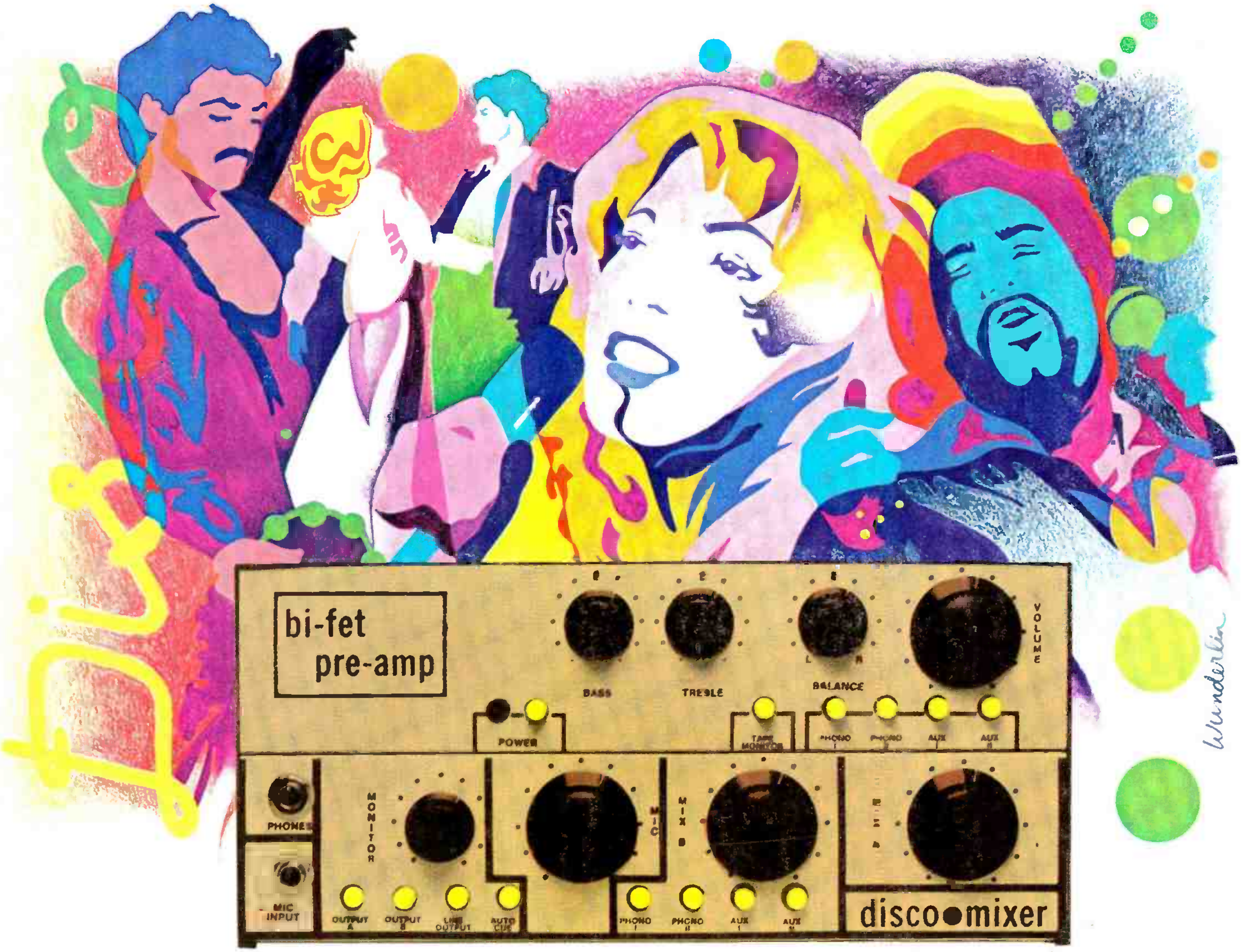
Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE SEPTEMBER 1978/$1

Analog-to-Digital with Two IC's
Converting Schematics to PC Patterns

Special Focus On Audio

NEW! METAL TAPE **NEW!** IHF AMPLIFIER STANDARD
NEW! HI-FI TV SOUND **PLUS!** HOME DISCO PREAMP/MIXER FOR $110



Tested

Sony "Class D" Switching Amplifier
Electro-Voice "Series II" Speaker Systems
Panasonic 5-Band Portable Receiver

FOR THOSE OF YOU WHO ARE HAVING SECOND THOUGHTS ABOUT YOUR FIRST CB.

Move up to the all-new Cobra 29GTL. It's the third generation of the trucker-proven Cobra 29. And like the 29 and the 29XLR before it, it advances the state of the art.

Transmitter circuitry has been refined and updated to improve performance.

Receiver circuits have been redesigned to include dual FET mixers, a monolithic crystal filter and a ceramic filter to reduce interference and improve reception.

By improving the transmitter circuitry the 29GTL keeps you punching through loud and clear. By incorporating new features for better reception everything you copy comes back loud and clear.

So if you're having second thoughts about your first CB, make your next CB the Cobra 29GTL.

We back it with a guaranteed warranty and a nationwide network of Authorized Service Centers where factory-trained technicians are available to help you with installation, service and advice.

But more important than that, we sell it at a price you won't have second thoughts about.

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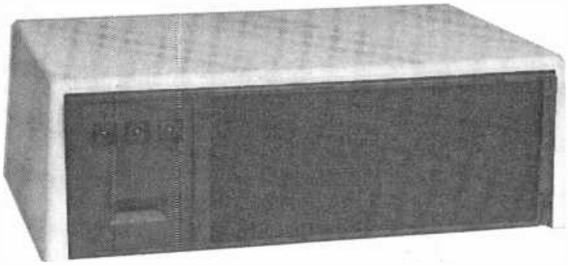
CIRCLE NO. 1 ON FREE INFORMATION CARD

Burglar Alarm Breakthrough

A new computerized burglar alarm requires no installation and protects your home or business like a thousand dollar professional system.

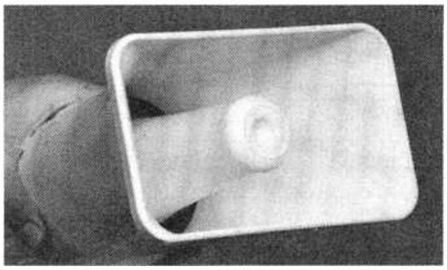


The Midex security computer looks like a handsome stereo system component and measures only 4"x 10½"x 7."

It's a security system computer. You can now protect everything–windows, doors, walls, ceilings and floors with a near fail-safe system so advanced that it doesn't require installation.

The Midex 55 is a new motion-sensing computer. Switch it on and you place a harmless invisible energy beam through more than 5,000 cubic feet in your home. Whenever this beam detects motion, it sends a signal to the computer which interprets the cause of the motion and triggers an extremely loud alarm.

The system's alarm is so loud that it can cause pain–loud enough to drive an intruder out of your home before anything is stolen or destroyed and loud enough to alert neighbors to call the police.



The powerful optional blast horns can also be placed outside your home or office to warn your neighbors.

Unlike the complex and expensive commercial alarms that require sensors wired into every door or window, the Midex requires no sensors nor any other additional equipment other than your stereo speakers or an optional pair of blast horns. Its beam actually penetrates walls to set up an electronic barrier against intrusion.

NO MORE FALSE ALARMS

The Midex is not triggered by noise, sound, temperature or humidity–just motion–and since a computer interprets the nature of the motion, the chances of a false alarm are very remote.

An experienced burglar can disarm an expensive security system or break into a home or office through a wall. Using a Midex system there is no way a burglar can penetrate the protection beam without triggering the loud alarm. Even if the burglar cuts off your power, the four-hour rechargeable battery pack will keep your unit triggered, ready to sense motion and sound an alarm.

DEFENSE AGAINST PEEPING TOMS

By pointing your unit towards the outdoors from your bedroom and installing an outside speaker, light, or alarm, your unit can sense a peeping Tom and frighten him off. Pets are no problem for the Midex. Simply put them in one section of the house and concentrate the beam in another.

When the Midex senses an intruder, it remains silent for 20 seconds. It then sounds the alarm until the burglar leaves. One minute after the burglar leaves, the alarm shuts off and resets, once again ready to do its job. This shut-off feature, not found on many expensive systems, means that your alarm won't go wailing all night long while you're away. When your neighbors hear it, they'll know positively that there's trouble.

PROFESSIONAL SYSTEM

Midex is portable so it can be placed anywhere in your home. You simply connect it to your stereo speakers or attach the two optional blast horns.

Operating the Midex is as easy as its installation. To arm the unit, you remove a specially coded key. You now have 30 seconds to leave your premises. When you return, you enter and insert your key to disarm the unit. You have 20 seconds to do that. Each key is registered with Midex, and that number is kept in their vault should you ever need a duplicate. Three keys are supplied with each unit.

As an extra security measure, you can leave your unit on at night and place an optional panic button by your bed. But with all its optional features, the Midex system is complete, designed to protect you, your home and property just as it arrives in its wellprotected carton.

The Midex 55 system is the latest electronic breakthrough by Solfan Systems, Inc.–a company that specializes in sophisticated professional security systems for banks and high security areas. JS&A first became acquainted with Midex after we were burglarized. At the time we owned an excellent security system, but the burglars went through a wall that could not have been protected by sensors. We then installed over $5,000 worth of the Midex commercial equipment in our warehouse. When Solfan Systems announced their intentions to market their units to consumers, we immediately offered our services.

COMPARED AGAINST OTHERS

In a recent issue of a leading consumer publication, there was a complete article written on the tests given security devices which were purchased in New York. The Midex 55 is not available in New York stores, but had it been compared, it would have been rated tops in space protection and protection against false alarms–two of the top criteria used to evaluate these systems. Don't be confused. There is no system under $1,000 that provides you with the same protection.

YOU JUDGE THE QUALITY

Will the Midex system ever fail? No product is perfect, but judge for yourself. All components used in the Midex system are of aerospace quality and of such high reliability that they pass the military standard 883 for thermal shock and burn-in. In short, they go through the same rugged tests and controls used on components in manned spaceships.

Each component is first tested at extreme tolerances and then retested after assembly. The entire system is then put under full electrical loads at 150 degrees Fahrenheit for an entire week. If there is a defect, these tests will cause it to surface.

PEOPLE LIKE THE SYSTEM

Wally Schirra, a scientist and former astronaut, says this about the Midex 55. "I know of no system that is as easy to use and provides such solid protection to the homeowner as the Midex. I would strongly recommend it to anyone. I am more than pleased with my unit."

Many more people can attest to the quality of this system, but the true test is how it performs in your home or office. That is why we provide a one month trial period. We give you the opportunity to see how fail-safe and easy to operate the Midex system is and how thoroughly it protects you and your loved ones.

Use the Midex for protection while you sleep and to protect your home while you're away or on vacation. Then after 30 days, if you're not convinced that the Midex is nearly fail-safe, easy to use, and can provide you with a security system that you can trust, return your unit and we'll be happy to send you a prompt and courteous refund. There is absolutely no obligation. JS&A has been serving the consumer for over a decade–further assurance that your investment is well protected.

To order your system, simply send your check in the amount of **$199.95** (Illinois residents add 5% sales tax) to the address shown below. Credit card buyers may call our toll-free number below. There are no postage and handling charges. By return mail you will receive your system complete with all connections, easy to understand instructions and a one year limited warranty. If you do not have stereo speakers, you may order the optional blast horns at **$39.95** each, and we recommend the purchase of two.

With the Midex 55, JS&A brings you: 1) A system built with such high quality that it complies with the same strict government standards used in the space program, 2) A system so advanced that it uses a computer to determine unauthorized entry, and 3) A way to buy the system, in complete confidence, without even being penalized for postage and handling charges if it's not exactly what you want. We couldn't provide you with a better opportunity to own a security system than right now.

Space-age technology has produced the ultimate personal security computer. Order your Midex 55 at no obligation, today.

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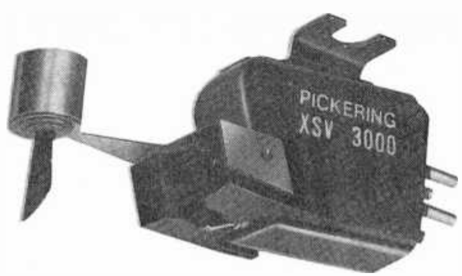


The XSV/3000 is the source of perfection in stereo sound!

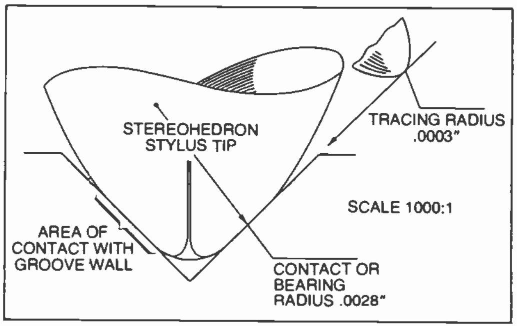
Four big features ... all Pickering innovations over the past 20 years ... have made it happen.

1976: Stereohedron® This patented Stylus tip assures super traceAbility™, and its larger bearing radius offers the least record wear and longest stylus life so far achievable.

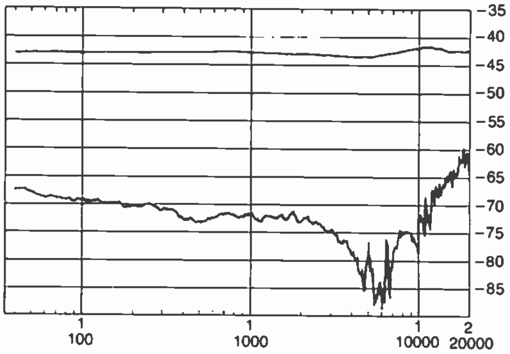
1975: High Energy Rare Earth Magnet Another Pickering innovation, enabling complete miniaturization of the stylus assembly and tip mass through utilization of this type of magnet.

1968: Dustamatic® Brush This Pickering patented invention dynamically stabilizes the cartridge-arm system by damping low frequency resonance. It improves low frequency tracking while playing irregular or warped records. Best of all, it provides record protection by cleaning in front of the stylus.

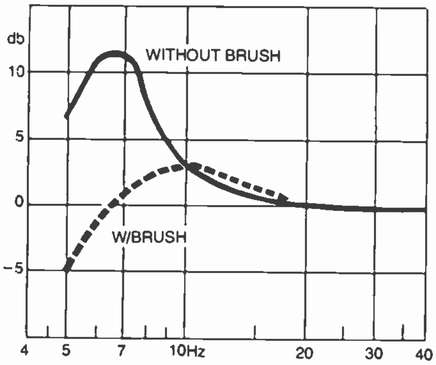
1959: Record Static Neutralizer The patented V-Guard Record Static Neutralizer has been a feature of all Pickering cartridges since 1959. It eliminates electrostatic dust attraction at the stylus and discharges record static harmlessly into the grounded playback system.



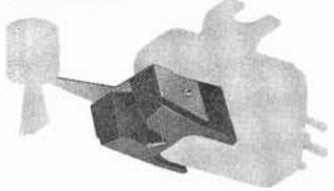
1. Technical drawing of the Stereohedron shape.



2. Typical frequency response and channel separation curves of the XSV/3000.



3. Damping effect on tonearm resonance.



4. V-Guard Static Neutralizer, "Where the Stylus meets the groove."

PICKERING
"for those who can hear the difference"

For further information write to Pickering & Co., Inc.,
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CIRCLE NO 46 ON FREE INFORMATION CARD

SEPTEMBER 1978
VOLUME 14, NUMBER 3

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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- DESIGNING FOR "WORST CASE" OPERATION
- SECRETS OF THE NEW AMATEUR CODE EXAMS

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ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue, New York, New York 10016
212-725-3500
Joseph E Mesics (725-3568)
John J Corton (725-3578)
Bonnie Kaiser (725-3580)

Midwestern Office
Suite 1400, 180 N Michigan Ave.,
Chicago, IL 60601 (312-346-2000)
Midwest Representative: Harry L. Vincent

Western Office
9025 Wilshire Boulevard, Beverly Hills, CA 90211
213-273-8050; BRadshaw 2-1161
Western Advertising Manager: Bud Dean

Western Representative: Norm Schindler
Suite 205, 20121 Ventura Blvd
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Editorial

THE SOFTWARE RIGHTS DILEMMA

How does one protect intellectual property rights such as computer programs? In many instances, only with hope and prayer!

Since 1972, efforts to patent software have not met with success. In June, 1978, the U.S. Supreme Court ruled that yet another computer program involved in a case it considered could not be patented because its only distinctive feature was the algorithm. (The first Supreme Court software patent denial occurred in 1972, owing to simply an unusual mathematical algorithm—*In re Benson and Tabbot*: Converting binary coded decimal signals into binary number signals.)

Doubtlessly, there are some computer programs out there that will eventually stand the test of patentability. But, would it really be worth the effort to obtain such a patent given the reluctance of the Patent Office to issue software protection, and the history of denials by the Court of Customs and Patent Appeals right through to the U.S. Supreme Court?

Well, there's an alternative that can be used to protect proprietary rights: the copyright. This is the route suggested by the National Bureau of Standards, which recommended that a copyright for a program's source language should also cover machine-code copies made from it. (For more information, buy the NBS Study, Special Publication 500-17, *Copyright in Computer-Readable Works*, from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Cost is $4, and ordering number is 003-003-01843-1.)

This second source of protection has a term that's three times that of a patent. Moreover, it's easy to register within the copyright program under the classification of "books." This form of protection, however, is not particularly sound since a unique concept is not a consideration here. Thus, ripoffs are easier to accomplish. For an IBM, this is no problem. It's staffed to diligently pursue any infringement. In fact, IBM prefers to copyright programs rather than try to patent them, and has even argued *amicus curiae* against patenting computer programs!

In light of the foregoing problems related to statutory methods of protecting computer programs, what can the small software developer do to inexpensively protect his investment? At the moment, very little. In many instances, however, it's not a severe problem since it really doesn't pay to photocopy some 30 pages of documentation for a $5 or $10 package. Moreover, some software is designed to complement only specific hardware and language variations. In other cases, some positive action is necessary.

Clearly, the new software technology is something that the patent and copyright offices should address without delay. With an estimated $20-billion invested annually in software development, and almost $1-billion in 1977 packaged software sales, we're talking about big bucks that are getting bigger every day. Furthermore, I believe that protecting one's innovative work and investment will provide an incentive for others to advance the technology as well as to continue to write new, useful programs.

Art Salsberg

The C2-4P

The Professional Portable by Ohio Scientific

Ohio Scientific now offers you the world's most powerful portable personal computer in both BASIC-in-ROM and mini-floppy configurations.

C2-4P Mod 2 Standard Features:

- Minimally equipped with 8K BASIC-in-ROM, 4K RAM, machine code monitor, video display interface, cassette interface and keyboard with upper and lower case characters. (Video monitor and cassette recorder optional extras.)
- The fastest full feature BASIC in the microcomputer industry.
- The C2-4P Mod 2 features the most sophisticated video display in personal computing with 32 rows by 64 columns of upper case, lower case, graphics and gaming characters for an effective screen resolution of 256 by 512 elements.
- The CPU's direct screen access, coupled with its ultra-fast BASIC and high resolution, makes the C2-4P capable of spectacular video animation directly in BASIC.
- The C2-4P features computer "BUS" architecture. It internally utilizes a 4 slot backplane. Two slots are used in the base machine leaving 2 slots open for expansion.
- Comes fully assembled and tested. BASIC and machine code are always accessible immediately after powerup.
- A new high density static RAM board and two economical minifloppy options give the C2-4P tremendous expansion capability without sacrificing portability.

The C2-4P offers the user mainframe performance in a portable package. This performance makes the C2-4P suitable for use in home computing, education, scientific and industrial research and small business applications.

Other small personal computers can satisfy the requirements of the computer novice, but no other personal portable can match the C2-4P in professional and computer enthusiast applications.

Yet the C2-4P and its accessories are priced only slightly above the mass marketed "beginner" or "home" computers.

For more information, contact your local Ohio Scientific dealer or the factory at (216) 562-3101.

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Hobbiests! Engineers! Technicians! Students!

Write and run machine language programs at home, display video graphics on your TV set and design microprocessor circuits—the very first night—even if you've never used a computer before!

ELF II featuring **RCA COSMAC microprocessor/mini-computer**

$99^95

Get "hands on" experience with a computer for just $99.95. Then, once you've mastered computer fundamentals, expand ELF II with low cost add-ons and you've got an advanced personal computer powerful enough to solve business, industrial or scientific problems.

ELF II by NETRONICS as featured in POPULAR ELECTRONICS shown with optional 4k Memory Boards, GIANT BOARD™, Kluge Board and ASCII Keyboard

Learning Breakthrough!

A Short Course On Microprocessor And Computer Programming

Written for anyone! Minimal background needed!

Using advanced computers is now as easy as driving a car with an automatic transmission. We will teach you, step by step, instruction by instruction, how to use an RCA COSMAC computer

Not only does our short course *explain* computers, it helps anyone write and run programs and solve complex problems requiring a computer Knowing how a computer works can help you

(1) Spot situations where a computer can assist you in business, industry, personal applications, etc; (2) Select the most economical computer (or microprocessor) and related hardware for your specific needs; (3) Write and run the programs you need; and (4) Keep your computer costs down

This course was written for ELF II users but . . *it's a blockbuster for every RCA COSMAC user or owner!*

Stop reading about computers and get your hands on one. ELF II is an outstanding trainer for anyone who needs to use a computer to maximize his or her personal effectiveness But ELF II isn't just a trainer. Expanded, it becomes the heart of a powerful computer system

For $99.95 You Get All This—

No other small personal computer offers video output and ELF II's expansion capabilities for anywhere near $99 95. ELF II can create graphics on your TV screen and play electronic games! It pays for itself over and over again in the fun it provides for your whole family. Engineers and hobbiests can use ELF II in microprocessor-based circuits as a counter, alarm, lock, thermostat, timer, telephone dialer, etc The possibilities are endless!

The ELF II Explodes Into A Giant!

Once you've mastered computer fundamentals, ELF II can give you POWER! Plug in the GIANT BOARD™ and you can record and play back your programs, edit and debug programs, communicate with remote devices and make things happen in the real world. Add Kluge Board to solve specific problems such as operating a more complex alarm system or controlling a printing press. 4k memory units let you write longer programs and solve even more sophisticated business, industrial, scientific and personal finance problems.

Add ELF II Tiny BASIC And Keyboard!

To make ELF II easier to use, we've developed ELF II Tiny Basic. It lets you program ELF II with simple words you can type out on a keyboard such as PRINT, RUN and LOAD. ELF II responds by displaying answers on your printer, video monitor or TV screen

Write And Run Programs The Very First Night!

The ELF II kit includes all components and everything you need to write and run your own programs plus the new Pixie Graphics chip that lets you display any 256 byte segment of memory on a video monitor or TV screen. No wonder ELF II is now being used as a trainer in many high schools and universities.

Easy instructions get you started right away, even if you've never used a computer before The newly expanded ELF II Manual covers assembly, testing, programming, video graphics and games.

ELF II can be assembled in a single evening and you'll still have time to run programs including games, video graphics, etc. before going to bed!

SPECIFICATIONS

ELF II features an RCA COSMAC COS/MOS 8-bit microprocessor addressable to 64k bytes with DMA, interrupt, 16 registers, ALU, 256 byte RAM, full hex keyboard, two digit hex output display, 5 slot plug-in expansion bus (less connectors), stable crystal clock for timing purposes and a double-sided, plated-through PC board plus RCA 1861 video IC to display any segment of memory on a video monitor or TV screen.

EXPANSION OPTIONS

- **ELF II GIANT BOARD™** with casssette I/O, RS 232-C/TTY I/O, 8-bit P I/O, decoders for 14 separate I/O instructions and a system monitor/editor. Turns ELF II into the heart of a full-size system with massive computing power! $39.95 kit.
- **4k Static RAM.** Addressable to any 4k page to 64k. Uses low power 2102's. Chip select circuit allows original 256 bytes to be used. Fully buffered Onboard 5 volt regulator $89.95 kit.
- **Prototype (Kluge) Board** accepts up to 36 I.C.'s including 40, 24, 22, 18, 16, 14 pin. Space available for onboard regulator. $17.00.
- **Gold plated 86-pin connector.** $5.70.
- **ELF II Full ASCII Keyboard.** Upper and lower case. $64.95 kit.
- **5 amp Expansion Power Supply.** Powers the entire ELF II (Not required unless adding 4k RAM boards.) $34.95 kit.

All of the above PC boards plug directly into ELF II's expansion bus.

ELF II TINY BASIC

Communicate with ELF II in BASIC! ELF II Tiny BASIC is compatible with either ASCII keyboard and TV screen or standard teletype/video terminal utilizing RS 232-C or 20 mil TTY interface. Commands include SAVE and LOAD for storing programs on standard cassettes, a plot command to display graphic information and special commands for controlling ELF II I/O devices. 16-bit integer arithmetic, ±, x, ÷, (). 26 variables A-Z. Other commands include LET, IF/THEN, INPUT, PRINT, GO TO, GO SUB, RETURN, END, REM, CLEAR, LIST, RUN, PLOT, PEEK, POKE. Comes with maintenance documentation and excellent user's manual that allows even beginners to use ELF II for sophisticated applications. (4k memory required.) $14.95 on cassette tape.

Coming Soon . . . D-A, A-D Converter • Controller Board • Cabinet • Light Pen (Lets you write or draw *anything* on a TV screen. Imagine having a "magic wand" that writes like a crayon!)

SEND TODAY!

NETRONICS R&D LTD., Dept. PE9 (203) 354-9375
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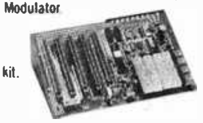
☐ *YES! I want to run programs at home and have enclosed.* ☐ $99.95 plus $3 p&h for RCA COSMAC ELF II kit. ☐ $4.95 for power supply, required for ELF II kit. ☐ $5.00 for RCA 1802 User's Manual.

☐ $4.95 for Short Course on Microprocessor & Computer Programming.

☐ ELF II connects to the video input of your TV set. If you prefer to connect ELF II to your antenna terminals instead, enclose $8.95 for RF Modulator



☐ $39.95 plus $2 p&h for ELF GIANT BOARD™ kit.

__ 4k Static RAM kit, $89.95 ea. plus $3 p&h.

☐ $17.00 plus $1 p&h for Prototype (Kluge) Board

☐ $34.95 plus $2 p&h for Expansion Power Supply kit.

__ Gold plated 86-pin connectors at $5.70 ea.

☐ $64.95 plus $2 p&h for ASCII Keyboard kit

☐ $14.95 for ELF II Tiny BASIC cassette.

☐ I want my ELF II wired and tested with the power transformer, RCA 1802 User's Manual and Short Course on Microprocessor & Computer Programming for $149.95 plus $3 p&h.

Total enclosed (Conn. res. add tax) $________ ☐ Check here if you are enclosing Money Order or Cashier's Check to expedite shipment

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Dealer Inquiries Invited!

CIRCLE NO. 37 ON FREE INFORMATION CARD

Letters

PC PATTERN PATENTS

I am writing in response to a letter that appeared in the May 1978 Letters column regarding my "Transfer of PC Patterns" article that appeared in the February 1978 issue. In his letter, Mr. Cannon states that U.S. Patent #3,791,905 covers the process described in my article. He noted further that he did not promote his own version of the process because he "did not have the legal right to do so." After researching it, my patent attorney sees no conflict with my patent application. The results of this are due shortly and I am quite optimistic that I will be granted a patent on this process. *—G.D. Fisher, Printed Circuit Products Co., Helena, MT.*

LIFE BEGINS AT FORTY

Late last year, I purchased an Elf microcomputer kit and now, at age 44, I am into a whole new hobby. Until I purchased my Elf, I had no knowledge or interest in microprocessors. Since that time, POPULAR ELECTRONICS has been my sole source of information on the 1802 microprocessor. *—Richard A. DeForest, Fulton, NY.*

A 9-MHZ PIANO NOTE?

As a former piano student, I had always been satisfied with a frequency range of from 27.5 to 8720 Hz. Now, in your June 1978 Editorial, you tell me that the range goes all the way up to 9 MHz!*—Wilfred J. Cote III, Stockton, CA.*

Sorry about the "typo." Obviously, we meant "9 kHz," not "9 MHz."

DIAGRAM AND TABLE NOT IN AGREEMENT

While reading "Microprocessor Microcourse, Part 2" (April 1978) on basic digital logic, I realized that the description for a D-type latch/flip-flop does not match Fig. 13 and the truth table. Which is correct?*—B. Malik, Tehran, Iran.*

The diagram shown in Fig. 13 is correct. However, the Q and $\overline{Q}$ in the truth table in Fig. 13 were accidentally transposed.

Out of Tune

In the July "Experimenter's Corner," in Fig. 4, the poles of the switches should be connected to the 2k resistors and the logic-1 positions to the positive terminal of the battery.

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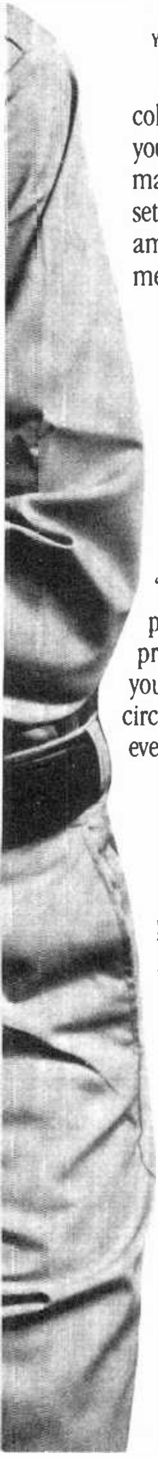


You build color TV, hi-fi, professional instruments.

Now, in addition to learning color TV and audio systems servicing, you get state-of-the-art lessons in maintaining and repairing video cassette recorders, playbacks and the amazing new video disc players, both mechanical and laser-beam types.

Learn at Home in Your Spare Time

And you learn right at home, at your own convenience, without quitting your job or going to night school. NRI "bite-size" lessons make learning easier...NRI "hands-on" training gives you practical bench experience as you progress. You not only get theory, you actually build and test electronic circuits, a complete audio system, even a color TV.

Build Color TV, 4-Channel Audio

As part of your training in NRI's Master Course in TV and Audio Servicing, you actually assemble and keep NRI's exclusive, designed-for-learning 25" diagonal color TV. As you build it, you introduce and correct electronic faults, study circuits to gain a better understanding of what they're for and how they interface with others.

Likewise, as part of your audio training, you construct a 4-channel stereo amplifier and tuner, complete with cabinet and speakers. You even assemble professional-grade test instruments, so you know what makes them tick, too. Then you use them in your course, keep them for actual TV and audio servicing work.

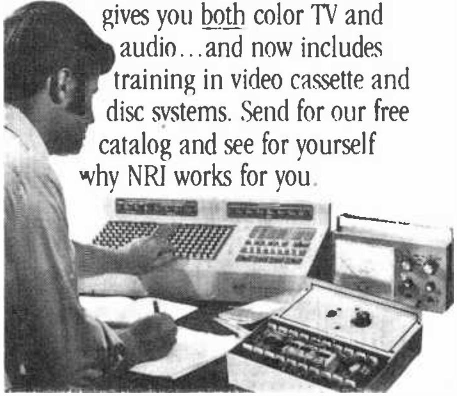
NRI Includes the Instruments You Need

You start by building a transistorized volt-ohm meter which you use for basic training in electronic theory. Then you assemble a digital CMOS frequency counter for use with lessons in analog and digital circuitry, FM principles. You also get an integrated circuit TV pattern generator, and an advanced design solid-state 5" triggered-sweep oscilloscope. Use them for learning, then use them for earning.

NRI Training Works... Choice of the Pros

More than 60 years and a million students later, NRI is still first choice in home study schools. A national survey of successful TV repairmen shows that more than half have had home study training, and among them, it's NRI 3 to 1 over any other school. (Summary of survey on request)

That's because you can't beat the training and you can't beat the value! For hundreds of dollars less than competing schools, NRI gives you both color TV and audio...and now includes training in video cassette and disc systems. Send for our free catalog and see for yourself why NRI works for you.



Other NRI training includes Computer Technology, Complete Communications Electronics.

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Our free 100-page catalog completely describes all the equipment and every lesson. You can choose from five different TV and audio courses. Or explore the opportunities in other NRI home study courses like Computer Technology, CB and Mobile Radio, Aircraft and Marine Radio, or Complete Communications. Send the postage-paid card today and get a head start on the state of the art.

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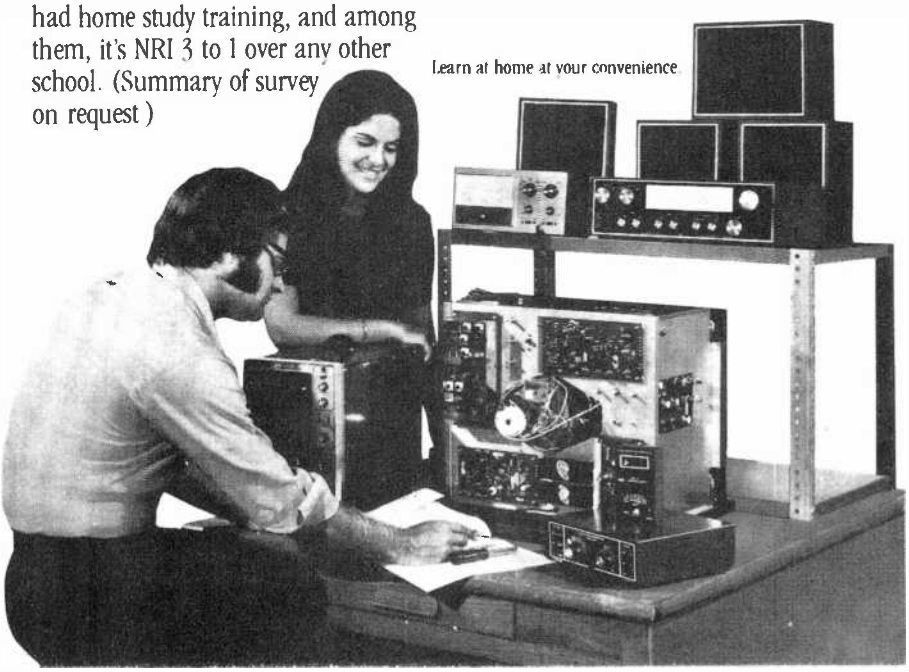
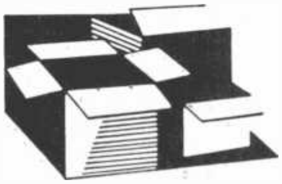


Learn at home at your convenience.

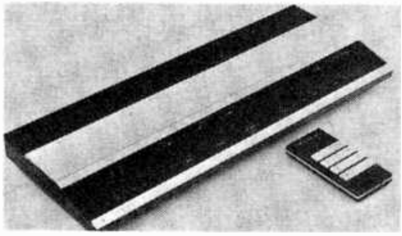


New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Bang & Olufsen FM Receiver

The Beomaster 2400 is a uniquely styled stereo-FM receiver with remote control, rated at 30 watts per channel continuous power into 4 ohms. The remote control, included, can be used to select any of four preset FM stations, adjust the volume, switch from FM to phono input, and turn the receiver on and off. An illuminated panel on the receiver includes displays that allow control status to be read from across the room, plus touch-sensor controls duplicating the remote-control functions, with the added choice of one more input (tape) and one more FM station. Additional controls for bass, stereo balance, FM-preselect settings and manual tuning are beneath a hinged top cover. Amplifier specifications include less than 0.2% distortion, and S/N better than 65 dB. FM sensitivity ratings are: 19.2 dBf (5.0 μV) monophonic usable sensitivity; 50-dB quieting sensitivities of 18.5 dBf (4.6 μV) mono and 38.9 dBf (48 μV) stereo. FM S/N is 80 dB in mono, 66 dB in stereo. Dimensions are 2½" H x 24¼" W x 9¾" D (6 x 62 x 25 cm). $595.



CIRCLE NO 88 ON FREE INFORMATION CARD

Johnson Mobile CB Transceiver

E. F. Johnson's Viking 260 AM mobile CB transceiver features LED numeric channel display with an automatic LED brightness control circuit. Discrete LED's are also used to form a bar-graph S/r-f meter. Interference problems are said to be reduced through the use of twin ceramic selectivity filters, switchable noise-blanker/ANL system. Controls include three-position range switch, delta tune switch, tone, CB/PA switch, and calibrated squelch. The Viking 260's cabinet is covered with leather-textured black vinyl (other colors available). $199.95.

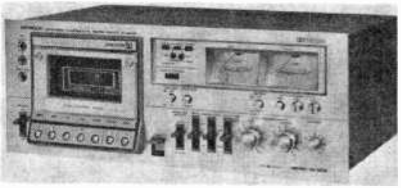
CIRCLE NO 89 ON FREE INFORMATION CARD

Microcomputer/TV Receiver Interface

ATV Research's "Micro-Verter" interfaces microcomputers to standard color or monochrome TV receivers. It accepts video input and generates modulated r-f output above uhf channel 14 to avoid image degradation from computer switching harmonics. It's tunable over at least four channels. In most cases, r-f is coupled to a uhf tuner input through a 1-cm stub at the back of the device. The r-f modulator is powered by four self-contained "AA" cells (not supplied) and comes with video cable and r-f output stub coupler. Dimensions are 2.2" × 3.3" × 4.5" (5.5 × 8.5 × 11.5 cm). $35. Address: ATV Research, 13th & Broadway, Dakota City, NB 68731.

Hitachi 3-Head Cassette Deck

Hitachi's Model D 900 is a front-loading, three-head stereo casette deck with Dolby noise reduction and calibration. Rated wow and flutter of the dual capstan servo drive system is ±0.05%. Frequency response is said to be 30-18,000 Hz ±3 dB with CrO_2 tape. Separate front panel, three-position bias and equalizer switching is provided. Other features include full logic controls, stereo mike and headphone jacks, three-digit tape counter, dual switchable peak/VU meters, L/R line and mike/DIN record controls, and single output control. $495.00.



CIRCLE NO. 91 ON FREE INFORMATION CARD

Work Surface Traction Pad

"Slidestop" is a high traction plastic material which prevents tools and parts from slipping or sliding. Available in rolls, the flexible material is non-sticky, for easy removal of objects placed upon it, yet has sufficient traction to hold objects even when the surface is nearly vertical. Prices range from $22 for an 8" × 2.2-yd. roll to $139 for a roll 16" wide by 10 yds. Colors include green, red, blue, yellow and white. Address: Kager International, Suite 710, 1180 South Beverly Dr., Los Angeles, CA 90035.

Koss Stereophone

The new Koss K/6ALC Stereophone has a low-angle 2.5" (63 mm) diameter driver in each earcup. Rated sensitivity for 100-dB SPL is 0.14 V rms (1 kHz sine wave). THD is said to be below 1% with 100-dB SPL (1 kHz), and impedance is 94 ohms. A slide-type volume/balance control is provided for each earcup. Earcushions are foam-filled vinyl, and the headband is sponge-cushioned nylon with pivoting, self-adjusting yokes. A three-conductor coiled 10-ft cord is supplied. Weight is 14 oz (390 g) less cord. $34.95.

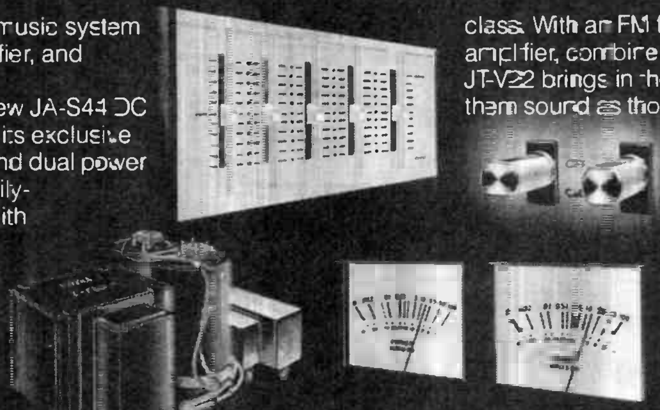
CIRCLE NO. 92 ON FREE INFORMATION CARD

8-Track Tape Amplifier Converter

Shur-Lok's "Star-Trak" converter permits use of any 8-track tape playback system for audio and musical instrument amplification. No wiring is necessary since it inserts into the tape player's cartridge slot. Four

THE JVC SEPARATES.

Sensitive tuners, plus DC amplifiers that help eliminate sonic backlash.



If you've ever listened to a JVC music system with a separate tuner and amplifier, and thought, "One of these days . . ."

Well that day is here. The new JA-S44 DC integrated stereo amplifier, with its exclusive built-in SEA graphic equalizer and dual power meters, provides clean, uncannily-accurate music reproduction with all the power you're ever likely to need.*

Our "Tri-DC" design in the JVC JA-S55 and JA-S77 further eliminates distortion-causing capacitors within the DC phono equalizer, DC tone control and DC power amplifier sections, providing frequency response from 5Hz to 100kHz (+0, −1.0dB). And they have dual power supplies—not one for each channel, as in conventional designs—but one for the Class A-operated preamp/tone control section, and a second which performs even heavier duty for the Class B-operated DC power amplifier section. This unique design practically eliminates both inter- and intra-channel crosstalk and distortion, or what we call "sonic backlash." The results: increased tonal definition and brilliance, especially with high-level transient signals.

The new JVC JT-V22 AM/FM stereo tuner is a standout in its class. With an FM front end that uses an FET RF amplifier, combined with a 3-gang tuning capacitor, the JT-V22 brings in the most timid FM stations and makes them sound as though they're just around the corner.

Or, if you're in an area where FM stations are a hairline away from each other on the dial, it delivers clear, interference-free reception. Then, to help you make sure you're on target, it has both signal strength and center-channel tuning meters.

Probably the most significant advance in recent FM tuner technology is JVC's Phase Tracking Loop circuitry in our new top model—JT-V77. This advanced circuit provides high signal-to-noise ratio as well as excellent interference rejection and freedom from multipath effects and adjacent channel interference. It's still another example of JVC's innovative engineering. But sounds speak louder than words. See and hear these magnificently-designed separates at your JVC dealer soon.

JVC High Fidelity Division, US JVC Corp., 58-75 Queens Midtown Expressway, Maspeth, N.Y. 11378. Canada: JVC Electronics of Canada, Ltd., Ont.

Top: JA-S22 Bottom: JA-S55 Top: JT-V77 Bottom: JA-S77

JVC

We build in what the others leave out.

JT-V22, JA-S44

---

*[illegible]5 watts/channel, min. RMS 8 ohms, from 20Hz-20kHz, with no more than 0.02% THD. Rack-mount handles and wood-grain cabinets optional.

CIRCLE NO 63 ON FREE INFORMATION CARD

Q. How close can hi-fi get to an authentic musical experience?

A. Slip on new Audio-Technica Stereophones and hear for yourself.

If you want to find out how good the new Audio Technica Stereophones really are, don't just compare them with other headphones. Put them up against the very finest *speaker* systems. But don't just listen to the equipment. Listen to the *music*. And be ready for a surprise!

Judged on the basis of flatness of response, freedom from distortion, transient response, sensitivity, and independence from room acoustics, these new dynamic and electret condenser models are perceptibly better sounding than speaker systems costing hundreds of dollars more.

And if you think that great performance can only come from heavy, bulky stereophones, get ready for another surprise. Our heaviest model is less than 7½ ozs. and our lightest is an incredible 4¾ ounces light. Comfort that lasts an entire opera if you wish.

For all the facts, send for our catalog. But for the revealing truth about stereophone performance, listen and compare at your nearby Audio-Technica showroom. It will be a great *musical* experience.

Model ATH-7
Our finest Electret Condenser with LED peak level indicators
$149.95

Model ATH-1
The moving coil dynamic stereophone that weighs just 4¾ oz.
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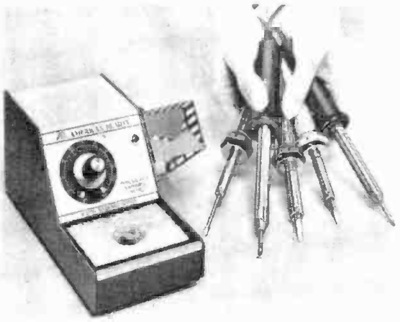
Available In Canada from Superior Electronics, Inc.

¼" phono jack inputs are provided. Signals from any instrument are processed by "Star-Trak" and transduced to the tape unit's pick-up head for stereo reproduction. $49.95. Address: Shur-Lok Mfg. Co., Inc., 412 N Main, Hutchins, TX 75141.

Variable-Power Soldering Station

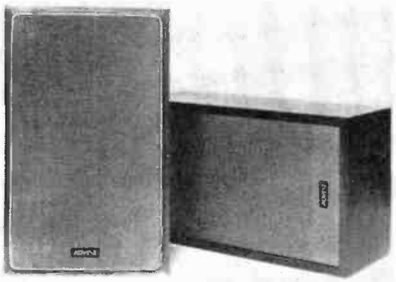
American Beauty's V-3600 is a solid-state, continuously variable power unit for any 15-to-60-watt soldering iron. It is said to be capable of delivering zero to 100 percent of line voltage. Other features are a built-in sponge tip cleaner, and a ventilated iron holder. The unit is available with or without soldering iron. Dimensions are 8.5" × 4" × 6" (22 × 10 × 15 cm).



CIRCLE NO. 93 ON FREE INFORMATION CARD

Advent/1 Loudspeaker

The Advent/1 is a two-way "bookshelf" speaker system with 10" acoustic suspension woofer and 1⅜" ferro-fluid-damped cone tweeter. Minimum recommended input is 15 watts/channel. Dimensions of this



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IF YOU'RE WAITING FOR SOLDERLESS BREADBOARDS TO BE FASTER, EASIER, MORE VERSATILE AND LOWER-PRICED...

Incredibly inexpensive. EXPERIMENTOR solderless sockets begin at $5.50* ($4.00* for the 40 tie-point quad bus strip). A spool of solder costs more.

Mix and match. Use large and small chips in the same circuit without problems. There are two sizes of EXPERIMENTOR sockets with 0.3" and 0 6" centers

Full fan-out. A CSC exclusive. The only solderless breadboard sockets with full fan-out capabilities for **micro-processors** and other larger (0.6") DIP's.

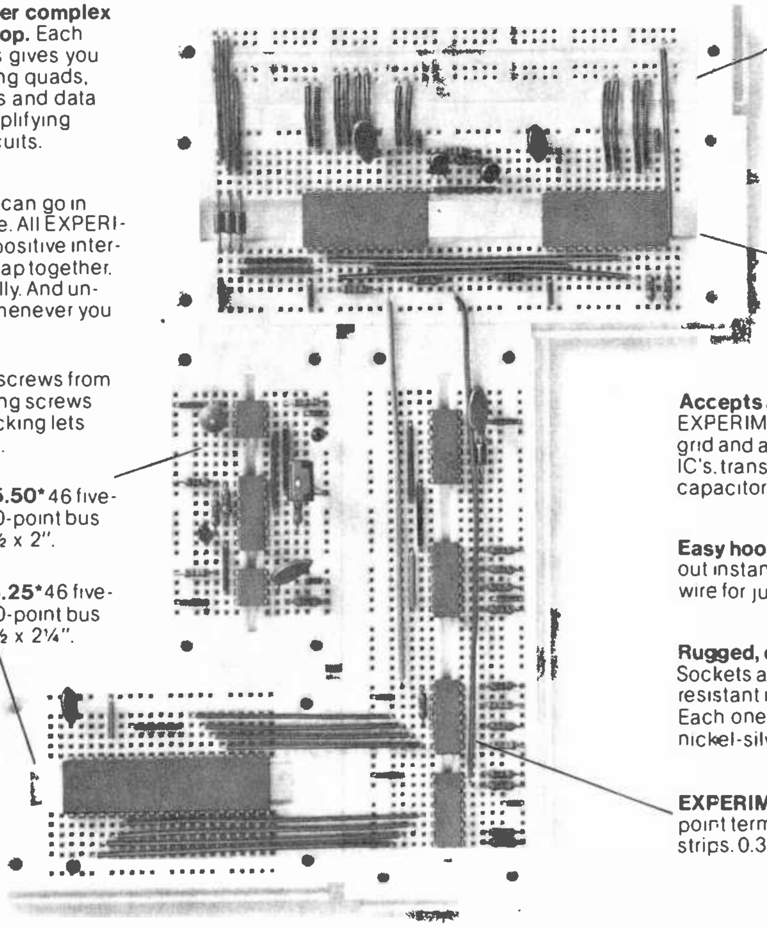
Microprocessors and other complex circuits are easy to develop. Each EXPERIMENTOR quad bus gives you four bus lines. By combining quads, 8-, 12- and 16-line address and data buses can be created, simplifying complex data/address circuits.

Infinitely flexible. Circuits can go in any direction, up to any size. All EXPERIMENTOR sockets feature positive interlocking connectors that snap together. Horizontally and/or vertically. And unsnap to change a circuit whenever you wish.

Easy Mounting. Use 4-40 screws from the front or 6-32 self-tapping screws from the rear. Insulated backing lets you mount on any surface.

EXPERIMENTOR 350. $5.50* 46 five-point terminals plus two 20-point bus strips. 0.3" centers; ⅜ x 3½ x 2".

EXPERIMENTOR 650. $6.25* 46 five-point terminals plus two 20-point bus strips. 0.6" centers; ⅜ x 3½ x 2¼".



EXPERIMENTOR QUAD BUS STRIP. $4.00* Four 40-point bus strips. ⅜ x 6 x ¾".

Designated tie-points. Simplify translation from breadboard to PC-boards or wiring tables.

EXPERIMENTOR 600. $10.95* 94 five-point terminals plus two 40-point bus strips. 0.6" centers; ⅜ x 6 x 2¼".

Accepts all standard components. EXPERIMENTOR sockets conform to an 0.1" grid and are DIP compatible. Also accept IC's, transistors, diodes, LED's, resistors, capacitors, transformers, pots, etc.

Easy hookup. Components push in and pull out instantly. Use #22-30 solid AWG wire for jumpers.

Rugged, dependable construction. Sockets are constructed from abrasion resistant materials and withstand 100°C. Each one features non-corrosive nickel-silver contacts.

EXPERIMENTOR 300. $9.95* 94 five-point terminals plus two 40-point bus strips. 0.3" centers; ⅜ x 6 x 2".

WHAT ARE YOU WAITING FOR?

Discover today how solderless breadboarding can save time and money on every circuit you build. Get acquainted with EXPERIMENTOR™ sockets† and how they simplify circuit design, assembly and testing. Eliminate the hassles and component damage of soldering. No special hardware or jumper cables required, either. And the price is so low, it's hard to believe.

"*Order today.* Call 203-624-3103 (East Coast) or 415-421-8872 (West Coast): 9 a.m.-5 p.m. local time. Major credit cards accepted. Or see your CSC dealer. Prices slightly higher outside USA."

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CANADA: Len Finkler Ltd.; Ontario

CIRCLE NO 11 ON FREE INFORMATION CARD

†U.S Patent No D235,554

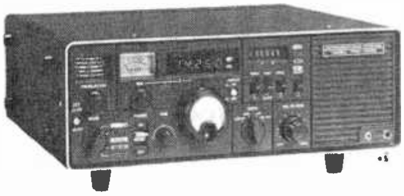
*Manufacturer's recommended resale
© 1977, Continental Specialties Corporation

8-ohm system are 22" H × 13.25" W × 9.25" D (55.9 × 33.7 × 23.5 cm). Two finishes are available: walnut-grain vinyl, $99.95; walnut veneer, $120.

CIRCLE NO 94 ON FREE INFORMATION CARD

Yaesu Communications Receiver

The FRG-7000 is a new shortwave receiver from Yaesu featuring five-digit numeric frequency display. It offers continuous coverage of 0.25 to 29.9 MHz in five ranges and operates in AM, SSB, and CW modes.



On the front panel are: an hours-minutes-seconds timer with numeric readout, main and fine tuning controls, AM anl switch, preselector, tone controls, S-meter, and headphone jack. It includes a built-in speaker and a 2-watt output audio amplifier. Rated AM and SSB/CW sensitivities are 0.7 and 2 μV, respectively, for 10 dB S/N. The 6- and 50-dB selectivity points are ±1.5 and ±4 kHz (SSB/CW), ±3 and ±7 kHz (AM). Drift is said to be less than ±500 Hz during any 30-minute period after warm-up. Dimensions are 4.9" H × 14.2" W × 11.6" D (12.5 × 36 × 29.5 cm).

CIRCLE NO 95 ON FREE INFORMATION CARD

Tonearm Shell

A universal tonearm shell, the AT-N, has been introduced by Audio-Technica. The shell is said to mate with virtually all Japanese and most European tonearms. The AT-N facilitates changing cartridges when more than one is used. $5.95.

CIRCLE NO 96 ON FREE INFORMATION CARD

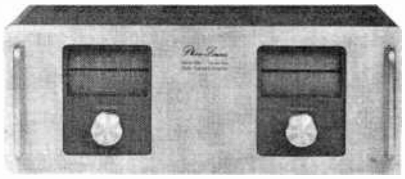
Burwen Remote Equalizer

Burwen's "Remote Variable Field Equalizer" consists of a base power system joined to a hand-held control unit by a 20-ft cord so that one can make adjustments while located anywhere in a room. There are six bands per channel, controlled by horizontal slides. Frequency range is said to be 15-25,000 Hz. Combination peaking/shelf controls are at 15, 120, 500, 2000, 5000, and 25,000 Hz. Maximum equalization is ±44 dB at 15 Hz and ±33 dB at 25,000 Hz. When the controls are set to zero, frequency response is claimed to be flat to 1 dB. THD is rated at 0.03% with 7.8 V (1 kHz). An input level slide control and tape monitor switch are provided. Dimensions are 1.5"H × 4.75"W × 7.375"D (3.8 × 12.1 × 18.7 cm).

CIRCLE NO 97 ON FREE INFORMATION CARD

Phase Linear Power Amplifier

The New Phase Linear Model 400 Series Two amplifier has a rated power output of 210 watts rms/channel into 8 ohms over 20-20,000 Hz with no more than 0.09% THD. It has BI-FET high-loop gain circuitry and electronic energy limiters said to prevent overload damage. Dual peak-reading LED meters and twin input sensitivity controls are mounted on the front panel. $599.95.



CIRCLE NO 98 ON FREE INFORMATION CARD

Kantronics Portable CW Receiver

The Kantronics 8040-A CW receiver offers coverage of 3.65 to 3.75 and 7.05 to 7.15 MHz for monitoring and code practice. This lightweight unit operates from two 9-volt batteries. Front-panel controls include audio gain and a preselector. It also features vernier dial action. A standard phono jack allows connection of an 8-ohm speaker or monophonic headphone (not supplied). The 8040-A is said to provide readable audio output with a 1-μV input signal; selectivity is rated as −6 dB at ±500 Hz. Dimensions are 2.9" H × 6.6" W × 6" D (7.4 × 16.8 × 15.2 cm). $59.

CIRCLE NO 99 ON FREE INFORMATION CARD

M&K Passive Crossover

M&K's LP-1 is a totally passive crossover system which provides separate drive to sub-woofer and mid-range/high-frequency amplifiers for bi-amping. The LP-1 follows the preamplifier in the signal path and is said to have virtually no transmission loss in its passband. Crossover rates are 12 dB/octave from low-pass to high cutoff and 18 dB/octave from high-pass to low cutoff. On the front panel are tape input, bass and treble outputs, and bass and treble level controls. $120.

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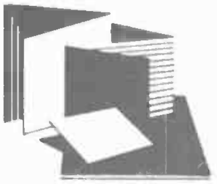


New Literature

TURNER COMMUNICATION CATALOG

Turner Division of Conrac Corporation has issued a 28-page catalog covering their CB product line. Included are microphones, stainless steel antennas, fiberglass antennas and accessories. Featured is a section on Turner's new no-solder microphone connector program, "The Turner Connection." General information and engineering specs are also included. Address: Turner Division Conrac Corp., 716 Oakland Rd., N.E., Cedar Rapids, IA 52402.

SIMPSON INSTRUMENT CATALOG 4700

Simpson Electric Company has available a 60-page catalog listing its line of stock analog and digital panel meters, meter relays, controllers and test instruments. New products include the model 461 digital multimeter and the series 2860 digital panel meters. Address: Simpson Electric Co., 853 Dundee Ave., Elgin, IL 60120.

MOUSER SEMICONDUCTOR CATALOG

An 88-page catalog from Mouser Electronics describes its lines of zener, germanium, and silicon diodes, rectifiers, and TO-18 and TO-92 transistors. Low-, medium-, and high-current triacs, logic triacs, and triacs with internal diacs are also presented. The catalog covers an expanded line of quality IEE LED's, including sockets. Address: Mouser Electronics, 11511 Woodside Avenue, Lakeside, CA 92040.

HEATH SOLDERING MANUAL

Heath Company announces its new, self-instructional Soldering Manual EI-3133. It covers the basic aspects of learning to solder, and uses programmed instruction techniques. This self-learning manual contains a comprehensive final exam and a complete glossary of soldering terms. An accompanying practice kit gives "hands-on" experience in soldering and unsoldering. Price: $9.95. Address: Heath Company, Dept. 350-380, Benton Harbor, MI 49022.

TRANSFORMER BULLETIN

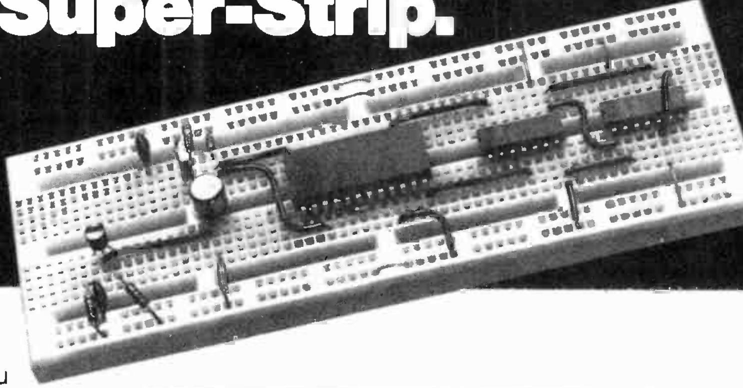
Hammond Bulletin 117 describes the new 117 series of line-matching transformers for sound distribution. The transformers couple 3.2-, 8-, and 16-ohm speakers to 25- or 70-V line outputs of amplifiers, and feature two-winding construction. Address: Hammond Manufacturing Co., Inc., 385 Nagel Dr., Buffalo, NY 14225.

TEXAS TUNER GUIDE

Texas Tuner Service has announced availability of its new list of both new and rebuilt tuners for popular TV sets. Address: Texas Tuner Service, 4210 N.E. 28th St., Fort Worth, TX 76117.

NATIONAL MICROPROCESSOR REFERENCE GUIDE

A reference guide to National Semiconductor's 8080A microprocessor family of over 60 bus-compatible parts is now available. The booklet gives an overview of National's 8080A family, describing the basic functions of each component, the pin numbers and signal names and how the components interface to National's system bus—the Microbus.™ A description of the 8080A CPU group, as well as its series of peripheral control, communications, digital input/output, and memory components is included. Address: National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051.



box. The drive is a quartz-locked servo-controlled system, and the extremely unobtrusive base/subframe is said to have beneficial effects on resonance problems. A number of other new models of a more conventional bent back up the DQX-500. There is also a new tonearm, the MA-707, which can be mass-tuned to suit various cartridges.

Kenwood's new turntables numbered two, a direct-drive and a belt-drive model, the former employing Kenwood's resin-concrete base and selling for an attractive $260. Kenwood also showed a new 125-watt-per-channel receiver, the KR-8010, two new cassette decks, and four 2- and 3-way speaker systems.

Getting back to tape, the contributions of Teac for this show were four cassette decks and a replacement for the astonishingly popular A-3340 four-channel multitrack machine, the new A-3440. The foremost of the cassette units, the C-1, has three heads, three motors, solenoid switching, an attractive low-silhouette rack-mountable front-panel, and an instrument-type support bracket for shelf installation. Optional dbx noise-reduction modules are available, as are interchangeable modules to match the deck's electronics to various tape types. Other new decks include three- and two-head models, one with automatic reverse in playback.

JBL announced it will now sell its professional line of monitor loudspeakers through selected hi-fi dealers, and also noted that the popular, recently discontinued L100 consumer loudspeaker will be replaced by the Model 4311, its professional counterpart. The company also introduced a new low-price speaker and an interesting new "state-of-the-art" design, the L220, the first deliberate attempt on JBL's part to align the acoustic centers of the various drivers for synchronized arrival times at the listener's ear. One design objective was to achieve this goal without breaking up the front-panel surface.

Dynaco chose the show as the proper place to unveil its new "non-kit" series, beginning with four models sporting entirely new front-panel styling. There is a preamplifier, the Model 2510, a tuner with a varactor front end, and integrated and power amplifiers, each rated at 100 watts per channel. Proposed price range is from $500 to $800.

Transduction, Anyone? Thorens has integrated moving-coil cartridges with its Isotrack tonearms to create the TMC 63 and TMC 70, plug-in arm-cartridge modules for the newer Thorens turntables. The company has also introduced two receivers, the AT-410 and AT-403, at 50 and 20 watts, respectively. Finally, the company also introduced two speaker systems, called "Sound Walls," about which absolutely no information was available at show time except for a nominal impedance of 4 ohms. Two new turntables, the TD-115C and TD-110C, both incorporating a new suspension system, should be noted.

The Sonus cartridge line has been entirely revamped with models that have evolutionary improvements in new materials and techniques. A top-of-line series of three, the Sonus Golds, are identical except for stylus tip configuration, as are the two Sonus Silvers, which have somewhat lower compliance. Elsewhere in cartridges, ESS has recaptured the Dynavector moving-coil cartridge line and is pressing ahead with it.

The day will surely come when new loudspeaker designs outnumber the people at one of these shows. To touch briefly on some of the highlights: Bozak, newly reorganized, has embarked on the phase/time-corrected approach with the LS-300, a $250 design that sounded quite respectable. Win Burhoe of The Little Speaker Company has come up with yet another new tweeter, a 1-inch design with a compound diaphragm curvature and frequency-response and dispersion characteristics confidently specified up to 25,000 Hz.

Cerwin-Vega has a remarkable looking new truncated-pyramid system that was being demonstrated with a subwoofer—a cabinet containing an 18-inch driver with the center of its cone bolted stationary. Cizek also had a new subwoofer, employing two 10-inch drivers in a sealed cabinet, as did Audioanalyst. I noted two new full-range electrostatic designs, the Acoustat Monitor and the "naked" Dayton-Wright, which not only lacks the gas-filled envelopes of the original but also any vestige of grille cloth or cabinetry. And an Israeli company marketing under the name of Ramko displayed a rather extensive line of mostly ported designs.

