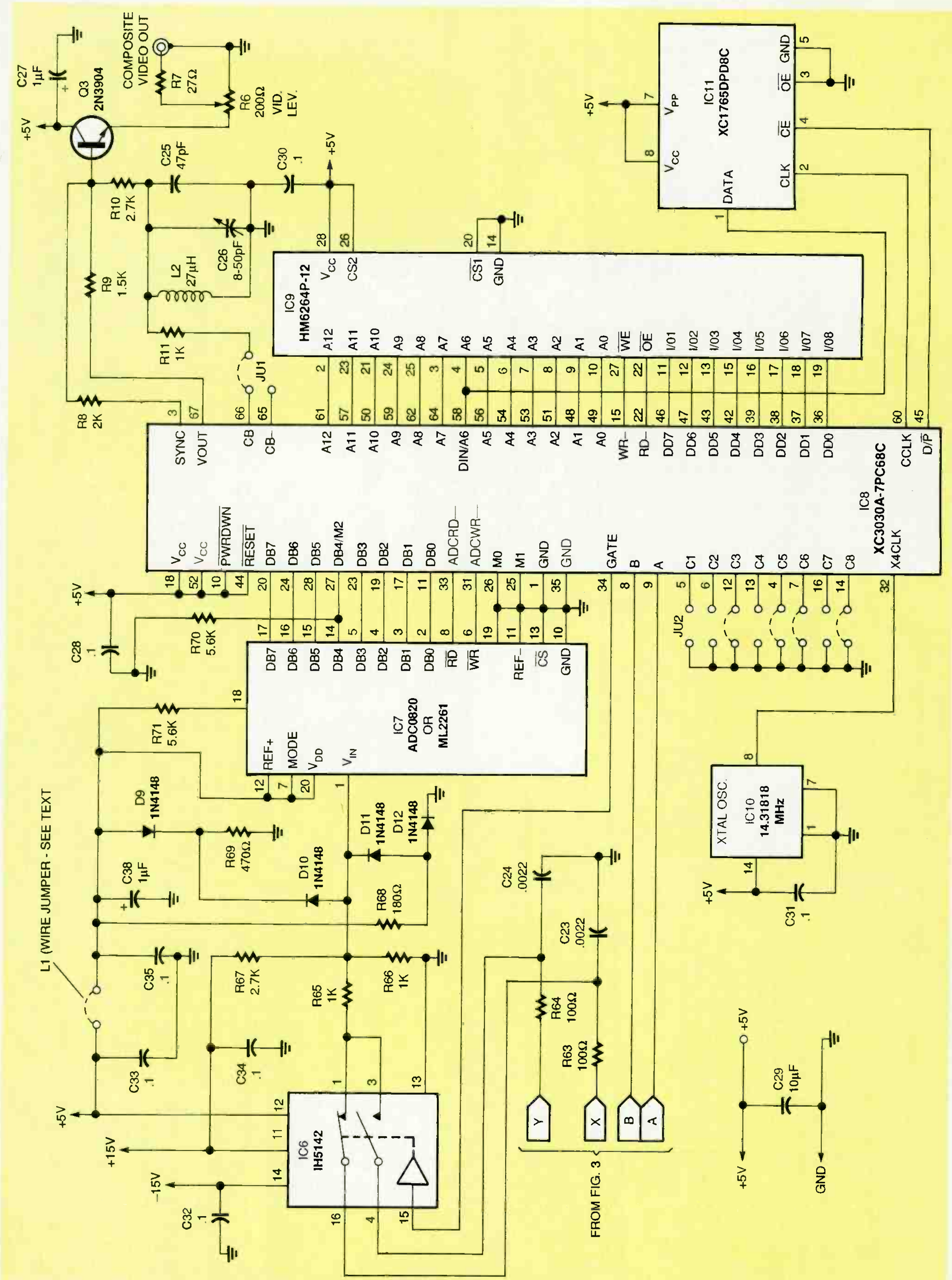


FIG. 7—VIDEO CONTROL CIRCUIT consists of high-speed, two-channel analog switch IC6, 8-bit analog-to-digital converter IC7, crystal controlled TTL oscillator IC10, 8K × 8-bit static RAM IC9, and timing control logic implemented via IC8 and IC11.

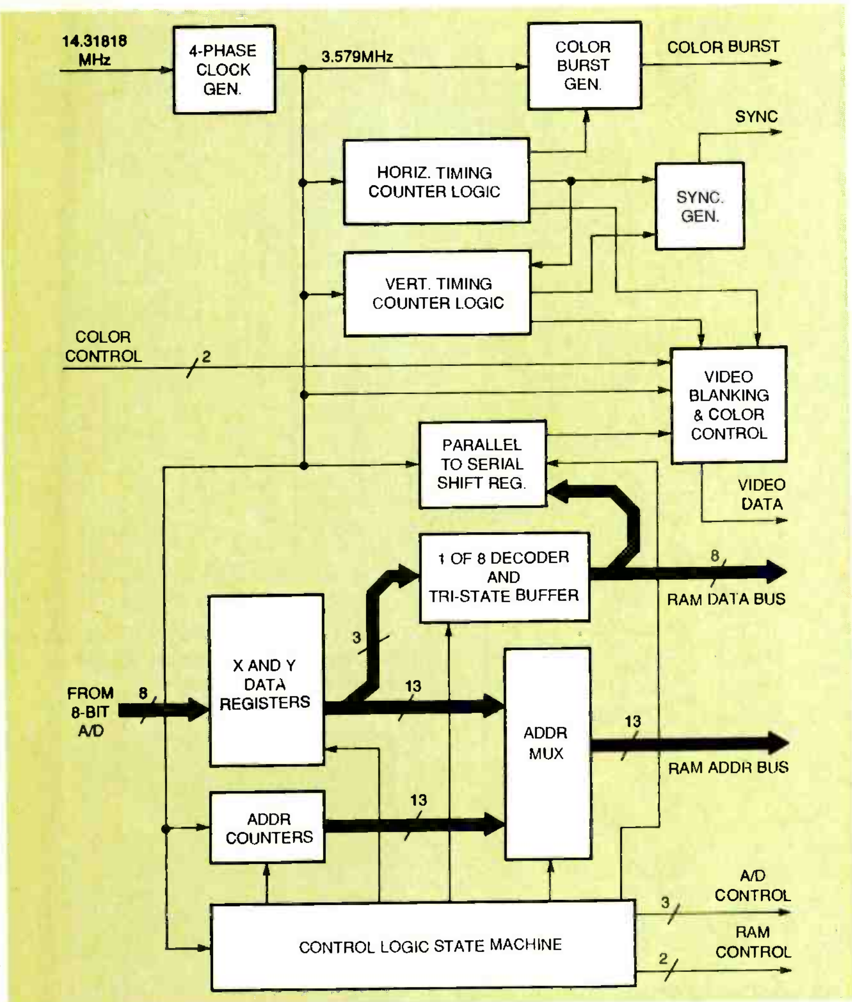


FIG. 8—BLOCK DIAGRAM of the internal logic functions performed by the XC3030 FPGA.

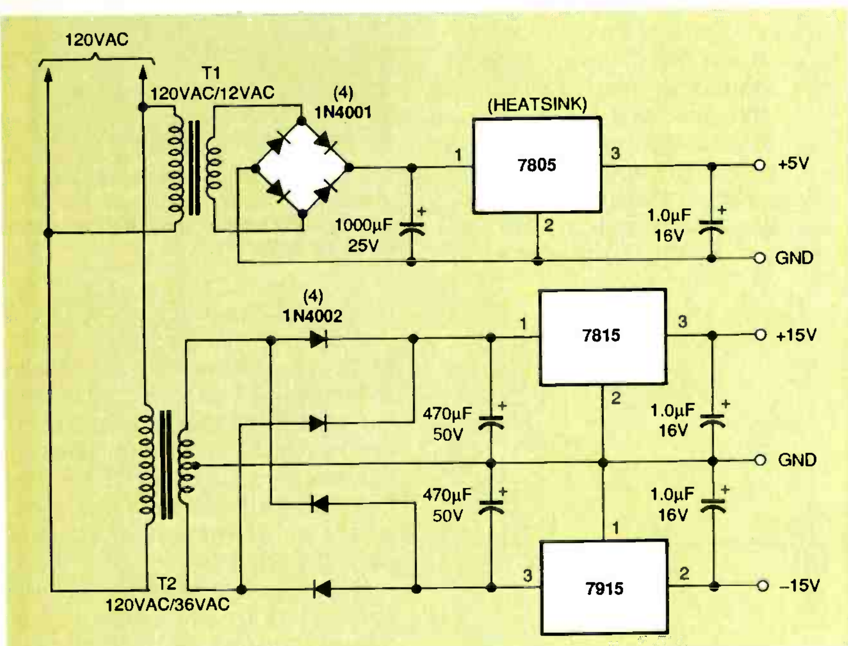


FIG. 9—THE MUSIC VISION CIRCUIT requires +5 volts at 200 milliamperes, and plus and minus 15 volts at 100 milliamperes each. This power supply provides those voltages.

Pin 1 of TTL crystal oscillator IC10 is tied to ground on the circuit board. This is compatible with the operation of most oscillator devices, however some of them use pin 1 as a control function which inhibits oscillation when grounded. Physically remove pin 1 from this type of oscillator before installing it on the board. Solder IC10 directly to the circuit board without using a socket. Now install IC1 through IC9 and IC11 into their appropriate sockets on the PC board. Pin 1 of FPGA IC8 is marked with a small dimple in the middle of a beveled edge of its package. Orient pin 1 as indicated in Fig. 10.

Wire the +5-, +15-, and −15-volt power supply outputs and the audio/video signals to the circuit board as shown in Fig. 11. Packaging this project in a metal enclosure will greatly reduce the possibility of RF interference with your stereo tuner or TV. Figure 12 shows how the board was installed in a metal enclosure for the prototype unit.

Testing and adjustments

An audio signal generator and oscilloscope are handy but not necessary to perform the following testing and adjustment steps. Initially set trimmers R1 through R6 to mid-point. Apply power and verify that the correct voltages exist on the circuit board. If an oscilloscope is available, monitor the video output from the circuit board using a high-impedance (>1 megohm) probe. The video signal level should be adjusted with R6 to obtain the approximate signal amplitude shown in Fig. 13. If you do not have an oscilloscope handy, simply leave R6 set in the middle of its range and proceed with the next step. The R6 adjustment is not critical and normally affects only the brightness of the display.

Now connect the video output to the composite video input connector on a color TV or monitor. With the Music Vision audio inputs shorted to ground, you should see a small grouping of rectangular "dots" near the center of the screen. Use hori-

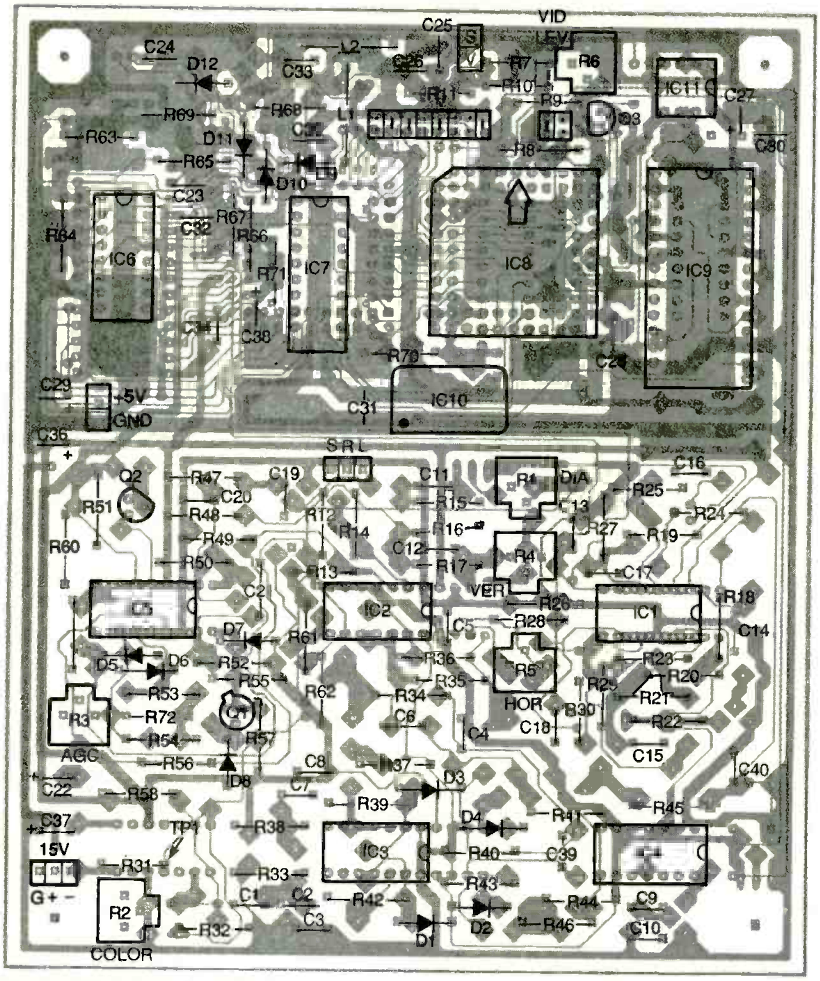


FIG. 10—PARTS-PLACEMENT DIAGRAM. Do not substitute a different part for the 68-pin PLCC socket specified in the Parts List since other sockets might physically interference with other parts on the circuit board.

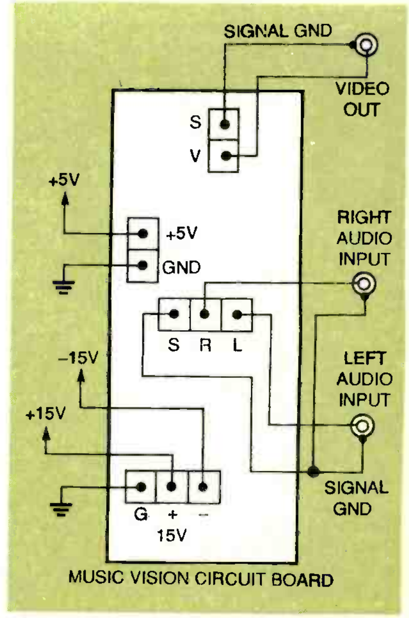


FIG. 11—WIRE THE POWER SUPPLY and the audio/video signals to the circuit board as shown here.

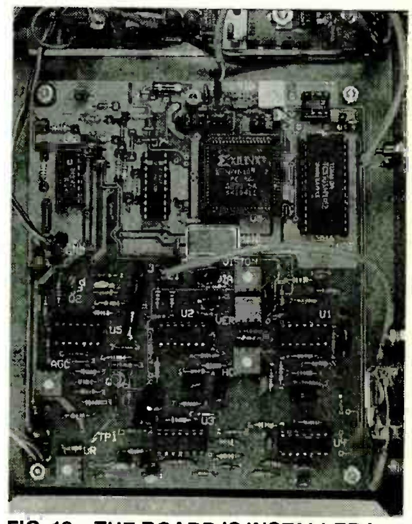


FIG. 12—THE BOARD IS INSTALLED in a metal enclosure to reduce the possibility of RF interference with your stereo tuner or TV.

zontal adjustment potentiometer R5 and the vertical adjustment potentiometer R4 to position the dots in the center of the screen.

If an audio signal generator is available, set it for a 1-volt p-p, 500 Hz sine wave and connect it to one of Music Vision's audio inputs. Connect an oscilloscope to monitor the TP1 side of R31, located near trimmer R2. Adjust AGC trimmer R3 for a signal level of approximately 14-volts p-p at TP1. Because of the long AGC recovery time constant, you must wait at least 10 seconds after adjusting R3 before reading the signal level at TP1. If you do not have a signal generator or oscilloscope available, leave R3 set at approximately the middle of its range and proceed with the next step. This adjustment is not critical and normally affects only the symmetry or distortion of the displayed pattern.

With the signal generator still connected to the audio input, adjust trimmer R1 until an oval-shaped pattern completely fills the TV screen, reaching within one or two inches from each

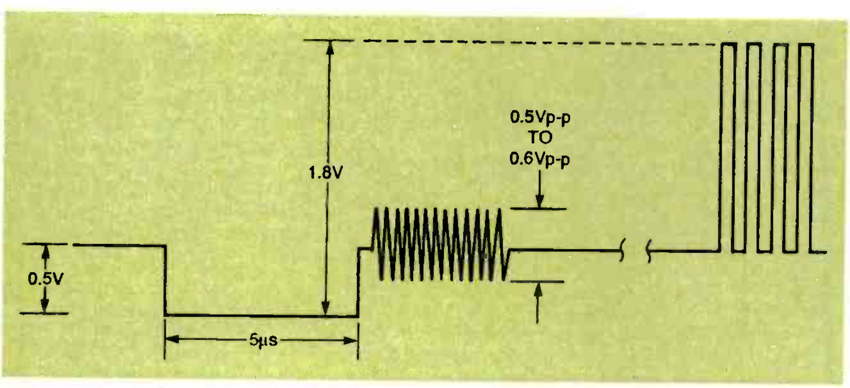


FIG. 13—THE VIDEO SIGNAL LEVEL should be adjusted to obtain the approximate amplitude shown here with no output load.

edge of the screen. If you do not have a signal generator, connect the audio line outputs of your stereo system to the Music Vision audio inputs. Then adjust R1 until the displayed patterns fill most of the TV screen, only occasionally reaching the edge of the screen.

