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★ Ask R-E
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<th>Features</th>
<th>2246</th>
<th>2245</th>
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<tr>
<td>Bandwidth</td>
<td>100 MHz</td>
<td>100 MHz</td>
</tr>
<tr>
<td>No. of Channels</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Scale Factor Readout</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SmartCursors™</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Volts Cursors</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Time Cursors</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Voltmeter</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Vertical Sensitivity</td>
<td>2 mV/div</td>
<td>2 mV/div</td>
</tr>
<tr>
<td>Max. Sweep Speed</td>
<td>2 ns/div</td>
<td>2 ns/div</td>
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<tr>
<td>Vert Hor Accuracy</td>
<td>2%</td>
<td>2%</td>
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<tr>
<td>Trigger Modes</td>
<td>Auto Level, Auto. Norm., TV Field, TV Line, Single Sweep</td>
<td>No</td>
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<tr>
<td>Trigger Level Readout</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Weight</td>
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<td>6.1 kg</td>
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<tr>
<td>Warranty</td>
<td>3-year on parts and labor including CRT</td>
<td>3-year on parts and labor including CRT</td>
</tr>
<tr>
<td>Price</td>
<td>$2400</td>
<td>$1875</td>
</tr>
</tbody>
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sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.

Accuracy is excellent: 2% at vertical, 2% at horizontal. And four-channel capability includes two channels optimized for logic signals.

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Features four channels, flexible triggering, extensive CRT readouts and push-button ease of use, the new Tek 2246 (left) and 2245 (above) bring high-quality, low-cost analysis to diverse applications in digital design, field service and manufacturing.
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RADIO-ELECTRONICS, (ISSN 0033-7862) February 1987, Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735 Second-Class Postage paid at Farmingdale, NY and additional mailing offices: Second-Class mail registration No. 9242 authorized at Toronto, Canada. One-year subscription rate U.S.A. and possessions $16.97, Canada $22.97, all other countries $25.97. Subscription orders payable in US funds only, international postal money order or check drawn on a U.S.A. bank. Single copies $1.95. © 1987 by Gernsback Publications, Inc. All rights reserved. Printed in U.S.A.

POSTMASTER: Please send address changes to RADIO-ELECTRONICS, Subscription Dept., Box 55115, Boulder, CO 80321-5115

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FEBRUARY 1987
If you are an experimenter, then there's nothing more fun than attacking a challenging problem. One of the bigger challenges to the electronics experimenter today is cracking the various TV-signal scrambling schemes. The device shown on the cover is one experimenter's results: a cable-TV Tri-mode descrambler. It was built not to steal cable-TV signals without authorization, but rather in response to the challenge that was offered (because the scrambled signal was there). If you feel the challenge, too, then here's a great circuit which with no experiment. Have fun, and turn to page 43!

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VHS-C Vs. 8mm—what do you buy?

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**SEMICONDUCTOR TESTING**
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**CABLE TESTERS**
A look at the technology to find cable faults.

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“Car of the future” obeys voice commands

A feature of the recent Paris Auto Show was a special Renault that “obeyed its driver’s every command.” The demonstration car was a state-of-the-art Renault Model 21 that incorporated the latest in computer-assisted driving aids. The high light was a Votan voice-recognition system that gave the driver voice control over such accessories as windshield wipers, windows, radio, heating, and air conditioning. The car also featured a navigation system that used a high-resolution graphics monitor with a “touch screen”.

According to Renault’s safety design engineers, the Votan system allows drivers to keep their hands on the wheel and their eyes on the road while controlling the many accessories of contemporary cars. No more groping for the windshield wiper controls in a cloudburst—simply say “Windshield wipers on high!”

The Votan system uses speaker-dependent voice-recognition technology, which requires that “voice-prints” of the driver be taken. A new driver simply hits a switch to begin a quick voice-training session. He then repeats each of two dozen commands into the car’s built-in microphone in response to instructions from the graphics monitor. The Votan system stores those individual voice patterns and recognizes that driver’s commands from then on.

New Optical disk holds 600 megabytes

A new 5.25-inch optical disk, named WORM, and capable of storing 13,000 letter-size pages on its two sides, has been introduced by Maxwell Corp of America (600 Oxford Drive, Moonachie, NJ 07074). WORM is an acronym for Write Once, Read Many times.

The new disk will find applications in record management, archival storage, office automation, data processing, and high-resolution imaging applications. Each disk has 18,624 tracks, with 16 sectors-per-track. Recording density is 24,000 bits-per-inch, and track density is 16,000 turns-per-inch. Rotation speed is 1,800 rpm.
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  - AC voltage: 200mV - 750V, 5 ranges
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  - AC/DC current: 200μA - 10A, 6 ranges
  - Capacitance: 200pF - 20μF, 3 ranges
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  - Lab quality compensated 10X probes included
  - Delayed and single sweep modes
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**VIDEO NEWS**

- **4mm VCR.** As the dispute continues to rage between the proponents of the 8mm and the VHS VCR formats, there’s a new dark-horse entry in the field: 4mm. Well, perhaps it is not so dark at that. The new video system doesn’t require the development of a special tape or cassette because it uses the tape cassette already developed for DAT (Digital Audio Tape) systems. The DAT system uses metal-particle tape similar to that used in 8mm video recorders.

  The 4mm VCR is in a tiny camcorder developed by Samsung of Korea and displayed for the first time at the Korea Electronics Show. It weighs about 2.5 pounds, without battery, and is about 14% lighter and one-third smaller than the smallest previous record-and-play camcorder. But even with its tiny proportions, the 4mm camcorder offers something the others don’t have: a built-in 2.5-inch LCD TV set that serves as a viewfinder. That TV set’s tuner makes it possible for the camcorder to record off the air. The unit also features autofocus and automatic white balance, and it is expected to go on sale this year in Korea; it is also scheduled for eventual export. The DAT cassette measures about 2 x 1.3 x 0.3 inches and will record up to 80 minutes using the Samsung camcorder.

- **VCR circuits go digital.** The new wave of videorecorders have been dubbed “digital VCR’s,” but that’s really a misleading description since the recording technique itself is still analog. But the new recorders do use digital circuitry for clean still pictures and fast motion. The first of the new units is already on the market in this country, and a wide variety of upcoming versions were shown at the past Japan Electronics Show.

  In this column we have already reported on some of the new picture-in-picture VCR’s, but soon Japan will send VCR’s our way that are capable of filling the screen with nine pictures to provide a slow-scan sample of what’s showing on nine different TV channels, or to display a sequence of pictures, frame by frame, with each picture changing every two seconds. A new special effect in some of the digital VCR’s is “strobe,” which shows a rapid series of still pictures, thereby providing a stroboscopic effect. Also at the show, Matsushita, Japan’s biggest producer of VCR’s, introduced several models that use a bar-code reader for programming. When the wireless infrared reader, which resembles a large pen, is drawn across a bar code in a TV listing or an advertisement for a TV program, the VCR is automatically programmed to record the show. The bar codes resemble those used on grocery packages, etc. Matsushita will publish its own program guides containing the bar codes, and will try to convince independent publishers to do the same.

  Among the new VCR’s shown at the Japan Electronics Show was a tiny 8mm camcorder from Aiwa. The camera/recording portion of the unit weighs about 2.36 pounds. The detachable playback section adds less than 8 ounces when it’s clipped on. An accessory is a wired remote control that contains a two-inch Watchman-type flat video monitor.

- **More new camcorders.** Not too long ago, Sony’s tiny Handycam camcorder could record but couldn’t play back, while JVC’s VHS-C could do both. Thanks to competition, now you can buy a Sony Handycam that can both record and play back or a JVC VHS-C camcorder that can only record. Sony’s new Auto Handycam weighs about 3.75 pounds, with battery and cassette, and has a CCD pickup, an electronic viewfinder, autofocus, and a 2.5:1 zoom lens. JVC’s record-only VHS-C unit weighs just a little over 2 pounds, with battery and cassette, and has an optical viewfinder and two focus settings. For playback, the VHS-C cassette is placed in an adaptor and then into any standard VHS video recorder.

- **Stereo TV grows.** In the first nine months of 1986, the EIA reported that a total of 2,100,000 color-TV sets with built-in stereo capability were sold. That’s 16.6% of the total number of color-TV set sales during the period and compares with 1,500,000 sets sold during all of 1985. The EIA forecasts that some 5,000,000 sets will be sold in 1987. According to one survey, as of last October, 337 stations in the United States, and 16 stations in Canada, were equipped to broadcast stereo sound. Those stations reached about 90% of TV-equipped homes in the United States.

R-E
Here’s your chance to win a complete monitoring package from Regency Electronics and Lunar Antennas. 18 scanners in all will be awarded, including a grand prize of the set-up you see above: the Regency HX1500 handheld, the Z60 base station scanner, the R806 mobile unit, and a Lunar GDX-4 Broadband monitoring/reference antenna.

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When you’re on the go, and you need to stay tuned into the action, take along the Regency HX1500. It’s got 55 channels, 4 independent scan banks, a top mounted auxiliary scan control, liquid crystal display, rugged die-cast aluminum chassis, covers ten public service bands including aircraft, and, it’s keyboard programmable.

Compact Mobile

With today’s smaller cars and limited installation space in mind, Regency has developed a new compact mobile scanner, the R806. It’s the world’s first microprocessor controlled crystal scanner. In addition, the R806 features 8 channels, programmable priority, dual scan speed, and bright LED channel indicators.

Base Station Plus!

Besides covering all the standard public service bands, the Regency Z60 scanner receives FM broadcast, aircraft transmissions, and has a built-in digital quartz clock with an alarm. Other Z60 features include 60 channels, keyboard programming, priority control, digital display and permanent memory.

Lunar Antenna

Also included in the grand prize is a broadband monitoring/reference antenna from Lunar Electronics. The GDX-4 covers 25 to 1300 MHz, and includes a 6 foot tower.

Grand Prize (1 awarded)
1—Regency Z60 Base station scanner
1—Regency HX1500 Handheld scanner
1—Regency R806 Mobile scanner
1—Lunar GDX-4 Antenna

First Prize (5 awarded)
1—Regency Z60 Base station scanner
1—Regency R806 Mobile scanner

Second Prize (5 awarded)
1—Regency HX1500 scanner

Contest rules: Just answer the questions on the coupon, (all answers are in the ad copy) fill in your name and address and send the coupon to Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226. Winners will be selected from all correct entries. One entry per person. No purchase necessary. Void where prohibited by law. Contest ends June 30, 1987.

1. The Regency Z60 is □ a digital alarm clock □ an FM radio
□ a scanner □ all of the above
2. The Regency R806 is the world’s first controlled crystal scanner.
3. The Regency HX1500 features □ 55 channels □ Bank scanning
□ Liquid crystal display □ all of the above
4. The Lunar GDX-4 antenna covers ___ to ___ MHz.

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There's no stopping the incredible boom in consumer electronics. Soaring sales, new and improved video products, entirely new technologies have opened up new opportunities for the trained technician as never before. 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!

And the revolution has spread to the business sector as tens of thousands of companies are purchasing expensive high-tech video equipment used for employee training, data storage, even video conferencing.

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(If someone has already used the card, write to us at the address below.)
HELP WANTED

I am restoring an old Fisher Model 400 AM-FM receiver. I have a problem in the right channel. When the set is first turned on, the volume is normal, but then it drops to a very low level. I am a beginning student in electronics and I've mostly studied solid-state electronics. I've checked the four 7868 output tubes, and I don't know where else to look. I don't have a schematic so I'd appreciate any help you can supply.—J. T., Thonotossa, FL.

To begin with, I assume that both speakers are OK. If you're not sure, try swapping them. If the troubled channel works now, and the other doesn't, you've located the problem.

Otherwise, you may want to obtain some service information. A schematic and a wealth of service data on the Model 400-C is available in Sams Photofact Set 432, folder 7. If your set is the 400-T, the service data is in the MHF (Modular Hi-Fi) Volume 24. Call Sams at 1-800-428-SAMS for the names of distributors in your area. The service data was published in 1959, so it may not be in stock. However, it can be ordered. Folder sets are $9.95, and the MHF manuals are $11.95.

In the meantime, some "eyeball" and "seat-of-the-pants" servicing is in order. First, try listening to the AM radio. If both channels deliver the same volume level, the audio amplifier is probably OK. Next, try a stereo record. If one channel drops, there may be a defect in the phono cartridge, the phono input cable, or the phono preamp tube. While the bad channel is still out, switch to a stereo FM broadcast. If the channel is still out, the phono system is probably OK, as is the FM circuit. The problem is probably in the main section of the audio system.

You'll probably find one stage of amplification ahead of the tone controls and one or two stages of amplification between the tone controls and the phase inverter driving the push-pull output tubes.

In most hi-fi receivers and amplifiers of the 1950's and 1960's, non-output stages used twin triodes like the 12AX7/ECC83, the 12AU7/ECC82, the 12AT7/ECC81, and the 7247. In those twin 12-volt triodes, each section has a 6-volt heater. The heaters are brought out to three pins so they can be connected in series for 12-volt heater supplies or in parallel for 6-volt operation. Figure 1-a shows the pin terminals for those tubes; Fig. 1-b shows the series heater connection; and Fig. 1-c shows the parallel heater connection.

I've run across quite a few of those tubes with intermittent heaters; the circuit opened as soon as the tube got hot. If the set has a 12-volt heater circuit, an intermittent open in one section is likely to cause both sections of the heater to go out, so the tube will be completely dark. With a 6-volt heater supply, the heaters are in parallel and only the defective section should go out. So, eye-ball the tubes carefully and see whether one heater is dim or completely out. If you spot a tube whose heater appears to be intermittent, wiggle the tube in its socket. The intermittent may be due to a bad contact between a tube pin and the socket, or possibly a break or a cold-solder joint at the socket terminal pin.

If the heaters and heater circuits appear to be OK, now's the time for one more trick. Swap all tubes between the two channels. If the drop-out moves to the other channel, the problem is one of the tubes. It could be gassy, or it could have some other problem that you can't catch without a good tube tester. Regardless, you can isolate the defective tube by swapping tubes one by one.

Now suppose that you've eliminated the possibility of a defective
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ELECTRONIC MOTOR CONTROLS

I have a fan with a 117-volt, 60-Hz
motor that is rated at 2 amps. I want
to reverse the fan but I don't know
how. How can I add a reversing
switch? — C. S., Ft. Worth, TX.

I have a drill press powered by a
1/4-horsepower motor. I'd like to con-
trol motor speed by varying the fre-
quency of the supply voltage. Please
publish a circuit that shows how to
do that. — J. C., Yuma, TN.

The method of reversing a
motor depends on its type and,
often, on having certain internal
connections readily available. An
experienced motor rebuilder and
armature rewinder can talk at a
glance whether or not a particular
motor is easily reversed. If rever-
sing is simple and easy to accom-
plish, he'll probably do it for a
nominal fee. Look in the Yellow
Pages under "Electric Motors,
Dealers, and Repair Service."

It doesn't seem practical to use
the variable-frequency method of
varying the speed of a drill-press
motor. It probably draws about 600
watts, allowing for circuit losses
and inefficiency, and will draw
considerably more when starting.
For a variable-frequency power
source, you'd need an adjustable-
frequency oscillator covering from
about 45 to 65 hertz and a low-
frequency amplifier capable of de-
delivering at least 700 watts. The cir-
uitry is relatively simple, but
some components are either very
expensive or not readily available.
A better method of speed control
would be to use a variable-speed
gear box or a belt and pulleys.

STEREO SPREAD CIRCUIT

A year or so ago, I bought a stereo
chassis from a company handling
manufacturers' close-outs. I've added
8-track and cassette players, a
loudness switch, and a good antena,
but I was never completely satis-
fied with the unit's performance. I
wasn't sure just what I wanted until
I listened to a friend's set-up that
includes a "stereo-wide" circuit. Do
you know of a circuit that will pro-
duce that effect? — A. S.

I believe you're looking for something to enhance the appar-
ent stereo effect so that the sound
source appears to be wider. You
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CIRCLE 101 ON FREE INFORMATION CARD
OLD VACUUM-TUBE DAYS
Your "Antique Radios" department in the November 1986 issue triggered memories of the vacuum-tube business of the 1950's and 1960's. My company manufactured tube testers at the time, and our greatest success was with "user-friendly" tube testers that could be placed in any drug or hardware store for individuals to test their tubes for free. Naturally, new tubes could be purchased on-the-spot.

The new fall television shows (including football) typically brought streams of males with brown bags or pockets full of tubes—often the TV set's entire complement. On many weekends, sleet-covered feet would leave a grand puddle in front of a free tester. And many 12- to 18-dollar service calls were lost forever.

So I was surprised to spot one of those hated "free-testers" in a local TV-repair shop, placed for all comers to use. Old Mel, the proprietor, was a tight old geezer who had been moaning like a wounded cow since the free-testers started showing up nearly everywhere. Still more surprising was the "20% Discount" notice boldly posted in Mel's window, totally contradicting what I knew to be his skinflint nature.

Only after buying Mel lunch (he loved a free lunch) did he reveal the reasons for such an about-face in the free-testing department. I was already aware that Mel received a much better discount than other retailers, due to a tradition that began when tube manufacturers were backing their distributors in a war for the repairman's business. Yes, that explained the 20% discount.

But the real secret was that Mel had watched a free-tester in action

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and discovered that the average buyer would often replace any tube that did not nearly peg the meter. Even the best brand of new tubes, depending upon type, might put the needle in the low end of the green-colored "Good" field. Those not-so-smart weekend TV experts would not only replace perfectly good tubes but also would usually leave the "weak" tubes on the counter.

"Hell," Mel told me, "I've sold some of those tubes three times just this week."

ROBERT C. REYNOLDS
Rockford, IL

RELEVANT ERROR
Upon reading part two of the article, "Inside the Telephone," in the November 1986 issue, I noticed a relevant error.

Near the top of page 53 we read: "A USOC RJ-11 designation tells you the type of standard jack that the device accepts. A USOC RJ-11 designation tells you that the device requires a single line (four-conductor) jack; a RJ-14 designation tells you that the device requires a two-line (eight-conductor) jack." The latter part of that statement is incorrect.

RJ-11 (four-conductor) jacks, for single-line installations, use only the red and green wires (the first pair tip/ring, in telephone terminology). The same four-conductor jack also can provide two-line service (RJ-14 type jack) by using the black and yellow wires. Additionally, since that "four-conductor" jack can actually accommodate six wires, commonly the white/blue wires are included. That set of wires can accommodate a third line, and the USOC code for that configuration is RJ-25.

The eight-conductor jack mentioned in the article is used primarily for three purposes. First, it is used in connecting special modems and/or data equipment. Second, it will be used as the standard Integrated Services Digital Network (ISDN) connector. And third, it is used for series-connected apparatus (e.g., burglar-alarm dialers, and some others types of automatic dialers that need to disconnect other apparatus). In the latter case, the USOC would be RJ-31X for an alarm dialer that dis-connects all phones on the line, and the USOC would be RJ-35X for an accessory dialer hooked to a multi-line phone.

On a different note, I must say that I thoroughly enjoy your magazine and look forward to its monthly arrival! Also, I am elated that you didn't change the primary focus of your magazine toward computers, especially since I already receive a specific publication for computers.

All in all, I do recognize the vast amount of meticulous work that is necessary to prepare the articles and the magazine for publication, and even being an outstanding magazine, an error is published occasionally.

DAVE WOZNIAK
Farmington Hills, MI

SURFACE-MOUNTED COMPONENTS
I have been in the TV and stereo repair business for many years, and I would like to caution all con-
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MAIL TODAY!
sumers about a grave problem on the horizon. It relates to home-entertainment products. A new trend is emerging, and it is a nightmare: so-called surface-mounted components.

They will cost you more money for repair because of the difficulty in repairing equipment. The situation now is like that when printed-circuit boards were first introduced. At that time customers paid for repairs related to a new breed of problems that rarely existed in hand-wired chassis. Of course, printed-circuit boards are much cheaper to manufacture, and you do save money on the purchase price. However, I don’t think that you will save money on any TV set that uses surface-mounted components.

With ordinary components mounted on a printed-circuit board, the component will yield some, due to circuit-board flexing caused by temperature changes, etc. However, with leadless sur-

face-mounted components, there is no room for slack. It is very difficult to see a broken connection. Those components are much smaller, too.

With that new nightmare coming, I am seriously thinking of getting out of the business. I have a customer now who has paid dearly for that type of repair on a GE TV set. My advice is to buy products, especially TV sets, that do not use surface-mounted components.

JAKE J. AUGUSTINE
Reading, PA

DUAL AUTO BATTERY
Here’s another solution, and perhaps an easier one, for G. McC. of Palmetto, SC. (See “Dual Auto Battery” in the “Ask R-E” department, November 1986.)

The average auto or 4 x 4 comes equipped with a 60-amp alternator. Replace it with a 110-amp alternator, and replace your regular voltage regulator with a heavy-duty one to match the alternator. If you can’t handle the installation yourself, have an automotive electrician do it for you. Then install the largest car battery you can get your hands on. Your worries are over for at least the next 300,000 miles.

Around here, taxis are set up that way, because they do more idling and slow cruising than anything else. An ordinary alternator and battery constantly lets them down. You might find the setup expensive at first bite, but rarely will a heavy-duty setup, such as I’ve just described, give up sooner than 300,000 miles. The longest-running one to my knowledge was 320,000 miles on a Malibu. The car played out and the alternator and battery were transferred to a big Dodge, and went on for another 150,000 miles trouble-free. And that rig also powered a communications system, cassette deck, meter, halogen lights, and an ordinary boosted CB set.

B. HARLEY
B. C., Canada

WIRE IS CONTRABAND
I have read the “Antique Radio” department of Radio-Electronics for several years and just want to say that it is excellent and much appreciated.
I’m a State prisoner in maximum security—even wire is contraband! For years, since I was a child, I have been interested in radio and electronics, especially shortwave. Mr. Fitch’s article in the May 1986 issue was very good.

At present, I’m researching communications law and case law for my civil-rights suit against the state’s prison system, the Governor, and the Attorney General for the department’s policy about multiband receivers. They are banned, and for four years I have tried to get those restrictions lessened; and after writing to no avail, have sued in 1983 civil rights suit #86-0055-L in Lynchburg.

I was wondering if Mr. Fitch (or anyone else) would be so kind as to provide me with an outline of the shortwave spectrum of 1920-1950—experimentation at the beginning, users, as well as the devices that sprang up for reception. In order to claim equal protection, I need to find a prison that allows, or did allow, inmates to receive shortwave radio broadcasts.

I have four long sheets of case law that apply to the censorship, and I have received publicity from the Times Mirror and its book about freedom of the press, Radio Israel, Radio Ecuador, the BBC, and I was on “Talknet” with Sarah Jane Raphell—by phone, of course. Though I really do not like much publicity, as I’m not that kind of person, still one man was—and I guess still is—in the “hole” in Belford, PA.

His name is John Demmitt; if you haven’t heard of him, all he did was to convert an AM radio to be able to hear the world. I can’t write to him, though I tried. He is the reason that, day after day, I continue to try to get my case into the Supreme Court, because the State is under the illusion that that type of radio receiver would be a security risk—or is it to stifle free expression or to prevent exposure of public officials?

In any case, any help you could provide would be appreciated. And since the prison sent me here because I won’t be silenced, at least I can take radio and advanced college courses. I still like AM and FM, but it’s a simple matter to convert AM-BCB to SW, and that’s despite the fact that they took my alignment tools (plastic).

JAMES P. SMITH WDX41PS
Nottoway C. C., Box 488, Burkeville, VA

SERVICE TIP

Service technicians, especially in the VCR field, may be interested in a quick and easy way to test the reset function of sequential logic circuits, microprocessors, etc. The common method of viewing that event is using dual-trace or freeze-scanning mode. However, that can be tricky to the eye, because reset pins are normally held at a low level until approximately ½ supply has been obtained.

The X-Y or vector mode is ideal for viewing the event. Simply use either input (X or Y) to monitor the supply line. The other input is connected to the reset pin. A characteristic “L” pattern trace will result, due to the reset rise time.

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THE VOLKSWAGEN BEETLE IS A GREAT car for day-to-day use, but it's not what you choose to use when performance really counts. Likewise, the IBM-PC is a great machine for simple activities like word processing; but when it comes to heavy-duty number crunching (with, say, a complex spreadsheet, or a design package such as AutoCAD), you realize that the poor little PC really has to struggle to keep up. And you can develop a few gray hairs in the process.

What's the solution? You've got two choices: You could trade in that bug for a Mercedes, or you could retro-fit the bug to improve its performance.

The problem is that replacing a PC or an XT with an AT can be an expensive proposition. However, for much less money you can perform the retro-fit. In doing so, you can turn the PC into a machine that runs much faster—five to seven times faster—than it used to. In fact, you may be able to improve its performance so much that it actually can outperform the AT.

The PCTurbo 286e

Orchid Technology (47790 Westinghouse Drive, Fremont, CA 94539) designs and manufacturers several add-in cards (including accelerator and display boards) for the IBM family of personal computers; the 286e represents their top-of-the-line accelerator card. The board contains an 8-MHz 80286, 1 megabyte of 120-ns no-wait-state RAM, and it has a socket for an 80287 math co-processor and provision for a daughterboard that contains an additional megabyte of RAM. The 286e plugs into a standard expansion slot, and requires about 3.5 amps in its full configuration. There is an additional connector that contains most of the important CPU and bus signals.

What does all that hardware do? Basically, it puts a computer inside your computer. The two computers share resources like keyboard, screen, and disks, but otherwise operate independently. The "host" (the PC) handles all I/O (keyboard, video, disk). Normally, you use one or the other at a time, but Orchid can provide you with experimental multi-tasking software that allows you, for example, to sort a database on the host while calculating a spreadsheet on the 286e.

The RAM on the card cannot be used to expand the host PC's system RAM; it's all dedicated to 286e use. 640K is used as the 286e's...
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system RAM; an additional 64K is used as a buffer for communicating with the host PC; the remainder is used as EMS (Expanded Memory Specification) RAM.

Some applications programs (like Lotus' Symphony, Ashton-Tate's Framework, the Ready! outline processor, and AutoCAD 2.5) use EMS RAM to swap programs and data in and out of system RAM. What if your application cannot make use of EMS RAM? Elenco supplies several software packages (a RAM disk, a disk cache, and a print spooler) they call "Productivity Software" with the 286e; the RAM disk and the disk cache can be allocated to EMS RAM.

**Getting it running**

Installation consists of running a program and setting some switches and jumpers on the 286e. The installation program modifies your AUTOEXEC.BAT file and creates two new "boot" files, HOSTEXEC.BAT and TURBEXEC.BAT. It also creates a TURBO.SYS file, the 286e's counterpart to CONFIG.SYS. HOSTEXEC.BAT and TURBEXEC.BAT now load your memory-resident software and start your applications going; HOSTEXEC.BAT loads the host PC, and TURBEXEC.BAT loads the 286e. If you use any of Orchid's Productivity Software, your CONFIG.SYS file will be modified to contain the appropriate driver.

If you have a standard PC or XT with no special add-on hardware, the default hardware and software installation procedures work fine. But if you're running any hardware that uses an IRQ line or I/O ports, you may have to reconfigure either your pre-existing hardware or the 286e. In addition, the 286e cannot be used with an EGA board or a network interface board.

After you've gotten the installation straightened out, using the 286e is simple. To run programs on the 286e, execute the TURBO.COM program. To run programs on the host, execute the UNTURBO.COM program.

If you've ever used an AT, using the 286e will feel more or less the same. But if you're used to a standard PC or XT, you're in for a big surprise, because, in turbo mode, things move fast. For example, the disk directory scrolls by so fast that it's nearly unreadable. Block moves and copies in a word processor happen almost instantaneously. Likewise with sorting a database.

Further, regenerating an AutoCAD (2.18) screen takes about one third the time it used to. That saves a tremendous amount of time—as well as frustration. AutoCAD is a powerful program, but it's slow, and you can get crazy waiting for it to catch up. But not with a PCturbo 286e.
Is it worth it?
If you spend most of your time doing word processing, you don’t need a 286e. But if you spend a great deal of time running any compute-intensive (not disk-intensive) program, a 286e is well worth its $1195 list price. Just make sure that it’s compatible with your hardware and software.

Philips Compact Disc Test Set

Compare and test the performance of CD players

CIRCLE 10 ON FREE INFORMATION CARD

While the compact-disc player has brought wide dynamic range, superb stereo separation, and low noise levels to the general public, it has also brought some unique problems to audio service technicians. Two compact-disc test sets are now available to help technicians measure the performance of CD players. They come from the co-developer of the Compact Disc standard, Philips (N.A.P. Consumer Electronics Corp., P.O. Box 309, Snapp Ferry Rd., Greeneville, TN 37744-0309).

A two-disc defect-test set evaluates a CD player’s ability to play dirty or scratched CDs, and a single audio-frequency test disc supplies signals that allow you to measure the performance of a player. It also allows the player to be used as a signal source for checking amplifier response, speaker performance, etc.

Defect test discs
The defect test-disc set (part number 1716550040) is priced at $89.95 and contains two discs.

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One of the discs contains a variety of simulated defects, while the other doesn't. Otherwise, the discs are identical and contain selections that range from excerpts of Beethoven symphonies to swing jazz to a country selection by Teresa Brewer. Despite the defects, both discs should sound the same. A CD player in proper working order should be able to correct the data errors caused by the defects, and it should be able to play back all selections without any audible errors.

Three different defects are simulated: fingerprints, dust, and scratches. The fingerprints are simulated by very fine lines printed on the plastic protective surface of the disc. Dust is represented by black dots, also printed on the plastic surface. The diameter of the dots range from 300 to 800 micrometers (which would be a rather large piece of dust).

Scratches are simulated by interruptions in the reflective information layer. The simulated scratch widths range from 400 to 900 mil-

crometers (which would be a rather severe scratch).

A CD player that is operating properly can cope with all the defects, because the audio information is recorded with extensive error-detection and error-correction coding. Errors are detected with the help of two 32-bit sets of parity bits (for each 588-bit audio frame) and the correction is handled by a system based on a Cross Interleave Reed-Solomon Code or CIRC.