If all this has proven too much for you, Bose can simplify your life with the Model 360 compact system (really a prepackaged turntable-receiver-speaker ensemble) that will take you back to the days of "buy it, plug it in, and listen." But whatever happens, don't let anyone ruin your day by springing on you the reason for the new GAS tuner's being named Charlie. Tuner = "tuna." Get it? ◇

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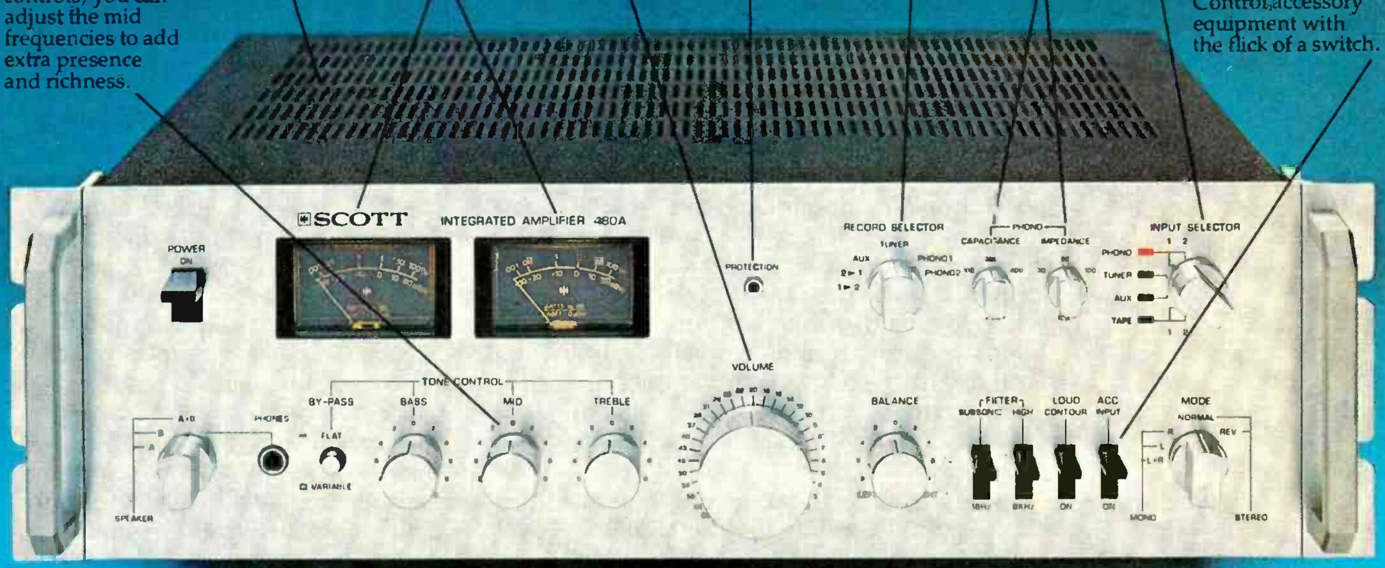

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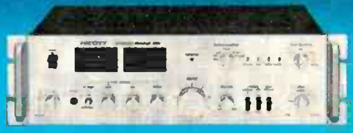

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New Scott 440A Integrated Amplifier
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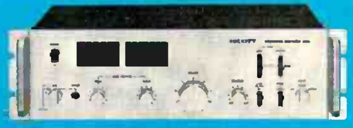

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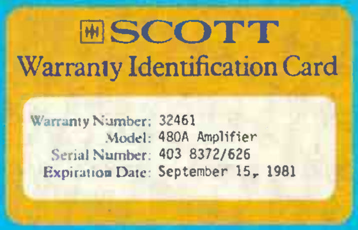

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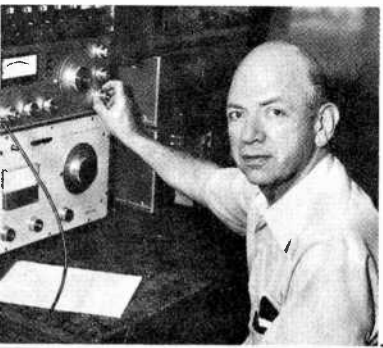

HIRSCH/HOUCK LABORATORIES

Julian Hirsch Audio Report

Audio Amplifier Classes

SINCE the earliest days of vacuum-tube amplifiers, designers have been trying to increase amplifier efficiency without sacrificing performance quality. The first audio amplifiers used what we refer to as "class-A" operation, and were characterized by good linearity (freedom from distortion) and low efficiency. However, a considerable power input had to be supplied to the tube in order to obtain a relatively small useful output. Most of the power input (typically 75% to 80%) was dissipated as heat from the tube anodes; the result was a large, heavy and costly amplifier with low power output.

From an electrical standpoint, a class-A amplifier stage is one which is biased to conduct current throughout the entire signal waveform cycle. It is never driven to saturation or to cut-off. The next step was to use two tubes in "push-pull," each biased to conduct during one half of the signal cycle. In other words, one tube amplified the positive half-cycles and the other amplified the negative half-cycles. This "class-B" amplifier design is much more efficient than a class-A amplifier since the tubes use little or no plate power while signal levels are low (a class-A amplifier draws the same power from its supply whether or not a signal is present). Under the most favorable conditions, a class-B amplifier can be about 65% efficient.

". . . 'new' amplifier classes . . . represent efforts to combine high short-term power capability with a small power supply."

As a rule, a class-B amplifier has higher distortion than a class-A amplifier. The tube characteristics become nonlinear near the cut-off region, and it is difficult to match the two tubes so that their distortions cancel (as they do in an ideal case). To deal with this problem, they are usually biased to conduct for somewhat more than half a cycle, minimizing the crossover distortion that takes place during the transition of conduction from one tube to the other. This bias condition is known as "class-AB" operation, and results in an operating efficiency intermediate between that of class A and class B.

Although we have used vacuum tubes in these examples, for historical perspective, the operation of transistor amplifiers is fundamentally the same. Practically all of today's high-fidelity power amplifiers use class-AB operation in their output stages. They are designed to run at a fairly cool temperature under low-signal conditions (which is the way home music system amplifiers operate most of the time) and to dissipate more heat from their output devices as the power output is increased. The adoption of the FTC rules on advertised power ratings a few years ago caused consternation among many amplifier manufacturers when it was found that the required one-hour preconditioning period in which the amplifier operates at one-third of rated power coincidentally placed a class-AB or class-B stage close to its condition of maximum power dissipation (which is at about 40% of full power). Not all amplifiers could withstand an hour of this treatment without overheating, so there was an industry-wide "beefing up" of output stages and heat dissipating systems that speedily solved the problem.

Among some audio purists, there is a tendency to return to pure class-A amplification, sometimes in combination with novel circuits that attempt to reduce the quiescent dissipation of the amplifier. Fairly high power levels are the norm today, and a class-A amplifier able to deliver more than 100 watts per channel is a formidable unit in regard to size, weight, and price. The sonic qualities of a fully class-A design are still the subject of some debate, but their physical bulk and heat dissipation are not.

More recently, two "new" amplifier classes appeared on the market in commercial form. Actually, it is debatable whether they should be considered as bona fide "classes" of operation, but both represent efforts to combine a high short-term power capability with the smaller power supply and heat sink of a lower-power amplifier. These are not necessarily incompatible conditions. As we mentioned before, a hi-fi amplifier usually operates at a small fraction of its full capability, and is only called upon to deliver full power peaks for brief, infrequent periods. The Hitachi "Class-G" amplifier and the Soundcraftsmen "Class-H" amplifier are two very different approaches to this problem.

Both of the above are successful, although they work no miracles. By using a second set of output transistors, separately powered, to handle only the high-level portions of a signal waveform, Hitachi has been able to nearly double its long-term power for the brief periods required by a music waveform. However, the key word is "brief," since the higher power can be maintained only for a matter of milliseconds. The Soundcraftsmen circuit increases the power supply voltages to a conventional output transistor configuration as required to accommodate large voltage swings, while keeping the voltage (and power dissipation) relatively low during most of the time when high power is not required. This amplifier can deliver its maximum power for a sustained period of time necessary, but is a relatively large, heavy amplifier.

During the past several years, we have been hearing of the efforts of several manufacturers to develop switching amplifiers, often referred to as "class D." In a class-D amplifier, the output devices are always either fully on or cut-off. Such an amplifier dissipates very little power under low-signal conditions, since at cutoff there is no current flowing in the transistors, and in saturation the voltage drop across the transistor is very small. In an ideal case, there would be no power dissipated in the transistors. But even in practical amplifiers, the dissipation is far less than in any of the linear classes of amplifier operation.

With no input signal, the output of a class-D amplifier is a high-frequency square-wave signal. This serves as a carrier for the program information, which modulates the square-wave signal in any of a number of ways. Some of the possible techniques include pulse-code modulation, pulse-frequency modulation, pulse-position modulation, and pulse-width modulation. The latter is one of the simpler methods. Here, the relative widths of the positive and negative portions of the square-wave carrier are varied in accordance with the instantaneous amplitude and polarity of the audio input signal. Since the carrier frequency is many times higher than the highest modulation frequency, it can be removed at the amplifier output by a low-pass filter, leaving only the amplified signal waveform. This is the method used in the Sony TA-N88 PWM amplifier that is reviewed here this month.

Although output transistor linearity is no longer of any importance in a class-D amplifier, this responsibility has been transferred to the modulating circuit, which controls the pulse width in accordance with the input waveform. Any departure from ideal operation here will have much the same effect as ordinary amplifier nonlinearities in a class-AB amplifier. Also, the ideally high efficiency of a class-D amplifier can only be realized to the extent that its transistors simulate a perfect switch, either full on or off. However, even in practical amplifiers it is possible to achieve impressive reductions in size and weight, as compared to any conventional linear amplifier of similar power ratings.

Apparently, the most severe problem to be overcome in the design of a class-D amplifier is not related to its sound quality or amplifying performance. Containing, as it does, very powerful amplifiers which are continuously driven to their limits by square waves in the range of hundreds of kilohertz, a class-D amplifier must be shielded with extreme care. The carrier waveform has strong harmonics that extend into the hundreds of megahertz, posing a potential interference problem to FM and TV receivers, and the only barrier between this waveform and the speaker output terminals is a low-pass filter. The extensive shielding and filtering that must be applied to all parts of a class-D amplifier give it many of the mechanical properties of a high grade laboratory r-f signal generator. These steps include seamless cast chassis, multiple layers of copper shielding, and extensive filtering of every lead going into or out of the cabinet—signal input, speaker outputs, and ac line input. With these comes a high price, at least in the amplifiers shown so far.

The Sony TA-N88 is the first commercial version of a class-D amplifier to reach us for testing. As our test data show, it is a most impressive device, when one considers its power ratings in relation to its size and weight. Not only is it small and light, but under normal conditions it runs cooler than any conventional amplifier of comparable power ratings.

Although our early sample of the TA-N88 exhibited a slight r-f radiation problem, we have no doubt that this is not typical of a normal production amplifier. We understand that Sony plans to incorporate the class-D amplifier in some future receiver designs (where its size-reducing benefits would be obvious) and this would not be possible if r-f leakage could not be controlled. To us, the degree to which the harmonics of the switching waveform have been suppressed and contained is far more impressive than the small degree to which they have leaked out. Although a substantial price reduction will be required to make the class-D amplifier competitive with conventional linear amplifiers, technology is certain to provide the means for that soon.

(Audio Test Reports begin on page 32.)

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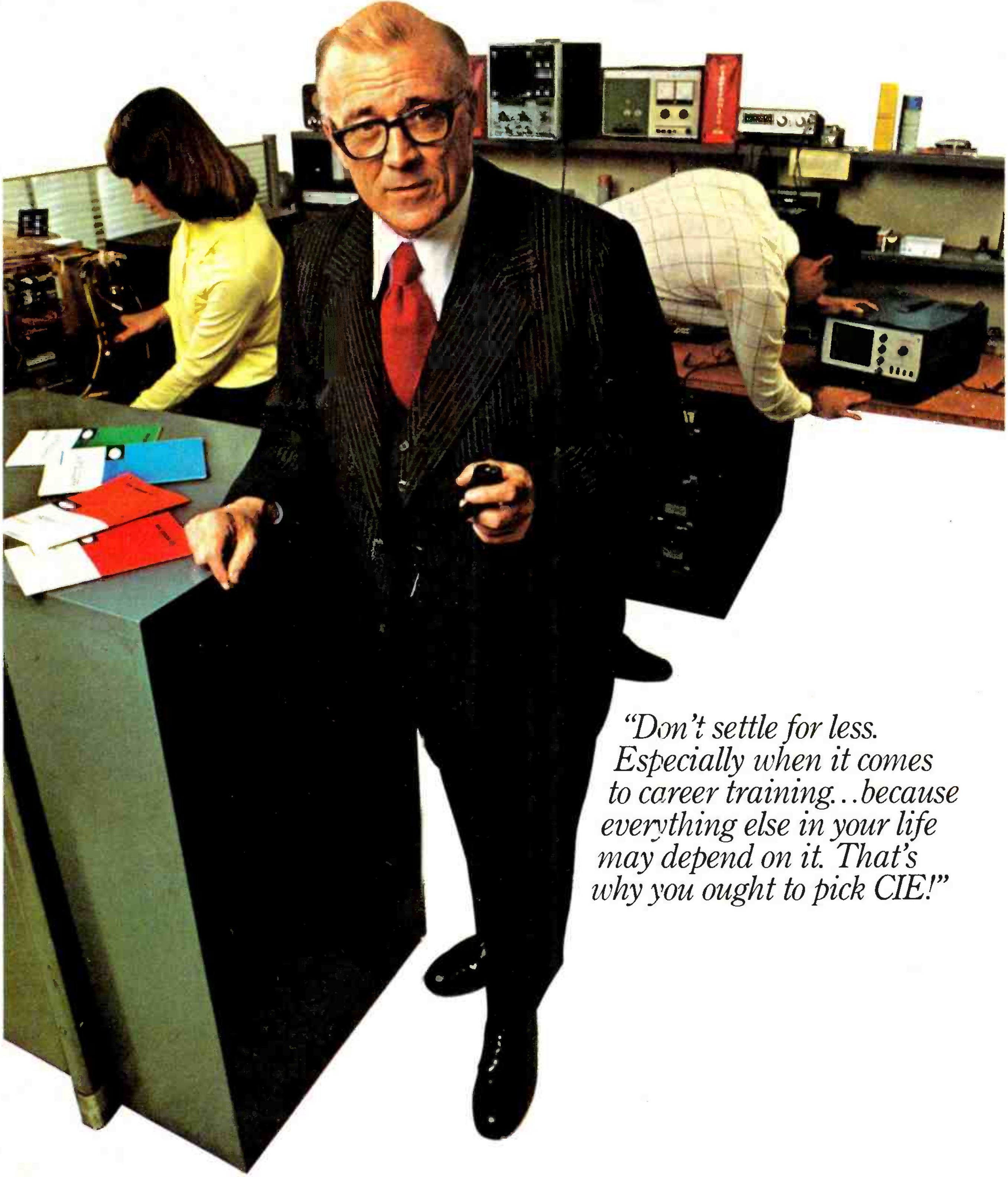

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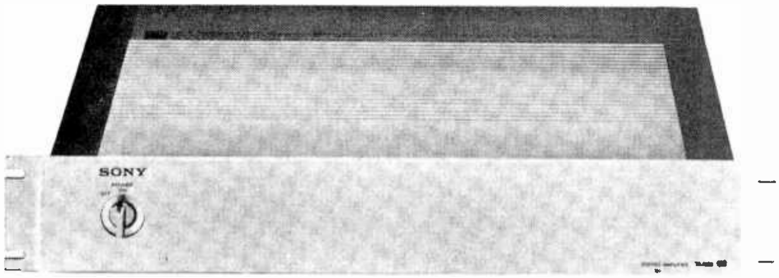
Audio Test Reports

HIRSCH-HOUCK LABORATORIES

Sony Model TA-N88 Basic Power Amplifier



"Class D" pulse-width-modulated power amplifier delivers 160 watts/channel and is smaller than many preamplifiers.

HIRSCH-HOUCK LABS REPORT

Sony's Model TA-N88 basic power amplifier has a 160-watt/channel rating into 8-ohm loads from 20 to 20,000 Hz at no more than 0.5% THD. The novel aspect about this amplifier, however, is not in what it does, but in how it does it. This is a pulse-width-modulated (also called class D) amplifier!

Except for its input stage, it has no conventional linear amplifier circuits. High-speed vertical FET's (VFET's) amplify a 500-kHz square-wave signal whose width (duty cycle) varies in proportion to the amplitude of the signal. The switching frequency is removed from the amplifier's output by a low-pass filter, leaving a greatly amplified audio signal to drive the speaker systems.

The amplifier is powered by a novel switching power supply that operates at a nominal frequency of 20,000 Hz. The space and weight saved in power transformer and filter capacitors at this frequency, compared to a conventional 60-Hz power supply, are considerable. The result is a high-power amplifier that is smaller than many preamplifiers and not much heavier. The Model TA-N88 amplifier measures 18⅞"W × 14¼"D × 3⅛"H (47.9 × 36.2 × 7.9 cm) and weighs 23 lb (10.4 kg). Suggested retail price is $1000.

General Description. The compact size of the amplifier is made possible by the high efficiency of its circuits. The circuits do not require the usual large heat sinks to dissipate heat from the output transistors and power supply components. In fact, there are no visibly identifiable heat sinks internally or externally. The eight vertical FET's (VFET's) that make up the output circuit and other heat-producing components are thermally coupled to a rugged die casting that forms a chassis pan and acts as an r-f shield for the amplifier. In the power supply section, a tiny ferrite-core power transformer operates at about 20,000 Hz instead of the usual 60 Hz. This means that correspondingly smaller filter capacitors are needed to filter the ultrasonic ripple from the dc output.

The amplifier's Pulse-Locked Power Supply (PLPS) is said to reduce the voltage variation to 1% or less. (The variation in power supply voltage in most amplifiers can be as great as 10%.) This limits the possibility of hum, enhances transient response, and helps to provide a well-defined bass.

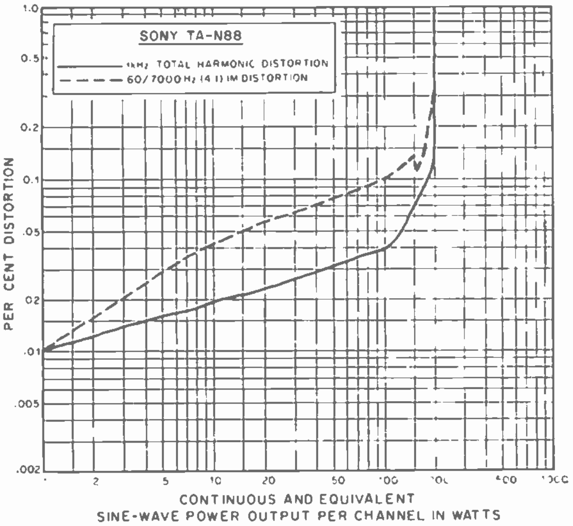
Multiple protection circuits are used throughout the amplifier. Current sensors shut down the input drive to the amplifier in less than 1 μs in the event excessive current is drawn by the output transistors. This is accomplished by a fast-acting FET attenuator in the input stage. The temperature of the output transistors is also monitored. If it becomes excessive or if a significant dc component appears at the speaker output terminals, the amplifier is shut down and the speakers are disconnected by a relay. (This relay also provides a few seconds of delay when the amplifier is initially turned on to prevent transients from reaching the speakers.) A separate thermal protection system shuts down the power supply's transistors if they become too hot, a condition that can occur only following long periods of operation at full power.

The input and output connectors for the amplifier are located on the sides of the cabinet. Only the socket for the plug-in ac power cord is located on the rear apron. The input connectors are gold plated, and a somewhat unconventional insulated pressure connector makes very positive contact with the stripped ends of the speaker cables.

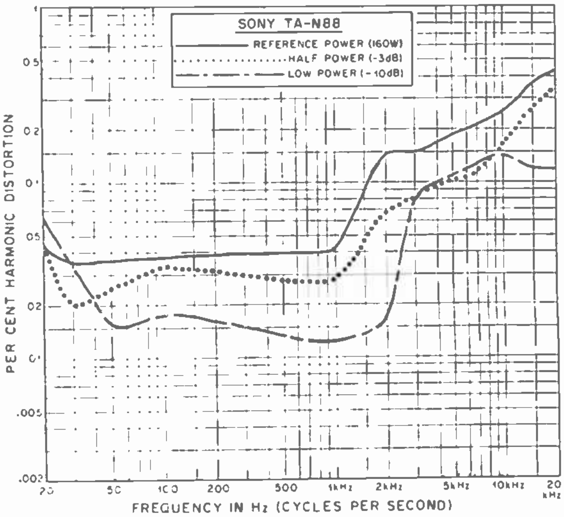
The amplifier is completely devoid of such adornments as meters, lights, control knobs, and switches that are currently a part of conventional amplifier styling. Its front panel contains only a small rotary POWER switch and a barely visible power-on indicator. Metric hex-head screws discourage casual removal of the side panels and protective covers. We removed the bottom plate, but all we were able to see was a heavy copper shield plate fastened to the cast aluminum chassis with an impressive number of screws. This, of course, is necessary to maintain the r-f shielding integrity of the amplifier.

Laboratory Measurements. Unlike conventional amplifiers, the Model TA-N88 does not dissipate its maximum power at about 40% of its rated output. It runs coolest under no-signal conditions, and its power dissipation rises steadily with increasing output power. When we subjected the amplifier to the FTC preconditioning period of 1 hour at 33% rated power (about 53 watts into 8 ohms), it became quite warm due to its small size and lack of heat sinks. But it was no hotter than most similarly rated power amplifiers of conventional design, with large heat sinks.

The 1000-Hz THD was about 0.01% at 1 watt. It increased smoothly with in-



THD and IM distortion at 8 ohms.



Percent harmonic distortion at three power levels at 8 ohms.

creasing power to 0.04% at 100 watts, to 0.075% at the rated 160 watts, and to 0.1% at 180 watts. The output waveform clipped at 200 watts/channel. We noticed a small burst of high-frequency signal, apparently at the 500-kHz switching rate, on the peaks of the audio signal when the output exceeded 150 or 160 watts/channel.

A spectrum analyzer examination of low-level distortion was made to check out a detectable amount of r-f leakage from the pulse signals in the power supply and amplifier circuits. We detected components at 23,000 and 46,000 Hz in the speaker outputs. There were doubtlessly higher harmonics above the 50,000-Hz upper limit of the analyzer. Each of the components we saw was about 72 dB below 1 watt.

The IM distortion varied in much the same way as the harmonic distortion over the power range of the amplifier. It was 0.011% at 0.1 watt, 0.115% at 160 watts, and 0.17% at 180 watts. The amplifier was stable with capacitive loads up to 2 μF in parallel with an 8-ohm resistor load. In fact, we found it beneficial to use about 0.22 μF across the speaker outputs to reduce the level of 500-kHz leakage that was present in sufficient amounts to affect our low-level distortion measurements. (The output reading on a wideband voltmeter was 100 mV with no signal input.)

Although the amplifier is rated primarily for use with 8-ohm loads (with 16 ohms a maximum figure), we checked its performance with 4- and 16-ohm loads. The amplifier delivered 138 watts per channel into 16 ohms. When we checked it with 4-ohm loads, the protective circuits shut down the amplifier at 182 watts, before any visible waveform clipping occurred. An input signal level of 0.11 volt drove the amplifier to a 1-watt output. Amplifier noise in the audio band, unweighted, was 160 μV, or 85 dB below 1 watt.

The distortion at rated power was less than 0.04% from 20 to 1000 Hz. It rose to 0.15% at 2000 Hz, 0.24% at 10,000 Hz, and 0.43% at 20,000 Hz. At half and one-tenth power, the distortion curves were similar, but the measured values were lower. The IHF clipping headroom, referred to 160 watts, was 1.0 dB, and the dynamic headroom was 1.83 dB. (The output on a 20-ms burst was 244 watts at the clipping point.) The output with a 1000-Hz square-wave input signal revealed a few cycles of ringing at an ultrasonic frequency, and we observed a 4-μs risetime. The slew rate of the amplifier was 6 V/μs.

The low-level frequency response of the amplifier was flat within +0/− 0.4 dB from 5 to 10,000 Hz. It was −1.6 dB at 20,000 Hz and +1.6 dB at 40,000 Hz.

Performance Specifications

Specification	**Rating**	**Measured**
Power output (8 ohms)	160 watts per channel, 20–20,000 Hz at less than 0.5% THD	Confirmed
Harmonic distortion	Less than 0.5% at rated output	0.43% (20,000 Hz)
IM distortion	Less than 0.1% at rated output	0.115%
Frequency response	5 Hz to 40 kHz, +0.5/−1 dB (8 ohms)	±1.6 dB
S/N ratio	Noise less than 100 μV (8 ohms, A-weighted)	160 μV unweighted (audio band)
Damping factor	20 (8 ohms at 1000 Hz)	Not Measured
Input	1.4 V for rated output 50,000 ohms	0.11 V for 1 watt
Output	Speakers, 8–16 ohms	

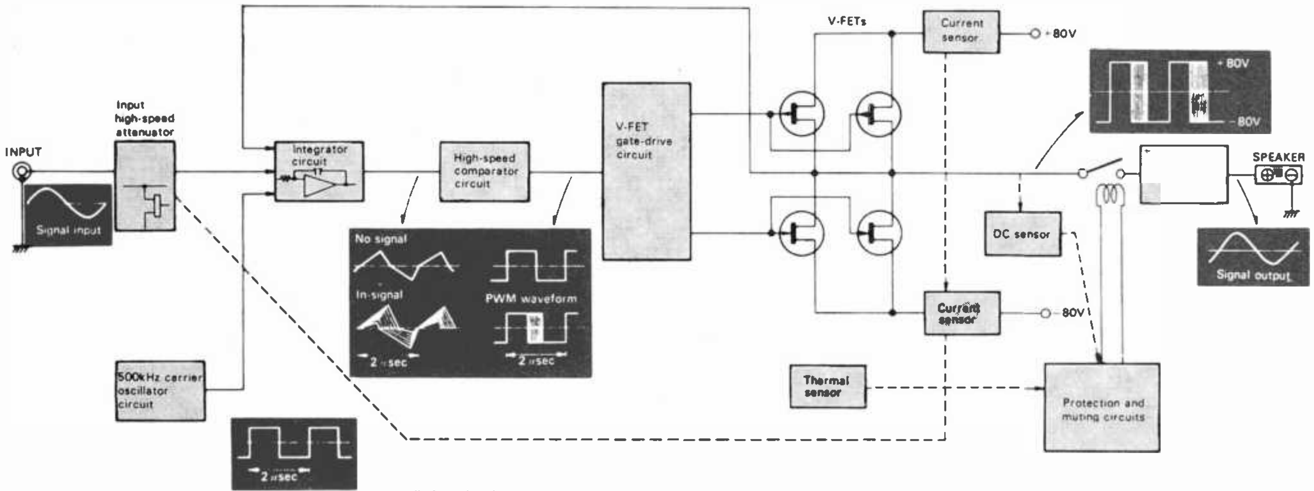
Sony's Model TA-N88 is a class-D amplifier that employs pulse width modulation (PWM). Class-D circuits function like switches. They are either fully on or completely cut off. Consequently, there is no wasted energy. The circuits convert relative amplitude into time. The higher the amplitude of a signal, the longer the time during which current flows. This time is called the "pulse width." The output from the Class-D system is a train of square waves of varying widths.

An internal 500-kHz oscillator, common to both channels, develops a carrier that is converted to a square-wave signal by a differential clipping amplifier. It is then converted to a sawtooth waveform by an integrator and summed linearly with the audio input signal. The composite signal is continuously compared to a precision reference voltage in the next stage. The output of the comparator is a square-wave signal whose duty cycle is determined by the instantaneous amplitude and polarity of the input signal's waveform.

After further amplification, the PWM signal drives an output stage that consists of four vertical-FET (VFET) transistors connected in push-pull parallel. The VFET's are driven into saturation and cutoff by the PWM signal. They have a very fast (50-ns) switching time. The 160-volt peak-to-peak output square-wave signal then goes through a low-pass filter that removes the ultrasonic component, leaving the amplified audio signal to drive the speaker systems. Since the passband's flatness directly affects the amplifier's overall frequency response, the filter is designed to have a flat response to 40,000 Hz when terminated in 8 ohms and to have a high rejection at 500 kHz and above.

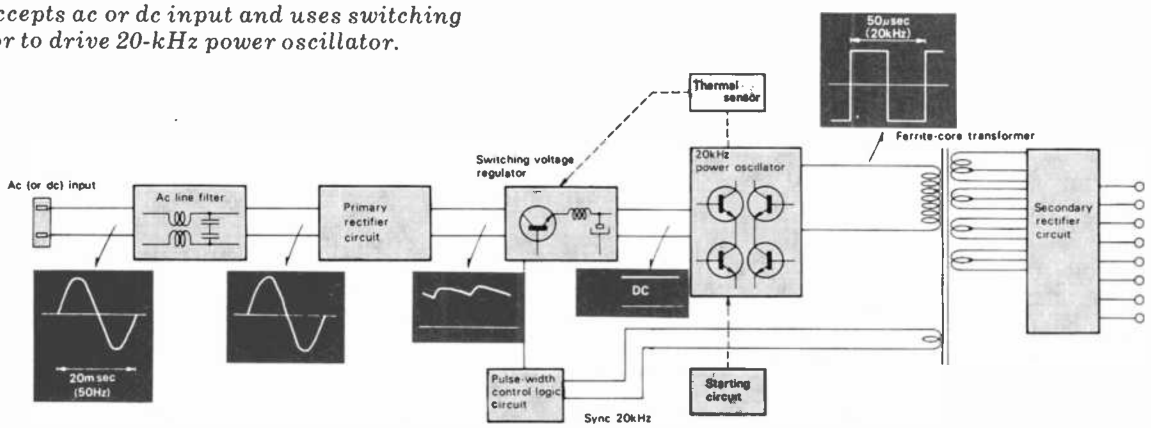
The amplifier is operated from a high-frequency switching power supply that eliminates the need for a heavy power transformer and huge filter capacitors that are part of every conventional high-power amplifier. The ac line voltage goes directly to a rectifier that supplies a dc output between 110 and 140 volts. After passing through a switching voltage regulator, which maintains a constant 110-volt dc output, it powers a 20-kHz oscillator whose circuit includes a ferrite-core transformer. A winding on this transformer supplies the feedback control voltage to the regulator stage so that the voltage induced into its other secondary windings is maintained constant over a wide range of line-voltage variations. (The transformer and oscillator are capable of supplying far more power than the amplifier circuits ever require, and there is no problem with regulation during changes in load impedance.) The output of the principal secondary winding is rectified by a second rectifier to produce ±80 volts dc for the VFET's. Other windings supply lower voltages to the other stages in the amplifier.

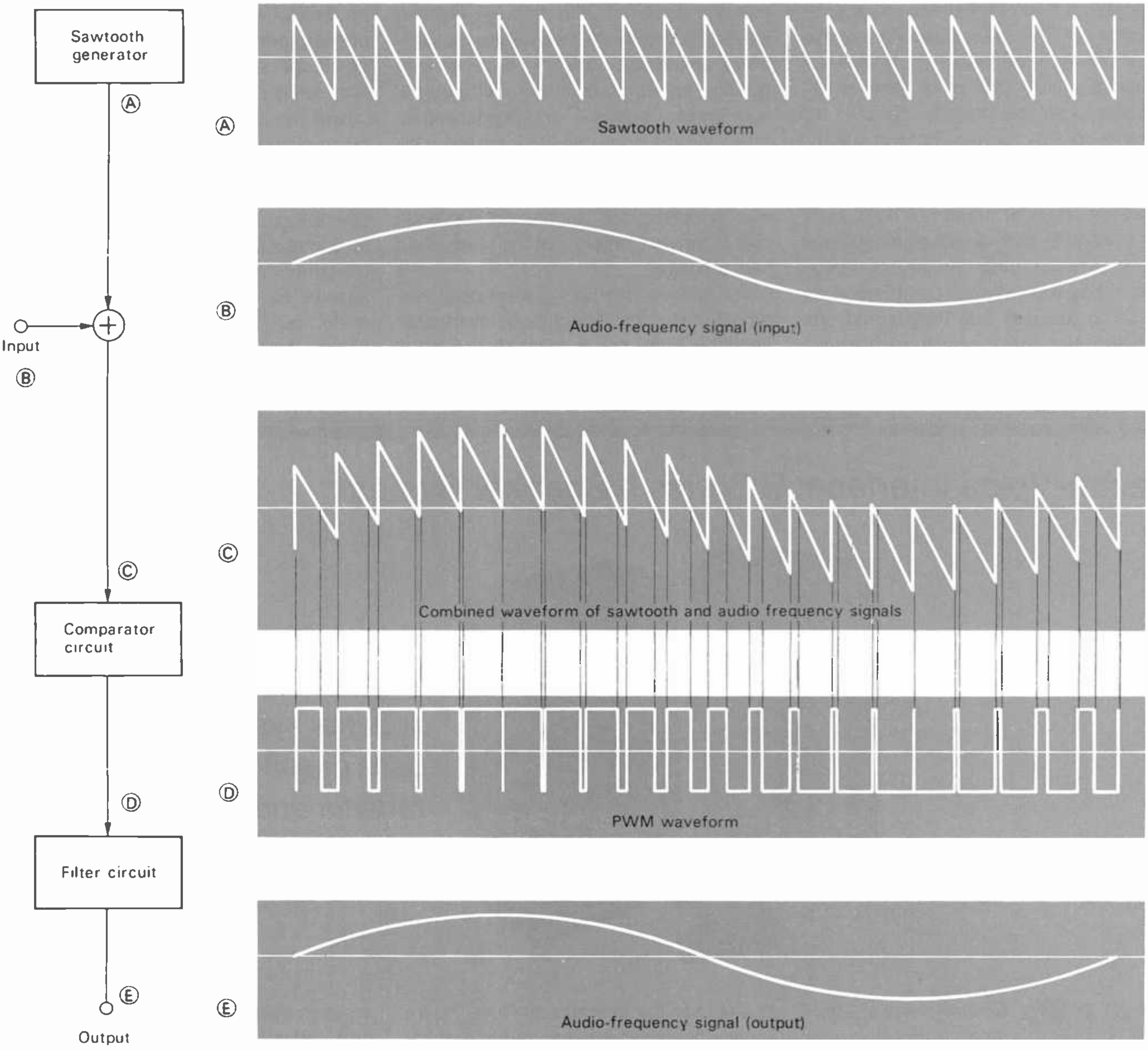
Compared to a conventional 60-Hz power supply, the switching supply in this amplifier is far lighter and smaller. Like the amplifier itself, however, the power supply must be carefully shielded and filtered to prevent harmonics of the 20-kHz switching frequency from leaking out. Because the power supply is a true dc-to-dc converter, it can operate with equal effectiveness from ac line inputs of 90 to 130 volts over a power frequency range from 50 to 400 Hz or a 110-to-140-volt dc supply.



Block diagram of power amplifier showing push-pull parallel VFET's. Analog input is converted to variable-width pulses to drive power output stage, after which low-pass filter removes carrier component.

Power supply accepts ac or dc input and uses switching voltage regulator to drive 20-kHz power oscillator.





Basic block diagram and waveforms resulting from pulse-width modulation.

These measurements were made with an 8-ohm resistive load. There were additional response "ripples" at higher frequencies, to +3.9 dB at 50,000 Hz and −4.1 dB at 100 kHz.

User Comment. The amplifier was impressively cool in normal operation. In fact, after hours of driving low-efficiency 4-ohm speaker systems to rather high levels, its exterior was almost cool.

The amplifier's sound was as conventional as its circuits are unconventional. We found no peculiarities or distinguishing characteristics in its sound quality, which was clean and free from extraneous noises and obviously backed by considerable power. There were no turn-on or turn-off transients. Since it requires no particular amount of ventilation and does not become hot in use, it could presumably be placed in some location where a conventional amplifier could not be safely operated.

We did discover a weakness in the behavior of our amplifier test sample. It radiated enough energy at harmonics of the switching frequencies to interfere with radio reception under some conditions. The harmonics of the power supply circuitry's frequency produced "birdies" every 23 kHz across the AM broadcast band. And there was enough high-order harmonic output from the amplifier's switching frequency to cause "hash" in the background of many FM signals as well. These effects were audible only when the receiving antenna, an indoor dipole, was within a few feet of the unshielded speaker cables. Locating the tuner and amplifier across the room from the speaker systems so that the cables did not come close to the antenna cured the problem, even though the tuner and amplifier were within a few feet of each other. The noise remained on AM, however.

We have been assured by Sony that this is not typical behavior of the Model TA-N88 amplifier. (Our test model had a very low serial number and was evidently from a pilot production run.)

Some people who have become accustomed to the unmeasurably low distortion and frequency-response variations of some of the better conventional separate power amplifiers may look askance at the specifications of the Model TA-N88 amplifier. Its frequency response, unlike that of an ideal linear amplifier, can be directly affected to some degree by the variations in speaker-system impedance that occur at the higher end of the audio range. These variations might or might not be detectable in an A-B comparison against other amplifiers with some speaker systems. Even if they were detectable, there is no reason to assume that they would detract from the sound quality of the system. To us, there was no evidence of any response aberrations when listening to the amplifier with several types of speaker systems, although we did not attempt to make A-B comparisons with other amplifiers. Similarly, the high-frequency harmonic distortion, although it was greater than we have measured in other top-ranking amplifiers, is still well below the threshold of audibility. Anyone who is more concerned with sound than with specifications will find little to criticize in the performance of the Model TA-N88 amplifier.

We believe that the significance of this amplifier is not in its actual performance (which is fine), but in its small size, cool operation, and in what it portends for the future. It is really remarkable to see and hear how much clean audio power can be delivered by this very compact piece of equipment. The amp can be stowed in small spaces where no other type can. Accordingly, we can visualize a high-power receiver in the near future with a pulse-width-modulation amplifier tucked away into its compact interior. It is obvious, however, that a sizable price reduction will be required for such amplifiers to come into common use, but we are confident that technology will provide an answer to this in due course. Meanwhile, our compliments to Sony's research and development engineers in Shibaura, Tokyo.

CIRCLE NO 101 ON FREE INFORMATION CARD

Electro-Voice Interface: B Series II Speaker System

High-efficiency, vented, floor speaker system uses passive radiator and equalizer for extended bass response.

HIRSCH-HOUCK LABS REPORT

Electro-Voice's Interface series was among the first commercial speaker systems to be based on the analysis of vented loudspeaker operation published by the Australian A.N. Thiele. Thiele showed how to establish the detailed interrelationships between enclosure volume, port dimensions, low-frequency response, speaker efficiency, and driver parameters. His work effectively dispelled the belief that vented (bass-reflex) enclosures were necessarily an inferior approach to generating clean low-frequency audio.

When the original E-V Interface:A appeared several years ago, it was widely recognized for the fine bass performance it delivered from a very small enclosure, with assistance from an outboard equalizer. E-V later added the Interface:B, which was larger and more efficient than the Interface:A. Now, the Interface line has been expanded and improved. It consists of four models designated as the "Series II."

The Interface:B Series II reviewed here is a medium-size floor-standing speaker system that's sold in pairs with a separate, special-purpose equalizer. Compared to the original Interface:B, the Series II's midrange response is flatter, and its deep-bass response is slightly better. It's also somewhat larger. The system's walnut-finished cabinet measures 29¼"H × 16"W × 10¼"D (74.3 × 40.6 × 26 cm) and weighs 42 lb (19.1 kg). The suggested retail price of a complete Interface:B Series II stereo speaker system, consisting of two speaker systems and an equalizer, is $675.

General Description. The Series II is basically a two-way speaker system. It contains an 8" (20.3-cm) woofer that crosses over at 1500 Hz to a 2½" (6.35-cm) tweeter. This tweeter radiates through a felt- and plastic-foam acoustic lens to improve its dispersion at high frequencies. A second similar tweeter, this time without the lens, radiates from the rear of the enclosure at frequencies beyond 8000 Hz to augment the output in the highest audible octave.

The Series II is a vented system. To obtain the desired 30-Hz bass response in an enclosure of its compact size, however, would normally require an impossibly large vent. E-V's solution, following Thiele's guidelines, has been to use what the company calls a "vent substitute," or passive radiator, instead of an open port. The passive radiator looks much like a conventional 12" (30.5-cm) driver sans voice coil and magnet, but with a large metal plug in its center to increase its mass. The effective *acoustic* crossover from the 8" driven woofer to

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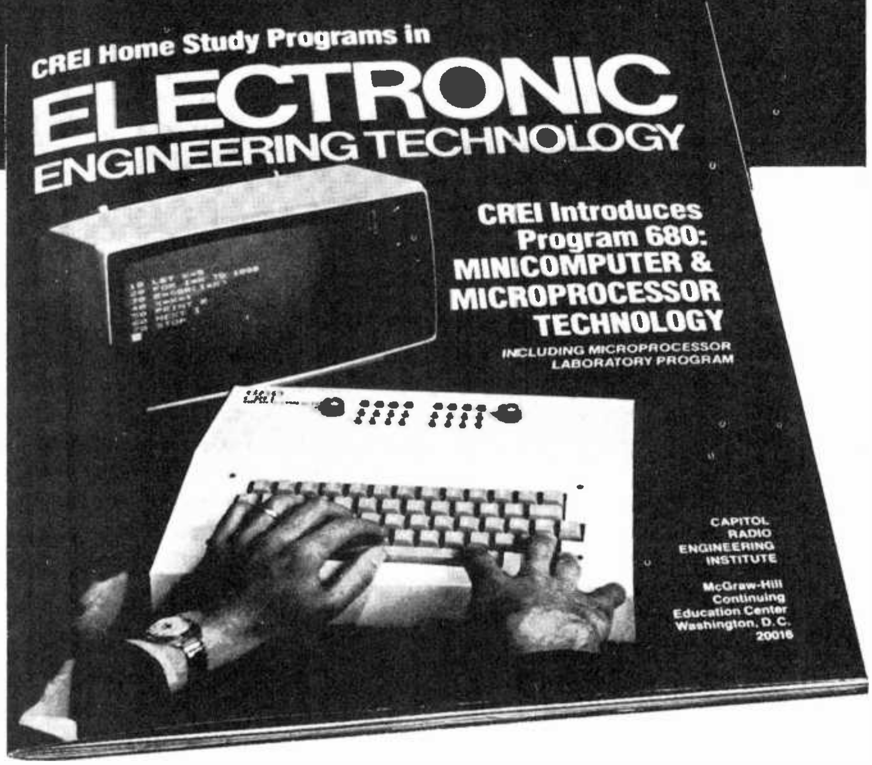

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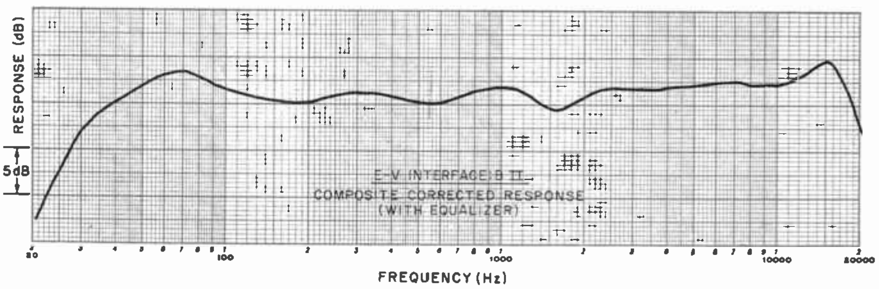
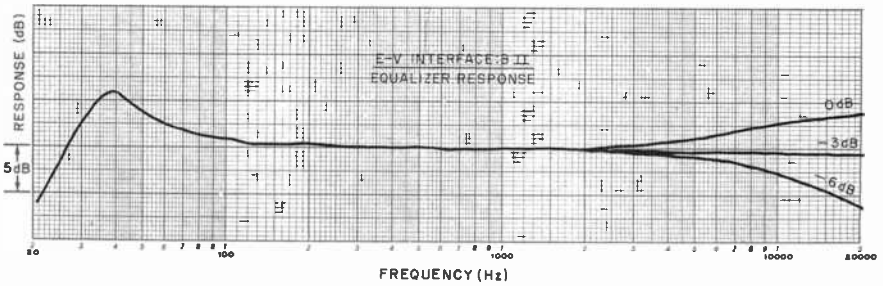
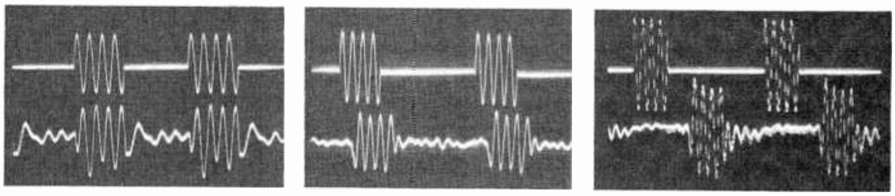


Composite corrected response curve with equalizer.



Curves show effect of equalizer control set at 0, −3 and −6 dB.



Tone-burst responses (from left to right) at 100, 1000 and 10,000 Hz.

the passive cone is at 42 Hz.

To obtain the desired bass response from this combination of radiators would normally require an enclosure with about twice the volume of that used for the Series II. To circumvent this problem, E-V uses an equalizer that boosts the bass response by 6 dB at 35 Hz and has a gradual and mild high-frequency boost to flatten out the overall response. (Three different high-frequency response curves are selected by a switch on the equalizer's panel.)

The unity-gain equalizer can be connected into the tape-monitoring loop of an amplifier or between the preamplifier and power amplifier. It has a duplicate set of tape-monitor jacks and a switch so that the monitoring function is not lost if the equalizer is inserted in the tape path. The equalizer has negligible noise and distortion and accepts up to a 7-volt input in the midrange without distortion.

Another important function of the equalizer is to sharply reduce the system's response at infrasonic frequencies below 30 Hz, which is the system's designed lower limit. Otherwise, a large-amplitude low-frequency signal, such as might occur if a pickup were dropped onto a record with the volume control turned up, could damage the woofer. (A vented woofer is not loaded by the air in the room at very low frequencies.)

One of the benefits of a vented system is its relatively high efficiency, compared to an acoustic-suspension system. The Series II is claimed to be at least 6 dB more efficient than a comparable acoustic-suspension speaker system, yet is said to be able to handle the full output of a 200-watt amplifier in the midrange without being damaged. Built into each speaker system is a tweeter "protector" that consists of a bridge rectifier whose output operates a fast-acting relay. When the relay trips, it instantly reduces the drive level to the tweeter. The time constant of the protective circuit has been set to pass transients of less than 10 ms duration, regardless of their amplitude, but to trip at much lower levels on sustained high-frequency signals. When the protector trips, a light comes on at the lower right corner of the grille. Since its effect is only to reduce the high-frequency level rather than interrupt it completely, it has a small audible effect.

The nominal rated impedance of the Interface:B Series II speaker system is 8 ohms. Its minimum rated is 5 ohms.

Laboratory Measurements. We measured the system's frequency response in the semireverberant field of our listening room. We then averaged the response curves from the two drivers to obtain a total response curve. The low-frequency response was measured with close microphone spacing to simulate anechoic chamber conditions. At all times, our pair of speaker systems was driven through the equalizer to allow us to test the performance of the complete system.

With the high-frequency level on the equalizer set to the 0-dB maximum, the overall response was within ±3 dB from 33 to 18,500 Hz, which was remarkably close to E-V's specification. The high-frequency dispersion was excellent, with only about 3 dB difference between the response curves taken on-axis and 30° off-axis at frequencies beyond 10,000 Hz.

We measured the frequency response of the equalizer separately. It, too, closely matched the published specification. The effective acoustic crossover between the driven woofer and the passive radiator was at 45 Hz. There was a slight bass peak of 2 to 3 dB at 70 Hz. Otherwise, the response was very smooth, and there was close agreement between the bass and mid-range/high-frequency curves when they were matched. In particular, we were struck by the flat response of ±1.5 dB from 80 to 10,000 Hz, with no sign of the lower-midrange peak or dip that colors the sound of many speaker systems.

When we drove the speaker system with a constant-amplitude input voltage (at the equalizer input), corresponding to a 1-watt speaker drive in the midrange, the system's distortion was less than 1% between 50 and 100 Hz. The distortion rose slowly to 2% at 40 Hz and 8.5% at 20 Hz. A 10-dB increase in drive level raised the distortion to 1.7% at 100 Hz and to 4.5% at 30 Hz before it rose sharply at lower frequencies. The distortion was measured at the driven cone for frequencies beyond 50 Hz and at the passive cone at frequencies below 40 Hz, where the passive cone contributes most of the output.

The speaker system's impedance, according to our measurements, should be rated at 4 ohms, which was the measured value at 33 Hz and between 150

Performance Specifications

Specification	Rating	Measured
Frequency response (anechoic)	30–18,000 Hz ±3 dB	33–18,500 Hz ±3 dB
Total acoustic power output (SPL at 1 meter, 1 W in.)	92 dB	92.5 dB
Recommended amplifier power	3.6 to 200 watts	
Long-term average power handling capacities		
30–1500 Hz	20 watts	
1500–20,000 Hz	20 watts, to 5 watts/10 kHz	
Crossover frequencies	42 Hz (acoustic) 1500 Hz and 800 Hz (electrical)	
Impedance: nominal	8 ohms	4 ohms
minimum	5 ohms	4 ohms
Equalizer		
Midband gain	1.0	
Maximum equalization	6 dB @ 35 Hz fixed	Confirmed
Maximum input signal		
80–3000 Hz	7 volts	
35–20,000 Hz	3.5 volts	
Noise output (20–20,000 Hz)	−80 dB re 200 mV	
THD (3.5 V rms input)	Less than 0.05% 20–20,000 Hz	
Accessory outlet	200 watts, unswitched	
Dimensions	2 × 8 × 7 in.	

and 200 Hz. The impedance was 12 ohms at the 22-Hz lower-bass resonance, 20 ohms at 58 Hz, and 18 ohms at 2200 Hz. At other frequencies, it was typically 7 to 8 ohms. The system's toneburst response, although not exceptional, was good throughout. Its efficiency was very high, as claimed: An input of 2.8 volts of random noise in the octave centered at 1000 Hz, corresponding to 1 watt into 8 ohms, produced a 92.5-dB sound pressure level (SPL) at a distance of 1 meter from the grille.

User Comment. Before we measured the response of this speaker system, we spent some time listening to it alone and in comparisons with other good speaker systems we had on hand. Hence, our test results came as no surprise.

This speaker system has a delightfully smooth and transparent sound. Many if not most speaker systems have sufficient coloration in the lower midrange and upper-bass range, between 80 and 200 Hz, to make voices sound unnatural and in general impair the clarity of music reproduced. This one, however, is about as flat throughout this range as any speaker system known to us.

The system's low bass is clean and powerful, with no trace of artificial heaviness. The highs are strong and crisp, without ever being strident or overbearing. E-V points out that the −3-dB equalizer setting would be considered as "normal" by many people and probably gives the best overall sound with most high-quality recordings. The 0-dB setting can give startlingly realistic effects with the finest source material, but it can be merciless in revealing any faults in the program itself. Very few speaker systems are capable of delivering the flat response to the highest audible frequencies that the Series II does with its 0-dB setting. It is worth hearing even if it is too much for ordinary listening. Although we drove the Series II to very high levels from a 200-watt amplifier, we never tripped its tweeter protector.

In conclusion, E-V's Interface: B Series II is a speaker system we really enjoyed listening to. The Interface:B, with its equalizer, is certainly worthy of serious consideration for matching to any low-power to medium-high-power amplifier.

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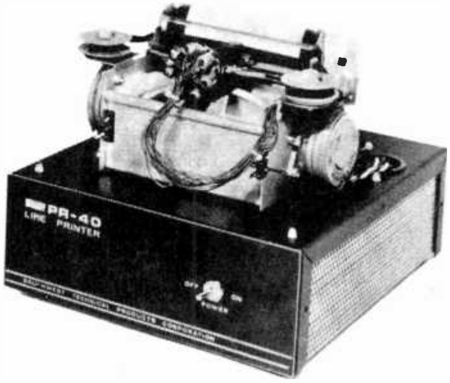

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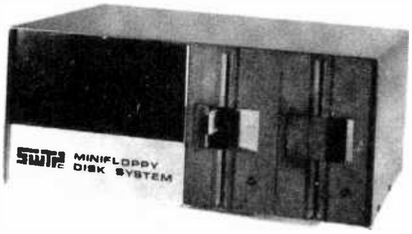

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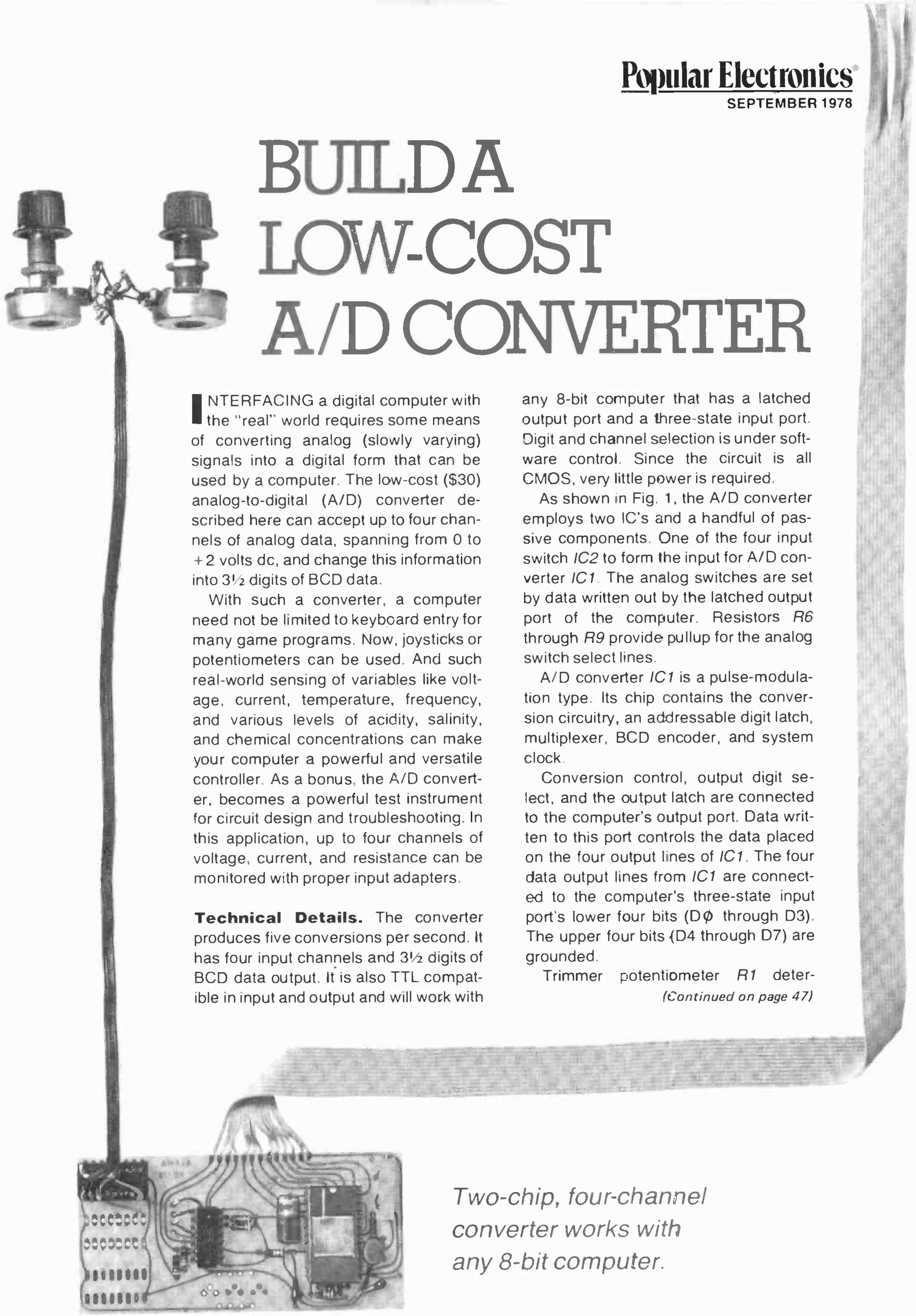


INTERFACING a digital computer with the "real" world requires some means of converting analog (slowly varying) signals into a digital form that can be used by a computer. The low-cost ($30) analog-to-digital (A/D) converter described here can accept up to four channels of analog data, spanning from 0 to +2 volts dc, and change this information into 3½ digits of BCD data.

With such a converter, a computer need not be limited to keyboard entry for many game programs. Now, joysticks or potentiometers can be used. And such real-world sensing of variables like voltage, current, temperature, frequency, and various levels of acidity, salinity, and chemical concentrations can make your computer a powerful and versatile controller. As a bonus, the A/D converter, becomes a powerful test instrument for circuit design and troubleshooting. In this application, up to four channels of voltage, current, and resistance can be monitored with proper input adapters.

Technical Details. The converter produces five conversions per second. It has four input channels and 3½ digits of BCD data output. It is also TTL compatible in input and output and will work with any 8-bit computer that has a latched output port and a three-state input port. Digit and channel selection is under software control. Since the circuit is all CMOS, very little power is required.

As shown in Fig. 1, the A/D converter employs two IC's and a handful of passive components. One of the four input switch *IC2* to form the input for A/D converter *IC1*. The analog switches are set by data written out by the latched output port of the computer. Resistors *R6* through *R9* provide pullup for the analog switch select lines.

A/D converter *IC1* is a pulse-modulation type. Its chip contains the conversion circuitry, an addressable digit latch, multiplexer, BCD encoder, and system clock.

Conversion control, output digit select, and the output latch are connected to the computer's output port. Data written to this port controls the data placed on the four output lines of *IC1*. The four data output lines from *IC1* are connected to the computer's three-state input port's lower four bits (D0 through D3). The upper four bits (D4 through D7) are grounded.

Trimmer potentiometer *R1* deter-

(Continued on page 47)

Two-chip, four-channel converter works with any 8-bit computer.

BY W. L. GREEN

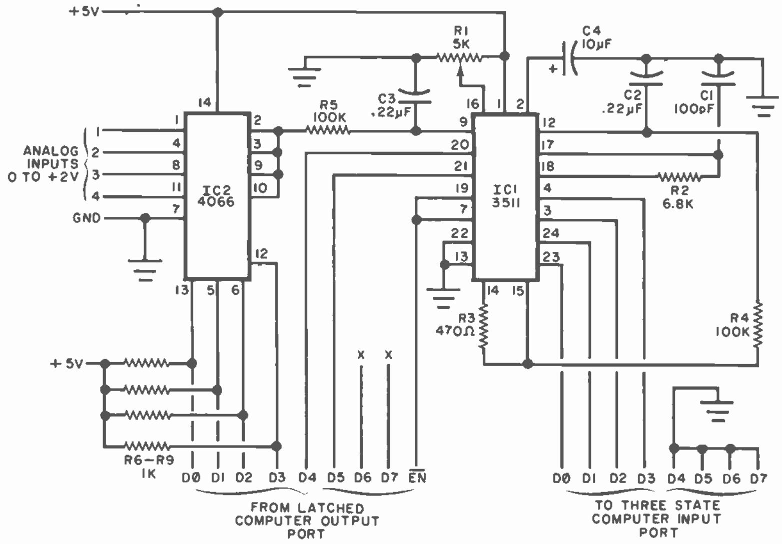
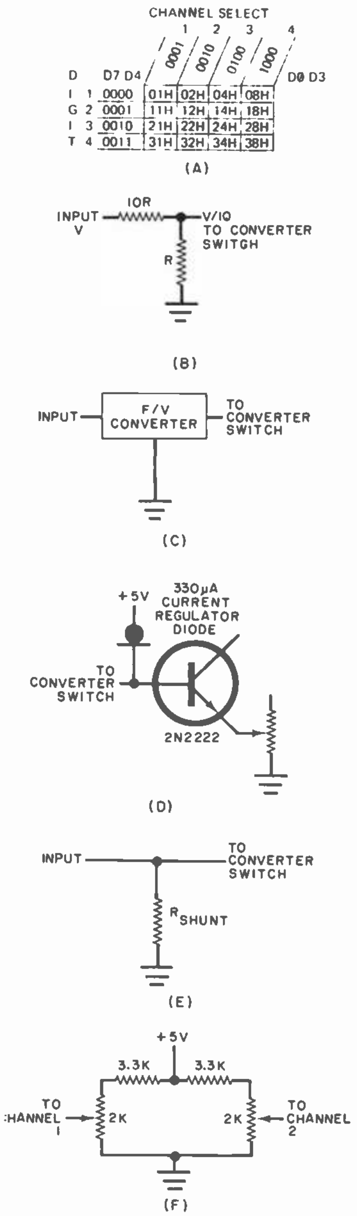


Fig. 1. Analog switch IC2 selects the input drive for A/D converter IC1. Up to four inputs can be used.

PARTS LIST

C1—100-pF disc
C2, C3—0.22-µF, 10-volt Mylar
C4—10-µF, 10-volt electrolytic
IC1—3511 A/D converter (National)
IC2—4066 quad analog switch
R1—5000-ohm, 10-turn trimmer pot.
R2—6800-ohm, ¼-watt resistor
R3—470-ohm, ¼-watt resistor
R4, R5—100,000 ohm, ¼-watt resistor
R6 through R9—1000-ohm, ¼-watt resistor
Misc.—Printed circuit board; edge connector; multilead ribbon connector; IC sockets (optional); hookup wire; solder; etc.

Note—The following is available from Alpha Electronics, Box 1005, Merritt Island, FL 32952 (tel. 305-453-3534): complete kit of parts, excluding wire and sockets, No. A/D4. for $29.95 plus 3.50 postage and handling. Also available separately: pc board No. PC178 for $9.00 + 1.00 p&h; and IC1, No. 3511, for $15.00 + 1.00 p&h.



CHANNEL SELECT

D		D7 D4	1 0001	2 0010	3 0100	4 1000
I	1	0000	01H	02H	04H	08H
G	2	0001	11H	12H	14H	18H
I	3	0010	21H	22H	24H	28H
T	4	0011	31H	32H	34H	38H

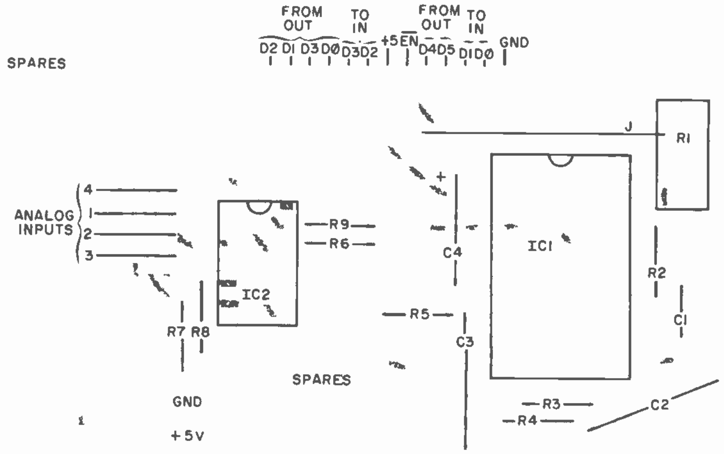


Fig. 3. Actual-size foil pattern (below) and component layout (above).

