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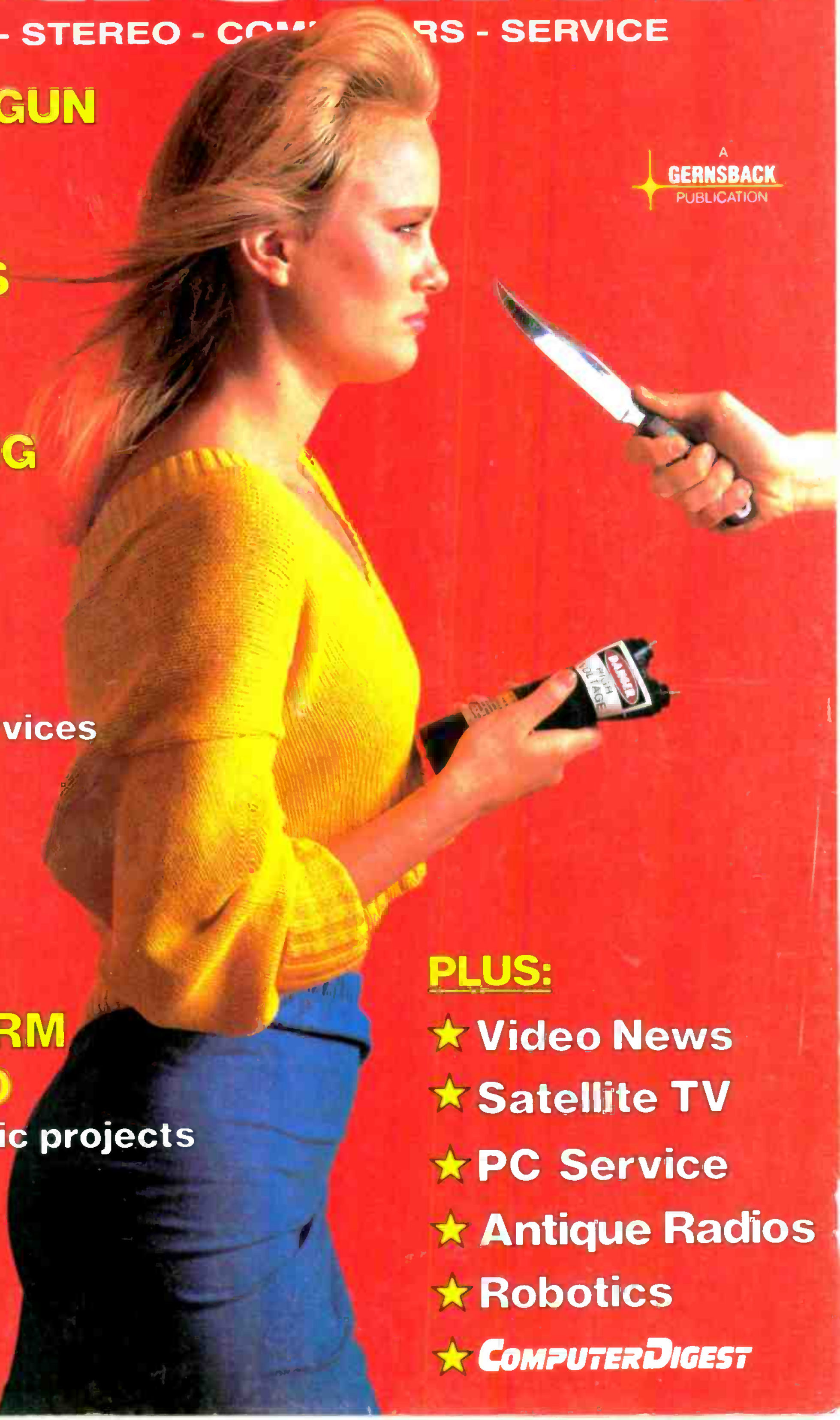

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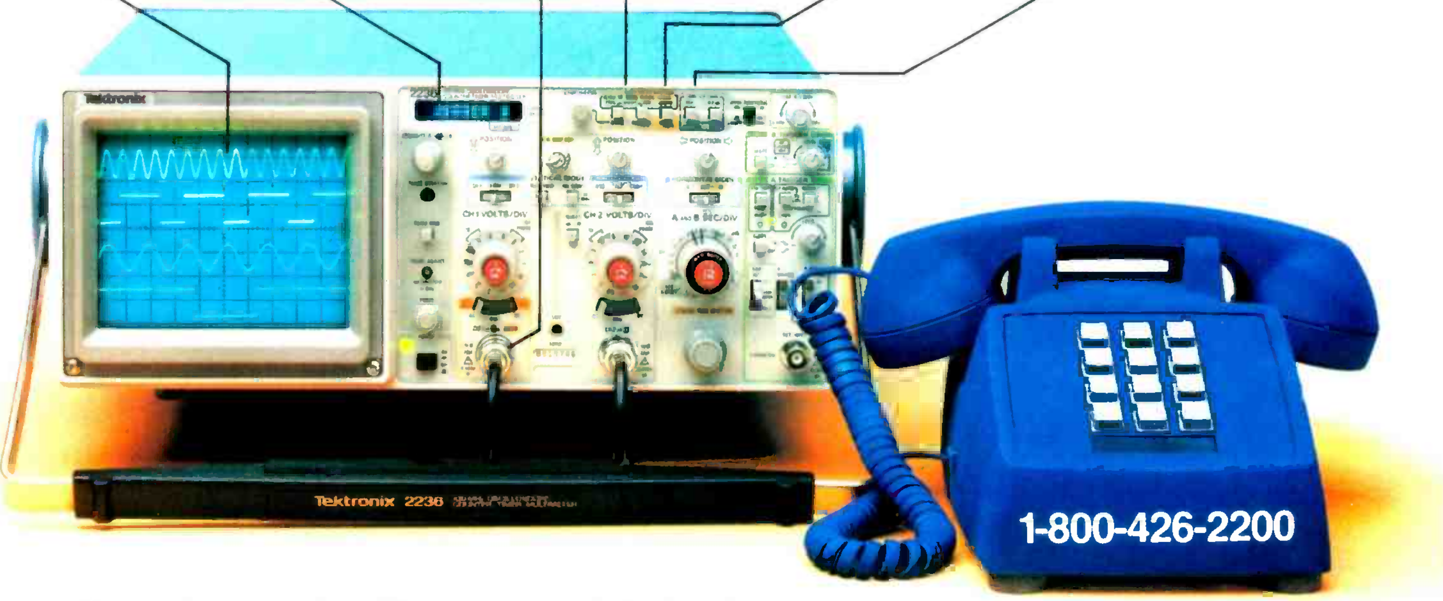

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September '86

Radio-Electronics

Electronics publishers since 1908

Vol. 57 No. 9

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COVER 1

We certainly hope you don't run into the same situation that our cover model is in, but if you do, we hope you have some protection. We're not going to tell you that a stun gun is your best protection, or that carrying a stun gun should make you feel confident in unsafe situations. But we think it's better to have some form of defense than none. The stun gun is a non-lethal weapon that can stop an attacker with its 75,000-volt discharge.

The stun gun is not a toy. It is a dangerous project and it is not recommended for beginners. To find out how to build yours, turn to page 41.

NEXT MONTH

THE OCTOBER ISSUE IS ON SALE SEPTEMBER 2

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To decode Telease-Maast programming.

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Advertising Sales Offices listed on page 114.

NEW! Lower Price Scanners

Communications Electronics™ the world's largest distributor of radio scanners, introduces new lower prices to celebrate our 15th anniversary.

Regency† MX7000-GR

List price $699.95/CE **price $469.95**
10-Band, 20 Channel • Crystalless • AC/DC
Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.3 GHz. continuous coverage.
The *Regency* MX7000 scanner lets you monitor Military, Space Satellites, Government, Railroad, Justice Department, State Department, Fish & Game, Immigration, Marine, Police and Fire Departments, Broadcast Studio Transmitter Links, Aeronautical AM band, Aero Navigation, Paramedics, Amateur Radio, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* MX7000 is the perfect scanner to receive the exciting 1.2 GHz. amateur radio band.

Regency® Z60-GR

List price $299.95/CE **price $179.95/SPECIAL**
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz.
The *Regency* Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

Regency® Z45-GR

List price $259.95/CE **price $159.95/SPECIAL**
7-Band, 45 Channel • No-crystal scanner
Bands: 30-50, 118-136, 144-174, 440-512 MHz.
The *Regency* Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

Regency® RH250B-GR

List price $659.00/CE **price $329.95/SPECIAL**
10 Channel • 25 Watt Transceiver • Priority
The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A *60 Watt* VHF 150-162 MHz. version called the **RH600B** is available for $454.95. A UHF 15 watt version of this radio called the **RU150B** is also available and covers 450-482 MHz. but the cost is $449.95.

NEW! Bearcat® 50XL-GR

List price $199.95/CE **price $114.95/SPECIAL**
10-Band, 10 Channel • Handheld scanner
Bands: 29.7-54, 136-174, 406-512 MHz.
The Uniden Bearcat 50XL is an economical, hand-held scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order part # **BP50** which is a rechargeable battery pack for $14.95, a plug-in wall charger, part # **AD100** for $14.95, a carrying case part # **VC001** for $14.95 and also optional cigarette lighter cable part # **PS001** for $14.95.

NEW! Scanner Frequency Listings

The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulances & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. All Fox directories are $14.95 each plus $3.00 shipping. State of Alaska–**RL019-1**; State of Arizona–**RL025-1**; Baltimore, MD/Washington, DC–**RL024-1**; Buffalo, NY/Erie, PA–**RL009-2**; Chicago, IL–**RL014-1**; Cincinnati/Dayton, OH–**RL006-2**; Cleveland, OH–**RL017-1**; Columbus, OH–**RL003-2**; Dallas/Ft. Worth, TX–**RL013-1**; Denver/Colorado Springs, CO–**RL027-1**; Detroit, MI/Windsor, ON–**RL008-3**; Fort Wayne, IN/Lima, OH–**RL001-1**; Hawaii/Guam–**RL015-1**; Houston, TX–**RL023-1**; Indianapolis, IN–**RL022-1**; Kansas City, MO/KS–**RL011-2**; Long Island, NY–**RL026-1**; Los Angeles, CA–**RL016-1**; Louisville/Lexington, KY–**RL007-1**; Milwaukee, WI/Waukegan, IL–**RL021-1**; Minneapolis/St. Paul, MN–**RL010-2**; Nevada/E. Central CA–**RL028-1**; Oklahoma City/Lawton, OK–**RL005-2**; Orlando/Daytona Beach, FL–**RL012-1**; Pittsburgh, PA/Wheeling, WV–**RL029-1**; Rochester/Syracuse, NY–**RL020-1**; San Diego, CA–**RL018-1**; Tampa/St. Petersburg, FL–**RL004-2**; Toledo, OH–**RL002-3**. New editions are being added monthly. For an area not shown above call Fox at 800-543-7892. In Ohio call 800-621-2513.

NEW! Regency® HX1500-GR

List price $369.95/CE **price $239.95**
11-Band, 55 Channel • Handheld/Portable Search • Lockout • Priority • Bank Select Sidelit liquid crystal display • EAROM Memory Direct Channel Access Feature • Scan delay
Bands: 29-54, 118-136, 144-174, 406-420, 440-512 MHz.
The new handheld *Regency* HX1500 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 55 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Includes belt clip, flexible antenna and earphone. Operates on 8 1.2 Volt rechargeable Ni-cad batteries (not included). Be sure to order batteries and battery charger from accessory list in this ad.

Bearcat® 100XL-GR

List price $349.95/CE **price $203.95/SPECIAL**
9-Band, 16 Channel • Priority • Scan Delay Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1⅜" x 7½" x 2⅞." The *Bearcat* 100XL has wide frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the AM aircraft band, the 2-meter and 70 cm. amateur bands, *plus* military and federal government frequencies. Wow...what a scanner!

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

Bearcat® 210XW-GR

List price $339.95/CE **price $209.95/SPECIAL**
8-Band, 20 Channel • No-crystal scanner Automatic Weather • Search/Scan • AC/DC
Frequency range: 30-50, 136-174, 406-512 MHz.
The new Bearcat 210XW is an advanced third generation scanner with great performance at a low CE price.

NEW! Bearcat® 145XL-GR

List price $179.95/CE **price $102.95/SPECIAL**
10 Band, 16 channel • AC/DC • Instant Weather
Frequency range: 29-54, 136-174, 420-512 MHz.
The *Bearcat* 145XL makes a great first scanner. Its low cost and high performance lets you hear all the action with the touch of a key. Order your scanner from CE today.

TEST ANY SCANNER

Test any scanner purchased from **Communications Electronics™** for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in original condition with all parts in 31 days, for a prompt refund (less shipping/handling charges and rebate credits).

NEW! Bearcat® 800XLT-GR

List price $499.95/CE **price $317.95**
12-Band, 40 Channel • No-crystal scanner Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz.
The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

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TSG-GR "Top Secret" Registry of U.S. Govt. Freq.	$14.95
TIC-GR Techniques for Intercepting Comm.	$14.95
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USAK-GR ¾" hole mount VHF/UHF ant. w/ 17' cable	$35.95
USATLM-GR Trunk lip mount VHF/UHF antenna	$35.95

Add $3.00 shipping for all *accessories* ordered at the same time.
Add $12.00 shipping per shortwave receiver.
Add $7.00 shipping per scanner and $3.00 per antenna.

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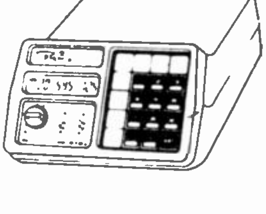

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CIRCLE 79 ON FREE INFORMATION CARD

WHAT'S NEWS

Three firms team up to manufacture custom IC's

RCA and Sharp have signed a five-year agreement with Waferscale Inc., on manufacturing and technology of customer-specified, highly-integrated semiconductor components. The bulk of the development will be in *A*pplication-*S*pecific *I*ntegrated *C*ircuits, or ASIC's. Those are circuits tailored to perform a customer-specified set of functions.

A particularly promising ASIC design method, and the one on which the three companies will focus their joint efforts, is the "cell library" approach, in which a *C*omputer-*A*ided *D*esign (CAD) system modularly configures a custom circuit from pre-designed circuit function blocks called "cells."

As part of the agreement, RCA/Sharp Electronics has acquired about 7 percent of the stock of Waferscale and will be represented on its board of directors.

Voice forward systems to take over in offices?

Voice store and forward (VSF) devices may change office procedures in the next few years, by permitting sender and receiver of a telephone message to communicate asynchronously, suggests international market-research firm Frost & Sullivan. In VSF, the sender's voice is digitized and stored on magnetic disk. When the receiver is ready to take the message, it is loaded into the machines's memory, restored to analog form and played back at the listener's phone.

Though one telephone answering machine is cheaper than one VSF, the VSF machine can support a whole office, serving hundreds of users at an average cost that's much lower than that of individual tape answering machines.

FCC proposes 1605–1705-kHz guidelines

The FCC recommends that the United States submit two proposals to the upcoming International Telecommunications Union administrative radio conference in regard to the use of the expanded AM broadcast band (1605–1705 kHz) in the western hemisphere. Those proposals are that allotment planning be used and that station power be limited to 10 kW.

Allotment planning has several advantages over its alternative, assignment planning. In assignment planning each signatory country must submit its complete and detailed requirements, pinpointing each prospective station and stating power, antenna systems, and other characteristics for each. Under allotment planning, designated frequencies are made available for designated areas. Although the allotment of frequencies is based on the presumption of stations with presumed characteristics within presumed areas, the signatories are not bound to follow exact details. However, any departures from the plan must not increase interference to the services of other signatories.

As to the proposed power limit, the Commission believes that 10 kW provides for adequate service range, while making it possible to have enough stations to meet the requirements of the area.

New polymer material simulates body tissue

Scientists of the National Bureau of Standards report the development of a new material that acts like living body tissues when exposed to the electromagnetic waves produced by certain medical instruments.

That substitute for living muscle marks a great step ahead for research by the Food and Drug Administration. The FDA will use the new material to evaluate the heating patterns of devices used to generate the electromagnetic waves that heat body tissues for physical therapy, rewarm bodies after low-temperature surgery, and treat certain types of cancers.

The new substance will provide the FDA with a more stable research material, having a longer shelf life than currently available polymers. The FDA also will place the new NBS "phantom flesh" in test kits for the National Cancer Institute and others to use in checking the quality assurance of their medical devices.

Asian TV sets and tubes are "dumped" on U.S. market

Jerry Pearlman, Zenith chairman and president, speaking at the annual shareholders meeting, condemned the "unfair and largely illegal" trade practices of Japanese, Korean, Taiwanese, and other Far-Eastern manufacturers of television sets.

Japanese TV manufacturers have been operating under a U.S. dumping finding since 1971. In 1984, Korean and Taiwanese manufacturers were also found guilty of dumping. To avoid dumping penalties, Far-Eastern producers have been shifting their exports from fully assembled TV sets to kits, including picture tubes and electronics. Those kits can be simply "snapped together" at the exporter's U.S. warehouses. Picture tubes are also being dumped directly at less than their fair-market price, Mr. Pearlman said.

Zenith asks that the government investigate those cases and take action against Far-Eastern manufacturers. The company is encouraged by bills seeking to stop unfair import practices; those bills have been initiated in both the House and Senate. **R-E**

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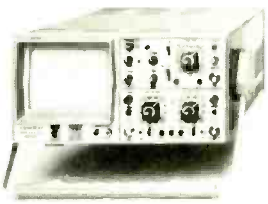
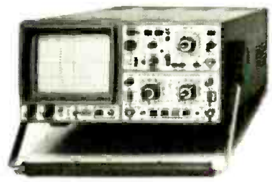


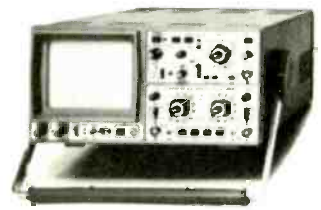
HM 203-6 DC to 20MHz **$489.00**

- **Rectangular screen, internal graticule 8x10cm.**
- **Deflection:** 5mV/cm to 20V/cm
- **Timebase:** 0.5us/cm to 0.2s/cm X-Magnification x 10
- **Component Tester**
  Test voltage: max. 8.5Vrms (open circuit)
  Test current: max. 24mA rms (shorted)



HM 204-2 DC to 20MHz **$629.00**

- **Component Tester**
- **Deflection:** 5mV/cm to 20V/cm Y-Magnification x 5
- **Timebase:** 0.1 us/cm to 0.5s/cm X-Magnification x 10
- **Sweep delay:** 100 ns to 0.1 s.
- **Calibrator:** square-wave generator, ≈1 kHz/1MHz switchable, risetime<5ns, for probe compensation, output voltages: 0.2V and 2V ± 1%.



HM 605 DC to 60 MHz **$899.00**

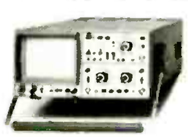
- **Component Tester**
- **Deflection:** 5mV/cm to 20V/cm Y-Magnification x 5
- **Y-Output from Ch.I or Ch.II:** ≈45 mV/cm into 50Ω.
- **Timebase:** 50ns/cm to 1 s/cm X-Magnification x 10
- **Sweep delay:** 100ns to 0.1s.

HM 205 **$799.00**

Real-time - See 203-6 Specifications

Digital Storage

- **Operating modes:** Refresh and Single with Reset (Incl. LED Indication for Ready), Hold Ch.I, Hold Ch.II. 1024x8 bit for each chan. Sample rate: max. 100kHz. Resolution: vertical **28 pts/cm**, horiz. **100 pts/cm**.
- **Option:** Interface for plotter.
- **Component Tester**

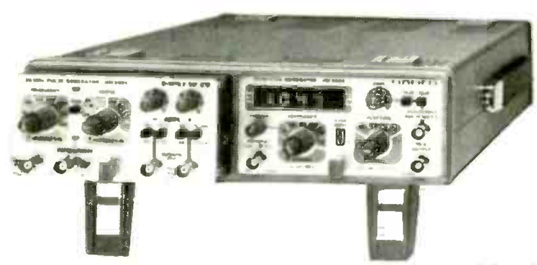


HM 208 **$2,380.00**
HM 208-1 **$2,860.00**
(with IEEE Interface)

Real-time - See 203-6 Specifications

Digital Storage

- **Operating modes:** XY, Roll, Refresh, Single (LED ind.), Hold Ch.I, Hold Ch.II, Plot I and Plot II with read-out check on screen, backing storage, **Dot Joining** button. **2 x 1024 x 8bit** for each ch. Sample rate: **max. 20MHz**. Resolution: vert. **28 pts/cm**, horiz. **200** or **100 pts/cm**.
- **Plotter output:** vertical 0.1V/cm, horizontal 0.1V/cm. Output imped.: 100Ω each. Penlift: TTL/CMOS compat. Output speed rate: 5-10-20/10-20-40 s/cm.
- **Option:** Lithium battery for memory backup.



Modular System 8000

ATTACHES TO ALL HAMEG SCOPES ON THIS PAGE!

HM 8001	2 BAY Mainframe	$228.00
HM 8002	4 BAY Mainframe	call SOON
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HM 8014	Milli Ohm Meter	298.00
HM 8021-2	Counter, 0.1Hz-1GHz	324.00
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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Universal remote control.** Recently, one of the big features in many home-entertainment lines has been the unified remote-control, a unit that is capable of operating both a TV and a VCR—assuming both are made by the same manufacturer. The rub is that most people own TV sets and VCR's made by different manufacturers. GE introduced one solution last year when it marketed its programmable remote. That unit lets you operate several different pieces of equipment using just a single remote control; the GE remote "learns" the code used by your different infra-red remote control systems in just a few simple steps.

Now North American Philips has introduced a "universal remote" as standard equipment with most remote-control TV sets in its Magnavox, Sylvania, and Philco lines. That remote is pre-programmed with infrared codes for 29 different brands of VCR's (in addition to the brand of TV set with which it is sold). The user merely aims the remote at his VCR, simultaneously presses two buttons, and the remote-control unit starts to sequence through all of its built-in program codes. When it finds the right one and the VCR starts to change channels, the user merely releases the two buttons, and from then on the remote will control the VCR as well as the TV set. A more deluxe unit is also pre-programmed to operate with 15 different brands of remote-control cable-TV converters.

• **And Philips makes four.** Speaking of North American Philips, the illustrious worldwide Philips brandname will soon appear on some consumer electronics products in the U.S. Beginning in 1987, the company will affix that name to a new line of audiophile and videophile products, giving the company a fourth trade-name here and finally giving the Philips name visibility in the U.S. (Faithful audio fans will recall the Philips name was used on turntables and loudspeakers here several years ago.) In the early days of radio, the Philips name was kept out of this country because of the possibility that it would infringe on the name Philco. Now North American Philips owns the Philco trade name.

• **Big, bigger, biggest.** That sequence, applied to color picture tubes, might refer to 27, 35, and 40 inches. The 35-inch tube was recently introduced by Mitsubishi and is featured in a $3,300 color set. So encouraged has Mitsubishi become with the idea of large direct-view picture tubes that it plans to introduce a 40-inch color monitor-receiver priced at $9,000 to $12,000 in Japan.

Although the big tube is new, the idea isn't. In the 1950's, the late TV-pioneer Dr. Allen B. DuMont proposed theater-sized direct-view monochrome tubes with diagonal measures approaching 10 or 11 feet.

• **Flat is flat.** There has been a lot of discussion in the last couple of years about "flat faced" picture tubes. Toshiba's former Flat Square Tube was recently renamed Flattest Square Tube. Now it will have to be renamed something else, because Zenith has introduced a color picture tube whose face is flat, period. So flat, in fact, that a sheet of window glass can be used for implosion protection. The secret of Zenith's new FTM tube is a *F*lat *T*ension *M*ask, which gives the tube its name. Instead of the normal domed shadow mask, the new tube has a thin foil shadow mask stretched flat, held under tension and sealed into the glass just behind the faceplate. Unlike conventional shadow masks which can expand and shift with heat, Zenith says the stretched mask doesn't move at all under most conditions, even at brightness that can cause distortion or wrong colors in conventional tubes.

Also, because the face is flat, it inherently is less reflective. Thus an image on the tube appears similar to a slide viewed on a screen or in a viewer. The first FTM tube, available by the middle of 1987, will be a 14-inch ultra-high-resolution computer display, but future versions are expected for TV and all other CRT applications. Zenith says its cost involves a "very modest" premium over conventional tubes. **R-E**

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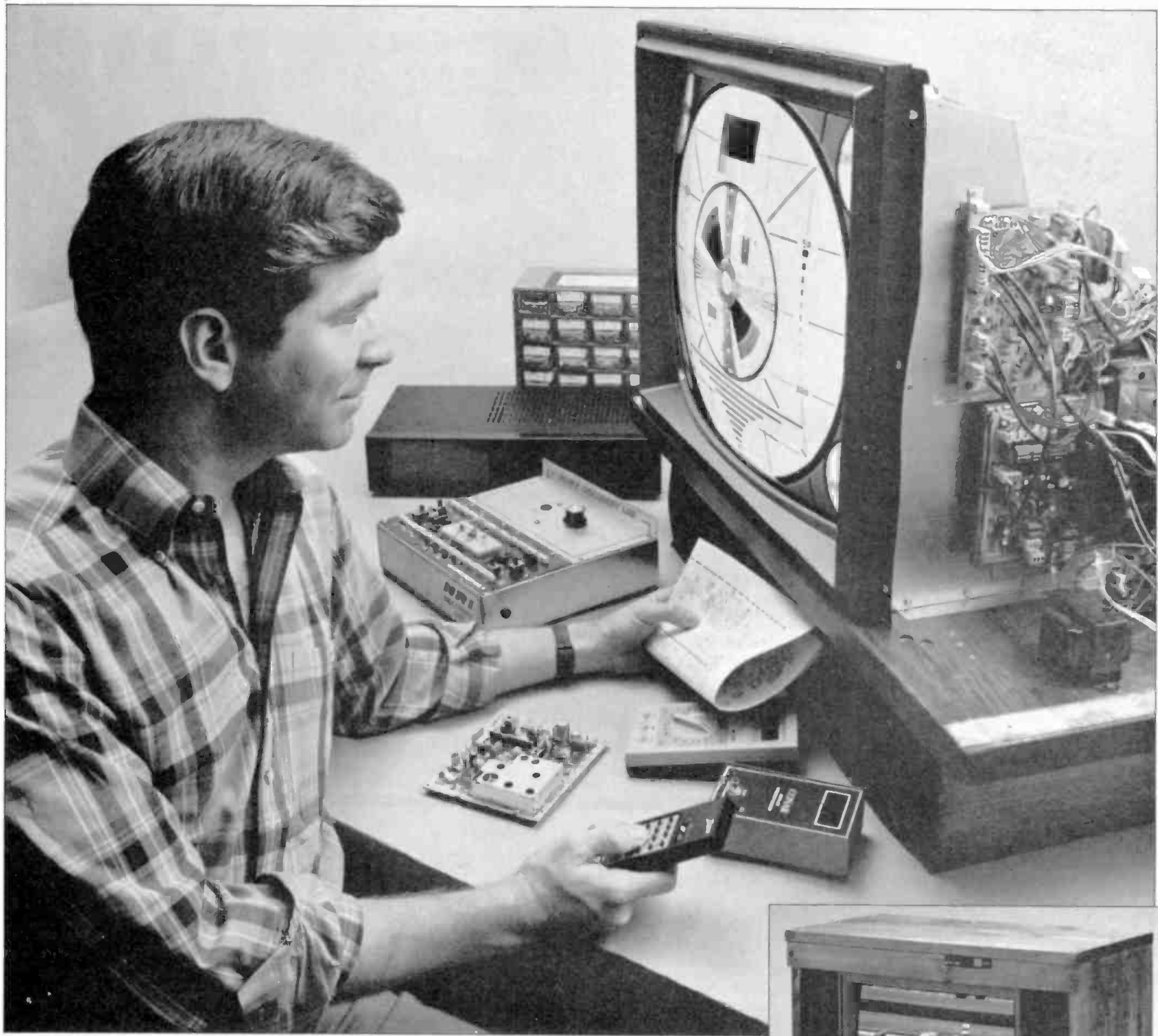

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Now at $26 billion in annual sales, the consumer electronics industry is creating a whole new servicing, installation, and repair market. This year, TV sales alone are expected to hit 16.2 *million* units. Every day, sales of home VCRs, a product barely conceived of 10 years ago, reach 20,000 units. Every day!

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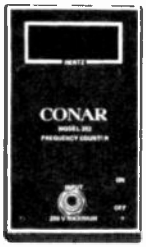

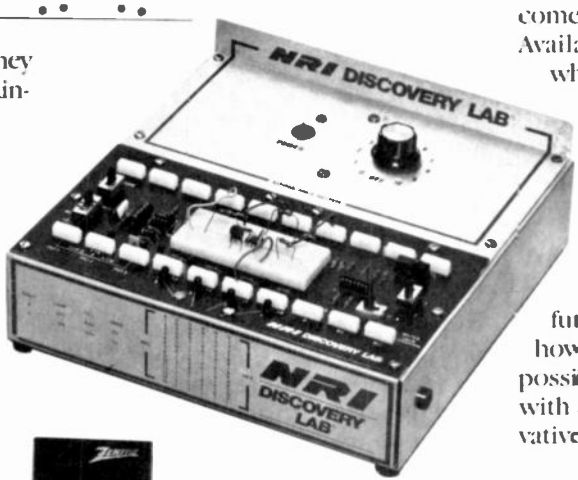

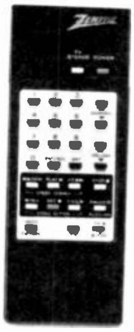

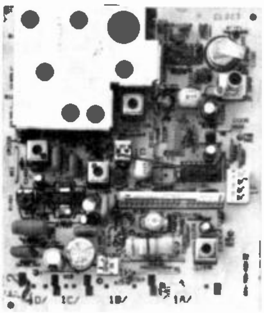

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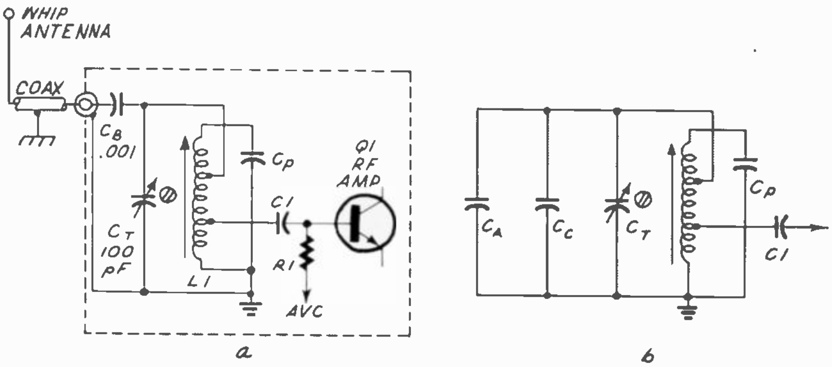

FIG. 1

TRIMMING AM AUTO RADIO

Recently, I replaced the AM radio in my car with an AM/FM stereo model and installed a new antenna designed for AM/FM operation. FM performance is fine, but AM reception is miserable and doesn't compare with that of the set it replaced. Sensitivity is low, selectivity is poor, and there is a great deal of cross-talk from co-channel and adjacent-channel stations. What's wrong? Is there a defect in the AM section of the radio, or is the trouble in the installation?--R. U. P., Long Beach, CA

Figure 1-*a* shows a typical automotive AM antenna input circuit. A small padder capacitor, C_P, is connected across the coil, which is permeability tuned. That capacitor, along with stray circuit capacitance, ensures high selectivity.

The highest frequency is tuned when the slug (the powdered-iron or ferrite core) is out of the coil; tuned frequency decreases as the core moves into the coil. The inductance of the coil is chosen so that the coil can be tuned to the highest frequency (1550 or 1600 kHz) by adjusting a trimmer.

The antenna is connected to a tap on the high (i. e., high-impedance) end of the antenna coil through a shielded cable and a DC-blocking capacitor, C_B. A trimmer capacitor, C_T, is connected between the tap and ground.

Figure 1-*b* shows how various stray capacitances must be considered part of the circuit. Capacitor C_A represents the capacitance between the antenna and the body of the car, and C_C is the capacitance of the shielded connecting cable. Blocking capacitor C_B is not shown because it is effectively in series with C_t and, because it is much larger than C_A and C_C, can be ignored. Note that C_A and C_C affect the resonant frequency of the circuit; their effect is most pronounced at high frequencies.

When a new antenna is installed (or the radio is replaced), trimmer C_T must be adjusted. Use a service manual, the manufacturer's instructions, or, lacking those, follow this procedure:

1. Extend the antenna to full length.

2. Tune in a weak station between 1200 and 1500 kHz.

3. Adjust the volume control for maximum output.

4. Locate C_T. You can usually adjust it through a hole in the case near the antenna's input jack.

5. Use a non-conductive alignment tool and adjust the trimmer for maximum output, as heard through the speaker. If you can't tune in a signal at the high-frequency end of the band, adjust the trimmer for maximum background noise. Now, assuming your radio has no other problems, reception should be drastically improved.

Here's a cheap-and-dirty trick you can use to check alignment. Tune in a weak high-end station and turn up the volume. While standing on dry ground, grasp the antenna near the tip. If the volume drops, alignment of the antenna-circuit is probably OK. The reason is that you are detuning the circuit by adding capacitance between the antenna and the car body.

FLUORESCENT LIGHTS

How does a fluorescent lamp work? I know that it usually needs a ballast and a starter, but I can't find any information on its principles of operation.—D. A.

A good article on the subject appeared in the March 1976 issue of *Popular Mechanics*. The article is called "What You Should Know About Fluorescent Lamps;" it appears beginning on page 120 of that issue. Your local library may have that issue on file, or it may be able to borrow a copy for you from another library.

Another good source of information is the booklet *Fluorescent Lamps* (TP-111R, Dec. 1978), published by General Electric Company, Lamp Products Division. You may be able to get a copy of that booklet from General Electric, Lighting Business Group, Nela Park, Cleveland, OH 44112. **R-E**

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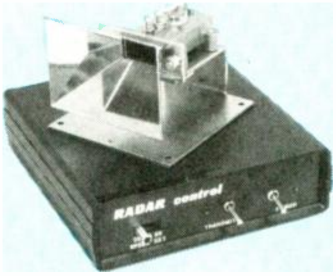
LETTERS

SPEED-GUN CALIBRATOR

The address of the parts supplier for the speed-gun calibrator was listed incorrectly in the Parts List ("Build This Radar Speed-Gun Calibrator," **Radio-Electronics**, August 1986). The correct address is: Microwave Control, 1701 Broadway, Suite 263, Vancouver WA 98663. Microwave Control can be reached by telephone at 1-206-693-6843.



LARGE TESLA COILS

First, I would like to say that I enjoy **Radio-Electronics**. It has something for everybody, and your articles are both informative and interesting. I especially like Jack Darr's "Service Clinic" and the "Antique Radios" department.

Now I have a couple of questions. I am interested in large Tesla coils—the RF oscillator type, not especially the spark gap. Could you feature an article on that subject, or could you tell me a source of article reprints or construction plans in that area?

Also, I think that other readers also might like to see schematics of antique radios presented in the "Antique Radio" department. That should help us to restore old sets.

NOLAN F. SMITH
Fayetteville, NC

THE REGENCY *MX-7000*

I have been the proud owner of a Regency *MX-7000* for quite some time now, and want to expand on the review it received in the May 1986 **Radio-Electronics**. There are several points that require correction and also a very important aspect of that unit that was not mentioned.

The *MX-7000* was somewhat underestimated by your review, even though what was described would be enough to put it at the top of the list. For instance, the top-end frequency coverage is specified to 1.2 GHz, not just 1.1, and actually the processor will allow it to be programmed up to 1.3 GHz. No doubt, the performance at 1.3 GHz is not great, but it should be interesting to the amateur radio community, which is seeing an increase in FM repeater activity in that range. In addition, the unit has selectable delay and search-frequency increments.

I think that the search-frequency increment selection was misquoted as selectable bandwidth, which it is not. It is, however, very important to be able to search in 5, 12.5, or 25 kHz steps, depending on the service of primary interest. As for variable bandwidth, the unit operates in three different modes, each of which has a bandwidth appropriate for that mode.

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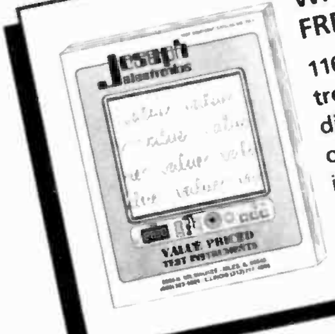

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Of some interest is the ability to listen to broadcast FM transmissions between 88 and 108 MHz. I have a feeling that, for some prospective buyers, that single fact may be enough to allow some strain on the budget. Needless to say, the *MX-7000* is quite a radio and is worthy of consideration by the serious user.

A couple of quick points: The article noted that the BNC connector on the back of the *MX-7000* is more secure than the connectors normally found on monitor radios. That's true, but there's an even more significant reason for its use. The Motorola-type connectors (and, for that matter, the so-called UHF connectors) become inadequate at higher frequencies. A BNC connector is what is called a "constant impedance" connector. That means that it exhibits the same electrical properties as the transmission line, and results in a more efficient signal transfer. I can vouch for that through experience with the 450-MHz ham band, where using a UHF-type barrel connector between two cables will do serious damage to your SWR. When operating at near microwave frequencies (0.8 to 1.3 GHz) the effect would be very substantial.

Second point: In looking at the frequencies that are stored in the 20 memory channels, it appears that they are more likely for testing and adjustment of the unit. Trying to assume which frequencies—of over 200,000 possibilities—are going to be popular may be a bit presumptuous.

I regret to say that one quality of the *MX-7000* is not so admirable: the sluggish way in which it gets around to doing things. No doubt the microprocessor (mounted on the back of the front panel) is very busy, but the speed at which it operates is responsible for the lack of crisp response that one should get from the keypad and for the somewhat lethargic scanning speed. Fortunately, the manufacturer decided not to use a crystal-based clock, and that gives the user an opportunity to find out just how fast this thing really can go. The resistor marked R6 on the back of the front-panel assembly is part of an R/C time-constant circuit which sets the processor's clock speed; its value can be changed easily. I found a value of 39K suitable for my unit.

Unfortunately, it has been a while since I changed that part, and I'm not sure of its original value—but there is a substantial increase in speed. To make installation of the new resistor easier, I didn't bother to desolder the leads of the old resistor; I simply clipped off the old one near the board and tacked the new one on.

The performance increase using the new value effectively eliminates the *MX-7000's* single limitation. Most likely, the manufacturer was trying to be conservative in selecting the processor speed to ensure reliable operation throughout the temperature specification. In reality, most users would not subject it to such extremes, and in any case would be unable to vary the value of R6 should erratic operation occur. As for my unit, it has been in our van through all sorts of environmental conditions and hasn't burped once.

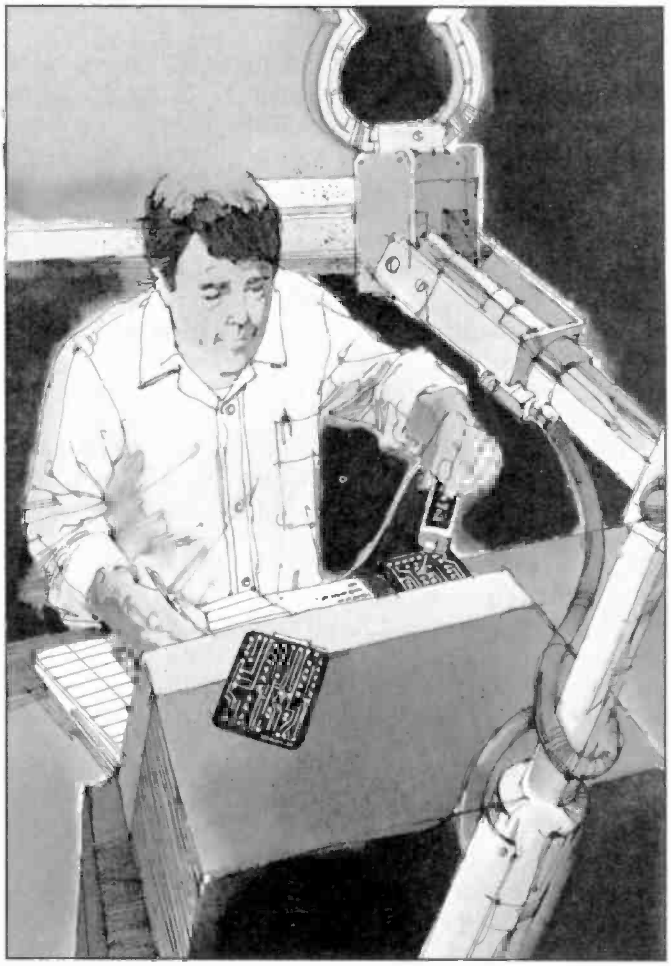
Final note: While the price may seem a bit high, there are outlets who sell the *MX-7000* at a very competitive price. As an example one of your advertisers sells that unit for under $400.00. At that price, considering the advanced functionality, and with the change in clock speed, the Regency *MX-7000* graduates with high honors.

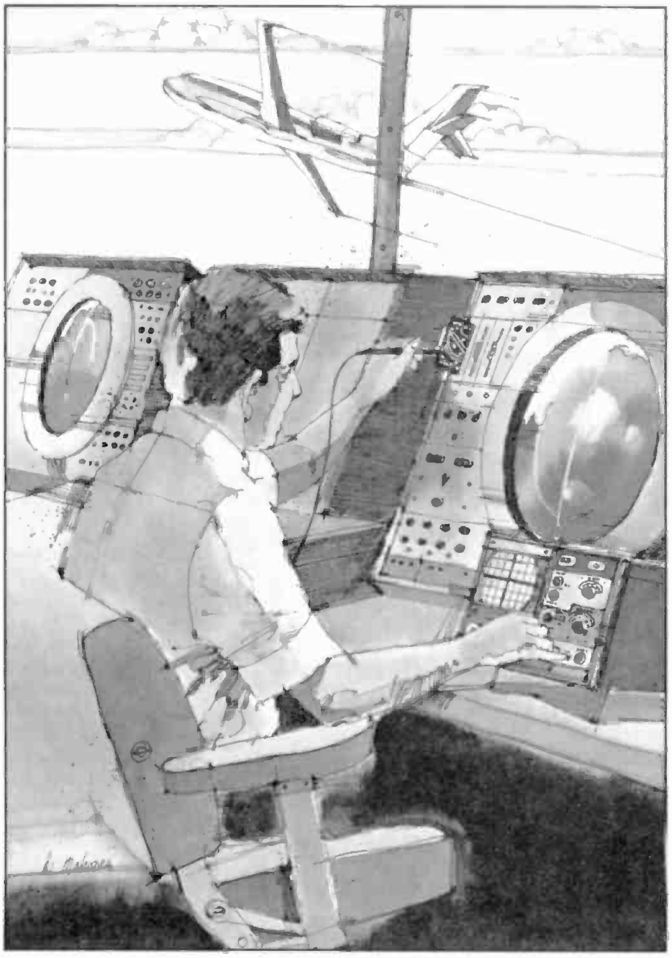
CHARLES P. SCOTT
Mt. Sterling, KY

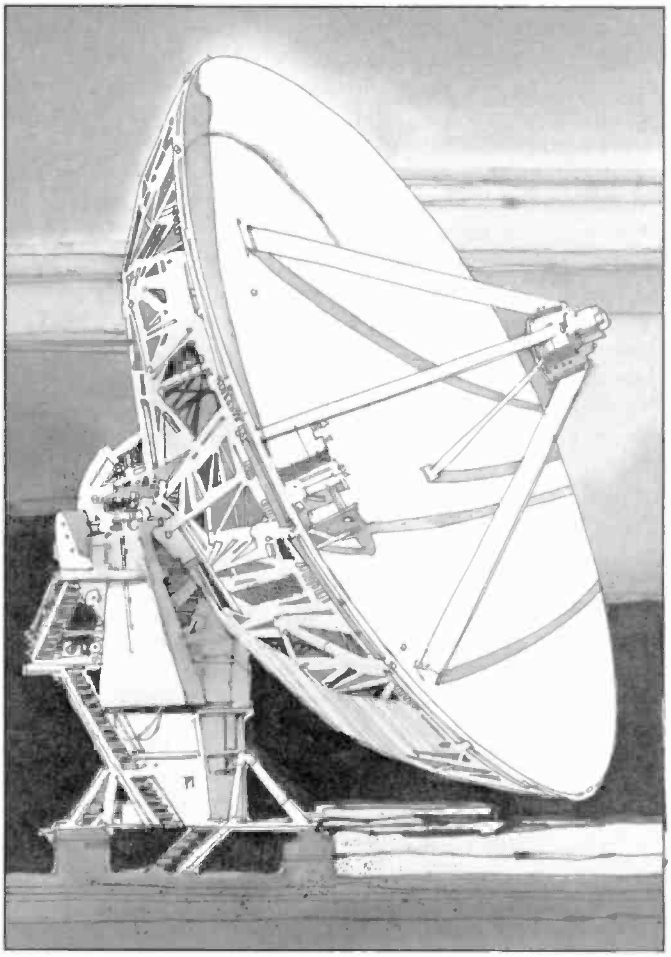
VOLTAGE COMPARATORS

I have just read the article on the care and feeding of voltage comparators in the June, 1986 **Radio-Electronics**, and am impressed with the range of circuits and applications available. However, I find one of the circuits a bit less than impressive, due to two rather well-hidden flaws that will prevent its being useful for its intended purpose.

The circuit in question is the one shown in Fig. 16. That circuit is intended to be a "micro-power" circuit by virtue of applying power to the sensing and control circuit for a very small fraction of the time. The first problem with that ap-







proach is that the sample-pulse generator, which determines how long the main control-circuit is powered, must itself be powered continuously in order to work. That flaw, perhaps, is not so bad, since presumably the sample-pulse generator could be built out of CMOS components and draw minimal power.

A much worse difficulty arises from the fact that, when the controller determines that power must be applied to the load, the *relay* will draw considerable power, regardless of how low the drain of the control circuit is. Thus, the overall circuit is truly micropowered only if the load is never turned on! But in that case, who needs a control circuit?

HOWARD MARK
Suffern, NY

OOOOPS!

Several errors crept into the article, "Build This Little Leakage Checker," which appeared in the May 1986 issue. In the Parts List on page 56 and the schematic on page 57, C3 should be 0.0022 µF, polyester. Resistor R22 in the schematic should be 249K; it is shown correctly in the Parts List. Switch S1-b is shown incorrectly in the schematic; it should complete the discharge path to ground as shown in the block diagram on page 56.

In the parts-placement diagram on page 58, capacitor C7, which is located between Q1 and R5, should be C2 (0.1 µF). Near IC3, R15 should be R4 (270 ohms). And the locations of D11 and R14 are transposed, as are the locations of D12 and R13.

GARY McCLELLAN

BI-POLAR POWER SUPPLY

Regarding the bi-polar power supply shown on page 9 of the May 1986 **Radio-Electronics,** I hope that N. J. S. did not build the supply and try to use it for his project. Two errors make the project unworkable. The center tap of T1 should go (only) to the junction of C1 and C2; that point is circuit ground. In addition, the junction of D1 and D2 should go (only) to the negative side of C2. That is the negative nine-volt output of the circuit.

Rather than using individual IN4001 diodes, a fullwave bridge rectifier, such as Radio-Shack catalog number 276-1151, could be used. It costs only pennies more, is rated 50PIV, 1.5 amps, and is small. The whole unit is built into one of Radio-Shack's plastic enclosures. The size of the case depends on the size of the transformer used. Output terminals are used for easy connection. It makes a nice, neat package when used in conjunction with 35-volt radial-type capacitors.

I hope that N. J. S. can use the corrected circuit to full advantage now.