Audio frequency test disc

The audio-frequency test disc (part number 1716550030) contains 20 tracks that range from silence to pink noise, to tonebursts. It is meant to be used primarily to help measure the performance of a CD player to verify that it is operating within specifications. Most CD-player manufacturers publish specifications that include frequency response, dynamic range, signal-to-noise ratio, THD (Total Harmonic Distortion), and channel separation. The test disc provides signals to help make those measurements, and more. Special signals called doubletones can be used to measure intermodulation distortion, and tonebursts can help you determine the phase linearity of the system.

The first track is simply a voice that points out which is the left channel and which is the right. There are tracks for each channel that contain a 1-kHz synchroniza-
tion tone, followed by a 20-Hz to 20-kHz logarithmic sweep.

For harmonic distortion measurements, there are tracks with tones ranging from 41 Hz to 1999 Hz. (THD is distortion characterized by the appearance of harmonics of the input signal at the output of the system. The "strange" frequencies are prim

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numbers used to avoid interaction with the CD player's sampling frequency.) The same track is repeated 24 dB and 30 dB down, for both left and right channels.

The other tracks include dou-bletones, sweeping doubletones, squarewaves, tonebursts, impulses, phase checks, and pink noise. We won't go into detail here on how to use those signals to test CD players, but keep watching for an upcoming article that will tackle the subject in some depth!

Manuals
The instruction pamphlets sup-plied with both the audio-frequency and the detect-test discs are not very good. They are very skimpy on details, and are obviously translated into English. They are, as a result, difficult to follow. That's unfortunate: all service tools should be supplied with high-quality service literature.

Further, there is no discussion of CD technology. That technology is still new enough that many service professionals are unfamiliar with it. As such, extensive background information would be appropriate and useful.
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The model D6000 is priced at $599.00.—Shure Brothers Incorporated, 222 Hartrey Avenue, Evanston, IL 60202-3696.

continued on page 37

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NEW IDEAS

Sequential flasher

Here's an easy and inexpensive way to liven up a store window, decorate a Christmas tree, or create a do-nothing toy for the kids. As many as ten lightbulbs can be connected to the circuit and arranged in a circle, or in any other pattern. The lights flash sequentially; when the flash rate is about five or six Hz, an optical illusion of a "running dark spot" is produced.

How it works
As shown in Fig. 1, a 555 timer, IC1, drives a 4017 CMOS decade counter. Each of the 4017's first four outputs drives a CA3079 zero-voltage switch. Pin 9 of the CA3079 is used to inhibit output from pin 4, thereby disabling the string of pulses that IC normally delivers. Those pulses occur every 8.3 ms, i.e., at a rate of 120 Hz. Each pulse has a width of 120 µs.

Due to the action of the CA3079, the lamps connected to the TRI-AC's turn on and off near the zero crossing of the AC waveform. Switching at that point increases lamp life by reducing the inrush of current that would happen if the lamp were turned on near the high point of the AC waveform. In addition, switching at the zero crossing reduces Radio-Frequency Interference (RFI) considerably.

Construction
CAUTION: The CA3079's are driven directly from the 117-volt AC power line, so use care in building the sequential flasher. Keep lead lengths short, use insulated wire, and mount the entire circuit in a rigid, insulated enclosure.
NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their model #333, the Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions. Also, it'll be a vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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We didn't specify part numbers for the TRIAC's, because the type will depend on the lamps you will drive. The TRIAC's will almost certainly require heatsinks; the size of the heatsinks will depend on the amount of power the TRIAC's will have to dissipate, and that depends on the lamps you use.

You'll need a low-voltage source (+VCC) to drive the 555, the 4017, and the bias inputs of the CA3079's. One possibility would be to wire up a 7805 regulator circuit and a step-down transformer. It would also be possible to run the circuit from a 24-volt AC source. Doing so would allow the use of lamps with lower voltage and current ratings. The lower power required by the lamps would also allow use of smaller TRIAC's, smaller heatsinks, and a smaller enclosure. The circuit would also be much safer. See RCA Solid State's Integrated Circuits for Linear Applications for more information.—Michael Cicir

NEW PRODUCTS

continued from page 34

UNIVERSAL COUNTER/TIMERS

the model 5010 and the model 5110, incorporate frequency, period, period average, time-interval, time-interval average, frequency ratio, and totalize-measurement modes. The A and B inputs of both models have bandwidths of DC to 100 MHz, AC or DC coupling, scope selection, and a \( \times 1 \times 10 \) attenuator. The model 5110 has an extra input (C) that allows frequency measurements to 1 GHz. Channel A also has an HF filter. Both channels (A and B) have trigger-level controls with 3-state trigger indicators.

The model 5010 (100MHz) costs $1195.00; the model 5110 (1GHz) costs $1395.00.—O.K. Electronics Division, 4 Executive Plaza, Yonkers, NY 10701.

SPECTRUM ANALYZER

the model R360, is a fast, totally turnkey spectrum analyzer and digital signal processing peripheral for the IBM PC, XT, and AT, and compatibles. It is the only PC-based instrument featuring the TI TMS320010 and offering four-channel, real-time spectrum analysis.

CIRCLE 31 ON FREE INFORMATION CARD

Applications include: multiprobe channel spectrum analysis to 250 kHz, vibration analysis, impact testing, chromatography, ultra-
sonic-frequency analysis, power-line monitoring, and audio and speech analysis.

The model R360 is priced at $2699.00. Its is also available with a less expensive data-acquisition module for $1499.00 (model R340) and alone for development work or OEM at $999.00 (model R320).—Rapid Systems, Inc., 755 N. Northlake Way, Seattle, WA 98103.

CABLE TIE. Cables-Away, is a durable neoprene and velcro strap that stretches to fit any size cable for binding and storage. The bright colors make them easy to spot, and re-useable velcro provides cost and time-saving ease.

Standard colors are royal blue, red, and orange and the price starts at $9.00 for a bag of 5. Custom sizes 1” x 2,3,5, or 6”, and colors are also available, starting at $12.15 for a bag of 5.—Cables Away, Division of Playback, Inc., 3504 Eighth Street, Boston, MA 02129.

CURING LIGHT, the Ultracure 100, is a high-intensity UV (Ultra Violet) curing light, designed to be used with a new generation of UV adhesives. UV adhesives are being used extensively in electronics, automotive, and medical devices, and in fiber-optics industries, and may be used in many assembly procedures where epoxies are presently being used. Once the adhesive is applied to a work area it will remain in a liquid state until exposed to UV light. UV bonding occurs within five seconds.

The Ultracure 100 provides radiation in the long-wave ultra-violet region with a peak output at 365 nanometers, producing 400 mW/cm² of light intensity. The lamp is a 100-watt DC short-arc mercury-vapor lamp. An hour meter records accumulated usage of the bulb. A flexible wand is used to guide the UV light precisely to where it is needed, thus enabling the operator to cure areas otherwise unobtainable with conventional systems. The wand may be used in a fixed position or hand-held for spot curing. The use of a liquid-filled light guide eliminates infrared light; that, combined with a heat-reducing filter and a high-speed fan, allows the unit to be operated continuously.

The Ultracure 100 is priced at $3600.00.—Efos, Inc., Statler Building, 107 Delaware Ave., Suite 1648, Buffalo, NY 14202.

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TSM 122 - All band FM entenna amplifier 20 db UHF - VHF.

CIRCLE 198 ON FREE INFORMATION CARD
Tri-Mode Cable-TV Scrambling

Learn about one of the more sophisticated cable-TV scrambling techniques in this informative article. Included is an experimental descrambler that can help you gain even more insight.

JIMMY COFFELL
is that the TV set’s horizontal- and color-sync circuits can not identify the pulses they need to perform their tasks.

In a Tri-mode scrambling system, there is not one level (or mode) of sync suppression; there are three: 0 dB, 6 dB, and 10 dB; and they can be changed randomly. In the 6-dB mode, the sync pulses are suppressed 6 dB (see Fig. 1-b); in the 10-dB mode, the sync pulses are suppressed 10 dB (see Fig. 1-c); in the 0-dB mode, there is no suppression at all (see Fig. 1-a), but a signal is sent to “fool” unauthorized descramblers into thinking that there is. An unsophisticated circuit itself winds up scrambling the signal by trying to introduce sync into a signal that already has it. The 0-dB mode is also called the “clear” mode. The audio is neither scrambled nor relocated in the Tri-mode system.

Descrambling the signal

Obviously, in order to descramble the signal you must restore the sync pulses to their proper levels. As with most scrambling schemes, sync information is hidden elsewhere. To further complicate matters, however, information on the amount of suppression is also hidden. The job of the descrambler then is to find those signals and use them to restore proper sync levels.

Finding the sync information is relatively simple. Just as in the in-band gated-sync system, the sync signal is amplitude modulated onto the sound carrier. Because the sound carrier is 4.5 MHz above the picture carrier, we know where to look for the hidden pulses. For example, Channel 3, whose picture carrier is at 61.25 MHz, has its sound carrier at 65.75 MHz. Therefore, to decode signals from a cable system that uses a Channel-3 output on their converters, you would have to demodulate the horizontal-sync pulses at 65.75 MHz.

In the NTSC system, the first 18–21 lines of video following the vertical-blanking interval are unused. In a Tri-mode-encoded signal, a 17-bit data string is placed within those lines. As shown in Fig. 2, the string begins with a start bit that is a logic 1. Each data bit follows a horizontal sync pulse by 20 μs.

That data string conveys several pieces of information. Data bits 0 through 7 (8 bits) are used for program authorization codes, and data bits 8 through 15 (8 bits) contain the control codes for the descrambler. Data bits 12 through 15 contain the specific codes that tell the descrambler which of the three scrambling modes is currently being used.

To enhance security, the state of each of those four bits is constantly changing. The scrambling mode is conveyed by the value of the bits in the state immediately prior to the one in which the value is 1111. The 6-dB, 10-dB, and clear modes are identified by a value of 1000, 0100, or 0010, respectively. By using a serial-in, parallel-out shift register, we can determine the correct mode by capturing the logic states of data bits 12, 13, and 14 in D latches and then looking at those latches when bits 12 through 15 are all at logic 1.

Once we extract the horizontal-sync pulses and the current mode of scrambling, we can direct the horizontal sync to one of three amplitude stages. For example, when the scrambling mode is 10 dB, the horizontal sync is used to turn on the 10-dB stage during horizontal blanking, which amplifies the sync signal and overcomes the 10-dB suppression. The video portion of the signal is passed through the clear stage, which has no amplification.

When a non-scrambled signal is received, both sync and video are automatically passed through the clear stage.

Circuit description

The schematic of a circuit that will do what we want is shown in Figs. 3 and 4. The 61.25-MHz (Channel 3) input signal is fed to Q2 and Q3. The gain of Q2 is on the order of four to ten. Potentiometer R14 is used to vary the level of signal fed to F1, a Plessey SY323 SAW filter. Such adjustment is needed because the output signal from the cable converter can vary from 20 to 200 mV. The SAW filter passes only 65.75 MHz, which is the sound carrier for Channel 3. Since some of the 65.75-MHz signal is attenuated by the SAW filter, the signal is then amplified by Q10, which also provides an impedance match to the input of IC1. That IC is a low-level video detector that is used here to demodulate the sound-carrier signal that contains the horizontal and data pulses.

Horizontal and data pulses appear at the output of IC1 (pin 5) when coil L1 is adjusted so that L1 and C25 are tuned to the 65.75-MHz sound carrier. Transistor Q16 is used to square up the analog pulses to a 0- to 12-volt digital signal.

That digital signal is fed to pin 1 of NAND gate IC2-a and the scrambled sense circuit, Q15 and Q16. Transistors Q15 and Q16 form a frequency detector that senses the presence or absence of the 15.734-kHz horizontal sync. With the presence of horizontal sync (scrambled), Q16’s collector floats high, allowing NAND gate IC2-a to send the horizontal-sync and data pulses to the decode logic.

Horizontal-sync and data pulses from IC2-a’s output are delayed and fed back to
FIG. 3—DESCRAMBLING TRI-MODE. All fixed resistors are 1/4-watt, 5% units. Capacitor C25 is an NPO type. Capacitors C31 and C33 are mica units, and all polarized capacitors are electrolytics. All other capacitors are ceramic discs.
its input via IC2-b. That provides horizontal pulse-width control, which is adjusted by potentiometer R44. The signal from IC2-a is also fed into IC2-d, IC4-a, and IC4-b to separate horizontal-sync pulses from data pulses. Horizontal sync appears at IC2-d, pin 11 and is also fed to IC3-d and IC14-a. Pure data pulses are extracted by IC3-a and IC3-d and fed to pin 7 of shift register IC5.

A delayed and inverted version of the horizontal-sync signal from IC4-c is fed to shift registers IC5, IC6, and IC7 as a data clock. Those three IC’s are dual 4-bit serial-in shift registers with parallel outputs, configured to output data bits 12 through 15 to D flip-flops IC8 and IC9.

The outputs of IC8 and IC9 are latched to their input levels when the start bit appears at pin 5 of IC7 and at the clock inputs of IC8 and IC9. That occurs 17 data-clock pulses after the VBI (Vertical Blanking Interval), when data bits 12, 13, 14, and 15 are at IC5 output pins 10, 3, 4, and 5, respectively. Data bits 12, 13, and 14 are then loaded into IC12-a, IC11-a, and IC10-a when the D-latches are clocked by the next data-clock pulse. Since data bits 12 through 15 following one VBI have now been stored in the D-latches, shift registers IC5, IC6, and IC7 are reset on the next data-clock pulse.

On the data stream following the next VBI, IC8 and IC9 will be updated with new data. As such, we now have the new data stored in IC8 and IC9 and the previous data stored in IC10-a, IC11-a and IC12-a. We have stored both of these states temporarily so that when we detect a value of 1111 on data bits 12 through 15, we have the previous states of data bits 12, 13, and 14, which identifies the current scrambling mode.

The AND function used to detect a 1111 on data bits 12 through 15 is performed by IC3-e, IC3-b, IC2-e, and IC4-d, whose output loads only the true current scrambling mode into IC10-b, IC11-b, and IC12-b. Those D-latches are used to gate the sync pulses to the proper sync-amplifier stage and also to switch transistors Q19, Q18, and Q17, which in turn drive LED indicators for the clear, 10-dB and 6-dB modes, respectively.

An all-0’s condition on data bits 12 through 15 is sensed by OR gate IC13-a. That state indicates the presence of a 6-dB sync-suppression signal with no tri-mode data (that is, standard in-band gated sync). However an all-0’s code is also sent randomly in the Tri-mode system. To eliminate that confusion, binary counter IC15 is used to force IC10-b, IC11-b, and IC12-b into the 6-dB mode only after counting 32 consecutive VBI’s that contain no data (all zeros). Operation is returned to Tri-mode by IC13-b if even one non-zero state is detected.

Horizontal sync from IC2-d is combined with the vertical blanking signal, which is derived from the signal at IC2-a by IC4-f and IC4-e, by NAND gate IC14-a. The total sync waveform at IC14-a’s output is directed to the proper sync amplifier stage by one of two NAND gates, IC4-b and IC4-c. In the 6-dB mode, IC4-e is turned on by pin 13 of IC12-b, thereby passing the sync pulses to the 6-dB amplifier stage. Similarly, in the 10-dB mode, IC4-b is turned on by pin 13 of IC11-b, thereby passing the sync pulses to the 10-dB amplifier. The outputs of the two NAND gates are now independent 6-dB and 10-dB sync lines that are normally high, with low-going sync pulses. They are NAND-ed by IC14-d to create the clear signal needed for the clear-amplifier stage. The clear line carries an inverted sync waveform in either of the two scrambling modes.

We now have all the signals necessary to return the suppressed sync back to its normal level on the signal. Remember the 61.25-MHz (Channel 3) input signal is fed to transistor Q3, which provides a fixed gain of four to ten. From there, the amplified signal is delivered to three amplifier stages, Q4, Q7, and Q11, which are the 10-dB, 6-dB and clear circuits, respectively. Those circuits are identical with one exception: The clear circuitry has no gain adjust.

Let us study the operation of the 10-dB stage before we try to understand the combined action of all three. In the 10-dB mode, Q4 amplifies the signal only during horizontal-blanking and only when it is turned on by Q5. Transistor Q5 is turned on by the 10-dB sync line from IC14-b. Gain-adjust potentiometer R10 allows you to select the proper amount of amplification to overcome the 10-dB suppression. Transistor Q6 is also driven by the 10-dB sync line and is turned on when Q5 is turned off. That sets the DC level at the collector of Q4 at approximately +6 volts when Q4 is off. Without Q6, the collector of Q4 would float to +12 volts, causing unwanted spikes in the output signal. Bias-adjust potentiometer R8 is used to set the DC level on the collector of Q4 when that transistor is on, so that the level is essentially the same as the level set by Q6, when Q4 is off.

The same process occurs in the 6-dB stage when that stage amplifies the sync pulses that were suppressed in the 10-dB mode. Between sync pulses, during the video portion, both stages are off.

In the clear stage, the reverse process takes place. That stage is controlled by an inverted-sync waveform in either the 6-dB or 10-dB modes. The result is that video is passed, but not the sync signal. In the clear mode, or when no scrambled signal is detected, Q12 causes the clear stage to stay on all of the time, so both video and sync are passed. The outputs of the stages, sync from either the 6-dB, 10-dB, or clear stage plus the video from the clear stage, are summed at R38, which is part of a 75-ohm matching network, then they are fed to output jack J2.

When a non-scrambled signal is received, the frequency detector output the
The have want to is normal picture. The same true liar detector IC1-7 works properly, a signal that resembles the one shown here should be visible on a scope at the base of Q14.

Building the circuit
A photograph of the author's prototype is shown in Fig. 5. For those of you who want to experiment with the circuit, we have provided a foil pattern in PC Service. The corresponding parts-placement diagram is provided in Fig. 6.

Mount all components as flush with the PC board as possible. We suggest you install the resistors first and use the trimmed leads for the many jumpers (57) required. When installing C38, C50, and C8, be careful to check for proper polarity. The same holds true for the six diodes and the five LED's. Use good soldering techniques, and a low-wattage (15–30-watts) iron.

Coil L1 must be modified by cutting off the plastic between the leads before it can be installed on the board. Note that IC2–IC15 are CMOS devices. Take the usual precautions to prevent damaging those static-sensitive devices. The 12-volt regulator, IC16, can generate a lot of heat. It must be adequately heat sanked; it is also a good idea to add extra ventilation to the case (by punching some additional holes) in the vicinity of that component. On H1, the Philco SY323 SAW filter, pin J1 found can be located by locating the part number on the filter's metal can.

Jacks J1 and J2 are PC-mounted F connectors. We mounted ours by laying them on the board's component side and strapping a bare wire around them. We then soldered the ends of the wire to the board, in the holes provided, and soldered the bare wire to the connector's body for a good ground. Solder a short piece of wire between the center connector and the appropriate hole on the board. Depending on the AC adapter you use, you can connect the adapter to the board via a plug, or solder the adapter's leads directly to the pads marked +18V and ground. Be sure to observe the proper polarity.

Checkout and alignment
Do not hook up the device unless you are authorized to do so and are otherwise in compliance with Federal and the applicable State law. Note the warning set forth in boldface type at the beginning of this article.

Check the power supply voltage at IC16 at the positive side of C8, for +12 volts. Then check that you have +12 volts to all the IC's in the circuit.

The next step is to tune to a non-scrambled channel and connect the circuit between a cable-TV converter, set to output on Channel 3, and your TV set, tuned to receive Channel 3. However, once again, do not hook up the unit until you have received the required authorizations and are otherwise in compliance with all applicable Federal and State laws. Make sure to fine-tune the cable-TV converter so that the Channel-3 output is correct, because, if it's not, the circuit will not detect the Tri-mode pulses.

Begin alignment by performing the following initial adjustments. The adjustments are designed to provide a starting point that will yield the best and quickest results. Ignore anything that you may see on the TV screen at this time. Set the input level potentiometer, R14, to the middle of its range. Adjust L1's tuning slug so that it is even with the top of the plastic coil form. Turn width potentiometer, R44, to the middle of its range.
Part 3  Last month, we began to look at the computer system used to control our robot. In a future installment we will look at that computer in depth and present complete construction plans, including PC-board patterns. But for now, let’s step back and look at some of the robot’s mechanical details.

This month we’ll turn our attention to the design and construction of the R-E Robot’s base unit. In keeping with this project’s emphasis, remember that you are free to build your robot to any size, form, or power that fits your needs or imagination, and that the robot can be designed to use almost any available motor or batteries.

However, that is not to say that the mechanical components can be chosen without care. The components you use will strongly affect the success of your project. Therefore, to help guide you in your design, we will present a step-by-step look at the design of the author’s robot base, and the factors that were considered in selecting the motors, batteries, etc.

Motor selection

The first step is to select the motors. Since the motors usually are the most expensive part of the mechanical system, they likely will determine the configuration of the remainder of the system.

When choosing the motors, a key parameter will be the voltage rating. Motors rated at less than 12-volts DC are rare in the power range we will need. Even if such motors could be located, they would severely tax the current-carrying capacity of our motor-controller board and hookup wires. Motors rated at greater than 48-volts DC could be used, but the battery-pack and motor-control transistors must be selected to withstand that voltage level.

The result is unnecessary expense.

We have found that the best choice is a brush-type, permanent-magnet torque motor, rated at 12- to 36-volts DC. Those motors are commonly used in automotive applications as starter motors, windshield-wiper motors, or electric-window actuators.

The power output of the motors is another key specification. The output is expressed in either HorsePower (hp) or watts, with one horsepower being equal to 746 watts. The motor’s nameplate usually will indicate the power input, such as 12 volts at 10 amps, which translates to a power input of 120 watts. Assuming, for the moment, a 100% conversion efficiency, that yields approximately a ½-hp power output (12/746). (We will show you how to calculate the actual power output of the motor later on in this article.) In our prototype, we used 24-volt, ½-hp motors.

You should notice that as the motor voltage increases, the current decreases for a given power output. That factor will determine the gauge of the wires used to connect the motors to the controller. If more than 10 amps of current are drawn by the motors, large-gauge wire will be required.

Speed calculations

After selecting the motors for your robot, you must calculate the rotational speed of the tires necessary to achieve a desired speed. Our robot uses 10.5-inch tires, so the following calculations will be for that size tire. Of course, different tire diameters will yield different results.

The first step is to calculate the distance traveled for each tire revolution. That is equal to the tire diameter multiplied by π, or 10.5π. The result is 33 inches, or about 2.75 feet. To find how fast the wheels must turn to achieve a given speed in Miles-Per-Hour (mph), we must convert the preceding result to miles-per-revolution. The result is:

\[
\frac{2.75 \text{ feet}}{1 \text{ revolution}} \times \frac{1 \text{ mile}}{5280 \text{ feet}} = 0.00052 \text{ miles per revolution}
\]

That result is then converted to mph as follows:
Therefore, a total of 40 pounds of force is delivered at a radius of 5.25 inches, or 17.5 ft-lbs of torque (40 × 5.25/12). In order to go 3.8 mph, that torque must be delivered at a rate of 2 rev/sec × 2π radians/rev, or 220 ft-lbs/sec (2 × 6.2832 × 17.5). Foot-pounds-per-second (ft-lbs/sec) is a measure of power; 550 ft-lbs/sec is equal to 1 hp. Expressed in horsepower, our robot requires 0.04 hp (220 ft-lbs/sec ÷ 550 ft-lbs/hp). A handy formula to remember is:

\[
hp = (\text{ft-lbs} \times \text{rpm})/5252.
\]

**Torque motors**

The characteristic curves of a DC permanent-magnet torque motor are derived from two basic phenomena:

- Back emf (ElectroMotive Force) is proportional to motor speed.
- Output torque is proportional to current drain.

**FIG. 1—TO GENERATE A DRIVING FORCE of 20 pounds at a radial distance of 5.25 inches, 8.75 ft-lbs of torque must be supplied to the wheel.**

Let’s assume that the robot must deliver 20 pounds of force from each wheel. Figure 1 reveals that that force is derived from the rotational force of the wheel and is a torque measured in foot-pounds (ft-lbs).

In other words, the robot will go about 1.9 mph for every revolution-per-second (rev/sec) of the wheel. For example, if our wheels were turning at 2 rev/sec, the robot would go 1.9 × 2 = 3.8 mph. In effect, we select the top speed of the robot, and then calculate the required tire spin.

**Motive-power requirements**

Our next task is to calculate the amount of power it will take to achieve the desired speed. Calculations of the motive power required to drive the robot are influenced by many factors, such as the final weight of the robot, additional payload, the type of surface the wheels are on, the state of the batteries, and the type of wheels you use. However, we can still roughly determine the necessary amount of power.

The torque required at the wheels is largely a function of the surface the robot is operating on. Obviously, a hardwood floor and a shag rug will require different amounts of torque. In order to get a rough idea of the force required to move the robot, we loaded a mock-up of our robot with 150 pounds, attached a spring scale, and pulled it across the floor. On the shop’s concrete floor, the scale showed that three pounds of force were sufficient to move the unit. On a moderate-pile carpet, however, the required force increased to eight pounds. You must remember to make additional allowances for climbing grades, towing, and rough terrain.
Feedback

The robot's torque-motor controls require feedback information for each motor. That information can be obtained at any point in the drive train, including the motor shaft, the drive belt or chain, or the wheel. Of course, we need some way to transform the mechanical motion of the drive system to an electronic signal. That can be done in many ways, but the simplest and most economical way is to use an optical encoder. Typically such an encoder consists of a light source, a light detector, and an encoding mechanism that blocks and passes light in such a way that the signal generated by the light detector can be decoded to provide motor-speed information. Full details on an optical decoder will be provided in a future installment of this series.

When selecting your motor, bear in mind that one in which the drive shaft protrudes from both sides of the housing will afford you an ideal setup for mounting the encoder. But while some motors are built that way, most are not. If you cannot locate such a motor, but wish to mount the encoder at the motor anyway, you will have to provide some type of mounting mechanism. The easiest way is to drill a 6-32 tap hole in the capped end of the drive shaft. Once the hole is drilled, tap the hole. Note that since the encoder will impose only a light load on the screw to which it is attached, only a few threads are required.

If you choose to drill a mounting hole, you will need to disassemble the motor. Otherwise, you are likely to break off the tap. Open the motor housing and remove the armature/shaft assembly. Place the armature in a padded vice (soft pine will serve nicely for padding), and then carefully drill the shaft.

Battery selection

As the batteries must power the robot at all times, except during discharging, their selection is an important part of the design process. Two factors must be considered when selecting the batteries: the amount of power that must be supplied, and the length of time that that power must be supplied.

It is important to remember that the robot has two basic modes of operation: moving and non-moving. In our robot, the motors draw five amps during motion. When the robot is stationary, the draw drops to about one amp, at 5-volts DC.

Battery specifications include an Ah (Amp-Hour) rating. That specification tells you how much current can be delivered, multiplied by the length of time (in hours) that the current drain can be maintained. From that, one might expect that a battery with a 100-Ah rating could supply 100 amps for one hour, or one amp for 100 hours. However, the battery's capacity can be affected by many factors, including temperature, battery-charging history, and the rate of discharge. The rate of discharge is particularly important because the battery's capacity is less at high discharge rates than at low discharge rates. Generally a battery has a current-discharge rating that is equal to 0.1 times the Ah rating, or in our example, 100 x 0.1 = 10 amps. So we can expect more than 100 hours of service at one amp, but less than an hour at 100 amps.

When evaluating automotive or motorcycle batteries, you will find that the automotive industry has developed its own specifications that must be interpreted carefully. The battery's "cranking power" is defined as the number of amps that a fully charged battery can deliver for 30 seconds. That parameter is a measure of the internal resistance of the battery and has little to do with the amount of power stored in the battery. The battery's "reserve capacity" is defined as the number of minutes a fully charged battery can deliver 25 amps while sustaining a cell voltage of 1.75. To convert that figure to Ah, divide the number of minutes specified by 60, and multiply the result by 25.

We decided to power our robot using utility batteries with a rated reserve capacity of 40 minutes. That converts to an Ah rating of 17. The effective Ah capacity that we will derive from the battery will be greater, however, because our current drain is less than 25 amps. Our standby power consumption is about 10 watts. Assuming a DC-DC converter efficiency of 75%, the total power output of the battery will be 15 watts, and the drain on a 24-volt battery will be 1 = P/E = 15 watts/24 volts = 0.625 amps.

We inferred a capacity of 17 Ah in each utility battery at 25 amps. The actual application will be at a current drain of about 1/4 of that. Consulting a battery data book, we find that our battery capacity may be expected to be about 180% of the rating, or about 30 Ah. During mobile periods, the battery drain will be about 5 amps. We can expect about 120% of the rated capacity at that rate, or about 20 Ah.

Therefore, we can expect about 48 hours of electronics-only operation (30 Ah/0.625 amps). During mobile periods, the batteries will last about four hours (20 Ah/5 amps). That gives the robot a total range of 15 miles (3.8 mph x 4 hours).

Building the robot

After selecting the batteries and motors, the actual building process is very straightforward. Basically, the process involves creating and then assembling the chassis, and then mounting the components on it. The operation is simple, but it requires careful attention to innumerable details. We'll begin building the R-E Robot next time by showing you how to fabricate and assemble the chassis.

Sources

Can you imagine what a robot we could build with a staff of 250,000 (the entire readership of Radio-Electronics)? One key to the success of the R-E Robot is the collective development capability of that readership. In an effort to encourage the exchange of software, sources of parts, hardware enhancements, and any other items of general interest, Radio-Electronics will open a special section of its new remote bulletin-board system (REBBS) to builders of the R-E Robot. You can reach the bulletin board by calling 516-293-2283.

To help simplify the mechanical aspects of building the robot, Vesta Technology (7100 W. 44th Avenue, Suite 101, Wheatridge, CO 80033, 303-422-8088) will offer an aluminum chassis similar to the one discussed in these articles. Vesta also will offer the RPC, its PC board, and the source code for testing the robot and implementing the RCL. For pricing and availability information, contact Vesta Technology directly. Complete construction details, including schematics and PC board patterns, will be presented in a future installment of this series.