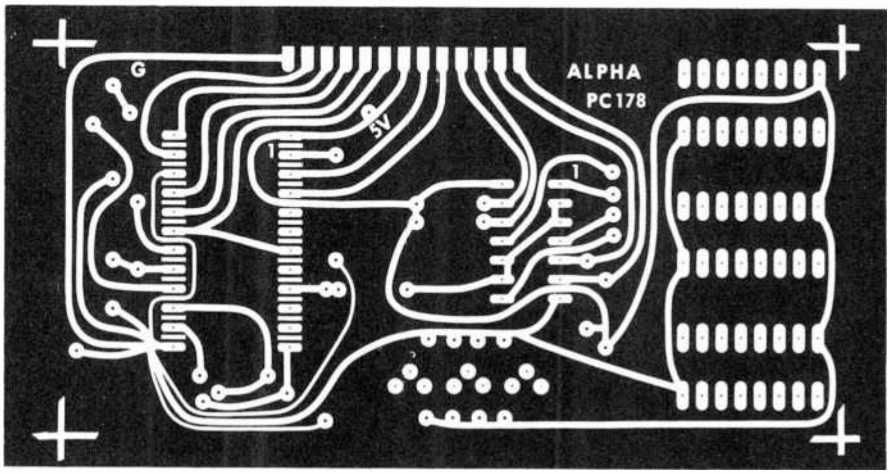


Fig. 2. Channel-digit select is shown at (A); a 10:1 voltage divider is at (B); a frequency-to-voltage scheme at (C); temperature converter (D); current measurement (E); and joystick input (F).

TABLE I—8080 ASSEMBLY LISTING

Assembly listing for 8080 (IMSAI). Inputs three most significant digits and writes to front panel.

```
4000    3E 11      BGN     MVI     A, 11H     Load A with Dig2, Ch1
4002    CD 38 40           CALL    INPUT
4005    32 35 40           STA     DIG2
4008    3E 21              MVI     A, 21H     Dig3, Ch1
400A    CD 38 40           CALL    INPUT
400D    32 36 40           STA     DIG3
4010    3E 31              MVI     A, 31H     Dig4, Ch1
4012    CD 38 40           CALL    INPUT
4015    32 37 40           STA     DIG4
4018    3E 00              MVI     A, 00H
401A    2A 35 40           LHLD    DIG2       Dig2  L,  Dig3  H
401D    BC                 CMP     H          Compare H for 0
401E    06 00              MVI     B, 00H     Clear B
4020    C4 4A 40           CNZ     SUB        Gosub if H≠0
4023    3A 37 40           LDA     DIG4
4026    FE 00              CPI     00H
4028    CA 2D 40           JZ      WRT        If A≠0, fall thru
402B    3E 64              MVI     A, 64H
402D    80         WRT     ADD     B          A=A+B
402E    2F                 CMA                Invert data
402F    D3 FF              OUT     0FFH       Write it
4031    C3 00 40           JMP     BGN        Do again
4034               STR     DS      01
4035               DIG2    DS      01
4036               DIG3    DS      01
4037               DIG4    DS      01
4038    D310       INPUT   OUT     10H        Setup port 10H
403A    CD 40 40           CALL    DLY        A/D settling time
403D    DB 10              IN      10H        Input A/D data
403F    C9                 RET
4040    11 00 30   DLY     LXI     D, 3000H   200-ms delay
4043    1B         UP      DCX     D
4044    7A                 MOV     A, D
4045    B3                 ORA     E
4046    C2 43 40           JNZ     UP         If D>0 do again
4049    C9                 RET
404A    C6 0A      SUB     ADI     0AH        A+A+0AH
404C    25                 DCR     H          H=H−1
404D    C2 4A 40           JNZ     SUB        If H>0, do again
4050    85                 ADD     L          A=A+L
5051    47                 MOV     B, A       B=A
4052    C9                 RET
4053    76                 HLT
```

TABLE II—6800 OP CODE LISTING

Op code listing for 6800. Inputs four digits from channel 1 and stores data in memory in BCD format.

```
01    BDN      LDAA    01H       Load digit 1, channel 1 into A
02             BSR     INPUT
03             STAA    DIG1      Store A in memory
04             LDAA    11H
05             BSR     INPUT
06             STAA    DIG2
07             LDAA    21H
08             BSR     INPUT
09             STAA    DIG3
10             LDAA    31H
11             BSR     INPUT
12             STAA    DIG4
13             JMP     BGN       Do again
14    DIG1     RES     01        Res —reserves one byte of memory
15    DIG2     RES     01
16    DIG3     RES     01
17    DIG4     RES     01
18    INPUT    STAA    insert    output port #
19             BSR     DLY       200—ms delay for A/D settling
20             LDAA    insert    input port #
21             RTS
22    DLY      LDAA    --        enter values here and 23 to create
23    UP       LDAB    -         a 200—ms delay
24    UP1      SUBB    01
25             BGT     UP1       do until B=0
26             SUBA    01
27             BGT     UP        do until A=0
28             RTS
```

TABLE III—ASSEMBLY LISTING FOR 2650

Assembly listing for 2650 (Central Data). Inputs three most significant digits and writes to data bus on WRTD instruction. Converts to hex before outputting data.

```
1600    75 FF              CPSL      FF       Clear PSL and setup register
                                                                    bank 0
1602    05 11     BGN      LODI, 1   11       Setup for channel 1, digit 2
1604    3B 20              BSTR, 3   INPUT
1606    CA 1B              STRR, 2   DIG2
1608    05 21              LODI, 1   21
160A    3B 1A              BSTR, 3   INPUT
160C    CA 16              STRR, 2   DIG3
160E    05 31              LODI, 1   31
1610    3B 14              BSTR, 3   INPUT
1612    CA 11              STRR, 2   DIG4
1614    08 0D              LODR, 0   DIG2
1616    0B 0C              LODR, 3   DIG3
1618    B8 24              BSFR, 0   SUB      BR if DIG3≠0
161A    0B 09              LODR, 3   DIG4
161C    18 02              BCTR, 0   WRT      BR if DIG4=0
161E    84 64              ADDI, 0   64
1620    F0        WRT      WRTD, 0            Write it
1621    1B 5F              BCTR, 3   BGN      do again
1623    00        DIG2     RES       01       RES 01 reserve one byte
1624    00        DIG3     RES       01
1625    00        DIG4     RES       01
1626    D5 00     INPUT    WRTE, 1   00       Setup port 00
1628    3B 03              BSTR, 3   DLY      A/D settling time delay
162A    56 00              REDE, 2   00       read port 00 into R2
162C    17                 RETC, 3
162D    77 10     DLY      PPSL      10       select register bank 01
162F    05 FF              LODI, 1   FF       gives 200 ms delay with 1633
1631    A5 01     UP       SUBI, 1   01
1633    06 40              LODI, 2   40
1635    A6 01     UPI      SUBI, 2   01
1637    5A 7C              BRNR, 2   UP1      do again until R2=0
1639    59 76              BRNR, 1   UP       do until R1=0
163B    75 10              CPSL      10       select register bank 00
163D    17                 RETC, 3
163E    A7 01     SUB      SUBI, 3   01       R3=R3-1; converts BCD to hex
1640    84 0A              ADDI, 0   0A       R0=R0+0A
1642    5B 7A              BRNR, 3   SUB      do until R3=0
1644    17                 RETC, 3
1645    40                 HALT
```

(Continued from page 45)

mines the reference voltage used by *IC1*. The other passive components determine clock frequency, provide signal filtering, and interconnect *IC1*.

Software. The digit and channel select codes are shown in Fig. 2A. The values shown are in hexadecimal code. To use the table, move down the rows until the proper digit is located. Then move over until the proper channel is located. The hex number at this point is the data to be written to the output port to set up the converter. The strobe that enables the output port (EN) must be active low when connected to the converter. If necessary, an inverter can be wired into the circuit to perform the inversion.

When reading data from the converter, it is necessary to access only the correct input port. Examples of programs written for an 8080, 6800, and 2650 are shown in Tables I through III. The program flow is essentially the same for any 8-bit computer. The digit/channel information is loaded into a register and then the program is stepped to a subroutine (INPUT) and outputs that register to the output port. A 200-ms delay (DLY) subroutine is used to allow the A/D converter to settle. Then the data is read from the input port into a register.

Upon returning from the INPUT subroutine, the BCD digit is stored in memory (DIGX) and is repeated for each digit required before branching back to the

TABLE IV—BASIC SAM GAME

SAM (surface-to-air missile) GAME
Central Data Basic (2650)

```
0000          RESTORE
0010          READ, R, W, M, P, Z
0020          DATA 0, -1, 0, 11, 0   REM sets up port 0, chan#1, digit#3
0100          EXTOUT 0, 33
0105          X=SIN(1)   REM delay for A/D settling
0110          EXTIN 0, B   REM reads port 0, chan#1, digit#3 into B
0120          EXTOUT 0, 49
0125          EXTIN 0, A
0130          EXTOUT 0, 34
0135          X=SIN(1)
0140          EXTIN 0, D
0150          EXTOUT 0, 50
0155          EXTIN 0, C
0160          A=INT (A*10+B)*.8)+1
0165          C=(C*10+D)*4
0170          ERASE   REM clears screen
0175          IF R>17 GOTO 1010
0200          W=W+1
0210          P=P-1
0220          IF W>10 W=10
0230          IF P<0 P=0
0240          PRINT@14, 15' MISSILES FIRED'#W
0250          PRINT@15, 15' MISSILES LEFT'#P
0300          PRINT@13, 9'I'
0310          PRINT@14, 8'I'
0320          PRINT@15, 5'IIIII'
0330          PRINT@10, 50'I I I'
0340          PRINT@11, 50'IIIIIII'
0400          Z=Z+4
0410          Y=1+INT(RND(7))
0500          PRINT@Y, Z'++++++'
0510          PRINT@Y-1, Z'    +'
0520          PRINT@Y+1, Z'    +'
0530          IF Z>50 GOTO 0900
0600          READ Q, V, L
0610          DATA 12, 9, 1
0620          RESTORE 0610
0630          IF W=0 GOTO 0800
0640          PRINT@Q, V'↑'
0650          IF C+1>19 L=3
0660          IF C+1>31 L=6
0670          IF V>C+1 V=V-1
0680          IF V<C+1 V=V+L
0700          Q=Q-1
0710          IF Q=A IF V=C+1 GOTO 0740
0720          IF Q<A GOTO 0740
0730          GOTO 0640
0740          PRINT@A, C+1'X'
0800          PRINT@14, 40'TARGET: RANGE'#Y' BEARING'#Z
0810          PRINT@15; 40'MISSILE: RANGE'#A' BEARING'#C+1
0820          IF C>Z IF C<Z+6 GOTO 0880
0825          IF P=0 M=1
0830          IF M=1 GOTO 0170
0835          IF R>0 GOTO 0850
0840          INPUT'    FIRE'R
0845          IF R=22 GOTO 0100
0850          R=R-1
0860          IF R<0 GOTO 0800
0870          GOTO 0100
0880          PRINT@A.C+1'X DESTROYED'
0890          PRINT@15, 5
0895          GOTO 1000
0900          PRINT@11, 50'DESTROYED'
0910          PRINT@15, 5
1000          STOP
1010          PRINT@A, C+1'X'
1020          PRINT@15, 40'MISSILE:   RANGE'#A'   BEARING'=C+1
1030          R=R-1
1040          IF R>17 GOTO 0100
1050          R=0
1060          GOTO 0840
1070          END
```

This program prints a missile launching site, a factory, an airplane (bomber), and a printout of the airplane's and missile's range and bearing. When FIRE appears at the bottom of the screen, type a number (1 through 10) for the number of missiles you wish to fire. The missiles will fire in sequence. Type 22 to clear the screen and display the missile range and bearing adjustments. You may then adjust the controls to alter these values. After 5 shots, the program will return to FIRE. If you input 1 (CRLF), then carriage-return/line-feed, an arrow will print the track of the missile until it reaches its range, and an X will appear to simulate an explosion. The object is to hit the plane on its fuselage, in which case, X DESTROYED will be printed. You have 10 missiles. If you do not destroy the plane in 10 shots, or if the plane reaches space 50 on the screen before you destroy it, the plane will destroy the factory. The aircraft will progress across the screen at the rate of 4 spaces for each missile fired. However, the plane will move up and down by a random amount (line 0410 controls this).

Note that the FIRE 22 routine does not subtract from the missiles remaining, but you cannot destroy the plane in this routine either. All entries must be followed by CRLF. After each missile is fired, and FIRE is displayed, you can adjust the range and bearing controls to alter the missiles course and range.

beginning (BGN). The 8080 listing also includes a routine to convert the three most significant digits into hex code and place the result in storage (STR). When programming, allow for the fact that this data has no decimal point.

Some typical input adapters are shown in Fig. 2B through 2F; B, C, and E are conventional, while D illustrates a temperature converter. If you use this or a similar circuit, allow for any voltage offset in this type of converter. Also, keep in mind that only the two least significant digits are required for a temperature reading. This data should be viewed as relative and not absolute. Decisions should be based on exceeding a relative number, rather than a specific number of degrees. For example, if the temperature converter is adjusted for an output of 1.050 volts at 25° C and the voltage decreases by 2.3 mV/°C, the program can be written to do something when the temperature is 20° C, or 1.039 volts. The 1.039 volts is related to the temperature but is not actually in degrees.

Figure 2F illustrates a joystick (or two independent potentiometers) for use in game programs.

A BASIC program to play the game SAM is shown in Table IV. Note that the data written to the output port (EXTOUT) is in decimal, rather than in hex. The REM statements should help explain the program. Table V illustrates a 4-channel DVM program, which is also written in BASIC.

Construction. An actual-size etching and drilling guide and a component-installation diagram for the A/D converter are shown in Fig. 3. During assembly, note the polarity of *C4* and, if you wish, use sockets for the IC's. Note also that there are provisions on-board for optional inverters (IC's or discrete transistors); these can be Wire Wrapped.

When installing the IC's, observe the usual precautions for handling MOS devices. Since the 5-volt power supply is also used as the reference, make sure it is well regulated and stable. After assembly, adjust *R1* for as near to an exact 2.000 volts at pin 16 as possible.

If your system employs an active high strobe, use an inverter. Flat ribbon cable can be used to interconnect the converter to the host computer. If desired, a 16-pin socket can be mounted at one of the extra positions on the board, and, with Wire Wrap, it can be used to make the external connections instead of the edge connector shown.

Testing. After assembling the board

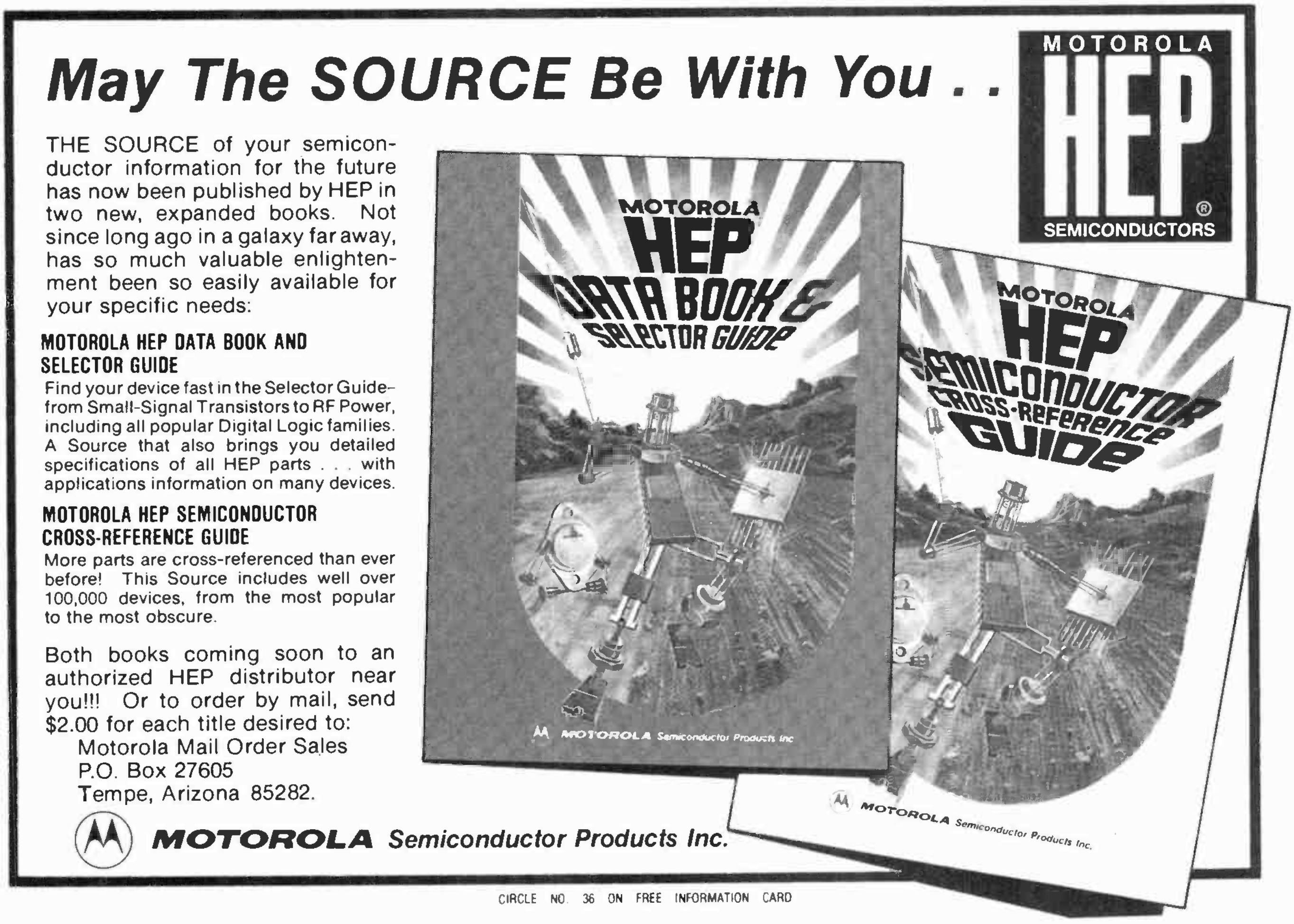
TABLE V—4-CHANNEL DVM PROGRAM

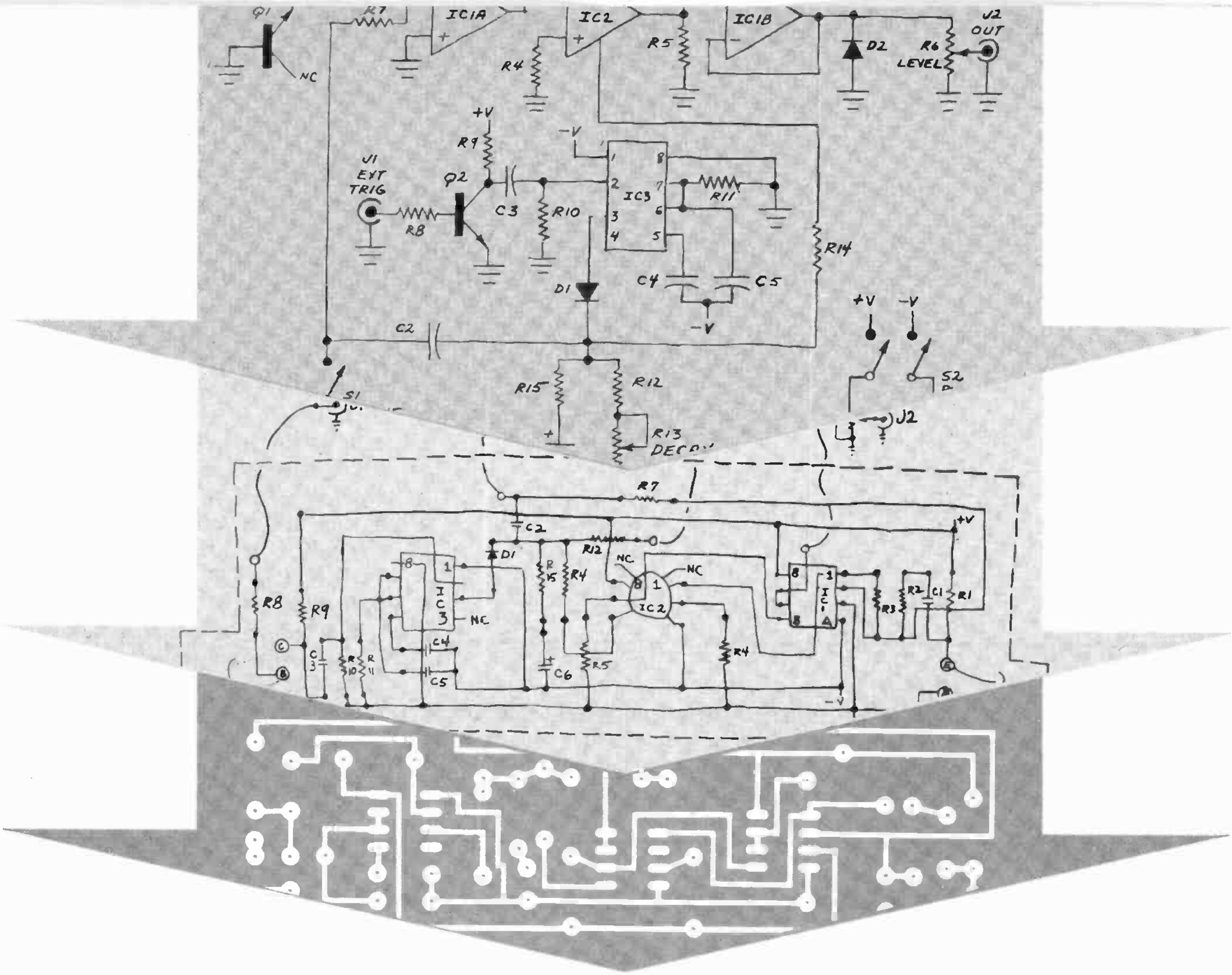
```
4-Channel DVM Program
Central Data Basic (2650), Version 1.2

000         RESTORE
010         DATA 1, 17, 33, 49, 1, 2, 18, 34, 50, 2, 4, 20, 36, 52, 3, 8, 24, 40, 56, 4
020         READ A, B, C, D, E          REM A=Ch#Digit 1:B=Ch≠Digit 2:C=Ch≠
                                             Digit 3:D=Ch#Digit 4:E=Ch≠
030         GOSUB 100
040         IF E=4 GOTO 000
050         GOTO 010
100         EXTOUT 0, A                 REM sets up I/O port Ch&digit
110         S=SIN(1)                    REM delay for A/D settling time
120         EXTIN O, Z                  REM reads port 0 into Z
130         EXTOUT 0, B
140         EXTIN 0, Y
150         EXTOUT 0, C
160         EXTIN 0, X
170         EXTOUT 0, D
180         EXTIN 0, W
190         PRINT@E, 5'CHANNEL#'#E'='#(W*1000+X*100+Y*10+Z)' MILLIVOLTS'
                                        REM prints at line E, character position 5,
                                             channel ≠E=(voltage) MILLIVOLTS
200         RETURN
300         STOP
310         END
```

and adjusting *R1* for the 2-volt reference, load a driver program and check the system for accuracy. If the data appears to be unstable, check the 200-ms delay between the output port strobe and the input port strobe. You may have to vary the values loaded into the DLY routine until the correct delay is obtained. This delay is required only when the channel information is first changed. If only one channel is used, the delay need be used only the first time the channel is selected.

The 6800 program shown is not exact; it is given here as an example of a driver routine for the 6800 CPU. The 8080 program, tested in an 8080-based computer, uses I/O port 10H and a delay (DLY) routine for a 2-MHz system. The CMA and OUT-OFFH instruction invert the data and write it into the front panel. Location 4034 reserves one byte of memory that can be used to store the hex data, if desired. The 2650 program was written for and tested on a Central Data computer. The port used here was OOH, and the DLY routine is for a 1.25-MHz clock.

The A/D converter offers the computer user an inexpensive way for his computer to "communicate" with the analog happenings that dominate our lives. It offers a multitude of ways of sensing and measuring analog data not possible in a simple keyboard-entry system. ◇





HOW TO DESIGN PC BOARDS FROM A SCHEMATIC

Simple, inexpensive procedure takes much of the time and effort out of making pc boards.

BY JAMES BARBARELLO

MANY GOOD electronic project designs never get built because the usual methods of making printed-circuit boards are just too laborious for one-time projects. In this article, we will describe a design-and-fabrication system that can take much of the time and effort out of making pc boards. Using the procedure outlined here, you can, with a few simple and inexpensive tools, lay out and fabricate a pc board in about the same time it would take you to build a circuit using point-to-point wiring.

Initial Phase. Once you have completed your circuit design, breadboard the circuit and thoroughly check out its operation. Only when you are satisfied with the circuit's operation can you draw up a full working schematic diagram.

To illustrate the etching-and-drilling guide layout procedure, we will use the sample schematic diagram shown in Fig. 1. (This circuit is a different configuration of the Snare Accessory featured in the September 1977 "Cabonga" article; see "How It Works" box for description of circuit operation.) Tape a sheet of tracing paper over your schematic diagram or make a photocopy of the diagram. Then start your layout by drawing the IC's as they physically appear with their leads pointing toward you. While you can work directly on graph paper, sizing and spacing your layout for the specific components you will be using, you can also use plain blank paper.

The next step is to draw in the other components near the IC's to which they will be connected. As you draw in each component and complete each interconnection, keep tabs of your progress on

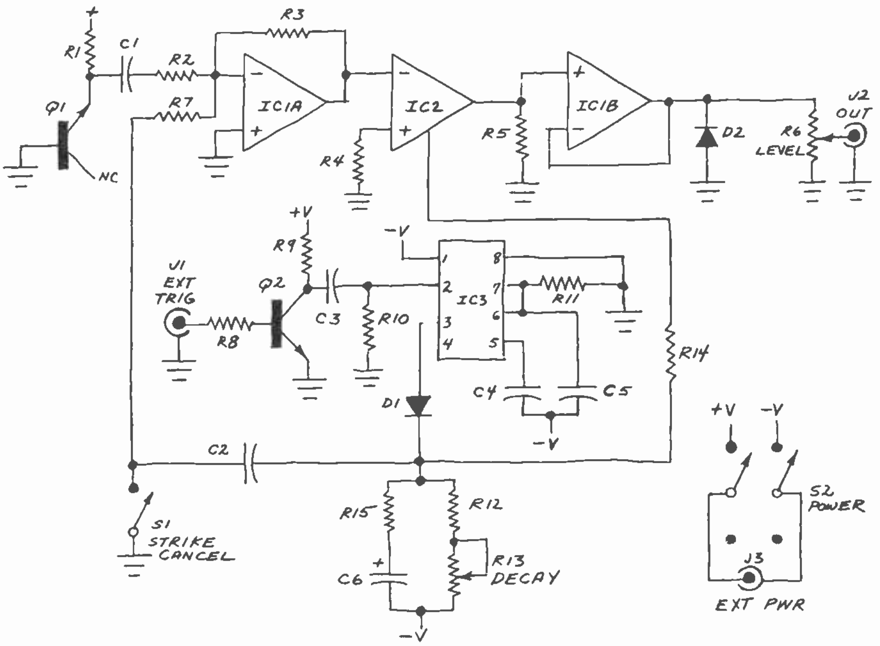


Fig. 1. Example of circuit for which pc board is to be made. See "How It Works" on next page for circuit details.

the schematic's tracing paper or the photocopy. Bear in mind that for every connection you must enter a dot. For example, pins 6 and 7 of *IC3* and the top of *R11* in Fig. 1 must each have a dot indicated (see Fig. 2).

If connecting lines cannot be made without crossing previously drawn lines, try to rearrange the components and/or reroute the lines to eliminate the crossovers. However, if repeated attempts fail to eliminate crossovers, you must use jumpers. You do this by indicating two dots and a line labelled "J" for each jumper you must use. Do not hesitate to use jumpers where necessary; a medium-sized pc board with 10 to 20 jumpers is not uncommon.

While lines between components cannot be interconnected without using jumpers, connecting lines *can* pass between the dots in the areas that will be occupied by resistors, capacitors, diodes, etc., since the component and the connecting line will be on opposite sides of the board. A good example of this is the −V line that passes between the pads for *R4*, *R5*, and *D1* in Fig. 2.

The connections between the pc board and external components *J1*, *S1*, *R13*, and *R6* are shown originating from dots on the pc guide and terminating at the external components via curved lines. Note, too, that all components on the guide are identified, either by symbol number (*IC1*, *R2*, *D1*, etc.) or by component value (10 µF, 100K, etc.).

In most cases, you will discover that the physical layout of the etching-and-drilling guide closely resembles the layout of the schematic diagram's components. You can check this by comparing Fig. 1 with Fig. 2.

At this point, it is best to breadboard your circuit once again, carefully following the layout just drawn. Power the circuit up and again check its operation. In some rare cases, you may have to rearrange component placement and/or reroute conductors to eliminate unwanted effects. For example, in very high gain audio circuits, you want to get the inputs and outputs as far apart from each other as possible to prevent feedback. Also, in vhf and uhf circuits, you want lead lengths and component spacing as short as possible to prevent excessive signal losses and reduce the chances of interactions. This done, you can proceed to the final layout phase.

(Continued on page 52)

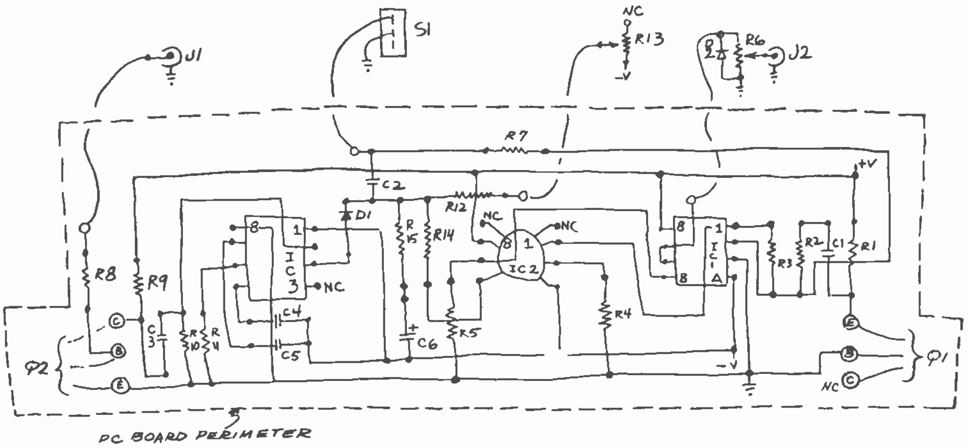


Fig. 2. Redraw circuit as it will be laid out physically.

HOW IT WORKS

Transistor *Q1* serves as a noise source that generates a constant approximation of a white-noise signal. The signal is coupled through *C1* to the input of summing amplifier *IC1A*.

A positive-going trigger pulse applied to *J1* is routed to the base of *Q2* where it is inverted and coupled through *C3* to pin 2 of one-shot timer *IC3*. The inverted pulse triggers *IC3* to produce a 0.25-second positive-going output pulse that is coupled to the input of *IC1A* and also quickly charges *C6* through *R15*. Capacitor *C6* immediately begins to discharge at an exponential rate determined by the values of *R12* and *R15* and the setting of DECAY control *R13*. Diode *D1* reverse biases as the potential across *C6* decays, thus isolating the output of *IC3*, which would tend to maintain a full charge on *C6*. In this manner, a voltage envelope with a very fast attack time and an adjustable exponentially decaying release time is generated and used to control the gain of transconductance amplifier *IC2*.

The gain of *IC2* is set by the level of the voltage envelope and the value of *R14*. The output of *IC2* is a combination of the noise signal and the pulse from *IC3* (a drum-stick-strike sound) whose voltage envelope is the control voltage described above. Resistor *R5* serves as the load for *IC2*. Integrated circuit *IC1B* buffers the signal and *D2* clips the negative portion of the *IC1B* output to produce a realistic sound effect. Potentiometer *R6* provides for a variable output level.

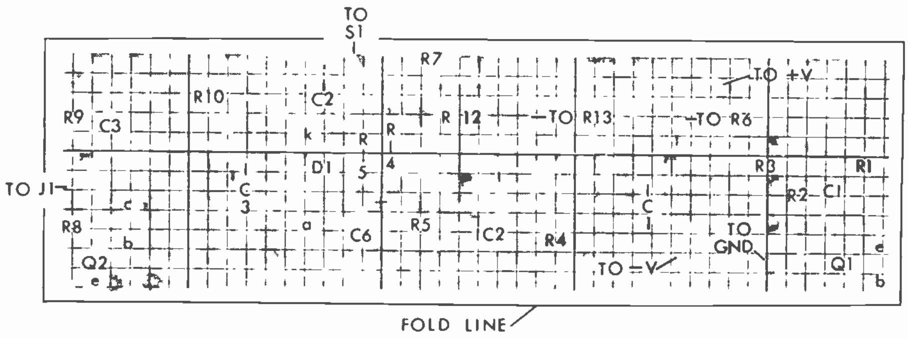


Fig. 3. Final artwork laid out exactly to scale. It helps to use 10 × 10 squares-per-inch graph paper for accurate placement of pads.

Finalizing the Layout. The final layout of the etching and drilling guide is essentially a redrawing of the rough layout to the exact scale of the components you plan to use. You can do the layout directly on graph paper and use it as a guide for drilling holes and transferring to the pc blank simple circuit designs with an etch-resist pen. For more complex and critical layouts, it is best to tape a sheet of clear Mylar over the graph paper and use pc artwork aids (donuts, IC pad patterns, tapes, etc.) to lay out the guide. This guide can then be used directly to expose positive photoresist treated pc blanks. For the remainder of this article, we will concentrate on the use of the paper guide. Mylar film guides are used in the traditional manner.

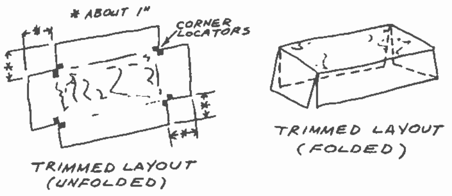


Fig. 4. Trim and fold final artwork as illustrated here.

As you work up your layout, plot your progress on either the rough layout or a piece of tracing paper taped over the rough layout.

TYPICAL DIMENSIONS FOR PC ARTWORK

Component	Spacing
¼-watt resistor, signal diode	0.4" (4 boxes) between leads
½-watt resistor, power rectifier diode	0.5" (5 boxes) between leads
Disc capacitors	0.3" (3 boxes) between leads
Radial-lead electrolytic capacitors	0.2" (2 boxes) between leads
Other resistors, capacitors	Measure for spacing
Transistors (small signal)	0.2" (2 boxes) between leads
DIP IC's with up to 18 pins	0.1" (1 box) between pins, 0.3" (3 boxes) between rows of pins
DIP IC's with more than 18 pins	0.1" (1 box) between pins, 0.6" (6 boxes) between rows of pins
Distance between pc copper conductors	0.05" (½ box) minimum, 0.1" (1 box) standard
Spacing between component pads	0.05" (½ box) minimum, 0.1" (1 box) standard

Note: Number of boxes is for 10 box/in. graph paper only.

Typical spacing between component lead pad centers and copper foil conductor widths and spacings between foil conductors are detailed in the Table. For components not listed, take the dimensions directly from the actual components you will be using in your project.

When the final layout is completely drawn up, indicate all component locations by schematic designation and orientation. See Fig. 3 for details.

Making the PC Board. Trim and fold your final layout as illustrated in Fig. 4. Then cut the pc blank to the exact size of the folded guide and remove any burrs from the cut edges with a file. Fold the guide over the pc blank with the copper side of the blank directly under the guide. Secure the loose tabs of the guide to the blank side of the pc blank with masking tape (Fig. 5).

Lightly indent the pc blank in the center of every hole location with a sharp-pointed center punch or an awl. Drill a hole at every hole location through both the guide and the board.

When all holes are drilled, carefully remove the guide from the blank and store it away for later reference. Give the pc blank a thorough cleaning with No. 00 steel wool (do not use the type of steel wool that comes saturated with its own soap). Once the blank is cleaned, handle it only by its edges.

The pad-and-conductor pattern on the guide can easily be reproduced on the pc blank with a resist pen because the drilled holes themselves provide a "map" on which to build. In most cases, the resist pattern can be laid down with nothing more than the resist pen, working freehand. If you have a relatively complex pattern that must accommodate many IC's, you can speed the operation with the aid of rub-down pads and fill conductor lines and discrete-component pads freehand with the resist pen. As you work, be certain to fill in the areas around the drilled holes with resist to assure that, during etching, excessive copper will not be removed.

When you are finished reproducing the pattern on the pc blank, carefully compare it with your final-layout guide. The two must be identical. If you have made an error, you can correct it by erasing with an ordinary pencil eraser and laying down new resist.

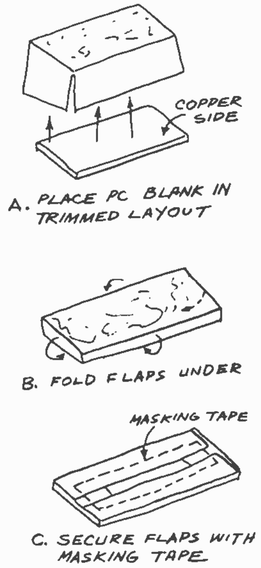


Fig. 5. Cover pc blank with trimmed artwork (A), fold flaps under (B), secure with tape (C).

Pour pc etchant (ferric chloride or ammonium persulfate) into a plastic or glass tray to a depth of about ¼" (6.4 mm). Place the prepared pc blank copper-side down into the tray and slowly agitate the solution by rocking the tray gently. Periodically check your progress with the etching action by carefully lifting one end of the pc blank with a toothpick. When etching is complete, all the copper cladding from the uninked areas will be etched away. At this point, you can remove the pc board from the etchant and thoroughly rinse it under running water. (Discard the used etchant. Don't try to save it for re-use.)

Now remove the etch-resist ink from the copper pattern remaining on the board. Use scouring powder and steel wool under running water for this. Then pat the board dry with a paper towel.

The only thing remaining now is to install and solder into place the components that go on the board. Use your final-layout guide as a reference to component locations and orientations. ◇

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BY LEN FELDMAN

A New IHF Standard for Amplifier Measurement

Latest standard reflects advances in audio technology and understanding of psychoacoustics.

AMPLIFIER specification sheets will soon be more meaningful than ever before, thanks to the new amplifier measurement standard recently approved by the Institute of High Fidelity. Officially entitled "Standard Methods of Measurement for Audio Amplifiers, IHF-A-202 1978," it spells out test conditions and procedures covering each aspect of amplifier performance considered by the Institute to be significant in high-fidelity applications. In all, the standard describes 28 ratings.

For a power amplifier to carry an IHF rating, a few *primary* specifications must be listed:

- Continuous Average Power Output
- Dynamic Headroom
- Frequency Response
- Sensitivity
- A-Weighted Signal-to-Noise Ratio

A preamplifier specification sheet must include:

- Frequency Response
- Maximum Output Voltage
- Total Harmonic Distortion
- Sensitivity
- A-Weighted Signal-to-Noise Ratio
- Maximum Input Signal
- Input Impedance

Integrated or control amplifier literature should contain the following preferred specifications: Continuous Average Power Output (including the rated bandwidth, load impedance and total harmonic distortion); Dynamic Headroom; Frequency Response; Sensitivity; A-Weighted S/N; Maximum Input Signal; and Input Impedance.

In addition, there are a number of *secondary disclosures* that can be included at the manufacturer's option. Let's examine the key primary specifications first and then briefly look at some of the secondary disclosures.

Continuous Average Power Output has been included in the new standard to satisfy the Federal Trade Commission's 1974 "Power Rule." It specifies the minimum continuous output power each amplifier channel can deliver into a given load (usually 8 ohms resistive) over a specified bandwidth (usually 20 to 20,000 Hz) with a given total harmonic distortion content (in percent) when all channels are driven simultaneously. Thus, continuous average power output informs the prospective purchaser how much power the amplifier can deliver *over the long term*.

It is a well-known characteristic of many amplifiers, however, that they can generally provide more output power for brief intervals than they can on a continuous basis. The earlier IHF standard, which had been in use since 1966, provided for two power specifications—continuous power and "IHF Dynamic (or Music) Power, both measured in watts. The latter was intended to give the purchaser an idea of how much power the amplifier could deliver for brief intervals. To avoid confusion, IHF-A-202 1978 specifies only continuous average power output in watts. A new specification has been developed to describe the amplifier's short-term power capability.

Dynamic Headroom is the name of this new amplifier specification. Rated in dB, dynamic headroom expresses the ratio of an amplifier's power output for short periods of time to its continuous power capability. Accordingly, if an amplifier has a dynamic headroom of 3 dB, it can deliver twice its continuous power rating for brief intervals. The nature of high-fidelity program material—low average levels accompanied by occasional high-level transients—makes this specification of special interest to the audiophile. Here's why.

In a typical home audio system, one watt or less per channel of average, continuous power output is enough to drive the speakers to normal listening levels. Transient peaks of, say, 20 dB will call on the amplifier to briefly supply 100 watts to each speaker. If the amplifier can deliver such power levels, it will not "clip" the transient peaks. Therefore, the speakers will be able to generate a pleasing, full sound. If the amplifier clips the peaks, the sound will lack depth; if

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Since there's nothing ordinary about the RS-M85's performance, there's nothing ordinary about its meters. The RS-M85 features Fluorescent Bar-Graph meters. They're completely electronic and therefore highly accurate. Response time is a mere 5μS. There's also a peak-check mode plus two selectable brightness levels.

To all this sophistication, the RS-M85 adds all this: A separate, coreless DC motor for reel drive. Dolby NR.* Full IC logic control in all modes. A low-noise, high-linearity amplifier section. And a 3-position bias/EQ selector with bias fine adjustment.

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Technics RS-M85. Compare specifications. Compare prices.

FREQ. RESP. (CrO_2): 20-18,000 Hz. WOW AND FLUTTER: 0.035% WRMS. S/N RATIO (DOLBY): 69 dB. SPEED DEVIATION: No more than 0.3%.

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clipping is severe, it'll be very distorted.

As an example of the foregoing, let's examine a hypothetical system with a peak output power requirement of 100 watts for undistorted sound reproduction of each channel. There are two ways to get this amount of output power—either purchase an amplifier whose continuous power output is 100 watts/channel, or choose an amplifier with a lower continuous power output rating but with sufficient dynamic headroom to reach 100 watts/channel on peaks. For example, a 50-watt/channel (continuous) amplifier with 3 dB of dynamic headroom will provide the needed 100 watts/channel on a momentary basis.

Both amplifiers will sound equally loud because perceived loudness is a function of *average* audio output. This is illustrated by the heavily compressed audio tracks of some television and radio commercials. These messages sound louder than normal program material because their average levels are higher. Peaks, however, are the same for both—they must not exceed FCC modulation limits. Depending on its dynamic headroom, the higher-power amplifier might be able to provide even more output on peaks, but in our application this reserve might never be tapped. Also, this amplifier will loaf along most of the time, delivering its rated (continuous) power for only brief intervals of time.

Dynamic headroom is really a function of voltage regulation in the amplifier's power supply. A typical amplifier's supply might consist of a power transformer, a full-wave or bridge rectifier, and two filter capacitors. The supply is designed to deliver a bipolar dc output, $+V_{CC}$ and $-V_{CC}$, to a complementary-symmetry amplifier circuit. Charge is delivered to the two filter capacitors at a 120-Hz rate. When the amplifier is first turned on (but before any input signals are applied), the capacitors are charged up to a given voltage.

Under quiescent (no signal) conditions, the rectifier can supply more than enough charge to the capacitors to make up for that drawn by the amplifier circuit. Thus, voltages across the filter capacitors, $+V_{CC}$ and $-V_{CC}$, remain constant. (We are assuming that the amplifier is operating in the Class AB or B mode.) However, when the amplifier is driven so that it is providing appreciable amounts of output power, the rectifier is not able to replenish the capacitors' charge as fast as the amplifier is depleting it. Therefore, $+V_{CC}$ and $-V_{CC}$ decrease until equilibrium is reestablished.

For example, assume that the quiescent voltages across the capacitors are ±40 volts. This implies that the amplifier will be able to deliver an 80-volt peak-to-peak or 28.3-volt rms sine-wave output, or 100 watts continuous into 8 ohms. Placing a voltmeter across the power supply output, however, shows us that the voltages drop to, say, ±35 volts when the amplifier is being heavily and continuously driven. The amplifier can therefore deliver a 70-volt peak-to-peak or 24.7-volt rms sine-wave output, which corresponds to 76.5 watts continuous into 8 ohms, before it starts to clip the waveform.

If the amplifier under consideration is driven to maximum output by narrow pulses or transient spikes, $+V_{CC}$ and $-V_{CC}$ remain at their quiescent values. The low duty cycle of such an input waveform keeps appreciable amounts of charge from being drained from the capacitors. As a result, a full 80-volt peak-to-peak (or 100 watts peak into 8 ohms) output can be obtained without clipping. Because musical waveforms resemble such input signals, 100 watts of output power on musical peaks can also be obtained. Such an amplifier, therefore, has a dynamic headroom of 20 log (28.3 V/24.7 V), 10 log (100 W/76.5 W), or 1.16 dB.

If an amplifier's power supply is stiffly regulated, either by using massive filter capacitors which can store very large amounts of charge, by the use of zener diodes or IC regulators and pass transistors, or by a combination of both techniques, its output voltages will vary little, if at all, when large demands are placed on it. This amplifier will have a dynamic headroom of 0 dB. This means that no more power is available on peaks of a low-duty-cycle waveform (such as music) than is available on a continuous, steady-state sine-wave basis.

Test Procedure. To make dynamic headroom a meaningful audio specification, the IHF devised a test signal and procedure which approximates what happens to an amplifier when it is driven by music signals. A photograph of the

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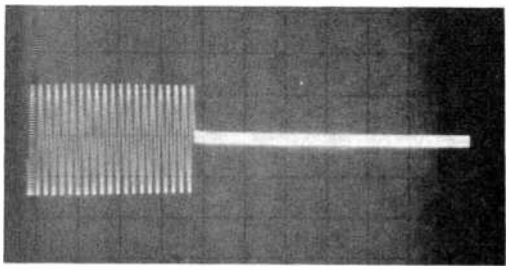

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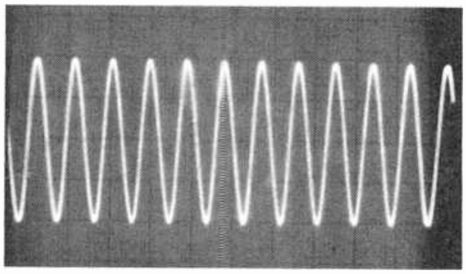

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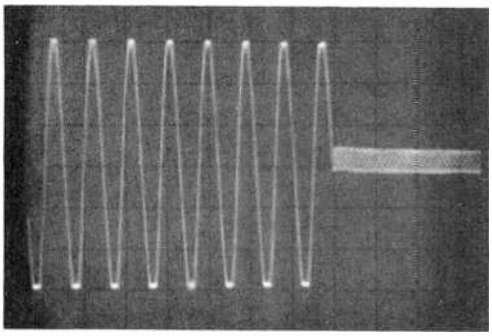


Fig. 1 *First 60 ms of the Dynamic Headroom test signal.*

Fig. 2 *The amplifier is driven to rated continuous output by 1000-Hz sine wave.*

Fig. 3 *The "burst" portion of DH test signal drives amplifier beyond rated output.*

oscilloscope trace produced by the first 60 milliseconds of the test signal is shown in Fig. 1. It comprises 20 cycles of a 1000-Hz sine wave, followed by 480 cycles of a sine wave at the same frequency at −20 dB relative to the high-level tone burst. This waveform is repeated every 500 milliseconds. Musical peaks lasting more than 20 milliseconds (the high-level portion of the test signal period) are rare, and apparently do not occur as often as twice in one second. The test signal, therefore, is more demanding than typical music waveforms, while the rate of repetition makes measurement more convenient. The test procedure is as follows.

A continuous train of 1000-Hz sine waves is applied to the amplifier input, with the output monitored on an oscilloscope. The amplifier's gain is adjusted so that the rated continuous average power output is delivered to the rated load impedance. Figure 2 shows this output on a scope whose vertical sensitivity is 10 volts/cm. As you can see, the peak-to-peak output voltage is 40 volts, which corresponds to 25 watts into 8 ohms, the rated continuous average power of the amplifier under test.

Next, the test signal shown in Fig. 1 is applied to input jacks of both channels of the amplifier, while the output is carefully monitored on the scope. The test signal's amplitude is adjusted so that clipping of the high-level portion of the output waveform barely becomes visible (Fig. 3). This portion of the amplified test signal is 6-cm high, so it is 60 volts peak-to-peak across the 8-ohm load.

The amplifier's dynamic headroom can now be calculated using the expression DH = 20 log (*V2/V1*), where *V2* is the peak-to-peak voltage of the high-level portion of the amplified test signal and *V1* is the peak-to-peak voltage of the output sine wave delivered by the amplifier to the rated load when it is producing its rated continuous average output power. [Alternatively, the rms values of these voltages can be used in place of the peak-to-peak values, or the two respective power levels in watts can be inserted into the familiar 10 log (*P2/P1*) formula.] In the case of the amplifier under test, the dynamic headroom is 20 log (60/40) or 3.52 dB. In general, dynamic headroom is expected to vary from 0 dB for an amplifier with a very well-regulated supply to 3 dB or so for an amplifier which can deliver twice its rated continuous power on an intermittent basis.

Frequency Response. Under the new standard, this measurement must be performed so that the amplifier is subjected to *standard test conditions*, which are spelled out in the second section of IHF-A-202 1978. An amplifier's frequency response can be measured after a 0.5-volt signal has been applied to its input, and its gain control adjusted so that a 1-watt output signal is delivered to the rated load. Previously, this measurement was performed at maximum amplifier gain, the most favorable setting for high-end response in some amplifiers. Also, the frequency response must now be given as +X, −Y dB referenced to the amplifier's output at 1000 Hz. Accordingly, an amplifier's response must appear as, say, +0, −2 dB from 7 to 70,000 Hz rather than ±1 dB over the same bandwidth. A phono preamplifier's frequency response will appear as a plus-and-minus equalization error in dB referenced to 1000 Hz.

For a preamplifier, input signals must be 0.5 volt for a line (Aux, Tape, Tuner) input, 5 mV for a moving-magnet phono input, and 500 μV for a moving-coil phono input. The preamplifier's gain control should be adjusted to produce 0.5 volt into the new standard preamplifier load—10,000 ohms in parallel with 1000 pF; and all tone controls, filters, etc., should be defeated or at least set to their nominally flat positions. Standard input terminations should also be used—1000 ohms for line and moving-magnet phono inputs and 100 ohms for moving-coil phono inputs.

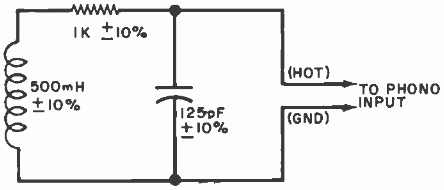


Fig. 4. Connect this circuit to preamp's moving-magnet phono inputs for noise measurements.

Sensitivity. In the past, this specification has been used to relate how much input signal was required to drive a component to its *rated* output. The new standard defines sensitivity as the input signal required to drive a component to the appropriate *reference* output (0.5 volt for a preamp, 1 watt for an amplifier) into its standard output termination.

This means that sensitivity figures published in accord with the new standard will be *lower* than those previously published, giving the impression that the new crop of audio components are much more sensitive. Let's consider a practical example.

Assume that one 100-W amplifier can be driven to rated continuous average power output by a 1-volt rms input signal, and that another requires the same 1-volt rms input to produce its rated continuous average power output of 10 watts. Under the old system, both amplifiers would have the same sensitivity rating—1.0 volt. However, with the new standard, their sensitivities differ substantially as the following illustrates.

For an amplifier driven by a sine-wave input to deliver 100 watts to an 8-ohm load, it must produce a 28.28-volt rms output waveform. For 10 watts, the output voltage is 8.94 volts rms; for 1 watt, 2.828 volts rms. The 100-watt/channel amplifier has a voltage gain of 28.28. But the 10-watt/channel amplifier's voltage gain is only 8.94. Therefore, the 100-watt/channel amplifier requires only 0.1 volt rms if it is to produce the reference 1 watt output. The 10-watt/channel amplifier, on the other hand, requires a 0.313-volt rms input to produce the same 1-watt reference output. The two amplifiers' "new" IHF sensitivities differ by slightly more than a factor of three, and are 0.1 and (about) 0.3, respectively, of their "old" sensitivities.

A-Weighted S/N. Signal-to-noise ratios published under the auspices of the new IHF standard will differ from those determined by other methods for several reasons. In measuring a component's signal-to-noise ratio, a manufacturer will typically apply an input signal of a given strength (the exact amplitude varies from one manufacturer's test procedure to the next) and adjust the component's gain so that it is producing its rated output. Next, the input signal source is replaced with a short circuit, whereupon the output signal's amplitude is measured. The resulting ratio of the component's output amplitude when its input is shorted to the rated output is the signal-to-noise ratio.

As straightforward as this procedure seems, there are several variables associated with it that can cause confusion when one manufacturer's ratings are compared to those of another. One problem area is the amount of input signal used to drive the component to its rated output. Consider, for example, the effect of input signal level on the signal-to-noise ratio of a phono preamplifier. Some manufacturers perform this test with a 2- or 3-millivolt input signal, which is enough to drive the preamplifier to its rated output with the volume (gain) control at its maximum setting. Others, recognizing that most moving-magnet cartridges produce considerably higher outputs when they track heavily recorded passages, apply 10 mV to the phono input. They then advance the volume control until the preamplifier produces its rated output.

Obviously, applying a greater input signal to the preamplifier means that less gain is required if the preamplifier is to produce its rated output. This results in a greater signal-to-noise ratio because the noise, most of which is generated in the input circuit *before* the volume control, will be amplified less. Also, referencing a component's signal-to-noise ratio to its rated output makes comparison to the signal-to-noise ratio of another component misleading unless both have the same rated output or a corrective factor is introduced to put both components on an equal footing.

The new standard attempts to set matters right by dictating that signal-to-noise measurements be performed in accord with the *standard test conditions* mentioned earlier. Input levels are to be 5 mV for moving-magnet phono inputs, 500 mV for line level inputs, and 500 μV for moving-coil phono inputs. A component's gain control is to be adjusted so that the appropriate reference output level (0.5 volt for a preamp, 1 watt for an amplifier) is presented to the standard load impedance.

The way in which a component's inputs are terminated has also complicated matters. Most noise measurements are made with the inputs shorted to ground. However, the impedance seen by the preamp when driven by an actual cartridge is by no means a short circuit. Measurements made when a cartridge is connected to the preamp's inputs can vary considerably from those obtained when the inputs are shorted.

To approximate the effect of a phono cartridge, the new standard specifies that the network shown in Fig. 4 be connected to each channel's moving-magnet phono input when noise measurements are performed. Moving-coil inputs are to be terminated with a 100-ohm resistor and line level inputs with a 1000-ohm resistor. Standard output terminations are also to be used.

Another key area in which signal-to-noise specifications published under the new standard differ is in the area of *weighting*. The philosophy behind weighting is that not all noise signals are equally annoying to the listener. The famous Fletcher-Munson curves clearly indicate that, at low listening levels, the human ear is considerably more sensitive to midrange frequencies than to bass and, to a lesser extent, treble frequencies. Weighting, therefore, is an attempt to take this characteristic of the ear into account when measuring a quantity such as signal-to-noise ratio. The goal is to make specifications more meaningful so far as "real life" audibility is concerned, not to make the "numbers" look better.

Accordingly, the new standard calls for the use of the ANSI "A" weighting curve shown in Fig. 5A. This curve corresponds to the sensitivity of the human ear at a listening level of 40 phons. It peaks at about 2000 Hz and rolls off (at different rates) above and below that frequency. Weighting can be accomplished by inserting a suitable network between the output of the device under test and the measuring instrument.

Shown in Fig. 5B is an RC network which will provide "A" weighting and also match a 600-ohm output impedance to a test instrument (such as a VTVM) with a high input impedance. If a voltmeter is used to measure noise, the greatest reading will be obtained if the bulk of the noise components are at midrange frequencies. Noise consisting mainly of hum at the power-line frequency or its second harmonic and high-frequency hiss will produce lower readings.

Total Harmonic Distortion. The new standard changes the definition of this key specification. It states that the spectrum analyzer, as opposed to the "old reliable" nulling distortion analyzer, is the preferred instrument to be used to measure THD. Total harmonic distortion in percent is determined as follows.

The amplitudes in rms volts of the fundamental frequency and its harmonics appearing at the output of the device under test are to be measured using a spectrum analyzer. Then the amplitudes of the harmonics are squared, added, and the square root of the resulting sum extracted. The square root is divided by the rms amplitude of the fundamental and the quotient multiplied by 100.

The older method of determining THD, namely by taking the reading from a conventional distortion analyzer, was flawed because it included residual noise in the "distortion." (The output of the conventional analyzer is now defined as total harmonic distortion plus noise, THD + N.) When measuring distortion at low output power levels, it was difficult to satisfy the FTC requirement that rated distortion not be exceeded at any power level from 0.25 watt to the rated continuous power output.

The problem is illustrated in the following practical example. An amplifier was driven to a high output level by a 1000-Hz sine wave so that its output had

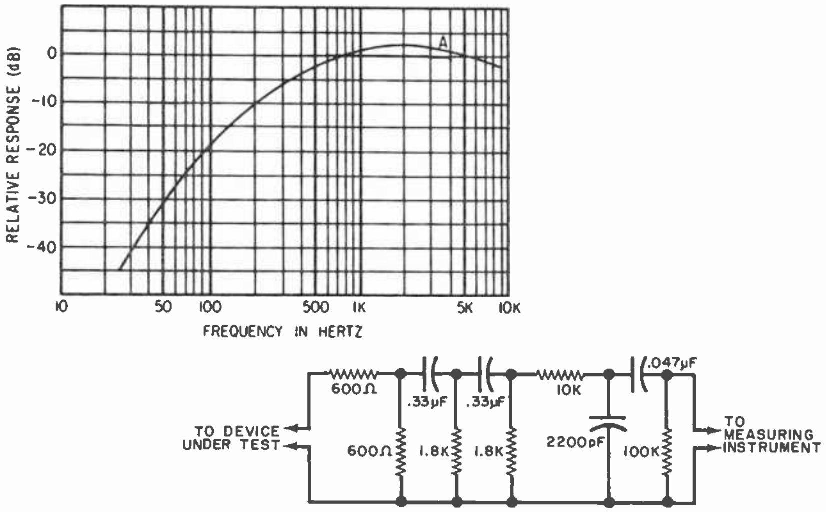


Fig. 5. The "A" weighting curve (top) reflects the ear's sensitivity vs. frequency at listening level of 70 phons. Circuit below provides "A" weighting and matches 60-ohm output to high-impedance instrument.

a THD content of 1%, as indicated on a conventional harmonic distortion analyzer. (The conventional analyzer nulls out the fundamental component of the amplifier output, measuring the amplitude of remaining signal components.) The amplifier's output is shown as the top oscilloscope trace in Fig. 6, and the output of the distortion analyzer as the lower trace. The output signal was then applied to a spectrum analyzer. The 1000-Hz fundamental of the input signal appears at the center of the spectrum analyzer's output (Fig. 7), and the harmonics to the right. The THD of the amplifier output was calculated to be 1% by including the amplitudes of all harmonics which were less than 10 dB below the strongest harmonic (3000 Hz) in the algorithm previously described. Calculated distortion agreed closely with the reading on the conventional distortion analyzer.

Next, the level of the input signal was reduced so that the output of the amplifier was only 0.25 watt. The output was sampled by the distortion analyzer, and a reading of *1%* was obtained. Something was obviously wrong!

Applying this low-level output signal to the input of the spectrum analyzer while monitoring amplifier and distortion analyzer outputs on a scope, revealed the reason for the puzzlingly high distortion reading. (The top trace in the scope photo of Fig. 8 is the amplifier output, with vertical sensitivity increased; the lower trace shows the distortion analyzer's output. Fig. 9 displays a CRT trace on a spectrum analyzer.)

The false distortion analyzer reading was actually caused by the low-level *noise* in the amplifier output, not by harmonic components. At this low power level, the noise produced by the amplifier was −40 dB referenced to the amplified test signal. The THD content, however, is substantially better (about −70 dB). Clearly, the distortion products were masked by noise. For this reason, the new standard defines the conventional distortion analyzer's reading as THD + *N*.

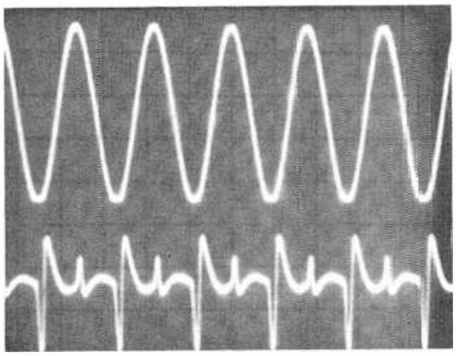


Fig. 6. Amplifier output driven to mild clipping (top) has a THD content of 1% as indicated by a distortion analyzer, whose output is shown at bottom.

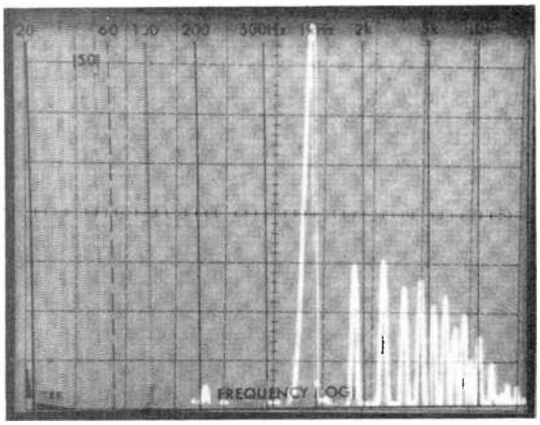


Fig. 7. Spectral analysis of the amplifier output shown as top trace in Fig 6.

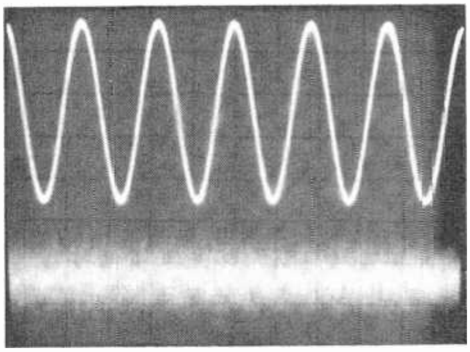


Fig. 8. When amplifier output is reduced to 0.25 watt (top), output of nulling distortion analyzer (bottom) consists almost entirely of noise.

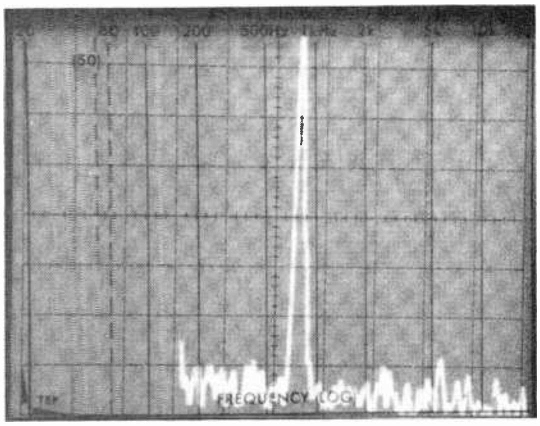


Fig. 9. Spectral analysis of low-level amplifier output shows that any harmonic distortion products are so low as to be below "grass" of noise floor.