With the signal generator still connected to the audio input, adjust the color trimmer R2 until the oval-shaped pattern turns blue. Slowly change the signal frequency over the range 40 Hz to 4 kHz, while observing the displayed color. You should see four distinct colors corresponding to four different frequency ranges. Re-adjust R2 if necessary to obtain this effect. In addition, you may have to adjust the trimmer capacitor C26 (tint control) to achieve the colors that are indicated in Fig. 4.

If you do not have a signal generator, connect the audio line outputs of your stereo system to the Music Vision audio inputs. Then adjust trimmer R2 until the displayed patterns exhibit a varying mixture of the four colors.

Note that this will depend on the type of music being played, so try to choose something with a good balance of bass, midrange, and treble frequencies present. You may also have to adjust the trimmer capacitor C26 (tint control) to achieve the colors.

If you were using a signal generator, disconnect it now and connect the audio line outputs of your stereo system to the Music Vision audio inputs. This completes the assembly and the testing of the Music Vision project.

To achieve the optimum visual effects, you may need to adjust your TV as follows: Adjust the TV brightness/black level control for a dark background while viewing Music Vision. Adjust the TV color control for desired color intensity (you may have to switch from automatic color to manual color control).

Now all that's left is to sit back and enjoy the pleasing visual effects produced by Music Vision while you listen to your favorite music selections. Ω

X-RAYS

continued from page 30

duced also depends on the size of the tube and the impressed voltage. However, Crookes discovered that the cathode rays could cast a shadow on fluorescent material at the end of the tube.

Crookes' demonstrations inspired other scientists to experiment with cathode rays passing through glass tubes with partial vacuums, gas, and combinations of these. The flow of electricity in the Crookes tubes was initiated by an induction coil. Figure 1 is a simplified diagram of the tube and its power supply. The electrons that formed the current originated at the cathode and passed through the partial vacuum to the anode.

Ironically, photographic plates that Crookes kept in his laboratory were mysteriously fogged and ruined, although they were in protective containers, but he never knew why. Thus, he missed his opportunity to discover of X-rays. The effects he produced could not be explained with the physics of the day—much as science today cannot explain the phenomena known as ball lightning.

Now back to Professor Röntgen. On that fateful day in 1895, he set out to study discharge from a Crookes tube so he could explain the phenomena. His apparatus was the same as that used by Crookes (shown in Fig. 1), and it included a Ruhmkorff coil. Because the Crookes tube glowed slightly when the current flowed, Röntgen darkened the room to see the glow better. He also covered the end of the tube with black cardboard to block the cathode rays.

However, much to his annoyance he noticed a fluorescent glow from a sheet of paper coated with a barium salt across the room. He looked around for the cause of the fluorescence and saw only that the Crookes tube was operating. But the end of the tube was still covered. He shut off the power and saw that the glow of the paper faded. and the room was dark again.

After turning the tube back on the greenish glow reappeared. He put a book in front of the tube and the paper still glowed. Then he replaced the book with a block of wood and even used rubber as a shield, but the strange radiation passed right through. He then put a box of laboratory weights in front of the tube and found that dark silhouettes of the weights showed up on the paper screen.

Finally, he placed his hand between the tube and distant coated paper and was astonished to see the faint outline of the flesh of his hand and the dark outline of the bones. Next, he made the first intentional X-ray photograph by asking his wife to put her hand between the tube and a photographic plate. That's when he knew he was on to something.

His observations drove Dr. Röntgen to carry out more experiments to confirm that what he saw actually happened and could be reproduced. The Crookes tube was indeed the source of the mysterious invisible rays. Because, at the time, he could not explain them, he called them X-rays. At the end of December in 1895 Professor Röntgen submitted his first paper on the mysterious rays.

In January of 1896 Professor Röntgen gave the first public demonstration of X-rays. Soon scientists in laboratories around the world had duplicated his results. More than a thousand scientific articles were published on X-rays within a year of their discovery!

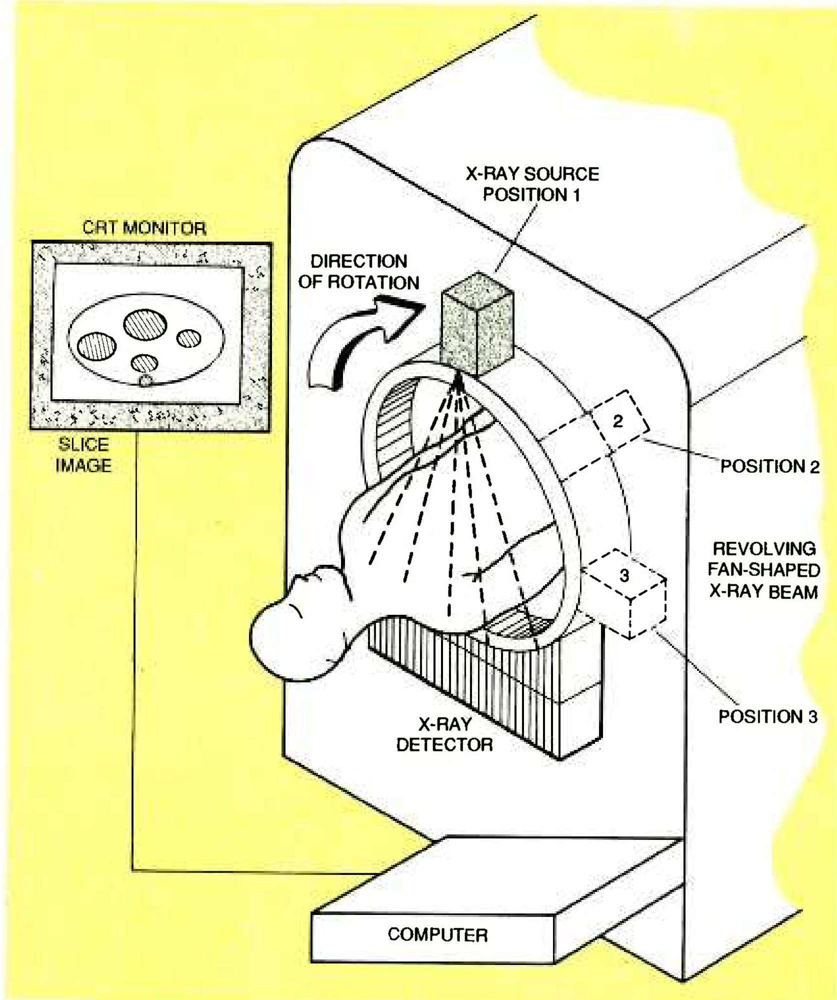


FIG. 3—A COMPUTED TOMOGRAPHY SYSTEM has an X-ray scanner that revolves around the patient. Data taken from the scanner is processed by computer to form a cross-section image of a "slice" of the human body, eliminating X-ray shadows.

Although Professor Röntgen never became wealthy as a result of his discovery, he did gain the recognition of the world's scientific community. In 1901, Dr. Röntgen became the first physicist to receive a Nobel prize. However, in 1903 a French scientist, Antoine Becquerel, also received a Nobel prize for the discovery of *natural radiation*. Today this term means radioactivity and it includes alpha, beta, and gamma rays. Gamma rays are more energetic than X-rays and they generally have shorter wavelengths and higher frequencies. Otherwise, they have the same general characteristics.

X-ray apparatus

Figure 1 shows that the Crookes tube was pretty simple. It was, in effect, a vacuum tube diode without a plate. Electrons emitted from the cathode are accelerated by the charge on the anode, which in his tube was only a wire. Thus, some of the radiation bypasses the small anode and exits through the end of the glass tube. If the voltage on the anode is high enough, X- rays will be produced by the collision of electrons with the glass of the tube.

Figure 2 is a simplified diagram of a modern X-ray tube. When high-speed electrons strike a massive target such as one made of lead or tungsten, X rays are generated. This X-ray tube contains a heated cathode that emits electrons as in most vacuum tubes and the anode target, typically made of tungsten embedded in a water-cooled copper block. The tungsten resists the destructive effects of heat caused by the energetic electron bombardment. The anode surface is beveled to deflect the X rays, and the gap between the cathode and the anode is only a few inches.

The heated cathode emits electrons, and the anode has a positive voltage. It is essentially a vacuum-tube diode. A high-voltage power supply accelerates the electrons which strike the anode at an angle of about 45°. As a consequence, X rays are scattered in all directions, but most focused into a cone whose axis is at right angles to the centerline of the tube.

Conventional X ray radiograms view the body from only one angle. The rays are absorbed (shadowed) by dense objects like bones, artificial joints, and metal foreign objects. However, the softer tissues—muscles, organs, and skin are more easily penetrated. X-ray films or radiograms represent the amount of X-ray penetration with different gray (intensity) levels.

Over the past 20 years, the introduction of image-intensifier technology in X ray machines has permitted a significant reduction in the duration and intensity the X-ray to which the patient are exposed without sacrificing picture sharpness and quality.

Some new X-ray systems include electronics that can scan and digitize the image and send signals to a closed circuit television set for such functions as real-time inspection of welds without endangering the operator of the inspection equipment.

Some X-ray systems include electronics that can scan the image and, by means of Xerography, produce an instant picture on paper. This saves the time lost and expense of manually developing a photographic film. These systems are not like-

WHAT ARE X-RAYS?

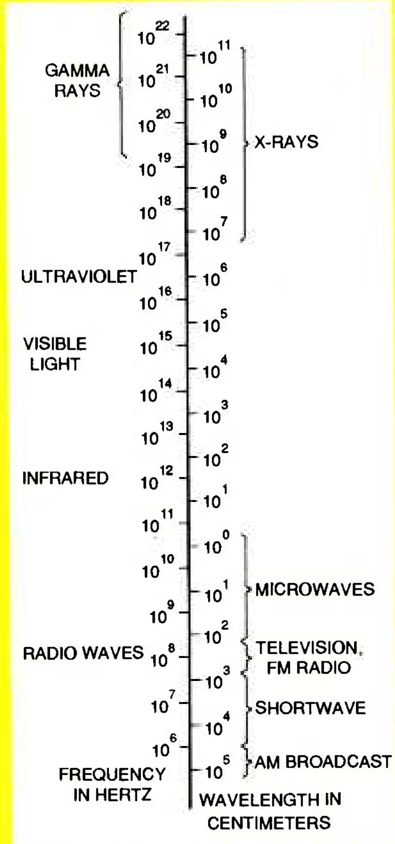
X-rays are electromagnetic radiation with properties similar to light, but with much shorter wavelengths (from about 10 -7 to 1-10 centimeters or 0.1 to 100 angstroms). These wavelengths are shorter than ultraviolet but not as short as some gamma rays at the far end of the spectrum. There is some overlap in frequency and wavelength between gamma and X rays. Longer wavelength X-rays are termed "soft" and shorter wavelengths are termed "hard."

X-rays are usually generated by accelerating electrons to a high velocity and suddenly stopping them by collision with a metal target. The resulting bombardment of the atoms in the target causes the atoms to lose energy, and this energy is radiated as X-rays of a definite wavelength.

Gamma rays behave essentially the same way as X-rays, but they have higher energy. Grouped with alpha (positive) and beta (negative) rays, they are considered to be *natural rays* that radiate from radium, uranium, and other natural substances. By contrast X-rays are considered to be *man-made* because they can be derived from tubes, synchrotrons and even lasers. X rays are produced when a stream of electrons strikes a target. This was the glass tube in the Crookes tube and is the tungsten anode in the modern X-ray tube.

X-rays propagate through a vacuum in the same way and at the same speed as other forms of electromagnetic radiation, including visible light. However, X-ray photons contain a considerable amount of energy, giving them exceptional penetrating power in comparison with visible light and radio waves.

X-rays, like ultraviolet rays and gamma rays, can cause severe burns and even cancer. Lead shields provide the usual protection against the frequencies and strengths of X-rays encountered in hospital and dentist and phsician offices. Nevertheless, carefully controlled X-rays are used to treat cancers.



ELECTROMAGNETIC SPECTRUM showing the position of X-rays with respect to ultraviolet and gamma rays at the far end of the spectrum.

ly to replace conventional X-ray equipment because there is a tradeoff in detail. However, they can cut the cost of routine physical exams, and they can be lifesavers in situations where surgeons are treating severe trauma victims. No time is lost waiting for a negative to be developed.

Directions in X-ray technology

One of the most innovative X-ray systems developed within the past 25 years is computer-aided tomography, now generally called computed tomography (CT). This system, a marriage between the X-ray machine and a computer, converts signals generated by X rays into video images of a cross section of a patient. Figure 3 is a simplified diagram of the system showing its principal component, an X-ray source and detector array mounted on a scanning ring that so they revolve 360 ° around the patient is a single plane.

The patient is placed within the frame as shown in Fig. 3. The X-rays are focused in a thin fan-shaped beam that penetrates the patient's body. When the circular frame rotates, all sides of the patient are exposed to X rays. The sensitive detectors opposite the source convert the changing patterns of radiation received from the scanner into digital signals. A computer with a specialized applications program processes the data from the detectors and compares the views from many source positions to create a single video image on the monitor. The monitor presents a cross section or "slice" view of the patient's body. Because all sides of the internal bones, organs and tissues are exposed to X rays, no parts of the body are in "shadow." The patient can be positioned inside the scanner so images can be taken from head to foot. Multiple images permit the creation of 3-D images.

The later development of magnetic resonance imaging (MRI), based on the phenomenon of nuclear resonance, has stolen some of the thunder from computed tomography. However, the systems do not perform the same functions. Thus, the images gained from one can supplement the images obtained from the other to provide additional information valuable to surgeons performing certain critical operations. CT and MRI images can even be superimposed.

X-ray lithography

X-ray lithography is a process for transferring mask patterns to a resist-covered semiconductor wafer as an alternative to the more conventional ultraviolet-light lithography. It is also an alternative to electron-beam lithography. The shorter X-ray wavelengths of 10 to 50 angstroms vs. 2000 to 3000 angstroms for ultraviolet light minimize diffraction and extend the useful range of lithography toward the goal of 0.1 micrometer features on integrated circuitry. Optical lithography is expected to reach its limit at feature sizes shorter than 0.25 micrometer.

IBM, Motorola, and several Japanese electronics giants are actively developing synchrotron-based IC fabrication. Synchrotrons are X-ray sources that are expected to cost between $25 and $50 million. The magnetic fields of the synchrotron accelerate subatomic particles such as electrons and positrons to speeds that approach that of light. The speeding particles emit X-rays when the magnetic field lines are perpendicular to the direction of the particles.

X-ray equipment manufacturers and at least three laboratories are developing lower-cost sources of X-rays than synchrotrons. They will be equipped with hardware to reflect, collimate, and manipulate X-rays for chip fabrication.

Multiple application

X-ray diffraction is a phenomena used in the study and identification of materials. A beam of X-rays is diffracted when passed through the regular lattice structure of crystals. Characteristic diffraction patterns can be obtained for each crystalline material in the form of curved lines on photographic film.

An X-ray fluroescence absorptiometer measures the thickness of plating such as tin on steel. The primary X-ray beam is directed at the coating, causing the base metal to fluoresce. The resulting secondary radiation from the fluorescence is partially absorbed by the coating, giving an indication of its thickness.

X-ray spectrometers are instruments that direct X-rays at material specimens and measure the wavelengths of the various components of those materials for analysis. X-ray thickness gages measure the thickness of moving materials such as sheet steel during processing without making contact with the sheet. An X-ray beam directed through the sheet is absorbed in proportion to thickness of the material

Directions in X-rays

An exciting new area of research is the X-ray laser. X-ray lasers already exist, but they are not yet practical devices. Some experimental versions fill a complete building. Scientists in the United States, Great Britain, France, Germany, Russia, China, and Japan have been working on various designs for years, and they seem undaunted by the technical difficulties that must be overcome.

An X-ray laser microscope would give biologists a new research tool. Conventional microscopes are limited by the wavelength of visible light, which is a thousand times longer than that of X-rays. Electron microscopes can approach X-rays in their ability to distinguish detail, but the specimen must be stained, dead, and mounted on a slide. The X-rays from a laser could penetrate living cells permitting holographic 3-D photos to be taken of structures within the cell's plasma. Details could be resolved to a billionth of a meter.