A complete description of a drive-train system for the robot, including parts specifications, also will be presented in a future installment. For those that have difficulty finding the necessary components for the robot, a good source is Stock Drive Products (55 S. Denton Ave. New Hyde Park, NY 11040, 516-328-0200). Contact them directly for pricing and availability information.

Additional sources for various sub-systems and parts for the robot will be provided as appropriate in future installments of this article.

R-E
Part 2 In the first part of this article we showed the complete set of schematic diagrams (in Fig. 3-Fig. 6) while we discussed the decoder’s theory of operation. However, due to a printing error, a line connecting R13, R14, and pin 7 of IC4 was deleted from Fig. 3, the decoder stage schematic. After you go back to your January issue and draw the line in, you’ll be ready to start building. But before purchasing any parts, read the section on interfacing below: you may not need the board-mounted demodulator and its associated components, depending on how you interface the decoder with your TV or VCR.

To build the decoder, it’s best to use a PC board. If you wish to etch your own, the foil pattern is shown in PC Service. Otherwise you can buy a board from the source mentioned in the Parts List.

However you obtain a board, before beginning construction, inspect it carefully for shorted and open traces, and make sure that the copper is clean. If necessary, rub it with steel wool and then clean it with soap and water.

When the board is in good shape, start stuffing it, as shown in Fig. 7 (which shows all board-mounted components) and Fig. 8 (which shows all off-board components and the three jumpers). First insert the low-profile components, and then work up to the larger components. Be sure to observe the polarity of all semiconductors and electrolytic capacitors—one mistake could be deadly!

When the board is stuffed, clean flux from the foil side and check your work once more. Then mount the board in a case, as shown in Fig. 9.

Interfacing

Before building the decoder, you should determine how you’ll interface it with your TV or VCR. If your TV or VCR has a MPX audio-output jack, then you can simply connect the decoder’s MPX input to that jack. In that case, you won’t need to buy parts for, or build the 4.5-MHz demodulator. However, few late-model sets include such a jack, so you’ll probably have to build and connect a special interface circuit. Doing so may void any warranty that is in effect, so don’t undertake any modifications to your set unless you’re quite sure you know what you’re doing—or are willing to accept the consequences.

We’ll present several ideas for interfacing the demodulator: whichever you choose, be sure you never work on any device while it is plugged into a 117-volt AC power outlet. Many TV chassis are extremely dangerous because they do not have power transformers to isolate them from the AC power line. Sets that lack such a transformer are said to be hot-chassis types, because there may be a 117 volts between the chassis and ground.

Converted VCR output

This is probably the most difficult option physically, because you must remove the case of your VCR and drill a hole in the rear panel to mount a small SPST switch. You must also locate the 75-μs audio de-emphasis capacitor in the tuner section, and lift the leg that goes to ground. To find that capacitor, you’ll probably need a copy of the schematic diagram for the tuner section of your VCR. Your dealer’s service department may have that information, and you may be able to ask a technician there for help in locating the capacitor.

The de-emphasis capacitor is always located close to the audio-demodulator IC. The capacitor forms part of a series RC network; one leg goes to ground, and the other is connected to a resistor that’s in series with the audio path through the circuit. In some sets one IC may perform both audio and video demodulation.

After locating the proper capacitor, remove the grounded leg. Then prepare a piece of shielded cable that is long enough to reach from the capacitor to the rear-panel switch. As shown in Fig. 10-a, solder the shield to the hole from which the capacitor’s leg was removed, and the center conductor to the free leg. Connect the other end to the switch.

Now, when the switch is in the stereo position, the capacitor is disconnected from the circuit. That allows the high-frequency portion of the audio signal that contains the pilot and the I—R signals to pass through the remainder of the circuitry and appear at the VCR’s regular audio output jack. Closing the switch returns the recorder to normal mono operation.

Because we tapped the demodulated audio directly, IC1 and associated components can be eliminated from the decoder’s PC board. In addition, you can use that technique with a TV or a monitor, but only if it is not a hot-chassis type.

IF output jack

Conversely, the following technique may be used on a TV with a hot chassis. You’ll have to build the 4.5-MHz section of the decoder. Before beginning conversion, obtain a copy of the schematic diagram of your set. What you’re looking for is a place to pick up the 4.5-MHz IF signal before it is demodulated.

Locate the audio-demodulator section of the TV set; it should look something like Fig. 10-b. In many cases, the circuit will look similar to the demodulator circuit in the decoder. Older sets will probably use a 4.5-MHz IF transformer.
FIG. 7—MOUNT ALL ON-BOARD COMPONENTS on the MTS decoder's PC board as shown here.

All resistors are 1/4-watt, 5% unless otherwise noted.

<table>
<thead>
<tr>
<th>R1</th>
<th>120 ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2, R7, R35, R37</td>
<td>10,000 ohms</td>
</tr>
<tr>
<td>R3, R23, R49, R53, R54</td>
<td>10,000 ohms, trimmer potentiometer</td>
</tr>
<tr>
<td>R4, R6, R11, R12, R42, R43, R44, R46, R48, R50, R51, R59, R60</td>
<td>100,000 ohms</td>
</tr>
<tr>
<td>R5</td>
<td>2200 ohms</td>
</tr>
<tr>
<td>R8</td>
<td>10 ohms</td>
</tr>
<tr>
<td>R9, R24, R31, R57, R58, R63</td>
<td>1000 ohms</td>
</tr>
<tr>
<td>R10, R16, R17, R28</td>
<td>3300 ohms</td>
</tr>
<tr>
<td>R13</td>
<td>330,000 ohms</td>
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<td>R14, R15, R21, R62</td>
<td>4700 ohms</td>
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<td>R18</td>
<td>12,000 ohms</td>
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<tr>
<td>R19</td>
<td>25,000 ohms, trimmer potentiometer</td>
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<tr>
<td>R20</td>
<td>4300 ohms</td>
</tr>
<tr>
<td>R22, R27</td>
<td>5100 ohms</td>
</tr>
<tr>
<td>R25, R29</td>
<td>5000 ohms, trimmer potentiometer</td>
</tr>
<tr>
<td>R26</td>
<td>1500 ohms</td>
</tr>
<tr>
<td>R29, R30, R31, R32, R33, R39, R40</td>
<td>20,000 ohms</td>
</tr>
</tbody>
</table>

PARTS LIST

| R34, R41, R55, R56 | 39,000 ohms |
| R36, R38 | 22,000 ohms |
| R45 | 68,000 ohms |
| R47, R57, R60 | 470,000 ohms |
| R52 | 100,000 ohms, dual-gang potentiometer |
| R61 | 330 ohms |

Capacitors

- C1, C4, C13, C32 | 0.01 µF, ceramic disk |
- C2, C3, C19 | 470 pF, ceramic disk |
- C3, C14 | 0.05 µF, ceramic disk |
- C5 | 5-60 pF, trimmer |
- C6 | 10 pF, ceramic disk |
- C7, C8, C10, C11, C27, C38, C47 | 1 µF, 50 volts, electrolytic |
- C12, C23, C25 | 0.0022 µF, ceramic disk |
- C15, C30, C34-C37 | 0.22 µF, ceramic disk |
- C16, C17 | 0.47 µF, ceramic disk |
- C18 | 0.0047 µF, ceramic disk |
- C20, C21 | 0.0015 µF, ceramic disk |
- C22, C24 | 0.0039 µF, ceramic disk |
- C26 | 0.015 µF, ceramic disk |
- C28 | 0.015 µF, ceramic disk |
- C29 | 0.015 µF, ceramic disk |
- C33 | 50-553 | 2.2 µF, 50 volts, electrolytic |
- C48 | 2200 µF, 50 volts, electrolytic |
- C49 | 470 µF, 50 volts, electrolytic |

Semiconductors

- IC1-MC1358 stereo demodulator |
- IC2, IC4, IC5, IC7, IC6-LM358 dual op-amp |
- IC3-LM1800 stereo decoder |
- IC6-NE570 comander |
- D1, D1-1N4002 rectifier diode |
- LED1, LED2-standard |
- Q1, Q3-2N3904 NPN transistor |
- Q2-2N3906 PNP transistor |
- Q4-2N2222 NPN transistor |

Other components

- F1-1/4-amp, 250-volt fuse |
- J1-J4—RCA phono jack |
- J5-stereo headphone jack |
- L1-33 µH S1-SPTD toggle switch |
- S2-SPST toggle switch |
- T1, T2-10.7 MHz IF transformer |
- T2-25-volt CT power transformer |

Note: A drilled, etched, and plated PC board is available from Tod. T. Templin, 5329 N. Navajo Ave., Glendale, WI 53217 for $9.00.
between the video and the audio demodulator sections: newer sets may use a ceramic filter.

In either case, solder one lead of a 100-pF capacitor to the output side of the transformer or filter. Cut a length of shielded cable that is long enough to reach from the capacitor to the rear of the set. Prepare one end by completely removing about one inch of the braid. Cover the part of the cable where the shield ends with tape or heat-shrink tubing. There must be no possibility of the shield wire's touching any part in the TV.

Now solder the center lead to the free end of the 100 pf capacitor. Dress the capacitor and the cable so that they don't touch any other parts. Locate a convenient, non-conductive place on the rear cover of the set and mount the RCA jack. Do not mount the jack on any metal part of the set. Finish the installation by soldering the 1-megohm resistor and the shielded cable to the jack.

**RF probe**

The RF probe is probably the best interface to use if you're not familiar with the inner workings of TV's and VCR's. Your set needn't be modified in any way, and you don't have to deal with high voltages. However, you'll almost certainly have to remove the cabinet in order to pick up the RF signal. In addition, you'll have to build the 4.5-MHz demodulator section of the decoder, but in that case, replace 0.01-μF input capacitor C1 on the decoder board with a wire jumper.

The basic idea is to build a small antenna that is tuned to 4.5 MHz and is placed as close as possible to the TV's audio demodulator. The antenna will pick up the RF signals that are naturally radiated in the set.

The circuit is very simple, as shown in Fig. 10-c. Use several drops of quick-set glue to hold the coil to a stick. Then solder the capacitor close to the body of the coil. Cover the assembly with heat-shrink tubing to help hold it together and to provide insulation. Cut a small hole in the tubing so you can adjust the trimmer capacitor. Then attach a length of shielded cable about six feet long, and terminate it with an RCA plug.

Finding the optimal location for the probe requires that the decoder be operational. On the other hand, you can't make the decoder operational without an input signal from the probe. That leaves you in a bit of a dilemma.

The best solution is to locate the audio demodulator in the television. Then use a rubber band or a piece of tape to secure the probe close to that portion of the circuit. Temporarily remove any shielding, if necessary. Now you should be able to get enough signal to align the decoder, after which you can go back and reposition the probe and adjust the setting of the
trimmer capacitor for maximum signal strength.

In practice we have found that many sets, particularly older models and tube types, radiate so much RF that, after the probe is tuned, it can pick up enough signal to work as far as two feet from the set.

Alignment

The decoder was designed to be easy to align. The values of all components were selected so that by setting each adjustable part to the center of its range, it will be near its optimal setting.

Begin alignment by setting all potentiometers and trimmer capacitors to their center positions. Supply an input signal to the decoder by one of the circuits above. Be sure that you are tuned to a station that is transmitting a stereo signal. Most TV stations leave the pilot on all the time and transmit a synthesized stereo signal during shows that are not true stereo. You'll need to monitor the decoder's outputs via headphones or a stereo amplifier. If everything is working, you should hear some audio from the decoder, although it may be low in volume or highly distorted.

If you're using the on-board 4.5-MHz demodulator, you must adjust it first. Input transformer T1 is broadly tuned, so any adjustment to it will have little effect. Leave it centered, and adjust trimmer capacitor C5 for maximum audio output from the decoder.

If you're using the RF probe for input, you must adjust it while the television is operating, so be extremely careful not to touch anything inside the TV set. While carefully holding the probe in a position where you can hear some signal, adjust the probe's trimmer capacitor for maximum output. Then move the probe around to find the point where the signal level is strongest. Unplug the TV set and attach the probe as close as possible to that point.

Now adjust R3 for maximum signal. Then adjust R19, the stereo PLL adjustment, rotating it through its entire range. At some point the stereo pilot LED should come on. Set R19 to the point midway between where the LED goes on and off. Re-adjust R3 until the LED goes off, then increase R3 to just beyond the point where it comes back on. Set R19 again. You may need to increase the resistance of potentiometer R3 a little to ensure reliable PLL lock up.

Now you should be hearing a fairly good stereo signal. While listening closely to the program material, adjust R25 to where the sound becomes distorted or noisy. Then reduce it until the sound becomes muffled or dull. Then set it midway between the extremes.

The matrix-input-level controls, R23 and R49, affect overall left/right separation. If everything is working normally, each control should be set to approximately the same position near the center of its range. You may, however, wish to experiment with their settings. While listening to stereo program material, alternately adjust each to obtain the greatest apparent separation.

Another method of adjusting R23, R25, and R49 requires an oscilloscope capable of X-Y display. Connect the right-channel output of the decoder to the X input of the oscilloscope and the left-channel output to the Y input of the oscilloscope. Depending on the signal you're receiving, as separation decreases, the display becomes more of a straight line that tilts one way or the other.

For example, as shown in Fig. 11-a, a mono signal will appear as a straight line at a 45-degree angle. A good stereo signal fills all four quadrants of the oscilloscope display about equally, as shown in Fig. 11-b. A mostly L-R signal appears as shown in Fig. 11-c.

To adjust the decoder with a scope, observe the pattern and listen to the signal. Adjust R25 to the point where the sound is cleanest. Now alternately adjust R23 and R49 for the most circular display. With patience and experience with different types of program material, you'll quickly learn how the controls affect the sound, and thus find the best setting for each.

When you're satisfied with your adjustments, assemble the decoder and your TV set, sit back, and enjoy the new stereo-TV shows.
Using The New Generation Oscilloscopes

Make complex measurements with just the push of a button.

CALVIN DILLER*

If you haven't looked at a new oscilloscope in a while, the information in this article is going to surprise you. Sure, prices are going down, and bandwidths are going up, but that's to be expected. The real surprise is the ease with which advanced measurement functions can be performed.

For example, on some oscilloscopes you can push a button and see a peak-to-peak waveform displayed on a CRT. Push another button and the average value of the waveform is displayed. It's clean and simple. You don't have to count CRT divisions, and you don't have to do scale-factor multiplications. You just read the values off of the display.

Single-button measurements are just one of many advanced features showing up in low- and medium-cost oscilloscopes. Waveform cursors and gated measurements are other advanced features now found on those units. Those new features provide more waveform information faster and with less chance of error. But to get the most from those features, you'll need to understand some basics of their operation, as well as where and how they should be used.

Push-button answers

You may have read about push-button oscilloscope measurements in an engineering journal. Or perhaps you've seen them touted in an advertisement.

The idea of being able to push a button to get pulse amplitude, DC offset, or average voltage is attractive, to say the least. It's comparable to moving from a slide rule to a handheld calculator. But there's a problem. Until recently, pushbutton measurements have been available only on the more expensive digital-processing storage oscilloscopes.

Now, however, advanced push-button measurements are becoming available on relatively inexpensive analog oscilloscopes. Those scopes analyze the analog waveform directly, without using expensive waveform digitizing techniques. For example, a DC-average measurement is made by directing a portion of the signal through a 7-Hz filter. Peak and peak-to-peak measurements are done using a peak-detecting microprocessor feedback system. It amounts to having a specialized "waveform tracking" voltmeter built right into the scope.

The technology behind those oscilloscopes is a topic for another time. Here, what we are interested in is how we can take the maximum advantage of those oscilloscopes' capabilities. To show you how to do that, we'll look at the operation of one oscilloscope in detail. That scope is the Tektronix (Tektronix Industrial Park, P.O. Box 500, Beaverton, OR 97077) model 2246.

Using the 2246

To make an amplitude measurement, you set up the scope as you would any other. Once you get a display of the waveform on the oscilloscope screen, pressing a measurement-menu button causes a menu of available measurement functions to be displayed on the screen; on the 2246 that button is labeled CH1/CH2/VOLTMETER. The measurement menu then appears on the CRT, and the desired item is selected with a push of a second button. See Fig. 1.

If you wished to make a quick check of a digital circuit's voltage parameters, you
ment function and the peak-to-peak value of the input waveform will be displayed on-screen. See Fig. 3.

With the peak-to-peak value of the input displayed, you can adjust the amplifier test signal for a convenient measurement level, 1 volt, for example. Since the display of the peak-to-peak signal is “live” (it tracks the waveform level like a voltmeter), you can use it for precise adjustment of input level. Once the input level is where you want it, switch the scope input selection to channel 2. Now the peak-to-peak reading on the scope will be for the amplifier output waveform. It will also be the amplifier gain if you adjusted the input-test signal level to 1 volt. See Fig. 4.

Of course, there are cases where a 1-volt input could overdrive your amplifier. So it might be better to use a 0.1-volt or even 0.01-volt input, depending on your amplifier’s operating range. In those cases, the correct gain is obtained by mentally shifting the decimal point to the appropriate place on the scope’s channel-2 peak-to-peak reading. If you will be working with low-power circuitry, you will need an oscilloscope with high input-sensitivity. Look for a scope with a minimum sensitivity of at least 2 mV/div.

The +peak or –peak measurement function can also be used to measure gain. However, since +peak or –peak will, by definition, include any DC offset, you’ll need to make sure that channels 1 and 2 are both set for AC input-coupling. That will exclude the DC component. On the other hand, you may want to include the DC component. That could be the case, for example, in DC-coupled amplifiers used in some sense and control applications. Then, DC input-coupling on the scope and the +peak or –peak functions would be preferable.

In still another measurement situation involving DC level, you might be working on a solid-state power-control circuit—for a dimmer, a fader, or a motor-speed control. The kinds of waveforms seen there are usually asymmetric. They’re rectified, chopped, or otherwise modified versions of sinewaves. Those oddly shaped waveforms can be quite deceiving if you are trying to estimate an average DC value from the oscilloscope display. Unless, of course, your scope features an AC-average measurement function. Then, all you need do is press a button and the correct value will be displayed. See Fig. 5.

Voltage and time cursors

In the measurements illustrated by Figs. 2-5, notice the horizontal dashed lines. Those lines are voltage measurement cursors. Whenever a push-button measurement is made with the 2246, those cursors are automatically placed on the waveform by the unit.

That automatic cursor-placement is extremely important and helpful. It gives you visual verification that the correct portion of the waveform is being measured. For example, Fig. 6 shows a +peak measurement of a pulse. The automatic cursor placement shows that +peak includes pulse overshoot.

But you may not want to include overshoot in the measurement. If that is the case, you can switch to cursor mode and move the cursors to the points of interest, the flat top of the pulse for example. The cursor readout is the voltage difference between the two cursor lines. So, by placing the cursors as shown in Fig. 7, you get...
a pulse-amplitude measurement that excludes the overshoot.

Another mode, cursor referenced to ground, brings a single cursor up on screen. The readout for that cursor is voltage-referenced to ground, which is quite useful for checking absolute voltages, logic levels, and voltages in switching devices, among others.

You can also select a time-difference cursor mode. That is indicated by vertical cursor lines (see Fig. 8). Now the cursor readout is the time difference between horizontal cursor locations. By positioning the cursors on the transition midpoints of a pulse, you get a pulse-width measurement, as shown in Fig. 8.

Similar cursor placement on alternate sinewave zero crossings would produce a readout of period. Or, in the dual-channel mode, the time cursors can be used to measure propagation delay.

Gated measurements

Between push-button amplitude measurements and cursor time and amplitude measurements, you can simplify the majority of day-to-day oscilloscope measurements. There are, however, additional measurements that can benefit from another new feature of analog oscilloscopes.

Consider again the pulse with overshoot. You can use a gated-measurement function to confine push-button measurements to a selected portion of the waveform. That allows you to measure, for example, pulse overshoot while ignoring the pulse itself.

Such a gated measurement is shown in Fig. 9. The pulse overshoot is isolated by positioning an "intensified zone" on just the overshoot. The intensified zone is the brighter part of the trace and can be positioned anywhere on the trace or made shorter or longer to include just the desired part of the waveform. With the intensified zone on, the pushbutton measurements are made for just the intensified portion of the waveform.

In Fig. 9, for example, the intensified zone confines a + peak measurement to the pulse overshoot. The result is a peak-overshoot measurement. That measurement can then be used with a cursor measurement between pulse top and base to compute percent overshoot.

There are a number of other cases where gated measurements prove extremely useful. For example, step amplitudes can be quickly isolated and measured on incremental devices such as stepper motors and analog-to-digital converters. Peak-to-peak noise can be monitored on a gated segment of a waveform for determining signal-to-noise ratio. Or you can zero in on the amount of ripple in a power supply.

More for the money

All of the advanced measurement capabilities discussed here can be doubled if the oscilloscope also includes different triggering modes. For example, the 2246 that we've been using as an example has the standard triggering modes offered on most 100-MHz scopes. But it also has TV-field and TV-line triggering. As a result, the pushbutton peak-to-peak, + peak, −peak, DC-average, cursor, and gated measurements can all be used in television applications as well.

The bottom line

That extra measurement capability is nice, even surprising for an analog scope, but is it worth the extra cost? That's the other surprise, and a pleasant one too. Because of engineering and manufacturing advances, those capabilities are basically free extras on scopes from many manufacturers. For instance, the Tektronix 2246 that we've used as an example here, and the 2245 and 2465 scopes shown in Fig. 10, are priced competitively with other analog oscilloscopes that lack many of the advanced features we've discussed.
Learn the importance of diode and bipolar-transistor parameters, and how to test them, in the first installment of our new back-to-school series.

TJ BYERS

Part 1 Even if you are comfortable using semiconductors in your designs and projects, you may not know how to test those components to ensure correct performance. You may not even realize the importance of such tests. Testing allows you to guarantee performance, improve circuit parameters, and reduce project costs. In addition, it helps you to understand better the nature of semiconductor electronics.

With this article, Radio-Electronics begins a new series on semiconductor testing. In the coming months we will examine everything from simple diode leakage to complex environmental testing and burn-in.

Test procedures

Essentially, there are two methods by which semiconductors are tested. The first is called static testing. As the word static implies, the semiconductor device is subjected to a constant voltage or current, as appropriate, and a measurement is made. The relationship between the applied values and the measured values is then analyzed. Static tests are generally referred to as DC measurements.

The second method is called dynamic testing. In a dynamic test, DC values are again applied to the semiconductor. In addition, however, an AC component, normally in the form of an input signal, is present. The effect of the semiconductor device on the AC signal is then measured and the results interpreted. Not surprisingly, dynamic tests are listed as AC measurements.

As you can imagine, those two test methods yield completely different results, and often both tests are required before we have a complete picture of the semiconductor device. We will begin our survey of semiconductor testing with DC measurements.

Leakage current

The most often specified DC parameters are leakage current and breakdown voltage, both of which normally determine the usefulness of a device within a specific application. Those two parameters have an intimate relationship, though, and what affects one usually affects the other. Keep that in mind as we examine those two DC parameters.

Let's begin our analysis with the simplest of semiconductor devices: the diode. Basically, a diode is a simple PN junction that acts like an electronic valve. When the diode is forward-biased, it conducts current; when the diode is reverse-biased, it blocks current.

Ideally, a reverse-biased diode passes no current. Unfortunately, no actual device performs like the theoretical "ideal" device. Thermal agitation and impurities in the semiconductor material allow a small but measurable amount of current to escape through the junction. That current is referred to as leakage current and is called I_R (for Reverse) on data sheets.

Leakage current is measured by reverse-biasing a diode with a known voltage, as shown in Fig. 1, and monitoring the current flow through the device. Under those conditions, the semiconductor junction behaves like a bulk resistance. As the voltage across the junction increases, so does the leakage current.
Breakdown voltage

Breakdown voltage is the voltage at which the semiconductor junction is no longer functional. That is due, in large part, to the strong electric field created within the junction by the applied voltage. As the field increases in intensity, it adds energy to the leakage-current electrons passing through the junction. Those high-energy electrons collide with other electrons in the junction, dislodging them. The freed electrons are accelerated by the strong electric field and, in turn, collide with more electrons.

A voltage is eventually reached where the electric field is so strong that it creates an uncontrolled chain reaction. That process is called avalanche multiplication and results in a rapid rise in leakage current. When avalanche multiplication occurs, the junction has reached its breakdown voltage, and the diode no longer functions as a one-way valve. Sustained avalanche current produces great amounts of heat and literally melts the junction, thus destroying it.

The curve in Fig. 2 shows the relationship between reverse voltage, leakage current, and breakdown voltage (avalanche point). Notice that the curve is fairly linear up to the avalanche point. At the avalanche point, however, the curve takes a sudden turn, and there is very little voltage increase for a large current increase. That turn is called the knee of the reverse-operating curve.

There are several methods of measuring breakdown voltage. When working with large numbers of diodes, one simple method of measuring the breakdown voltage is to take advantage of the linear characteristic of the breakdown curve. First, take a representative sampling of the diodes in question and measure the leakage current of each using a standard voltage. Then subject the sample diodes to an increasing reverse voltage until the junction goes into avalanche. Avalanche is monitored by observing the ratio between voltage rise and current increase. When the increase in current no longer corresponds to a change in voltage, the avalanche point has been reached. A current-limiting resistor is normally placed in series with the diode during that phase of the test to prevent the avalanche current from destroying the component. The relationship between leakage current and breakdown voltage is then documented and correlated. It is then possible to predict the breakdown voltage of any diode in the lot by simply measuring the leakage current at the standard voltage and comparing it to the test samples.

Testing transistors

Since the transistor is more complex than a diode, one would assume that it requires more complex testing procedures. But the testing is not different because the transistor also shares many electrical characteristics of the diode.

Basically, you can think of the transistor as two back-to-back diodes, with the base lead connected to the junction between the diodes. Table 1 lists and defines some of the more important transistor parameters.

Let's turn our attention to the leakage parameters. Those are shown in Fig. 3, along with their related voltages. Of the leakage parameters shown, only one is significant for most designs. It is ICBO—the amount of reverse leakage current from Collector to Base with the emitter Open. Throughout the semiconductor industry, ICBO is commonly measured using the same arrangement as for diodes. A reverse voltage is applied across the collector and base terminals and the leakage current is monitored. It is important to realize, however, that the open emitter lead plays an important part in that measurement.

Leakage and breakdown voltage

As we've already indicated, each leakage configuration also has an associated breakdown voltage. The voltage complement to ICBO, for instance, is VBBO—the breakdown voltage between base and collector. The other two parameters of concern are VCEO and VBBO. VCEO is the maximum voltage the transistor can sustain between its collector and emitter. Typically, that value is less than VBBO and can be as little as half of that parameter.

The reason for that seeming paradox is actually simple. When voltage is applied...
between the collector and the emitter, the collector/base diode becomes reverse-biased. As we have seen, a reverse-biased diode has leakage current. That leakage current flows through the base and into the base-emitter junction in the forward direction. Since any current flowing through the base-emitter junction is amplified by the transistor, be it signal or leakage current, the product of that current appears at the collector, which in turn lowers the voltage drop across the collector and the emitter. The effect the $I_{CH0}$ leakage current has on $V_{CEO}$ is largely determined by the transistor’s geometry.

Through prudent use of external resistance, the effect of $V_{CEO}$ can be minimized. While $V_{CEO}$ is an important design consideration, exceeding it doesn’t normally damage the transistor, unless $V_{CH0}$ is also exceeded.

The value of $V_{CH0}$, the breakdown voltage between the emitter and base in the reverse mode, is sometimes important in switching applications, especially when reverse voltage is used to shorten transistor switching times. It is typically a low value, usually 8 volts or less.

**Testing breakdown voltage**

The procedure for measuring transistor breakdown voltage is slightly different that for diodes. To properly measure a transistor’s breakdown voltage, we must actually subject the transistor to avalanche conditions. In other words, we must apply a voltage that is greater than the breakdown voltage of the device under test.

One popular method is to measure the breakdown voltage using a constant-current source. As you recall, a reverse-biased diode produces a very sharp increase in leakage current at the breakdown voltage. By passing a constant current through the transistor, as shown in Fig. 4, we can force the junction into an avalanche state. Once the junction is in avalanche, we can measure the breakdown voltage with a voltmeter. The technique used to measure $V_{CEO}$ is shown in Fig. 4-a, while the technique used to measure $V_{CH0}$ is shown in Fig. 4-b.

Of course, the current must be precisely controlled. The current must be sufficient such that the junction goes into avalanche, yet small enough that it does not destroy the transistor. While the required current varies from device to device, a safe bet is usually the maximum $I_{CH0}$, specified on the data sheet. If, for example, a transistor is listed as having a maximum $I_{CH0}$ leakage current of 1 mA, it is safe to assume that the junction will sustain an avalanche current of 1 mA, from which we can safely measure our breakdown potential.

**Impedance multipliers**

You should perform voltage measurements across a transistor junction with a high-impedance meter to avoid loading the circuit. At 100 volts, a meter that presents a resistance of 10,000 megohms will steal 10 nA from the circuit. Often, that current level is greater than $I_{CH0}$. Consequently, you must take meter resistance into account or the measuring device will have more effect on the meter than the transistor itself.

You can effectively increase a meter’s input resistance by using an impedance multiplier, which is a resistance divider that reduces the loading effect of the voltmeter. It does that by scaling the voltage down to a very low value, allowing you to measure the breakdown voltage on a lower voltmeter scale, which has less influence on the circuit.

By using a divider network, like the one shown in Fig. 5, it is possible to increase the effective input impedance by 50 times or more. A 100-megohm voltmeter suddenly becomes a 5000-megohm voltmeter. Just remember that your voltage reading must be scaled up accordingly. In the example of Fig. 5, you must multiply the reading by 100 to arrive at the correct value.

**Helpful hints**

Just a word about breakdown voltages as listed on a data sheet. The voltages you see on the data sheet are guaranteed minimum values. In other words, if the data sheet specifies 60 volts as a $V_{CH0}$ value, it means that every transistor shipped will have a $V_{CH0}$ of at least 60 volts.

But the $V_{CH0}$ could be higher. In fact, testing for breakdown voltage could yield a transistor with breakdown characteristics equal to that of a more expensive device. Therefore, testing for $V_{CH0}$ is a good way to reduce project costs without degrading performance.