Input Impedance. As a rule, the output impedance of one audio component is not closely matched to the input impedance of the component it is driving. For example, the output impedance of a preamplifier is usually low, on the order of a few hundred ohms, but the input impedance of a power amplifier is high, commonly tens of kilohms. However, the components are compatible.

The exception to this rule is the junction of the phono preamplifier and cartridge. Most moving-magnet cartridges perform optimally only when they see a specific preamp input impedance, typically 47,000 ohms resistive shunted by a small amount of capacitance. The exact amount varies from one cartridge to the next, but is usually within the 200-to-500-pF range. If the cartridge is not properly loaded, aberrations in its frequency response will occur.

The new standard takes the critical nature of phono input impedance matching into account by requiring that the input impedance be measured at several frequencies. If it can be accurately described as a parallel *RC* circuit, then the *R* and *C* values are to be given as the rated input impedance. If the impedance is too complex to be modelled by a simple *RC* network, it is to be rated as the magnitude of the impedance in ohms at 1000 Hz.

Secondary Disclosures. In addition to primary specifications, the new standard also includes many secondary disclosures any or all of which may be published at the manufacturer's option. Many of these specifications are similar to those published in earlier standards, so most readers are probably acquainted with at least a few of them. However, several new ones have been developed in response to advances in both amplifier technology and our understanding of psychoacoustics. Let's look at a few of these new specifications.

Clipping Headroom. Most amplifier manufacturers have been rating continuous average power outputs of their products at THD levels that are undetectable by the human ear. However, it's useful to know when an amplifier's power output is exceeded to the point of clipping, which grossly (and audibly) distorts the input signal. That's what a clipping headroom spec reveals. It is the ratio (expressed in dB) of the continuous average power output at actual clipping to the rated continuous average power output of the amplifier.

Damping Factor. The new standard defines damping factor as the ratio of 8 ohms to the output impedance of the amplifier. Output impedance is to be measured while a standard output current is flowing from the amplifier into the load to simulate typical operating conditions. There are *two* damping factors which can be published. An amplifier's wideband damping factor is the minimum damping factor measured over its rated power bandwidth. The amplifier's low-frequency damping factor is measured at 50 Hz, the resonant frequency of a typical speaker system. Previously, an amplifier's damping factor was rated at 1000 Hz. The new spec is an improvement because a high damping factor can be more important in the bass region than in the midrange, and an amplifier's damping factor is not necessarily constant with frequency.

Intermodulation Distortion. Two methods of measuring IM distortion are specified in IHF-A-202 1978. In the old method, low- and high-frequency test signals were applied, and the output sampled. Here, if the amplifier is nonlinear, the high-frequency tone will be modulated to an extent by the low-frequency signal. Products will appear at the sum and difference frequencies. This method is called SMPTE-IM because the Society of Motion Picture and Television Engineers developed it.

Recent investigations, however, indicate that intermodulation of two relatively high-frequency tones may be more audibly significant. Accordingly, the new method, called IHF-IM, employs test signals at two frequencies which are swept across the audio band so that the difference between them remains a constant 1000 Hz. The mean frequency is to be swept from 2500 Hz to the upper limit of the amplifier's rated power bandwidth.

All IM products up to the fifth order within the 20-to-20,000-Hz band are to be measured and combined using an algorithm similar to that for THD calculations to determine IHF-IM in percent. Measurements can be made at a series of power levels to produce a family of IM distortion vs. frequency curves. Either a spectrum analyzer (the most convenient instrument) or a swept filter and oscilloscope (or voltmeter) can be used to perform IHF-IM measurements.

For those wanting more complete information on the new amplifier standard, *Standard Methods of Measurement for Audio Amplifiers, IHF-A-202 1978,* is available for $7.50 from the Institute of High Fidelity, 489 Fifth Avenue, New York, NY 10017.

Transient and Slew Specifications. The importance of an amplifier's ability to respond accurately to short-lived musical transients has been recognized in recent years. Two new specifications which help to rate transient-handling ability are Transient Overload Recovery Time and Slew Factor.

To measure an amplifier's transient overload recovery time, the test signal shown in Fig. 1 (the same one used in the dynamic headroom test) is applied to its input. The amplitude of the input signal is then adjusted so that the low-level trailing portion is amplified to −10 dB relative to the rated continuous average power output of the amplifier. This means that the high-level, 20-millisecond "burst" portion of the test signal drives the amplifier 10 dB into overload.

The portion of the output signal immediately after the trailing elge is scrutinized on a scope. The time in milliseconds required by the amplifier to recover so that there is no visible distortion on the oscilloscope is measured for each input. The worst-case result (longest recovery period) is the rated transient overload recovery time.

The second transient-related specification is *slew factor.* This new term should not be confused with the more familiar slew rate, which is the maximum time rate of change in voltage at the output of the amplifier. There are several ways to measure slew rate, but not all of them will yield the same result. For this reason, the new standard speaks in terms of slew factor rather than slew rate.

Slew factor is a ratio which describes the highest frequency (normalized to 20,000 Hz) that can be applied to the input of a component and be presented in amplified form at the output with a THD content of not more than 1 percent. The slew factor is obtained by dividing the highest frequency that satisfies these conditions by 20,000 Hz. The test is performed by applying a 1000-Hz input signal and adjusting its level so that the component delivers its rated output. The input signal is maintained at this level as it is swept upward in frequency. Harmonic distortion measurements are made as outlined earlier.

In Conclusion. The new IHF standard should do much to dispel the ambiguities encountered by prospective purchasers when comparing the specifications of preamplifiers, power amplifiers, and integrated amplifiers that are produced by different manufacturers. Perhaps its greatest accomplishment is to bring printed specifications into closer agreement with what we actually hear, thereby allowing the consumer to make a fully informed buying decision. ◇

Build a Disco Preamp/Mixer

BY JOHN ROBERTS

Provides multi-source inputs and mixing/fading for your home disco.

A TYPICAL audio system is not suitable for disco applications. It lacks the mixing, monitoring, and microphone preamps normally found in such facilities. The Disco Mixer presented here is a special-purpose audio preamplifier/mixer with a number of attractive and unusual features. It has two independent phono preamplifiers employing the new IEC equalization characteristic, two IC-buffered auxiliary inputs, a low-noise microphone preamplifier, switching and mixing capability for multiple inputs, and the traditional preamp's bass, treble, balance, and volume controls. The Disco Mixer also contains a monitor circuit that allows the user to cue records or listen to one program source while another is driving the system's power amplifier.

You can build either a preamp/mixer or a preamplifier only. A kit for the preamp/mixer is $110, while one for the preamp alone is just $70.

The Disco Mixer is designed around six integrated circuits. Thanks to the advent of specialized IC's, signal processing functions previously performed by dozens of discrete components can now be accomplished by single chips. In many cases, both stereo channels can be handled by one IC.

High-level signals in this project are processed by members of a new family of high-performance op amps that are fabricated by "BIFET" technology. This is a process which allows diffusion of both junction-field-effect and bipolar-junction transistors on the same chip. These op amps exhibit the excellent input characteristics of JFET's and the highly desirable output characteristics of BJT's—literally, the best of both worlds. BIFET op amps have higher slew rates and cause less TH and IM distortion than common bipolar IC's (see Fig. 1).

About the Circuit. A block diagram of the complete mixer/preamplifier is shown in Fig. 2. Functionally, the Disco Mixer can be considered to be made up of three types of circuits: input conditioning, high-level processing, and output conditioning. Let's examine each.

Input conditioning for the line-level auxiliary inputs, which would typically be driven by a tuner or tape deck, consists of simple unity-gain inverting buffers. One of the four buffers included in the preamp is shown in Fig. 3. An RC network at the buffer input acts as a high-pass filter to prevent the passage of a dc level or infrasonic ac signals. One section of a quad BIFET operational amplifier, *IC3*, presents an inverted version of the input signal to the switching matrix composed of *S2* and *S4*. This buffer displays a relatively high impedance (about 50,000 ohms) to the program source and a very low output impedance to the switching matrix. This avoids loading down the signal source and prevents interaction in the mixing process.

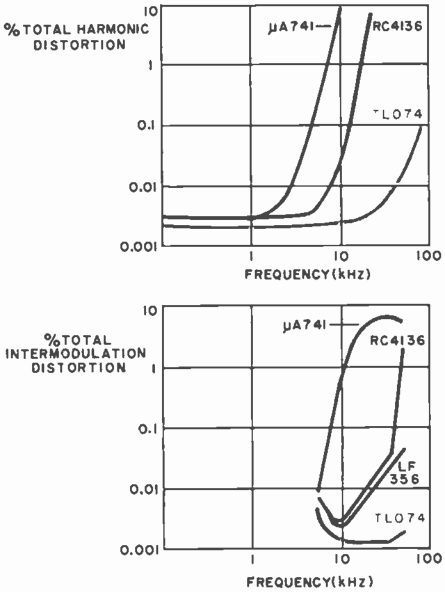
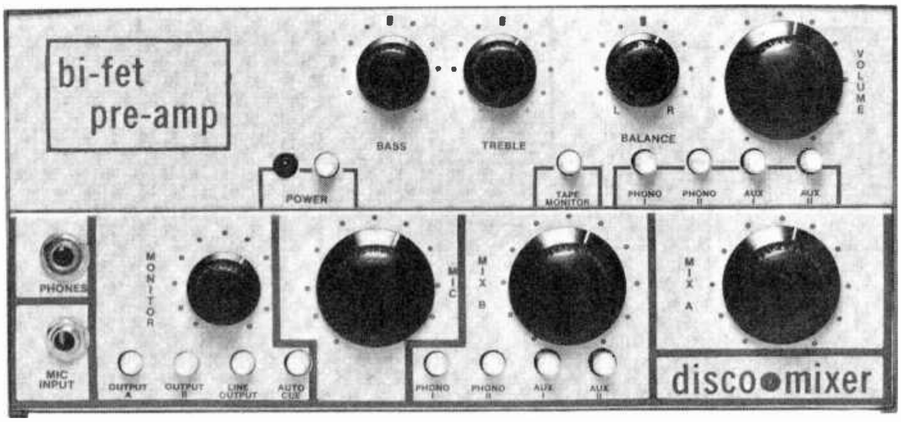


Fig. 1. TI's TL074 BIFET op amp generates less distortion than common bipolar linear IC's.

The signal conditioning stage for the microphone input must be able to amplify signals generated by the microphone by 60 dB (1000 V/V) or more. An NE5534N integrated circuit was selected for this task (Fig. 4) because it has a high open-loop voltage gain and a very low input noise voltage. The open-loop gain—the gain of the device in the absence of feedback—must sufficiently exceed the closed-loop gain selected by the proper choice of feedback components if the amplifier is to exhibit gain accuracy and low distortion. (An amplifier's closed-loop distortion is its open-loop distortion divided by the ratio of open-loop to closed-loop gain.) The microphone preamp's input noise voltage is of critical importance because this noise signal will be amplified along with the millivolt-level microphone output signal.

With an open-loop gain of 6000 V/V at 10,000 Hz and less than one microvolt of input noise, the NE5534 (*IC7*) meets the foregoing requirements easily. The noninverting microphone preamp fea-



tures a pc-mounted trimmer potentiometer *(R43)* which allows the user to adjust the stage's gain to suit the sensitivity of a particular microphone. As is the case with the auxiliary input buffers, signals are capacitively coupled to the op amp. The microphone preamplifier has a high input impedance that will not load down the microphone, and presents a low output impedance to the mixing stage.

Similar gain and noise requirements must be satisfied by the phono preamplifiers. In addition, these stages must contain an equalization network which properly compensates for the preemphasis introduced in the recording process to increase dynamic range and suit the constant-velocity characteristic of the playback transducer (phono cartridge). At present, there is some debate as to the ideal de-emphasis (playback) curve. The existing RIAA does not clearly specify exactly how a phono preamplifier's gain should roll off at low frequencies.

This has resulted in many phono preamps with very high gain at infrasonic frequencies, a situation which can cause serious problems when warped records are played or acoustic feedback combines with turntable rumble. The phono cartridge, preamplifier, power amplifier and speakers try to reproduce the warp or rumble as if it were a valid audio signal. However, many speakers are not designed and lack the ability to generate such strong, very low frequency output and can be damaged while attempting to do so.

Therefore, a feedback network comprising *R3* through *R7* and *C7*, *C9* and *C10* has been incorporated into the phono preamplifiers (Fig. 5) so that these stages exhibit a frequency response which agrees with the International Electrochemical Commission's proposed amendment to the RIAA characteristic. The deviation from the RIAA curve is slight and only at the lowest audible frequencies, and the improvement in infrasonic signal attenuation considerably outweighs the almost imperceptible (−3 dB at 20 Hz) low-frequency rolloff.

The LM387AN dual low-noise preamplifier has been chosen for *IC1* and *IC2* because of its excellent (high) open-loop gain and (low) noise characteristics. That there are two independent, identical amplifiers in one 8-pin DIP helps simplify the pc layout. The phono cartridge drives the noninverting input and is loaded by *R2*, a 47,000-ohm resistor and *C6*, a small disc ceramic, glass, polystyrene or silver mica capacitor. The user should consult the manufacturer for the recommended capacitance for his particular cartridge. In most cases, the value will lie between 10 and 300 pF.

Now that all input signals have been amplified to reasonable levels and impedances normalized, mixing can be performed in a straightforward manner. Two four-station interlocked switch arrays (*S2* and *S4*) assign any one of four input signals to two mixer potentiometers, *R46* and *R47*, as shown in Fig. 6. The wipers of these potentiometers are connected to one quarter of *IC6*, a quad BIFET operational amplifier, which is used as a unity gain inverting summer. This allows the user to mix any two of the four inputs or pan back and forth between the two as a disc jockey at a discotheque would. A third potentiometer, *R51*, mixes in a portion of the microphone preamp output so that the disc jockey can voice over his mix.

The inverting summer drives both the output conditioning circuitry of the preamplifier and a special monitor circuit which has been designed into the mixer section. This circuit allows the user to listen to other program sources without affecting the main preamplifier output, an especially convenient feature when

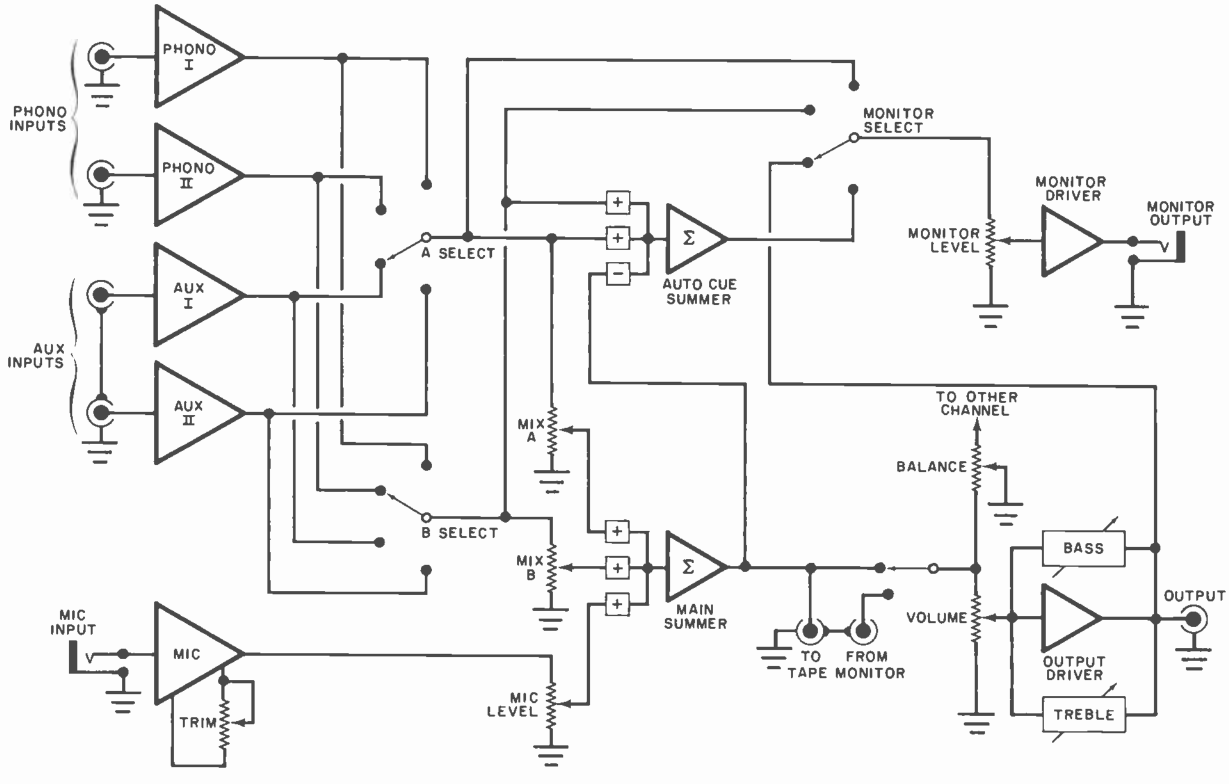


Fig. 2. Block diagram of combined preamplifier and mixer showing inputs, outputs, and controls.

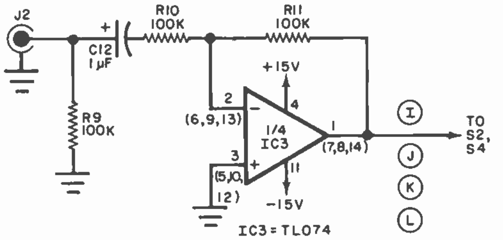


Fig. 3. Schematic of one of four auxiliary input buffers which employ the new BIFET IC.

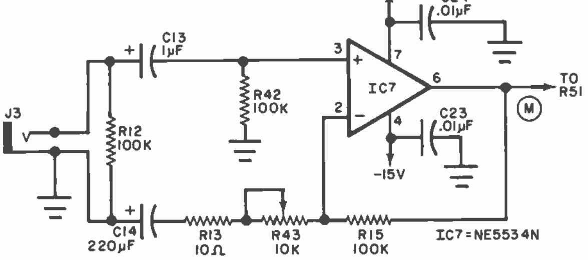


Fig. 4. Microphone preamp features high gain and sensitivity control.

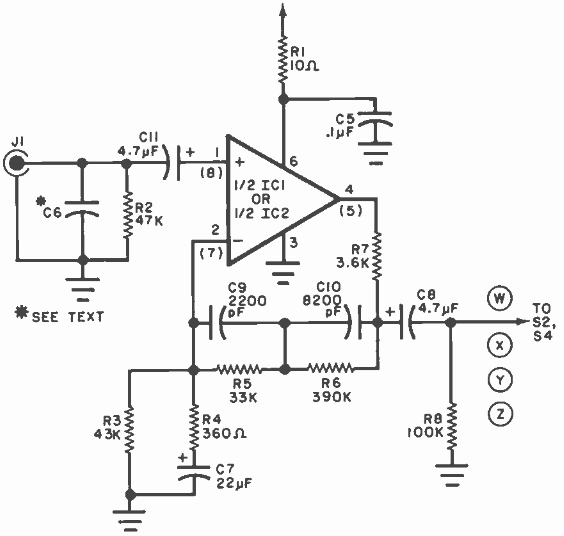


Fig. 5. One of four phono preamps with IEC equalization. Capacitive coupling is used as in all other inputs.

cueing up special record cuts or verifying the desired operation of a program source before routing it to the output.

A four-station interlocked switch array, *S5*, selects the monitoring mode. The user can monitor the *A* mixer input only, the *B* input only, the main preamplifier output (highly desirable if he is in a booth away or acoustically isolated from the sound system), or monitor in the "Auto-Cue" mode. Auto-Cue monitoring means that the user is listening to the exact opposite of his mix settings. For example, if MIX A potentiometer *R46* is at its maximum setting and MIX B potentiometer *R47* is at its minimum setting, he will hear the MIX B signal through the monitor if *S5* is in the Auto-Cue position. Then, if the MIX A potentiometer is rotated fully counterclockwise and MIX B fully clockwise, MIX A will be heard. This mode is very useful in two-turntable systems because it allows the deejay to always listen to the one being cued.

The level of the monitor signal is controlled by MONITOR LEVEL potentiometer *R48*. A dual 2-watt audio amplifier, *IC5*, amplifies the monitor signal and delivers it to *J4*, a stereo phone jack. Either a pair of headphones or small monitor speakers can be plugged into *J4*. The audio IC, an LM377N, has internal current limiting and thermal protection so that, if overloaded, it will shut itself off until it

PARTS LIST

C1, C2, C3, C20*, C25—1000-µF, 16-volt electrolytic
C4, C14—220-µF, 35-volt electrolytic
C5*, C21, C22, C26—0.1-µF, 50-volt disc ceramic
C6**—10-to-300-pF (see text)
C7**—22-µF, 16-volt electrolytic
C8**, C11**—4.7-µF, 16-volt electrolytic
C9**—2200-pF, 5% tolerance polystyrene
C10**—8200-pF, 5% tolerance polystyrene
C12**, C13, C17*, C18—1-µF, 16-volt electrolytic
C15*—0.1-µF, 10% tolerance Mylar
C16*—0.01-µF, 10% tolerance Mylar
C19*—100-pF disc ceramic
C23, C24—0.01-µF disc ceramic
C27*—10-pF disc ceramic
D1 through D6—1N4001 rectifier
F1—½-ampere fast-blow fuse
IC1, IC2—LM387AN dual low-noise preamplifier (National Semiconductor)
IC3, IC4, IC6—TL074CN BIFET quad operational amplifier (Texas Instruments)
IC5—LM377N dual 2-watt audio amplifier (National Semiconductor)
IC7—NE5534N low-noise preamplifier (Signetics)
J1**—insulated phono jack
J2**, J5*, J6*, J7*, J8*—phono jack
J3—¼-inch phone jack
J4—¼-inch stereo phone jack
LED1—20-mA light emitting diode
The following are ¼-watt, 5% tolerance carbon-film resistors.
R1*, R13, R40—10 ohms
R2**—47,000 ohms
R3**—43,000 ohms
R4**—360 ohms
R5**—33,000 ohms
R6**—390,000 ohms
R7**—3600 ohms
R8**, R9**, R10**, R11**, R12**, R15, R17*, R20*, R27*, R28*, R29*, R30*, R31*, R32*, R33*, R34*, R35*, R36*, R37*, R38, R41*, R42—100,000 ohms
R16*, R26*—100 ohms
R19*—24,000 ohms
R21*, R22*, R23*—5600 ohms
R14, R24*, R25*—1800 ohms
R43—10,000-ohm linear-taper printed circuit trimmer potentiometer
R44—100,000-ohm linear-taper potentiometer
R45 through R48—50,000-ohm dual audio-taper potentiometer
R49, R50—50,000-ohm dual linear-taper potentiometer
R51—50,000-ohm audio-taper potentiometer
S1, S3—Dpdt pushbutton switch
S2, S4, S5—four-station dpdt interlocked pushbutton swich
T1—24-volt, 100-mA center-tapped transformer (Signal Transformer Co. #241-4-20)
Misc.—Printed circuit boards and standoffs, IC sockets or Molex Soldercons (if desired), shielded cable, LED holder, hookup wire, suitable enclosure, machine hardware, line cord and strain relief or grommet, solder, etc.

Note—The following are available from Phoenix Systems, 375 Springhill Road, Monroe, CT 06468, (203) 261-4904: Complete kit of parts including enclosure for preamp/mixer, No. P-1130-DM, for $110.00; complete kit of parts including enclosure for preamp only, No. P-1130-PA, for $70.00; etched and drilled preamplifier pc board, No. P-1130-BPA, for $7.50; etched and drilled mixer pc board, No. P-1130-BDM, for $7.50; power transformer *T1*, No. P-1130-T, for $6.00; dpdt pushbutton switch, No. P-1130-SW1 $1.00; four-station dpdt interlocked switch, No. P-1130-SW2, for $4.00; BIFET quad op amp, No. P-1130-C-TL074CN, for $3.50; dual low-noise amplifier, No. P-1130-C-LM387AM, for $3.50; dual 2-watt audio amplifier, No. P-1130-C-LM377N, for $3.00; and low-noise, high-gain op amp, No. P-1130-C-NE5534, for $3.00. All integrated circuits are fully tested. Please allow six weeks for delivery. Connecticut residents add 7% sales tax; COD charge $0.85. Handling charge is $1.00 for orders of less than $10.00. No shipping charges within continental U.S.

*—two of each component required for full stereo preamp/mixer.

**—four of each component required for full stereo preamp/mixer.

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cools down, thus avoiding thermal self-destruction.

The output of the mixer is applied to the output conditioning section of the preamplifier (Fig. 7). Switch *S3* provides tape monitor facilities. Potentiometers *R44* and *R45* are balance and volume controls, respectively. A BIFET buffer amplifies the signal and presents it to the output stage in which the tone controls are found. Drive signals for the system's power amplifier(s) are available at jacks *J7* and *J8*.

The excellent power supply rejection of the integrated circuits employed in this project eliminates the need for a regulated supply. As shown in Fig. 8, two full-wave rectifiers and filter capacitors furnish the ±15 volts required by the BIFET operational amplifiers and the microphone preamp. The +15-volt line is tapped to power the monitor audio driver. A voltage doubler composed of *C3*, *C4*, *D5* and *D6* develops the +25 volts required by the phono preamps.

Construction. Printed circuit assem-

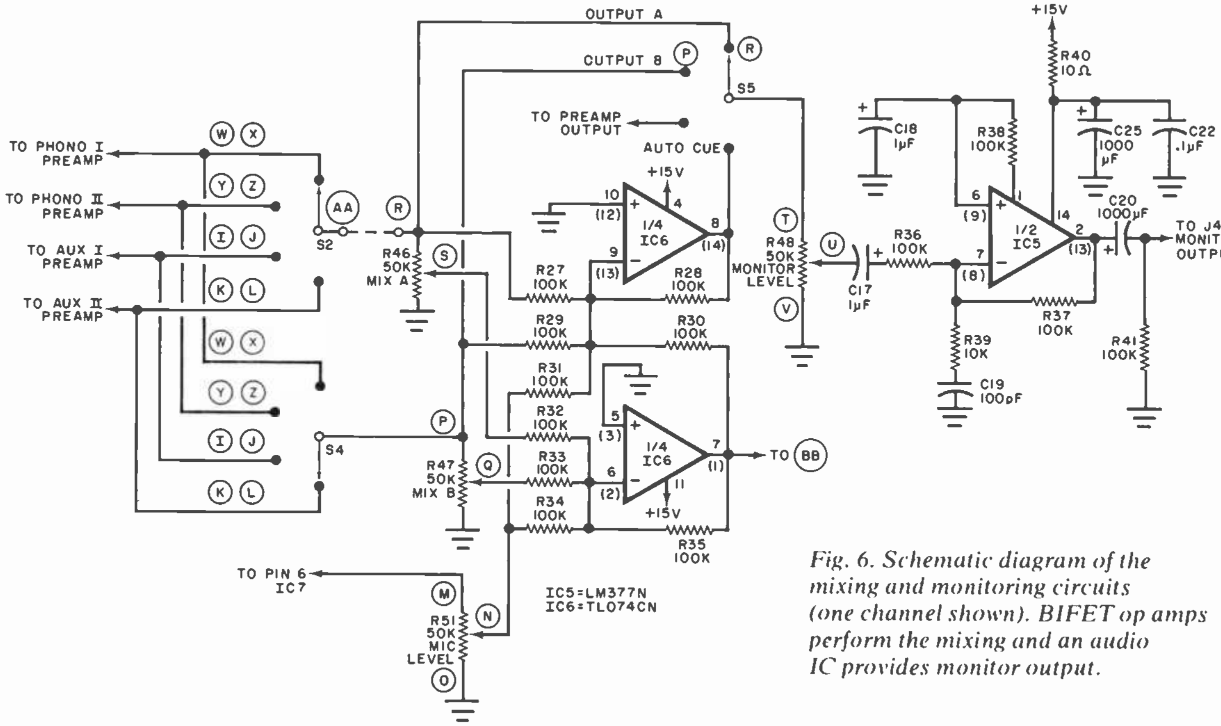


Fig. 6. Schematic diagram of the mixing and monitoring circuits (one channel shown). BIFET op amps perform the mixing and an audio IC provides monitor output.

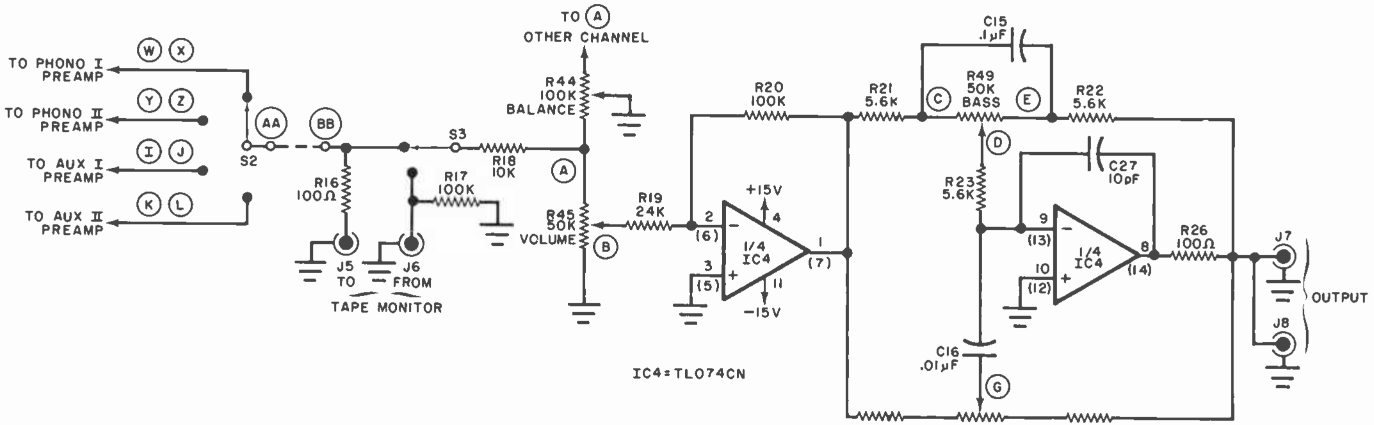


Fig. 7. Output stages of the preamplifier for one channel. Conventional bass and treble tone controls are included, as well as a tape monitor loop.

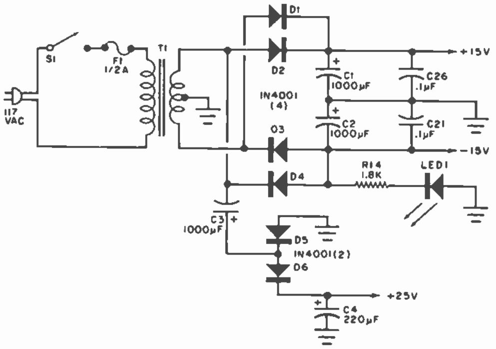
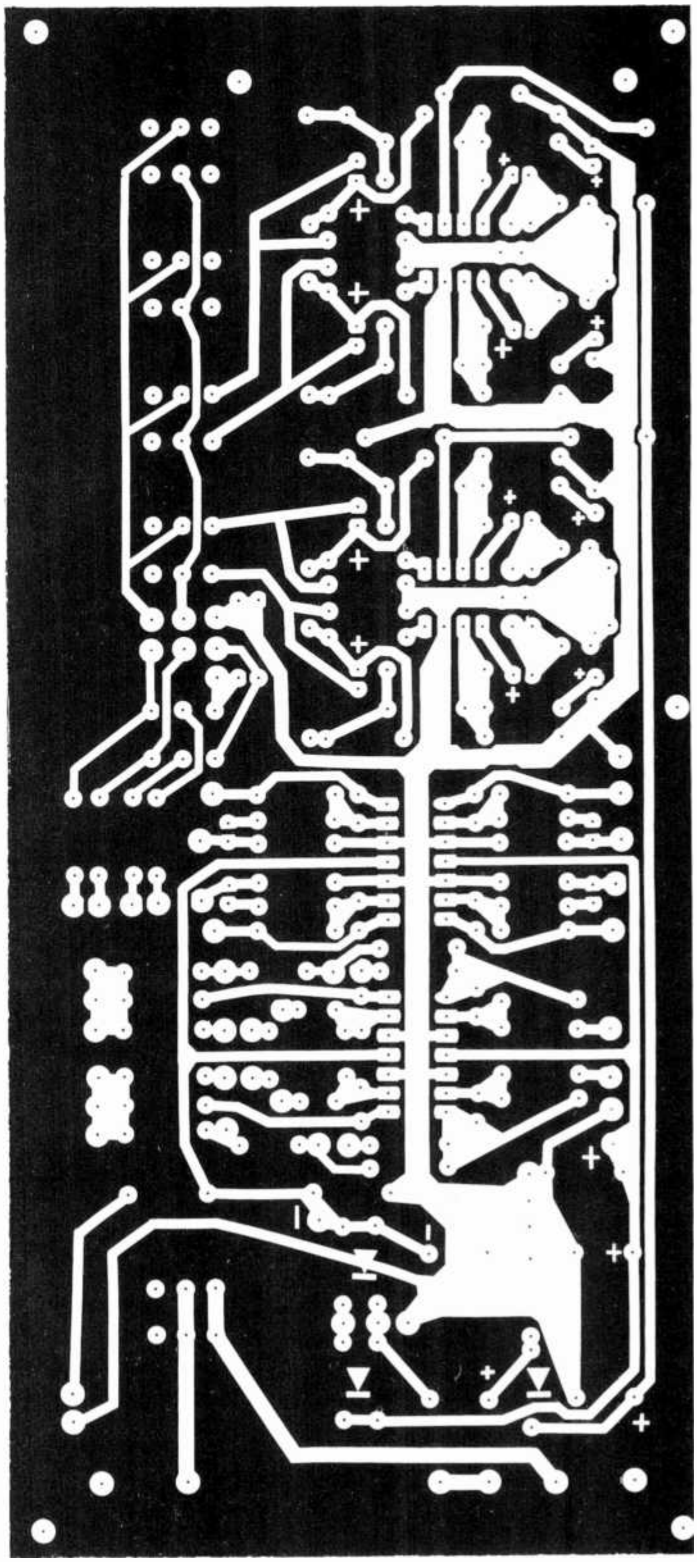


Fig. 8. Schematic of power supply, which delivers three voltages required by the disco mixer stages (+15, −15 and +25 V).



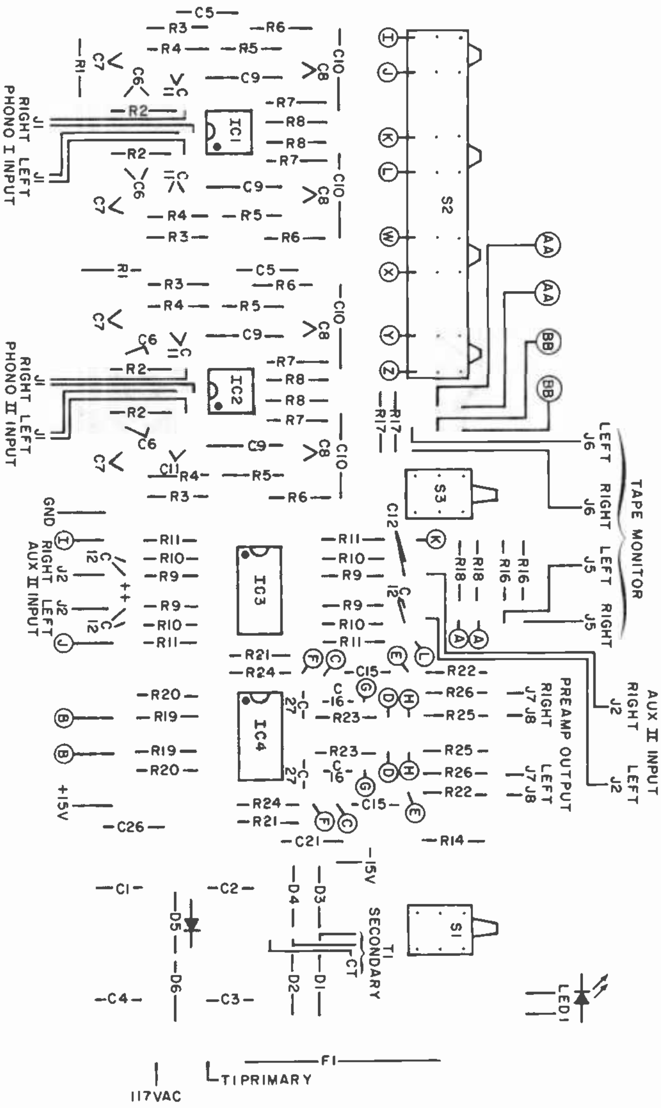


Fig. 9. Actual-size etching and drilling guide for the pc board for the preamplifier is shown at left. A diagram for components placement is above.

bly techniques are strongly recommended. Although it is possible to employ perforated board and point-to-point wiring, the layout of the high-gain stages (phono and microphone preamplifiers) is critical. These circuits are very sensitive to ground loops, hum fields and stray feedback paths. Extensive power supply decoupling is called for because the IC's employed in this project have very high gain-bandwidth products and can break into oscillation very easily.

Suitable etching and drilling and parts placement guides for the preamp and mixer boards are shown in Figs. 9 and 10, respectively. If mixing facilities are not desired, the preamp board can be used on its own as a high-quality stereo preamplifier. You will notice that both the schematic diagrams and the pc guides contain numerous points labelled with letters of the alphabet. These have been included to ease interconnections between the boards, and the boards and the jacks, switches and potentiometers. Most of these connections can be made

(Continued on page 71)

SPECIAL FOCUS ON AUDIO

Phono Equalization — Time For a Change?

Due to the nature of cutting heads, playback cartridges, and the recording medium itself, a precise amount of pre-emphasis and de-emphasis is introduced in the record/playback process. The pre-emphasis characteristic attenuates low frequencies so that "cutover" (the excursion of the cutting stylus through the wall of one groove into the wall of the preceeding one) is avoided and boosts high frequencies to improve the signal-to-noise ratio. During playback, a mirror image de-emphasis characteristic must be introduced so that a flat overall frequency response is achieved.

Exactly how much pre-emphasis and de-emphasis is used has for many years been determined by the RIAA (Recording Industry Association of America) standard. The standard has been universally accepted—even the state recording labels of Eastern European countries (Melodiya, USSR; Supraphon, Czechoslovakia; Hungaroton, Hungary; etc.) employ it. This world-wide acceptance of one recording standard has resulted in benefits to the recording industry and the consumer.

Recently, however, this unquestioned acceptance has been challenged by a proposal from the International Electrochemical Commission. This group has suggested an amendment to the existing RIAA standard which incorporates two modifications. The proposed changes are slight, as shown in the Figure, but a discussion of them is warranted.

The existing RIAA recording and playback curves have been around so long that they cover a frequency range of only 30 to 15,000 Hz. No one will take issue with the IEC proposal to extrapolate the existing curves to 20,000 Hz. In fact, phono preamp designers have been doing it for years. The amendment will merely give this practice official sanction.

The really controversial part of the IEC proposal deals with the lower end of the equalization characteristic. The Commission is suggesting a low frequency rolloff—down 3 dB at 20 Hz and having a −6-dB/octave slope below that frequency. Informally, circuit designers have extrapolated the curve to 20 Hz, but there has been no general consensus as to what should be done below that frequency. It is below 20 Hz that serious difficulties are encountered.

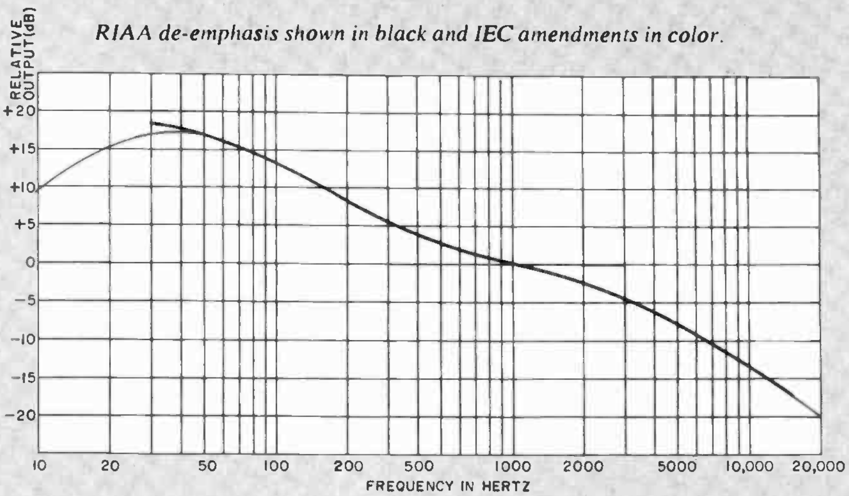
Record Warps. The gradual but continuing deterioration—on some labels, at least—of record quality has made warped discs the rule rather than the exception. Spectral analysis indicates that the waveforms caused by warps possess significant amounts of energy in the 5-to-10-Hz region even though their fundamentals lie octaves lower at about 0.03 Hz. Ten hertz is below the response of the human ear and that of most audio systems, and playback at moderate sound levels should not and usually does not present any difficulty. Problems can arise, however, when sound levels are increased or signal processing is introduced.

For example, a warp waveform superimposed on an audio signal can cause a tape recorder to saturate the tape, resulting in a very disturbing amplitude modulation and/or distortion. Furthermore, nonlinear signal processors such as noise reduction units can be tricked into interpreting the warp as a valid audio signal during encoding. This by itself is not a problem until an attempt is made to decode the signal and the infrasonic signal has been lost to the tape medium's limited low-frequency response. The resulting output signal is the audio signal modulated by the infrasonic warp which is no longer present even though it is really required for proper decoding. The infrasonic signal is long gone, but the modulation or distortion it has caused remains.

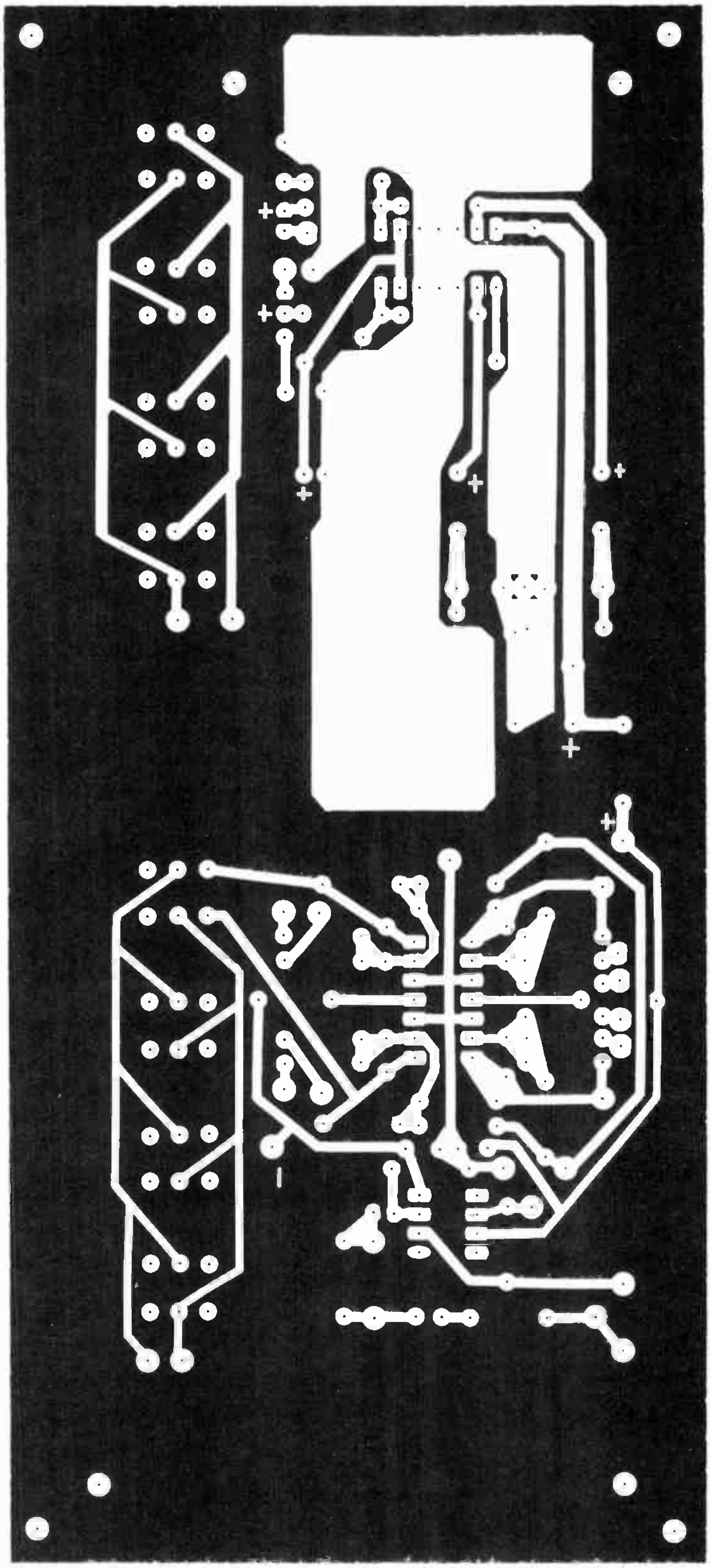
In straight playback situations, the effects of record warps on signal processors are not encountered but other serious problems can crop up, especially at high listening levels. The power amplifier, if its frequency response extends sufficiently low, cannot discriminate between audible and infrasonic signals and will try to drive the speakers with an amplified version of whatever is applied to its input jacks. The possible deleterious effects of excessive speaker cone excursion and amplifier clipping are well-known and can result in permanent speaker damage and/or objectionable levels of distortion.

The ideal solution to the record warp problem would be an improvement in the manufacture and quality control procedures at the record plant. However, in the design of the Disco Mixer, a more realistic approach has been taken. RC networks have been included in the project's phono preamplifiers to give a de-emphasis characteristic coinciding with the IEC proposal. The difference in bass response between the existing and proposed standards is so slight (−1 dB at 40 Hz, −3 dB at 20 Hz) as to be barely audible, and will certainly not render obsolete existing record collections.

Probably the only people who will be upset by the IEC characteristic are those who put more faith in figures that they read rather than in the sounds that they hear. Of course, such people could be satisfied by a phono preamp with switchable equalization. But they should be warned to pay close attention to the setting of the equalization switch. It will be very difficult for them to tell the difference solely on the basis of what they hear—they are listening to a warped record!



RIAA de-emphasis shown in black and IEC amendments in color.



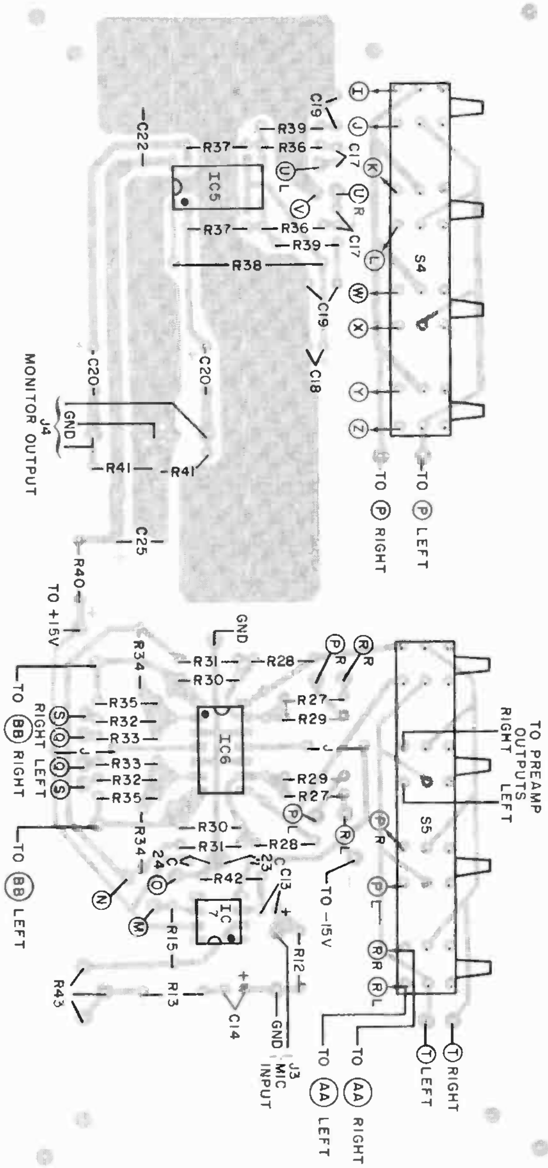


Fig. 10. Etching and drilling guide (left) and components place diagram (above) for the mixer pc board.

(Continued from page 69)

with hookup wire, but two-conductor shielded cable should be used between the phono input jacks and the preamp circuit board. If the preamp-only version of the project is built, install jumper wires between points *AA* and *BB*.

If desired, IC sockets or Molex Soldercons can be used when mounting the integrated circuits. Be sure to observe polarity and pin basing when installing electrolytics and semiconductors. Use good soldering practices.

When circuit board wiring has been completed, mount the boards in a metallic enclosure using machine hardware and spacers. The power transformer should be mounted directly in the enclosure. Those assembling the project using perforated board should take care to keep the power supply away from the high-gain sections of the preamplifier.

Use. The Disco Mixer is straightforward in its use. Patch in the various program sources with suitable lengths of shielded cable and experiment with the different preamp and mixer controls and monitor modes. Then invite your friends over and have a disco party! ◇

SPECIAL FOCUS ON AUDIO

BY MILES H. MARKS

Now You Can Enjoy Hi-Fi Television Sound

Diplexed program transmission system allows networks to send audio and video on one cable and offers viewers high-quality sound.

ON January 23, 1978, in a concerted effort to reduce operating costs, the three major television networks began to use the "Farinon FV-43 FM Transmission Channel System." This is a diplexed method of transmitting audio and video signals on the same coaxial cable. Previously, audio and video were transmitted separately from the point of origin to local network affiliates via AT&T wire and microwave links. The old system had two serious disadvantages—the high cost of maintaining two separate transmission lines and the low-fidelity sound that was actually delivered. The new method, however, not only saves the networks money but also delivers *high-fidelity* FM sound to local studios!

Very little (if any) fanfare accompanied the changeover, so most people don't realize the hi-fi capabilities of TV audio. And given the crude audio provisions in many television receivers, most viewers are unaware that the potential for hi-fi is there.

Actually, the frequency response of network audio program material now delivered to local studios is 50 to 15,000 Hz ±0.3 dB (Fig. 1) and its THD content at 1000 Hz and +18 dBm is less than −54 dB. The networks had originally planned to start using the new system a few weeks earlier than they did. However, CBS requested a delay to ensure that the old, proven system would deliver the audio portion of its "Super Bowl" coverage (the most widely watched program of the year) without interruption.

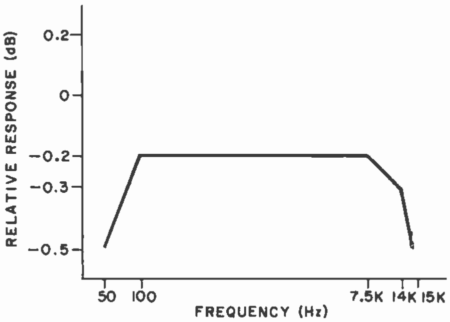


Fig. 1. Frequency response of demodulated audio of FV-43.

How It Works. A block diagram of the FV-43 FM Transmission Channel System is shown in Fig. 2. It provides transmission facilities for one or two high-quality audio channels, positioned immediately above the standard video baseband—channel 1 at 5.8 MHz and channel 2 at 6.4 MHz. These channels provide low-noise, low-distortion, and wide-bandwidth audio program facilities that can be transmitted simultaneously with a video signal. Each requires an FM channel transmitter at the point of origin and an FM channel receiver at the distant terminal.

The diplexer passes video components below 5 MHz. There is at least 40 dB of video attenuation at the transmission channel sub-carrier frequencies. The diplexer is carefully designed to minimize video signal degradation. Wideband amplifiers, low-ripple filters, and equalizers provide very good amplitude response. The input and the output of the diplexer are direct-coupled to minimize bounce and variations in low-frequency response. Filtering in the video line at the transmit terminal rejects spurious signals at FM channel sub-carrier frequencies. An identical filter in the video path at the receiving terminals prevents FM channel sub-carriers from entering the video output line.

In the diplexer, the video signal passes through a transient voltage suppression network and an impedance matching network to the input of a differential amplifier. The amplifier output is filtered and equalized to compensate for phase distortion caused by the filter. The equalized signal is then applied to the input of a second differential amplifier which boosts it to standard line level. The output of the FM channel transmit-

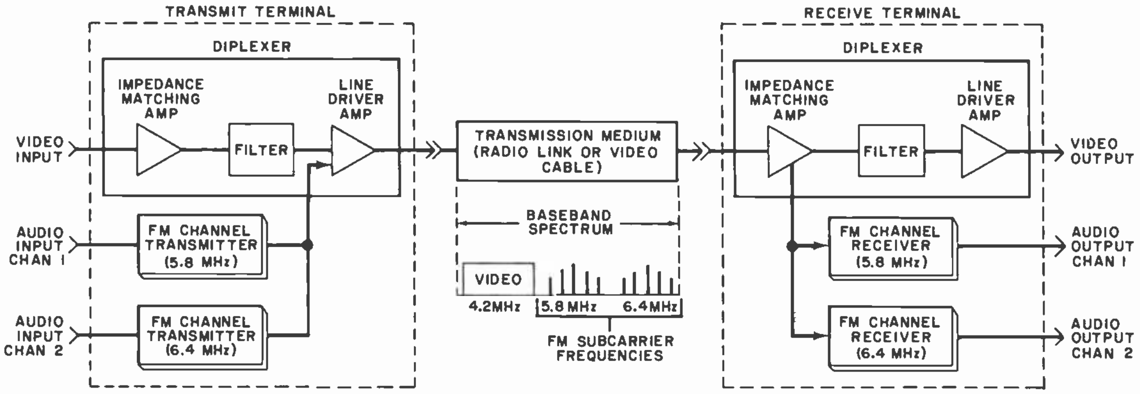


Fig. 2. Block diagram of the FV-43 FM Transmission Channel System.

ter is applied to the other input of the second differential amplifier. The baseband signal and the FM channel subcarriers leave the diplexer through either a balanced or unbalanced output.

FM Channel Transmitter and Receiver. In the FM channel transmitter, an applied audio signal is amplified and receives pre-emphasis before it is used to modulate a voltage-controlled oscillator (vco). The frequency-modulated oscillator signal is filtered to suppress oscillator harmonics and reduced in amplitude by a variable attenuator to the desired output level. Frequency stability of the transmitter is obtained by phase-locking the vco to a crystal-controlled reference oscillator.

In an FM receiver, a signal from the diplexer is first applied to an attenuator pad and then to a bandpass filter that selects the appropriate FM channel subcarrier. The receiver circuits following the filter limit and demodulate the subcarrier, add de-emphasis, and amplify the recovered audio program material.

The Future. The FV-43 FM Transmission Channel System opens up a whole new dimension in television receiver design and product appeal. Now television manufacturers can bring the audio sections of their products to a level that matches the technology of their video counterparts. Existing television receivers can be modified for high-fidelity reproduction by tapping the audio at the output of the FM detector and feeding it to an external audio system.

To maintain isolation between the receiver and the audio system, an interstage audio transformer or an emitter or voltage follower is needed. If the television is transformerless (chassis tied directly to one side of the ac line), *do not* connect its chassis to the chassis of the preamplifier or integrated amplifier unless you either use a coupling transformer on the audio line or an isolation transformer on the television's power line.

Interestingly, the FV-43 system incorporates provisions for *two* audio channels, leaving open the options of stereophonic sound for television, off-line data communications or even computer control. One needn't wait for TV models with hi-fi audio provisions or modify present receivers, however. At least two companies offer separate tuners for TV audio only—Pioneer and Rhoades—which can do the hi-fi trick with no muss or fuss. ◇

BY ALEXANDER W. BURAWA
Features Editor

Metal Cassette Tape Debuts

Fine-metal formulation tape may revolutionize cassette deck design.

EVER since its introduction, magnetic recording tape has used metal oxides in one form or another for the recording material. Now, a new type of recording material made up of fine metal—not metal-oxide—particles is expected to make a tremendous impact in audio and video recording. The new tape is said to produce a level of performance that surpasses that of the best conventional metal-oxide tapes. Although the metal tapes are playback-compatible with current tape decks equipped with 70-µs playback equalization (the CrO_2 setting), satisfactory recording will require new recording equipment.

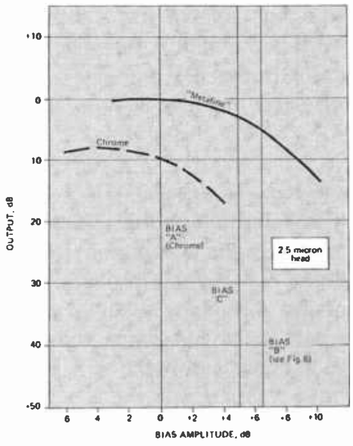


Fig. 1. Maximum output levels as function of bias.

One of the first of the new metal tapes to come on the consumer audio market is 3M Company's Scotch brand "Metafine" in the popular cassette format. (Other tape manufacturers are sure to market their own versions soon.) At a recent press conference, a Metafine audio cassette was recorded, erased, and played back on a tape deck that was specially modified to accommodate its characteristics. The cassette delivered a maximum output 5 to 10 dB greater than typical chrome tapes and 3 to 7 dB greater than Scotch Master II tape. This means that maximum output is at least double that of other tapes, depending upon the frequency selected.

Lower distortion, additional high-frequency response, improved S/N, and increased maximum output are among the benefits it is claimed one will realize with metal tapes.

Exact increases in performance will depend upon the selection of benefits manufacturers build into future tape recorders, of course.

Metal tape is said to permit higher performance characteristics at present tape speeds and packing densities. Accordingly, it also opens the way for dramatic changes in speed, format, and component size without sacrificing performance capabilities.

Technical Details. The level and frequency distribution of the new metal tapes are similar to those for CrO_2 tapes. A 70-µs equalization was selected to minimize noise, while new metal-tape recorders will utilize Sendust heads because they do not saturate as easily as other types of heads. Because of its

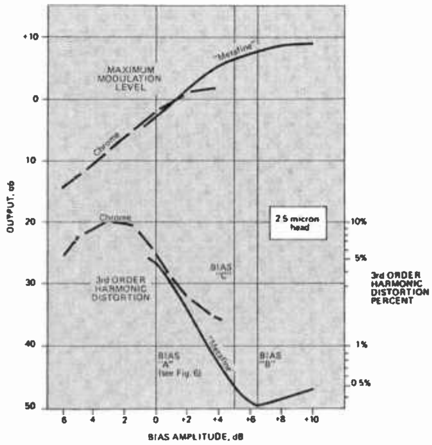


Fig. 2. Maximum modulation and harmonic distortion levels.

high-density recording capability, it has been suggested that a 15/16-ips recording speed is possible, providing better sound quality than is obtainable at today's 3 ¾ ips!

The characteristics of metal-tape audio cassettes are best realized at a recording bias significantly different from those of present recorders, which is one of the reasons new equipment is necessary for recording. Another is that a stronger erase current is required.

One has only to look at the specifications in the table for various tapes to see the superiority of metal tapes.

The curves in Fig. 1 show comparative output levels for Scotch Metafine and a top CrO_2 audio tape. The maximum output level at saturation at 12,500 Hz is 7 dB greater for Metafine at the optimum bias for each tape. Figure 2 illustrates comparative modulation and harmonic-distortion levels for the same tapes. The maximum modulation level (3% third-order harmonic distortion at 333 Hz) is up to 9 dB greater for Metafine tape.

TAPE SPECIFICATION COMPARISONS

	Retentivity (gauss)	Remanence (lines/¼ in.)	Coercivity (oersted)
Typical Chrome	1400	0.43	550
Scotch "Master II"	1500	0.60	550
Scotch "Metafine"	3400	0.80	1000

The Agenda. 3M Company (and undoubtedly other manufacturers) plans to have its Metafine tape on the consumer market before the end of this year. It will first be introduced in the popular C-90 cassette size and will carry a list price of about $10. So far, there is at least one manufacturer who announced production of a cassette deck to accommodate the new metal tape for both playback *and* recording. It is the Model TCD 340 AM three-motor/three-head cassette deck from Tandberg. And $1300 is the suggested retail price. Other recorder manufacturers will likely follow and may already be offering for sale metal-tape recorders by the time you read this. ◇

BY ROBERT R. FAULKNER

Build a Super Audio Filter

Capacitance multiplier reduces hum in hi-fi equipment by 80 dB.

Although most dc power supplies have a very low hum level, there are many applications that require as pure a dc as possible. Among these are high-gain preamplifiers, and phono amplifiers, as well as instrumentation amplifiers and many types of digital circuits.

The obvious answer to a slight amount of hum (ripple) in a dc power supply is to add more filter capacitance. However, there is an easier and better way—add the "Super Filter" described in this article.

The circuit shown in Fig. 1 is a simple ripple filter, sometimes called capacitance multiplier. It can reduce hum level by a factor of 250:1. For example, if the ripple is 250 mV peak-to-peak, the use of this filter will reduce the hum to 1 mV or less. Obviously, the better the power supply is filtered, the smoother the output when using Super Filter.

Ripple voltage should not exceed 3 volts peak-to-peak and the new filter will handle up to 35 volts at 2 amperes, without a heat sink. Insertion loss is about 1.1 volt.

Construction. The circuit can be built using the full-size foil pattern shown in Fig. 2, along with the component installation. When completed, the small pc board can be mounted within a small shielded metal enclosure whose case is connected to chassis ground.

Use. Connect the filter to the dc output of the power supply, observing the correct polarity. Connect an ac voltmeter, or an oscilloscope, to the output of *Q2*.

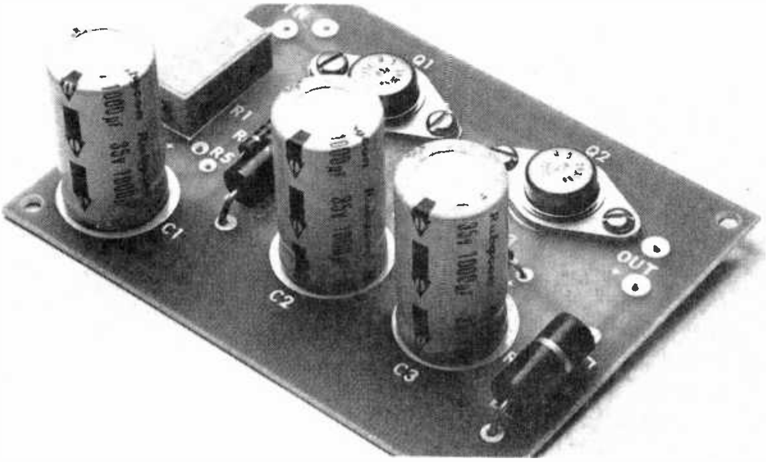


Photo shows layout of author's prototype filter.