X-ray lasers might also etch electronic circuits one-thousandth the size of those being made today. Ω

AUDIO AMPLIFIER

continued from page 32

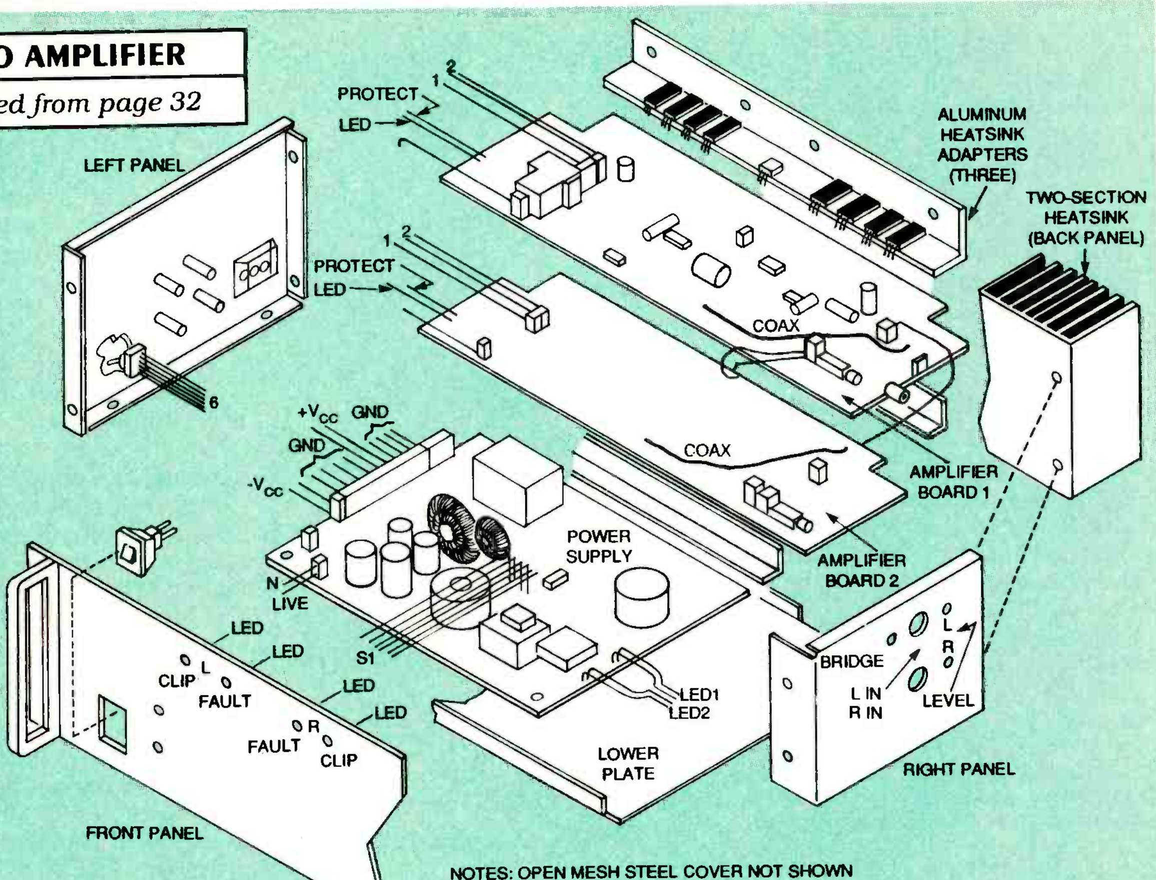


FIG. 8—CASE LAYOUT, HOME AMPLIFIER. The case height provides sufficient internal space for natural thermal convection, conduction and radiation. The output MOSFETs are fastened to the aluminum heatsink adapters, as shown.

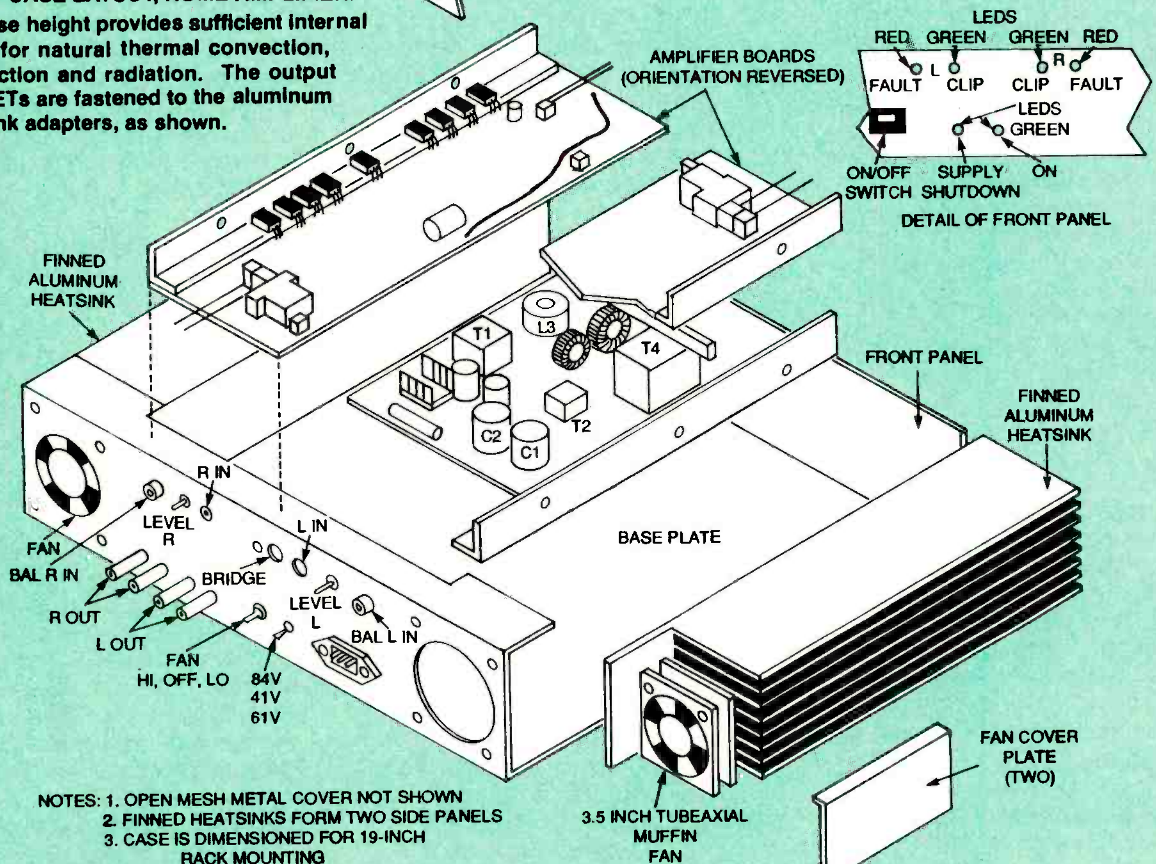


FIG. 9—INSIDE CASE DIMENSIONS FOR PORTABLE AMPLIFIER. The minimum inside dimensions are given for a case to be made by you or purchased. The locations for mounting the three heatsink adapters in this case are also given.

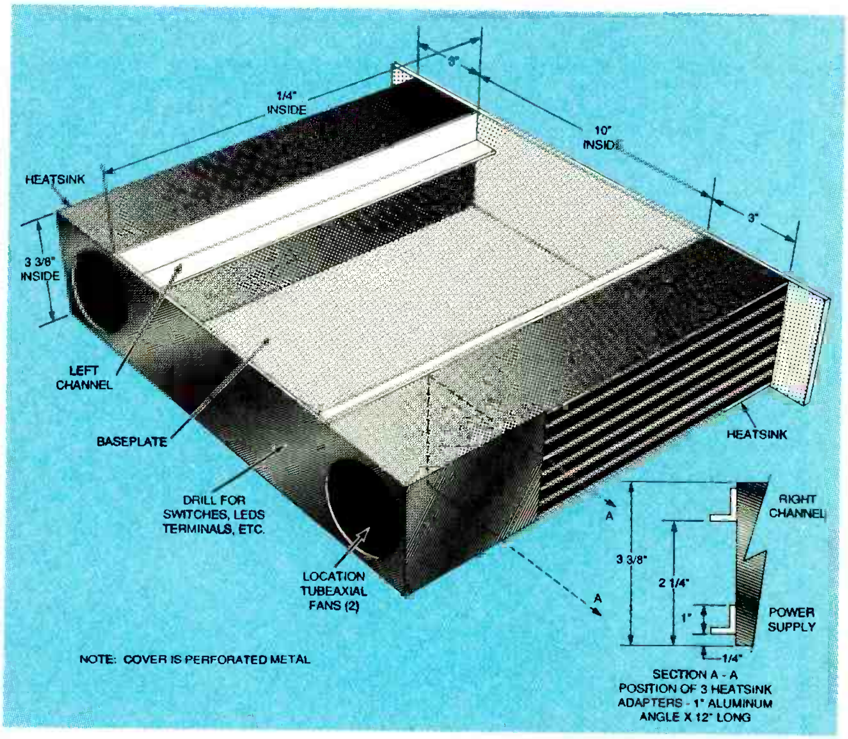


FIG. 10—CASE LAYOUT, PORTABLE AMPLIFIER. Two 3½-inch, muffin-type cooling fans permit a case height of only 3½-inches. The output MOSFETs are fastened to aluminum heatsink adapters, as shown.

its minimum inside dimensions. Figure 10 is the assembly drawing of this version, comparable to Fig. 8, presenting the same kinds of information. Note that the locations for mounting the cooling fans are indicated in that drawing.

Heatsinks and fans

Both the amplifiers and the switching power supply boards were designed with the mounting holes for the power transistors to be located at their edges. As stated in part 1 of this article, the transistors, when soldered in place, are bolted to the heatsink adapters.

Figures 7 and 9 show the mounting locations for the three heatsink adapters within the cases, and Figs. 8 and 10 show how the output transistors are mounted on the adapters. The adapters are fastened directly to the heatsinks in both packaging versions of the amplifier.

Cut the 1-inch aluminum angle stock to obtain three 12-inch lengths. Use either the circuit boards or the artwork for the circuit boards as drilling templates to locate the mounting holes for the power MOSFETs on the inside lower surface of each adapter, as shown in Figs. 8 and 10. Drill those holes with an appropriate sized drill bit. Then drill the four holes in the opposite surfaces of the angles for mounting them to the heatsink or heatsinks, depending on the case selected. Carefully deburr all holes.

If you do not have access to the facilities or equipment necessary to build the metal case of your choice, a standard 19-inch rack-mount case can be purchased and modified. It might be necessary to do some mechanical design work to adapt the circuit boards to the purchased case.

The inside dimensions of the case can be larger than the minimum values shown in Figs. 8 and 10, but it is not recommended that they be smaller because of possible mechanical interference and thermal problems. To obtain sufficient natural thermal convection and conduction in the home version, a larger heatsink area is required than that for the fan-cooled portable version, and the overall case height is higher.

After building or purchasing the metal case for the version you intend to build, drill the holes for the panel-mounted switches, jacks, LEDs and other components as well as access holes for external adjustments, as required. Mount the off-board components on the panels of the case, as shown in either Figs. 8 or 10, and set the case aside. Do not wire the panel mounted components to the circuit boards at this time.

Convection-cooled case

Figure 8 shows how the two amplifier boards in the convection-cooled amplifier are stacked one above the other in the same orientation. The switching power supply is mounted on the baseplate. It will be necessary to solder in point-to-point hookup wires to light the-panel mounted LEDs in this version.

Forced-air-cooled case

Figure 10 shows the board arrangement for the forced-air cooled version of the amplifier. If you build this version, drill the holes necessary for mounting the two 3.5-inch muffin-type fans within the case and provide access holes in the case for wiring them.

Power supply testing

Examine the completed power supply circuit board for the correct placement of all components, the correct orientation of all polarized components, and the absence of any inadvertent solder bridges or cold solder joints. Make any corrections necessary at this time before proceeding.

Fasten the transistors to the aluminum heatsink adapter with nuts and bolts, placing mica electrical insulators and a film of silicone grease between the device tabs and the heatsink adapter. Verify that there are no short circuits between the transistors and the heatsink adapter.

Next, install fuses F1 and F2 in their holders, but do not install fuse F3 at this time. Be sure that jumper J1 is installed for 120-volt AC-line operation.

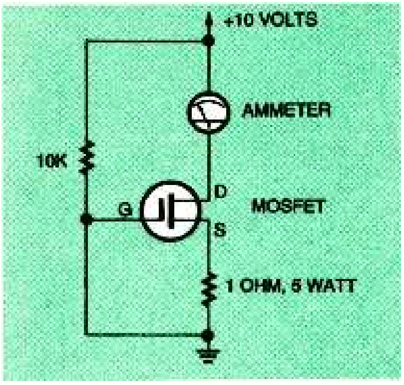


FIG. 11—MOSFET MATCHING CIRCUIT. After the 10-kilohm potentiometer is set to 0.5 to 1.0 amperes, the MOSFETs are measured for gate voltage or drain current so they are matched within 10% of their measured values.

Apply the AC input power by turning on the switch. *Caution*: Exercise extreme caution while handling the power supply board or any components on the board when making electrical measurements. The input circuitry of the power supply is connected directly to the power line, so contact will expose you to life-threatening electrical shock.

With a voltmeter, measure at the input to fuse F3 with respect to the ground side of capacitor C2, and verify that +320 volts is present. Also, measure the output of voltage regulator IC3 with respect to the board's ground, and verify that +15 volts is present. Double check to verify that transformer T2 is oriented as shown on Fig. 3. Turn off the input power and install fuse F3.

Install one 5-kilohm, 10-watt resistor per bus to provide a light load for the switching power supply. Set switch S2 to the 41-volt position, and apply AC line power. Verify that ± 41 volts is present at the power supply output. Switch S2 to ±58 volts and ± 82 volts, and verify that each of those voltage appears at their output terminals. Temporarily connect the shutdown input pin to +15 volts, and verify that the output is turned off.

Amplifier testing

The amplifier test procedure calls for each amplifier board to be tested first before the output transistors are installed. Begin the test procedure by verifying that all of the components have been correctly installed in their specified locations and that all polarized components have been oriented correctly. Then carefully examine all solder joints to verify that there are no inadvertent solder bridges or cold solder joints that will later cause problems. Make any corrections necessary at this time before proceeding.

Exercise patience and inspect all of your work carefully at this time. This attention to detail early on in the game will avoid the destruction of expensive components and save you disappointment with your project and perhaps hours of troubleshooting later.

Install ½-ampere amplifier fuses F1 and F2. Temporarily connect the power supply to an amplifier board and verify that the polarities are correct. For these tests you might want to use the current limiting capabilities of the power supply for extra protection. This can be done by placing a jumper on the power supply board between the junction of R17 and R18 and the junction of D5 and D9.

Apply power to the circuit and measure the ±15-volt supplies on the board and the ±30 volts at the input stages. Do all probing carefully, because if the probe slips, you could cause a destructive short circuit between two pins.

Carefully measure the voltages across diodes D7 and D8. The voltage values should be between 3 and 5 volts. Adjust trimmer potentiometer R18 until the voltages are each less than or equal to 3.5 volts. If you have a signal generator and an oscilloscope available, perform an additional valuable test by applying a small-signal voltage of 5 to 10 millivolts at a frequency of 1 kHz at the input and check for drive signals at the emitters of transistors Q14 and Q15.

Because the amplifier is open-loop at this time, the drive signals can easily be overloaded. The drive signal should appear as a train of squarewaves with an amplitude of about 12 volts peak-to-peak, as limited by diodes D7 and D8.

If all the tests have been passed satisfactorily, it is time to mount the matched output MOSFETs Q16 to Q23. Matched MOSFETs can be obtained from the source given in the Parts List, or you can match them by first building the simple matching circuit shown in Fig. 11. After the 10-kilohm potentiometer is set to 0.5 to 1.0 amperes, measure the MOSFETs for gate voltage or drain current. They must be matched within 10% of their measured values.

Install the matched MOSFETs on the aluminum heatsink adapters as shown in either Fig. 8 or Fig. 10 with nuts, lockwashers, and screws, after first placing mica thermal conducting washers and a film of silicone grease between the transistor tabs and the heatsink adapter. With an ohmmeter, measure the resistance to verify that there are no short circuits between the power transistors and the adapter.

For the home convection-cooled configuration or operations limited to 8-ohms, four output transistors per bus should be sufficient. However, if you plan to operate the amplifier in a bridging mode, or at high power with low impedance loads, include the additional MOSFETs Q26 and Q27 as well as resistors R79 and R80 in each channel.