While we haven’t made the distinction yet, transistors come in two types: PNP and NPN. The difference between the two devices is the way the semiconductor materials are arranged. In an NPN transistor, such as we have been discussing so far, the collector is made of N-type material, the base is P-type, and the emitter is N-type; hence, the name NPN. A PNP transistor, on the other hand, is structured with a P-type collector, an N-type base, and a P-type emitter, which is just the opposite of an NPN. All tests outlined here can be performed on a PNP transistor by simply reversing the polarity of the test voltage.

**Temperature effects**

Leakage current is temperature sensitive. As you’re undoubtedly aware, temperature agitates electrons, even to the point where some of them spin free. As temperatures increase, more kinetic energy is assumed by the electrons, and more are liberated.

You can plainly see that the more free electrons you have wandering about, the more likely they will be attracted by beckoning voltages, and the more leakage current that will flow. That is despite the fact that no change has been made in the applied voltage.

Semiconductor leakage currents are specified at 25°C (room temperature), unless otherwise stated, and the measurement is made at $V_{CH0}$. When measuring leakage at elevated temperatures it is necessary to select a test voltage considerably lower than $V_{CH0}$.

That is because temperature also affects breakdown voltage. Since $I_{CH0}$ and $V_{CH0}$ are so intimately related, it stands to reason that a shift in one brings on a change in the other. In fact, that is the case. As $I_{CH0}$ increases due to increasing temperature, $V_{CH0}$ decreases. Hence, you must lower test and working voltages when operating at higher temperatures.

**Dealing with $h_{fe}$**

Many terms are used to express the gain of a transistor, but none are as familiar as $h_{fe}$. By definition, $h_{fe}$ is the static value of the forward-current transfer ratio and is equal to $I_{c}/I_{b}$, where $I_{b}$ is the base current and $I_{c}$ is the collector current. The values of $I_{b}$ and $I_{c}$, and hence the value of $h_{fe}$, can be found using the circuit shown in Fig. 6. It must be stressed, however, that $h_{fe}$ is not an absolute value. Instead, its value depends $I_{c}$ and $V_{CE}$.

continued on page 120
Using The Polapulse Battery

Ever wonder how to squeeze high power capacity into a very small space? Keep reading—we'll show you how.

FRED BLECHMAN

WHAT'S THE SIZE AND SHAPE OF A PLAYING CARD but can supply 100 mA of current for more than 20 hours? Polaroid's Polapulse power pack, that's what. It's a flat battery, originally designed for use in Polaroid's instant cameras; but now it's used in everything from computer terminals to portable TV's to stuffed animals. In this article we'll discuss several Polapulse batteries: their size and shape, how they work, their performance characteristics, experimental and real-world applications, and where to buy and salvage them.

The mechanics

There are several types of Polapulse batteries, all of which are high-capacity versions of the P70 flat battery that was originally developed in the late 1970's for the Polaroid 600 camera.

The P80 is a version of the original P70 that is available only to OEM's; it is used in the type 600 film pack. As shown in Fig. 1, the P80 is mounted on a card; it powers the camera's electronic flash, the film-advance motor, the shutter, and the sonar-based autofocus unit.

In 1980 Polaroid introduced the P100, shown in Fig. 2, a six-volt slim-line battery about the size of a playing card. The P100 uses Leclanche technology (discussed in the accompanying box.) If you remove the outer covering from a P100, you'll find a P80 inside, with a slightly modified contact mask. Therefore, it's no surprise that the performance of the P80 and that of the P100 are identical. In this article, unless otherwise specified, any reference to the P100 also includes the P80.

Later, in 1983, the P500 was introduced. It has the same size and shape as the P100, but a lot more power, because it uses lithium technology (also discussed in the accompanying box). Lithium cells are normally available only in small 3-volt coin or button cells, but Polaroid has flattened the construction and put lithium technology to good use.

In the P100 and the P500, both positive and negative terminals are mounted on one side of the battery. Front and side views of a spring contact suitable for making electrical connections with the battery are shown in Fig. 3-a and Fig. 3-b. The spring may be bent from a scrap of sheet metal; a special copper-nickel alloy contact strip is available from PowerCard Corporation, whose address is given later. A type-600 film pack, and P80, P100, and P500 batteries are shown in Fig. 4.

How it works

The Polapulse is a primary battery—it's not rechargeable. It's relatively expensive, so it's not practical in general-purpose substitute for carbon zinc, or alkaline batteries. However, the Polapulse battery is ideal for special applications where other batteries are too large, too heavy, or simply don't have enough energy capacity.

The Polapulse battery has a number of special features, including the following:

- It's very safe (see accompanying box).
- It delivers a great deal of power for its weight. The P80 weighs a little more than half an ounce, and the P100 weighs just under an ounce. The P500 lithium battery delivers as much as four times the energy of the P80 and P100, but weighs a little more than an ounce.
- Its voltage is very stable under heavy load. The P100 performs like an alkaline battery in its efficient use of chemical energy at low drain rates. But it's superior to alkaline batteries at a high rate of current drain, because it delivers high current with low internal resistance and fast voltage recovery.

Figure 5 shows a comparison of the voltage that is available from P100, alkaline, and carbon/zinc batteries at different load currents. The P100 is a six-volt battery, so it takes four series-connected AA alkaline or carbon/zinc cells to equal the P100's nominal output. The curves shown in Fig. 5 are based on a load that is drawn for 150 milliseconds every 15 seconds. Note that, at a load current of 1 amp, the P100 maintains more than six volts, but the alkaline cells drop to about five volts, and the carbon/zinc cells drop to about four volts. With a two-amp load, the P100 is still above 6 volts, but the alkalines have dropped to four volts, and the carbon/zinc cells to about 1.5 volts! Obviously, then, the P100 is far superior to the other types where voltage must be maintained at high load currents.

- It's hard to connect a Polapulse battery to a circuit incorrectly polarized, because both of the battery's terminals are mounted on the same side of the battery. That built-in polarity protection eliminates the need for protective diodes.

- Every Leclanche-type battery generates gases as part of its electrochemical
process. The Polapulse has a unique venting system that allows gas to escape via a special membrane that is permeable only to that gas.

- Polapulse batteries have high reliability because each one is inspected electrically and visually at assembly, and again after 90 days of controlled aging. The P100 commonly has a three-year shelf life, and the P500, a five-year shelf life.

- The technology is safe: There has been no known damage due to leakage from more than 500 million film packs!

**Construction**

The internal makeup of the P100 battery is shown in Fig. 6-a. It consists of a laminated stack of zinc and manganese-dioxide cells. The bottom sheet is a paper carrier. It’s followed by the anode collector (the negative contact), and an aluminum sheet lined with zinc-coated conductive plastic. A polymeric separator

---

**LECLANCHE BATTERIES**

The chemical system for generating electricity was invented by George Leclanche in 1862; his process is the basis of several types of battery, including the common carbon-zinc dry-cell battery. In the Leclanche system, zinc metal is the anode (the negative electrode), and a chemically inert electrical conductor produces electrical contact with a manganese-dioxide/carbon cathode (the positive electrode). Usually, that electrode is a carbon rod or a sheet of carbon particles with a binder. The nominal output is 1.5 volts.

The carbon is needed as an electrical conductor because manganese by itself is nearly an insulator. The carbon particles (usually "fluffy" acetylene black) also serve as a "sponge" to hold the electrolyte. The latter usually consists of a water solution of ammonium-chloride and zinc-chloride salts. The electrical path is provided by the movement of charged ions in the electrolyte. The grade of manganese dioxide used determines both price and performance of the cell.

The success of the Leclanche cell was due to the low-cost ingredients, stability and good shelf-life, and the portability of the closed-cell design. Further, zinc is a low-cost metal with many non-battery uses, and manganese is the eleventh most abundant element in the earth's crust.

Leclanche cells come in familiar cylindrical forms, and in flat cells used in layers to produce batteries like the popular snap-type nine-volt battery.

The cylindrical design consists of a zinc can coated inside with a thin electrolyte paste. Inside is a separator, usually paper, and then the "black mix" of manganese dioxide, carbon, and electrolyte. At the center is the carbon rod, which serves as the positive terminal.

In a flat cell, the negative terminal is a flat zinc plate that has an electrically conductive but chemically inert film of carbon and a binder that coats the other side. That side makes contact with the positive terminal of the next cell. Each cell has a nominal voltage of 1.5 volts. So, in a typical nine-volt battery, six flat cells are stacked in series and wrapped in a moisture-proof seal.

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**FIG. 1—DIMENSIONS OF POLAROID'S 600 film pack are shown here.**

**FIG. 2—DIMENSIONS of the P100 and the P500 batteries are shown here.**

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LITHIUM-BATTERY TECHNOLOGY

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THE NOMINAL OUTPUT OF A LITHIUM CELL IS 3.0 VOLTS; IT HAS A FLAT DISCHARGE CURVE; AND TEMPERATURE HAS LITTLE EFFECT ON OPERATING CHARACTERISTICS.

THE P500 USES A SPECIAL "DUPLEX" PACKAGE WITH THE ANODE AND THE CATHODE EFFECTIVELY IN SERIES TO PROVIDE A SIX-VOLT OUTPUT, AS SHOWN IN FIGURE 6-B OF THE ACcompanying ARTICLE.

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electrically conductive plastic sheet, the battery is not subject to the type of corrosion and leakage that is common to old-
style cylindrically shaped batteries.

The P500 lithium battery combines the high energy density and the high voltage of a lithium anode with a safe manganese-
dioxide cathode. Fig. 6-h shows how the P500 battery is built. Two three-volt lithium cells are packed into the same
space as the P100. A unique hermetic seal and careful manufacturing controls result in an expected minimum shelf life of five
years for the P500.

Temperature variation

Like most Leclanche batteries, the capacity of a P100 battery is affected by
temperature. Capacity is usually rated at
80°F. Figure 7 shows that, with a one-amp
drain, capacity drops to a little over 60% at 20°F. At 120°F, there's about 5% "ex-
tax." The P500 lithium battery is not signif-
ically affected by temperature.

FIG. 7—HIGHER TEMPERATURE Increases
available capacity from a P100.

P100 curves

The performance curves of the P100
shown here are based on a usage tem-
perature of 80°F. Bear in mind that, if the
temperature of your operating environ-
ment varies from 80°F, performance will
also vary. And keep in mind the fact that
some equipment generates heat as it oper-
ates; that heat will also affect operation.

The capacity of the Polapulse battery is
measured in milliampere-hours (mAh) at a
particular voltage with a constant cur-
rent drain. Figure 8 shows the mAh capacity
of a P100 battery at continuous current
drains of 1, 10, and 100 mA, and at 1 amp.
If you want to know how long a P100
could deliver ten mA before its output
dropped to five volts, follow the ten-mA
curve down to where it crosses the five-
volt line. Moving straight down, that's
about 150 on the mAh scale. Now divide
150 mAh by 10 mA, and you find that the
battery should last 15 hours.

Figure 9 provides the same information
in another way, but for a cut-off at 3
volts—the point where the P100 delivers
only three volts at the specified current.
For example, at 10 mA the curve shows
about 250 mAh of capacity. That's the
same value shown at the intersection of
the 10-mA curve and the three-volt scale
in Fig. 8.

P500 Curves

Figure 10 shows the performance
characteristics of the P500 lithium power
pack. Curves are shown for 5, 10, 20, 50,
100 and 150 mA. For example, at 10 mA,
the curve crosses the five-volt line at about
1200 mAh. Dividing 1200 by 10 gives
120, which means the P500 should
provide 120 hours of service at a constant
drain of 10 mA before output drops to five
volts.

Figure 11 shows the three-volt cutoff
point for the P500; that curve can be inter-
SAFETY INFORMATION

The following questions and answers were provided by Polapulse specifically regarding the Polapulse P100 battery:

Q. Are the chemicals used in the P100 toxic?
A. In tests where rats were fed the complete P100 chemical contents undiluted, no deaths resulted. Subsequent evaluation of internal organs showed no effect. The rats suffered no ill effects at the highest dosage level, which is the equivalent of a 100-pound person's eating 230 grams of the chemical, of which there are only 12 grams in a P100 battery.

However, all batteries contain material that is severely irritating to the eye. In case of accidental eye contact with the liquid from any battery, flush the eye with water for 15 minutes and contact a physician immediately.

Q. Will it leak or explode?
A. The P100 battery is nearly identical to the battery used in Polarium's SX-70 film packs. Hundreds of millions have been manufactured and used throughout the world with no reported leakage in normal use.

We have subjected the P100 battery to a variety of tests to simulate customer misuse, and in no case did the P100 battery leak or rupture explosively as other carbon-zinc batteries have been known to do. Some of those tests include the following:

- Electrical: Dead short for 24 hours; two batteries connected in reverse polarity; charging with a 9-volt dry-cell charger, and with a 12-volt, 4-amp auto-battery charger; placing across a 110-volt, 60-Hz power line.
- Heat: 48 hours in 190°F oven; placed in paper fire and gasoline fire; grilled in 1200°F flames.
- Mechanical abuse: crushing in trash compactor; stapling; puncture with screw and 1/4" rod; run over with full-size car; pressed between aluminum plates; flexure/torque tests; chewing and biting simulation.
- What will happen if I cut the battery with scissors?
A. Our tests show that the chemical contents, which are in the form of a gel, do not leak from the battery. One can force gel out of a cut battery by kneading it. When cutting an unused battery, the scissors will temporarily short the cells; then small sparks and slight heating will occur, and gel will adhere to the scissors.
- Can a shorted battery cause a fire or a burn?
A. In the event of a dead short, the surface temperature of the P100 battery rises to a maximum of about 63°C (145°F) in three minutes. That is too hot to hold comfortably, but not hot enough to burn the skin or ignite a fire. In some of our compaction and shorting tests, we attempted to make the battery light a fire. None occurred. However, deliberate shorting of any powerful 6-volt battery with a conductive combustible material can cause that material to ignite.
- Are there any problems with discarded P100 batteries?
A. Studies on disposal of charged and discharged P100 batteries show no problems in disposal, including trash compaction or incineration. Disposed of in normal quantities, the P100 poses no environmental problems and it can be mixed with household rubbish.
- How much mercury is in the battery, and is that amount of mercury hazardous?
A. The small quantity of mercury in the P100 battery creates no environmental or toxicity hazard. Maximum total mercury in the P100 battery is 50 mg—a bit more than a quarter of a drop. That is about four percent of the amount found in AA alkaline batteries of equivalent voltage. That small quantity is present in the form of an insoluble amalgam, similar to the silver-mercury amalgam used in dental fillings. If incinerated, the mercury will vaporize, but the small amount released is readily diluted in ambient air. The amalgam form impedes leaching of mercury from discarded batteries.
- Can I use the P100 battery in an explosive environment?
A. No six-volt battery capable of short-circuit current greater than 2.5 amperes (including normal lantern batteries and P100 batteries) is recommended for use in an explosive environment without special safeguards.

Polapulse batteries have found their way into a multitude of products. They can be used in series or in parallel to increase voltage or current capacity. In most cases, the P100 and the P500 are interchangeable, but the P500 provides more than four times the service life of the P100.

For example, the Polapulse battery has been used in a Hallmark musical greeting card, a Sears safety flasher, and an electronic kitchen scale. Sinclair uses a P500 in its new flat-screen pocket TV (shown in Fig. 12), where it provides 15 hours of use. A P100 can be used for about 2 hours.

The Exergen Corporation (307 West Central Street, Natick, MA 01760) makes several hand-held industrial instruments that use ultrasonic and infrared technology for distance and thermal measurements. Those instruments use the P100 for power.

The Rangescanner (shown in Fig. 13) is a high-accuracy ultrasonic tape measure with digital readout; it can provide instant measurements from 1 to 35 feet. The Microscanner (shown in Fig. 14) infrared unit instantly measures temperature in both scan or direct mode. The extension lenses can narrow the field of view to as little as 0.001" for long-distance temperature scanning. Exergen makes other devices that use the P100.

Meland Technologies, Inc. (5 Westchester Plaza, Elmsford, NY 10523) markets Access, a portable personal-computer terminal that is far smaller (8½ × 3½ × 1¼ inches) and more powerful than limited hand-held terminals.

Access has an 8-line × 40-character LCD display that windows a full 80-character by 24-line screen. In addition, Access has as much as 120K of memory, a full ASCII keyboard, and a telecommunications package built into the 24-ounce package. Small size, light weight, and dependable operation for extended periods of time were primary design parameters of Access, so it’s not surprising that the internal power source is a ship-in P500 Lithium Power Pack battery, good for 12 hours of continuous use.

IXO, Inc. (5757 Uplander Way, Culver City, CA 90230) offers an even smaller telecomputer. The TC200, is shown in Fig. 15. It is designed specially for use as a telex terminal, measures 7½ × 1½ × 4¼ inches, and weighs under a pound. The TC200 includes a P500 that provides power for one year of normal daily use, or 40 hours of continuous use. It includes a built-in modem and phone dialer, together with enough built-in programming and permanent memory to access any computer or data base from any telephone.

The single-line 16-character screen windows an 80-character line; 8000 characters may be retained in memory.

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Experimenter applications

The film pack of the Sun 600 camera is a perfect source for a Polapulse battery. The plastic frame of the film pack pulls apart easily; inside the frame is a P80 Polapulse battery neatly packaged in a cardboard holder. The "used" battery often has plenty of power remaining. In general, you can put a "used" P80 internal six-volt rechargeable battery pack of about anywhere you need a source of six-volt power. Any portable device that normally devours carbon/zinc batteries is a candidate for use with a P80.

Battery sources

The PowerCard Corporation (454 Brookline Street, Newton, MA 02159) is the exclusive distributor of Polaroid batteries. They sell the spring contacts mentioned earlier, as well as a series of "Designer Kits."

The P100 Designer Kit, Part Number 604155, contains five P100 batteries and a pre-wired plastic battery holder for $16.75, postpaid. The P500 kit, Part Number 606166 consists of two P500 batteries, two P100 batteries, and a pre-wired plastic battery holder for $22.50, postpaid.

For single battery needs, your local hobby shop may carry the P100 (for about $4 each), since it is used in model rocketry. You can also call Polaroid Customer Service at 1-800-225-1384 to purchase small quantities of the P100 ($3.50 each) or the P500 ($5.25 each).

Also, dealers that carry the Sinclair Flat Screen TV also offer three P500's for $9.95—which is less each than a P100 directly from Polaroid or from your local hobby shop! One source for P500 three-packs is Curry Computer (P.O. Box 5607, Glendale, AZ 85312-5607). One three-pack costs $10.95, postpaid.
All About A-to-D Converters

There's no mystery about the analog-to-digital converter. In this article we show you how it works and how to connect it to a microprocessor.

HARRY L. TRIETLEY

ADC types

There are five types of ADC's in general use: Voltage-to-Frequency (V/F), dual-slope integrating, successive-approximation, tracking, and parallel (or "flash") converters. Table 1 shows some of the strengths and weaknesses of each type.

Integrating and V/F converters are relatively slow, typically requiring from several milliseconds to a significant fraction of a second to perform a conversion. On the other hand, they're capable of high resolution at moderate cost, and they offer the additional advantage of inherent noise filtering. Dual-slope integrating A/D converters are widely used in digital voltmeters and in other single-input meters and instruments.

Successive-approximation converters are fairly fast, completing a conversion in one to several microseconds. Resolution is typically eight bits, which provides 2^8 or 256 discrete values. Some successive-approximation converters now provide twelve or even sixteen bits of resolution, which yield 4096 and 65,536 discrete values, respectively. The conversion time of a successive-approximation converter increases as the number of bits increases. Generally available units are fast enough to deal with signals having frequencies into the audio range. They're also good for quickly converting multiplexed, switched inputs often found in data-acquisition and other types of microprocessor applications.

The output of a tracking converter continuously follows its analog input. The tracking converter is slow, but it can follow small changes in input rapidly. It is easily modified to function as a track-and-hold or peak-reading device.

The parallel, or "flash" converter performs essentially instantaneous conversions. It is fast; some operate at fast as 100 MHz. Flash converters are mainly used for high-speed processing of video data in applications including radar, digital oscilloscopes, and digital TV. The disadvantage of the flash converter is that...
TABLE 1—A/D CONVERTERS

<table>
<thead>
<tr>
<th>Type</th>
<th>Speed</th>
<th>Resolution</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage-to-frequency converters</td>
<td>Several kHz to 100 kHz</td>
<td>Depends entirely on number of pulses counted or on resolution of period measurement.</td>
<td>Inexpensive</td>
</tr>
<tr>
<td>Integrating converters, including dual-slope integrators</td>
<td>Milliseconds to hundreds of milliseconds.</td>
<td>Typically $\frac{3}{2}$ to $\frac{5}{2}$ digits (11 to 18 bits)—higher possible.</td>
<td>Most common for high-accuracy digital meters.</td>
</tr>
<tr>
<td>Successive-approximation converters</td>
<td>1 to several microseconds.</td>
<td>Typically 8 to 12 bits, 16 bits available.</td>
<td>Widely used in microprocessor applications.</td>
</tr>
<tr>
<td>Tracking converters</td>
<td>1 microsecond or less per step; may be milliseconds for full-scale change.</td>
<td>Typically 8 to 12 bits, 16 bits available.</td>
<td>Good for track-and-hold or peak-reading applications.</td>
</tr>
<tr>
<td>Parallel (&quot;flash&quot;) converters</td>
<td>Sub-microsecond; up to $10^8$ conversions per second.</td>
<td>Typically 4 to 6 bits, 8 bits available.</td>
<td>Expensive. Used for video and other high-speed data.</td>
</tr>
</tbody>
</table>

The circuit complexity doubles with each added bit of resolution; hence resolution usually is low. Four to six bits of resolution is typical, although eight-bit units are commercially available.

A/D converters are available commercially in several forms, including integrated circuits, hybrid packages, and printed-circuit boards. Many include input/output interface circuits such as addressable-analog-input multiplexers, sample-and-hold circuits, and microprocessor interface circuits.

Now that we've got some idea of what each of the five types of A/D converters can do, let's see at each in detail.

**V/F converters**

A voltage-to-frequency converter is shown in Fig. 1. In that circuit, $R_{IN}$, $C_{INT}$, and the op-amp form an analog integrator. Negative feedback holds the non-inverting input at ground, so the current in $R_{IN}$ is equal to $V_{IN}/R_{IN}$. Op-amps have high input impedance, so all of $R_{IN}$'s current flows into $C_{INT}$, thereby charging it. As a result, the integrator's output charges linearly (in a negative direction) at a rate that is proportional to the input.

Meanwhile, reference capacitor $C_{RHF}$ is charged negatively by $V_{REF}$. When the integrator's output goes negative, the comparator sends a high to the pulse generator. The pulse generator's output operates switch $S_1$, and causes $C_{RHF}$ to discharge into the integrator's input. That discharge returns the op-amp's output to a positive level.

The op-amp's non-inverting input remains at ground, due to negative feedback, and that allows $C_{RHF}$ to discharge completely. The charge that leaves $C_{RHF}$ flows into $C_{INT}$, causing an output increase equal to:

$$\Delta V = V_{REF} \left( \frac{C_{REF}}{C_{INT}} \right)$$

(EQ. 1)

The time required for the output to return to zero comes from this equation:

$$\Delta V = \frac{1}{R_{IN} C_{INT}} (V_{IN} T)$$

(EQ. 2)

which may be rearranged as:

$$T = \frac{R_{IN} C_{INT} \Delta V}{V_{IN}}$$

(EQ. 3)

Because frequency is the inverse of period, that equation can be written like this:

$$f = \frac{V_{IN}}{R_{IN} C_{INT} \Delta V}$$

(EQ. 4)

Then, substituting equation 1 for $\Delta V$, we obtain:

$$f = \frac{V_{IN}}{R_{IN} C_{INT}} \cdot \frac{1}{V_{REF}} \cdot \frac{C_{INT}}{C_{REF}}$$

(EQ. 5)

which reduces to:

$$f = \frac{V_{IN}}{R_{IN} C_{REF}} \cdot \frac{1}{V_{REF}}$$

(EQ. 6)

Note that the circuit's output frequency depends on the input voltage, as well as reference voltage $V_{REF}$ and components $C_{RHF}$ and $R_{IN}$.

The digital representation of the analog input frequency is obtained by counting pulses for a period of time. The length of time depends upon the resolution required; for ten-bit resolution (about $0.1\%$ of full scale), time should be long enough to count 1,024 pulses at the full-scale frequency. Typical frequencies are tens of kHz; a ten-bit conversion at 10 kHz requires just over 10 ms. Each additional bit doubles the time requirement; however, extremely high resolution is possible at low cost. Of course, for best accuracy it is necessary to use high-grade components in the circuit.

When both high resolution and high speed are required, period may be measured, rather than frequency. Measuring period is accomplished by counting the number of pulses from a clock during one
Commerically available dual-slope integrating converters include circuit refinements not shown here. Most are able to convert both positive and negative inputs, and include an output line that indicates input polarity. They also contain sophisticated auto-zero circuitry that not only discharges the integrating capacitor but also compensates for input offset voltages of the op-amp and the comparator. Conversion rate depends on clock frequency and required resolution. Normally, a few conversions can be done per second.

Dual-slope integrating converters provide inherent noise filtering, since the input is filtered by the RC integrator. If the integration time \( t_1 \) is equal to a multiple of the power-line frequency, stray pickup is averaged to zero.

The combination of high accuracy, high resolution, and slow speed best suits dual-slope A/D converters to measuring steady or slowly changing quantities. They are most commonly used in instruments such as DVMs, digital thermometers, and digital panel indicators.

**Successive-approximation**

These are by far the most common A/D converters in computer and data-acquisition applications. They’re fast—conversion speeds of 100,000 or more per second are not uncommon—and that makes them ideal for digitizing several multiplexed analog inputs in a short time. IC-packaged devices are available with eight to twelve bits, accuracy ranges from 0.125% to 0.020%. Sixteen-bit hybrid devices are also available.

The theory of operation is straightforward. Figure 4 illustrates the principle, and Fig. 5 shows a typical sequence for a four-bit converter. A comparator compares the analog input signal to the output of a Digital-to-Analog (D/A) converter, which, in turn, is controlled by logic circuitry known as a Successive Approximation Register (SAR).

The circuitry inside a SAR can be quite complex. However, single-IC SAR’s are available, so design is simplified. Under clock control, the SAR outputs are set to zero. Assuming the input is positive, the SAR then turns on the first (most significant) bit. If the comparator decides that the D/A’s output is less than the input, that bit is left on; otherwise it’s turned off. That same process is carried out on each bit in turn, until the least-significant bit has been compared. Then the DATA VALID line from the converter indicates that the the conversion is finished.

In the example shown, \( V_{IN} \) is about ten volts. First bit eight is turned on and left on, because eight is less than ten. Then bit seven is turned on and then turned back off, because twelve is greater than ten. The process continues until the combination of bits equals the input voltage.

The example circuit can handle only

---

**FIG. 2**—IN A DUAL-SLOPE INTEGRATING A/D CONVERTER, \( C_{INT} \) is charged and then discharged. The discharge time, which is proportional to the input voltage, is counted and latched for output.

**FIG. 3**—BY COUNTING THE NUMBER OF PULSES between \( t_1 \) and \( t_2 \), a digital representation of the analog input is obtained.
positive inputs. If bipolar operation is required, an offset equal to 50% of full scale must be added to the comparator’s reference input. That results in an offset binary code; in our four-bit example, 1000 equals zero, 1111 equals 7, and 0000 equals -8.

We won’t go into the workings of the SAR, except to say that it usually consists of a shift register and other logic circuitry. But we will discuss the D/A converter, because those are useful for converting computer outputs into analog signals.

D/A converter

The most common arrangement, shown in Fig. 6, uses a series of solid-state switches and a resistive ladder network (known as an R-2R network, because the 2R resistors have twice the resistance of the R resistors). Each switch, when connected to \( V_{\text{REF}} \), increases the amount of current entering the inverting input of the op-amp. The switches are usually weighted according to binary value. (Other weightings, such as binary-coded decimal, are possible, but will not be discussed here.)

To understand how the ladder works, suppose that \( S_4 \) is connected to \( V_{\text{REF}} \), and that the others are grounded. Since the op-amp’s inverting input is maintained by feedback at ground, the input current comes entirely from the 2R resistor connected to \( S_4 \), that current equals \( V_{\text{REF}}/2R \). In addition, that current flows through the op-amp’s feedback resistor, which also has a value of \( R \). The output voltage is then equal to \(-1\cdot R \), which equals \( -(V_{\text{REF}}/2R)\cdot R \), which equals \( -(V_{\text{REF}}/2) \).

Now, imagine instead that only bit 2 is turned on. By combining resistors in parallel and in series, you can see, as shown in Fig. 7-a, that the equivalent resistance of all the resistors to the left of the bit 2 position is \( 2R \). The voltage divider composed of \( V_{\text{REF}} \) and the \( 2R \) resistors can be further simplified to a single resistor, \( R \), and a voltage equal to \( 1/2 V_{\text{REF}} \), as shown in Fig. 7-b. The circuit is thus equivalent to a simple inverting amplifier with a gain of \(-1\).

Similar (but more complex) analysis shows that bit 3 contributes \(-V_{\text{REF}}/8 \), and bit 4, \(-V_{\text{REF}}/16 \). Furthermore, the individual contributions may be summed together when more than one switch is on.
FIG. 8— IN A TRACKING A/D CONVERTER, the comparator controls operation of the up/down counter which in turn controls a D/A converter. The output of the latter is what is compared to the input signal.

FIG. 9— THE FLASH CONVERTER makes all comparisons at once, so it can operate at extremely high speeds. The disadvantage is circuit complexity.

The total output is an analog voltage that is proportional to the digital value of the 4-bit word.

Keeping the basics of D/A converters in mind, now let's resume our discussion of the successive-approximation converter.

In that type of ADC, a complete conversion takes only a few clock cycles, so conversion can occur in microseconds. Unlike integrating converters, however, it is mandatory that the input remain steady and noise-free throughout the conversion. If the value of the input changes from one comparison to the next, erroneous comparisons will take place, possibly resulting in erroneous outputs. For that reason, the successive-approximation converter is usually preceded by a sample-and-hold circuit. In fact, some IC and hybrid devices include a built-in sample-and-hold circuit.