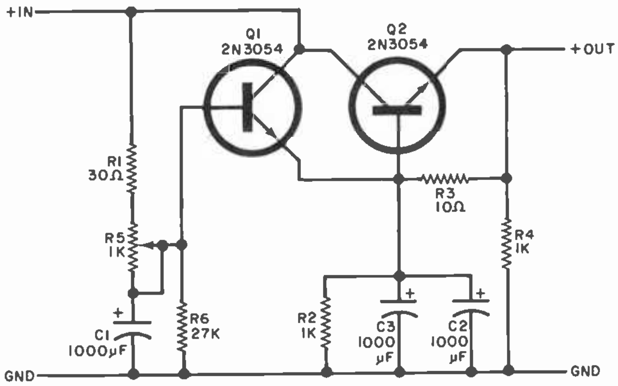
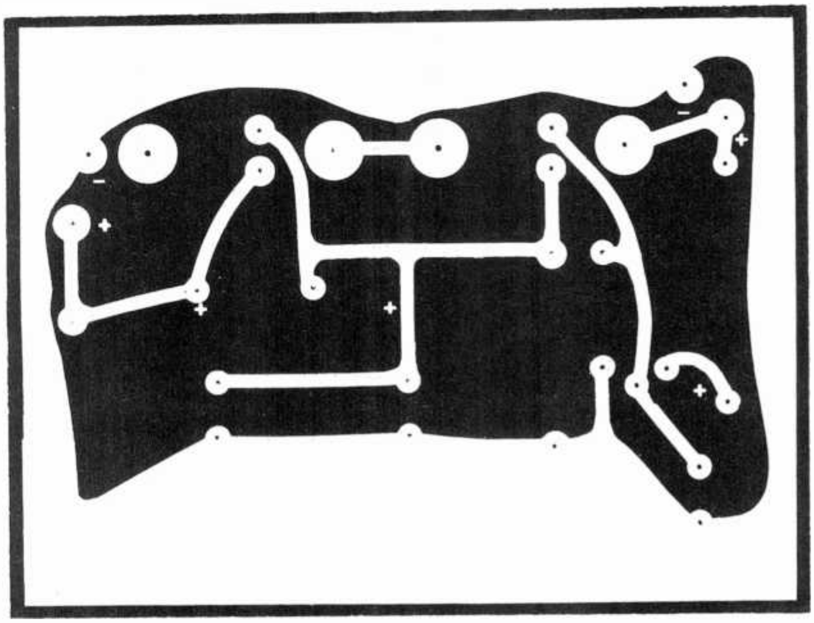


Fig. 1. Schematic diagram shows the circuit is a simple ripple filter or capacitance multiplier.

PARTS LIST

C1, C2, C3—1000-µF, 35-volt electrolytic
Q1, Q2—2N3054 transistor
R1—30-ohm, 5-watt resistor
R2, R4—1000-ohm, 2-watt resistor
R3—10-ohm, ½-watt resistor
R5—1000-ohm, 5-watt linear taper WW potentiometer
R6—27,000-ohm, ½-watt resistor
Misc.—small metal enclosure, mounting hardware, etc.
Note—The following are available from Robert R. Faulkner, Box 26, Redondo Beach, CA 90277: pc board at $6; board and components, $19.95. California residents, please add sales tax.



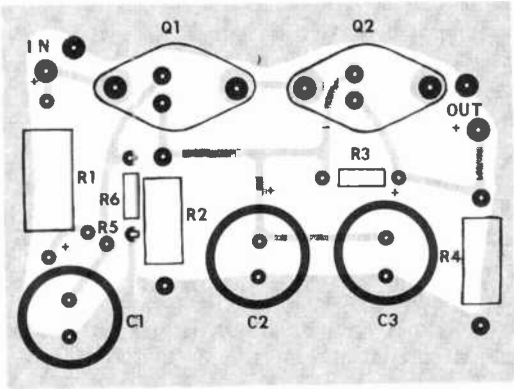


Fig. 2. Full-size foil pattern for filter pc board and component placement diagram are shown above.

Carefully adjust potentiometer *R5* for a minimum reading on the meter, or minimum display on the scope. This adjustment should decrease the hum level by at least 80 dB. The leads to the audio ac voltmeter, or scope, should be well shielded and as short as possible. ◇

BY JERALD M. COGSWELL

Protection for DC-Coupled Speakers

Direct coupling of the output stages of an audio amplifier has its advantages, but speaker system protection should be provided.

DIRECT-COUPLED output stages are commonly found in contemporary audio amplifiers. Although there are definite advantages associated with dc coupling, there is also a danger—a collector-to-emitter short in an output transistor will impress the full power-supply voltage across the speaker terminals. Under such conditions, a speaker's voice coil will quickly burn out. The project presented here can save your speakers from destruction by removing ac power from the amplifier if a dc level appears across the speaker outputs.

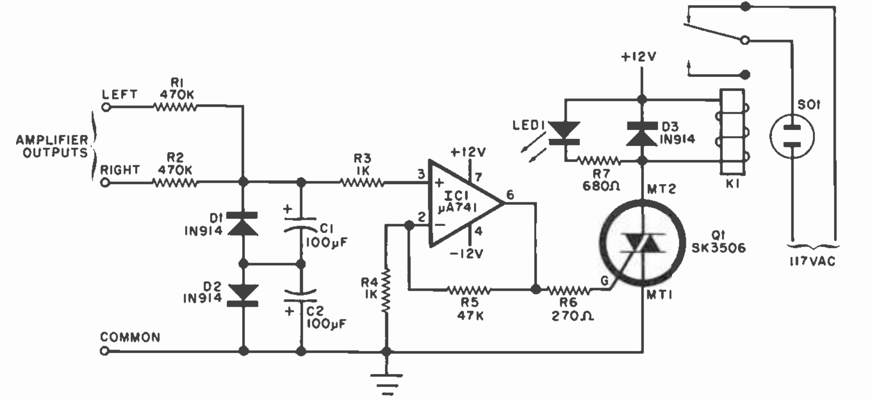
Technical Details. The relatively simple circuit of the speaker protector is shown schematically in the diagram. Output signals from the amplifier are coupled to the protector by *R1* and *R2*. A symmetrical audio (ac) signal will not cause *C1* or *C2* to accumulate any steady-state, unbalanced charge. However, a positive dc level will cause *C1* to charge to a given voltage. A negative dc level will similarly cause *C2* to acquire a charge. Diodes *D1* and *D2* protect the electrolytic capacitors from reverse-polarity voltages.

An unbalanced charge results in a positive or negative voltage across the series connection of *C1* and *C2*. This voltage is applied to the noninverting input of *IC1* via *R3*. The amplified voltage appearing at the output of the op amp triggers thyristor *Q1*, which conducts and energizes the coil of relay *K1*. The relay then interrupts the flow of current from the ac power source to the amplifier. A LED is also included to act as a visual indication that the circuit has been activated. Diode *D3* protects the LED from inductive spikes generated as the relay is activated.

The author has selected a triac as the device controlling relay current for two reasons. First, the latching characteristic of the thyristor keeps the relay coil energized even after power has been removed from the amplifier. To reset the circuit, current flow from the +12-volt source to the triac must be interrupted.

Secondly, although the device need only conduct in one direction (implying the suitability of an SCR), it must be able to latch on when triggered by either a positive or negative pulse of gate current. This the SCR cannot do, but is a fundamental property of the triac. That's why this application, which involves a power amplifier having a bipolar power supply, dictates the use of a triac.

Construction. The project can be assembled using printed circuit, point-to-point, or Wire-Wrap techniques. Use appropriate sockets for the op amp and relay. The project board and a suitable power supply should be mounted in a suitable enclosure, taking care to avoid shock hazards. A barrier strip or push-button terminals can be mounted on the enclosure to simplify connections to the speaker outputs of the power amplifier.



An unbalance across capacitors C1 and C2 triggers Q1 and energizes K1 to shut off the amplifier power.

PARTS LIST

C1,C2—100-μF, 35-volt tantalum capacitor (see text)
D1,D2,D3—1N914 silicon diode
IC1—μA741CV operational amplifier
K1—12-volt dc relay, 10-ampere contacts, 600 ohms max. coil resistance (Radio Shack 275-208 or equivalent)
LED1—20-mA light emitting diode
Q1—SK3506 (RCA) triac or equivalent.
The following are ¼-watt, 10% tolerance carbon-composition resistors:
R1,R2—470,000 ohms
R3,R4—1000 ohms
R5—47,000 ohms
R6—270 ohms
R7—680 ohms
SO1—117-V ac power socket
Misc.—Printed circuit or perforated board, ±12-volt regulated power source, suitable enclosure, barrier strip, IC socket, relay socket (included with *K1*), line cord, strain relief, hookup wire, hardware, etc.

You will note that *C1* and *C2* are specified in the parts list as tantalum capacitors. This was done to avoid the wide tolerances (−50%, +100%) of common aluminum electrolytic components which could disturb the symmetry of the input circuit. Tantalum capacitors are typically rated at ±20% or better, but you might have a hard time finding components with the specified capacitance. This can be easily overcome by paralleling smaller values, say, two 47-μF capacitors. However, it is not critical to have 100 μF of capacitance. Smaller values will work well, but will reduce the time constant of the RC input network.

Checkout and Use. After you have finished building the speaker protector, examine it for cold solder joints, incorrect wiring, and semiconductors and electrolytic capacitors with reversed polarity. Then plug an incandescent lamp into socket *SO1* and apply power to the circuit. The lamp will glow. Using two flashlight batteries in series, apply 3 volts dc across either the left or right channel protector inputs. After three to five seconds, the relay will be energized, a click will be heard, and the lamp will darken. The glowing LED will also indicate that the triac has been triggered.

Next, disconnect the speaker protector from its power supply, remove the batteries from the input and discharge *C1* and *C2*. Reverse the polarity of the batteries, connect them to the same input as before, and apply power to the protector circuit. After a short delay, the same sequence of events will occur as described earlier. Repeat this test procedure for the other channel's input.

You have now verified proper circuit behavior, and the speaker protector is ready for use. Remove the test lamp's power plug from *SO1* and replace it with that from your audio amplifier. Interconnect the amplifier's speaker outputs and the input barrier strip of the speaker protector with lengths of zipcord. Be sure to observe proper phasing. Do not attempt to test the circuit while the speakers are connected because flashlight batteries cannot deliver their rated voltage into such a low impedance. ◇

The difference between these cassette decks isn't sound.

The Nakamichi 1000II: $1,650*

The Pioneer CT-F1000: $600*

There's hardly an audio enthusiast alive who doesn't admire the Nakamichi 1000II.

But at $1,650,* admiring it is about all most people can do.

That's why Pioneer created the new CT-F1000. A cassette deck that offers all the features and performance of the Nakamichi 1000II, but costs almost $1,000 less.

(We realize this is hard to believe, but be patient. The facts bear us out.)

It's a fact that the $600* Pioneer CT-F1000 and the $1,650 Nakamichi 1000II are both honest three headed cassette decks that let you monitor right off the tape as you record.

Both feature separate Dolby systems for the playback and recording heads. So when you're recording with the Dolby on, you can monitor the same way.

And both are filled with all the remarkable features you'd expect to find on cassette decks of this caliber: there's everything from jam-proof solenoid logic controls, to multiplex filters for making cleaner FM recordings, to memories that automatically let you go back to a particular spot on the tape.

It's value.

The comparison holds up equally well when it comes to performance.

The CT-F1000 and the Nakamichi 1000II both have total harmonic distortion levels of less than 1.5%.

Both have all but conquered the problem of wow and flutter. (An identical 0.05% for each deck.)

And both have signal to noise ratios that are so similar only sophisticated laboratory equipment can tell them apart.

If the incredible value of the CT-F1000 still sounds a bit hard to believe, we suggest you go hear it for yourself at any Pioneer dealer.

Our viewpoint is simple: if you can't hear the difference, why pay the difference?

PIONEER®
We bring it back alive.

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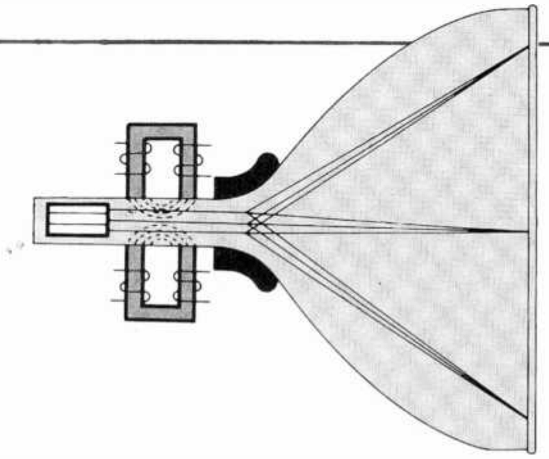
*Manufacturer's suggested retail price. Handles optional at extra cost.

CIRCLE NO. 61 ON FREE INFORMATION CARD

BY JAMES B. PENNY



A LOW-COST DOT/BAR GENERATOR

A DOT/BAR video signal generator is an essential piece of test equipment for the setup and convergence of a color-TV receiver or monitor. The generator can also be used to adjust horizontal and vertical linearity of monochrome receivers and monitors.

The circuit (Fig.1) shown here can be built for about $15, and is small enough to be permanently installed in a color-TV cabinet. It can also be housed in a small case (including a 9-volt battery) for portable use. Since the output is video, some form of FCC-approved r-f modulator is required if you wish to inject the signal into the antenna of a TV receiver.

Circuit Operation. Oscillator *IC1* is preset to 251,752 Hz (16 times the horizontal scanning rate) by the setting of potentiometer *R1*. When a 555 is operated with D17 as shown, the data sheet formulas for frequency are not valid, and the frequency of oscillations becomes more dependent on the supply voltage. The output of *IC1* (pin 3), drives 12-stage counter *IC2* to generate the other frequencies required to create the composite video output signal. Various *IC2* outputs are diode OR'ed to produce the proper pulse widths.

Horizontal and vertical video components are combined in NOR gate *IC3A*, while the horizontal and vertical sync components are mixed in *IC3B*. Output transistors *Q1* and *Q2*, arranged as an AND gate, combine video and sync into composite video and provide sufficient drive for a 75-ohm output load.

With *S1* in its center (off) position, the video display will be white dots on a black background. The other positions of *S1* yield horizontal or vertical white bars on a black field. These are the output signals most commonly used for static and dynamic convergence of color receivers. They can also be used to set linearity of monochrome receivers.

The values of *R9* and *R10* determine the base currents of *Q1* or *Q2*, and their connections to *IC3* determine positive or negative video. Resistor *R11* determines the blanking (black) level of the display. Resistor *R12* determines the peak-to-peak output voltage level, while *R13* determines the output impedance.

When powered by 9 volts, the values shown for *R9* through *R13* provide a nominal one volt peak-to-peak composite video with negative-going sync into a 75-ohm load.

If *R9* is disconnected, the unit becomes a sync generator. Increasing the value of *R3* (retuning *R1*) will increase the width of the bars or dots. Eliminating *D9* will increase the height of the bars or dots.

Construction. The circuit can be assembled using any type of wiring technique; the foil pattern shown in Fig. 2 may be used. This illustration also shows component installation.

With the generator powered and *S1* in

Build this essential instrument for setup and convergence of color TV for $15.

PARTS LIST

C1—100-pF, disc ceramic
C2—0.1-μF, disc ceramic
C3—220-μF, 35-volt electrolytic (optional)
D1 through D17—1N914 silicon diode
IC1—555 timer
IC2—CD4040, 12-stage ripple counter (CMOS)
IC3—CD4001, quad 2-input NOR gate (CMOS)
Q1, Q2—2N5449 npn silicon transistor
The following resistors are ¼-watt, 10%:
R2—10,000 ohms
R3,R13—75 ohms
R4, R11—2200 ohms
R5, R6, R7—100,000 ohms
R8—27,000 ohms
R9, R10—1000 ohms
R12—470 ohms
R1—10,000-ohm trimmer potentiometer
S1—Spdt, center-off switch
Misc.—battery holder, suitable enclosure, interconnect cable, mounting hardware, etc.

Note—A complete kit of parts including drilled pc board, is available for $14.95 plus $1.50 P+H within the continental US from ABCOR Inc., Box 58216, Houston, TX 77058. Texas residents, please add 5% sales tax. The r-f modulator is available from ABCOR, or M&R Enterprises, PO Box 1011, Sunnyvale, CA 94088 for $24.95 with 60-dB isolation switch and cables. Modulator only is $14.95.

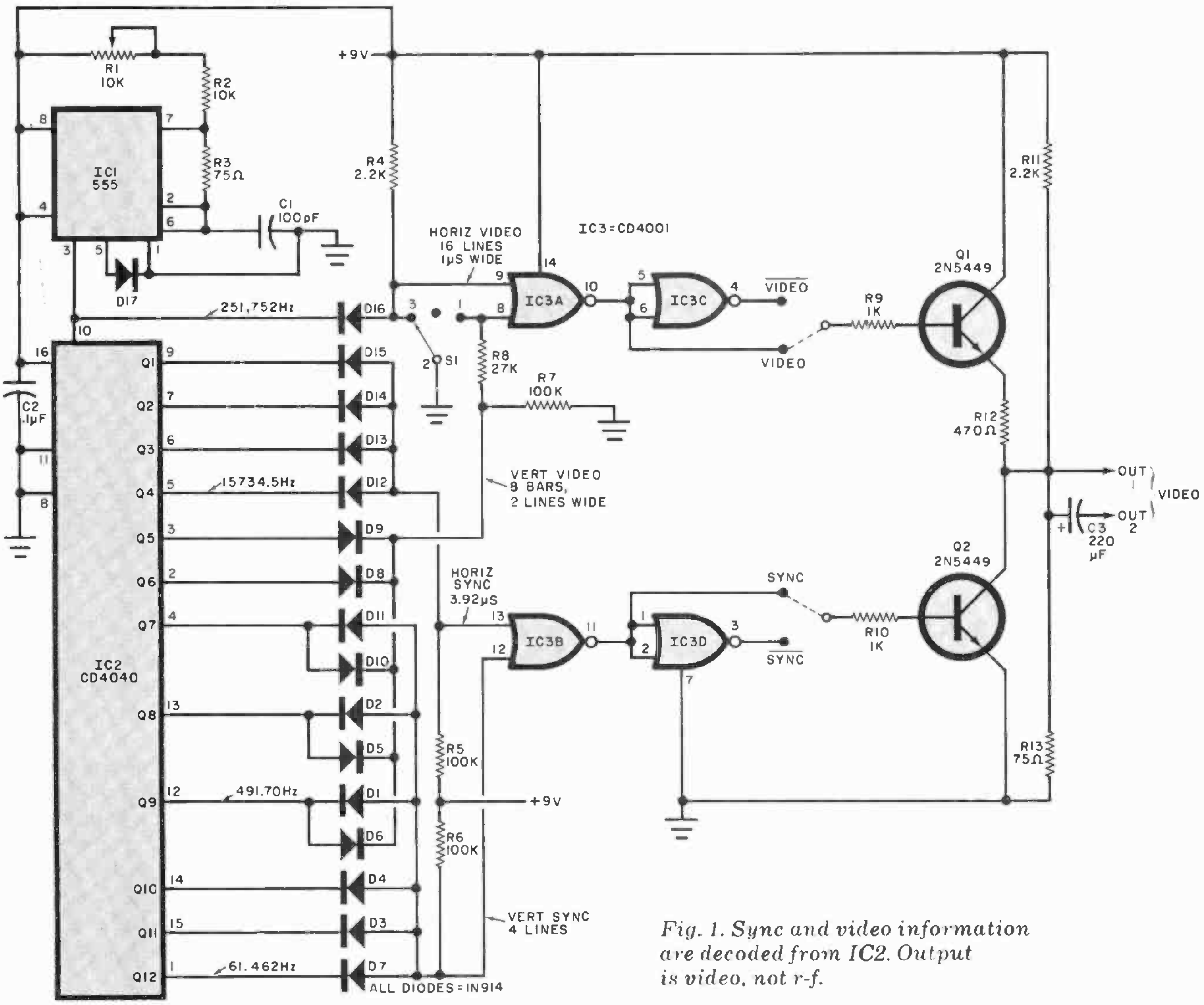


Fig. 1. Sync and video information are decoded from IC2. Output is video, not r-f.

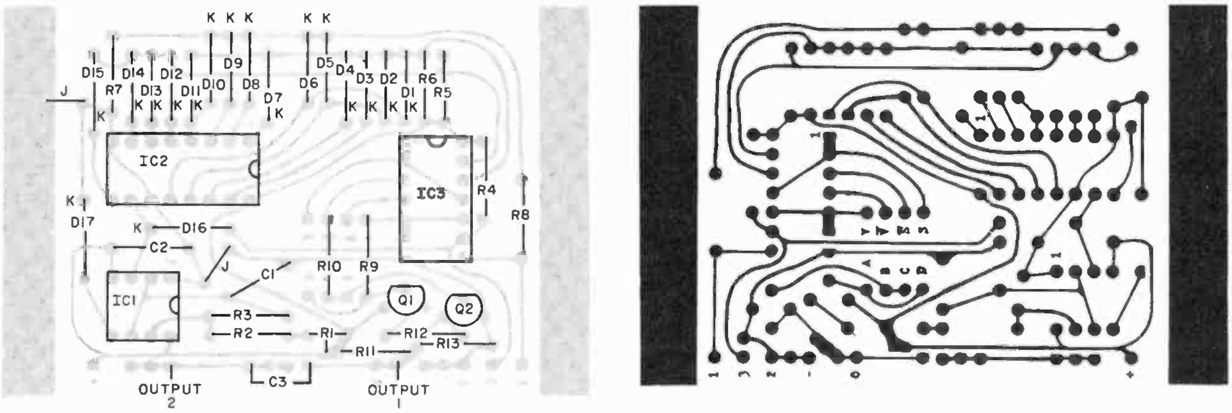


Fig 2. Actual-size foil pattern and component installation for the generator. The two large end bars are used for mounting, and are not required for operation.

the center position, connect the generator to the *video* input of the receiver to be checked, and turn on the power. Adjust *R1* until the sync locks and a stable pattern appears on the screen.

With the manual provided by the color-TV receiver manufacturer or other source, the generator can now be used for convergence. In a monochrome system, the bars or dots can be used in conjunction with the linearity controls to set up the screen for proper proportions.

Two video outputs are provided: One (out 1) is dc coupled to the output stage, while the other (out 2) is dc isolated from the output stage. Use either one, depending on the type of input required. If the video stage will not tolerate a dc offset, then use output 2. If the video stage has capacitor input, use output 1. ◇

USE AN INTERFACE PANEL

And End Test-Lead Clutter

BY ROBERT SHAW

ONE OF THE biggest problems when working with two or more pieces of test equipment at the same time is the messy tangle of test leads that often results. Because most test leads look alike, it is easy to lose track of which set goes to a given instrument. One practical way to avoid this mess and confusion is to use a "patch panel." What makes this scheme practical is the fact that most test instruments have unbalanced inputs and/or outputs.

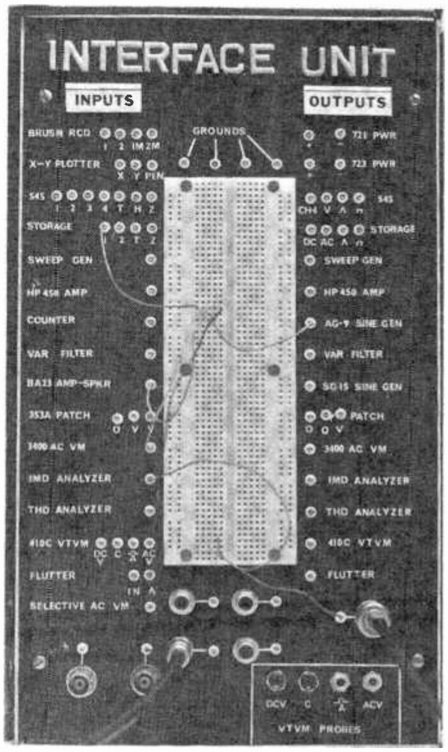
The secret to making a reliable patch panel is to employ good grounding and shielding practices. A properly fabricated patch panel will accommodate audio signal levels as low as −70 dB at 1 megohm impedance, provided all outputs are spaced at least 1" (25.4mm) away from the low-level inputs. For higher levels, between −60 and +45 dB, no special precautions are required, even at high impedances. The only time safety becomes a factor is when signal levels approach 100 volts. And the patch panel can easily handle signal frequencies up to about 500 kHz.

Putting It Together. The prototype patch panel, shown in the photo, was built on a front-panel plate taken from a sturdy steel instrument enclosure. At the center of the panel is a large solderless socket that greatly simplifies hook-ups to instruments and has the added advantage of providing a breadboarding medium for inserting all types of networks between instruments and equipment under test. The solderless socket selected for the prototype was the largest one available. It has 64 sets of five parallel-connected solderless plug-in holes on each side of a center slot, plus a number of parallel-connected "buses" running down each side of the main socket. Of course, smaller sockets can be used in less elaborate setups.

The best way to mount the solderless socket is to orient it vertically on the panel's plate. The bottom of the socket is fully insulated. So there is no need to use spacers; just bolt it directly to the plate. Label one side of the panel INPUTS, and label the other side OUTPUTS.

Now, determine which items of test equipment you have to go to the patch panel, keeping in mind the upper frequency limit of 500 kHz. Such equipment might include: VOM's; VTVM's, TVM's, or DMM's; audio signal generators; low-frequency oscilloscopes; sweep generators; intermodulation and total-harmonic distortion meters; power meters; low-voltage power supplies; etc. Account for every input and output (if any) for each instrument. (Don't forget the Z-axis input for the oscilloscope.)

Once you know how many input and output tie points you need, drill holes for mounting standard push-in solderless terminal pins in the panel. Use a 0.136" (3.454-mm) drill for the holes. Push the pins into the holes until they are solidly seated against the panel. The insulating plastic around the pins will swell to form a tight mechanical fit. Mount some BNC and phono-jack connectors along the bottom of the panel, with the "hot" lead of each connector going to a separate press-in terminal. Then use a good-quality dry-transfer lettering kit to label all input and output points on the panel.



The test instruments are connected to the solderless pins from the back of the patch panel via high-quality slender coaxial cable that is properly terminated at the instrument ends. The shields of the cable go to a common ground bus, while the hot conductors go to the appropriate press-in pins. Plan to have all multimeter test-lead points "floating." You can use the BNC and phono-jack connectors for the cables going to and coming from the equipment being serviced and for test equipment not otherwise terminated on the patch panel.

Using the Patch Panel. Because all the front panel terminations are solderless, you will need a supply of short lengths of No. 22 or No. 24 solid insulated hook-up wire for making the various interconnections between solderless pins and the socket. Strip about ¼" to ⅜" (6.35 to 9.53 mm) of insulation from each end of the wires.

Mount the patch panel on your workbench in a location where it will be conveniently accessible under all working conditions. Place the device or equipment to be tested on the bench and connect its inputs and outputs to the BNC and/or phono-jack connectors, or simply plug them into the holes in the large socket. Then, using lengths of prepared hookup wire, it becomes very simple to interconnect the test instruments as needed. Because each row of connectors on the socket has five parallel-connected tie points, you can couple to the equipment being tested up to four instruments to the inputs and four more to the outputs without having to jumper to another set of terminals.

The solderless socket is designed to accommodate the leads of low-wattage resistors, most capacitors, transistors, diodes, and the pins of IC's. The solderless socket and connector pins (from E&L, Continental Specialties, or AP Products), and the other connectors, are available at most electronic parts stores or in hobby electronics catalogs. ◇

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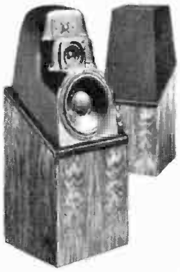

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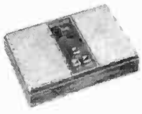

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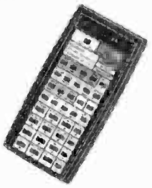

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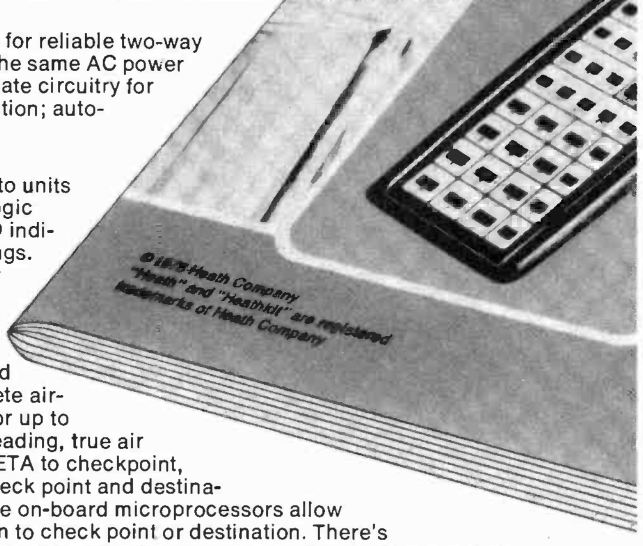

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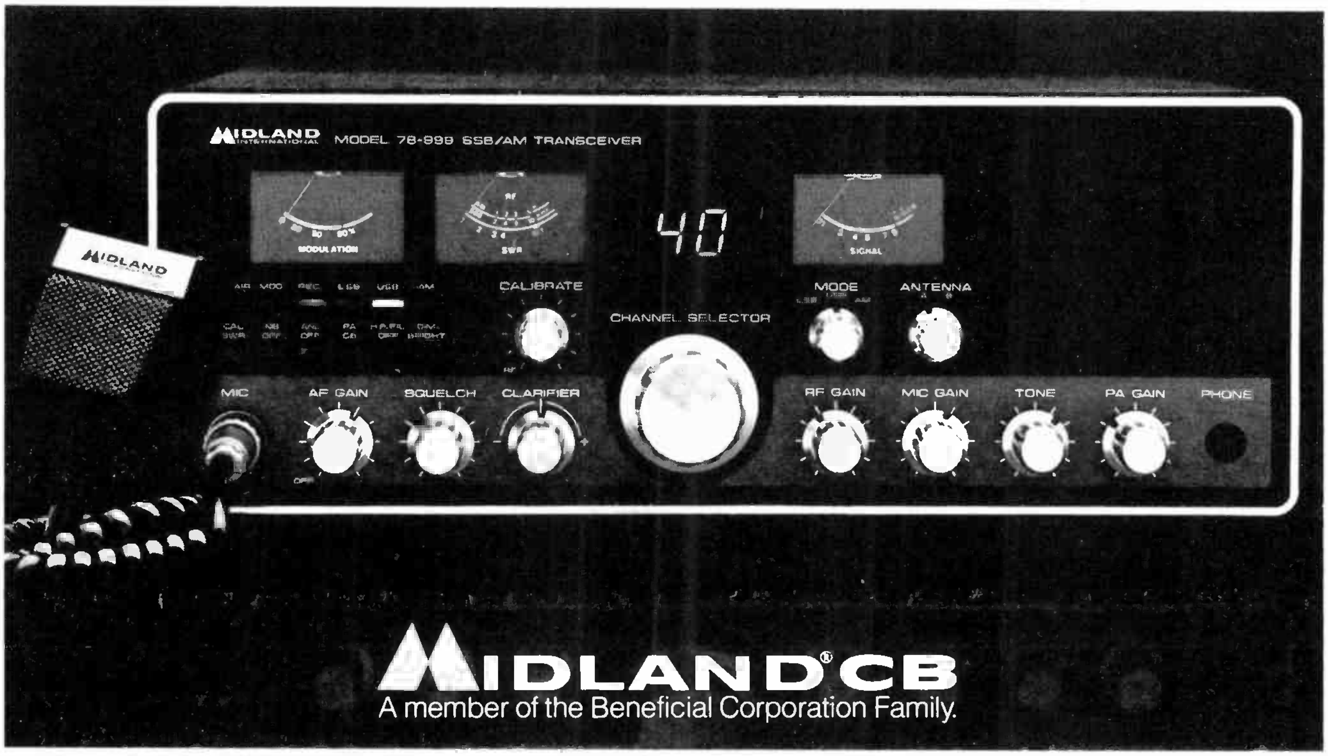

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CIRCLE NO. 35 ON FREE INFORMATION CARD

Solid State

By Lou Garner

SOLID (STATE) SECURITY

CHANCES are we'll never know who invented the first security alarm system. We know, of course, that trained animals have been used as living intruder alarms, and early cave dwellers doubtlessly sprinkled dry twigs or other objects at the openings of their dwellings to alert the occupants to possible entry by a potential enemy. Time moves on, however, and life styles, situations and technologies change.

Our dwellings today, unlike the ancient caves, often have multiple entrances (front and rear doors, windows, and maybe a basement or garage door), all of which should be protected. There are other dangers as well. Our modern homes are literally crammed with inflammable goods. As a result, danger from fire in some areas may be much greater than that from burglars or other intruders. The fire danger is so great, in fact, that some localities have enacted laws requiring the installation of adequate fire or smoke alarms in all new buildings, including private homes.

Fortunately, the assembly and/or installation of burglar and fire alarm systems are well within the capabilities of most electronics hobbyists. Where there are no local laws requiring such equipment, a carefully chosen and properly installed system can bring peace of mind and a sense of security to the home owner and may even save a loved one's life. Here, a system may be assembled either from "scratch" or using a kit. Optionally, a commercially manufactured system may be installed. On the other hand, if local ordinances mandate the use of protective equipment, such as smoke alarms, it may be necessary to use *only* specially approved factory-built units in the installation.

The basic circuit for an inexpensive, but quite reliable, solid-state combination fire and burglar alarm system is given in Fig. 1. Easily assembled in two or three evenings using noncritical, readily available components, the system is designed to serve as a fire alarm at all times and as a combination fire and burglar alarm during the night. It is *fail safe* in that it provides protection even during power line failures, and will sound an alarm if there is an "open" anywhere in the alarm sensor line, as by an intruder cutting or breaking a wire. Once the alarm is activated, it will continue sounding until the battery (*B1*) is discharged, unless deliberately switched off or reset using a key or hidden switch.

Referring to the schematic diagram, the fuse, switch (*S1*), neon pilot light assembly transformer (*T1*), bridge rectifier (*RECT1*), and current-limiting resistor (*R1*) form a simple line-operated trickle charger for rechargeable battery (*B1*). The latter serves as the main power source for the system. The alarm system itself includes a key-operated spst power/reset switch (*S2*), a separate (optional) pilot lamp circuit (*R2/ LED1*), an audible alarm, such as a horn, buzzer or bell (*LOAD*), a silicon controlled rectifier (*SCR1*), a gate current-limiting resistor (*R3*), a spst pushbutton *Panic* or TEST switch (*S3*), a spdt NIGHT/DAY switch (*S4*), a group of series-connected NC magnetic switches, and a group of series-connected NC thermostatic switches or fusible links. The magnetic switches are used to protect access openings to the guarded area, such as doors and windows or, in the cases of apartments and offices, even larger air conditioner or ventilator registers. The temperature sensitive devices are installed in heat "wells" (areas where heat is likely to accumulate, such as at the top of stair wells) and in fire-prone areas, such as kitchens and furnace rooms.

In operation, the SCR normally is in a nonconducting or high-impedance state, for its gate current source, *R3*, is effectively shorted to its cathode through the closed sensor circuit, comprising switch *S3* and the NC magnetic and temperature sensitive switches. Switch *S4* shorts out the magnetic switches during the day, permitting access to the protected area while maintaining normal operation of the fire alarm system. If an open occurs *anywhere* in the sensor line, as by depressing *S3*, cutting or breaking the interconnecting wire, or opening either the magnetic (*S4* in the *night* position) or temperature sensitive switches, gate current will be supplied to the SCR through *R3*, causing this device to "fire." In the conducting state, it supplies current to the alarm device (horn, buzzer, bell, etc.) serving as its load. Thereafter, the SCR will continue to conduct, *even if the sensor line continuity is restored*, until *B1* is discharged or until the system is reset by opening the key operated power/reset switch, *S2*.

Component values are not specified in the schematic diagram because they are not critical and depend on the builder's choice of major devices. As a general rule, however, the trickle charger circuit will be designed to match the characteristics of the power supply battery, *B1*, which may be a 3-to-12-volt nickel-cadmium or a conventional lead-acid storage battery, depending on the power requirements of the alarm device serving as the SRC's load. Similarly, *R2*'s value will depend on the supply voltage and the LED's maximum current rating. In most applications, the SCR will be a low-voltage, sensitive-gate type, with a current rating adequate to handle the load device used.

If the alarm device is an "interrupter"-type electromechani-

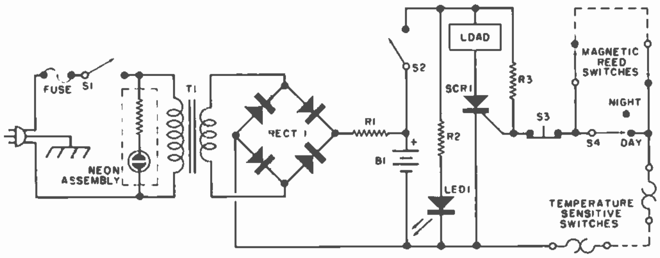

Fig. 1. Combination fire and burglar alarm circuit.

cal unit, it may be necessary to add a moderately large bypass capacitor across the terminals to maintain an adequate current through the SCR. This will prevent its switching back to a nonconducting state when the alarm's internal contacts open. Gate resistor *R3*'s value must be large enough to limit the SCR's gate current to the maximum value specified for the type of device used. Switch *S3* is a NC momentary-contact pushbutton type and may be located either on the main control panel as a *test* switch or remotely, as by the householder's bed, as a panic switch, permitting the alarm to be activated manually for other emergencies. If desired, several such switches may be installed at various locations, provided they are *all wired in series*. The alarm device may be mounted within the main cabinet or installed in a remote location, as preferred. If a remote installation is used, the connections to the main control should be through armored cable or conduit to prevent an intruder from disabling the alarm by cutting wires. For maximum protection, the entire circuit, except for external sensors, panic switch(es), and remote alarm (if used), should be assembled in a sturdy, wall-mounted, key-locked metal cabinet, preferably in a semi-hidden location, such as a closet.

In those areas where the dangers of fire are more of a threat than burglars and housebreakers, smoke detector alarms have become increasingly popular. Generally, these are self-contained units intended for mounting on the ceilings of individual rooms, with from two to six or more units per household. The potential market for these instruments is so large that several major semiconductor manufacturers, including Motorola Semiconductor Products, Inc. (3501 Ed Bluestein Blvd., Austin, TX 78721) and the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), have introduced special-purpose IC's designed specifically for use in smoke detector alarms. Motorola offers two devices, types MC14461 and MC14462; both are assembled in standard 16-pin plastic DIP's and are fabricated using CMOS MSI technology. Both devices are designed for use with standard ionization chambers and for operation on either 9- or 12.6-V dc supplies. The MC14462 features an on-chip MOSFET preamp for the external ionization chamber while the MC14461 requires a separate preamp but, otherwise, the two devices are quite similar. *National*'s entry, the LM1801, is designed for use with either ionization type (with external preamp) or photoelectric smoke detectors and, if desired, can be adapted for use as an intrusion alarm. The LM1801 is supplied in a 14-pin plastic DIP.

Featuring the MC14461, the circuit shown in Fig. 2A employs an MFE825 MOSFET as a preamp for the smoke detector ionization chamber. An MDS-DO5 npn transistor is used to drive the signal horn, for the IC output current should be limited to approximately 12 mA. Except for an optional IN4001 reverse battery protection diode, all other active devices are contained within the IC chip. The second circuit, Fig. 2B, is similar, but features the MC14462 and, therefore, does not require an external preamp for the ionization chamber. Both circuits are designed for operation on standard 9-volt dc sources. And both have adjustable sensitivity (via 5-megohm potentiometers), and both will emit short warning "beeps" when the battery supply nears the end of its useful life, indicating that replacement is necessary for continuing protection.

With neither layout nor lead dress overly critical, the Motorola circuits may be assembled using either pc or perf board construction techniques. The signal paths must be kept as short and direct as practicable, however, and *special care*

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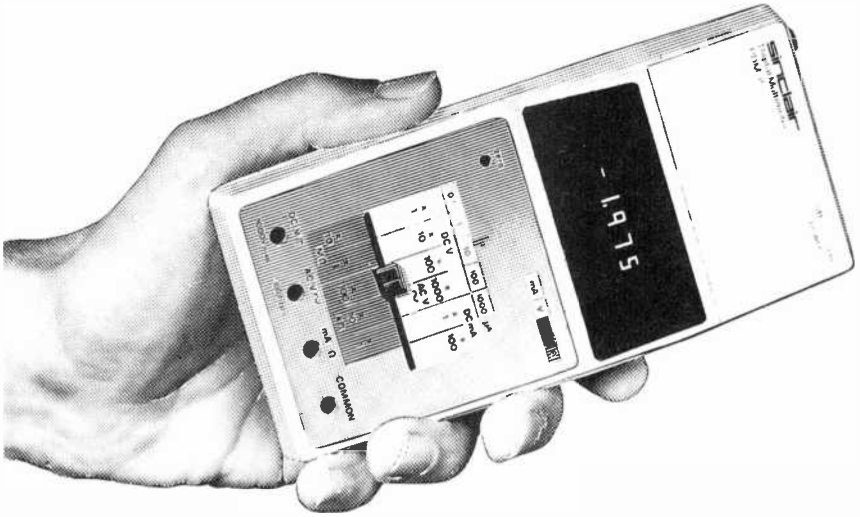

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must be exercised to minimize pin-to-pin and board leakage currents near the input terminal (pin 1). If a PC board is used, a guard ring should be etched around pin 1 and the ionization input terminal (pad), connected to pin 2. The customary precautions required when working with MOS devices should be observed during the installation and wiring of the IC's and MOSFET (if used). In the case of the MC14462, this device is protected by a shorting bar between pins 1 and 2 which should be broken *only after* the wiring is completed and checked. In addition, Motorola suggests that a 0.001-μF capacitor be connected between V_{DD} and ground near the IC to bypass transients that may be generated in the power source connection leads by peak currents in the horn driver loop.

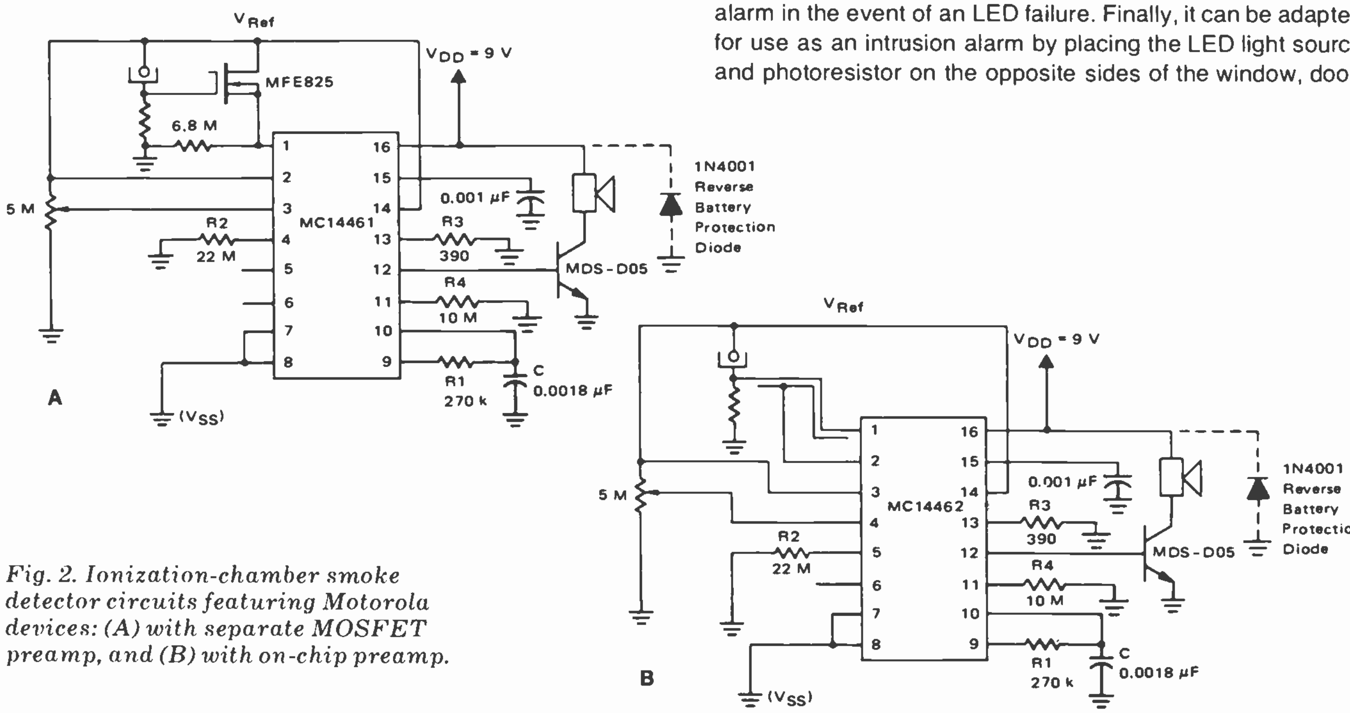


Fig. 2. Ionization-chamber smoke detector circuits featuring Motorola devices: (A) with separate MOSFET preamp, and (B) with on-chip preamp.

Although primarily designed for operation on 9- to 14-volt battery supplies, National's LM1801 smoke detector IC features an on-chip zener voltage regulator which, combined with its rugged construction, permits operation on ac power line sources. It includes the customary low-battery detector alarm and, in addition, offers an output stage capable of furnishing currents of up to several hundred mA. This eliminates the need for an external power amplifier to drive typical low-voltage 85-dB horns. The versatile LM1801 may be used in either the ionization-chamber or photoelectric type of smoke alarm. Both types of circuits are illustrated in Fig. 3.

In Fig. 3A, the battery-operated design employs a standard ionization chamber in conjunction with an NF5301 JFET preamp. Alarm threshold sensitivity is adjustable by means of 5-megohm potentiometer *R4*. Other features include provisions for a manual test (via an NO momentary-contact spst pushbutton switch) and for interconnecting two or more alarms so that all will sound if any one is activated. For the latter mode of operation, a single pair of wires is used to parallel all 10 IC pins and ground. The low-battery "beep" alarm will sound only on the individual units, however. The low-battery alarm level is set by the ratio of *R1* and *R2* so that the voltage at pin 12 is equal to the oscillator trip voltage when the battery voltage nears its low limit. With the resistor values specified in the diagram, the alarm will sound when the battery voltage drops to approximately 8.2 volts.

In contrast, the photoelectric alarm circuit shown in Fig. 3B does not require a "low-battery warning" because it is designed for operation on a standard 120-V ac power line. Here, smoke is detected as a decrease in the light transmission between the NSL5020 LED light source and the CL904 photoresistor. Alarm threshold sensitivity is controlled by 1-megohm potentiometer *R7*. This circuit also features a high-power 120-V ac horn, controlled by an external 2N5064 SCR which, in turn, is activated by the IC when it switches to an alarm mode. In addition to detecting smoke, the circuit will sound an alarm in the event of an LED failure. Finally, it can be adapted for use as an intrusion alarm by placing the LED light source and photoresistor on the opposite sides of the window, door, or other access opening requiring protection. Depending on the distance(s) involved, it may be necessary, in some cases, to add a lens system direct and focus the LED's radiation on the photo detector. Once installed and adjusted, the system will respond with an alarm when the light beam is broken by an intruder.

Reader's Circuit. Dale McClintock (c/o Heil Sound, Ltd., Marissa, IL 62257) was one of a number of readers responding to our discussion of solid-state motor controls in last June's column. Dale has been seeking—without much success—a solid-state design to replace the inefficient rheostats used for controlling miniature electric racing cars. The circuits he has tried have failed to provide the realistic action achieved with pot controls, yet he feels there must be "a better way."

The problem is not as simple as it may appear at first glance, for there are *three* important factors to consider: (1) maximum speed, (2) acceleration, and (3) braking. Unless the design chosen takes these three factors into account, the results are likely to be disappointing. First, consider the maximum speed possible with a given design. If a rheostat is used, it will provide *full* source voltage across the motor when turned to zero resistance. A series transistor used as a control element *cannot* apply full source voltage to its load, even at saturation currents, due to the inherent voltage drop across the transistor itself. This may be small, perhaps only a fraction of a volt, but is enough to limit the maximum motor speed. Acceleration is another problem which, interestingly, can be

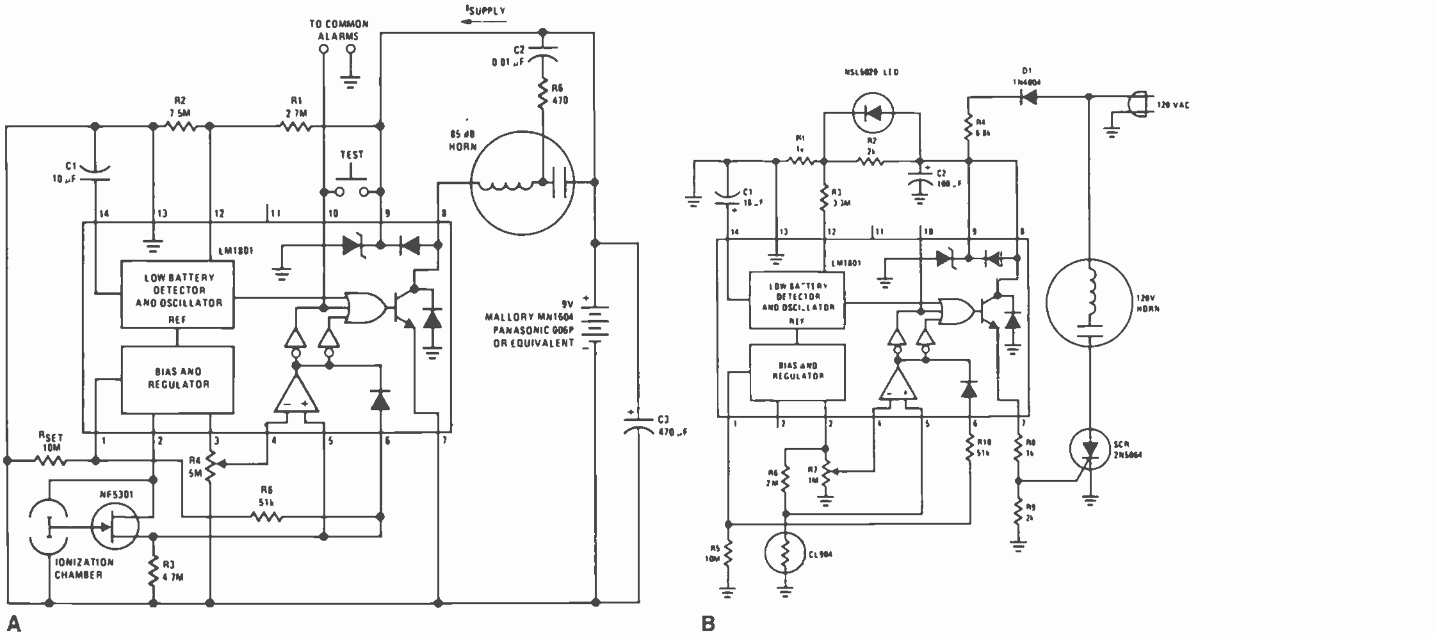


Fig. 3. Smoke detector circuits using National's LM1801: (A) ionization-chamber type, and (B) photoelectric type.

solved more easily with solid-state designs than with a conventional rheostat. The third and final problem, braking, is achieved with rheostat design by providing an electrical load (essentially, a short circuit) across the motor when source power is removed. Here, the dc motor acts as a loaded generator and provides the desired braking action. A similar technique can be used with solid-state circuits.

A circuit which should satisfy Dale's requirements (and those of other model racing car enthusiasts) is illustrated in Fig. 4. In the circuit, *Q1* is a high-gain npn Darlington transistor and should have a maximum current capability of (at least) 10 to 15 amperes. Speed control *R1* will range in value from a few hundred to a few thousand ohms, depending on the transistor's gain. Series resistor *R2* is chosen to limit *Q1*'s maximum base current to the value recommended by the transistor manufacturer. Shunt capacitor *C1* is a relatively large electrolytic, perhaps as high as 500 to 2000 μF, but its actual value will depend on *R2*'s value; that is, the larger *R2*, the smaller the capacitor's value. Control switch *S1A*/*S1B* is a ganged dual spst switch wired so that one section closes when the second opens, and vice-versa. Finally, the power supply, *B1*, is chosen to provide a *higher* voltage than normally is specified for the motor used and thus compensate for the voltage drop across *Q1* at saturation. Generally, adding a single cell to a battery supply will be adequate (i.e., using a 14-volt source instead of a 12.6-volt source) for most applications.

In operation, closing *S1A* opens *S1B* and the motor current, hence speed, will depend on *R1*'s adjustment. If *R1* is turned up (toward the positive battery terminal), *C1* will act as a momentary short to *Q1*'s base, providing a momentary "boost" in current. This, in a fashion, is analogous to the action of the accelerator pump in an automobile's carburetor. When *S1A* is opened, *S1B* closes, shorting the motor terminals and providing the desired braking action.

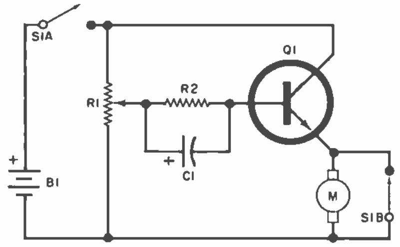
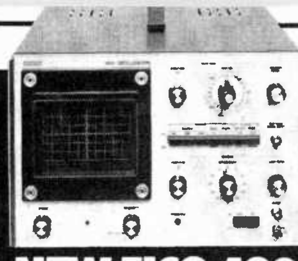


Fig. 4. Reader's dc motor control circuit with accelerator and braking action.

Device/Product News. You can add life to your pilot lights by using a *flashing* LED introduced recently by Litronix, Inc. (19000 Homestead Road, VALLCO Park, Cupertino, CA 95014). Identified as type FLR-4403, the new device comprises a gallium-arsenide-phosphide LED and integral IC chip in a single T1-¾ package. The IC flashes the LED on and off at approximately three times per second. Directly compatible with standard TTL and CMOS circuits, the FRL-4403 lists for less than a dollar each in unit quantities.

RCA's Solid State Division (Box 3200, Somerville, NJ 08876) has announced a new family of high-voltage npn silicon power transistors. Designated the "SwitchMax" series, the initial offering includes eight devices, types 2N6671 through 2N6678. Of these, types 2N6671-3 are rated for a saturation current of 5 A, types 2N6674-5 for 10 A, and types 2N6676-8 for 15 A. The devices have V_{CEV} ratings of 450 to 650 volts, and are particularly suited to such applications as off-line power supplies, inverter/converter circuits, and pulse-width-modulated regulators. The new transistors are supplied in standard JEDEC TO-204MA (TO-3) metal packages.

Motorola Semiconductor Products, Inc. (P.O. Box 20912, Phoenix, AZ 85036) is offering a new automotive temperature-range, single-supply, dual op amp. Featuring a low current drain over a wide voltage range, the LM2904, basically similar to the LM158 series, is ideal for automotive and other battery operated systems where available voltages from 3.0 to 26 and temperatures from −40° C to +85° C are encountered. In many such systems, the most solid ground reference is also the negative battery terminal, making the LM2904's common-mode input range especially useful in simplifying external biasing. Depending on suffix designation, the LM2904 is available in a metal TO-100 can (H), 8-pin ceramic DIP (J), or 8-pin plastic DIP (N). ◇



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Experimenter's Corner

By Forrest M. Mims

ANALOG TO DIGITAL CONVERTERS, PART 1

IN JULY and August we examined some of the basic characteristics of digital-to-analog (D/A) converters. Now we're going to devote equal time to analog-to-digital (A/D) converters.

Both D/A and A/D converters play key roles in such applications as digital multimeters, solid-state data loggers, speech synthesizers, digital communications devices, motor speed controllers and many others. In all these applications the converter interfaces the analog world of continuously variable information and signals such as temperature, voltage, velocity, force and light intensity with the two-state binary operation of digital circuits.

We've already seen how a simple D/A converter can convert a four-bit binary code into a voltage to vary the brightness of a lamp or the speed of a motor, generate waveforms, etc. An A/D converter performs the mirror image task of transforming a variable signal like the voltage from a pressure transducer into the binary format that a digital circuit can process. Probably the best-known application for the A/D converter is the digital multimeter, but such converters can be found in other applications working with a variety of digital circuits.

The digital circuit associated with the A/D converter can be as simple as a RAM and a counter that together store a series of analog measurements for later retrieval (a data logger). Alternatively, it might be a sophisticated flat-screen, solid-state oscilloscope that uses an array of hundreds of LED's in place of a bulky cathode ray tube. It could just as well be a microcomputer programmed to monitor and make decisions about various analog signals, trends or events.

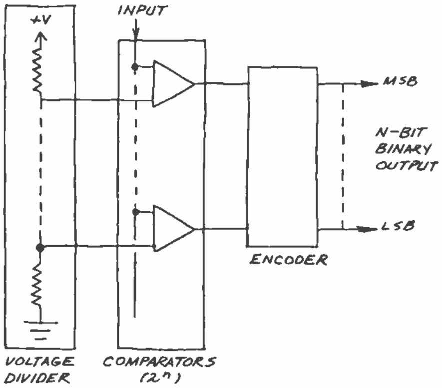

Fig. 1. Block diagram of parallel or flash A/D converter.

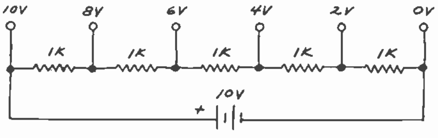

Fig. 2. Schematic diagram showing how a voltage divider works.

Types of A/D Converters. Converting an analog signal into digital form is not as easy as converting a set of binary digits into an analog voltage. Nevertheless, several ingenious methods of achieving A/D conversion have been

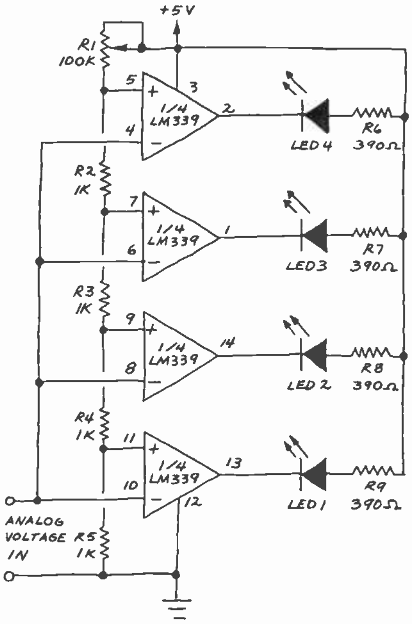

Fig. 3. LED thermometer-style bargraph readout.

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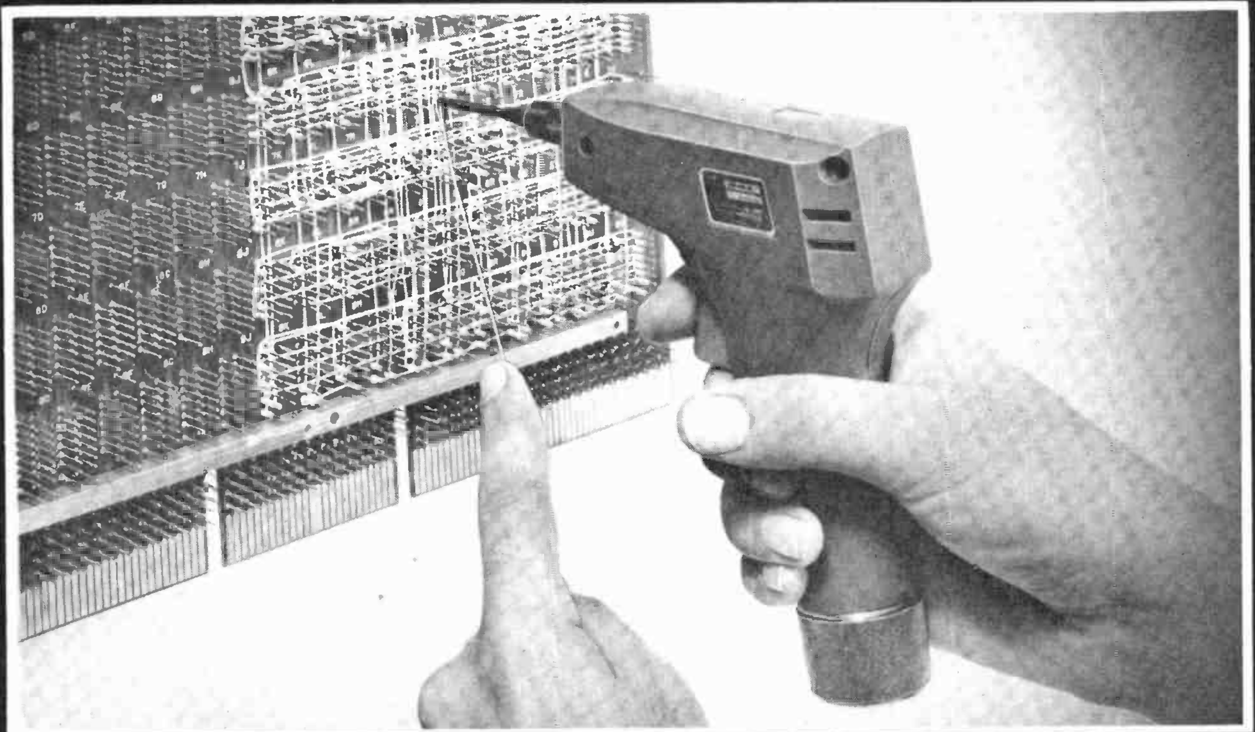

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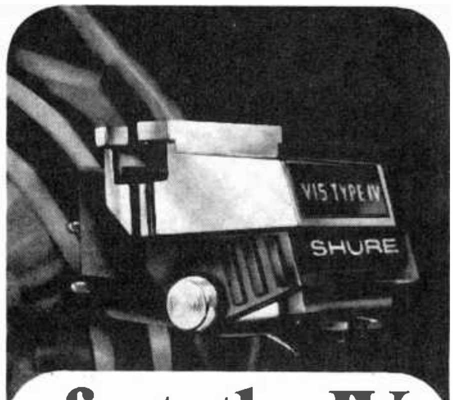

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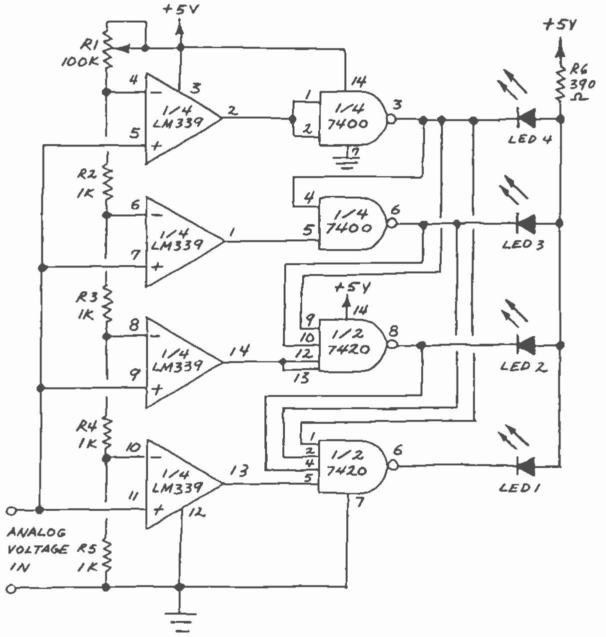

Fig. 4. A NAND gate decoder converts 4-element bargraph output into 1-of-4 moving dot readout.

developed. One of the simplest of these employs a D/A converter and a counter. The counter is initially cleared so that all its outputs are at logic zero. A clock increments the counter, and each successive count is converted into an analog voltage by the D/A converter and applied to an op amp comparator along with the incoming analog signal. When the two analog signals are equal, the comparator changes states and inhibits the clock. The binary word stored in the counter is the digital equivalent of the analog input signal.