WILLIAM N. BROOKS
Henrietta, NY

KIRLIAN PHOTOGRAPHS

The article, "How to Make Kirlian Photographs," which appeared in the May 1986 **Radio-Electronics,** has done a disservice to your readership and to science by

continued on page 87

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WP-706A	0-25v/2a	327.00
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WP-709	5or13v,7.5a	329.00
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B&K DYNASCAN		
1803	100MHZ	149.00
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MAX-100A	100MHZ	99.00
6000	650MHZ	379.00

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TFC-1214	650MHZ	395.00
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EQUIPMENT REPORTS

Soar Model 3430 DMM

A 4½-digit meter with all the bells and whistles

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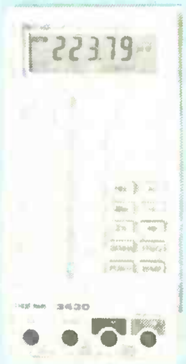


FOR MOST OF US, SELECTING A DMM boils down to a process of weighing which features we need or want against the price of the instrument. Often, we wind up doing without some of the features we would like because a DMM without some of the bells and whistles is better than no DMM at all.

But for a select few such compromises are not acceptable. The reason is not ego, but a genuine need for a full-featured, highly accurate unit for aligning or trou-

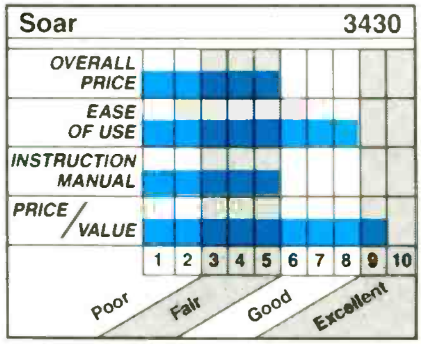
bleshooting sophisticated electronics gear. The Soar (1126 Cornell Ave., Cherry Hill, NJ 08002) model *3430* is a DMM designed with those users in mind. As a bonus, considering its features, the unit is a bargain; just a few years ago, it would easily have cost many times more.

The model *3430*

The model *3430* is a microprocessor-controlled, true rms-reading, 4½-digit DMM. It features 13 functions, and either AUTO or MANUAL ranging modes can be selected at the press of a button.

Unlike conventional DMM's that are 20,000-count units, the *3430* is a 25,000-count instrument. That allows for full 4½-digit resolution to the second decimal place. For example, 0.1-volt resolutions are possible on the 1000-volt DC range and 1-kilohm resolutions are possible on the 25-megohm range. At the other end of the scale, quantities as low as 10 μV and 0.01-ohms can be read.

Turning first to the standard functions, the meter can measure AC and DC voltages over 5 ranges from 250-mV to 1000-volts (750-volts AC) full-scale. Accuracies on the DC ranges are specified as 0.05% ± 2 digits or better. On the AC ranges accuracy is 0.5% ± 2 digits on all ranges except 750 volts, where it is 1% ± 2 digits.



Resistance is measured over 6 ranges from 250 ohms to 25 megohms full-scale. Accuracies are specified as 0.06% ± 2 digits ± 0.02 ohms on the 250-ohm range; 0.06% ± 2 digits on the 2500-, 25,000-, and 250,000-ohm ranges; 0.5% ± 2 digits on the 2500 kilohm range, and 2% ± 3 digits on the 25-megohm range.

The unit measures AC and DC current over two ranges, 250-mA and 10-amps full-scale. Accuracies are 0.25% ± 2 digits (250-mA DC), 1% ± 2 digits (10-amps DC), 0.75% ± 10 digits (250-mA AC), and 2% ± 10 digits (10-amps AC).

All ranges and functions, except the 10-amp range, are overload protected.

Special functions

The *3430* also has a host of special functions. Those so-called bells-and-whistles quickly become indispensable when you've become accustomed to using them. Note that while many other meters have some of these functions, few have integrated as many as the *3430* in one unit.

CONTINUITY CHECK and DIODE TEST functions have now become commonplace. Thay even can be found on some low-end instruments. Both functions are, of course, present here. They work as you would expect, and the CONTINUITY-TEST function has the requisite audible indicator.

More interesting are the PEAK HOLD and DATA HOLD functions. Those will freeze either a high reading or a current reading on the display. The PEAK-HOLD function will work only when the meter is in the manual mode and only for AC and DC voltage, AC and DC current, and temperature (more on that in a moment). Further, it will capture any transitory reading that has a duration of greater than 5 ms.

Since we've already alluded to it, let's next turn to the TEMPERATURE function. The meter, through a standard k-type thermocouple (not included, but available as an accessory), can measure temperature and display the result in either °C or °F. The measuring range is −50°C to 1200°C or −58°F to 2192°F. Accuracies are 0.5% ± 3 digits (°C) and 0.5% ± 5 digits (°F).

Relative voltages can be displayed using the DBM function. In that function, all readings are referenced to 0 dBm (0.7746-volts rms at 600 ohms, 1 mW).

A REL or relative function relates all subsequent measurements to an input reference. That function can only be selected when the meter is in the manual mode and will work on AC and DC current and voltage ranges as well as on the resistance range.

One disadvantage of a 4½-digit meter such as this one is that it takes a relatively long time to obtain a reading. Maximum response times can range from one to as many as eight seconds. For instances where speed is more important than a high degree of accuracy, the meter can be placed in a 3½-digit mode. In that mode, the least significant display digit is blanked and response times are significantly shortened.

Last, but certainly not least, the *3430* features a FREQUENCY mode. In that mode, the meter acts as a 100-kHz (actually, a 99.999-kHz) frequency counter. Accuracy is specified as 0.05% of reading and resolutions as high as 0.001 Hz are possible.

Odds and ends

The large LCD readout is capable of displaying a full range of annunciators. In addition to showing range, function, etc., such conditions as overvoltage and low battery are clearly indicated when appropriate. The input connectors are of the recessed safety type.

All functions and modes are selected using a front-panel keypad. Operation in both AUTO and MANUAL modes is simple and straightforward.

Battery life is estimated to be 100 hours with alkaline units. An optional AC adapter is available also.

The instruction manual is nothing special. To make things worse, because of a poor translation job (both the manual, and the meter were produced in Japan) it takes quite a bit of effort to get the most out of the manual and hence the meter.

But don't let that stand between you and this outstanding instrument. At $339.00, the model *3430* is the answer to many a technician's wish list. **R-E**

continued on page 32

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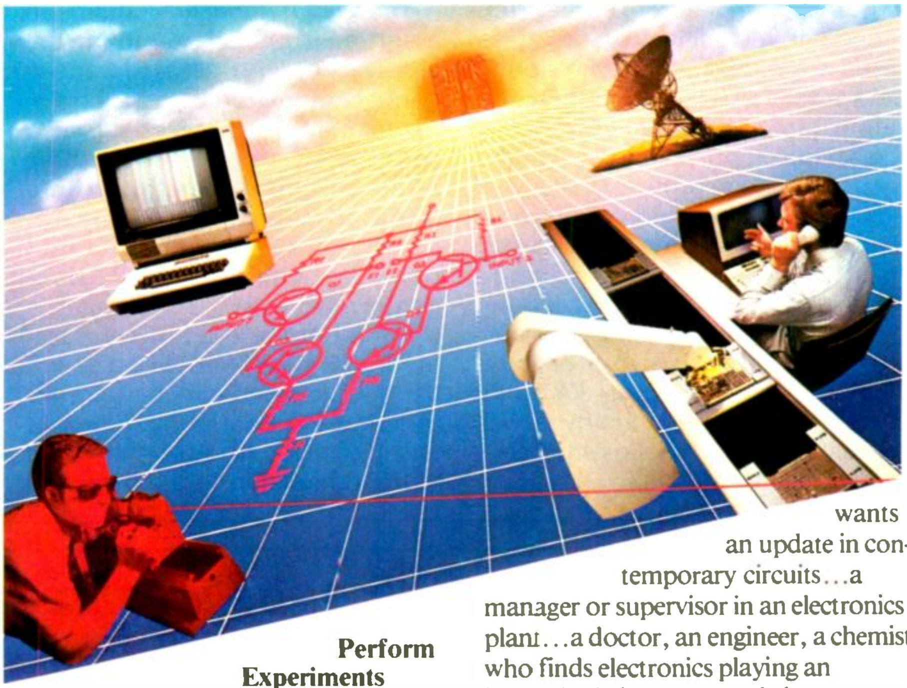

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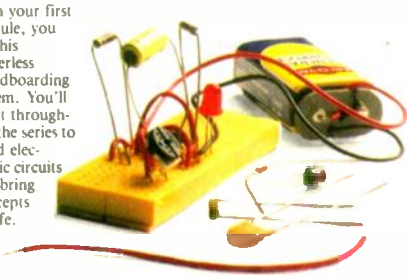

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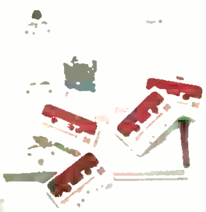

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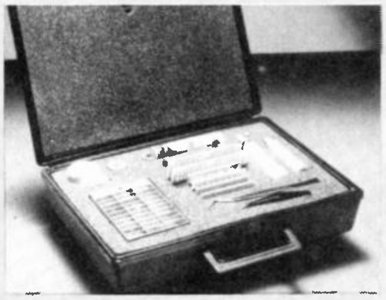


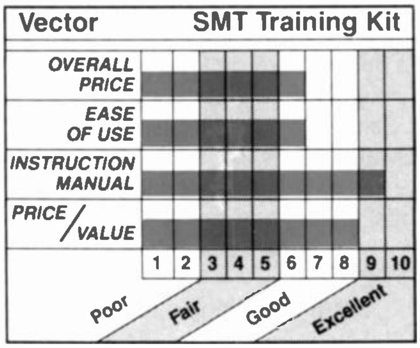
CIRCLE 10 ON FREE INFORMATION CARD

WHETHER YOU ARE AN ELECTRONICS engineer, technician, or, perhaps, even a hobbyist, you're no doubt aware that Surface Mount Technology (or SMT) is becoming increasingly important in the fight to cram more circuitry into a given space. It's important for anyone with an eye on the future to get hands-on experience with surface-mount devices. We recently examined what we think is a superb way to get that experience: the *SMT2000 SMT Training Kit* from Vector Electronic Company (12460 Gladstone Ave., P.O. Box 4336, Sylmar, CA 91342-0336).

The *SMT Training Kit* contains an assortment of surface-mount devices, prototyping boards, interconnection materials, and a training manual. The devices supplied with the kit include almost three hundred chip capacitors, three hundred ⅛-watt, thick-film resistors, ten 1N914 diodes in SOT-23 packages, and ten 2N2222 transistors, also in SOT-23 packages.

Although there are no surface-mount IC's supplied with the kit, the double-sided epoxy-glass prototyping PC boards have tinned foil patterns to accommodate SOIC (Small Outline Integrated Circuit) and PLCC (Plastic Leaded Chip Carrier) IC's. Of course the kit also includes solder, solder paste, terminal pins, stainless steel and plastic tweezers, and conductive adhesive.

The most important part of the *SMT Training Kit*, however, is the training manual. For the most part, it is very well written. It begins



with a general description of surface mount technology and surface-mount devices, including packaging schemes and manufacturing processes. It then describes the kit and gives hints on how to use it most effectively. A SMT resource directory is included in the manual. It contains a listing of manufacturers and suppliers of SMT products.

Getting some experience

Let's look at an example of how the kit can give some practical hands-on experience. (We will assume that you have the IC's that you'll need to complete your circuit.) The first step is to plan the board layout by drawing it on the layout paper that's provided. Once that's done, you're ready to mount components. If you've never worked with surface mount devices, it can be a real learning experience. For example, since surface-mount components don't have mounting holes to hold them in place, there's no easy way to get them to stay in place while you solder them. Tack soldering works—once you get the hang of working with chip components—but it's not the easiest way. That's especially true if you're working with IC's with "J" leads, which bend in under the package. There are two compounds—solder paste and conductive adhesive—that let you get you components mounted in place reliably.

Solder paste is a mixture of tin/lead solder and flux, and there are two common ways to use it. The first is to apply the paste to the solder pads using a syringe. The other is simply to dip the component contacts into the paste. Once your components are "pasted" on the board, the real soldering begins—but not with a soldering iron!

Solder reflow is the method used to melt the solder paste. First, the entire board is pre-heated in a convection oven (85°C for about 20 minutes) to drive off undesirable volatile solvents, to lessen thermal shock to the board and its components, and to get better solder contacts. After preheating, the oven temperature is increased to about 210°C to melt the solder. Solder reflow should occur within about 30 seconds. You have to be careful and quick—electronic components cannot withstand the temperature of molten solder for very long. (If a con-

continued on page 38

New Products

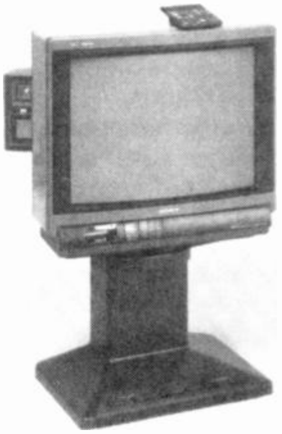
CIRCLE 30 ON FREE INFORMATION CARD

OSCILLOSCOPE INTERFACE, the model *IC-4802,* is an interface that turns the computer into a dual-trace 50-MHz storage oscilloscope with a 7-nanosecond rise time. It adds testing capabilities to any IBM PC-compatible computer, and can make a computer an integral part of any engineering workstation. The Computer Oscilloscope is available as a kit *(IC-4802)* or in assembled form *(SC04802)*.

Supplied software enables full programmability of the oscilloscope from the keyboard of the computer. The computer displays the dual traces, one for each channel, on an 8 × 10 division graticule. There are three display modes: Y1, Y2, and DUAL. All displays are chopped except for the highest time-base range, which uses an alternate display. Waveforms can be stored on a floppy disk for later use as a reference or for waveform manipulation, such as signal averaging.

The model *IC-4802* (kit) is priced at $399.00; the model *SC-4802* (assembled) costs $575.00—**Heath Company**, Benton Harbor, MI 49022.

COLOR-TV SET, the model *KV-25VXR*-is combined with an 8mm VCR that provides all standard 8mm features, including four-hour recording (on a P6-120 videocassette), as well as digital audio-stereo recording capability and a new head design for a noiseless still picture.



CIRCLE 31 ON FREE INFORMATION CARD

The deck shares a 181-channel cable-compatible tuner/timer with the TV set for recording regular TV and cable programs for later playback. It can be programmed up to three weeks in advance to record as many as four programs off the air automatically. Nineteen step-by-step on-screen displays, such as "Timer has not been set," and "Please insert a tape," make the programming procedure almost foolproof.

The TV set itself is a 27-inch screen model and features a digital picture-in-picture (PIP) capability. PIP allows users to watch one channel while also displaying a small image of another channel in a corner of the screen.

The model *KV-25VXR* has a suggested retail price of approximately $2200.00.—**Sony Corporation of America,** Sony Drive, Park Ridge, NJ 07656.

STEREO HEADPHONES, the model *ATH-M7 PRO,* is a moving-coil device with extended frequency response and distortion-free sound through a combination of design features that include a self-supporting voice coil, and a low-mass, high-compliance diaphragm. A tangential surround ensures linear diaphragm motion.

CIRCLE 32 ON FREE INFORMATION CARD

A soft, semi-elastic pad on each earpiece provides a seal against ambient noise without exerting undue pressure. The frequency response is essentially flat over a 20–20,000 Hz range. A padded headband and adjustable side extensions permit a precise, self-adjusting fit.

The model *ATH-M7 PRO* is priced at $99.95.—**Audio-Technica U. S., Inc.**, 1221 Commerce Drive, Stow, OH 44224.

DC POWER SUPPLY, the model *1630*, features regulated voltage and current outputs that can supply a maximum of 30 volts and 3 amps respectively. In addition, the model *1630*, has built-in metering; two current ranges; a pre-regulator to limit internal dissipation; isolated outputs so that either polarity may be floated or grounded; and reverse-polarity protection to prevent damage to the power supply from an external voltage or a reversed polarity input.

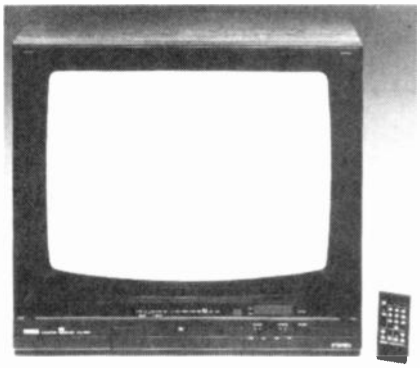
CIRCLE 33 ON FREE INFORMATION CARD

It also has fully-adjustable current limiting (from 5% to 100% of maximum output current) that protects the circuit under test and the power supply. The model *1630* can be hooked up in series or in parallel with another model *1630* for 0–30-volt, 6-amp, or 0–60-volt, 3-amp operation.

The model *1630* comes with test leads, spare fuse, schematic and parts list, and complete instruction manual. It is priced at $225.00.—**B&K Precision, Dynascan Corporation,** 6460 West cortland Street, Chicago, IL 60635.

VIDEO MONITOR/RECEIVER, the model *YM-950*, is a 25-inch color stereo unit with MTS (Multichannel Television Sound) and SAP (Separate Audio Audio Program) capabilities, as well as infrared remote control.

The 134-channel cable-ready receiver features a complete set of

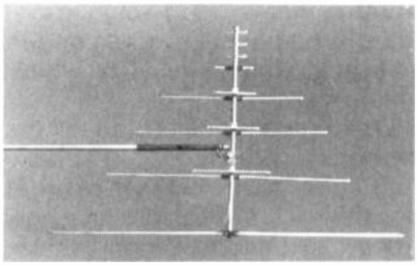


CIRCLE 34 ON FREE INFORMATION CARD

input and output jacks, some of which, along with the conventional TV controls, are hidden behind a flip-down lid on the front panel. Connections to and from an audio system, a VCR, a videodisc player, a game, and a computer can be made easily and quickly.

The model *YM-950* has a suggested retail price of $950.00.—**Yamaha Electronics Corp., USA,** 6660 Orangethorpe Avenue, Buena Park, CA 90620.

SCANNER BEAM ANTENNA provides 30–50 MHz low band, 108–136 MHz aircraft, 136–174 MHz high band, 225–400 MHz military aircraft and satellites, 406–512 MHz UHF, and 806–960 MHz microwave



CIRCLE 35 ON FREE INFORMATION CARD

mobile reception. Hams can use it for transmitting up to 25 watts on the 144-, 220-, and 420-MHz bands. The *Scanner Beam* can also be used with an inexpensive TV antenna rotator, if desired.

A balun transformer, offset pipe, and all mounting hardware are included. (A type F connector on the user's coax is required.) The approximate size of the *Scanner Beam* is 6′ × 4″. It is priced at $40.00 plus $3.00 shipping via UPS or $6.00 via the U.S. Post Office, within the U.S.—**Grove Enterprises,** P.O. Box 98, Brasstown, NC 28902. R-E

EQUIPMENT REPORTS

continued from page 33

vection oven is not available, a hot plate can be used.) After you remove the board from the oven and let it cool, you must remove the solder flux and carefully inspect all solder bonds.

Conductive adhesive, as its name implies, is a compound that lets you simply "glue" components to the board. Unfortunately, the adhesive was not included with our pre-production version of the *SMT Training Kit.* The compound is made up of two parts: a liquid activator, and the adhesive. When the activator contacts the adhesive, a conductive bond is formed.

Judging from the manual's instructions, using the adhesive requires care and a steady hand, but using it is the only way to go if you don't have an oven for the reflow process.

You can read volumes of literature on surface-mount technology (including "A Revolution in IC Packaging," an article that appeared in the May 1986 **Radio-Electronics**) and get a pretty good idea of what's important when working with surface-mount devices. But nothing beats hands-on experience to help you get a real understanding of all aspects of what's involved.

Our only complaint is that the kit does not include any surface IC's. We understand why it doesn't—it's impossible to know what IC's someone will want to use in a prototype circuit. But we still wish we could have tried our hand at soldering surface-mount IC's without having to go to another source for the parts.

The *SMT2000* sells for $348. The *SMT1000,* a version of the training kit that does not include any surface-mount devices, sells for $215. While those prices put the kits out of the range of someone who's only interested in SMT, it's a small price to pay for an electronics design engineer or technician who needs to become involved with all aspects of surface mount technology. We feel that the SMT Training Kit serves its intended purpose very well. **R-E**

BUILD THIS

STUN GUN

This experimental high-voltage generato: can produce 75,000 volts at a peak power of 25,000 watts.

ROBERT GROSSBLATT, and ROBERT IANNINI

Man's fascination with high voltages began with the first caveman who was terrified by a bolt of lightning. In more recent times, electronics experimenters and hobbyists have found the Tesla coil and the Van de Graaff generator equally fascinating. In this article we'll show you how to build a hand-held high-voltage generator that is capable of producing 75,000 volts at a power level as high as 25,000 watts. The stun gun can be used to demonstrate high-voltage discharge and as a weapon of self-defense. Before building one, however, you should read and pay very close attention to the warning in the accompanying text box, as well as to the description of physiological effects that follows.

WARNING

THIS DEVICE IS NOT A TOY. We present it for educational and experimental purposes only. The circuit develops about 75,000 volts at a maximum peak power of 25,000 watts. The output is pulsed, not continuous, but it can cause a great deal of pain should you become careless and get caught between its output terminals. And you should never, repeat, NEVER, use it on another person! It may not be against the law in your area to carry a stun gun in public, but, if you use it on another person, you may still be liable for civil action.

To help you build, test, and adjust the device safely, we have included a number of tests and checks that must be followed strictly. Do not deviate from our procedure.

Physiological effects

So that you may understand the danger inherent in the stun gun, let's discuss the physiological effects first. When a high voltage is discharged on the surface of the skin, the current produced travels through the nervous system by exciting single cells and the *myelin sheaths* that enclose them. When that current reaches a synapse connected to a muscle, it causes the muscle to contract violently and possibly to go into spasms.

The longer contact with the high voltage is maintained, the more muscles will be affected. If the high voltage maintains contact with the skin long enough to cause muscle spasms, it may take ten or fifteen minutes before the brain is able to re-establish control over the nerve and muscular systems.

How much power is required to cause such spasms? That's not an easy question to answer because, although it is relatively easy to make precise measurements of the power produced by a high-voltage device, it is difficult to rate the human body's susceptibility to shock accurately. Some obvious factors include age and diseases such as epilepsy. But the bottom line is simple: *The only one who fools around with a stun gun is a fool.*

The amount of energy a device delivers is actually the amount of power delivered in a given period of time. For our purposes, it makes sense to talk about energy in joules (watt-seconds). Using a fresh 9.8-volt Ni-Cd battery, the stun gun is capable of delivering peak power pulses of 25,000 watts. Actually, pulses start out at peak power and then decay exponentially. The length of the decay time depends on the components used in the circuit, the ambient temperature, the battery's capacity, and the positioning of the output contacts with respect to each other.

Assuming that the decay rate is purely exponential, the stun gun can produce about 0.5 joules of energy, provided that the battery is fully charged. Let's put that number in perspective.

Both the Underwriter's Laboratory (in Bulletin no. 14) and the U. S. Consumer Product Safety Commission state that ventricular fibrillation (heart attack) can be caused in humans by applying 10 joules of energy. Since the stun gun only generates about half a joule, you might think that a device that produces only one twentieth of the critical amount has a more-than-adequate margin of safety. *Don't bet on it.* A brief contact with the stun-gun's discharge hurts a great deal, but it takes only about five seconds of continuous discharge to immobilize someone completely.

Let's compare the stun gun's output with a similar device, called a Taser gun, which appeared on the market a few years ago. You may have seen a film demonstrating just how effective the Taser could be as a deterrent. A foolhardy volunteer was paid an enormous sum of money to have the Taser fired at him. No matter how big, strong, (and stupid) the person was, as soon as the Taser's "darts" hit him, he would collapse to the ground and go into uncontrollable convulsions.

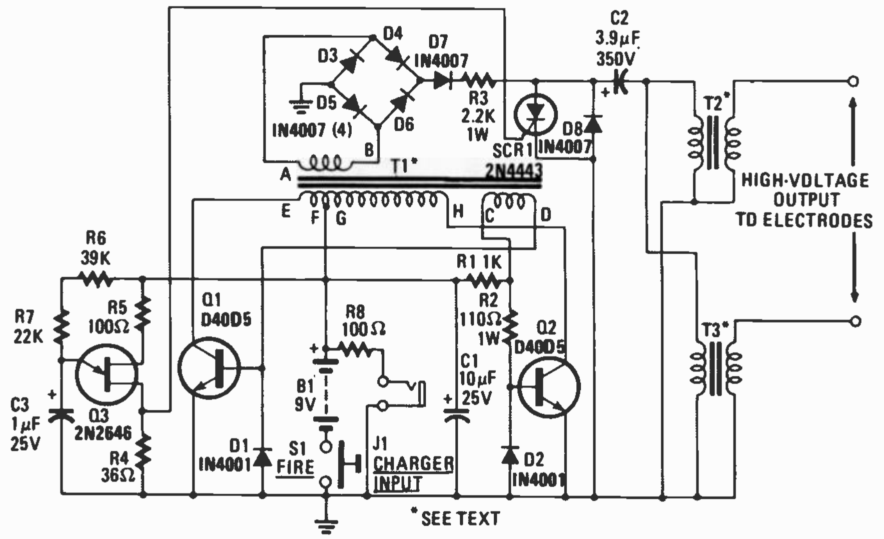


FIG. 1—THE STUN GUN'S CIRCUIT is a multi-stage voltage step-up circuit. The Q1/Q2 circuit produces a squarewave output of about 10 kHz, and Q3 produces 15-µs discharge pulses at a rate of about 20 ppm. Those pulses fire SCR1, which induces a voltage in the windings of step-up transformers T2 and T3.

The energy produced by the Taser is only 0.3 joules—about 60% of what our stun gun produces! Even so, the Taser has been officially classified as a firearm by the Bureau of Tobacco and Firearms because it shoots its electrode "darts" through the air. Even though our stun gun doesn't operate that way, the Taser puts out considerably less energy than the stun gun. Keep those facts and figures in mind as you assemble and use the device.

How it works

The schematic diagram of the stun gun is shown in Fig. 1. Basically, it's a multi-stage power supply arranged so that each succeeding stage multiplies the voltage produced by the preceding stage. The final stage of the circuit feeds two oppositely-phased transformers that produce extremely high voltage pulses. If that description sounds familiar, you've probably studied capacitive-discharge ignition systems—the stun gun works on the same principles.

The first section of the power supply is a switcher composed of Q1, Q2, and the primary windings (connected to leads E, F, G, and H) of T1. When FIRE switch S1 is closed, R1 unbalances the circuit and that causes it to start oscillating. Since base current is provided by a separate winding of T1 (connected to leads C and D), the two transistors are driven out of phase with each other, and that keeps the circuit oscillating. Resistor R2 limits base drive to a safe value, and diodes D1 and D2 are steering diodes that switch base current from one transistor to the other. Oscillation occurs at a frequency of about 10 kHz.

The switching action of the first stage generates an AC voltage in T1's high-voltage secondary (leads A and B). The amount of voltage depends on the battery used, but a battery of seven to nine volts should produce 250 to 300 volts across T1's secondary.

That voltage is rectified by the full-wave bridge composed of diodes D3–D6. Capacitor C2 charges through D7 at a rate that is controlled by R3.

The value of capacitor C2 affects the output of the stun gun. The greater the capacitance, the more energy that can be stored, so the more powerful the discharge will be. A larger capacitor gives bigger sparks, but requires more charging time, and that gives a lower discharge rate. On the other hand, a smaller capacitor gives smaller sparks, but a faster discharge rate. If you wish to experiment with different values for C2, try 3.9 µF (as shown in Fig. 1), 7.8 µF, and 1.95 µF. Those values were arrived at by using one 3.9 µF capacitor alone, two of the same capacitors in series, and two in parallel.

Meanwhile, UJT Q3 produces 15-µs pulses at a rate of about 20 ppm. That rate is controlled by C3 and the series combination of R6 and R7. When a pulse arrives at the gate of SCR1, it fires and discharges C2. That induces a high-voltage pulse in the primary windings of T2 and T3, whose primaries must be wired out of phase with each other. The result is a ringing wave of AC whose negative component then reaches around and forces the SCR to turn off. When the next pulse from Q3 arrives, the cycle repeats.

The outputs of the stun gun appear across the secondaries of T2 and T3. The hot leads of those transformers connect to

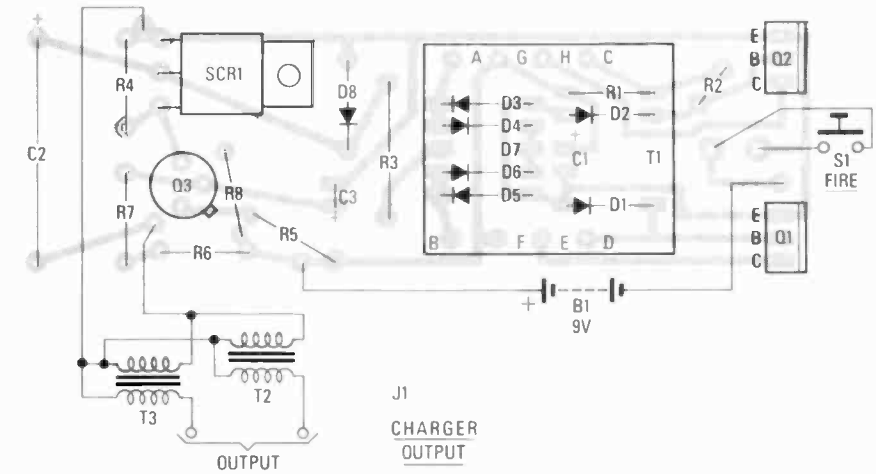


FIG. 2—MOUNT ALL COMPONENTS ON THE PC BOARD as shown here. Note that T2 and T3 are mounted off board, and that J1, C1, and D7 mount on the foil side of the board. In addition, a number of components mount beneath T1: D1–D6, R1, and R3. Those diodes and resistors must be installed before T1.

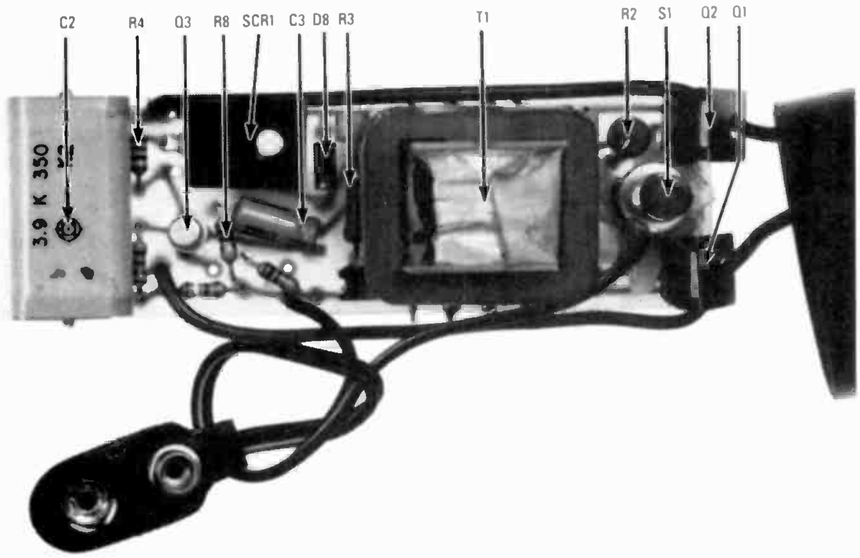


FIG. 3—BEND SCR1'S LEADS 90° so that the nomenclature faces up and then solder the SCR to the board. Also note that C3 must be bent over at a 90° angle, and that R2 is mounted vertically.

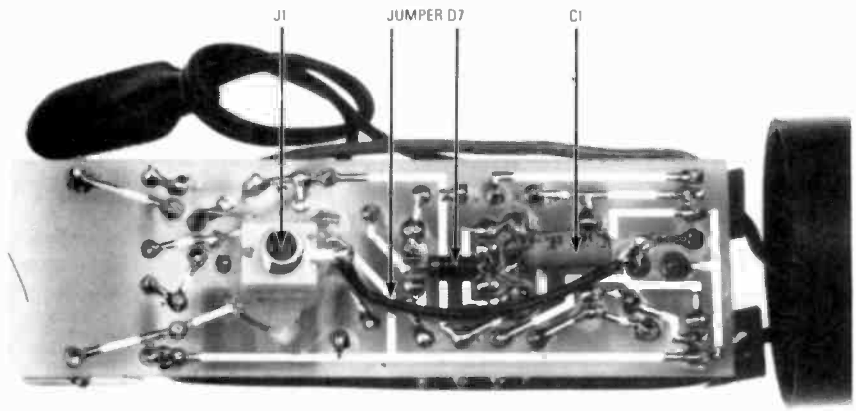


FIG. 4—JACK J1, DIODE D7, AND CAPACITOR C1 mount on the foil side of the PC board. One terminal of J1 mounts to the same pad as R8, and the jack should be glued to the board with RTV (or other high-voltage compound) after you verify that the circuit works properly.

PARTS LIST

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

R1—1000 ohms
R2—110 ohms, 1 watt
R3—2200 ohms, 1 watt
R4—36 ohms
R5, R8—100 ohms
R6—39,000 ohms
R7—22,000 ohms

Capacitors

C1—10 µF, 25 volts, electrolytic
C2—3.9 µF, 350 volts, electrolytic
C3—1 µF, 25 volts, electrolytic

Semiconductors

D1, D2—1N4001, 50-volt rectifier
D3–D8—1N4007, 1000-volt rectifier
Q1, Q2—D40D5, power transistor
Q3—2N2646, UJT
SCRI—2N4443

Other components

B1—9-volt Ni-Cd battery
S1—SPST momentary pushbutton switch
T1—12 to 400 volts saturable-core transformer. See text
T2, T3—50 kilovolt pulse transformer, 0.32 joules. 400-volt primary. See text

Note: The following components are available from Information Unlimited, P. O. Box 716, Amherst, NH 03031: T1, $12.50; both T2 and T3, $12.50; C2, $1.50; PC board, $4.50; case, $3.50; case with T2 and T3 potted, $17.50; charger, $6.50; 9.8-volt battery, $16.50; complete kit of all parts including all components, PC board, case, and charger, but no battery, $39.50.

the output electrodes, which should be held securely in position about two inches apart, and which should be insulated from each other and from the environment with high-voltage potting compound.

Batteries

The stun gun can be powered with almost any battery that can supply at least seven volts at one amp. A Ni-Cd battery would be a good choice: R8 and J1 will allow the battery to be recharged without removing it from the case.

The higher the battery's voltage, the higher the stun-gun's output voltage. Most nine-volt Ni-Cd's actually have a maximum fully-charged output of only 7.2 volts. However, batteries that deliver 9.8 volts when fully charged are available from several sources.

Construction

Keep in mind the fact that the stun gun produces dangerously high voltages, and don't approach the construction of the stun gun with the same nonchalance with which you might build a light dimmer.

The circuit can be built on a PC board or on perfboard. The foil pattern for a PC

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BUILD THIS

PHONY BURGLAR ALARM

MICHAEL RINGENBERGER

Scare off burglars without emptying your wallet with this simple, inexpensive electronic "scarecrow."

IT'S A SAD COMMENTARY THAT THESE days a burglar alarm is becoming as common a household "appliance" as a refrigerator or a dishwasher. But burglar alarms are not inexpensive. Most will cost a few hundred dollars, and some elaborate systems could cost a thousand dollars or more.

If your household possessions are simply not worth that kind of outlay, there is a very inexpensive alternative. Most burglars are burglars because it's the easiest way they know of to make a fast buck. When they look for a house to ransack, they try to find the easiest target. The trick, then, is to make your house *look* like it is protected by a sophisticated alarm system. That can be done for less than $20 with the circuit described here.

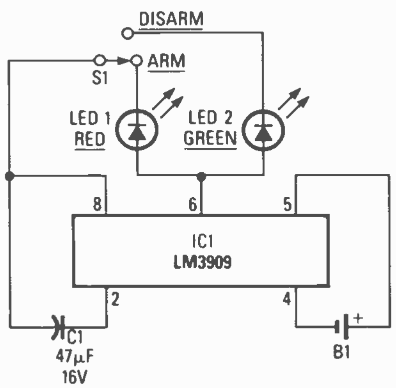


FIG. 1—IT'S NOT A REAL BURGLAR ALARM, but this "electronic scarecrow" can do almost as good a job as a real one when it comes to scaring away a burglar.

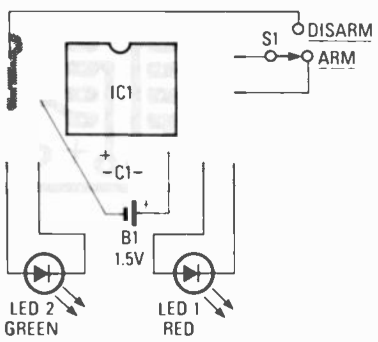


FIG. 2—THE CIRCUIT CAN BE BUILT on a tiny PC board. The pattern is provided in our PC Service section.

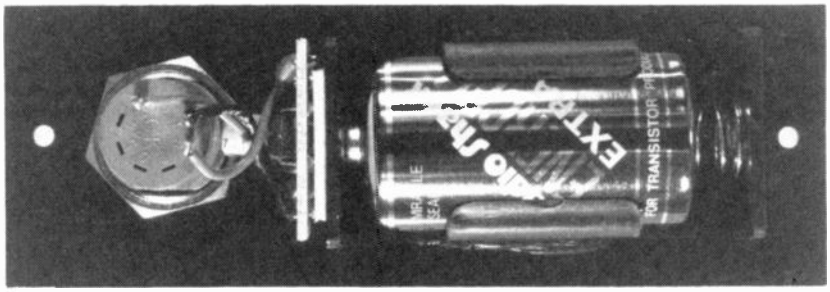


FIG. 3—THE CIRCUIT SHOULD be assembled on a piece of anodized aluminum.

An electronic scarecrow

No burglar alarm will make your home absolutely burglar proof. If you have something a burglar wants badly, and the burglar is a professional, he'll find a way to defeat the alarm. Otherwise, an alarm's principal value is as an "electronic scarecrow." Seeing that the house is protected, a burglar will move on to easier pickings.

How does a burglar know that there is an alarm? Most alarm systems have their sensors hidden from view, so frequently the only sign of an alarm system is a status display located near the entrance. That display usually consists of a red and a green LED that show whether or not the system is armed.

By now you may have guessed where we are headed: Since the presence of an alarm-status display alone is enough sometimes to scare off a burglar, why not set up a dummy display and do away with the rest of the system? That's precisely what our circuit does. Of course it won't give you the degree of security that a real alarm-system would, but its cost is much, much lower.

The schematic diagram of the circuit is shown in Fig. 1. The circuit is extremely simple and is built around an LM3909 LED flasher IC. With the value of C1 shown, the circuit will flash an LED at a rate of 5.5 times-per-second. It is powered by an alkaline "C"-size cell; estimated battery life is 15 months.

Switch S1 should be a key type as is typically found in burglar-alarm installations. The switch should be mounted on the dummy status-display's front panel to give the set up a more realistic look.

PARTS LIST

C1—47 µF, 16 volts, electrolytic
IC1—LM3909 LED flasher IC
LED1—green jumbo LED
LED2—red jumbo LED
S1—SPST, key switch
B1—1.5 volts, "C" cell
Miscellaneous: PC or perforated-construction board, anodized aluminum panel, battery holder, wire, solder, etc.
The following are available from Enberg Electronics, PO Box 55087, Indianapolis, IN 46205: Complete kit, including anodized aluminum cover, $18.95; assembled unit, $22.95; anodized cover, $2.50; PC board, $2.50. Indiana residents please add 5% sales tax.

Building the circuit

The circuit is simple enough to be built on a piece of perforated construction board. If you wish to use a PC board, an appropriate pattern is shown in our PC Service section. The parts-placement diagram for the board is shown in Fig. 2.

Two construction details bear special mention. One is the lead length of the LED's. They should be ¼-inch long to allow for flexibility when mounting the board (more on that in a moment). Secondly, the lead length of C1 should be kept to an absolute minimum. Be sure that the bottom of that electrolytic capacitor is flush with the board.

The circuit is mounted on a piece of anodized aluminum. Size is not critical, as long as it is appropriate for the task. The author's prototype was 1½ × 4 inches. The other side of the aluminum piece will serve as the dummy status-panel.

continued on page 98

COMMUNICATIONS:

From DC to Microwave

On this guided tour of the RF spectrum we'll see what types of communications take place where, and why.

JOSEF BERNARD

ALMOST EVERY FREQUENCY IN THE RF spectrum, from near DC to billions of cycles per second, is used for some type of communication. Indeed, at times it seems as if there are almost as many communications services as there are frequencies for them to occupy. And at times it seems that the ordering of the different services that make use of the RF spectrum is purely random. Of course it is not. There is usually a good reason for a service being located where it is. In this climb up the "electromagnetic ladder" we'll see some of the varied services that make use of the RF spectrum, and learn why they are in their particular niches.

Meters and hertz

You no doubt have noticed that the location of a signal in the RF spectrum is often specified in hertz, but that sometimes it is specified in *meters*. Meters are a unit of distance, as you might expect. What is being measured is the *wavelength* of the signal. A wavelength is the distance from one point on one cycle to the corresponding point on the next. See Fig. 1. On the other hand, the hertz (abbreviated Hz) is a unit of *frequency*. It indicates how many cycles occur in one second. One hertz is equal to one cycle-per-second.

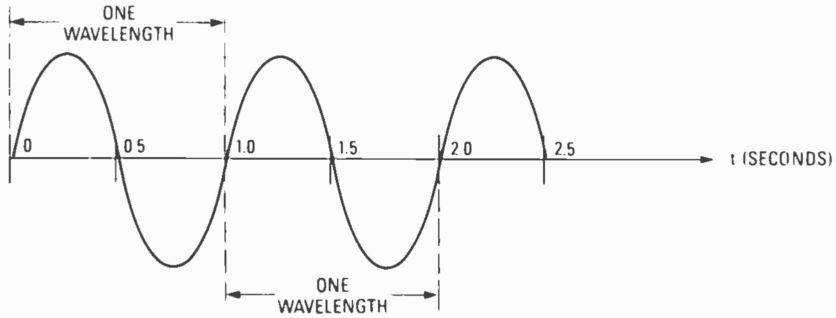


FIG. 1—THE WAVELENGTH AND FREQUENCY of a wave are related through $f = c/\lambda$. Therefore a wave with a frequency of one cycle-per-second (1 hertz) would have a wavelength of 300,000 kilometers.

The relationship between the two measures is simple, and if you know one you can easily determine the other. That's because the wavelength of an electromagnetic wave is inversely proportional to its frequency—that is, the longer the wavelength, the lower the frequency. The relationship between frequency and wavelength is given by $f = c/\lambda$, where f is the frequency in Hz, λ is the wavelength in meters, and c is the speed of light in meters-per-second.

Obviously, either measure can be used to specify the location in the spectrum of an RF (*R*adio *F*requency) signal completely. Why, then, are some signals usually specified in meters while others are specified in hertz?

The main reason is simply tradition. A general rule-of-thumb is that in regions of the spectrum that have been in use the longest—for the most part since before World War II—the common usage is to describe a signal using meters. Thus, the shortwave broadcast bands, and the "high-frequency" bands used by amateur radio operators, are still usually referred to in terms of their wavelengths in meters (25, 31, 40, etc.), and shortwave receivers, which these days frequently are called "communications receivers," have their dials scaled in meters.

On the other hand, bands in the more-recently exploited part of the spectrum usually are referred to by the frequencies used. An exception to that is in the portion used by radar, and for terrestrial-microwave and satellite communications, where terms such as C-band, Ku-band, K-band, X-band, and the like abound. To confuse matters, those designations have nothing to do with either frequency or wavelength.

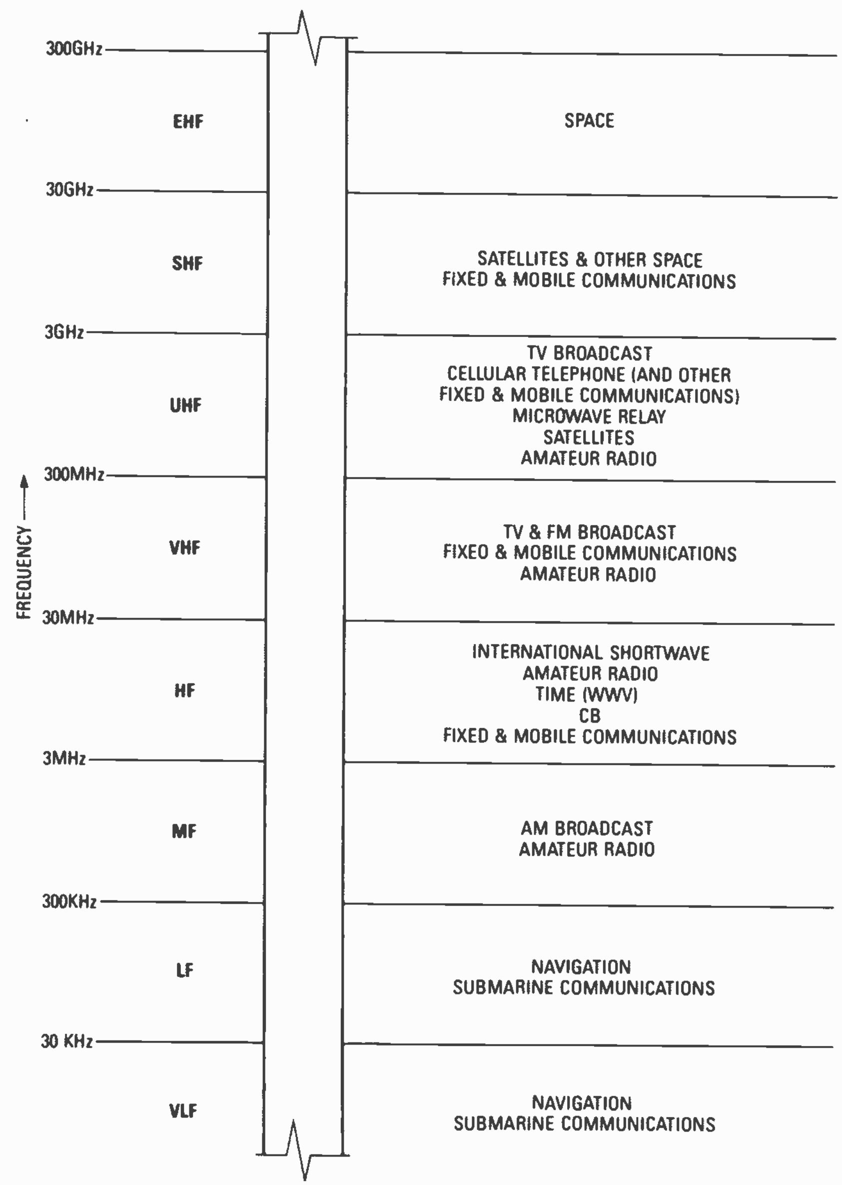
Starting at the bottom

The RF spectrum runs from 10,000 Hz (10 kHz) up beyond 300 gigahertz (300×10^9 Hz). The lower limit is within the realm of sound; the upper limit borders on infrared light.

At the very bottom of the RF spectrum are frequencies of tens or hundreds of kilohertz, with corresponding wavelengths of thousands of meters (at 100 kHz an electromagnetic wave has a wavelength of three kilometers, or about 1.8 miles). There, the ground-wave phenomenon predominates; radio waves tend to hug the earth rather than bounce off the ionosphere as they do at higher frequencies. That low-frequency region used to be the domain of the early radio pioneers.

The selection of those frequencies was not made freely; the mechanical spark-gap communications sets used by Marconi and others were not capable of generating higher frequencies.

With the spark-gap age long behind us, those lowest frequencies are now used primarily for navigational purposes and for long-range military communications with submarines (although in general water is a poor propagation medium, best results are achieved at lower frequencies). Low and very low frequencies are not used widely for communications because of the problems encountered when attempting to use those frequencies to convey even moderately complex data. Remember, as the frequency of the modulating information increases, so does the bandwidth of the resulting signal. The problem is similar to that encountered when trying to transmit computer data over standard telephone



THE RF SPECTRUM extends from 10 kHz, which is within the realm of sound, to 300 gigahertz, which borders on infrared light.

circuits. Beyond a certain speed of transfer, the bandwidth of the signal exceeds the capability of the telephone lines. At low and very-low frequencies, it doesn't take much modulation to eat up vast stretches of the spectrum. And even low-frequency earth-hugging navigational beacons are being supplanted by newer satellite-based systems.