Install a 1-ampere fuse in the F1 holder, and position a milliammeter across the terminals of the holder for fuse F2. Apply 120-volt line power at the holder terminals for fuse F2. Adjust trimmer potentiometer R18 for an "idle" current of about 200 milliamperes.

Remove the milliammeter, and install 1-ampere fuse F2. Verify that the output is within a few millivolts of ground. Apply an input signal at a low level, and verify that an amplified output appears.

If the amplifier responds as expected, replace fuses F1 and F2 with 8 ampere fuses, and repeat the tests on the second

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FUNCTION GENERATOR

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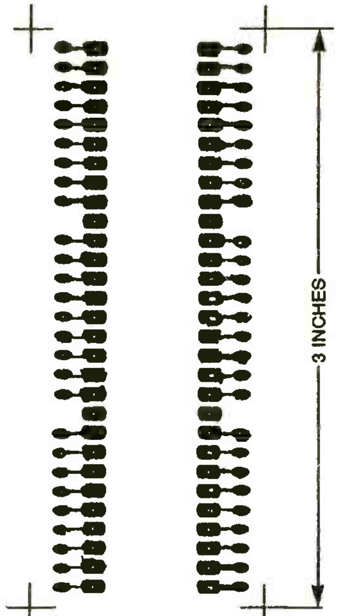
ing would be visible when applied. Paint the front panel any color that contrasts with the labeling you apply. After applying labels, spray a thin coat of clear lacquer over the lettering to protect it from damage. When the finish is completely dry, mount the front-panel components and display board. Then attach the main PC board and power transformer to the bottom half of the case. Figure 4 shows the inside of the prototype unit.

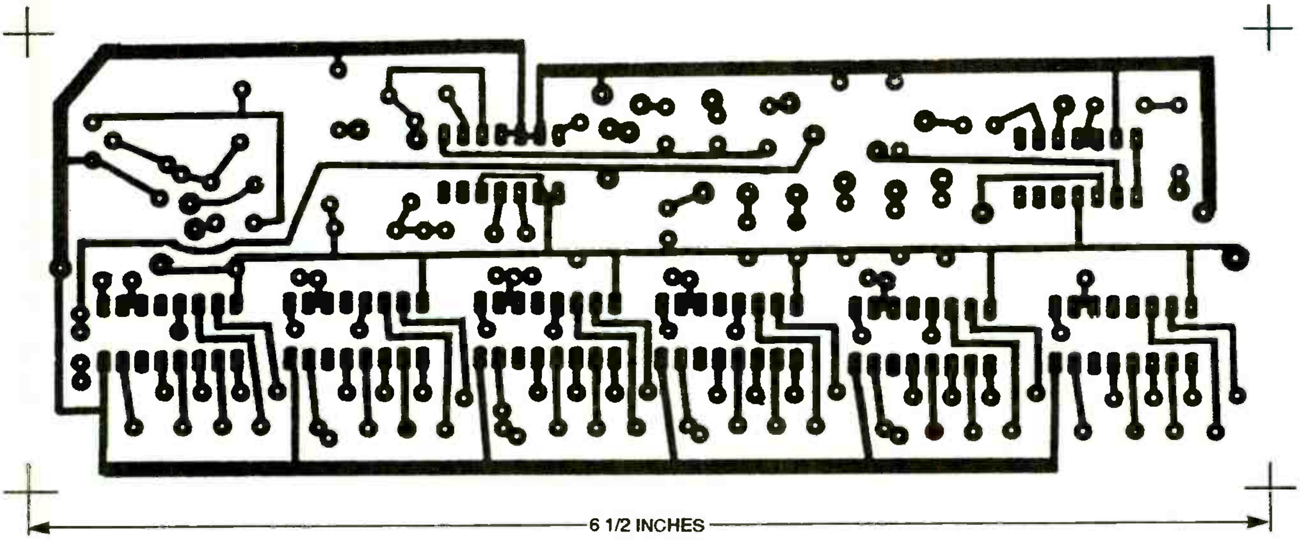
Calibrating the generator

The accuracy of the frequency counter depends on the accuracy of the gate time. If another signal generator is available, apply a known frequency, say 5 kHz, to the frequency counter's external input. Set the sample time for 10 milliseconds (switch in C8), and adjust R6 until the display reads 00005.0. Now switch to the 100-millisecond sample time and adjust R6 for a display of 0005.00. Then switch to 1000 milliseconds and adjust R6 for a display of 005.000. Repeat this process several times to obtain the best average setting for R6.

If only a frequency counter is available, connect the output of the 8038 (IC1) to the frequency counter and adjust potentiometer R1 for a 5 kHz output signal. The 8038 can now be used to calibrate the display section.



DISPLAY BOARD FOIL PATTERN.



MAIN BOARD FOIL PATTERN.

If neither test instrument is available, Fig. 5 shows a simple clock circuit based on a 555 timer IC that will produce a frequency of about 5.2 kHz. This method is not ideal, but will provide reasonably accurate results.

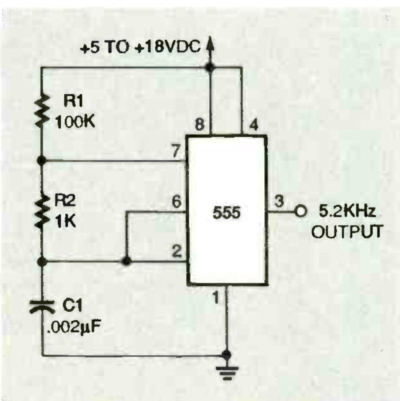


FIG. 5—THIS SIMPLE CLOCK CIRCUIT based on a 555 timer IC will produce a frequency of about 5.2 kHz, and can be used to calibrate the display section.

Operating the generator

With power on, select the signal shape desired with switch S2, the frequency range with S1, and the exact frequency with R1. With counter switch S4 in the "in" position, the output frequency will be displayed on the built-in counter, and the selected signal will be present at the output terminals. The voltage level of the output waveforms varies, with a peak-to-peak voltage of 2 volts for a squarewave, 1 volt for a sinewave, and 4 volts for triangle wave. Those levels provide enough signal for test purposes, but do not exceed the 5.25-volt maximum for TTL ICs. Thus, the generator can be used safely with any type of logic circuit. Switch S3 sets the counter sample time and the decimal point.

With S4 in the "out" position, any signal in the frequency counter's range can be sent to the external jacks, and its frequency will be displayed. This does not affect the operation of the function generator. Ω

EEPROM PROGRAMMER

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pin 1 is not connected (NC), but on Microchip Technology's 28C64A, pin 1 is a ready/busy output status signal. There is potential for conflict here, but use of R2 avoids the conflict.

To handle different device densities, it is necessary to "low-justify" the desired device, and to use DPDT switch S1. Figure 2 shows the concept of low justification by overlaying the pinouts of the 24- and 28-pin device types (2816s and 2864/28256s, respectively). Returning to Fig. 1, for high-density devices (2864s and 28256s), the upper position of S1 connects the high-order address lines to the appropriate socket pins. For low-density devices (2816s), pin 26 of the socket (pin 24 of a 24-pin device) is tied to V_{CC}, and the microcontroller's $\overline{WE}$ output is tied to pin 23 of the socket (pin 21 of the device).

Software

There are two major chunks of software in this project. One is the 8031 control program that runs on the EEP-1; the other is a communication program, called EEP1.EXE, that runs on a PC compatible. Communication between the EEP-1 and the host PC takes place at

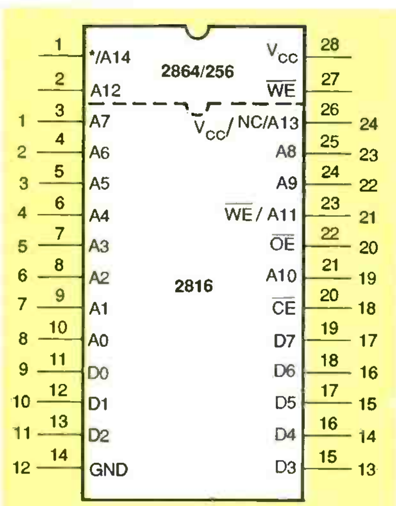


FIG. 2—PINOUTS OF 24 AND 28-PIN EEPROMs are very similar. By "low-justifying" a 24-pin device in a 28-pin socket, a single socket can do double duty.

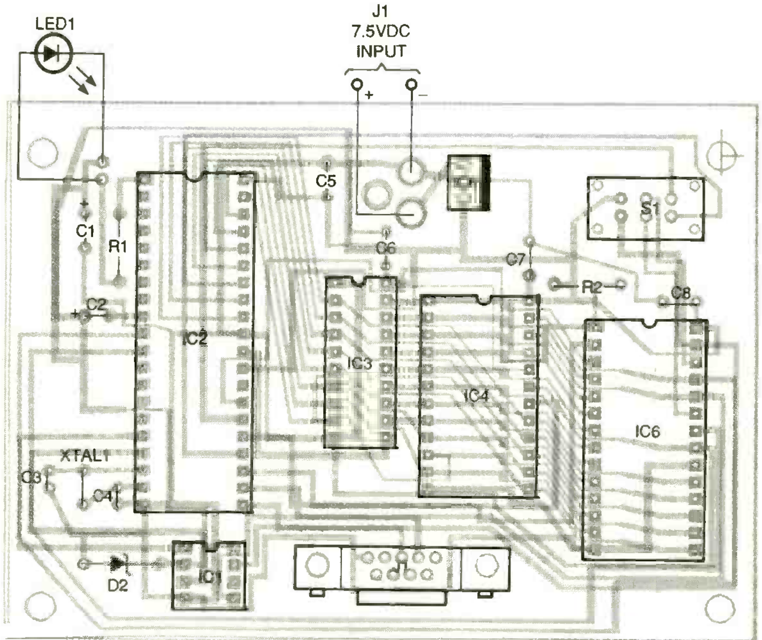


FIG. 3—PARTS-PLACEMENT GUIDE for the EEP-1. Don't solder the ZIF socket directly to the board in the IC6 location; instead, install a machined-pin socket, and insert the ZIF socket into that.

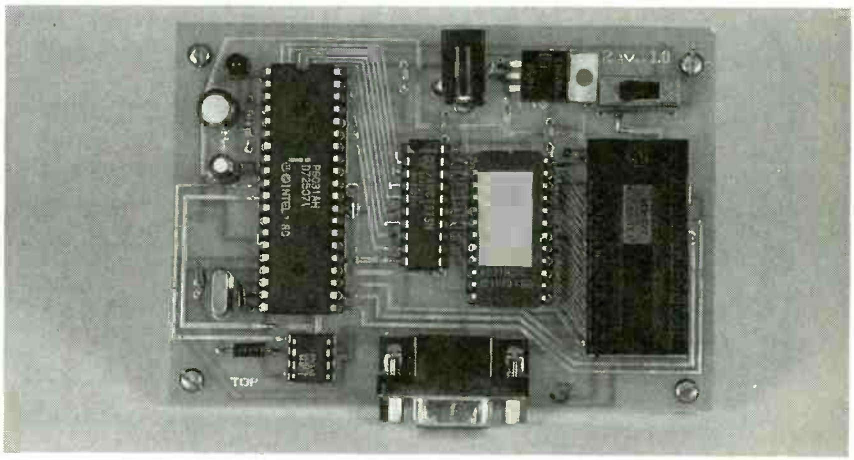


FIG. 4—COMPLETED EEPROM PROGRAMMER BOARD. The board has a screw and nut at each corner acting as legs to support it.

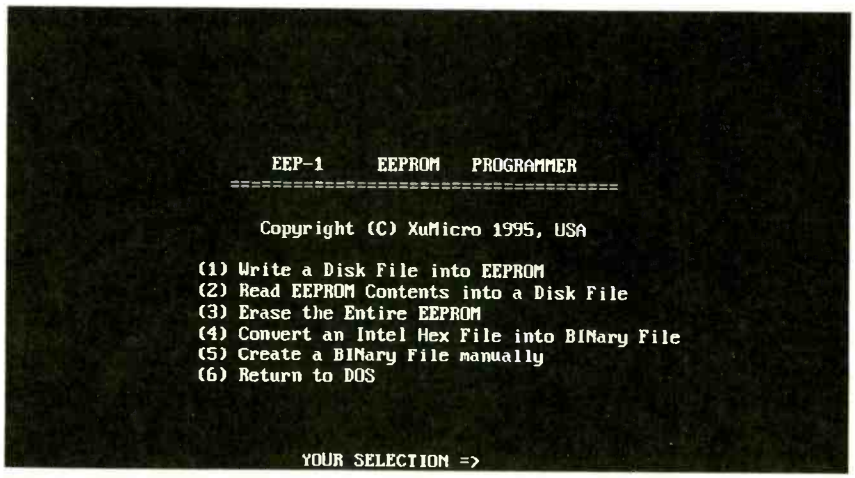
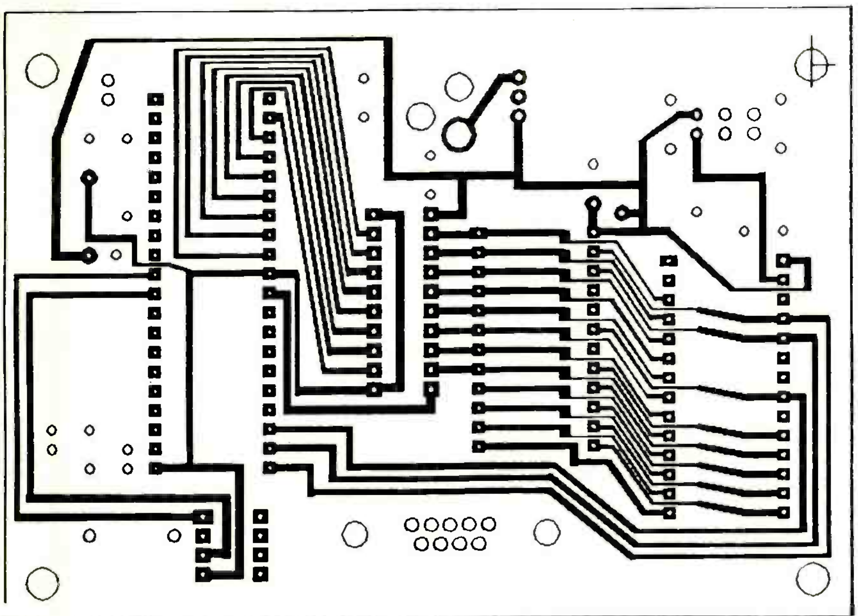
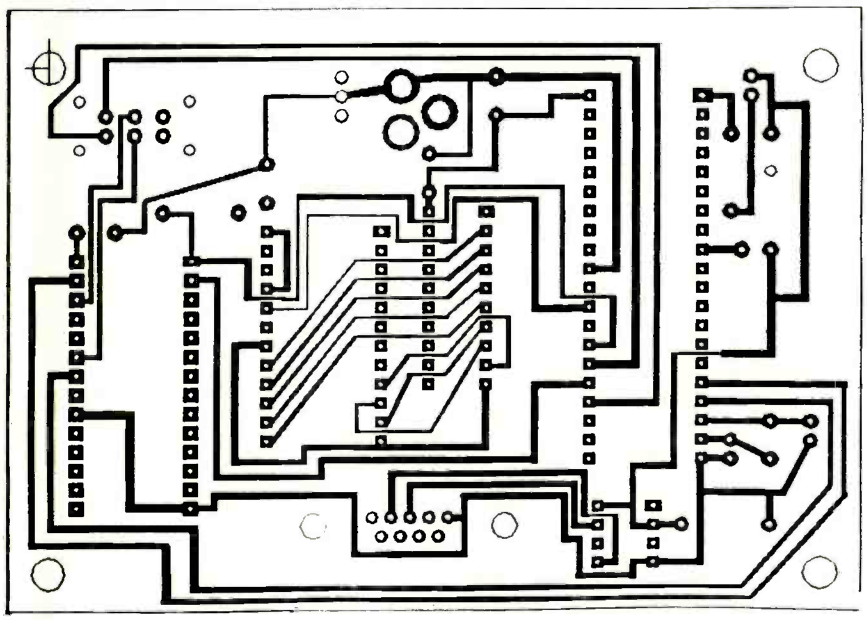


FIG. 5—MAIN MENU DISPLAY of the DOS-based program EEP1.EXE, which accepts both binary and Intel-format hex images.



4 1/2 INCHES

COMPONENT SIDE FOIL PATTERN.



4 1/2 INCHES

SOLDER SIDE FOIL PATTERN.