The demands on the ladder network and switches in the D/A converter double with each added bit. Precision is critical; at no point must an increasing digital signal result in a decreasing analog output signal. The resistor ratios and their temperature tracking must be no worse than ±1 LSB (Least Significant Bit). In an eight-bit converter, ±1 LSB equals 0.25%; at twelve bits that becomes 0.025%; and at sixteen bits, less than 0.002%. The "off" leakage and the "on" resistance of the analog switches must be closely matched (or compensated for). High resolution carries a high price tag; the practical limit is about 16 bits. By contrast, dual-slope integration can readily be carried out to an accuracy of one count in a million (20 bits).

Tracking converters

The tracking A/D converter diagrammed in Fig. 8, provides nearly instantaneous tracking of small input changes. Like the successive-approximation converter, the tracking converter compares the input to a signal fed back from a D/A converter driven by the digital output.

Logic gates controlled by the output of the comparator direct pulses from a clock to an up/down counter, causing the count to increase if the input is greater than the feedback voltage or to decrease if it is less. Unlike the other converters discussed so far, the digital output will track a one-bit change in the input in just one clock cycle. Noise will be followed just as any other input, but will not result in erroneous output codes. Tracking of large changes is slow: a twelve-bit converter requires 4096 clock pulses to go from zero to full scale. The accuracy of components in the D/A converter must be high, as with the successive-approximation converter.

Tracking converters are not often used for conventional data acquisition, but are useful in track-and-hold applications, in which an input signal is followed until the clock is disabled by an external logic input. Tracking converters also make excellent peak-reading devices. By disabling the counter's down input, the converter will follow input increases and hold the highest reading until a new input exceeds it (or unit the counter is reset to zero).

Parallel converters

Easy to understand but expensive to build, a parallel converter provides almost instantaneous A/D conversion (hence the nickname flash converter). The basic circuit, shown in Fig. 9, uses a precision voltage divider to create a series of equal reference voltage increments. A bank of comparators compares each of those voltages to the input voltage, and each turns on when the input exceeds its particular reference. If each of the comparators drove a lamp or LED, a bar-graph type display would result.
An array of logic gates combines those outputs to form the desired digital output code (binary, BCD, etc.). In the circuit shown no clock is required; however, in most applications it is necessary to clock the output into a digital latch in order to hold the reading steady while it is read by a computer or microprocessor. Sampling rates of 10 or 20 MHz are common, and at least one commercially available IC function as fast as 100 MHz.

Circuit complexity essentially doubles with each added bit. A one-bit converter requires one comparator, two bits require three comparators, three bits require seven comparators, etc. The complexity of the gate array similarly increases. It is circuit complexity, rather than component accuracy, that limits the size of parallel A/D converters. Six-bit flash converters (which require 63 comparators) are common; eight-bit units (which require 255 comparators) are available.

The number of bits of resolution can be doubled using a "half-flash" or two-step flash converter. As shown in Fig. 10, doubling is done by using separate circuits for the most and the least significant parts of the analog input. Conversion time is doubled using that approach.

The analog input is applied to the first comparator string to determine the most significant part of the input signal. The output of the first gate array is converted to analog form and subtracted from the input to obtain the least significant part. That signal is applied to a second string of comparators to produce the LSB outputs.

A word of caution: you cannot make an accurate twelve-bit converter from two six-bit flash converters. The first comparator string (and the D/A converter) must provide enough accuracy that the difference signal's error is no more than one LSB. The accuracy requirement makes the two-step flash converter somewhat expensive. But all flash converters are expensive.

Microprocessor interface

A/D converters operate sequentially, periodically updating their outputs, and generally producing incorrect (or no) outputs between conversions. Computers also operate sequentially according to a programmed set of instructions, and may not necessarily be able to receive data when the converter is ready to send it. Therefore, communications must proceed according to a defined sequence. The process is often called handshake.

Figure 11 shows the basic interface circuit. First the microprocessor must select the A/D converter through its addressing mechanism. Then it sends the ADC a signal (converter) that tells it to start its conversion cycle. Conversion requires some time to complete, so the microprocessor waits for it to finish. When it does, the DATA READY signal informs the microprocessor that conversion is complete. After which time it can re-address the ADC and read its output via the data bus.

The whole process may be interrupt driven. In that case, the DATA READY line is connected to an interrupt input on the microprocessor. Then, assuming the software is set up to recognize and process the interrupt, any time a conversion is complete, the microprocessor will stop its current task, read the ADC data, store it, and then resume the previous task. The previous task and the data-gathering task may be totally unrelated.

Data-bus width can be a problem. If you use a twelve-bit converter with an eight-bit data bus, two reads will be necessary in order to capture all bits. In fact, a third read may be necessary in order to capture internal status bits and flags.

Control and output lines vary from converter to converter. With some the actual functions vary, and with others, only the name differs.

Control inputs generally include one or more lines (called chip select or chip enable, for example) to address the IC. Other control pins activate the outputs. Different IC's vary greatly in output control. For example, there may be HIGH BYTE ENABLE and LOW BYTE ENABLE pins. But there is not universal agreement about how bits in a twelve-bit converter, for example, should be split. In some, the
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FIG. 12—SEVERAL A/D CONVERTERS may be connected to a single microprocessor as shown here. The circuit could be expanded by providing more decoded addresses.
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<th>Screwdriver, offset, slotted</th>
<th>Solder removal tool*</th>
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<td>Screwdriver, pocket-clip, Phillips</td>
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<td>Pliers, diagonal cutter, 5/16&quot;</td>
<td>Screwdriver, pocket-clip, slotted</td>
<td>Soldering iron</td>
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<tr>
<td>Handle for driver blades, 4 1/2&quot;</td>
<td>Pliers, long nose, 4 3/4&quot;</td>
<td>Screwdriver blade, Phillips #1</td>
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<td>Scissors, thinline, 5&quot;**</td>
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These versatile containers are "lined" with 2" of foam on all sides and you can add additional foam to customize them to fit the equipment you are shipping. Permanent white finish won't chip or rub off, is impervious to solvents.

JRE-377B165 Container, 23¾ x 15 x 11" . . . $179.00
JRE-377B155 Container, 18¼ x 16¼ x 13" . . . 189.00
JRE-377B175 Container, 22¾ x 23¾ x 14" . . . 219.00

Rust-Proof, Dent-Proof Six Drawer Storage Chest Has 47 Compartments

This handsome chest has plenty of room for convenient storage of precision tools, small parts and components. Constructed of tough, durable rust-proof polypropylene to provide years of dependable service. Drawers are easily removable and have tongue and groove rails and fingertip releases. The front cover has padlock tab to secure cabinet when closed, can be used as bottom tray when chest is open. Other features are non-slip rubber feet, twin latches, luggage-style handle. Overall dimensions: 19½ x 10½ x 15". Color: Mahogany and Birch Tan with Orange drawers.

JRE-352B762 Six Drawer Chest . . . $79.95

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Protect your cameras, delicate equipment!

 Blow-molded double-wall high density polyethylene construction combines strength and toughness with light weight. Multi-layer polyester foam in bottom is cut in checkerboard pattern. Just remove foam cubes to custom-fit your gear. No need for cutting or replacing foam to hold varying size equipment. Simply shift location of foam cubes. Convoluted foam in lid provides additional protection. Other features: luggage style handle, metal latches with key locks, textured Black finish. Four sizes to choose from, inside dimensions given.

JRE-889B860 16½ x 12½ x 5" Case . . . $49.00
JRE-889B070 18½ x 14½ x 6" Case . . . 59.00
JRE-889B350 21¼ x 16½ x 5" Case . . . 69.00
JRE-889B375 21¼ x 16½ x 6½" Case . . . 75.00

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Fast, Safe, Dependable Self-Igniting Micro Torch

The Blazer provides instant push-button ignition every time. Ignites from built-in piezo electronic starter. Two adjustment valves provide precise control of 2500°F flame for pinpoint soldering, brazing, welding, etc. Delivers up to two hours from butane gas cylinder. Can be refilled from a butane cigarette lighter canister. Sturdy brass body with rubber cushioned grip to fit comfortably in the hand. Or you can use it "hands-free" by setting your Blazer upright in the included removable stand. Made in Japan.

JRE-680B201 Blazer Torch . . . $49.95

Portasol Portable Gas Soldering Iron

★ Runs On Ordinary Butane Lighter Fuel
This lightweight, portable soldering iron can be carried in your pocket like a pen. Delivers power equivalent to a 60-watt electric iron without hookups or trailing cord. Provides adjustable tip temperature of up to 400°C (752°F) for fast, efficient soldering. Patented catalytic converter provides heating at the tip without flame during soldering. Can be refilled with ordinary butane lighter fuel in seconds and delivers up to 60 minutes of continuous use from one filling. Protective cap includes lighter to start catalytic conversion. Iron comes complete with 2.4mm chisel tip. Made in Ireland.

JRE-149B100 Gas Soldering Iron . . . $29.95

JENSEN* Soldering Accessory Kit

★ Everything you need in one compact kit
This handy kit contains the basic accessories most often used during soldering/desoldering operations. The central item in the kit is a low static desoldering tool for safe and efficient solder removal. Also included is a fork/reamer soldering aid, a reverse action tweezer, a lead former, a flux brush, and a 6" hemostat. The tools are contained in an 8½ x 10" vinyl roll pouch which fits easily in tool case or workbench drawer.

JRE-23B350 Soldering Accessory Kit . . . $19.95

Precision Tweezer Kit

★ Imported from Switzerland
We selected the six most popular stainless steel RUBIS tweezers and packaged them in a velvet-lined, deluxe padded vinyl zipper case for protection and ease of accessibility. This kit is ideal for instrument assembly, watchmaking, laboratory operations and many more microelectronic tasks. Included are the following styles: Style 00, 2A, 3, 6, 7 and 524.

JRE-23B580 Tweezer Kit . . . $58.00
JRE-54B168 Zipper Case only . . . 10.00

Master Ultratorch 3 Portable 3-In-1 Soldering/Heat Tool

This compact, cordless butane gas powered tool is a combination soldering iron, flameless heat tool and torch. Perfect for field service maintenance as no AC current or batteries are required.

The Ultratorch burns ordinary butane lighter fuel to generate infra-red and ultra-infra-red heat by means of a unique catalytic combustion system. Fingertip controls let you adjust the temperature from 394 to 932°F for soldering; to 1292°F for heat shrinking; to 2372°F for use as a torch. Operates up to 3 hours at 700°F on a single filling.

Comes complete with soldering/heat ejection, torch ejection, tapered needle soldering tip, heat tip, solder sponge, tip cleaner and spanner wrench. Japanese import.

JRE-10B700 Ultratorch* 3 . . . $68.95

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Finest quality production line soldering iron made for Jensen by a leading U.S. manufacturer. Combines light weight balanced design, fast heating action, comfort grip handle, 3-wire proof cord, and long-life plated screw-on tips. The 23-watt heating element and 13° chisel tip are included. All replacement components are interchangeable.

JRE-46B723 Jensen 23-watt iron . . . $17.50

JENSEN* "D-SOD-R" Tools

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★ Standard and Micro Models
★ Regular and Anti-Static Styles

Now from Jensen, an economical line of precision desoldering tools. Feature evenly balanced all-metal body with one-hand plunger action and easy pushbutton release. Double "O" ring seals assure maximum suction for fast, efficient desoldering. Choose from standard (8") or Micro (6½") models in regular or anti-static styles. Replacement tips and repair parts are also available. Made in Mexico.

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JRE-983B300 Micro tool, Teflon tip . . . 8.95
JRE-983B300 Std. tool, A-S tip . . . 9.95
JRE-983B990 Micro tool, A-S tip . . . 10.95

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Shows the intensity and polarity of static charges on surfaces without touching them. Reads directly, in kilovolts, the charge on the test surface. Indispensable in the detection, monitoring and control of potentially harmful or destructive static charges in work areas where sensitive CMOS electronic devices, explosives or flammables are encountered. Range 0 to ±5 kilovolts, full scale at 6-inch distance. 0 to ±10 kilovolts at 12-inches. Accuracy ±10%. Powered by two 9V batteries (included). One year repair/replacement warranty. Dimensions: 4¾ x 2¾ x 1¼".

JRE-801B121 Static Meter . . . $295.00

**JTK-33™ Executive Tool Kit**

- Compact size
- Padded, leather-like vinyl case
- Complete selection of essential tools

This Executive Tool Kit contains a select assortment of top quality American-made tools designed to perform a wide variety of jobs. Yet the complete kit is no larger than a textbook for easy portability and storage.

The tool selection includes pliers, screwdrivers, tape measure, hex keys, pocket knife, adjustable wrench, 13-piece socket set, AC/DC circuit tester and more (see complete listing).

The compact 9 x 7 x 2" case is constructed of handsome leather-like vinyl with padded sides, heavy-duty zipper and 13 pouches to hold the tools securely. There is also a Velcro® closure pocket for storing the tape measure and hex key set.

JRE-33 JTK-33 Executive Tool Kit . . . $189.00
JRE-548132 Tool Case Only . . . 18.00

The Executive Tool Kit includes these fine tools:

- Adapter, ¼" Hex—¼" Sq
- Circuit tester, AC/DC
- Hammer/Screwdriver Set, 5-piece
- Hex Key Set, 10-piece
- Knife, pocket, two blade
- Pliers, chain nose, 4¼" Pliers, diagonal cutter, 4¼" Pliers, slip-joint, 5" Pliers, Vise Grip, 6" Rule, stainless steel, 6" Screwdriver, magnetic, 5-in-1
- Screwdriver, Phillips, #0, pocket clip
- Screwdriver, slotted, ⅜". pocket clip
- Screwdriver, stubby, 2-in-1 driver
- Socket Set, 13 pc.
- Tape measure, inch/metric, 6'
- Wrench, adj. 6'
- Zipper Tool Case

**Charge-Guard™ Static Control Wrist Straps**

Comfortable wrist straps dissipate the static charge normally found on personnel before static can damage devices. Feature silver-plated mono-filament fibers woven within the elastic band. The result is a highly conductive, corrosion-resistant band which gently conforms to the wrist for reliable contact to ground. Insulative outer surface reduces the chance of accidental injury to personnel. A 5-foot coil type ground cord (w/1 megohm resistor) terminated with an alligator clip, a Charge-Guard™ wrist strap complete with a 5-foot coiled ground cord (w/1 megohm resistor) and one large and one small wrist band. Kit folds to 8½ x 12 x 1¼". Stores easily in case or drawer.

JRE-872B805 Static Control Kit . . . $48.50

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Compact, portable kit provides electrostatic protection of static sensitive components in the field service environment. Includes a 10 mil, 24 x 24" conductive Velostat® workmat with two built-in storage pouches, a 15-foot ground cord (w/1 megohm resistor) terminated with an alligator clip, a Charge-Guard™ wrist strap complete with a 5-foot coiled ground cord (w/1 megohm resistor) and one large and one small wrist band. Kit folds to 8½ x 12 x 1¼". Stores easily in case or drawer.

JRE-872B805 Static Control Kit . . . $48.50

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Rugged Super-Tough cases made of high density polyethylene with top, bottom and sides covered with pink-poly foam to provide both anti-static and physical protection. Regular size accommodates up to twelve 11½ x 9" partitions to divide the case side-to-side or up to nine 15 x 9" partitions to divide the case front-to-back. Overall inside dimensions: 17¾ x 14½ x 10½" (usable, 15 x 11½ x 9")

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JRE-377B930 Reg. PC Board Case Only . . . $159.00
JRE-377B950 Large PC Board Case Only . . . $189.00
JRE-377B904 Four, 9 x 11¾" partitions . . . 15.00
JRE-377B903 Three, 9 x 15" partitions . . . 15.00
JRE-377B902 Three, 15 x 12" partitions . . . 20.00

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Portable, pocket-size test provides access to all 25 conductors of the EIA RS-232C and CCITT interface between the data terminal and the data modem. Twelve LED's monitor the status at the source of twelve primary signals, and two additional LED's sense either positive or negative voltage levels greater than ±3V and may be used to monitor any selected signal. Twenty-four miniature switches allow all interface conductors (except frame ground on pin 1) to be individually interrupted allowing isolated testing and observation of terminal or modem signals. Pins on each side of each switch and small jumper cables are provided to allow cross-patching and monitoring of signals. Power is supplied by two penlite batteries (included). Lifetime factory warranty. Dimensions: 3.75 x 5 x 1.75".

JRE-822B066 Interface Monitor...$159.00

Datacheck I
RS-232C Breakout Box

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A compact, light-weight, communication line monitoring device that may be used either "stand alone" to examine a serial data port or "in-line" for continuous monitoring of data/control lines. Thirteen dual-color LED's indicate the condition of the signal under test. A "Red" signal voltage equates to ≤ -3 volts (marking) and a "Green" signal voltage equates to ≥ +3 volts (spacing). No light from an LED equates to an indeterminate signal voltage condition ( > ±3V ). The 50 patch pins and 25 switches allow the device to be used as a breakout box for the various EIA signals. This allows connection of incompatible equipment types over a straight-through EIA interconnect cable. The breakout box may be used to facilitate this interconnection without the recourse of constructing a special cable. Line powered. Dimensions: 3.3 x 5.1 x 0.8". Comes with 10" male to female ribbon cable, a jumper set (6 straight and one T-Jumper) and padded case.

JRE-862B232 Line Tester...$159.00

JENSEN
RS-232/RS-449 Connector Kit

The answer to on-site fabrication and maintenance of RS-232 and RS-449 cable connectors. This unique kit contains all necessary components needed to repair or fabricate 9 pin, 25 pin and 37 pin connectors to meet RS-232 and RS-449 requirements. The kit includes 6 plugs and 3 receptacles in each configuration (9 pin, 25 pin, 37 pin), 6 each hood assemblies in each configuration (9 pin, 25 pin, 37 pin), 100 each gold-plated #20 DM contact pins and sockets, 50 cable ties and an insertion/extraction tool. Kit is packaged in a 21-compartment meta' box.

JRE-808249 RS-232/RS-449 Kit...$199.00

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RS-232
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Lets you instantly inter-connect computers, terminals, modems, printers and other RS-232 interfaced devices with just one cable. Just a flick of the switch and the unique on-board computer circuitry looks at the RS-232 interface on both the computer and the peripheral and then correctly connects the interface together. All open outputs are enabled. Monitors hand-shake lines required for bi-directional data transfer. Eliminates the need for breakout boxes, custom cables, etc. The Smart Cable has indicators that point out which device is disabling data transfer when needed. Dimensions: 3½ x 2½ x 2½". Connectors: Dual Male/Female connectors on free end of ribbon cable; Order 9708870 for male connector or 9708875 for female connector on Smart Cable body.

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Contact Insertion and Removal Kits

Insert and remove contacts on all types of connectors conforming to MIL-C-26482 and MIL-C-26500: Amphenol, Bendix, Burndy, Cannon, Cinch, Continental, Deutsch, Elco, Flight, Pyle National, etc. Handles properly shaped for gripping with strong durable tool steel probes. Tools color-coded for easy identification of contact sizes. 3-piece kits consist of one each of size 12 (yellow), 16 (blue), 20 (red) tools in zipper case. For front release contacts.

JRE-924B263 Contact Insertion Kit...$70.00
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The most versatile case you’ll ever own!

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JRE-612B030 Free with order of $75.00 or more.

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This special kit contains a selection of precision tools manufactured to extremely fine tolerances and designed for critical adjustments of VHS and Beta videocassette recorders.

Includes a base plate reference jig and a height gauge, used together for precision height adjustment of the reel discs, guide posts, tape transport, pinch wheel, audio, synchronization and erase heads.

Also included is an 8-piece driver/wrench set with precisely configured bits for adjusting the tape feed guide, tape tension heads, tape transport, audio and control heads.

The tools are furnished in a padded Gray vinyl zipper case with elastic straps to hold the drivers and height gauge. A Velcro closure pouch holds the base plate reference jig. Case size: 10 x 8 x 1 ½”.

JRE-23B840 VCR Alignment Kit . . . $166.00
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Practical descrambling

The M/A-Com TV-signal scrambling system known as Videocipher has been breached. As of early November, there are no fewer than six techniques that claim significant or total success in busting Videocipher. Information and equipment are being offered in the marketplace, but not in the U.S. as yet. The reason is fear. There are several laws that appear to apply to the marketing of bootleg scramblers, and it is feared that anyone who attempts to market such equipment would be promptly hauled into court.

Of the busting techniques, some are software-oriented, and use an EPROM (Erasable Programmable Read-Only Memory) to re-instruct Videocipher what to do and when. Other techniques are hardware solutions designed to work around the encryption process. However, none of the techniques developed so far are foolproof.

Cloning

Let's talk about Videocipher hardware. Inside device U7, a TI microprocessor, are several bytes of RAM. In that RAM resides each unit's unique authorization-code number. That number is addressed via the satellite link. When the transmitted address matches the internal, locked-away, and protected address, the Videocipher responds to commands that follow the matching of the authorization code.

The microprocessor has a lithium battery to keep its RAM memory intact during power-down, and attempts to go inside and read its data proved fruitless at first. But then a researcher found a technique for extracting those bytes without penetrating the IC. At that point the code number could be accessed.

The ID-number data stream can be decoded with software to make it usable with other VC2000's. In fact, a technique was created to allow the authorization information from one Videocipher to be transferred to another (and another, etc.) Videocipher. The process involves taking the authorization information extracted from one device, burning it into an external EPROM, and then using the new EPROM to authorize additional devices. As shown in Fig. 1, the new EPROM clips to the Videocipher circuit board.

FIG. 1

Using that approach, one VC2000 pays for services (HBO et al) and then shares its authorization code with other non-paying units. If you inspected two or more such devices, you would discover they all have the same on-screen ID number; the reason is that the clones are functionally identical to the original (master) unit. The clone system is now being marketed outside the U.S.

Tiering

The same authorization information, extracted from U7 through an indirect route, can also be massaged by software to create "tiering." For example, say the unit in question pays for CNN ($25 per year). After the authorization information is extracted and rewritten, it is reloaded into the same VC2000, but now the VC2000 will decode all the scrambled services, not just the paid-for CNN. That approach is being marketed in Latin America.

A variation of those approaches appeared in British Columbia in mid-fall. A customer has his or her VC2000 re-worked so that U30 is replaced with a socket, and an additional socket is mounted on the rear panel of the VC2000. The customer goes to the friendly neighborhood authorization center to have a 2716 EPROM re-authorized on or around the first of each month. Of course, a fee is paid for that bootleg authorization, but the fees significantly lower than the normal charges of HBO et al.

Dangers

At the moment, all the techniques mentioned above seem invulnerable to anything that M/A-Com might do via their satellite data stream. In other words, to ensure against bootleg reception, legitimate decoders currently in the field apparently would require factory modifications.
Cloning and tiering work because some very clever software people have been able to locate holes in the original Videocipher software. Any or all of those holes could be sealed if M/A-Com found them. Videocipher descramblers already in the field would not be affected, but all future units would be affected, and most likely corrected. In addition, after working out the bugs, M/A-Com could recall all existing devices and change their software as well.

Neither cloning nor tiering leaves a trail. In M/A-Com's hands a recalled device would be indistinguishable from one that was factory stock. However, the Canadian approach is traceable, of course, because of the outboard EPROM socket.

If M/A-Com obtained a unit that was part of a cloning network, it would identify itself with the clone's ID, not the factory-original ID. The number would appear to be genuine, but if there were any suspicion of unauthorized activities, M/A-Com could shut it down through the uplink authorization center. Of course, any devices sharing that ID would also become de-activated.

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**Interested in TVRO?**

For nearly two years Bob Cooper has provided a no-charge kit of printed materials that describes the challenges of opportunities in selling TVRO systems. With the present intense interest in scrambling systems, Coop's CSD has made available a new no-charge service. The SCRAMBLE FAX hotline is a 24-hour per-day telephone service that provides accurate, detailed, and hard-to-find facts concerning the changeover to scrambling in the satellite communications industry. Information describing satellite receivers tested for scrambling compatibility, sources for authorized descramblers, wholesale rates of scrambling equipment and services—all are provided on the SCRAMBLE FAX hotline. There is no charge for that service, other than your long-distance telephone expenses. Simply dial (305) 771-0575 for a concise and timely three-minute capsule report that covers the latest in scrambling news.

**Finances**

Cloners typically charge a $600 fee to extract the authorization number from the master Videocipher. Then a per-clone fee is also charged, around $300 apiece. It costs about $650 per year to receive HBO, Cinemax, CNN, WGN, WTBS, Showtime, The Movie Channel, and SelectTV. If there are 25 clones sharing the master unit's ID, that makes a total of 26 paying $25 each per year ($650/26). If the owner of the master charges $300 per year for services valued at $650, he makes a profit of $275 ($300-$25) per unit per year, and the consumer is getting his services for less than half price, not counting the hardware.

Of course, all that is very upsetting to the firms who manufacture Videocipher, and to those who sell programming. Strict U.S. laws appear to forbid marketing descramblers inside the U.S., but in Canada, Latin America, and the Caribbean the laws are much less specific. Next time, we'll turn our attention to some hardware descrambling techniques.
The joys of equalization

LAST TIME WE DISCUSSED SIGNAL PROCESSORS AND SOME OF THE CONFESSIONS ABOUT WHAT THEY DO, HOW THEY DO IT, AND WHY YOU MIGHT WANT IT DONE. I INDICATED THAT THE MAJOR PROBLEMS IN AUDIO REPRODUCTION ARE NOISE, DYNAMIC-RANGE LIMITATIONS, FREQUENCY BALANCE, AND IMAGING. WE ALSO TALKED ABOUT NOISE AND DYNAMIC RANGE; NOW LET'S LOOK AT FREQUENCY BALANCE AND SEE WHAT AN EQUALIZER CAN DO TO HELP.

Balance and equalization

A loudspeaker designer once said to me that, in his experience, differences in frequency balance are 95% of the reasons why audio products sound different. I agree with him, even though I know that many audiophiles, and some engineers, prefer to make other more esoteric factors—such as the crystalline structure of the copper in their cables or the dielectric constants of their amplifier's capacitors—primarily responsible for whatever differences are heard.

In any case, the sonic phenomena that trouble (or enhance) an audio system are mostly dips, peaks, or slopes in frequency response. Those aberrations come about for electrical, acoustic, and psychoacoustic reasons, and they are translated by the ear into a large variety of positive and negative effects, which are heard as colorations, crispness, nasality, openness, glassiness, muddiness, harshness, etc. Anybody who spends time playing with a good ten-band equalizer can prove all that for himself.

Some audiophiles bad-mouth equalizers, claiming that they introduce more audible problems than they solve. That might have been true at one time—how many readers remember the Blonder-Tongue Audio Baton from the late 1950's—but today's better units are clearly free of any audible problems.

FIG. 1

Why would anyone want an equalizer in his system, aside from the pleasure of owning a component with more than twenty control knobs? I've had equalizers in my systems—usually as part of the preamp—since the 1960's, and I would feel lost without one. As I said last time, even in the unlikely event that you are blessed with a perfect-sounding audio system, the program material you are playing in that ideal system is likely to be flawed in a number of ways. An equalizer can help improve the sound of program-source material—and, if needed, loudspeakers and listening-room acoustics.

A typical equalizer, the Technics model SH-8046, is shown in Fig. 1. Note the bar-graph display that shows the cut and boost applied.

FM tuners

The FCC requires that a high-frequency equalization boost (called preemphasis) be applied during the FM broadcast process. Its purpose is to minimize hiss during FM reception by means of a complementary high-frequency deemphasis circuit built into all FM tuners.

Unfortunately, preemphasis makes it difficult to broadcast high-frequency audio at its natural strength without overloading the broadcast transmitter. Therefore, most stations—even classical ones—are forced to cut back on the high-frequency content of their records, tapes, and CDs before broadcast.

A more natural treble level can be restored by boosting the 8-and 16-kHz controls until cymbals, high-hats, harps, and guitars sound natural. The 8-kHz slider will probably need to be raised only slightly: the 16-kHz slider at least halfway. (The control bands referred to are typical of those found on most ten-band octave equalizers.) Since stations vary as to how they handle their preemphasis problem, the optimum setting for a system will vary from station to station. But you should be able to find a good compromise that will make most stations sound better.

Record players

The frequency responses of phonograph cartridges vary from unit to unit, as does the capacitance of record-player leads and phono inputs. Most important is the variation, from record to record, in frequency balance. An equalizer can compensate for all those factors simultaneously. Shrihillness can be eliminated (or openness and detail restored) with the 8- and 16-kHz controls; bass muddiness can be minimized (or warmth added) with the 125-Hz control; and low bass can be add-
ed (or low-frequency noise can be reduced) with the 32- and 64-Hz controls.

Cassette players
Hiss can usually be reduced by cutting back on the 8- and 16-kHz controls. The trick is to adjust for maximum attenuation of hiss with minimum loss of music. Weak bass is sometimes a problem; it can be helped by boosting the 64-Hz control.

You can usually improve the sound of tapes to be played in your car by recording them with some bass boost at 64 Hz and 125 Hz, and with some treble boost at 8 kHz and above. Trial and error will be necessary to determine what sounds best with a specific type of tape in a specific car.

One potential problem is low-bass block. Some home and car cassette players react badly to recordings with very low bass or with the very low frequencies produced by record warps. If a player "blocks" or distorts on a recording, try redubbing it through an equalizer with its 32-Hz control set for full cut.

CD players
It's no secret that many CD recordings have been poorly engineered and that they sound shrill or harsh. A slight cut applied by the 8- and 16-kHz controls can help significantly.