Medium waves

The MW (*M*edium *W*ave) region stretches from 300 kHz to 3 MHz. The best known part of that region, at least to most of us, is the AM broadcast band. It occupies the frequencies from approximately 540 to 1600 kHz.

At MW frequencies an interesting phenomenon begins to occur. That is, the ground-wave propagation of the low frequencies begins to give way to sky-wave propagation. See Fig. 2. In sky-wave propagation, signals no longer follow the contours of the earth. Instead they travel a line-of-sight path to the horizon, and out into space. Part of the signal may be reflected back to earth by the ionosphere, a region of the atmosphere made up of charged particles. The amount of reflection depends on several factors, but primarily on the frequency of the transmission and the state of the ionosphere itself. The state of the ionosphere changes depending on the time of day (during the daylight hours the sun is bombarding the atmosphere with energy that can cause ionization; at night, the amount of ionization decreases) and the state of solar activity (solar flares and the like can also pour tremendous amounts of energy into the atmosphere). Anyone who has listened to an AM broadcast radio has heard the effects of the changing state of the ionosphere. During the day, reception is limited pretty much to local stations, but after the sun has set stations from hundreds or even thousands of miles away can be heard.

Short waves

The boundaries between the segments of the RF spectrum are not clearly defined, but somewhere around 200 kHz (150 meters) we find the beginning of the shortwave region of the spectrum. That region extends to beyond 30 MHz (10 meters). The band between 3 and 30 MHz is also known as the HF (*H*igh *F*requency) region. At those frequencies, the reflective properties of the ionosphere are the strongest.

Until the advent of the communications satellite, all long-distance radio communications took place on the shortwave bands, and those bands are still full of activity; not everyone, after all, can afford a satellite earth station.

Note that we are still in the pre-World-War-II part of the spectrum, and thus we most often speak in terms of wavelengths

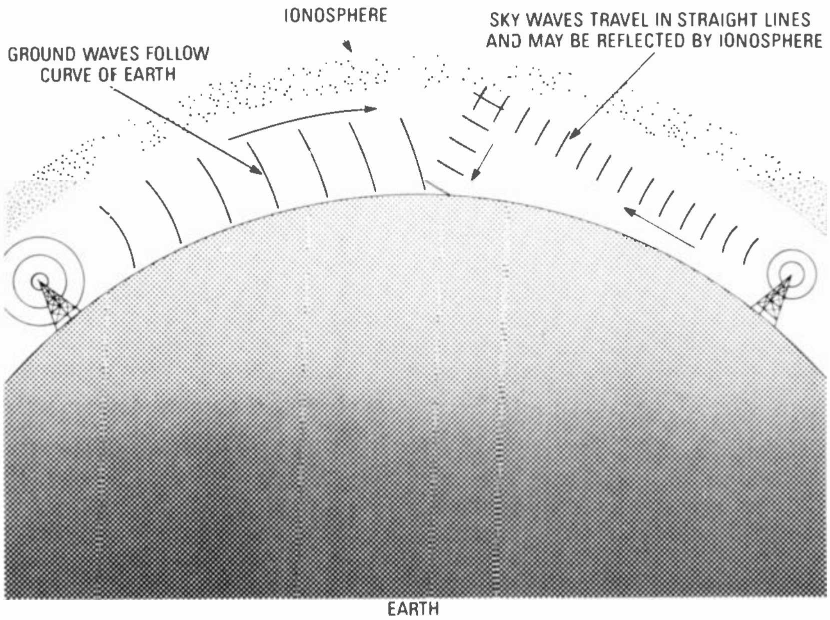


FIG. 2—GROUND WAVES, usually associated with low frequencies, hug the earth. Sky waves resulting from higher-frequency sources travel in straight lines. Depending on their frequency, and on other conditions, the waves may either travel out into space, or be reflected back to earth by the ionosphere.

rather than frequencies. Thus SWL's (*S*hort *W*ave *L*isteners) refer to international broadcasts in the 25-, 31-, or 49-meter bands, and amateur radio operators work the 80-, 20-, or 15-meter bands.

The characteristics of the shortwave bands change as they increase in frequency. In the lower reaches of the shortwave portion of the spectrum, propagation is primarily ground wave during the day and sky wave during the evening, much like the AM broadcast band that is located not far below in frequency. Around 30 meters (10 MHz) or so, things begin to turn around and there is good long-distance sky-wave propagation during the day, but the bands shut down at night as there is only short range ground-wave communication.

Propagation on the shortwave bands varies not only with the time of day, but also with the 11-year sunspot cycle. Over a period of 11 years, the degree of sunspot activity rises to a peak, and then falls off considerably. No one is quite sure exactly why that happens, but when sunspot activity is low, as it is now, the higher frequencies become useless for long-distance communications. There simply is no skip. As sunspot activity gradually increases, the ionosphere is restored, and long-distance communications again become possible on the higher shortwave frequencies. The next peak in the sunspot cycle is expected around 1991.

International broadcast services, usually operated by the government of one country or another, abound in the shortwave bands. Sometimes they carry programming for citizens or subjects of those countries to keep them abreast of developments at home. Frequently too, those services are used to disseminate political propaganda—sometimes subtle, and sometimes not so subtle: two such services are Radio Moscow and the Voice of America. Broadcasts from those international services go on 24 hours a day, changing frequencies and transmitter sites to obtain the best propagation conditions to various parts of the world.

Many amateur radio operators, or hams as they are frequently called, make extensive use of shortwave frequencies to talk to other hams around the country and around the world. Frequently, there are contests, with elaborate rules for scoring, in which hams accumulate points for contacting as many stations as they can—the farther away and the harder to find, the better—in a given period.

(An aside in the interest of amateur radio: The primary purpose of that "hobby" —some would call it a way of life—is to engage in two-way communications with other hams. If you just listen—whether it's with a communications receiver or with a VHF or UHF scanner—you're an SWL. When the news services reported last year that "any ham with the proper equipment could have listened in on the president's unscrambled conversations from Air Force One," they should have said, instead, "any listener . . ." Eavesdropping is not the intent of the amateur radio service.)

There's a lot more on the shortwave bands. Although there has been a shift to satellites, with their greater reliability, many commercial services still depend on those bands. Time services, such as WWV, are found at several places on the HF bands, transmitting accurate time and other information around the clock. Much international news and weather information is sent on the shortwave bands by radioteletype (that "jingle-jingle" sound you hear often on the shortwave bands). Many governments maintain contact with their embassies or consulates abroad by shortwave, and the astute observer can spot their "antenna farms" atop buildings in major cities.

Another shortwave service, familiar to just about all, is the *C*itizens' *B*and (CB) service located at around 27 MHz, the old 11-meter ham band. While it's too late to do anything about it at this late date (about 30 years too late), 27 MHz was not a wise place to locate CB. That service was intended for short-range, local use but, as many a CB-er and ham can tell you, when conditions are right there is no better place in shortwave for catching the ionospheric "skip" and talking to stations all over the world, even with just a few watts of output power. (Skip is ham and SWL slang for long-distance sky-wave communications). There is talk of opening up a citizens' band around 900 MHz, and that would make a lot more sense, as well as for shorter antennas! (For another view see "The New World of Communications," which immediately follows this story.)

Very high frequencies

Once above 30 MHz or so, we enter the *V*ery *H*igh *F*requency (VHF) realm. Because that portion of the spectrum, as well as the portions above it, were not exploited until after World War II, signals there are generally specified in terms of frequency rather than wavelength. (Exceptions to that are the six- and two-meter amateur bands.) Except at the very bottom of the VHF region, propagation by skip is rare, and all communications are line-of-sight, or about as far as the horizon, depending on the height of the transmitting and receiving antennas. Maximum ranges of 50 to 60 miles are typical.

Here are found the FM broadcast band, the VHF (naturally) television channels, all sorts of local mobile-communications services (including police and fire departments, mobile telephones, business communications such as taxis and local truckers, airplane-to-airport communications, and many government and military services). Because the communications range is only line-of-sight, those frequencies are ideal for local services and can be reused time and again at fairly short geographic intervals.

The assignment of the frequencies used for television broadcasting is interesting—there are two VHF-TV bands. The lower one starts at 54 MHz for Channel 2; there used to be a Channel 1 but it disappeared a long time ago (For more information see "Whatever Happened to Channel 1" in the March 1982 issue of **Radio-Electronics**). That band continues up to to 88 MHz, the top of Channel 6. There is then a gap of 86 MHz, which is used by the FM broadcast service (between 88 and 108 MHz), among others. The VHF-TV channels begin again at 174 MHz (Channel 7) and continue to 216 MHz, which is the top of Channel 13, the last VHF channel. That gap between the upper and lower VHF-TV bands explains why, if you live in a fringe area, Channel 7 or 8 may be more difficult to receive than Channel 5 or 6. At higher frequencies it is more difficult (and more expensive) to build sensitive receiving equipment, and the efficiency of old antennas and feedlines falls off.

Almost all of us have witnessed the "venetian blind" effect on our TV sets. It is caused by VHF skip, which usually takes place in the spring and fall. The effect is caused by the reception of two TV stations on the same channel. One station is your local one, while the other might be located hundreds of miles away. The horizontal bars that give the venetian-blind effect its nickname are the result of the two signals interfering with one another. If the bars seem to move up or down the screen, it's because the horizontal-sync frequencies of the two stations aren't exactly the same. It takes just a fraction of a percent of difference at 15,734 kHz (the standard horizontal-sync frequency) to be noticeable. That type of interference is analogous to beat notes at audio frequencies or diffraction patterns in light.

Many people have the impression that it is the nature of FM that limits the range of broadcasts made using that type of modulation. That is simply not true! The reason for the limited range of FM broadcasts is that the frequencies assigned to that service are restricted to line-of-sight propagation. Frequency modulation is actually far superior to AM—not only in resistance to atmospheric noise, but in resistance to other types of interference, as well as in resistance to fading. It's just that by the time the usefulness of FM was recognized, the lower frequencies were all occupied. Perhaps that's just as well—the 20-MHz spread of the FM broadcast band allows for plenty of wideband stations transmitting high-quality audio.

Ultra high frequencies

Starting at about 300 MHz and extending to about 3,000 MHz is the UHF (*U*ltra *H*igh *F*requency) band, perhaps best known because of the TV channels found there between 470 and 890 MHz. Until the late 1950's, those frequencies were hardly used at all because the cost of building transmitting and receiving equipment for that part of the spectrum was just too high. In fact, until just a few decades ago, virtually all the frequencies in that band and the ones higher in frequency were part of the FCC's legacy to amateur radio. Amateurs, it was hoped, would learn how to tame those "esoteric" regions of the RF spectrum.

These days, UHF is pretty much an extension of the VHF band. Many of the services found on VHF also now have allocations in the UHF band. Those include the land mobile services (especially cellular telephones and pagers, which have been assigned what was formerly the top of the UHF-TV band). UHF television, and government agencies (police, fire, etc.).

Other than the fact that the VHF frequencies are just about completely occupied, UHF offers a significant advantage to those services where hand-held receivers and/or transmitters are commonplace. That is, UHF communications gear, especially the antenna (remember antenna length is dependent on wavelength), can be made much smaller.

As an aside, handheld transceivers (a transcevier is a combination transmitter/receiver) are commonly called walkie-talkies, but the proper term is "handie-talkie" (because it fits in your hand). A walkie-talkie is actually defined as a transceiver that you can carry around with you—usually strapped to your back or slung over your shoulder on a strap—to leave your hands relatively free. The term "creepie-peepie," for a portable TV-camera/transmitter combination, never caught on (and that's probably a good thing).

Incidentally, you can tell whether a handie-talkie is operating on VHF or UHF by its "rubber duckie" antenna. If it's about as thick as a finger, the unit is for VHF; if it's about the thickness of a wire, it's for UHF.

Once we get to the UHF band, we are dealing with frequencies that begin to approach those of light. Not surprisingly, then, signals here begin to acquire some of the properties of light. One of the most common examples of that is the deterioration of UHF-TV reception during rainy weather. That happens because raindrops tend to block the radio waves, just as they do light, and fewer and fewer get through as the distance between transmitter and receiver increases.

Super high frequencies

While the microwave band "officially" begins at about 250 MHz, the term microwave is now popularly used to describe signals in the *S*uper *H*igh *F*requency (SHF) region, above 3000 MHz. Here it is no longer convenient to refer to frequencies in terms of megahertz; instead we speak in terms of gigahertz, or billions of cycles per second. While wavelengths here are still far longer than those of light, they are also short enough to begin exhibiting many more of the properties of light. At the upper end of the SHF band, 30 GHz, wavelengths are as short as a couple of inches. Like light, microwaves travel in straight lines. They are easily reflected by even small metallic surfaces;

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BENN KOBB*

THE 800-MHZ BAND, REGARDED AS THE last feasible band for mobile radio, is the subject of some the most heated controversies in the communications world. In dispute are who should have the right to transmit in that band, and even who should have the right to listen to those transmissions.

This article will describe some of the current and proposed radio services in the 800-MHz band. We'll also see how the battle for control of 800 MHz may affect the future of communications electronics.

Cellular telephone

If you live in one of the more than 100 U.S. cities that have cellular telephone service, you may have noticed that the business pages of your local newspaper have become inundated with advertisements for cellular phones. In an effort to relieve the congestion that had plagued conventional UHF mobile-phone service for years, the FCC in 1983 opened the 825–845 and 870–890-MHz bands to cellular systems. In each market, one 20-MHz band is allocated to a "wireline" carrier affiliated with the telephone company that serves the area, while the other 20 MHz is allocated to an independent "non-wireline" carrier.

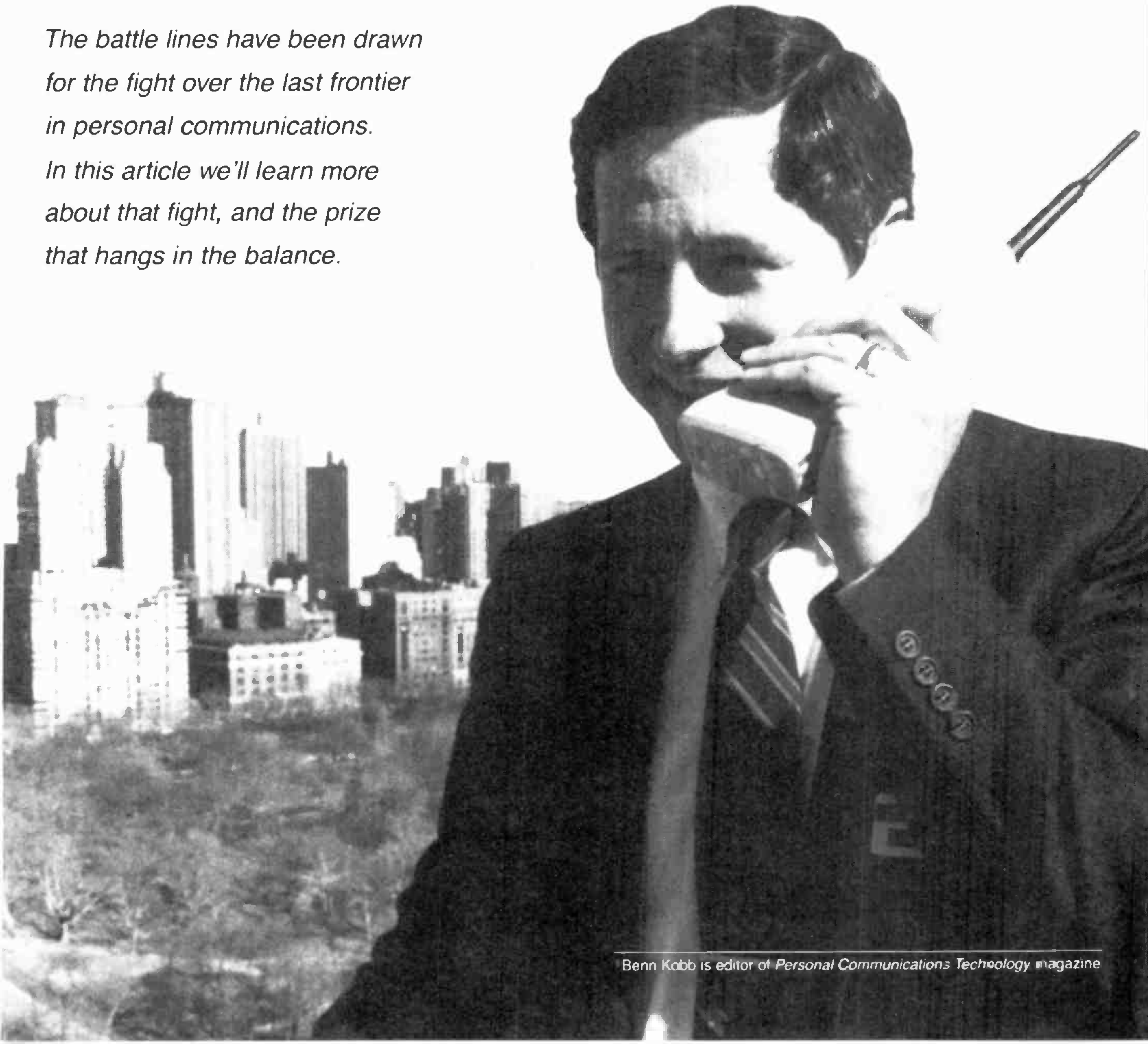
Conventional mobile-phone systems typically use a single, high-power transmission site and fewer than 20 channels to cover an area. In contrast, cellular systems operate through a network of many low-power "cell" sites and hundreds of channels. Cell sites can be identified by their towers, which typically sport peculiar, triangular antenna platforms.

As a customer engaged in a cellular call drives from the coverage area of one cell into that of another, changes in signal strength trigger an automatic hand-off of the call from one cell to the next. Ideally, at worst the user hears only a split-second gap in conversation while his mobile unit switches by remote command to the channel required by the next cell.

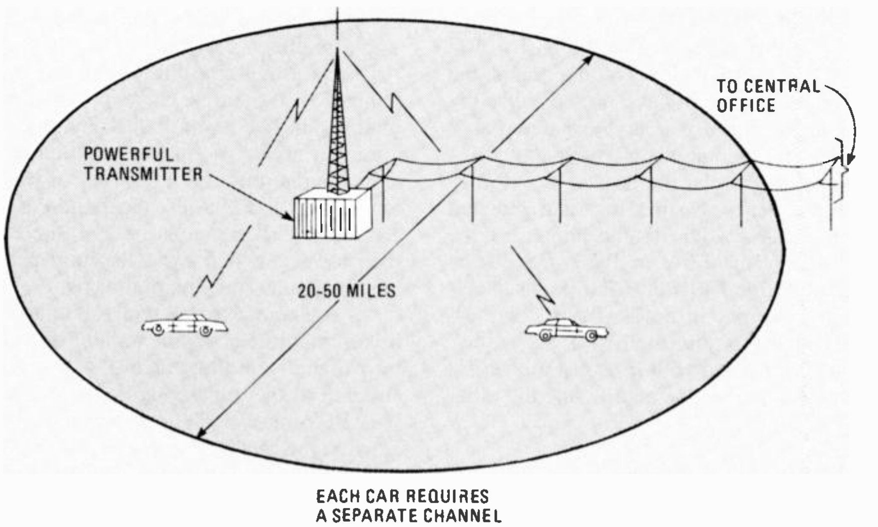
A typical large-city cellular carrier uses 20 or 30 cell sites, all connected via landline (telephone line) or microwave to a

The New World of Communications

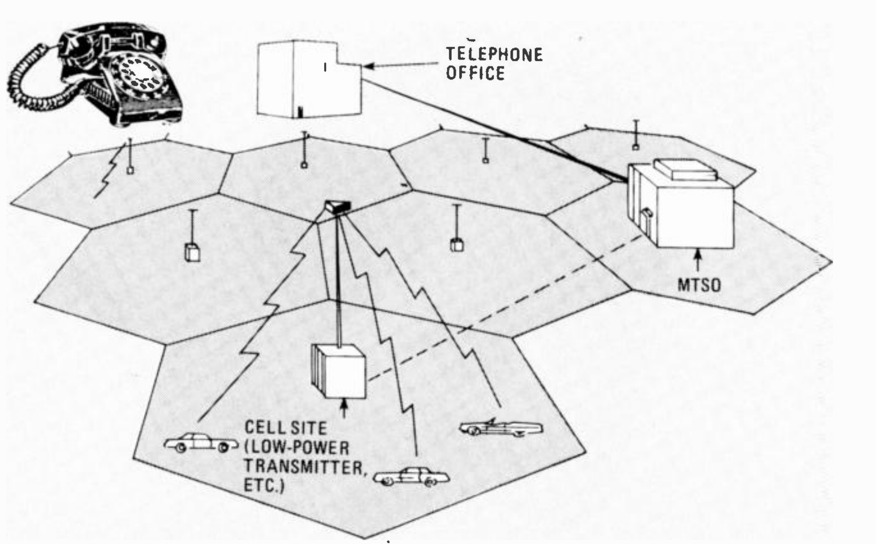
The battle lines have been drawn for the fight over the last frontier in personal communications. In this article we'll learn more about that fight, and the prize that hangs in the balance.



*Benn Kobb is editor of *Personal Communications Technology* magazine



IN A CONVENTIONAL MOBILE TELEPHONE SYSTEM, only a single base station is used to cover the entire service area.



IN THE CELLULAR SYSTEM the service area is divided into smaller "cells." Each cell has its own low-power base station, called a cell site.

central *M*obile *T*elephone *S*witching *O*ffice (MTSO). Essentially a telephone exchange, the MTSO transmits and receives calls between the cellular network and the public telephone-network.

Frequencies can be re-used several times within a cellular system. That feature is what gives cellular its widely-touted spectrum efficiency. Also, the cellular system has a built-in growth mechanism. If the communications traffic in a particular cell becomes too much for it to handle, the cell can be split into smaller cells, freeing additional channels to serve customers without the need to actually expand beyond the already-allocated 20 MHz.

In theory, cell-splitting was designed to help the cellular industry serve larger numbers of customers without the need for more frequencies. In practice, things have not worked out all that well. Major-market cellular carriers have split cells to some extent, but the process is expensive. To split a cell, outlays of hundreds of thousands of dollars are required for site acquisition, engineering, and construction. Further, there have been many instances of local opposition to new tower construction. That opposition has most often been based on aesthetics or the perceived dangers of RF radiation. Because of all of that, carriers have returned to the FCC for more channels after all.

The radio spectrum, however, is a very scarce resource. Only a few megahertz remain unused at 800 MHz, and the FCC has found itself faced with many competing claims for that piece of the spectrum. After considering the claims, the Commission tentatively allocated an additional 12 MHz to the cellular service, even though it appears that the additional spectrum is only needed by a handful of carriers in the nation's largest cities, and that most cellular systems won't even need to use all of their existing 20 MHz.

Other countries that have cellular service are facing a similar dilemma. Should more spectrum be granted to cellular, with its analog FM technology, or should the airwaves be conserved for modulation techniques that could bring consumers exciting new services and better spectrum efficiency? Several European countries that already have FM cellular have decided to conserve parts of the radio spectrum for a futuristic project known as the Pan-European Digital Mobile Telecommunications Network.

That plan promises to bring European consumers a miniature, handheld digital communicator that could eventually replace the mobile telephone and the radio pager, and that could transmit and receive voice and text, as well as images. Tests are already underway in Sweden and Germany of competing time-domain and frequency-domain multiplexed digital-radio systems. Such systems offer greater channel capacity and flexibility than existing systems.

Will digital mobile-radio eventually take the place of analog FM in the United States? The future depends in large part on whether the FCC grants more of the spectrum for FM systems or conserves some of it for more spectrum-efficient technologies. With heavy investments in FM, substantial incentives must emerge for industry in this country to convert to digital. A successful deployment of digital radio in Europe could provide that needed incentive.

Mobile satellite

Cellular telephone is essentially an urban technology. That is, an expensive network of cells and switching centers is necessary to provide cellular service, and only those markets with sufficient population and business activity can profitably support cellular systems. What about the rest of the country? To serve what it viewed as a large, untapped market for mobile communications in the rural U.S., NASA in 1982 announced an ambitious proposal for a *M*obile *S*atellite *S*ervice (MSS) to provide two-way radio, paging, mobile telephone, data, and position-location services to vehicles across the country. A very similar program is underway in Canada, where widely separated remote populations could benefit greatly from a mobile satellite.

A dozen companies agreed with the basic concept and forwarded applications to the FCC for licenses to launch mobile satellites. NASA even agreed to provide a free ride on a Space Shuttle for the winning applicant's satellite, in return for communication services. *(That, of course, was before the Challenger disaster; that incident will considerably delay,* *if not jeopardize, the MSS program, as well as many others.—Editor*) Satellite entrepreneurs projected markets in the millions of units for vehicular, transportable, and, eventually, hand-portable satellite radios. Of course, the cost of implementing MSS will be "astronomical;" one applicant estimated its startup cost to be in the vicinity of $700 million.

The FCC tentatively allocated 821–825 and 866–870 MHz to MSS in November, 1984. No licenses have been granted, however, because that proposed allocation is the target of intense lobbying in Washington by trade associations representing the two-way radio industry and the nation's police, fire, and emergency-medical radio users. Those users insist that their need for additional channels far outweighs any public benefit that might come from MSS. Recent Congressional action requires the FCC to give top priority to public-safety communications in making spectrum decisions. Aspiring mobile-satellite entrepreneurs argue instead that MSS will help to fill the need for public-safety radio, and that metropolitan public-safety agencies could make more use of cellular systems to meet their communication needs.

The MSS debate has escalated beyond the public safety vs. high-tech arena, and has entered the rural vs. urban and even international arenas. Several influential congressmen have lined up firmly behind MSS as the answer to under-served rural-communication needs, while others argue just as strenuously that urban areas, facing severe spectrum shortages, need the 800-MHz band for police and fire radios.

As a way out of the 800-MHz MSS dilemma, many proponents are pushing to kick MSS upstairs to the 1.6-GHz L-band where land-mobile stations do not operate. The L-band technology, they believe, will result in lower costs for satellite radios. In fact, INMARSAT, the *IN*ernational *MAR*itime *SAT*ellite Organization, has just introduced a shoebox-sized L-band mobile satellite-communicator for ships of any size—even the smallest canoe. Expected to cost well under $5000, the unit sends and receives error-free alphanumeric messages through the INMARSAT satellite system anywhere in the world.

Canada, with its substantial commitment to an 800-MHz MSS, is having to reevaluate its frequency selection. If the U.S. moves ahead with an 800-MHz MSS, the two nations' systems will be compatible, each picking-up the other in the event of a malfunction. On the other hand, should the U.S. use the 800-MHz band instead for regular police and fire radios, the Canadian satellite could easily interfere with and receive interference from U.S. users. The FCC has given Canada and international telecommunications authorities official notice that the U.S. desires to use the L-band for MSS.

Radio-determination satellite

A parallel development to MSS is the *R*adio-*D*etermination *S*atellite *S*ervice (RDSS) recently approved by the FCC. Originally proposed by physicist-pilot-science writer Gerard O'Neill as a navigation aid for aircraft, the RDSS service would pinpoint the location of any user in an instant and enable the user to send and receive short alphanumeric messages via satellite from a palm-sized device expected to cost around $500.

Although marine-, aviation-, and land-transportation interests are seen as major customers for RDSS, O'Neill's company, Geostar Corp. of Princeton, NJ, envisioned the system being used also by pedestrians who could signal for help if they witnessed a crime, accident, or other emergency. Geostar weathered lengthy legal and technical battles at the FCC in order to have the RDSS service approved. The Commission concluded that there is a need for RDSS, and allocated spectrum to it in the 1610–1626.5-, 2483–2500-, and 5117–5183-MHz bands. The next step is for Geostar and several other prospective RDSS companies to complete their funding and begin construction and launch of the satellites. How much money will they have to raise? The business plans submitted to the FCC indicate an average required investment of $300 million to start commercial RDSS operation.

Communications privacy

If you're a radio amateur, shortwave listener, or scanner enthusiast, chances are you've heard of the *E*lectronic *C*ommunications *P*rivacy *A*ct (ECPA), a bill pending before the House and the Senate that could have a dramatic impact on hobby radio listening if enacted into law. Where did the ECPA come from and how will it affect radio communications?

Essentially, the ECPA is an attempt by concerned congressmen to bring federal wiretap laws up to date to accommodate new technology, especially electronic mail and mobile-telephone systems. As you may know, existing provisions of the Communications Act of 1934, as amended, prohibit the divulging or misuse of any information you may obtain by monitoring a communication not intended for you. It is that feature of existing law that permits SWL's and scanner listeners to engage in their hobby without fear of criminal prosecution—as long as they don't divulge what they hear or use the information for personal gain or criminal purposes.

The emergence of computer crime, of satellite-TVRO technology, and of cellular-telephone systems have led various trade associations to lobby congressmen to support legislation that would have a broad application to penalize illegal interception of any electronic communication—whether transmitted by wire, fiber optics, cellular, satellite, or a not-yet-invented communications system. Accordingly, two similar bills were introduced providing stiff penalties for unauthorized interception of communications. Those bills are aimed not at amending the Communications Act, but at the wiretap provisions of the Omnibus Crime Control and Safe Streets Act.

The sponsoring trade associations, including the Cellular Telecommunications Industry Association, the Electronic Mail Association, and others, were generally satisfied with the wording of the proposed legislation which would, it appeared, protect their constituencies from invasion of privacy.

Radio-hobby organizations, however, were aghast at the sometimes draconian—and other times just plain confusing—wording of the bills. For example, the ECPA initially would have made it illegal to listen to a signal emitted by a radio in a vehicle but gave the green light to listening to a hand-held radio. Fortunately, that portion was later removed. The status of amateur-radio "autopatch" or telephone interconnection was extremely vague; although the bills "exempted" amateur radio from their privacy protections, they did make it illegal to listen to telephone calls. That issue is still unclear in the current version of the bills, although most observers interpret the language to mean that you won't be criminally liable for listening in on a ham's autopatch call.

UNDER SOME PROVISIONS of the ECPA, if passed, the legal use of scanners and other communications gear would be curtailed.

The bills appeared to make listening to marine, aviation, or governmental stations illegal, too. After lengthy hearings that included testimony from the *Amer*ican *R*adio *R*elay *L*eague (ARRL) and the *A*ssociation of *N*orth *A*merican *R*adio *C*lubs (ANARC), changes were introduced in the legislation to make it at least somewhat more palatable to radio hobbyists and amateurs.

The current version of the House bill, HR 3378, permits monitoring of most of the radio services you might hear on a scanner or shortwave receiver—as long as those services are not scrambled or encrypted. Unfortunately, the mere reception of a scrambled radio signal—even if you do not unscramble or demodulate the signal—will carry criminal penalties, at least under the current version. Unauthorized reception of a cellular telephone conversation could result in a fine of up to $500 and up to six months in jail. That provision was adopted even though cellular telephones can be received on 800-MHz scanners, service monitors, spectrum analyzers, and on many TV sets and videocassette recorders when they are tuned above Channel 80. If you recall, in the 1970's the FCC reappropriated the frequencies for the little-used UHF Channels 70 through 83 and reassigned them to mobile-communications services. Part of that allocation went to cellular telephone.

Monitoring of other common-carrier communications, such as microwave radio, paging, or international marine-radiotelephone services, would carry stiffer penalties. However, listening to cordless telephones would be exempt from any criminal sanctions.

How those proposed laws would affect satellite-TVRO owners is anything but clear at this point. Legislators involved in the ECPA have publicly conceded that they don't want the bills to have any effect one way or the other on satellite-TVRO owners, even though monitoring of satellites is specifically prohibited by the legislation unless the material received is intended for use by television broadcast-stations.

The final legislation, if adopted by Congress and signed by the President, could of course end up being more, or less, restrictive than HR 3378. Watch the What's News, Satellite News, and Video News columns in **Radio-Electronics** for any late-breaking information on the ECPA. Hopefully, you won't have to retire your communications receiver and take up butterfly collecting.

Personal radio

The *C*itizens *B*and (CB) radio service operates at 27 MHz. However, the original "Citizens Radio Service" occupied the entire band between 460–470 MHz when it was created in the 1940's. The FCC eventually took most of the UHF band from Citizens Radio and reallocated the frequencies to business and industrial radio-services, turning the old 11-meter ham band over to CB as a sort of compensation for the loss.

A sliver of that 460-MHz band—eight channels—still exists for citizens radio (now called "personal" radio) at UHF, and it is in that band that the "CB of the future" may find a home.

To understand what may happen to the UHF band, and how its fate is tied to the 800-MHz proceedings, it's necessary to backtrack to 1975 when the CB boom was hitting its peak. Millions of Americans were installing CB's in homes and cars, and legitimate users were being crowded

DURING THE CB BOOM of the mid 1970's millions of Americans were installing CB gear, such as the unit shown here, in their cars and homes.

out by those "experimenting" with skip and using illegal amplifiers. The FCC was experiencing one of the biggest headaches in its history: A runaway radio service that was impossible to control and license effectively.

The commission at that time received several proposals to initiate a new CB-radio service at 220 MHz in order to take some of the pressure off of the 27-MHz band. The 220-MHz band was the domain of amateur-radio operators, and they strongly objected to that reallocation, predicting that the result would be even more on-the-air chaos.

Hams were successful in keeping 220 MHz. The FCC's eyes turned to establishing the new CB service at 800 MHz, and in 1979 the agency began a large-scale inquiry into how that could be accomplished. Consultants were hired. Thousands of questionnaires were distributed. Comments were received from industry and the public.

In 1983, the General Electric company filed a request with the FCC to expedite the process of authorizing a new service at 800 MHz. It reported the results of its program to develop what it called a *P*ersonal *R*adio *C*ommunications *S*ervice (PRCS), a highly advanced base- and mobile-radio system for the family or small business user. The projected cost for both the base and the mobile unit was under $500. That FM system used selective addressing and microprocessor-controlled channel selection to assure users of a free channel and to reduce interference to the maximum extent possible.

PRCS was a flexible system that would have lent itself well to travelers-assistance and motorist-safety applications. PRCS had, however, one particular capability that represented both its most exciting feature and its downfall. PRCS could be used as a mobile telephone. The user could make telephone calls from a mobile or portable unit, through one's own base station at home, connected to the telephone line in a similar manner as an answering machine. No special charges would apply, unless the user chose to operate through an optional local-repeater system for greater range. Repeater fees were expected to be about $10 a month.

The competition PRCS could have given to the then-infant cellular-telephone industry was considerable. Unlike cellular, PRCS was capable of direct mobile-to-mobile communication and through-the-home mobile-telephone calling at no cost. Attorneys for General Electric's competitors are unwilling to sacrifice any of the precious 800-MHz spectrum to a consumer-oriented personal-radio service. So they filed mountains of documents with the FCC claiming that PRCS would be beset by massive interference and that there was little or no measurable demand for the service anyway, even though GE was attracting interest as a result of PRCS demonstrations.

Faced with competing demands for 800-MHz, and contending that the higher-priced cellular telephone could meet most of the needs projected for the PRCS, the FCC elected not to authorize PRCS and to let the experimental authorizations for the small number of existing PRCS stations expire. A petition for reconsideration of that action, filed by the Personal Radio Steering Group Inc. of Ann Arbor, MI, is still pending.

The FCC did not forget about the promise of personal radio and the possibility of creating some kind of improvement in CB. In January of this year, the Commission returned to those 8 460-MHz channels that belonged to the Citizens Radio of old, now called the *G*eneral *M*obile *R*adio *S*ervice (GMRS), and proposed to establish in those channels a CB Consumer Radio Service based on low-power hand-held radios.

That proposal was greeted with astonishment by a large user of the GMRS channels, REACT, the national association of volunteer emergency-communications teams, and by many non-affiliated personal-radio users and community-watch groups. Those users have operated GMRS repeater systems for years and did not take kindly to the FCC's recommendation that the Consumer Radio Service be limited to short-range, unlicensed walkie-talkies. GMRS licensees are busy with a campaign to alert their congres-

THIS MIDLAND *70-526* mobile UHF transceiver is designed for GMRS use.

sional representatives to the take-away that the Consumer Radio Service seems to represent. The FCC maintains that it's keeping an open mind on the subject and won't do anything with the GMRS channels until all of the formal comments are received (the deadline for that was this past June 30) and it has had a chance to analyze them.

Flexible radio service

So far, there is still one part of the 800-MHz band that remains unallocated. We've looked at some of the radio services proposed for this band, including one (PRCS) that appears to have been ruled out. The lucky radio service or services that receive an 800-MHz allocation will undoubtedly start a new industry or enhance an existing one, depending on how the allocations are made. Has the FCC given any indication as to what it will do?

Several Commissioners and staff members have indicated that they would like to try a totally different approach to spectrum allocation. Instead of weighing the arguments presented by petitioners and granting the requests they determine are most in the public interest, the FCC is examining the possibility of throwing the remaining portion of the 800-MHz band wide-open for any lawful use by selected licensees.

That would be accomplished by a lottery or auction process to award a limited number of nationwide licenses to parties who in turn would decide for themselves which service—mobile radio, cellular telephone, paging, satellite, video, etc.—would be most profitable. They could then implement their spectrum allocation. That would relieve the commission of the difficult task of deciding which proposed communication services are most beneficial to the public, and would leave the future of the spectrum in the hands of the marketplace.

That proposal, known generally as the Flexible Allocation or Flexible Radio Service, has produced heated debate from within and outside the FCC. The approach could result in the necessity for two-way radio users to buy their channels instead of receiving them "free" with an FCC license.

Such a Flexible Radio Service could, theoretically at least, bring new communications technologies to market faster because detailed FCC approval at every step along the way would not be needed. Proponents of flexible allocation say it is our last chance to try something innovative with the radio spectrum. Opponents of the controversial proposal say it is wrong to conduct economic experiments with precious frequencies needed for public services.

Millions, if not billions of dollars hang in the balance of those critical decisions about how the radio spectrum should best be allocated. The UHF band—particularly 800 MHz—will be the cause of quite a few interesting battles over the future of communications. Who do *you* believe should win the "Spectrum Wars?" **R-E**

FROM DC TO MICROWAVE

continued from page 48

that property is what makes things like radar (which is an acronym for *RA*dio *D*etection *A*nd *R*anging), used for tracking airplanes as well as speeding motorists, possible.

Microwave is used for communications in areas where it is impractical to lay or string cables. Microwave receivers and transmitters located atop high towers in rural areas, or on tall buildings in cities, relay communications over spans of dozens of miles at a time. Much transcontinental voice and data communications, once handled by cable, is now accomplished via microwave links.

The frequencies used by communications satellites are also located in the SHF part of the spectrum. Because, with their relatively short wavelengths, microwaves act like light, they can be treated like light. The familiar satellite dish (see Fig. 3) is actually the radio equivalent of a reflecting telescope. The purpose of the dish in a receiving installation is to collect the microwave signals coming from a satellite transponder and focus them on an antenna (called a probe) located at the dish's focal point (within a feedhorn). Similarly, in a transmitting set-up, the dish is used to concentrate microwave signals into a tight beam. Satellite-TV activity takes place between 3.4 and 4.2 gigahertz (the C-band) and between 11.7 and 12.7 gigahertz (the Ku-band—pronounced "cue-band").

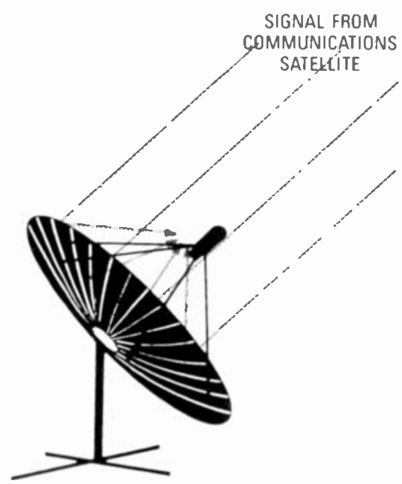
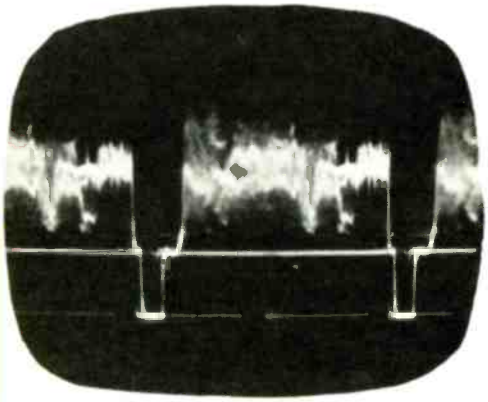


FIG. 3—BECAUSE THEY HAVE PROPERTIES similar to those of light, microwave signals can be collected and focused on an antenna element by a metalic surfaced reflector. That property is the basis of the satellite dish. The satellite dish is the radio equivalent of the optical reflecting telescope.

There is some concern over the effects of microwave radiation on the human body. Just as a microwave oven can induce heating in organic (and metallic) materials by stimulating molecular motion (the faster molecules or atoms move, the hotter they become), any microwave source can do the same. There have been reports that microwave technicians, particularly those working with high power levels, have suffered higher than normal rates of certain disorders such as cataracts. To most of us microwaves pose no health threat but nevertheless, like anything that is potentially dangerous, they should be treated with care and respect.

And beyond

Above the SHF band is the EHF (*E*xtremely *H*igh *F*requency) region. Frequencies there are most conveniently specified in terahertz—thousands of billions of cycles per second. Wavelengths in the EHF region are only in the millimeter range (for reference, a dime is a little less than a millimeter thick). At the top end of the range, the frequencies border on those of infrared light. While little use is made of these frequencies at present, they are beginning to be exploited for communications in space. It is safe to expect that use of those frequencies will grow as our exploration of space continues, and as the frequencies below become occupied. **R-E**



TV SIGNAL DESCRAMBLING

More on PLL's and how they can be used in practical descrambling circuits.

WILLIAM SHEETS and RUDOLF F. GRAF

Part 4

LAST TIME, WE looked at some practical descrambling circuits. At the heart of several of those circuits was the *P*hase-*L*ocked *L*oop (PLL). This month, we'll begin by looking more closely at PLL's, and how they can be used to descramble various types of signals.

Phase-locked loops

Thanks, in part, to the widespread popularity of FM stereo radio, a number of single-IC PLL FM-stereo demodulators have been developed. Generally those devices contain an input amplifier, a phase detector, a VCO (*V*oltage *C*ontrolled *O*scillator), some form of lock detector for audio muting or stereo lamp switching, a decoder matrix, and a voltage regulator that allows the unit to operate from a wide variety of supply voltages. Some of those devices require little in the way of external components, including hard-to-find coils, to operate.

PLL's are ideal for regenerating the 15-, 31-, 40-, or 62-kHz subcarriers used in the gated-sync, sinewave, or SSAVI systems that we have discussed previously. Where appropriate, PLL's can also be used to demodulate hidden audio subcarriers, thus doing two jobs for the price of one. Further, because PLL's are mass produced, they are easily obtained and inexpensive.

Figure 1 is a block diagram of a typical PLL. Basically, a PLL operates by comparing the frequency of an input signal with that of a signal generated by an onboard VCO. The VCO is set up to shift frequency such that its output frequency and that of the PLL's input signal are identical. Both signals are applied to a phase detector, which is where the actual comparison takes place. (In some instances the VCO is set up to operate at a multiple of the input frequency range. In PLL's where that is done, a frequency divider is inserted in the loop between the VCO and the phase detector.) If the frequencies of the input and the VCO signals differ, the phase detector produces an AC signal. Otherwise, a DC voltage that is proportional to the *phase* difference between the two signals is produced. Thus, once the PLL is "locked," that is, once the input and VCO frequencies match, only a phase error exists between the two signals. The frequencies of the input and output signals are equal. The output of the phase detector is fed to an amplifier/integrator. That stage produces the control voltage for the VCO.

> Over the next few months, **Radio-Electronics** will be presenting a series of articles describing the techniques used by pay-TV and cable companies to scramble their signals. While specific circuits for specific scrambling systems will be discussed, they are presented for *informational and experimental purposes only*. Therefore, parts lists, parts suppliers, and additional technical support *will not be available* for those circuits.

recovering only one mono channel. Therefore, only one of the audio outputs is used. However, we do need to recover the pilot signal. In FM-stereo systems, the pilot is used only to indicate the presence of a stereo signal. But in some scrambling systems, such as gated pulse, that signal is needed for sync regeneration. For other scrambling systems, the pilot signal could be used to switch in the decoder automatically at the appropriate time.

The PLL used in the circuit of Fig. 2 is designed for 19/38-kHz operation. If needed, we feel that the LM1800 could be made to operate at frequencies up to 100 kHz because it's fabricated using transistors that inherently can operate to several megahertz. However, we have not been able to confirm that.

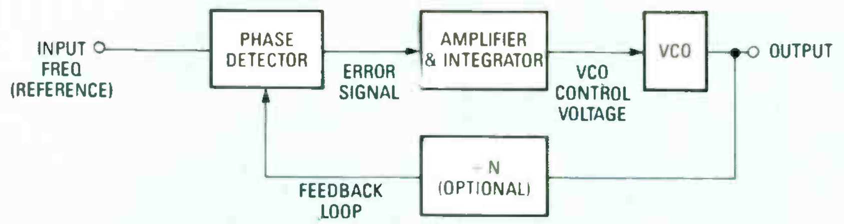


FIG. 1—A PLL IS AT THE HEART of many descrambling circuits. A block diagram of that device, commonly available in IC form, is shown here.

A circuit that can be used for subcarrier regeneration is shown in Fig. 2; the heart of the circuit is an LM1800 PLL stereo-demodulator IC. The circuit is very similar to the one that would be used for FM-stereo detection. With subcarrier-regeneration circuits, we do not have to worry about stereo separation, since we are

In any event, the most commonly used subcarrier frequencies are within the range of the LM1800. In the gated-pulse system, where the audio is usually encrypted on a 15-kHz subcarrier, the circuit of Fig. 2 could be used both to recover the subcarrier and to decode the audio.

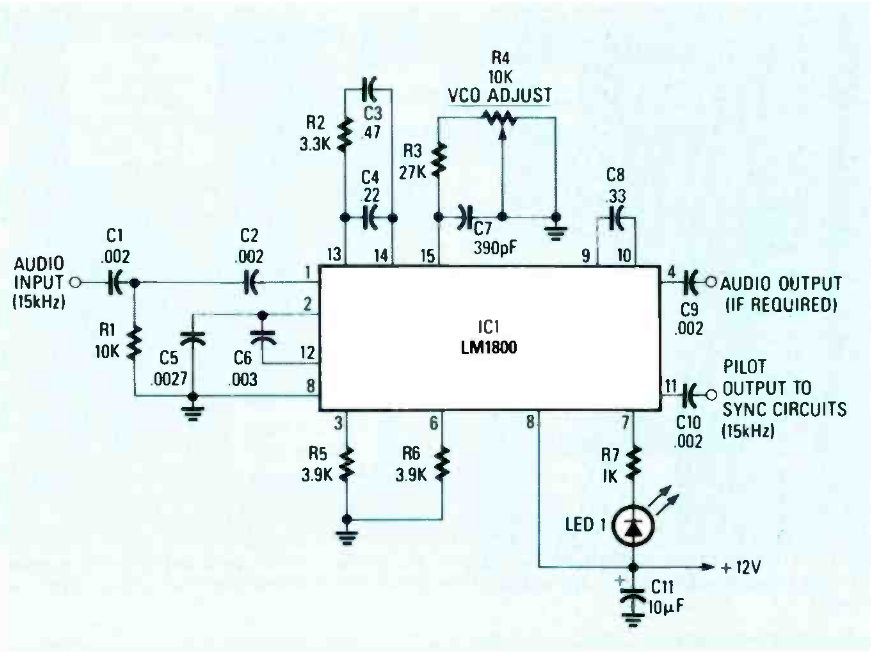


FIG. 2—THOUGH DESIGNED FOR FM-STEREO DEMODULATION, the LM1800 PLL can be used to good advantage in descrambling systems. Here that IC is used to regenerate a hidden subcarrier.

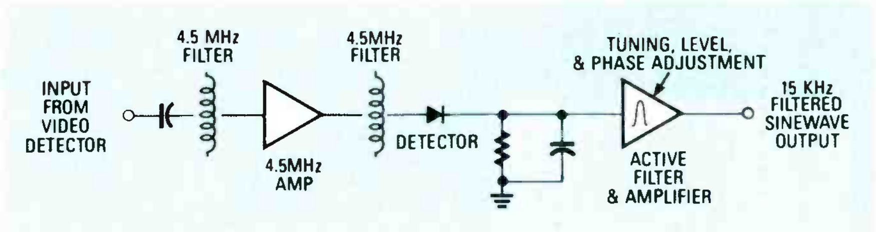


FIG. 3—THIS BLOCK DIAGRAM shows the system used to recover the descrambling sinewave required by a sinewave decoder.