Although this method of conversion is simple, it's very slow. The time for a conversion can range from no clock period (0 volts in) to 2^N clock periods where N is the counter's capacity in bits. Thus, an 8-bit counter would require between 0 and 256 clock periods for a single data conversion.

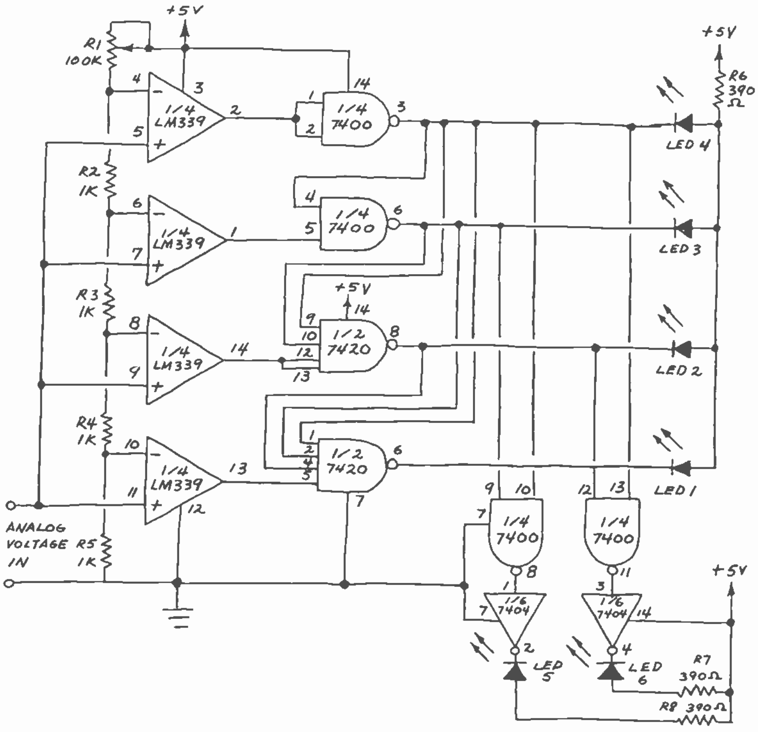

Fig. 5. An A/D converter with binary output is made by adding a 2-bit encoder as shown here.

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A method called *successive approximation* can reduce the conversion time to only *N* clock periods. Briefly, this method employs a D/A converter connected to a "successive approximation" register that stores a binary number equivalent to half the full-scale output of the converter. Both the output from the converter and the incoming analog signal are fed into a comparator. If the D/A converter's output is *less* than the input signal, the most significant bit (MSB) in the data register remains high. The next-most significant bit goes high when the next clock pulse arrives. The updated output from the D/A converter is then compared with the input signal. If it is greater than the input, the second-most significant bit goes low and the third-most significant bit goes high.

The conversion process continues bit by bit until the least significant bit (LSB) is reached. The data register then contains the binary word that corresponds to the analog input.

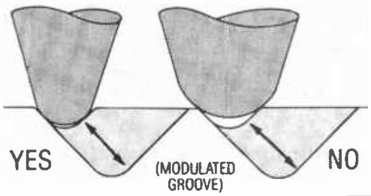
Another popular method of A/D conversion is called dual-slope conversion. Like the two previous methods, dual-slope conversion requires a clock and various control circuits. In other words, it's both complicated and slow.

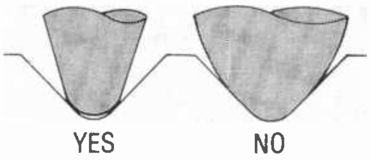
The fastest A/D converter is also the simplest. It's called the *parallel* or *flash* converter, and is made from a voltage divider connected to a series of comparators and an encoder. Figure 1 shows how the components in a flash converter are organized. As you can see, the flash converter doesn't require a clock. Data conversion takes place as fast as the comparators can change state and the encoder encode.

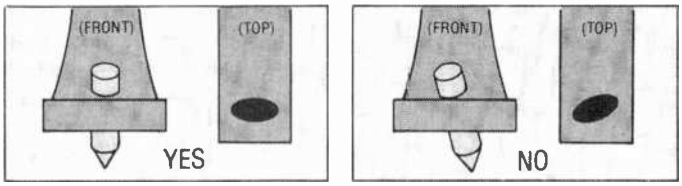
Commercial flash converters are very expensive because converting an analog signal into an N-bit word requires 2^N comparators. This means that an 8-bit output word requires 256 comparators!

Fortunately for us experimenters, low-resolution (anything less than 4 bits) A/D flash converters are easy to design and build. Therefore, the remainder of this installment of "Experimenter's Corner" will be devoted to the step-by-step design and assembly of the various sections of a flash converter. As you'll soon realize, there are many applications for both the completed converter and the various stages that make it up.

The Voltage Divider. The first stage of a flash A/D converter is a standard voltage divider. In case you're relatively new to electronics, voltage dividers are more common than you might think. An







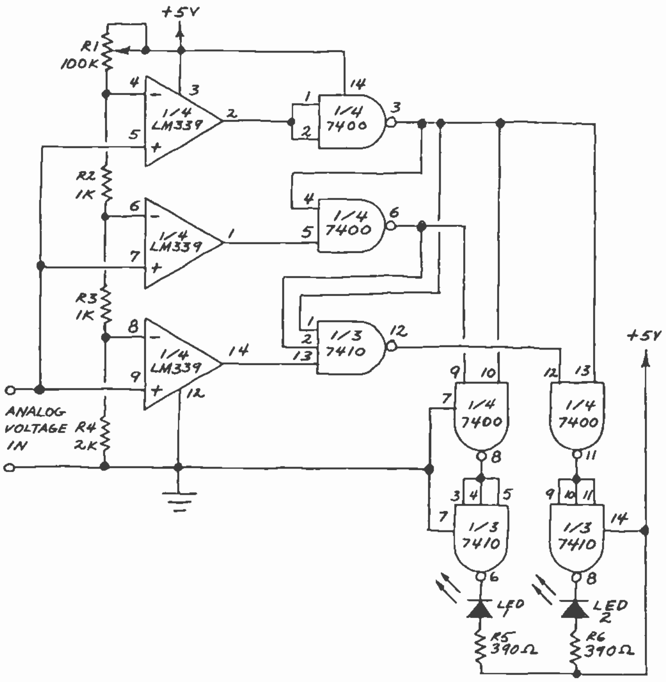


Fig. 6. Simplification of A/D converter by elimination of one NAND gate in Fig. 5

ordinary potentiometer is actually a variable voltage divider. If the end terminals of a linear potentiometer are connected across a 10-volt supply, 5 volts will appear between the wiper and ground when the wiper has been rotated to its mid-point.

You can begin assembly of the flash A/D converter *and* see how a voltage divider works by building the circuit in Fig. 2 on a solderless breadboard. The accuracy of the divider is determined by the tolerances of the resistors. Five or 10-percent resistors will work, but 1-percent resistors are much better. If you can't find 1-percent components, use a multimeter to select five resistors having values as close to 1000 ohms as possible. After you connect power to the divider, use a multimeter to measure the voltages between ground and the junctions of the resistors. The voltage across each resistor will be 20 percent of the input voltage.

Comparators and a Bargraph Readout. A comparator is an op amp designed to provide very high gain. The result is a stage whose output rapidly changes state when the voltage at one input exceeds the second input.

Figure 3 shows how to connect the four comparators in an LM339 quad comparator to a slightly modified version of the voltage divider of Fig. 2. The modification consists of substituting a 100,000-ohm or higher potentiometer for the uppermost fixed resistor to permit the range of voltages available from the points in the divider to be adjusted. The output of each comparator is connected to an LED, and the result is a bargraph or thermometer-style readout.

Since the inputs of each comparator are connected to both the incoming analog voltage and the resistor junctions in the divider, the comparators switch on one after another in succession, from the lowest to the highest, as the incoming voltage is increased. The circuit can be easily adjusted to light up successive LED's in increments of as little as one millivolt per LED if the potentiometer has a resistance of several megohms. If you calibrate the circuit with a known input voltage you can use it for a voltmeter.

The circuit can also be used as both a resistance indicator and timer. In the resistance mode, the potentiometer can be adjusted to indicate up to 10 megohms per LED. To use the circuit as a timer, connect a capacitor directly across the input leads. Depending on the value of the capacitor, the LED's will turn on in succession at intervals ranging from less than a second to a few minutes.

You can even use the circuit as a light meter by connecting a cadmium-sulfide photocell across the inputs. Because the readout is luminescent you can use the meter in very dim light—but you'll have to optically isolate the photocell from the display to prevent false readings.

Moving Dot Readout. A bargraph

readout is preferred for some applications, but for others only a single LED need glow at any one instant. I've not discovered a preferred name for this kind of readout, but *moving dot display* seems as good as any.

Figure 4 shows how to make a NAND gate decoder to convert the 4-element bargraph output into a 1-of-4 moving dot readout. Study the decoder to see how it works. In particular, notice how the outputs of the top three gates are coupled down to the inputs of the lower gates.

The circuit shown in Fig. 4 can be used in most if not all applications of the bargraph readout. It's even possible to keep the bargraph readout by adding a four-pole switch to connect either the bargraph or the moving dot display to the circuit.

Completing the A/D Converter. The transformation of the moving dot readout into an A/D converter with a binary output is completed by adding a 2-bit encoder comprising two previously unused 7400 NAND gates in the moving dot display's decoder (Fig. 5). Notice the two inverters at the output of the encoder. These inverters could be eliminated by using AND gates for the encoder, but the 7404 hex inverter is more readily available than the 7408 quad AND gate. Besides, the two NAND gates were already available.

If you've built the circuits described so far, you're probably wondering if it's worth four chips, a handful of resistors and a bird's nest of wires to obtain a mere 2 bits of data conversion. First, it's important to note that only 2 bits are available because only four comparators are used. This gives a 1, 2, 3, 4 count in decimal or a 00, 01, 10, 11 count in binary. As was mentioned earlier, it takes 2^N comparators to give N bits of data conversion.

Next month, we'll expand the basic A/D converter to provide a 4-bit BCD output. Meanwhile, let's conclude this column by simplifying the 2-bit circuit as shown in Fig. 6.

As you can see, the simplified circuit eliminates the moving dot LED's. Since an LED is not needed for the 00 position, the bottom 7420 NAND gate in Fig. 5 can be eliminated. This means one 3-input NAND gate in a 7410 can be substituted for the 7420 dual 4-input NAND gate used originally.

On page 98, is the first of what is planned as a regular monthly addition to this column—the "Project of the Month." Try your hand at it. ◇

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PROJECT OF THE MONTH

BACK-AND-FORTH SEQUENTIAL FLASHER

THIS IS the first in a planned series of monthly additions to the "Experimenter's Corner"—the "Project of the Month." Many different projects of an experimental nature, using a variety of circuits and construction methods, will be described in future issues.

This first project was suggested by reader Al Rieke of Santa Isabel, Puerto Rico. Al writes that he's familiar with circuits that sequentially flash each LED in a row in one direction only. But he's not been able to find a back-and-forth sequential flasher in his ten-year collection of back issues of POPULAR ELECTRONICS.

The circuit that should solve Al's problem is shown in Fig. A. A 555 timer connected as an astable multivibrator supplies clock pulses to a 74193 4-bit (0000-1111) up/down counter through a pair of gates in a 7400. The output from the counter is fed into a 74154 decoder that lights one of 16 LED's.

The inputs of an RS flip-flop (or latch) made from the remaining two gates in the 7400 are connected to the 0 (0000) and 15 (1111) outputs of the decoder. This provides electronic limits that switch the counter between its *up* and *down* modes .as it reaches its upper (1111) and lower (0000) limits. The actual switching is accomplished by steering the clock signal to either the up or down input through the first two gates according to the status of the latch's outputs.

Front and back views of a Wire-Wrapped prototype version of the circuit are shown in the photos. The prototype was assembled on a 4-x-8.5-cm rectangle of perforated board with copper solder pads and bus strips (Radio Shack 276-152 or similar cut to size).

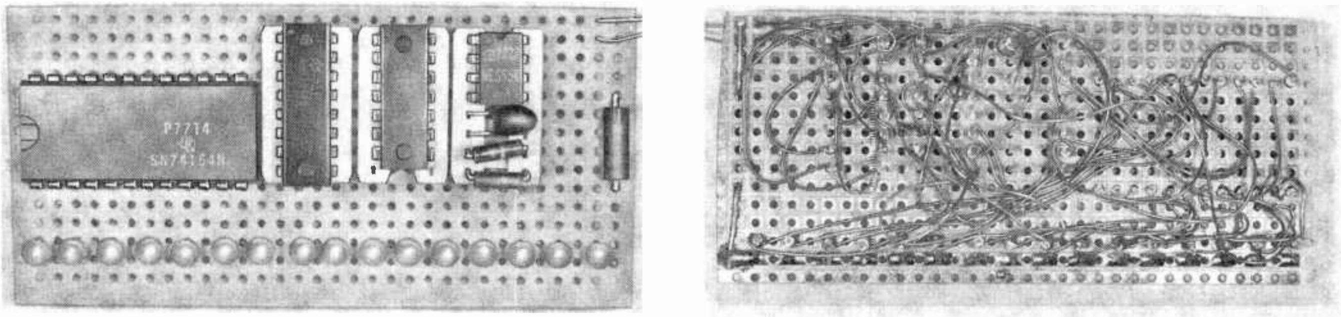
Note how *R1*, *R2* and *C1* (a miniature tantalum capacitor) are inserted in the unused portion of the 555's socket. Not having a 24-pin, Wire-Wrap socket handy, I wrapped wires directly to the pins of the 74154 without any problems. The anodes of the LED's were soldered to a common bus strip. All other connections were made with wrapped wire.

You can change the speed of the moving dot display by substituting a 1-megohm potentiometer for *R1*. Mount the LED's in various configurations for special effects. When arranged vertically, the column of LED's becomes a "bouncing ball" display. When arranged horizontally, it can be called a "Ping-Pong" or "pendulum" display. For a more realistic pendulum effect, mount the LED's in an arc.

An interesting way to simulate the swing of a *real* pendulum is to replace *R1* with a high dark resistance cadmium sulfide photocell and place the cell near the center of the display. The room lights should be dimmed.

The resistance of the cell is *decreased* by the presence of light, and this *increases* the clock speed. Therefore the moving dot will speed up as it passes by the cell and slow down at either end of its "swing."

The photocell can also be used to simulate a bouncing ball. (Can you figure out how to do it?) Both applications provide interesting experiments in mechanical simulation *and* optoelectronic feedback, so try them after you assemble the circuit. ◇



Photos of the front and back of the prototype project show how Wire-Wrapped connections were used. It was assembled on perforated board with copper solder pads and bus strips.

Note: The Project of the Month is planned as a regular feature of the Experimenter's Corner. This "Back-and-Fourth Sequential Flasher" circuit is the first.

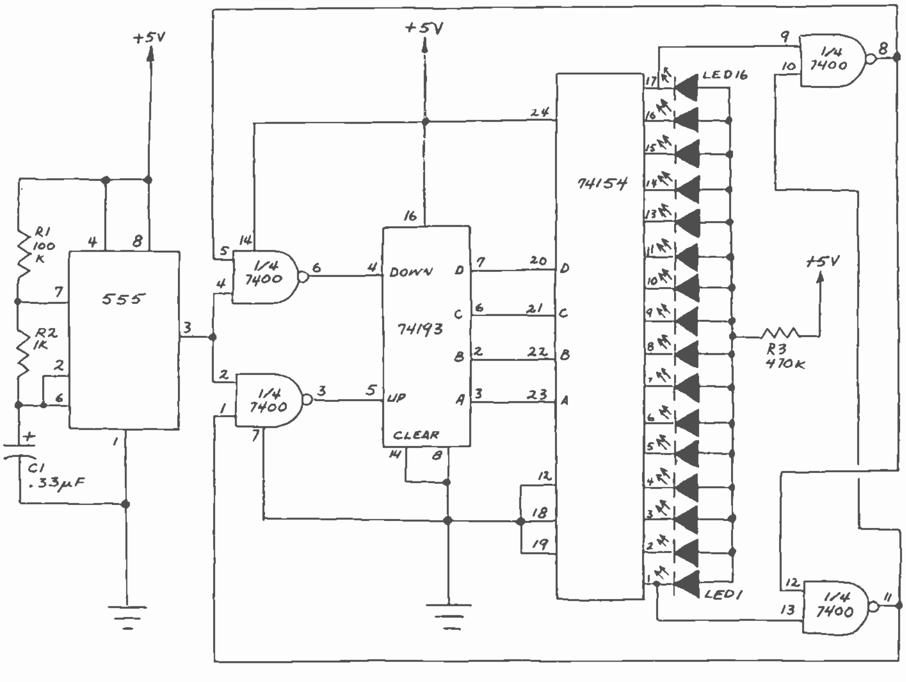


Fig. A. Schematic of the flasher circuit. A 555 used as a multivibrator supplies clock pulses to a counter.

Hobby Scene

By John McVeigh

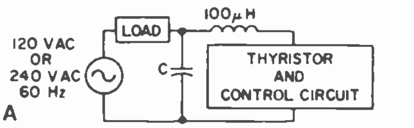
LIGHT DIMMER RFI

Q. ***I purchased a light dimmer and mounted it in a light switch box in the wall. The dimmer creates a buzz and static in any AM radio in the house that is turned on at the same time as the dimmer. Varying the brightness control has no effect on the interference. Using a transistor radio as a signal sniffer, I found that the noise is loudest near the switch box, and is also loud when I follow the wiring in the wall up to the bulb. The dimmer doesn't cause any interference to my FM radio. What can I do to remedy this situation?—Duane Anderson, Leeds, ND.***

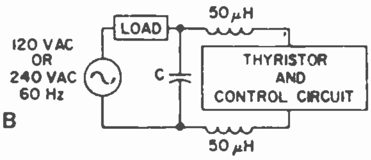
A. I have discussed the problem of light dimmer RFI in previous columns, but recently a batch of letters on this subject has been received. So, it seems appropriate to deal with it again. The information that follows and the schematics are abstracted from the RCA *Transistor, Thyristor, and Diode Manual.*

The fast switching action of triacs connected to resistive loads causes the current through them to rise to a certain level in a very brief time interval. Triacs typically transit from the high to the low impedance state within one or two microseconds. This rapid switching generates a current step function (an almost instantaneous jump from zero) which is largely composed of high-frequency harmonics. The amplitude of these harmonics varies inversely with frequency.

In phase-control applications such as light dimming, this current step is produced each half cycle of the line voltage. Because the triac switches on and off many times each second, a noise pulse is generated which can affect amplitude-sensitive devices such as AM radios. The amplitude of the vhf harmonics is so small that they generally do not interfere with television reception or with FM radios, which have the additional advantage of having a limiter stage. Limiting gives the FM receiver a high degree of immunity to impulse noise signals.



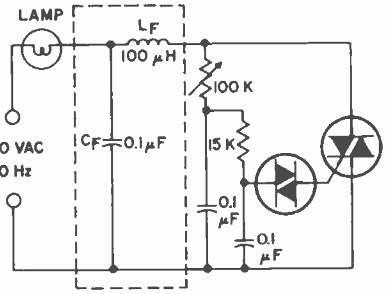
A



B

There are two basic types of RFI associated with triac switching. One, radiated RFI, consists of the high-frequency energy radiated by the triac-equipped appliance. In most cases, this radiated RFI is insignificant unless the radio is located very close to the source of radiation.

Of more significance is conducted RFI, which is carried along the power line and affects equipment connected to it. Because the current waveform contains high-frequency energies, a simple choke placed in series with the load will increase the current's rise time and reduce the amplitude of the higher-order harmonics. To be effective, however, the choke must be quite large.

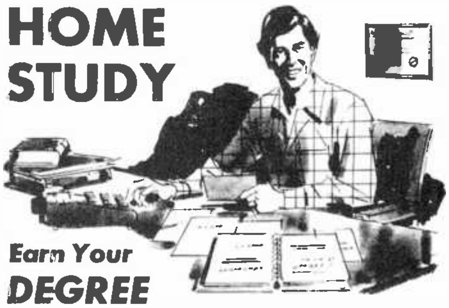


C

A more effective filter, one that has been found to be adequate in most light dimming applications, is shown at A. An alternative design is shown at B. The inductors attenuate the harmonic signals and reduce the noise interference to a low level. The capacitor bypasses the harmonics so that they are not passed to any external circuits connected to the power line.

At C, a triac control circuit is shown which includes an RFI suppression network for the purpose of minimizing high-frequency interference. The values indicated are typical of those used in lamp dimmer circuits. The two-terminal semiconductor is a bilateral trigger diode, and the triac is usually chosen to handle a given load demand, say, 600 watts or 6 amperes. In all these circuits, bypass capacitors should be rated at 1000 volts minimum and approved for power-line bypass applications.

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.



Product Test Reports

PANASONIC MODEL RF-2800 5-BAND RECEIVER

Low-cost, multi-band portable has digital LED frequency readout on shortwave.

THE SOLID-STATE portable Model RF-2800 receiver from Panasonic provides continuous coverage of the 3.2-to-30-MHz shortwave bands and also covers the standard AM and FM broadcast bands. SW coverage is in five selectable bands.

The RF-2800's LED numeric frequency display, for the SW bands only, provides accurate tuning to any given frequency in the receiver's range and affords exact resettability to any SW station. This eliminates the hit-or-miss tuning usual with nondigital dials.

The receiver also offers a choice of two i-f bandwidth positions on the AM bands only; treble and bass controls; calibration setup; variable bfo with product detector for CW and SSB; two-speed tuning; afc on/off on FM; r-f and audio gain controls; built-in ferrite-core for the AM broadcast band and telescoping whip for the other bands; provision for an external antenna; built-in speaker with jacks for external speaker (or earphone), multiplex-FM reception, and recording outputs; operation from 117 volts ac or six "D" cells (supplied); panel light switch; signal strength and battery-condition meter; and carrying handle.

The receiver measures nominally 14¾"W × 10"H × 4½"D (37.5 × 25.4 × 11.3 cm) and weighs 8.6 lb (3.9 kg) with batteries installed. Price is $250.

General Description. Double conversion to 2 MHz and 455 kHz is used for the AM SW bands. Single conversion to 455 kHz is employed for the standard AM broadcast band and to 10.7 MHz on the FM broadcast band. AM selectivity is obtained with multituned i-f circuits and a ceramic filter that is switched in and out according to the desired selectivity. Ceramic filters are switched in for FM.

Separate FET-type r-f input amplifiers are provided for the AM and FM bands to ensure good signal-handling capabilities. An IC-type balanced mixer for the signal is used on the AM bands to minimize spurious responses. Incorporated here is the local heterodyning oscillator that is tuned simultaneously with the r-f input circuits. The r-f output circuit (mixer input) is not similarly gang-tuned, which results in some degradation in image rejection. A transistor oscillator and mixer are used for FM, with the circuits simultaneously tuned.

The remainder of the lineup is conventional, with AM detector, audio amplifiers (without noise limiter), agc, bfo (with product detector), FM detector (with limiters), de-emphasis amplifiers, afc circuit, etc. When the bfo is switched on, the product detector is automatically engaged on CW and SSB.

The digitally generated numeric display is obtained from a divide-by-16 counter with a 5-MHz time base.

The receiver is housed in an all-black case, including the control panel, which has high-contrast white lettering. The frequency display is behind a two-part window. A drum dial with scales calibrated for the FM and AM broadcast bands as well as scales for the three SW sections are at the left behind the window. (Calibrations for the SW sections are only approximate and located just at strategic points.) To the right of the drum dial is a five-decade LED display.

The exact frequency for only the SW bands appears in the LED display. The frequency is displayed to the nearest 1000 Hz. A switch permits the display to be turned off to conserve battery power once the desired frequency is tuned in. This switch also has a spring-return position to permit momentary frequency checks after the display has been switched off.

Slow-speed tuning is recommended on the SW bands. This is accomplished by pulling out on the large spinner-type TUNING knob. Another large control knob is used on the VOLUME control, presumably to readily distinguish it from the other less frequently used controls.

The meter operates in the reverse direction from that usually encountered. Pointer deflection is minimum at the right index of the meter scale and maximum at the left index. Calibrations are in linear units from 0 through 10. The telescoping whip antenna can be oriented vertically or horizontally.

When the receiver is initially set to one of the SW bands, the frequency display must be calibrated against a signal of known frequency, such as WWV or CHU. This is done by adjusting the SW CAL control while tuning the signal until the display coincides with the known frequency. Best accuracy is obtained by simultaneously observing the meter for maximum signal strength while tuning, using the narrow-bandwidth mode. If the meter's pointer swings fully upscale, the r-f gain can be reduced to yield a more precise setting. Since the signal may register quite broadly, the display might vary by 2 or 3 kHz. However this is close enough for all practical tuning purposes.

CW and SSB signals are copied by switching on the bfo and varying it for the desired pitch or sideband. (The BFO PITCH control is labelled for the LSB and USB directions.) More precise frequency calibration is obtained with the bfo tuned for zero beat.

When the receiver is operated in the FM mode, the BANDWIDTH switch is used only to switch in and out automatic frequency control (AFC on the switch). The bandwidth in the FM mode does not change.

Laboratory Measurements. Sensitivity for 10 dB (S + N)/N (30% modulation at 1000 Hz and in the wideband

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mode) on the low SW band (SW1) was 2 μV at 3.2 MHz and 1.3 μV at 8 MHz. On SW2, it was 2 μV at 8 MHz and 1 μV at 16 MHz, while on SW3, it was 1.4 μV at 16 MHz and 2 μV at 30 MHz. CW and SSB sensitivity were about 6 dB better in all cases.

Image rejection at 6, 12, and 24 MHz was 25, 20, and 20 dB, respectively. Variations in sensitivity and image rejection occur at other frequencies, due to changes in gain and circuit tuning.

FM sensitivity measured 1.5 μV for 15 dB of noise quieting, and image rejection (from the high-side signal) was 40 dB, measured at 108 MHz.

The overall AM response, including that resulting from the i-f selectivity, was 120 to 1800 Hz at the 6-dB down points in the wideband mode and 110 to 1500 Hz in the narrow-band mode. These tests were made with the bass control set to maximum and the treble control set to minimum.

The maximum sine-wave audio output measured about 1.5 watts at less than 10% THD with a 1000-Hz test signal into 8 ohms. Because the performance of the agc system varied according to frequency, we did not perform our usual test. However, our listening test indicated that the performance was relatively flat over a wide range.

User Comment. We found the stability and calibration to conform with the published specifications (±1 kHz for each 30-minute period after warmup). The stability was good for holding SSB signals without frequent retuning.

The product detector did not function as a true product detector on SSB; it allowed AM to be reproduced as well as SSB. This resulted in some SSB audio distortion, particularly at the lower audio frequencies. Even so, we were able to satisfactorily "read" SSB signals by properly setting the bfo and using the narrow bandwidth mode.

During tuning on the FM band, the afc snapped in quite positively as the signal was approached. Due to the excellent stability of this receiver, we generally found it unnecessary to engage the afc to hold the signal on frequency. (The r-f gain control does not function on FM.)

As can be noted from our lab measurements, the AM audio response extends slightly into the low frequencies, resulting in a tendency toward bassy sounding reception at times. Nevertheless, SW reception was somewhat more intelligible than we have usually experienced. Standard AM broadcast quality was also good. Switching in the narrow bandwidth selectivity made no practical improvement in minimizing interference, its effectiveness being mostly in reducing heterodyning beat notes.

FM reception quality was excellent, given speaker and amplifier limitations.

The unusual features and performance capability of this 5-band receiver make it stand out among other portables. Basic SW reception, even with the built-in whip antenna, was comparable to that obtained with several communications receivers that cost appreciably more. Of course, the Model RF-2800 does not include some sophisticated SW receiver features such as a noise limiter or blanker, variable avc, antenna trimmer, etc. But its portability and modest price preclude such provisions.

Accordingly, if one wants an all-band portable and has a serious interest in receiving international shortwave broadcasts, the Panasonic RF-2800 is certainly a most impressive value. The 5-digit LED frequency display, in particular, takes the hassle out of tuning.

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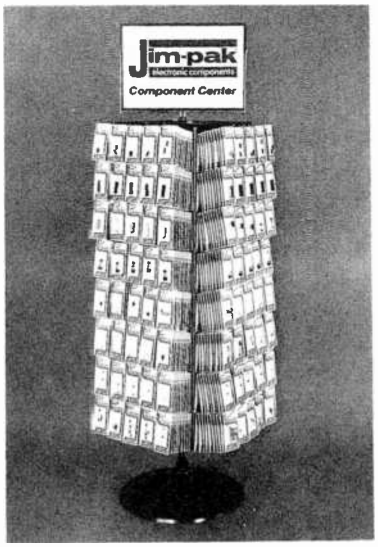

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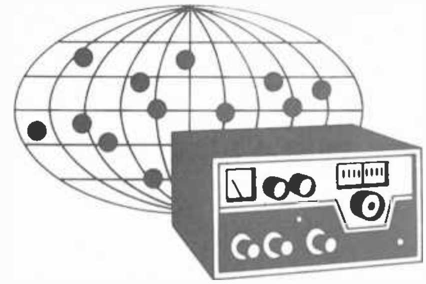


DX Listening

By Glenn Hauser

CHANGES WITH THE SUNSPOTS

As THE sunspot count rapidly climbs, the high-frequency bands become increasingly efficient for international shortwave broadcasting, while lower bands become less and less efficient. So stations are all moving from 6 up to 21 MHz, right? Wrong! Some are, but far from all. Thus we can observe which countries are on the ball, and which are stuck in a frequency rut.

Except during the increasingly frequent blackouts, you can tune across the 21-MHz band any time during the North American morning and hear a multitude of signals, mostly from Europe. But with the exception of France on 21,645 kHz, *not one* of those transmissions is intended to be received in North America! Instead, transmissions are directed to Asia, the Middle East, or Africa. As a result, the band is getting more crowded and the jamming level is rising. This is a shame, but inevitable. Still, there is room for a few more stations to use the band, beaming toward North America. Why aren't they using it?

There is a hard-to-break tradition of not using the 21-MHz band for Europe-to-North America—though the VOA has long used it over the reciprocal path. A rather small number of European countries trying to reach North America in our mornings feel safer using the crowded and propagationally inferior 15- and 17-MHz bands.

It is a fact that channels on the 21-MHz band *not* beamed to North America often provide better reception here than channels from the same station on lower bands, which *are* beamed here. Switzerland and the BBC are good examples.

One often-heard excuse for avoiding the 21-MHz band is that there aren't enough receivers which can be tuned this high. If this were ever true, it is definitely less so now. And it's certainly difficult to believe that receivers with 21-MHz bands are more widespread in Africa, the Middle East, and Asia (for which Europeans used 21 MHz even during the solar cycle trough) than they are in North America.

Another factor that overseas stations tend to overlook is that during the summer, thunderstorms in North America keep a high noise level on all the bands below 15 MHz. So even if a lower band were propagationally ideal, there would still be a higher noise level to cope with than on a higher band.

Favoring the 21-MHz band has other advantages: it is currently 300 kHz wide, while 17 MHz is only 200 kHz wide. Signals at 21 MHz penetrate steel-frame buildings significantly better than 15- and 17-MHz signals. Both transmitting and receiving antennas are smaller, more efficient and less expensive at higher frequencies. There have been times when the *only* shortwave station I could receive well enough to listen to on an insensitive portable in my office was the BBC on 21,710 kHz, off the back of their beam in the opposite direction!

Maximum usable frequency (MUF) charts, as a rule, show higher frequencies over north-south paths than over east-west paths, partly because of the lack of auroral absorption. A 25-MHz MUF is not unusual between the USA and Argentina, for instance. Yet, is any broadcasting done on the 21-MHz band between these two areas, let alone on 25 MHz? No, none at all! Moreover, it is a well-known fact that frequencies near the MUF are best from the standpoint of signal strength and minimum fading. Nevertheless, Argentina sticks to its perennial, but heavily interfered 11,710 kHz for its 2300 broadcast in English. However, they could use lower power, and get much better results at the same time on 21 MHz.

South American stations are really scarce on the 17- and 21-MHz bands. (Colombia has registered 25,750 kHz, but never uses it.) There were none at all on 21 MHz, until HCJB activated 21,480 this summer (for Europe, not North America); and on 17 MHz, only HCJB, the Voice of Chile, and one Brazilian, Radio Cultura, São Paulo. The latter does quite well with only one kilowatt when 17,815 is free of interference. Many more South American stations could use the 17- and 21-MHz bands to great advantage.

A similar situation exists in our evenings. Countries such as Belgium, Austria and Germany stick to the noisy and interference-laden 6- and 9-MHz bands for North American broadcasts. Others, such as Italy, Hungary, Sweden, Finland, and Switzerland quickly realized the superior potential of the 15-MHz band, which now is ideal, though just a year ago it was at the upper fringe of reception possibility.

Future Plans. Austrian Radio should be thinking about the present—using the 15-MHz band to North America in our evenings and the 21-MHz band in the mornings. Instead, they are planning to modify their antennas and build a coupling unit so that two 100-kW transmitters can be combined on one frequency. The Voice of America is looking into building a new relay station in Botswana to improve its coverage in southern Africa.

Scheduling Problems. Our twice-yearly daylight time shift causes problems for DX listeners. Since it is an artificial measure, not a single overseas station changes its broadcast scheduling to compensate. As a result, everything seems to be an hour later during half the year, by the local clock, while transmissions remain at the same time by GMT.

Just when trans-Atlantic conditions improved to allow reliable Europe-to-North America paths in our afternoons, Radio Nederland dropped its 2130 GMT broadcast to North America as of this summer, converting it into a daily Dutch service for Surinam. Of course, even in the EDT zone, 2130 GMT (5:30 p.m.) is a bit early for some people. However, now the *first* broadcast for us does not begin until 0230 GMT, or 10:30 p.m. EDT. This is too late for many listeners.

I sent Radio Nederland an urgent proposal that an additional English broadcast be scheduled at 2330 or 0030 GMT (7:30 or 8:30 p.m. EDT). If this were done via Bonaire, it would probably mean bumping a Spanish or Dutch broadcast. However, transmitters in Holland itself are normally silent after 2320 GMT so if they were left on the air an hour longer, we could easily have another English broadcast in the early evening, on the 15- or 11-MHz bands. But the 2130 transmission was dropped because Radio Nederland's only English-speaking announcers on duty at that hour are Africans, whose accent is unsuitable for American ears.

Listening Tips. One DW program not to be missed by those thirsting for the light side of the news is Larry Wayne's "Germany This Week" each Saturday evening. Radio Australia has begun a similar show, "The Week Here and There," Saturdays at 10:40 p.m. (EDT).

Switzerland has been using 21,585 kHz for South America from 1530 to 2245 GMT, also providing excellent reception in eastern North America, including English at 1815-1845; and at 2205-2215, Esperanto on Mondays, Thursdays and Saturdays, with Romansh on Tuesdays and Fridays. Esperantists can hear another weekly ten-minute program from Radio Portugal during the last portion of Sunday evening broadcasts.

Uganda is the latest country to start a service to the USA. Idi Amin has had a 250-kW transmitter for several years, but only last May began to use it to improve his image over here. Tests were run on 15,325 kHz between 0300 and 0400; and 1800-1900 GMT.

Another station which surprised us with an English mailbag program is Radio Republik Indonesia, Sorong, West Irian, Saturdays at 1230-1300 GMT on 3364 and 4875 kHz.

BBC has been testing from its newest shortwave relay site, Masirah Island, off the Arabian peninsula. Since more than one site is customarily used on a single frequency don't assume you have heard Masirah without further evidence. The summer schedule was: on 7250 kHz at 1545-2030 GMT; 11,780 at 0545-0815; 11,910 at 1330-1645; 11,955 at 0200-0430; and 15,310 at 0845-1515. Both English and South Asian languages are used, effective August 1.

English Language Broadcasts. You were expecting, maybe, the English Language Broadcasts schedule, which normally appears in the September issue? We decided to publish them one month later than previously, in the October, December, April and June issues, so that the information contained can be more up-to-date. This DX Listening column will appear in most other issues, including some schedule changes.

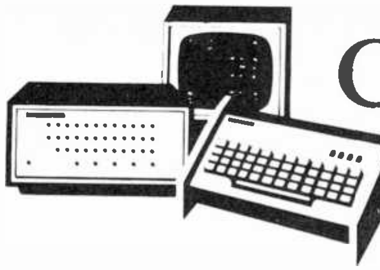
Here are a few tentative changes planned for the broadcasting season, beginning Sept. 3. Change Radio Canada International, at 1800-1830 GMT, & 1900-1930 to Africa, to 17.75 MHz (previously 17.78). At 1900-1930 to Europe, add 11.855. At 2130-2200, on 15.15 and 9.745, instead of 15.105 and 9.53. At 0100-0130, on 9.755 instead of 9.535. And at 0200-0230 and 0300-0330, on 9.755 instead of 11.94.

For Radio Norway, at 1600-1630 add 17.795. At 2200-2230, on 9.55 instead of 17.795. At 0000-0030, add 6.08. At 0200-0230, on 6.18 and 9.55, instead of 9.61 and 11.735. At 0400-0430, on 6.18 instead of 11.86. At 0600-0630, on 9.645 instead of 11.895. (English Sundays and GMT Mondays only).

Change Radio RSA at 2100-2150 to 17.78 and 15.155 from 9.585 and 11.80; and at 2230-2320 to 15.155 and 11.80 from 5.98 and 9.65.

Change Radio Sweden at 0030-0100 to 9.59 from 11.905; and at 0230-0300 to 11.705 from 11.80.

This year should see fewer shifts to lower frequencies for fall and winter than in previous years. Although there will be the same amount of darkness to traverse, the increasing sunspot count should keep higher bands open during the night. ◇



Computer Bits

By Hal Chamberlin

COMPUTER ARITHMETIC—MULTIPLY AND DIVIDE

IN OUR July column, the simpler multiple precision arithmetic operations were described. This month, we will discuss multiple precision multiplication and division. These two operations, which are invariably absent even in single precision form on 8-bit processors, make the difference between simple number shuffling and really sophisticated computing.

Unlike addition, subtraction, and the other operations described earlier, multiplication and division are *iterative* in nature. Although both could be done by successive addition and subtraction respectively, a very slow routine would be the result. For example, 16-bit by 16-bit multiplication could require over 30,000 iterations with straight successive addition and take well over a second even on a fast microprocessor. Much faster methods using addition/subtraction along with *shifting* can cut the same operation down to 16 somewhat more complex iterations requiring about 850 microseconds total. However, even this is too slow for some applications, so hardware multiplication/division boards, or newer 16-bit microprocessors with multiply and divide instructions built-in, become very attractive.

Another complication is that the result of, say, a 16-by-16-bit multiplication will very likely require more than 16 bits to represent. In fact, the product of two 16-bit integers can require as many as 32 bits. Division conversely always forms a quotient that will fit in half as many bits as the dividend and the divisor is restricted to half the length of the dividend. Thus a double precision (16-bit) multiply routine would take two 2-byte factors and produce a 4-byte product.

A division routine would accept a 4-byte dividend and 2-byte divisor and generate a 2-byte quotient and possibly a 2-byte remainder. Often 4-byte addition, subtraction, etc. is needed in a double precision package to facilitate handling 4-byte intermediate results without loosing accuracy.

Multiplication. The shift and add multiplication algorithm to be described is the fastest for software implementation on a microprocessor. For simplicity and generality, the routine is designed to multiply *unsigned* numbers. The more usual signed operands and result are handled by *correcting* the unsigned product.

The multiply routine uses two pseudo registers in memory. MPCD is two bytes long and holds the multiplicand. PROD must be 4 bytes long as discussed earlier. Before multiplication, the least significant two bytes of PROD hold the multiplier and the most significant two bytes are normally zero. If desired, a 2-byte number can be placed there and it will be automatically added to the product with no extra execution time required. After multiplication, PROD contains the 4-byte product; MPCD is unchanged.

The actual multiplication proceeds much like a decimal multiplication on paper. Each digit of the multiplier multiplies the entire multiplicand creating a series of partial products which are staggered left and added up to give the full product. For binary numbers however, each partial product is either zero for a zero multiplier bit or equal to the multiplicand for a one multiplier bit. Also, it is more efficient to add the partial products into a running total as they are formed. Bit-by-bit examination of the multiplier and staggered positioning of the partial products as they are added are both handled by quadruple shifting PROD alone.

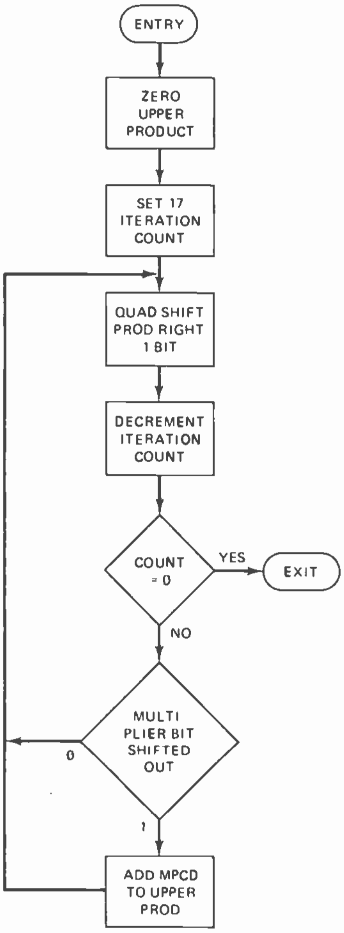


Fig. 2. Multiply flowchart.

A register diagram and a flowchart of the multiply routine are shown in Figs. 1 and 2. Sixteen full iterations are required to form the product, while a seventeenth iteration performs a final shift to position it properly. Each iteration starts with a right shift of all 4 bytes of PROD. This action simultaneously shifts the current sum of partial products right and puts the next multiplier bit to be examined into the carry flag where it is easily tested. After testing for completion, the carry

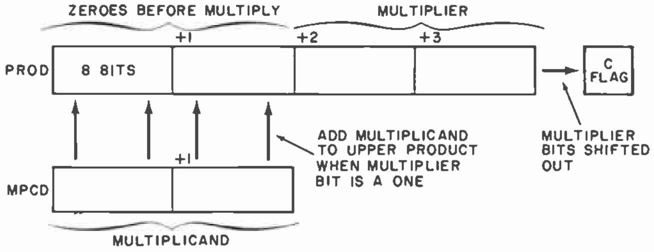


Fig. 1. Multiply subroutine pseudo registers.

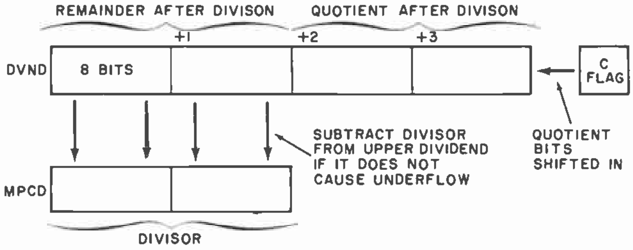


Fig. 3. Divide subroutine pseudo registers.

flag (which holds the current multiplier bit) is tested. If it is a zero, the iteration is complete. If it is a one, then the multiplicand is *double-precision* added to the upper 2 bytes of PROD. Quad-precision addition of partial products is not needed which is one reason for the efficiency of this algorithm.

It is possible however for this addition to overflow. Fortunately, the overflow bit is retained in the carry flag and it will be shifted into the most significant bit of PROD during the next iteration. As the multiplication progresses, the multiplier is pushed off the right end of PROD while the product expands. There is never any interference between the two.

The correction needed for signed operands is actually quite simple. First, the numbers are multiplied together *as-is* with the above unsigned multiply subroutine. After multiplication, the sign bit of each factor is tested. If a factor is negative, the *other* factor is double-precision subtracted from the *upper half* of the product. The final result is a properly signed product. If signed fractional numbers were being multiplied, it is necessary to shift the product left one position after correction. The signed fractional result then is the *leftmost* two bytes of PROD.

Division. Division (Figs. 3 and 4) is the exact reverse of multiplication. Again, an unsigned algorithm will be used with correction applied for signed operands. For clarity, a different set of pseudo registers will be used but in practice they would occupy the same memory locations as those for multiply. DVND is 4 bytes long and holds the quad precision dividend. DVSR is two bytes and holds the divisor. After division, the quotient is in the low two bytes of DVND and the remainder is in the high two bytes.

A division iteration starts by subtracting the divisor from the high two bytes of the dividend and saving the difference. An underflow, evidenced by the carry flag being off after the subtraction, prevents updating of the upper divisor and a zero quotient bit to be recorded. If there was no underflow, the subtraction result is copied into the upper divisor and a quotient bit of one is produced. Following this the entire dividend is shifted left and the quotient bit, which is contained in the carry flag, is shifted in on the right. Only zeroes are ever shifted out at the left. As the division progresses, the divi-

EXAMPLES OF MULTIPLY AND DIVIDE SUBROUTINES

```
                ;        16 X 16 UNSIGNED MULTIPLY SUBROUTINE
                ;        ENTER WITH UNSIGNED MULTIPLIER IN PROD+2 AND PROD+3
                ;        ENTER WITH UNSIGNED MULTIPLICAND IN MPCD AND MPCD+1
                ;        RETURN WITH 16 BIT UNSIGNEO PRODUCT IN PROD (HIGH) THROUGH
                ;        PROD+3 (LOW)

0000 A900       UNSMPY:  LDA    #0          ; CLEAR UPPER PRODUCT
0002 B565                STA    PROO
0004 8566                STA    PROD+1
0006 A211       UNSMO:   LDX    #17         ; SET 17 MULTIPLY CYCLE COUNT
0008 18                  CLC                ; INITIALLY CLEAR CARRY
0009 204B00     UNSM1:   JSR    SRQL        ; SHIFT MULTIPLIER ANO PRODUCT RIGHT 1
                                            ; PUTTING A MULTIPLIER BIT IN CARRY
000C CA                  DEX                ; DECREMENT AND CHECK CYCLE COUNT
000D F01A                BEQ    UNSM2       ; JUMP OUT IF DONE
000F 90FA                BCC    UNSM1       ; SKIP MULTIPLICANO AOO IF MULTIPLIER EIT
                                            ; IS ZERO
0011 A566                LOA    PROO+1      ; ADD MULTIPLICAND TO UPPER PRODUCT
0013 18                  CLC
0014 656A                ADC    MPCO+1
0016 8566                STA    PROD+1
0018 A565                LDA    PROD
001A 6569                AOC    MPCD
001C 8565                STA    PROD
001E 4C0B00              JMP    UNSM1       ; GO FOR NEXT CYCLE
0021 60         UNSM2:   RTS                ; RETURN

                ;        DOUBLE PRECISION UNSIGNED DIVIDE SUBROUTINE
                ;        ENTER WITH UNSIGNED DIVIDEND IN OVND (HIGH) THROUGH DVND+3 (LOW
                ;        ENTER WITH UNSIGNED OIVISOR IN DVSR AND DVSR+1
                ;        EXIT WITH UNSIGNEO QUOTIENT IN DVNO+2 ANO OVNO+3 AND UNSIGNEO
                ;        REMAINOER TIMES 2 IN OVNO AND DVND+1 AND CARRY FLAG
                ;        NO CHECK FOR OVERFLOW OR OIVIDE BY 0

0022 A211       UNSOIV:  LDX    #17         ; SET OIVIDE CYCLE COUNT
0024 18                  CLC                ; INITIALLY CLEAR CARRY
0025 A56C       UNSOV1:  LDA    OVNO+1      ; SUBTRACT OIVISOR FROM HIGH OIVIDEND
0027 38                  SEC                ; AND SAVE DIFFERENCE IN Y AND A
0028 E570                SBC    DVSR+1
002A A8                  TAY
002B A56B                LDA    DVND
0020 E56F                SBC    DVSR
002F 9013                BCC    UNSDV2      ; SKIP IF UNOERFLOW
0031 856F                STA    OVSR        ; UPDATE HIGH OIVIDEND IF NOT
0033 98                  TYA
0034 8570                STA    DVSR+1
0036 205800     UNSDV2:  JSR    RLQL        ; SHIFT DIVIOENO LEFT 1 BRINGING IN
                                            ; QUOTIENT BIT
0039 CA                  DEX                ; DECREMENT CYCLE COUNT
003A DOF1                BNE    UNSOV1      ; LOOP IF NOT DONE
003C 60                  RTS                ; RETURN

                ;        QUAD SHIFT RIGHT SUBROUTINE
                ;        ENTER AT RRQL TO SHIFT IN THE CARRY
                ;        ENTER WITH QUAD PRECISION VALUE TO SHIFT IN PROD THROUGH PROD+3
                ;        RETURNS BIT SHIFTED OUT IN CARRY

003D 6665       SRQL:    ROR    PROD        ; ROTATE RIGHT ENTRY
003F 6666                ROR    PROD+1
0041 6667                ROR    PROD+2
0043 6668                ROR    PROD+3
0045 60                  RTS                ; RETURN

                ;        QUAD SHIFT LEFT SUBROUTINE
                ;        ENTER AT RLQL TO SHIFT IN THE CARRY
                ;        ENTER WITH QUAD PRECISION VALUE TO SHIFT IN DVND THROUGH DVND+3
                ;        RETURNS BIT SHIFTED OUT IN CARRY

0046 2668       RLQL:    ROL    PROD+3      ; ROTATE LEFT ENTRY
0048 2667                ROL    PROD+2
004A 2666                ROL    PROD+1
004C 2665                ROL    PROD
004E 60                  RTS                ; RETURN

                ;        STORAGE FOR THE MULTIPLY AND DIVIOE SUBROUTINES

004F 00000000   PROD:    .BYTE  0,0,0,0     ; 4 BYTES FOR MULTIPLIER AND PRODUCT
0053 0000       MPCD:    .BYTE  0,0         ; 2 BYTES FOR MULTIPLICAND
0055 00000000   DVND:    .BYTE  0,0,0,0     ; 4 BYTES FOR OIVIDENO, QUDTIENT, AND REM
0059 0000       OVSR:    .BYTE  0,0         ; 2 BYTES FOR OIVISDR
0000                     .END
```

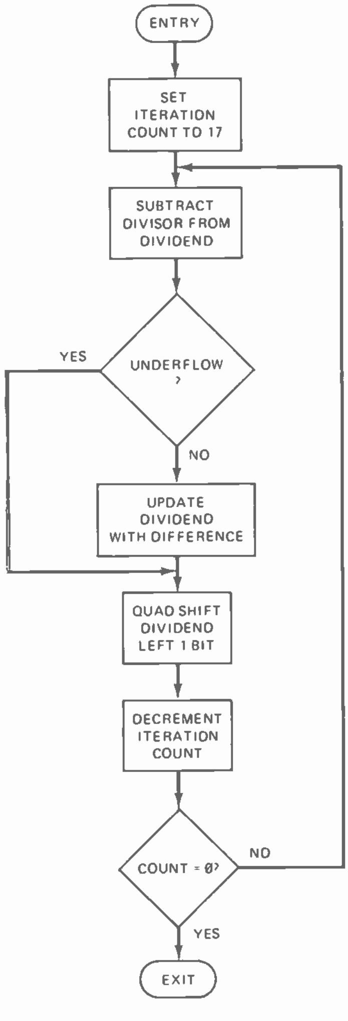
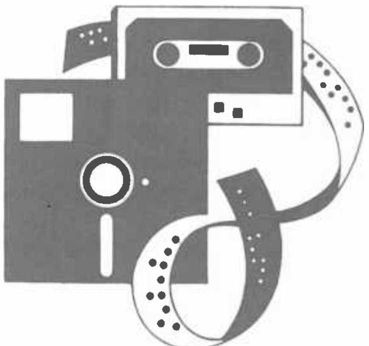


Fig. 4. Divide flowchart.

dend is progressively eaten away as it shifts left and the quotient grows as additional bits are shifted in on the right. When complete, the quotient fills the right half of DVND and the remainder occupies the left half. As before there is no interference between the two numbers sharing DVND.

The most straightforward way of dividing signed operands is to compute their absolute values and record their signs. After dividing what are now signed *positive* numbers, the proper sign of the result is determined by applying the rules of algebra. Actually this amounts to nothing more than exclusive-OR'ing the sign bits of the original operands together to get the sign of the result. If this indicates that the quotient should be negative, then it is negated. When dividing signed fractions, it is necessary to shift the quotient right one position before doing the sign correction. Also, the fractional dividend is placed in the *upper* 2 bytes of the dividend and the lower 2 bytes are zeroed.

Unlike multiplication, it is possible for division to overflow. To avoid overflow, the upper two bytes of the dividend must be smaller than the divisor. This is easy to test for in the division routine itself and is often included. ◇



Software Sources

6800 and 6502 Calculator Programs. HUEY and HUEY LXVIII are calculator programs for the 6502 and 6800, respectively. Such functions as sine, exponent, log, arc tangent and others are pre-programmed, and the user can program other functions. Program area required is 2.25K. HUEY LXVIII, the 6800 version, resides at 1000 to 18FF hex. Hex listing with basic instruction is $10, and a manual containing commented disassembly and instructions on adding your own functions is $20. HUEY 6502 is available as a commented manual, with a zero-page location, for $20. Either version can also be custom-reassembled for any memory location for $5.00 above cost of the manual, or $25 total. The Bit Stop, P.O. Box 973, Mobile, AL 36601.

8080/Z80 Word Processing System. The Electric Pencil II is a character-oriented word processing system. Lines are not delineated, so any number of characters, words, lines or paragraphs may be inserted or deleted anywhere in the text, which opens up or closes as needed. Text lines are automatically formatted, with no typing of carriage returns required. Words partially completed when the end of a line is reached are shifted to the beginning of the following line. Text may be examined at will with variable-speed forward and reverse scrolling. Commands allow text strings to be located and/or replaced as desired. In printing, the Electric Pencil II automatically inserts carriage returns where they are needed with right-column justification, page numbering and page titling available. Diablo versions also include character spacing, bold face, multicolumn and bidirectional printing. Hardware requirements are: 8080 or Z80 processor, printer, video display, and disk or cassette interface. Base price, in Cuter or Tarbell cassette formula, for TTY or similar printers, is $100. Add $50 for Diablo Hy-term, $25 for North Star disk; CP/M compatible diskette systems are available for an additional $125, with such added features as file management, page-at-a-time scrolling, automatic word and record number tally, and others. From dealers or Michael Shrayer Software, 3901 Los Feliz Blvd., Los Angeles, CA 90027.

Amateur Radio

By Karl T. Thurber, Jr., W8FX

THE ANTENNA: GETTING OUT THE SIGNAL

OBTAINING the best station equipment is pointless if the signal isn't radiated properly. Fortunately, getting the signal out of the rig and into the air is *not* difficult at all, unless one lives under particularly restrictive conditions such as in a trailer park or an apartment where outside antennas are frowned upon or flatly prohibited. Assuming that you are not limited in this way, you would do well to stick with either a basic half-wave dipole antenna designed for single-band operation on your favorite band, a "trap" dipole for mulit-band work, or a multiband vertical.

Simple Dipoles. The proper dimensions for a half-wave dipole can be easily calculated or found in the *ARRL Radio Amateurs Handbook* or the *ARRL Antenna Book*, so we won't repeat them here. What bears repeating is that the antenna should be mounted as high and in the clear as possible, free of bends, and fed with good quality 75-ohm coax. At hf, RG-59/U is perfectly capable of handling more than 250 watts of power with very moderate line loss, even at 10 meters. Within the Novice subbands, a properly 'pruned' dipole (adjusted using an SWR bridge or directional wattmeter) should easily take power from the transmitter's pi output network without the aid of an antenna tuner.

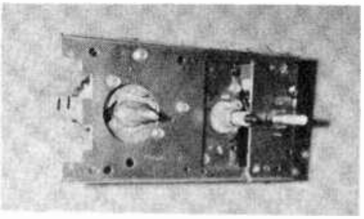
Multi-band operation is possible by paralleling individual dipoles cut for the desired bands. The shorter dipoles can be suspended from the lowest-frequency (longest) one. You can use 4-wire rotator cable, cutting the longest conductors for the 80-meter band and cutting back the others to the proper length for resonant operation on the higher bands. All four wires are then joined on each side at the center point. The four dipoles will thus be fed with a single transmission line. This system generally works well, as the nonresonant dipoles are "not there" electrically speaking. However, one should be prepared to have to carefully prune dipole lengths after the antenna has been installed to get a low SWR because there is some electrical interaction between the dipoles. An antenna coupler is recommended for use with this antenna for two reasons: the antenna easily radiates unwanted harmonics of the fundamental frequency (which can lead to FCC citations known as "Pink Slips") and it is sometimes difficult to load up the transmitter on all bands. Commercially available trap dipoles generally work well unless they are physically very short for the lowest band in use (usually 80 meters). Unless operations are restricted to relatively narrow frequency ranges, trap dipoles require an antenna coupler for good transmitter loading.

Hustler's Model 4-BTV trap vertical covers 40 through 10 meters.

Verticals. The mulit-band vertical working against a good ground/radial system is an excellent radiator, and is well suited for DX chasing. It is very practical when space is at a premium, especially when the length of a 40- or 80-meter dipole would preclude its erection on a small city or suburban lot. All that's needed is vertical space and some room for radial wires, which can be fairly short if necessary. Hy-Gain, Mosley, and Gotham all make excellent verticals. They are generally mounted at ground level, using one or more long ground rods to get a low-resistance earth return in conjunction with four to a dozen or more buried radials. The radials may not be necessary in all cases. You may find the ground rod alone will provide good results, especially in areas with high ground conductivity, although theory dictates the installation of as many radials as possible to prevent the waste of r-f energy through ground losses. As in the case of the dipole, the vertical should be mounted in as clear an area as possible, away from TV antennas, power and telephone lines, and other signal obstacles. It should also be fenced-in or otherwise blocked off to prevent children from coming into contact with the antenna and suffering r-f burns. The Hy-Gain 18AVT, fed with 50-ohm coax, is a favorite among Novices and is well-known for excellent performance on 80 through 10 meters and its sturdy construction. The advanced Novice interested in chasing DX might consider Gotham's relatively inexpensive ($60) three-band (10/15/20 meters) quad which should work very well on 15 and 10 meters and come in handy once the license is upgraded.

Those able to erect full-size, single-band dipoles and verticals should certainly do so. Although there are literally hundreds of various hf antenna designs described in the amateur literature—more than enough to thoroughly confuse the beginner—the newcomer is best advised to "keep it simple." Zepps, random wires, rhombics and other exotica have their places, but lead to poor results when tried by the beginner, usually due to problems associated with matching and transmitter loading. The apartment dweller may have to experiment with loops, random wires and indoor dipoles, and should study the literature thoroughly before trying to pump power into a haywire antenna. He might even want to consider a window-mounted mobile antenna and loading coil arrangement if antenna space is a severe problem. I have found many interesting and novel antenna designs for "problem cases" in the paperback, *Ham Antenna Construction Projects* by J. A. Stanley, available from Howard W. Sams and Co. This little gem has some good ideas, particularly on "invisible" and restricted space antennas. The *ARRL Antenna Book* and the *73 Magazine* series of antenna publications also provide some very good ideas for difficult antenna installations.

Matching and Coupling. After the station has been set up and the antenna erected, the beginner sometimes finds that he just can't make any contacts. Most often the problem lies in matching the pi-network output circuit of the transmitter or transceiver to the antenna. If



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impedances are mismatched, there will be an inefficient transfer of power from the transmitter to the antenna. Adjusting feed-line lengths can sometimes make loading easier, but contrary to a popular misconception, nothing can be done at the transmitter, including lengthening or shortening the feed line, to reduce a high SWR (standing wave ratio) on the transmission line. If a high SWR is indicated, one must go to the *antenna* to find the cause.

When multi-band trap dipoles or verticals are used, the SWR can often be brought down to reasonable levels, say, less than 3:1, but no lower. This is especially true at the band edges, and results in an inability to load the transmitter to full power. This problem can usually be alleviated by using a coax-to-coax antenna coupler such as the R. L. Drake Models MN-4 and MN-2000 which are designed to accommodate moderate mismatches and allow the transmitter to *see* the ideal 50 ohms into which it can deliver its full rated power. The MN-4 is popular among Novices as it allows either straight-through or coupler operation at the flick of a switch, has a built-in SWR bridge and wattmeter, and permits selection of one of several antennas or a dummy load used in tuning up the transmitter. Price class is about $120 for the MN-4. Although that might seem expensive, an antenna tuner provides operating flexibility and can help prolong the lives of final amplifier tubes, too!

The wide-range Johnson Matchbox is found on used equipment market.

A fancier antenna coupler or "transmatch" is required when nonresonant antennas such as "random wires", or Zepp antennas with balanced feeders such as 300-ohm TV twinlead, or 600-ohm open-wire line are used. In these situations wide-range tuners must be used. These are more expensive, but have more flexibility, usually being able

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to match practically any type of load—balanced line, coax, or random wires and the like. Murch Electronics, Dentron, and Nye Viking all make very competitive multi-purpose tuners, some of which can handle well over 2 kW *and* feature built-in SWR bridges or, better yet, directional wattmeters. Some even have built-in dummy loads. For the adventurous Novice, Apollo Products of Vaughnsville, OH make a wide-range tuner *kit*, the Model 2500X-2 "Trans Systems Tuner," which has met with good acceptance. A number of tuner designs suitable for home brewing can be found in ham literature. A standard and basic design is Lew McCoy's "Ultimate Transmatch" described in the *ARRL Radio Amateur's Handbook*.

Heathkit's inexpensive Cantenna allows tuneup off the air.

A directional wattmeter or SWR bridge is a *must* when using an antenna coupler to insure that it is properly adjusted. In using a coupler, one should keep in mind that its basic purpose is to facilitate the transfer of power from the transmitter or transceiver to the feedline and antenna, and should not be expected to compensate for a poor antenna. Some wide-range antenna tuner manufacturers boast that their products will enable you to "load a bedspring." However, that ability does not guarantee good signal reports!