PARTS LIST

All resistors are ¼-watt, 5%.
R1—220 ohms
R2—10,000 ohms
Capacitors
C1—100 µF, 25 volts, electrolytic
C2—4.7 µF, 25 volts, electrolytic
C3, C4—47 pF ceramic
C5–C8—0.1 µF ceramic
Semiconductors
IC1—DS1275 transceiver, RS-232 (Dallas Semiconductor)
IC2—8031/8051 microcontroller (Intel)
IC3—74LS573 octal D latch
IC4—2716 EPROM or 2816 EEPROM
IC5—7805 regulator, 5 volts
IC6—2816, 2864, or 28256 EEPROM
LED1—red light-emitting diode, T 1¾
D1—not used
D2—1N5817, diode, Schottky
Other components
XTAL1—3.6864 MHz crystal
S1—DPDT slide switch
J1—coaxial power jack
J2—DB9 female connector, right-angle, PC mount
Miscellaneous: Nine-conductor cable, 28-pin ZIF socket, IC sockets, wire, solder, etc.

ORDERING INFORMATION

The following items are available from G. Y. Xu, P.O. Box 14681, Houston, TX 77021:
- Assembled and tested EEP-1 programmer—$49.95
- Complete kit including software, PCB, hardware, cable, and power adapter—$39.95
- Software and PCB only—$29.95
- 2816 EEPROM—$4.50

Send check or money order. All orders add $5.00 for shipping & handling.

9600 bps. The host program can read disk files stored in both Intel hex (OBJ) and binary (BIN) formats.

The 8031 control program provides three basic functions: communications with the PC, reading and writing EEPROM data, and system status indication, including proper connection, completion of each step, and so on. The system also has extensive error checking. For example, if the serial cable is not wired correctly, or is connected to the wrong COM port, the software simply won't run.

If you're building this project from scratch, download the file EEP1.ZIP from the Gernsback BBS (516-293-2283, v.32, v.42bis). It contains both the PC host software and the 8031 control software. It also contains two sample 8031 programs that you can use to experiment with the EEP-1.

Assembly and test

A PC board should be used for this project. Foil patterns accompany this article; alternatively, double-sided boards with plated-through holes are available from the source given in the Parts List. Figure 3 shows

EEPROM VS. EPROM

The biggest difference between EPROM and EEPROM is the relative ease with which each can be programmed, erased, and reprogrammed. EPROMs typically require programming voltages ranging from 12 to 22 volts, which are not easy to come by in many digital circuits. The high programming voltage also makes in-place programming difficult. In addition, to be erased, EPROMs require exposure to special ultraviolet lamps, a time-consuming and inconvenient process.

EEPROM overcomes all those difficulties. EEPROM can be programmed from a +5-volt source, it can be programmed in place, and it can be erased (electrically!) in place. Of course, that extra capability comes at a price; for many years, EPROM offered serious cost advantages over EEPROM. But in recent years, that has changed; low-cost EEPROM is now readily available. And in some ways, it is more cost effective than EPROM.

For example, a 2764 EPROM may cost $5.00, and can be erased and reused perhaps 100 times. By contrast, a 2864 EEPROM costing $7.00 can be erased and reused as many as 10,000 times. Add to that the 15 minutes saved by not having to perform a UV erasure, and EEPROM starts to look like a real winner.

Here's a real-life example of the value of using both EPROM and EEPROM. The author used EEPROM extensively in developing this project. But when the software was complete, he burned it into an EPROM, and sells kits with the firmware in that format. For volume production, the cost advantage of EPROM makes sense, whereas during development, convenience and time far outweigh device cost. Ω

the parts-placement guide.

To begin construction, first insert and solder sockets for IC1 to IC4. Then install a 28-pin machined-pin socket in the IC6 position and, mount the ZIF socket in it. Next install J1, J2, and S1, and voltage regulator IC5.

Now install all remaining components, including the resistors, capacitors, and semiconductors. Make sure that you observe correct polarity for the LED and Schottky diode. Last, solder the 3.6864 MHz crystal XTAL1 in place. Figure 4 shows the completed board.

After all components have been mounted, check your work carefully for short and open circuits, and fix any mistakes. Then, before inserting any ICs, plug in the power adapter and measure the voltage at the power-input pin of each IC. If all is well, remove power, insert all the ICs, and re-apply power; LED1 should light up. If you have access to an oscilloscope, you can check the 8031's ALE line; its frequency should be one-seventh of the crystal frequency, or about 0.53 MHz.

Using the programmer

With both PC and EEP-1 power off, connect the DB9 cable between them, and set S1 to the appropriate position. Then power up EEP-1; the LED should light. Now power up the PC and run the host program. You should see a screen like that shown in Fig. 5.

Note that when programming EEPROMs, the host software accepts both binary and ASCII-encoded, Intel-format hexadecimal object files. With a binary file, the software simply sends each byte in the file as is to the EEP-1. With an object file, the software first converts it to binary format, then sends it the programmer.

After programming an EEPROM, the EEP-1 verifies results. If successful, the host software displays an affirmative message ("EEPROM Programming Successful"). If, on the other hand, an error occurred during the process, an error message will be displayed.

Sample programs LED1.BIN and LED2.BIN are both simple control programs that make the EEP-1's LED blink. These programs can help verify correct system operation. LED1.BIN is a simple program containing only 34 bytes of code. To use it, program an EEPROM with the code. Then power down, remove the control program EEPROM (or EPROM), and insert the new EEPROM. When you power back up, the LED should blink on for two seconds, off for two seconds, on for two seconds, and so on. LED2.BIN has a more complicated blinking pattern; otherwise, the two programs are very similar. Source code for both programs is included on the diskette sold separately. Ω

AUDIO AMPLIFIER

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channel. If you elect to include thermal protection, mount the thermal cutouts on the heatsink adapters now.

Final assembly

After all three circuit boards have been tested, install them already attached to their aluminum heatsink adapters in the case.

Connect the power supply and perform all point-to-point wiring for the LEDs and power output connections to their related board terminals.

Connect input power to the power supply, and connect the amplifier inputs to the jacks. Connect the amplifier protection leads to the power supply shutdown input. Carefully recheck all of your workmanship for errors and if none are found, perform the final test procedure.

Operating instructions

These special operating instruction are limited to the proper use of the switching power supply voltage select switch S2. In general, the available lower voltages have two purposes: (1) To limit the power available to sensitive loads, and (2) for driving speakers with low impedance values that might otherwise be damaged.

Some listeners prefer to limit the available power to about 100 watts into an 8-ohm load. To operate under those conditions, select the 58-volt setting. If you have speakers with impedances of 1 to 4 ohms, the power dissipation in the amplifier can be limited by setting the voltage to 41 volts.

With either alternative, the current-detection circuitry in the power supply will protect the amplifier sections whether the output is 58 or 41 volts. A momentary shutdown will occur, and a LED indicator will light if an overload condition occurs. The power supply will reset itself when the overload is removed. Ω

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pin drives the EEPROM's OE (output enable) pin.

The 8031 multiplexes its data bus with the eight low-order address lines. This means that the same pins carry both data and address information at different times during the controller's machine cycle. In particular, when IC1's ALE line goes low, IC2 latches the address bits on pins 32–39 of the microcontroller, and uses that information to address external program memory (IC3). At other times, pins 32–39 function as the microcontroller's data bus.

This project requires only six address lines, A0–A5, because the control program is only 34 bytes long, and $2^6 = 64$, nearly double the required number. (The Project II hardware is nearly identical, except that it requires an additional address line to accommodate more complex software.)

The software, shown in Listing 2, consists of three routines: the main loop, a short delay, and a long delay. The main loop simply clears bit 0 of port 1, executes the long delay, turns the bit back on, calls the long delay again, and starts over. The short delay provides a delay of approximately 10 milliseconds, and the long delay, approximately 2000 milliseconds, or 2 seconds. The actual time passed during the short delay depends on the frequency of the microcontroller's clock. A different clock frequency would require different constants in the short delay loop.

LISTING 2—8031 LED PROGRAM I

```
0000                ;LED1.ASM        Single blinking LED program
0000                ;Using 8031 at 3.6864 MHz (15 blinks per minute).
0000
0000                        .ORG     H'0000
0000
0000                START:
0000 C290                CLR      P1.0    ; Logic 0 at Port 1.0 (LED=ON)
0002 111A                ACALL    DLY2    ; 2 sec Delay
0004                ;
0004 D290                SETB     P1.0    ; Logic 1 at Port 1.0 (LED=OFF)
0006 111A                ACALL    DLY2    ; 2 sec Delay
0008 0100                AJMP     START   ; loop back
000A
000A                ;------------------------------------------------------
000A                ; Subroutine for 10 ms Delay
000A                DLY10ms:
000A C0E0                PUSH   ACC
000C 74E0                MOV    A, #D'224
000E                LOOP:
000E 75F005              MOV    B, #D'5
0011                LOOP1:
0011 D5F0FD              DJNZ   B, LOOP1
0014 D5E0F7              DJNZ    ACC,LOOP
0017 D0E0                POP    ACC
0019 22                  RET
001A                ;-----------------------------
001A                ; Subroutine for 2 sec delay
001A                DLY2:
001A 74C8               MOV     A, #D'200
001C                LOOP2:
001C 110A               ACALL   DLY10ms
001E D5E0FB             DJNZ    ACC, LOOP2
0021 22                 RET
0022                ;
0022                        .END
```

Project II

An almost identical circuit is used for Project II. The exception is that an additional address line is required to accommodate a larger control program. This program provides a more interesting blinking pattern than the previous. The overall cycle lasts six seconds. At the beginning, the LED blips on briefly two times for half a second each, separated by ⅓ second. Then the LED goes off for a period of 4.7 seconds, and the cycle repeats.

Listing 3 shows the Project II program. As in Project I, the Project II software contains a main loop and several delay loops. The main loop functions as described above. The short delay here also provides a 10-millisecond delay, but instead of two nested loops, there's a single loop consisting of several NOP (no operation) instructions. There was no technical reason to rewrite the short delay; it was done just to illustrate

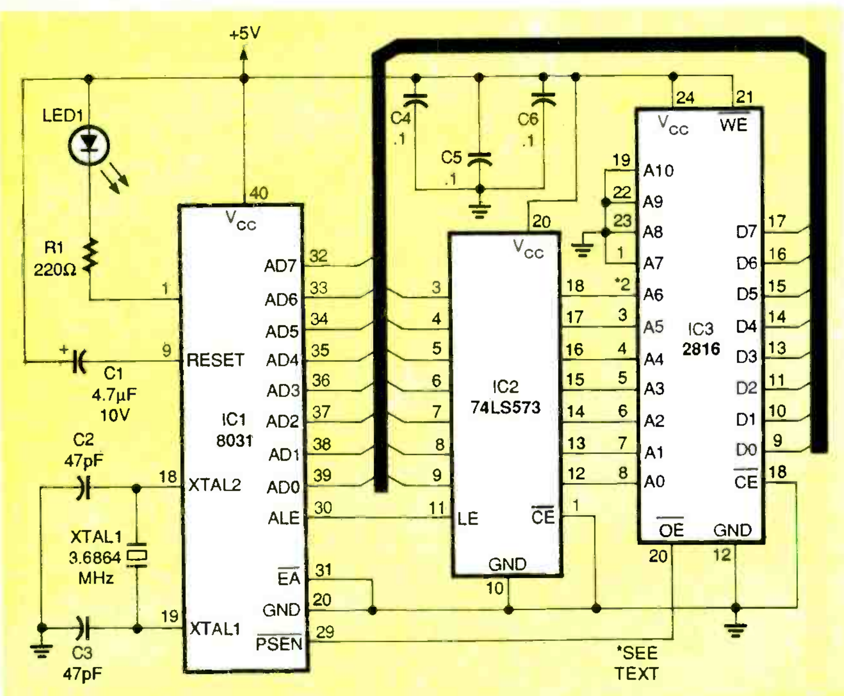


FIG. 1—THE 8031 MICROCONTROLLER has multiplexed data and address lines, hence latch IC2 is required. For Project I, only six address lines are required; for Project II, seven are required.

LISTING 3—8031 LED PROGRAM II

```
0000                ;LED2.ASM       Double blinking LED program
0000                ;Using 8031 at 3.6864 MHz (10 Double Blinks per minute).
0000
0000                        .ORG     H'0000
0000
0000                START:
0000 C290                CLR    P1.0    ; Logic 0 at Port 1.0 (LED=ON)
0002 1126                ACALL  DLY1    ; .5 sec Delay
0004 D290                SETB   P1.0    ; Logic 1 at Port 1.0 (LED=OFF)
0006 112E                ACALL  DLY2    ; .3 sec Delay
0008
0008 C290                CLR    P1.0    ; Logic 0 at Port 1.0 (LED=ON)
000A 1126                ACALL  DLY1    ; .5 sec Delay
000C D290                SETB   P1.0    ; Logic 1 at Port 1.0 (LED=OFF)
000E 1136                ACALL  DLY3    ; 4.7 sec Delay
0010
0010 0100                AJMP   START   ; loop back
0012                ;---------------------------------------------------
0012                ;Subroutine for 10ms delay
0012                DLY10ms:
0012 C0E0                PUSH   ACC
0014 74FF                MOV    A, #D'255
0016                LOOP:
0016 00                  NOP
0017 00                  NOP
0018 00                  NOP
0019 00                  NOP
001A 00                  NOP
001B 00                  NOP
001C 00                  NOP
001D 00                  NOP
001E 00                  NOP
001F 00                  NOP
0020 D5E0F3              DJNZ   ACC,LOOP
0023 D0E0                POP    ACC
0025 22                  RET
0026                ;------------------------------
0026                ;Subroutine for 0.5 sec delay
0026                DLY1:
0026 7432                MOV    A, #D'50
0028                LOOP1:
0028 1112                ACALL  DLY10ms
002A D5E0FB              DJNZ   ACC, LOOP1
002D 22                  RET
002E                ;------------------------------
002E                ; Subroutine for 0.3 sec delay
002E                DLY2:
002E 741E                MOV    A, #D'30
0030                LOOP2:
0030 1112                ACALL  DLY10ms
0032 D5E0FB              DJNZ   ACC, LOOP2
0035 22                  RET
0036                ;------------------------------
0036                ; Subroutine for 4.7 sec delay
0036                DLY3:
0036 74E6                MOV    A, #D'230
0038                LOOP3:
0038 1112                ACALL  DLY10ms
003A D5E0FB              DJNZ   ACC, LOOP3
003D
003D 74F0                MOV    A, #D'240
003F                LOOP4:
003F 1112                ACALL  DLY10ms
0041 D5E0FB              DJNZ   ACC, LOOP4
0044 22                  RET
0045
0045                        .END
```

PARTS LIST—PROJECTS I AND II

R1—220 ohms
C1—4.7 µF, 10 volts, tantalum
C2, C3—47 pF, disk
C4–C6—0.1 µF
IC1—8031 or 8051 microcontroller
IC2—74LS573 octal latch
IC3—2816 EEPROM
LED1—Red light emitting diode
XTAL1—3.6864 MHz crystal

the idea that there is often more than one way to solve a software problem. In this case, the Project I method is actually more efficient in terms of memory used. Anyway, by repeatedly calling the short delay, Project II builds long delays of 0.3, 0.5, and 4.7 seconds.

Project III

The next project, shown in Fig. 2, uses an 8085 microprocessor. Functionally it is similar to Project I, because it simply blinks an LED off and on in a regular pattern.

The hardware is similar to that used in the 8031 projects. For example, the 8085 multiplexes the data bus and the low-order address lines, so a 74LS573 is required once again (IC2). On the other hand, the 8085 has no output port like the 8031. However, the 8085 does have a pair of pins designed to be used for software-controlled serial input/output. For our purposes the serial output data (SOD) line (pin 4) will drive the LED.

One interesting feature of this project is that is has no RAM. Whereas the 8031 has 128 bytes of built-in general-purpose storage, the only writeable storage available in this project is contained within the CPU's registers. One implication of having no RAM is that there can be no stack. And if there is no stack, there can be no subroutines. So delay routines can't be called as in Project I and Project II. Instead, the delay loops must be embedded directly within the main routine of the program. So the main routine ends up doing everything: turn off LED, delay, turn on LED, delay, turn off LED, ...

PARTS LIST—PROJECT III

R1—10,000 ohms
R2—220 ohms
C1—4.7 µF, 10 volts, tantalum
C2–C4—0.1 µF
C5—22 pF
IC1—8085A microprocessor
IC2—74LS573 octal latch
IC3—2816 EEPROM
LED1—Red light emitting diode
XTAL1—1.8432 MHz crystal

As in Project I, the program is very short—only 27 bytes. So rather than running the source code through the assembler, you may simply want to create a binary file using DEBUG as outlined above. To do so, use the hex bytes in the third column of Listing 4. Because only 27 bytes are involved, only five address lines are needed ($2^5 = 32 > 27$).