In the sinewave system, the audio is placed on a 62.5-kHz subcarrier. For that scrambling system, the circuit of Fig. 2 would be used only for recovering the audio. Note that some modifications to the highpass filter at pin 1 and the VCO's frequency-control circuit at pin 15 would be necessary to accommodate the different frequency. The circuit as shown is designed for 15-kHz operation. In the highpass filter, C1 and C2 should both be changed to 470-pF units. In the VCO control circuit, C7 should be replaced with a 100-pF unit. Alternately, R3 and R4 could be replaced with 6.8K and 5K units, respectively. You may need to modify the PLL loop filter and the threshold filter.

A worthwhile experiment would be to set up the circuit on a breadboard and to check out its operation using an audio or function generator to supply the needed input signal.

Sinewave decoding

The procedure used to recover the sync in the sinewave scrambling system differs somewhat. In the sinewave system, the synchronized 15-kHz sinewave is encoded on the 4.5-MHz sound subcarrier. In a conventional TV-sound limiter, that AM component is stripped away. Therefore it does not appear at the output of the sound detector and we must obtain that signal at a different point in the signal processing trail.

Figure 3 shows a block diagram of a circuit that could be used to recover the decoding sinewave. The 4.5-MHz sound subcarrier is taken from the video detector. It could also be taken from the TV set's sound/sync detector, if the set has one (not all do), or, if possible, from the sound IF *before* limiting has taken place.

After the 4.5-MHz sound subcarrier has been obtained, it is amplified and then fed to an envelope-detector stage. The output of the detector contains the low-level 15-kHz signal (modulation percentages of 5 to 15 are typical), as well as unwanted components such as induced AM audio from the sound channel.

The unwanted components are removed by a high-Q active filter. In that stage the signal is also amplified and its phase adjusted so that it differs from the encoding signal by 180°. Finally, any distortion due to non-linearity, harmonics, etc. is removed; the recovered signal must match the encoding one exactly, except for the phase difference, or incomplete cancellation will take place. The result would be ripples, shading, etc. in the picture.

It is possible to distort the recovered signal deliberately to compensate for non-

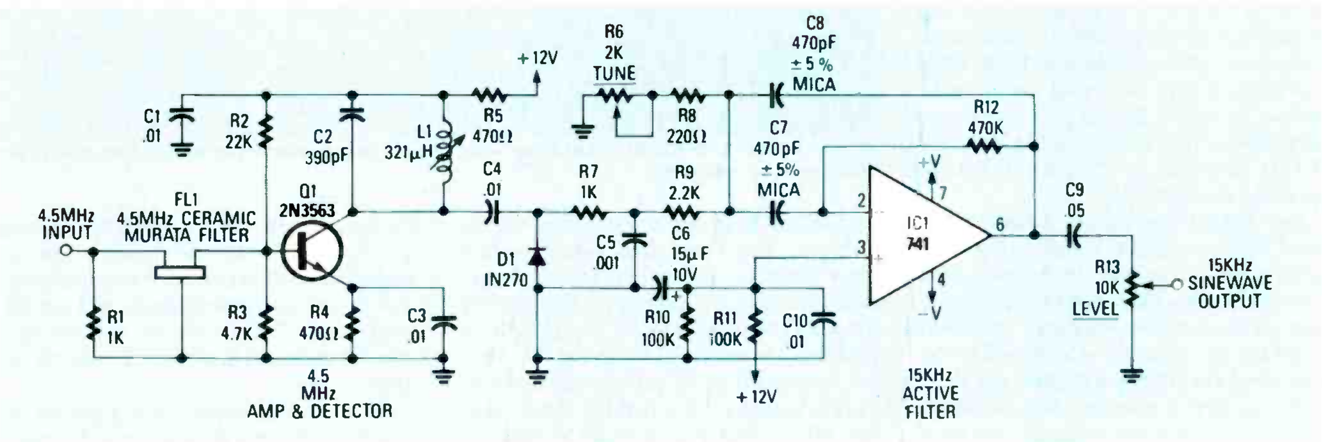


FIG. 4—HERE THE BLOCK DIAGRAM OF Fig. 3 is translated into a practical circuit. Any op-amp designed for audio work may be used for IC1.

linearity elsewhere in the decoder, such as in the modulator. However the best decoders are the ones that are well designed (i.e. linear) in the first place. Generally, if the sinewave-recovery circuit requires tweaking or tailoring to match the balance of the decoder, it is an indication of a poorly designed system. A circuit that is well engineered should work the first time, and not require any critical adjustments or adjustment techniques. For the most part, the circuits that we are presenting in this series meet that criteria. If the circuit is unstable, or requires critical adjustment, it is an indication that something is wrong.

Now let's translate our block diagram into a practical circuit. One representative circuit is shown in Fig. 4. In that relatively simple circuit, the 4.5-MHz signal is taken from the TV sound system *before* limiting. It is passed through a 4.5-MHz ceramic filter to eliminate any "junk" (unwanted components), and then amplified by Q1, an NPN transistor that has a gain of 25 to 30 dB. A 4.5-MHz tuned circuit in the collector circuit of Q1 serves as a load, across which the 4.5-MHz output-signal is developed. The signal is then diode detected and fed to the active-filter stage. The filter has a nominal gain of 40 dB and is tuned to 15 kHz. In that stage the phase shift of the signal is adjusted as previously described. That adjustment is made by varying the setting of R6. The response of the active filter is much like that of a tuned LC circuit. While a 741 is specified for IC1, almost any op-amp designed for AF operation is suitable. Among the other possible choices are an RC4558, an LM1458, or a 747. The output of the circuit is taken from R13, the 10K LEVEL potentiometer.

During operation, the circuit should be checked with a scope for linearity. To be conservative, the 15-kHz signal seen at the output of the op amp should never exceed about one half the supply voltage. For example, in the circuit of Fig. 4, which is designed to use a 12-volt supply, that voltage should not exceed 6-volts p-p. The level of the 4.5-MHz input signal will be between about 30 and 100 millivolts, depending on the modulation level. Note that levels higher than that could cause limiting in either the amp or the active filter stages. That will result in a distorted 15-kHz sinewave at the output and incomplete descrambling.

The circuit shown in Fig. 4 can be combined with the circuit shown in Fig. 7 of Part 3 of this series (see the August, 1986 issue of **Radio-Electronics**) to form a functional sinewave decoder. However, installing the decoder would require at least some familiarity with how a TV set works, as several internal connections are required. Among other things, you must know where to tap off the required inputs, where to feed the descrambled output,

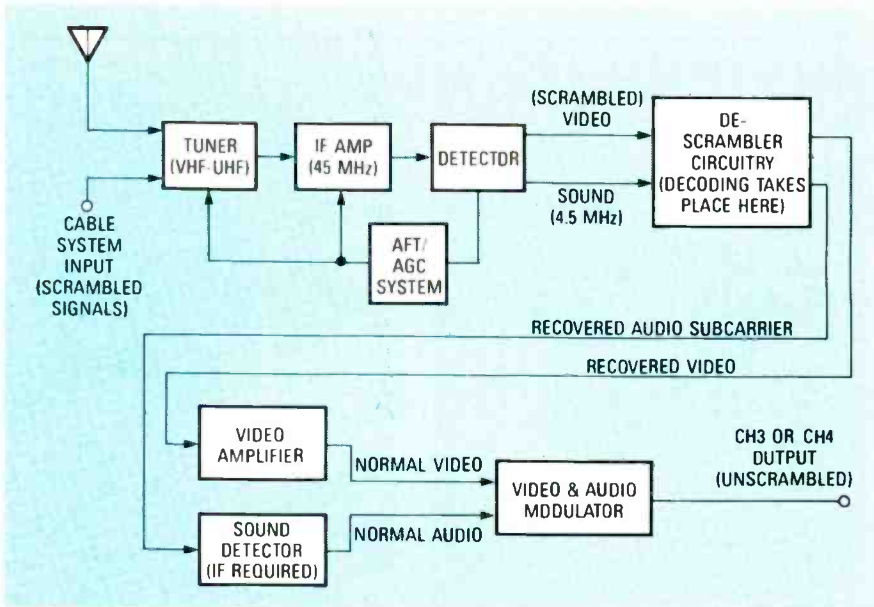


FIG. 5—TO AVOID COMPLICATED INSTALLATIONS, the decoder can be combined with a TV front-end to form a converter-descrambler. The output of that circuit can be fed directly to the antenna input on a TV set.

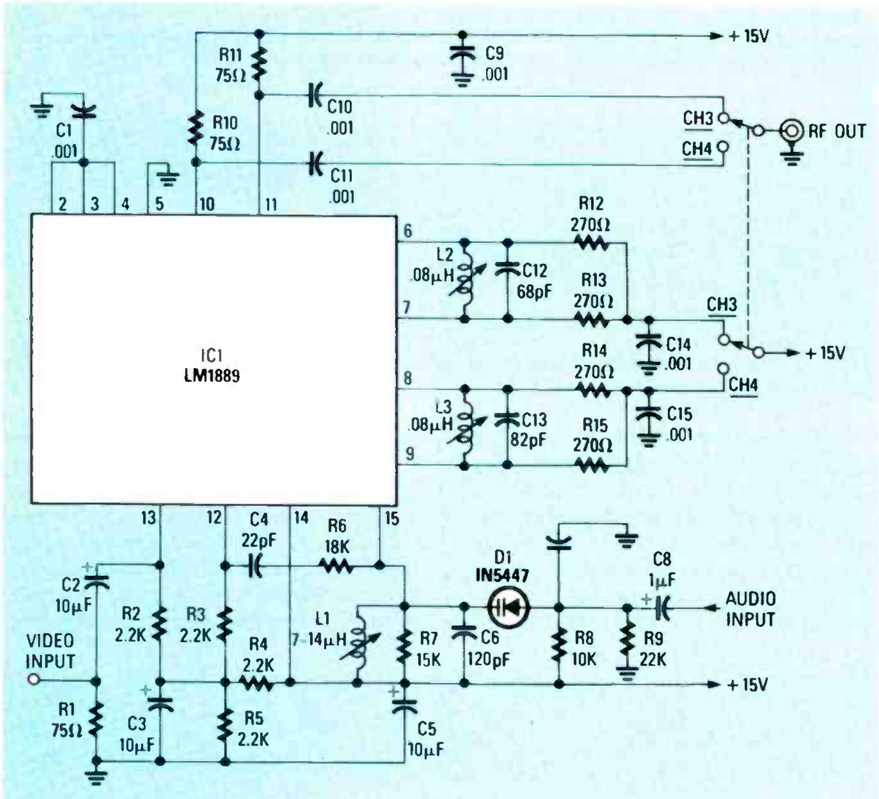


FIG. 6—A SIMPLE RF MODULATOR. If you wish, a modulator could also be obtained from a discarded videogame or computer.

and where to obtain the required supply voltages. For some, that would present little problem. But many others do not have the required expertise. Further, the growing use of IC's in TV sets presents a problem. In many IC-intensive TV sets, the required tap-off points may be contained within an IC, making them inaccessible. In that case, it would be virtually impossible to connect our decoder.

The solution to those problems is to design a decoder that essentially contains a complete TV-set "front-end." The decoder would then contain a tuner, IF amp, video and audio detectors, and an RF modulator. The output of the decoder could then be fed to a user's TV set via the antenna input.

Such a unit would most properly be called a converter-descrambler. Its block diagram is shown in Fig. 5. In it, signals from an antenna or cable system are fed to

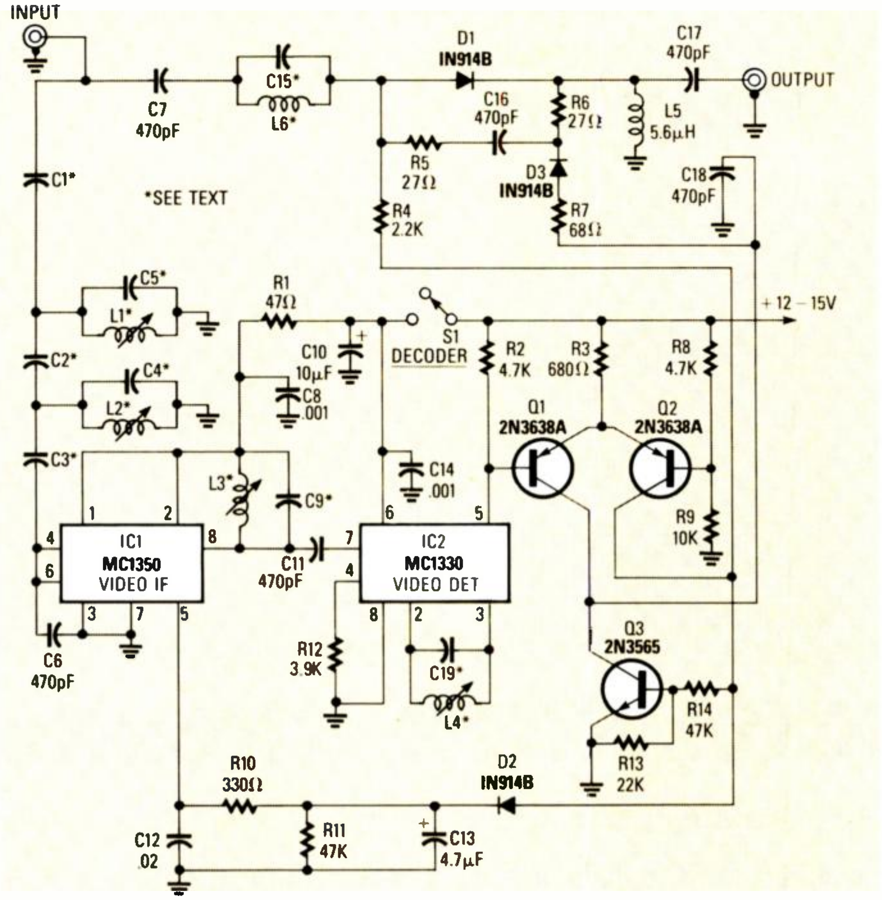


FIG. 7—IN THE OUTBAND SYSTEM, used only on cable-TV systems, the sync is hidden on an unused frequency, outside of the channel itself. Therefore, a decoder, like the one shown here, must have some way to "tune in" that out-of-channel sync signal.

a tuner and on to a 45-MHz IF amp; 45 MHz is a standard TV IF frequency. From the amp, the signal is fed to standard TV sound and video detectors. The outputs from the detectors are scrambled video and the 4.5-MHz audio subcarrier. Those are the signals that the descrambler needs to do its job. The outputs of the descrambler stage are a normal video signal and either a normal audio signal or a recovered audio subcarrier, depending on the scrambling system. In the latter case, the subcarrier is fed to a second sound detector to recover a normal audio signal. The audio and video could be fed directly to a set with audio/video inputs, but a more "universal" approach would be to feed those signals to an RF modulator set up to output on either Channel 3 or 4. A standard RF modulator circuit is shown in Fig. 6. Alternately, RF modulators are available commercially or can be salvaged from a discarded videogame or computer.

The SSAVI system

As previously discussed, SSAVI (*S*uppressed *S*ync *A*nd *V*ideo *I*nversion) is one of the more sophisticated of the scrambling techniques. In that system, four modes of operation are possible. Those are: suppressed sync and inverted video, suppressed sync and normal video, normal sync and inverted video, and normal sync and normal video (unscrambled). The system has the capability to switch between any of the four modes on a frame-to-frame basis. Therefore the scrambling method can change as often as 60 times-per-second, if desired. The sound is stripped from the audio subcarrier and placed on another subcarrier located at 39.335 kHz (2.5 times the horizontal frequency).

Further complicating the task of descrambling is the fact that no reference signal is sent with the scrambled picture. The decoder must provide its own reference. Also, the decoder must be able to detect whether or not the video is inverted. Note that the sync signal is never inverted, so the decoder circuitry must only invert the video portion of the signal, when required. The sync signal may, however, be suppressed.

How does a decoder regenerate the sync and detect when the video is inverted? In the SSAVI system, the first 26 lines of the picture are sent with normal sync pulses. A PLL can lock onto that information and supply the missing information for the rest of the frame. The regenerated sync is used to restore normal sync, which in turn is used as a reference. The leading edge of the vertical sync pulse is used as a reference from which all operations are timed. During the 20th line, which is picked out by the decoder by using a counter circuit, information is sent as to whether the video in the frame is inverted or normal.

As you can see, the SSAVI decoder is called on to perform a number of tasks. Because of that, the circuitry is rather extensive. Fortunately, it is also rather straightforward. We will look at the details in the next installment in this series.

Note that the typical SSAVI descrambler contains much circuitry that is not involved in the descrambling process. That includes anti-theft circuitry, as well as circuitry that allows for two or more tiers of premium programming. As such circuits play no part in the descrambling process, they will not be discussed.

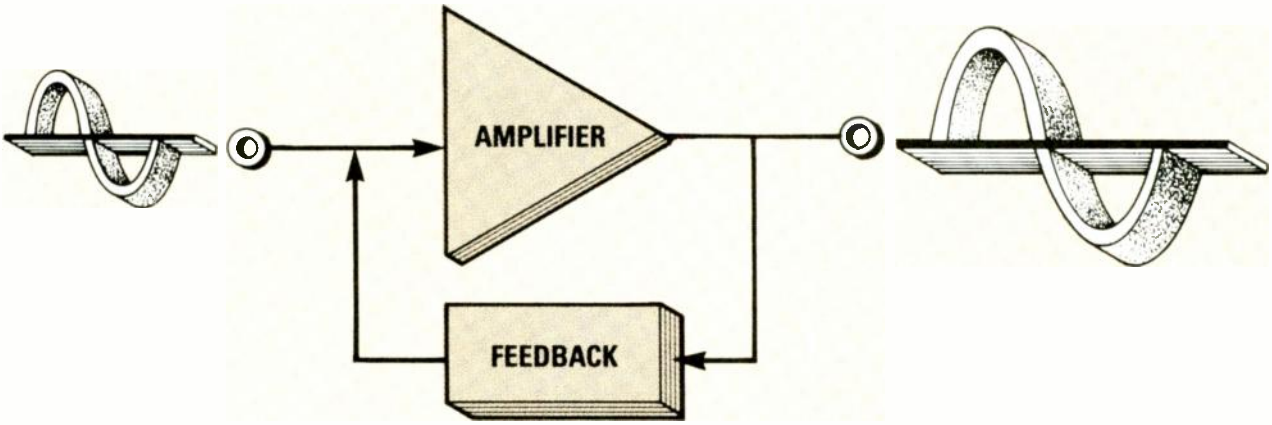
Outband descramblers

Before we wrap up for this month, let's look at a system that is used in many cable systems. Called the outband system, in it the sync signal is placed on a subcarrier, but the subcarrier frequency is not within the channel. Instead, it is within an unused cable channel. The frequencies most often used are somewhere around 50 MHz (below broadcast Channel 2) or between 90 and 120 MHz (those frequencies fall in the FM-broadcast and aviation bands).

As described in a previous installment, to recover the sync the decoder requires a circuit that can "tune in" the out-of-channel carrier. A typical outband decoder is shown in Fig. 7. In that circuit, the composite cable signal is split two ways. The sync frequency is passed by an appropriately tuned input filter and fed to a video IF-amp stage. A trap, set up to be resonant at the sync-carrier frequency, prevents the sync signal from appearing at the output. From the IF amp, the sync signal is fed to a video detector. The output of the video detector (pin 5, IC2), which consists solely of sync pulses, drives a differential amplifier. The differential amp drives a voltage-controlled attenuator. When a sync pulse is not present, the output of the video detector goes negative and the current from the differential amp reverse biases D1 and forward biases D2. That "inserts" the attenuator in the circuit. When a sync pulse is present, the output of the detector goes positive. Then, D1 is forward biased while D2 is reverse biased. That removes the attenuator from the circuit.

Note that values for the components in the traps and filters have not been specified. That's because those values can vary widely, depending on the frequency of the sync channel. In a future installment we will present a more detailed version of the circuit. **R-E**

How to Design OSCILLATOR Circuits



JOSEPH J. CARR

Our series continues with a discussion of RC oscillators, ways of generating sinewaves from other waveforms, and other topics.

Part 3

IN THE PAST TWO INstallments of this series we discussed relaxation oscillators and feedback oscillators built from LC tank circuits. This time we'll look at RC oscillators. Some of our example circuits are built from FET's and bipolar transistors; others are built from operational amplifiers. But whatever components they're built from, all our circuits have one thing in common: The frequency at which a given circuit oscillates is determined by one or more RC time constants in the circuit.

The phase-shift oscillator

As we learned in a previous installment, a feedback oscillator works by feeding a portion of a circuit's output signal back to its input. The signal that is fed back must be applied in phase with the input signal. Since we usually use an inverting amplifier (which provides 180 degrees of phase shift) as the active element of a feedback oscillator, we must obtain an additional 180 degrees of phase shift from other circuit elements. In the three-leg RC phase-shift oscillator shown in Fig. 1, each leg provides 60 degrees of phase shift, for a total of 180 degrees. An op-amp version of the phase-shift oscillator is shown in Fig. 2. Both circuits produce a sinewave output signal.

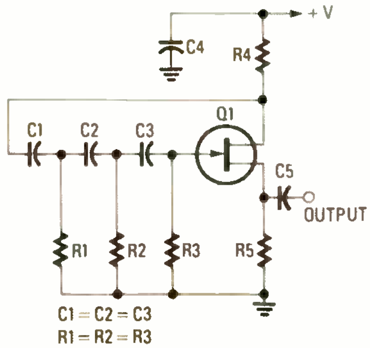


FIG. 1—EACH RC PAIR PROVIDES 60 of phase shift for a total of 180 ; that phase shift combines with the 180 provided by the FET for a total of 360 .

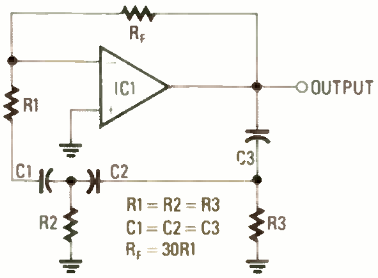


FIG. 2—A PHASE-SHIFT OSCILLATOR can also be built from an op-amp. R_F must be at least 30 times the value of R1 for the circuit to oscillate

The frequency at which either circuit will oscillate is determined by the values of R1–R3 and C1–C3; to keep the mathematics simple, we usually give each resistor the same value; likewise with the capacitors. In Fig. 1, the other resistors (R4 and R5) serve to bias the FET, and capacitor C5 provides DC isolation. We'll discuss the function of the op-amp circuit's R_F below; first let's see how to calculate oscillating frequency.

Assuming that R1 = R2 = R3 and that C1 = C2 = C3, then

$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

In that equation, R = R1 and C = C1. If resistance is specified in ohms and capacitance in farads, then frequency will be given in hertz.

When the constant terms in that equation are combined, we can rewrite the equation as follows:

$$f = 1/(15.4\ RC)$$

or as

$$f = 0.408/(2\pi\ RC)$$

When designing an oscillator we usually need to find a resistor/capacitor combination that will produce a desired frequency, so another form of the equation can also be useful. Since there are fewer standard capacitor values, we tend to select one and then plug it and the desired operating frequency into the equation to find the closest resistor value which will produce that frequency. So we rearrange the equation as follows:

$$R = 0.408/(2\pi fC)$$

Let's take an example: Find the resistance required to produce a 1000-Hz oscillator with a 0.01-µF capacitor.

$$R = \frac{0.408}{2 \times 3.14 \times 1000 \times .01 \times 10^{-6}}$$

$$R = 0.408/(6.28 \times 10^{-5})$$

$$R = 6497 \text{ ohms}$$

In any feedback oscillator we must ensure that the closed-loop gain is unity or more. The closed-loop gain of the circuit in Fig. 2 is the ratio R_F/R. Analysis reveals that the loss in the feedback circuit is $1/29$, so circuit gain must be greater than 29 in order to ensure oscillation. So R_F should be at least 30 times the value of R. For the 1000-Hz oscillator discussed previously, R_F should be $30 \times 6497 = 194{,}910$ ohms. You could use a 200K resistor, which is the closest standard value.

BASIC program

To ease the tedium of calculating the values of the frequency-determining components in a phase-shift oscillator, we wrote the simple BASIC program shown in Listing 1. The program was written in the dialect of BASIC that runs on the IBM-PC, but it will run on many machines unmodified, and it should be easy to translate into another dialect.

The program calculates component values for either three-leg phase-shift oscillator presented above; in addition, it will calculate minimum and maximum resistor values for a variable-frequency oscillator. To build a variable-frequency oscillator, you would have to use a triple-gang potentiometer or a triple-pole switch to select appropriate resistors.

When you run the program, it asks whether you want to calculate values for a fixed- or a variable-frequency oscillator. You must then type in the frequency (or the frequency range) you need. Then the program will request the value of the timing capacitor. Last, it calculates and displays the resistance (or range of resistance) that will be required.

It is possible to vary the frequency of a variable-frequency phase-shift oscillator over a range greater than 10:1 using just resistors, but it is impractical to do so. Circuit considerations aside, it becomes difficult to adjust the frequency accurately. Hence the program prints a warning if you enter high and low frequencies that are in a ratio greater than 10:1. If you really need a wide-range variable-frequency oscillator, be patient; we'll discuss a technique for designing one below.

LISTING 1

```
10 GOSUB 920
20 PRINT "This program calculates
30 PRINT "the component values
40 PRINT "for an RC phase-shift
50 PRINT "oscillator.
60 PRINT
70 PRINT
80 GOSUB 960
90 GOSUB 920
100 PRINT "CHOOSE one:
110 PRINT
120 PRINT "1. Fixed oscillator
130 PRINT "2. Variable oscillator
140 PRINT
150 INPUT "SELECTION?",A
160 IF A > 2, THEN GOTO 100
170 ON A GOTO 180, 480
180 GOSUB 880
190 PRINT "Fixed Frequency
200 PRINT "option selected
210 PRINT
220 INPUT "Frequency in Hz?",F
230 PRINT
240 PRINT
250 INPUT "Capacitance in uF",C
260 C = C/(10^6)
270 R = 1/(15.391*C*F)
280 R = INT(R)
290 R4 = 30*R
300 C = C*10^6
310 GOSUB 880
320 R4 = INT(R4)
330 PRINT "Component Values for
340 PRINT "fixed frequency version
350 PRINT
360 PRINT "Operating Frequency:";
370 PRINT F;" Hz
380 PRINT "Capacitors C1=C2=C3=";
390 PRINT C;" uF
400 PRINT "Resistors R1=R2=R3=";
410 PRINT R;" Ohms
420 PRINT "Feedback Resistor R4=";
430 PRINT R4;" Ohms
440 PRINT
450 PRINT
460 GOSUB 960
470 GOTO 1150
480 GOSUB 920
490 PRINT "Variable Frequency
500 PRINT "Option Selected
510 PRINT
520 PRINT "Set upper and lower
530 PRINT "frequency limits
540 PRINT
550 INPUT "Lower Limit in Hz?",FL
560 PRINT
570 INPUT "Upper Limit in Hz?",FH
580 PRINT
590 IF FH > 11*FL THEN GOSUB 990
600 GOSUB 880
610 PRINT "Value of capacitor:
620 PRINT
630 INPUT "Capacitance in uF?",C
640 C = C/10^6
```

```
650 RL = 1/(15.391*C*FL)
660 RL = INT(RL)
670 RH = 1/(15.391*C*FH)
680 RH = INT(RH)
690 R4 = 30*RH
700 R4 = INT(R4)
710 C = C*10^6
720 GOSUB 880
730 PRINT "Component Values for
740 PRINT "Variable Frequency
750 PRINT "Oscillator
760 PRINT
770 PRINT "Frequency Range:";
780 PRINT FL;" to ";FH;" Hz
790 PRINT "Capacitors C1=C2=C3=";
800 PRINT C;" uF
810 PRINT "Resistor Range";
820 PRINT RH;" to ";RL;" Ohms
830 PRINT "Feedback Resistor R4:"
840 PRINT R4;" Ohms
850 GOSUB 880
860 GOSUB 960
870 GOTO 1150
880 FOR I = 1 TO 5
890 PRINT
900 NEXT I
910 RETURN
920 FOR I = 1 TO 30
930 PRINT
940 NEXT I
950 RETURN
960 PRINT "Press any key . . .";
970 A$=INKEY$: IF A$="" THEN 970
980 RETURN
990 GOSUB 880
1000 PRINT "Frequency range is
1010 PRINT "greater than 10:1.
1020 PRINT "It would be better
1030 PRINT "to break the range
1040 PRINT "into two bands.
1050 PRINT "    You can:
1060 PRINT
1070 PRINT "1.  Continue anyway
1080 PRINT "    or
1090 PRINT "2.  Do something else
1100 PRINT
1110 INPUT "SELECTION?",W
1120 IF W > 2, THEN GOTO 990
1130 ON W GOTO 1140,90
1140 RETURN
1150 PRINT
1160 PRINT "What's Your Pleasure?
1170 PRINT
1180 PRINT "1. Repeat
1190 PRINT "2. Start over
1200 PRINT "3. All done
1210 PRINT
1220 INPUT L
1230 IF L > 3, THEN GOTO 1150
1240 ON L GOTO 170,100,1250
1250 GOSUB 920
1260 PRINT "PROGRAM ENDED
1270 END
```

Wien-bridge oscillator

Another common RC oscillator is called a Wien bridge; it is a bridge circuit that resembles a Wheatstone bridge. As you can see in Fig. 3, two arms of the Wien bridge are purely resistive, and the other two are RC networks. One of the RC networks is a series circuit, and the other is a parallel circuit. The feedback loop is degenerative (hence stable) at all frequencies other than the oscillating frequency, which is given by:

$$f = \frac{1}{2\pi\sqrt{R3 \times R4 \times C1 \times C2}}$$

If R3 = R4 and C1 = C2, then that equation can be simplified as follows:

$$f = 1/(2\pi\, R3 \times C1)$$

Like the phase-shift oscillator, the Wien-bridge oscillator produces a sinewave output, but its amplitude tends to be some-

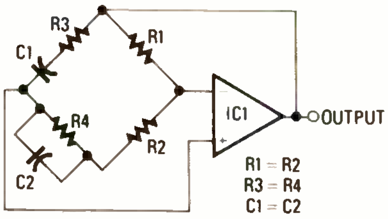


FIG. 3—A WIEN-BRIDGE OSCILLATOR resembles a Wheatstone bridge. Amplitude stability can be improved by substituting a low-current lamp for R2.

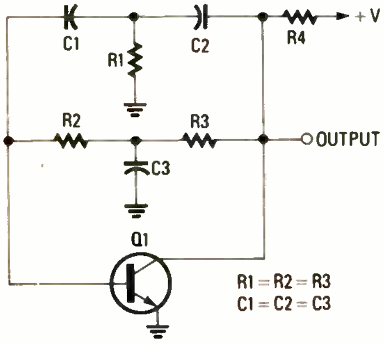


FIG. 4—TWIN-TEE OSCILLATOR is composed of two "T" shaped networks. One has series capacitors and a shunt resistor; the other has series resistors and a shunt capacitor.

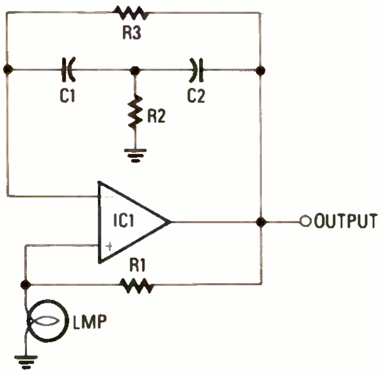


FIG. 5—THIS BRIDGED-TEE OSCILLATOR uses an incandescent lamp to increase amplitude stability of the output signal.

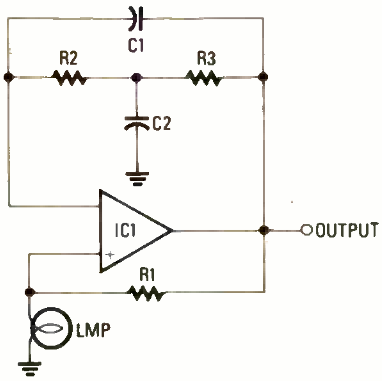


FIG. 6—ANOTHER BRIDGED-TEE OSCILLATOR; in both this circuit and the one shown in Fig. 5, the bridging component is the "opposite" of the T's series element.

what unstable, especially in a variable-frequency oscillator. It is possible to reduce that instability by replacing R2 with a low-current (40-mA) incandescent lamp. That type of lamp has a non-linear voltage-current characteristic that helps stabilize the output amplitude and prevent the amplifier from saturating. The lamp should be operated below incandescence.

Twin- and bridged-tee oscillators

There are several other types of sinewave oscillators based on RC networks. The circuit in Fig. 4 is called a twin-tee oscillator because its feedback network consists of two T-shaped networks. Note that those networks are, in a sense, opposites. One uses series resistors and a shunt capacitor, and the other uses series capacitors and a shunt resistor. If R1 = R2 = R3 and C1 = C2 = C3, the circuit's oscillating frequency is about:

$$f = 1/(2\pi RC)$$

A more useful form of that equation is:

$$R = 1/(2\pi fC)$$

For example, when each capacitor has a value of 0.01 µF, the resistance required for a 500-Hz twin-tee oscillator is:

$$R = 1/(2 \times 3.14 \times 500 \times 0.01 \times 10^{-6})$$

$$R = 1/(3.14 \times 10^{-5})$$

$$R = 31{,}831 \text{ ohms}$$

Another type of "tee" oscillator is called the bridged-tee oscillator. In that type of circuit, an RC tee-network is bridged by either a resistor or a capacitor. If the series elements of the tee-network are capacitors, then the bridging element will be a resistor (Fig. 5). If the series elements are resistors, then the bridging element will be a capacitor (Fig. 6).

Generating sinewaves

As we have seen, the output amplitude of many sinewave oscillators tends to be unstable. On the other hand, the output amplitude of a squarewave oscillator is inherently stable because it operates in a saturating mode wherein the output swings between two well-defined voltages. Therefore some designers prefer to use a squarewave or a triangle wave generator as the basic oscillator, and then shape its output into a sinewave.

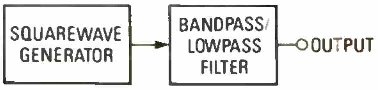


FIG. 7—LOWPASS OR BANDPASS FILTERS can clean up a squarewave source and provide a pure sinewave output.

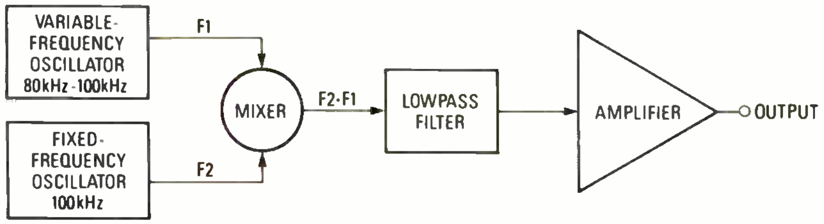


FIG. 8—A WIDE-RANGING OSCILLATOR can be built from a fixed- and a variable-frequency oscillator. Their outputs are mixed, the difference is taken, and that signal is then filtered and amplified for output.

Extracting a sinewave from a wave of some other shape is possible because all non-sinusoidal waveforms are composed of a number of sinewaves summed together. The squarewave and the triangle wave, for example, contain a sinewave at the fundamental frequency and a number of harmonics (multiples) of the fundamental frequency. For example, a squarewave with a fundamental frequency of 200 Hz would be composed of a 200-Hz sinewave, plus 400-Hz, 600-Hz, 800-Hz, . . . sinewaves.

If we filter out all of the harmonics, we'll be left with a sinewave at the fundamental frequency. The purity of the sinewave can be quite good, especially if a high order of filtering is used. As shown in Fig. 7, we can use a lowpass or bandpass filter.

Wide-range oscillators

Another way to bypass the limited frequency range of an RC oscillator is to use a dual-oscillator circuit; that type of circuit was popular in the 1950's. As shown in Fig. 8, the frequency of one oscillator is fixed (at 100 kHz); the other oscillates at a variable frequency (80–100 kHz) that is determined by the user. Both oscillators are LC types.

Their signals are fed to a non-linear mixer, the output of which is a new signal whose frequency is equal to the difference between the frequencies of the two input signals. That signal is sent through a lowpass filter to remove residual traces of f_1 and f_2, and then to an amplifier and the outside world.

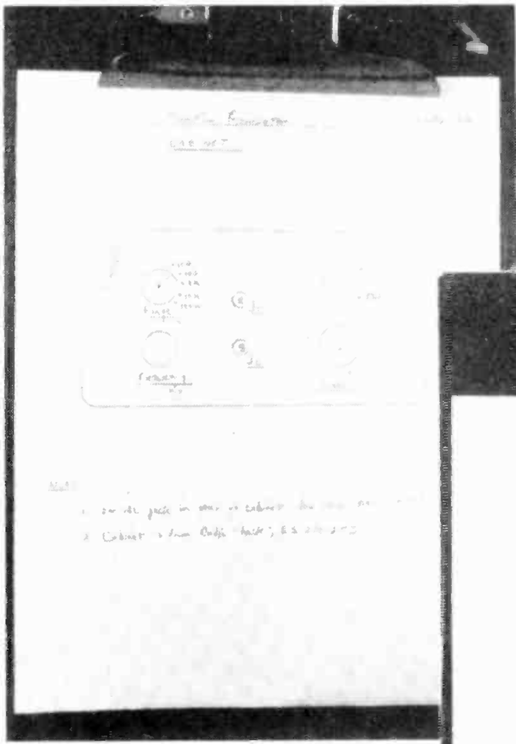
For example, when f_1 is 100 kHz, the difference between f_1 and f_2 is 0 Hz, so there is no output. However, when f_1 is 80 kHz, the output frequency is 100 – 80 = 20 kHz. So the output frequency may vary from 0 to 20 kHz.

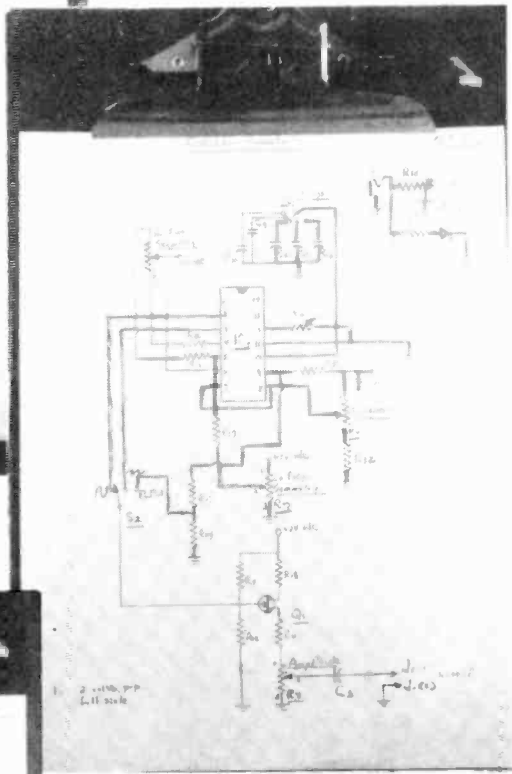
In our next installment we'll discuss RC triangle wave and squarewave oscillators; in addition we'll introduce the monostable multivibrator circuit. **R-E**

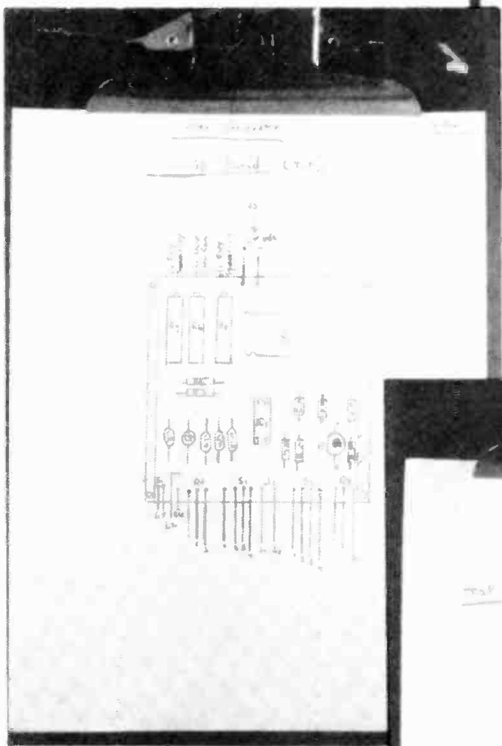
From Brainstorm to Bread Board

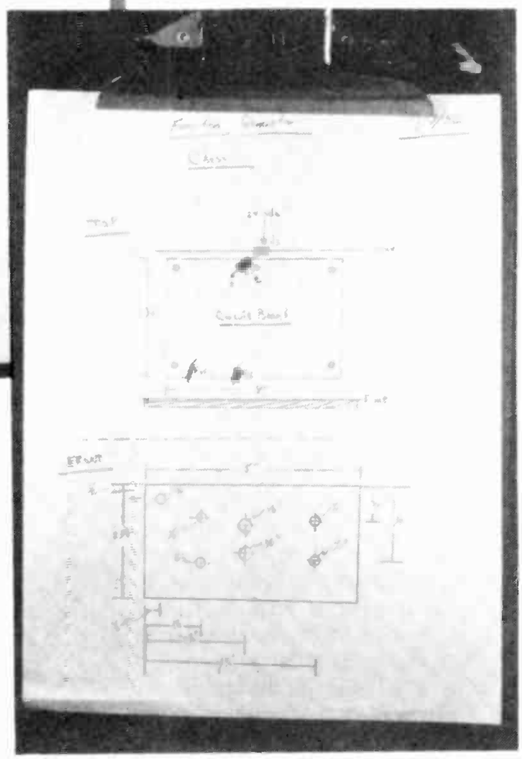
There are a lot of twists in the road between a good idea and a properly working circuit. In this article we'll show you how good paperwork, like a good map, can keep you from getting lost!

DAVID J. SWEENEY









IF YOU HAVE EVER DESIGNED AN ELECTRONICS project, you probably know that the job goes faster with an organized method for documenting the device as you build it. Despite that, diagrams and notes are usually produced as an afterthought, especially by less experienced designers. But rather than being a chore, or something that slows down the process of getting a project up and running, effective documentation can greatly reduce the time it takes to design an effective circuit. That's because poor documentation, or none at all, can cause design errors and construction mistakes, and constant rechecking; that can make building of a project drag on for weeks when it really should take only days.

To focus on methods for applying paperwork to electronics construction projects, this article splits the record-keeping task into manageable pieces. We'll look at a drawing plan that can be used to completely describe any type of electronics equipment, and we'll show you how to make that plan a part of the creative process as you design your own project. We'll also show you a way to keep track of circuit wiring during the construction phase of your project. It can be applied to point-to-point, wire-wrap, or PC-board construction and automatically shows what has been connected to what, and simplifies keeping track of progress.

Starting the paper trail

The process of getting an idea, diddling with it, deciding to do it, then establishing a formal set of drawings to control the project is shown in block-diagram form in Fig. 1. If you follow the procedure shown, when you finish you'll have a document that fully describes the device, the hardware housing it, and the history of your experience with it. The documentation process does not take long. Instead, it

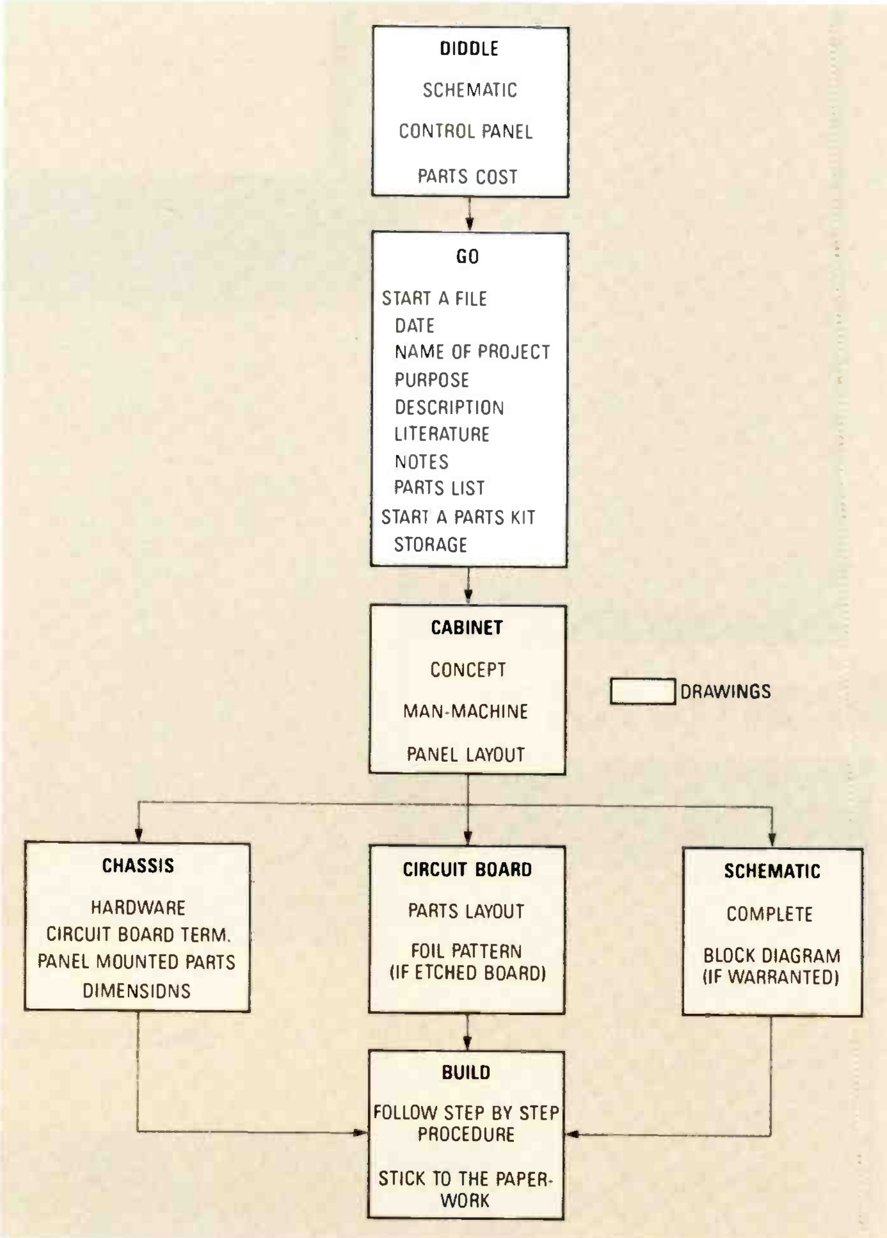


FIG. 1—THIS FLOW CHART shows the proper sequence of steps for turning your brainstorm into a properly working project.

saves time. You begin in the "diddle" stage.

During the diddle stage, the idea germinates. You sketch a schematic, make some changes, theorize about how the circuit works, and decide whether you have the time and money to build the device. The device requires controls, so you diddle with the front-panel layout, add more controls, and imagine how nice the device will look. You might also consider the possibility of using parts from your junk-box. Perhaps you can use the audio section from a portable stereo you stopped using long ago or the control board from a mothballed printer. In addition, you might search a library for books or magazines with useful information.

After diddling with the various aspects of the project, you enter the "go" stage. In the go stage, you gather the information that forms the basis for the project. First, open a document file. Enter the name of the project, the purpose of the device, any preliminary sketches, and a list of the parts you will need. Also, establish a project kit—simply a box for keeping the construction materials as you acquire them. If the idea requires a lot of complex circuitry, generate a block diagram and place it in the file. If a magazine article sparked the project, it, too, should go in the file. Finally, any other information regarding use or purpose should be included.

You're entering all of that information for a good reason: If you get sidetracked for a while, when you get back to the project you could find that you have forgotten some of the details. A lot of very good ideas get lost that way.

After you've completed the steps outlined in the go stage, it's time to make the drawings that will become the formal documentation for the project. Four separate drawings should be made. Those are cabinet layout, chassis layout, schematic, and circuit layout. All of the drawings must coordinate with each other. If done properly, those drawings will contain all the information required to completely describe any device under construction.