Loudspeakers
Speaker systems typically suffer from a variety of frequency-response problems. An equalizer can be of help in many cases. Here are some examples of how boosting or cutting response with a graphic equalizer can cure some common shortcomings:

- If low bass frequencies are lacking, try a moderate boost at 32 Hz.
- Standing waves in a room produce areas of bothersome heavy bass reinforcement, typically in the 40- to 70-Hz range. If there's a standing wave in your chosen listening area, you can reduce its effect by adjusting the setting of one or more of the bottom three equalizer controls. Note, however, that bass in other areas of the room may be cut more than is desirable as a result.
- Many loudspeaker systems are weak in the upper treble registers. They can be boosted as required by adjusting the settings of the 8- and 16-kHz controls.
- One speaker of a stereo pair must be placed in a part of the room that differs acoustically from the rest of the room. That could happen if one speaker is installed in a corner or near sound-absorbing drapes or soft furniture. In that situation, the bass or treble output of one speaker may need adjustment to bring it in line with that of the other. You can make the adjustment by switching your amplifier to mono, and adjusting the equalization of one channel until both speakers sound the same as you listen to one and then the other by using your amplifier's balance control. The same frequency performance from both speakers will help maintain good stereo perspective and imaging.
To add more "sock" to a disco beat, try some boost at 64 Hz.
To add body and warmth, try boosting 125 and 250 Hz.
If male voices sound "boomy," try a slight cut at 125 Hz.
If voices sound "nasal," try cutting back at 2 kHz and 4 kHz.
If brushed cymbals and chimes lack "shimmer" and "air," try boosting 16 kHz, and perhaps—to a lesser degree—8 kHz.
For a more natural balance when listening at background music levels, boost the frequencies at 125 Hz and below.

Ear training
Aside from all the corrective virtues described above, equalizers can be used as wonderful ear-training tools.
As I said earlier, many of the elusive sonic properties, both positive and negative, that are discussed endlessly in various audio publications turn out to be nothing more than minor variations in frequency response.
Those "variations" are translated by the ear into colorations and other sonic artifacts. It is instructive to play a clean recording through a well-balanced system that includes an equalizer, and then to manipulate the equalizer's controls while listening to the frequency bands responsible for steeliness, hollowness, airiness, muddiness, and other sonic properties. For example, the extra "inner detail," "air," and clarity provided by many moving-coil cartridges and a few audio amplifiers can be duplicated in large measure by a judicious boost of the two upper-octave controls of almost any ten-band equalizer.
It may be disillusioning to learn that the mysterious special quality of a high-end audio product results from nothing more than a rising high-frequency response—but that's life. It's easy enough to prove it to yourself.

Although ear training may induce a slightly cynical attitude toward the special qualities of some audio products, ultimately it should make you into a more critical listener—one who is better able to appreciate genuine sonic advances when they do actually appear.

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ANTIQUE
RADIOs

The telegraph and WWI

FOR ABOUT TWO YEARS NOW WE'VE been discussing many facets of antique radio. This time, let's take a look at some early developments in the field, how World War I affected development, and another closely related technology, the telegraph. In addition, we'll try to nail down the origin of the term radio.

Antique of the month
The U.S. Army Signal Corps Receiver shown in Fig. 1 is a De Forest receiver that belongs to Charles Dold, of Florida. I'd like to thank Mr. Dold for sharing information and the fine photos of his WWI receiver with us.

The date on the lid of the set is July 11, 1918. The radio still operates with the original crystal; it covers what is now the broadcast band.

You can see (in the right side of the cabinet) an added-on single-stage audio amplifier that occupies the space formerly used to store headphones. The amplifier uses a Radiotron V199 tube whose grid circuit is coupled to the emergency telephone connection of the receiver. Volume level is adjusted by a filament rheostat on the added panel. In addition, a battery-powered buzzer is coupled to the antenna circuit; the buzzer provides a broadband signal for finding a sensitive spot on the crystal.

For soldiers in the field who were unfamiliar with servicing or operating the receiver, a diagram and instructions are mounted inside the lid. A transcription of those instructions appears in the text box.

The telegraph
The telegraph had a 50-year head start on the wireless in practical use, and it wasn't until the very end of that period that the two were in direct competition. Like radio, the telegraph got off to a confusing start in this country.

Actually, the U.S. Government helped build the first telegraph line in 1844. It ran between Baltimore, MD and Washington, DC. The government appropriated $30,000 for the project, which amounted to about $1000 per mile. The government operated the line for about two years, but they refused to buy the patent rights. Within five years there were some 50 different telegraph companies operating in the U.S. As with many early radio companies, many of the telegraph companies went into receivership and were never heard from again. In addition, there were many patent-rights infringement claims.

Also like wireless, many men contributed to the development of the telegraph. But later it was ruled that Samuel Morse was the inventor of the practical telegraph. It's interesting to note that some historians even credit Morse with inventing wireless.

The reason is that Morse inadvertently performed an experiment in 1842, wherein he made water the medium of radio transmission. He had laid one mile of insulated wire in New York harbor, preparing for a telegraph demonstration. Without warning, a vessel in the harbor weighed anchor and severed the wires. That caused Morse to conduct "wireless" experiments using metal plates in opposite banks of the river, using water as the transmission medium.

Although wireless didn't replace the telegraph, it had many advantages. For one, the Army didn't have to guard miles of telegraph wire to prevent the enemy from cutting it.

The spark gap
Developments in wireless during WWI brought about the end of the spark-gap transmitter. If you're unfamiliar with the term spark-gap transmitter, you should know that it was widely used before WWI, and that a development of it (called the rotary spark-gap transmitter) was widely used ten years before the U.S. entered the war.

In its simplest form, the spark-gap transmitter consists of an an-
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far back as the 1890's man-made signals were being sent through the air. Government and civilian transmissions cluttered the air waves in some locations.

Even before WWI, armies in the U.S. and in Europe were quick to realize the importance of wireless communications. The war, of course, started in 1914, but the delayed entry of the U.S. in 1917 afforded a grace period that allowed development of better equipment. However, the early field station was a far cry from the field station of later years.

When the U.S. entered WWI, all wireless activity by civilians had to cease (just as it did during WWII). It’s hard to say whether that restriction aided or impeded the development of radio. Most of the amateurs and other experimenters who had been deeply involved in wireless were recruited as soldiers, so they had to leave their labs and stations anyway. Of course, those wireless enthusiasts became invaluable to the armed forces. How did the armed forces know who those knowledgeable men were? Even as far back as 1917 they had to be licensed. As a matter of fact, they had to be licensed as far back as 1912, when the Wireless Act was passed.

That’s not to say that the war was responsible for advances that wouldn’t have been accomplished anyway. I’m sure that those experimenters would have worked just as hard at advancing wireless had they stayed at home, working in their radio shacks.

To be useful to the Army Signal Corps in the field, the entire wireless station had to be mobile. In the pre-WWI era, mobility meant cavalry, and cavalry meant horses. It took at least half-a-dozen horses to carry the entire field station. Yes, the gasoline engine was used, but its sole purpose was to supply power to operate the radio. Like other components, the gasoline engine was carried on a horse fitted with a specially designed saddle. As primitive as it may sound, the horses could be unloaded and the station erected in about 15 minutes.

The technically minded soldier shared his pre-war radio experience, and in return gained knowl-
edge from the Army on the latest advances in wireless. However, when the radiomen returned home, their licenses had expired. Even after the official end of the war in November 1918, the ban on hams and experimenters was not lifted. Most likely the problem was what to do with the 200-meter band. That “useless” band had been delegated to the amateurs when licensing and controls began earlier.

After much effort by returning veterans and organizations like the ARRL, the ban was lifted, and licensing was restored in October of 1919. Even then, however, there was still some debate about whether receivers should be licensed. If, as was the case in some foreign countries, U. S. receivers had to be licensed, it’s probable that the development of radio would have occurred much more slowly. Eventually, of course, it was decided that receivers didn’t need to be licensed. The easing of restrictions started a whole new hobby for those who wanted to listen to what was on the air, but who didn’t want to experiment or to make transmissions of their own.

Restoration

To rebuild the obsolete sets required much technical information—but where would that information and the necessary parts come from? It came from early Gernsback and other publications of the times. The alert magazine editors coordinated readers’ needs with mail-order advertisers who could meet those needs. Learned contributors sent in plans, diagrams, schematics, and parts lists for many different types of experimental circuits.

Many of those early home-built sets are still around, and they usually have no identification, except, perhaps, on some parts. Many home-made sets are better made and are of generally higher quality than later commercially produced sets. If you come across one of these unnamed home-made receivers, you’d do well to buy it, if you can get it for a reasonable price. It’s as much a part of radio history as any commercially produced product.

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The MAX600 and the MAX610 connect directly to the AC power lines and provide a five-volt output using an internal full-wave rectifier. The MAX601 and MAX611 are similar devices with half-wave rectifiers, and the MAX602 and MAX612 convert 8-volt rms to 5 volts DC using full-wave rectifiers. The MAX600, MAX601, and MAX602 have 0 to +50°C temperature ranges, and the MAX610, MAX611, and MAX612 have 0 to +70°C ranges.

Contained in the 8-pin DIP package is a half-wave rectifier, a 12.4- or 18.6-volt Zener-diode shunt regulator, and a bipolar series-pass regulator. The nominal output voltage of all devices is 5 volts DC ±4%; the output of the MAX600, MAX602, MAX610, and MAX612 can be set to any desired value between 1.3- and 15.0-volts DC.

A block diagram of the MAX600 series is shown in Fig. 1. Open-drain pin OUV goes low during under- and over-voltage conditions. The under- and over-voltage thresholds are fixed at 4.65 and 5.4 volts, respectively. Those thresholds do not change even if the output voltage is changed via the VSET terminal, explained below.

Output voltage is determined by the state of pin 4, VSET. If pin 4 is grounded, the output voltage will be the preset 5-volts DC. Otherwise pin 4 can be used to set the output to any voltage from 1.3 to 10 (for the MAX600/10) and from 1.3 to 15 (for the MAX602/12) by installing a simple resistive voltage divider. Pin 4 of the MAX601/11 controls a reset delay—the amount of time before pin 3 returns to a high level following an over- or under-voltage condition. The reset delay is directly proportional to the value of an external capacitor connected to pin 3. Each 0.01 μF of capacitance results in a 30-ms delay.

Pin 5 is the current-limit input. The output short-circuit current limit is 0.6V/Rsense, where Rsense is a current-limiting resistor connected between pins 5 and 6.

The rectified but unfiltered output of the diode bridge appears at pin 8. The desired filter capacitor should be connected between pins 8 and 2. The output of the regulator appears at pin 6.

Figure 2 shows a MAX600 configured as a 5-volt, 50-mA DC power supply. By substituting a 100Ω, 1-watt resistor for R1 and a 0.82-μF, 280-volt capacitor for C1, the circuit will run from a 220-volt, 60-Hz AC power line.

When output current demand is less than 10 mA, capacitor C1 can be omitted; the available current will be determined by the value of R1. For 5-volt, 10-mA output, R1 should be 8200 ohms. Power dis-
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Image interference

MODERN TECHNIQUES of design and manufacture save money and thereby bring more equipment that functions better to more people. However, cost-cutting can have unwanted and unforeseen side effects.

For example, in recent months we've received a rash of complaints about powerful shortwave stations (voice, code, and RTTY) that interfere with standard broadcast-band stations. In fact, that interference often jams even the clear-channel stations. According to some correspondents, the problem is most severe in Boondocksville, where reception isn't good to begin with, and where outdoor antennas are a fact of life. The way it's told, the longer the antenna, the worse the interference, which sometimes is so bad that it is impossible to listen to the radio.

The problem is image interference. If you've had much experience with communications gear, you've probably run across image interference, even if you didn't know what it was. Usually it affects a station or two, or a portion of the band, but it's seldom so bad that it wipes out almost the entire band.

The solution

A letter from reader Wilfred Caron, of Ridgecrest, CA, provided a clue to the nature of the problem. Mr. Caron noticed that several of his radios suffering from severe shortwave interference on the broadcast band had the same problem. He examined their schematics and discovered that each used a similar front end: the composite type shown in Fig. 1. In addition, each radio had an all-plastic cabinet, so neither the front end nor anything else was shielded.

To those of you familiar with the old "All-American Five" vacuum-tube radio, the Fig. 1 circuit should look familiar. It's a solid-state version of the combination RF amplifier/oscillator/mixer stage—what is called a converter. Unfortunately, the transistor version seldom includes the metal shielding common to the tube-type circuit. Also, simple transistor oscillators generate greater odd-order products than vacuum-tube types. Although we would expect the third harmonic of a tube-type converter to be greater than 35 dB down, we have measured third-harmonic products from an equivalent solid-state circuit as little as 10 dB down.

Now let's look at the circuit. For the sake of discussion, assume that no shortwave frequency gets past the tuned-antenna circuit composed of L1 and C1. That circuit is what tunes the broadcast band. However, the wire that connects the antenna coil and Q1's input is unshielded. That wire functions as an antenna that receives signals from all frequencies and feeds them to Q1's base.

One of Q1's duties is to function as an oscillator whose frequency is tuned by L2 and C2 to 455 kHz above the desired frequency. For example, assume we want to tune in a station at 1100 kHz. Therefore the oscillator is tuned to 1100 + 455 = 1555 kHz. The third and fifth harmonics of 1555 kHz are 4665 and 7775 kHz. The oscillator's harmonics can beat (add and subtract) with any signals fed into Q1's base, so both the additive and the subtractive products will be fed into the 455-kHz IF amplifier.

There will also be intermodulation products caused by beating the third and the fifth harmonic products with the IF. So the 4665-kHz harmonic will produce signals at 4665 ± 455 = 4210 kHz and 5120 kHz, and the 7775-kHz harmonic will produce output at 7320 and 8239 kHz. The upshot is that any shortwave signal received on any of the product frequencies will be received clearly if it gets into Q1's base. And that type of pickup can happen easily in an unshielded radio.

Bear in mind that, as the radio is tuned to different stations, the oscillator is also tuned. Hence the harmonics also vary—so the radio actually tunes both the broadcast and the shortwave bands.

The problem is compounded because Q1 functions as a regenerative detector, a very-high-gain circuit that is much used in

continued on page 98
Hear it All!

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Oscillators are probably the most popular kind of circuit around. Just about every piece of equipment you can buy has at least one oscillator buried inside it. More than likely there are several, because different kinds of jobs call for different kinds of oscillators.

We've discussed several types of oscillators in this column, but we've never even mentioned the one that's probably the most useful of all: the crystal oscillator. Once upon a time it was anything but simple to design one of those things, but, like many other things, that design difficulty is now a matter of history. These days, a reliable crystal oscillator can be built easily by throwing together a handful of easy-to-find parts.

A simple crystal oscillator

The circuit shown in Fig. 1 is a good example of how simple it can be to build a crystal-controlled oscillator. To understand how the circuit works, temporarily ignore the crystal and the capacitors. What's left is an inverter set up as a linear amplifier, another circuit we've discussed in this column before. (See, for example, the negative-voltage generator in this column in the March 1986 issue.)

By adding the crystal and the capacitors to the feedback path, we turn the amplifier into an oscillator and force it to oscillate at, or at least very near, the crystal's resonant frequency. The trimmer capacitor (C2) allows you to adjust the actual operating frequency of the circuit. The crystal should be a parallel-resonant type; maximum frequency will depend partly on supply voltage, but you should have no trouble getting at least 1 MHz. Use quality mica capacitors to minimize thermal drift.

The circuit is built from a simple inverter, but you can use just about any CMOS gate that can be set up as an inverter. A TTL gate doesn't behave well when you force it into linear operation. The bandwidth is limited, it sucks up a lot of current, and all sorts of other nasty things can happen.

If you use a two-input NAND or NOR gate instead of an inverter, you can use the other input as a gate to turn the buffer. And, no matter what sort of gate you use, it's a good idea to buffer the output with another gate. Often you can simply use another gate in the same package as the buffer. And if you have more than one gate available, you can feed the buffered output through another inverter. That will give you two outputs that are equal in frequency but 180 degrees out of phase. Microprocessor and other circuits occasionally need out-of-phase clock signals.

If you need other output frequencies that are integrally related to the crystal's frequency (100 kHz, 50 kHz, 10 kHz, etc.), they can be obtained using dividers.

Setting up a home lab

I receive many letters from people asking what basic equipment one needs for doing electronic circuit design at home. That's an easy question to ask, but a difficult one to answer. What you need depends entirely on what you want to do. At the risk of having everyone disagree with me, I'll say that I think a minimum workbench would include a multimeter, a logic probe, a pulse catcher, an RC substitution box, a variable power supply, breadboards, and a good soldering iron. After you acquire those basic items, you can start thinking about oscilloscopes and other more expensive items.

But, as you get more and more involved in circuit design you'll also find that the handiest stuff to have around isn't necessarily what you ordinarily think of as test equipment. No workbench can be considered complete without a slew of debounced switches, digital display circuits, oscillators, variable frequency generators, and other circuits that you can design and build yourself.

If you find yourself using the same sort of circuit over and over on the bench, it's a good idea to take the time to refine it and put it on a PC board. It will make circuit development easier, and you'll find that you can drop the PC layout right into some other circuit.
STATE OF SOLID STATE
continued from page 93

Current-limiting capacitor C1 is critical when used in a 110/220-volt input supply. It should be non-polarized and rated for at least 150-volts r.m.s. Metallized film capacitors are preferred to metal-foil types.

The value of C1 determines the power dissipated in the regulator IC and the maximum output current. It should be the smallest value that will deliver the desired output current at the minimum line voltage, because the power dissipated in the IC increases with the value of C1. For the full-wave MAX600 devices,

\[ C_1 = \frac{(V_{RMS} - V_{OUT}) \times 4 \times \sqrt{2} \times F_{IN}}{I_{IN}} \]

where \( I_{IN} \) is the input line frequency, for half-wave MAX601/11 devices, the value of C1 is doubled.

Resistor R1 limits maximum peak current to 5 amps. That amount of current could flow if power were connected just as the instantaneous line voltage was at its maximum. With a 117-volt 60-Hz input, dissipation in mW is \( 1.6 \times C_1 \times R_1 \), where C1 is in microfarads and R1 is in ohms. For a 220-volt input, the constant in that equation is 2.7 instead of 1.6.

The maximum input to the MAX600/10 is 10 volts; those devices can supply outputs from 1.3 to 9 volts. Similarly, the maximum input to the MAX602/12 is 16 volts; those devices can supply outputs from 1.3 to 15 volts—Maxim Integrated Products, 510 N. Pastoria Ave., Sunnyvale, CA 94086.
That's the basics of how a simple converter stage can generate shortwave interference to broadcast-band stations. Other means are possible: Intermodulation products could be caused by a strong signal that overdrove Q1's base-emitter junction.

How to get rid of that interference? Change the circuit design to reduce oscillator harmonics, eliminate the possibility of strong-signal overload, and shield the front-end.

By the way, direct harmonic interference of the type we've been discussing—not that caused by intermodulation products—is usually described as second image, third image, etc. What happened to first image, you ask? For our 1100-kHz reference signal, the first image would occur at $1100 + 455 + 1100 = 2655$ kHz.
BUILD AN IBM CLONE
It's cheap, it's easy!

MULTITASKING
True concurrency—or is it just an illusion

VOLTAGE REGULATOR DESIGN
Let your computer pick the numbers
IBM-Compatible Clone Computer
A PC-compatible computer doesn't have to be expensive. You can assemble your own, complete computer for less than you might think. Best of all, it's easy! Jack Flack

Computer Regulator Design
Here's another way to put your computer to work. This program will provide a means to help pick the correct values the next time you're designing a regulator. Jack Cunkelman

Concurrency
Just how many different tasks can you really set your computer to doing at the same time? Despite what the salesmen say, is concurrency just a myth? Our author says "a myth is good as a mile!" Marc Stern

Editorial
Letters
Computer Products
Software Review

ON THE COVER
If you've been thinking about IBM-PC compatibility, now's the time to do something about it. You'll be amazed at how inexpensive it can be if you're willing to do some simple assembly work. The things you learn from assembling your own computer can help you when it comes time to upgrading your system or, heaven forbid, repairing it!

COMING NEXT MONTH
Look for a bang-up issue next month, as we kick off with a really-important story about a new way to store and distribute software. And we're going to round out that issue with an important piece on a Protocol Converter that you'll want to clip-and-save. And if you want even-more for your money, check out the article on our Computer Power Control System that will convince even your wife that computers are important! Don't miss our March Issue.
EDITORIAL

Do me a favor...

Don’t do me any favors!

My computer keyboard has a feature that is being touted as a wonderful development, an advancement that makes it superior to other keyboards. It’s called “rollover.” And for my money, they can take it and keep it. I don’t want it, and don’t know how to get rid of this super-wonderful feature that makes computing a pain in the neck.

First, let me explain what rollover is. I suppose it’s a blessing for people that touch-type. It has to do with hitting two keys at the same time (or almost the same time). The rollover feature is a super-pain-in-the-neck for us hunt-and-peckers (no pun intended) that learned to type on upright manual typewriters before the days of electrics. Now back in my newspaper days everybody typed with two fingers. We called it the “Biblical System.” Seek and ye shall find! And before you start putting me down for not touch-typing, let me tell you that I probably go a heck of a lot faster than you do with all ten of your digits!

The problem with rollover is that if I’m slightly off with the positioning of my fingers, I have to go back and remove all the wrong letters and characters that (thanks to rollover) I accidentally hit. For instance, usually every time I hit an “O,” I’ll have to go back and remove a “P” that follows it. And after every “C,” there’s a “V” that doesn’t belong there. After each “B” you’ll find an “N” and believe it or not, preceeding most of the “Ts,” you’ll find a 5. And why, when I write the word “the,” does it come out “tyhe?”

So for my own part, they can remove that rollover feature any time now. I can live without it.

Byron G. Wels
Editor
LETTERS

Biofeedback
I wrote the article on the Graphic Biofeedback Monitor and there has apparently been a problem with the software. The program as published is correct. I have run it many times with no failures. However, I have discovered what might be a source of error. The machine-language routines are placed in memory close to the end of the BASIC program. If you add lines of your own to the BASIC program you run a chance of interfering with the machine code. Even one or two comment lines added to the start of the program seem to be enough to cause the machine-language routines to load improperly. Enter the code exactly as published.—Ron Peterson, Milford, NH.

Thanks for the info Ron. That should help cut back on some of the mail!

T'anks Pal!
I know you'll probably make some wisecrack about this letter, if it gets into print, but I just wanted to tell you that I really appreciate the way you inform your readers and still keep a good sense of humor.—B.K., Providence, RI.

See the sub-head, above.

In Print
What exactly do I have to do to see my letter in print. I've written to many magazines with no success. And this one is wasted too, right?—K.T., Houston, TX.

Right.

No Bets
Okay, now bear with me: If I get all the results of my local state lottery for the past umpteen years and feed the winning numbers into my computer, can't I get a list of the most-frequently called numbers? And if I bet those numbers, isn't there a good chance that I'll win? R.D., Jersey City, NJ.

One thing for sure, you're letting yourself in for a lot of work! And since most lotteries are random drawings, there are still no guarantees.

Another Fan
One of the first pages I turn to in your magazine, is the Letters Column. I get a real boost out of your good-natured sarcasm. Keep up the good work! K.A., Elko, NV.

Sarcasm? Who, me? I haven't the remotest idea of what you're talking about! Why I'm the nicest, most easy going...

COMPUTER PRODUCTS

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

ART SOFTWARE, Graphics & Symbols 1 and Artfolio 1, are part of the Desk Top Art line, each volume of which has more than 300 illustrations, stored on two diskettes as MacPaint documents. Also included in every package is a 94-page how-to guide, a complete pictorial index to the art, and suggested applications of the art.

Graphics & Symbols 1 is a collection of high-contrast pictograms and symbols, and sells for $66.95. Artfolio 1 is a miscellany of styles and subjects that includes people, familiar objects, and animals. It sells for $74.95. —Dynamic Graphics, Inc., 6000 N. Forest Park, PO Box 1901, Peoria, IL 61656-1901

PC X.25 CIRCUIT BOARD, the DialCard, allows users of personal computers who have been relying on asynchronous data communications to take full advantage of their equipment's inherent sophistication to utilize the first U.S. X.25 Dial™ service. Data communication end users now will have the ability to communicate synchronously over the Telenet® public data network simply by dialing into the network through a modem. The software for DialCard25 uses the same command format as Telenet's assembler/dissembler (PAD) software.

Automatic end-to-end error detection and retransmission, rates up to 4800 bps per second, and the ability to perform multiple tasks simulta-

CIRCLE 19 ON FREE INFORMATION CARD

neously are among the product's leading features. DialCard operates at either 1200, 2400 or 4800 bits per second. It offers three virtual circuits, enabling users to talk to three separate computers at one time. It is transparent to the network.

DialCard25 has a retail price of $595.00—Western Digital, 2445 McCabe Way, Irvine, CA 92714.
Certificate Maker

How often have you wanted to reward someone for a job well done, a game well played, or maybe just for fun?

Award a certificate—maybe with a gold seal—attesting to someone's prowess, cooking, or proficiency in anything. Even an award to someone for Eating All Of Your Yucky Vegetables.

All you need to crank out a customized award on the spur of the moment is your personal computer (almost any well-known brand), almost any well-known matrix printer, and Certificate Maker.

Pre-Designed

Certificate Maker lets you create attractive, personalized awards in just minutes, because the hard part is already done for you. It provides more than 200 professionally-designed, partially-completed certificates called templates. Some are for special occasions such as academic achievement, sporting triumphs, and the like—with title and appropriate artwork. Other templates are multi-purpose; with no artwork and only a partial title like Certificate of......—you fill in the rest.

In addition to a template, you can select any of 24 pre-designed borders, and any of 5 type styles (fonts): Serif; Sans Serif; Script; Gothic; Art Deco. All fonts can be toggled on a line-by-line basis for medium or large size (there is no "small" size). The screen displays only the maximum number of characters allowed for each particular template line. Although it is possible to enter characters beyond the line width shown on the screen, only the screen characters will be printed on the certificate. If the type size is changed to large after entering text—thereby reducing the number of characters that can be accommodated per line—only the displayed characters print.

Six Elements

A certificate contains six specific elements: A pre-designed title; pre-designed graphic; the user-selected border (or no border); open body text and a "name" wildcard area (explained below); open date line; and open signature line.

Menu Driven

Although an operating manual is provided, it really isn't needed because the program is completely menu driven: you need only respond to screen prompts, and the prompts include display of the selected type style and border.

To create a certificate or award, you enter the number of the desired template (all templates are shown in the manual), select a border, and then the type style. The screen will display the maximum number of lines permitted, and you can use some or all of the lines.

A names mode allows a continuous file of names to be created and imprinted on the same template, much in the manner of a mailing list that's merged into a form letter. For example, if you prepare a list of club members winning an achievement award, the program will print a series of personalized certificates bearing only one name from the list.

To make the certificates "official," they can contain a signature line and date.

Alignment

Because there are two certificate sizes—which can be printed either vertically and horizontally—prior to printing you can call up a Print Test, which prints a four-corner test pattern of the certificate; thereby avoiding having to print the certificate to check its alignment. It lets you align or position the paper to center smaller certificates.

The program works with dual floppies and hard disk. Printer selection is done through a Setup mode, which lists virtually all commonly-used printers.

While the certificates don't resemble the quality from a press—matrix printing always looks like matrix printing, no matter how good it might be—they are a lot of fun, and a fast way to reward the deserving; or even the undeserving, because a few templates are somewhat biting.

Certificate Maker is available for the Apple II/e/c and the Commodore 64/128 ($49.95), and the IBM-PC ($59.95). For more information, write to Springboard Software, Inc., 7808 Creekridge Circle, Minneapolis, MN 55435.

FEBRUARY 1987

CIRCLE 17 ON FREE INFORMATION CARD
Now's the time to build your own IBM PC-compatible "clone" computer.

There's no reason to wait any longer!

JACK FLACK

A lot has happened since we last looked at how to put an IBM PC-compatible clone computer together (Radio-Electronics, July and August 1985). If you weren't ready back then, maybe the time is now. The entire computer industry has gone wild with PC's and peripherals. And prices continue to fall as we are bombarded with literally hundreds of quality compatible motherboards and add-ons ranging from 20-megabyte hard-disk drives to enhanced graphics-adapter cards.

The PC clone that we assembled to prepare this story was put together from boards and components supplied by JDR Microdevices (110 Knowles Drive, Los Gatos, CA 95030). We would like to thank JDR for their help and cooperation.

Why should you assemble your computer instead of buying a complete unit? First, you can learn about and become familiar with your computer hardware during the assembly process so you'll be better able to deal with hardware problems, should they arise in the future. Also, you'll certainly have more confidence when it's time to expand and upgrade your system with such add-ons as hard disks and expansion cards.

Of course, the reason that most people assemble a clone computer is that it's (relatively) cheap.

Decisions, decisions

Before you can start to put a PC clone together, you have to decide how you want to configure it. Table 1 lists the various items you need to consider. Items marked with an asterisk (*) are necessary in a minimum configuration.

There are many add-on boards and peripherals available for IBM PC's and compatibles, and most can be added at a later date without retrofitting parts initially installed. For example, you can start out with only one floppy-disk drive and then add up to three more later (depending on your floppy disk controller). Installing a 20-megabyte hard-disk drive is as easy to do later as it is at the beginning. So don't be tempted to get more than you really need at the start. You can always add more later.

However, you should look closely at your requirements for a keyboard and monitor (and monitor-adapter board). You will use both more than any other system component, and they're not upgradable (though they can be replaced easily enough).

Many expansion boards are available that offer serial ports, game ports, parallel printer ports, light pen interfaces, expanded memory, clock/calendars, modems, and more. What do you need?

Some of your choices will be based simply on personal preference. For example, some people find that a clock/calendar board is very convenient, because it can be annoying to set the date and time each time you boot-up. On the other hand, some people never set their computer's clock, and would find a clock/calendar an unnecessary expense.

On the other hand, some of your choices will be based on what type of equipment (such as printers, modems, etc.) you intend on using with your computer.

And now to build

For your convenience, Table 2 is an abbreviated check list of the assembly process. We suggest you read the manufacturer's instructions thoroughly several times and then use Table 2 during assembly. That check list provides for the installation of a moderately
FIG. 1—EVERYTHING YOU NEED to assemble a complete computer system. Turn to page 108 for a description of each component.