Another item that belongs in every ham shack is a good dummy load. The load makes it possible for you to tune the transmitter for a 50-ohm load without putting a signal on the air and possibly causing interference to other hams. After the transmitter has been tuned for maximum output power, the transmatch can be adjusted for a perfect match between the rig and feedline. All transmatch adjustments should be made with the transmitter's r-f level control backed down as far as possible. Only after these adjustments have been made should the transmitter's r-f output be brought to maximum again. ◇

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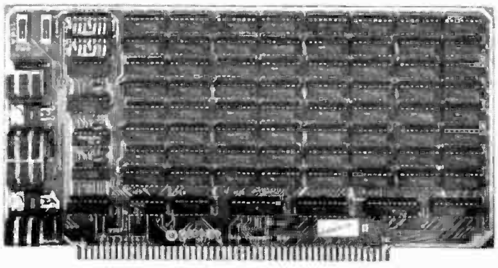

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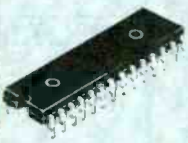

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7409	.17	7494	.60
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7411	.18	7496	60
7412	.13	74107	.28
7413	.25	74109	.22
7414	.61	74121	29
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SN7450N	20	SN74151N	59	SN74365N	69
SN7451N	20	SN74153N	59	SN74366N	69
SN7453N	20	SN74154N	99	SN74367N	68
SN7454N	20	SN74155N	79	SN74368N	69
SN7459A	25	SN74156N	79	SN74390N	1 95
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CD4007	25	CD4030	49	CD4081	23
CD4009	49	CD4035	99	CD4082	23
CD4010	49	CD4040	1 19	CD4093	99
CD4011	23	CD4041	1 25	CD4098	2 49
CD4012	25	CD4042	99	MC14409	14 95
CD4013	39	CD4043	89	MC14410	14 95
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CD4016	49	CD4047	2 50	MC14433	19 95
CD4017	1 19	CD4048	1 35	MC14506	75
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CD4020	1 19	CD4051	1 19	MC14583	3 50
CD4021	1 39	CD4053	1 19	CD4508	3 95
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CD4025	23	CD4066	79	CD4518	1 29
CD4026	2 25	CD4068	39	CD4520	1 29
CD4027	69	CD4069	45	CD4566	2 25

74C00

74C00	39			74C163	3 00
74C02	55			74C164	3 25
74C04	75	74C89	6 49	74C173	2.60
74C08	75	74C90	3 00	74C192	3 49
74C10	65	74C93	2 00	74C193	2 75
74C14	3 00	74C95	2 00	74C195	2 75
74C20	65	74C107	1 25	74C922	9 95
74C30	65	74C151	2 90	74C923	8 95
74C42	2 15	74C154	3 00	74C925	14 95
74C48	4 75	74C157	2 15	74C926	11.95
74C73	1 50	74C160	3 25	80C95	1 50
74C74	1 15	74C161	3 25	80C97	1 50

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LM301H	35			LM741CH	35
LM301CN	35			LM741CN	35
LM302H	75	LM340T-8	1 25	LM741-14N	39
LM304H	1 00	LM340T-12	1 25	LM747H	79
LM305H	60	LM340T-15	1 25	LM747N	79
LM307CN/H	35	LM340T-18	1 25	LM748H	39
LM308H	1 00	LM340T-24	1 25	LM748N	39
LM308CN	1 00	LM350N	1 00	LM1303N	90
LM309H	1 10	LM351CN	65	LM1304N	1 19
LM309K	1 25	LM370N	1 15	LM1305N	1 40
LM310CN	1 15	LM373N	3 25	LM1307N	85
LM311H	90	LM377N	4 00	LM1310N	2 95
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LM317K	6 50	LM380CN	99	LM1414N	1 75
LM318CN	1 50	LM381N	1 79	LM1458CN/H	59
LM319N	1 30	LM382N	1 79	MC1488N	1 95
LM320K-5	1 35	NE501N	8 00	MC1489N	1 95
LM320K-5 2	1 35	NE510A	6 00	LM1496N	95
LM320K-12	1 35	NE529A	4 95	LM1556V	1 75
LM320K-15	1 35	NE531H	3 00	MC1741SCP	3 00
LM320K-18	1 35	NE536T	6 00	LM2901N	2 95
LM320K-24	1 35	NE540L	6 00	LM3053N	1 50
LM320T-5	1 25	NE550N	1 30	LM3065N	69
LM320T-5 2	1 25	NE555V	39	LM3900N(3401)	49
LM320T-8	1 25	NE556N	99	LM3905N	89
LM320T-12	1 25	NE560B	5 00	LM3909N	1 25
LM320T-15	1 25	NE561B	5 00	MC5558V	1 00
LM320T-18	1 25	NE562B	5 00	LM7525N	90
LM320T-24	1 25	NE565H	1 75	LM7534N	75
LM323K-5	5 95	NE565N	1 25	8038B	4 95
LM324N	1 80	NE566CN	1 75	LM75450N	50
LM339N	99	NE567H	1 25	75451CN	39
LM340K-5	1 35	NE567V	99	75452CN	39
LM340K-6	1 35	NE570N	10 50	75453CN	39
LM340K-8	1 35	LM703CN/H	45	75454CN	39
LM340K-12	1 35	LM709H	29	75491CN	79
LM340K-15	1 35	LM709N	29	75492CN	89
LM340K-18	1 35	LM710N	79	75494CN	89
LM340K-24	1 35	LM711N	39	RC4151	5 95
LM340T-5	1 25	LM723H	55	RC4194	5 95
LM340T-6	1 25	LM723N	.55	RC4195	4 49

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74LS00	23			74LS139	69
74LS01	23			74LS151	69
74LS02	23	74LS51	.23	74LS155	.69
74LS03	.23	74LS54	23	74LS157	.69
74LS04	.29	74LS55	.23	74LS160	89
74LS05	29	74LS73	35	74LS161	89
74LS08	23	74LS74	35	74LS162	89
74LS09	29	74LS75	.49	74LS163	89
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74LS14	99	74LS85	99	74LS181	2.49
74LS15	.29	74LS86	35	74LS190	89
74LS20	.23	74LS90	49	74LS191	89
74LS21	29	74LS92	.59	74LS192	89
74LS22	29	74LS93	.59	74LS193	89
74LS26	29	74LS95	79	74LS194	.89
74LS27	.29	74LS96	.89	74LS195	89
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MAN 82	Common Anode-yellow	300	99	DL704	Common Cathode-red	300	99
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		68 OHM	82 OHM	100 OHM	120 OHM	150 OHM		
ASST. 2	5 ea.	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	1/4 WATT 5%	50 PCS
		470 OHM	560 OHM	680 OHM	820 OHM	1K		
ASST. 3	5 ea	1 2K	1 5K	1 8K	2 2K	2 7K	1/4 WATT 5%	50 PCS.
		3 3K	3 9K	4 7K	5 6K	6 8K		
ASST. 4	5 ea	8 2K	10K	12K	15K	18K	1/4 WATT 5%	50 PCS
		22K	27K	33K	39K	47K		
ASST. 5	5 ea	56K	68K	82K	100K	120K	1/4 WATT 5%	50 PCS.
		150K	180K	220K	270K	330K		
ASST. 6	5 ea.	390K	470K	560K	680K	820K	1/4 WATT 5%	50 PCS
		1M	1 2M	1 5M	1 8M	2 2M		
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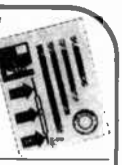

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XR1310P	1 30	XR2212	4 35	XR4558	75
XR1468CN	3 85	XR2240	3 45	XR4739	1 15
XR1488	1 39	XR2264	4 25	XR4741	1 47

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1N751A	5 1	400m	4 1 00	1N4006	800 PIV	1 AMP	10/1 00
1N752	5 6	400m	4 1 00	1N4007	1000 PIV	1 AMP	10/1 00
1N753	6 2	400m	4 1 00	1N3600	50	200m	6/1 00
1N754	6 8	400m	4 1 00	1N4148	75	10m	15 1 00
1N959	8 2	400m	4 1 00	1N4154	35	10m	12 1 00
1N965B	15	400m	4 1 00	1N4305	75	25m	20/1 00
1N5232	5 6	500m	28	1N4734	5 6	1w	28
1N5234	6 2	500m	28	1N4735	6 2	1w	28
1N5235	6 8	500m	28	1N4736	6 8	1w	28
1N5236	7 5	500m	28	1N4738	8 2	1w	28
1N456	25	40m	6/1 00	1N4742	12	1w	28
1N458	150	7m	6 1 00	1N4744	15	1w	28
1N485A	180	10m	5 1 00	1N1183	50 PIV	35 AMP	1 60
1N4001	50 PIV	1 AMP	12 1 00	1N1184	100 PIV	35 AMP	1 70
1N4002	100 PIV	1 AMP	12 1 00	1N1185	150 PIV	35 AMP	1 70
1N4003	200 PIV	1 AMP	12 1 00	1N1186	200 PIV	35 AMP	1 80
1N4004	400 PIV	1 AMP	12 1 00	1N1188	400 PIV	35 AMP	3 00

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MPSA06	5 1 00	MJE3055	1 00	2N3906	4 1 00
TIS97	6 1 00	2N3392	5 1 00	2N4013	3 1 00
TIS98	6 1 00	2N3398	5 1 00	2N4123	6 1 00
TIS133	5 1 00	PN3567	3 1 00	PN4249	4 1 00
TIS135	5 1 00	PN3568	4 1 00	PN4250	4 1 00
40409	1 75	PN3569	4 1 00	2N4400	4 1 00
40410	1 75	MPS3638A	5 1 00	2N4401	4 1 00
40673	1 75	MPS3702	5 1 00	2N4402	4 1 00
2N918	4 1 00	2N3704	5 1 00	2N4403	4 1 00
2N2219A	3 1 00	MPS3704	5/1 00	2N4409	5 1 00
2N2221A	4 1 00	2N3705	5/1 00	2N5086	4 1 00
2N2222A	5 1 00	MPS3705	5/1 00	2N5087	4/1 00
2N2369	5 1 00	2N3706	5 1 00	2N5088	4/1 00
2N2369A	4 1 00	MPS3706	5 1 00	2N5089	4/1 00
MPS2369	5/1 00	2N3707	5 1 00	2N5129	5 1 00
2N2484	4 1 00	2N3711	5 1 00	PN5134	5 1 00
2N2906	4 1 00	2N3724A	65	PN5138	5 1 00
2N2907	5 1 00	2N3725A	1 00	2N5139	5/1 00
2N2925	5 1 00	2N3772	2 25	2N5210	5/1 00
MJE2955	1 25	2N3823	1 00	2N5449	3/1 00
2N3053	2/1 00	2N3903	4 1 00	2N5951	3/1 00

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100 VOLT MYLAR FILM CAPACITORS

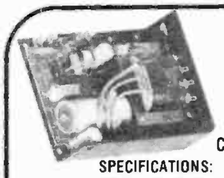
001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	22mf	33	27	22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

1/35V	28	23	17	1 5/35V	30	26	21
15/35V	28	23	17	2 2/25V	31	27	22
22/35V	28	23	17	3 3/25V	31	27	22
33/35V	28	23	17	4 7/25V	32	28	23
47/35V	28	23	17	6 8/25V	36	31	25
68/35V	28	23	17	10/25V	40	35	29
1 0/35V	28	23	17	15/25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47/50V	15	13	10	47/25V	15	13	10
1 0/50V	16	14	11	47/50V	16	14	11
3 3/50V	14	12	09	1 0/16V	15	13	10
4 7/25V	15	13	10	1 0/25V	16	14	11
10/25V	15	13	.10	1 0/50V	16	14	11
10/50V	.16	14	12	4 7/16V	15	13	10
22/25V	17	15	12	4.7/25V	15	13	10
22/50V	24	20	18	4 7/50V	16	14	11
47/25V	19	17	15	10/16V	14	12	09
47/50V	25	21	19	10/25V	15	13	10
100/25V	24	20	18	10/50V	16	14	12
100/50V	35	30	28	47/50V	24	21	.19
220/25V	32	28	25	100/16V	19	.15	.14
220/50V	45	41	38	100/25V	.24	.20	.18
470/25V	33	29	27	100/50V	.35	30	28
1000/16V	55	50	.45	220/16V	23	17	16
2200/16V	70	.62	.55	470/25V	31	.28	26



ELPAC POWER SUPPLIES

Completely Assembled

SPECIFICATIONS:

105-125/210-250 Vac, 47-440 Hz input:

Line Regulation	±0.1%
Load Regulation	±0.1%no-load to rated-load
Output Ripple and Noise	±0.1%p-p,dc to 10 MHz
Input/Output Isolation	100 megohm dc, 900 Vac
Short Circuit Current	35% rated current

PART NO.	RATINGS			PRICE
	WATTS	VOLTS	AMPS	
SOLV15-5*	15	5	3	$36.95
SOLV15-12*	15	12	1.5	36.95
SOLV30-5	30	5	6	59.95
SOLV30-12	30	12	3	59.95
OVP1	over voltage protection for SOLV30-5,-12			9.95

*SOLV15-5, 12 includes OVP installed

NEW! BULB-ENERGY SAVER

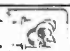
Bulb lasts 3 or more times longer. Fits Standard Socket 6 watts to 200 watts

BULB-ENERGY SAVERS used for years by major industrial users — now available for home or office use. Bulb Savers can cut electrical bills by as much as 3%.

BULB-SAVERS lengthens light life by.

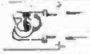
1. Acting as an electrical "shock absorber", turns the bulb on slowly, eliminating the "thermal shock". Bulb life increases 300 percent.
2. Banishes Current "Surges". Cushions line voltage surges when other loads cut power line.
3. Reduces Energy Consumption

	1-9	10+
BES-1	1.39 ea.	1.20



CRYSTALS

THESE FREQUENCIES ONLY



PART NO.	FREQUENCY	CASE	PRICE
CY1A	1.000MHz	HC33	5.95
CY1.84	1.8432MHz	HC33	5.95
CY2A	2.000MHz	HC33	5.95
CY2.01	2.010MHz	HC33	1.95
CY2 50	2.500MHz	HC33	4.95
CY3.27	3.2768MHz	HC33	4.95
CY3.57	3.579545MHz	HC33	4.95
CY3A	4.000MHz	HC18	4.95
CY4.91	4.916MHz	HC18	4.95
CY7A	5.000MHz	HC18	4.95
CY5.18	5.185MHz	HC18	4.95
CY6.14	6.144MHz	HC18	4.95
CY6.40	6.400MHz	HC18	4.95
CY6.55	6.5536MHz	HC18	4.95
CY12A	10.000MHz	HC18	4.95
CY14A	14.31818MHz	HC18	4.95
CY19A	18.000MHz	HC18	4.95
CY18.43	18.432MHz	HC18	4.95
CY22A	20.000MHz	HC18	4.95
CY30A	32.000MHz	HC18	4.95

TRIMMERS

10MM size trimmers -.394" Dia.

Part No.	1-9	10-24	25-49	100+
TR-11(valve)	.35	.30	.25	20

Resistance values - 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1 meg

TRIMPOTS

Single-Turn - 1/2 Watt

Square - Top Adjust - 3/8" Size

Part No.	1-9	10-24	25-49	50-99
840P(value)	.99	.89	.80	.70

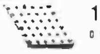
Resistance Values - 50, 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1 meg

15-Turn - 3/4 Watt

Rectangular Side Adjust 3/4" x 1/4" Size

Part No.	1-9	10-24	25-49	50-99
830P(value)	1.35	1.25	1.20	1.15

Resistance Values - 50, 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1 meg.



1/16 VECTOR BOARD

	0.1" Hole Spacing	P-Pattern		Price	
	Part No	L	W	1-9	10 up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY	64P44 062WE	4.50	6.50	2.07	1.86
GLASS	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

CONNECTORS

25 Pin-D Subminiature

DB25P(as pictured)	PLUG	$3.25
DB25S	SOCKET	4.95
DB51226-1	Cover for DB25 P or S	1.75

MOLEX CONNECTOR PINS

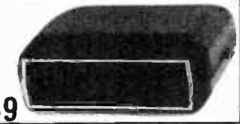
Pre-packaged in strips

M-530-1 $1.95/100 pins (minimum order) $16.00/1000 pins

INSTRUMENT/ CLOCK CASE

Injection molded unit. Complete with red bezel. 4½" x 4" x 1-9/16".

$3.49



MICROPROCESSOR COMPONENTS

P8085	CPU	$29.95	CDP 1802	CPU	$19.95
8080A	CPU	10.95	Z80	CPU	24.95
8212	8-Bit Input/Output	4.95	2650	MPU	26.50
8214	Priority Interrupt Control	7.95	MC6800	MPU	19.95
8216	Bi-Directional Bus Driver	4.95	MC6810API	128 x 8 Static Ram	5.95
8224	Clock Generator/Driver	5.95	MC6820	Periph. Interface Adapter	7.95
8228	System Controller/Bus Driver	5.95	MC6821	Periph. Interface Adapter	11.50
8251	Prog. Comm. Interface	9.95	MC6830L8	1024 x 8 Bit ROM	14.95
8255	Prog. Periph. Interface	10.95	MC6850	Asychronous Comm. Adapter	14.95

RAM'S

1101	256 x 1	Static	$ 1.49
1103	1024 x 1	Dynamic	.99
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
2112	256 x 4	Static	5.95
2114	4K x 1	Static 450ns	9.95
2114L	4K x 1	Static 450ns Low Power	10.95
2114-3	1K x 4	Static 300ns	10.95
2114L-3	1K x 4	Static 300ns Low Power	11.95
7489	16 x 4	Static	1.75
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
21L02	1024 x 1	Static	1.95
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	3/1.00
MK4027 (UPD414)	4K	DYNAMIC 16 PIN	5.95
MK4116 (UPD416)	16K	DYNAMIC 16 PIN	29.95
TMS4044-45NL	4K	STATIC	14.95

ROM'S

2513(2140)	Character Generator (upper case)	$ 9.95
2513(3021)	Character Generator (lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048 Bit Read Only Memory	1.95

USER MANUALS

1802M	CDP1802 Manual	$ 7.50
Z80M	Z80 Manual	7.50
2650M	2650 Manual	5.00

PROMS

1702A	2048 x 1	Famous	$ 5.95
5203	2048 x 1	Famous	14.95
82S23	32 x 8	Open C	5.00
82S115	4096 x 1	Bipolar	19.95
82S123	32 x 8	Tristate	5.00
74S287	1024 x 1	Static	7.95
2708	8K	EPROM	10.95
2716 T.I.	16K	EPROM	29.95
2716 Intel (2516 T.I.)	16K	EPROM	59.95
6301-1	1024 x 1	Tri-State Bipolar	3.49
6330-1	256 x 1	Open C Bipolar	2.95
74186	512 x 1	TTL Open Collector	9.95
74188	256 x 1	TTL Open Collector	3.95

SHIFT REGISTERS

MM5013N	1024 BitAccumulator Dynamic	2.95
MM5016H	500/512 Bit Dynamic	.89
MM5017N	Dual 500/512 Bit Dynamic	2.95
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2519	Hex 40 Bit Static	4.00
2522	Dual 132 Bit Static	2.95
2524	512 Dynamic	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
2533	1024 Static	2.95
3341	Fifo	6.95
74LS670	4 X 4 Register	1.95

UART'S

AY-5-1013	30K BAUD	$ 5.95

SPECIAL REQUESTED ITEMS

TELEPHONE KEYBOARD CHIPS

AY-5-9100	$14.95
AY-5-9200	14.95
AY-5-9500	4.95
AY-5-2376	14.95
HD0165	7.95
74C922	9.95

ICM CHIPS

ICM7045	$24.95
ICM7205	19.95
ICM7207	7.50
ICM7208	19.95
ICM7209	6.95

TV GAME CHIP SET

AY-3-8500-1 Chip and 2.010 MHz Crystal **$7.95**

NMOS READ ONLY MEMORIES

MCM6571	$13.50
MCM6574	13.50
MCM6575	13.50

MISCELLANEOUS

11C90	$19.95	MK40240	$17.50
MC3061P	11.95	DS0026CH	3.75
MC1408L7	4.95	TIL308	10.20
MC1408L8	5.75	95H90	11.95

LD110/111	$25.00/set
MC4016(74416)	7.50
4N33	3.95

The Sinclair PDM35. A personal digital multimeter for only $59.95

Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 is supplied completely assembled with test leads and prods, protective wallet and Operator's Manual.

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

Technical specification

DC Volts (4 ranges) Range 1mV to 1000 V. Accuracy of reading 1.0%±1 count. Note 10 MΩ input impedance

AC Volts (40 Hz-5 kHz) Range 1V to 500 V. Accuracy of reading 1.0% ± 2 counts

DC Current (6 ranges) Range 1nA to 200 mA. Accuracy of reading 1.0% ± 1 count. Note Max resolution 0.1nA

Resistance (5 ranges) Range 1Ω to 20 MΩ. Accuracy of reading 1.5% ± 1 count. Also provides 5 junction-test ranges

Dimensions: 6 in x 3 in x 1½ in

Weight: 6½ oz

Power supply: 9V battery or Sinclair AC adapter (battery not incl.)

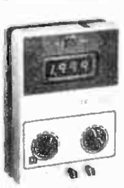
Sockets: Standard 4 mm for resilient plugs

Options: AC adapter for 117 V 60 Hz power. De-luxe padded carrying wallet

PART NO	DESCRIPTION	PRICE
PDM35	Digital Multimeter (Completely Assembled)	$59.95
PDM-AC	117volt AC Adapter	6.95
PDM-DP	Deluxe padded carrying case	6.95

B+K PRECISION

3½-Digit Portable DMM



- Overload Protected
- .3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mv, 1µa, 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accracy 1% typical

Ranges: DC Voltage 0-1000V, AC Voltage 0-1000V, Freq Response 50-400 HZ, DC/AC Current 0-100mA, Resistance 0-10 meg ohm, Size 6.4 x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC

100 MHz 8-Digit Counter

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

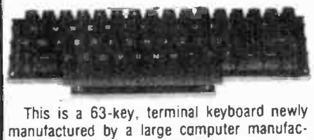
ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — Model 100 — CLA $3.95

Charger/Eliminator use 110 V AC — Model 100 — CAI $9.95

KEYBOARDS

63-Key Unencoded



This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK **$29.95/each**

Hexadecimal Encoder

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key **$10.95/each**

$5.00 Minimum Order – U.S. Funds Only
California Residents – Add 6% Sales Tax

Spec Sheets – 25¢
1978 A Catalog Available—Send 41¢ stamp

NEW NAME

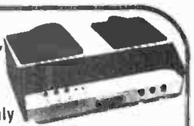
Jameco ELECTRONICS

a division of JAMES ELECTRONICS of California

PHONE ORDERS WELCOME (415) 592-8097

MAIL ORDER ELECTRONICS – WORLDWIDE
1021 HOWARD AVENUE, SAN CARLOS, CA 94070
Advertised Prices Good Thru September

The Incredible "Pennywhistle 103"



$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications for the deaf. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character).
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark, High = 025 space, 2225 mark.
Receive Sensitivity	-46 dbm accoustically coupled
Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm.
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements	120 VAC, single phase, 10 Watts.
Physical	All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align

The Original the 3rd Hand

$9.95 each

- *Leaves two hands free for working
- * Clamps on edge of bench, table or work bench
- * Position board on angle or flat position for soldering or clipping
- * Sturdy, aluminum construction for hobbyist, manufacturer or school rooms

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

IMK

3½ DIGIT DPM KIT

- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	**$49.00**
Model KB503 5V Power Kit	**$17.50**

JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout and the MM5314 clock chip.

12 or 24 Hour

115 VAC

KIT ONLY **$16.95**

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

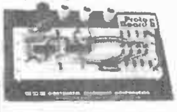
T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **JE225 $9.95 Per Kit**

CSC CONTINENTAL SPECIALTIES CORPORATION

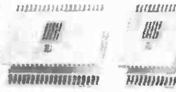
PROTO BOARDS

PROTO BOARD 6
$15.95
(6" long X 4" wide)



PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾	129.95

(includes power supply)



PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

CIRCLE NO. 31 ON FREE INFORMATION CARD

RADIO HUT

1-800-527-2304

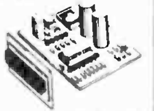
Use Our Toll Free Watts Line

For Master Charge and BankAmericard Orders

Jumbo LED Car Clock Kit

FEATURES:
A. Bowmar Jumbo .5 inch LED array.
B. MOSTEK — 50250 — Super clock chip.
C. On board precision crystal time base.
D. 12 or 24 hour Real Time format.
E. Perfect for cars, boats, vans, etc.
F. PC board and all parts (less case) inc.

Alarm option — $1.50
AC XFMR — $1.50



$16.95

MUSICAL HORN

One tune supplied with each kit. Additional tunes — $6.95 each. Special tunes available. Standard tunes now available: — Dixie — Eyes of Texas -- On Wisconsin — Yankee Doodle Dandy — Notre Dame — Pink Panther — Aggie War Song — Anchors Away — Never on Sunday — Yellow Rose of Texas — Deep in the Heart of Texas — Boomer Sooner — Bridge over River Kwai.

CAR & BOAT KIT	HOME KIT	Special Design Case $3.50	Assembled & Tested
34.95	29.95		Add $10.00

TELEPHONE RELAY

Assembled & Tested $29.95

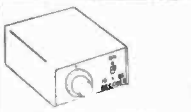
Automatically Starts & Stops Tape Recorders

Surreptitious interception of telephone conversation is a violation of Federal Law and this device is not intended for such use.

6 DIGIT ALARM CLOCK KIT

Features: Litronix dual 1/2'' displays, Mostek 50250 super clock chip, single I.C. segment driver, SCR digit drivers. Kit includes all necessary parts (except case). Xfmr optional Eliminate the hassle.

AC XFMR — **$1.50 Case $3.50** **$12.95**



NEW IMPROVED UNSCRAMBLER!

$25.00

Punched and Printed Case

Plugs into earphone or external speaker of any Scanner or Monitor. Guaranteed to unscramble any 1085 call.

- Easily tuned
- Full instruction included
- Drilled fiberglass P.C. Board
- One Hour Assembly

12V 1 AMP POWER SUPPLY

INPUT VOLTAGE 25V MAX. OUTPUT CURRENT 1 AMP. MAX. LOAD REGULATION 50mV. OUTPUT VOLTAGE 12V. LINE REGULATION 0.01%. KIT CONTAINS ALL PARTS EXCEPT FOR LINE CORD AND TRANSFORMER.

ONLY **$4.50**

7400 TTL DIGITAL CIRCUITS

7400	11	7442	47	7490	65	74156	89
7401	13	7443	59	7491	61	74157	55
7402	13	7444	59	7492	.43	74160	55
7403	13	7447	.68	7493	.43	74161	65
7404	15	7448	.71	7494	.67	74163	65
74L04	29	7450	13	7495	.67	74164	85
74S04	.44	7451	13	7496	.67	74165	89
7406	16	7453	13	74100	.30	74174	.85
7408	19	7460	19	74104	.49	74175	.85
7410	13	7470	.27	74107	.28	74180	.67
7411	18	7472	.25	74109	31	74181	1.93
7412	.26	7473	.29	74121	29	74182	.68
7416	15	7474	.29	74123	.48	74191	98
7420	13	7475	.47	74132	.99	74192	79
7423	.25	7476	.31	74136	.99	74193	81
7425	.29	7480	.31	745138	1 95	74194	81
7433	.26	7481	.55	74141	.75	74195	69
7437	.23	7482	.57	74151	61	9316	85
7438	23	7483	.67	74153	.61	9601	3/$1
7440	13	7485	89	74154	98	9L04	35
7441	76	7489	1.25	74155	89		

74LS00 LOW POWER SCHOTTKY

74LS00	.21	74LS47	.73	74LS136	37	74LS258	71
74LS02	.21	74LS51	.26	74LS138	.71	74LS260	26
74LS03	.21	74L654	.26	74LS139	71	74LS266	26
74LS04	.28	74LS55	.26	74LS145	1.00	74LS279	55
74LS05	.28	74LS73	.35	74LS151	.70	74LS290	.75
74LS08	.21	74LS74	.35	74LS153	.70	74LS293	.61
74LS09	.28	74LS76	.49	74LS155	.69	74LS295	95
74LS10	.21	74LS83	.73	74LS156	.70	74LS298	95
74LS11	.21	74LS85	1.35	74LS157	75	74LS365	55
74LS13	.45	74LS86	.36	74LS158	.71	74LS366	55
74LS14	.99	74LS90	.55	74LS160	.85	74LS367	55
74LS15	.26	74LS92	.55	74LS161	.85	74LS368	55
74LS20	.24	74LS93	.55	74LS162	.85	74LS390	1 75
74LS21	.28	74LS109	.38	74LS163	.85	74LS393	1 45
74LS22	.28	74LS112	.38	74LS164	1.49	74LS670	2 30
74LS26	.32	74LS113	.38	74LS168	.85	74LS192	95
74LS27	.32	74LS114	.38	74LS169	.85	74LS193	.95
74LS30	.26	74LS122	.49	74LS170	1.69	74LS194	.95
74LS32	.32	74LS124	.99	74LS173	1.10	74LS195	.85
74LS37	.32	74LS125	.47	74LS174	1.00	74LS196	.85
74LS38	.32	74LS126	.47	74LS175	.81	74LS197	85
74LS40	.26	74LS132	.79	74LS190	.95	74LS251	85
74LS42	.65	74LS133	.35	74LS191	.95	74LS253	81
						74LS257	71

CMOS

CD400	.19	CD4017	95	CD4040	1.00	CD4071	19
CD4001	.19	CD4018	.95	CD4041	.69	CD4081	.19
CD4002	19	CD4019	.19	CD4042	.69	CD4507	.35
CD4006	1.20	CD4020	.97	CD4043	.60		
CD4007	19	CD4021	.97	CD4044	.60	CD4510	1.00
CD4009	.47	CD4022	.97	CD4046	1.39	CD4512	1 10
CD4010	.39	CD4023	.19	CD4047	1.50	CD4516	79
CD4011	19	CD4024	.75	CD4049	.35	CD4518	1 10
CD4012	.29	CD4025	.19	CD4050	.39	CD4520	69
CD4013	.32	CD4027	.39	CD4051	1.19	CD4528	.85
CD4014	.78	CD4028	.85	CD4053	1.19	74C02	.45
CD4015	78	CD4029	.99	CD4056	1 15	74C04	.32
CD4016	.32	CD4030	.35	CD4066	78	74C107	79

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• 16 Pin Low Profile	25	• 40 Pin Low profile	89

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LM 308	Operational Amplifier	.95
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LM 311	Voltage Comparator	85
LM 318	Operational Amplifier	1.15
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NE 556	Dual Timer	95
NE 567	Tone Decoder	1.25
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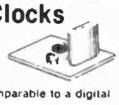

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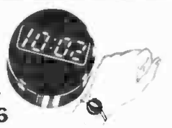

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7-SEGMENT READOUTS

			ONE CENT SALE
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☐	SPERRY FLAT NIXIES, orange, .3" dual digit (#9E5014)	3 for 1.19	6 for 1.20
☐	SPERRY FLAT NIXIES, orange, .3", 1½-dig (#9E5015)	3 for 1.19	6 for 1.20
☐	MAN-3 BUBBLE READOUT, .19" red, com, cath. (#9E3338)	6 for 1.00	12 for 1.01
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☐	FND-10 BLOCK READOUT, .122" com cathode (#9E2082)	2 for 1.19	4 for 1.20
☐	8-DIGIT READOUT, led, com cathode, red (#9E5190)	1 for 1.95	2 for 1.96
☐	FND-503, .5" red, com cathode, 7-seg. (#9E2949)	1.50	2 for 1.51
☐	FND-500, .5" red, com anode, 7 seg. (#9E2950)	1.50	2 for 1.51
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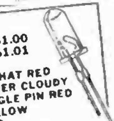

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☐ #9E1802	MICRO SINGLE PIN RED
☐ #9E1948	MICRO YELLOW
☐ #9E2135	JUMBO RED
☐ #9E2136	JUMBO TAPER RED
☐ #9E2137	MICRO RED
☐ #9E2790	JUMBO RED CLEAR

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Order By Cat. No. 9E1981 & Type No.

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☐ SN7409	.39	.40	☐ SN7482	.29	.30	☐ SN74163	1.39	1.40
☐ SN7410	.25	.26	☐ SN7483	.99	1.00	☐ SN74164	.79	.80
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☐ SN7446	1.25	1.26	☐ SN74113	.39	.40	☐ SN74193	.99	1.00
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☐ LM300N	.49	.50	☐ LM340T-6	1.49	1.50	☐ LM704H	.19	.20
☐ LM301V	.45	.46	☐ LM340T-8	1.49	1.50	☐ LM709H	.19	.20
☐ LM301H	.45	.46	☐ LM340T-12	1.49	1.50	☐ LM709N	.49	.50
☐ LM307V	.45	.46	☐ LM340T-15	1.49	1.50	☐ LM733N	.79	.80
☐ LM308V	.29	.30	☐ LM340T-18	1.49	1.50	☐ LM741V	.25	.26
☐ LM308H	.69	.70	☐ LM340T-24	1.49	1.50	☐ LM741H	.30	.31
☐ LM309K	1.49	1.50	☐ LM350N	.49	.50	☐ LM747H	.59	.60
☐ LM311V	.29	.30	☐ LM376V	.29	.30	☐ LM1304	1.49	1.50
☐ LM311H	1.49	1.50	☐ LM377N	2.25	2.26	☐ LM1310	1.79	1.80
☐ LM318V	.99	1.00	☐ LM380N	1.39	1.40	☐ LM1312	2.49	2.50
☐ LM320H-5	.99	1.00	☐ LM381N	1.99	2.00	☐ LM1414V	.19	.20
☐ LM320H-12	.99	1.00	☐ LM386N	1.49	1.50	☐ LM1458V	.39	.40
☐ LM320H-15	.99	1.00	☐ LM531H	1.49	1.50	☐ LM1800N	.79	.80
☐ LM320T-6	1.49	1.50	☐ LM532N	.25	.26	☐ LM3028H	.65	.66
☐ LM322N	1.19	1.20	☐ LM532H	.25	.26	☐ LM3900N	.49	.50
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☐ LM339N	1.79	1.80	☐ LM555V	.75	.76	☐ LM4250	1.20	1.21
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☐ LM340K-6	1.49	1.50	☐ LM558V	.39	.40	☐ LM75453	.69	.70
☐ LM340K-8	1.49	1.50	☐ LM558H	.39	.40	☐ LM75491	.80	.81
☐ LM340K-12	1.49	1.50	☐ LM561N	1.00	1.01	☐ LM75492	.80	.81
☐ LM340K-15	1.49	1.50	☐ LM565N	1.00	1.01	☐ LM75494	.60	.61
☐ LM340K-18	1.49	1.50	☐ LM565H	1.00	1.01	☐ PA263	1.50	1.51
☐ LM340K-24	1.49	1.50	☐ LM566	2.49	2.50	☐ DM8864N	1.29	1.30
			☐ LM567	2.39	2.40			

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☐ 5262	2K x 1 Dynamic RAM	.99	1.00	
☐ 1702A	256 x 8 EPROM	4.95	4.96	
☐ MM5280*	4K x 1 Dynamic RAM	3.95	3.96	

*Removed from new tested equipment

1 AMP SCR'S

TO-92 Case, 2N5060 series.
Order by Cat No. 9E2367 and voltage

☐ 30	4 for $1	8 for 1.01
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Cat. No.	Type	Volts	Sale	1¢ SALE!
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☐ 9E2379	1N4003	200	10 for .95	20 for .96
☐ 9E2380	1N4004	400	10 for 1.19	20 for 1.20
☐ 9E2381	1N4005	600	10 for 1.39	20 for 1.40
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• Mini ature!

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☐ 400	1.99	2 for	2.00
☐ 600	2.25	2 for	2.26
☐ 800	2.50	2 for	2.51

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1.5 AMP

☐ 50V	10 for $.59	20 for $.60
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☐ 200V	10 for .79	20 for .80
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(m) = multiturn
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Order by Cat. 9E3939 and Conductors

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☐ 40	3-ft.	1.98	6-ft.	1.99

10 AMP - POWER TABS!

9E1730 - SCR'S
9E1448 - TRIACS
9E1590 - QUADRACS

PRV	Sale	2 for
☐ 50	$ .55	$ .56
☐ 100	.69	.70
☐ 200	1.10	1.11
☐ 400V	1.60	1.61

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Order . No. 9E3269 and value
Electrolytic capacitors

UF	V	Style	Sale	1¢ SALE
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☐ 50	15	P.C.	8 for 1.00	16 for 1.01
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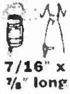
☐ 50	25	P.C.	6 for 1.00	12 for 1.01
☐ 100	25	P.C.	5 for 1.00	10 for 1.01

CONDENSER MIKE

"TIE-PIN" TYPE



It's a little giant in sound quality. Metal encased with built-in FET circuit, omni-directional, freq. resp. 20-12,000Hz. Less tie pin or lapel clip. 600 ohm impedance, 1.5VDC.

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2 for $4.96

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☐ 9.1V	5 for 1.	10 for 1.01
☐ 10.V	5 for 1.	10 for 1.01
☐ 11.V	5 for 1.	10 for 1.01
☐ 12.V	5 for 1.	10 for 1.01
☐ 15.V	5 for 1.	10 for 1.01

Order by Cat. No. 9E5210B

5 WATTS	Sale	1¢ SALE
☐ 6. V	3 for 1.	6 for 1.01
☐ 8.2V	3 for 1.	6 for 1.01
☐ 15. V	3 for 1.	6 for 1.01
☐ 18. V	3 for 1.	6 for 1.01
☐ 24. V	3 for 1.	6 for 1.01
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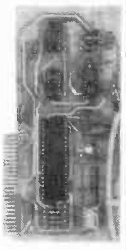
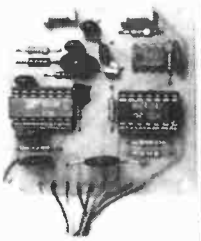
APPLE II SERIAL I/O INTERFACE *



Part no. 2
Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer. • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some selectrics. Board only — $15.00; with parts — $42.00; assembled and tested — $62.00.

MODEM *

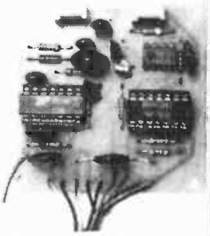


Part no. 109
• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • No coils, only low cost components • TTL input and output-serial • Connect 8 ohm speaker and crystal mic. directly to board • Uses XR FSK demodulator • Requires +5 volts • Board $7.60; with parts $27.50

DC POWER SUPPLY *

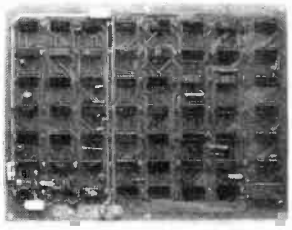
Part no. 6085
• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. • Board only $12.50; with parts excluding transformers $42.50

TAPE INTERFACE *



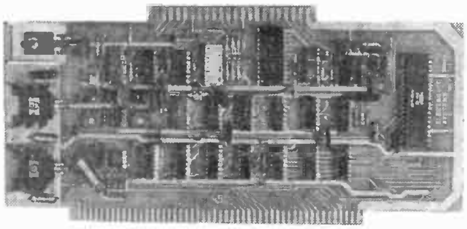
Part no. 111
• Play and record Kansas City Standard tapes • Converts a low cost tape recorder to a digital recorder • Works up to 1200 baud • Digital in and out are TTL-serial • Output of board connects to mic. in of recorder • Earphone of recorder connects to input on board • No coils • Requires +5 volts, low power drain • Board $7.60; with parts $27.50

T.V. TYPEWRITER



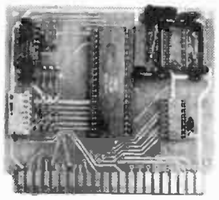
Part no. 106
• Stand alone TVT • 32 char/line, 16 lines, modifications for 64 char/line Included • Parallel ASCII (TTL) input • Video output • 1K on board memory • Output for computer controlled curser • Auto scroll • Non-destructive curser • Curser inputs: up, down, left, right, home, EOL, EOS • Scroll up, down • Requires +5 volts at 1.5 amps, and -12 volts at 30 mA • All 7400, TTL chips • Char. gen. 2513 • Upper case only • Board only $39.00; with parts $145.00

TIDMA *



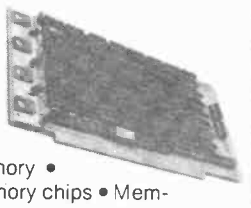
Part no. 112
• Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate. • S-100 bus compatible • Board only $35.00; with parts $110.00

UART & BAUD RATE GENERATOR *



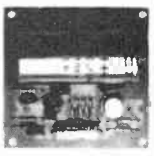
Part no. 101
• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity. • All connections go to a 44 pin gold plated edge connector • Board only $12.00; with parts $35.00 with connector add $3.00

8K STATIC RAM



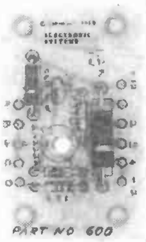
Part no. 300
• 8K Altair bus memory • Uses 2102 Static memory chips • Memory protect • Gold contacts • Wait states • On board regulator • S-100 bus compatible • Vector input option • TRI state buffered • Board only $22.50; with parts $160.00

RF MODULATOR *



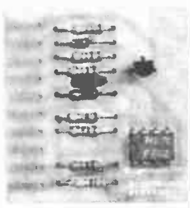
Part no. 107
• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple. • Power required is 12 volts AC C.T., or +5 volts DC • Board $7.60; with parts $13.50

RS 232/TTY * INTERFACE



Part no. 600
• Converts RS-232 to 20mA current loop, and 20mA current loop to RS-232 • Two separate circuits • Requires +12 and -12 volts • Board only $4.50, with parts $7.00

RS 232/TTL* INTERFACE



Part no. 232
• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin gold plated edge connector • Board only $4.50; with parts $7.00 with connector add $2.00

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DON'T FORGET OUR DISCOUNTS WHEN COMPARING PRICES

I.C.'S • RESISTORS • TRANSISTORS • CAPACITORS • DIODES • I.C. SOCKETS & PINS • SWITCHES CLOCK MODULES • OPTOELECTRONICS • BREADBOADING & TESTING DEVICES • DRAFTING SUPPLIES DATA BOOKS • HEAT SINKS • WIRE • TOOLS . . . AND MORE . . . WRITE FOR FREE CATALOG . . . .

INTEGRATED CIRCUITS

TTL

7400	.21
7401	.21
7402	.21
7403	.21
7404	.21
7405	.21
7406	.25
7407	.25
7408	.21
7409	.21
7410	.21
7411	.21
7412	.21
7413	.25
7414	.89
7416	.25
7417	.25
7420	.21
7421	.25
7423	.35
7425	.35
7426	.25
7427	.33
7428	.28
7430	.21
7432	.25
7433	.30
7437	.25
7438	.25
7439	.50
7440	.21
7442	.53
7445	.70
7446	.70
7447	.70
7448	.70
7450	.21
7451	.21
7453	.21
7454	.21
7460	.21
7470	.30
7472	.30
7473	.30
7474	.30
7475	.49
7476	.32
7480	.70
7483	.70
7485	.89
7486	.28
7489	2.19
7490	.44
7491	.70
7492	.44
7493	.44
7494	.70
7495	.70
7496	.70
74100	1.28
74107	.30
74109	.33
74116	1.26
74121	.35
74122	.44
74123	.61
74125	.40
74126	.40
74128	.48
74132	.70
74141	.88
74145	.70
74147	1.63
74148	1.30
74150	1.16
74151	.70
74153	.65
74154	1.03
74155	.70
74156	.70
74157	.70
74160	.88
74161	.88
74162	.88
74163	.88
74164	.96
74165	1.15
74166	1.26
74170	2.64
74173	1.47
74174	.98
74175	.93
74176	.79
74177	.79
74180	.70
74181	2.15
74182	.79
74184	2.15
74185	2.19
74189	3.50
74190	1.23
74191	1.23
74192	.88
74193	.88
74194	.88
74195	.88
74196	.88
74197	.88
74198	1.49
74199	1.49
74221	.86
74251	1.09
74279	.55
74298	.94
74365	.67
74366	.67
74367	.67
74368	.67

74LS00

74LS00	.28
74LS01	.28
74LS02	.28
74LS03	.28
74LS04	.79
74LS05	.29
74LS08	.29
74LS09	.29
74LS10	.28
74LS11	.28
74LS12	.28
74LS13	.47
74LS14	1.02
74LS15	.28
74LS20	.28
74LS21	.28
74LS22	.28
74LS26	.33
74LS27	.33
74LS28	.33
74LS30	.28
74LS32	.33
74LS33	.33
74LS37	.33
74LS38	.33
74LS40	.28
74LS42	.67
74LS47	.79
74LS48	.77
74LS51	.28
74LS54	.28
74LS55	.28
74LS73	.39
74LS74	.39
74LS74	.39
74LS75	.53
74LS76	.39
74LS78	.39
74LS83	.79
74LS85	.49
74LS86	.39
74LS90	.57
74LS92	.57
74LS95	.88
74LS96	.88
74LS107	.39
74LS109	.39
74LS112	.39
74LS113	.39
74LS114	.39
74LS125	.49
74LS126	.49
74LS132	.81
74LS136	.39
74LS138	.73
74LS139	.73
74LS151	.75
74LS153	.75
74LS154	1.10
74LS155	.75
74LS156	.75
74LS157	.75
74LS158	.75
74LS160	1.02
74LS161	1.02
74LS163	1.02
74LS164	1.02
74LS168	1.14
74LS169	1.14
74LS170	1.73
74LS173	1.34
74LS174	1.06
74LS175	.84
74LS181	2.50
74LS190	1.18
74LS191	1.18
74LS192	.98
74LS193	1.06
74LS194	.88
74LS195	.86
74LS196	.86
74LS197	.86
74LS197	.86
74LS240	1.90
74LS241	1.90
74LS242	1.70
74LS243	1.70
74LS244	1.70
74LS247	.79
74LS248	.79
74LS249	.79
74LS253	.84
74LS257	.75
74LS258	.75
74LS260	.34
74LS261	2.00
74LS266	.39
74LS273	1.28
74LS283	.79
74LS290	.65
74LS293	.65
74LS295	1.12
74LS298	1.30
74LS365	.67
74LS366	.67
74LS367	.67
74LS368	.67
74LS377	1.50
74LS386	.39
74LS395	1.74
74LS670	2.34
81LS95	.77
81LS96	.77
81LS97	.77
81LS98	.77

74C00

74C00N	.25
74C02N	.25
74C04N	.27
74C08N	.25
74C10N	.25
74C14N	.90
74C20N	.25
74C30N	.25
74C32N	.25
74C42N	.98
74C48N	1.28
74C73N	.72
74C74N	.48
74C76N	.72
74C83N	1.38
74C85N	1.38
74C86N	.40
74C90N	.98
74C93N	.98
74C95N	1.10
74C107N	.70
74C150N	2.90
74C151N	1.90
74C154N	2.90
74C157N	1.90
74C160N	1.18
74C161N	1.18
74C162N	1.18
74C163N	1.18
74C164N	1.10
74C165N	1.10
74C173N	1.30
74C174N	1.16
74C175N	1.16
74C192N	1.38
74C193N	1.38
74C195N	1.10
74C221N	1.90
80C95N	.48
80C96N	.48
80C97N	.48
80C98N	.48
74C901N	.48
74C902N	.48
74C909N	1.78
74C926N	7.80

4000 CMOS

4000	.23
4001	.23
4002	.23
4006	1.23
4007	.23
4008	.79
4009	.44
4010	.44
4011	.23
4012	.23
4013	.40
4014	.96
4015	.96
4016	.40
4017	1.05
4018	1.05
4019	.23
4020	1.14
4021	1.14
4022	.96
4023	.23
4024	.84
4025	.23
4026	1.68
4027	.40
4028	.89
4029	1.14
4030	.23
4033	1.51
4034	3.50
4035	1.14
4040	1.14
4041	.79
4042	.79
4043	.70
4044	.70
4046	1.86
4049	.40
4050	.40
4051	1.26
4052	1.26
4053	1.26
4060	1.58
4066	.79
4071	.23
4072	.23
4073	.23
4075	.23
4081	.23
4082	.23
4502	.79
4510	1.14
4511	1.05
4514	2.80
4515	2.80
4516	1.23
4518	1.14
4520	1.14
4527	1.68
4528	.88

INTERFACE

8093	.40
8094	.40
8095	.67
8096	.67
8097	.67
8098	.67
75450	.88
75451	.61
75452	.61
75453	.61
75454	.61
75491	.81
75492	.84
75493	1.09
75494	1.19
MC1488N	.90
MC1489N	.90

MISC IC

MM5314N	3.75

LINEAR

CA3046	.75
CA3086	.50
LF351N	.76
LF356N	1.20
LF357N	1.20
LF13741	.76
LM301AN	.44
LM307N	.64
LM308N	1.00
LM311N	.90
LM317T	3.00
LM317MP	1.90
LM318N	2.70
LM320MP-5	1.30
LM320MP-6	1.30
LM320MP-8	1.30
LM320MP-9	1.30
LM320MP-12	1.30
LM320MP-15	1.30
LM320MP-18	1.30
LM320MP-18	1.30
LM320MP-24	1.30
LM323K	7.50
LM324N	.72
LM325N	2.70
LM326N	2.70
LM327N	2.70
LM339N	1.15
LM340T-5	1.25
LM340T-6	1.25
LM340T-8	1.25
LM340T-10	1.25
LM340T-12	1.25
LM240T-15	1.25
LM340T-18	1.25
LM340T-24	1.25
LM341P-5	.98
LM341P-6	.98
LM341P-8	.98
LM341P-10	.98
LM341P-12	.98
LM341P-15	.98
LM341P-18	.98
LM341P-24	.98
LM348N	1.60
LM349N	1.60
LM358N	.72
LM386	.85
LM1310N	.84
LM1800N	.94
LM1801N	1.70
LM1812N	4.80
LM1830N	1.30
LM1889N	2.00
LM2111N	1.25
LM2907N	1.50
LM2917N	1.50
LM3089N	1.30
LM3900N	.88
LM3900N	.88
LM3905N	1.40
LM3909N	.69
LM3911N	1.50
MC1456V	1.00
MC1458V	.53
MC1496N	.70
MC3302P	1.15
NE536T	2.50
NE540L	2.04
NE555V	.48
NE556A	.88
NE558N	2.40
NE559N	2.40
NE560B	2.50
NE561B	2.50
NE562B	2.50
NE565A	1.25
NE566V	1.28
NE567V	1.36
UA709CV	.44
UA710CV	.44
UA711CA	.53
UA723CA	.60
UA733CA	.75
UA741CV	.44
UA747CA	.70
UA748CV	.49
UA7805CU	1.25
UA7806CU	1.25
UA7808CU	1.25
UA7812CU	1.25
UA7812CU	1.25
UA7815CU	1.25
UA7818CU	1.25
UA7824CU	1.25
UA78L05ACZ	.40
UA78L06ACZ	.40
UA78L08ACZ	.40
UA78L10ACZ	.40
UA78L12ACZ	.40
UA78L15ACZ	.40
UA78L18ACZ	.40
UA78L24ACZ	.40
UA7905CU	1.70
UA7906CU	1.70
UA7908CU	1.70
UA7909CU	1.70
UA7912CU	1.70
UA7915CU	1.70
UA8918CU	1.70
UA7924CU	1.70

PREPAID SHIPPING AND INSURANCE
(on U.S. and Canadian our choice transport)

I.C. SOCKETS

SOLDER TAB SOCKETS ARE LOW PROFILE • WIRE WRAP SOCKET ARE STANDARD PROFILE

Part No.	Description	Prices		
8-ST	8 Pin Solder Tab I.C. Socket	.17	1.60/10	14.50 C
14-ST	14 Pin Solder Tab I.C. Socket	.20	1.90/10	17.00 C
16-ST	16 Pin Solder Tab I.C. Socket	.22	2.10/10	18.75 C
18-ST	18 Pin Solder Tab I.C. Socket	.29	2.75/10	24.50 C
20-ST	20 Pin Solder Tab I.C. Socket	.30	2.85/10	25.25 C
22-ST	22 Pin Solder Tab I.C. Socket	.33	3.15/10	27.75 C
24-ST	24 Pin Solder Tab I.C. Socket	.38	3.60/10	32.25 C
28-ST	28 Pin Solder Tab I.C. Socket	.45	4.25/10	38.25 C
40-ST	40 Pin Solder Tab I.C. Socket	.63	6.00/10	53.50 C
8-WW	8 Pin Wire Wrap I.C. Socket	.24	2.30/10	20.50 C
14-WW	14 Pin Wire Wrap I.C. Socket	.26	2.50/10	22.00 C
16-WW	16 Pin Wire Wrap I.C. Socket	.30	2.85/10	25.50 C
18-WW	18 Pin Wire Wrap I.C. Socket	.60	5.70/10	51.00 C
20-WW	20 Pin Wire Wrap I.C. Socket	.70	6.65/10	59.50 C
22-WW	22 Pin Wire Wrap I.C. Socket	.84	8.00/10	71.50 C
24-WW	24 Pin Wire Wrap I.C. Socket	.96	9.10/10	81.50 C
28-WW	28 Pin Wire Wrap I.C. Socket	1.12	10.00/10	95.20 C
40-WW	40 Pin Wire Wrap I.C. Socket	1.36	12.50/10	115.00 C

MOLEX I.C. SOCKET PINS

85/C 8.20/M 38.20/5M 275.00/50M

MICROPROCESSORS

8080A	8-BIT CPU 2 USEC CYCLE	$ 9.95
8212	8-BIT I/O PORT	$ 3.25
8216	BI-DIRECTIONAL BUS DRIVER	$ 3.75
8224	CLOCK GENERATOR	$ 3.25
8228	SYSTEM CONTROLLER	$ 6.00
8251	COMMUNICATIONS INTERFACE	$10.50
8255	PERIPHERAL INTERFACE	$10.50
1702A	2K EPROM 1 USEC	$ 5.75
2708	8K EPROM 450 NSEC	$15.75
2102AN-4L	1K LOW POWER 450 NSEC RAM	$ 1.69
SC/MP	5 VOLT SC/MP CPU	$ 9.95
2650	MICROPROCESSOR 1.25 MH-Z CLOCK 40 DIL	$24.95

½ WATT ZENER DIODES

.15 1.30/10 11.00/C

1N5226B	3.3V	1N5242B	12V
1N5227B	3.6V	1N5243B	13V
1N5228B	3.9V	1N5244B	14V
1N5229B	4.3V	1N5245B	15V
1N5230B	4.7V	1N5246B	16V
1N5231B	5.1V	1N5247B	17V
1N5232B	5.6V	1N5248B	18V
1N5233B	6.0V	1N5249B	19V
1N5234B	6.2V	1N5250B	20V
1N5235B	6.8V	1N5251B	22V
1N5236B	7.5V	1N5252B	24V
1N5237B	8.2V	1N5253B	25V
1N5238B	8.7V	1N5254B	27V
1N5239B	9.1V	1N5255B	28V
1N5240B	10V	1N5256B	30V
1N5241B	11V	1N5257B	33V

SILICON DIODES

1N4001	.64	10	5.50/C
1N4002	.66	10	5.60/C
1N4003	.68	10	5.80/C
1N4004	.70	10	5.95/C
1N4005	.82	10	7.05/C
1N4006	.90	10	7.75/C
1N4007	.99	10	8.60/C
1N4148	.40	10	3.50/C

SLIDE SWITCHES

SPST	.15	1.25/10	10.00/C
SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

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FREE CATALOG

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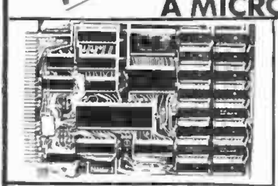
NEW!

The "NIBBLER"
A MICROCOMPUTER AT A MICROPRICE!



The NIBBLER is Digi-Key's new low cost personal/hobby computer. Based on National Semiconductor's SC/MP-II microprocessor, the NIBBLER includes 4K NIBL Basic in ROM and 2K of RAM. The NIBBLER requires 5 volts at ½ amp providing 110 baud serial ASCII I/O which is easily interfaced with a CRT or Teletype. And our low price of $149.95 is for an assembled and tested system! Software/Hardware manual included with NIBBLER available separately for $5.00.

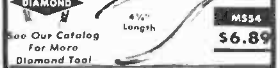
FEATURES:

- Assembled and Tested, yet only $149.95
- Standard 4.5" by 6.5" card with 72 pin edge connector pattern
- All IC's are socketed for easy maintenance
- Memory expandable to 28K
- 110 Baud Serial I/O
- It Speaks Basic Beautifully
- 4K NIBL Basic in ROM and 2K of RAM
- Easily Interfaced with CRT or Teletype

CATALOG NUMBER NIB1-ND $149.95
(not discountable)
SOFTWARE/HARDWARE MANUAL MAN1-ND $5.00
(not discountable)

SILICON TRANSISTORS

MPS918	.16	1.55/10	13.60/C	130.00/M
MPS930	.16	1.55/10	13.60/C	130.00/M
MPS2222A	.16	1.55/10	13.60/C	130.00/M
MPS2369A	.16	1.55/10	13.60/C	130.00/M
MPS2907A	.16	1.55/10	13.60/C	130.00/M
MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3394	.16	1.55/10	13.60/C	130.00/M
MPS3395	.16	1.55/10	13.60/C	130.00/M
MPS3563	.16	1.55/10	13.60/C	130.00/M
MPS3565	.16	1.55/10	13.60/C	130.00/M
MPS3638A	.16	1.55/10	13.60/C	130.00/M
MPS3641	.16	1.55/10	13.60/C	130.00/M
MPS3643	.16	1.55/10	13.60/C	130.00/M
2N3904	.16	1.55/10	13.60/C	130.00/M
2N3906	.16	1.55/10	13.60/C	130.00/M
2N4124	.16	1.55/10	13.60/C	130.00/M
2N4126	.16	1.55/10	13.60/C	130.00/M
2N4401	.16	1.55/10	13.60/C	130.00/M
2N4403	.16	1.55/10	13.60/C	130.00/M
2N4410	.16	1.55/10	13.60/C	130.00/M
2N5087	.16	1.55/10	13.60/C	130.00/M
2N5089	.16	1.55/10	13.60/C	130.00/M
2N5210	.16	1.55/10	13.60/C	130.00/M
2N3055	.99	9.20/10	85.00/C	800.00/M
MPF102	.36	3.35/10	30.60/C	300.00/M
2N5457	.48	4.50/10	41.00/C	400.00/M
MPSA13	.28	2.60/10	24.00/C	230.00/M
MJ2955	.99	9.20/10	85.00/C	800.00/M



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4¾" Length

MS54 **$6.89**

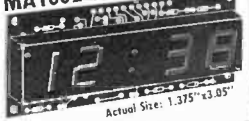
ELECTROLYTIC CAPACITORS

VALUE	RADIAL LEADS			AXIAL LEADS		
.47 50V	.10	.78/10	6.20 C	.13	1.10/10	8.50 C
1 50V	.10	.78/10	6.20 C	.13	1.10/10	8.50/C
2.2/50V	.10	.78/10	6.20/C	.13	1.10/10	8.50/C
3.3/50V	.10	.78/10	6.20/C	.13	1.10/10	8.50 C
4.7/35V	.10	.78/10	6.20/C	.13	1.10/10	8.50 C
4.7 50V	.10	.78/10	6.20/C	.16	1.30/10	10.25 C
10 16V	.10	.78/10	6.20/C	.13	1.10/10	8.50 C
10 25V	.10	.78/10	6.20/C	.13	1.10/10	8.50 C
10 35V	.10	.78/10	6.20/C	.16	1.30/10	10.25 C
10 50V	.12	.94/10	7.60/C	.18	1.45/10	11.60 C
22 16V	.10	.78/10	6.20 C	.16	1.30/10	10.25/C
22 25V	.11	.86/10	6.90 C	.16	1.30/10	10.25 C
22 35V	.14	1.12/10	8.95 C	.18	1.45/10	11.60/C
22 50V	.15	1.25/10	9.95 C	.21	1.70/10	13.55/C
33 16V	.11	.86/10	6.90 C	.16	1.30/10	10.75/C
33 25V	.12	.94/10	7.60 C	.18	1.45/10	11.60 C
33 35V	.15	1.25/10	9.95/C	.21	1.70/10	13.55 C
33 50V	.16	1.31/10	10.43/C	.24	1.95/10	15.55 C
47 10V	.11	.86/10	6.90/C	.16	1.30/10	10.25 C
47 16V	.12	.94/10	7.60/C	.18	1.45/10	11.60 C
47 25V	.15	1.22/10	9.74/C	.21	1.70/10	13.55 C
47 35V	.16	1.31/10	10.43/C	.25	2.00/10	16.10 C
47 50V	.17	1.39/10	11.12/C	.27	2.20/10	17.55 C
100 10V	.12	.94/10	7.60/C	.18	1.45/10	11.60 C
100 16V	.15	1.22/10	9.74 C	.21	1.70/10	13.55 C
100 25V	.16	1.32/10	10.57 C	.25	2.00/10	16.10 C
100 35V	.17	1.39/10	11.12 C	.32	2.65/10	21.05 C
100 50V	.29	2.36/10	18.85/C	.33	2.75/10	21.85 C
220 10V	.16	1.32/10	10.52/C	.22	1.85/10	14.55 C
220 16V	.17	1.39/10	11.12 C	.25	2.00/10	16.10 C
220 25V	.25	2.08/10	16.59 C	.33	2.75/10	21.85 C
220 35V	.30	2.47/10	19.75/C	.38	3.13/10	25.05 C
220 50V	.36	2.97/10	23.69/C	.45	3.68/10	29.90 C
330 6V	.16	1.32/10	10.52/C	.22	1.85/10	14.55 C
330 10V	.17	1.39/10	11.12 C	.25	2.00/10	16.10 C
330 16V	.25	2.08/10	16.62/C	.33	2.68/10	21.43 C
330 25V	.30	2.47/10	19.75 C	.37	3.10/10	24.55 C
330 35V	.36	2.96/10	23.69/C	.45	3.68/10	29.43 C
330 50V	.59	4.86/10	38.83 C	.57	4.70/10	37.50 C
470 6V	.17	1.35/10	10.74 C	.25	2.00/10	16.10/C
470 10V	.26	2.12/10	16.95 C	.33	2.75/10	21.85/C
470 16V	.28	2.34/10	18.65/C	.37	3.10/10	24.55 C
470 25V	.35	2.84/10	22.71 C	.45	3.80/10	30.05 C
470 35V	.45	3.71/10	29.62 C	.48	4.00/10	31.80 C
470 50V	.65	5.37/10	42.92/C	.69	5.68/10	45.40/C
1000/6V	.28	2.28/10	18.18/C	.37	3.05/10	24.25/C
1000/10V	.29	2.35/10	18.27/C	.43	3.55/10	28.15 C
1000/16V	.34	2.84/10	22.72 C	.45	3.70/10	29.40 C
1000 25V	.59	4.86/10	38.83 C	.63	5.20/10	41.45 C
1000 35V	.63	5.18/10	41.46 C	.73	6.05/10	48.35/C
2200 6V	.38	3.09/10	24.68 C	.45	3.75/10	29.60/C
2200 10V	.49	4.02/10	32.09 C	.58	4.80/10	38.30/C
2200 16V	.63	5.19/10	41.46 C	.68	5.70/10	45.78/C

MINIBOX METALIZED POLYESTER CAPACITORS

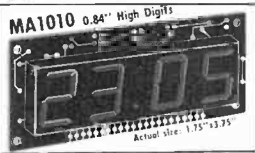
.001 1000V	.16	1.32/10	10.35 C	.0022 1000V	.16	1.32/10	10.35/C
.0033 1000V	.16	1.32/10	10.35 C	.0047 630V	.14	1.15/10	9.00 C
.0068 630V	.14	1.15/10	9.00 C	.01 630V	.16	1.32/10	10.35 C
.022 400V	.17	1.44/10	11.50 C	.033 250V	.17	1.44/10	11.50 C
.047 250V	.15	1.25/10	10.00 C	.068 250V	.17	1.44/10	11.50 C
.1 100V	.19	1.55/10	12.65 C	.22 100V	.26	2.13/10	17.25 C
.33 100V	.35	2.88/10	23.00 C	.47 100V	.41	3.45/10	27.60 C

MA1002 0.5" High Digits

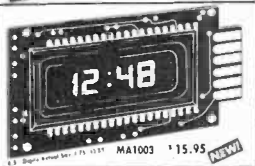


Actual Size: 1.375"x3.05"

MA1010 0.84" High Digits



Actual size: 1.75"x3.75"



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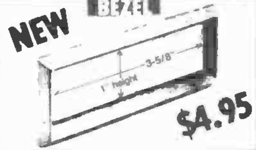
MA1002A SET Module with Transformer & Switches		SOLD OUT
MA1002C .5" LED 24 Hour Clock Module	~~10.60~~	7.95
MA1002C SET Module w Transformer & Switches	~~10.95~~	9.95
MA1003 12 Volt Car Clock with Switches	~~17.60~~	15.95
MA1010A .84" LED 12 Hour AM-PM Clock Module	~~13.00~~	9.95
MA1010A SET Module w/Transformer & Switches	~~16.45~~	11.95
MA1010C .84" LED 24 Hour Clock Module	~~13.00~~	9.95
MA1010C SET Module w/Transformer & Switches	~~16.45~~	11.95

The MA1002 and MA1010 series clock modules by National Semiconductor are fully assembled and tested clocks using a 4 digit LED display, and an MOS integrated circuit on the same board. Simply connect switches and our special transformer and you have a fully functioning clock.