Cabinet

In many ways, the cabinet design is the one from which all of the other designs evolve. That's because the cabinet's design can directly affect any of the subsequent drawings. Even a simple change can affect the layout of the chassis or the circuit board. Those changes can, in turn, cause changes in the appearance of the schematic.

When designing the cabinet, thought should be given to both function and aesthetics; after all, the cabinet is the "interface" between the user and the device. More is involved here than mere appearance. Careful design should consider the mechanical factors in the operation and mounting of the various potentiometers, trimmers, switches, jacks, meters, displays, or what have you. Some considerations are obvious—spacing between controls must be sufficient to allow for comfortable operation. Others, however, may not become apparent until after you've cut the mounting holes. What may be a relatively small knob on the exterior can be attached to a relatively large rotary switch on the interior. If spacing is too tight, there might be insufficient clearance to mount all of the controls. To avoid such problems, consider all of the physical requirements for the cabinet as you design the unit's appearance.

Chassis

That drawing indicates the relative location of circuit boards, includes hardware dimensions and mounting holes, and locates any other parts that are mounted inside the cabinet. The identification of the electrical components should match the identification in the schematic. For example, if the panel-mounted potentiometer that controls the frequency of a function generator is called R4 in the schematic, it should be labeled R4 in the chassis diagram. In the cabinet drawing that control might have been labeled FREQUENCY; such labeling is acceptable for that drawing only.

In the chassis drawing, the circuit board or boards, regardless of their actual component count, are treated as units. Components that are located off the circuit boards should be shown in their relative positions so that they are easy to spot, but interconnecting wiring should not be shown. Showing such wiring would add

continued on page 94

THE VERSATILE 4007

Need a versatile CMOS building block for a one-of-a-kind application? Then the 4007 is for you. Find out how to use it here.

RAY MARSTON

THE 4007 IS THE SIMPLEST IC IN THE CMOS line. It contains just two pairs of complementary MOSFET's and a CMOS inverter. However, each element is independently accessible, so the elements can be combined in a great variety of ways. In fact, the 4007 is sometimes known as the "design-it-yourself" CMOS IC, as it can function as a digital inverter, a NAND or a NOR gate, or an analog switch. It can also function as a linear device.

Therefore, not only is the 4007 the simplest CMOS IC, but it is also the most versatile. And that makes it an ideal device for demonstrating the principles by which CMOS devices operate to students, technicians, and engineers. In this article we'll examine the 4007 from both theoretical and practical points of view, and we'll include many circuits that you can use as-is in your next design.

Basic digital operation

The guts of the 4007 are shown in Fig. 1. All MOSFET's in the 4007 are enhancement-mode devices; Q1, Q3, and Q5 are p-channel, and Q2, Q4, and Q6 are n-channel types. The drains and sources of MOSFET's Q1–Q4 are independent; the drain of Q6 is connected to the drain of Q5, so those two MOSFET's compose the inverter mentioned above. Each pair of transistors is protected by a network like the one shown in Fig. 2.

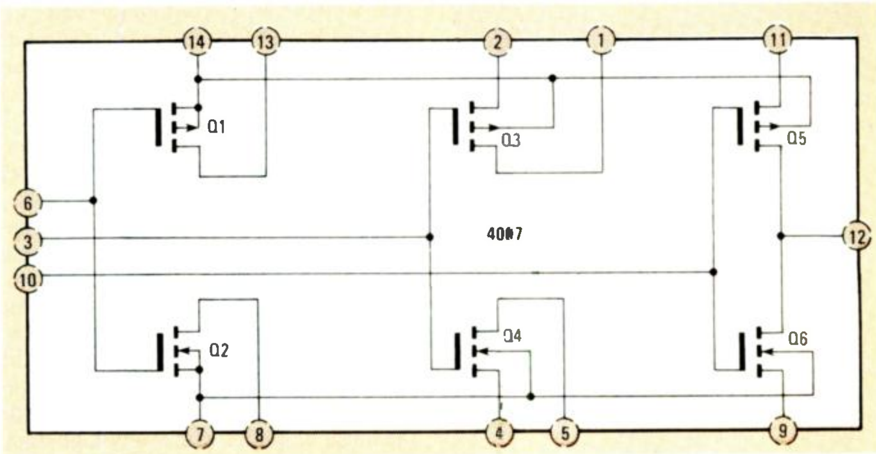


FIG. 1—THE 4007 IS COMPOSED OF three pairs of complementary enhancement-mode MOSFET's.

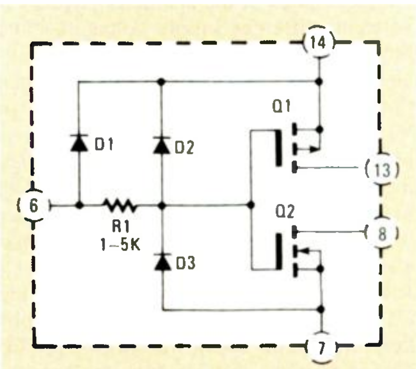


FIG. 2—INPUT PROTECTION CIRCUITRY R1,D1–D3) of each pair of MOSFET's is shown here.

As you recall, the term *CMOS* is an acronym for *C*omplementary *M*etal *O*xide *S*emiconductor; it is fair to say that most CMOS IC's are designed around CMOS devices like those that compose the 4007. Therefore it is worthwhile to get a good understanding of how those elements work. Let's look first at their digital characteristics; later we'll examine them in light of their analog capabilities.

The two fundamental characteristics of a MOSFET are as follows. First, the gate, or input terminal, of a MOSFET has a near-infinite impedance. Second, the magnitude of the voltage applied to the gate controls the magnitude of drain-to-source current flow.

In an enhancement-mode *n*-channel MOSFET the drain-to-source circuit is a high impedance when the gate is at the same potential as the source. However, that impedance decreases as the potential applied to the gate becomes positive with respect to the source. So an n-channel MOSFET can be used as a digital inverter by wiring it as shown in Fig. 3-*a*. With a low applied to its input the MOSFET is cut off, so the output goes high. With a high applied to its input the MOSFET saturates, so the output goes low.

In a *p*-channel enhancement-mode MOSFET the drain-to-source circuit is also a high impedance when the gate is at the same potential as the source. But, unlike the n-channel device, that impedance decreases as the potential applied to the gate becomes *negative* with respect to the source. So a p-channel MOSFET can be used as a digital inverter by wiring it as shown in Fig. 3-*b*.

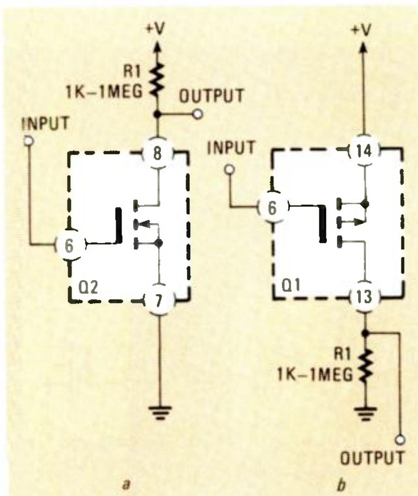


FIG. 3—A DIGITAL INVERTER can be built from either an n-(*a*) or a p-channel MOSFET (*b*).

In both n- and p-channel inverters, the amount of current that flows through the device is limited by the value of R1. And both circuits draw a finite quiescent current in the on state. However, quiescent current drain can be reduced to almost zero by connecting a pair of complementary MOSFET's as shown in Fig. 4.

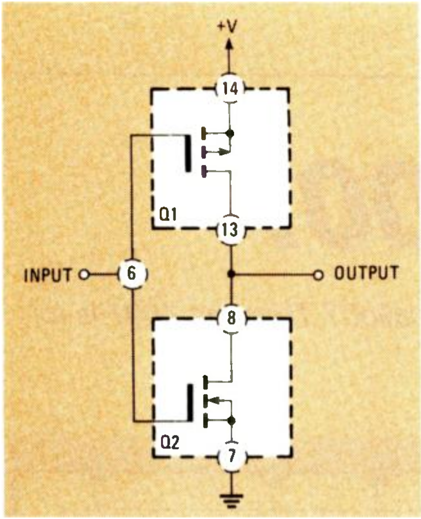


FIG. 4—THE STANDARD CMOS INVERTER is built from two stacked MOSFET's.

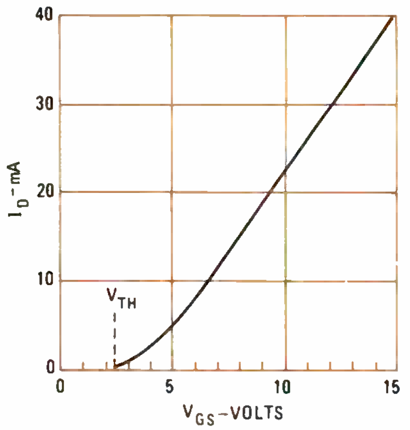


FIG. 5—THE N-CHANNEL MOSFET conducts almost no current until V_{GS} exceeds about 2 volts.

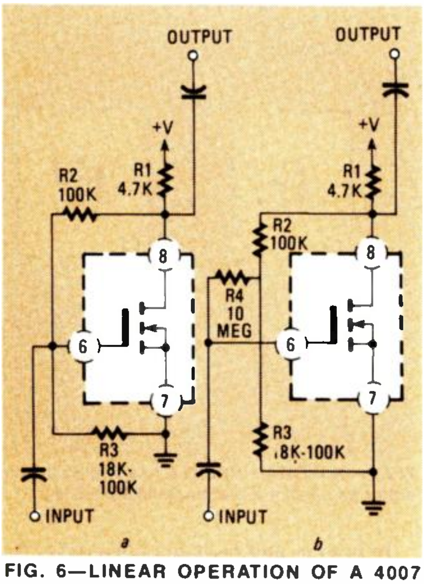


FIG. 6—LINEAR OPERATION OF A 4007 MOSFET requires simple biasing (*a*); very high input impedance is achieved by the addition of R4 (*b*).

In that configuration, which is standard for many CMOS inverters and buffers, with a low applied to the input, Q1 is on, so the output is high. However, Q2 is off, so no quiescent current can flow. With a high applied to the input, Q2 is on, so the output is low. In that case Q1 is off, so quiescent current flow is still nil. Of course, there is no requirement that the MOSFET's be operated solely in the digital mode; let's find out how they can be used otherwise.

Basic linear operation

To understand the operation of CMOS circuitry, it is essential to understand the linear characteristics of the basic MOSFET. Figure 5 shows the typical gate-voltage (V_{GS}) to drain-current (I_D) curve of an n-channel enhancement-mode MOSFET. Note that negligible drain current flows until the gate voltage rises to a threshold value, V_{TH}, of about 1.5 to 2.5 volts. After that point, however, drain current increases almost linearly with further increases in gate voltage.

Figure 6-*a* shows how to connect an n-channel MOSFET as a linear inverting amplifier. Resistor R1 is the drain load, and R2 and R3 bias the gate so that the device operates in the linear range. The value of R3 must be selected to give the desired quiescent drain current; it normally ranges from 18–100K. To provide the linear amplifier with a very high input impedance, wire a 10-megohm resistor (R4) as shown in Fig. 6-*b*.

Figure 7 shows typical VI characteristics of an n-channel MOSFET at various fixed values of V_{GS}. To understand that graph, imagine that, for each curve, V_{GS} is fixed at V_{DD}, but that V_{DS} can be varied by altering the value of the drain-load resistor. The graph can then be divided into two characteristic regions, as indicated by the dotted line: the ohmic region and the pinch-off region.

For each curve shown in Fig. 7, the beginning of the pinch-off region—the point where the dashed line crosses the solid line—is called the pinch-off voltage, or V_P, which is the value of V_{DS} above which I_D increases little, if at all, for further increases in V_{DS}.

When the MOSFET is in the pinch-off region and V_{DS} is more than 50% of V_{GS}, the drain functions as a constant-current source. The amount of current that flows is controlled by V_{GS}. A low value of V_{GS} gives a low current flow, and a high value of V_{GS} gives a high current flow. Those saturated constant-current characteristics protect CMOS devices from short-circuit failure and also determine operating speed at various supply voltages. Both current-drive and operating speed increase in proportion to the supply voltage.

When the MOSFET is in the ohmic region and V_{DS} is less than 50% of V_{GS}, the drain functions as a voltage-controlled resistance. That resistance increases approximately as the square of V_{GS}.

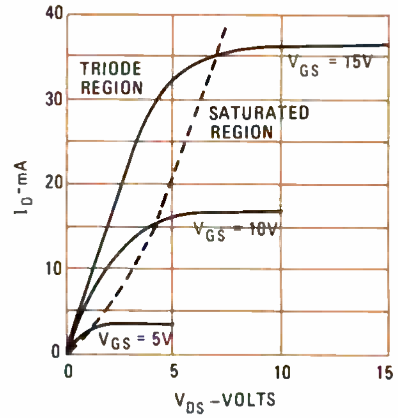


FIG. 7—AN N-CHANNEL MOSFET operates linearly in the ohmic region above the dashed line and digitally in the pinch-off region below the dashed line.

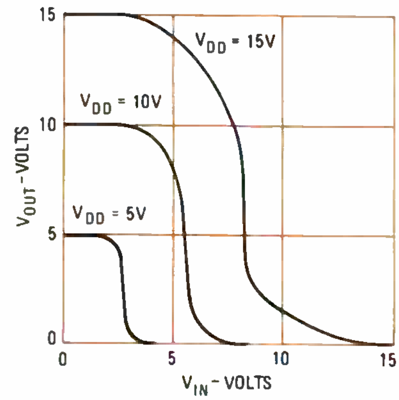


FIG. 8—VOLTAGE-TRANSFER characteristic of the CMOS inverter (Fig. 4) reveals that, for inputs near ground and V_{DD}, output changes very little.

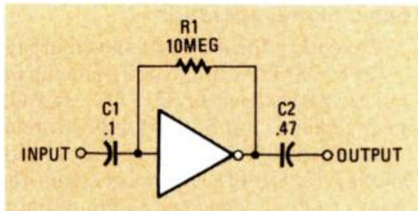


FIG. 9—LINEAR OPERATION of the inverter (Fig. 4) is possible, as shown here.

Figure 8 shows typical voltage-transfer characteristics of the standard CMOS inverter at different supply voltages. Note that when V_{DD} is 15 volts, the output voltage changes a very small amount when the input voltage is near either zero or V_{DD}. However, when the input voltage is biased at roughly $V_{DD}/2$, a small change in input voltage produces a large change in output voltage. Typically, the inverter has a voltage gain of about 30 db when used with a 15-volt supply, and 40 db at 5 volts. Figure 9 shows how to connect the CMOS inverter for use as a linear amplifier; the circuit has a bandwidth of 710 kHz at 5 volts, and 2.5 Mhz at 15 volts.

We can wire three simple CMOS inverters (like the one shown in Fig. 4) in series

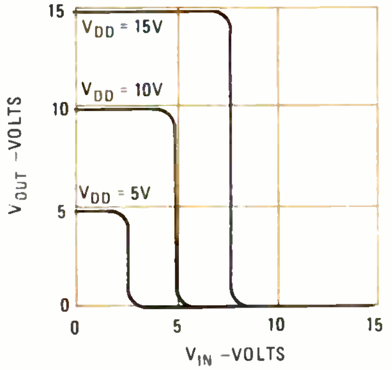


FIG. 10—VOLTAGE-TRANSFER characteristic of a B-series CMOS inverter is similar to that of the simple inverter.

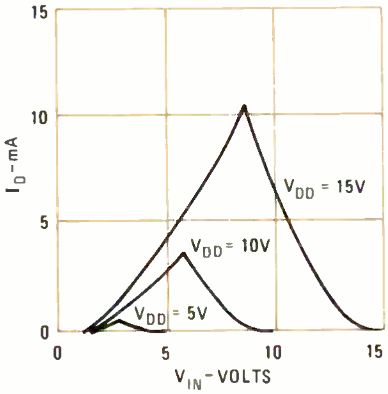


FIG. 11—DRAIN CURRENT of the simple inverter peaks at an input voltage just over $V_{DD}/2$.

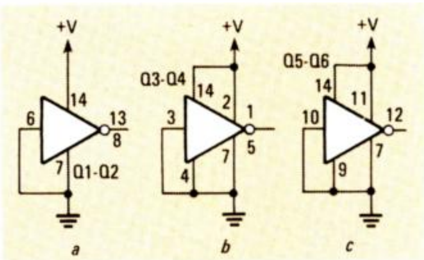


FIG. 12—DISABLE AN UNUSED INVERTER pair as shown here; Q1 and Q2 are disabled as in *a*; Q3 and Q4 as in *b*; Q5 and Q6 as in *c*.

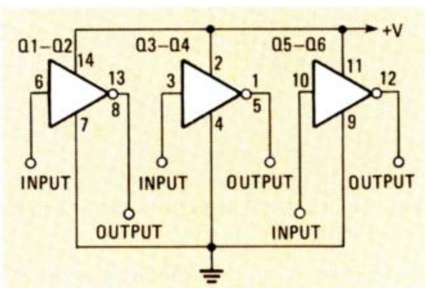


FIG. 13—EACH PAIR OF TRANSISTORS may be used independently as an inverter.

to obtain the direct equivalent of a modern "buffered" B-series inverter, which has the overall voltage transfer curve shown in Fig. 10. A B-series inverter typically gives about 70 db of linear voltage gain, but it tends to be quite unstable when used in the linear mode.

To finish up our discussion of basic operation, take a look at Fig. 11. Shown there is the drain-current transfer characteristics of the simple (non-buffered) CMOS inverter. Note that drain current is zero when input voltage is zero or V_{DD}. However, in the middle range, current rises to a maximum value when the input is at approximately $V_{DD}/2$, at which point both MOSFET's are on. That on current can be reduced by wiring resistors in series with the source of each MOSFET. We'll use that technique in the "micropower" circuits discussed below.

Basic rules

There are a few basic rules to follow in order to use the 4007 successfully. First, you must ensure that all unused elements of the devices are disabled. A pair of MOSFET's can be disabled by connecting them as an inverter and grounding their inputs. As shown in Fig. 12-*a*, to disable the Q1-Q2 pair, just ground pin 6. To disable the other pairs, in addition to grounding the inputs, the sources and drains must be connected to ground and +V as shown in Fig. 12-*b* and Fig. 12-*c*.

In use, the input terminals must not be allowed to rise above V_{DD} (the supply voltage) or below ground. To use an n-channel MOSFET, the source must be tied to ground, either directly or through a current-limiting resistor. To use a p-channel MOSFET, the source must be tied to V_{DD}, either directly or through a current-limiting resistor.

Digital circuits

A single 4007 can be configured as three independent inverters, as shown in Fig. 13. In that figure, and in others that follow, we won't necessarily show all details of how to wire the circuit under discussion. Also, multiple pin connections that terminate in a single function will be shown as in Fig. 13. For example, the output of the Q1-Q2 inverter in that figure is obtained by connecting pins 13 and 8 together.

Figure 14 shows how to connect the 4007 as one inverting and one non-inverting buffer. In the non-inverting circuit, the Q1-Q2 and Q3-Q4 inverters are simply wired in series to provide two stages of inversion—which provides a non-inverting buffer.

The maximum source (load-driving) and sink (load-absorbing) currents of a simple CMOS inverter are about 10—20 mA when either output MOSFET is fully on. To increase that sink current, several n-channel MOSFET's can be connected in parallel in the output stage. Figure 15 shows how to configure the 4007 as a high sink-current inverter. Similarly, Fig. 16 shows how to configure the IC as a high

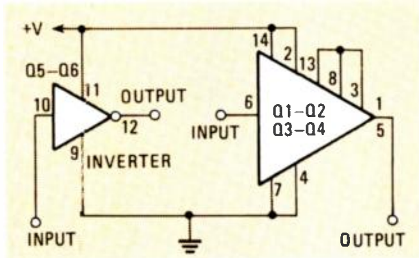


FIG. 14—A NON-INVERTING BUFFER is composed of two inverters connected in series (Q1–Q4). The other inverter (Q5 and Q6) can be used independently.

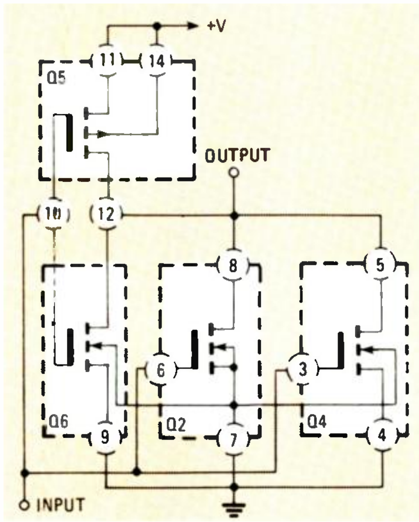


FIG. 15—SINK CURRENT may be increased by connecting the n-channel MOSFET's in parallel.

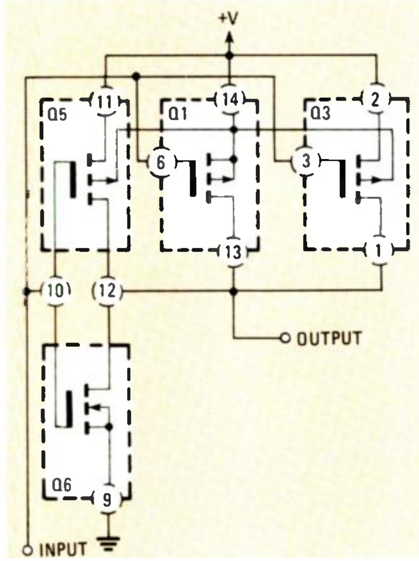


FIG. 16—SOURCE CURRENT MAY BE INCREASED by connecting the p-channel MOSFET's in parallel.

source-current inverter. Last, Fig. 17 shows how to connect all the elements of a 4007 in parallel to produce a single inverter that will both sink and source three times the current of a standard inverter.

Logic circuits

The 4007 is well-suited for demonstrating the basic principles of CMOS logic

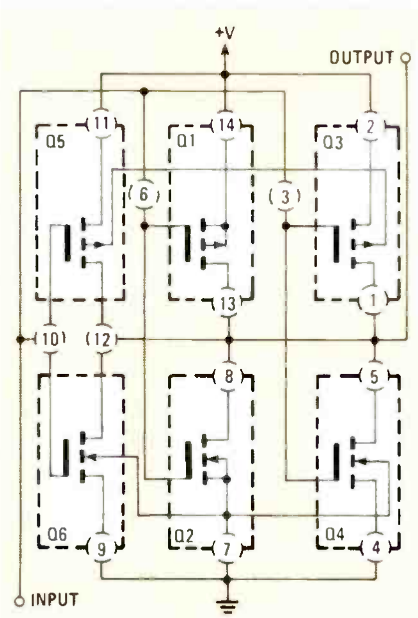


FIG. 17—BOTH SINK AND SOURCE CURRENT may be increased by connecting all transistors of each type in parallel.

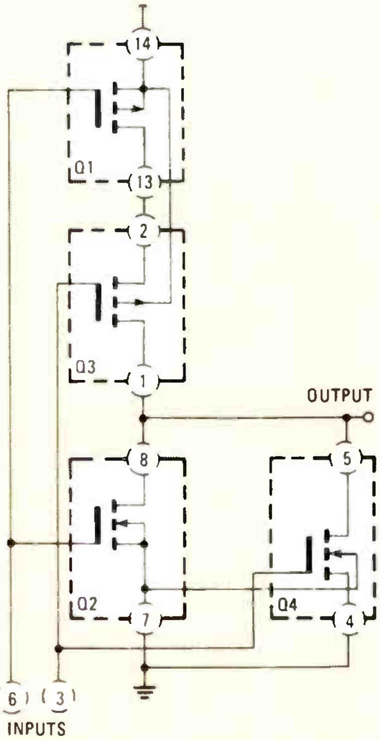


FIG. 18—A TWO-INPUT NOR GATE can be built from a 4007.

gates. Figure 18 shows how to configure the 4007 as a 2-input NOR gate. In that circuit two n-channel MOSFET's are wired in parallel so that either can pull the output to ground with a high input. Also, two p-channel MOSFET's are wired in series so that, with low inputs, both must turn on to pull the output high. Figure 19 shows how to wire up a 3-input NOR gate: it is composed of three series- and three parallel-connected MOSFET's, and its principle of operation is the same as the 2-input circuit. Figure 20 shows how to configure the 4007 as a 2-input NAND gate. When both inputs are high, Q2 and Q4 both turn on, so the output goes low. Otherwise Q1 or Q3 pull the output high.

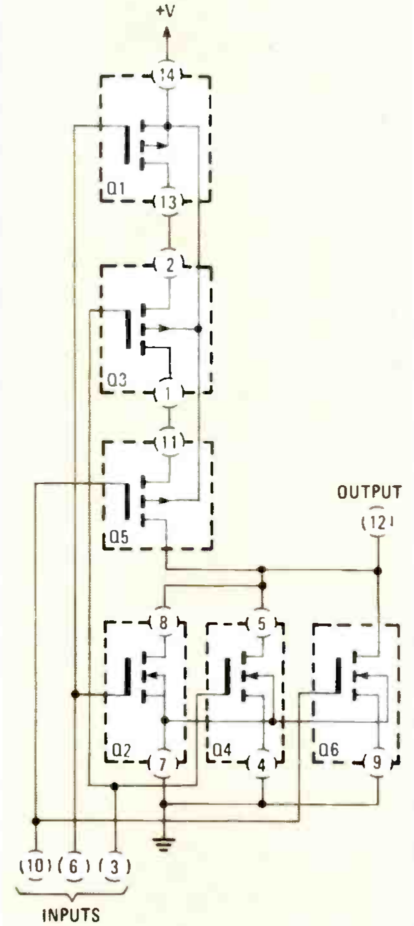


FIG. 19—A THREE-INPUT NOR GATE can be built from a 4007.

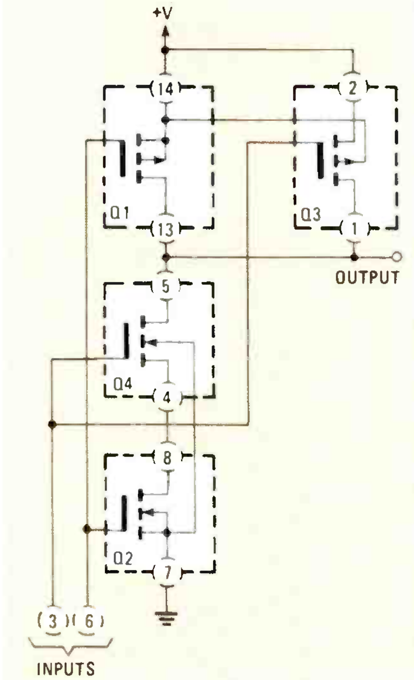


FIG. 20—A TWO-INPUT NAND GATE can be built from a 4007.

An important element of many digital circuits is called an analog switch. It is an electronically-controlled SPST, SPDT, or other switch. The principle of the SPST type is shown in Fig. 21-*a*. When the CONTROL input is high, signals can flow between points X and Y unimpeded. When that input is low, no signal can flow.

The 4007 analog switch has a near-infinite off resistance and an on resistance of about 600 ohms. It can handle signals between zero volts and the positive supply voltage. And since the gate is bilateral, terminals X and Y can function as either input or output.

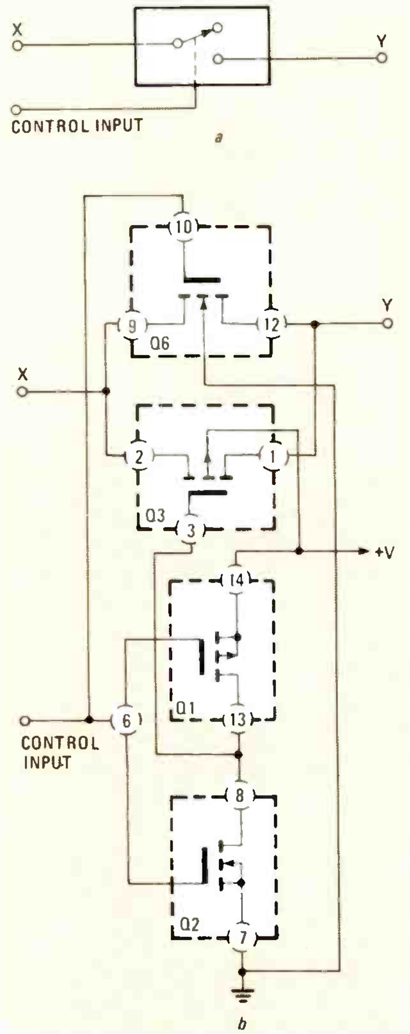


FIG. 21—AN SPST ANALOG SWITCH can be built from a 4007.

Circuitry to implement the SPST switch is shown in Fig. 21-*b*. An n-channel and a p-channel MOSFET are wired in parallel (source-to-source and drain-to-drain), but their gate signals are applied out of phase by means of the Q1-Q2 inverter. To turn the Q3-Q6 pair of transistors on, Q6's gate must be high, and Q3's gate low; to turn the switch off, the opposite conditions must be present.

An SPDT analog switch is shown in Fig. 22-*a*; circuitry which accomplishes that function is shown in Fig. 22-*b*. Here two transmission elements are connected in parallel, but their control voltages are applied out of phase, so that one switch opens when the other closes, and vice versa.

We saw earlier that the 4007 can also be used in a linear mode; now let's look at how to do that, and at the sort of performance we can expect from a linearly-operated 4007.

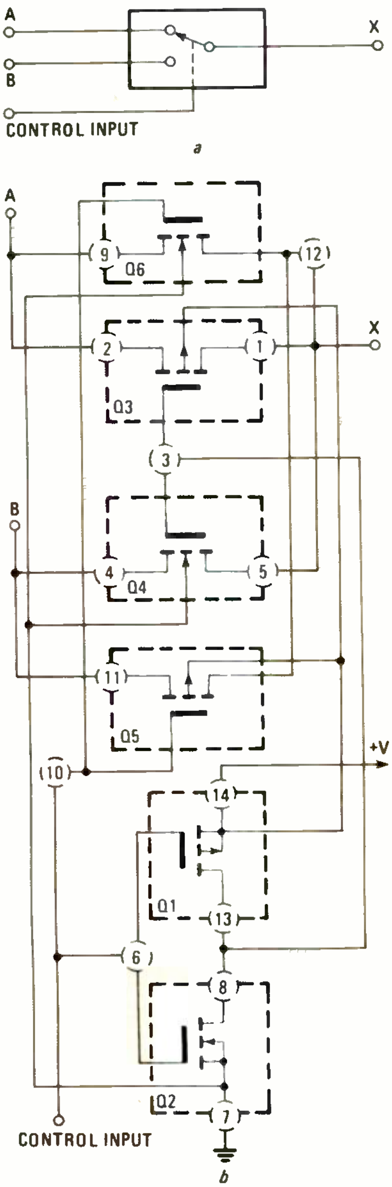


FIG. 22—AN SPDT ANALOG SWITCH can be built from a 4007.

Linear circuits

Figure 23 shows how voltage gain and frequency response vary according to supply voltage. The curves shown in that figure assume that the 4007 is driving a high-impedance (10 megohm), low-capacitance (15 pF) scope probe. The output impedance of the open-loop amplifier typically varies from 3K (at 15 volts) to 5K (at 10 volts) to 22K (at 5 volts). The product of the output impedance and the ouput load capacitance determines the circuit's bandwidth. Increasing either load capacitance or output impedance decreases bandwidth.

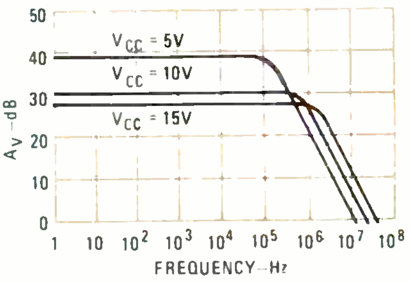


FIG. 23—FREQUENCY RESPONSE and voltage gain of a linear-mode CMOS amplifier is dependent partially on supply voltage.

TABLE 1— LINEAR-MODE PERFORMANCE

R1 R2	I_D	A_V	Bandwidth
0	12.5mA	20	2.7 MHz
100Ω	8.2mA	20	1.5 MHz
560Ω	3.9mA	25	300 kHz
1K	2.5mA	30	150 kHz
5.6K	600μA	40	25 kHz
10K	370μA	40	15 kHz
100K	40μA	30	2 kHz
1MEG	4μA	10	1 kHz

As you can see in the voltage transfer curve back in Fig. 8, the distortion characteristics of the CMOS linear amplifier are not particularly impressive. Linearity is good for small-amplitude signals, but distortion increases progressively as the output swing approaches the upper and lower limits of the power supply.

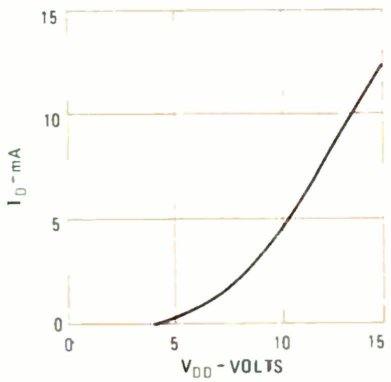


FIG. 24—VERY LITTLE CURRENT FLOWS until V_{DD} exceeds 5 volts.

Figure 24 shows the typical drain-current versus supply-voltage charcteristic of the basic CMOS linear amplifier. Note that supply current typically varies from 0.5 mA at 5 volts to 12.5 mA at 15 volts.

As we mentioned above, in many applications, the quiescent supply current of a 4007 CMOS amplifier often can be reduced (at the expense of reduced bandwidth) by wiring external resistors in series with the source terminals of the two MOSFET's. In Fig. 25 we show how a micropower circuit would be configured.

It is important to understand that the source resistors increase the output impedance of the amplifier; output impedance is roughly equal to the product of R1 and A_V. That impedance, and the resistance and the capacitance of the load affect the circuit's gain and bandwidth.

Table 1 shows how supply current, voltage gain, and bandwidth vary with the value of those source resistors. As you can see, with 10K source resistors, bandwidth is about 15 kHz. However, by increasing load capacitance to 50 pF, bandwidth decreases to about 4 kHz; by reducing capacitance to 5 pF, bandwidth increases to 45 kHz. Similarly, reducing the resistive load from 10 megohms to 10 kilohms causes voltage gain to fall to unity. The conclusion is that, to obtain significant gain, load resistance must be large relative to the amplifier's output impedance.

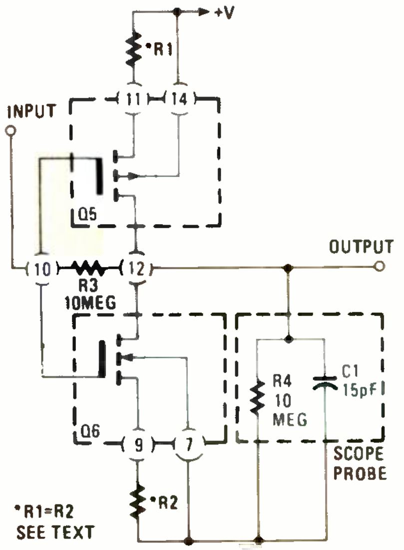


FIG. 25—SOURCE RESISTORS R1 AND R2 decrease current consumption drastically.

An unbiased 4007 inverter has an input capacitance of about 5 pF and an input resistance near infinity. So, if the output of the circuit in Fig. 25 is fed directly to the input of another 4007 stage, the overall voltage gain will be about 30 dB, and the bandwidth will be about 3 kHz. Those values will be obtained when R1 has a value of 1 megohm. For extremely low current drain (.4 μA!), R1 could be increased to 10 megohms.

Now you can see why we said that the 4007 is the most versatile CMOS IC. With the ideas we've presented here, you should have no trouble thinking of many more applications for the 4007. **R-E**

PC SERVICE

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

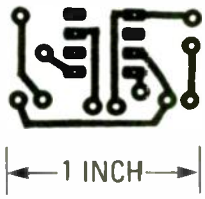
In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are probably used to.

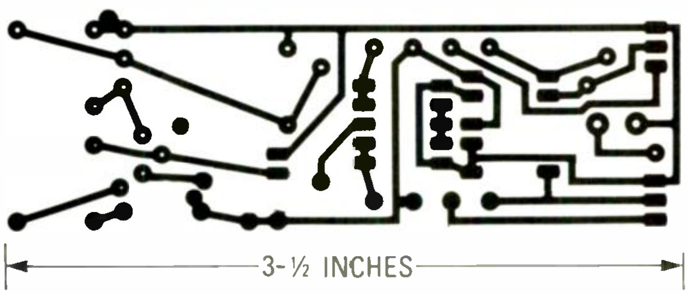
We can't tell you exactly how long an exposure time you will need but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735



OUR ELECTRONIC SCARECROW can help chase away a less than determined burglar. If you chose to build that circuit on a PC board, here's a pattern that's approriate.



BECAUSE OF THE DANGEROUS VOLTAGES that the stun gun develops, be extra careful when laying out and etching this PC pattern for that circuit.

PC SERVICE

SATELLITE TV

BOB COOPER, JR.,
SATELLITE-TV EDITOR

Microwave test equipment

WHEN THE FIRST HOME SATELLITE DISH systems appeared in the marketplace late in 1979, they were priced at just under $4,000 (wholesale). Most people were astounded that so complex a system could be assembled for so small an amount of money. Competition and technological evolution have improved things to the point that today a system with similar (or improved) performance characteristics sells for as little as $350 (wholesale). However, it is not just the dish systems themselves that have benefited from the on-going evolution in electronics.

In fact, the growth of TVRO has fueled a number of innovations in the microwave area, but none is more dramatic than the innovations in microwave test equipment. And that new equipment surely must must frighten old-line builders of microwave test instruments such as Hewlett Packard. The spectrum analyzer is a case in point. High-performance spectrum analyzers have always cost an arm and a leg. The most important factors to consider include: maximum operating frequency, resolution, sensitivity, and stability.

The unit shown in Fig. 1 is a good example of a low-cost, high-performance spectrum analyzer. We'll discuss it in detail below, but for now let's consider some of the problems involved in setting up a TVRO system, and how a spectrum analyzer can help.

Installation

Installing a small-dish satellite-receiving system (whether for video, audio, or data communication) has changed little since 1979. First the components of the system must be brought together. Then the dish must be erected on its mount and outfitted with the necessary electronics. Last, the dish must be aimed at the desired satellite, which is located some 24,000 miles away.

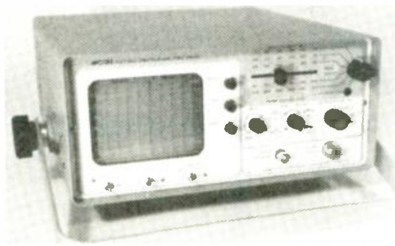


FIG. 1

The aiming process is complicated by the number of satellites now in operation, by those soon to be, and by the rapidly expanding use of the same frequency band (3,700 to 4,200 MHz) for point-to-point terrestrial communications. In short, there are many possibly interfering signal sources, and only one is right for a particular installation.

Of all of the instruments designed to measure the strength and quality of a microwave signal, none approaches the spectrum analyzer for either accuracy or spectral integrity. Unfortunately, however, until very recently the cost of a good microwave spectrum analyzer made those less-accurate instruments more attractive than they, on their own merits, deserved.

A breakthrough

The good news is that the same technology that made it possible for the price of a TVRO receiver to drop by a factor of 10 (or even 20) has now been applied to the spectrum analyzer. In fact, an entirely new generation of microwave test instruments is now available; many are priced at 10% or less of the cost of the older HP-style units. And they have been designed from the ground up to be portable, self-powered, field-usable instruments.

One portable spectrum analyzer is made by AVCOM of Virginia Inc., (500 South Lake Blvd., Richmond, VA 23235), a veteran of the satellite-TV field. The *PSA-35*, shown in Fig. 1, offers six bands of coverage as follows:

- Below 10 MHz to 770 MHz
- 270 MHz to 770 MHz

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.

VOL. 3 NO. 9 September 1986

COMPUTER DIGEST

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SOUP UP YOUR PC

How to turbocharge your computer

A GERNSBACK PUBLICATION

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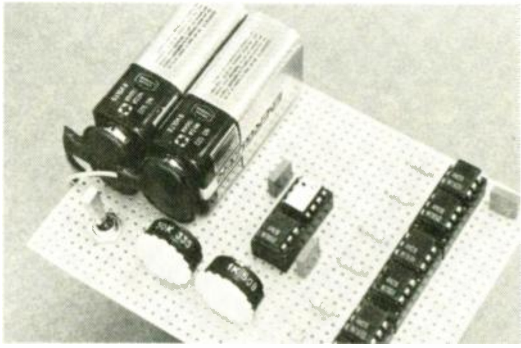

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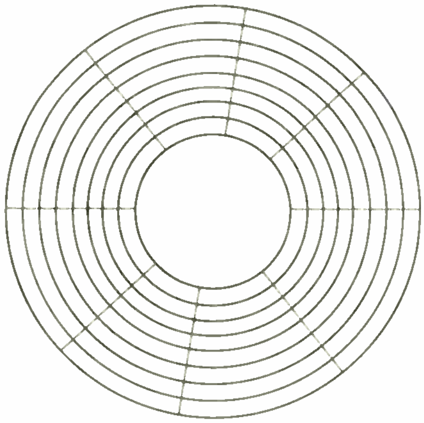

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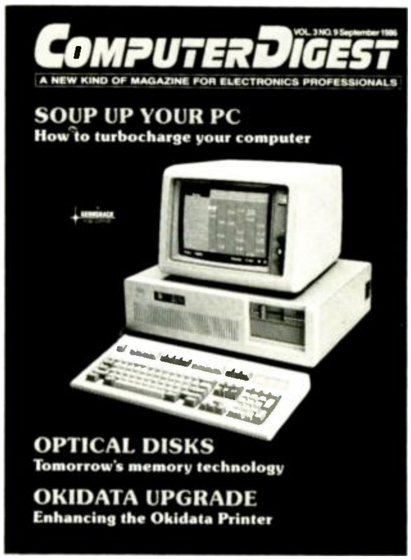
ON THE COVER

You can make your PC perform like the beautiful IBM PC/AT shown on this month's cover. For full details, see the article that starts on page 11 or buy one of the new ones from IBM!



COMING NEXT MONTH

Man, have we got a fantastic line-up for you! We're kicking off this issue with a Graphic Biofeedback monitor that does everything but feed you tranquilizers. Then there's a TVRO antenna pointer that gives you all the numbers via computer. Finally, you'll find a story on how to upgrade your Okidata printer. Don't miss it.

EDITORIAL

Told ya so!

■The shaking-out period is just about over. For awhile back there, "computer" was a magic word that opened the bank. If you had a computer-oriented product, you automatically made lots of money. Opportunists the world over jumped on the bandwagon just as they did when "stereo" was the magic word, or "CB."

And of course, magazines sprung up like weeds. Some long-established publications in the electronics industry changed their direction to cater to the new interest. At least one went so far as to change its name. So-called "vertical" publications appeared to cater to the purchasers of a particular brand of computer. Newsletters appeared all over the place to cater to particular interests. And people who had never before been in the publishing business now saw reason to give it a try.

Gernsback Publications, a long-established force in the communications industry, took a different tack. **ComputerDigest** Magazine was brought out as a 16-page insert in the well-established **Radio-Electronics** Magazine. Readers who had long-subscribed to this publication, began to worry and wonder. Mail poured in from concerned readers who did not want the tail to wag the dog. Was their favorite magazine going to follow the others and become another Computer Magazine? Were more and more pages to be given over to computers until a full transistion had been made?

We assured the readers that this would never be the case, and told them not to be concerned.

ComputerDigest is now in its third year. It still occupies only 16 pages, at no cost to the space allocated for **Radio-Electronics**.

As we said at the start of this editorial, the shaking-out period is about over. The many new businesses and new magazines that offered little more than another place to spend your money have dropped by the wayside. Those who are still in business will, no doubt, remain in business.

We're glad we're still here.

We *told* you!

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Hookup

How can I adapt my Sinclair so I can plug it directly into a composite video monitor instead of using a TV set? How do you bypass the RF modulator?—J.D., Methuen, MA.

At the very moment of this writing, we've got an author work on an article covering that subject. Keep an eye on **ComputerDigest.**

Users' Group

A new international word processing users' group has been formed. It offers a bi-monthly newsletter, called SCROLL and we're planning our own national bulletin board system. A complete telecommunications package will be offered to all members. And a library of public domain and tutorial disks in over 100 different computer formats will be available to members. Cost is just $15.00 per year annual membership. Write to W/PUG, Box 144, Malverne, NY 11565 or call me at (516) 746-0056.

Could you give us a "plug" in **ComputerDigest** Magazine?—A.G., Malverne, NY.

No Al, sorry. We don't do that.

Help!

I don't know a thing about computers, but my new secretary told me our old typewriter is passe. I was ready to buy a new one, but she suggested either a computer or at least an electronic typewriter. I don't want to invest heavily and then find that massive training programs are required. What's your recommendation?—L.M., Great Neck, NY.

Go for the computer! (What else would I say?) Make sure you get a letter-quality printer with it and a good word processing program. Give her the instruction manual over a weekend, and when she comes in on Monday morning, stand back! The efficiency and throughput will floor you.

Danger?

My father tells me that there's a hazard of radiation exposure if I spend time in front of the VDT (Video Display Terminal). I say he's getting as much exposure from the TV set he's watching.—F.S., Detroit, MI.

Try an experiment: Get some X-Ray film from your dentist, wrap one piece in lead foil as a control. Tape another piece to the CRT screen of your terminal, another to the TV screen. Rig another piece a foot away from each screen, still another two feet away. Keep 'em in place for a week, then have them all developed, making sure they're numbered so you know which was where. With a densitometer or photographic light meter, you'll get relative indications of the exposure and the rate of decay of each through free space. Let us know how you make out!

COMPUTER PRODUCTS

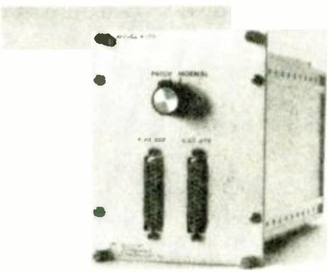
For more details use the free information card inside the back cover

CIRCLE 18 ON FREE INFORMATION CARD

UNIVERSAL INTERFACE, the model *488-2000,* is a GPIB-488 interface for all IBM PC, IBM XT, IBM AT, IBM CLONES, Apple Macintosh, Tandy 3000, 2000, 1200HD, and 1000. It can be used with any computer having RS232, and with any language having access to RS232 port (BASIC, Pascal, C). It can also be used with assembler or machine code.

The baud rate is 300, 600, 1200, 2400, 4800, and 9600; size is 7.5" × 2.25" × 5", and the power requirements are 105–125 volts AC, 60 Hz.

The model *488-200* is priced at $675.00.—**Scientific Engineering Laboratories, Inc.,** 104 Charles Street, Suite 143, Boston, MA 02114.



CIRCLE 19 ON FREE INFORMATION CARD

PATCH & MONITOR MODULE, the model *9179* allows the user to monitor signals at the high-speed data interface and reconfigure the interconnection between modems and terminals when equipment malfunction occurs or data-path re-routing is required.

The model *9179* V.35 module is connected in series between each V.35 modem and its associated data-terminal equipment. When switched to normal, the modem and terminal are connected together, and their interface signals are accessible at a front-panel connector for monitoring by a data-link analyzer. If equipment malfunction is detected, the module may be switched to its patch mode. When switched to patch, the modem and terminal connection is broken and all signals are routed to the front-panel connectors, thereby allowing a patch connection to back-up equipment while repairs are being made. Up to four modules slide into a standard 19" module rack. Delivery is from stock.

The model *9179* is priced at $229.00.—**Electro Standards Laboratory, Inc.,** PO Box 9144, Providence, RI 02940.

XT-COMPATIBLE COMPUTER, has all the features of an IBM PC/XT, such as 256K RAM memory, 8 full expansion slots, 135-watt power supply, floppy-disk controller board— up to 4 drives, full-function keyboard, 360KB 48TPI floppy-disk drive, high-resolution monochrome monitor, monochrome

CIRCLE 20 ON FREE INFORMATION CARD

graphics card w/printer port, and BIOS compatible with IBM PC/ XT. The complete system is FCC-approved.