<table>
<thead>
<tr>
<th>Component</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Motherboard:</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>640K RAM capacity on board</td>
</tr>
<tr>
<td>Turbo</td>
<td></td>
</tr>
<tr>
<td>*BIOS ROM</td>
<td></td>
</tr>
<tr>
<td>RAM:</td>
<td></td>
</tr>
<tr>
<td>*256K bank</td>
<td>Runs at faster clock speed, switchable, many programs must run at slower speed</td>
</tr>
<tr>
<td>2nd 256K bank (512K total)</td>
<td></td>
</tr>
<tr>
<td>128K bank (640K total)</td>
<td></td>
</tr>
<tr>
<td>*Case</td>
<td></td>
</tr>
<tr>
<td>*Power supply</td>
<td></td>
</tr>
<tr>
<td>Keyboard:</td>
<td></td>
</tr>
<tr>
<td>*5150</td>
<td></td>
</tr>
<tr>
<td>5151</td>
<td></td>
</tr>
<tr>
<td>Display Adapter:</td>
<td></td>
</tr>
<tr>
<td>*Monochrome</td>
<td></td>
</tr>
<tr>
<td>Monochrome/Hercules</td>
<td></td>
</tr>
<tr>
<td>Color Graphics Adapter (CGA)</td>
<td></td>
</tr>
<tr>
<td>portable tester</td>
<td></td>
</tr>
<tr>
<td>Multi I/O Floppy card</td>
<td></td>
</tr>
<tr>
<td>Modem card</td>
<td></td>
</tr>
<tr>
<td>*MS-DOS Software</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 1 COMMON PC COMPONENTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Graphics Adapter (EGA)</td>
<td></td>
</tr>
<tr>
<td>Display (monitor):</td>
<td></td>
</tr>
<tr>
<td>*Monochrome (TTL)</td>
<td></td>
</tr>
<tr>
<td>Color (Composite)</td>
<td></td>
</tr>
<tr>
<td>Color (RGBI TTL)</td>
<td></td>
</tr>
<tr>
<td>Enhanced Display (Analog RBG)</td>
<td></td>
</tr>
<tr>
<td>*Floppy disk drive</td>
<td></td>
</tr>
<tr>
<td>*Floppy disk controller</td>
<td></td>
</tr>
<tr>
<td>Hard disk drive:</td>
<td></td>
</tr>
<tr>
<td>10 Megabytes</td>
<td></td>
</tr>
<tr>
<td>20 Megabytes</td>
<td></td>
</tr>
<tr>
<td>20 Megabytes (card)</td>
<td></td>
</tr>
<tr>
<td>Multi I/O Floppy card</td>
<td></td>
</tr>
<tr>
<td>*MS-DOS Software</td>
<td></td>
</tr>
</tbody>
</table>

**Comments**

Will emulate mono and CGA boards, EGA mode requires enhanced monitor

Amber or green phosphor

Use with the CGA board

Use with the CGA board, 40 x 25 text and 320 x 200 color graphics

Supports all CGA modes

21kHz, 28mm dot pitch, use with EGA

360K double sided, doubled density, half height

Available on multi I/O Floppy card

With controller

Half-height

Drive and controller on same card

Clock/calendar, serial port, parallel port, floppy disk controller, game port

Hayes compatible

Similar to PC-DOS but with disk BASIC

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equipped system with 640K RAM, 1 floppy-disk drive, a 20-megabyte hard-disk drive, monochrome adapter and display, multi I/O floppy card (clock, I/O, floppy disk controller, etc.), and modem card. You can skip over those steps involving parts that you do not have. But pay special attention to the manufacturer’s configuration requirements on each expansion card. Your PC will get confused if it sees more than one serial port or parallel port with the same address. It’s also a good idea not to get all the parts out before you need them. Some of the cables look very similar and can get mixed up easily.

The motherboard

The motherboard may look intimidating, but when you become familiar with it, you’ll realize that it’s not as complicated as it appears. To begin, lay the motherboard down on a flat work surface with the 8 card connectors oriented away from you. (See Fig. 1.) You’ll have to insert the ROM and RAM ICs and set DIP switches and a jumper before you can install the motherboard in its case.

Leave all the ICs in their conductive foam until you’re ready to insert them in the motherboard. Then do so one at a time. It’s also a good idea to touch a large metal object to discharge any destructive static electricity.

The RAM and ROM ICs usually come with the pins bent out slightly for use with automatic insertion equipment. Straighten the pins by laying the IC on its side on a flat surface, and gently rocking the chip toward the leads.

When you insert an IC, first place it on top of the

---

**TABLE 2**

**IBM PC ASSEMBLY CHECK LIST**

<table>
<thead>
<tr>
<th>STEP</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prepare motherboard</td>
<td>Refer to Figure 1 Bend leads perpendicular, orient pin 1 to rear of board. See Table 3 Refer to manufacturer’s documentation</td>
</tr>
<tr>
<td>2. Install motherboard in case</td>
<td>Remove drive bracket from case and set aside. Mount board on standoffs loosely first. Align with expansion card(s) installed and then tighten.</td>
</tr>
<tr>
<td>3. Install Power Supply</td>
<td>Use 4 screws on back of supply. Connect to motherboard with 2 6-pin connectors.</td>
</tr>
<tr>
<td>4. Configure/install display adapter</td>
<td>Assign ports if necessary</td>
</tr>
<tr>
<td>5. Test power supply/ mother-board/display adapter</td>
<td>Power up system, should see boot sequence, check connections and configuration settings if problems.</td>
</tr>
<tr>
<td>6. Install speaker</td>
<td>Use outer 2 pins of speaker connector.</td>
</tr>
<tr>
<td>7. Install hard drive on bracket</td>
<td>Bracket removed in step 2. Remove front plate, set jumper on drive to “DSO”, DO NOT DROP OR BUMP!</td>
</tr>
<tr>
<td>8. Install floppy drive on bracket</td>
<td>Line up in case, adjust as needed.</td>
</tr>
<tr>
<td>9. Ensure drives align with front</td>
<td>Reinstall hard drive cover plate.</td>
</tr>
<tr>
<td>10. Install drives/bridge in case</td>
<td>Connectors are slotted (Fig. 9). Ribbon cable with twist goes on 1st floppy.</td>
</tr>
<tr>
<td>11. Install ribbon cable on drives</td>
<td>4-pin connectors, note polarity.</td>
</tr>
<tr>
<td>12. Connect power supply to drives</td>
<td>34-pin ribbon, middle connector for 2nd floppy drive. If you use Multi I/O set up ports (beware of other cards).</td>
</tr>
<tr>
<td>13. Install floppy controller card (or Multi I/O card)</td>
<td>Power up, watch for drive light and motor after boot, hard drive light should not come on.</td>
</tr>
<tr>
<td>14. Test floppy drive</td>
<td>Connect on back of motherboard</td>
</tr>
<tr>
<td>15. Install keyboard</td>
<td>Insert system disk in floppy drive, all but hard disk should work</td>
</tr>
<tr>
<td>16. Boot up</td>
<td>Connect 20 and 34-pin ribbons from drive, neatly stow cables (Fig. 10).</td>
</tr>
<tr>
<td>17. Install hard disk controller card</td>
<td>Instructions in MS-DOS manual.</td>
</tr>
<tr>
<td>18. Format hard drive</td>
<td></td>
</tr>
</tbody>
</table>

**FIG. 2—THE MOTHERBOARD** is the heart of the computer. You’ll have to become familiar with it.
appropriate socket so that all pins make light contact. Inspect all pins to ensure they’re headed into the socket and not underneath the IC. Then apply even pressure on the top of the IC with your thumb or two fingers until it seats firmly in the socket. It wouldn’t hurt to re-examine each IC after insertion with a good light source. (A bent pin is easier to repair if caught before your heart stops from a system failure!) If a pin gets bent, don’t panic! Just remove the IC (pry up the ends with a small screwdriver), straighten the pin, and reinsert it.

Insert the BIOS (Basic Input/Output System) ROM in the “ROM 7” socket on the motherboard. Make sure the notch on the IC is toward the rear of the board. The 16-pin RAM chips are installed in the four rows of nine sockets. If you’re using 256k RAMs (41256), the rear two rows (rows 0 & 1) are for those. The front two rows (rows 2 & 3) are for 64k RAM’s (4164). The motherboard has a jumper that allows you to install 4164s in all four rows (limiting the total RAM capacity to 256k). In order to install 640k on the motherboard you must use 41256 RAM’s in rows 0 and 1. (Never mix 4164s and 41256 on the same row!) Refer to Table 3 for general guidelines for memory configuration.

Next set the DIP switches using Table 3 and verify that the board jumper (J1) is properly in place. Most manufacturers have greatly reduced the number of jumpers and switches on their boards. Take a moment and verify that there are no other switches or jumpers on the motherboard. If others are present, set them according to the manufacturer’s specifications.

Installing the motherboard

You’re now ready to install the motherboard in the case. Start by removing and setting aside the disk-drive bracket located inside the case on the right. Loosely install the nine standoffs in the case. The male portion of the standoff should be up. Next place one insulated flat washer over each of the standoff studs. Carefully place the motherboard over the nine studs with the 8 expansion slots toward the rear of the case. Move the studs until they pass through the holes on the motherboard. Place another insulated flat washer and nut over each stud and hand tighten. Temporarily install a couple of expansion cards to align the motherboard with the back cutouts on the case and then tighten the nuts and screws.

![FIG. 3—TO ALIGN THE MOTHERBOARD, temporarily install a couple of expansion cards.]

Installing the power supply

Remove and set aside the four screws on the back side of the power supply (the side with the power connector). Position the power supply in the right rear portion of the case with the switch on the right. It should slide back against the back wall. Fasten with the four screws previously removed. (If screws were not present, locate 4 large-head screws in the hardware included with the case.)

Locate two sets of wires with 6-pin connectors. One connector has only five wires and should be inserted in the rear six posts of the power connector on the motherboard with the empty slot toward the rear. The other 6-pin connector should be inserted in the front six posts on the motherboard. When installed properly, four black wires will be grouped together in the middle of the motherboard connector.

If you’re installing a speaker, do so now. Refer to the installation guidelines for your case. The speaker wires should be attached to the two outside pins of the 4-pin speaker connector on the motherboard.

Go ahead and install your monitor card in one of the left expansion slots at this time so you can check out your work so far. Connect your monitor and power up the motherboard. You should see memory and I/O checks and the BIOS logo. If not, check all your connections and switch settings, and especially the RAM and ROM IC’s.

The disk drives

Hard-disk and floppy-disk drives are both installed on the disk-drive bracket previously removed. The hard
FIG. 4—HERE'S EVERYTHING YOU NEED to assemble a complete, deluxe IBM-compatible clone computer: 1) Motherboard with 640K RAM capacity; 2) 640K RAM IC's; 3) BIOS ROM; 4) Screwdrivers and pliers; 5) TTL monochrome monitor; 6) Flip-top case with side switch cutout; 7) Half-height floppy disk drive; 8) Half-height hard-disk drive; 9) Keyboard; 10) Modem card; 11) Multi i/O floppy controller card; 12) Hard-disk controller card; 13) Enhanced graphics adapter card; 14) 135-watt power supply.

TABLE 4—GETTING THE PARTS

The clone computer we put together to prepare this article was supplied by JDR Microdevices 1224 S. Bascom Avenue, San Jose, CA 95128. We would like to thank them for their cooperation.

We worked with JDR because we found their prices competitive, and their product line complete. To give you a point of reference, here is a list of the parts that we used, and JDR's prices for those elements. We suggest you contact JDR at 800-538-5000 for more information regarding the manufacturer of the individual products, or for the latest pricing in this constantly changing market.

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Price</th>
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<tr>
<td>XT-compatible motherboard</td>
<td>$109.95</td>
</tr>
<tr>
<td>BIOS ROM</td>
<td>19.95*</td>
</tr>
<tr>
<td>256K RAM</td>
<td>26.55</td>
</tr>
<tr>
<td>Power Supply (130 watts)</td>
<td>69.95</td>
</tr>
<tr>
<td>Case</td>
<td>39.95</td>
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<tr>
<td>Keyboard (IBM5150)</td>
<td>59.95</td>
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<tr>
<td>floppy disk drive</td>
<td>79.95</td>
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<tr>
<td>floppy disk controller</td>
<td>34.95</td>
</tr>
<tr>
<td>Monochrome adapter card</td>
<td>49.95</td>
</tr>
<tr>
<td>Monochrome monitor</td>
<td>99.95</td>
</tr>
<tr>
<td>20-Megabyte hard disk drive and controller</td>
<td>369.95</td>
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<tr>
<td>Enhanced keyboard 5151</td>
<td>79.95</td>
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<tr>
<td>Modern Card</td>
<td>139.95</td>
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<tr>
<td>Multi I/O floppy controller</td>
<td>89.95</td>
</tr>
<tr>
<td>Enhanced graphics adapter</td>
<td>199.95</td>
</tr>
<tr>
<td>EGA monitor</td>
<td>479.95</td>
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</table>

*Note: BIOS ROM is free with purchase of motherboard. EGA monitor and adapter available as a set for $629.
disk is first. Locate the "select" jumper on the drive and make sure it's set at "DS0." Be very careful not to drop or bump the drive—it's very fragile!

Remove the front cover plate and mount the hard disk loosely on the right side of the bracket. It is usually mounted from below. Place the bracket back in the case where it will be permanently fastened later. Adjust the drive flush with the front of the case, lift the bracket back out and tighten the mounting screws. You may have to repeat that process several times to get proper alignment. Re-install the cover plate and position the bracket and drive back in the case, but do not permanently install it until the floppy drive is attached.

Manufacturers of floppy drives use different mounting techniques and hardware, so refer to the instructions that came with the drive. Set the "select" jumper on the drive to "DS1" and slide it on the bracket through the front of the case. (The floppy drive goes on the left.) As with the hard drive, adjust the floppy drive on the bracket until it is flush with the front of the case. When all looks straight, permanently mount the drive bracket and drives in the case.

Configure the hard disk controller but do not install it yet. Connect the 20-conductor and 34-conductor ribbon cables to the hard drive only. There should be slots cut in the edge connectors to insure proper polarity. The last connection to the hard drive is the power connection. Insert one of the four polarized 4-pin power connectors from the power supply into the hard drive.

Next insert the floppy disk controller card (or Multi I/O Floppy card) into one of the right-hand expansion slots on the motherboard. If you’re using the Multi I/O Floppy cards, don’t forget to configure the parallel and serial ports so as not to conflict with other cards (if any) with these ports.

Now connect the 34-conductor ribbon between the floppy controller card and the floppy disk drive. The edge connector with the twisted section in the ribbon should be installed on the drive. The other end goes on the controller card and the middle connector is for a second floppy drive. When installing a second drive, be sure and remove the terminating resistor network from that drive. (Refer to the drives documentation for the location and description of the terminator chip.)

Locate another 4-wire power card from the power supply and insert it into the floppy drive power connector. Remove the cardboard shipping insert and prepare to power up the system.

Power it up!

Power up the system (without the system diskette installed) and watch and listen for anything unusual. After the BIOS logo appears (30–40 seconds), the floppy-drive light and motor should come on for several seconds. When that happens, all is well and you should insert the system diskette, and re-boot. If you run into problems, check all your connections and the “select” jumper on the floppy drive.

You’re now ready to install the hard-disk controller card into one of the right-hand expansion slots and connect it to the 20 and 34-conductor edge connectors previously connected to the hard drive. Neatly stow the excess ribbon cables, making sure they do not interfere with the moving parts of the drive.

Configure and install your modem card in an empty expansion slot, ensuring that the serial port used by the modem doesn’t conflict with serial ports (if any) on the other cards in your system.

Finishing touches

A few more steps and your system will be complete. Install the card separators on the inside front left wall of the case. Fasten the cards to the inside back wall of the case with the screws provided with the case. Install one of the metal plates wherever there is an empty slot.

The final step is to hook up the keyboard to the connector on the rear of the motherboard through the opening provided in the rear of the case. Refer to the documentation on the hard disk controller and initialize the drive.
Most electronic circuitry requires a source of stable, low ripple dc voltage to function. The power supply regulator is called upon to satisfy this requirement. Not too many years ago this meant assembling a dozen or so components on a circuit board. Since so many projects required a regulator, this circuit was built over and over again.

Modern IC linear regulators have eased this problem. We now get better specifications in a smaller package. The two types of adjustable linear regulators that have proven to be the most useful in my projects are the 317 series regulators for positive voltages and the 337 series regulators for negative voltages. This program deals with selecting the correct input voltages and resistor values when using these regulators.

The circuit

The output voltage is set by the ratio of R1 and R2 (see Figures 1 and 2). For best stability R1 is kept constant and the value of R2 is varied. The value for R1 in the 317 circuit is 290 ohms and the value for R1 in the 337 circuits is 120 ohms. The input and the output of the regulator should be bypassed with tantalum capacitors to make sure the circuit is unconditionally stable. A value of 1µF or so should be used. This value is not critical but the capacitors should be mounted as close to the regulator pins as possible.

Although the junction temperatures of most regulators can get as high as 150°C and still operate, a lower operating temperature is recommended for reliable operation. This would mandate the use of some sort of heat sink. When a heat sink is used, the regulator IC must be electrically isolated from the heat sink with an insulating washer. Diagrams of the various regulator case types are included in Figures 1 and 2.

The program

Two options are given to you: a screen output or a printer output. On the screen output, once you have answered the prompt as to what voltage you require, the program calculates what value of R2 will give you this voltage. Since this will not likely be a standard resistor value, the closest 5% resistor value is chosen for you. A new output voltage, using this 5% resistor value, is calculated and displayed. This new output voltage will always be within 5% of the target value. This should be more than adequate for most projects.

Two other parameters are also listed on the screen: minimum input voltage and maximum output voltage. Every linear voltage regulator must have a voltage drop across it in order to work properly, (i.e. the input voltage to the regulator must be higher than the output voltage). This minimum, for the chosen output voltage, is listed. The maximum input voltage relates to the amount of power the regulator can dissipate. To be able to draw the maximum output current, the input voltage to the regulator should be at or below this value. If it is above this value the output current will be reduced. In any case, absolute maximum input voltage is 40 volts.

The printer output option produces a table of values for all output voltages from 2 to 37 volts. It includes all values that are available on the screen display.

This program along with the Computer Assisted

Jack Cunkelman

Figures 1—OUTPUT VOLTAGE is set by the ratio of resistors R1 and R2. For stability, R1 is kept constant and R2 is varied. (See text.)

Fig. 2—WHILE FIGURE 1 shows the typical 317 series adjustable positive regulator, the diagram above provides the same information for the 337 series adjustable negative regulator.
PROGRAM: Identify CAD for Regulators

10 CLS
20 REM THREE TERMINAL ADJUSTABLE REGULATOR
OR APPLICATIONS
30 REM BY JACK CUNNELMAN - SEPT 1985
40 PRINT:PRINT
50 INPUT"SCREEN OUTPUT (S) OR PRINTER OR
TPUT (P)";FM
60 IF FM = "S" THEN 500 ELSE 70
70 IF FM = "P" THEN 3000 ELSE 50
500 CLS
610 PRINT "CALCULATIONS FOR USING THE:" 
620 PRINT "317 SERIES POSITIVE REGULATOR
RS (-1.2 TO 37 VOLTS)"
630 PRINT "337 SERIES NEGATIVE REGULATOR
RS (-1.2 TO -37 VOLTS)"
700 PRINT:PRINT
710 PRINT "SELECT TYPE:" 
720 INPUT "POSITIVE (P) OR NEGATIVE (N)
"VOLTS"
730 IF T$ = "P" THEN 750 ELSE 740
740 IF T$ = "N" THEN 900 ELSE 720
750 CLS
760 REM ** 317 CALCULATIONS **
770 INPUT "OUTPUT VOLTAGE DESIRED (0 TO
END FGM)";V
775 IF V = 0 THEN END
775 PRINT "MINIMUM INPUT VOLTAGE = "V+2.5
"VOLTS"
776 VM = V + 12
778 IF VM > 40 THEN VM = 40
780 PRINT"MAXIMUM INPUT VOLTAGE FOR MAXI
MUM OUTPUT CURRENT = VM"VOLTS"
790 R1 = 220 : R2 = ((220*(V-1.25))/1.25)
800 PRINT"R1 = 220 OHMS
R2 = "R2"
810 GOSUB 2000
820 PRINT "STANDARD 5% VALUE FOR R2 = "RS
"OHMS"
830 V = 1.25 + (1.25 * RS)/220
835 V1 = V+10
838 V2 = INT(V1)/10
840 PRINT "THE VOLTAGE OUTPUT USING"RS
"OHMS IS"V1"VOLTS"
850 PRINT "------CALCULATIONS FOR
317 SERIES REGULATORS-------"
900 GOTO 770
900 CLS
910 REM ** 377 CALCULATIONS **
920 INPUT "OUTPUT VOLTAGE DESIRED (0 TO
END FGM)";V
930 PRINT "MINIMUM INPUT VOLTAGE = "V+2.5
"VOLTS"
932 VM = V + 12
934 IF VM > 40 THEN VM = 40
940 PRINT"MAXIMUM INPUT VOLTAGE FOR MAXI
MUM OUTPUT CURRENT = VM"VOLTS"
950 R1 = 120 : R2 = ((120*(V-1.25))/1.25)
960 PRINT"R1 = 120 OHMS
R2 = "R2"
970 GOSUB 2000
980 PRINT "STANDARD 5% VALUE FOR R2 = "RS
"OHMS"
990 V = 1.25 + (1.25 * RS)/120
1000 V1 = V+10
1010 V2 = INT(V1)/10
1020 PRINT "THE VOLTAGE OUTPUT USING"RS
Power Supply Component Selection program should enable you to provide correct, well-regulated voltages for that next project with a minimum of effort.

DHMS IS "V2" VOLTS"
1030 PRINT "----CALCULATIONS FOR
37 SERIES REGULATORS -------"
1050 GOTO 920
2000 RESTORE
2010 READ RX
2020 RZ = R2 - RX
2030 IF SGN(R2) = -1 THEN 2060
2040 RA = RX
2050 GOTO 1010
2060 RX = RA
2070 E = ABS(RA - R2) : F = ABS(RB - R2)
2080 IF E < F THEN RS = RA ELSE RS = RB
2090 RETURN
2100 DATA 62,68,75,82,91,100,110,120,130
150,160,180
2200 DATA 200,220,240,270,300,330,360,39
430,470,510
2210 DATA 560,620,680,750,820,910,1000,1
100,1200,1500
2220 DATA 1500,1600,1800,2000,2200,2400,
2700,3000,3300
2230 DATA 3600,3900,4300,4700,5100,5600,
6200,6800,7500
2300 CLS
2300 PRINT "PRINTER ROUTINES**
3010 PRINT"PRINT TABLES FOR :"
3020 PRINT"317 SERIES POSITIVE REGULATOR
S (1.2 TO 37 VOLTS)"
3030 PRINT"337 SERIES NEGATIVE REGULATOR
S (-1.2 TO -37 VOLTS)"
3040 PRINT "TABLE FOR :"
3050 INPUT "POSITIVE (P) OR NEGATIVE (N)
VOLTS";T$
3060 IF T$ = "P" THEN 3500 ELSE 3070
3070 IF T$ = "N" THEN 3700 ELSE 3050
3100 R1 = 220 : LPRINT:LPRINT:LPRINT
3520 LPRINT TAB(20):"CALCULATIONS FOR
317 SERIES REGULATORS" 
3520 LPRINT:LPRINT:LPRINT
3530 GOTO 4020
3540 GOTO 4020
3550 DATA 5000
3560 FOR V = 2 TO 37
3570 IF V = 2 then 3570 ELSE 3550
3580 VL = V + 2.5
3590 VM = V + 12
3600 IF VM > 40 THEN VM = 40
3610 IF V = 2 THEN 3600 ELSE 3570
3620 RZ = ((R1*(V-1.25))/1.25)
3630 GOSUB 2000
3640 V = 1.25 + (1.25 * RS)/120
3650 V1 = V+10
3660 V2 = INT(V1)/10
3670 PRINT TAB(12):V1:TAB(22) R2:TAB(32)
RS:TAB(42) V2:TAB(52) VL:TAB(62) VM
3680 NEXT V
3690 END
3700 LPRINT TAB(10):"V"TAB(20)"CALCULATED"
TAB(34)"%"TAB(40)"OUTPUT V"TAB(50)"MIN"
TAB(60)"MAX"
5010 LPRINT TAB(10):V"TAB(20)"RZ 
TAB(34)"R2"TAB(40)"% R2"TAB(50)"INPUT V"
TAB(60)"INPUT V"
5200 LPRINT
5200 RETURN
5020 PRINT
5020 RETURN
This program was written in Microsoft Basic and contains no esoteric Basic functions and should be easily translated into any basic dialect. Appreciation.

FEBRUARY 1987 — ComputerDigest 111
CONCURRENCY

You don't get something for nothing...

Marc Stern

One of the myths in the microcomputer world is that you can have true concurrency and multitasking—the ability of a microcomputer to handle two applications at once—with an IBM PC or a close clone.

It is fairer to say that all of today's concurrent operating environments present the illusion of concurrency, but at a cost in system performance speed. Only those which open a constantly accessed temporary disk file on a high-speed, high-density fixed disk—Quarterdeck Office System's Descqview—have a chance of approaching reasonable operating speed.

The reason, is the 8086/8088 family of microprocessors used in the IBM world. Asking these micros to handle concurrency is like asking a four-cylinder car to pull a 10-ton trailer. You'll get where you're going eventually but it will take a long time.

(We're not talking about the high-performance, high-powered 80286 or 80386, because it would be like comparing apples and ducks. We're addressing the real world of 8086/8086 machines and there are more than 2.5 million at last check.)

Where the problem lies

You can't expect true concurrency from an 8086/8088 microprocessor because of its architecture. The speed of the unit and the amount of Random Access Memory are secondary.

The 8086/8088 microprocessors use an internal 16-bit architecture. This means that within the microprocessor chip itself everything moves around as 16-bit chunks of data or instructions. This internal architecture allows a marginal measure of concurrency because the 16-bit architecture is more powerful than an 8-bit architecture. But, this isn't the issue. The issue in concurrency is external and on this even the 8086/8088 machines diverge because of external differences.

In a strict sense, the 8086 microprocessor, a true 16-bit microprocessor, should handle a reasonable level of concurrency. It can theoretically address more than 1 megabyte of memory directly.

It must have various support chips to handle every input-output or direct memory access function (See Fig. 1). So, in order for this chip to have a measure of concurrency it must poll its support chips for input and when those chips have information it must fetch that information for its internal registers. Once the information is within those registers the 8086 functions as a 16-bit micro but its performance is slowed by the need to poll support chips and fetch the information.

One factor is that everything is handled via a 16-bit data bus so that only one poll and one fetch is needed per machine cycle—roughly every 1/18th of a second. This results in a speed increase over the 8088 because of a difference in architecture between the chips.

Concurrency still pushes the 8086 to its limits because the only way it can be implemented is by time-slicing or devoting some of the microprocessor's clock time to the second application. For several microseconds any first application freezes while the microprocessor handles the chores of the second.

A 16-bit microprocessor which is up to handling one application at reasonable speeds and flexibility slows down to the point of unacceptability when it must handle two or more chores.

So if a microprocessor with a different external architecture and different requirements which can affect performance, the 8088, the 8/16-bit version of the 8086 is a lower cost version, but uses the same instruction set.

The 8088 imposes its own set of constraints on a system because of its data bus. Where the 16-bit 8086 microprocessor has a 16-bit wide data bus, the 8088 has an internal data architecture of 16 bits, but an external data bus of 8 bits (See. Fig. 2). Where the 8086 needs only one data fetch and latch, the 8088 must...
make two because it is accessing data 8 bits at a time.

So, the 8088 must make two passes on its data bus for every one of the 8086 and this affects the performance of the 8088. Externally, the 8088 appears to be an 8-bit microprocessor in terms of its data bus and this imposes its own limitations on its adaptability to concurrency.

Instead of having to be concerned about time-slicing and fetching 16-bit instructions, which is how the 8086 works in a concurrent system, the 8088 must be concerned with time-slicing, and also the need for two passes at the data bus for complete data. This slows a processor which is already handling a great deal.

Superimpose the need to devote x microseconds to a second application, and the need for two passes at the data bus and true concurrency is impossible on an 8088. What is possible, is pseudo concurrency where a second application is frozen in the background, while the first application works in the foreground. You switch between the two with a combination of keys and while it looks as if you have concurrent processing, what you actually have is clever memory management.

The second function remains alive in RAM and video RAM so when the microprocessor sees a key combination, the environment application program controlling the microcomputer—Topview, Windows, Desqview, for example—switches over to the second application, while freezing the first (See Fig. 3).

The result looks like concurrent processing, but isn’t.

And even though pseudo-concurrency is the most efficient way for way for an 8086/8088 machine to be used in this situation, the machine still experiences a slowdown. Its single-task microprocessor is being asked to share some of its resources to keep the second application alive in memory. This requires the resources to refresh the second application, as well as the system resources to monitor I/O so the second application isn’t being called for.

There are some applications on the market which have long periods of microprocessor inactivity and you can keep these programs active in the background, instead of suspending their function as you might with most other types of programs that constantly ask for system resources.

These programs usually ask for microprocessor resources on demand—an incoming or outgoing call—and because they can be included in a system where there is a measure of background or concurrent processing. It will only activate when a data call comes in and so can remain active even though handling some foreground task. It works reasonably well even on an 8088 machine. You will notice a slowdown in your first task as you work with it.

The 8086/8088 series of microprocessors is meant for single use. Although their internal architecture makes them marginally capable of concurrent processing, there are too many factors against concurrency.

Clock Speed

Most 16-bit computers run in the 4.7 MHz range, if they are IBM PC compatible, which constrains the capabilities of the microprocessor. The micro itself, is happy at speeds of up to 8 MHz, but is throttled back.

At 4.7 MHz, concurrency is acceptable because the micro must handle all applications installed; housekeeping; input-output; memory access, and video memory refresh. In turn, this cuts the already slow 4.7 MHz clock speed to two-thirds or less so a system which moves along at nearly 5 MHz with one application suddenly runs about 3 MHz with a second and third and slows with more.

If the micro ran at 6 MHz or more, its speed would be more acceptable, on the order of 4 MHz or more so the system works more efficiently.

Random Access Memory

Concurrency requires vast amounts of memory. Imagine trying to run not only the original concurrent environment application program with its own memory requirements, but then installing the operating system and the applications you want to run concurrently with 128K of RAM. It’s impossible.