Project IV

Here is yet another implementation of the blinking-LED theme, this time using a Zilog Z80A, as shown in Fig. 3. This circuit provides some interesting variations on the previous ones. First, the Z80 has separate data and address buses, so no demultiplexer is needed. On

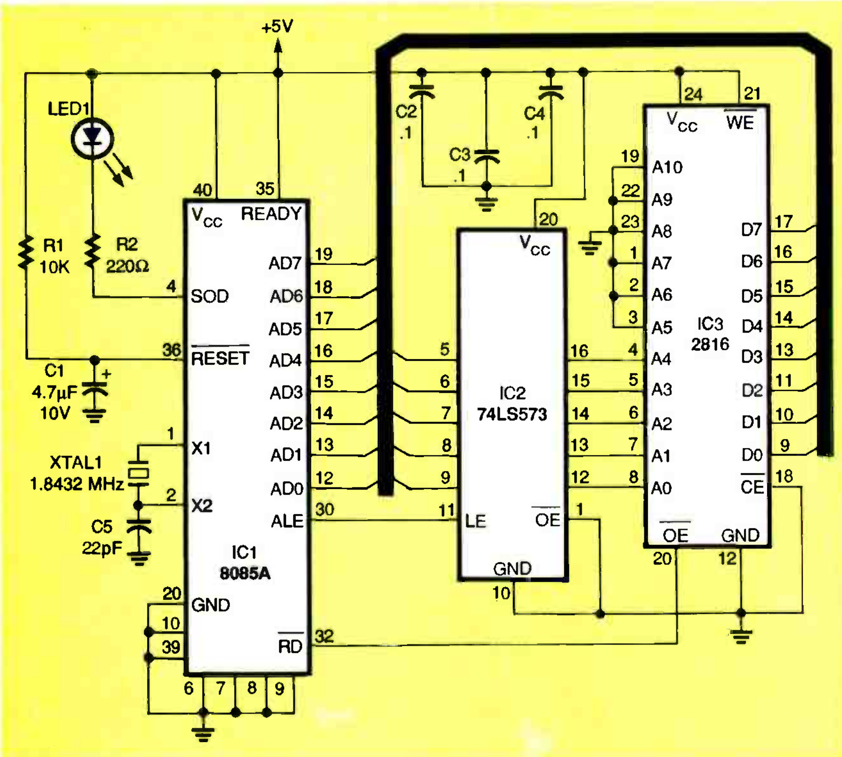


FIG. 2—THE 8085A MICROPROCESSOR requires nearly identical support circuitry, including the low-order address latch.

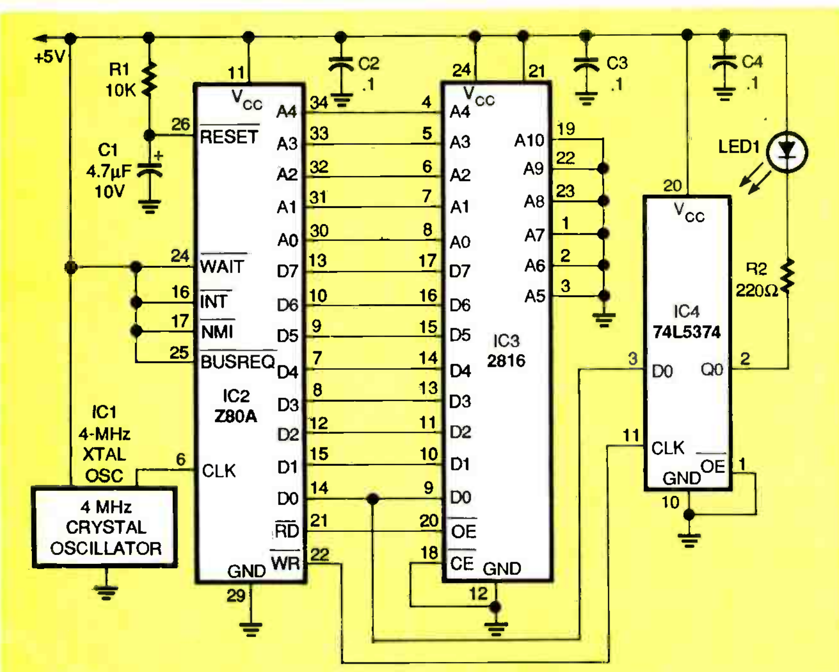


FIG. 3—THE Z80 DEMUXES THE DATA AND ADDRESS BUSES ITSELF, but requires an external crystal oscillator.

the other hand, the Z80 cannot simply run off a clock crystal; instead, it must be driven by a TTL-level clock signal.

Another difference is that the Z80 has no I/O ports whatsoever, so an external flip-flop drives the LED. Any time a Z80 program writes a value to the CPU's I/O space, the $\overline{\text{WR}}$ line pulses low. The clock input of the flip-flop is driven by the $\overline{\text{WR}}$ signal. Data-bus bit 0 feeds the flip-flop's "D" input. Thus, by writing a 0 or a 1, the LED can be turned on or off.

PARTS LIST—PROJECT IV

R1—10,000 ohms
R2—220 ohms
C1—4.7 µF, 10 volts, tantalum
C2–C4—0.1 µF
IC1—4-MHz crystal oscillator
IC2—Z80A microprocessor
IC3—2816 EEPROM
IC4—74LS374 octal latch
LED1—Red light emitting diode

PARTS LIST—PROJECT V

R1—100,000 ohms
R2–R5—1000 ohms
R6—150 ohms, ½-watt
C1—33 µF, 10 volts, tantalum
IC1—4093 CMOS NAND gate
IC2—7493 binary counter
IC3—2816 EEPROM
IC4—74LS244 octal buffer
DISP1—MAN74A 7-segment LED display
S1, S2—SPST switch
XTAL1—1.8432 MHz crystal

As in the previous project, this one has no RAM, so subroutine calls can't be made. To create the object code for the EEPROM, you can either assemble the ASCII source code or create a binary file directly from Listing 5 using DEBUG.

Project V

The final project has no computer intelligence. It uses a simple counter circuit to sequence through a series of sixteen EEPROM addresses. Each address contains a display pattern for a single seven-segment LED. The circuit appears in Fig. 4. Depending on whether S1 or S2 is closed, a different display pattern is generated. With S1 closed, the LED sequentially displays characters 0–F (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, b, C, d, E, F), and then repeats. With S2 closed, the display pattern is zero to eight, back down to one, then repeat (0, 1, 2, 3, 4, 5, 6, 7, 8, 7, 6, 5, 4, 3, 2, 1, 0, ...).

The counter portion of the circuit consists of AND gate IC1 and hexadecimal counter IC2. The AND gate has Schmitt-trigger inputs, so creating an oscillator out of it is as simple as adding a resistor (R1) and a capacitor (C1). The oscillator drives the

LISTING 4—8085 LED PROGRAM

```
0000            ; LED8085A.ASM
0000            ; 2/19/95
0000            ;-----------------------------------------------
0000              .ORG  0000H
0000            AGAIN:
0000 3E C0        MVI   A, 0C0H            ; LED = OFF
0002 30           SIM
0003
0003 11 FF 7F     LXI   D, 7FFFH
0006            LOOP1:
0006 1B           DCX   D
0007 7A           MOV   A, D
0008 B3           ORA   E
0009 C2 06 00     JNZ   LOOP1
000C
000C 3E 40        MVI   A, 40H        ; LED = ON
000E 30           SIM
000F
000F 11 FF 7F     LXI   D, 7FFFH
0012            LOOP2:
0012 1B           DCX   D
0013 7A           MOV   A, D
0014 B3           ORA   E
0015 C2 12 00     JNZ   LOOP2
0018
0018 C3 00 00     JMP   AGAIN
001B              .END
```

LISTING 5—Z80 LED PROGRAM

```
0000            ; LEDZ80A.ASM
0000            ; 2/19/95
0000              .ORG  0000H
0000
0000            AGAIN:
0000 3E 00        LD    A, 0          ; LED = ON
0002 D3 00        OUT   (0), A
0004
0004 01 FF 9F     LD    BC, 9FFFH
0007            LOOP1:
0007 0B           DEC   BC
0008 78           LD    A, B
0009 B1           OR    C
000A 20 FB        JR    NZ, LOOP1
000C
000C 3E 01        LD    A, 1            ; LED = OFF
000E D3 00        OUT   (0), A
0010
0010 01 FF 9F     LD    BC, 9FFFH
0013            LOOP2:
0013 0B           DEC   BC
0014 78           LD    A, B
0015 B1           OR    C
0016 20 FB        JR    NZ, LOOP2
0018
0018 18 E6        JR    AGAIN
001A              .END
```

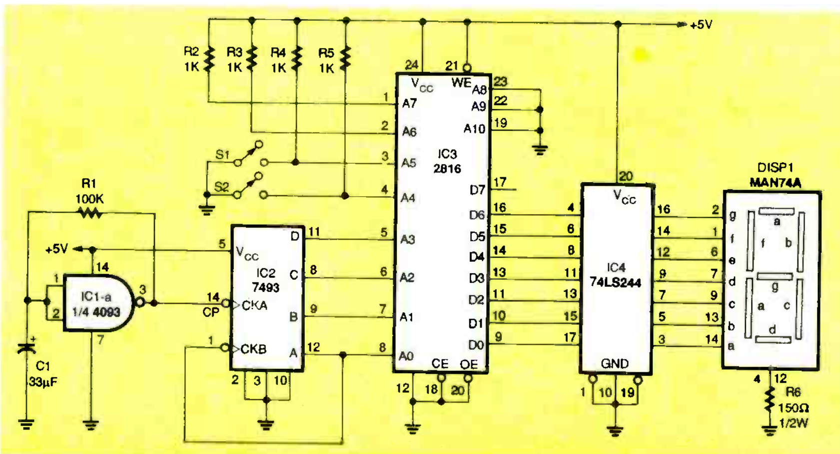


FIG. 4—AN EEPROM CAN ALSO BE USED AS A DISPLAY STORAGE MECHANISM. In this circuit, the counter continually cycles through a set of 16 addresses, depending on the settings of switches S1 and S2.

TABLE 1—LED DISPLAY PATTERNS

Addr.	Char.	7	6	5	4	3	2	1	0	Hex
0D0	0	0	0	1	1	1	1	1	1	3F
0D1	1	0	0	0	0	0	1	1	0	06
0D2	2	0	1	0	1	1	0	1	1	5B
0D3	3	0	1	0	0	1	1	1	1	4F
0D4	4	0	1	1	0	0	1	1	0	66
0D5	5	0	1	1	0	1	1	0	1	6D
0D6	6	0	1	1	1	1	1	0	1	7D
0D7	7	0	0	0	0	0	1	1	1	07
0D8	8	0	1	1	1	1	1	1	1	7F
0D9	9	0	1	1	0	1	1	1	1	6F
0DA	A	0	1	1	1	0	1	1	1	77
0DB	b	0	1	1	1	1	1	0	0	7C
0DC	C	0	0	1	1	1	0	0	1	39
0DD	d	0	1	0	1	1	1	1	0	5E
0DE	E	0	1	1	1	1	0	0	1	79
0DF	F	0	1	1	1	0	0	0	1	71

TABLE 2
LED DISPLAY PATTERNS

Addr.	Char.	Hex
0E0	0	3F
0E1	1	06
0E2	2	5B
0E3	3	4F
0E4	4	66
0E5	5	6D
0E6	6	7D
0E7	7	07
0E8	8	7F
0E9	7	07
0EA	6	7D
0EB	5	6D
0EC	4	66
0ED	3	4F
0EE	2	5B
0EF	1	06

counter, which simply sequences its outputs (A, B, C, and D) from 0 to 15 in binary (0000, 0001, 0010, ...).

Then, depending on whether S1 or S2 is closed, a different set of addresses is selected. If S1 is closed, then A4 is grounded, and A5–A7 are all high. Thus the address bus looks like 1110xxxx. This means that addresses in the range E0–EF will be selected. If S2 is closed, the bus looks like 1101xxxx, which yields addresses D0–DF.

Now that we know how different locations are addressed, let's see what the nature of the patterns stored in those addresses is. Table 1 shows the S1 (hex up-count) EEPROM addresses, display characters, binary bit pattern to enable the correct LED segments, and hexadecimal representations of the bit patterns. Table 2 shows the S2 addresses, characters, and hex values.

Use DEBUG to create a binary data file and then burn the data into the EEPROM. The earlier instructions for using DEBUG specified starting at address 100h. For this project, begin entering data at address 01D0h and continue through 01EFh. Specify "F0" as the number of bytes to write (in the CX register), give it the desired name, and then write the file to disk. Random data will be stored in EPROM addresses 00–CF, but that doesn't matter. Ω

BRIDGES

continued from page 42

amplifier IC1's SET BALANCE control R13 should need adjustment only rarely. In all further matching operations, the following procedure can be followed, after verifying the correct meter and toggle balances.

Position R_S, R_{MATCH}, and the external multimeter. Turn switch S2 to the ×1.0 position, and switch the bridge on with switch S4. If R_{MATCH} is within ±0.5% of the R_S value, it should now be possible to set the bridge to a null with potentiometer R1. If necessary, trim the R_{MATCH} value until a null is obtained. At null, read the R_{MATCH} error on the potentiometer R1 scale. Refer to Fig. 3, and make the appropriate error correction.

(1) To increase the value of R_{MATCH} by a fixed percentage, add a series resistor with a value of:

$R_{SERIES} = (R_{MATCH}/100) \times$ % error

(2) To reduce the R_{MATCH} value by a fixed percentage, add a shunt resistor with a value of:

$R_{SHUNT} = (R_{MATCH} \times 100)/$% error

Thus, a 1000-ohm resistor (nominal value) can be increased by 0.3% by adding a 3.0-ohm series resistor, or reduced by 0.3% by adding a 330-kilohm shunt resistor. When an acceptable match has been obtained on S2's ×1.0 range, repeat the process on ranges ×0.1 and ×0.01, until the match is adequate.

An alternative to this technique is to leave R1 in its mid-scale position and trim R_{MATCH} with R_{M2} to obtain a null on all ranges of S2.

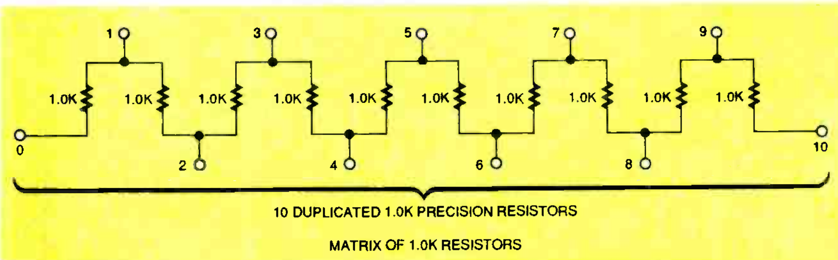


FIG. 4—THIS MATRIX OF 1-KILOHM RESISTORS yields a value equal 10 kilohms when connected in series or 100 ohms when connected in parallel.

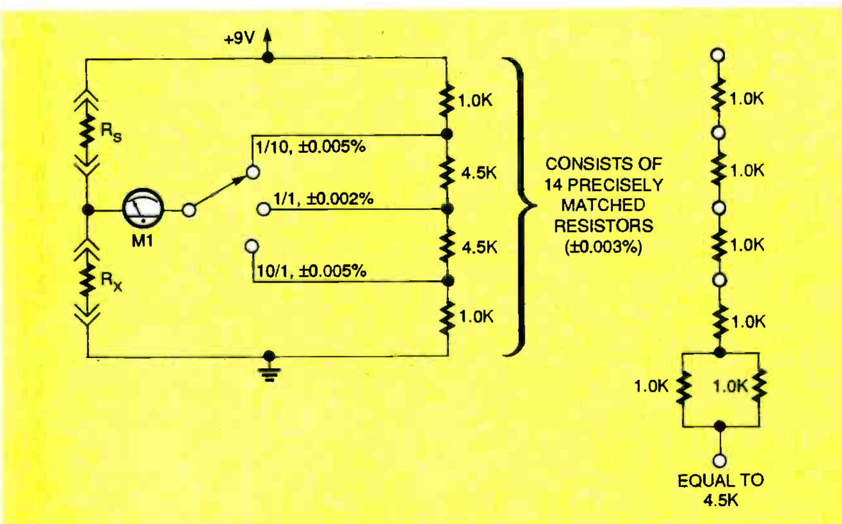


FIG. 5—CIRCUIT FOR a precision ratio-matching bridge.