Many add-on options are available, such as 640KB mother board; 10, 20, and 40 MB disks; RGB monitors; tape back-up systems; color graphics board; hard-disk controller board, and color monitors. The price of the complete system (not including add-ons) is $999.00.—**Sintec Company,** 28 Eighth St., Box 410, Frenchtown, NJ 08825.

FINANCIAL PLANNER, is the Commodore 128 computer version of "Sylvia Porter's Personal Financial Planner." The user is taken step-by-step through a series of questions that will help him or her develop comprehensive plans to determine the best financial moves for his or her career, marital status, savings, life insurance,

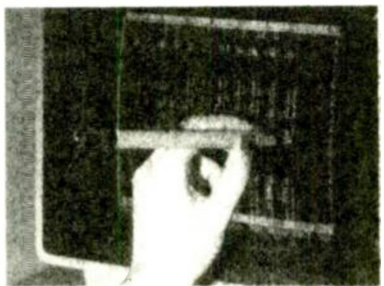
CIRCLE 21 ON FREE INFORMATION CARD

investments, life style, retirement, and estate. The user can also plan ahead for protection against major medical expenses, prolonged disability, and other possible adversities.

The program also includes electronic checkbook and checkwriting, budget preparation, tax aids, financial-statement preparation, and financial-inventory tracking.

The suggested retail price for the *Financial Planner* is $129.95 for the IBM; $99.95 for Apple: $69.95 for the Commodore 128, and $59.95 for the Commodore 64.—**Timeworks,** 444 Lake Cook Road, Deerfield, IL 60015.

LIGHT PEN, the *Feather,* is cordless, fully self-contained, and lightweight. Typical uses include rapid data-entry and retrieval in medical settings, CAD



CIRCLE 22 ON FREE INFORMATION CARD

design of a new mechanical part, and high-speed manipulaiton of business spread-sheets. It uses an infra-red communications link, powered by commonly available batteries.

The *Feather* is priced at $195.00.—**Hei, Inc.,** Victoria, MN 55386.

SOFTWARE REVIEW

MINI-JINI—A record keeper for the Commodore 64.

There are probably more *64*'s in use than any other personal computer. It's difficult to say how many, but depend on it, the numbers are really up there. Mostly, it's used for games because the software required for business applications is beyond the convenience or capability of the *64*'s slow cassette and disk storage systems. If used with software that allows and compensates for this slowness, the *64* can be a sparkling performer. Such a program is MINI JINI, an in-memory record keeping system attractive to hobbyists, technicians and small service shops because it's easy to use, easy to set up and provides a convenient way to computerize a modest-size customer file or inventory, mailing list or just substitute for a 3 × 5 file card index. It's extremely versatile.

MINI JINI is a data filing system that organizes data into customized reports. The program stores related data in individual records, each consisting of a list of up to ten related items called "fields" such as name, date, telephone, etc. A field can have any kind of format or content, as long as several characters required by the program itself aren't used, such as the comma, colon or quotation mark. One of the fields can even store data created from other fields through an internal function called MATHPACK, which performs calculations on the whole file, letting the user add, subtract, multiply or divide two fields or a field and a constant. MathPack functions include: Add a constant, add two fields, subtract a constant, subtract two fields, multiply a constant, multiply two fields, divide a constant, divide two fields, sum and average.

While each record can be 800 characters, an individual field length is limited to two complete lines (80 characters), and unused characters in one field cannot be used in another field. 80 characters is the absolute maximum for any field. Since all data is within the RAM the total number of records per file depends on the individual record size(s). If a data file gets too large for the *64*'s RAM it must be split and stored on cassette or disk as two separate files.

As each record is entered into RAM, MINI JINI assigns a sequential number which is not used unless changing or deleting a record. If a record is deleted, the program closes the gap, renumbers the records, and frees the RAM for other records.

The entire file can be scanned to view data. Specific data can be found through GLOBAL SEARCH through the entire database, or FIELD SEARCH which looks through a specified field. The actual search is rapid because the entire database exists in memory and nothing is faster than reading RAM. To view or print data in a specified sequence, records can be alphabetized in ASCII for any given field: For example, a file might be ordered by customer's last name, by Zip, or by the date on which you last serviced.

Unlimited updating is possible simply by overtyping the screen display. When this is entered as a "changed record," it substitutes for the RAM record. It is likewise possible to selectively delete data for a particular field or the entire record.

The PRINT FILE mode provides hardcopy for a record or up to four lines from any user-selected fields on standard 15⁄16 inch mailing labels. And fields can be printed in any desired order.

A WRITE-A-FILE mode writes data to tape, disk or a printer, even a modem with the correct modem hard and software. A READ mode, similarly, reads data from tape or disk.

MINI JINI is supplied as a ROM cartridge that resembles and works like a standard game cartridge. Just plug it in and the program comes up running with a logo that changes to a menu. All functions and operating modes including an initial selection of screen colors are menu driven and all modes provide a means for returning to main menu should something go wrong or if you change your mind. No entries become permanent until entered by the user.

MINI JINI is not in the same class as a sophisticated data-management system with unlimited storage capacity and reporting formats. It does provide a way to store and access moderate amounts of information. Keep in mind that loading data from tape or disk still takes time. It required almost six minutes to load a file of 85 ten-field records. The program runs fast only when the data is in RAM, not when loading or unloading.

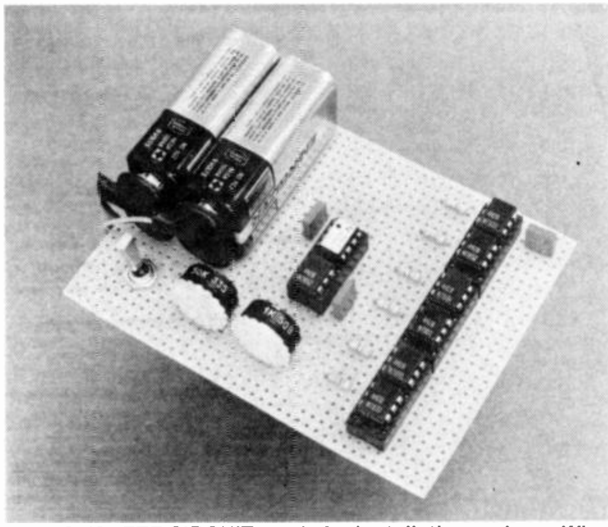
MINI JINI is sold by JINI Micro Systems, Inc., Box 274, Riverdale, NY 10463.

CIRCLE 17 ON FREE INFORMATION CARD

COMPUTER CB SCANNER

How to use your computer to scan the CB channels

Dr. Frank P. Maloney



THE COMPLETE CIRCUIT, ready for installation and use. Wire wrap techniques were used by author, on perf board.

■Although the CB craze seems to be over, there continues to be a great deal of activity on the channels. In fact, now that the first rush has passed, activity seems to have become more serious. Fire up your transceiver, and you'll find social groups using the inexpensive conference-call, REACT on channel 9, your neighborhood townwatch, security at civic and sports events, hobbyists, local paging, and of course, the channel 19 circus. While your interest may be piqued, I suspect that you will soon rediscover why you abandoned CB in the first place. We grow weary of constantly flipping that 40-channel switch looking.

Use the computer

How much more convenient it would be if, using a home computer, we could directly access any channel from the computer's keyboard, or step through the channels one-at-a-time, or rapidly display the activity on all 40 channels (like an oscilloscope) or even scan a pre-set group of channels, stopping on one of them when there is activity (like a scanner)? If you have a recently-manufactured CB that uses a phase-locked loop integrated circuit (PLL IC) synthesizer instead of individual crystals, and a home computer, the above features are simple to implement. And if yours is a Commodore C64, SX64 or C128 computer, the programs are already written for you.

Locate the schematic diagram of your CB transceiver, or open the unit up and take a look around. Make sure you disconnect it from the power source first. Near the 40-channel selector switch, will be the PLL IC. Chances will be good that it is a type LC7131, used in many Cobra and Radio Shack units. Should it *not* be a 7131, don't worry. Although I will be describing the 7131, the basic principles are the same for all PLL IC's.

Note that there are six lines going from the selector switch to pins 1 through 6 of the 7131 chip. These lines contain the binary-coded decimal (BCD) value of the channel number, and hold the unit's digit, lines 5 and 6 hold the tens digit. As an example, channel 23 is coded:

PIN 65:4321 : DATA 10:0011 : CHANNEL 2: 3

Channel 40 is an exception, it is coded all zeroes. A data 1 means about 9 volts on that pin, a data zero is about 0 volts. So there is the plan, set the selector switch to channel 40, and have a home computer's peripheral port control these lines to select the desired channel. Then have the computer "read" the S-meter with the game paddle port. Any home computer will do, as long as it has a peripheral port and a game port that you can control.

Other chips?

If you found other chips than the 7131, such as the uPD2824 or the LC7132 used in some Radio Shack units, you're still in business. The 2824 is almost identical to the 7131. The 7132 uses 8 lines instead of 6 to control the channel, so the coding will be different from what I have previously described. Spend a few minutes with a voltmeter, and by changing the selector switch while you test pin voltages, you can figure out the coding for most any PLL IC.

Look at interface circuit, Fig. 1., showing the optocoupling to pins 1 through 6 on the 7131 PLL IC. A data zero on the cathode of optocoupler OC1 allows

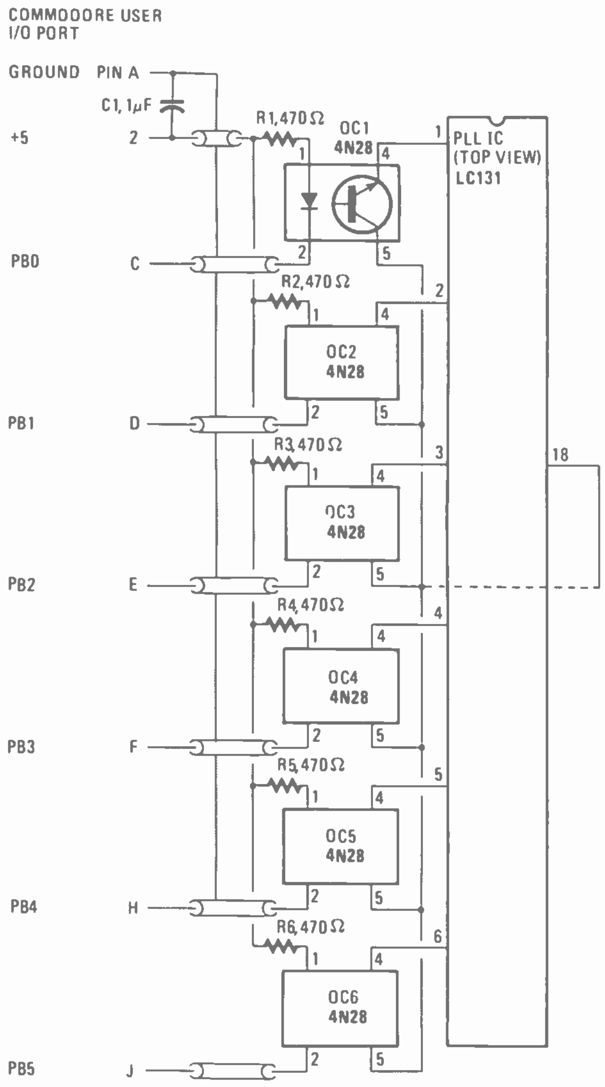


FIG. 1—SCHEMATIC DIAGRAM of the interface circuit, linking the computer's peripheral port to the PLL IC in a CB transceiver.

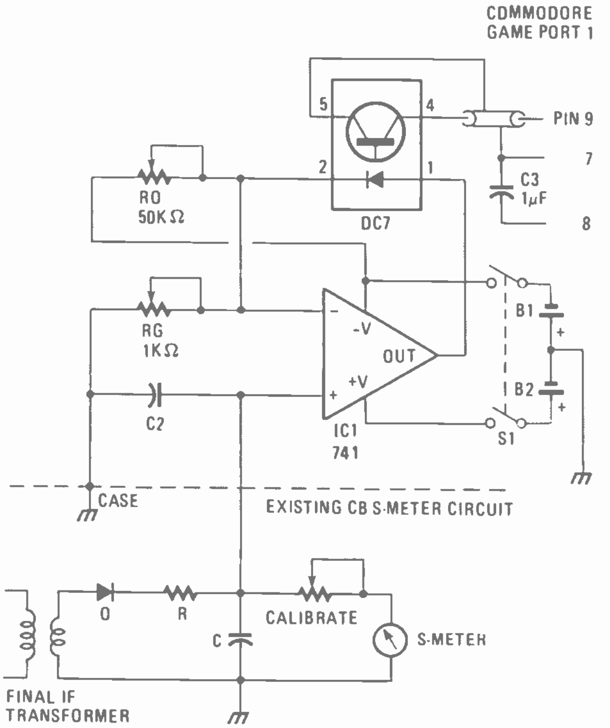
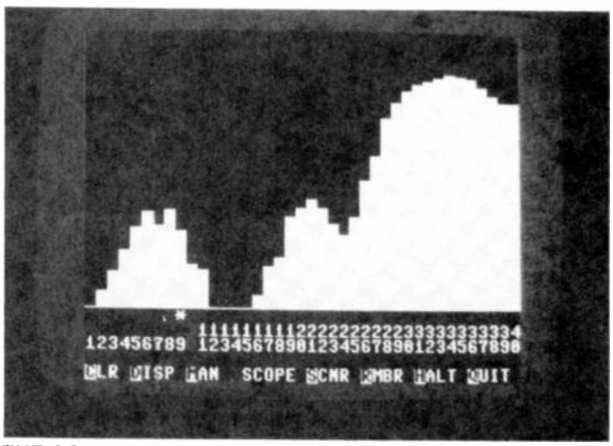


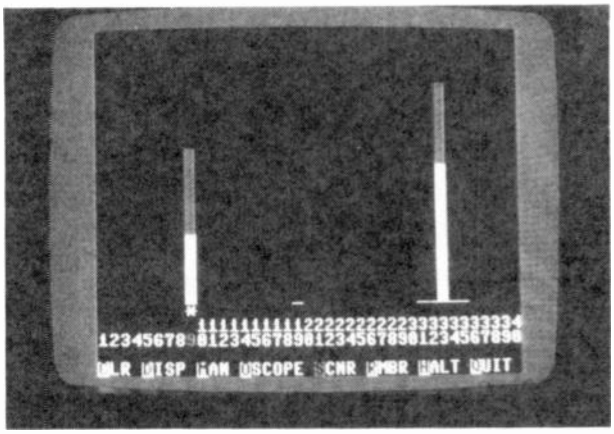
FIG. 2—S-METER buffer amplifier interface circuit is shown here schematically.

current to flow from the +5 volt supply from the computer into the peripheral port (PBO on the Commodore). That turns the transistor on, allowing current to flow from pin 18 to pin 1 of the PLL IC, placing a data 1 there. The 6 optocouplers are required to isolate the computer's from the transistor's differing voltages, as well as to prevent the RF hash from the computer from interferring with CB reception. Even so, be sure to use shielded cable from the peripheral port to the optocouplers, as shown in the schematic.

The S-meter level is communicated to the computer's game paddle input by a simple 741 op-amp and another optocoupler. The circuit is shown in Fig. 2. A typical S-meter circuit consists of a diode detector on the final IF transformer, and a smoothing



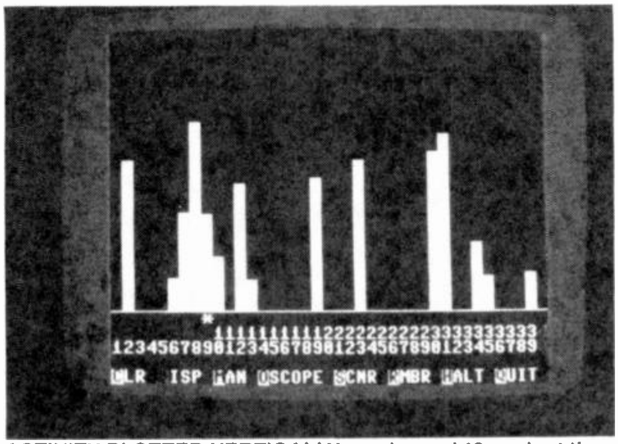
THE COMPUTER MONITOR, showing display of activity plotted vertically on the 40 channels. Observe the bleed-over on channel 8 to adjacent channels caused by overmodulation.



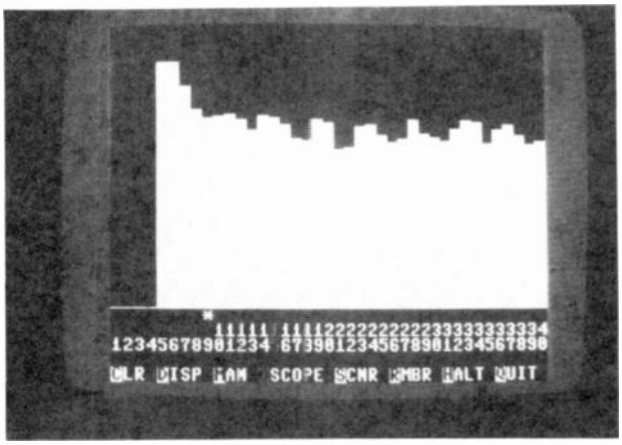
VERTICAL PLOT OF ACTIVITY ON CHANNEL 15 plotted as a function of time (horizontal). A transmitter has just keyed up. Notice the overshoot of the receiver's automatic gain control (AGC).

filter, R and C. The attack time constant is T = RC seconds (without C2). We sample the voltage V on C with the op-amp, which forces a current i = V/Rg through the optocoupler diode. Thus, trimpot Rg sets the gain of the circuit. Offset current is provided by trimpot Ro. These gain and offset levels will be set later so the range S1 through S9 + 30 dB on your S-meter results in the correct display range on your computer. Also, C2 must be chosen so that T is about twice as long as the digitization speed of the computer's paddle port. For the Commodore, a reading is completed every 512 phase-two cycles, about 0.0005 second. So choose C2 so that T = RC + C2) = 0.001 second. If you cannot determine R and C for your CB, a good value to try is 1 microfarad. The resulting current through the optocoupler diode varies the resistance between the collector and the emitter of the transistor, functioning like a variuable resistance paddle. That resistance is digitized by the computer.

The cost of these materials is less than $15., depending on how fancy an enclosure you buy. You can use simple point-to-point wiring on perf board. Wire wrap is particularly easy with the IC socket pins, and these can be tack-soldered to the foil side of your CB. You can tap the S-meter voltage between C and



ACTIVITY PLOTTED VERTICALLY on channel 10 against time (horizontal). A distant transmitter is seen fading in and out, indicating poor skip conditions.



SCANNER OPERATION. Channels 9, 19, and 31-35 have been programmed. Channel 33 was last active, but has timed out. Channel 9 is presently being monitored.

transceiver ground, from the C-side of R or the calibrate trimpot.

PARTS LIST

Semiconductors
OC1 - OC7—4N28 Optocouplers
IC1—741 Op-Amp

Resistors
(All resistors ⅛ watt, 10% unless otherwise specified)
R1 - R6—470 ohms
Rg—1000 ohm gain trimpot
Ro—50,000 ohm offset trimpot

Capacitors
C1, C3—1μF ceramic, 50V
C2—See text

Miscellaneous
B1, B2—9-volt batteries
S1—DPST or DPDT switch
24-pin female edge connector for Commodore I/O port, 9-pin DB9 female connector for Commodore game I/O port, enclosure, shielded microphone cable, IC sockets.

The software

Once you have the circuit working poroperly, you will need to work on the software. Initially, you can use simple POKE's and PEEK's from BASIC to see if the coding for the PLL IC is correct. A complete program should enable to you to:

-directly access any channel by using the keyboard digits
-step up or down a channel at a time
-display the activity on any all 40 channels
-display, in oscilloscope fashion, the activity on a channel
-scan a programmable set of channels, stopping to monitor whenever the activity exceeds a threshold.

If you have a Commodore computer and wish to avoid re-inventing the wheel, I can send you a machine language routine which implements the above functions. Just send a *new, formatted* but otherwise *blank* diskette with your name and address *on the disk* and a sturdy, stamped, self-addressed envelope to: Dr. F. P. Maloney, Department of Astronomy and Astrophysics, Vilannova University, Villanova, PA 19085. The disk and full operating instructions will be returned to you.

SOUP-UP YOUR PC

Add punch to your IBM PC.

T J Byers

■While it is rumored that the new super-microprocessor chips, such as Intel's 80386, are going to revolutionize the personal computer, some think there is more than enough power in the architecture of the popular 8086 microprocessor to keep the computer industry satisfied for some time to come.

In the wake of claims for chips with mainframe power, NEC Electronics has taken the venerable 8086 and given it more punch. The new design, the V30, promises to improve system performance by 25 to 30 percent. And, this achieved inside the chip so no changes to the computer system are required.

Microprocessor architecture

The secret to this turbocharged performance lies in the architecture of the new chip. Unlike the 8086, which uses a single 16-bit internal bus, the NEC microprocessor uses an advanced interface controller that feeds two internal buses. Fewer ticks of the clock process the data as operations can be divided into two groups and run simultaneously.

To understand how, we must learn how microprocessors work. The microprocessor is divided into five sections, as illustrated in Fig. 1. Each division performs a function that affects the operation of another part of the internal microprocessor system.

First is the I/O interface bus, which stands between the internal structure of the chip and the outside world. It translates incoming and outgoing signals into voltages that are compatible with both sides of the system.

Steering the I/O interface is a bus interface controller. This is the traffic cop. It tells the data which way to go and when. The bus interface controller contains five on-board memory cells called registers. Each register holds 16 bits of user-inputted binary data used to coordinate the operations of the controller.

Beyond the bus interface controller is the microprocessor itself. It is composed of three parts: a microcode ROM (Read-Only Memory), an arithmetic logic unit (ALU), and the data registers.

Processing data through the microprocessor consists of entering the data into one or more of the data registers and performing an operation on it. The ALU is the engine which manipulates the data. Coordinating the effort is the microcode ROM.

If we have two numbers that we wish to add, we begin by telling the microprocessor that the next operation will be addition. The ROM looks up a table that contains all the instructions necessary to derive the sum of two numbers. These are the microcodes. For addition, three microcode instructions are needed. The process goes something like this.

First, fetch the number from register A, pass it through the internal bus, and place it in the ALU. Second, fetch the number from register B, pass it through the internal bus, and place it in the ALU. Third, add the two together and place the sum in register A using the internal bus. Each instruction requires one tick of the clock. If a clock pulse occurs every microsecond, it will take three microseconds to tally the two numbers. Multiplication and division are much more complicated because more steps are involved. To multiply a number by 10, for example, the base number must be added to the sum ten times. It is not uncommon to see functions requiring hundreds of microcoded instructions. Remember, each instruction uses one clock cycle, and the longer the microcode, the longer it takes to execute the command.

Take the "A" bus

Each instruction of our example used the internal bus for part of its operation. This is not unusual. In fact, most microcode instructions make use of the internal

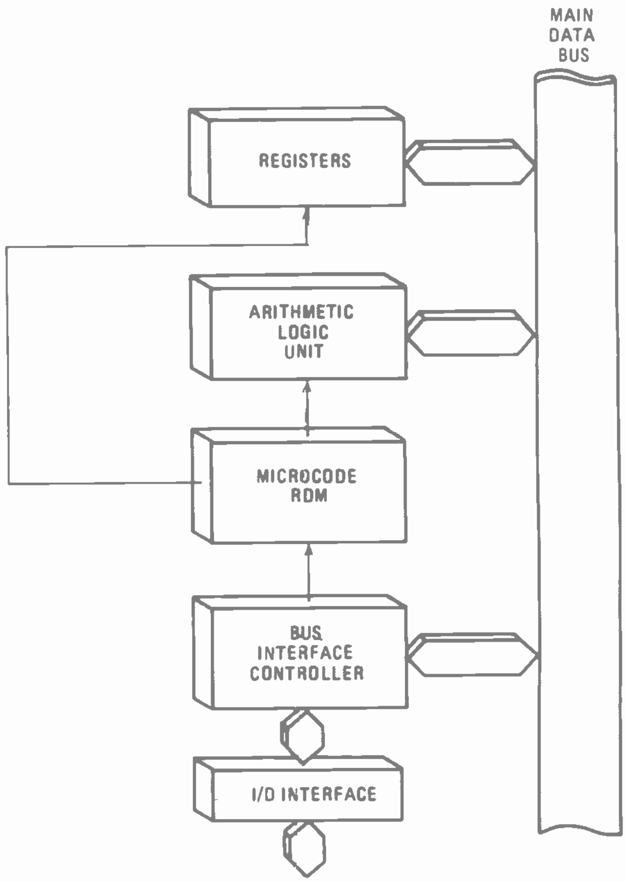


Fig. 1—THE 8086/8088 MICROPROCESSOR is divided into five sections. Each division performs a function that controls or affects the operation of another part of the internal microprocessor system. Data within the chip is passed from function to function through a single 16-bit wide main data bus.

bus in one way or another.

The internal bus is the data link between the elements of the processor. Before bus technology, all data was treated serially, with each bit passing through each element one bit at a time. The bus allows data to be routed in parallel, which improves throughput.

Unfortunately, the bus can pass only so much data at a time, depending on its width. If the bus is 8-bits wide, then it can transfer a byte at a time. A 16-bit bus can pass two bytes, etc. Designers realized that to get more done, the bus would have to be made wider, and current trends are towards a 32-bit bus, such as the one Intel is developing for its 80386 super-computer chip.

Present day personal computers, however, use either an 8-bit or 16-bit bus, so a major redesign is necessary before the new 32-bit microprocessors can be used.

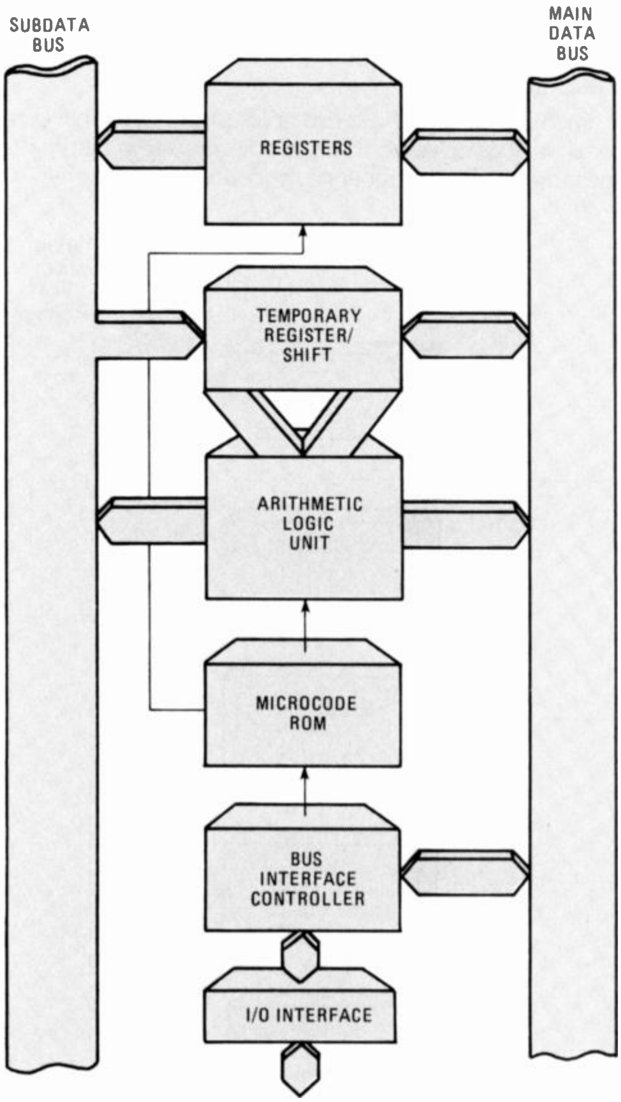


Fig. 2—IN THE DUAL BUS METHOD, such as supported by NEC's V20 and V30, there is a main data bus and a subdata bus. Data is passed through the main bus for all main input and output operations. Concurrently, internally-routed data may be passed through the subdata bus, thus improving data throughput.

Add the "B" bus

There is another way to do more. We can leave the bus as is and add a second internal bus to the structure. This is what NEC has done in the V30.

In the dual-bus method, there is a main data bus and a subdata bus, as outlined in Fig. 2. Data is passed through the main bus according to the needs of the microprocessor. In addition, data may be concurrently passed through the subdata bus in a similar fashion. The result is a greater throughput of data.

Let's refer to our previous example. Like the single bus method, the microcode ROM contains the instructions for the operation—addition. This time, only two instructions are necessary to derive the sum of two numbers. It goes as follows.

First, the number contained in register A is passed to the ALU through the main data bus. At the same time, the number contained in register B is passed through the subdata bus and loaded into the ALU. This operation requires one microcode instruction, and one tick of the c'ock. Second, the numbers are summed and the result is passed through the main data bus to register A. The entire process takes two clock cycles.

We have increased the speed of the microprocessor by 33 percent, without modification to the clock or the external I/O interface. The new chip is compatible with the old chip All modifications to the system are internal and not apparent to the user or the computer system.

A new chip in an old package

If this was all NEC did to enhance the 8086, it would still be a significant improvement. But since the internal architecture was being redesigned anyway, it wasn't that difficult for NEC to enhance it further.

To further improve performance, NEC added two temporary shift registers to the internal structure. Each register is 16-bits wide. These registers are attached directly to the ALU and actually become an extension of the ALU. Whencascaded, these registers serve as immediate data storage that provides speedier multiplication and division operations because the data doesn't have to travel through the data bus but twice: Once to load the registers and once to unload them.

The second register, when split from the first, can be used to hasten shift and rotate functions. The register is actually a part of the ALU, and fewer microcode commands are required per function. And, NEC added a loop counter to the ALU that keeps track of repeat instructions for rotate and shift so they don't have to be constantly inputted from the microcode ROM.

NEC also added an Effective Address Generator (EAG) to the V30. This performs high-speed processing of memory locations for memory accessing. Calculating by the microcode method normally requires 5 to 12 clock cycles. The EAG generates effective addresses using hardware and needs only two clock cycles. A program counter and a prefetch pointer offer more efficient use of the branch, call, return, and break operations by keeping track of current and future program addresses.

The entire procedure requires nearly twice as many transistors as the original microprocessor. This approach is necessary, however, if the new architecture is to be externally compatible with existing designs.

Improved instruction set

Complete compatibility between the 8086 and V30 is, of course, essential to the V30's success. And the same qualifications apply to the software. NEC duplicates the entire 8086 instruction set. To take full advantage of the hardware improvements, they found it necessary to enhance 16 of the original instructions and add 14 brand new ones.

Enhancements are made to the SHIFT (SH) and ROTATE (RO) instructions, as well as the MULTIPLY (MUL) command, to take advantage of the new temporary shift registers attached to the ALU. PUSH and POP are enhanced to deal with 8 general registers at once and there are changes in the way the chip deals with block memory and block I/O instructions. A list of enhancements is shown in Fig. 3.

In addition to the 8086 instructions and the enhanced instructions, the V30 also contains the following unique instructions.

Two instructions are used for variable length bit field operations. These are effective for dealing with packed arrays found in screen graphics and higher-level languages, like PASCAL. Another group of instructions manages packed BCD (binary coded decimal) data as strings or byte-formatted operands. The third group deals with the manipulation of specific data bits within data registers or memory locations. A breakdown of the new instruction set is outlined in Fig. 4.

Starting a family

NEC is offering two enhanced versions of the 8086 microprocessor. The first, an 8-bit external bus microprocessor that NEC affectionately calls the V20, is the electrical and logical equivalent of the 8088. The second, the V30, duplicates the 8086 with its 16-bit external bus structure. Both use 16-bit internal buses and both are hardware and software replacements for their counterparts.

ENHANCED INSTRUCTIONS

Instruction	Function
PUSH imm	Pushes immediate data onto stack
PUSH R	Pushes 8 general registers onto stack
POP R	Pops 8 general registers from stack
MUL imm	Executes 16-bit multiply of register or memory contents by immediate data
SHL imm8 SHRA imm8 ROL imm8 ROR imm8 ROLC imm8 RORC imm8	Shifts/rotates register or memory by SHR imm8 immediate value
CHKIND	Checks array index against set boundaries
INM	Moves a string from an I/O port to memory
OUTM	Moves a string from memory to an I/O port
PREPARE	Allocates an area for a stack frame and copies previous frame pointers
DISPOSE	Frees the current stack frame on a procedure exit

Fig. 3—THE ABOVE INSTRUCTIONS have been enhanced from the 8086/8088 instruction set as indicated.

NEW INSTRUCTIONS

Instruction	Function
INS	Insert bit field
EXT	Extract bit field
ADD4S	Adds packed decimal strings
SUB4S	Subtract packed decimal string
CMP4S	Compares two packed decimal strings
ROL4	Rotates one BCD digit left through AL
ROR4	Rotates one BCD digit right through AL
TEST1	Tests a specific bit and sets Z flag
NOT1	Inverts a specific bit
CLR1	Clears a specific bit
SET1	Sets a specific bit
REPC	Repeats next instruction until CY is clear
REPNC	Repeats next instruction until CY is set
FPO2	Additional floating point processor call

Fig.4—THE INSTRUCTIONS ABOVE are new to the 8086/8088 instruction set. Altogether, there are 14 new instructions divided into three categories: variable length bit field operations, packed BCD operations, and bit manipulation instructions.

Things are moving fast, and the computer of the future will be something to behold. It is reassuring to know, though, that companies like NEC are doing their best to keep existing technology current.

If you ever wanted to feel the acceleration of a turbocharged machine, now is your chance. The NEC V20 offers the perfect opportunity for IBM PC and PC compatible owners to upgrade for a fraction the cost of a turbo board. To begin, remove your old 8088 microprocessor chip and replace it with a V20 to gain both speed and expanded programming capabilities. The chips are pin-for-pin compatible and no software or hardware adjustments are required.

To install the new chip you remove the five 1/4-inch screws securing the cover to the back panel and sliding the cover forward. Locate the 8088 microprocessor chip. It is at the rear, ahead of the cassette connector.

Make sure you are free of static electricity before proceeding. A good precaution is to touch your hands to the metal chassis before working. Gently remove the 8088 from its socket using a chip puller.

Insert the new chip by aligning its legs with the socket pins (locating notch facing the rear apron) and firmly push into place. Replace the cover.

This $30 chip won't transform your PC into an AT. But it will improve overall performance by 10 to 20 percent. This is just the tip of the iceberg. The real impact of the upgrade will be realized when software houses start incorporating the new instruction set in their products. Meanwhile, enjoy the benefits of tomorrow's technology.

NOTE: If you are having trouble locating a V20 processor, contact Westpro Data Sources at 21704 Golden Triangle Road, Saugus, CA 91350. They will ship you a V20 for $30 ppd. Other V-series chips are also available; contact Westpro for price and availability.

OPTICAL DISKS

Soon you may be "playing" Compact Disks on your computer!

Marc Stern

■Do you remember when laser disk players were the rage? It was a short time ago they were supposed to sweep the video field. It never happened and they faded from that picture temporarily. Well, they're back, but their name and use has changed radically.

Instead of creating TV images, they are creating sounds heard in compact disk audio players and are beginning to appear as read-only storage devices in microcomputers. And instead of being called laser video disks, they're now called compact audio disks, or, in the computer world, optical storage disks, compact disks or compact-disk-read-only memory (CD-ROM).

When you think about it, using a laser-created optical disk for storage makes sense.

Unlike magnetic media where data are recorded via frequency modulation, optical disks are created as a laser-through burn in tiny sections of substrate within the disk. The burn or lack of a burn determines if a digital 1 or 0 has been recorded. Optical disks are instantly digital.

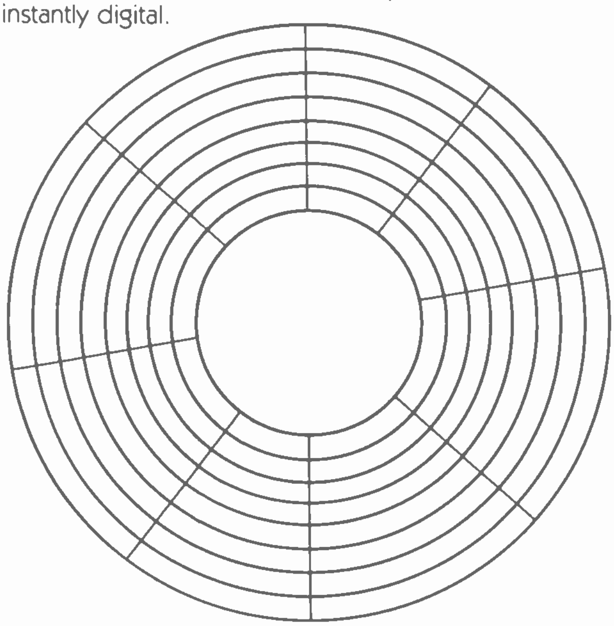


FIG 1—ORGANIZED IN CONCENTRIC RINGS, the outer sectors of a standard disk are recorded using constant angular velocity where the outer sectors are physically larger than the inner sectors of a disk. Each track is made up of a specific number of sectors and the size differential is due to the fact that the speed of the outer rim of the disk seems greater than that of the inner areas. To keep things equal, the size of the outer sectors increases because of the increased apparent speed.

Advantages

The most obvious advantage of an optical disk is its permanence. Like a compact audio disk, data are recorded and encased within a compact disk's plastic shell and can't be changed or erased. On a floppy or hard disk, coated with magnetic media, stray magnetic fields, heat, cold, dust or smoke may cause data to be corrupted. Floppy or hard disks can at best be thought of as temporary long-term storage, while optical disks can be thought of as long-term, permanent storage.

The most-obvious advantage of an optical disk is its permanence. Optical disks are impervious to damage. Since the optical disk's recording surface is in a plastic layer or shell, it can be manhandled.

Optical disks are impervious to damage. If you've worked with microcomputers you know the caveats of disk handling, watching out for fingerprints; dust; cigarette smoke, and the like. Since the optical disk's recording surface is in a plastic layer or shell, it can be manhandled. Fingerprints won't harm the data surface and neither will dust, cigarette smoke or magnetic fields.

From a storage standpoint, the key to an optical disk is data density. Rather than just storing 10 megabytes or 20 megabytes, as is now commonly done on personal computer hard disks, optical disks are capable of storing from 200 megabytes to 1 gigabyte of data. As an analogy, think of storing the entire "Encyclopaedia Brittanica" in your microcomputer. It will take several hard disks or many boxes of floppies. In contrast, you can easily store it on one optical disk and still have some room left over.

An optical disk's biggest storage disadvantage is its one-write nature. After it has been filled once, nothing can be added. Research has been conducted for the last several years in an effort to make optical disks read-and-write devices, but it still hasn't paid off to any cost-effective degree.

In a way, optical disk technology is perhaps the ultimate solution to computer compatibility. In the floppy and hard disk world, PC/MS-DOS has offered a measure of compatibility among differing systems. However, since there is only one major standard for optical disks, developed by Phillips and Sony, optical disks for one microcomputer system should work on another.

The impetus to this standard, by the way, was the digital audio standard developed for compact disk players by the two electronics giants.

Differences

Up to now, we've explored the chief differences between traditional magnetic disk technology and optical disk technology. Now let's look at the more technical issues that explain other differences.

Foremost among the technical differences is the format of the surface of the disk. Like a traditional disk, the optical disk has tracks and sectors, but, unlike the traditional disk, it uses a different physical format.

Traditional disk technology defines its format using constant angular velocity. To explain, take a close look at Fig. 1 and you'll see that the data sectors toward the center of the disk are smaller than those at the rim where the circumference is greater and the disk's relative linear speed also seems greater, with respect to the center. Because of the seeming speed difference the physical size of the data sectors must be larger to keep sectors equal. Thus, angular velocity across the section of the disk is kept equal by the changing size factor of each sector.

An optical disk differs because the read head and the disk surface retain the same relative speed at all times. To do this, the disk's speed is changed as the read head moves across. This results in a spiral arrangement of data sectors, all having the same linear length because they're recorded at the same apparent speed. If you look closely at Fig. 2, you'll see that since data tracks spiral toward the rim, there are fewer data sectors on the center than at the edge. The ratio can vary by more than 2 to 1, or 9 sectors at the center and 20 at the rim, per track.

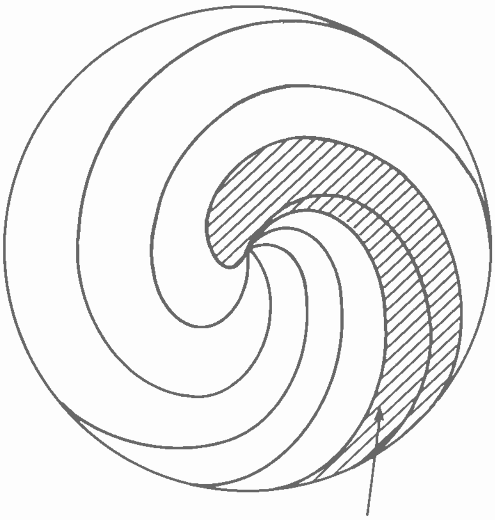


FIG 2—WITH CONSTANT LINEAR VELOCITY, the read head and disk speed remain the same across the disk. The result is a series of tracks whose sectors are physically the same length but which appear spiral in shape.

This complicates things on an optical disk because there are no fixed reference points. With constant angular velocity recording each track contains a fixed number of sectors. It is easy to find the location of a track and sector, if your system knows the starting track and sector address of a file. The read-write head moves ahead N locations to find it, once it knows the original address.

Things are more complicated on an optical disk. With a surface of spiral tracks, try to find a specific location easily. Because there is no fixed relationship between the an optical disk's track and the number of sectors on the track, the microcomputer has to go through a more complicated routine finding a location.

Further complicating this is speeding up or slowing the disk's rotation so the speed of the head and disk remain constant. When these two factors are taken into consideration, accessing information is slower than other types of storage media.

It's not uncommon for an average seek to take 500 ms, while the worst case time approaches 1 second. This contrasts with average seek times in the 100 ms range for an average 10 megabyte hard disk and worst case times in the 200 ms range. Performance differences can also be seen in the fact that an optical disk's average latency is 100 ms, while it is only 8.3 ms for the fixed disk.

Rather than storing 10 to 20 megabytes as is done on PC hard disks, optical disks can store 200 megabytes to one gigabyte. More than enough to hold the entire Encyclopedia Britannica!

Optical disks have good transfer rates, about 150Kbytes per second, while most hard disks are in the 96Kbyte range. Data transfer can be speedy on an optical disk, once the location is found. Average track-to-track seek times run in the 1 ms range for the optical disk, while they average 3 ms for the standard 10-megabyte hard disk. The reason the optical disk is quicker is the mirrored head has a sequential access range of 40 nearby tracks without a move, while the fixed disk's head must move from track to track. Further, data on an optical disk remain sequential, while they become random on a hard disk that has been accessed a great deal.

In favor of optical disks is storage. The average optical disk can store between 200 and 500 megabytes of data, while high-performance disks approach 1 gigabyte. This contrasts markedly with the average hard disk that stores only 10 megabytes of data.

Unique address scheme

An optical disk has a unique address scheme. Since it is based on digital audio recording technology, we must think in those terms. So, we must first consider the optical disk as "playing," rather than accessing or running.

Each disk plays (records) for 60 minutes and each minute is divided into 60 seconds. This is the basis of the optical disk addressing. There is one more factor, the sector number.

Instead of addressing a piece of data as X track-Y sector as on a traditional hard or floppy disk, the optical disk addresses it as X-minutes-Y-seconds-Z-sectors. A third dimension has been added to this relationship. It means that current software and directory addressing systems have to be rewritten to work with the new address mode.

This type of addressing is important given the changing nature of the data tracks and the number of sectors. In this manner, the three coordinates locate a given piece of data with pinpoint accuracy.

The read-write head consists of mirrors; a laser data decoder, and read circuitry. It is more complex than a typical read-write head on a hard or floppy disk.

As the head records each block of data, a correction code is generated. That error correction code mirrors the information stored in a particular sector so if something is corrupted during the recording session, there is backup data encoded so the information will be read correctly when called for. This cuts the amount of space available for storage, but ensures that data will be read correctly.

Despite their performance problems, optical disks represent great potential for the microcomputer user and industry. Now you know why the optical disk is the hot ticket in town this year.

- 400 MHz to 900 MHz
- 950 MHz to 1450 MHz
- Any 500-MHz band between 300 and 1500 MHz
- 3,700 MHz to 4,200 MHz.

That combination of bands makes it possible for the installer to detect and display either a full 500-MHz-wide satellite downlink, or, with the assistance of the unit's controls, any span as narrow as 2 MHz within any of the covered bands.

The 3,700- to 4,200-MHz band covers the satellite downlink frequencies. A built-in low-noise amplifier can be coupled to the TVRO antenna of the system to be installed or to a separate horn antenna. In either case, the analyzer can be used to display both the desired signal and any interfering signals directly.

The other five bands cover all of the commonly found TVRO IF's (*I*ntermediate *F*requencies). That allows the system installer to verify the performance of downconverter and LNB (*L*ow-*N*oise *B*lock Downconverter) units, to check cable losses and fittings, to measure distribution system parameters, and even to check for the correct operation of a cable-TV system.

What made it possible

Low-cost microwave test equipment has been feasible for several years. However, the specialized knowledge that designers of TVRO receivers had acquired was missing. In particular, flat mixers and flat sweep oscillators had to be developed using the same low-cost approach as TVRO receivers. Some exciting developments in YIG (*Y*trium-*I*ron-*G*arnet) oscillator designs also helped pave the way for low-cost spectrum analyzers and other high-frequency test equipment.

For example, other generally-available test gear can provide: direct frequency readout of carriers to 4,200 MHz (accurate to 1 MHz) for under $1,000; accurate readout at 4,200 MHz of signal levels to within ±2 dB for under $500; and direction-finding interference-locating systems accurate to within 5 degrees for under $600. You can even purchase microwave signal generators capable of generating significant amounts of power modulated by color bars and an audio tone, or by your own video source (such as a tape deck or a video camera), for under $1,000. None of that equipment was practical, and a great deal of it was simply impossible, as little as two years ago.

The new microwave gear can be put to use in other bands as well. For example, Ku-band equipment (which operates in the 11- and 12-GHz bands) may be tested and aligned by simply connecting an LNB ahead of a 4,200-MHz instrument. That's a cost-effective solution to a potentially sticky problem, because an LNB can be obtained for under $200.

Other fields may also benefit from advances made in microwave test instrumentation. Virtually any electrical quantity can now be measured with a high degree of accuracy at frequencies as high as 4,200 MHz, and even higher.

So if you service or install high-frequency equipment of any sort, you should be grateful to the TVRO industry—advances made there will benefit all of us. **R-E**

ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Position sensing

YOU DON'T HAVE TO WORK WITH A robot arm for long to realize that position information is highly important. There are numerous ways of obtaining that sort of information; let's examine several.

Digital position sensing

Most digital approaches to position sensing involve optical devices. Recently in this column we discussed tactile sensing using IR emitters and detectors. Some of the same approaches can be used for position sensing.

For example, a device called an optical shaft encoder or an optical interrupter encodes the position of a shaft by means of opto-electronics. An infrared (IR) detector/emitter pair couples to the shaft of a motor or the pivot of a robot arm and provides a series of digital pulses. The encoder requires only a source of five-volt power. How does it work?

A disk like the one shown in Fig. 1 is used to interrupt a beam of infrared light passing from an LED

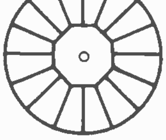


FIG. 1

to a photo-transistor. Overall the disk is transparent, but it has dark stripes that block the IR periodically as it spins. The LED and the transistor are integrated in a single package, as shown in Fig. 2. The encoder disk is attached to the end of a rotating shaft, and then it passes through the slot in the optical interrupter. As the shaft turns, the disk rotates, so the dark areas of the disk periodically prevent the LED light from reaching the photo-transistor. The output of the detector is a series of pulses that may be squared up and fed to digital control circuitry.

The disk is manufactured so that the distance between each radial stripe is equal. So the number of pulses that are output indicate how far the shaft has turned. Industrial optical encoders may have several hundred, or a thousand or more divisions.