All of these require certain base amounts of memory to run which means your machine will probably need a minimum of 512K of memory installed. And imagine this 512K is only marginally acceptable in most instances. You need 640K and in most cases, performance is only marginally acceptable, especially if

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**FIG. 3—**This is a representation of the relationship of two applications that are used in a concurrent environment.

**FIG. 4—**The PC'S DISK operating system effectively limits the PC to 640K of memory.
the environment program keeps everything in active memory as Topview does. This slows down reaction time and, in some cases, may freeze the machine because it is processor bound.

The constraining factor is the 640K limit imposed by the disk operating system. When it was designed it was believed machines would be well equipped with 640K and those needs would serve for several years. However, applications have raced ahead of the disk operating system to the point where 640K is becoming average for most PC users and 1.2 megabytes of RAM is actually needed. But, DOS can’t look beyond 640K without program help (See Fig. 4) This is the final factor which effectively constrains true concurrency. You don’t have enough memory to enable a PC to have as many programs installed in memory as you need.

Quarterdeck’s Desqview allows you to open five or more windows with different applications and automatically opens a temporary disk buffer. Only the actual kernel of the program is kept in RAM with the rest residing in the disk file, being called when needed. But the ultimate answer lies in a different breed of microcomputer, the 32-bit chip. These have the power, flexibility and capability of accessing enough memory to make true concurrency possible. Their 32-bit architecture enables this, and they can address over 16 megabytes of memory directly. With this much power and nearly 7 MHz speed available as standard, a micro is capable of handling two or more tasks at once.

While some ads indicate that concurrency is possible, remember it is — on a new 32-bit machine. The standard 16-bit micro is only marginally up to the task and then it takes some sophisticated memory management to pull it off.
FOR SALE
TUBES, new, unused. Send self-addressed, stamped envelope for list. FALAL ELECTRONICS, Box 1376-2, Milwaukee, WI 53201.

FREE microprocessors, memory chips, etc. Free electronics magazines subscriptions. Free education in computers. For information write MICRO-SAT CORPORATION, 2401 N.E. Cornell, Bldg. 133, Hillsboro, OR 97124.

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( ) Education Instruction ( ) Wanted ( ) Satellite Television

Special Category: $23.00

PLEASE PRINT EACH WORD SEPARATELY, IN BLOCK LETTERS.

(No refunds or credits for typesetting errors can be made unless you clearly print or type your copy.) Rates indicated are for standard style classified ads only. See below for additional charges for special ads. Minimum: 15 words.

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Card Number Expiration Date

Please Print Name Signature

IF YOU USE A BOX NUMBER YOU MUST INCLUDE YOUR PERMANENT ADDRESS AND PHONE NUMBER FOR OUR FILES. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

CLASSIFIED COMMERCIAL RATE: (for firms or individuals offering commercial products or services) $2.05 per word prepaid (no charge for zip code) MINIMUM 15 WORDS. 5% discount for same ad in 6 issues. 10% discount for same ad in 12 issues within one year. If prepaid, NON-COMMERCIAL RATE: (for individuals buying or selling personal items) $25.00 per word prepaid. No minimum. ONLY FIRST WORD AND NAME set in bold caps at no extra charge. Additional bold face (not available as all caps) 50¢ per word additional (20% premium). Entire ad in boldface, add 20% premium to total price. TINT SCREEN BEHIND ENTIRE AD: add 25% premium to total price. TINT SCREEN BEHIND ENTIRE AD PLUS ALL BOLD FACE AD: add 45% premium to total price. EXPANDED TYPE AD: $4.30 per word prepaid. All other items same as for STANDARD COMMERCIAL RATE. TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD: add 25% premium to total price. TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD PLUS ALL BOLD FACE AD: add 45% premium to total price. DISPLAY ADS: 1" x 2¼"—$320.00; 2" x 2¼"—$640.00; 3" x 2¼"—$960.00. General Information: Frequency rates and prepayment discounts are available. ALL COPY SUBJECT TO PUBLISHERS APPROVAL. ADVERTISEMENTS USING P.O. BOX ADDRESS WILL NOT BE ACCEPTED UNTIL ADVERTISER SUPPLIES PUBLISHER WITH PERMANENT ADDRESS AND PHONE NUMBER. Copy to be in our hands on the 2nd of the third month preceding the date of the issue. (i.e., August issue copy must be received by May 12th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding working day.

CHANNEL 3—6010 notch filter, 63.5 MHz. $19.95. All other channels $29.95. Cable converter and accessory catalog $1. (514) 739-9326. CROSLEY(A), Box 840, Champaign, NY 12919.

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TESTING SEMICONDUCTOR

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Normally, $h_{fe}$ increases with an increase in collector current. Eventually, however, a point is reached where increasing the collector current no longer produces a rise in $h_{fe}$, and further increases in collector current actually cause the gain to decline. That phenomenon is shown in the curves of Fig. 7. Several reasons are cited for that peaking of forward gain, but it basically boils down to the construction of the transistor.

The voltage across the transistor, $V_{CE}$, is also responsible for variations in gain. Most of the variations, however, are attributed to the electric field created across the diode junctions. The electric field influences the electrons as they pass through the base region, further complicating the forward-gain pattern. The strength and contour of the electric field at the junctions is determined by the physical geometry of the device.

When trying to draw a correlation between the $h_{fe}$ value specified on the data sheet and the value you have measured, you must know what voltages and currents were used by the manufacturer to obtain the specified $h_{fe}$. Those values are normally listed on the data sheet.

Let's finish up by showing you a simple circuit for measuring $h_{fe}$ that can be built using a 9-volt battery and a 1-mA meter. See Fig. 8. The base current is fixed so that the meter reads $h_{fe}$ directly on a ×100 scale. A setting of 0.5, for example, translates into an $h_{fe}$ of 50. Reverse the battery and meter polarities for testing PNP transistors.

In our next installment we will take a look at the important characteristics of another kind of transistor—the FET, or Field-Effect Transistor.

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TRI-MODE

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range. Set the bias potentiometers, R8 and R16, fully clockwise, then back one quarter of their range to about the nine o'clock position. Set the 10-DB and 6-DB gain potentiometers, R10 and R18, to the middle of their range. Set the clear bias potentiometer R27 fully clockwise.

Select a known-scrambled channel. If the non-scrambled (NS) LED is lit, it indicates that no pulses are being detected by IC1. In that event, turn R14 counter-clockwise until the LED goes out, then back clockwise just until it comes on. If the NS LED never goes out, that may indicate a weak signal. If the NS LED is not on, turn R14 clockwise until it just comes on. If the LED never comes on, that may indicate a signal that is too strong. If your signal is too weak, use an adjustable line amplifier: if it is too strong, use an adjustable attenuator (6 to 12 dB). However, proceed to the next step before trying a line amplifier or attenuator.

Slowly turn L1's slug clockwise until the NS LED goes out and one of the other LED's comes on. Depending on the cable system, the modes may be changing, but only one LED should be on at a time. If they are all on and flashing, the circuit is getting incorrect data. As you continue to turn clockwise, the NS LED will come back on. Now turn the slug counter-clockwise until you are halfway between the two points where the NS LED comes on.

At this point, if you have an oscilloscope, you can adjust L1 by looking at the signal on the base of Q14. It should resemble the waveform shown in Fig. 7.

Next, determine the mode by examining the LED indicators. During 10-DB scrambling, adjust only R8 and R10. During 6-DB scrambling, adjust only R16 and R18. Do not make any adjustments during the clear mode.

Course adjust the appropriate gain potentiometer to obtain a stable picture. Then tweak the adjustment so that the picture looks normal in color, brightness, and contrast. If you cannot obtain a proper picture in one of the modes, adjust the clear bias potentiometer, R27, slightly counterclockwise and try again.

Once you have obtained a stable picture in one of the modes, turn width potentiometer R44 clockwise. You will notice that the picture gets darker, and the colors, if you had any before, fade. Turn R44 counterclockwise and you will notice that the picture gets lighter and the colors get brighter. If you continue turning counterclockwise, the color brightness will level off. If you go a little further, the picture starts to tear. While watching the picture, adjust back and forth slowly and get a feel for the effect. Then, starting fully clockwise, turn R44 counterclockwise to a point just a hair beyond where the color brightness seems to level off. If you have an oscilloscope, you can adjust R44 more precisely. Set that potentiometer for a 12-µs pulse width at IC14-a, pin 3.

Final adjustment of the bias potentiometers is done by adjusting them so that there is no ripple in the picture. Remember, you can only make the adjustment for the stage that you have already set the gain for, and only when the appropriate LED-mode indicator is on. Once you have completed the gain and bias adjustments for one of the scrambled modes, follow the same procedure for adjusting the gain and bias for the other.

The final step is to check the picture when the scrambling modes change between 6 dB, 10 dB and clear. You can eliminate any shifts in picture level by fine tuning the width adjustment, R44, and the 6-DB and 10-DB gain potentiometers.

Once alignment is complete, you may notice a problem with power-supply noise (60-Hz interference). If you have such a problem, try adding a jumper between the negative side of C50 and the negative side of C8.
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Power Supply Diodes

Micromini 1-Amp. 30-amp surge.

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<td>N4003</td>
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<td>N4005</td>
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3-Amp "Barrel" 200-amp surge.

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<tr>
<td>N5402</td>
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<tr>
<td>N5404</td>
<td>400</td>
<td>276-1444</td>
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Resistor Kit Bargains!

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<th>Pkg of 2</th>
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<td>N5404</td>
<td>400</td>
<td>276-1144</td>
<td>99</td>
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</table>

Brushless 3" DC Fan

Quiet, Compact, Powerful!

Lightweight yet delivers 27 CFM airflow. Ideal for cooling circuits that’s sensitive to hum or AC fields or mobile equipment. Ball bearings for long life and low noise. Requires 7 to 13.8 VDC. $273-243

Over 1000 items in stock: Binding posts, Books, Breadboards, Buzzers, Capacitors, Chokes, Clips, Coax, Connectors, Fuses, Hardware, ICs, Jacks, Knobs, Lamps, Multimeters, PC Boards, Plugs, Rectifiers, Relays, Resistors, Switches, Tools, Transformers, Transistors, Wire, Zeners and more

CIRCLE 78 ON FREE INFORMATION CARD

Radio Shack
A DIVISION OF TANDY CORPORATION

Prices apply at participating Radio Shack stores and dealers
### Integrated Circuits

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Quantity</th>
<th>Price</th>
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<tbody>
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<td>CA3100</td>
<td>NPN Transistor</td>
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<td>$1.50</td>
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<td>MC74HC00</td>
<td>CMOS Logic</td>
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<td>Schottky TTL</td>
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### Solder Tag DIP Sockets

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<td>TSSOP-8</td>
<td>8-Pin Thin Small Outline Package</td>
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<td>NSOP-16</td>
<td>16-Pin Narrow Small Outline Package</td>
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<td>WSO-24</td>
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### Wire Wrap DIP Sockets

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<th>Type</th>
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<td>WWR-2</td>
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<td>3-Pin Wire Wrap</td>
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<td>BF195</td>
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### SEC Memory Chips

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<tr>
<td>28660</td>
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### SEC Microprocessor Chips

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</thead>
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<tr>
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<td>8086</td>
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**Factory Firsts**

*256K (262,144 x 1) DRAM 150NS $5.70/1; $39.95/9*

**VOLUME DISCOUNT**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Discount</th>
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<td>2000</td>
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<tr>
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**SERVICE CHARGES**

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<tr>
<td>Non-Stock</td>
<td>15%</td>
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**Telex:** Digi-Key Corp. 1-800-344-4539

**FEBRUARY 1997**

**CIRCLE 82 ON FREE INFORMATION CARD**
## 20MB HARD DISK SYSTEM ONLY $369.95!

### STATIC RAMS

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>256K (50ns)</td>
<td>1.99</td>
</tr>
<tr>
<td>1M (50ns)</td>
<td>1.99</td>
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<tr>
<td>2M (50ns)</td>
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</tr>
<tr>
<td>4M (50ns)</td>
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### DYNAMIC RAMS

<table>
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<td>4116-200</td>
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<td>4116-150</td>
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### 8000

<table>
<thead>
<tr>
<th>Capacity</th>
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<tbody>
<tr>
<td>256K</td>
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### 6500

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### BIT RATE GENERATORS

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### 74LS00

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### EPROMS

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<tr>
<td>27C04</td>
<td>4.95</td>
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### ORDER TOLL FREE 800-538-5000

### HIGH-SPEED CMOS

A new family of high-speed CMOS logic featuring the speed of low power Schmitt...
### CMOS
<table>
<thead>
<tr>
<th>Model</th>
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### 74S00
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### Voltage Regulators

#### TO-220 Case
- 7805T 4.9 750.99
- 7809T 4.9 750.99
- 7812T 1.3 7912K 1.49

#### TO-234 Case
- 7808K 1.59 7801K 1.69
- 7812K 1.39 7912K 1.49

### IC Connectors

#### Header
- 50 PIN 1440 RIGHT ANGLE 1.49

### Edgecard Connectors

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<td>44 PIN WW STD</td>
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### LED Displays

#### LEDS
- RED 75K 2.2R 1.25 220 1.49 1.99 2.49
- GREEN 50K 2.3K 1.3K 1.8K 2.8K 3.7K 4.7K

### Switches

#### DPDT
- MINI TOGGLE ON-OFF 1.25
- MINI TOGGLE ON-OFF-ON 1.75
- MINI PUSHBUTTON NC 1.25
- TOGGLE OVERLOAD 1.25

### Diffused LEDs

#### 4x7 HEW LOGIC 270.95
- LM2904 7200.95

### RIBBON Cable

#### 5pin $1.00

### D-SUBMINIATURE

#### DIP Connectors

#### IC Connectors

### Hard to Find "Snappable" Headers

- 140 STRAIGHT LEAD 1.99
- 140 RIGHT ANGLE 1.99
- 140 STRAIGHT LEAD 2.29
- 240 RIGHT ANGLE 2.99

### Shorting Blocks

#### Metal
- Gold Contacts 1.50 Centered

### Special Order

#### Service Center

### Call for Volume Quotes

#### Scott Felickert

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Circle 176 CN Free Information Card

February 1987
DISK DRIVE ACCESSORIES
FDD CONTROLLER CABLE $49.95
ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE II

DISK FILE
HOLDS 70 5½" DISKETTES
$89.95

POWER STRIP
UL APPROVED
$12.95

BUILD STEVE CIARCIA'S INTELLIGENT EPROM PROGRAMMER
45-SEEN-IN-BYTE OCT. 86
- STAND-ALONE OR RS-232 SERIAL OPERATION
- MENU SELECTABLE EPROM TYPES—NO CONFIGURATION JUMPERs
- PROGRAMS ALL 5V 27XXX EPROMS FROM 2716 TO 27512
- READ, COPY OR VERIFY EPROM
- UPLOAD/DOWNLOAD INTEL HEX FILES
- PROGRAMMER DRIVER USER MODIFIABLE
ONLY $199
Kit includes PCB and all components except case and power supply

TEST EQUIPMENT FROM JDR INSTRUMENTS
DIGITAL MULTIMETER PEN DPM-1000
AUTO RANGING, POLARITY AND DECIMAL!
- LARGE 3½ DIGIT DISPLAY
- DUAL SOE OLD SWITCH FREEZES READING
- FAST 25 μS CONTINUITY TEST
- LOW BATTERY INDICATOR
- OVERLOAD PROTECTION
$54.95

FSR 5 MB HARD DISK SYSTEM ONLY $369.95!
APPLE COMPATIBLE INTERFACE CARDS
EPROM PROGRAMMER $59.95
MODEL RP523
- DUAL OR DUMP ANY STANDARD 27XX SERIES EPROM
- EASY TO USE MENU DRIVEN SOFTWARE INCLUDED
- MENU SELECTION FOR 2716, 2728, 2732, 2734 AND 2750
- HIGH SPEED WRITE ALGORITHM
- LED INDICATORS FOR ACCTIVITY
- NO EXTERNAL POWER SUPPLY NEEDED
- ONE YEAR WARRANTY
16K RAMCARD $39.95
- FULL TWO YEAR WARRANTY
- EXPAND YOUR 48K APPLE TO 64K
- USE IN PLACE OF AP LANGUAGE CARD
- BASE PC CARD W/INSTRUCTIONS $8.95

MC5435 $249.95
- 3.5" ADD-ON DISK DRIVE
- 100% MAC/INTOSH COMPATABLE
- DOUBLE SIZED 800K BYTE STORAGE
- HIGH RELIABILITY DRIVE
- SAVE AUTO ELECT MECHANISM
- FULL ONE YEAR WARRANTY

AD-3C $139.95
- 100% APPLE II COMPATABLE
- READY TO PLUG IN W. SHIELDED CABLE & MOLDED 10 PIN CONNECTORS
- FAST, RELIABLE SLIMLINE DIRECT DRIVE
- SIX MONTH WARRANTY

DISK DRIVE ACCESSORIES
FDD CONTROLLER CABLE $49.95
ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE II

KB-1000 $79.95
CASE WITH KEYBOARD FOR APPLE II TYPE MOTHERBOARD
- USER DEFINED FUNCTION KEYS
- NUMERIC KEYPAD
- CAPS LOCK
- AUTO-REPEAT

JOYSTICK CR-401 $7.95
FOR ATARI 400, 800, 2600, VIC-20, 64 AND APPLE II

JOYSTICK CR-401 $9.95
FOR APPLE OR IBM

APPLE INTERFACE CARDS
eprom programmer $59.95
model rp523
- dual or dump any standard 27xx series eprom
- easy to use menu driven software included
- menu selection for 2716, 2728, 2732, 2734 and 2750
- high speed write algorithm
- led indicators for activity
- no external power supply needed
- one year warranty

Bal-500 $129.95
- teac mechanism direct drive
- 100% apple compatible
- full one year warranty

ap-135 $129.95
- full ht shielded mechanism
- direct replacement for apple disk ii
- six month warranty

MAC5435 $249.95
- 3.5" add-on disk drive
- 100% mac/intosh compatible
- double sized 800k byte storage
- high reliability drive
- save auto select mechanism
- full one year warranty

ad-3c $139.95
- 100% apple ii compatible
- ready to plug in w. shielded cable & molded 10 pin connectors
- fast, reliable slimline direct drive
- six month warranty

disk drive accessories
fdd controller cable $49.95
adapts standard apple drives for use with apple ii

KB-1000 $79.95
CASE WITH KEYBOARD FOR APPLE II TYPE MOTHERBOARD
- user defined function keys
- numeric keypad
- caps lock
- auto-repeat

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JOYSTICK CR-401 $9.95
FOR APPLE OR IBM

APPLE INTERFACE CARDS
EPROM PROGRAMMER $59.95
MODEL RP523
- DUAL OR DUMP ANY STANDARD 27XX SERIES EPROM
- EASY TO USE MENU DRIVEN SOFTWARE INCLUDED
- MENU SELECTION FOR 2716, 2728, 2732, 2734 AND 2750
- HIGH SPEED WRITE ALGORITHM
- LED INDICATORS FOR ACTIVITY
- NO EXTERNAL POWER SUPPLY NEEDED
- ONE YEAR WARRANTY
16K RAMCARD $39.95
- FULL TWO YEAR WARRANTY
- EXPAND YOUR 48K APPLE TO 64K
- USE IN PLACE OF AP LANGUAGE CARD
- BASE PC CARD W/INSTRUCTIONS $8.95

IC TEST CAR $39.95
- QUICKLY TESTS MANY COMMON ICs
- DISPLAYS PASS OR FAIL
- ONE YEAR WARRANTY
- TESTS 4000 SERIES CMOS, 74HC SERIES CMOS, 7400, 74LS, 74H, 74S

DIRECT CONNECT CABLE FOR APPLE IIe $14.95
- FCC APPROVED
- BELL SYSTEMS 103 COMPATIBLE
- INCLUDES AC ADAPTOR
- AUTO-DIAL
- DIRECT CONNECT

FDD CONTROLLER CABLE $49.95
ADAPTS STANDARD APPLE DRIVES FOR USE WITH APPLE II

DISK FILE
HOLDS 70 5½" DISKETTES
$89.95

3.5" DISKFILE HOLDS 40 $9.95

TEST EQUIPMENT FROM JDR INSTRUMENTS
DIGITAL MULTIMETER PEN DPM-1000
AUTO RANGING, POLARITY AND DECIMAL!
- LARGE 3½ DIGIT DISPLAY
- DUAL SOE OLD SWITCH FREEZES READING
- FAST 25 μS CONTINUITY TEST
- LOW BATTERY INDICATOR
- OVERLOAD PROTECTION
$54.95

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.
IBM COMPATIBLE INTERFACE CARDS

MULTI I/O FLOPPY CARD
$99.95
- 2 DRIVE FLOPPY DISK CONTROLLER
- 1 RS232 SERIAL PORT-OPTIONAL 2nd SERIAL PORT
- PARALLEL PRINTER PORT
- GAME PORT
- CLOCK/CALCULATOR
- SOFTWARE CLOCK UTILITIES
- RAM DISK
- SPEAKER IN/OUT"OPTIONAL SERIAL PORT $15.95"

COLOR GRAPHICS ADAPTOR
FULLY COMPATIBLE WITH IBM COLOR CARD
$69.95
- 4 VIDEO INTERFACES: RGB, COMPOSITE COLOR, H-RES, V-RES
- CONNECTOR FOR RF MODULATOR
- COLOR GRAPHICS MODE: 200 x 200
- MONO GRAPHICS MODE: 640 x 200
- LIGHT PEN INTERFACE

IBM COMPATIBLE KEYBOARDS
IBM-5150 $59.95
IBM-5151 $79.95
- "5150" STYLE KEYBOARD
- FULLY IBM COMPATIBLE
- LED STATUS INDICATORS FOR CAPS & NUM LOCK
- 32 KEY - SAME LAYOUT AS IBM PC/XT KEYBOARD
- REPLACEMENT FOR KEYTRONICS KB-5131
- SEPARATE CURSOR & NUMERIC KEYPAD
- CAPS LOCK & NUMBER LOCK INDICATORS
- IMPROVED KEYBOARD LAYOUT

IBM COMPATIBLE INTERFACE CARDS

MONOCHROME MONOCHROME ADAPTOR & HERCULES GRAPHICS
$79.95
- 1024X768 GRAY LEVELS
- TEXT MODE: 80 x 25
- GRAPHICS MODE: 720 x 350
- PARALLEL PRINTER INTERFACE
- OPTIONAL SERIAL PORT $19.95

MONOCHROME ADAPTOR
$49.95
- AND ANOTHER FANTASTIC VALUE FROM JDR!
- IBM COMPATIBLE TTI OUTPUT
- 720 x 350 PIXEL DISPLAY
- PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS AND DOES NOT INCLUDE A PARALLEL PORT

FLOPPY DISK DRIVE ADAPTOR
$34.95
- INTERFACES UP TO 4 STANDARD FDDs TO IBM PC OR COMPATIBLES
- INCLUDES CABLE FOR TWO EXTRA DRIVES
- STANDARD DB37 FOR EXTERNAL DRIVES
- RUNS QUAD DENSITY DRIVES WHEN USED WITH JDR

POWER SUPPLY

DISK DRIVES
TANDON TM50-2 $79.95
- 1/2 HT DS/DD
- IBM COMPATIBLE
- EXTREMELY QUIET!

IBM COMPATIBLE INTERFACE CARDS

IBM COMPATIBLE INTERFACE CARDS

MULTI I/O FLOPPY CARD
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TANDON TM50-2 $79.95
- 1/2 HT DS/DD
- IBM COMPATIBLE
- EXTREMELY QUIET!
CLEARANCE

Buy merchandise worth $50 or more from this ad at these incredibly reduced prices, and get a FREE Soldering Iron! Offer valid from January through February 1987 or while supplies last, so hurry!! For details, see below.

BOOKS

Australia the Beautiful (288 pp) $19.95 (B-9901)
Reference Data for the Radio Engineer (198 pp) $39.95 (B-3995)
Complete Battery Book (352 pp) $14.95 (B-3624)
CMOS 74HC00 Data Book Was $2.95 Today $1.95 (B-3632)
IC Master (2 volume set) Was $19.00 Today $7.95 (B-4001)

MAGAZINE BINDERS 10 for $29 Were $4.55 each. Save $20 on 10!

AudioVisual Accessories

Monochrome Monitor for Apple computers Was $39.95 Today $20.95
Voyager Modem Was $39.95 Today $20.95 IBM & compatibles. 300/1200bps RS232C port modem switch selectable Was $169.95 Today $80.95

Computer Accessories

Challenger Modem 0-300/1200/2400bps. Bell or Hayes compatible Auto answer/Dial B external status indicators Was $189 Today $80.95
Discovery Modem Incredible features: 0-300/600/1200/2400bps Voice data switching AT command set. Much, much more! Was $139 Today $85.95

Computer Books

Introduction to Turbo Pascal Was $14.95 Today $22.95 (268 pp) $2364
From Chips to Systems Was $15.00 Today $12.95 (502 pp) $2378
Micropro/Interface (456 pp) $12.95 (B-2375)
Programming the Macintosh in Assembly Language Was $16.00 Today $13.95 (178 pp) $2702

Audio/Visual Accessories

Lightweight Stereo Headphones Was $16 Today $9.95 Was $49.95 Today $6.95 (C-1106)
Video Cable Set Was $12 Today $9.99 Was $22.22 Today $10 for $4.99 (W-1287)

Audio/Visual Accessories

CANON-type Audio Connectors

Here are the high quality audio connectors used by music fanatics around the world. Buy now and SAVE!

3-Pin Line Socket (P-1620) Was $12 Today $9.99
Now Only $1.49
You save 80%!

3-Pin Line Panel (P-1621) Was $12 Today $9.99
Now Only $1.49
You save 80%!

3-Pin Line Plug (P-1624) Was $12 Today $9.99
Now Only $1.49
You save 80%!

3-Pin Panel Socket (P-1626) Was $13 Today $9.99
Now Only $1.49
You save 80%!

We have also specially reduced our quality 'rubber-like' audio lead. Shielded with two center conductors.

High Screen Shielding

Very Flexible Rubber-Covered Outer Sheath

Was $5.95 Today $2.99
Now Only $1.99
You save 33%

4 audio lines for only $2.99 (W-2037)

Jeweler's Saw

Cut any shape in wood, plastic or metal. It is an invaluable value by itself, but we need to move them so $10 off. Use the cleaners... with this great deal!

Buy the saw & get 3 sets of blades FREE! 12 Extra-Fine blade, 12 Fine blade, 12 Medium blade. Smallest stock available. Regularly $1.95 per set. Use the cleaners. 

Jeweler's Saw

Ultrasonic Home Alarm

No wiring required. Compact alarm Was $17 Today $5.99

Tape-a-Message

Press a button to record, pick it up for instant playback. Was $12.95 Today $4.99

HOME ELECTRONICS

Ultrasonic Home Alarm

No wiring required. Compact alarm Was $17 Today $5.99

Tape-a-Message

Press a button to record, pick it up for instant playback. Was $12.95 Today $4.99

Electronics

Stepping Motors for Robotics Single Shaft (J-0015) $9.95 EACH
10 for $75


0.5V CI/4A Transformer Was $19.95 Today $7.99 (M-0145)

Cooling Fan 110V AC, 3x3 ⅜ x ¾ x ⅛ in. Was $12.95 Today $6.99 (M-0505)

Ni-Cad Charger 2.5mm plug for NICD packs from 3 to 15 AA cells. Was $4 Today $2.99 (M-9517)
### SEMICONDUCTOR SPECIALS

<table>
<thead>
<tr>
<th>Cat No</th>
<th>Description</th>
<th>WAS</th>
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**FREE SOLDERING IRON**

Get a FREE soldering iron when you buy the $29.95 Mix 2 Car Alarm Kit! Limit 1 Free Iron per Order. Free Iron will not be shipped if order is returned or cancelled. 

**MORE KITS**

**Mixer Preamp Kit (k-5035) $15.95**

4 Input Mixer Preamp Kit (k-5036) $29.95

**Mix 2 Car Alarm Kit (k-3253) $14.95**

Was $24.95 You save 35%

### Visit our Retail Centers:

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Redwood City: 390 Convention Way 415-368-8844
San Jose: 4980 Stevens Creek Blvd 408-241-2267
Los Angeles: 1830 Westminster 213-474-0626

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We ship UPS Ground unless otherwise requested. Add 5% of order total (min $1.50) for shipping. Outside USA and 20% (min $4). There is an additional $1.50 handling fee for California residents. Add sales tax & VISA MASTERCARD welcome.

Due to the nature of this special promotion, all SALES ARE FINAL, but standard warranties apply.

### Rack 'em up!

We've sold thousands of rack cabinets and we want to sell even more! Our prices are so discounted, but we have a new offer you can't resist! Buy any two cabinets and receive a very rack (a $11.95 value for FREE) Please specify type of cabinets required and rack when ordering.

### Free FunWay books with purchase of kits!

We have to reduce our inventory of the popular FunWay kits, so in addition to offering spectacularly low prices, we're including a FREE FunWay II instruction manual for the purchase of any kit for $10 or more. This manual provides front panels for projects when you buy two or more of the FunWay II kits listed below. Or buy any three FunWay II kits projects, and we'll give you the FunWay III book (with 10 more advanced projects & valuable electronic information) FREE! Please specify book(s) and mention this ad when ordering.

### Specials

**THE SEMICONDUCTOR SPECIALS**

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Mini-Meters with Maxi-Specs

SCOPE 3½ Digit LCD with 8 Full Functions

Model DVM-632
$4495
OUR PRICE

Measures only 5½" x 2½" x 1¼"
Deluxe test leads included
- 5.5% accuracy
- Transistor gain test
- Audible continuity checking & diode test
- 10 Amp measurement

Zipped Carrying Case
CC-30 $450

SCOPE 3½ Digit LCD

Measures only 5" x 2¼" x ½"

Model DVM-630
$2995
OUR PRICE
Test leads included
- 0.5% accuracy
- 6 functions, 19 ranges
- Automatic zero adjust
- Low battery indication

Zipped Carrying Case
CC-30 $450

ASK FOR FREE CATALOG.
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Continental U.S.A.

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