Bridge applications

A precision resistor-matching bridge has many useful applications in the electronics laboratory. One of these is the duplication of precision resistor values. Figure 4 is a schematic showing how this capability can be applied. Ten identical 1-kilohm resistors are connected so that they form a series string. Together they form a resistor whose value increases in 1-kilo-

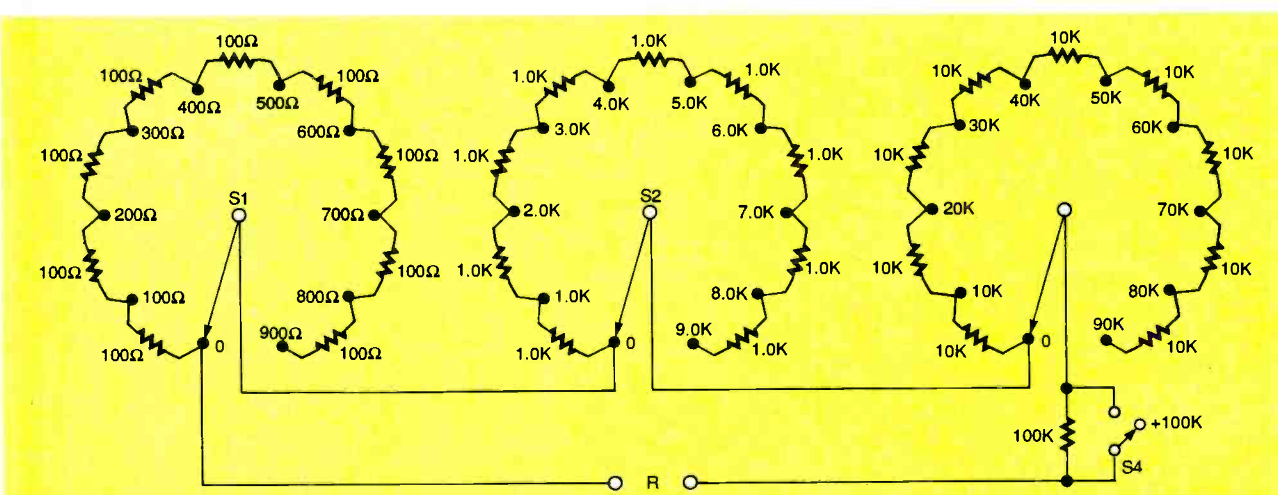


FIG. 6—THIS THREE-DECADE RESISTOR SUBSTITUTION box spans the range of 0 to 99.9 kilohms in 100-ohm steps.

hm steps up to a maximum of 10 kilohms. If arranged in parallel, they can act as a resistor whose value decreases in steps down to 100 ohms.

It is worth noting that as more resistors are connected in parallel or series, their $\pm 0.003\%$ duplication errors average out and diminish. As a result, the precision of the final 10-kilohm series or 100-ohm parallel resistance is essentially equal to that of the original "master" resistor.

The actual value of the summed duplication error is equal to the original error divided by the square root of the number of summed resistors (10). In this example, it is equal to 0.001 %.

Another important application for the resistor-matching bridge application is in the formation of a precision, ratio-matching bridge, as shown in Fig 5. Here, 14 resistors are matched with a 1-kilohm (nominal) master and connected together to form a three-ratio (10/1, 1/1, and 1/10) divider.

Because all of these resistors have been precisely matched to within ± 0.003 %, the ratios are defined with great precision. That value of precision is $\pm$ 0.002 % on the 1/1 range and $\pm$ 0.005% on the 10/1 and 1/10 ranges. This bridge can produce direct or decade multiple or submultiple matches with a master resistor.

If the bridge is paired with a sensitive null detector that gives a duplication precision value of 0.003%, the overall matching precision is ± 0.005 % on the 1/1 range, and ± 0.008 % on the 10/1 and 1/10 ranges.

Substitution boxes

Another application of the circuit shown in Fig. 5 is in matching the range and ratio arms of conventional bridges, to enhance bridge precision. Yet another is in the identification of high-precision resistors for use in decade resistor substitution boxes.

A resistance box eliminates the guesswork in determining appropriate resistance values. It facilitates circuit design, breadboarding, and the solving of circuit problems. Figure 6 is the schematic for a three-decade resistance box that spans the range of 0 to 99.9 kilohms in 100-ohm steps; 100-kilohm overranging can be obtained with switch S4.

This circuit can be made from a single precision reference resistor (1 kilohm in this example). It has many applications in the laboratory, including the calibration of bridge scales and the determination of resistor values by substitution.

A useful companion to the resistance substitution box is the multidecade capacitor substitution box. Again, like the resistance box, a capacitance box eliminates the guesswork in determining appropriate values, simplifies circuit design, breadboarding, and the solving of circuit problems. Capacitors are either selected individually or are connected in parallel to make up specific values with these boxes.

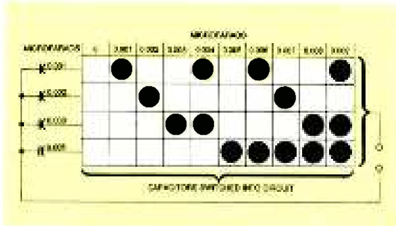


FIG. 7—THIS DECADE CAPACITOR substitution box, capable of measuring (0 to 0.009μF, is based on four capacitors and a three-pole, 10-throw switch.

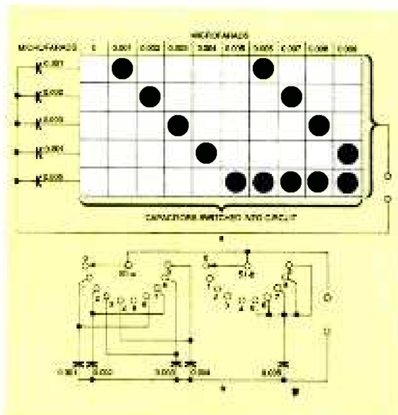


FIG. 8—A DECADE CAPACITOR matching box, organization (a) and schematic (b), can measure 0 to 0.009μF. It is based on five capacitors and a two-pole, ten-throw switch.

Figure 7 shows a capacitance box in tabular form. This is one way to organize a single-decade, 0 to 0.009 microfarad box with only four capacitors. (The 0.005-microfarad value can be made by padding up a 0.0047μF capacitor. Three capacitors must be connected in parallel to obtain the 0.009μF value. Consequently, this design calls for a three-pole, ten-throw switch.

Figure 8-a is the organization table and Fig. 8-b is the schematic for an alternative design for a 0 to 0.009μF capacitor decade substitution box. It includes five capacitors, but it requires only a two-pole, ten-throw switch. This capacitor box will cost less to build than the one shown in Fig. 7 because multideck rotary switches are more expensive than microfarad-value capacitors.

Two extra boxes based on this design will give 0.01μF and 1000.1μF steps. They can be built and connected in parallel with the circuit of Fig. 8. This combination will form a three-decade box that spans the 0 to 0.999μF range in 0.001μF steps.

Potentiometric voltmeter

Another important applica-

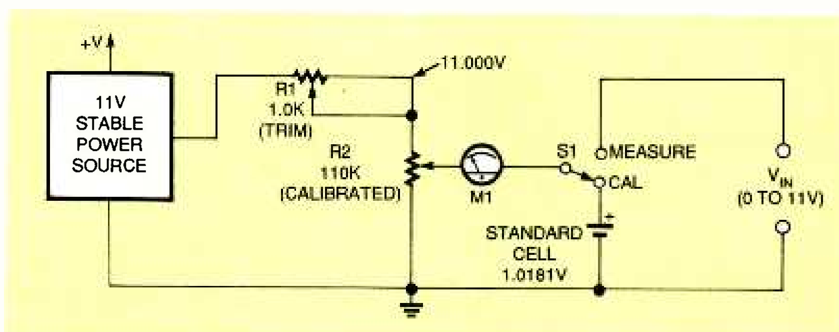


FIG. 9—SCHEMATIC FOR a potentiometric voltmeter.

tion for the precision resistor-matching bridge is as a component of a potentiometric voltmeter, such as that shown in Fig. 9. This instrument measures DC voltages with enough precision to make it useful for calibrating the voltage scales of typical 3½ and 4½-digit digital multimeters.

The potentiometric voltmeter in Fig. 9 includes R2, a precision-calibrated 110-kilohm precision potentiometer with a scale dial. The 11.000 volts DC across this potentiometer is obtained from a stable power supply. Potentiometer R1 permits fine trimming. As a result, 0.1 millivolt passes through the resistive element for each ohm of resistance of potentiometer R2, which is accurately calibrated in terms of its output voltage.

Potentiometer R2 is used in conjunction with a primary cell that has a voltage which is accurate and constant enough to be a calibration standard for instruments. In Fig. 9, a Weston standard cell is shown. It has an output voltage of 1.018636 volts DC at 20° C.

The electrolyte of the Weston cell is a solution of cadmium sulfate. The positive electrode is a paste of mercury sulfate, and the negative electrode is made from a mixture of mercury and cadmium. The cell is housed in a pair of vertical glass tubes connected by a horizontal glass tube that forms an "H"- shaped configuration.

To make a measurement, set potentiometer R2 to read 1.0186 volts, and move S1 to the calibration (CAL) position. Trim R1 to give a zero or null reading on the meter. When this is done, the output voltages of R2 and the standard cell are equal, and precisely 11.000 volts are applied across R2.

The external DC test voltage (which must not exceed 11 volts) is then connected to the posts at the right side of the diagram, and S1 is switched to the MEASURE position. Then R2 is adjusted to give a null on meter M1. The voltage value can now be read directly from the dial scale of R2. Zero current is drawn from the test voltage at

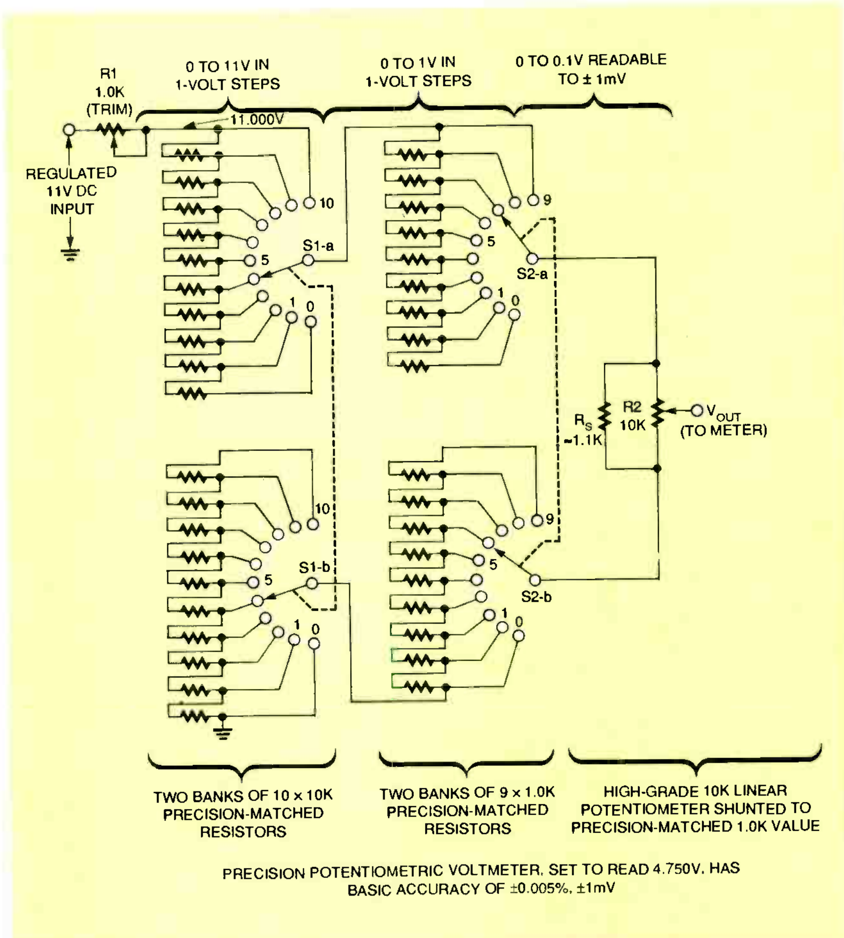


FIG. 10—THIS PRECISION POTENTIOMETRIC voltmeter, set to read 4.750 volts, has a basic accuracy of ±1.0 millivolt.

the null position. Voltages greater than 11.00 volts can be measured by applying them to the potentiometric voltmeter through a precision voltage attenuator.

Figure 10 is a circuit for the potentiometer section of the instrument shown in Fig. 9. In this precision potentiometric circuit, 110 kilohms of resistance is connected at all times, and 1 volt appears across each active 10-kilohm resistance block when 11 volts is applied to the potentiometer.

Consequently, with the wiper of S1 at contact 4, as shown, +4 volts appears on the common terminal of S1-b, and +5 volts appears on the common terminal of S1-a. These voltages are applied to the S2 resistor network. With the wiper of S2 at contact 7, there will be an output of 4.7 volts at the bottom of R2 and 4.8 volts at its top. With R2 set to its midscale, the circuit gives an output of 4.750 volts, when the controls are set as described.

The circuit in Fig. 10 can only read voltages to within the nearest 1 millivolt, so the initial calibration reading must be set to 1.0186 volts when the standard cell is in the circuit. An additional decade can be added to the circuit by replacing R2, and its associated components with a duplicate of the S2 and R2 related circuitry (i.e., all the circuitry to the right of S1). However, all resistor values must be reduced by a factor of ten.

This modification permits the potentiometric voltmeter to measure voltages to within the nearest 0.1 millivolt, and it permits the circuit to be calibrated initially to 1.0186 volts. All resistors in the voltmeter circuit must be precisely matched against a single 10-kilohm reference resistor. Ω

dB METER

continued from page 113

dBm. A pattern for the meter graduations is included in this article for a meter with a scale length (chord) of 1½ inches. However, a meter with decibel graduations can be purchased from the source given in the Parts List. An off-the-shelf, standard sheet metal project case is suitable for packaging this project.

If you make your own circuit board, be sure to drill holes in each or three corners for mounting the finished board on standoffs to the bottom of the project case. Refer to the parts placement diagram, Fig. 3. Insert and solder the components to be located on the circuit board, observing the correct orientation of the pins of IC1 and the polarities of electrolytic capacitor C5 and diode D1. After all soldering is complete, check to be sure there are no inadvertent solder bridges or cold solder joints, and make any repairs necessary. Set the completed circuit board aside.

Metal case cutouts

The prototype decibel meter was built into a standard, two-part metal project case that measured 5⅞ inches wide × 3 inches high × 5¼ inches long, but any other case of comparable size will be suitable. A metal case will shield the circuitry of the decibel meter from external RF fields.

Refer to the assembly diagram Fig. 4. Carefully lay out and center punch all of the holes to be drilled or formed in the bottom and sidewall of the lower half of the case. Cut a 1¾ inch diameter mounting hole for meter M1, and appropriate-sized holes for switch S1, and jack J1. Also drill the holes necessary for mounting the circuit board to the base of the case (using the pre-drilled mounting holes in the circuit board as a pattern). Then drill the holes for clamping the eight-cell battery pack B1 to the bottom of the case within the case.

Cut lengths of insulated hookup wire long enough to reach from the circuit board to meter M1, switch S1, and connector J1 when all components are assembled in the case, leaving sufficient slack. Cut a length of shielded RG-174/U coaxial cable to make a connection from pin 1 of IC1 to BNC jack J1. Strip, insert, and solder

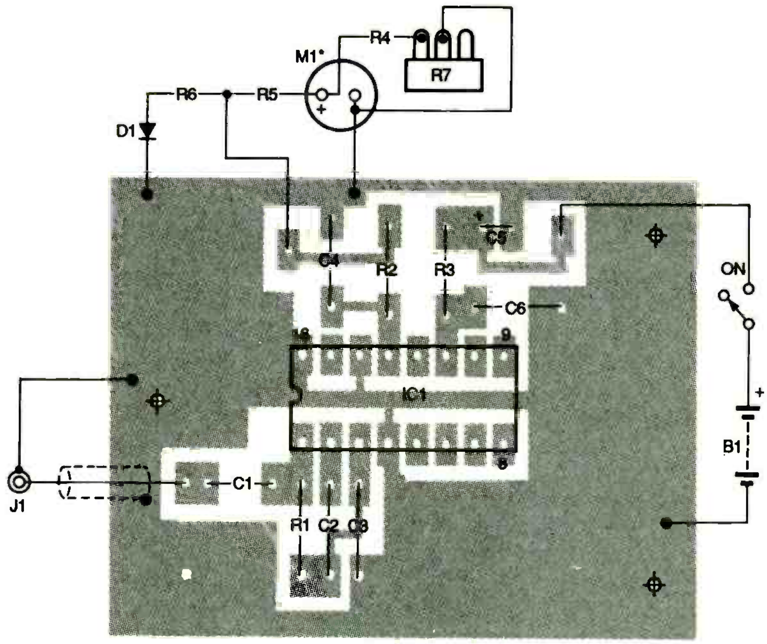


FIG. 3—PARTS LAYOUT for the decibel meter. Some components are mounted on the case wall and on the back of the meter.