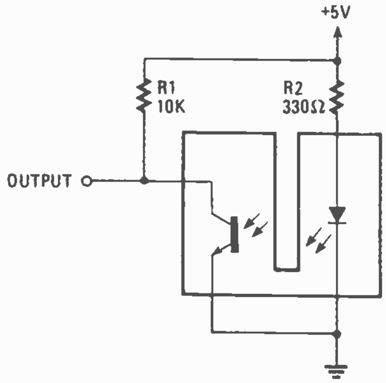


FIG. 2

Commerical encoder disks are usually expensive because they are manufactured under tight mechanical tolerances. In addition, they offer a minimum of 256 slits. For purposes of experimentation, sixteen slits are sufficient because hobbyist-grade motors cannot be positioned very accurately.

You could photocopy the disk in Fig. 1 on a piece of acrylic to provide position information for a Milton Bradley *Robotix* arm. The basic idea is shown in Fig. 3.

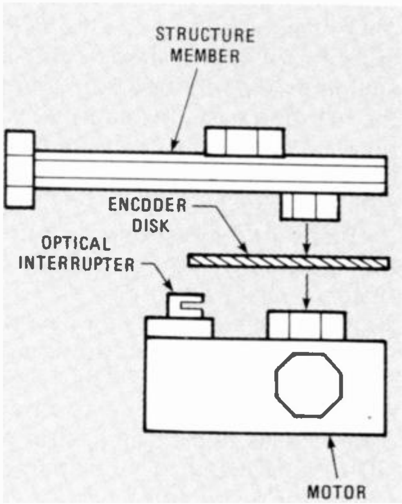


FIG. 3

The optical interrupter is readily available, but if you have trouble locating one, or if you would like to purchase some encoder disks, MJR Digital (Mason Road, Milford, NH 03055) has an experimental kit consisting of nine transmissive encoder disks, nine reflective encoder disks, five H22A1 optical interrupters, and an application note available for $19.95. We'll discuss use of the reflective encoder disks below.

Because two connections go to ground, only three wires must be brought to the encoder. In addition, several encoders may share the ground and five volt lines.

To use the encoder, the computer that controls the motor must monitor the output of the encoder. To begin a motion sequence, the arm must be "homed." In other words, the joint (or joints) in question must be brought to a limit—all the way up, down, left, right, etc.

The computer must then read the status of the encoder. If the output is low, then any subsequent high indicates movement. Conversely, if the initial reading is low, then subsequent highs indicate an absence of movement. It's important to know whether you're starting with a high or a low; otherwise you may not be able to return the arm to the home position accurately.

To move the arm to a specified position, load a counter with the number of slits that must be counted. Then, after homing the arm, turn on its motor and monitor the encoder's output for a pulse. When a high or a low (as previously described) is detected, decrement the internal counter. Repeat that operation until the counter has a value of zero. At that point the arm should be in the desired position.

You could perform the counting in hardware (without a computer) if you like. Doing that is simply a matter of using a counter IC and a logic gate to shut the motor off when the counter reaches zero.

Reflectance decoder

In some situations, a *reflectance-type* encoder disk is more practical. Rather than a clear disk with dark stripes, a reflectance disk is basically reflective with dark stripes. It is used as shown in Fig. 4.

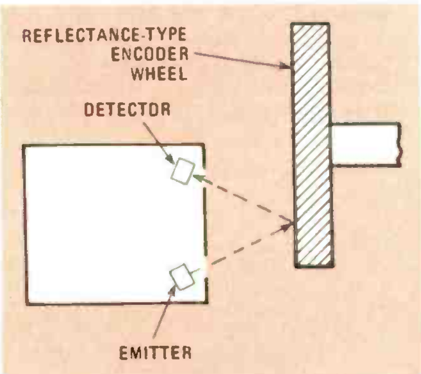


FIG. 4

A beam of infrared light is emitted from an IR emitter at an angle. An IR detector is mounted at a complementary angle. Light will be reflected from the reflective areas of the disk, and not from the striped areas. As the joint moves, the wheel turns, so the output of the detector is a series a highs and lows, like those produced by the transmissive disk. That data can be used to position the arm as previously described.

Analog sensing

Of course, there are other ways to sense the position of an arm. An analog approach might use a variable resistor, an A/D converter, and a little software. The shaft of a potentiometer is connected to the pivot point of a robot's arm, so the potentiometer's resistance should provide an accurate indication of the arm's position. The voltage across that resistor would be read by the A/D converter, and the control computer could then use that information to make an intelligent decision about what step should be done next.

The arm must start from a known position, so, on power up, the arm should be homed. That is best accomplished by rotating each pivot until a microswitch (used as a limit indicator) is activated. At that point motion must halt. Then the control computer should check the output of the A/D device. The voltage read there represents a reference point in relation to which other positions are known.

Some A/D converters require supply voltages of ±12 or even ±15 volts. However, there are several 5-volt A/D IC's on the market. For example, National Semiconductor's A/D0816 can digitize 16 channels of analog information. Each channel has eight bits, so any input between 0 and 5 volts will be converted to one of 256 digital values in steps of about 20 mV. Other A/D IC's provide 12 bits, for a total of 4096 discrete values.

There are several drawbacks to the analog approach. The first is that the potentiometer must be coupled physically to the arm's pivot, and that may be difficult. Also, the mechanical drag of the potentiometer may adversely affect the operation of the arm. And for the beginner, the most serious drawback may be creating the software required to operate the A/D converter.

Speed may also be a problem. Many A/D converters operate much slower than the digital systems controlling them. Often a computer must wait until the A/D converter is ready.

A typical computer-to-A/D dialog might go like this: The computer asks for the current reading, then the A/D works on the request. Some hundreds of microseconds later, the A/D signals the computer that the current reading is ready. Then the computer reads the value. If necessary, the process then repeats.

The speed problem can be alleviated by using a faster A/D converter. However, they're harder to find and more expensive than run-of-the-mill hobbyist-grade devices. And for experimental purposes, a slow A/D converter should prove to be quite sufficient.

As you can see, there are a number of ways of gaining position information about a robot arm. Some of those methods are more useful than others in different circumstances, but the digital approach is generally the simplest to implement as well as the most accurate. R-E

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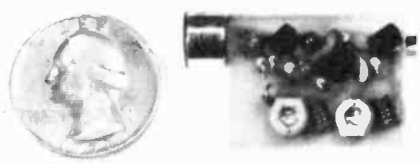

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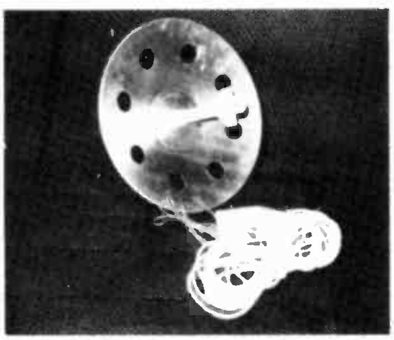

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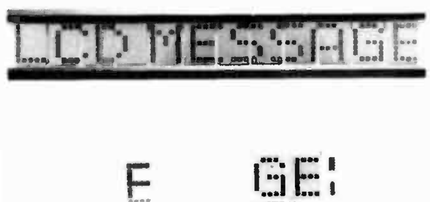

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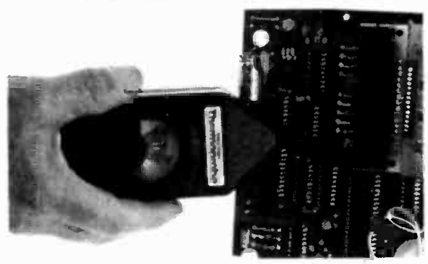

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CIRCLE 53 ON FREE INFORMATION CARD

SERVICE CLINIC

Customer psychology

JACK DARR,
SERVICE EDITOR

EVERYBODY HAS HAD THIS EXPERIENCE: you're ready to fix a set, and suddenly you go blank! You look at the chassis, and it resembles a cake-pan full of firecrackers! When you go blank like that, there's only one thing to do: Get away from it for a while. Go drink a cup of coffee, or do something totally different for awhile. I know that method works; I've done it a million times myself.

The LGC's

While you're away, what Hercule Poirot calls the *L*ittle *G*rey *C*ells in your brain will continue working. The LGC's keep working even though your conscious mind thinks that it's completely off the problem. If you're lucky, they'll come up with the right answer, or at least a more logical one. So, when you return, you can usually sit down and fix your set right away.

The subconscious mind is a very handy test instrument. Leave it alone and it will come up with the answer. The only things it can't fix are imaginary problems. And they're more real than you might think.

For example, a cranky old man had a TV set that seemed (to me) to be working perfectly. I was kneeling behind the set when suddenly he said, "There! There! What makes it do that?" I couldn't see that anything at all had happened.

So I tried a bit of psychology on him. I turned the AGC control up to the point where the picture became completely white. Then I said, "I can't tell how it looks from back here. You tell me when I get it right." I brought the AGC control down a little at a time, and finally he said, "There, there! That's just right!" So my service call was really an exercise in Applied Customer Psychology—but it worked. The customer was satisfied, so I closed my tube caddy and went home.

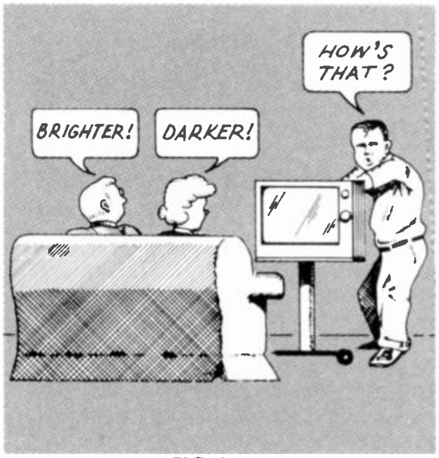


FIG. 1

Another thing to watch out for is a situation like like that pictured in Fig. 1. Try to establish a relationship with *one* customer—otherwise your LGC's may require servicing of their own!

It may be hard to satisfy a customer who insists on watching a distant, fading station. You'll just have to shoot from the hip. Try deliberately rotating the antenna (from outside, if necessary) *away* from the desired station. Next gradually bring it back on target. Then ask your customer, "How's that?" and chances are good that he'll say. "There. That's much better." When you hear that, you're in like flint.

That kind of trick only works with older sets, which have the contrast and AGC controls mounted on the rear. If they're front-mounted, you'll have to figure out some other trick. And, wherever they're located, you'll just have to use whatever controls are present—and sometimes there aren't enough of them! Do the best you can with what you have to work with!

Of course, before you try psychology, make sure that the set really is working properly—after all, some TV's have real troubles. If you can't find anything else, clean all of the customer-operated controls (contrast, volume, etc.) so that they don't upset the picture when they're adjusted.

Fortunately, "picky" customers make up a very small percentage of the total population. But, when you run into one, you have to have a way to deal with him (or her). It's not easy, but it can be done. It may take a little extra time, but it's time well spent if the customer is pleased. And if he is pleased with you—and your work—he'll tell all the neighbors about you, and that's good for business. **R-E**

SERVICE QUESTIONS

NO HORIZONTAL SWEEP

I have no horizontal sweep on an RCA CTC-71, just a straight vertical line. I changed the flyback; no improvement. Then I disconnected the tripler, the yoke, and the convergence panel; still no change. DC supply voltages are about normal. I'm completely confused. Help!—R. B., Toledo, OH.

Say no more; help is on the way.

Look at your DC voltage readings, especially on the emitter of the horizontal output transistor. You should see +5.5 volts; since you read 0.0, the transistor is either open, or the bias is way off. Remove the transistor from the circuit and measure the DC resistance of all junctions, especially the collector-emitter junction. Chances are that it is open.

MISCONVERGENCE IN SONY

I've got a Sony that's got me completely baffled. It has a good picture but the screens will not align! The red screen is a full inch to the left. Horizontal static has no effect. I've changed the convergence transformer; no luck. Is it the picture tube?—W.K., Lansing, MI.

Well, you've got a dandy, and I'm sorry you asked! However, something is causing it. Just for luck, give it a good going-over with a degaussing coil, especially around the neck and the nearby parts.

Strictly from way out in left field, it could have been caused by a lightning strike near the set. I have seen sets that were affected by lightning strikes; for example, convergence on an American set with a triad gun was severely disrupted. Degaussing cured that one, and I hope it will help you. Good luck!

SCANNER BOOSTER

Is it possible to amplify the signal before it is fed to a scanner? I live in an area where I need to increase the signal to get more audio. Can you tell me which type of antenna is best for signal gain?—T. W., Rogers, AR.

Yes, you can use a booster like the ones used for TV. Just be sure to get one that covers your frequency band. The Capri unit you mentioned should probably work.

The highest-gain antenna is a Yagi. If you're not working very low frequencies, you might try one.

A Yagi has a dipole, a reflector behind it, and from one to three directors in front of it. You can find drawings and dimensions in any good antenna handbook. Otherwise, a dipole antenna with a reflector located ¼ wavelength behind it is pretty sensitive. Aim it at a right angle to the desired signal.

LOW VOLTAGE IN SANYO

I've got a Sanyo 91C63. Several resistors were low in value so I replaced them. Now the power-supply voltage is lower than normal. I can't find any sign of a short, so I don't understand what's going on.—K. P., Zumbrota MN.

This sounds like a problem we've had many times! Check the input filter capacitor. If it's open, or low in value, your B+ will be low with no sign of a short circuit. The capacitor doesn't have the capacitance to maintain voltage under normal load.

You can check that capacitor easily: Just bridge another one about the same size across it and see if the voltage comes back up.

FOREIGN RADIO

I have acquired a radio that was made in Poland. It looks very much like a Grundig. I need service information and parts for it, especially a missing loopstick antenna. Can you help?—D. P., Ft. Dodge, IA.

Probably not much, but I'll try. It could be a Grundig; look up the tube lineup and see if you can match it with a Grundig that you have a schematic for. Since all small radios are basically the same, that should give you enough information.

As for the loopstick, does the radio have a dial so that you can tell which bands it can receive? If it can receive the standard U.S. broadcast band, any loopstick should work. If not, try your signal generator. See which bands are covered by whistling them in. It should be fun (???) to get it going.

ZENITH COLOR COIL

I have a Zenith 20Y1C50. When making the color adjustments, the phase-shift coil fell apart. I can't find a replacement for it anywhere. Zenith and Sams both list replacements which are themselves no longer available!—S. B., Bronx, NY.

I see the coil (transformer, actually) you mean. It couples the color signal into the two color amplifiers. I haven't been able to locate a direct sub for that part, but it appears that a J. W. Miller part no. 6092 or GO-1099 might work. They're color circuit coils, and both have dual secondaries like yours. **R-E**

COMMUNICATIONS CORNER

Communications wars

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

A FIERCE BEHIND-THE-SCENES WAR HAS raged for almost the entire 40-year history of radio communications. The war has been fought between the manufacturers of transmitting and those of receiving equipment. Sometimes it surfaces as an appeal to the FCC for some kind of regulation providing relief. At other times it has resulted in legal action between formerly friendly neighbors, or even in a western-type shoot-out.

The source of the dispute is RFI—*R*adio *F*requency *I*nterference. RFI is usually considered to be interference that is generated by something external to receiving equipment: for example, the hash that is sometimes induced in telephones by nearby personal computers.

Often, however, we use the term RFI to refer to interference generated within a receiver by an otherwise legal external source, even though that type of interference is not necessarily RFI in the true sense of the word. It is that pseudo-RFI which is really the problem in much consumer equipment, including tape recorders, telephones, TV's, VCR's, etc.

Pseudo-RFI can manifest itself in various forms including interference or image reversal in TV's, transmitter modulation in sound equipment and telephones, or cross-modulation products in receivers (wherein the listener hears stations to which the receiver is not tuned). Interference created by pseudo-RFI takes other forms, but those are usually considered the biggies.

Often, the cause of pseudo-RFI (and therefore the war for which it is responsible) is not a radio or TV transmitter—which usually delivers a clean signal—but cost-cutting in the receiver.

No filters

For many years, in order to trim a few dollars off the retail price of a piece of consumer equipment, much of the entertainment-equipment industry resisted installing filters. For example, until the advent of color TV it was highly unusual to find a "standard brand" TV that incorporated a lowpass filter in the tuner input to attenuate communication signals below 50 MHz.

Without the filter, an amateur, CB, or low-band VHF transmitter, or even a diathermy machine, could easily overload nearby TV front-ends and produce picture reversal or loss of synchronization. Although it is possible to keep the sub-50-MHz signals out of the TV by installing a highpass filter in the antenna lead-in (as shown in Fig. 1), unless the filter is properly installed—which is difficult when unshielded twinlead is used—radiation from strong local transmitters can be induced into the antenna lead-in *after* the highpass filter.

The term "shock-field" refers to the extremely strong RF energy in the immediate locality of a transmitter. Sound equipment that is located in the shock-field is particularly susceptible to RF, which can often bypass shielding. Problems generated by that RF usually manifest themselves as transmitter modulation heard in the background, or during quiet periods. Shock-field interference is even known to have produced erroneous traces on a hospital's EKG recorder.

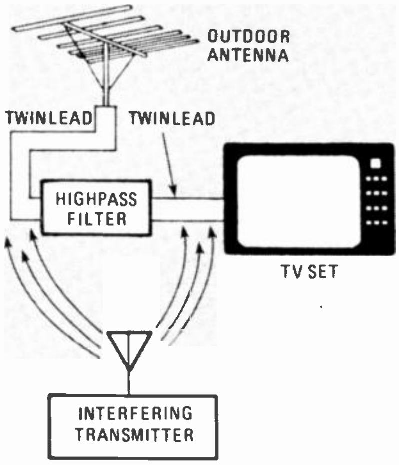
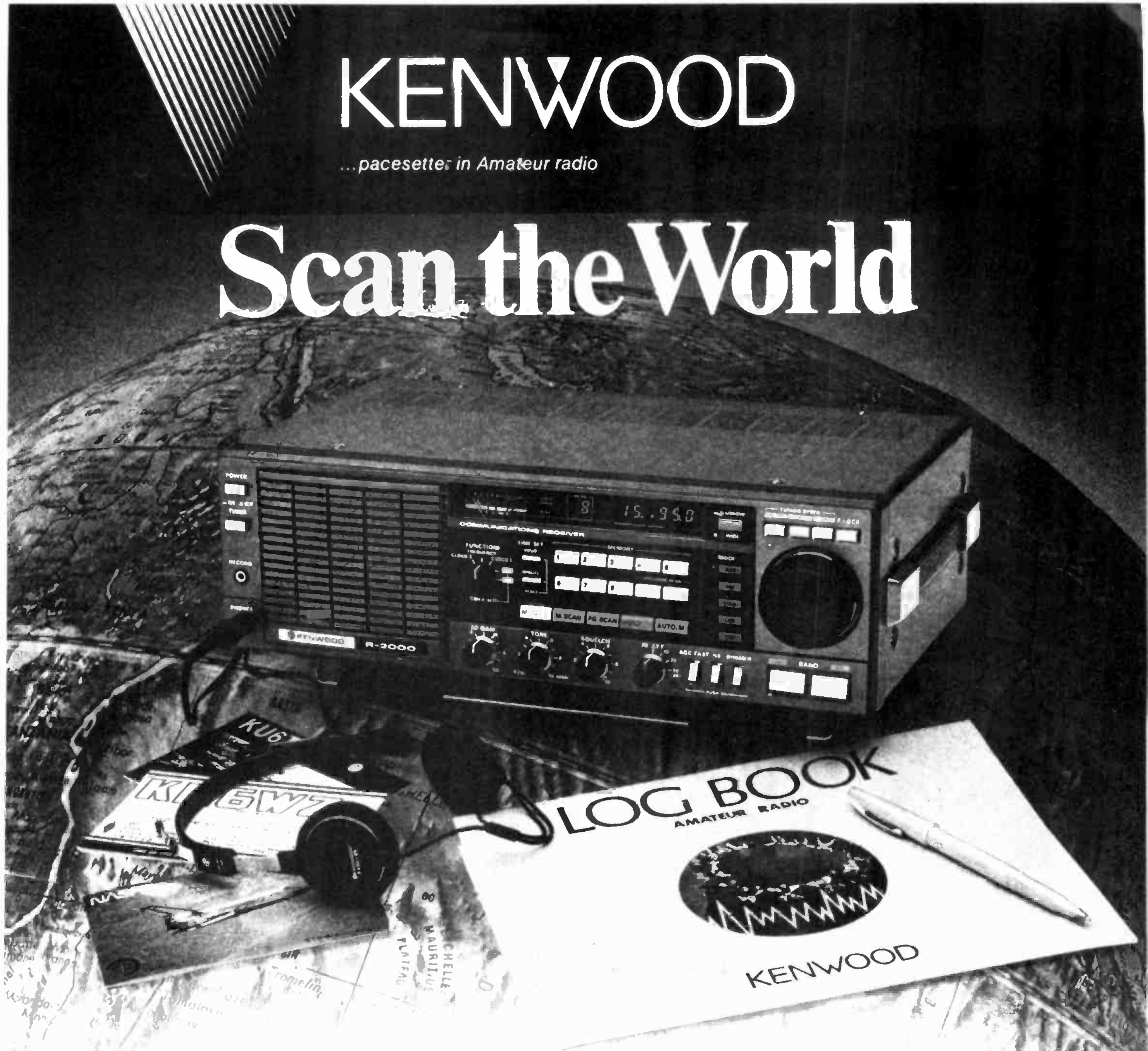


FIG. 1

In vacuum-tube amplifiers, whose high-impedance circuits are prone to RF interference, pseudo-RFI in audio amplifiers caused by local transmitters was filtered by brute force using filter chokes and capacitors in the wiring of the low-level preamplifiers.

It was hoped that the low impedances common to solid-state devices would alleviate the problem because, as a general rule, the lower a circuit's impedance, the less susceptible that circuit is to pseudo-RFI. Unfortunately, things didn't work out as hoped. The earliest circuit designs—many of which are still used today—employ transistors, and transistors consist of diode junctions. If there is enough RF energy in the circuit to cause the diode(s) to conduct, the stage becomes a rectifier, a broadband amplifier, or both. If



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- Covers 150 kHz – 30 MHz in 30 bands.
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- Lithium batt. memory back-up.
- Memory scan.
- Programmable band scan.
- Fluorescent tube digital display of frequency (100 Hz resolution) or time.
- Dual 24-hour quartz clocks, with timer.
- Three built-in IF filters with NARROW/WIDE selector switch. (CW filter optional.)
- Squelch circuit, all mode, built-in.
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- RF step attenuator (0-10-20-30 dB.)
- AGC switch. (Slow-Fast.)
- "S" meter, with SINPO scale.
- High and low impedance antenna terminals.
- 100/120/220/240 VAC operation.
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- Timer REMOTE output (not for AC power).
- Muting terminals.

Optional accessories:

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- YG-455C 500 Hz CW filter for R-2000
- HS-4 Headphones
- HS-5 Deluxe headphones
- HS-6 Lightweight headphones
- HS-7 Micro headphones
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COMMUNICATIONS CORNER

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the interference is caused by an AM transmitter, the RFI is detected just as it would be in an old-fashioned crystal radio, and the interference will be crystal clear (pun intended).

If the stage is a high-gain preamplifier, such as a magnetic phono preamp, and the interference is caused by a local low-band VHF (FM) transmitter, the listener hears the VHF transmitter's FM modula-

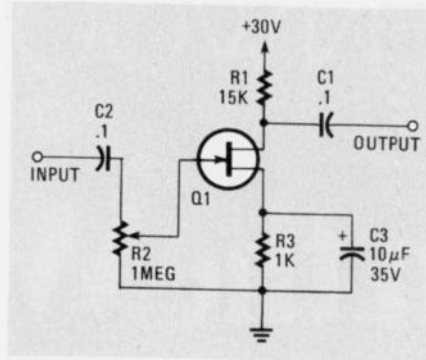

FIG. 2

tion in the background because, since the diode junction is nonlinear, it functions as a slope detector that will produce audio output from an FM signal.

If the stage is an RF amplifier, the diode causes it to function as a mixer that will output sum and difference signals, as well as the original input signal. Between the sum and difference frequencies many other frequencies may appear as by-products of the heterodyne (mixing) process. The result is that the listener may be subject to a garble of signals, or intermittent bursts of interference from strong local transmitters of any kind.

Much arm-twisting by industry groups and the FCC has convinced many manufacturers of consumer equipment to include various kinds of filters to prevent pseudo-RFI from lessening or destroying signal quality. However, stupidity—or just plain stubbornness—still reigns supreme among some circuit designers. For example, it is easy to design audio preamplifiers using FET's because it's usually easier to *bridge* the output of one stage with a circuit that has a high-impedance input than it is to *match* the impedance of that stage. In fact, any reasonably competent junior high school student could design a totally bridged amplifier.

Figure 2 shows the simplified circuit diagram of a preamplifier used in a recently-introduced consumer device. The input device is a FET, whose effective input impedance in this application is as high as a vacuum tube's input impedance. Although bridging with a FET is cheap and saves on circuit design time, it is precisely that kind of thinking which has produced the 40-year war between the users of communications equipment and those who watch TV, listen to the radio, and to recordings. The point is that, in this age of low-impedance devices and circuits, we must question the wisdom of anyone using that type of design, because the circuit is extremely sensitive to RF-pickup.

And it's ironic that the most difficult part of the problem is explaining to someone why the interference is caused not by your amateur, CB, or VHF rig, but that person's poorly-designed $3000 entertainment center. R-E

LETTERS

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stating, albeit obliquely, that there could be something beyond the realm of known physics that influences the Kirlian "aura."

The generation of Kirlian images, although a complex process subject to many variables that are not easily controlled, even in the laboratory (e. g., pressure, temperature, conductive residues deposited by the object being tested—or left over on the electrode from the previous object, exposure time, etc.), is explainable without invoking the paranormal.

For readers who would care to learn more about the physical aspects of Kirlian photography, an excellent study was published in the Spring issue of *Skeptical Inquirer*, a quarterly that is published by the Committee for the Scientific Investigation of the Paranormal (CSICOP).

Also, several years ago, in the trade journal *Functional Photography*, an article presented a fairly convincing theory of how the Kirlian corona interacts with the dyes in color film to yield those complex images.

I really enjoy **Radio-Electronics** magazine, particularly the construction projects. However, it's bad enough that Kirlian photography, pyramid power dowsing, and other such stuff get favorable coverage in the news media and supermarket tabloids. Let's at least try to keep it out of informed technical publications.

STEVE HANSEN,
Amherst, NH

MODULAR ROBOTS

I've been waiting for you to cover robots. It's took awhile, but you did it right in the March 1986 **Radio-Electronics**.

I'm an electronics technician (U. S. N.) by vocation, but I'm also an electronics hobbyist, because I want toys and tools that do more but cost less. I'd love to see you build on the March issue and do with robots what you've done with TV decoders, power supplies, and virtually everything else. I'd like to see plans and ideas for homebrew modular robots.

All told, it could be a big project, and could keep a regular department full for years to come. I'm sure that I'm not the only reader who's willing to submit hints, help, and new ideas. My plans are to start with a microprocessor-controlled base (rover type) then add various modules such as body, brain, various sensors, manipulators, interfaces etc.

Along those lines, there are many, many projects that I would like to see, and some are yet to be thought up!

Right now, the robot industry is "backyard" at best. I'd like to see the hobbyists, not Daddy Warbucks, make the robot a household *tool*. The computer industry will easily fall into place with software and interfaces. The robot will develop faster and farther if homebuilts have more in common than so-called standard RS-232 interfaces, or dialects of BASIC.

SCOTT ZINN
Souda Bay Creek, NY R-E

ANTIQUE RADIOS

Speakers and headphones

RICHARD D. FITCH,
CONTRIBUTING EDITOR

THIS MONTH WE'LL DISCUSS VARIOUS kinds of audio output devices including headphones, electro-dynamic, magnetic, and permanent magnet speakers, and troubleshooting information about each type of reproducer. But before we get to all of that, let's take a look at the antique of the month.

Looks good, doesn't work

Early Zenith console radios like the 1940-ish model shown in Fig. 1 were very popular in their day, and many of them still are. That Zenith could receive several different bands, and it has a tuning eye and assorted tone controls. That particular radio was chosen to make a point. Although it's in good outward condition, it will never play again. It is beyond repair because it has no tubes, no speaker, and a burned out transformer. But even though it's useless—as a radio—to a collector, it still has value as a display piece. For example, it could be used as a prop in a play or TV show.

The Zenith will be donated to the Golden Radio Buffs of Maryland, Inc. That organization doesn't collect radios and equipment; their interest is in broadcasting and personalities. They have a display at the Museum of Industry in Baltimore, MD. A few antique radios are on display there to set the mood while recordings of early radio programs are played. If you are interested in joining the Golden Radio Buffs, send an SASE to Gene Leitner at 7506 Iroquois Ave., Baltimore, MD 21219.

FIG. 1

Speaker history

Reproducers, like all chassis components, have seen many refinements over the years, although the major innovations were mostly completed during the 1920's. As with most advances in radio, it's difficult to say who invented the loudspeaker. And, as in other areas of electronics, the names of many early experimenters are undoubtedly lost.

There are three basic types of speakers: magnetic (not to be confused with either of the following types), dynamic (also called electro-dynamic), and PM (*P*ermanent *M*agnet). The names of the various types of speakers can be confusing. The names of magnetic speakers, for example, have many variations including the dynamic magnetic, diaphragm and horn, cone and armature, etc. Although all speakers operate magnetically, remember that the "magnetic" type of speaker differs from the other types in several significant ways. We'll discuss those differences below.

The earliest reproducers were headphones, but by the mid 1920's, magnetic horn-type speakers had supplanted earphones. Then came cone-type speakers, both single and double. And by 1930 the electro-dynamic loudspeaker was the most popular audio output device. Later, the development of new alloys brought about the permanent magnet, which simplified radio circuitry, because PM speakers don't require a field coil (which is discussed below).

Early radios were often sold without tubes, chassis, or speaker; in fact, the schematics of many early radios seldom indicate anything after the audio output tube. The manufacturers left it to the consumer to decide which type of reproducer to use, and great debates raged regarding the merits of various types of speakers. And, because radios often came without speakers, the manufacture of speakers and cabinets, as well as headphones, constituted a thriving business of its own. An example of each of the four major types of reproducer is shown in Fig. 2. Clockwise from the lower left are headphones, a magnetic speaker, a dynamic speaker, and a PM speaker.

Early headphones were made by about half a dozen manufacturers, and all were basically the same. The headset shown in Fig. 2 is from about 1920 and was probably designed to be used by a telephone operator. It was made by C.

Brandes, Inc., of New York; that company later made speakers and radios too. The Brandes headset is more collectable than many antique radios.

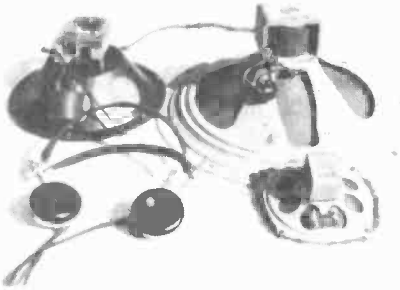

FIG. 2

That magnetic headset operates by means of a diaphragm that is suspended above a magnet. Coils wound around the magnet cause the diaphragm to vibrate when current flows through those coils.

Headphones have survived to the present day, but after speakers became generally available, they proved to be much more popular than headphones. Why did speakers become so popular? One reason is that the earphone cord severely restricts your freedom of movement. And only one person can listen at a time, although two friendly listeners can share a set of earphones if they put their heads together.

So designers began thinking of better ways for people to enjoy radio broadcasts. One method was simply to lay the headphones on a table and strap a megaphone to an earpiece. That method worked and was probably the beginning of the loudspeaker. But of course it left much to be desired, so designers continued their search for a more perfect reproducer.

Speakers

One early attempt at better sound reproduction is the magnetic speaker. There are many varieties of magnetic speaker, but, in general, a magnetic speaker uses an armature to move a diaphragm, although some use an earphone coil and a cone or a horn attached to the diaphragm.

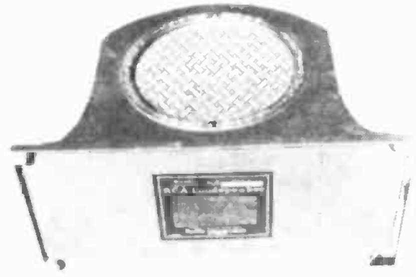

FIG. 3

Magnetic speakers, especially the various horn types, were popular during the mid 1920's. One very popular magnetic speaker was RCA's model *100-A*, which is shown in Fig. 3. There are still thousands of those speakers around, and many collectors have one or more.

The electro-dynamic speaker became popular in the late 1920's and early 1930's. It requires a DC voltage to operate a field coil, which, as its name suggests, generates the magnetic field that, in conjunction with the voice coil, causes the cone of the speaker to move. That field, of course, is generated in later speakers by a permanent magnet. The dynamic speaker also includes a hum-bucking coil that cancels hum introduced by the field coil.

Pros and cons

There was much discussion of the relative merits of various types of speakers in the late 1920's when the popularity of the dynamic type was increasing. Proponents of dynamic speakers focused on the faults of the magnetic units, which are really just glorified earphones that produce weak, scratchy sound. They are, however, excellent collectables today. The main advantages of the magnetic units are their lower initial cost and their lack of hum.

But, by the late 1920's, most listeners used dynamic speakers and never noticed the hum. And after a listener heard a dynamic speaker, it was difficult to return to a magnetic speaker.

However, economics sometimes caused a listener to buy a magnetic rather than a dynamic speaker, because the latter often required a separate power pack (with rectifier) to drive the field coil. Of course, a well-informed consumer knew that there was no need to purchase a separate power pack if his radio's chassis had provisions for a field coil built in.

Proponents of magnetic speakers pointed out that it was an advantage not to have to drive a field or hum-bucking coil. No storage battery, rectifier, or filter was needed. And since no hum was introduced, there was no need for a hum-bucking coil.

On the other hand, a magnetic speaker had problems reproducing low notes. Even with a large horn or cone, it couldn't match the frequency response of a dynamic speaker. Most people agreed that magnetic speakers sufficed for telephone use (which is where they began), but not for musical reproduction. The slight hum produced by a dynamic speaker was preferable to lack of fidelity.

Receiver manufacturers who didn't supply a reproducer with a receiver usually recommended that the consumer buy the more expensive unit, because that made the receiver itself seem better, so the consumer would be more likely to recommend that brand to other people.

Radios made by Zenith, Radiola, Bremer Tully, and others could use various types of speakers. Magnetic speakers were more popular with early battery-operated sets such as those made by Dayton and Radiola. Some radios had both a jack for a magnetic speaker and terminals for a dynamic speaker.

Troubleshooting headphones

There is little that can go wrong with magnetic headphones electrically. So first check a troubled set mechanically. Remove the caps on the earpieces. The diaphragm should fall out—and maybe a few other things besides. Remove any dust, dirt, or other foreign objects, because they can prevent the diaphragm from vibrating.

The coil connections should be clearly visible, so make a continuity test between the terminals and the plug. The coils may be open, but that's unlikely. The splice leading to the other earpiece is a likely suspect if one side of the headset is dead. When you re-assemble the earpieces, pay attention to the diaphragm. Some have a painted side which should face out.

Troubleshooting PM speakers

Unlike the complicated speaker array of early radios, small PM speakers can be checked quickly, and they have few components that can go bad. The voice coil (also called the moving coil) and the audio output transformer are the primary sources of trouble. Others include an off-center voice coil, a warped cone, and a bent frame, all of which will distort the sound. The labor involved in trying to straighten a cone or frame, or center a voice coil, simply isn't worth the effort. Just replace the entire speaker. But if the results of a continuity test are negative, don't assume that the voice coil is bad. The trouble is most likely at a terminal, plug, or other soldered connection. The voice coil rarely develops an open in the winding.

If you're not sure whether the speaker or some other component is at fault, the easiest way to check a small PM speaker is by substitution. Just make sure that you connect the speaker to the secondary of the output transformer. Some transformers are mounted on the chassis, and others are mounted directly on the speaker frame.

You may be able to salvage a seemingly open output transformer. If a winding fails a continuity test, the problem may be a solder joint. Just peel back some of the insulating paper to where the winding wire joins the hookup lead. If you don't find a bad joint there, it's usually cheaper to replace the transformer than to repair it.

Troubleshooting magnetic speakers

Many repairs required by magnetic speakers are mechanical. If the driving rod is loose, it may only require tightening the nut. If the center of the cone is torn, remove the rod and re-glue the cone. Repairing that type of cone is much easier than trying to attach a torn cone to the voice coil of a dynamic speaker.

Since a magnetic speaker is built like an earphone, it can be checked like an earphone. Continuity can be measured between the coil terminals and the plug. Remove any dirt or dust that may interfere with operation of the diaphragm. The pin connected to the diaphragm and to the center of the cone often breaks loose. A little glue around the area should fix it.

An armature-activated magnetic speaker might have a problem with the armature's striking the pole pieces. That generates an easily-identifiable sound that occurs mostly on low notes. Those pole pieces, by the way, are partly what limited the popularity of that type of loudspeaker. Many people found the mechanical adjustments more trouble than they were worth.

Troubleshooting dynamic speakers

A dynamic speaker may suffer from any problem that a PM speaker may suffer from, in addition to several of its own. Unwanted vibrations could be caused by a torn cone, dirt or metal particles, loose mounting screws, or other metal components on the loudspeaker's frame. Unlike PM speakers, most dynamic units provide a means of centering the voice coil.

That is done with a device called a spider, which comes in several variations. Besides centering the voice coil, the stiff material the spider is made of helps the voice coil return to its neutral position when no signal is applied. When centering the voice coil with a spider, sometimes it helps to place some stiff paper around the coil. Doing that helps ensure that the coil won't rub after the spider is adjusted.

Unfortunately, you'll probably have to make every effort to repair a damaged speaker cone yourself. The old speaker reconer is a dying breed.

Hum problems are easy to diagnose. A hum bucking coil is wired in series with the secondary of the output transformer and the voice coil. When disconnecting the voice coil or output transformer leads, be careful not to reverse them in relation to each other. You

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DRAWING BOARD

Program corrections and lab set-up

ROBERT GROSSBLATT,
CIRCUITS EDITOR

LISTING 1—CORRECTED PROGRAM

Address	Op Code	Source Code	Comments
ØØØØ	AF	XOR A	Zero the Accumulator
ØØØ1	26 ØF	LD H,ØF	Set the display number
ØØØ3	2E AØ	LD L,ØA	Set the loop counter
ØØØ5	7C	LD A,H	Load the Accumulator
ØØØ6	D3 FF	OUT (FF),A	Send it to the latch
ØØØ8	C3 ØØ 11	JP ØØ11	Go to delay subroutine
ØØØB	25	DEC H	Decrement port count
ØØØC	2D	DEC L	Decrement loop counter
ØØØD	C2 Ø5 ØØ	JP NZ ØØØ5	Do again if not zero
ØØ1Ø	76	HALT	End of the program
ØØ11	11 83 8B	LD DE,5161	Preset the delay loop
ØØ14	1B	DEC DE	Decrement the counter
ØØ16	B3	OR E	OR with the low byte
ØØ15	7A	LD A,D	Transfer the high byte
ØØ17	C2 14 ØØ	JP NZ ØØ14	Jump back if not zero
ØØ1A	C3 ØB ØØ	JP ØØØB	Return if finished

IT HAPPENS TO EVERYONE. I GOOFED when putting together the demonstration program for the Z80 circuit in the March 1986 issue. I'm glad that several of you caught the mistakes and let me know about them, but I'm also a bit disappointed that only three people let me know about it. Just for the record, if anybody sees what even looks like an error on my part, I'd be grateful if you'd take the time to drop me a card and point it out to me. The only way we'll profit from our discussions is to make sure that all the information presented here is correct.

The three people who found mistakes are Paul Fargen of Louisville, KY, L. Barker of Chicago, IL, and Steven Gray of Orlando, FL. Some of the points they made are real screw-ups on my part, one is a typo, and the last is a matter of opinion. We'll deal with the out-and-out mistakes first.

Delay loop

The worst error occurred in lines 11–14, a delay loop that was supposed to let the LED display remain stable for about half a second before displaying the next value. My first mistake was in calculating the number of T cycles needed to go through the loop. I said that 14 were needed but in actual fact the delay loop takes 16 T cycles. The DEC DE instruction in line 12 takes 6, and the JP NZ instruction in line 13 takes 10 cycles.

But even with the loop counter loaded with the correct number (in line 11), there was still a major problem. After the program entered the delay loop it would loop there forever. The reason is that the DEC DE instruction has no effect on the zero flag, and the zero flag is what we test to find out whether we can exit the delay loop. The program would continue decrementing the DE register until reset, power-down, etc. The result would be that all the LED's on the output port would light up and stay lit.

There are several ways to correct the problem. Probably the simplest approach involves realizing that when the loop counter reaches zero, both the D and the E registers will be zero. So, as shown in lines 13–15 of Listing 1, all we have to do is OR the the two registers with each other and test for a result of zero. If so, the program will jump back to the main display routine. However, adding the extra lines of code forces us to change the value we stored in DE to control the delay loop.

The 16 T cycles we had in the original loop increase to 24 because the LD A,D and the OR E each take four T cycles. A half-second delay means we want to wait 500,000 microseconds. Dividing that by 24 gives us 20,833 decimal or 5161 hex. Line 11 of the program loads that value into the DE register pair.

Of course, the Z80's instruction set is rich enough for you to find several other ways of fixing the original program to correct the mistake in the delay loop. As a matter of fact, figuring out other ways to solve the problem is a good exercise in programming!

Typo

There was a typo in line 3 of the original listing. The code printed in the column was LD A,A0. That's where we set the number of times we want the program to loop through the hex display. As it is, the program would loop through the display procedure 160 times.

What happened was that the two digits were reversed; the correct value should have been 0A. Then the program would loop ten times, as I called for in the text.

No RAM

Steve Gray also mentioned, as I did, that in RAM-less circuits the Z80 cannot use instructions that use the stack, so PUSHes, POP's, CALL's, and interrupts can't be used. Although the demonstration program avoids that problem by using JUMP's, an alternative would have been to stash calling addresses in one of the other Z80 registers such the IX or IY. Why not try that approach as it's a good exercise?

Programming style

The last comment I got in the mail was about the first line of the program, XOR A. Since the accumulator is loaded with a value in line 4 of the program, there's no real reason to zero it when the program starts.

Now I'm the first one to admit that the real hallmark of slick software is economy. Nobody gets more of a kick out of hacking bytes off a listing than I do. And when you deal in the real world where speed and memory constraints are very important considerations, an extra few bytes or so here and there can mean the difference between a working program and an embarrassment.

On the other hand, good programming skills (or skills of any sort), only come about by developing good habits, such as zeroing a register at the beginning of a routine, or preserving the environment before jumping to a subroutine. Unfortunately, habitual operations like those can't be applied blindly. Our XOR A doesn't hurt operation of the program, but it is unnecessary and can be deleted if you wish.

In our original discussion of the program, I stated Grossblatt's Fourth Law: *You have to know the rules to break the rules.* Let's put that another way: In the beginning you do it by the book, and when you think you know the book, you want to throw it out the window. But then again, it's probably better not to. R-E

ANTIQUE RADIO

continued from page 91

could end up with twice as much hum. To determine whether the hum bucking coil is operating, just bypass it with a piece of insulated wire. If the hum level increases, the coil is working. However, if the hum level decreases, check for a reversed connection.

While we try to maintain the authenticity of our antique radios, sometimes we have to use not-quite-original replacements. For example, you might have to replace a dynamic speaker that is beyond repair with a PM speaker. You can connect the voice coil of the PM unit directly to the output transformer. You don't have to worry about the hum bucking coil, but you may have to connect a resistor or a choke to the point where the field coil was wired. As mentioned above, some chassis allow you to use a PM speaker just by disconnecting the field coil leads. Check your schematic.

If you're troubleshooting an AC/DC radio, in which the output plate current flows through the filament of the pilot lamp, you can spot an open voice coil (or a bad solder connection) by watching the pilot lamp. With the volume turned up full, the light should flicker when you tune in a strong station. That's due to varying plate current flowing through the pilot lamp. If it flickers, but you get no sound output, disconnect one speaker lead and check the continuity of the voice coil. If there's no continuity, find the cause as described above.

Otherwise, the voice-coil may be off-center. Reconnect the speaker and then apply light finger pressure around the inside of the speaker cone. If the problem is an off-center voice coil, as you move your fingers around the cone, at some point you should hear a scratching noise. If there's no way to adjust the position of the coil, you'll have to replace the speaker.

Wrapping up

That's all for speakers and headphones; next time we'll discuss early radio gadgets and trends in cabinet design. R-E

STUNGUN

continued from page 43

board is shown in "PC Service;" alternatively, a PC board can be purchased from the source mentioned in the Parts List. If you build the circuit on a perfboard, follow our parts layout closely; otherwise you may have problems with arcing.

Due to the critical nature of the three transformers, we are not providing details on winding them. They are available from the source mentioned in the Parts List.

Referring to the parts-placement diagram in Fig. 2, and the photos in Fig. 3 and Fig. 4, mount all components except C2, T1, T2, and T3 on your board. Note that several components mount on the foil side of the PC board: C1, D7, and J1. Do not install those parts yet either.

After all components (except those mentioned above) are installed, check your work very carefully, especially D1–D6, R1, and R3, because T1 will be installed above them, and there will be no chance to correct errors later. After you're absolutely sure that they're installed correctly, install T1 with the black mark on the windings mounted toward C2.

Foil-side components

One of J1's tabs shares a hole on the PC board with resistor R8, which should be mounted already. Solder the tab of J1 that corresponds to the tip (not the barrel) of an inserted plug to the indicated pad. Then mount C1 and D7. Last, solder a 1¾-inch piece of 18-gauge wire to the barrel pin of J1, and connect the opposite end of that wire to the appropriate pad beneath S1, the FIRE switch.

Preliminary check-out

WARNING: While measuring voltages and currents, keep your face, hands, and all metallic objects away from the high-voltage end of the stun gun. If if you want to prod a component, use a non-conductive rod such as a plastic TV alignment tool. High voltage behaves very differently than low voltage. Any material that retains moisture can serve as a discharge path. THAT INCLUDES WOOD! Also, never work on or use the unit when your hands are wet.

Connect a voltmeter (set to a 1000-volt DC range) to ground and to the output of the D3–D6 diode bridge. Then power up the circuit using either a freshly-charged battery or an external supply capable of delivering 9.8 volts at one amp. If everything is working properly, you should measure about 400-volts DC at the output of the bridge when you press S1.

If you don't measure that voltage, connect an oscilloscope to the collector of Q1 or Q2. You should see a squarewave with a period of about 100 µs. If that waveform is not present, the switching circuit is not operating correctly. *Remove power* and check your wiring again. *Do not debug the circuit with a battery connected!*

Resistor R6 controls the rate at which the UJT (Q3) discharges, and R3 controls the rate at which C2 charges. You can experiment with the values of those components if you are not satisfied with the circuit's high-voltage output. R3 can vary from 2.2 to 4.7K. You can also experiment with the value of C2. See Table 1.

After the circuit is operating correctly, attach J1 to the board with high-voltage potting compound or RTV. And before you mount the circuit in a case, make sure there's no arcing on the PC board. If there is, you can stop it with a liberal application of RTV, paraffin, or epoxy.

Conclusion

The stun gun's discharge is very impressive. The spark is highly visible and each discharge produces a sharp, resounding crack. The circuit can teach you much about voltage-multiplying circuits and power supply design. But don't ever forget that the stun gun is not a toy. It can cause much damage to both you and others. Never leave it lying around where children, pets, or anyone unfamiliar with how to use it can handle it. It's a good idea to remove the battery before storing the stun gun. Above all: be careful! **R-E**

BRAINSTORM

continued from page 62

no additional information, as it is indicated in the schematic; instead, it would only clutter up the chassis drawing.

Circuit board and schematic

Many projects begin with a vague idea for a device followed by some rough circuit sketches. That's OK for the diddle stage, but when its time to generate the schematic, the diagram that will control the building stage of the project, the drawing must be exact and complete.

Once you've finished the schematic, you need to design the circuit-board layout. As you're no doubt aware, when you draw a schematic, the symbols used bear no relationship to the actual size of the components themselves. Thus, while a resistor and capacitor may appear to occupy areas that are roughly equal, in reality the resistor may be only a fraction of the size of the capacitor, especially if the capacitor is a large electrolytic. To be sure that you've allowed sufficient space for each component in your design, use the actual parts and lay them out on an actual-size drawing of the circuit board. That is especially important when designing PC-board layouts. See "Designing Double-Sided Printed Circuit Boards," in the September 1985 issue of **Radio-Electronics** for tips on laying out complicated circuitry. The circuit-board drawing should include identification of the connection points to any off-board components.