The MA1003 clock module is a fully assembled and tested 12 hour clock using a high brilliance green flourescent display and crystal time base making it perfect for car, boat or other portable use. It operates directly from 12 volts DC so no transformer is needed. Our price includes three push button switches for setting the time.

JMJ DIGITAL DISPLAY BEZEL

NEW



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420 MOUNTING ADAPTER FOR MA1002 & MA1002	.69
421 MOUNTING ADAPTER FOR MA1010	[illegible]

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SOLDERLESS BREADBOARDING WITH POWER FROM AP

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923102 . . . . . $114.95

POWERACE—for fast, solderless circuit building and testing. All models will accept all DIP sizes—plus TO-5's and discretes with leads to .032" diameter. POWERACE 101 has a variable 5-15 VDC 600 ma power supply. POWERACE 102 features a fixed 5VDC 1 amp power supply, and PHWERACE 103 has a fixed 5VDC 750 ma power supply, A fixed plus 15VDC 250 ma power supply and a fixed 15VDC power supply at 250 ma.

5% CARBON FILM RESISTORS

¼ WATT RESISTOR ASSORTMENTS

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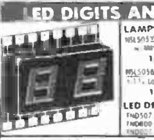
LED DIGITS AND LAMPS



LAMPS

NSL5053 Red T-1¾ Lamp w/Mtg. Hdwr 1.80/10 16.00/100

NSL5056 Narrow Angle Red T-1¾ Lamp w/Mtg. Hdwr 1.80/10 16.00/100

LED DISPLAYS

FND507 .5"	Single Digit	CA	Red	1.35
FND800 .8"	Single Digit	CC	Red	2.50
FND8[illegible] .8"	Single Digit	CA	Red	2.10

DEVICE TYPE	DIGIT SIZE	FORMAT	DRIVE	PRICE
[illegible]			CA DIRECT	$2.20
[illegible]			CC DIRECT	2.20
[illegible]	[illegible]		CA DIRECT	2.20
[illegible]	Red		CC MULTI	2.20
[illegible]			CA MULTI	2.20
[illegible]			CA DIRECT	2.60
[illegible]			CC MULTI	2.60
[illegible]	[illegible]		CA MULTI	7.60
[illegible]	Red		CC DIRECT	7.60
[illegible]			CA DIRECT	2.60
[illegible]			CA DIRECT	3.00
[illegible]			CC MULTI	3.00
[illegible]	[illegible]		CA MULTI	3.00
[illegible]	Red		CC DIRECT	3.00
[illegible]			CA DIRECT	3.00
[illegible]			CA MULTI	4.40
[illegible]	[illegible]		CC MULTI	4.40
NSH3882	Red		CA MULTI	4.40
[illegible]			CA MULTI	5.20
NSB5881	[illegible]		CC MULTI	5.20
NSB5882	Red		CA MULTI	5.70
NSB7882			CA MULTI	6.00
NSB7881	0.7		CC MULTI	6.00
NSB7882	Red		CA MULTI	6.00

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Part No. [illegible]
$18.95

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- Size 4 9/16 by 5 5/16
- Kit form lowest cost

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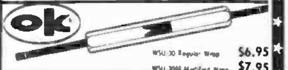
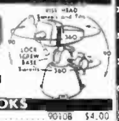


WSU-30 Regular Wrap $6.95
WSU-30M Modified Wrap $7.95

STRIPS — WRAPS — UNWRAPS

PANAVISE



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220 PF	.40/10	3.50/C
470 PF	.40/10	3.50/C
.001 UF	.40/10	3.50/C
.0022 UF	.40/10	3.50/C
.0047 UF	.40/10	3.50 C
.01 UF	.45/10	3.65/C
.022 UF	.50/10	4.00 C
.047 UF	.70/10	5.60/C
.1 UF	1.35/10	11.50 C

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20 ga PVC	2.50/100'	10.00/500'
22 ga PVC	2.80/100'	11.25/500'
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B&K-PRECISION's new Model 2800 portable DMM features 3-1/2 digit display, auto-zeroing and 100% overrange reading for only $99.95. Basic DC accuracy is 1%. Twenty-two ranges read up to 1000 volts DC or AC, 1000mA and 10 megohms.

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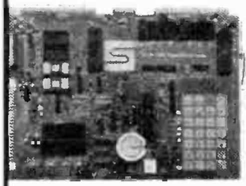
Model 2800 .... $99.95

VIM-1

THE COMPLETE MICROCOMPUTER SYSTEM



The VIM-1 is a fully assembled and completely integrated system that features KIM-1 hardware compatibility utilizing the powerful 6502 Microprocessor. The VIM-1 includes – a 28 double-function keypad (with audio response) – easy-to-view 6 digit HEX LED display – three on-board programmable interval timers – 4K byte ROM resident monitor –1K bytes of 2114 static RAM (expandable to 4K bytes on-board – 3 PROM/ROM expansion sockets for 2316/2332/2716 EPROMs. Standard Interface include – Audio Cassette Recorder Interface (Two Modes: 135 Baud KIM-1 compatible and Hi-speed 2400 Baud) – Full Duplex 20 ma TTY Interface – System Expansion Bus Interface (KIM-1 compatible) – TV Controller Board Interface – CRT compatible Interface – Additional Application Port with 15 Bi-directional TTL lines for user applications. Requires a single 5 Volt supply.

Planned VIM-1 Expansion Features – TV Interface Card (with ASCII Keyboard and Numeric Pad) – Basic Interpreter – Resident Assembler/Editor – Port Expansion Kit – RAM Expansion Kit.

VIM-1
$269 00

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- Enjoy simulating various sounds, playing games and much more.
- Operates on standard 110 Vac, 60 Hz power.

$22900

KX-33B MICROCOMPUTER
COMPLETELY ASSEMBLED—READY TO USE

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MP-0100-25-DW-5	3.30	.156 Wirewrap		H411121-25	3.07
MP-0100-36-DW-5	4.30	MP-0156-18-DW-5	3.40	MP-0125-50-DS-5	5.50
MP-0100-40-DW-5	4.70	MP-0156-22-DW-5	3.70	.156 Soldee Eye	
MP-0100-50-DW-5	5.70	MP-0156-36-DW-5	4.90	H411131-10	1.37
.125 Wirewrap		MP-0156-43-DW-5	5.90	H411131-15	1.98
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*SPECIFY COLOR

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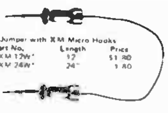
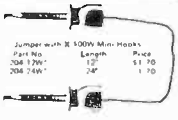


Jumper with XM Micro Hooks

Part No.	Length	Price
204XM 12W*	12"	$1.80
204XM 24W*	24"	1.80

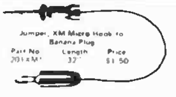
*SPECIFY COLOR



Jumper with X100W Mini Hooks

Part No.	Length	Price
204-12W*	12"	$1.70
204-24W*	24"	1.70

*SPECIFY COLOR



Jumper, XM Micro Hook to Banana Plug

Part No.	Length	Price
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*SPECIFY COLOR

Jumper X100W Mini Hook™ to Stacking Banana Plug

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XM-S MICRO HOOK SET Includes 1 ea. red, black, blue, green, orange, yellow, white, brown, violet and gray Micro Hooks. At this low price you can afford more than one set.

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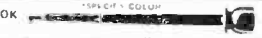
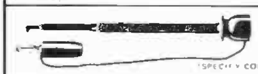


XL-1 Mini Hook (5.0" long) combines all the proven features of the X100W with an extra long body. It will make safe, short free test connections in card racks and through deep wiring nets up to 4". $1.30 ea

Part No. XL-1



*SPECIFY COLOR

Jumper, XL-1 Mini Hook™ to Stacking Banana Plug

Part No.	Length	Price
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27pf	9/pkg	330pf	7/pkg	.003mfd	9/pkg	.03mfd	8/pkg
47pf	8/pkg	390pf	7/pkg	.0047mfd	9/pkg	.039mfd	7/pkg
68pf	8/pkg	470pf	7/pkg	.005mfd	9/pkg	.047mfd	7/pkg
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.0012	8/pkg	.0082	8/pkg	.047	7/pkg	.27	4/pkg
.0015	8/pkg	.01	8/pkg	.056	7/pkg	.33	4/pkg
.0018	8/pkg	.012	8/pkg	.068	7/pkg	.39	3/pkg
.0022	8/pkg	.015	7/pkg	.082	7/pkg	.47	3/pkg
.0027	8/pkg	.018	7/pkg	.1	7/pkg	.56	3/pkg
.0033	8/pkg	.022	7/pkg	.12	6/pkg	.68	2/pkg
.0039	8/pkg	.027	7/pkg	.15	6/pkg	.82	2/pkg
.0047	8/pkg	.033	7/pkg	.18	5/pkg	1.0	2/pkg
.0056	8/pkg						

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22	7/$1.00	6/$1.00	5/$1.00	4/$1.00	4/$1.00
33	6/$1.00	6/$1.00	4/$1.00	4/$1.00	4/$1.00
47	6/$1.00	5/$1.00	4/$1.00	4/$1.00	3/$1.00
100	5/$1.00	5/$1.00	4/$1.00	4/$1.75	3/$1.00
220	4/$1.00	4/$1.00	3/$1.00	3/$1.25	2/$1.00
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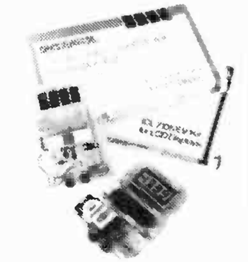

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13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2.0K	20K	200K	2.0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6.8M
75	750	7.5K	75K	750K	7.5M
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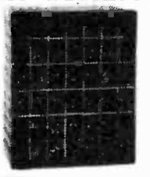

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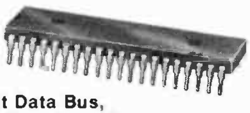

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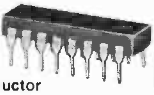

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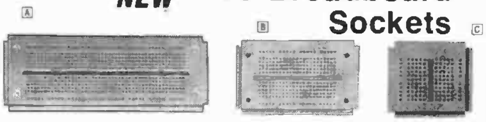

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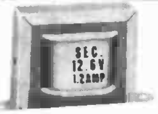

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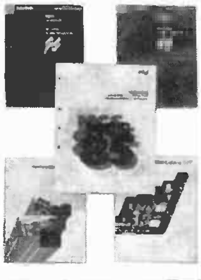

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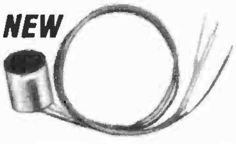

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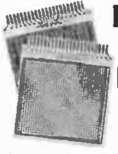

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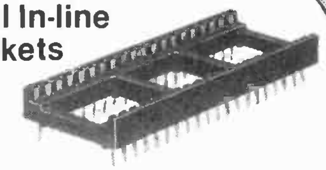

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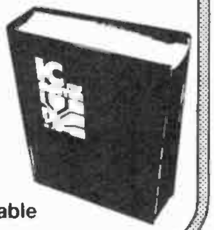

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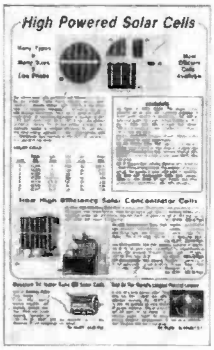

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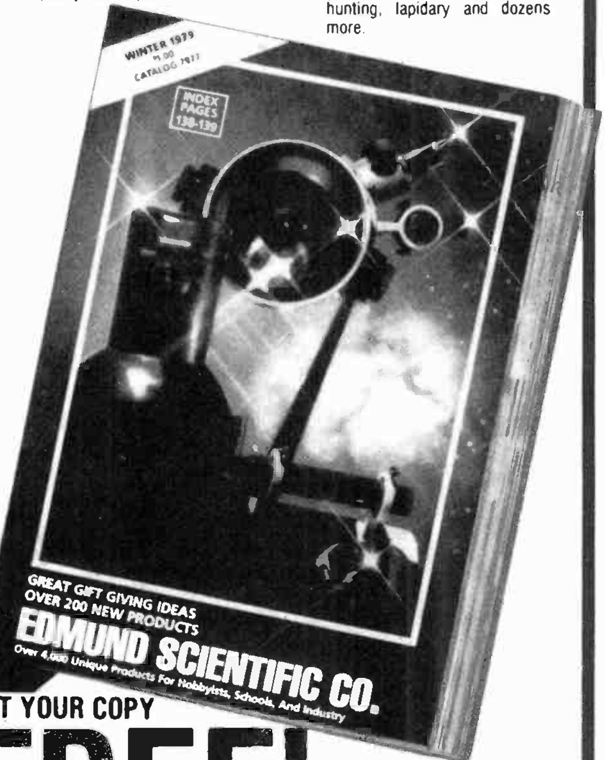

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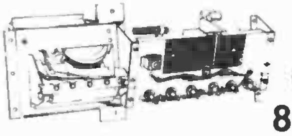

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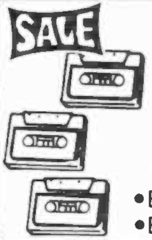

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7426	0.22
7427	0.19
7430	0.15
7432	0.23
7437	0.21
7438	0.21
7439	0.25
7440	0.15
7441	0.70
7442	0.38
7443	0.55
7444	0.55
7445	0.55
7446	0.62
7447	0.57
7448	0.60
7450	0.15
7451	0.15
7453	0.15
7454	0.15
7459	0.15
7460	0.15
7470	0.27
7472	0.24
7473	0.24
7474	0.24
7475	0.45
7476	0.29
7480	0.31
7482	0.50
7483	0.54
7485	0.80
7486	0.27
7489	1.75
7490	0.40
7491	0.51
7492	0.40
7493	0.40
7494	0.60
7495	0.60
7496	0.60
7497	2.45
74107	0.29
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74121	0.29
74122	0.35
74123	0.39
74125	0.37
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74LS32	0.30
74LS37	0.31
74LS38	0.31
74LS40	0.26
74LS42	0.60
74LS47	0.75
74LS48	0.72
74LS51	0.25
74LS54	0.25
74LS55	0.25
74LS73	0.38
74LS74	0.35
74LS76	0.37
74LS78	0.36
74LS83	0.75
74LS85	1.30
74LS86	0.36
74LS90	0.50
74LS92	0.50
74LS93	0.50
74LS95	0.85
74LS107	0.35
74LS109	0.35
74LS112	0.35
74LS113	0.35
74LS114	0.35
74LS123	0.90
74LS125	0.46
74LS126	0.46
74LS132	0.72
74LS133	0.34
74LS136	0.35
74LS138	0.70
74LS139	0.70
74LS151	0.65
74LS152	0.65
74LS153	0.66
74LS154	1.00
74LS155	0.62
74LS156	0.62
74LS157	0.62
74LS158	0.70
74LS160	0.82
74LS161	0.82
74LS162	0.82
74LS163	0.82
74LS164	0.98
74LS168	0.83
74LS169	0.83
74LS170	1.60
74LS173	1.00
74LS174	0.75
74LS175	0.79
74LS181	2.50
74LS190	0.90
74LS191	0.90
74LS192	0.90
74LS193	0.90
74LS194	0.85
74LS195	0.50
74LS196	0.80
74LS197	0.80
74LS221	1.05
74LS251	0.80
74LS253	0.80
74LS257	0.70
74LS258	0.70
74LS259	1.60
74LS260	0.34
74LS266	0.26
74LS279	0.52
74LS283	0.72
74LS290	0.60
74LS295	0.90
74LS298	0.90
74LS365	0.52
74LS366	0.52
74LS367	0.52
74LS368	0.52
74LS386	0.36
74LS390	1.65
74LS393	1.35
74LS490	1.10
74LS670	2.29

74Sxx TTL

74S00	$0.35
74S02	0.35
74S03	0.35
74S04	0.36
74S05	0.36
74S08	0.38
74S09	0.38
74S10	0.35
74S11	0.38
74S15	0.38
74S20	0.35
74S22	0.36
74S30	0.27
74S32	0.50
74S40	0.35
74S51	0.17
74S60	0.35
74S64	0.38
74S65	0.38
74S74	0.58
74S76	0.58
74S78	0.58
74S112	0.58
74S113	0.58
74S114	0.58
74S132	0.75
74S133	0.38
74S134	0.38
74S135	0.49
74S138	0.77
74S139	1.50
74S140	0.47
74S151	1.25
74S153	2.10
74S157	0.75
74S158	1.25
74S174	1.50
74S175	1.45
74S189	2.75
74S194	1.75
74S200	3.25
74S206	3.75
74S253	0.95
74S257	1.15
74S258	1.15
74S280	2.25
74S287	3.20
74S289	3.55
74S300	1.60
74S305	1.90
74S310	2.85
74S312	1.05
74S313	1.55
74S316	2.80
74S341	4.10
74S342	1.20
74S343	4.95
74S346	1.25
74S362	2.15
74S387	4.70

74Cxx TTL

74C00	$0.24
74C02	0.24
74C04	0.26
74C08	0.25
74C10	0.24
74C14	0.90
74C20	0.25
74C30	0.24
74C32	0.25
74C42	0.94
74C48	0.96
74C73	0.62
74C74	0.48
74C76	0.68
74C83	1.28
74C85	1.20
74C86	0.40
74C89	3.95
74C90	0.92
74C93	0.92
74C95	1.04
74C107	0.68
74C151	1.78
74C154	2.90
74C157	1.78
74C160	1.08
74C161	1.08
74C162	1.08
74C163	1.08
74C164	1.08
74C165	1.08
74C173	1.16
74C174	1.08
74C175	1.04
74C192	1.30
74C193	1.30
74C195	1.10
74C200	7.50
74C221	1.38
74C901	0.48
74C902	0.48
74C903	0.48
74C904	0.48
74C905	6.00
74C906	0.48
74C907	0.48
74C908	0.96
74C909	1.78
74C910	6.00
74C914	0.90
74C918	1.16
74C925	7.80
74C926	7.80
74C927	7.80
74C928	7.80

4xxx CMOS

4000	$0.16
4001	0.16
4002	0.16
4006	0.85
4007	0.16
4008	0.74
4009	0.35
4010	0.35
4011	0.16
4012	0.16
4013	0.31
4014	0.73
4015	0.73
4016	0.28
4017	0.78
4018	0.78
4019	0.21
4020	0.83
4021	0.83
4022	0.83
4023	0.16
4024	0.66
4025	0.16
4027	0.37
4028	0.73
4029	0.98
4030	0.21
4031	2.97
4034*	2.75
4035	0.84
4040	0.86
4041	0.64
4042	0.64
4043	0.62
4044	0.62
4046	1.35
4047	1.45
4048	0.95
4049	0.33
4050	0.33
4051	0.89
4052	0.89
4053	0.89
4060	1.40
4066	0.54
4068	0.34
4069	0.26
4070	0.40
4071	0.19
4073	0.21
4075	0.21
4076	1.16
4077	0.46
4078	0.35
4081	0.19
4085	0.64
4086	0.64
4089	2.75
4093	1.55
4099	2.10
4104*	2.40
4503	0.98
4507	0.37
4510	0.95
4511	0.93
4512	0.64
4516	0.76
4518	0.76
4519	0.62
4520*	0.68
4527	1.48
4528	0.86
4532*	0.86
4539	1.10
4555	0.67
4556	0.88
4582	0.88
4584	0.74
4702	7.10
4703	8.25
4704	7.30
4705	9.25
4706	9.75
4707*	9.25
4708*	14.35
4710*	6.40
4720	6.95
4721*	31.35
4723	0.93
4724	1.29
4725	1.29
40014	0.72
40085	1.47
40097*	0.54
40098*	0.54
40106	0.90
40160	1.08
40161	1.08
40162	1.08
40163	1.08
40174	1.08

Items indicated by (*) were in transit to us by the time that this ad copy was being prepared. Please inquire about availability.

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Merchandise Total	Discount
$ 0.00–$ 9.99	NET
$ 10.00–$ 24.99	LESS 5%
$ 25.00–$ 99.99	LESS 10%
$ 100.00–$499.99	LESS 15%
$ 500.00–$999.99	LESS 20%
$1000.00 and Up	LESS 25%

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If your Merchandise Total is between:

$ 0.00–$ 4.99	add $2.00
$ 5.00–$24.99	add $1.00
$ 25.00–$49.99	add $0.75
$ 50.00–$99.99	add $0.50
$100 and Up	NO CHARGE

The above charges include shipping via First Class Mail or UPS (your choice), and insurance on all domestic shipments.

SPECIAL SHIPPING CHARGES

COD	$1.00–additional
UPS Blue	$1.00–additional
Postal Insurance	$1.00–additional
Special Delivery	$1.25–additional

INTERNATIONAL COMPONENTS CORPORATION

P. O. BOX 1837
COLUMBIA, MO 65201
PHONE: (314) 874-1150

CIRCLE NO. 26 ON FREE INFORMATION CARD

New-Tone Electronics

Quality components at fair prices

HIGH FIDELITY SPEAKERS

8-INCH COAXIAL
Combines a high quality 8" woofer and a tweeter into a pre-phased sound reproducer. Built-in cross-over network. Excellent choice for a low cost Hi-Fi system for autos, vans, or in your home. Frequency response is a smooth 80-15000 Hz. 8 ohm VC. 10 oz. ceramic ring magnet. 25W rating. **NT577 $13.99 plus 40 cents postage**

10-INCH WOOFER
The speaker for your "big sound" system. Frequency response is 20-4000 Hz; 8 ohm aluminum VC, powerful 20 oz ceramic ring magnet and a rubberized accordion-edge suspension for excellent compliance. Handles 50W max. Use with the NT576 for a super system. **NT578 $17.99 plus 40 cents postage**

50W DOME TWEETER
Here is the super tweeter. A rugged 10 cm (4") dome tweeter which handles 50W max. Frequency response is 4000-20000 Hz. 8 ohm VC, 8 oz. ceramic magnet. Your system can have a brilliance you never imagined. **NT576 $6.99**

Resistors Standard values, ±5%, first quality. Packed 5 of one value.
¼W-5 for $.25 ½W-5 for $.30

Capacitor Special 3600 mF, 40Vdc Sprague "Powerlytic" $1.89

Relay SPDT, 12Vdc 5A contacts NT565 $1.79

Sound Activated Switch Complete, ready to use. Built-in microphone's output triggers a Triac which acts as a switch. Measures only 1" x 3". Requires 3-6Vdc. NT527 $1.29

And, the largest inventory of domestic and Japanese transistors and ICs in the United States.

ALL PARTS GUARANTEED
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Minimum Order $5. Add $1.50 Postage and Handling. Canada add $2.00. N.J. Residents add 5% Sales Tax.

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CB, HAM MICROPHONE

• Noise Cancelling Characteristics • Dynamic Microphone Element
A terrific push-to-talk dynamic microphone with a tailored 100-5000 Hz frequency range for high intelligibility. The "close talk" requirement is effective in eliminating off-axis noise. Originally made by Astatic for Pace. Complete with 4-wire coiled conductor. Can be used with hundreds of CB and Ham rigs. Output impedance is 400 ohms. Black plastic case with molded hanger. **NT566 $6.89**

ALARM HORN . . . Use anywhere a loud audio signal or buzzer is needed — as an alarm, to signal a "high" in your IC projects, as a timer signal, or as a low cost code practice tone generator. Requires only 3-6 volts dc. 1½" diam. **NT553 $.89**

SPDT Miniature Microswitch . . . The real thing! Rated 10A at 125 Vac, 5A at 250 Vac. Body measures 3/4''x1/4''x1/2''. Roller leaf actuated. **Three for $2.29 NT584 $.89**

DPDT-Toggle Switch . . . Rated 6 Amps at 125Vac. 3/8'' bat handle, 5/16'' stem. Gold plated wire terminals. Switch body measures 1/2''x1/2''x3/8''. Made by Cutler Hammer. **NT562 $1.49**

4PDT-Toggle Switch . . . Three position toggle switch with center position "OFF". Rated 6 Amps at 125 Vac. 3/8'' bat handle, 5/16'' stem. Gold plated wire terminals. Switch body measures 7/8''x 1/2''x1/2''. Made by Cutler Hammer. **NT563 $1.99**

NYLON HARDWARE . . . Hard-to-find Nylon screws, nuts and rivets. **NT514 - 50 piece assortment only $1.99**

Socket Extender 14-Pin DIL . . . Raises sockets 2½'' above the chassis. Solder to pc board or plug into an existing socket. Ideal for digital readout devices, IC testing and simplifying layout. **Three for $2.39 NT568 $.89**

CIRCLE NO. 39 ON FREE INFORMATION CARD

FORDHAM BEST BUYS

CSC CONTINENTAL SPECIALTIES
100 MHz 8-Digit Counter
- 20 Hz-100 MHz Range • 6" LED Display • Fully Automatic
- Includes 100-1PC clip lead input cable; manual

$119.00 Model MAX-100

B&K PRECISION 3½-Digit Portable DMM
- Overhead Protected • Battery or AC operation • 3" high LED Display
- Auto Zeroing

Model 2800 $85
comes complete with test leads, operating manual and spare fuse

EICO 3½ Digit DMM
- Flashing Over-Range Indicator
- Auto Polarity • Overload Protected

Model 270 wired Reg $80.00
Kit $65.00

Weller®·Xcelite®
Service Master Tool Kit
Model 99SM
$39.95

Attache Style Tool Cases
MODEL TC-100/ST
Reg $283.00
$239.50

Roll Kit Model 99PR
$13.95

WAHL NEW ISO-TIP "Quick Charge"
ISO-TIP 60 MODEL 7800
1-2 units $27.95
3 or more $26.95
- Model 7500 Cordless Soldering Iron $17.95
- Model 5800 Thermal Spot Circuit Tester $22.50

NLS 15 MHz Mini Oscilloscope
Model MS - 15
$246.50
- Battery or line operation
- Automatic and line sync modes
- Power consumption less than 15 W
- Vertical Gain 0.01 to 50 volts/div - 12 setting
- External or internal trigger

NOW AVAILABLE MS-215 Reg. $395.00
(Dual Trace Version of MS-15) $349.95

RCA Color Generator
Reg. $89.50 $59.95
MODEL WR 508

CSC QT Sockets & Bus Strips

QT type	# holes	price
QT-59S	590	12 50
QT-59B	bus strip	2 50
QT-47S	470	10 00
QT-47B	bus strip	2 25
QT-35S	350	8 50
QT-35B	bus strip	2 00
QT-18S	180	4 75
QT-12S	120	3 75
QT-8S	80	3 25
QT-7S	70	3 00

BSR Record Changer Accessories
Model BSR-129
$24.95

CSC Logic Probe
Model LP-1
$40.00 complete
- Compact, circuit powered
- Multi-family compatibility-DTL/TTL/HTL/CMOS
- Detects pulses as short as 50 nSec

LEADER Instruments Corp
20 MHz. Dual Trace
Model LBO-508
- Add, subtract modes on CH 1 & CH-2
- Front panel X-Y operation
- 17.5 nSec rise time

Reg. $769.95
$615.96 with accessories

Econo-Lamp
Colors Red, yellow, blue, black, oyster white U L listed
Model XL-334A $14.95

The Hobby Wrap Wire Wrapping Tool
- Battery Operated (not included)
- Wraps 30 AWG wire onto std DIP sockets (.025")
- Complete with built-in bit and sleeve

Model BW-630 $32.00

Logic Monitor
- Automatically displays static and dynamic logic • Works with DTL, HTL, TTL and CMOS • 16 LED display
- Circuit powered design.

Model LM-1 $67.50 complete

Transistor Tester Model 100
9 volt battery included $22.00
- Movable base pin (conforms to TO-5, TO-18 and small "in line" leads
- Tests transistors in or out of circuit • Operates on contact
- Clear speaker tone; no visual observations to make

Magnifier LAMP
700 Series
Precision ground and polished magnification lens Uses 22W T9 Circline flucrescent.
Model MG 10A
$42.50

Voltage Spike Protector
Limits voltage transients that might damage equipment. Plugs into any 120 volt grounded AC
Model GESP-752
$7.95

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Complete line available

B&K PRECISION
520 MHz Frequency Counter
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CIRCLE NO. 20 ON FREE INFORMATION CARD

MORE NEW ITEMS!

JUMBO LED READOUT ARRAY

By Bowmar. .5 in. character common cathode. Designed for use with multiplexed clock chips 4 digits in 1 pack!

$1.95 LIMITED STOCK

NATIONAL SEMICONDUCTOR JUMBO CLOCK MODULE

MA1008A BRAND NEW!

$6.95

2 FOR $13

(AC XFMR $1.95)

FEATURES:
- FOUR JUMBO ½ INCH LED DISPLAYS
- 12 HR REAL TIME FORMAT
- 24 HR ALARM SIGNAL OUTPUT
- 50 OR 60 Hz OPERATION
- LED BRIGHTNESS CONTROL
- POWER FAILURE INDICATOR
- SLEEP & SNOOZE TIMERS
- DIRECT LED DRIVE (LOW RFI)
- COMES WITH FULL DATA

ASSEMBLED! NOT A KIT!

ZULU VERSION!
We have a limited number of the 24 HR Real time version of this module in stock.
#MA1008D — $9.95

PERFECT FOR USE WITH A TIMEBASE.

COMPARE AT UP TO TWICE OUR PRICE!

MANUFACTURER'S CLOSEOUT!

MICRO-MINI TOGGLE SWITCH

SPDT. By RAYTHEON. MADE IN USA! WITH HDWR.

99¢ EACH

6 FOR $5

INTEL 2102 RAM SPECIAL

Brand New 2102A-4. "A" version for use in battery back-up. Factory Prime. These parts have been screened to meet LOW POWER specs. (40 MA. Max, 28 MA. Typical) FAST: 450 NS

8 FOR $7.95 32 FOR $28

EXPERIMENTER'S CRYSTAL

262. 144KHZ. This frequency is 2 to the 18th power. Easily divided down to any power of 2, and even to 1HZ. New by CTS-Knight. A $5 value!

$1.25 each

SALE! 1N4148 DIODES

High speed switching diodes. Silicion. Same as 1N914. Brand New. Full Leads. Prime!

100 FOR $2 1000 FOR $17.50

FAIRCHILD JUMBO READOUTS

.5 Inch Char. High Efficiency!
FND-503-Common Cathode
FND-510-Common Anode
YOUR CHOICE 69¢
10 FOR $5.75

DISC CAPACITORS

.1 MFD 16V. P.C. leads. Most popular value! By Sprague.

20 for $1.00

Full Wave Bridge

4 Amp 200 PIV
69¢ea. 10/5.75

MALLORY

POWER SUPPLY CAPACITOR
1500 MFD 16 WVDC
3/$1.00 10/$2.95
FACTORY FRESH! SMALL SIZE

2N3904-House No.

TO—92. NPN.
VCEO-45.
HFE 100 to 300
10 for $1.00

FET SALE!

2N4304. Brand New N Channel, Junction Fet. BVGD0-30V IDSS-15 MA Typ. 1500 uMHOS. TO-18 Plastic Case. Mfg. by Teledyne.

6 FOR $1

Motorola PNP Power!

2N4905 TO-3 case. 90W. VCEO-60. HFE-100 max. at 2.5A. Good mate for the 2N3055. PRIME!

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By GE. 36,000 MFD 15W VDC. Small Size: 4¾ x 1¾ Inches. SUPER DEAL! $2.95 Each

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LS SERIES TTL

74LS00—33c	74LS74—49c
74LS02—35c	74LS90—69c
74LS04—35c	74LS138-89c
74LS08—35c	74LS154-1.49
74LS10—33c	74LS175-1.10
74LS20—33c	74LS367-75c
74LS73—49c	74LS368-85c

Motorola Quad Op-Amp MC3401. Pin for Pin Sub for popular LM3900.

3/$1.00

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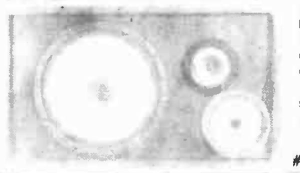

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Fantastic enclosures and matching components to build your own pair of superb full-range 3-way speaker systems. Kit includes enclosures, 10" foam edge woofers, 5" middlers, 4" super dome tweeters; crossovers, damping, hardware and instructions, PLUS: sculptured foam grills! Qty. Ltd., so order NOW! Cabinet size: 21x12x10. 50 Lbs/pr.

#8Z30338 . . . . . only $99.88/Pair

MOTOROLA® PIEZO-ELECTRIC TWEETERS!

HORNS, SUPER-HORNS, & DIRECT RADIATORS! Unique tweeters give all the things you'll want from a hi-freq speaker, plus flexibility for the do-it-yourself designers.

- No Crossover needed
- High Impedance
- High Output
- Flat Resp. 2K-20K Hz.
- Low Harmonic Dist.

FOR COMPLETE INFO Circle Reader Service Card for FREE CATALOG

Shown - 3½" SUPER HORN: #8E30248 . $7.88 ea or $14.88/Pair (2 Lbs)

ULTRASONIC

MOTION DETECTOR

This alarm sensor fills the protected area with an energy screen that cannot be seen, felt or heard. Triggers your alarm whenever burglar moves through detector field. Mounts on ceiling, wall, desk, shelf etc. Optional delay mode, auto-reset. Operates on 12.5 VDC.A close-out that originally sold for $179. 00! 3 Lbs. Qty. Ltd. #8D30336 . . . . $49.88

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Surplus Brand-name receiver/amplifier chassis, including bulls-eye stereo light on tuning needle, slide controls, amp & tuner (no case). Mfr.'s "questionables", may need repair. You fix & save! Qty. is limited. AS IS (no returns). W/data. 5 Lbs . . . . 8K30357 . . $19.88 ea.

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CIRCLE NO. 8 ON FREE INFORMATION CARD

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CMOS

4000	.15
4001	.20
4002	.20
4007	.20
4010	.36
4011	.20
4012	.20
4013	.35
4014	.80
4015	.80
4016	.35
4017	.92
4018	.92
4019	.20
4020	1.00
4022	.83
4023	.21
4024	.75
4025	.20
4027	.34
4028	.79
4029	1.00
4030	.20
4035	.95
4040	1.00
4041	1.00
4042	.70
4044	.60
4049	.35
4051	1.10
4066	.70
4068	.40
4069	.40
4075	.20
4082	.23
74C00	.25
74C02	.45
74C04	.32
74C08	.65
74C10	.25
74C14	1.75
74C20	.26
74C30	.26
74C32	.30
74C42	1.40
74C48	2.75
74C73	1.25
74C74	.75
74C86	1.00
74C90	1.10
74C93	1.25
74C151	2.75
74C154	3.00
74C157	2.10
74C160	1.40
74C162	1.70
74C164	1.75
74C165	1.75
74C174	1.50
74C902	.85
74C904	.85
74C905	3.00
74C914	1.95

TTL

7400	.16
7401	.17
7403	.17
7404	.19
7406	.40
7407	.40
7409	.25
7410	.18
7413	.78
7414	.68
7417	.38
7420	.18
7421	.35
7427	.35
7430	.15
7432	.30
7437	.44
7440	.18
7442	1.00
7445	.70
7446	.70
7448	.70
7450	.25
7451	.25
7453	.25
7454	.35
7460	.22
7472	.40
7473	.40
7474	.40
7475	.55
7476	.45
7483	1.05
7485	1.10
7486	.43
7489	2.00
7492	.75
7493	.65
7495	.78
7496	.85
74121	.35
74122	.49
74123	.65
74126	.65
74132	1.25
74141	1.15
74145	1.10
741481	1.20
74150	.90
74153	1.10
74154	1.25
74155	.75
74157	1.00
74161	1.00
74163	1.30
74164	1.45
74165	1.35
74166	1.20
74173	1.70
74175	1.05
74177	.90
74182	.95
74191	1.20
74192	1.45
74193	1.35
74195	1.00
74196	1.10
74197	1.10
74199	2.25
74367	.90

Interface

0025	3.50
0026	1.75
8640	1.25
8641	2.75
8806	3.00
8819	1.25
8820	5.00
8830	4.90
8833	2.45
8835	2.45
8836	1.25
8837	2.45
8838	2.45
8859	1.50
8865	1.50
8866	1.50
8867	1.85
8869	1.75
8879	2.25
8880	2.75
8884	2.45
8973	2.95
8974	2.95
8976	2.95
75107	3.25
75450	1.00
75451	.80
75452	.80
75453	.80
75491	1.25
75492	1.40
75494	1.50

Peripheral

8212	3.50
8214	8.50
8216	3.75
8224	4.75
8228	9.90
8251	11.50
8255	10.50
2513	9.50
2516	9.50
1013	6.50

8000 TTL

8T20	3.25
8T97	1.75
8092	.95
8094	.60
8095	.80
8096	.90
8098	.90
8121	2.25
8136	3.25
8220	3.25
8231	2.25
8242	1.75
8250	1.75
8260	2.25
8281	1.00
8334	4.00
8553	6.50
8556	3.25
8599	3.25

LINEAR

301N	.35
307N	.35
308H	1.00
309K	1.25
309H	1.00
318H	1.50
320H-5	.88
320T-5	1.25
320T-12	1.25
324N	1.75
340T-5	1.25
340T-12	1.25
340T-15	1.25
340T-24	1.25
387N	1.25
388N	1.15
555N	.35
556N	.85
558N	2.80
561N	5.00
566N	1.70
567N	1.65
709N	.30
741H	.25
3035	2.40
3401	1.25

74LSxx *

74LS00 .25
through
74LS670 3.95

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4001	.18	4019	.37	4049	.35	74C73	65
4002	18	4020	.90	4050	.35	74C74	.45
4006	.95	4021	.90	4053	1.10	74C83	1.15
4007	.18	4022	.90	4055	1.25	74C86	.40
4009	.37	4023	.18	4066	.70	74C93	75
4010	.37	4024	.75	4071	18	74C151	1.40
4011	.18	4025	.18	4076	.97	74C160	1.05
4012	.18	4027	.37	4518	1.00	74C161	1.05
4013	.29	4028	.80	74C00	.22	74C174	1.05
4014	.75	4029	.95	74C02	.22	74C175	1.05
4015	.75	4030	.33	74C04	24	74C193	1.20
4016	29	4035	.97	74C08	.22	74C901	48
4017	.90	4042	65	74C10	.27	74C902	48
4018	.90	4046	1.35	74C42	.85	74C914	1 70

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5204 4K PROM	$ 4.95
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AY 5 1013 UART	$ 5 75
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8228	$ 4 95

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6,144 MHz
8,000 MHz
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400	09	25	50	1.40	6 50	9.50
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7400	.13
7401	.13
7402	.13
7403	.13
7404	.15
7405	.13
7406	.16
7407	.20
7408	.18
7409	.18
7410	.13
7411	.18
7412	.13
7413	.36
7414	.60
7416	.22
7417	.25
7420	.13
7425	.25
7426	.22
7427	.19
7430	.13
7432	.22
7437	.21
7438	.21
7440	.13
7441	70
7442	37
7445	.65
7446	.68
7447	.58
7448	.68
7450	.15
7472	.25
7473	.28
7474	.28
7475	.45
7476	.30
7480	.31
7483	.65
7485	.87
7486	.28
7489	1.25
7490	.42
7491	.58
7492	.43
7493	.43
7494	.67
7495	.65
7496	.65
74107	.28
74121	.29
74122	.38
74123	.45
74125	.40
74126	.40
74150	.94
74151	.61
74153	.61
74154	94
74155	.58
74157	.55
74161	.55
74163	.55
74164	.85
74165	.95
74170	1.68
74173	1.20
74174	.95
74175	.85
74176	.75
74177	.75
74180	65
74181	1.90
74190	1.00
74191	1.00
74192	.79
74193	.79
74194	.80
75325	1.50
74196	.86
74279	.55
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200	.75	1.25	2.00
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68UF	35V	5 $1 00
1UF	35V	5 $1 00
2 2 UF	20V	5 $1 00
3 3UF	20V	4 $1 00
4.7UF	15V	5/$1.00
6 8UF	35V	4 $1 00
10UF	10V	$ .25
22UF	25V	$ 40
15UF	35V	3/$1.00
30UF	6V	5/$1.00
47UF	20V	$ .35
68 UF	15V	$ .50
100 UF	10V	$ .40

74LS SERIES

74LS00	19
74LS02	19
74LS03	19
74LS04	21
74LS05	21
74LS08	21
74LS09	21
74LS10	20
74LS11	20
74LS13	40
74LS14	80
74LS15	21
74LS20	21
74LS21	21
74LS22	21
74LS26	29
74LS27	25
74LS28	26
74LS30	21
74LS32	25
74LS37	28
74LS38	28
74LS40	21
74LS42	60
74LS47	73
74LS51	25
74LS54	25
74LS73	35
74LS74	34
74LS75	50
74LS76	35
74LS85	75
74LS86	35
74LS90	50
74LS92	50
74LS93	50
74LS109	.35
74LS112	35
74LS113	35
74LS114	35
74LS125	.45
74LS126	45
74LS132	70
74LS138	70
74LS139	70
74LS151	59
74LS153	59
74LS155	82
74LS156	62
74LS157	59
74LS160	79
74LS161	79
74LS162	79
74LS163	79
74LS168	80
74LS169	80
74LS170	1 40
74LS173	95
74LS174	72
74LS175	75
74LS181	2 00
74LS190	88
74LS191	88
74LS192	88
74LS193	88
74LS195	50
74LS196	75
74LS197	75
74LS221	1 00
74LS257	68
74LS258	68
74LS266	25
74LS279	50
74LS290	60
74LS293	58
74LS365	49
74LS366	49
74LS367	49
74LS368	49
74LS378	60
74LS386	35
74LS390	1 45
74LS670	2 00

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LM307	.30
LM 308	.75
LM 311	.75
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LM 382	1.25
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LM 553	2.50
LM 555	.39
LM 556	85
NE540L	2.25
560	2.00
565	.95
566	1.10
567	1 10
703	.90
709	.25
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400	1 10	1 60	2 60	1 00	1 20	2 20
600	1.70	2.30	3.60		1.50	3.00

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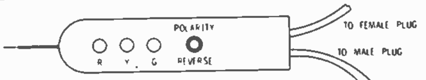

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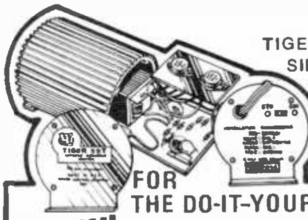

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2SA387A	.69	2SB554	8 00	2SC788	2 95	2SC1730	.95	AN271	3.20	STK056	11.35
2SA473	1.25	2SB561	.60	2SC789	1.00	2SC1756	2.75	AN289	7.90	STK405	9 20
2SA483	2.79	2SB627	2.95	2SC790	1 50	2SC1760	1 60	AN315	3.50	STK415	8.50
2SA484	2.44			2SC793	2.50	2SC1816	3.50	AN331	5.40	STK433	9.25
2SA485	1.95	2SC32	1.35	2SC798	3.95	2SC1908	49	AN343	3 90	STK435	9 50
2SA489	1.39	2SC116	3.00	2SC799	3.25	2SC1909	3.75	AN360	2.50	STK437	11.50
2SA495	.60	2SC172	1.75	2SC815	55	2SC1957	1.00	AN380	7.50	STK439	11.60
2SA496	.99	2SC206	2.50	2SC828	49	2SC1964	3.95	BA302	2.50	TA7028M	3 50
2SA497	1.44	2SC237	1.75	2SC829	.49	2SC1969	4.70	BA511	3.00	TA7045M	3 25
2SA509	.50	2SC281	50	2SC830	2.95	2SC1973	.90	BA521	3.40	TA7051P	3.00
2SA525	4.95	2SC284	1.20	2SC838	.50	2SC1974	3.50	C3001A	2.95	TA7054P	3.05
2SA537A	4.95	2SC287	1.25	2SC839	50	2SC1975	3.50	CX075B	2.95	TA7055P	3.00
2SA539	.60	2SC291	3 95	2SC853	.90	2SC2020	4.95	CX100D	8.50	TA7060P	1.40
2SA561	.48	2SC325	3.95	2SC866	5.00	2SC2027	6.00	CX101G	8.50	TA7061P	1.50
2SA562	.45	2SC367	.85	2SC867	6.00	2SC2028	.80	CX103D	8.50	TA7062P	1.50
2SA564	.50	2SC371	.49	2SC870	.50	2SC2029	3.40	CX104A	8.50	TA7063P	1.50
2SA565	1.05	2SC372	.49	2SC871	.50	2SC2034	2.95	CX121A	7.50	TA7072	3.00
2SA566	3.20	2SC373	.49	2SC900	.50	2SC2074	2.50	CX130A	7.00	TA7074	2.90
2SA606	1.69	2SC374	.49	2SC922	.69	2SC2075	4.00	CX148	11.70	TA7075	3.75
2SA624	.99	2SC375	.49	2SC929	.49	2SC2091	2.50	CX149A	14 00	TA7076	3.75
2SA628	.49	2SC380	.49	2SC930	.49	2SC2092	3.25	DN834	1.50	TA7089	2.90
2SA634	1.00	2SC381	.50	2SC938	.95	2SC2098	3.90	DN835	1.60	TA7102P	5 80
2SA636	1.25	2SC382	.55	2SC943	1.00	2SC2166	3.75	DN837	1.50	TA7106P	3 25
2SA640	.49	2SC384	.60	2SC945	.49	2SD45	4.95	DN838	1.70	TA7120P	1.50
2SA643	.60	2SC385	70	2SC959	1.35	2SD68	.90	HA1151	3.20	TA7122	1.50
2SA659	.49	2SC386	70	2SC960	2.95	2SD72	.80	HA1157	4.20	TA7124	1.85
2SA663	4.75	2SC387	50	2SC984	.80	2SD77	1.50	HA1158	4.20	TA7146P	3.75
2SA666	.69	2SC394	.49	2SC1000	.49	2SD81	3.95	HA1159	5.00	TA7148	3.90
2SA671	1.50	2SC403	.50	2SC1013	.95	2SD88	4.80	HA1199	3.25	TA7149P	3.90
2SA672	.70	2SC454	.49	2SC1014	.95	2SD118	3.00	HA1202	2.20	TA7150P	3.75
2SA673	.70	2SC458	.49	2SC1017	1.20	2SD130	1.20	HA1306	4.90	TA7153	6.90
2SA678	.65	2SC460	.49	2SC1018	1.00	2SD170	1.50	HA1308	4.50	TA7167	6.20
2SA679	4.95	2SC461	.49	2SC1030	2.80	2SD180	2.50	HA1312	3.40	TA7200P	3.50
2SA680	4.95	2SC478	80	2SC1034	5.60	2SD187	.49	HA1314	4 20	TA7201P	4.50
2SA682	1.49	2SC481	1.50	2SC1047	.59	2SD188	2.70	HA1316	3.50	TA7202	4.50
2SA683	.60	2SC482	1.40	2SC1060	1.40	2SD201	4.50	HA1318	5.00	TA7203	4.25
2SA684	.60	2SC484	2.60	2SC1061	1.25	2SD213	4.95	HA1322	4 20	TA7204	3 70
2SA695	.60	2SC485	1.40	2SC1079	3.95	2SD217	3.80	HA1325	3.20	TA7205	3 60
2SA699	1.30	2SC486	1.50	2SC1080	3.95	2SD218	3.90	HA1339A	4 95	TA7207	3 50
2SA699A	1.45	2SC493	3.50	2SC1096	.80	2SD227	.48	HA1342	4.50	TA7208	3 50
2SA705	75	2SC494	4.50	2SC1098	1.00	2SD234	.85	HA1366	4.20	TA7209	3.80
2SA706	1.45	2SC495	.85	2SC1114	4.92	2SD235	.85	HA11112	8.90	TA7210	6.50
2SA715	1.35	2SC496	.85	2SC1115	3.00	2SD257	3.50	HA11113	6.50	TBA800	4.40
2SA719	.59	2SC497	1.40	2SC1116	4.25	2SD261	1 00	HD3113	4.90	TBA810DS	4.40
2SA720	.59	2SC502	1 50	2SC1116A	4.75	2SD287	3.70	HD3127	7.80	TC4081P	1.75
2SA721	.59	2SC503	1.75	2SC1124	1.20	2SD288	1.50	LA1201	4.25	TC5080P	5.80
2SA733	.49	2SC504	1.75	2SC1162	1.00	2SD313	1.05	LA1240	3.30	TC5081P	3.60
2SA740	1.95	2SC509	75	2SC1166	.48	2SD314	1.50	LA1364	3 70	TC5082P	4.00
2SA745	4.50	2SC515	1.95	2SC1170B	4.95	2SD315	1.20	LA1366	4.25	TC9100P	8.50
2SA747	5.75	2SC517	3 60	2SC1172	5.25	2SD318	1.95	LA1369	4.25	TD3400P	1.55
2SA750	.49	2SC535	.55	2SC1173	75	2SD325	.90	LA3155	2 25	TD3441AP	5.10
2SA756	3.30	2SC536	.49	2SC1175	75	2SD330	1.50	LA3201	1.95	TM4312P	1.00
2SA758	5.60	2SC537	.49	2SC1209	75	2SD331	1.50	LA3301	3 40	UH1C001	6.50
2SA777	.99	2SC538	60	2SC1211	59	2SD356	1.00	LA3310	4.20	UH1C003	6 50
2SA816	.70	2SC563	90	2SC1212	1.65	2SD358	1.10	LA3350	3.30	UH1C004	6.50
2SA839	1.95	2SC580	1.95	2SC1213	.59	2SD360	1 05	LA4000	7.50	UH1C005	6.50
		2SC608	5.95	2SC1226A	.85	2SD382	1.20	LA4030	5.40	UH1C006	6.50
2SB22	.65	2SC609	5.95	2SC1237	4.00	2SD427	2 55	LA4031P	3 20	UPC16C	2.50
2SB54	.49	2SC614	3.95	2SC1239	3.50	2SD525	1.50	LA4032P	4 20	UPC20C	3.75
2SB56	.95	2SC619	65	2SC1306	3.50	2SCF6	1.25	LA4051P	3.20	UPC30C	3.75
2SB75	.48	2SC620	49	2SC1307	4 75	2SCF8	3.50	LA4101	3 20	UPC41C	2.80
2SB77	.48	2SC627	2.95	2SC1308	5.75	2SF8	3.00	LA4201	3.25	UPC48C	3.95
2SB111	.59	2SC632	60	2SC1312	.49	2SK19	1.25	LA4400	3.40	UPC157CA	2.50
2SB156	.95	2SC634A	.60	2SC1313	.49	2SK23A	1.00	LA4420	3.40	UPC554C	2 50
2SB172	.60	2SC644	.49	2SC1317	.49	2SK30A	75	LAD001	3 20	UPC555H	2.20
2SB175	60	2SC645	60	2SC1318	49	2SK33	90	LD3040	1.60	UPC563H2	8.00
2SB186	.49	2SC674	.60	2SC1327	49	2SK34	90	LD3120	2.40	UPC566H	1.25
2SB187	.55	2SC680	2.60	2SC1330	1 35	2SK40	1.30	M5112	8.40	UPC573C	3.25
2SB202	1.50	2SC684	1.20	2SC1342	.49	2SK55	1.00	M5151PR	7.80	UPC575C	2.60
2SB227	2.95	2SC693	.49	2SC1344	.49	3SK22	2 20	M5152L	2.75	UPC576	3.25
2SB234	2.95	2SC696	1.75	2SC1347	.85	3SK22Y	2.20	M5192	4.80	UPC587C2	2.95
2SB235	7.95	2SC699	5.95	2SC1359	.65	3SK35	2.00	M51171L	2 00	UPC592H2	1.40
2SB270	.79	2SC708	1.75	2SC1360	95	3SK39	2 00	M51513L	5 10	UPC595C	2.95
2SB303	.49	2SC710	.49	2SC1362	.52	3SK40	2.00	MB3705	3.35	UPC596C	2.75
2SB324	.60	2SC711	.49	2SC1364	1 10	3SK41	2.20	MN3001	19.50	UPC1001H2	3.50
2SB337	1.35	2SC712	.49	2SC1377	4.80	3SK45	2.20	MN3002	11.70	UPC1008C	5.75
2SB370	.65	2SC715	.69	2SC1382	95	3SK49	2.20	MN3003	9 45	UPC1020H	4.25
2SB405	.60	2SC717	.50	2SC1383	.50	JSP7001	.75	MN3004	17.95	UPC1025H	3.50
2SB407	1.35	2SC730	4.15	2SC1384	80	MA26	.28	MN3005	75.00	UPC1026H	3.10
2SB415	.65	2SC731	3.00	2SC1402	3.60	MPS8000	1.25	MN6040	16.75	UPC1152H	3.95
2SB434	1.15	2SC732	.49	2SC1403	3.60	MPS8001	1.25	MN6040A	16 75	UPC1154H	3.95
2SB435	1.35	2SC733	.49	2SC1419	.95	MPSU02	.50			UPC1155H	3.95
2SB440	.60	2SC734	.49	2SC1447	.90	MPSU31	4.00	PLLC1A	13.50	UPC1156H	4.50
2SB461	1.60	2SC735	.49	2SC1448	1.00	MRF8004	3.00	PLL02A	8.50	UPC1380C	9.50
2SB463	1.40	2SC738	.49	2SC1449	85	SD1074	19.95	PLL02A-G	8.50	UPC78L05	1.40
2SB471	1.40	2SC756A	2.40	2SC1475	1.25	SD1076	28 95	SG609	4.80	UPD277C	4 50
2SB472	2.60	2SC763	.49	2SC1507	1 40	4004	3.00	SG613	6.75	UPD857C	15.50
2SB474	1.10	2SC773	.60	2SC1509	.85	4005	3.00	S6080A	3.75	UPD858C	9.50
2SB481	1.50	2SC774	1.50	2SC1624	1.10	40080	1.25	S6080B	3 80	UPD861C	18 50

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7442N	50
7445N	.69
7447N	60
7448N	69
7450N	17
7474N	29
7475N	.49
7485N	88
7489N	2 00
7490N	43
7492N	.43
7493N	.43
7495N	69
74100N	90
74107N	.29
74121N	34
74123N	59
74125N	39
74145N	.69
74150N	.95
74151N	69
74154N	1 00
74157N	.69
74161N	.87
74162N	.87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	.85
74221N	1 55
74298N	1 65
74365N	.66
74366N	66
74367N	66

74LS00 TTL	
74LS00N	.25
74LS02N	.25
74LS04N	.25
74LS05N	25
74LS08N	25
74LS10N	25
74LS13N	.40
74LS14N	90
74LS20N	25
74LS22N	25
74LS28N	.41
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74LS33N	39
74LS38N	30
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74LS75N	.47
74LS90N	.51
74LS93N	.51
74LS95N	1 89
74LS107N	.35
74LS112N	35
74LS113N	35
74LS132N	72
74LS136N	35
74LS151N	.67
74LS155N	67
74LS157N	67
74LS162N	91
74LS163N	.91
74LS174N	.95
74LS190N	1.06
74LS221N	1.95
74LS258N	.67
74LS367N	.89

LINEAR	
CA3045	.90
CA3046	.67
CA3081	1 80
CA3082	1 90
CA3089	2 95
LM301AN/AH	35
LM305H	87
LM307N	35
LM308N	89
LM309H	1 15
LM309K	95
LM311H/N	.90
LM317T/K	2.92
LM318	1 35
LM320K-5	1 20
LM323K-5	6 95
LM320K-12	1 35
LM320K-15	1 35
LM320T-5	1 60
LM320T-8	1 60
LM320T-12	1 50
LM320T-15	1 60
LM324N	1.15
LM339N	1.55
LM340K-5	1 10
LM340K-8	1.10
LM340K-12	1 10
LM340K-15	1.10
LM340K-24	1 10
LM340T-5	1 10
LM340T-8	1 10
LM340T-12	1 10
LM340T-15	1.10
LM340T-18	1.10
LM340T-24	1.10
LM343H	4.50
LM370	1.15
LM377	4.50
LM379	5 00
LM380N	1.00
LM381	1 60
LM382	1 60
LM703H	.40
LM709H	28
LM723H/N	50
LM733N	.67
LM741CH	.35
LM741N	.25
LM747H/N	.62
LM748N	.35
LM1303N	82
LM1304	1 10
LM1305	1.27
LM1307	2 00
LM1310	2 75
LM1458	.47
LM1800	1.75
LM1812	7.50
LM1889	3 00
LM2111	1.75
LM2902	1 50
LM3900N	.60
LM3905	1.75
LM3909N	.61
MC1458V	.50
NE540L	2.89
NE550N	.65
NE555V	.43
NE556A	.79
NE565A	1.00
NE566V	1.15
NE567V	1 20
NE570B	5 00
NE571B	5 00
78L05	60
78L08	60
79L05	70
78M05	.85
75108	1.75
75491CN	50
75492CN	55
75494CN	89

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ICL7103	9 50
ICL7107	14 25

CMOS	
CD34001	50
CD4000	.16
CD4001	.21
CD4002	.21
CD4006	1 10
CD4007	21
CD4008	21
CD4009	39
CD4010	39
CD4011	21
CD4012	21
CD4013	36
CD4014	86
CD4015	86
CD4016	36
CD4017	94
CD4018	94
CD4019	21
CD4020	1 02
CD4021	1 02
CD4022	86
CD4023	21
CD4024	75
CD4025	21
CD4026	1 51
CD4027	36
CD4028	79
CD4029	1 02
CD4030	21
CD4035	1 02
CD4040	1 02
CD4042	71
CD4043	63
CD4044	63
CD4046	1 67
CD4049	36
CD4050	36
CD4051	1 13
CD4060	1 42
CD4066	71
CD4068	40
CD4069	40
CD4070	40
CD4071	21
CD4072	.21
CD4073	21
CD4075	.21
CD4076	1.75
CD4078	40
CD4081	.21
CD4082	21
CD4116	47
CD4490	5 50
CD4507	1 00
CD4508	4 25
CD4510	1 02
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1 02
CD4520	1 02
CD4527	1 51
CD4528	79
CD4553	5.75
CD4566	2 25
CD4583	4.50
CD4585	1.10
CD40192	3 00
74C00	28
74C04	33
74C10	28
74C14	2.10
74C20	28
74C30	28
74C48	1 95
74C74	75
74C76	1 40
74C90	1 15
74C93	1 40
74C154	3 00
74C160	1 44
74C175	2 00
74C192	2 40
74C221	2 75
74C905	3 00
74C906	1 50
74C914	1.95
74C922	7 50
74C923	7.50
74C925	10 50
74C926	10 50
74C927	10 50

INTERFACE	
8095	65
8096	65
8097	65
8098	65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5 50
8T23	3.10
8T24	3.50
8T25	3 20
8T26	1 69
8T28	2.75
8T97	1.69
8T98	1 69

MOS MEMORY RAM	
2101-1	3.95
2102-1	1 28
2102AL-4	1.60
21F02	1.85
2104A-4	4 95
2107B	4 95
2111-1	4 95
2112-2	3 95
2114	8 50
MK4116	24 95
2513B	6 30
21L02-1	1.49
MM5262	.40
MM5280	3 00
MM5320	9 95
MM5330	5 94
PD411D-3	4.00
PD411D-4	5 00
P5101L	13 95
4200A	12 95
82S25	2.90
91L02A	1.75
HD0165-5	6 95
MM57100	4.50
GIAY38500-1	9.95
MCM6571A	9 95
9368	3 50

CLOCKS	
MM5309	3 00
MM5311	3 60
MM5312	4.80
MM5313	3 60
MM5314	3.90
MM5315	4 00
MM5316	5.00
MM5318	3 60
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7001	5 80
CT7002	8 95
CT7010	8 95
CT7015	7.25
MM5375AA/N	3.90
MM5375AB/N	4.90
7205	16.50
DS0026CN	3 75
DS0056CN	3.75
MM53104	2.50

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Solder Tin		Low Profile	
PIN	1 UP	PIN	1UP
8	15	22	.30
14	18	24	35
16	.20	28	.42
18	.27	36	58
20	.29	40	.57

3 level wire wrap gold
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6850	12 95
6502	10 50

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AY5-1013	5.50
AY5-1014	7.50
3341	6 95

PROM	
1702A	3 95
N82S23	2 95
N82S123	3 50
N82S126	3.75
N82S129	3.75
N82S131	3.75
N82S136	8 75
N82S137	8.75
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8223	2.90
2716T1	22.50

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100 pin edge	4.50
100 pin edge WW	5 25

CRYSTALS	
1 MHz	4 50
2 MHz	4 50
4 MHz	4 25
5 MHz	4 25
10 MHz	4 25
18 MHz	3 90
20 MHz	3.90
32 MHz	3 90
32768 Hz	4 00
1 8432 MHz	4 50
3 5795 MHz	1.20
2 0100 MHz	1.95
2.097152 MHz	4 50
2.4576 MHz	4 50
3 2768 MHz	4 50
5.0688 MHz	4 50
5.185 MHz	4.50
5 7143 MHz	4 50
6 5536 MHz	4.50
14 31818 MHz	4 25
18 432 MHz	4 50
22 1184 MHz	4 50

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102P2 Transformer	2.25
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10 per type 03 1000 per type .012
25 per type 025 350 piece pack
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Red T018	.15
Green, Orange Yellow T018	20
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Green, Orange Yellow Jumbo	25
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Paratronics 100A Logic Analyzer Kit	$199.00
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12 Volt 300 ma transformer	1 25
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12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.50
24V CT 400 ma	3 95
10V 1.2 amp wall plug	4 85
18V 6 amp	12 95

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MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1 25
DL707/DL707R	CA	300	1 00
DL727/728	CA/CC	500	1 90
DL747/750	CA/CC	600	1 95
DL750	CC	600	1 95
FND359	CC	357	70
FND500/507	CC/CA	500	1 35
FND503/510	CC/CA	500	90
FND800/807	CC/CA	.800	2 20
3 digit Bubble			60
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