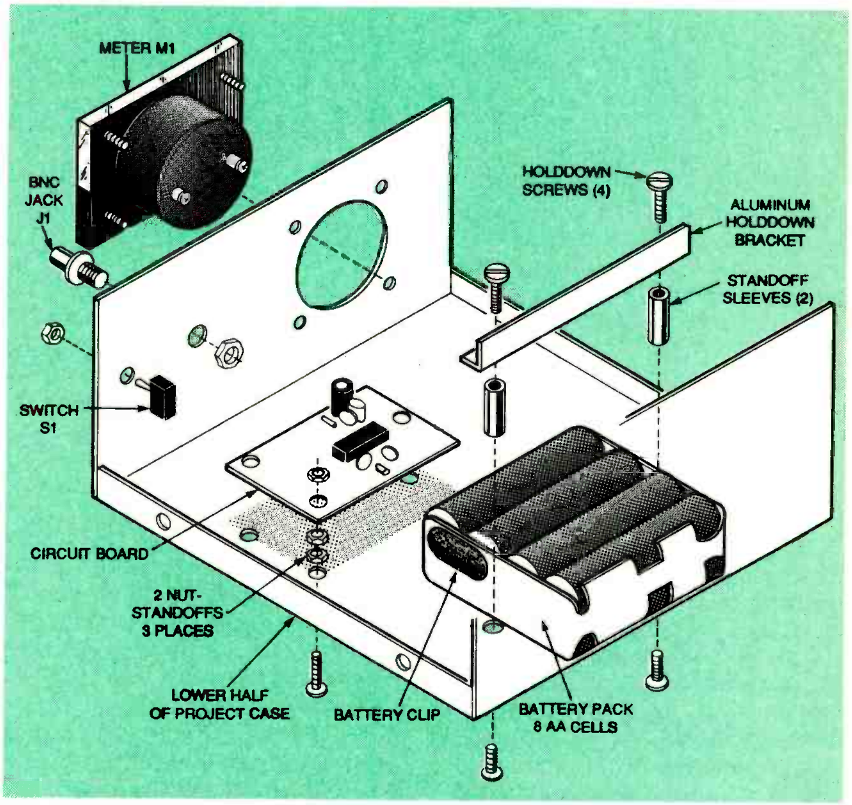


FIG. 4 —EXPLODED VIEW OF THE DECIBEL METER in a standard, two-part metal project case.The battery pack hold-down bracket is made from aluminum channel stock.

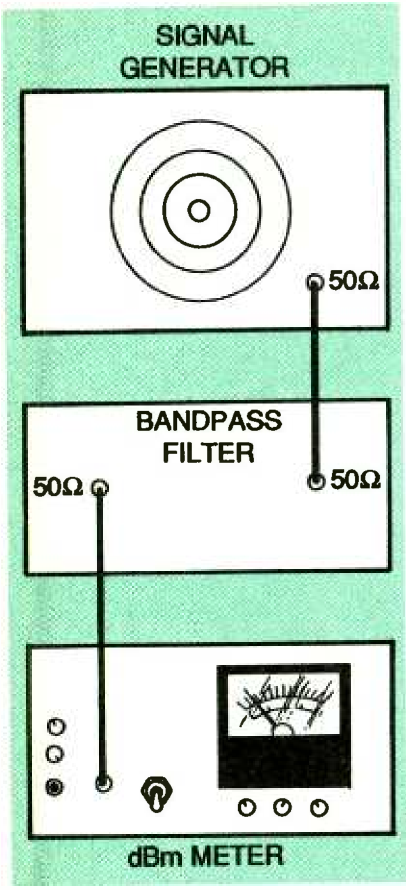


FIG. 5 —TYPICAL DECIBEL METER test setup for measuing the characteristics of a bandpass filter.

the ends of the wires and cable and insert and solder one end of each on the circuit board as shown. Insert the ends of the red and black wires from a 9-volt snap connector in the circuit board and solder them in place.

Insert and fasten meter M1, jack J1, and switch S1 in the panel holes cut for them and fasten them in position with the appropriate lockwashers, nuts and ring nuts. Attach two solder lugs to the terminals of meter M1 with screws.

Position the circuit board in the bottom half of the case on three screws with two nuts on each to act as standoffs. Then fasten the board in position with three nuts. Solder all hookup wires and the coaxial cable to the panel-mounted components, as shown in parts placement diagram Fig.3.

Insert the eight alkaline AA cells in the battery holder and clamp the battery holder to the bottom of the case.

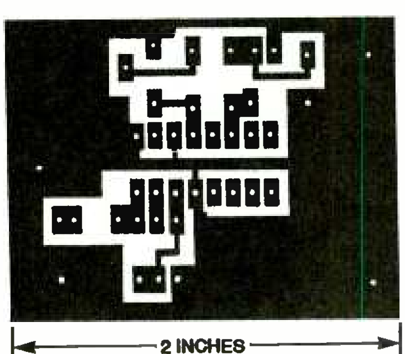
Test and checkout

For most amateur radio and hobbyist experiments, the meter can be coarsely calibrated after the wiring is complete. Couple a signal into BNC jack J1 and adjust signal amplitude for a 2-volt DC level on pin 11. Then adjust 10-kilohm trimmer potentiometer R7 until the meter reads −50 dBm (in the center of the scale). The decibel meter is now complete and ready to be used.

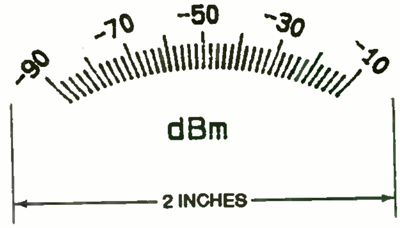
Meter limitations

The CA3089E was designed primarily for use at 10.7 MHz. As a result, the frequency response of the decibel meter is limited to the high-frequency region. Harris Semiconductor rates the CA3089E for use between 2 and 20 MHz. Below 2 MHz, the responses of the peak detectors within the integrated circuit start to roll off. However, the meter can be used for comparison purposes with signals above 20 MHz. The absolute value on the meter scale will be lower than expected as the frequency response drops off. The prototype provides useful readings up to 50 MHz.

Input impedance is fixed at 51 ohms by the resistor R1 between pins 1 and 3. This makes it easy to extend the meter's usefulness in measuring stronger signals through the use of 50-ohm attenuators. Any signal strengths above 0.1 volt peak should be attenuated with the 50-ohm attenuator before introducing them into the meter so that the reading will be remain on-scale. The absolute maximum limit for IC1 before it is damaged or destroyed is 1.2 volts.



FOIL PATTERN FOR CIRCUIT board



PATTERN FOR dBm graduations of meter scale

Measuring decibels.

Figure 5 is a diagram for a typical test setup for measuring the passband of a receiver's input filter. If it is a bandpass filter, read dBm at the center frequency, then tune the generator higher in frequency while recording the dB level after each adjustment. Finally, tune below the center frequency to record the lower skirt.

Crystal filters are evaluated the same way, but a very stable generator with very fine vernier tuning is required for the best results. Keep in mind that most crystal filters have termination resistances higher than 50 ohms, usually somewhere between 200 and 2000 ohms. Consequently, impedance transformation resistors or circuits will be required to match the 50-ohm meter and generator.

To read oscillator levels, feed the signal into the BNC jack on the front panel and read dBm directly. The meter will also function as a sensitive, wide-range, field-strength meter with a one-quarter- wave antenna at the input.

How to measure dBV

In a circuit with a 50-ohm input, the dBm unit is 20 times the logarithm of the ratio of the RMS voltage in a circuit to the value of 0.224 ohms. (See the box "What is a Decibel?")

The peak decibels above 1 volt or dBV unit is 20 times the logarithm of the ratio of the voltage to one volt. This can be read directly from the meter scale by taking the reading and subtracting 10 dB. Thus for dBV measurements, the meter will cover the range of −20 dBV to −100 dBV. However, that range can be shifted higher with a 50-ohm attenuator. Ω

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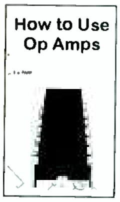
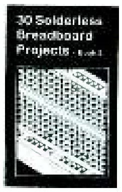
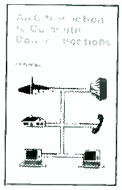


☐ **BP88—How to Use OpAmps...$5.95.** A designer's guide that covers operational amplifiers. Serving as both a source book of circuits and a reference book for design calculations. The text is non-mathematical and easy to understand by most readers.



☐ **BP113—30 Solderless Breadboard Projects-Book 2...$5.95.** Companion to BP107. Presented in exactly the same style using "Verobloc" breadboards. All the breadboard projects in this book are based on CMOS logic integrated circuits.

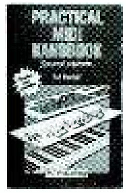


☐ **BP177—Introduction to Computer Communications...$5.95.** Details on types of modems and their suitability for specific application, plus details of connecting various computers to modems, and modems to the telephone system.

☐ **BP350—Electronic Board Games...$6.00.** Twenty novel electronic board games that you can build from the plans in this book. Some games are motor racing, searching for buried treasure or for gold in Fort Knox, — there is something for you to build and enjoy!

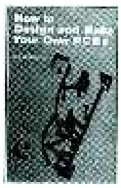
☐ **BP61—Beginners Guide to Digital Techniques...$5.00.** Covers the basics of digital techniques—decimal, binary, octal and hexadecimal numbering systems are covered plus insights on weighted and non-weighted binary-coded-decimal codes and alphanumeric codes. The basic building blocks of circuit logic, the common AND. OR, NAND, NOR and EXCLUSIVE-OR gates and bi-stables are thoroughly covered.

☐ **BP285—A Beginners Guide to Modern Electronics Components...$6.50.** It is easy for newcomers to electronics to become confused. There are a great many different types of components available often with numerous variations of each type. This book presents the reader with a vast amount of invaluable parts information to enable the right component to be selected every time for repairs and projects.



☐ **PCP103—Practical MIDI Handbook...$9.95.** The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding. This book is aimed at musicians and technicians who want to explore the vast capabilities of MIDI. It covers MIDI-based equipment you can use: keyboards, drum machines, sequencers, effects units, mixers. drum pads guitars. There's also a section on computer music.

☐ **PCP119—Electronic Music and MIDI Projects...$14.95.** Save cash by building the MIDI gadgets you need. Want a MIDI Thru box, program change pedal, Metronome, analog echo unit? Over 16 practical and very useful music and MIDI projects.



☐ **BP121—How to Design and Make Your Own PCBs...$5.75.** Simple methods for copying printed-circuit board designs from magazines and books on to copper. Covers all aspects of simple PCB construction as comprehensively as possible.

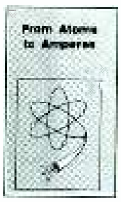
☐ **BP44—IC 555 Projects...$5.95.** Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer integrated-circuit chip is one such device. Included are basic and general circuits used by most hobbyists.

☐ **PCP109—Everyday Electronics Data Book ... $10.00.** An invaluable source of electronics information—the text contains sections that deal with the underlying theory of electronic circuits and a wide range of practical electronic uses for everyone.

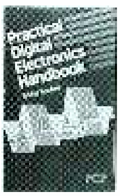
☐ **BP301—Antennas for VHF and UHF...$6.00.** From installing a TV or FM antenna to setting up a multi-antenna array for shortwave listening or amateur radio, this book explains the basics of VHF and UHF antenna operation and installation. The text describes in easy-to-understand terms the essential information about how antennas work, the advantages of different antenna types, and how to get the best performance.

☐ **BP297—Loudspeakers for Musicians...$6.25.** Contains all the information that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, available fittings, finishing and how to connect multi-speaker arrays. etc. Includes ten enclosure designs with plans.

☐ **PCP110—Electronic Power Supply Handbook...$10.95.** All types of power supplies used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilizers to modern switch-mode systems, IC switch-mode regulators, DC-converters and inverters. The devices, their operating principles and typical circuits, are dealt with in detail.

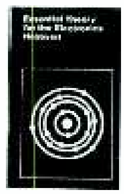


☐ **BP254—From Atoms to Amperes...$6.50.** Explains in crystal-clear terms the fundamentals behind the whole of electricity and electronics. Really helps you to understand the basis of the complex subject perhaps for the first time ever.



☐ **PCP101—Practical Digital Electronics Handbook...$9.95.** An introduction to digital circuits, logic gates, bi-stables, timers, microprocessors, memory and I/O devices. A special feature of the book is the section on digital test gear projects.

☐ **BP315—Introduction to the Electromagnetic Wave...$5.95.** A fundamental and easy-to-understand approach to a complicated theory topic. The beginner requires no more than elementary mathematics and basic knowledge of electronics.



☐ **#228—Essential Theory for the Hobbyist...$5.25.** Supplies to the hobbyist background knowledge tailored to the specific requirements of the hobbyist. Relevant material is presented it in a readable manner with minimum mathematics.

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☐ **BP267—How to Use Oscilloscopes & Other Testing Equipment...$6.95**
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☐ **PCP111—Electronic Test Equipment Handbook...$13.95**
The all-purpose, all-pro handbook that covers basics to in-circuit testing.

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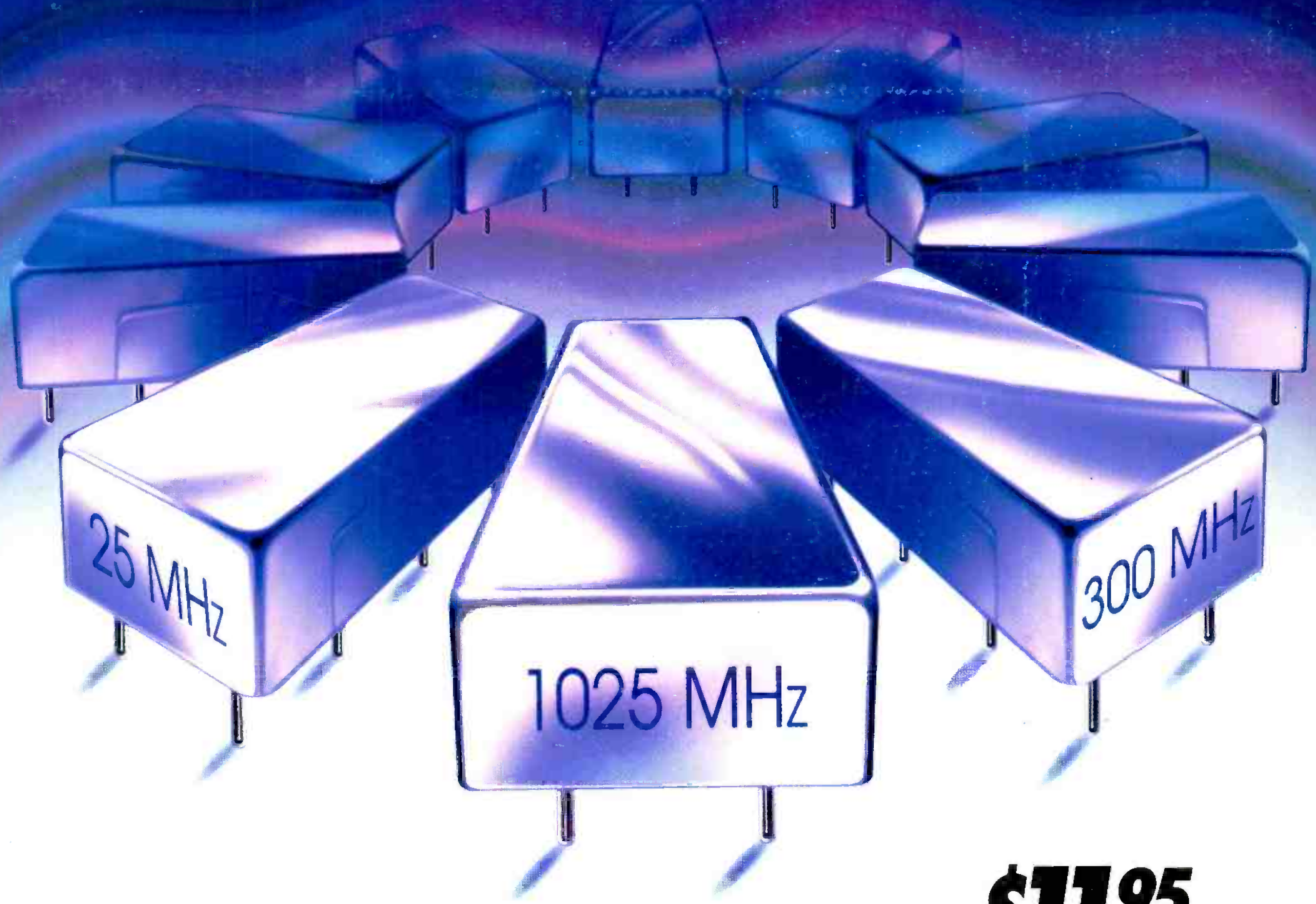

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