Procedure

You've prepared the paperwork, and you've assembled a kit with all of the parts. Now, you're ready to put the circuit together, turn it on, and watch for smoke. When the building process begins, you switch from designer to technician, with your paperwork guiding you every step of the way.

The following step-by-step procedure applies the paperwork to the construction job, and covers initial assembly to finished product. Steps 1 and 2 cover breadboarding individual circuits for design debugging, and will be repeated until each circuit works on the experimenter's solderless breadboard. Once the circuit operates correctly, final assembly requires repeating steps 1 and 2 to rebuild the circuit in its final form.

Step 1—Mount the components on your circuit board (solderless experimenter, perforated, wire wrap, or etched) using the circuit-board drawing as a guide.

Step 2—Do the wiring. When using wire-wrap or point-to-point techniques, as each connection is made, trace over the appropriate line on the schematic using a colored pencil.

For PC boards, the same technique should be followed, but is should be done while you are designing the board. As a trace is laid down, the line or lines on the schematic should be traced over.

Completely test the board using a temporary rig to mount any off-board parts. When the circuit passes all of your tests, it's ready for installation.

Step 3—Install the panel-mounted parts.

Step 4—Install the circuit board or boards.

Step 5—Wire the chassis. Keep the wiring as short and as neat as possible. Use wiring ties, cable clamps, etc.

Step 6—Apply power. If you've been very careful, and followed the steps we've shown you, the odds of getting a correctly working circuit the first time are greatly improved. Of course, they are not.

Fortunately, if you've done your paperwork properly, you will have a paper trail to follow if you run into trouble. Very often that trail will lead you directly to the cause of your problem. **R-E**

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7325½ RESEDA BLVD., DEPT. R-9 • RESEDA, CA 91335
(818) 716-5914 • *No Collect Calls* • (818) 716-5140

IMPORTANT: WHEN CALLING FOR INFORMATION
Please have the make and model # of the equipment used in your area. *Thank You*

BURGLAR ALARM

continued from page 44

Begin by drilling holes for the two LED's and the key switch; also drill two mounting holes. Be careful, as a neat, "professional" looking job will help enhance the effect. Next, secure a "C"-cell battery holder to the panel using RTV adhesive; the holder should be located just below the holes for the LED's. Then mount the key switch in the appropriate hole. Wire the switch and the battery holder to the appropriate points on the board, keeping lead lengths as short as possible. Bend the LED's 90° so that they are parallel with the board. Position the LED's in the holes you previously drilled for that purpose so that they protrude about ⅛ inch. Finish up by securing the board to the top of the battery holder with a piece of double sided tape. Fig. 3 shows how it should look.

The unit can be installed just about anywhere. We suggest mounting it in your door frame for a professional look.

Although the circuit doesn't actually do anything, you should make it a habit to "arm" and "disarm" it as appropriate. That little bit of theater will help convince a burglar who is "casing" your home that it is indeed protected as advertised. **R-E**

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Mail-Order Electronics 415-592-8097

7400

Part No.	Price	Part No.	Price
SN7400N	.19	SN7485N	.55
SN7402N	.19	SN7486N	.35
SN7404N	.25	SN7489N	1.95
SN7405N	.29	SN7490N	.39
SN7406N	.29	SN7493N	.35
SN7407N	.29	SN74121N	.29
SN7408N	.25	SN74123N	.49
SN7410N	.19	SN74125N	.45
SN7414N	.45	SN74126N	.49
SN7416N	.35	SN74143N	3.95
SN7417N	.35	SN74150N	1.29
SN7420N	.19	SN74154N	1.25
SN7430N	.19	SN74158N	1.39
SN7432N	.29	SN74173N	.75
SN7438N	.29	SN74174N	.59
SN7442N	.45	SN74175N	.59
SN7445N	.69	SN74176N	.89
SN7446N	.79	SN74181N	1.95
SN7447N	.79	SN74189N	1.95
SN7448N	.79	SN74193N	.69
SN7472N	.39	SN74198N	1.35
SN7473N	.35	SN74221N	.89
SN7474N	.35	SN74273N	1.95
SN7475N	.39	SN74365N	.59
SN7476N	.35	SN74367N	.59

74LS

74LS00	.19	74LS165	.79
74LS02	.19	74LS166	.89
74LS04	.25	74LS173	.49
74LS05	.25	74LS174	.39
74LS06	.99	74LS175	.39
74LS07	.99	74LS189	3.95
74LS08	.19	74LS191	.49
74LS10	.19	74LS193	.69
74LS14	.39	74LS221	.59
74LS27	.25	74LS240	.69
74LS30	.19	74LS243	.69
74LS32	.25	74LS244	.69
74LS42	.39	74LS245	.79
74LS47	.89	74LS259	1.19
74LS73	.35	74LS273	.79
74LS74	.25	74LS279	.39
74LS75	.29	74LS322	2.95
74LS76	.29	74LS365	.39
74LS85	.49	74LS366	.39
74LS86	.25	74LS367	.39
74LS90	.39	74LS368	.39
74LS93	.39	74LS373	.79
74LS123	.49	74LS374	.79
74LS125	.39	74LS393	.79
74LS138	.39	74LS590	5.95
74LS139	.39	74LS624	1.95
74LS154	1.49	74LS629	2.49
74LS157	.35	74LS640	.99
74LS158	.35	74LS645	.99
74LS163	.49	74LS670	.99
74LS164	.49	74LS688	1.95

74S/PROMS*

74S00	.29	74S188*	1.75
74S04	.35	74S189	1.95
74S08	.35	74S196	1.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.49	74S253	.79
74S85	1.49	74S287*	1.69
74S86	.35	74S288*	1.69
74S124	2.75	74S373	1.69
74S174	.79	74S374	1.69
74S175	.79	74S472*	3.49

74ALS

74ALS00	.35	74ALS138	.89
74ALS02	.35	74ALS174	.89
74ALS04	.39	74ALS175	.89
74ALS08	.35	74ALS240	1.79
74ALS10	.35	74ALS244	1.79
74ALS27	.39	74ALS245	2.49
74ALS30	.35	74ALS373	1.95
74ALS32	.39	74ALS374	1.95
74ALS74	.55	74ALS573	1.95

74F

74F00	.59	74F139	1.29
74F04	.65	74F157	1.29
74F08	.59	74F193	4.95
74F10	.59	74F240	2.49
74F32	.65	74F244	2.49
74F74	.69	74F253	1.79
74F86	.89	74F373	2.95
74F138	1.19	74F374	2.95

CD—CMOS

CD4001	.19	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.35	CD4093	.39
CD4016	.29	CD4094	1.49
CD4017	.49	CD40103	2.95
CD4018	.69	CD4503	.49
CD4020	.59	CD4510	.69
CD4024	.49	CD4511	.69
CD4027	.39	CD4515	1.39
CD4030	.39	CD4518	.79
CD4040	.65	CD4520	.79
CD4049	.29	CD4522	.79
CD4050	.29	CD4538	.89
CD4051	.65	CD4541	.89
CD4052	.65	CD4543	.99
CD4053	.65	CD4553	4.95
CD4059	3.49	CD4555	.89
CD4060	.89	CD4566	1.95
CD4066	.29	CD4583	1.19
CD4069	.25	CD4584	.59
CD4070	.29	CD4585	.75
CD4071	.25	MC14411	9.95
CD4072	.25	MC14490P	4.49
CD4076	.89	MC14572	.89

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*6525TPI	9.95	*6560VIC-I	14.95	*8721PLA	14.95
		*6567VIC-II	19.95		
*Specs. Available @ $1.50 ea.		*6581SID	19.95	NOTE: 82S100 = U17 (C-64)	

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CDP1802CE	6.95	6845	4.95	8243	2.49
2661-3	6.95	6850	1.95	8250A	6.95
Z80, Z80A, Z80B, SERIES		6852	4.75	8250B (For IBM)	7.25
Z80	1.75	68000L8	9.95	8251A	2.25
Z80-CTC	1.79	68661	8.95	8253-5	2.25
Z80-DART	4.95	**8000 SERIES**		8254	9.95
Z80-PIO	1.79	8031	6.95	8254-2	11.95
Z80A	1.85	80C31BH	19.95	8255A-5	2.25
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Z80A-DART	5.25	8073N	29.95	8259-5	2.49
Z80A-PIO	1.95	8080A	3.95	8272	4.95
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Z80B	3.95	8086	8.95	8741	8.95
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6500/6800/68000 SER.		8087-2(8MHz)	159.95	8751	29.95
6502	2.75	8088	7.95	8755	14.95
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6520	2.95	8116	8.95	ADC0804	3.49
6522	4.95	8155	2.75	ADC0808	8.95
6532	6.49	8155-2	3.95	ADC0809	3.95
6551	6.95	8156	2.75	ADC0816	14.95
6800	1.95	8202	9.95	ADC0817	8.95
6802	4.95	8203	24.95	DAC0808	1.95
6810	1.95	8212	1.95	DAC1008	7.95
6821	1.95	8224	2.25	AY-3-1015D	4.95
6840	6.75	8228	3.49	AY-5-1013A	3.95

Part No.	Function		Price
DYNAMIC RAMS			
4116N-15	16,384 x 1	(150ns)	.89
4128 (Piggyback)	131,072 x 1	(200ns)	5.95
4164N-150	65,536 x 1	(150ns)	1.25
4164N-200	65,536 x 1	(200ns)	1.15
TMS4416-12	16,384 x 4	(120ns)	4.95
MM5280	4096 x 1	(200ns) 2107	1.95
8118	16,384 x 1	(120ns) (+5V Only Required)	.99
41256-150	262,144 x 1	(150ns)	2.95
50464-15	65,536 x 4	(150ns) (4464) (41464)	5.49
STATIC RAMS			
TMM2016-12	2048 x 8	(120ns)	1.69
2102	1024 x 1	(350ns)	.89
2102-2L	1024 x 1	(250ns) L.P. (91L02)	1.49
2114N	1024 x 4	(450ns)	.99
2114N-L	1024 x 4	(450ns) L.P.	1.09
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) L.P.	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	4.95
5101	256 x 4	(450ns) CMOS	3.95
HM6116P-3	2048 x 8	(150ns) CMOS	1.45
HM6116LP-3	2048 x 8	(150ns) L.P. CMOS	1.49
HM6264P-12	8192 x 8	(120ns) CMOS	4.09
HM6264LP-12	8192 x 8	(120ns) L.P. CMOS	4.29
HM6264P-15	8192 x 8	(150ns) CMOS	3.75
HM6264LP-15	8192 x 8	(150ns) L.P. CMOS	3.89
6514	1024 x 4	(350ns) CMOS (UPD444C)	4.49
PROMS/EPROMS			
1702A	256 x 8	(1μs)	5.95
TMS2516	2048 x 8	(450ns) 25V	4.95
TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	3.49
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.15
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	CMOS	6.49
2732	4096 x 8	(450ns)	3.75
2732A-20	4096 x 8	(200ns) 21V	3.95
2732A-25	4096 x 8	(250ns) 21V	3.49
2732A-45	4096 x 8	(450ns) 21V	3.29
27C32	4096 x 8	CMOS	6.49
2758	1024 x 8	(450ns) Single +5V	2.95
2764-20	8192 x 8	(200ns) 21V	3.95
2764-25	8192 x 8	(250ns) 21V	3.49
2764A-25	8192 x 8	(250ns) 12.5V	3.25
2764-45	8192 x 8	(450ns) 21V	3.25
27C64	8192 x 8	CMOS 21V	4.95
27128-25	16,384 x 8	(250ns) 128K 21V	3.25
27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	5.95
27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	8.95
27512-25	65,536 x 8	(250ns) 512K (12.5V)	24.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.69
74S471	256 x 8	PROM T.S.	4.95
82S123	32 x 8	PROM T.S.	2.95

LOW PROFILE (TIN) SOCKETS Part No.	1-9	10-99	100-up	WIRE WRAP SOCKETS (GOLD) LEVEL #3 Part No.	1-9	10-99	100-up
8 pin LP	.13	.12	.11	8 pin WW	.55	.49	.45
14 pin LP	.15	.13	.11	14 pin WW	.69	.65	.59
16 pin LP	.17	.15	.13	16 pin WW	.75	.69	.65
24 pin LP	.31	.30	.29	24 pin WW	1.19	1.09	.99
28 pin LP	.39	.37	.35	28 pin WW	1.39	1.29	1.19
40 pin LP	.49	.46	.43	40 pin WW	1.79	1.69	1.59

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SATELLITE TV DESCRAMBLER

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321 .... $9.95

DIGITALKER™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc. The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. **The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.**

Part No.	Description	Price
DT1050	Digitalker™	$24.95
MM54104	Processor Chip	$12.95

DT1057-Expands the DT1050 vocabulary from 137 words to over 250 words. Includes two (2) ROMs and specs.

DT1057 .... $11.95

INTERSIL

Part No.	Price	Part No.	Price
FE0202D	12.95	7207AEV/Kit	8.49
FE0203D	12.95	7211IPL (TTL)	7.95
7106CPL	8.95	7211MIPL (Micro)	8.49
7106EV/Kit	46.95	7217IJI	10.95
7107CPL	8.95	7217AIPI	8.95
7107EV/Kit	46.95	7224IPL	10.95
7207AIPD	5.95	7226AEV/Kit	99.95

74HC HI-SPEED CMOS

74HC00	.35	74HC175	.89
74HC02	.39	74HC221	1.95
74HC04	.39	74HC240	1.39
74HC08	.39	74HC244	1.49
74HC10	.39	74HC245	1.59
74HC14	.59	74HC253	.79
74HC30	.39	74HC259	1.19
74HC32	.45	74HC273	1.79
74HC74	.45	74HC373	1.49
74HC75	.69	74HC374	1.49
74HC76	.69	74HC393	1.19
74HC85	1.19	74HC595	1.95
74HC86	.59	74HC688	1.95
74HC123	1.19	74HC4040	1.19
74HC125	.99	74HC4049	.79
74HC132	.79	74HC4050	.79
74HC138	.79	74HC4060	1.19
74HC139	.79	74HC4511	1.95
74HC154	1.95	74HC4514	2.95
74HC163	.89	74HC4538	1.95
74HC174	.89	74HC4543	2.95

74C—CMOS

74C00	.29	74C174	.89
74C02	.29	74C175	.89
74C04	.25	74C221	1.19
74C08	.35	74C240	1.59
74C10	.29	74C244	1.59
74C14	.49	74C373	1.95
74C32	.35	74C374	1.95
74C74	.49	74C912	7.95
74C85	1.19	74C915	1.19
74C86	.29	74C920	9.95
74C89	3.95	74C921	9.95
74C90	.89	74C922	3.95
74C154	2.95	74C923	3.95
74C173	.89	74C925	4.95

LINEAR

DS0026CN	1.69	LM399H	3.95
TL074CN	.79	TL497ACN	2.19
TL084CN	1.09	NE540H (C540H)	2.95
LM307CN	.45	NE555V	.29
LM309K	1.25	XR-L555	.69
LM311CN	.45	LM556N	.59
LM317T	.99	NE558N	1.19
LM318CN	1.19	LM565N	.99
LM319N	1.19	LM567V	.89
LM320K-5	1.35	NE592N	.89
LM320T-5	.59	LM741CN	.29
LM323K	4.49	LM747N	.59
LM324N	.39	LM1458CN	.49
LM338K	3.95	LM1488N	.69
LM339N	.49	LM1489N	.69
LM340K-5	1.35	LM1496N	.99
LM340K-12	1.35	LM1871N	1.95
LM340K-15	1.35	LM1872N	2.49
LM340T-5	.49	LM1896N	1.59
LM340T-12	.49	ULN2003A	.99
LM340T-15	.49	XR2206	3.95
LF347N	.99	XR2207	2.49
LM348N	.69	XR2211	2.95
LF351N	.49	LM2907N	1.95
LF353N	.59	LM2917N (8 pin)	1.55
LF355N	.89	LM3900N	.59
LF356N	.89	LM3905CN	1.19
LM358N	.49	LM3909N	.89
LM360N	2.19	LM3914N	1.95
LM361N	1.59	LM3916N	1.95
LM380CN	1.09	NE5532	.99
LM386N-3	.89	NE5534	.89
LM387N	.99	75477	1.19
LM393N	.45	76477	3.95

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20MB HARD DISK SYSTEM ONLY $389.95!

STATIC RAMS

2101	256x4	(450ns)	1.95
5101	256x4	(450ns)(CMOS)	3.95
2102L-4	1024x1	(450ns)(LP)	.99
2112	256x4	(450ns)	2.99
2114	1024x4	(450ns)	.99
2114L-4	1024x4	(450ns)(LP)	1.09
2114L-2	1024x4	(200ns)(LP)	1.49
2114L-15	1024x4	(150ns)(LP)	1.95
TMS4044-4	4096x1	(450ns)	1.95
TMM2016-150	2048x8	(150ns)	1.49
TMM2016-100	2048x8	(100ns)	1.95
HM6116-4	2048x8	(200ns)(CMOS)	1.89
HM6116-3	2048x8	(150ns)(CMOS)	1.95
HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.95
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	2.05
HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
HM6264LP-15	8192x8	(150ns)(CMOS)(LP)	3.95
HM6264LP-12	8192x8	(120ns)(CMOS)(LP)	4.49

LP=Low power

DYNAMIC RAMS

4116-250	16384x1	(250ns)	.49
4116-200	16384x1	(200ns)	.89
4116-150	16384x1	(150ns)	.99
4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-200	65536x1	(200ns)(5v)	1.19
4164-150	65536x1	(150ns)(5v)	1.29
4164-120	65536x1	(120ns)(5v)	1.95
MCM6665	65536x1	(200ns)(5v)	1.95
TMS4164	65536x1	(150ns)(5v)	1.95
4164-REFRESH	65536x1	(150ns)(5V)(REFRESH)	2.95
TMS4416	16384x4	(150ns)(5v)	4.95
41128-150	131072x1	(150ns)(5v)	5.95
TMS4464-15	65536x4	(150ns)(5v)	6.95
41256-200	262144x1	(200ns)(5v)	2.95
41256-150	262144x1	(150ns)(5v)	2.95

5v=Single 5 Volt Supply   REFRESH=Pin 1 Refresh

★★★★HIGH-TECH★★★★

NEC V20 UPD70108 $11.95

REPLACES 8088 TO SPEED UP IBM PC 10-40%

- HIGH-SPEED ADDRESS CALCULATION IN HARDWARE
- PIN COMPATIBLE WITH 8088
- SUPERSET OF 8088 INSTRUCTION SET
- LOW POWER CMOS

8MHz	V20	UPD70108-8	$13.95
8MHz	V30	UPD70116-8	$19.95

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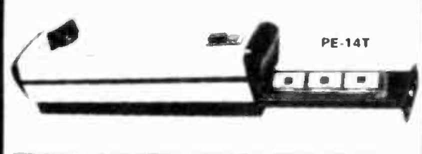
EPROMS

2708	1024x8	(450ns)	4.95
2716	2048x8	(450ns)(5V)	3.49
2716-1	2048x8	(350ns)(5V)	3.95
TMS2532	4096x8	(450ns)(5V)	5.95
2732	4096x8	(450ns)(5V)	3.95
2732A	4096x8	(250ns)(5V)(21V PGM)	3.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	4.25
27C64	8192x8	(250ns)(5V)(CMOS)	5.95
2764	8192x8	(450ns)(5V)	3.49
2764-250	8192x8	(250ns)(5V)	3.95
2764-200	8192x8	(200ns)(5V)	4.25
MCM68766	8192x8	(350ns)(5V)(24 PIN)	17.95
27128	16384x8	(250ns)(5V)	4.25
27C256	32768x8	(250ns)(5V)(CMOS)	10.95
27256	32768x8	(250ns)(5V)	7.49

5V=Single 5 Volt Supply   21V PGM=Program at 21 Volts

SPECTRONICS CORPORATION EPROM ERASERS



Model	Timer	Capacity Chip	Intensity (uW Cm²)	Unit Price
PE-14	NO	9	8,000	$83.00
PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

8000

8035	1.49
8039	1.95
8080	2.95
8085	2.49
8087-2	169.95
8087	129.00
8088	6.95
8088-2	9.95
8155	2.49
8155-2	3.95
8748	7.95
8755	14.95
80286	129.95
80287	199.95

8200

8203	24.95
8205	3.29
8212	1.49
8216	1.49
8224	2.25
8237	4.95
8237-5	5.49
8250	6.95
8251	1.69
8251A	1.89
8253	1.89
8253-5	1.95
8255	1.69
8255-5	1.89
8259	1.95
8259-5	2.29
8272	4.95
8279	2.49
8279-5	2.95
8282	3.95
8284	2.95
8286	3.95
8288	4.95

Z-80

Z80-CPU 2.5 MHz	1.69

4.0 MHz

Z80A-CPU	1.79
Z80A-CTC	1.89
Z80A-DART	5.95
Z80A-DMA	5.95
Z80A-PIO	1.89
Z80A-SIO/0	5.95
Z80A-SIO/1	5.95
Z80A-SIO/2	5.95

6.0 MHz

Z80B-CPU	3.75
Z80B-CTC	4.25
Z80B-PIO	4.25
Z80B-DART	14.95
Z80B-SIO/0	12.95
Z80B-SIO/2	12.95
Z8671 ZILOG	19.95

6500

1.0 MHz

6502	2.69
65C02 (CMOS)	12.95
6507	9.95
6520	1.95
6522	4.95
6526	26.95
6532	6.95
6545	6.95
6551	5.95
6561	19.95
6581	34.95

2.0 MHz

6502A	2.95
6520A	2.95
6522A	5.95
6532A	11.95
6545A	7.95
6551A	6.95

3.0 MHz

6502B	6.95

6800

1.0 MHz

6800	1.95
6802	4.95
6803	9.95
6809	5.95
6809E	5.95
6810	1.95
6820	2.95
6821	1.95
6840	6.95
6843	19.95
6844	12.95
6845	4.95
6847	11.95
6850	1.95
6883	22.95

2.0 MHz

68B00	4.95
68B02	5.95
68B09E	6.95
68B09	6.95
68B21	3.95
68B45	6.95
68B50	2.95
68B54	7.95

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MM5369-EST	1.95
MM58167	12.95
MM58174	11.95
MSM5832	2.95

CRT CONTROLLERS

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68B45	8.95
6847	11.95
HD46505SP	6.95
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8275	26.95
7220	19.95
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CRT5037	9.95
TMS9918A	19.95

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1791	9.95
1793	9.95
1795	12.95
1797	12.95
2791	19.95
2793	19.95
2797	29.95
6843	19.95
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BR1941	4.95
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MM5307	4.95

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AY3-1015	4.95
TR1602	3.95
2651	4.95
IM6402	6.95
IM6403	9.95
INS8250	6.95

SOUND CHIPS

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76489	8.95
SSI-263	39.95
AY3-8910	12.95
AY3-8912	12.95
SP1000	39.00

CRYSTALS

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1.0 MHz	2.95
1.8432	2.95
2.0	1.95
2.097152	1.95
2.4576	1.95
3.2768	1.95
3.579545	1.95
4.0	1.95
4.032	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
6.5536	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
15.0	1.95
16.0	1.95
17.430	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

CRYSTAL OSCILLATORS

1.0MHz	5.95
1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

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TMS99531	9.95
TMS99532	19.95
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11C90	19.95
2513-001 UP	6.95
AY5-2376	11.95
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74LS00

74LS00	.16	74LS165	.65
74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.99	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.39	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

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A new family of high speed CMOS logic featuring the speed of low power Schottky (9ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.49	74S196	2.49
74S30	.29	74S197	2.95
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
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74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	Adj	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0805	4.49	8T95	.39
ADC0816	14.95	8T96	.39
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0805	1.95	DP8304	2.29
DAC0803	2.35	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49

ST = SOLDERTAIL

8 PIN WW	.59	.63
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW = WIRE WRAP

16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF = TEXTOOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
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FEMALE

IDCEN36F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

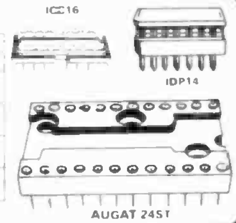
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	...	.95	.95	...	...	...	1.75	...	2.95

FOR ORDERING INSTRUCTIONS SEE D SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

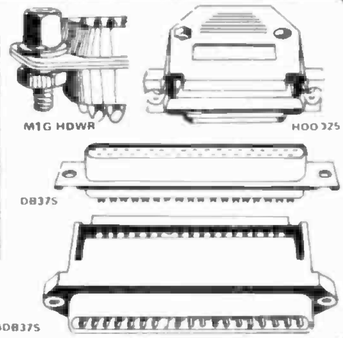
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	...	1.95	2.65	...
	FEMALE	DBxxSR	1.25	1.55	...	2.00	2.79	...
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	...	3.89	5.60	...
	FEMALE	DBxxSWW	2.76	4.27	...	6.84	9.95	...
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	...	3.98	5.70	...
	FEMALE	IDBxxS	2.92	3.20	...	4.33	6.76	...
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30		...
	GREY	HOODxx	.65	.65	...	.65	.75	.95

ORDERING INSTRUCTIONS INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W LOGIC	.290"	7.95

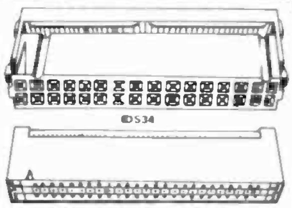
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	...	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	2.80	3.95

FOR ORDERING INSTRUCTIONS SEE D SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49

BCD OUTPUT 10 POSITION 6 PIN DIP 1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

Dear Mr. Rose:

I feel compelled to commend you and your people for the pleasant, polite, willingness to help and professional attitude you have displayed. In these times it is indeed refreshing to deal with a company whose staff consists of people of this caliber. My friends and associates will most certainly be doing business with you again.

Sincerely, Nicholas Chabra

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SPECIALS END 8/31/86

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PRECUT ASSORTMENT
IN ASSORTED COLORS $27.50
100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

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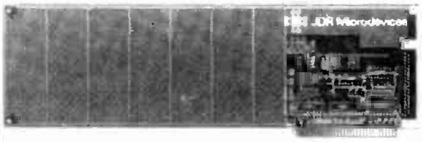
100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE WITH DECODING LAYOUT	$29.95

S-100

P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

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- MANUFACTURED BY CORCOM
- LOW COST
- FITS LC-HP BELOW
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6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	.39
LC-3	3 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/ STD FEMALE SOCKET	1.49

MUFFIN FANS

3.15" SQ	ROTRON	14.95
3.63" SQ	ETRI	4.95
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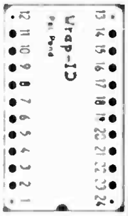
SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC, SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

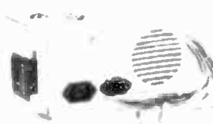
12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
12.6V AC CT	8 AMP	10.95
25.2V AC CT	2 AMP	7.95

25 PIN D-SUB GENDER CHANGERS $7.95

SWITCHING POWER SUPPLIES

PS-IBM $69.95

- FOR IBM PC-XT COMPATIBLE
- 135 WATTS
- +5V @ 15A, +12V @ 4.2A
- -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY



PS-IBM

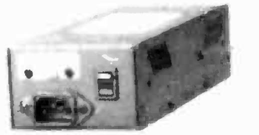
PS-IBM-150 $79.95

- FOR IBM PC-XT COMPATIBLE
- 150 WATTS
- +12V @ 5.2A, +5V @ 16A
- -12V @ .5A, -5V @ .5A
- ONE YEAR WARRANTY

PS-130

PS-130 $99.95

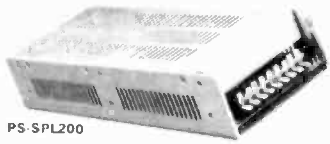
- 130 WATTS
- SWITCH ON REAR
- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY



PS-A

PS-A $49.95

- USE TO POWER APPLE TYPE SYSTEMS
- +5V @ 4A, +12V @ 2.5A
- -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR



PS-SPL200 $49.95

- +5V @ 25A, +12V @ 3.5A
- -5V @ 1A, -12V @ 1A
- UL APPROVED
- ALUMINUM ENCLOSURE

PS-SPL200

CAPACITORS

TANTALUM

1.0 µf	15V	.35	.47 µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10 pf	50V	.05	680	50V	.05
22	50V	.05	.001 µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01 µf	50V	.14	.1 µf	50V	.18
.047 µf	50V	.15	.47 µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1 µf	25V	.14	1 µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

DATARASE EPROM ERASER $34.95

- ERASES 2 IN 10 MINUTES
- COMPACT-NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

¼ WATT RESISTORS

5% CARBON FILM ALL STANDARD VALUES FROM 1 OHM TO 10 MEG. OHM

10 PCS same value	.05	100 PCS same value	.02
50 PCS same value	.025	1000 PCS same value	.015

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

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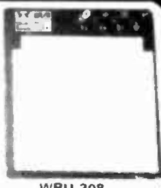
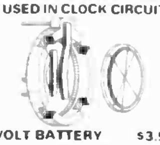
WBU-204-3	3.94 x 8.45"	1	100	2	1260	2	17.95
WBU-204	5.13 x 8.45"	4	400	2	1260	3	24.95
WBU-206	6.88 x 9.06"	5	500	3	1890	4	29.95
WBU-208	8.25 x 9.45"	7	700	4	2520	4	39.95



WBU-208

LITHIUM BATTERY

AS USED IN CLOCK CIRCUITS



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FOR APPLE COMPUTERS

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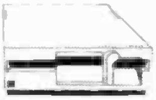

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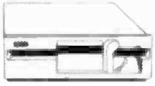
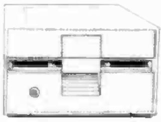
- 100% APPLE COMPATIBLE
- SIX MONTH WARRANTY

BAL-500 $129.95



- TEAC MECHANISM-DIRECT DRIVE
- 100% APPLE COMPATIBLE
- FULL ONE YEAR WARRANTY

AP-135 $129.95



- FULL HT SHUGART MECHANISM
- DIRECT REPLACEMENT FOR APPLE DISK II
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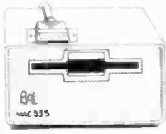
DOUBLE SIDED!

MAC535 $249.95



- 3.5" ADD-ON DISK DRIVE
- 100% MACINTOSH COMPATABLE
- DOUBLE SIDED 800K BYTE STORAGE
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- FULL ONE YEAR WARRANTY

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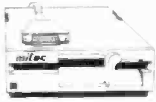

- 100% APPLE IIc COMPATIBLE, READY TO PLUG IN, W/ SHIELDED CABLE & MOLDED 19 PIN CONNECTOR
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
- SIX MONTH WARRANTY

DISK DRIVE ACCESSORIES

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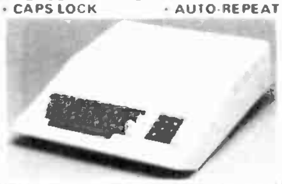
IIc ADAPTOR CABLE $19.95
ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE IIc

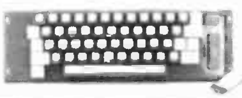
KB-1000 $79.95
CASE WITH KEYBOARD FOR APPLE TYPE MOTHERBOARD

- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD WITH CURSOR CONTROL
- CAPS LOCK • AUTO-REPEAT



KEYBOARD-AP $49.95

- REPLACEMENT FOR APPLE II KEYBOARD
- CAPS LOCK KEY, AUTO-REPEAT
- ONE KEY ENTRY OF BASIC OR CP/M COMMANDS



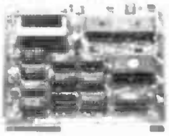
EXTENDER CARDS

IBM-PC	$45.00
IBM-AT	$68.00
APPLE II	$45.00
APPLE IIe	$45.00
MULTIBUS	$86.00

APPLE COMPATIBLE INTERFACE CARDS

EPROM PROGRAMMER $59.95

MODEL RP525



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- EASY TO USE MENU-DRIVEN SOFTWARE IS INCLUDED
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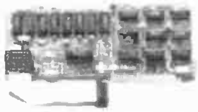
- HIGH SPEED WRITE ALGORITHM
- LED INDICATORS FOR ACTIVITY
- NO EXTERNAL POWER SUPPLY NEEDED
- ONE YEAR WARRANTY

16K RAMCARD $39.95



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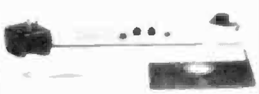
- EXPAND YOUR 48K APPLE TO 64K
- USE IN PLACE OF APPLE LANGUAGE CARD

BARE PC CARD W/INSTRUCTIONS $9.95

IC TEST CARD $99.95

- QUICKLY TESTS MANY COMMON ICs
- DISPLAYS PASS OR FAIL
- ONE YEAR WARRANTY
- TESTS: 4000 SERIES CMOS, 74HC SERIES CMOS, 7400, 74LS, 74L, 74H & 74S

300B MODEM $49.95
FOR APPLE OR IBM
INCLUDES ASCII PRO-EZ SOFTWARE



- FCC APPROVED
- BELL SYSTEMS 103 COMPATIBLE
- INCLUDES AC ADAPTOR
- AUTO-DIAL
- DIRECT CONNECT

CABLE FOR APPLE IIc $14.95

JOYSTICK CR-401 $7.95
FOR ATARI 400, 800, 2600, VIC 20/64 AND APPLE IIe

DISKFILE
HOLDS 70 5¼" DISKETTES

$8.95

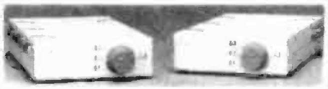
3.5" DISKFILE HOLDS 40 $9.95

POWER STRIP $12.95

- UL APPROVED
- 15A CIRCUIT BREAKER

BAL 3-WAY SWITCH BOXES

- SERIAL OR PARALLEL
- CONNECTS 3 PRINTERS TO ONE COMPUTER OR VICE VERSA
- ALL LINES SWITCHES
- HIGH QUALITY ROTARY SWITCH MOUNTED ON PCB
- GOLD CONTACTS
- STURDY METAL ENCLOSURE



SWITCH-3P CENTRONICS PARALLEL $99.95
SWITCH-3S RS232 SERIAL $99.95

BAL PRINTER BUFFERS

- FREES COMPUTER FOR OTHER TASKS WHILE PRINTING LONG DOCUMENTS
- STAND-ALONE DESIGN: WORKS WITH ANY COMPUTER OR PRINTER
- ALL MODELS FEATURE PRINT PAUSE, MEMORY CHECK, GRAPHICS CAPABILITY

SP120P PARALLEL $139.95

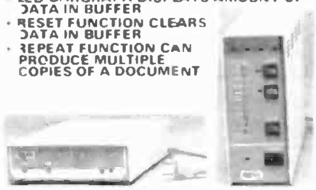
- 64K UPGRADABLE TO 256K
- LED INDICATOR SHOWS VOLUME OF DATA IN BUFFER

SP120S RS232 SERIAL $159.95

- 64K UPGRADABLE TO 256K
- 6 SELECTBALE BAUD RATES FROM 600B - 19,200B

SP110P PARALLEL $249.95

- 64K UPGRADABLE TO 512K
- SPOOLS OUTPUT OF UP TO 3 COMPUTERS
- LED BARGRAPH DISPLAYS AMOUNT OF DATA IN BUFFER
- RESET FUNCTION CLEARS DATA IN BUFFER
- REPEAT FUNCTION CAN PRODUCE MULTIPLE COPIES OF A DOCUMENT



SP120 SP110

NASHUA DISKETTES DEALS
5¼" SOFT SECTOR
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N-MD2D	DS/DD SOFT	$9.90
N-MD2F	DS QUAD SOFT	$34.95
N-MD2H	DS HD FOR AT	$49.95

NASHUA 8"

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NASHUA 3.5"

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TEAC FD-55GFV	½ HT DS/HD (FOR IBM AT)	$154.95
TANDON TM100-2	DS/DD (FOR IBM)	$119.00
TANDON TM50-2	½ HT DS/DD (FOR IBM)	$79.95
MPI-B52	DS/DD (FOR IBM)	$79.95
QUME QT-142	½ HT DS/DD (FOR IBM)	$79.95

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FD 100-8	SS/DD (SA/801 EQUIV)	$119.00
FD 200-8	DS/DD (SA/851R EQUIV)	$159.00

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MOUNTING RAILS FOR IBM AT	$4.95
"Y" POWER CABLE FOR 5¼" FDDs	$2.95
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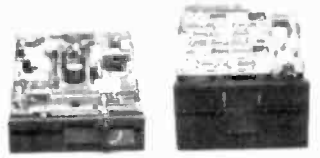

TEAC FD-55 TANDON TM100-2

DISK DRIVE ENCLOSURES

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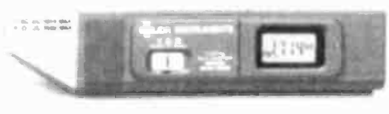

20MHz DUAL TRACE OSCILLOSCOPE	MODEL 2000	$389.00
35MHz DUAL TRACE OSCILLOSCOPE	MODEL 3500	$549.00

FOR MORE INFORMATION ON THE OSCILLOSCOPES, CALL US FOR FREE PRODUCT BRIEFS.

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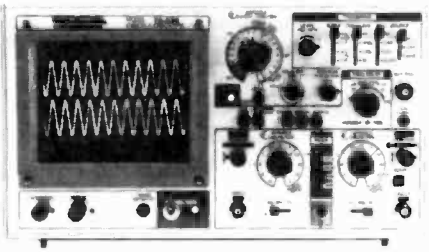
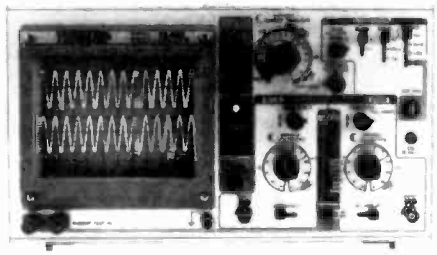


TENMA 35MHz Dual Trace Oscilloscope
- Two high quality 10:1 probes included
- For additional specification see MCM Catalog #12

#72-330

$569.95 (ea.)

2 YEAR LIMITED WARRANTY



TENMA 20MHz Dual Trace Oscilloscope
- Two high quality 10:1 probes included
- For additional specification see MCM Catalog #12

#72-320

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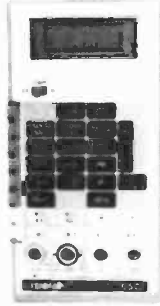

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TENMA 3½ Digit LCD Multimeter
- Measures resistance, AC-DC voltage and current
- Diode and hFe transistor tests
- Overload protection
- 10Mohm input impedance
- Carrying case included

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$39.80 (ea.)

TENMA 30A Power Supply
- Output voltage: 1-15VDC
- Lighted cross needle meter. Displays voltage, current and power simultaneously
- Output current: 30A, 22A continuous
- Fan cooled

#72-035

$199.00 (ea.)

NEW

TENMA 0-18V 3A Power Supply
- Regulated outputs — constant volt or constant current, both are continuously variable
- Can be connected in series or parallel for more voltage or current output
- Reverse polarity and overload protected
- Isolated output

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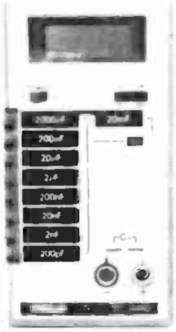

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TENMA Digital Capacitance Meter
- Measurement range from 0.1pF to 19,999µF
- Sampling time: .5 seconds
- Accuracy: ± 1% full scale
- Checks capacitors in or out of circuit
- Carrying case included

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$59.80 (ea.) **$54.95** (2-up)

TENMA Combination Function Generator and Frequency Counter
- 6 digit display
- Output range: 2Hz-2MHz: seven ranges
- Counter range: .1Hz-10MHz
- 5-15V TTL and CMOS output
- Wave forms: sine, triangle, square, pulse, and ramp.

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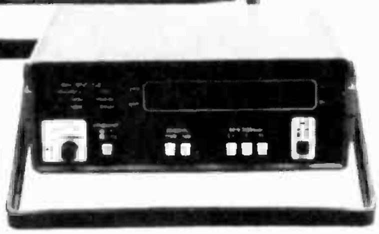

TENMA Frequency Counter
- 8 digit LED display
- Measurement range: 1Hz-120MHz
- High input sensitivity of 20mV RMS

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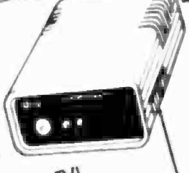

Featured In August Radio Electronics

Remote Control at your Fingertips!

Don't get out of bed to turn off the TV!
Don't stumble in the dark looking for the lamp.
Build these Infra-Red Transmitter/Receiver kits instead!

This project pays you back in convenience! The transmitter fits in a matchbox sized case with clip for belt or pocket (why not get several for the family!). It sends out a short burst of high energy infra red light coded to the matching receiver (which is connected to the power switch). The receiver rejects interference from other light sources (like fluorescents, sunlight, other I.R. transmitters etc.) and turns a relay on or off when the signal is detected. The DP relay contacts connect the incoming mains line to a 3 pin outlet socket. The contact system is capable of switching a 10 amp load, so it is suitable for most small appliances or even some heaters & air conditioners can be controlled. This system is also valuable in out-of-the-way areas, ceilings, danger areas, through windows etc. With clear line of sight between TX and RX, control distances up to 40' are possible (Electrical noise, strong light or RF signals may affect the sensitive high gain front end of the receiver, but even under adverse conditions, the system will operate in an average size room!)

Receiver WITH CASE — includes screen front, rear panel, all parts and hardware — **$32** Cat K-3428

Transmitter WITH CASE — includes parts — **$7.95** Cat K-3429

Battery for Transmitter (not incl) S-3335 $1.19

NEW!

The wait is over! Our newest transceiver kit is now in stock!

HF Transceiver Kit $229 Cat K-6330

Electronics Australia said: "For the keen amateur it represents an ideal opportunity to build a really worthwhile piece of gear. Despite the relative circuit complexity, construction is straight forward & alignment a breeze." (Oct '85) Now released in the U.S.A., this state-of-the-art design is supplied in the 80 meter version, but it can (with modification) cover any single 500 kHz segment within 2-30 mHz (call or write for release dates of band upgrade kits shown below). This kit is easy to build and includes all hardware, leads, mounting bracket, mic & our 14 day satisfaction guarantee!

SPECIFICATIONS

Frequency Range: any 500 kHz range within 2-30 mHz · Transmission Modes: LSB, USB, CW · Supply Voltage: 13.8V DC · Current Drain: 4.5A on transmit · Frequency Resolution: 100Hz · Stability: 100Hz/hour (after warm up) · Crystal Filter: 6 pole (10.6935) MHz

TRANSMITTER: Power Output: 30W PEP (SSB) 15W (CW) · Occupied Bandwidth: 3kHz (-25dB) · Harmonic Suppression: Better than 40dB

RECEIVER: Sensitivity: Better than 0.5 uV (10dB S+N/N) · Selectivity: 6dB at 4kHz, 60dB at 7 kHz · Image Rejection: Better than 50dB · Distortion Range: 1kHz audio output · Power: 2W into 8 ohms · Noise Blanker: 11 impulse type

Available Soon! Transceiver Band Upgrade Packs

Cat K-6331	40m/7.0-7.5 mHz	$14.95 EACH
Cat K-6332	20m/14.0-14.5 mHz	
Cat K-6333	15m/21.0-21.5 mHz	
Cat K-6334	10m/28.0-28.5 mHz	

Radio Direction Finder Kit $99 Cat K-6345

Featured in 73 for Radio Amateurs

- 12V ● 50-500 MHz range
- 170° calibration ● Internal alignment reference
- Adjustable internal monitor speaker
- Stable digital circuitry ● Self-aligning commutating filters

Featured in June, July, & Aug Radio Electronics

Build Your Own 200W Mosfet Stereo Amp!

An Electronics Australia Lab Design

We think this is the best build-it-yourself design available! Feature for feature, dollar for dollar, the Playmaster blows the "big names" (with the big prices) away. Electronics input circuitry handles moving magnet, moving coil, CD, hi-fi, VCR, cassette, tuner, & more. Soft-touch control, de-thump, and toroidal transformers are only a few of its many features, and the step-by-step instruction manual makes it easy to build! (Sorry, Dick, it doesn't work, repair coupon included, but if, after examination, you feel the kit is beyond your skill level, simply return it intact for a full refund!)

$299 Cat K-3516

- 100W RMS/channel into 8 ohms ● Hum -100dB below full output
- Freq Response: 8 Hz - 20KHz (3-dB), 2.8Hz - 65KHz (-1dB)
- Unconditional stability into any load ● Distortion < 0.01% (typ) 0.003% 20 Hz-20KHz ● Sensitivity: MM 2mV (80dB s/n) MC 200uV (75dB) Line 300mV (90dB) CD 2V (94dB)

Variable Power Supply Kit

This outstanding kit provides voltages from 1.3 to 30 volts, full protection, variable current limiting from 0 to 1 amp (with LED to indicate current limit mode). Plus metering of both voltage and current output.

You receive a complete kit of parts including US 117V AC transformer (designed for USA) plus metal case and all hardware right down to the last nut & bolt. A specially prepared silk screened front panel is included for ease of operation plus it gives your project that professional finish.
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Dick Smith Electronics price only $39.95 for a power supply kit worth much more

$39.95 Cat K-3475

Featured in MARCH RE

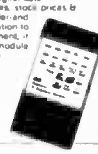
There's a Newspaper in your TV!

Teletext Decoder Kit

$199 Cat K-6315

Teletext is information & graphics transmitted as digital data between video frames. Get the latest weather, scores, stock prices & more at the touch of a button! All you need is a decoder and ours is a superb performer priced to put the competition to shame! Easy to build & requiring very little adjustment, it features: ● Pre-adjusted/pre-assembled decoder module ● TV Teletext & TV/Teletext modes ● Newsflash ● No user fees ● 21 button wired remote

Infra-Red Remote Control Kit



Go wireless! This sleek remote is designed just for K-6315. Requires only a handful of parts-easy to build! At this price it's not an option, it's a necessity!

$34.95 Cat K-3425

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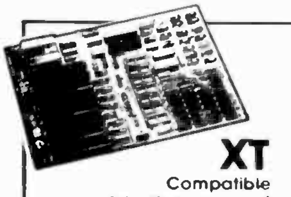
LASER 128 Apple Compatible **$399** Cat X-6000

Build this IBM PC/XT® compatible and SAVE!!



XT Compatible Motherboard

- 16-bit microprocessor 8088 CPU @ 4.77 MHz
- Optional 8087 socket for co-processor
- Expandable to 640 K
- 8 channel interrupt 8259
- 8 expansion slots
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- Only 54 watt power consumption

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BIOS for motherboard **$39.95** Cat X-1000

IBM PC/AT Compatible Motherboard — Call or write for specs! **$899** Cat X-1003

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- Fully compatible with IBM monochrome display/printer and Hercules graphics card

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- Controls 2 hard disk drives via ST-506/ST-412 disk interface.
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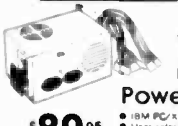

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12" Monochrome Monitors

IBM compatible

- Separated signals
- 9-pin D-type input
- 1100 lines resolution at center
- 25 MHz (-3dB) Video amp. response

Cat X-1132

Apple Compatible

- Composite Video
- RCA Jack Input
- 1000 lines resolution at center screen
- 20MHz (-3dB) Video amp response

Cat X-1130

$99.95 EACH

IBM PC/XT Compatible Case

- Attractive off-white heavy duty steel case with lid
- All hardware supplied for 8 card slot expansion & for mounting power supply
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cable tv

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A second generation, low cost, high performance, mini sized, single board for making your own RS232 Video Terminal. Use as a computer console or with a MODEM for hook up to any of the telephone-line computer services.

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* Character Attributes: De-Inten, Inverse or Underline.
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* Composite or split video.
* 5 X 8 Dot Matrix characters (U/L case).
* Answer back capability.
* Battery backed up status memory.
* For ASCII parallel keyboard.

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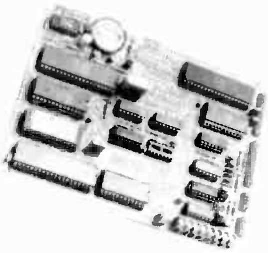

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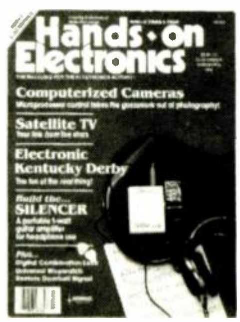

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